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GEOTECHNICAL AND GEOLOGIC HAZARDS INVESTIGATION
Bobcat Ridge Subdivision
Summit Powder Mountain Resort
Weber County, Utah

IGES Project No. 01628-028

July 26, 2018

Prepared for:

Summit Mountain Holding Group

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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 the *Bobcat Ridge* project, part of the currently on-going expansion at the Powder Mountain Ski Resort in Weber County, Utah. 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 to Summit Mountain Holding Group (Client), dated March 27, 2018. 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 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 a number of 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 project is accessed by Powder Ridge Road and Summit Pass Road.

The project site is located south of Phase 1C and 1D and west of the proposed Beach Club property, accessed by way of a southern extension of Summit Pass Road (see *Site Vicinity Map*, Figure A-1 in Appendix A). We understand that the project consists of developing an approximately 40-acre parcel to include 48 residential lots ranging in size from approximately 0.34 acres to 1.55 acres. The project will also include approximately 6,125 linear feet of new roadway, some of which will be private and some of which will be Weber County roadway, including approximately 960 feet of the southern extension of Summit Pass Road. The roadway is expected to be constructed with a series of relatively shallow cuts and fills. A single skier bridge is planned across the southern extension of Summit Pass Road, whereby a ski path will pass under the roadway. The residential units are anticipated to be assorted types of high-end vacation homes, likely multi-story residential structures; it is likely the structures will include a basement level, unless groundwater conditions preclude the practical construction of a basement.

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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 (IGES, 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. This includes a review of the geotechnical and geologic hazard investigations for the Beach Club property (IGES, 2017) and Village Lift (IGES, 2016).

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. Coogan and King (2001) provide more recent geologic mapping of the area, but at a 1:100,000 scale. An updated Coogan and King (2016) regional geologic map (1:62,500 scale) provides the most recent published geologic mapping that covers the project area. Western Geologic (2012) conducted a reconnaissance-level geologic hazard study for the greater 200-acre Powder Mountain expansion project, including the Bobcat Ridge area. 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). The corresponding United States Geological Survey (USGS) topographic maps for the Huntsville and Brown's Hole Quadrangles (2017) 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.

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2.2 FIELD INVESTIGATION

Site reconnaissance and site-specific geologic mapping was performed across the site prior to identifying the test pit locations, such that suspect geologic hazard areas could be appropriately investigated by subsurface methods. Subsurface soils were investigated by excavating 55 test pits at representative locations across the property. The approximate location of the test pits is illustrated on the *Geotechnical and Local Geology Map* (Figure A-2 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-3 through A-57 in Appendix A. A key to USCS symbols and terminology is presented as Figure A-58, and a key to physical rock properties is presented as Figure A-59.

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 & Dry Unit Weight (ASTM D7263, D2216)
- Unconfined Compressive Strength (ASTM D2166)
- Direct Shear (ASTM D3080)
- Ring Shear Test
- Soluble Sulfate, Soluble Chloride, pH and Resistivity

Results of the laboratory testing are discussed in this report and presented in Appendix B. Some test results, including moisture content, particle size distribution, and Atterberg Limits, have been incorporated into the test pit logs (Figures A-3 through A-57).

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3.0 GEOLOGIC CONDITIONS

3.1 GENERAL GEOLOGIC SETTING

The Bobcat Ridge 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 all normal faults, typically 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 Bobcat Ridge property is located approximately 10 miles to the northeast of the Weber Segment of the north-south-trending Wasatch Fault, which is the closest documented Holocene-aged (active) fault to the property (USGS and UGS, 2006).

3.2 SURFICIAL GEOLOGY FROM LITERATURE

According to Sorensen and Crittenden, Jr. (1979) and Crittenden, Jr. (1972), the property is entirely underlain by the undivided Tertiary/Cretaceous Wasatch and Evanston Formations (TKwe),

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described as "unconsolidated pale-red to greenish-red pebble, cobble, and boulder conglomerate. Forms boulder-covered slopes but does not crop out anywhere. Clasts are mainly Precambrian quartzite and are tan, gray, or purple; matrix is mainly poorly consolidated sand and silt." A generalized bedding attitude near the property shows this unit striking due north and dipping 10 degrees to the east; this map forms the basemap for the *Regional Geology Map 1* (Figure A-60). Coogan and King (2001) produced a regional-scale geologic map that covered the property; this map shows most of the property to be entirely underlain by the Wasatch Formation, though the northern portion of the property is within deposits mapped as undivided mass-movement deposits, which "includes slides, slumps, and flows, as well as colluvium, talus, and alluvial fans that are mostly debris flows." Western Geologic (2012) identified a number of landslide deposits contained within the Powder Mountain Resort expansion area, including some mapped within the Bobcat Ridge property boundary (*Regional Geology Map 2*, Figure A-61). While most of the property is located outside of mapped landslide deposits, Western Geologic (2012) maps the northwestern portion of the property as underlain by deposits mapped as "mixed slope colluvium, shallow landslides, and talus," while a Holocene to Late Pleistocene landslide lobe is mapped in the northeastern part of the property, and a large Pleistocene landslide lobe is mapped across the southernmost portion of the property. Finally, Coogan and King (2016) updated their 2001 map, which shows the northern part of the property to largely be underlain by landslide deposits (unit Qms), though the rest of the property is mapped as being underlain by the Wasatch Formation (unit Tw) (*Regional Geology Map 3*, Figure A-62). Wasatch Formation bedrock in the area is shown to be striking approximately to the north-northeast, and dipping between 3 and 6 degrees to the east-southeast; additionally, according to this map, the property is just west of a north-south trending syncline[1].

3.3 HYDROLOGY

The USGS topographic maps for the Huntsville and Brown's Hole Quadrangles (2017) show that the Bobcat Ridge project area straddles a ridge, whereby the topographic gradient for the northern approximately one-half of the property slopes down to the northwest towards Lefty's Canyon, while the southern approximately one-half of the property slopes down to the south towards Gertsen Creek (see Figure A-1). No active or ephemeral stream[2] drainages were observed on the property during the site reconnaissance. A spring is present in the northeastern portion of the property, noted on both the topographic map (Figure A-1) and by Western Geologic (2012; Figure A-61). This spring was observed in the field during the site reconnaissance, and was associated with a swath of ground containing standing water and abundant hydrophilic plants, most notably mule's ear vegetation. A cursory outline of this standing water area was mapped in the field and is shown on Figure A-2. Additional mule's ear vegetation was observed downslope in the

[1] Syncline: A fold of which the core contains the stratigraphically younger rocks; it is generally concave upward. (AGI, 2005)
[2] Ephemeral stream: A stream or reach of a stream that flows briefly only in direct response to precipitation in the immediate locality and whose channel is at all times above the water table. (AGI, 2005)

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northwestern portion of the property (Lots 6 through 8), though this was not accompanied by standing water. Anomalous moist ground on a south-facing slope was observed in the southeastern portion of the property near the Lot 33/34 boundary, though this was not accompanied by either mule's ear vegetation or standing water.

Baseline groundwater depths for the Bobcat Ridge property are currently unknown, and are anticipated to fluctuate both seasonally and annually. At the time of our subsurface exploration, groundwater seepage was observed in 28 of the 55 test pits excavated, with seepage occurring as shallow as 3 feet below existing grade.

3.4 GEOLOGIC HAZARDS FROM LITERATURE

Based upon the available geologic literature, regional-scale geologic hazard maps that cover the Bobcat Ridge 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.

3.4.1 Landslides

Two regional-scale landslide hazard maps have been produced that cover the project area. Colton (1991) maps the property to be underlain by a south-trending landslide lobe in the southern part of the property and a northwest-trending landslide lobe in the northeastern part of the property, largely consistent with the landslides as delineated by Western Geologic (2012; see Figure A-61). Elliott and Harty (2010) shows deposits mapped as "Landslide undifferentiated from talus and/or colluvial deposits" across most of the northern portion of the property, with a large area mapped as "Landslide and/or landslide undifferentiated from talus, colluvial, rock-fall, glacial, and soil-creep deposits" in the southeastern portion of the property and a smaller area mapped in the north-central portion of the property. As noted above, both Western Geologic (2012) and Coogan and King (2016) map various landslide deposits on the slopes of the northern and southern portions of the property (see Figures A-61 and A-62).

3.4.2 Faults

Neither Christensen and Shaw (2008a) nor the Quaternary Fault and Fold Database of the United States (USGS and UGS, 2006) show any Quaternary-aged (~2.6 million years ago to the present) faults to be present on or projecting towards the subject property. The 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 10 miles southwest of the western margin of the property (USGS and UGS, 2006).

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3.4.3 Debris Flows

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

3.4.4 Liquefaction

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

3.5 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 1946, 1952, 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 geologic lineaments or fault scarps were observed in the aerial photography on the subject property. Irregular topography, possibly coinciding with landslide deposits, were most pronounced in the northeastern portion of the property. A subdued bowl was observed in the southern part of the property, which could be indicative of an old landslide scarp; it is likely that this is the feature that was identified by Colton (1991), Elliott and Harty (2010), and Western Geologic (2012) used to delineate older (Pleistocene-aged) landslide deposits in this area. Immediately northwest of the property, a treeless linear swath of land was observed to extend downslope to Lefty's Canyon and likely represents an area of Holocene-aged landsliding.

Google Earth imagery of the property from between the years of 1993 and 2017 were also reviewed. The property appeared to remain largely unchanged across this time frame. A small pond along the preexisting two-track road that passes northwest-southeast across the middle of the property was observed to be present in the 1993 imagery. The subdued bowl in the southern part of the property was observed in the field; this bowl area is nearly devoid of trees. No definitive landslide deposits or other geological hazard features were noted on the property in the imagery. Most of the northern half of the project area was found to be densely covered in trees, though several open areas devoid of trees were readily observed. The southern half of the property contains more treeless ground, though where present, the tree clusters are dense. No bedrock exposures were observed to be present anywhere on the property, nor were any drainages observed on the property.

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

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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)	$S_S = 0.814$	$S_1 = 0.270$
MCE Spectral Response Acceleration Site Class C (g)	$S_{MS} = S_sF_a = 0.874$	$S_{M1} = S_1F_v = 0.413$
Design Spectral Response Acceleration (g)	$S_{DS} = S_{MS}*^2/_3 = 0.583$	$S_{D1} = S_{M1}*^2/_3 = 0.275$

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 1.075 and the long-period (F_v) site coefficient is 1.530. 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

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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 affecting the project, that the geologic conditions pertaining to the particular hazard are present in abundance, and/or that there is geologic evidence of the hazard having occurred at the area in the historic or geologic past. Areas with a high-risk determination 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 Bobcat Ridge property.

3.7.1 Landslides/Mass Movement

The extant geologic literature for the property shows the site to contain, at least in part, mapped landslide deposits (Elliott and Harty, 2010; Western Geologic, 2012; Coogan and King, 2016). These are most notably present in the northernmost and southernmost portions of the property (see Figures A-61 and A-62). During the site reconnaissance, much of the northern part of the property was observed to contain irregular, though not hummocky, topography. What appeared to be landslide deposits associated a notable break in slope, hummocky topography, and a collection of boulders weathering out at the surface was commonly observed in the northern portions of the northernmost lots. In the southern portion of the southernmost lots, a small though conspicuous break in slope corresponding to what appeared to be the headscarp of the mapped Pleistocene-aged landslide deposits was observed.

In the subsurface, shallow landslide deposits and associated shear plane clay were observed in some test pits. The landslide deposits were typically less than 10 feet in depth, and heterogeneous units that appeared similar to the weathered Wasatch Formation. The landslide deposits were differentiated from the Wasatch Formation in that they were commonly mottled with a light gray

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fat clay, were more clay-rich, contained pinhole voids, and generally contained a lower proportion of clasts than is common in the Wasatch Formation. Additionally, these units were frequently underlain by a light gray to dark reddish brown fat clay seam that was commonly slickensided and represented the shear plane for the landslide deposits. In some places, the landslide deposits were indistinct from the basal shear plane; in these cases, the landslide deposits are likely to have been deposited by an earthflow-type process as opposed to a translational or rotational slide.

The landslide deposits were most commonly encountered on the gentler slopes (approximately 10:1 (H:V)) in the southern half of the property, overlain by a thin layer of colluvium and underlain by weathered Wasatch Formation. These deposits are collectively delineated as Landslide C in Figure A-2. The geomorphology of this area suggests that these are older (Pleistocene-aged) deposits. However, abundant associated shallow groundwater conditions perched upon the landslide deposit clays provide a setting that may be conducive to shallow sliding, despite the gentler slopes present in this part of the property.

In the northern half of the property shallow landslide deposits were less common and more variable, and differentiated into two distinct lobes noted as Landslide A and Landslide B on Figure A-2. In the northeastern part of the property (Landslide B), a treeless area coinciding with multiple breaks in slope believed to be landslide scarps was observed. Test pits in this area displayed landslide deposits consisting of a heterogeneous mixture of fat clay, sand, and gravel, and lacked a basal slide plane clay. These deposits are interpreted to have been a product of Holocene-aged earthflow-type landsliding. In the northwestern part of the property (Landslide A), a deeper light gray fat clay seam underlying what appeared to be weathered Wasatch Formation was most commonly observed in the test pits excavated in this area. No natural slickensides were observed to be present in this clay, though it was easy to produce mechanically-induced slickensides in this material. Though this clay was similar in appearance and character to the clay observed in the southern part of the property, in TP-1 the clay was found to be forming upon weathered micaceous shale bedrock of the Calls Fort Shale Member and represented an older landslide slide plane. As such, it is interpreted that where encountered in the northwestern portion of the property, this unit represents the uppermost, weathered portion of the Calls Fort Shale Member and has the potential to be reactivated as a shear plane, especially where shallow groundwater conditions are present in the area.

As shown on Figure A-2, the material overlying the deeper fat clay seam observed in the test pits in the northwestern part of the property may represent older (Pleistocene-aged) landslide deposits. Surficial geomorphology in this area suggests that these may be landslide deposits, though this material was observed in the test pits in this area to be very consistent with weathered Wasatch Formation as seen in other test pits across the property. It is possible that this material represents a largely intact block of Wasatch Formation that had moved as a translational slide along the deeper clay seam.

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Given this data and the prevalence of shallow groundwater conditions across the property, the risk associated with landslide and mass movement hazards on the property is generally considered to be high for the lots in the northwestern and northeastern portions of the property, moderate to high for the lots in the southern portion of the property, moderate for the lots on the steeper slopes in the northern portion of the property, and low for the lots on the gentle terrain in the middle of the property.

3.7.2 Rockfall

Though the property is largely 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 WFZ, located approximately 10 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 largely underlain by 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 southwest. 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 encountered in 28 of the 55 test pits excavated as part of this investigation, with continuous seepage filling the test pits with standing water columns as much as 3 feet deep during logging efforts. These test pits were excavated in early to late June, and the groundwater level was likely to be at or near its annual high. Springs were observed in the northeastern part of the

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property, associated with an area containing standing water and abundant hydrophilic vegetation. Though no standing water was observed elsewhere on the property (aside from a small man-made pond), other areas were noted to contain similar hydrophilic vegetation and have moist surficial soils. The groundwater seepage was as shallow as 3 feet below existing grade, and appears to coincide with the presence of the fat clay seams found both above and below the weathered Wasatch Formation. These clay seams are the likely reason for the persistent shallow groundwater conditions observed across the property, which act as aquitards that induce a localized perched groundwater condition.

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 to be high. Spring thaw and runoff are likely to significantly contribute to elevated groundwater conditions. Shallow groundwater issues can be mitigated through appropriate grading measures and/or the avoidance of the construction of residences with basements, or constructing basements with foundation drains.

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4.0 GENERALIZED SITE CONDITIONS

4.1 SITE RECONNAISSANCE

Mr. Peter E. Doumit, P.G., C.P.G., and Mr. Bill Bragdon, P.G., of IGES conducted reconnaissance of the site and the immediate adjacent properties on May 23 and 29, 2018. The site reconnaissance was conducted with the intent to assess the general geologic conditions present across the property, with specific interest in those areas identified in the geologic literature and aerial imagery reviews as potential geologic hazard areas. Additionally, the site reconnaissance provided the opportunity to geologically map the surficial geology of the area. Figure A-2 is a site-specific geologic map of the Bobcat Ridge property and adjacent areas.

At the time of the site reconnaissance, the property was approximately bisected by a preexisting gravel road that passed from southwest to northeast across the property. The southern half of the property was observed to have a consistent, gentle topographic gradient down to the south-southwest with a slightly irregular, though not hummocky, surface. The northern half of the property was observed to have a steeper topographic gradient down to the northwest, with more irregular topography that was observed to be hummocky in places, especially in the northernmost portions of the property. Dense vegetation in the form of aspen trees and occasional pine trees was observed scattered across the property, but most was most prominent along the north-facing slopes in the northern part of the property. Strong soil creep was observed in the aspens in some places of the northernmost (downslope) part of the property. Treeless areas were generally found to be covered in grasses and small shrubs, and commonly contained subrounded to subangular cobbles and boulders of pale red to medium gray quartzite up to several feet in diameter; in rare cases, medium dark gray dolomite cobbles were observed at the surface. These rock clasts[3] are believed to be part of a surficial geologic unit considered to be colluvial deposits derived from weathered Wasatch Formation.

In the northeastern part of the property, an area containing springs emanating from the north-facing hillslope and associated standing water and common hydrophilic plants (mule's ear) was observed. The northern proposed road had been staked as passing through this area, and the area was found to include some of Lots 1 and 2 (see Figure A-2). Similar conditions were not found elsewhere on the property, though very moist ground was observed in the eastern side of Lot 34 (where TP-51 was later excavated), and mule's ear vegetation was observed in a couple small areas in Lots 6 through 8. A small man-made pond was observed adjacent to and north of the bisecting gravel road in between Lots 20 and 21.

[3] 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)

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No running water or ephemeral drainages were observed on the property at the time of the site visit. Possible landslide headscarps were observed both in the northern and southern portions of the property. The possible scarp in the southern part of the property was more subdued and coincided with a transition to a large treeless and cobble-rich area further to the south. Multiple possible scarps were observed in the northern part of the property, coinciding with notable breaks in slope with downslope hummocky topography. These areas were subsequently assessed in the subsurface investigation.

4.2 SUBSURFACE CONDITIONS

Between June 6 and 26, 2018, 55 exploration test pits were excavated at representative locations across the property to characterize subsurface conditions for both the proposed lots and roadways (Figure A-2). The test pits were excavated to depths ranging between 5½ and 17 feet below existing grade with the aid of Caterpillar 315C and 320 tracked excavators. The test pits excavated to evaluate the roadways were excavated to between 5½ and 10 feet below existing grade, while the test pits excavated to evaluate the lots were excavated to between 10 and 17 feet below existing grade. TP-14, originally planned to be a roadway test pit, was not excavated due to its proposed location being within an area of standing water. Additionally, TP-53B was excavated to assess subsurface conditions in the area of a proposed ski bridge. Detailed logs for the test pits are presented in Figures A-3 through A-57. In general, seven distinct geologic units were encountered in the subsurface. The soil and moisture conditions encountered during our investigation are discussed in the following paragraphs.

4.2.1 Earth Materials

<u>A/B Soil Horizon</u>: This topsoil unit was found to be approximately 6 to 18 inches thick, present in all of the test pits. The unit was typically a grayish brown to light brown, medium stiff to loose, dry to slightly moist, sandy lean CLAY with gravel (CL), with gravel and larger-sized subrounded to subangular quartzite clasts comprising generally between 10 and 25% of the unit. The topsoil was found to contain abundant plant and tree roots, and was forming upon the underlying colluvium, shallow landslide, or Wasatch Formation units.

<u>Colluvium</u>: This unit was found to underlie the topsoil in most test pits, but was absent in TP-8, TP-10, TP-29, TP-40, TP-43 through TP-47, TP-49, and TP-51 through TP-53; most conspicuously absent from the test pits excavated in the southeastern part of the property. The unit was typically between 1 and 2 feet thick, but was as thin as 6 inches and as thick as 3 feet in places. The unit consisted of a dark yellowish brown to moderate yellowish brown, medium-stiff, moist, sandy lean CLAY with gravel (CL). Gravel and larger-sized subrounded quartzite clasts comprised generally approximately 30 to 40% of the unit, with individual clasts up to 4 feet in diameter and a typical mode clast size of 3 to 4 inches. Clasts were largely supported within a topsoil matrix that hosted common to abundant plant and tree roots. The unit may also include an alluvial component, as seen elsewhere on Powder Mountain.

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Wasatch Formation: This unit was found in all but the southernmost test pits (except TP-50, in which it was observed), typically extending to the maximum depth of exploration in the test pits. The unit consisted of weakly consolidated conglomerate bedrock that had been largely disaggregated into a heterogeneous, moderate reddish brown to dark reddish brown, dense to medium-dense, moist to wet mixture of clay, sand, and gravel that commonly classifies as a clayey GRAVEL with sand (GC). The unit was variable between test pits, grading to a clayey SAND with gravel (SC) and sandy lean CLAY with gravel (CL) in places, representing facies changes[4] within the Wasatch Formation. Gravel and larger-sized subrounded quartzite clasts typically comprised between 20 and 50% of the unit, with individual clasts up to 3 feet in diameter and a common mode clast size of between 1 to 3 inches. The sand component was generally fine- to medium-grained subangular quartzite grains, but was observed to be coarse-grained in places. Where coarser-grained sand was present, the unit exhibited a fine-grained brecciated[5] appearance. Muscovite mica flakes and black manganese oxide staining were observed within the unit in some test pits excavated in the southern portion of the property, as part of a very stiff, dark reddish brown sandy fat CLAY (CH) subunit that was observed to be devoid of slickensides.

Based on the data collected from the test pits, it appears that this unit across the Bobcat Ridge property contains three distinct subunits: an upper clayey GRAVEL with sand; a middle sandy fat CLAY with rare slickensides and common muscovite mica grains and manganese oxide staining; and a lower sandy fat CLAY that exhibits a fine-grained brecciated appearance. In general, the upper and middle subunits were encountered in the test pits excavated in the northern half of the property, while the middle and lower subunits were encountered in the test pits excavated in the southern half of the property.

Shallow Landslide: This unit was found to underlie the topsoil in the southernmost test pits (except TP-50), and was found underlying the colluvium unit in several of the northern test pits (TP-6, TP-7, TP-13, TP-20, TP-24, TP-25). The unit was typically between 1 and 3 feet thick, but was as thick as 7 feet in places (TP-49). The unit consisted of a mottled light brownish gray to moderate reddish brown to dark yellowish orange, medium-stiff, moist to wet, sandy fat CLAY with gravel (CH). Gravel and larger-sized subrounded to subangular quartzite clasts typically comprised between approximately 10 and 30% of the unit, with individual clasts up to 1 foot in diameter and a typical mode clast size of 1 to 2 inches. The unit was commonly identified by way of a highly heterogeneous appearance, being poorly sorted with common organic and manganese oxide smears, commonly exhibited pinhole voids, and either contained or was underlain by slickensided fat clay.

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[4] Facies change: A lateral or vertical variation in the lithologic or paleontologic characteristics of contemporary sedimentary deposits. It is caused by, or reflects, a change in the depositional environment. (AGI, 2005)
[5] Brecciated: Converted into, characterized by, or resembling a breccia; especially said of a rock structure marked by an accumulation of angular fragments, or of an ore texture showing mineral fragments without notable rounding. (AGI, 2005)

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Shear Plane: This unit was observed in TP-1, TP-40, TP-41, TP-43, TP-44, TP-45, TP-46, TP-49, TP-51, and TP-52, immediately underlying the shallow landslide deposits. The unit was typically between 1 and 6 feet thick, and consisted of a light gray to mottled light brownish gray and dark yellowish orange to dark reddish brown, medium-stiff, moist to wet, high plasticity sandy fat CLAY (CH). Most commonly, the unit was devoid of or contained few gravel and larger sized clasts, exhibited a glossy sheen and greasy feel, and contained occasional to common discontinuous slickensides and pinhole voids. The unit appeared similar to weathered Norwood Formation fat clays observed elsewhere in the Ogden Valley, though the Norwood Formation has not been mapped this far north. Ordinarily, this feature would be considered part of the overlying landslide unit; however, the characteristics of this material appears unique from the shallow landslide unit and the underlying bedrock units, thus this thin layer is considered as a separate unit for the purposes of this report.

Deep Clay Seam: This unit was found to underlie the Wasatch Formation primarily in the northwestern portion of the property, observed in TP-2, TP-3, TP-8 as a light gray to mottled light gray and dark reddish brown, stiff, moist to wet, high plasticity sandy fat CLAY (CH). In these test pits, the unit extended to the maximum depth of the exploration, being at least 7 feet thick in TP-8. Gravel and larger sized clasts were rare to absent. The seam exhibited a common fat clay glossy sheen, though natural slickensides were not observed. The unit looked very similar to the shear plane unit observed in the southern portion of the property, though at a different stratigraphic position. It is possible that the *shear plane* described above existed as the *deep clay seam* prior to movement; this suggests that while the *deep clay seam* does not currently show evidence of movement, the *deep clay seam* nonetheless may be particularly susceptible to movement under certain circumstances.

Calls Fort Shale: This unit was only observed in TP-1, identified at a depth of 8 feet below existing grade and extending to the maximum depth of exploration in this test pit. The unit consisted of dark yellowish orange to light greenish gray weathered shale bedrock that has been largely disaggregated to a dense, moist, silty, clayey GRAVEL (GM-GC), with gravel and larger sized angular shale clasts comprising between 50 and 60% of the unit. The shale clasts were observed to be finely bedded, have a greasy feel, and contained very fine-grained mica crystals (biotite and muscovite). The clay component of the unit was a fat clay, the product of decomposition of the shale bedrock.

4.2.2 Groundwater

Groundwater was encountered in 28 of the 55 test pits (see Figure A-2), having been excavated in early to late June and likely at or near the annual high groundwater levels. Seepage was typically observed to be emanating from the sandy Wasatch Formation or shallow landslide deposits at depths as shallow as 3 feet below existing grade, but was also found in excess of 10 feet below existing grade. Continuous, persistent seepage in some test pits caused the pits to be filled with as

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much as 3 feet of water during the test pit logging. Notably, groundwater was shallowest in the areas where the shallow landslide deposits were present, most especially in the southern half of the property.

4.2.3 Strength of Earth Materials

To assess the shear strength of site soils for slope stability analysis, three direct shear tests (ASTM D3080) were performed on representative site soils. Two of the tests were performed on relatively 'undisturbed' tube samples of clayey soils, and one of the tests was performed on a remolded specimen of granular soil. The tests were conducted under drained conditions. The test results are summarized in Table 4.2.3; detailed test results are presented in Appendix B.

To assess the residual strength of clayey soils, a ring shear test (ASTM D6467) was completed on a remolded clay sample obtained from what was interpreted to be a landslide basal shear surface in TP-1. Residual shear strength values are required to model any pre-existing sheared earth material, typically isolated along a roughly planar surface along the base of a landslide. The tests were conducted under drained conditions. The test results are summarized in Table 4.2.3; detailed test results are presented in Appendix B.

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Table 4.2.3
Summary of Soil Strength Testing

Sample	Soil Type	Test	Results
TP-3 @ 9.5 ft	Fat CLAY (CH) (clay seam)	Direct Shear	Φ=19°, c=587psf LL=90 PI=54 Fines=82.3%
TP-9 @ 8 ft	Clayey GRAVEL w/sand (GC)		Φ=31°, c=115psf (remold) G:49.1% S:26.0% F:24.9%
TP-21 @ 5.5 ft	Sandy Lean CLAY (CL)		Φ=29°, c=311psf LL=32 PI=16
TP-1 @ 4 ft	Fat CLAY (CH) (clay seam)	Ring Shear	Φr=14.4° LL=126 PI=85 Fines=94.3%
TP-22 @ 10.5 ft	Fat CLAY (CH)	Unconfined	Su=907psf LL=77 PI=58
TP-40 @ 5.5 ft	Fat CLAY (CH)	Unconfined	Su=1,302psf LL=97 PI=74
TP-52 @ 4.5 ft	Fat CLAY (CH)	Unconfined	Su=4,400psf LL=72 PI=54
TP-49 @ 7.5 ft	Fat CLAY (CH)	UU	Su=966psf LL=95 PI=74

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To evaluate the unconfined compressive strength of the prevailing clayey soils, one unconsolidated-undrained (UU) triaxial compression test (ASTM D2850) and three unconfined compressive strength tests (ASTM D2166) were completed on relatively ‘undisturbed’ tube samples of clayey soils. These tests were completed to assess the *undrained shear strength* of the prevailing clay soils, which is correlated to the shear stress at failure. The test results are summarized in Table 4.2.3; detailed test results are presented in Appendix B.

4.3 STABILITY OF NATURAL SLOPES

4.3.1 Slope Stability

The stability of the existing natural slopes has been assessed in accordance with methodologies set forth in Blake et al. 2002 and AASHTO LRFD for Bridge Design Specifications with respect to several representative cross-sections, illustrated on Figures D-1 through D-5 in Appendix D (the section is identified in plan-view on Figure A-2). The stability of the slopes 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 circular-type failure occurring through surficial soils and the underlying conglomerate bedrock, as well as a translational-type failure occurring along existing or potentially new landslide basal shear surfaces. Analysis was performed for both static and seismic (pseudo-static) cases.

Soil strength parameters were selected based primarily on soil strength testing, with due consideration for soil types observed, local experience, and correlation with index properties (Atterberg Limits, clay content). Based on this assessment, appropriate soil strength values were developed – the values selected are summarized in Table 4.3.1a.

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Table 4.3.1a
Soil Strength Parameters

Earth Materials	Friction angle (degrees)	Cohesion (psf)	Unit Weight (pcf)
Calls Fort Shale (Cbc)	22	3,000	135
Wasatch Formation (Tw)	40	100	125
Landslide (Qls) mass	31	115	129
Landslide (Qls) *residual*	Φr=14.4°		129
Colluvium/Alluvium (Qac)	34	0	120
Colluvium (Qc)	36	0	125

Groundwater, e.g. a piezometric groundwater surface, was encountered in about half of the test pits during our subsurface investigation; shallow groundwater (less than 10 feet below existing grade) was fairly common. Although assumed to be a ‘perched’ condition, since the depth of the groundwater cannot be known with certainty, the groundwater was assumed to be a piezometric

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surface where encountered. Estimated groundwater levels are shown on the geologic cross-sections in Appendix D; measured groundwater levels are presented on the test pit logs.

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 0.35g. Half of the PGA, (0.175g), 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. Where the seismic factor-of-safety was less than 1.0, a simplified Newmark-type displacement analysis was performed in accordance with Bray and Travasarou (2007). The purpose of this additional analysis is to estimate the potential magnitude of seismic slope movement. It is important to note that developers of this simplified approach to estimate displacement consider the results of these analyses to be indices of expected seismic performance and not predications of exact amount or location of slope displacement amount. In general, a maximum of 5 cm of slope deformation is considered acceptable from a design standpoint (Blake et al. 2002). The results of the slope deformation analysis are also presented in Table 4.31b; detailed analysis is presented in Appendix D. Where the minimum criteria does not meet the minimum acceptable standard, the value is shown in red (static: min. FS of 1.50, seismic: min. FS of 1.0, displacement: max. allowed of 5 cm).

Table 4.3.1b
Results of Slope Stability Analyses

Section	Static Factor of Safety	Pseudo-Static Factor of Safety	Estimated Slope Deformation (cm)
A-A’	1.62	0.91	2.1
B-B’	2.11	1.19	n/a
C-C’	1.22	0.73	6.4
D-D’	2.29	0.89	2.5
E-E’	2.08	0.84	3.4

Discussion:

Section A-A’ – this analysis indicates that Landslide A is stable under static conditions, but is likely unstable under seismic conditions. Slope deformation analysis indicates an estimated slope deformation of 2 cm. Nonetheless, considering the high groundwater and the particularly weak clay seam identified at depth, development within this landslide lobe is not recommended pending further study.

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Section B-B' – this analysis indicates that the slope is stable under both static and seismic conditions, largely owing to the presence of relatively competent Wasatch Formation bedrock. Although the analysis shows a portion of Landslide A as being stable, since this portion is attached to the greater landslide mass, which is currently considered to be marginally stable, development within the lower reaches of Section B-B' (within the landslide deposits) should be avoided pending additional study.

Section C-C' – this analysis indicates a fairly low factor of safety for both static and seismic conditions, with slope deformation estimated to be in excess of 5 cm. Nevertheless, the landslide deposits within Landslide B (the young landslide deposits mapped within the northeastern part of the property) are relatively shallow, not exceeding 6 feet in depth and often shallower. Accordingly, development within the area covered by these landslide deposits is feasible, though complete over-excavation down to competent Wasatch Formation would be necessary for all improvements, including roadways.

Sections D-D' and E-E' – These sections delineate a broad, flat, shallow landslide mass that has translated on a seam of low-strength fat clay. Although the landslide mass is considered stable under static conditions (owing to the relatively subdued topography and low slope gradient), the landslide is nonetheless susceptible to re-activation under seismic conditions. Slope deformation analysis indicates estimated slope movements less than 5 cm; however, owing to the presence of shallow groundwater and a particularly low-strength clay seam that defines the basal shear of the landslide, development upon this landslide mass should be avoided unless remedial grading to disrupt the basal shear is performed. Remedial grading may be challenging in some areas due to the presence of shallow groundwater.

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5.0 CONCLUSIONS AND RECOMMENDATIONS

5.1 GENERAL CONCLUSIONS

Based on the results of the literature review, site reconnaissance, subsurface investigation, and laboratory results, the subsurface conditions are considered suitable for most of the proposed development provided that the recommendations presented in this report are incorporated into the design and construction of the project. Limited areas of the project area should be avoided for development pending additional subsurface investigation and/or analysis and the development of a suitable geologic hazard mitigation plan.

Supporting data upon which the following 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 Bobcat Ridge project area:

- **The Bobcat Ridge project area does have significant or imminent geological hazards that could adversely affect the development as currently proposed, in the form of landslide hazards and shallow groundwater conditions.**

- Shallow landslide deposits and an associated older (Pleistocene-aged) slide plane fat clay that was heavily slickensided was observed in test pits excavated in the southern portion of the property. Additionally, high plasticity clays were observed underlying the Wasatch Formation in the northwestern part of the property, though these were not found to be slickensided except in TP-1. Shallow landslide deposits were also observed in some test pits in the northeastern part of the property, though these were also not slickensided. Combined with the prevalent shallow groundwater conditions observed across the property, these subsurface conditions are conducive to slope instabilities in these areas that largely manifest as shallow, surficial landslides. As such, the landslide hazard is considered to be high for Lots 3, 7 through 9, 12, and 17; moderate to high for Lots 1, 2, 6, 13, and 31 through 42; moderate for Lots 4, 5, 10, 11, 14 through 16, and 23 through 27; and low for Lots 18 through 22, 28 through 30, and 43 through 48. The hazard classifications are based upon a combination of subsurface data, existing topography, and the presence/absence of shallow groundwater conditions, and are applied without consideration to any mitigation

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effort (since remedial grading or similar mitigation efforts could reduce the hazard classification for some lots). These ratings have been applied conservatively to represent the most hazardous conditions for any given lot. Due to the fact that topographic conditions and likely subsurface conditions are laterally variable across individual lots, some of these hazard ratings could be reduced depending on where residences are to be specifically located on certain lots, or by way of remedial grading (see Figure A-63 and the Table of Lots in Appendix E).

- Shallow groundwater conditions (less than about 10 feet below existing grade) were observed 28 of the 55 test pits, and an area containing a spring and standing water conditions was observed in the northeastern portion of the property. Because the test pits were excavated in June, groundwater levels were likely to be at or near their annual high. Shallow groundwater hazards are considered to be high for Lots 1, 2, 5 through 12, 16 through 19, 28 through 30, 32 through 42, and 44 through 48; moderate for Lots 3 through 5, 13, 20, 22,23, 31, and 43; and low for Lots 14, 15, 21, and 24 through 27 (see Figure A-63 and the Table of Lots in Appendix E).

- 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.

- 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:

- Foundations should be placed on competent bedrock (Wasatch Formation or Calls Fort Shale), or structural fill extending to competent bedrock; this will require over-excavating within the building envelope to below the base of the shallow landslide deposits and shear plane (where present), as well as over-excavating below the base of the deeper high plasticity clay seam (where present). This applies to Lots 1 through 3, 6 through 12, 17, and 31 through 42; it may also apply to Lots 4, 5, 13 through 16, and 23 through 27 (see the Table of Lots in Appendix E). The over-excavation applies to the entire building footprint. In some areas, the depth of landslide deposits may preclude the practicality of over-excavation under a single home; therefore, mass-grading may be an appropriate alternative for some areas.

- An IGES geologist or geotechnical engineer should observe the foundation excavations to assess that the excavations have been taken to an appropriate depth, and to further evaluate for adverse geologic conditions.

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- Given the presence of shallow groundwater conditions, residences without basements (on-grade structures) are recommended for those lots designated to have a high shallow groundwater hazard risk. This applies to Lots 1, 2, 10, 17 through 19, 28, 30, 32 through 42, 47, and 48 (see the Table of Lots in Appendix E).

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. If over-excavation is required, the excavations should extend ½ 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 engineered 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 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), although Soil Type B (stiff clay) will be encountered locally. Close coordination between the competent person and IGES should be maintained to facilitate construction while providing safe excavations.

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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 – where stiff clays are exposed, the slope may be steepened to 1H:1V (45 degrees). 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. Shallow groundwater was encountered at several locations – local dewatering may be necessary for some utility construction.

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. Soils classifying as Fat CLAY (CH) should not be used for structural fill placed below pavements or structures. Fat clay can typically be identified as sticky, highly plastic clays with a glossy luster and a greasy texture.

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.

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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 should not be water-densified in-place (jetting). Alternatively, pipe bedding and shading may consist of clean ¾-inch gravel, or a similar material approved by IGES. Native granular earth materials can be used as backfill over the pipe bedding zone – however, soils classifying as Fat CLAY (CH) should not be used under pavements or structures. 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 homes be founded either *entirely* on competent native soils or *entirely* on structural fill. Native/fill transition zones are not allowed. Due to the presence of shallow landslide deposits, foundation excavations must extend below the landslide deposits and basal shear plane clay and into the competent Wasatch Formation below – this recommendation applies to the entire building envelope, not just the footings. Alternatively, the foundations may be supported on structural fill extending to competent material below any identified landslide deposits (this alternative also applies to the entire building envelope). Estimated over-excavation for each lot is presented in the Table of Lots in Appendix E.

If landslide deposits or soft, loose, or otherwise deleterious earth materials are exposed in the footing excavations, then all footings must be deepened such that all footings bear on relatively uniform, competent native earth materials. Alternatively, the foundation excavation may be over-excavated a minimum of 2 feet below the bottom of proposed footings and replaced with structural fill, such that the footings bear entirely on a uniform fill blanket. We recommend that IGES assess the bottom of the foundation excavation prior to the placement of steel or concrete to identify the competent native earth materials as well as any unsuitable soils, transition zones, or landslide

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deposits. Additional over-excavation may be required based on the actual subsurface conditions observed.

Shallow spread or continuous wall footings constructed entirely on competent, *granular*, uniform native earth materials or on a minimum of 2 feet of *structural fill* may be proportioned utilizing a maximum net allowable bearing pressure of **2,800 pounds per square foot (psf)** for dead load plus live load conditions. The net allowable bearing value presented above is for dead load plus live load conditions. 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, which may be present at various times during the year, particularly spring run-off.

<u>Skier Bridge Foundations</u>: We understand the skier bridge foundations will likely consist of conventional spread footings. Considering that the skier bridge foundation will be constructed approximately 20 feet below existing grade and will likely be placed in competent bedrock, a maximum net allowable bearing pressure of 4,600 psf for dead load plus live load conditions may be utilized for design.

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.

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Based on the subsurface conditions encountered, and considering the engineering characteristics of the prevailing Wasatch Formation bedrock, 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.

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)	0.307	38.4	0.468	58.4
At-rest (Ko)	0.470	58.8	0.80	85
Passive (Kp)	3.26	407	—	—
*Seismic Active	0.113	14.2	0.417	52.1

* Based on Mononobe-Okabe

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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; this is particularly pertinent to soils classifying as Fat Clay (CH), which were encountered throughout the site. As such, 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.

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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. It should be noted that the Modulus of Subgrade Reaction is not a function of soil properties alone but is also influenced by other factors, including the width of the loaded area, the shape of the loaded area, and the specific location under the slab. As such, the structural engineer should exercise care and engineering judgment when using the above stated value 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 structure should be implemented.

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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, particularly around subterranean walls. Additionally, the ground surface within 10 feet of the structure should be constructed so as to slope a minimum of **five** percent away (2 percent is allowed if the ground surface within 10 feet is a relatively impermeable surface, such as a concrete slab). Pavement sections should be constructed to divert surface water off the pavement into storm drains, curb/gutter, or another suitable location.

For basements, IGES recommends a perimeter foundation drain be constructed in accordance with the 2012 or later International Residential Code (IRC).

5.9 SOIL CORROSION POTENTIAL

Laboratory testing of a representative soil sample indicated that the soil sample tested had a sulfate content of 5.8 ppm. Accordingly, the soils are 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 a sample was tested for soil resistivity, soluble chloride and pH. The test indicated that the onsite soil tested has a minimum soil resistivity of 978 OHM-cm, soluble chloride content of 18.9 ppm and a pH of 4.2. Based on this result, the onsite native soil is considered to be *severely corrosive* to ferrous metal. To address the acidic soil conditions, we recommend a lower water/cement ratio, ~0.4, for reinforced concrete. The lower water/cement ratio will reduce permeability of the concrete and reduce the susceptibility of the reinforcing steel to acidic corrosion.

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5.10 CONSTRUCTION CONSIDERATIONS

5.10.1 Over-Size Material

Large rocks (up to 48 inches in maximum dimension) were observed within the test pits; larger rocks may be present locally. As such, excavation of the lower levels may generate an abundance of over-size material that may require special handling, processing, or disposal.

5.10.2 Groundwater

Shallow groundwater was identified at many locations across the site. Depending on location, groundwater could adversely impact the proposed construction; groundwater could cause equipment mobility problems, and could cause localized excavation instability. In some areas, shallow groundwater presence could be a protracted or perennial condition, and would need to be dealt with accordingly via the installation of temporary or permanent land drains. The Contractor should be aware that shoring and/or localized dewatering may be necessary during construction of

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the foundations, particularly during spring and early summer. The Table of Lots (Appendix E) indicates the anticipated groundwater condition for each individual lot.

Considering the wide-spread presence of shallow groundwater, the Owner may wish to consider the use of land drains to reduce the groundwater level over a broader area, which would serve to facilitate development and would improve slope stability across the site.

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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 Bobcat Ridge 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.

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 of the 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.

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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.
- Quality control and testing during placement and compaction of asphalt.

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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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/

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APPENDIX A

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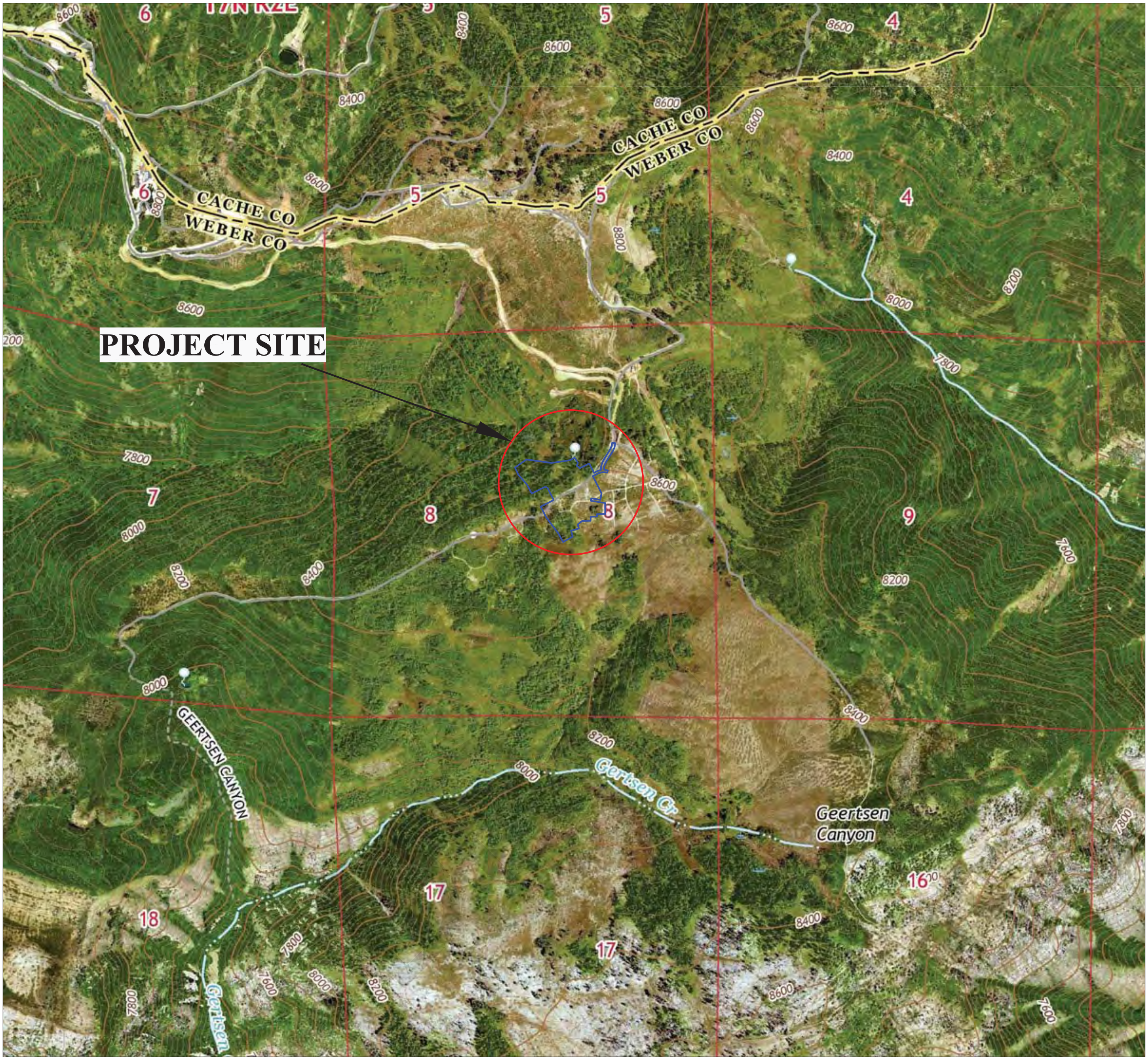

Base Maps:

-USGS *Brown's Hole, Huntsville, James Peak* and *Sharp Mountain* 7.5-Minute Quadrangles (2017)

N

0 1000 2000
FEET

1" = 2000'

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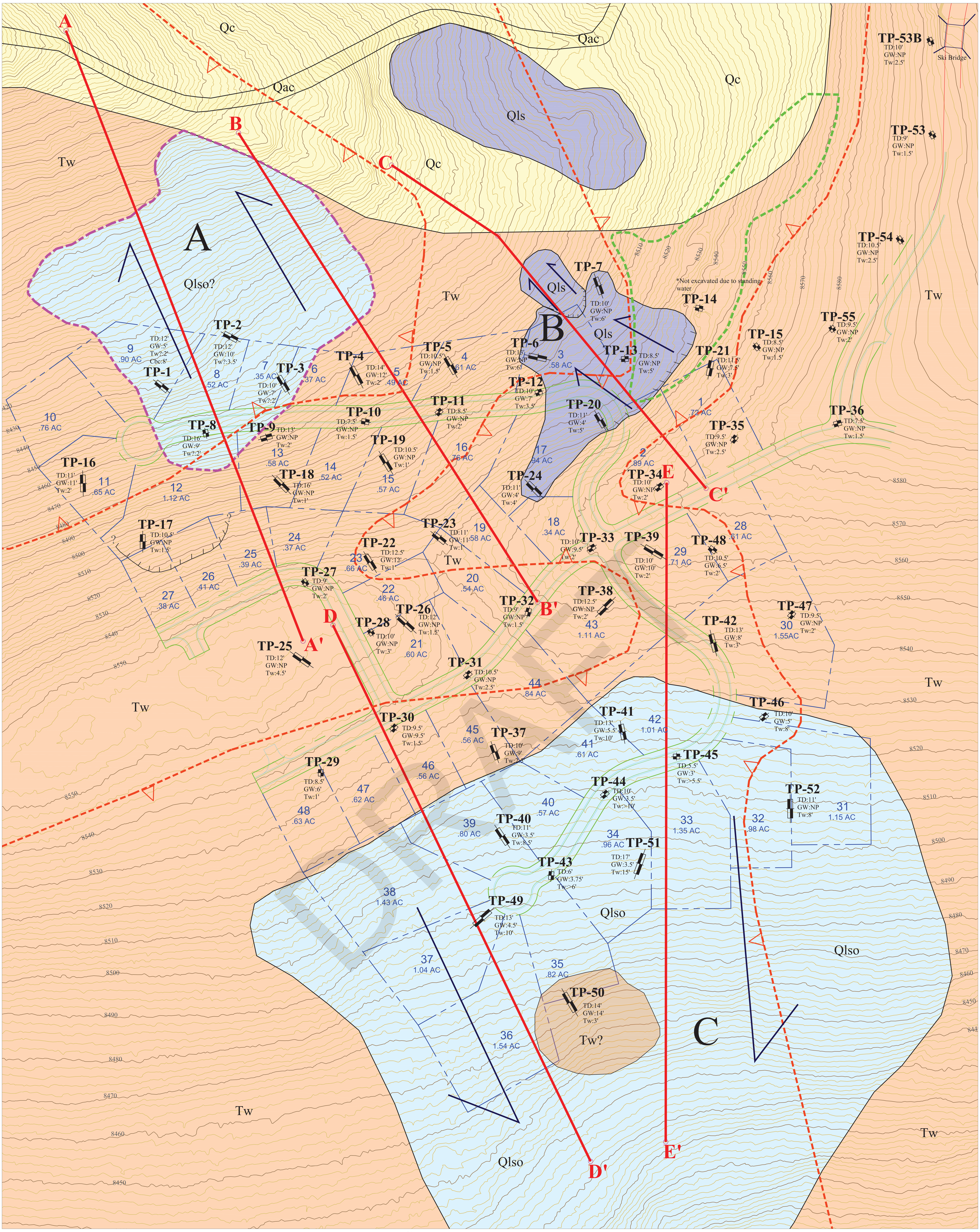
Geotechnical and Geologic Hazards Assessment
Bobcat Ridge Subdivision
Summit Powder Mountain Resort
Weber County, Utah

Site Vicinity Map

Figure

A-1



LEGEND

Basemap:

-Bobcat Ridge Preliminary Plat, provided by Talisman Civil Consultants, dated 7-12-2018

Contour Interval: 2'

*All Geologic Contacts Approximate

Qac — Alluvial and Colluvial Deposits

Qc — Colluvium

Project Boundary

Deeper clay seam area; possible older landslide

Qls — Landslide Deposit (Holocene-aged)

Qlso — Older landslide deposit (Pleistocene-aged)

Cross-Section

Area of Standing Water

Tw — Wasatch Formation

Test Pit Location — TD = Total depth; GW = Groundwater depth (NP=Not Present); Tw = Depth to Wasatch Fm; Cbc = Depth to Calls Fort Shale

Landslide Scarp; queried where uncertain

Landslide direction of movement

Area of Shallow Groundwater (~10' below existing grade) Triangle points in direction of groundwater

N

0 100 200 FEET

1" = 100'

A= Landslide A

B= Landslide B

C= Landslide C

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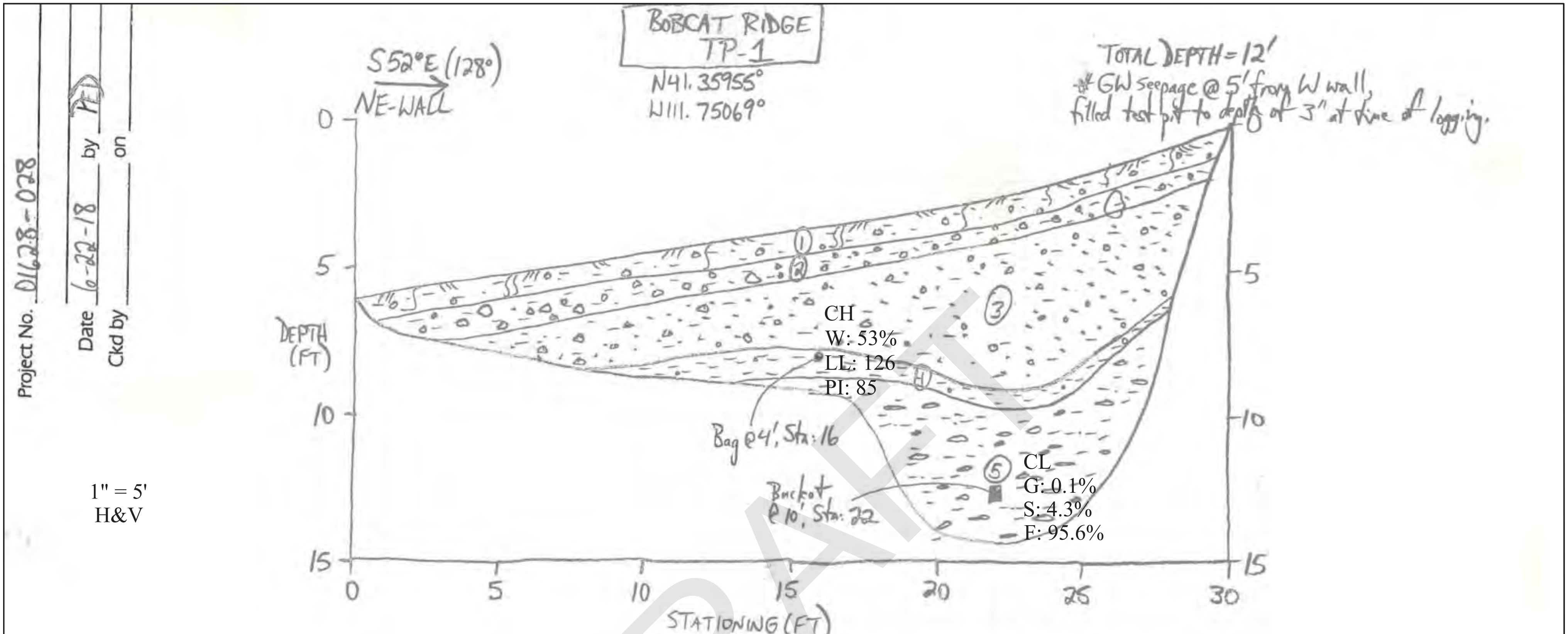
Geotechnical and Geologic Hazards Assessment
Bobcat Ridge Subdivision
Summit Powder Mountain Resort
Weber County, Utah

Geotechnical and Local Geology Map

Figure A-2



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LITHOLOGIC UNIT DESCRIPTIONS

1. A/B Soil Horizon: ~1' thick; grayish brown (5Y $\frac{3}{2}$) to brownish black (5YR $\frac{2}{1}$) sandy lean CLAY with gravel (CL), medium stiff, moist, low plasticity, massive; gravel and larger sized clasts comprise ~20% of the unit; clasts are subrounded to subangular pale yellowish orange (10YR $\frac{8}{6}$) to medium gray (N5) quartzite up to 8" in diameter, though mode clast size is ~1"; abundant plant and tree roots; gradational, irregular basal contact.

2. Colluvium: ~6"-1' thick; grayish brown (5Y $\frac{3}{2}$) sandy lean CLAY with gravel (CL), medium stiff, moist, low plasticity, massive; gravel and larger sized clasts comprise ~30% of the unit; clasts are subangular to subrounded quartzite as above up to 1' in diameter, though mode clast size is ~2-4"; topsoil matrix; common to abundant plant and tree roots; unit thickens downslope to the north; gradational, irregular basal contact.

3. Wasatch Formation?: ~2-5' thick; moderate reddish brown (10R $\frac{4}{6}$) to moderate yellowish brown (10YR $\frac{4}{2}$) clayey SAND with gravel (SC), medium dense to dense, moist to wet, low plasticity fines, massive; gravel and larger sized clasts comprise ~20% of the unit, clasts are subrounded quartzite as above up to 5" in diameter, though mode clast size is ~1-2"; possibly shallow landslide deposits; occasional plant and tree roots; sharp, wavy basal contact.

Old Slide Plane: ~6"-1' thick; light gray (N7) to dark reddish brown (10R $\frac{3}{4}$) fat CLAY (CH), stiff, moist, high plasticity, massive; gravel and larger sized clasts comprise ~5% of the unit; clasts are subrounded quartzite as above, up to 4" in diameter; uppermost ~3" is dark reddish brown and sandier, and may represent the lowermost portion of the Wasatch Formation though it grades quickly to fat clay; lower portion is very similar to light gray fat clay observed in other test pits, with blocky ped structures, mechanically-induced slickensides and appears similar to weathered Norwood Formation; sharp, wavy basal contact.

5. Calls Fort Shale: >5' thick; dark yellowish orange (10YR $\frac{6}{6}$) to light greenish gray (5GY $\frac{8}{1}$) highly weathered shale bedrock that has been disaggregated to a silty GRAVEL (GM), dense, moist, moderate plasticity fines, massive; gravel and larger sized clasts comprise ~50-60% of the unit; clasts are all light greenish gray, angular, finely bedded shale that has greasy feel and fine-grained mica crystals; clay component is fat; density of unit increases with depth.

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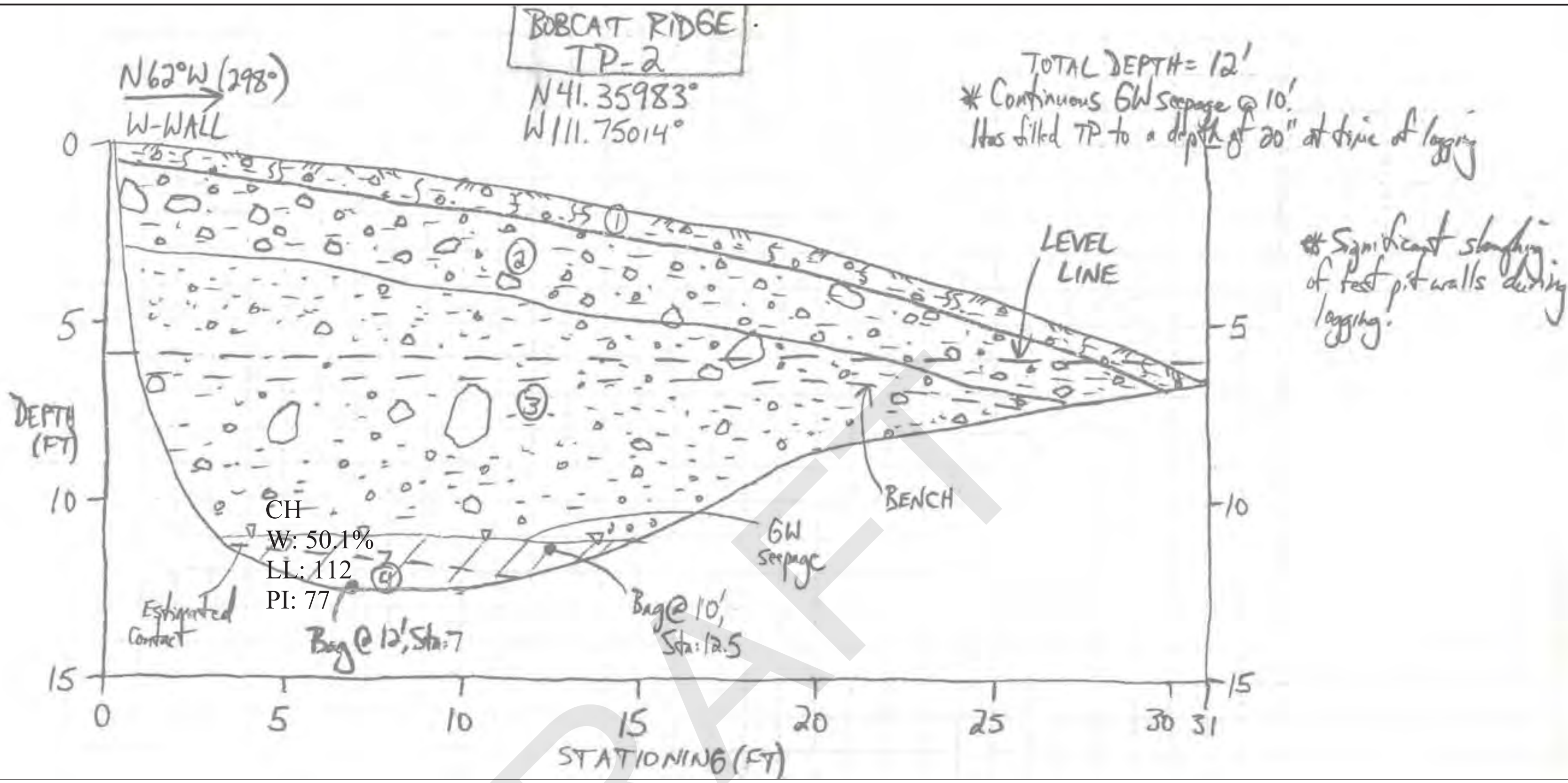
Geotechnical and Geologic Hazards Assessment
Bobcat Ridge Subdivision
Summit Powder Mountain Resort
Weber County, Utah

TP-1 Log

Figure

A-3

Project No. 01628-028
Date 6-21-18 by PED
Ckd by on



1" = 5'
H&V

LITHOLOGIC UNIT DESCRIPTIONS

1. A/B Soil Horizon: ~6-10" thick; grayish brown (5Y 3/2) sandy lean CLAY with gravel (CL), loose to medium stiff, dry to slightly moist, low plasticity, massive; gravel and larger sized clasts comprise ~20% of the unit; clasts are subrounded to subangular medium light gray (N6) to pale yellowish orange (10YR 8/6) quartzite up to 8" in diameter, though mode clast size is ~2-4"; abundant plant and tree roots; gradational, irregular basal contact.

2. Colluvium: ~2-2.5' thick; dark yellowish brown (10YR 4/2) to grayish brown (5Y 3/2) sandy lean CLAY with gravel (CL) gradational to clayey GRAVEL (GC) with sand, medium stiff to loose, moist to slightly moist, low plasticity, massive; gravel and larger sized clasts comprise ~40-50% of the unit; clasts are subangular to subrounded quartzite as above and also include moderate reddish orange (10R 6/6) sandstone; clasts are up to 1.5' in diameter, though mode clast size is ~3-4"; topsoil matrix; common plant and tree roots; sharp, irregular basal contact.

3. Wasatch Formation?: ~8' thick; moderate reddish brown (10R 4/6) to dark yellowish orange (10YR 6/6) clayey SAND with gravel (SC), medium dense, moist to wet, low to moderate plasticity fines, massive; gravel and larger sized clasts comprise ~20-30% of the unit; clasts are subrounded to subangular quartzite as above up to 1.5' in diameter, though mode clast size is ~3-4"; becomes sandier and more orange with depth; possibly shallow landslide deposits; occasional to common plant and tree roots; sharp, planar basal contact.

4. Clay Seam: >2' thick; commonly mottled light gray (N7) to dark reddish brown (10 3/4) fat CLAY (CH), stiff, wet, high plasticity, massive; devoid of clasts; common blocky ped structures; common fat clay sheen and easily mechanically slickensided but no natural slickensides observed; appears to be similar to deeper clay seen in TP-3.

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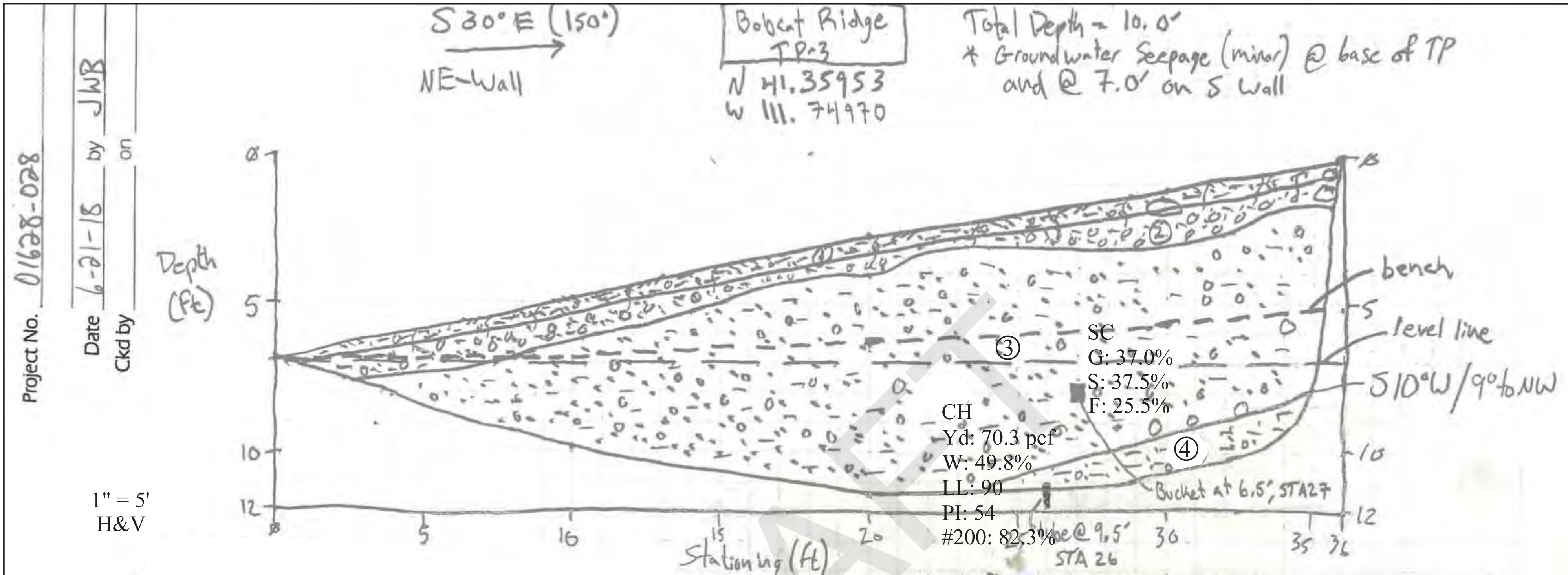
Geotechnical and Geologic Hazards Assessment
Bobcat Ridge Subdivision
Summit Powder Mountain Resort
Weber County, Utah

TP-2 Log

Figure A-4



LITHOLOGIC UNIT DESCRIPTIONS

1. A/B Soil Horizon: ~6" thick; grayish brown (5Y $\frac{3}{2}$) sandy lean CLAY with gravel (CL), medium stiff, slightly moist, low plasticity, massive; gravel and larger sized clasts comprise ~10-20% of the unit; clasts are subrounded to subangular light gray (N7) quartzite up to ~1' in diameter, though mode clast size is ~1/2 to 1"; common plant roots; unit is significantly thicker on the southwestern wall; sharp, irregular basal contact.

2. Colluvium: ~6"-1.5' thick; grayish brown (5Y $\frac{3}{2}$) sandy lean CLAY with gravel (CL), medium stiff, slightly moist, low plasticity, massive; gravel and larger sized clasts comprise ~30-40% of the unit; clasts are predominantly subrounded to subangular quartzite as above, though few dark yellowish orange (10YR $\frac{6}{6}$) oxidized sandstone clasts; clasts are up to 1.5' in diameter, though mode clast size is ~1-3"; occasional plant roots; unit thickness varies dramatically, and unit is almost non-existent in places; sharp, irregular basal contact.

3. Wasatch Formation?: ~6-8' thick; moderate reddish brown (10R $\frac{4}{6}$) to dark reddish brown (10R $\frac{3}{4}$) clayey SAND with gravel (SC), dense, moist, moderate plasticity fines, massive; gravel and larger sized clasts comprise ~20-40% of the unit; clasts are subrounded to subangular quartzite and sandstone as above; clasts are up to 10" in diameter, though mode clast size is ~2"; possible shallow landslide deposits; few plant roots; sharp, planar basal contact.

4. Clay Seam: >1.5' thick; mottled light gray (N7) and moderate reddish brown (10R $\frac{4}{6}$) sandy fat CLAY (CH), stiff to very stiff, moist to wet, high plasticity, massive; gravel and larger sized clasts comprise ~5% of the unit; clasts are subangular to subrounded quartzite as above up to 1" in diameter, though mode clast size is <0.5"; unit looks like weathered Norwood Formation and is similar to the shear plane unit seen in test pits on the southernmost part of the Bobcat Ridge property; fat clay sheen, though no slickensides observed.

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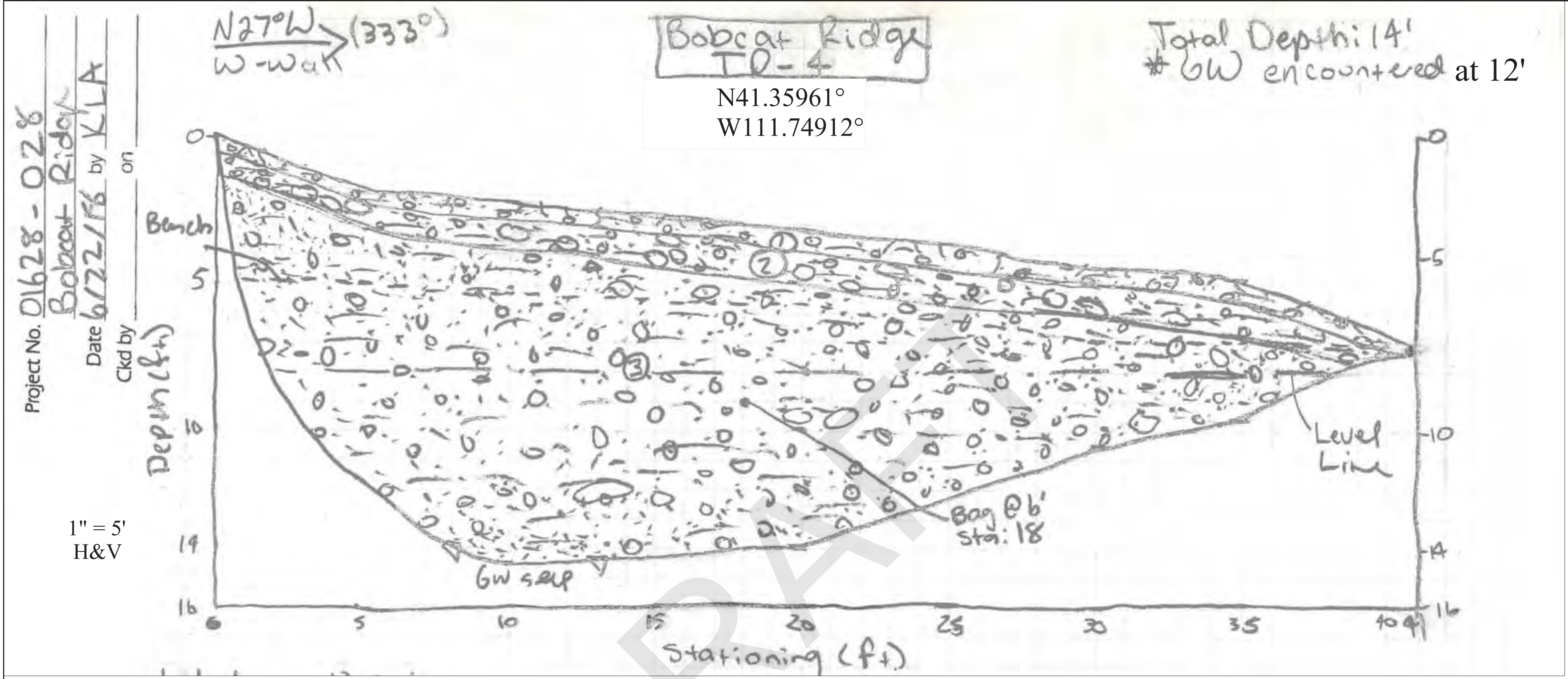

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LITHOLOGIC UNIT DESCRIPTIONS

1. A/B Soil Horizon: ~6" thick; grayish brown (5Y $\frac{3}{2}$) sandy lean CLAY with gravel (CL), medium stiff, moist, low plasticity, massive; gravel and larger sized clasts comprise ~10-20% of the unit; clasts are subrounded to subangular light brown (5YR $\frac{6}{4}$) to medium gray (N5) quartzite up to 4" in diameter, though mode clast size is ~0.5-1"; abundant plant and tree roots; gradational, irregular basal contact.

2. Colluvium: ~1' thick; dark yellowish brown (10YR $\frac{4}{2}$) sandy lean CLAY with gravel (CL), medium stiff, moist, low plasticity, massive; gravel and larger sized clasts comprise ~30-40% of the unit; clasts are subrounded to subangular quartzite as above up to 1.5' in diameter, though mode clast size is ~2-4"; topsoil matrix, abundant plant and tree roots; sharp, planar basal contact.

3. Wasatch Formation: >10' thick; moderate reddish brown (10R $\frac{4}{6}$) to dark yellowish orange (10YR $\frac{6}{6}$) clayey SAND with gravel (SC) gradational to sandy lean CLAY with gravel (CL), medium dense to dense, moist to wet, low to moderate plasticity fines, massive; gravel and larger sized clasts comprise ~25-30% of the unit; clasts are predominantly subrounded to subangular quartzite as above, though minor light gray (N7) sandstone and medium dark gray (N4) chert; clasts are up to 1.5' in diameter, though the mode clast size is ~2-3"; occasional plant roots; basal 1.5-2' is sandier and has groundwater seepage; sand is fine- to medium-grained.

*~1" of groundwater accumulation at bottom of test pit. Minor sloughing of pit walls in lower part of unit 3 during logging.

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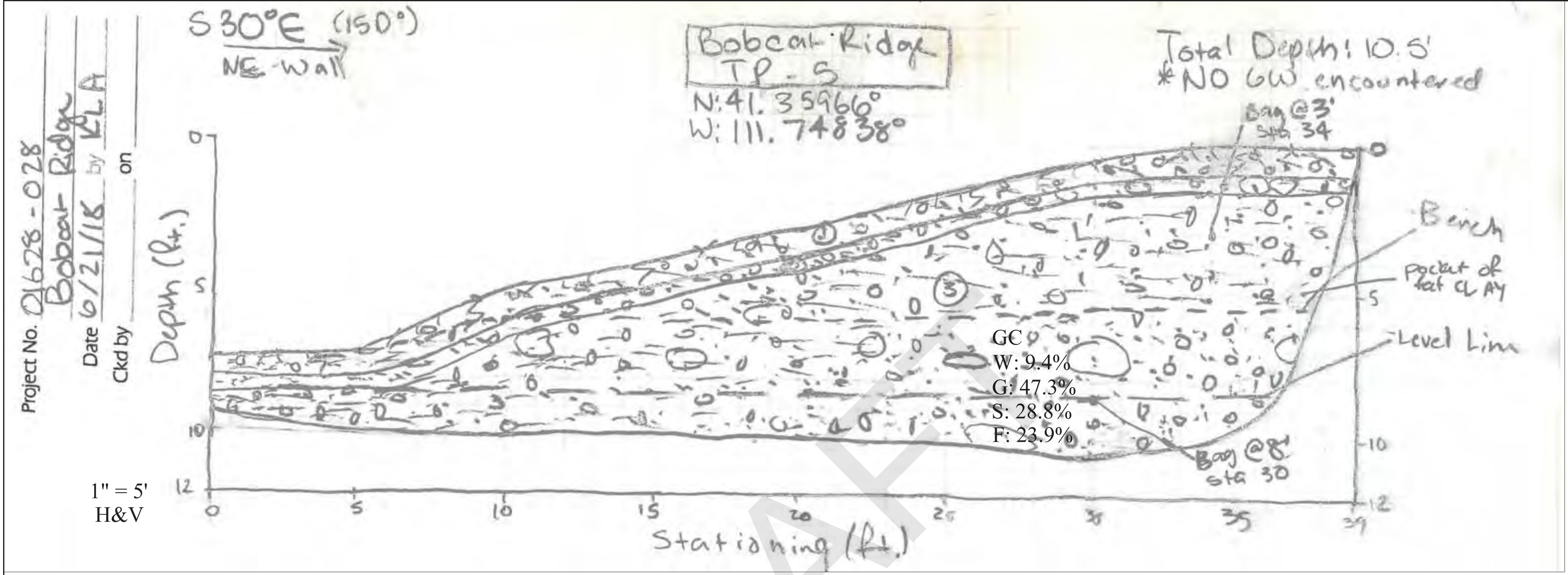
Geotechnical and Geologic Hazards Assessment
Bobcat Ridge Subdivision
Summit Powder Mountain Resort
Weber County, Utah

TP-4 Log

Figure

A-6



LITHOLOGIC UNIT DESCRIPTIONS

1. A/B Soil Horizon: ~1' thick; light brown (5YR $\frac{6}{4}$) to moderate yellowish brown (10YR $\frac{5}{4}$) sandy lean CLAY with gravel (CL), loose to medium stiff, dry to slightly moist, low plasticity, massive; gravel and larger sized clasts comprise ~20-25% of the unit; clasts are subrounded to subangular light brown to medium dark gray (N4) to moderate orange pink (10R $\frac{7}{4}$) quartzite up to ~2-3" in diameter, though mode clast size ~0.5"; abundant plant roots; gradational, irregular basal contact.

2. **Colluvium**: ~6" thick; light brown (5YR $\frac{6}{4}$) to moderate yellowish brown (10YR $\frac{5}{4}$) sandy lean CLAY with gravel (CL), loose to medium stiff, slightly moist, low plasticity, massive; gravel and larger sized clasts comprise ~20-30% of the unit; clasts are subrounded to subangular quartzite as above up to 1' in diameter, though mode clast size is ~2-3"; topsoil matrix; sharp, planar basal contact.

3. Wasatch Formation: >8.5' thick; moderate reddish orange (10R $\frac{6}{6}$) to moderate yellowish brown (10YR $\frac{5}{4}$) clayey GRAVEL with sand (GC) gradational to sandy lean CLAY with gravel (CL), medium dense, moist, moderate to low plasticity fines, massive; gravel and larger sized clasts comprise ~20-50% of the unit; clasts are subrounded to subangular moderate reddish orange to medium dark gray (N4) quartzite and sandstone up to 1.5' in diameter, though the mode clast size is ~2-4"; occasional plant roots; becomes sandier with depth; sand component is fine- to medium-grained; a fat clay lens is present at ~5' below existing grade on the southeast end of the test pit.

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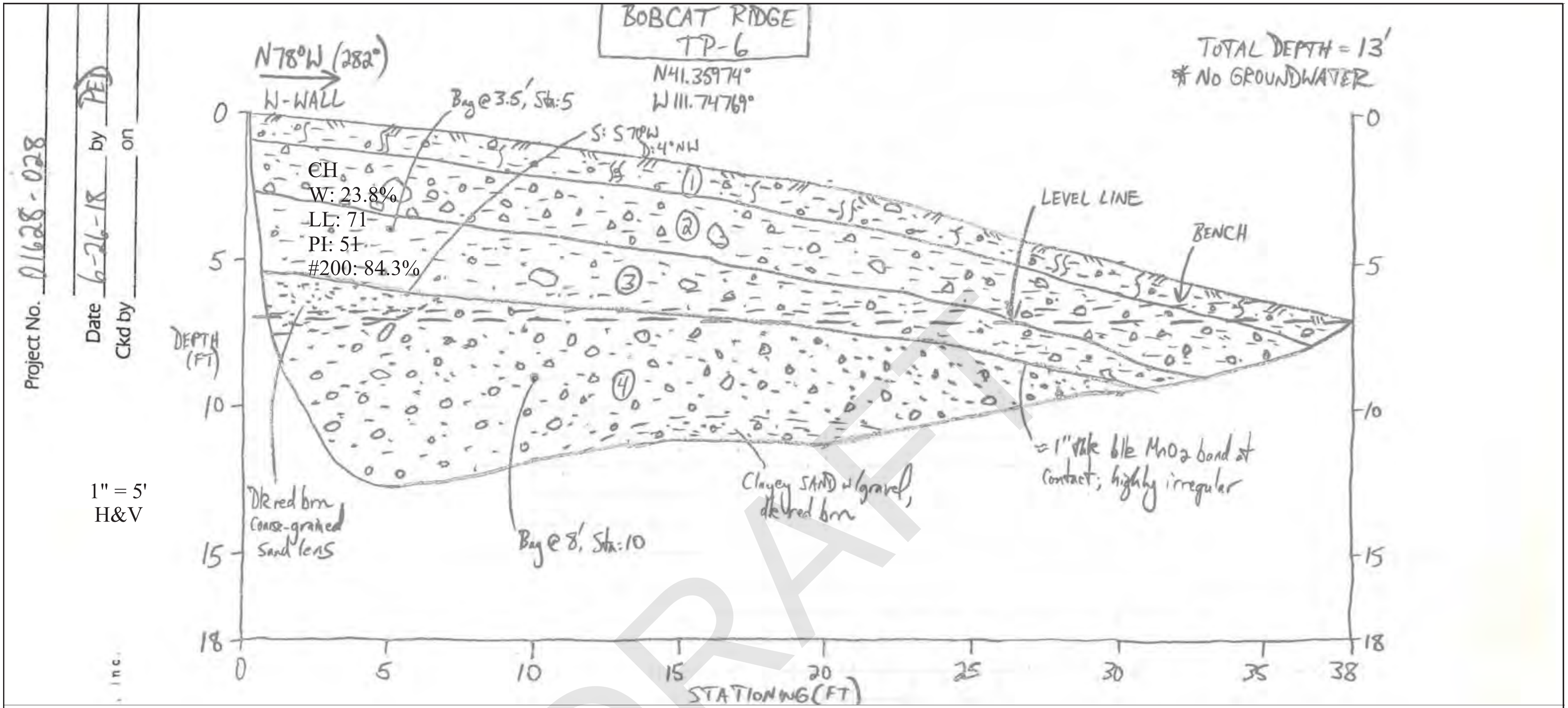
Geotechnical and Geologic Hazards Assessment
Bobcat Ridge Subdivision
Summit Powder Mountain Resort
Weber County, Utah

TP-5 Log

Figure

A-7



LITHOLOGIC UNIT DESCRIPTIONS

1. **A/B Soil Horizon:** ~12-14" thick; dark yellowish brown (10YR 4/2) to grayish brown (5Y 3/2) sandy lean CLAY with gravel (CL), medium stiff, moist, low plasticity, massive; gravel and larger sized clasts comprise ~10-15% of the unit; clasts are subrounded to subangular medium gray (N5) to pale yellowish orange (10YR 8/6) quartzite, up to 10" in diameter, though mode clast size is ~1-2"; common to abundant plant and tree roots; gradational, irregular basal contact.

2. **Colluvium:** ~2-3' thick; dark yellowish brown (10YR 4/2) sandy lean CLAY with gravel (CL), medium stiff, moist, low plasticity, massive; gravel and larger sized clasts comprise ~30% of the unit; clasts are subrounded to subangular quartzite as above, with minor angular dark yellowish orange (10YR 6/6) micaceous sandstone; clasts are up to 1.5' in diameter, though mode clast size is ~3-4"; topsoil matrix; common plant and tree roots; sharp, irregular basal contact.

3. **Shallow Landslide:** ~2-3' thick; mottled moderate reddish orange (10R 6/6), moderate reddish brown (10R 4/6) and moderate yellowish brown (10YR 5/4) sandy fat CLAY with gravel (CH), stiff, moist, moderate plasticity, massive; gravel and larger sized clasts comprise ~10% of the unit; clasts are subangular quartzite and sandstone as above up to 1' in diameter, though mode clast size is ~1"; minor fat clay sheen, though no slickensides observed; common light gray (N7) to dark reddish brown (10R 3/4) clayey lenses; silty in part; possibly uppermost Wasatch Formation; occasional plant and tree roots; sharp, irregular basal contact.

4. **Wasatch Formation:** >7' poorly graded SAND with gravel (SP) gradational to clayey SAND with gravel (SC) at depth, medium dense to dense, moist, low plasticity fines, massive; gravel and larger sized clasts comprise ~30-40% of the unit; clasts are subrounded to subangular quartzite and sandstone as above up to 7" in diameter, though the mode clast size is ~2-3"; sand component is medium- to coarse-grained; occasional plant and tree roots.

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Geotechnical and Geologic Hazards Assessment
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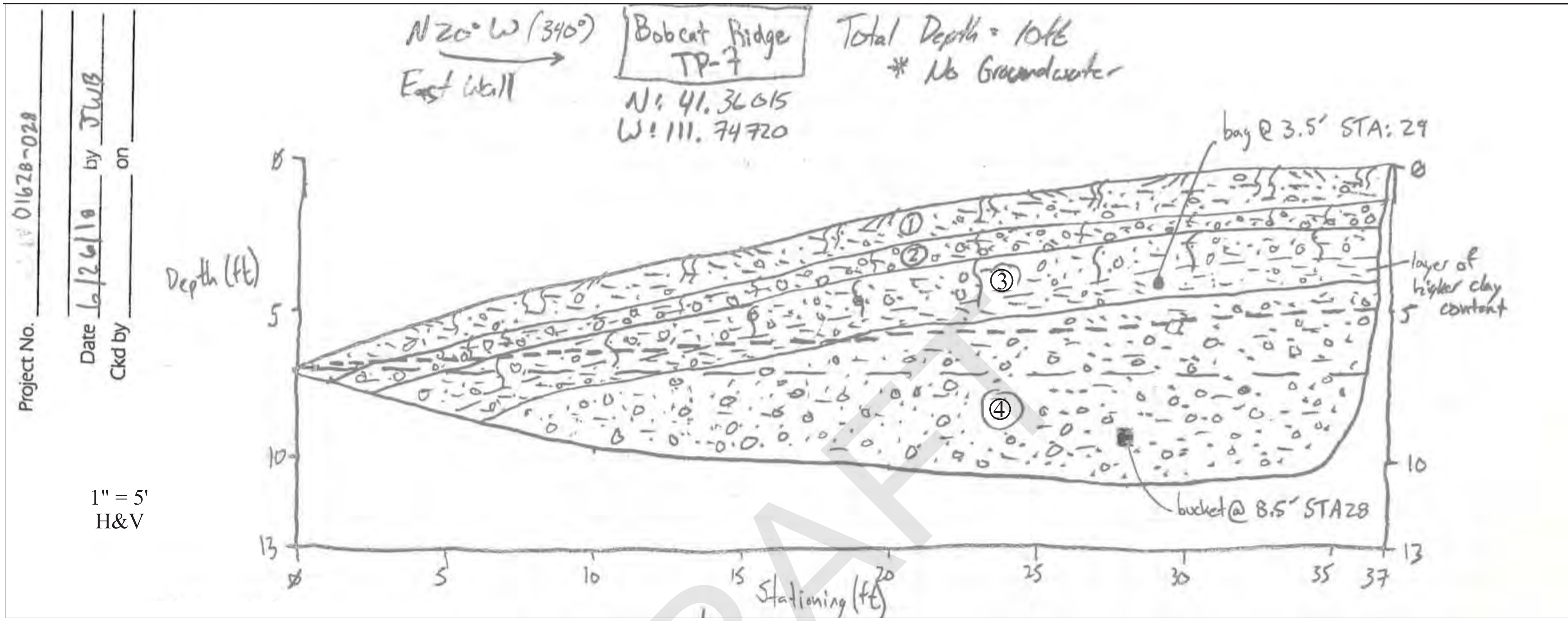
Summit Powder Mountain Resort
Weber County, Utah

TP-6 Log

Figure A-8



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LITHOLOGIC UNIT DESCRIPTIONS

1. A/B Soil Horizon:~12-18" thick; grayish brown (5Y $\frac{3}{2}$) to moderate yellowish brown (10YR $\frac{5}{4}$) sandy lean CLAY with gravel (CL), medium stiff, slightly moist, low plasticity, massive; gravel and larger sized clasts comprise ~10-15% of the unit; clasts are subrounded to subangular medium gray (N5) to pale yellowish orange (10YR $\frac{8}{6}$) quartzite up to ~6" in diameter, though mode clast size is ~1-2"; abundant plant and tree roots; gradational, irregular basal contact.

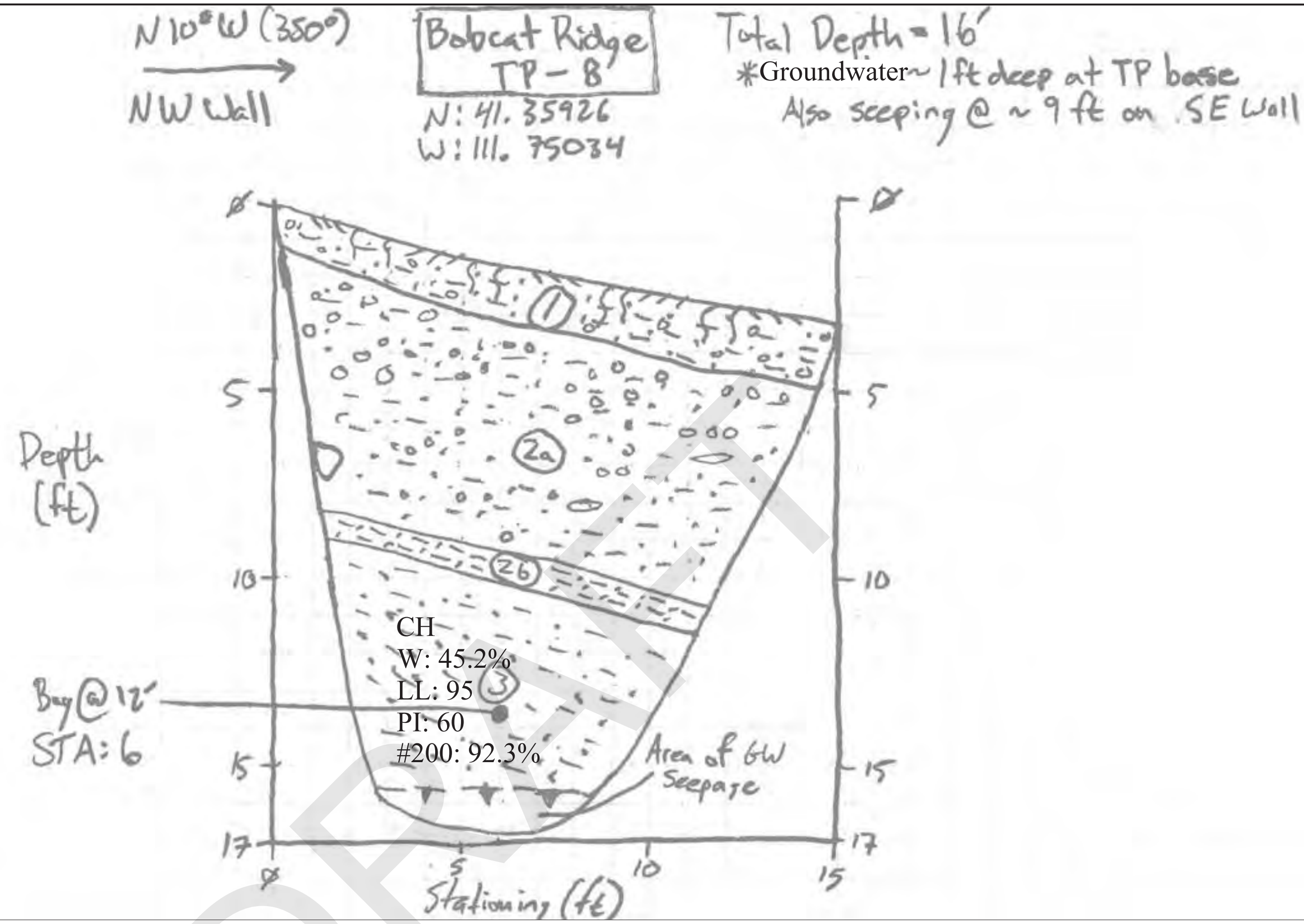
2. Colluvium: ~2-3' thick; dark yellowish brown (10YR $\frac{4}{2}$) sandy lean CLAY with gravel (CL), medium stiff, moist, low plasticity, massive; gravel and larger sized clasts comprise ~30% of the unit; clasts are subrounded to subangular quartzite as above, with minor angular dark yellowish orange (10YR $\frac{6}{6}$) micaceous sandstone; clasts are up to 1.5' in diameter, though mode clast size is ~3-4"; topsoil matrix; common plant and tree roots; sharp, irregular basal contact.

3. Shallow Landslide: ~2' thick; mottled light brownish gray (5YR $\frac{6}{1}$) to moderate reddish orange (10R $\frac{6}{6}$) to dark yellowish orange (10YR $\frac{6}{6}$) sandy lean CLAY with gravel (CL) gradational to clayey SAND with gravel (SC), stiff, moist, moderate plasticity, massive; gravel and larger sized clasts comprise ~20-30% of the subunit and decrease with depth; clasts are predominantly subrounded to subangular quartzite as above and minor dark yellowish orange (10YR $\frac{6}{6}$) sandstone; clasts are up to 8" in diameter, though mode clast size is ~1-2"; common to occasional plant and tree roots; unit is sandy at top and gets progressively more clayey with depth; clay plasticity also increases with depth; gradational, irregular basal contact.

4. Wasatch Formation: >6' thick; moderate reddish brown (10R $\frac{4}{6}$) clayey SAND with gravel (SC) gradational to clayey GRAVEL with sand (GC), dense, moist, low to moderate plasticity fines, massive; gravel and larger sized clasts comprise ~40-50% of the unit; clasts are subangular to subrounded quartzite and sandstone as above up to 2-3' in diameter, with a mode clast size of ~3"; few plant roots; occasional black organic or MnO2 staining.

Project No. 01628-028
Date 6/21/18 by JWB
Ckd by ____ on ____

1" = 5'
H&V



LITHOLOGIC UNIT DESCRIPTIONS

1. A/B Soil Horizon: ~1.5'-2' thick; grayish brown (5Y $\frac{3}{2}$) sandy lean CLAY with gravel (CL), medium stiff, slightly moist to moist, low plasticity, massive; gravel and larger sized clasts comprise ~10-15% of the unit; clasts are subrounded to subangular medium light gray (N6) quartzite up to ~1.5' in diameter, though mode clast size is ~1"; common plant roots; sharp, irregular basal contact.

2. Wasatch Formation?: ~6-7' thick; possible landslide deposits; 2 subunits.

a. ~6' thick; moderate reddish brown (10R $\frac{4}{6}$) to dark reddish brown (10R $\frac{3}{4}$) sandy fat CLAY with gravel (CH) gradational to clayey SAND with gravel (SC), stiff, moist, moderate plasticity, massive; gravel and larger sized clasts comprise ~30-40% of the subunit; clasts are quartzite as above up to 3' in diameter, though mode clast size is ~3-4"; upper ~1' may include intermittent colluvium; possibly fewer clasts with depth; sharp, irregular basal contact.

b. ~1' thick; moderate reddish brown (10R $\frac{4}{6}$) to dark reddish brown (10R $\frac{3}{4}$) sandy fat CLAY (CH) gradational to clayey SAND (SC), stiff, moist, moderate to high plasticity, massive; rare quartzite clasts as above; sharp, planar basal contact.

3. Clay Seam: >7' thick; medium light gray (N6) sandy fat CLAY, stiff, moist to wet, high plasticity, massive; appears like weathered Norwood Formation, as seen in other test pits; occasional fine-grained biotite and muscovite mica grains present; rare quartzite and dark yellowish orange (10YR $\frac{6}{6}$) sandstone clasts.

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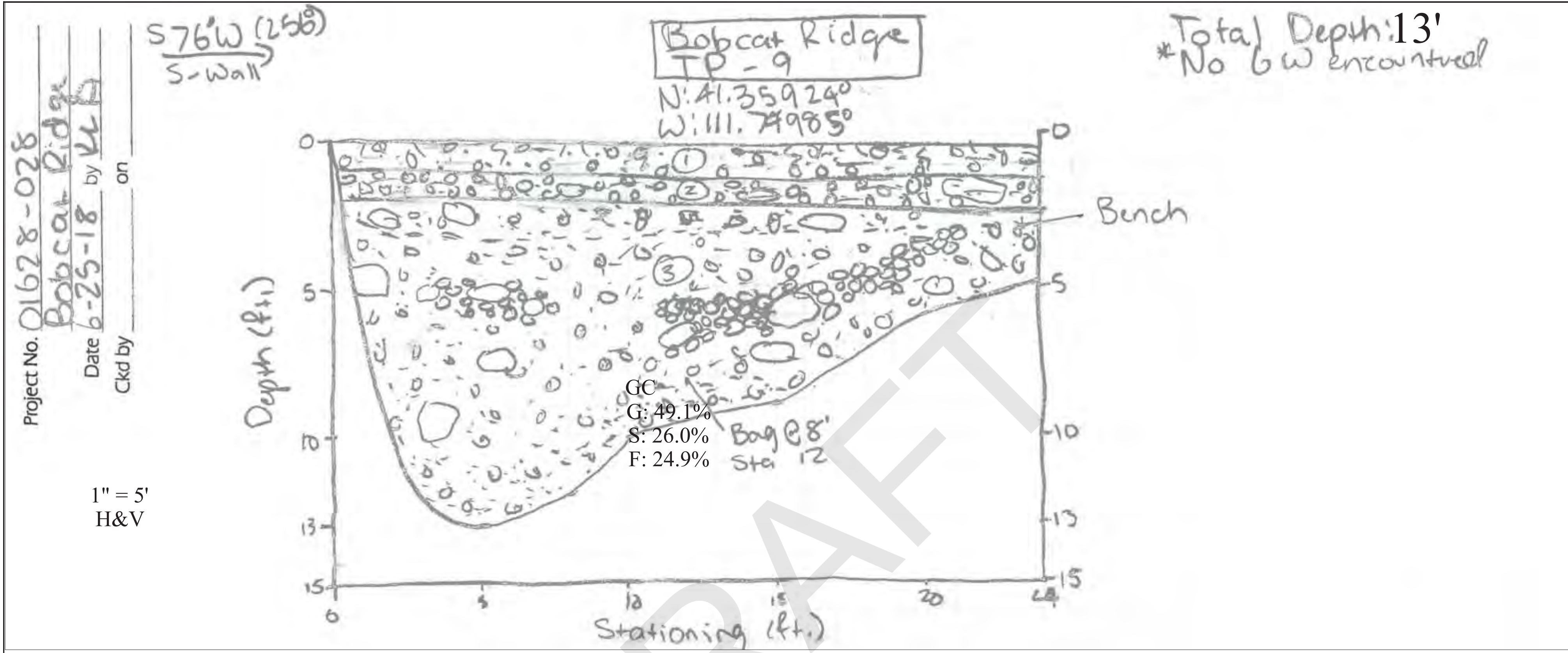
Geotechnical and Geologic Hazards Assessment
Bobcat Ridge Subdivision
Summit Powder Mountain Resort
Weber County, Utah

TP-8 Log

Figure A-10

DRAFT



LITHOLOGIC UNIT DESCRIPTIONS

1. A/B Soil Horizon: ~1' thick; light brown (5YR $\frac{6}{4}$) sandy lean CLAY with gravel (CL), medium stiff, dry, low plasticity, massive; gravel and larger sized clasts comprise ~10% of the unit; clasts are subangular to subrounded light brown (5YR $\frac{6}{4}$) to medium gray (N5) quartzite up to ~6" in diameter, though mode clast size ~0.5-1"; abundant plant and tree roots; gradational, irregular basal contact.

2. Colluvium: ~1' thick; light brown (5YR $\frac{6}{4}$) sandy lean CLAY with gravel (CL), loose to medium stiff, dry to slightly moist, low plasticity, massive; gravel and larger sized clasts comprise ~35% of the unit; clasts are subrounded to subangular quartzite as above up to 2' in diameter, though mode clast size is ~2-4"; abundant plant and tree roots; topsoil matrix; sharp, planar basal contact.

3. Wasatch Formation: >11' thick; moderate reddish brown (10R $\frac{4}{6}$) clayey GRAVEL with sand (GC), medium dense to dense, moist, low plasticity fines, massive; gravel and larger sized clasts comprise ~30-50% of the unit; clasts are subrounded to subangular grayish orange pink (10R $\frac{8}{2}$) to medium gray (N5) quartzite and moderate reddish orange (10R $\frac{6}{6}$) sandstone up to 1.5' in diameter, though the mode clast size is ~2-3"; multiple gravel lenses indicative of an alluvial component; basal 1' is a silty SAND with gravel (SM); sand component is fine- to medium-grained.

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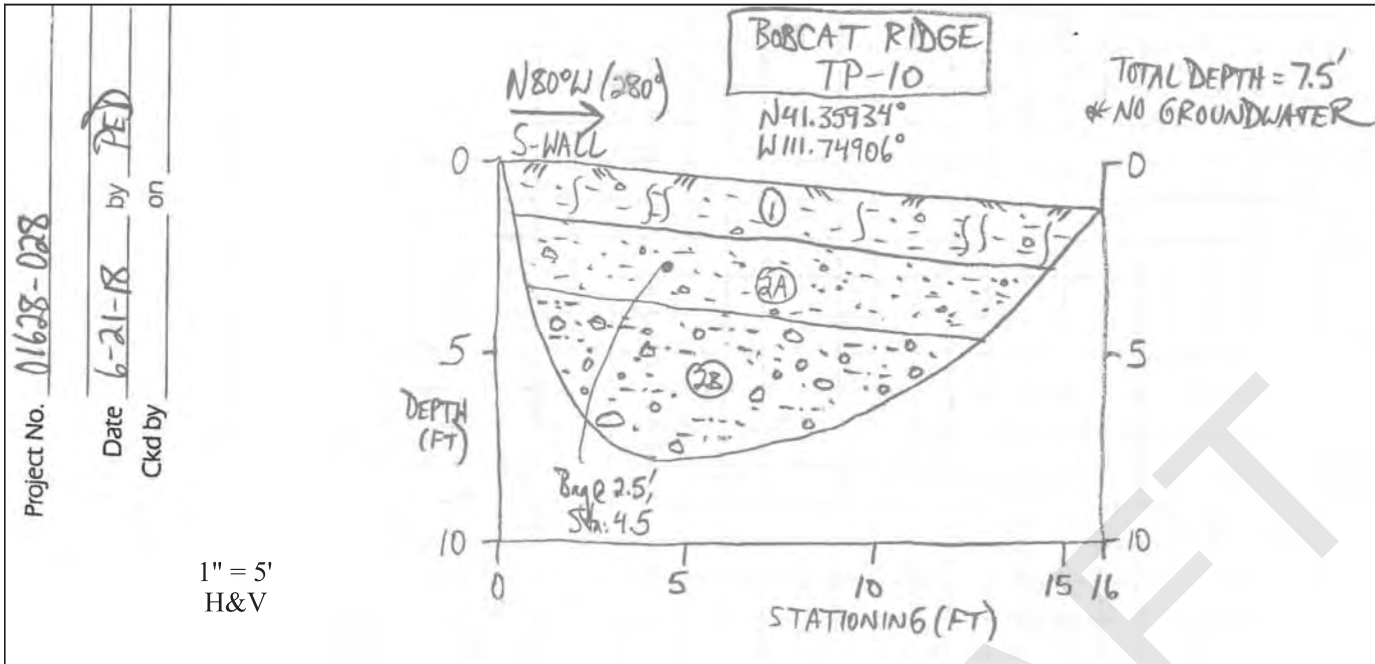
Geotechnical and Geologic Hazards Assessment
Bobcat Ridge Subdivision
Summit Powder Mountain Resort
Weber County, Utah

TP-9 Log

Figure

A-11



LITHOLOGIC UNIT DESCRIPTIONS

1. A/B Soil Horizon: ~1.5'-2' thick; grayish brown (5Y 3/2) sandy lean CLAY with gravel (CL), medium stiff, slightly moist to moist, low pl~1.5' thick; grayish brown (5Y 3/2) sandy lean CLAY with gravel (CL), medium stiff, moist, low plasticity, massive; gravel and larger sized clasts comprise ~5-10% of the unit; clasts are subrounded to subangular medium light gray (N6) to pale yellowish orange (10YR 8/6) quartzite up to ~2" in diameter, though mode clast size is ~1"; abundant plant and tree roots; sharp, irregular basal contact. asticity, massive; gravel and larger sized clasts comprise ~10-15% of the unit; clasts are subrounded to subangular medium light gray (N6) quartzite up to ~1.5' in diameter, though mode clast size is ~1"; common plant roots; sharp, irregular basal contact.

2. Wasatch Formation: >6' thick; 2 subunits.

a. ~2' thick; moderate yellowish brown (10Y 5/4) clayey SAND with gravel (SC), medium dense, moist, low plasticity fines, massive; gravel and larger sized clasts comprise ~10-15% of the subunit; clasts are subrounded to subangular quartzite as above with few dark yellowish orange (10YR 6/6) highly oxidized sandstone clasts; clasts are up to 4" in diameter, though mode clast size is ~0.5"; occasional plant and tree roots; possible B-horizon; sand is fine- to medium-grained; sharp, planar basal contact.

b. >4' thick; moderate reddish brown (10R 4/6) gravelly SILT (ML) gradational to clayey SAND with gravel (SC), dense, slightly moist to moist, low plasticity, massive; gravel and larger sized clasts comprise ~30-35% of the unit; clasts are subrounded to subangular quartzite as above up to ~10" in diameter, though mode clast size is ~ 3-4"; silt is gradational to very fine-grained sand; few tree roots.

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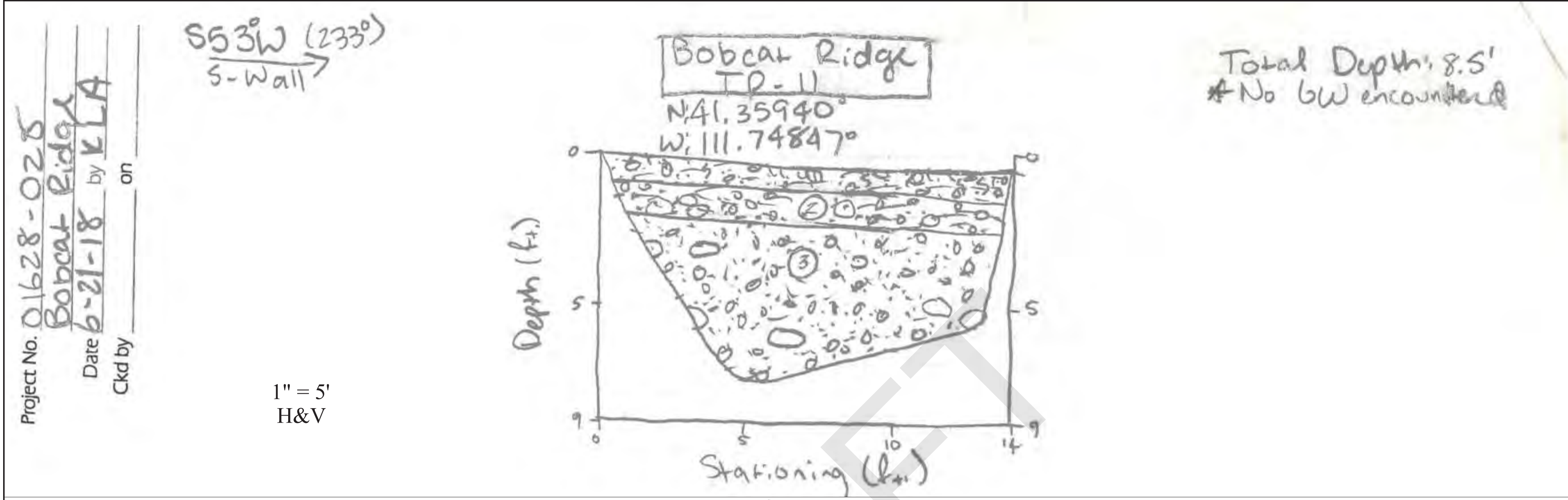


LITHOLOGIC UNIT DESCRIPTIONS

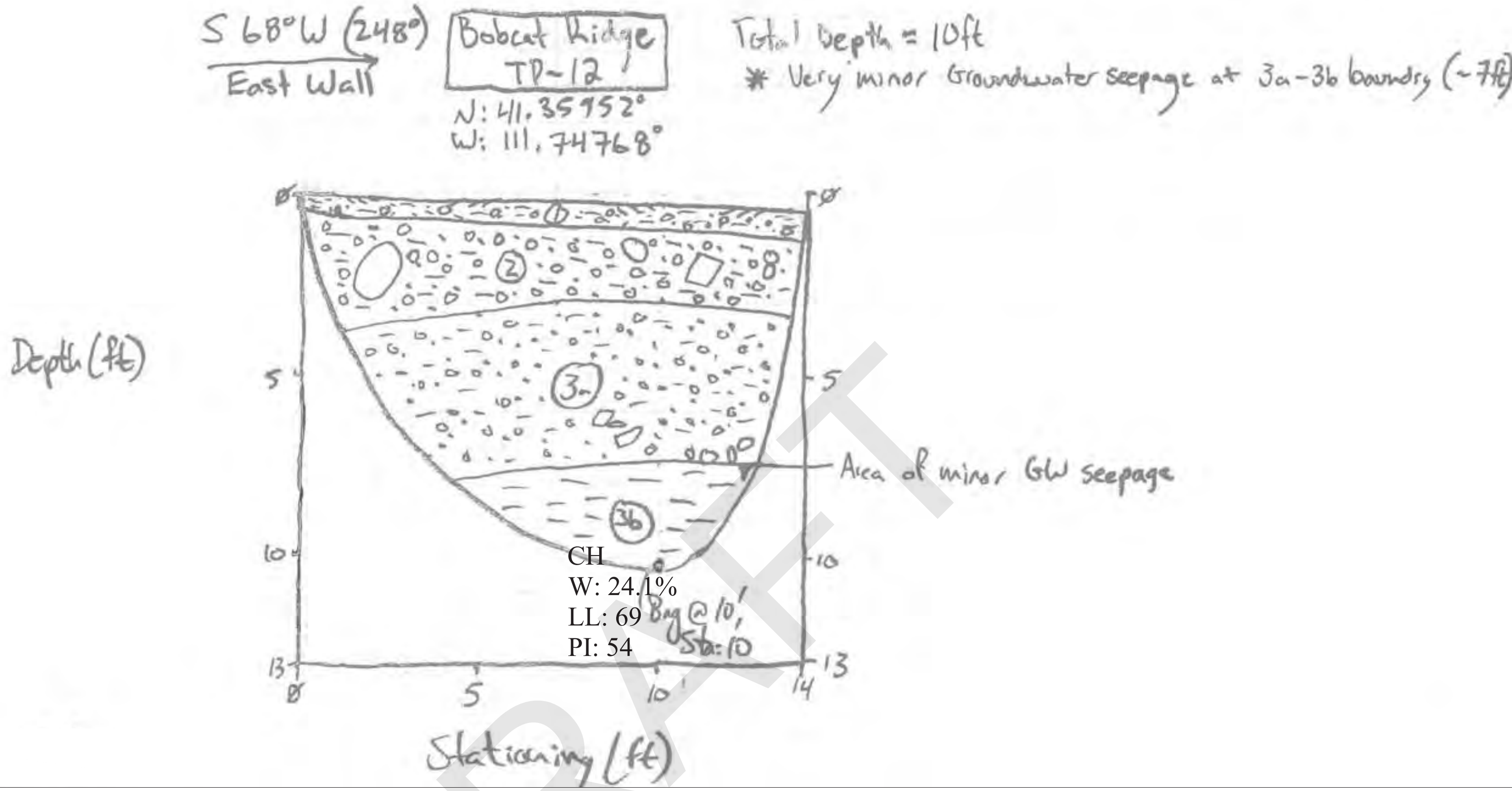
1. **A/B Soil Horizon:** ~1' thick; light brown (5YR $\frac{6}{4}$) to moderate yellowish brown (10YR $\frac{5}{4}$) sandy lean CLAY with gravel (CL), loose to medium stiff, dry to moist, low plasticity, massive; gravel and larger sized clasts comprise ~20-25% of the unit; clasts are subrounded to subangular light brown (5YR $\frac{6}{4}$) to medium dark gray (N4) to moderate orange pink (10R $\frac{7}{4}$) quartzite up to ~2-3" in diameter, though mode clast size ~0.5"; abundant plant roots; gradational, irregular basal contact.

2. **Colluvium:** ~1' thick; light brown (5YR $\frac{6}{4}$) to moderate yellowish brown (10YR $\frac{5}{4}$) sandy lean CLAY with gravel (CL), loose to medium stiff, slightly moist, low plasticity, massive; gravel and larger sized clasts comprise ~20-30% of the unit; clasts are subrounded to subangular quartzite as above up to 1' in diameter, though mode clast size is ~2-3"; topsoil matrix; sharp, planar basal contact.

3. **Wasatch Formation**: >5.5' thick; dark yellowish orange (10YR $\frac{6}{6}$) to moderate reddish orange (10R $\frac{6}{6}$) clayey GRAVEL with sand (GC), medium dense, moist, low plasticity fines, massive; gravel and larger sized clasts comprise ~35-40% of the unit; clasts are subrounded to subangular pale yellowish orange (10YR $\frac{8}{6}$) to medium gray (N5) quartzite and moderate reddish orange (10R $\frac{6}{6}$) sandstone; clasts are up to 3' in diameter, though mode clast size is ~2-4"; occasional plant roots; traces of lean clay; sand is fine- to medium-grained.

DRAFT

Project No. 01628-028
Date 6/26/18 by JWB
Ckd by on



1" = 5'
H&V

DRAFT

LITHOLOGIC UNIT DESCRIPTIONS

1. <u>A/B Soil Horizon:</u> ~6-8" thick; light brown (5YR $\frac{6}{4}$) sandy lean CLAY with gravel (CL), loose to medium stiff, slightly moist, low plasticity, massive; gravel and larger sized clasts comprise ~15-20% of the unit; clasts are subrounded to subangular medium gray (N5) to moderate reddish brown (10R $\frac{4}{6}$) quartzite up to ~6" in diameter, though mode clast size is ~1"; common plant and tree roots; sharp, irregular basal contact.

2. <u>Colluvium:</u> ~2-3' thick; light brown (5YR $\frac{6}{4}$) to moderate yellowish brown (10YR $\frac{5}{4}$) sandy lean CLAY with gravel (CL), medium stiff, slightly moist to moist, moderate plasticity, massive; gravel and larger sized clasts comprise ~30% of the unit, clasts are subrounded quartzite as above, clasts are up to 4' in diameter, though model clast size is ~3"; occasional plant roots; topsoil matrix; sharp, irregular basal contact.

3. <u>Wasatch Formation</u>: >7' thick; 2 subunits.

a. ~4-5' thick; mottled moderate yellowish brown (10YR $\frac{5}{4}$) to moderate reddish brown (10R $\frac{4}{6}$) clayey SAND with gravel (SC), dense, moist, moderate plasticity, massive; gravel and larger sized clasts comprise ~30% of the subunit; clasts are subangular to subrounded quartzite as above up to 1' in diameter, though mode clast size is ~1-2"; few plant roots; sharp, wavy basal contact.

b. >3' thick; moderate reddish brown (10R $\frac{4}{6}$) silty fat CLAY (CH), dense, moist to wet, high plasticity, massive; largely devoid of clasts; common muscovite mica flakes; minor fat clay sheen, though no slickensides observed.

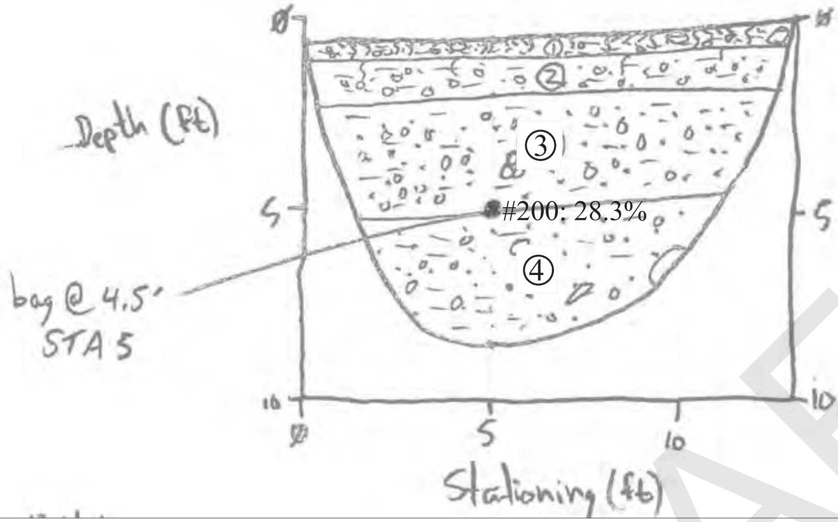
Project No. 01628-028
Date 6-26-18 by JWB
Ckd by ____ on ____

N87° E (087°)
North Wall

Bobcat Ridge
TP-13

N: 41.35973
W: 111.74700

Total Depth = 8.5'
* No Groundwater



1" = 5'
H&V

LITHOLOGIC UNIT DESCRIPTIONS

1. A/B Soil Horizon: ~8-10” thick; light brown (5YR $\frac{6}{4}$) sandy lean CLAY with gravel (CL), loose to medium stiff, slightly moist, low plasticity, massive; gravel and larger sized clasts comprise ~15-20% of the unit; clasts are subrounded to subangular medium gray (N5) to pale reddish brown (10R $\frac{5}{4}$) quartzite up to ~19” in diameter, though mode clast size is ~1-3”; abundant plant and tree roots; sharp, irregular basal contact.

2. Colluvium: ~1' thick; moderate yellowish brown (10YR $\frac{5}{4}$) sandy lean CLAY with gravel (CL), medium stiff, slightly moist, low plasticity, massive; gravel and larger sized clasts comprise ~30% of the unit; clasts are subrounded to subangular quartzite as above up to 15” in diameter, though mode clast size is ~1” in a wide variety of clast sizes; occasional plant roots; topsoil matrix; gradational, irregular basal contact.

3. Shallow Landslide: ~3' thick; mottled moderate yellowish brown (10YR 5/4) to moderate reddish brown (10R 4/6) to grayish blue (5PB 5/2) clayey SAND with gravel (SC), dense, moist, moderate plasticity, massive; gravel and larger sized clasts comprise ~30% of the unit; clasts are subrounded to subangular quartzite as above with minor medium gray (N5) dolomite and moderate yellowish brown (10YR 5/4) sandstone; clasts are up to 1' in diameter, though mode clast size is ~3-4”; gradational, irregular basal contact.

4. Wasatch Formation: >3.5' thick; moderate reddish brown (10R 4/6) clayey SAND with gravel (SC), dense, moist, moderate plasticity fines, massive; gravel and larger sized clasts comprise ~20-30% of the unit; clasts are quartzite, dolomite, and sandstone as above up to 1' in diameter, though mode clast size is ~3-4”; possibly increases in clay content with depth.

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Geotechnical and Geologic Hazards Assessment
Bobcat Ridge Subdivision
Summit Powder Mountain Resort
Weber County, Utah

TP-13 Log

Figure A-15

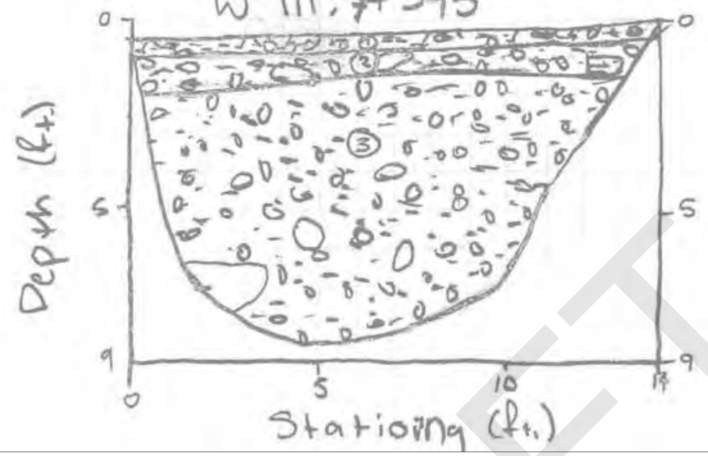
Project No. 01628-028 Bobcat Ridge
Date 6/21/18 by KLA
Ckd by ______ on ______

S39° E → (141°)
E-Wall

Bobcat Ridge
TP-15
N: 41.35978°
W: 111.74595°

Total Depth 8.5'
* NO GW encountered

1" = 5'
H&V



LITHOLOGIC UNIT DESCRIPTIONS

1. **A/B Soil Horizon:** ~6" thick; light brown (5YR $\frac{6}{4}$) to moderate yellowish brown (10YR $\frac{5}{4}$) sandy lean CLAY with gravel (CL), loose to medium stiff, slightly moist, low plasticity, massive; gravel and larger sized clasts comprise ~10-20% of the unit; clasts are subrounded to subangular light brown (5YR $\frac{6}{4}$) to medium gray (N5) to moderate reddish brown (10R $\frac{4}{6}$) quartzite up to ~4" in diameter, though mode clast size ~0.5"; abundant plant and tree roots; gradational, irregular basal contact.

2. **Colluvium:** ~1' thick; light brown (5YR $\frac{6}{4}$) to moderate yellowish brown (10YR $\frac{5}{4}$) sandy lean CLAY with gravel (CL), loose to medium stiff, slightly moist, low plasticity, massive; gravel and larger sized clasts comprise ~20-25% of the unit; clasts are subrounded to subangular quartzite as above up to 12" in diameter, though mode clast size is ~2-4"; topsoil matrix; abundant plant and tree roots; sharp, planar basal contact.

3. **Wasatch Formation**:>7' thick; moderate yellowish brown (10YR $\frac{5}{4}$) to moderate reddish orange (10R $\frac{6}{6}$) well-graded gravelly SAND (SW), medium dense, moist, low plasticity fines, massive; gravel and larger sized clasts comprise ~35% of the unit; clasts are subrounded to subangular quartzite as above with minor moderate reddish orange sandstone; clasts are up to 2' in diameter, though mode clast size is ~2-4"; clasts appear to become larger in size with depth; occasional plant roots; trace lean clay; sand is fine- to medium-grained.

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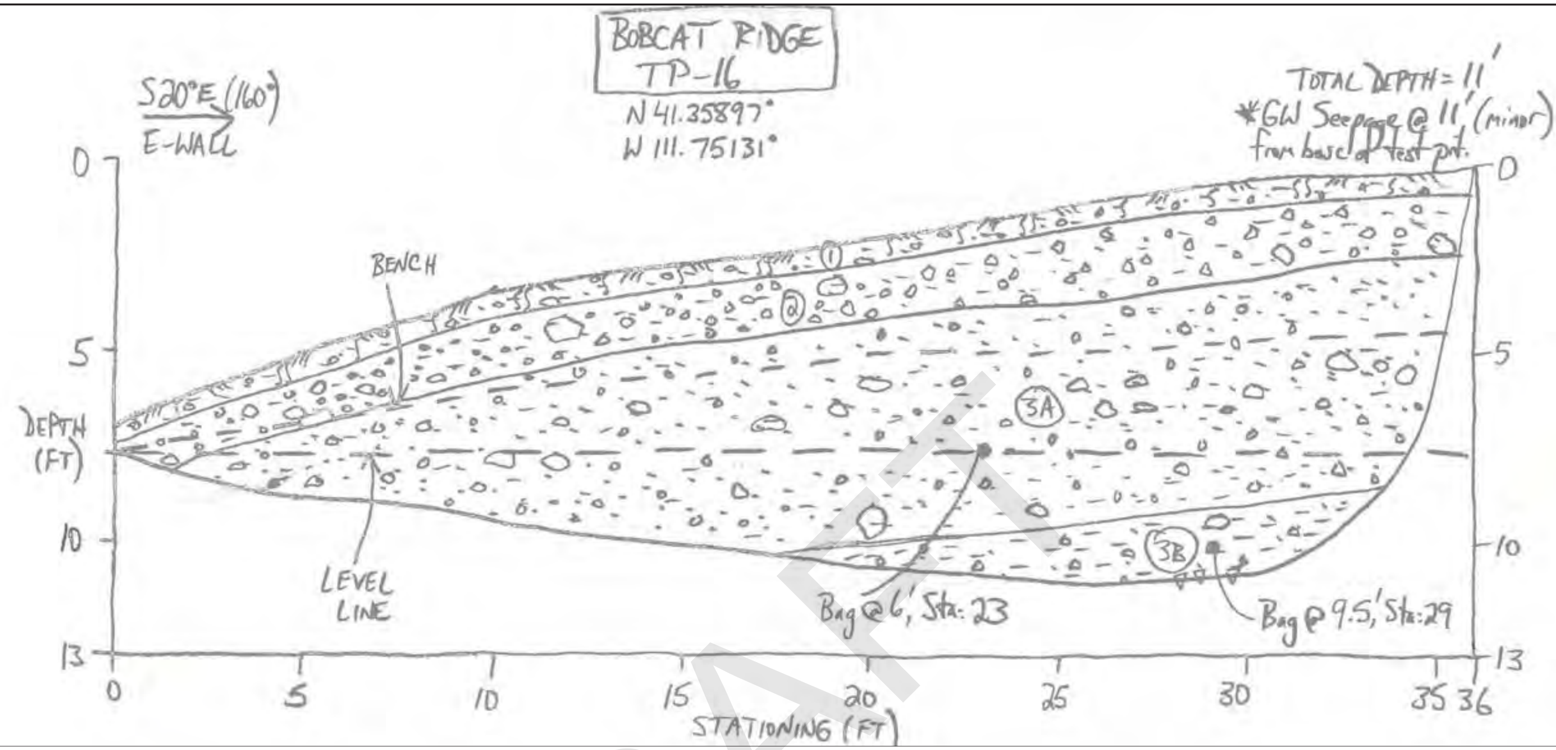
Project No. 01628-028
Date 6-22-18 by PED
Ckd by ____ on ____



1" = 5'
H&V

DRAFT

LITHOLOGIC UNIT DESCRIPTIONS

1. A/B Soil Horizon: ~6" thick; grayish brown (5Y $\frac{3}{2}$) sandy lean CLAY with gravel (CL), loose, slightly moist, low plasticity, massive; gravel and larger sized clasts comprise ~20-25% of the unit; clasts are subrounded to subangular medium gray (N5) to pale yellowish orange (10YR $\frac{8}{6}$) quartzite up to ~10" in diameter, though mode clast size is ~1-2"; abundant plant and tree roots; gradational, irregular basal contact.

2. Colluvium: ~1-1.5' thick; dark yellowish brown (10YR $\frac{4}{2}$) sandy lean CLAY with gravel (CL) gradational to clayey GRAVEL with sand (GC), medium stiff to loose, moist, low plasticity, massive; gravel and larger sized clasts comprise ~40% of the unit; clasts are subrounded to subangular quartzite as above up to 1.5' in diameter, though mode clast size is ~3-6"; common to abundant plant roots; topsoil matrix; possible B-horizon; becomes more clast-rich downslope to the north; sharp, irregular basal contact.

3. Wasatch Formation: >9' thick; 2 subunits.

a. ~7' thick; moderate reddish brown (10R $\frac{4}{6}$) clayey SAND with gravel (SC), medium dense to dense, moist, low to moderate plasticity fines, massive; gravel and larger sized clasts comprise ~30-40% of the unit; clasts are subrounded to subangular quartzite up to 1' in diameter, though mode clast size is ~2-4"; occasional plant and tree roots; sand is fine- to medium-grained; sharp, planar basal contact.

b. >2' thick; dark reddish brown (10R $\frac{3}{4}$) sandy lean CLAY with gravel (CL), stiff, moist to wet, moderate plasticity, massive; gravel and larger sized clasts comprise ~10-20% of the unit; clasts are subrounded to subangular quartzite as above up to 8" in diameter, with a mode clast size of ~1-2"; likely represents a facies change to a more clay-rich lithology during Wasatch Formation deposition.

Project No. 01628-028 Bobcat Ridge
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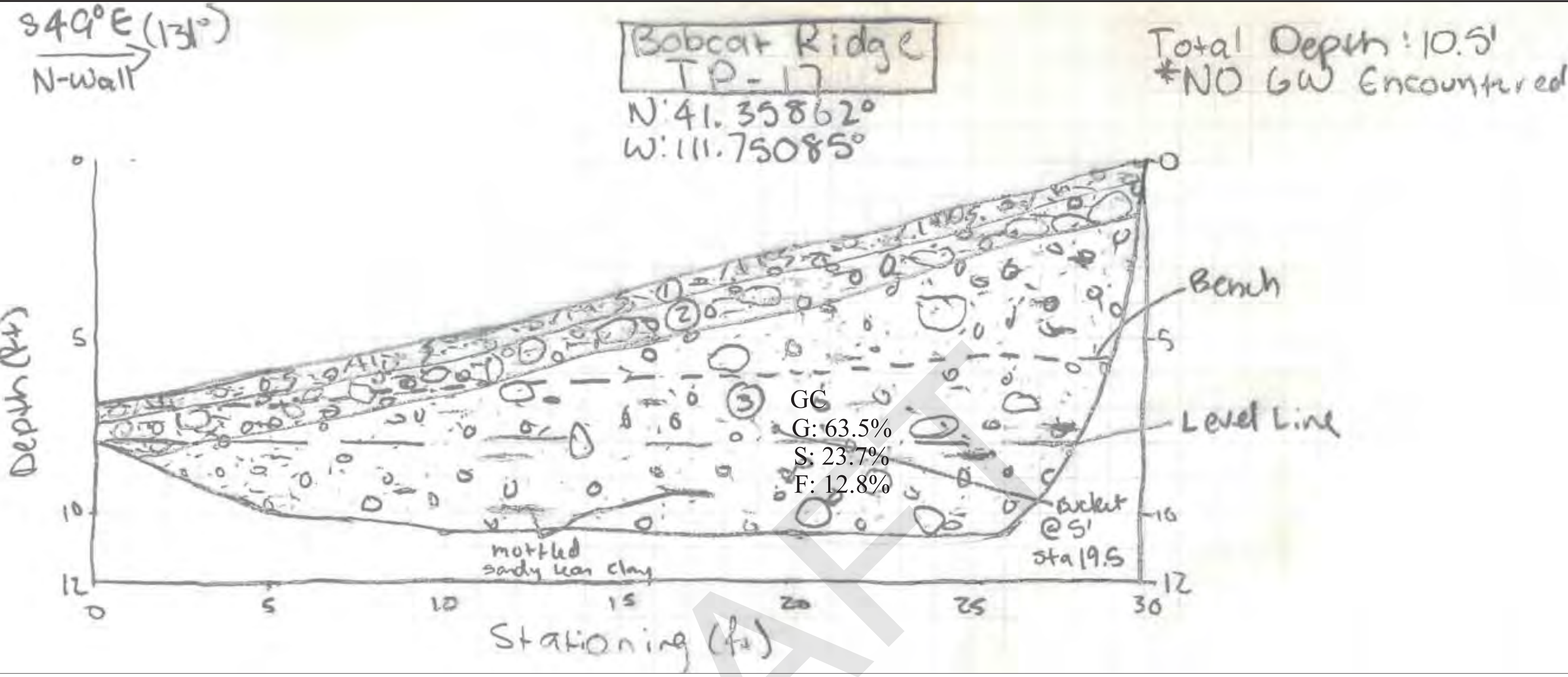
Ckd by ______ on ______



1" = 5'
H&V

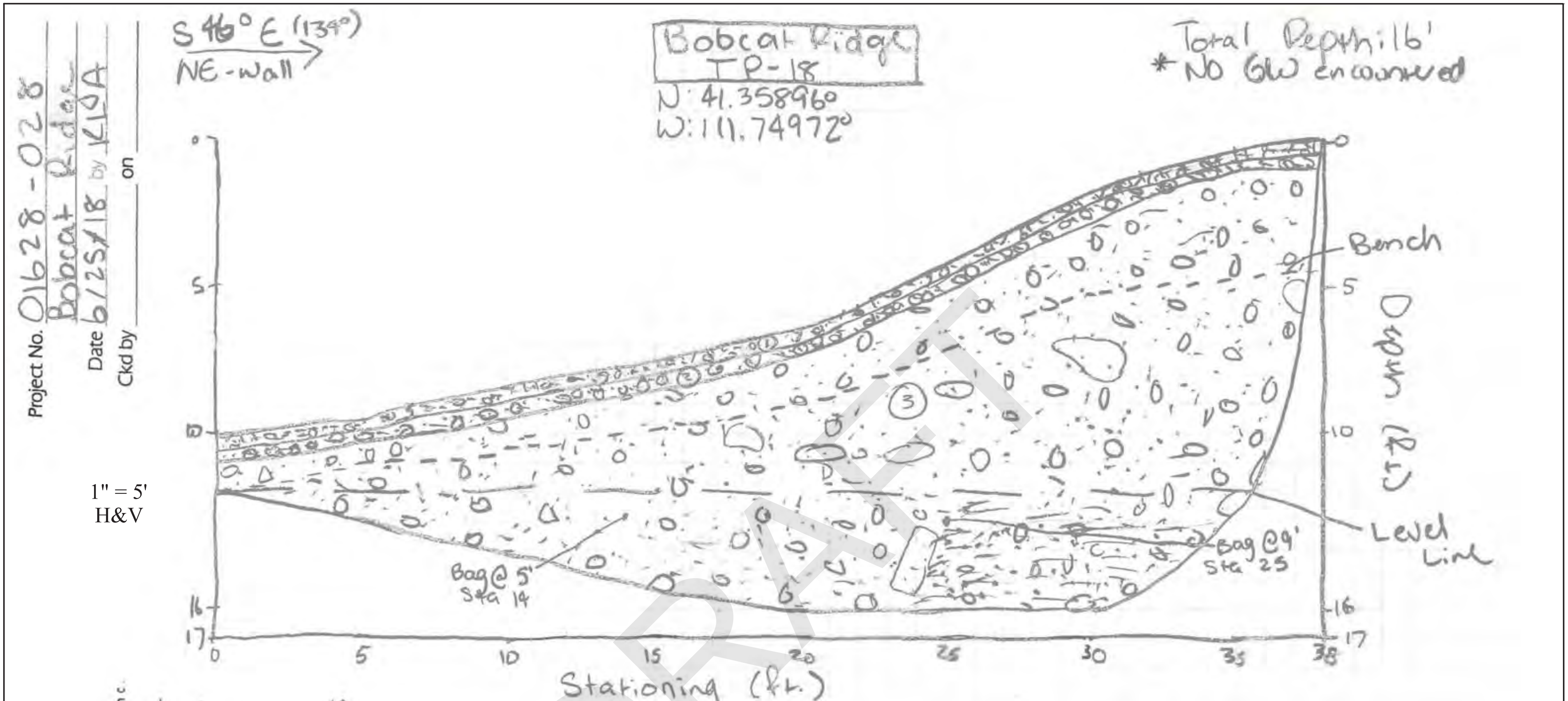
DRAFT

LITHOLOGIC UNIT DESCRIPTIONS

1. **A/B Soil Horizon:** ~6" thick; light brown (5YR $\frac{6}{4}$) to moderate yellowish brown (10YR $\frac{5}{4}$) sandy lean CLAY with gravel (CL), loose to medium stiff, dry to slightly moist, low plasticity, massive; gravel and larger sized clasts comprise ~20% of the unit; clasts are subrounded to subangular light brown to medium dark gray (N4) to moderate orange pink (10R $\frac{7}{4}$) quartzite up to ~2-3" in diameter, though mode clast size ~0.5"; abundant plant roots; gradational, irregular basal contact.

2. **Colluvium:** ~1' thick; light brown (5YR $\frac{6}{4}$) to moderate yellowish brown (10YR $\frac{5}{4}$) sandy lean CLAY with gravel (CL), loose to medium stiff, dry, low plasticity, massive; gravel and larger sized clasts comprise ~20-30% of the unit; clasts are subrounded to subangular quartzite as above up to 1' in diameter, though mode clast size is ~2-3"; topsoil matrix; sharp, planar basal contact.

3. **Wasatch Formation:** >8' thick; dark yellowish orange (10YR $\frac{6}{6}$) to moderate reddish brown (10R $\frac{4}{6}$) clayey GRAVEL with sand (GC) with areas of mottled moderate red (5R $\frac{5}{4}$) sandy lean CLAY with gravel (CL), medium dense, moist, low to moderate plasticity fines, massive; gravel and larger sized clasts comprise ~20-65% of the unit; clasts are subrounded to subangular quartzite as above with minor moderate reddish orange (10R $\frac{6}{6}$) sandstone; clasts are up to 2' in diameter, though the mode clast size is ~2-3"; sand is fine- to medium-grained.



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LITHOLOGIC UNIT DESCRIPTIONS

1. A/B Soil Horizon: ~6" thick; light brown (5YR $\frac{6}{4}$) to dusky yellowish brown (10YR $\frac{2}{2}$) sandy lean CLAY with gravel (CL), loose to medium stiff, dry to slightly moist, low plasticity, massive; gravel and larger sized clasts comprise ~10% of the unit; clasts are subangular to subrounded light brown to medium gray (N5) quartzite up to ~6" in diameter, though mode clast size ~0.5-1"; abundant plant and tree roots; gradational, irregular basal contact.

2. Colluvium:~6" thick; light brown (5YR $\frac{6}{4}$) sandy lean CLAY with gravel (CL), loose to medium stiff, dry to slightly moist, low plasticity, massive; gravel and larger sized clasts comprise ~35% of the unit; clasts are subrounded to subangular quartzite as above up to 2' in diameter, though mode clast size is ~2-4"; abundant plant and tree roots; topsoil matrix; sharp, planar basal contact.

3. Wasatch Formation: >12' thick; well-graded gravelly SAND (SW), medium dense, moist, low plasticity fines, massive; gravel and larger sized clasts comprise ~20-30% of the unit; clasts are subrounded to subangular quartzite as above with minor moderate reddish orange (10R $\frac{6}{6}$) sandstone; clasts are up to 3' in diameter, though mode clast size is ~2-3"; sand is fine- to medium-grained; occasional tree roots; basal 3' between stations 24 and 38 exhibits a moderate reddish brown (10R $\frac{4}{6}$) clayey SAND (SC).

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Bobcat Ridge Subdivision
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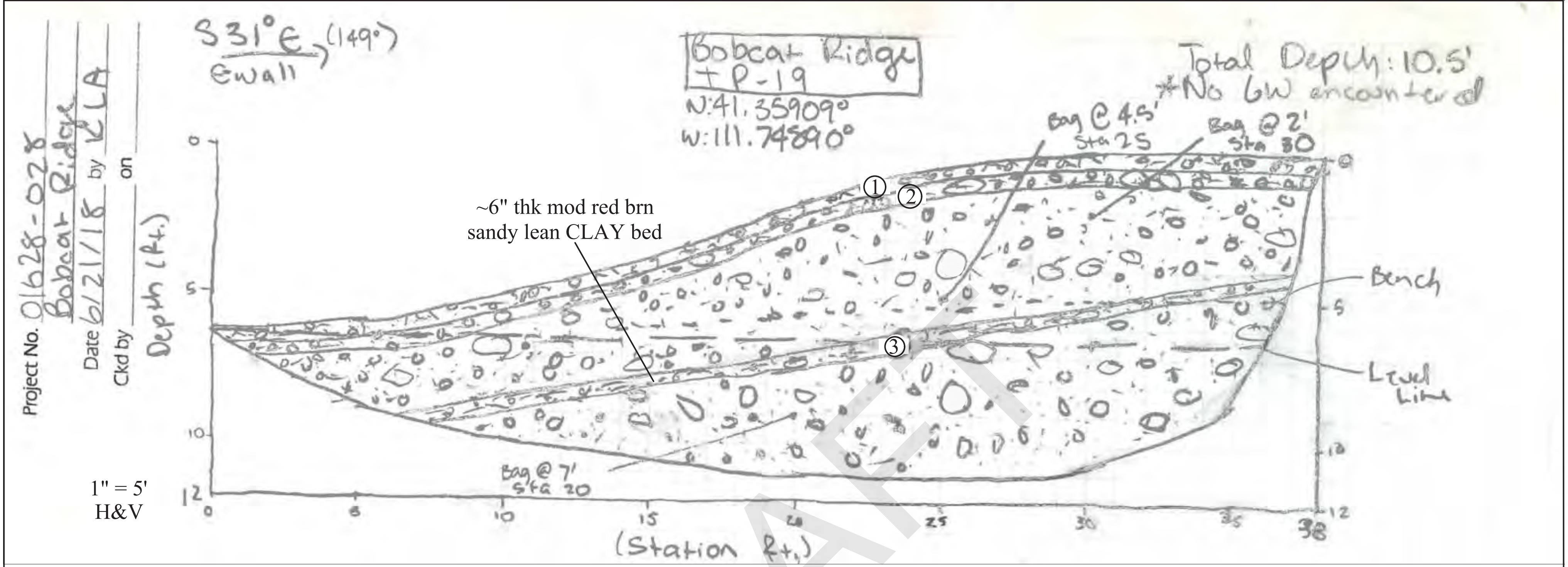
Weber County, Utah

TP-18 Log

Figure

A-19



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LITHOLOGIC UNIT DESCRIPTIONS

1. <u>A/B Soil Horizon:</u> ~6" thick; light brown (5YR $\frac{6}{4}$) to moderate yellowish brown (10YR $\frac{5}{4}$) sandy lean CLAY with gravel (CL), loose to medium stiff, dry to slightly moist, low plasticity, massive; gravel and larger sized clasts comprise ~20-25% of the unit; clasts are subrounded to subangular light brown to medium dark gray (N4) to moderate orange pink (10R $\frac{7}{4}$) quartzite up to ~2-3" in diameter, though mode clast size ~0.5"; abundant plant roots; gradational, irregular basal contact.

2. <u>Colluvium</u>:~6" thick; light brown (5YR $\frac{6}{4}$) to moderate yellowish brown (10YR $\frac{5}{4}$) sandy lean CLAY with gravel (CL), loose to medium stiff, slightly moist, low plasticity, massive; gravel and larger sized clasts comprise ~20-30% of the unit; clasts are subrounded to subangular quartzite as above up to 1' in diameter, though mode clast size is ~2-3"; topsoil matrix; sharp, planar basal contact.

3. <u>Wasatch Formation:</u> >10' thick; dark yellowish orange (10YR $\frac{6}{6}$) to moderate reddish orange (10R $\frac{6}{6}$) well-graded gravelly SAND (SW), medium dense, moist, low plasticity fines, massive; gravel and larger sized clasts comprise ~30-35% of the unit; clasts are subrounded to subangular pale yellowish orange (10YR $\frac{8}{6}$) to medium gray (N5) quartzite with minor moderate reddish orange (10R $\frac{6}{6}$) sandstone; clasts are up to 2' in diameter, though mode clast size is ~2-4"; occasional plant roots; trace lean clay; sand is fine- to medium-grained.

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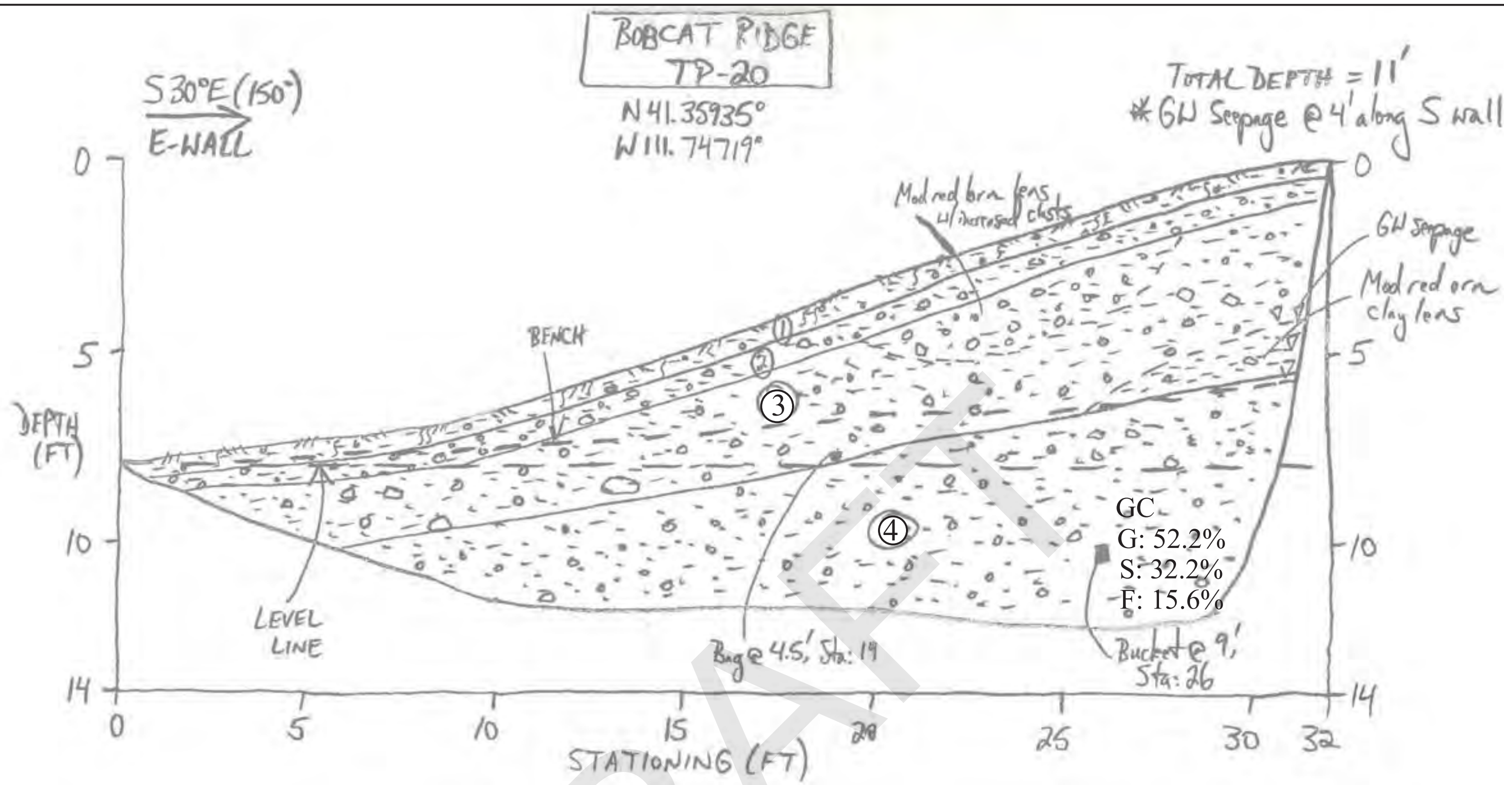
Date 6-26-18 by PED
Ckd by on



1" = 5'
H&V

DRAFT

LITHOLOGIC UNIT DESCRIPTIONS

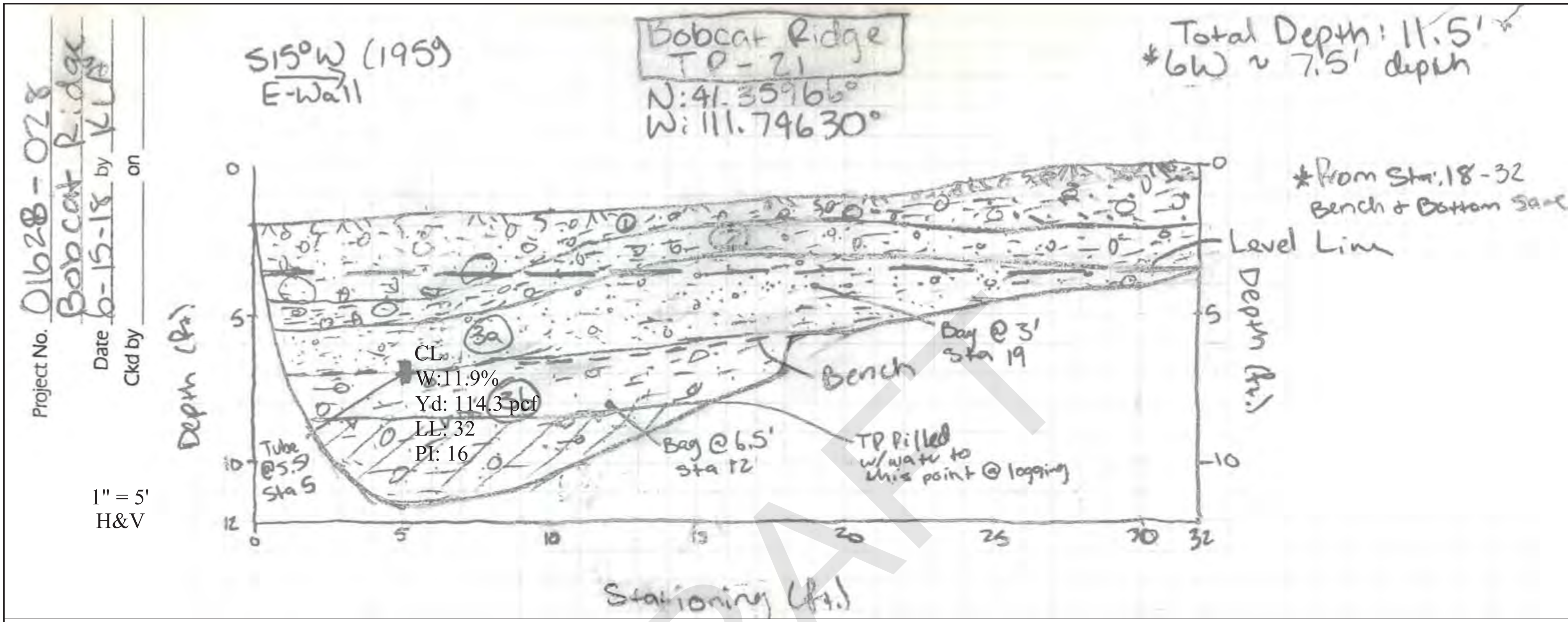
1. A/B Soil Horizon: ~8” thick; grayish brown (5Y $\frac{3}{2}$) sandy lean CLAY with gravel (CL), medium stiff, moist, low plasticity, massive; gravel and larger sized clasts comprise ~10-20% of the unit; clasts are subrounded to subangular medium gray (N5) to pale yellowish orange (10YR $\frac{8}{6}$) quartzite up to ~1' in diameter, though mode clast size ~1”; abundant plant and tree roots; gradational, irregular basal contact.

2. **Colluvium**: ~8” thick; moderate yellowish brown (10YR $\frac{5}{4}$) to dark yellowish brown (10YR $\frac{4}{2}$) sandy lean CLAY with gravel (CL), medium stiff, moist, low plasticity, massive; gravel and larger sized clasts comprise ~30% of the unit; clasts are subrounded to subangular quartzite as above up to 10” in diameter, though mode clast size is ~2-3”; topsoil matrix; common plant and tree roots; sharp, irregular basal contact.

3. **Shallow Landslide:** ~2-4' thick; mottled light gray (N7) and moderate reddish brown (10R $\frac{4}{6}$) clayey SAND with gravel (SC) gradational to sandy fat CLAY with gravel (CH), dense, moist to wet, moderate to high plasticity fines, massive; gravel and larger sized clasts comprise ~10-20% of the unit; clasts are subrounded to subangular quartzite as above up to 8” in diameter, though mode clast size is ~1-2”; sand component is fine- to medium-grained and increases in frequency with depth; unit is heterogeneous and includes multiple lenses of clay and sand; groundwater seepage from this unit; sharp, irregular basal contact.

4. **Wasatch Formation**: >6' thick; dark reddish brown (10R $\frac{3}{4}$) clayey GRAVEL with gravel (GC), dense to medium dense, moist to wet, moderate plasticity fines, massive; gravel and larger sized clasts comprise ~20-50% of the unit; clasts are subrounded to subangular quartzite as above with minor dark yellowish orange (10YR $\frac{6}{6}$) sandstone; clasts are up to 6” in diameter, though mode clast size is ~2-3”; sand component is medium- to coarse-grained; mottled with dark yellowish orange oxidation and black MnO2 staining in places; appears similar to unit that appears as a fine-grained breccia in other test pits, except less dense.

* Groundwater seepage also observed at a depth of 5' along west wall; continuous seepage induced sloughing of the south and west test pit walls during logging.



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LITHOLOGIC UNIT DESCRIPTIONS

1. A/B Soil Horizon: ~1'-2.5' thick; light brown (5YR $\frac{6}{4}$) to moderate yellowish brown (10YR $\frac{5}{4}$) sandy lean CLAY with gravel (CL), medium stiff, moist, low plasticity, massive; gravel and larger sized clasts comprise ~5-10% of the unit; clasts are subrounded to subangular dark gray (N3) to medium dark gray (N4) quartzite up to ~1' in diameter, though mode clast size ~1/2" to 1"; abundant plant and tree roots; sharp, wavy basal contact.

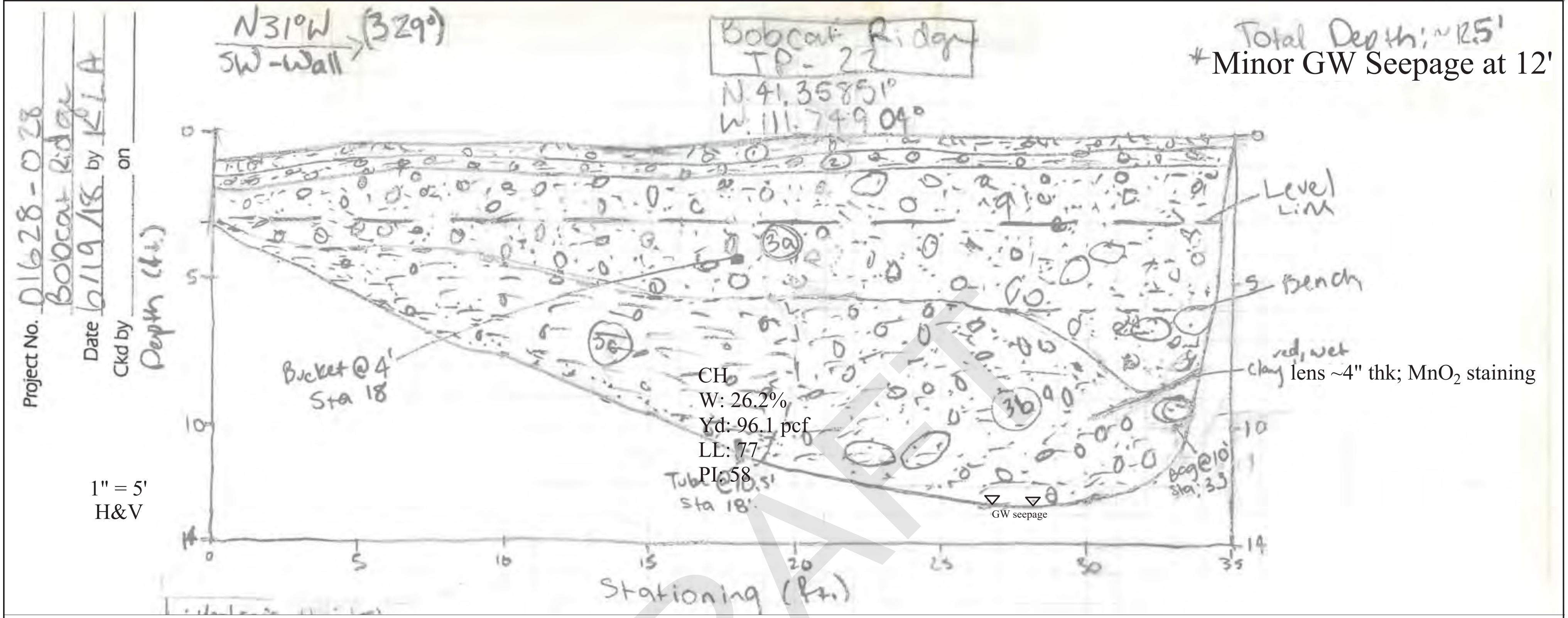
2. Colluvium: ~1' thick; light brown (5YR $\frac{6}{4}$) sandy lean CLAY with gravel (CL), medium stiff, moist, low plasticity, massive; gravel and larger sized clasts comprise ~20-30% of the unit; clasts are subrounded to subangular quartzite as above up to 9" in diameter, though mode clast size is ~1/2"-1"; possible small surficial slide deposit, though no shear observed; few plant roots; sharp, irregular basal contact.

3. Wasatch Formation: >6' thick, with two subunits:

a. ~1.5'-3' thick; moderate reddish orange (10R $\frac{6}{6}$) to moderate reddish brown (10R $\frac{4}{6}$) clayey SAND (SC), medium dense, moist, moderate plasticity fines, massive; gravel and larger sized clasts comprise ~5% of the unit; clasts are subrounded to subangular quartzite as above up to 4" in diameter, though mode clast size is ~1/2"; few plant roots.

b. >3' thick; moderate reddish brown to moderate red (5R $\frac{5}{4}$) sandy lean CLAY with gravel (CL) gradational to clayey SAND with gravel (SC), stiff, moist to wet, moderate plasticity, massive; gravel and larger sized clasts comprise ~10% of the unit; clasts are subrounded to subangular quartzite as above up to 6" in diameter, though mode clast size is ~1/2"-1"; few plant roots.

*At time of logging, the northern part of the test pit was filled with 3 feet of water.



LITHOLOGIC UNIT DESCRIPTIONS

1. A/B Soil Horizon: ~8" thick; light brownish gray (5YR $\frac{6}{1}$) to pale brown (5YR $\frac{5}{2}$) sandy lean CLAY (CL), loose to medium stiff, dry to slightly moist, low plasticity, massive; gravel and larger sized clasts comprise ~5% of the unit; clasts are subrounded to subangular medium gray (N5) quartzite up to 4" in diameter, though mode clast size is ~1/2"; abundant plant and tree roots; gradational, irregular basal contact.

2. Colluvium: ~6" thick; dark yellowish brown (10YR $\frac{4}{2}$) sandy lean CLAY with gravel (CL), medium stiff, moist, low plasticity, massive; gravel and larger sized clasts comprise ~30-40% of the unit; clasts are subrounded to subangular yellowish gray (5Y $\frac{7}{2}$) to medium gray (N5) quartzite up to 1' in diameter, though mode clast size is ~2"; topsoil matrix; abundant plant and tree roots; sharp, planar basal contact.

*~1" of water at bottom of west end of test pit during logging; 2" noted at base of test pit seeping from Unit 3b at a depth of 12' on 6/21/18.

3. Wasatch Formation: >11.5'+ thick, with three subunits:

a. ~2.5'-7.5' thick; moderate yellowish brown (10YR $\frac{5}{4}$) well-graded gravelly SAND (SW), medium dense to dense, moist, low to moderate plasticity fines, massive; gravel and larger sized clasts comprise ~30-35% of the subunit; clasts are subrounded to subangular quartzite as above and moderate reddish brown (10R $\frac{4}{6}$) sandstone; clasts are up to 1' in diameter, though mode clast size is ~2-3"; occasional plant roots; sand is fine-grained to medium-grained.

b. ~6.5' thick; moderate reddish brown (10R $\frac{4}{6}$) to dark reddish brown (10R $\frac{3}{4}$) clayey SAND with gravel (SC) gradational to sandy lean CLAY with gravel (CL), medium dense, moist to wet, low to moderate plasticity fines, massive; gravel and larger sized clasts comprise ~30-35% of the subunit; clasts are subrounded to subangular quartzite and sandstone as above up to 1' in diameter, though mode clast size is ~2"-4"; sand is fine-grained to medium-grained; common muscovite flakes.

c. ~5.5' thick; moderate reddish brown sandy fat CLAY with gravel (CH), stiff to very stiff, moist, high plasticity, massive; gravel and larger sized clasts comprise ~5-10% of the unit; clasts are subrounded to subangular quartzite and sandstone as above up to 2" in diameter, though mode clast size is <1/2"; few discontinuous slickensides observed; common muscovite flakes, especially on slickensided surfaces; occasional tree roots.

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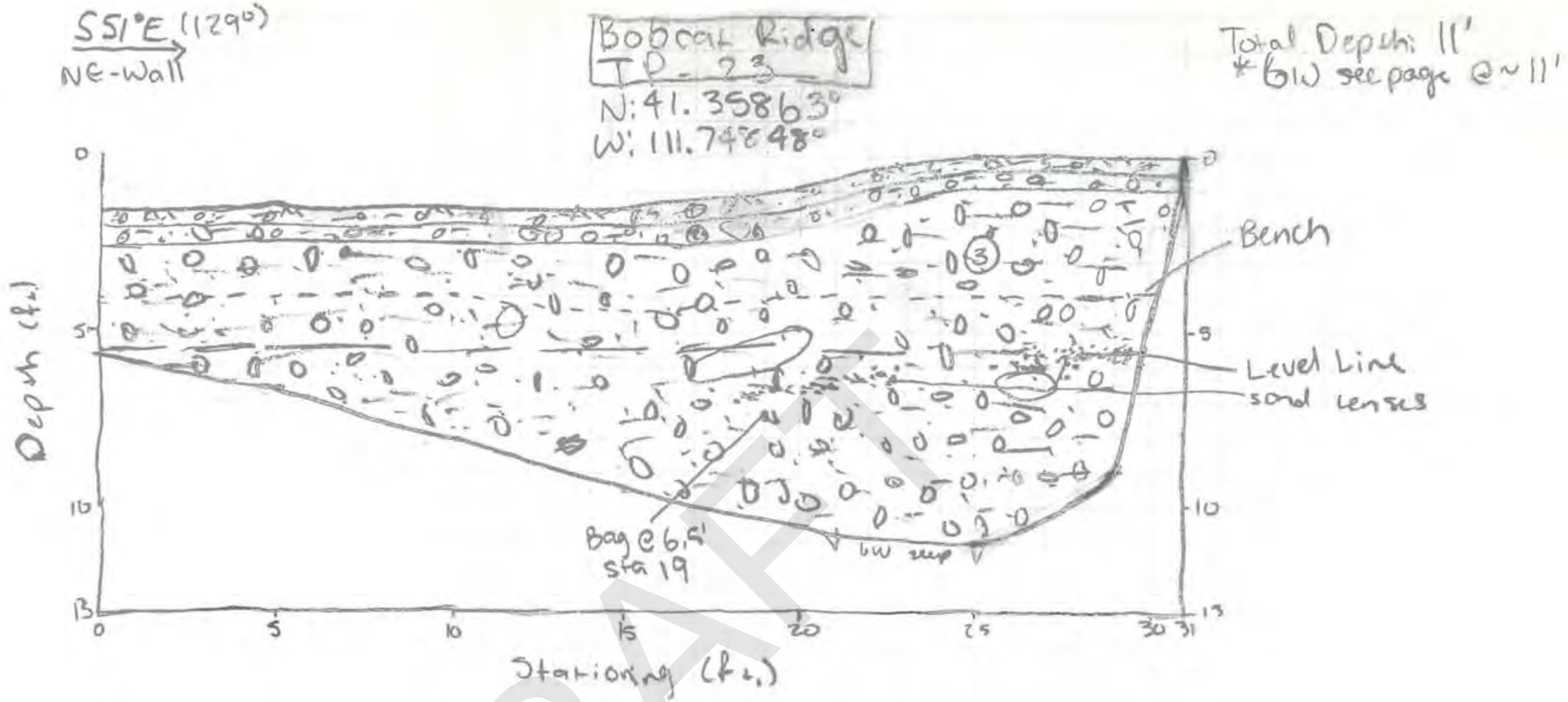
Ckd by ______ on ______

1" = 5'
H&V



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LITHOLOGIC UNIT DESCRIPTIONS

1. A/B Soil Horizon: ~6” thick; light brownish gray (5YR 6/1) to pale brown (5YR 5/2) sandy lean CLAY (CL), loose to medium stiff, dry, low plasticity, massive; gravel and larger sized clasts comprise ~5-10% of the unit; clasts are subrounded to subangular medium gray (N5) quartzite up to 4” in diameter, though mode clast size is ~1/2”; abundant plant and tree roots; gradational, irregular basal contact.

2. **Colluvium**: ~6” thick; dark yellowish brown (10YR 4/2) sandy lean CLAY with gravel (CL), medium stiff, slightly moist, low plasticity, massive; gravel and larger sized clasts comprise ~30-40% of the unit; clasts are subrounded to subangular yellowish gray (5Y 7/2) to medium gray (N5) quartzite up to 1' in diameter, though mode clast size is ~2”; topsoil matrix; abundant plant and tree roots; sharp, planar basal contact.

3. Wasatch Formation: >10'+ thick; moderate reddish orange (10R 6/6) sandy lean CLAY with gravel (CL) gradational to clayey SAND with gravel (SC) with depth, medium stiff, moist to wet, moderate plasticity, massive; gravel and larger sized clasts comprise ~20-30% of the unit; clasts are subrounded to subangular pale yellowish orange (10YR 8/6) to light gray (N7) to medium gray (N5) quartzite and moderate reddish orange sandstone up to 3' in diameter, though mode clast size is ~2-4”; several lean clay and sand lenses with few clasts; occasional plant roots; basal ~2-3' is clayey sand with gravel, moist to wet, dense.

*~3” of water at base of east side of test pit during logging.

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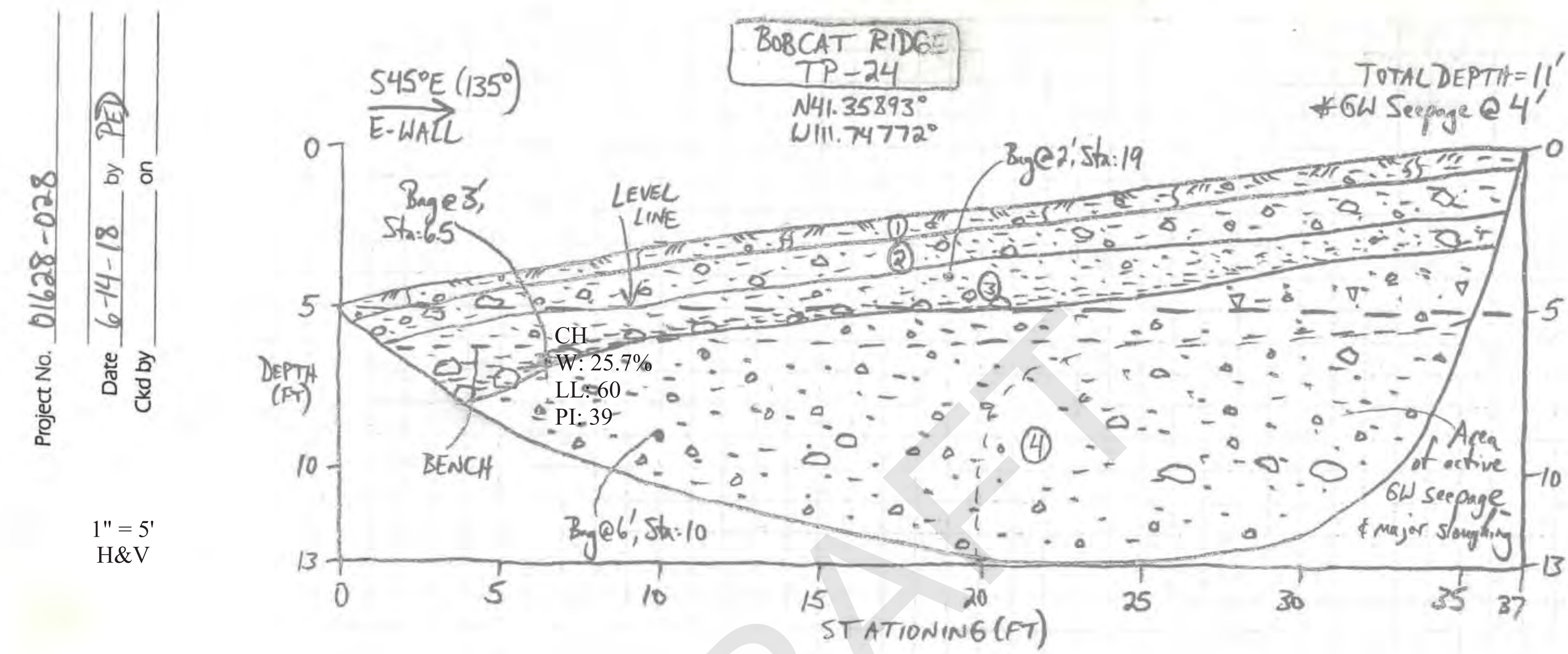
Weber County, Utah

TP-23 Log

Figure

A-24



LITHOLOGIC UNIT DESCRIPTIONS

1. **A/B Soil Horizon:** ~8"-10" thick; dark yellowish brown (10YR 4/2) to brownish black (5YR 2/1) sandy lean CLAY with gravel (CL), medium stiff to loose, moist, low plasticity, massive; gravel and larger sized clasts comprise ~10% of the unit; clasts are pale yellowish orange (10YR 8/6) to medium light gray (N6) quartzite and dark yellowish orange (10YR 6/6) sandstone up to 1' in diameter, though mode clast size is ~1/2"-1"; abundant plant and tree roots; gradational, irregular basal contact.

2. **Colluvium:** ~1-1.5' thick; dark yellowish brown (10YR 4/2) sandy lean CLAY with gravel (CL), medium stiff, moist, low plasticity, massive; gravel and larger sized clasts comprise ~30% of the unit; clasts are subrounded to subangular quartzite as above up to 1' in diameter, though mode clast size is ~3"; topsoil matrix; common to abundant plant and tree roots; sharp, irregular basal contact.

3. **Shallow Landslide:** ~1-2.5' thick; mottled dark yellowish orange (10YR 6/6) and medium light gray (N6) clayey SAND with gravel (SC) gradational to sandy fat CLAY with gravel (CH), dense, moist to wet, moderate to high plasticity fines, massive; gravel and larger sized clasts comprise ~10% of the unit; clasts are subrounded quartzite as above up to 8" in diameter, though mode clast size is ~6"; clasts largely restricted to basal ~6"; basal ~6" is sandy fat clay, though no slickensides observed; distinct color change, increase in clay and cobbles at base, and lithologic change indicate shallow slide; sharp, irregular basal contact.

4. **Wasatch Formation**: >8' thick; mottled dark reddish brown (10R 3/4) and moderate reddish brown (10R 4/6) clayey SAND with gravel (SC), dense, wet, moderate plasticity fines, massive; gravel and larger sized clasts comprise ~30% of the unit; clasts are subrounded to subangular quartzite as above up to 1' in diameter, though mode clast size is ~2-3"; occasional black MnO2 staining; actively seeping groundwater.

*Standing water to a depth of ~21" at time of logging.

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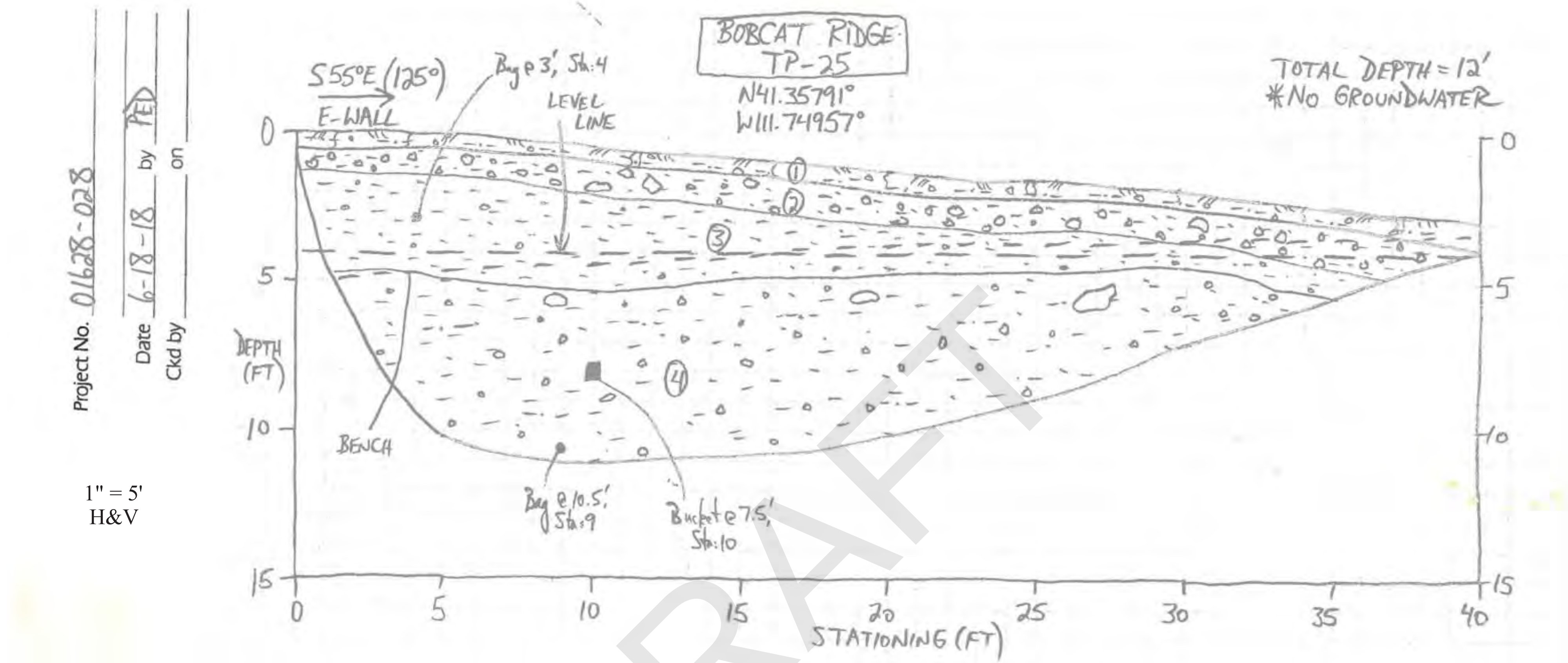
TP-24 Log

Figure

A-25



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LITHOLOGIC UNIT DESCRIPTIONS

1. **A/B Soil Horizon:** ~6" thick; light brown (5YR $\frac{6}{4}$) gravelly SILT (ML), medium stiff, dry, low plasticity, massive; gravel and larger sized clasts comprise ~20-25% of the unit; clasts are entirely subrounded to subangular medium light gray (N6) to pale yellowish orange (10YR $\frac{8}{6}$) quartzite up to 14" in diameter, though mode clast size is ~1"; common plant roots; gradational, irregular basal contact.

2. **Colluvium:** ~1-1.5' thick; moderate yellowish brown (10YR $\frac{5}{4}$) to dark yellowish brown (10YR $\frac{4}{2}$) sandy lean CLAY with gravel (CL), medium stiff to loose, slightly moist to dry, low to moderate plasticity; gravel and larger sized clasts comprise ~30-35% of the unit; clasts entirely subrounded quartzite as above up to 1.5' in diameter, though mode clast size is ~3-5"; common plant roots; largely topsoil matrix, though grades with depth to increased moisture and fat clay content in matrix, some dark reddish brown (10R $\frac{3}{4}$) coloration; sharp, irregular basal contact.

3. **Shallow Landslide?:** ~1-3' thick; mottled light gray (N7) and dark yellowish orange (10YR $\frac{6}{6}$) sandy fat CLAY with gravel (CH), stiff, moist, moderate to high plasticity, massive; gravel and larger sized clasts comprise ~10% of the unit; clasts are subrounded quartzite as above up to 4" in diameter, though mode clast size is ~ 1"; common fat clay glossy sheen, though no slickensides observed; looks similar to shallow slide deposit in TP-24, except no basal cobbles; sharp, irregular basal contact.

4. **Wasatch Formation**: >6' thick; dark reddish brown (10R $\frac{3}{4}$) sandy lean CLAY with gravel (CL) gradational to clayey SAND with gravel (SC), stiff, moist, low to moderate plasticity, massive; gravel and larger sized clasts comprise ~10-15% of the unit; clasts are subrounded quartzite as above up to 1.5' in diameter, though mode clast size is <1"; occasional 1 mm pinholes where clayey; becomes more clayey with depth; sand component is very fine-grained and gradational to silt.

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Weber County, Utah

TP-25 Log

Figure

A-26

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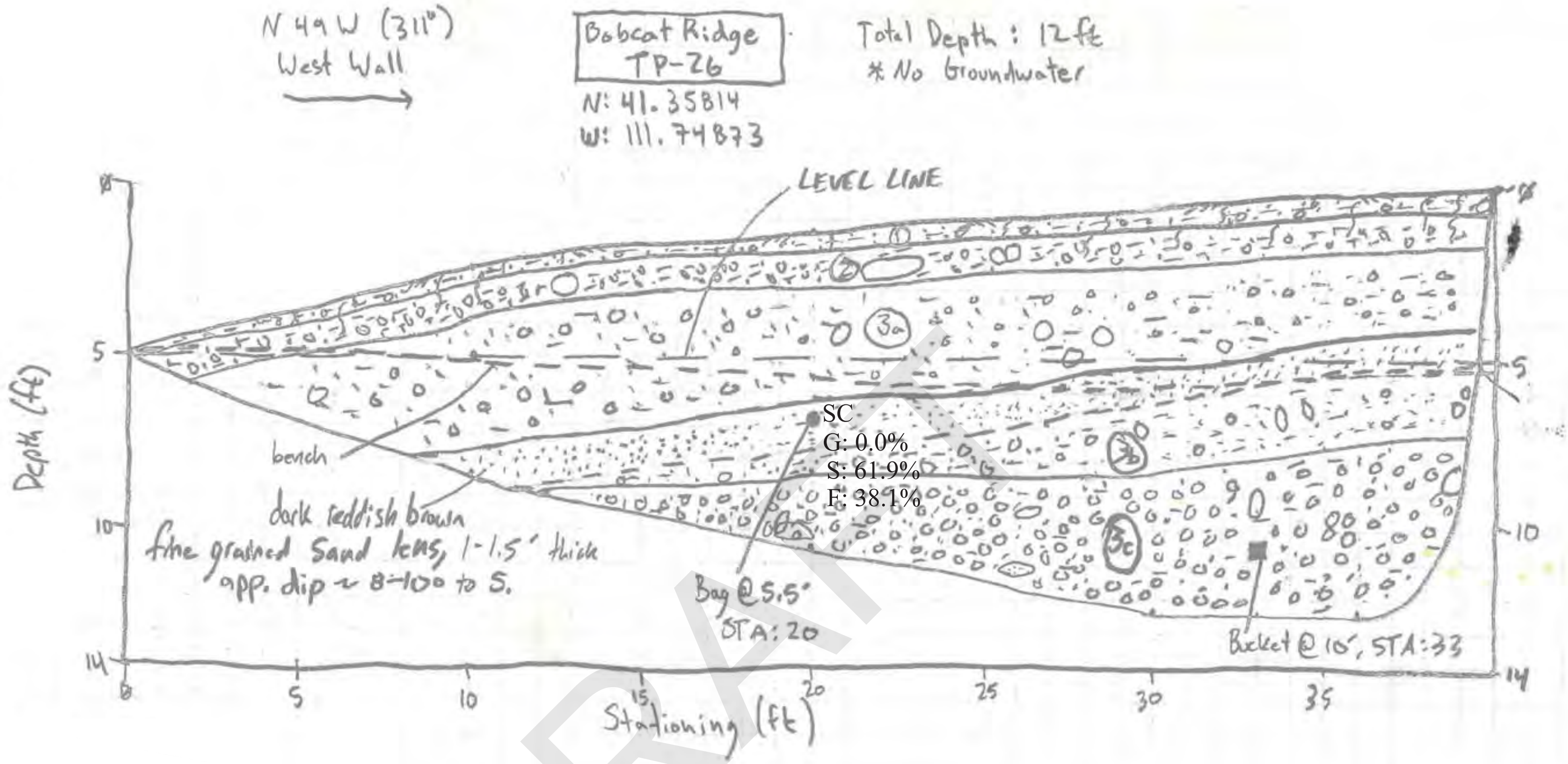
Date 6/18/18 by JWB
Ckd by ____ on ____



1" = 5'
H&V

LITHOLOGIC UNIT DESCRIPTIONS

1. **A/B Soil Horizon:** ~7" thick; light brown (5YR 6/4) sandy lean CLAY with gravel (CL), loose to medium stiff, slightly moist, low plasticity, massive; gravel and larger sized clasts comprise ~15-20% of the unit; clasts are subrounded to subangular medium gray (N5) quartzite and dark yellowish orange (10YR 6/6) sandstone; clasts are up to ~10" in diameter, though mode clast size ~1"; common plant roots; sharp, irregular basal contact.

2. **Colluvium:** ~1' thick; moderate yellowish brown (10YR 5/4) sandy lean CLAY with gravel (CL), medium stiff, slightly moist, low plasticity, massive; gravel and larger sized clasts comprise ~25-35% of the unit; clasts are subrounded to subangular quartzite and sandstone as above up to 2' in diameter, though mode clast size is ~3-4"; common plant roots; sharp, irregular basal contact.

3. **Wasatch Formation:** >10.5' thick, with 3 subunits.
   - **a.** ~3-4' thick; mottled moderate reddish brown (10R 4/6) and dark yellowish orange (10YR 6/6) clayey SAND with gravel (SC), dense, moist, moderate plasticity fines, massive; gravel and larger sized clasts comprise ~30% of the subunit; clasts are subrounded to subangular quartzite and sandstone as above, with minor grayish brown (5Y 3/2) to medium dark gray (N4) dolomite; clasts are up to 1.5' in diameter, though mode clast size is ~3"; occasional plant roots; sharp, irregular basal contact.
   - **b.** ~1.5-3' thick; dark reddish brown (10R 3/4) clayey SAND with gravel (SC), dense, moist, medium plasticity fines, massive; gravel and larger sized clasts comprise ~30-40% of the subunit and are concentrated at the base of the subunit, clasts are subrounded to subangular sandstone and dolomite as above, clasts are up to 10" in diameter, though mode clast size is ~2-4"; few plant roots; gradational, irregular basal contact.
   - **c.** >5' thick; dark reddish brown (10R 3/4) clayey GRAVEL with sand, dense to very dense, moist, moderate plasticity fines, massive; gravel and larger sized clasts comprise ~50-60% of the subunit; clasts are subangular to subrounded quartzite, sandstone and dolomite as above up to 10" in diameter, though mode clast size is <0.5"; significant portion of clasts are dolomite; highly weathered clasts in places; few plant roots.

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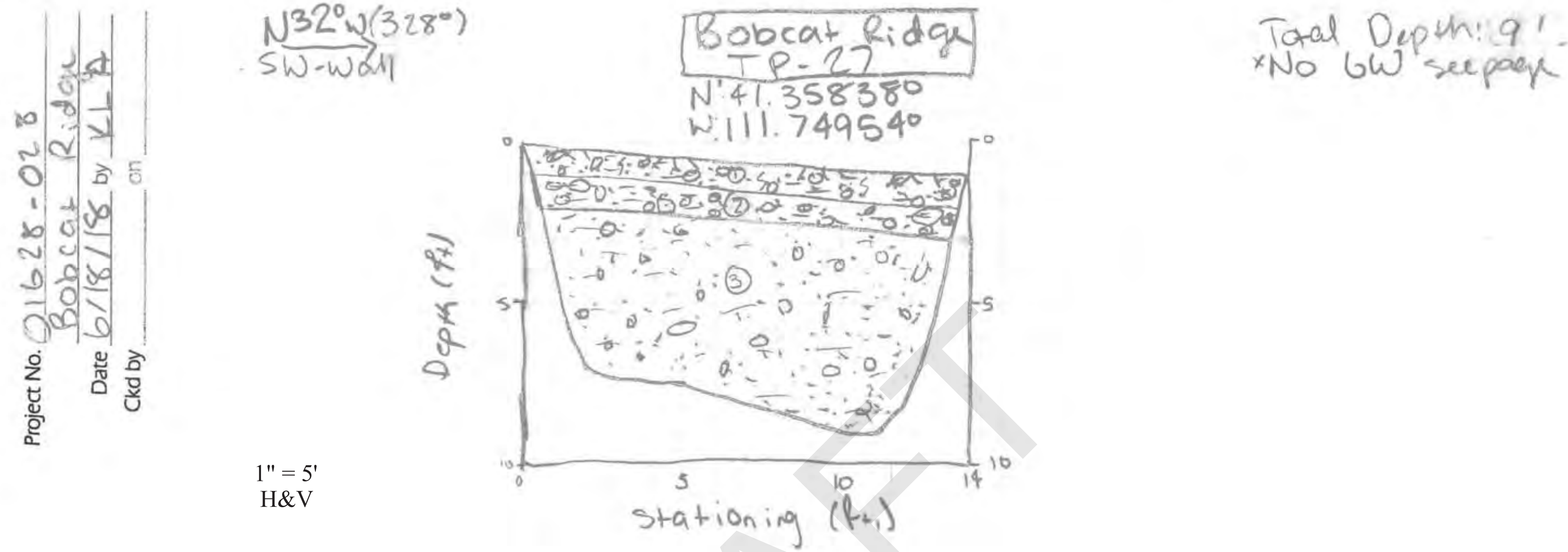
Geotechnical and Geologic Hazards Assessment
Bobcat Ridge Subdivision
Summit Powder Mountain Resort
Weber County, Utah

TP-26 Log

Figure A-27



LITHOLOGIC UNIT DESCRIPTIONS

1. A/B Soil Horizon: ~1' thick; light brown (5YR $\frac{6}{4}$) to yellowish gray (5Y $\frac{7}{2}$) sandy lean CLAY with gravel (CL), loose, dry, low plasticity, massive; gravel and larger sized clasts comprise ~10% of the unit; clasts are subrounded to subangular pale yellowish brown (10YR $\frac{6}{2}$) to medium gray (N5) quartzite up to ~3" in diameter, though mode clast size ~0.5"; abundant plant and tree roots; gradational, irregular basal contact.

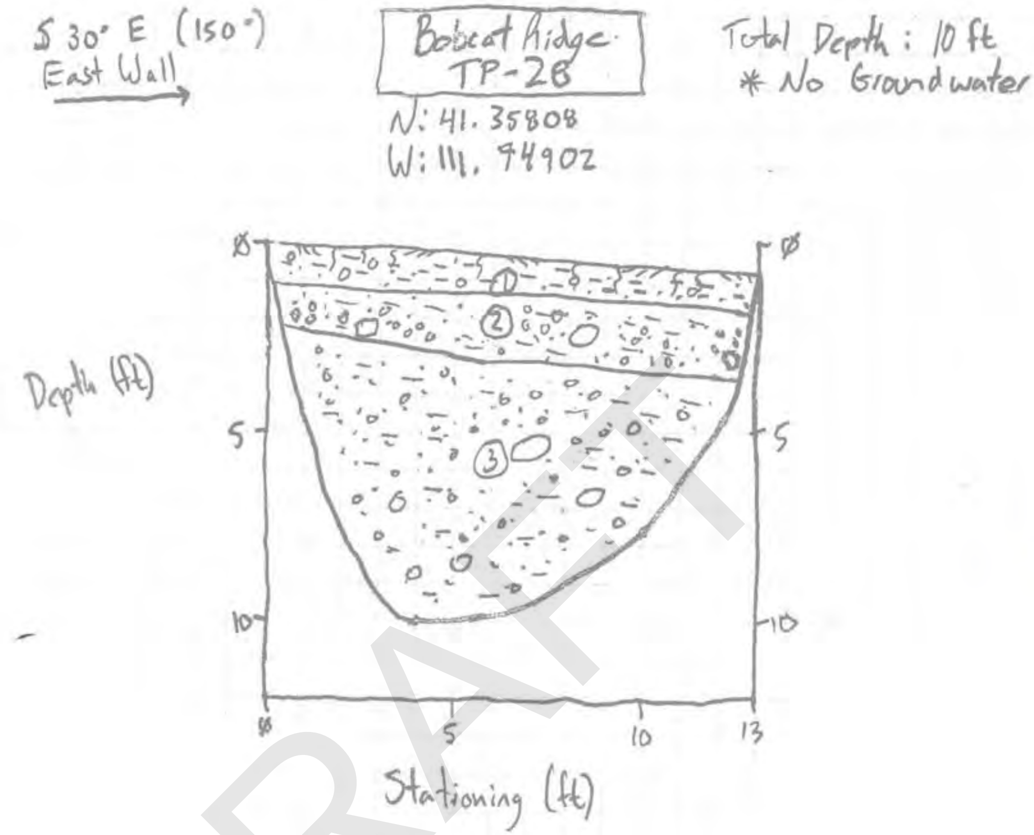
2. Colluvium: ~1' thick; light brown (5YR $\frac{6}{4}$) to yellowish gray (5Y $\frac{7}{2}$) sandy lean CLAY with gravel (CL), loose to medium stiff, dry to moist, low to moderate plasticity, massive; gravel and larger sized clasts comprise ~20% of the unit; clasts are subrounded to subangular quartzite as above up to ~1' in diameter, though mode clast size ~1-2"; topsoil matrix; abundant plant roots; sharp, irregular basal contact.

3. Wasatch Formation: >6.5' thick; moderate reddish orange (10R $\frac{6}{6}$) to moderate reddish brown (10R $\frac{3}{4}$) clayey SAND with gravel (SC), medium dense, moist, low to moderate plasticity fines, massive; gravel and larger sized clasts comprise ~30-35% of the unit; clasts are subrounded to subangular moderate reddish orange to medium gray (N5) quartzite with minor moderate reddish orange to moderate yellow (5Y $\frac{7}{2}$) sandstone; clasts are up to 2' in diameter, though mode clast size is ~2-3"; occasional plant roots; sand is fine- to medium-grained; some possible clay lenses.

DRAFT

Project No. 01628-028
Date 6/18/18 by JWB
Ckd by on

1" = 5'
H&V



DRAFT

LITHOLOGIC UNIT DESCRIPTIONS

1. A/B Soil Horizon: ~8-12” thick; light brown (5YR $\frac{6}{4}$) sandy lean CLAY with gravel (CL), loose to medium stiff, dry, low plasticity, massive; gravel and larger sized clasts comprise ~10-20% of the unit; clasts are subrounded to subangular light gray (N7) quartzite and dark yellowish orange (10YR $\frac{6}{6}$) fine-grained sandstone up to ~3” in diameter, though mode clast size ~1”; common plant roots; gradational, irregular basal contact.

2. Colluvium: ~1.5-2' thick; moderate yellowish brown (10YR $\frac{5}{4}$) to dark yellowish brown (10YR $\frac{4}{2}$) sandy lean CLAY with gravel (CL), medium stiff, slightly moist, low plasticity, massive; gravel and larger sized clasts comprise ~30-40% of the unit; clasts are subrounded to subangular quartzite and sandstone as above up to 1' in diameter, though mode clast size is ~3-5”; common plant roots; topsoil matrix; sharp, irregular basal contact.

3. Wasatch Formation: >7' thick; dark reddish brown (10R $\frac{3}{4}$) clayey SAND with gravel (SC), dense, moist, moderate plasticity fines, massive; gravel and larger sized clasts comprise ~30-40% of the unit; clasts are subrounded to subangular quartzite and sandstone as above up to 1.5' in diameter, though mode clast size is ~2-3”; few plant roots.

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Project No: 01628-028

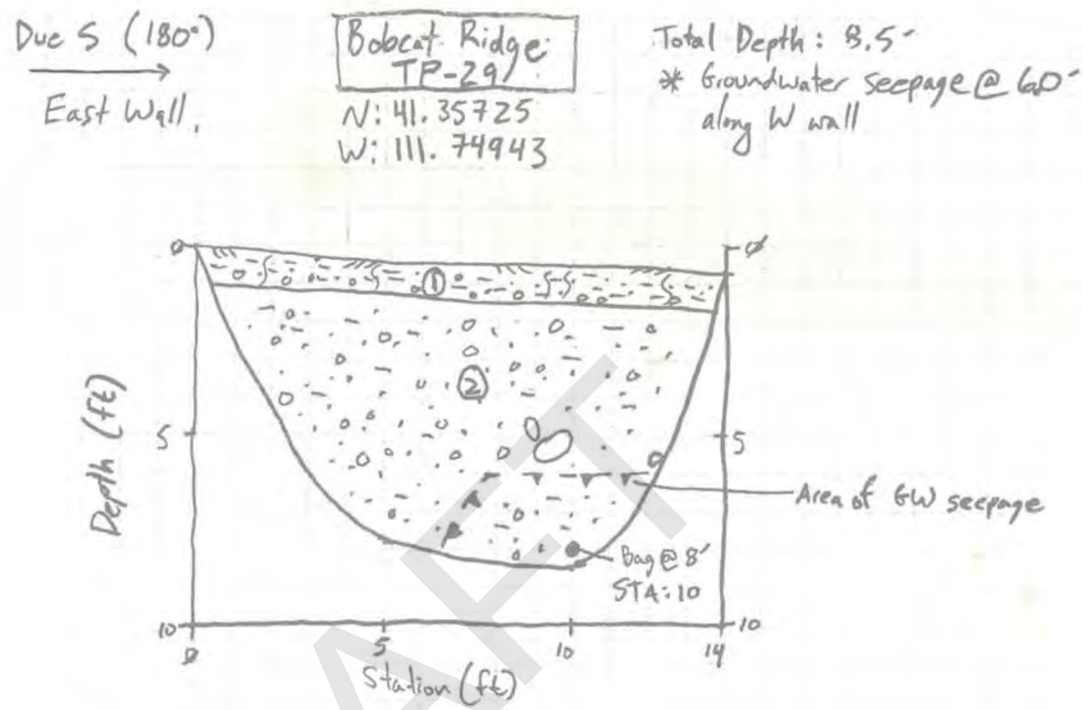
Geotechnical and Geologic Hazards Assessment
Bobcat Ridge Subdivision
Summit Powder Mountain Resort
Weber County, Utah

TP-28 Log

Figure A-29

Project No. 01628-028
Date 6-18-18 by JWB
Ckd by ____ on ____

1" = 5'
H&V

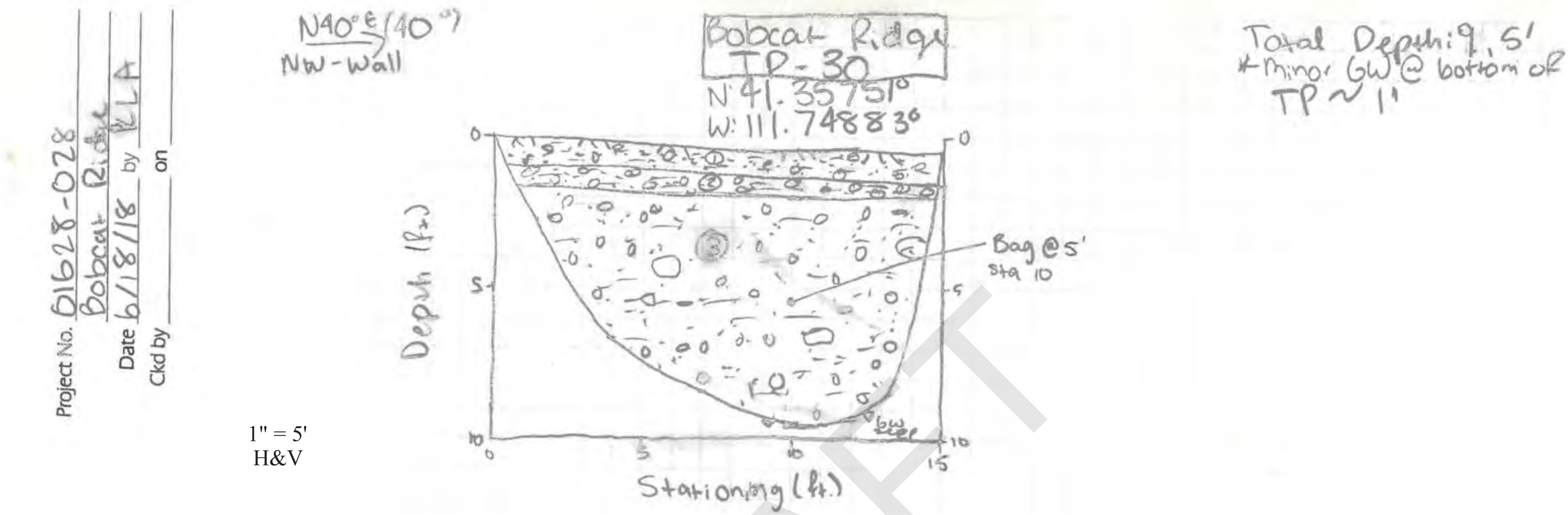


LITHOLOGIC UNIT DESCRIPTIONS

1. A/B Soil Horizon: ~1' thick; dark yellowish brown (10YR $\frac{4}{2}$) sandy lean CLAY with gravel (CL), medium stiff, moist, low plasticity, massive; gravel and larger sized clasts comprise ~10-15% of the unit; clasts are subrounded to subangular medium gray (N5) quartzite and moderate reddish orange (10R $\frac{6}{6}$) finely bedded, fine-grained, highly oxidized sandstone; clasts are up to ~5" in diameter, though mode clast size ~1"; common plant roots; mulch layer at surface; gravel concentrated at base of unit, possibly representing a thin colluvial unit; sharp, irregular basal contact.

2. Wasatch Formation: >7' thick; mottled dark reddish brown (10R $\frac{3}{4}$) and dark yellowish orange (10YR $\frac{6}{6}$) clayey SAND with gravel (SC), dense, moist, moderate plasticity fines, massive; gravel and larger sized clasts comprise ~25-35% of the unit; clasts are subrounded to subangular quartzite and sandstone as above up to 1.5' in diameter, though mode clast size is ~2"; few plant roots.

DRAFT



LITHOLOGIC UNIT DESCRIPTIONS

1. A/B Soil Horizon: ~1' thick; light brown (5YR $\frac{6}{4}$) to yellowish gray (5Y $\frac{7}{2}$) sandy lean CLAY with gravel (CL), loose, dry to slightly moist, low plasticity, massive; gravel and larger sized clasts comprise ~10% of the unit; clasts are subrounded to subangular pale yellowish brown (10YR $\frac{6}{2}$) to medium gray (N5) quartzite up to ~3" in diameter, though mode clast size ~0.5"; abundant plant and tree roots; gradational, irregular basal contact.

2. Colluvium: ~6" thick; ; light brown (5YR $\frac{6}{4}$) to yellowish gray (5Y $\frac{7}{2}$) sandy lean CLAY with gravel (CL), loose to medium stiff, dry to moist, low to moderate plasticity, massive; gravel and larger sized clasts comprise ~20% of the unit; clasts are subrounded to subangular quartzite as above up to ~1' in diameter, though mode clast size ~1-2"; topsoil matrix; abundant plant roots; sharp, irregular basal contact.

3. Wasatch Formation: >7.5' thick; moderate reddish orange (10R $\frac{6}{6}$) to moderate reddish brown (10R $\frac{3}{4}$) clayey SAND with gravel (SC), medium dense, moist to wet, low to moderate plasticity fines, massive; gravel and larger sized clasts comprise ~30-35% of the unit; clasts are subrounded to subangular moderate reddish orange to medium gray (N5) quartzite with minor moderate reddish orange to moderate yellow (5Y $\frac{7}{2}$) sandstone; clasts are up to 2' in diameter, though mode clast size is ~2-3"; occasional plant roots; sand is fine- to medium-grained; sandstone clasts are banded with alternating yellow and red color, likely a product of groundwater flow.

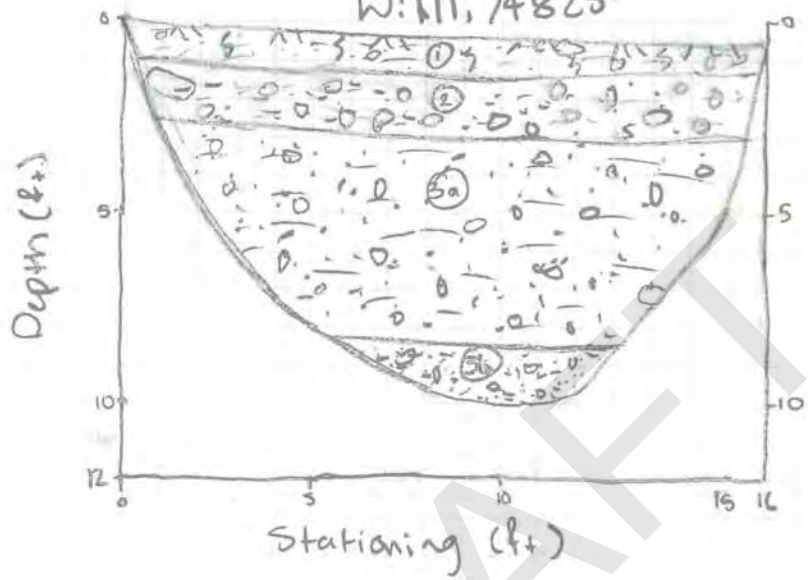
DRAFT

Project No. 01628-028
Bobcat Ridge
Date 6/18/18 by RLA
Ckd by ______ on ______

S48°W (228°)
E-Wall

Bobcat Ridge
TP-31
N:41.35783°
W:111.74825°

Total Depth: 10.5'
* No GW encountered



1" = 5'
H&V

LITHOLOGIC UNIT DESCRIPTIONS

1. A/B Soil Horizon: ~1' thick; light brown (5YR $\frac{6}{4}$) to yellowish gray (5Y $\frac{7}{2}$) sandy lean CLAY with gravel (CL), loose to medium stiff, dry to moist, low plasticity, massive; gravel and larger sized clasts comprise ~10-15% of the unit, clasts are subrounded to subangular pale yellowish brown (10YR $\frac{6}{2}$) to medium gray (N5) quartzite up to ~6" in diameter, though mode clast size ~0.5-1"; abundant plant roots; gradational, irregular basal contact.

2. Colluvium: ~1.5' thick; light brown (5YR $\frac{6}{4}$) to yellowish gray (5Y $\frac{7}{2}$) sandy lean CLAY with gravel (CL), medium stiff, moist, low plasticity, massive; gravel and larger sized clasts comprise ~20-30% of the unit; clasts are subrounded to subangular quartzite as above up to 1' in diameter, though mode clast size is ~3-4"; topsoil matrix; abundant plant roots; sharp, planar basal contact.

3. Wasatch Formation: >7' thick; 2 subunits

a. ~5.5' thick; moderate reddish orange (10R $\frac{6}{6}$) to moderate reddish brown (10R $\frac{3}{4}$) clayey SAND with gravel (SC), medium dense, moist, moderate plasticity fines, massive; gravel and larger sized clasts comprise ~30-40% of the unit; clasts are subrounded to subangular moderate reddish orange to medium dark gray (N4) quartzite; clasts are up to 2' in diameter, though mode clast size is ~3-4"; sand is fine- to medium-grained.

b. >2.5' thick; moderate red (5R $\frac{5}{4}$) silty SAND with gravel (SM), medium dense, moist, low plasticity fines, massive; gravel and larger sized clasts comprise ~20% of the unit; clasts are subrounded to subangular quartzite as above and moderate reddish orange (10R 6/6) sandstone; clasts are up to 4" in diameter, though mode clast size is ~0.5"; MnO2 traces; common muscovite mica flakes; sand is fine-grained; minor clay component.

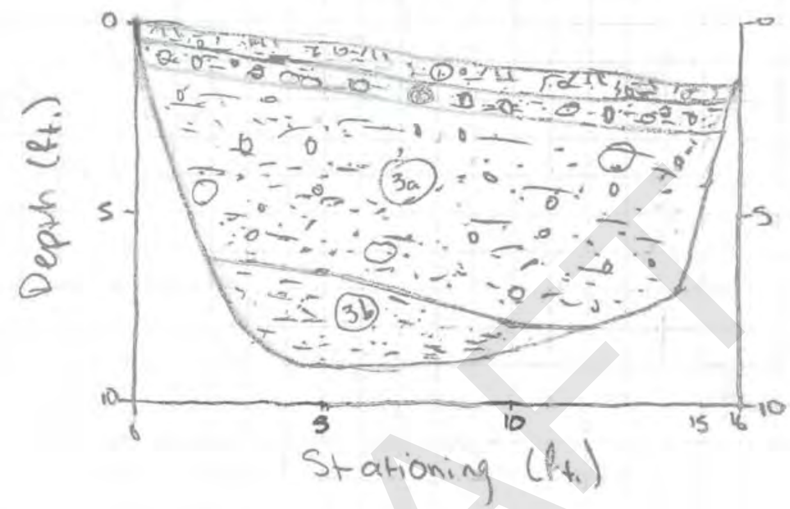
DRAFT

Project No. 01628-028 Bobcat Ridge
Date 6/18/18 by KLR
Ckd by ______ on ______

S15°W (195°)
E-Wall

Bobcat Ridge
TP-32
N: 41.35820°
W: 111.74776°

Total Depth: 9 ft
* No GW encountered



1" = 5'
H&V

LITHOLOGIC UNIT DESCRIPTIONS

1. A/B Soil Horizon: ~6” thick; light brown (5YR $\frac{6}{4}$) to yellowish gray (5Y $\frac{7}{2}$) sandy lean CLAY with gravel (CL), loose to medium stiff, dry to moist, low plasticity, massive; gravel and larger sized clasts comprise ~10% of the unit; clasts are subrounded to subangular pale yellowish brown (10YR $\frac{6}{2}$) to medium gray (N5) quartzite up to ~1” in diameter, though mode clast size ~0.5”; abundant plant roots; gradational, irregular basal contact.

2. Colluvium: ~6-12” thick; light brown (5YR $\frac{6}{4}$) to yellowish gray (5Y $\frac{7}{2}$) sandy lean CLAY with gravel (CL), loose to medium stiff, dry to moist, low to moderate plasticity, massive; gravel and larger sized clasts comprise ~20-30% of the unit; clasts are subrounded to subangular quartzite as above up to ~5” in diameter, though mode clast size ~1-2”; topsoil matrix; abundant plant roots; sharp, planar basal contact.

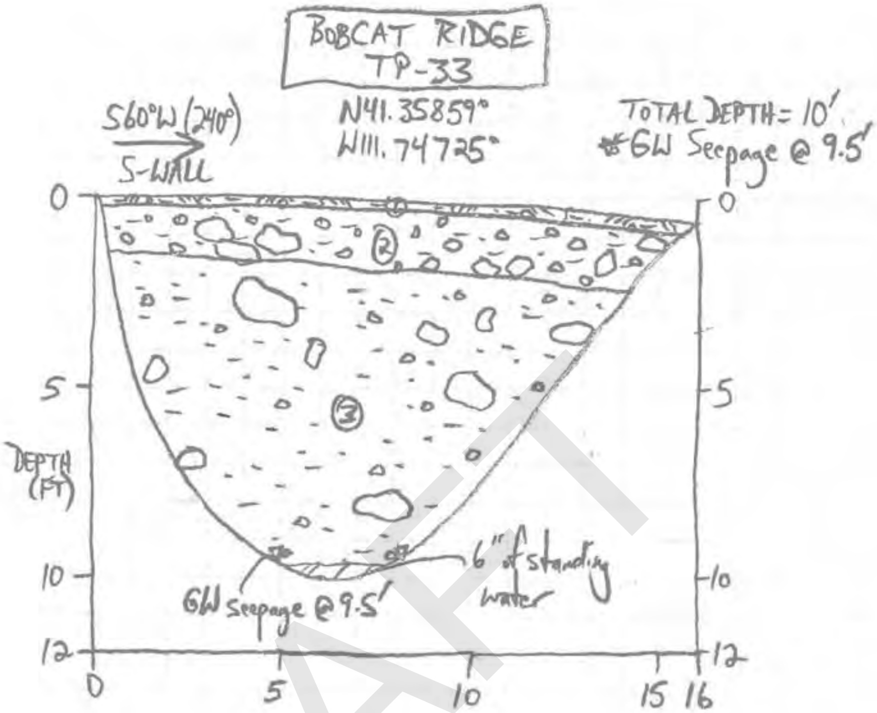
3. Wasatch Formation: >7' thick; 2 subunits.

a. ~5' thick; moderate reddish orange (10R $\frac{6}{6}$) to moderate reddish brown (10R $\frac{3}{4}$) clayey SAND with gravel (SC), medium dense, moist, moderate plasticity fines, massive; gravel and larger sized clasts comprise ~30-40% of the unit; clasts are subrounded to subangular moderate reddish orange (10R $\frac{6}{6}$) to medium dark gray (N4) quartzite, clasts are up to 2' in diameter, though mode clast size is ~3-4”; sand is fine to medium grained.

b. >2.5' thick; dark reddish brown (10R $\frac{3}{4}$) sandy fat CLAY (CH) medium stiff, moist, moderate to high plasticity, massive; devoid of clasts; exhibits fat clay glossy sheen, but no slickensides observed.

DRAFT

Project No. 01628-028 by PED
Date 6-14-18 on
Ckd by



1" = 5'
H&V

Stationing (ft)

DRAFT

LITHOLOGIC UNIT DESCRIPTIONS

1. A/B Soil Horizon: ~2-3" thick; light brownish gray (5YR $\frac{6}{1}$) sandy lean CLAY with gravel (CL), loose to medium stiff, dry, low plasticity, massive; gravel and larger sized clasts comprise ~10% of the unit; clasts are subrounded to subangular medium gray (N5) to moderate reddish brown (10R $\frac{4}{6}$) quartzite up to ~5" in diameter, though mode clast size ~1"; abundant plant roots; gradational, irregular basal contact.

2. Colluvium: ~1.5' thick; light brown (5YR $\frac{6}{4}$) clayey GRAVEL with sand (GC), medium dense, slightly moist, low plasticity fines, massive; gravel and larger sized clasts comprise ~50-60% of the unit; clasts are subrounded to subangular medium light gray (N6) to pale yellowish orange (10YR $\frac{8}{6}$) quartzite up to 15" in diameter, though mode clast size is ~4-6"; topsoil matrix; common plant roots; sharp, irregular basal contact.

3. Wasatch Formation: >8' thick; moderate reddish brown (10R $\frac{4}{6}$) to dark reddish brown (10R $\frac{3}{4}$) clayey SAND with gravel (SC), dense, moist to wet, low to moderate plasticity fines, massive; gravel and larger sized clasts comprise ~20% of the unit; clasts are subrounded to subangular quartzite as above up to 3' in diameter, though mode clast size is ~1-2" in a wide variety of clast sizes; sand is fine-grained; occasional highly weathered medium gray (N5) sandstone clasts; heterogeneous unit.

*Groundwater seepage at 9.5' has accumulated in base of test pit to a depth of 6" at the time of logging.

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Project No: 01628-028

Geotechnical and Geologic Hazards Assessment
Bobcat Ridge Subdivision
Summit Powder Mountain Resort
Weber County, Utah

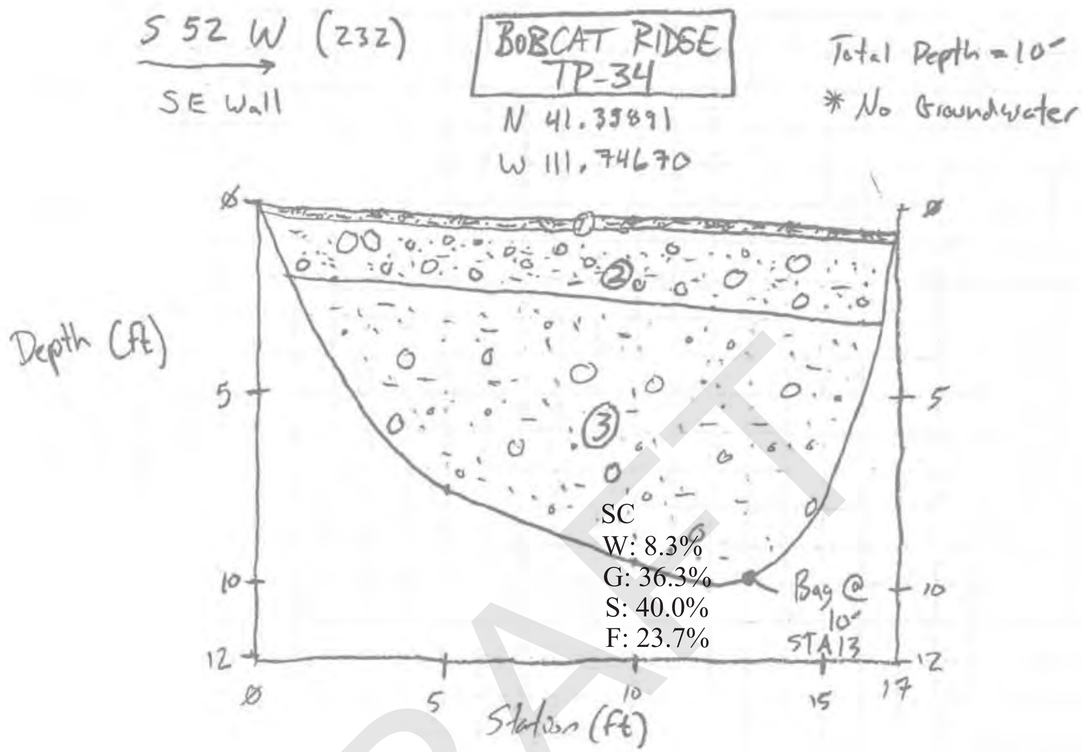
TP-33 Log

Figure A-34

Project No. 01628-028

Date 6-14-18 by JWB

Ckd by ___ on ___



1" = 5'
H&V

DRAFT

LITHOLOGIC UNIT DESCRIPTIONS

1. A/B Soil Horizon: ~3-4" thick; light brownish gray (5YR $\frac{6}{1}$) sandy lean CLAY with gravel (CL), loose to medium stiff, dry, low plasticity, massive; gravel and larger sized clasts comprise ~10% of the unit; clasts are subrounded to subangular medium gray (N5) to moderate reddish brown (10R $\frac{4}{6}$) quartzite up to ~5" in diameter, though mode clast size ~1"; abundant plant roots; gradational, irregular basal contact.

2. Colluvium: ~1.5-2' thick; moderate yellowish brown (10YR $\frac{5}{4}$) to dark yellowish brown (10YR $\frac{4}{2}$) clayey GRAVEL with sand (GC), medium dense, slightly moist, low plasticity fines, massive; gravel and larger sized clasts comprise ~40% of the unit; clasts are subrounded to subangular quartzite as above up to 1' in diameter, though mode clast size is ~4"; common plant roots; topsoil matrix; sharp, irregular basal contact.

3. Wasatch Formation: >8' thick; dark reddish brown (10R $\frac{3}{4}$) clayey SAND with gravel (SC), dense, moist, low to moderate plasticity fines, massive; gravel and larger sized clasts comprise ~20-30% of the unit; clasts are subrounded to subangular quartzite as above with minor dark yellowish orange (10YR $\frac{6}{6}$) sandstone; clasts are up to 1' in diameter, though mode clast size is ~2-3"; sand is fine- to medium-grained.

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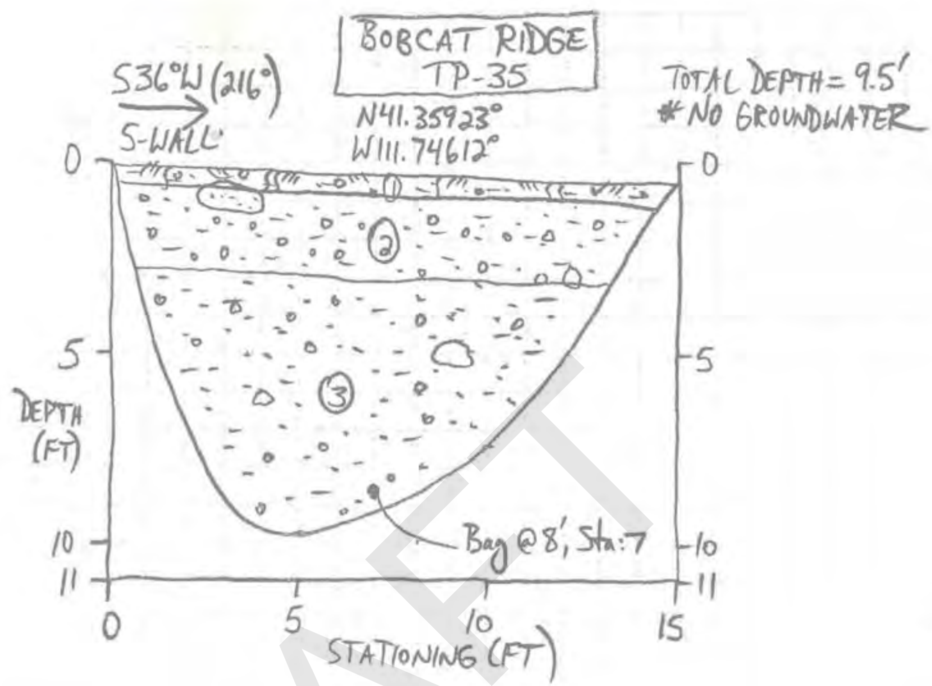
Project No: 01628-028

Geotechnical and Geologic Hazards Assessment
Bobcat Ridge Subdivision
Summit Powder Mountain Resort
Weber County, Utah

TP-34 Log

Figure A-35

Project No. 01628-028
Date 6-14-18 by PED
Ckd by ______ on ______



1" = 5'
H&V

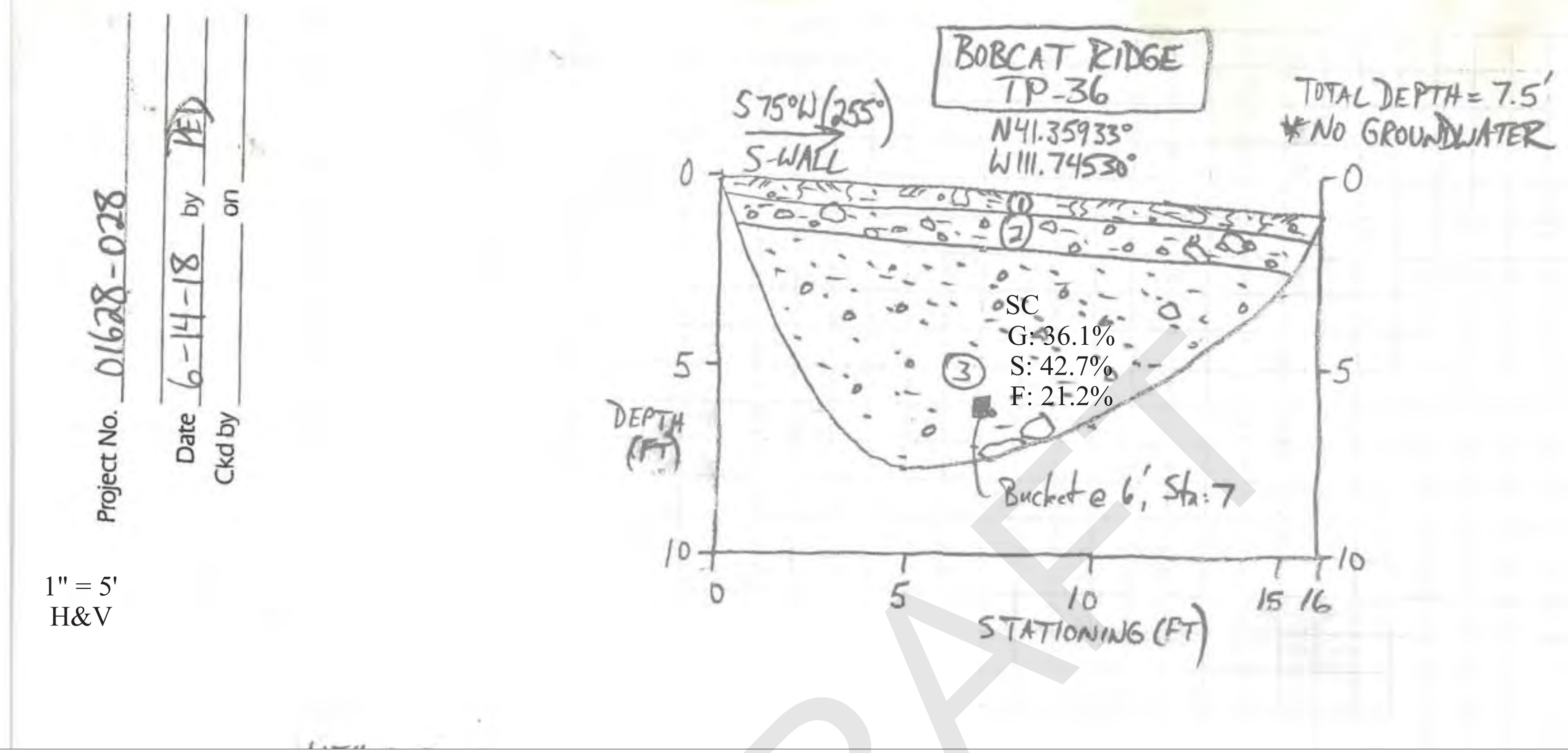
DRAFT

LITHOLOGIC UNIT DESCRIPTIONS

1. <u>A/B Soil Horizon:</u> ~6" thick; light brown (5YR $\frac{6}{4}$) sandy lean CLAY with gravel (CL), loose to medium stiff, dry, low plasticity, massive; gravel and larger sized clasts comprise ~20-30% of the unit; clasts are subrounded to subangular medium gray (N5) to dark reddish brown (10R $\frac{3}{4}$) quartzite up to ~1' in diameter, though mode clast size ~1"; common plant roots; gradational, irregular basal contact.

2. <u>Colluvium</u>: ~2' thick; dark yellowish brown (10YR $\frac{4}{2}$) sandy lean CLAY with gravel (CL), medium stiff, slightly moist to moist, low plasticity, massive; gravel and larger sized clasts comprise ~40% of the unit; clasts are subrounded to subangular medium gray (N5) to dark reddish brown (10R $\frac{3}{4}$) quartzite up to 2.5' in diameter, though mode clast size is ~1-2"; occasional plant roots; topsoil matrix; similar to as seen in TP-36, except thicker unit and smaller clast sizes; sharp, largely planar basal contact.

3. <u>Wasatch Formation</u>: >6.5' thick; moderate reddish brown (10R $\frac{4}{6}$) to dark reddish brown (10R $\frac{3}{4}$) clayey SAND with gravel (SC), dense, moist, moderate plasticity fines, massive; gravel and larger sized clasts comprise ~25-30% of the unit; clasts are subrounded to subangular quartzite as above; clasts are up to 8" in diameter, though mode clast size is ~1-2"; fine- to medium-grained sand, fining upwards; uppermost ~1' is clayier; few small plant roots.



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LITHOLOGIC UNIT DESCRIPTIONS

1. A/B Soil Horizon: ~6" thick; light brown (5YR $\frac{6}{4}$) sandy lean CLAY with gravel (CL), loose to medium stiff, dry, low plasticity, massive; gravel and larger sized clasts comprise ~20-30% of the unit; clasts are subrounded to subangular medium gray (N5) to dark reddish brown (10R $\frac{3}{4}$) quartzite up to 1' in diameter, though mode clast size ~1"; common plant roots; gradational, irregular basal contact.

2. Colluvium: ~1' thick; light brown (5YR $\frac{6}{4}$) to moderate reddish brown (10R $\frac{4}{6}$) clayey GRAVEL with sand (GC) gradational to sandy lean CLAY with gravel (CL), medium dense to loose, slightly moist, low plasticity fines, massive; gravel and larger sized clasts comprise ~40-50% of the unit; clasts are subrounded to subangular quartzite as above up to 13" in diameter, though mode clast size is ~3-4"; common plant roots; topsoil matrix; sharp, largely planar basal contact.

3. Wasatch Formation: >5.5' thick; moderate reddish brown (10R $\frac{4}{6}$) to dark reddish brown (10R $\frac{3}{4}$) clayey SAND with gravel (SC), dense, moist, moderate plasticity fines, massive; gravel and larger sized clasts comprise ~30-40% of the unit; clasts are subrounded to subangular quartzite as above up to 8" in diameter, though mode clast size is ~1-2"; fine- to medium-grained sand, fining upwards; uppermost ~1' is clay-rich; few small plant roots.

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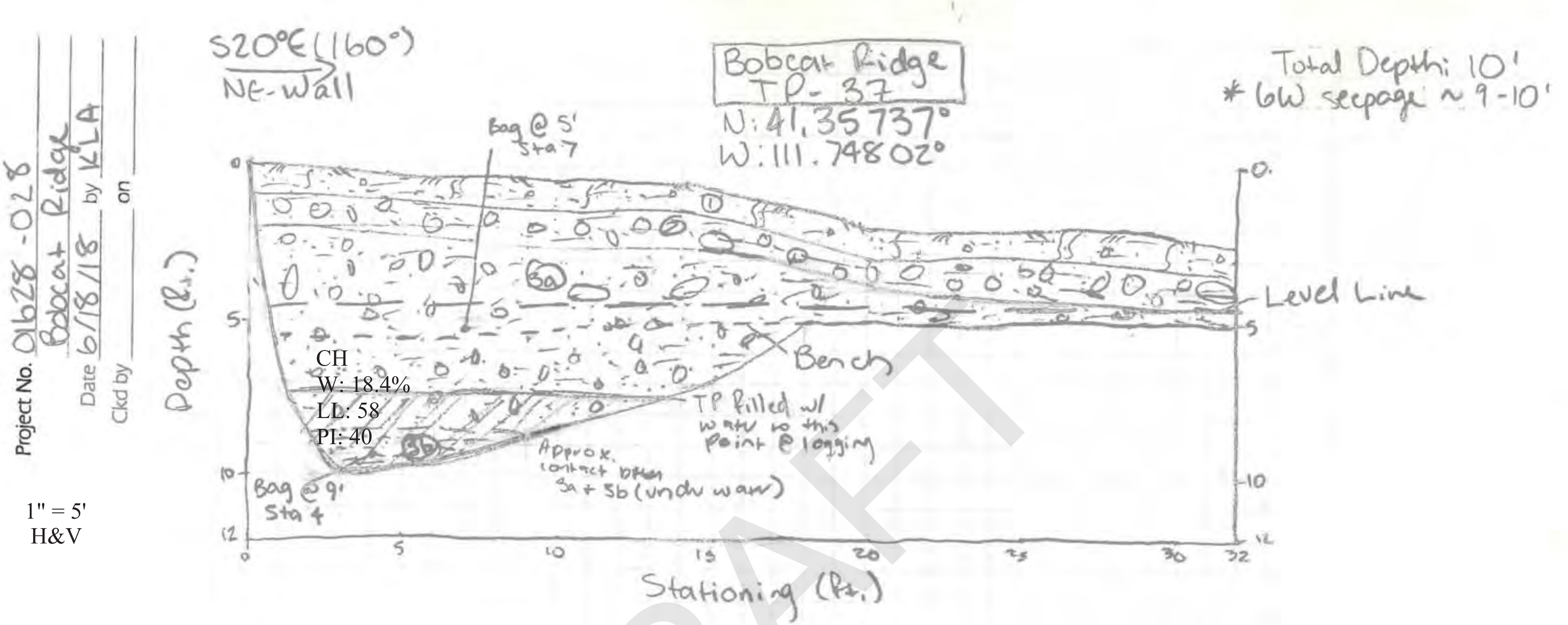
Project No: 01628-028

Geotechnical and Geologic Hazards Assessment
Bobcat Ridge Subdivision
Summit Powder Mountain Resort
Weber County, Utah

TP-36 Log

Figure

A-37



DRAFT

LITHOLOGIC UNIT DESCRIPTIONS

1. A/B Soil Horizon: ~1' thick; light brown (5YR $\frac{6}{4}$) to yellowish gray (5Y $\frac{7}{2}$) sandy lean CLAY with gravel (CL), medium stiff, slightly moist to dry, low plasticity, massive; gravel and larger sized clasts comprise ~5-10% of the unit; clasts are subrounded to subangular pale yellowish brown (10YR $\frac{6}{2}$) to medium gray (N5) quartzite up to ~2" in diameter, though mode clast size ~0.5"; abundant plant roots; gradational, irregular basal contact.

2. Colluvium: ~1-1.5' thick; light brown (5YR $\frac{6}{4}$) to yellowish gray (5Y $\frac{7}{2}$) sandy lean CLAY with gravel (CL), medium stiff, slightly moist, low plasticity, massive; gravel and larger sized clasts comprise ~20-30% of the unit; clasts are subrounded to subangular quartzite as above up to 1' in diameter, though mode clast size is ~1-2"; abundant plant roots; topsoil matrix; sharp, planar basal contact.

3. Wasatch Formation: >8' thick; 2 subunits.

- **a.** ~6.5' thick; pale yellowish orange (10YR $\frac{8}{6}$) to moderate reddish brown (10R $\frac{4}{6}$) clayey SAND with gravel (SC), medium dense to dense, moist to wet, low to moderate plasticity fines, massive; gravel and larger sized clasts comprise ~30% of the subunit; clasts are subrounded to subangular quartzite as above with minor moderate reddish orange (10R $\frac{6}{6}$) sandstone; clasts are up to 1' in diameter, though mode clast size is ~1-2"; sand is fine- to medium-grained; occasional plant roots; basal contact underwater at time of logging.
- **b.** >1-1.5' thick; moderate reddish brown (10R $\frac{4}{6}$) sandy fat CLAY (CH), medium stiff, wet, moderate to high plasticity, massive; devoid of clasts; muscovite mica flakes common; MnO2 mottled throughout.

*Groundwater seepage at 9-10', filling bottom of test pit 1-2' deep at time of logging.

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Project No: 01628-028

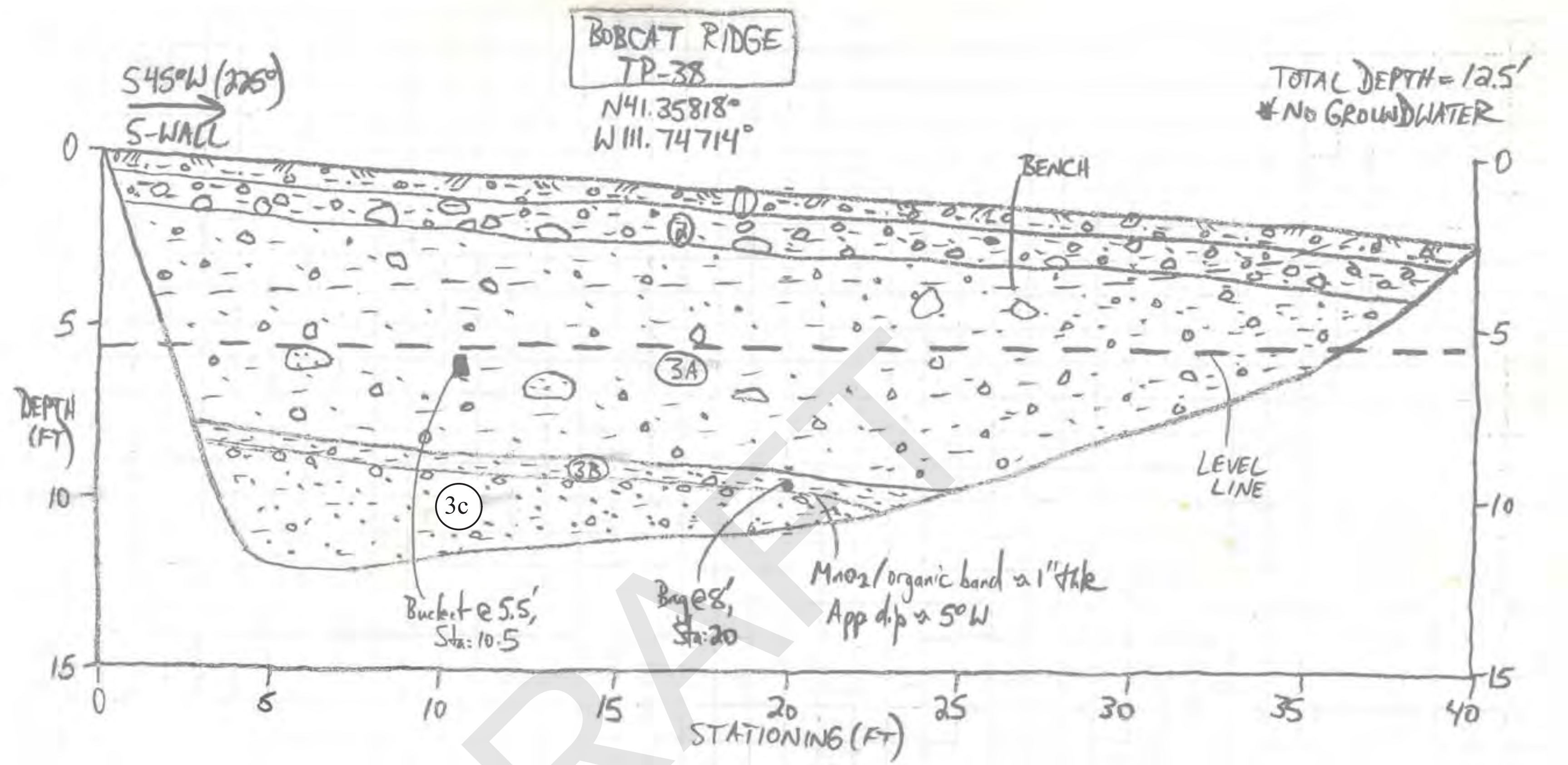
Geotechnical and Geologic Hazards Assessment
Bobcat Ridge Subdivision
Summit Powder Mountain Resort
Weber County, Utah

TP-37 Log

Figure

A-38

Project No. 01628-028 Date 6-15-18 by PED Ckd by ____ on ____



1" = 5'
H&V

LITHOLOGIC UNIT DESCRIPTIONS

1. A/B Soil Horizon: ~6-8" thick; light brown (5YR 6/4) gravelly SILT (ML), medium stiff, dry, low plasticity, massive; gravel and larger sized clasts comprise ~25-30% of the unit; clasts are subangular to subrounded medium gray (N5) to pale reddish brown (10R 5/4) quartzite up to ~6" in diameter, though mode clast size ~1"; common plant roots; gradational, irregular basal contact.

2. Colluvium: ~1' thick; light brown (5YR 6/4) to moderate yellowish brown (10YR 5/4) sandy lean CLAY with gravel (CL), medium stiff, slightly moist, low plasticity, massive; gravel and larger sized clasts comprise ~40% of the unit; clasts are subrounded to subangular quartzite as above up to 1' in diameter, though mode clast size is ~3-4"; common plant roots; topsoil matrix; sharp, irregular basal contact.

3. Wasatch Formation: >9' thick; 3 subunits.

a. ~5' thick; mottled dark reddish brown (10R 3/4) and dark yellowish orange (10YR 6/6) clayey SAND with gravel (SC) gradational to sandy lean CLAY with gravel (CL), dense, moist, moderate plasticity fines, massive; gravel and larger sized clasts comprise ~20-25% of the subunit; clasts are subrounded to subangular quartzite as above up to 1.5' in diameter, though mode clast size is ~1-2" in a wide variety of clast sizes; highly heterogenous unit with common clay lenses and highly weathered clasts; common glossy fat clay sheen but no slickensides observed; common 1 mm pinholes where clayey; possibly older landslide deposits.

b. ~8" thick; dark reddish brown (10R 3/4) clayey SAND (SC) gradational to sandy lean CLAY (CL), stiff, moist, moderate plasticity fines, massive; gravel and larger sized clasts comprise <5% of the subunit; clasts are subrounded to subangular quartzite as above up to 2" in diameter; no slickensides observed; sand is fine-grained and micaceous; minor MnO2 staining; sharp, irregular basal contact.

c. >3' thick; dark reddish brown (10R 4/6) with some dark yellowish orange (10YR 6/6) mottles; clayey SAND with gravel (SC), dense, moist, low to moderate plasticity fines, massive; gravel and larger sized clasts comprise ~10% of the subunit; clasts are subrounded to subangular quartzite as above up to 6" in diameter, though mode clast size is ~1"; occasional plant and tree roots; sand is fine- to medium-grained, though some coarse-grained; subunit has a fine-grained brecciated appearance as seen in other pits; some muscovite mica flakes; top of subunit denoted by presence of a MnO2 band and associated cobbles.

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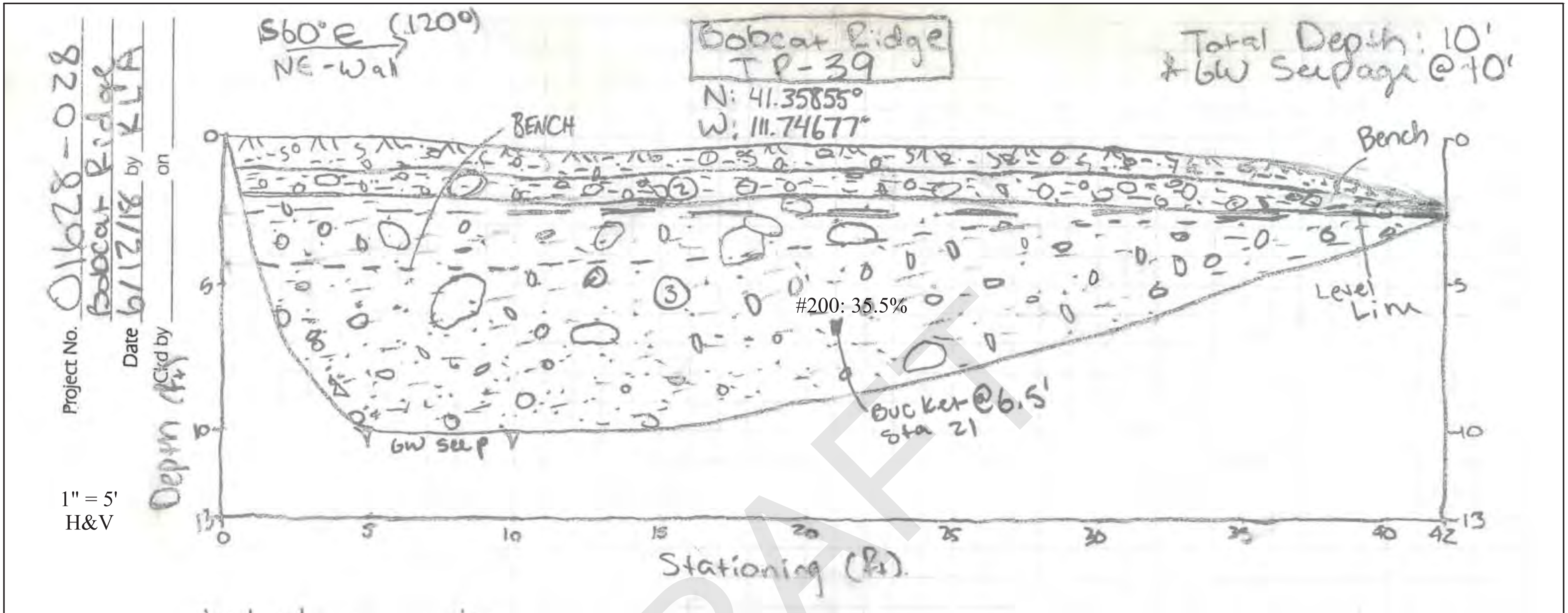
Project No: 01628-028

Geotechnical and Geologic Hazards Assessment
Bobcat Ridge Subdivision
Summit Powder Mountain Resort
Weber County, Utah

TP-38 Log

Figure A-39



DRAFT

LITHOLOGIC UNIT DESCRIPTIONS

1. <u>A/B Soil Horizon:</u> ~1' thick; pale brown (5YR $\frac{5}{2}$) gravelly SILT (ML), medium stiff to loose, moist, low plasticity, massive; gravel and larger sized clasts comprise ~5-10% of the unit; clasts are subrounded to subangular medium gray (N5) to moderate reddish brown (10R $\frac{4}{6}$) quartzite up to ~4" in diameter, though mode clast size is ~0.5-1"; abundant plant and tree roots; gradational, irregular basal contact.

2. <u>Colluvium</u>: ~1' thick; moderate yellowish brown (10YR $\frac{5}{4}$) sandy lean CLAY with gravel (CL), medium stiff, moist, low plasticity, massive; gravel and larger sized clasts comprise ~30-40% of the unit; clasts are subrounded to subangular quartzite as above up to 14" in diameter, though mode clast size is ~2-4"; common plant and tree roots; topsoil matrix; sharp, irregular basal contact; possible B-Horizon.

3. <u>Wasatch Formation</u>: >8' thick; moderate reddish brown (10R $\frac{4}{6}$) to dark reddish brown (10R $\frac{3}{4}$) with mottled yellowish gray (5Y 7/2; from highly weathered sandstone clasts) clayey SAND with gravel (SC) gradational to sandy lean CLAY with gravel (CL), dense, moist, moderate plasticity fines, massive; gravel and larger sized clasts comprise ~20-30% of the unit; clasts are subrounded to subangular moderate reddish orange (10R $\frac{6}{6}$) to light gray (N7) quartzite up to ~17" in diameter, though mode clast size is ~2-3"; occasional plant roots; minor muscovite grains; mottled yellowish gray areas are mostly fine-grained sand; no slickensides observed, though common fat clay glossy sheen where clayey; heterogenous unit, with pockets and lenses of sand and clay and clustered cobbles; possibly older landslide deposits; becomes sandier with depth.

*At the time of logging, ~6" of water, seeping from 10', had accumulated in the northern end of the test pit.

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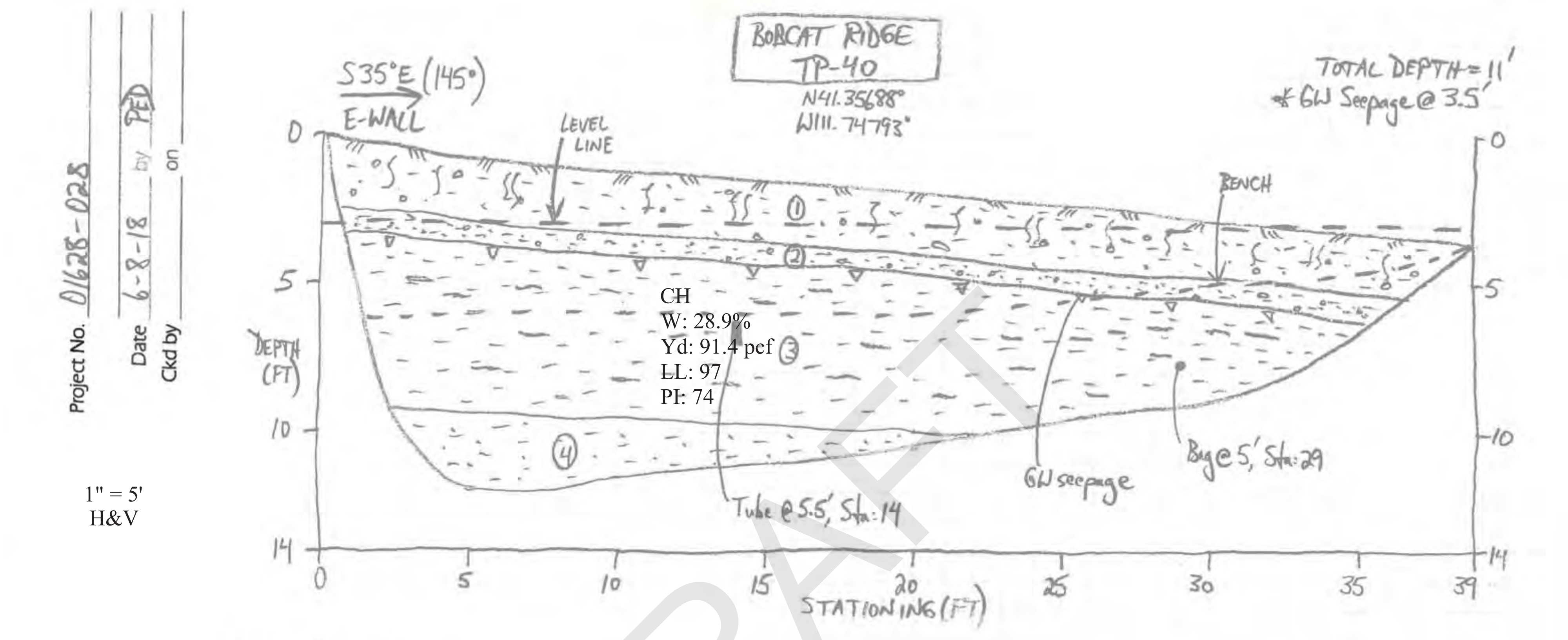
Weber County, Utah

TP-39 Log

Figure

A-40



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LITHOLOGIC UNIT DESCRIPTIONS

1. A/B Soil Horizon: ~2' thick; dark yellowish brown (10YR $\frac{4}{2}$) sandy lean CLAY with gravel (CL), loose to medium stiff, moist, low to moderate plasticity, massive; gravel and larger sized clasts comprise ~15-20% of the unit; clasts are entirely subrounded to subangular medium dark gray (N4) to pale yellowish orange (10YR $\frac{8}{6}$) quartzite up to 16" in diameter, though mode clast size is ~1-2"; abundant plant and tree roots; sharp, irregular basal contact.

2. Shallow Landslide: ~6"-1' thick; moderate reddish brown (10R $\frac{4}{6}$) to brownish gray (5YR $\frac{4}{1}$) sandy fat CLAY with gravel (CH) gradational to clayey SAND with gravel (SC), medium stiff, wet, moderate plasticity, massive; gravel and larger sized clasts comprise ~15-20% of the unit; clasts are subrounded to subangular quartzite as above; common 1 mm pinholes; common plant roots; sharp, irregular basal contact.

3. Shear Plane: ~5-6' thick; light gray (N7) to mottled light gray and dark yellowish orange (10YR $\frac{6}{6}$) fat CLAY (CH), medium dense to dense, wet, high plasticity, massive; devoid of clasts; heavily slickensided throughout with fat clay glossy sheen on every soil face, and a greasy feel; common 1 mm pinholes; occasional plant roots; sharp, irregular basal contact.

4. Wasatch Formation: > 3' thick; dark reddish brown (10R $\frac{3}{4}$) sandy fat CLAY (CH), very stiff, moist, moderate plasticity, massive; gravel and larger sized clasts comprise ~3-5% of the unit; clasts are subrounded to subangular dark yellowish orange (10YR $\frac{6}{6}$) sandstone to medium gray (N5) quartzite, all <0.5" in diameter; common muscovite sand flakes; no slickensides observed.

* Hole significantly sloughing while logging, mainly Unit 3. Groundwater seepage at a depth of 3.5' below existing grade along the length of the test pit, near the Unit 2/3 contact, but also appeared to be slowly emanating from Unit 3 as well. Pit base filled to a depth of 7" of water at the end of logging.

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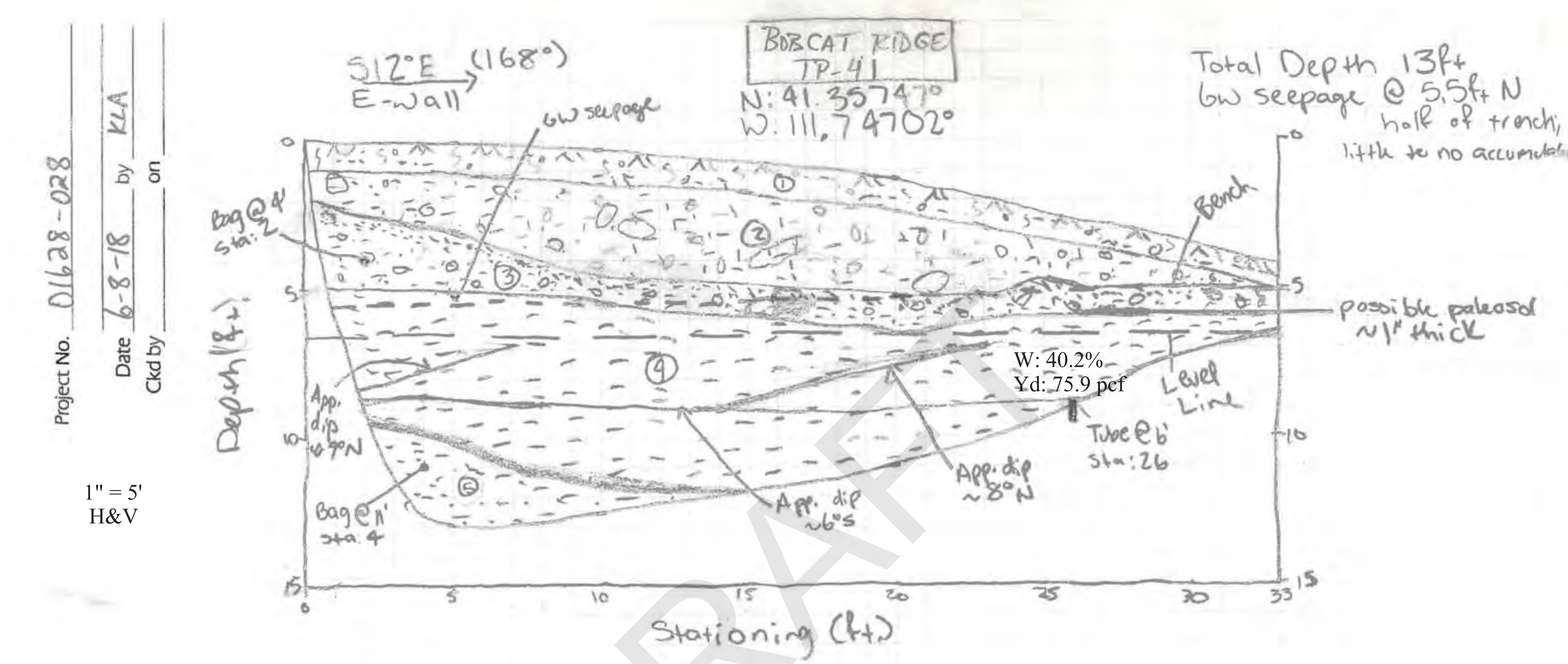
TP-40 Log

Figure

A-41



LITHOLOGIC UNIT DESCRIPTIONS

1. **A/B Soil Horizon:** ~1' thick; pale brown (5YR 5/2) gravelly SILT (ML), medium stiff to loose, moist, low plasticity, massive; gravel and larger sized clasts comprise ~5-10% of the unit; clasts are subrounded to subangular medium gray (N5) to moderate orange pink (10R 7/4) quartzite up to ~3" in diameter, though mode clast size is ~1-2"; abundant plant and tree roots; gradational, irregular basal contact.

2. **Colluvium:** ~2-3' thick; moderate yellowish brown (10YR 5/4) to dark yellowish brown (10YR 4/2) sandy lean CLAY with gravel (CL), medium stiff, moist, low to moderate plasticity, massive; gravel and larger sized clasts comprise ~40% of the unit; clasts are subrounded to subangular quartzite as above and include moderate reddish orange (10R 6/6) sandstone; clasts are up to 20" in diameter, though mode clast size is ~2-5"; topsoil matrix; common plant and tree roots; sharp, planar basal contact.

3. **Shallow Landslide:** ~1-2.5' thick; dark yellowish orange (10YR 6/6) clayey SAND with gravel (SC) gradational to a light brownish gray (5YR 6/1) mottled with dark yellowish orange sandy lean CLAY with gravel (CL), medium dense, moist to wet, moderate to low plasticity fines, massive; gravel and larger sized clasts comprise ~20-25% of the unit; clasts are subrounded to subangular quartzite and sandstone as above up to 9" in diameter, though mode clast size is ~1-3"; sandier at top of unit; common plant and few tree roots; ~1' thick pocket of MnO2 at station 16; gradational, irregular basal contact.

4. **Shear Plane:** ~5-6' thick; mottled light brownish gray (5YR 6/1) and dark yellowish orange (10YR 6/6) fat CLAY (CH), medium stiff to stiff, moist, high plasticity, massive; devoid of clasts; slickensides in places, with common fat clay glossy sheen and greasy feel; several continuous slide planes; common 1 mm pinholes; occasional plant roots; base is mottled with MnO2; gradational, planar basal contact.

5. **Wasatch Formation:** >2' thick; dark reddish brown (10R 3/4) sandy fat CLAY (CH), very stiff, moist, moderate plasticity, massive; devoid of clasts; common muscovite mica flakes; no slickensides observed; some mottled MnO2 especially common in uppermost ~1' of unit.

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TP-41 Log

Figure

A-42

Project No. 01628-028

Date 6-8-18 by PED

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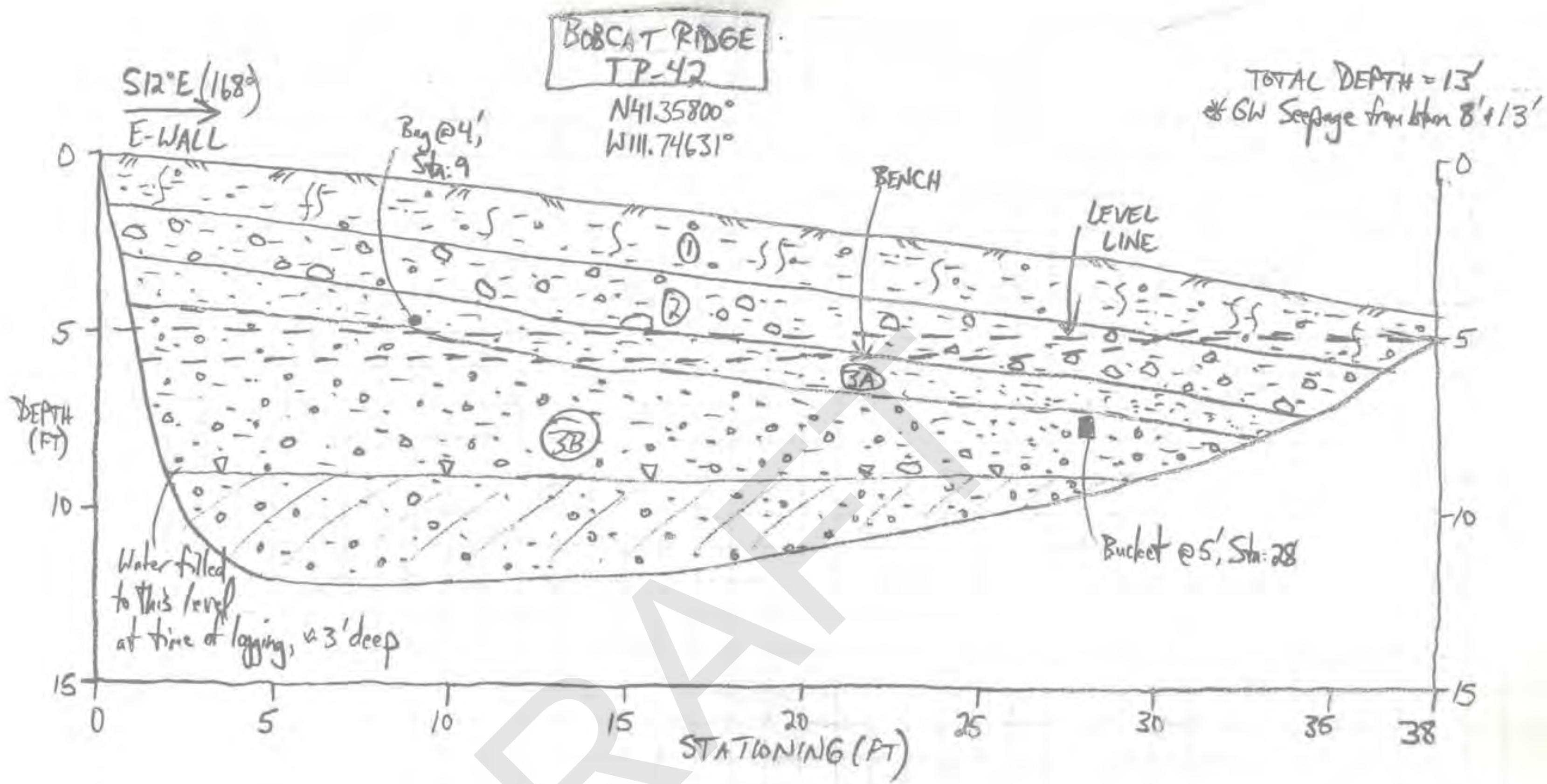

1" = 5'
H&V

DRAFT

LITHOLOGIC UNIT DESCRIPTIONS

1. A/B Soil Horizon: ~1.5' thick; dark yellowish brown (10YR $\frac{4}{2}$) to pale brown (5YR $\frac{5}{2}$) silty lean CLAY with gravel (CL), loose to medium stiff, dry to slightly moist, low plasticity, massive; gravel and larger sized clasts comprise ~10-15% of the unit; clasts are subrounded to subangular pale yellowish orange (10YR $\frac{8}{6}$) to medium gray (N5) quartzite up to ~7" in diameter, though mode clast size is ~1"; increases in moisture with depth; abundant plant roots; gradational, planar basal contact.

2. Colluvium: ~1.5' thick; dark yellowish brown (10YR $\frac{4}{2}$) sandy lean CLAY with gravel (CL), medium stiff, moist, low plasticity, massive; gravel and larger sized clasts comprise ~30% of the unit; clasts are subrounded quartzite as above up to 18" in diameter, though mode clast size is ~3-4"; abundant plant roots; topsoil matrix; possible B-Horizon; sharp, planar basal contact.

3. Wasatch Formation: >10' thick; 2 subunits.

a. ~1-1.5' thick; moderate reddish brown (10R $\frac{4}{6}$) clayey SAND (SC), medium dense, moist, low plasticity fines, massive; gravel and larger sized clasts are rare, likely comprise <3% of the unit; where present, clasts are subrounded quartzite as above up to ~2" in diameter; few small plant roots; gradational, irregular basal contact.

b. >9' thick; dark reddish brown (10R $\frac{3}{4}$) clayey SAND with gravel (SC), medium dense, moist to wet, low plasticity fines, weakly thinly bedded; gravel and larger sized clasts comprise ~30-40% of the unit; clasts are subrounded to subangular quartzite as above up to 6" in diameter with a mode size of ~1-3"; few small plant roots; homogeneous unit; fine- to medium-grained sand.

*Groundwater seepage filling pit 3' deep at time of logging.

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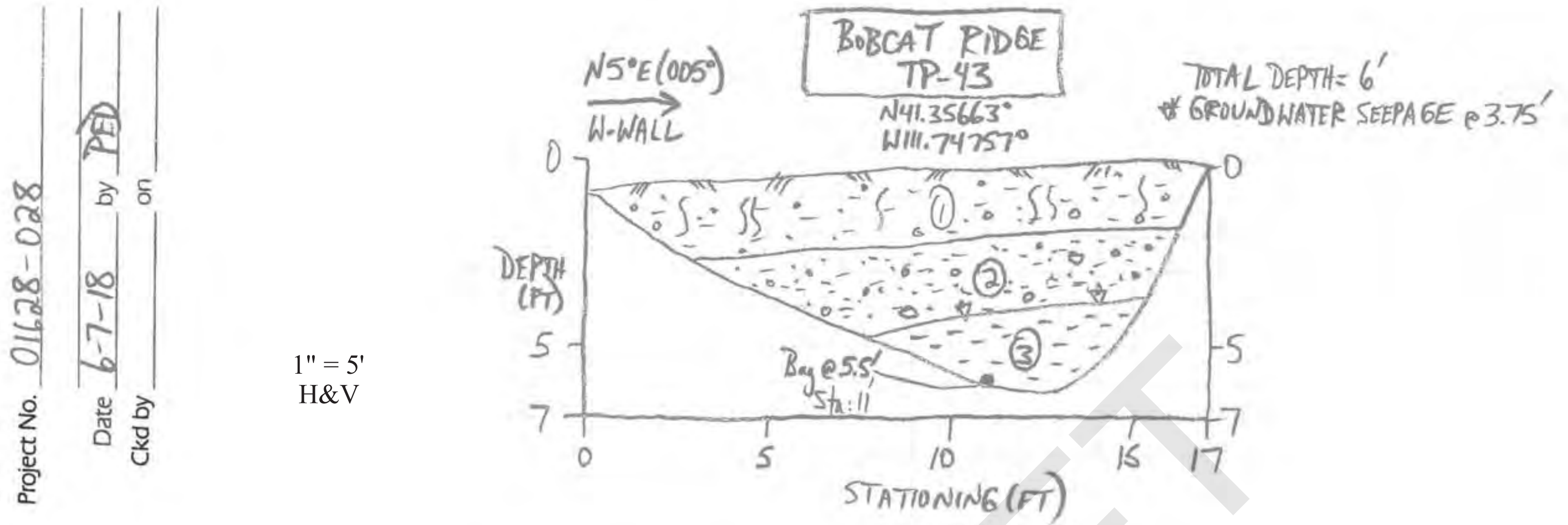
TP-42 Log

Figure A-43



LITHOLOGIC UNIT DESCRIPTIONS

1. **A/B Soil Horizon:** ~2' thick; dark yellowish brown (10YR $\frac{4}{2}$) sandy lean CLAY with gravel (CL), loose to medium stiff, moist, low plasticity, massive; gravel and larger sized clasts comprise ~10% of the unit; clasts are subrounded to subangular medium gray (N5) to dark yellowish orange (10R $\frac{6}{6}$) quartzite up to ~18" in diameter, though mode clast size is ~1-2"; abundant plant roots, sharp, irregular basal contact.

2. **Shallow Landslide:** ~2' thick; mottled light brownish gray (5YR $\frac{6}{1}$) and moderate reddish orange (10R $\frac{6}{6}$) clayey SAND with gravel (SC), medium dense, wet, moderate to high plasticity fines, massive; gravel and larger sized clasts comprise ~20% of the unit; clasts are subrounded to subangular quartzite as above up to ~3" in diameter, though mode clast size is ~1"; few plant roots; soil character is similar to that of the Wasatch Formation but not in color and unit appears similar to shallow landslide deposit observed in TP-51; groundwater seepage from base of unit; sharp, planar basal contact.

3. **Shear Plane:** >2' thick; medium light gray (N6) to pale yellowish orange fat CLAY (CH), stiff, moist to wet, high plasticity, massive; devoid of clasts; appears similar in character to slide plane seen in TP-49 except no slickensides (likely due to wetness) and no underlying dark red clay; also appears similar in character to weathered Norwood Formation fat clays.

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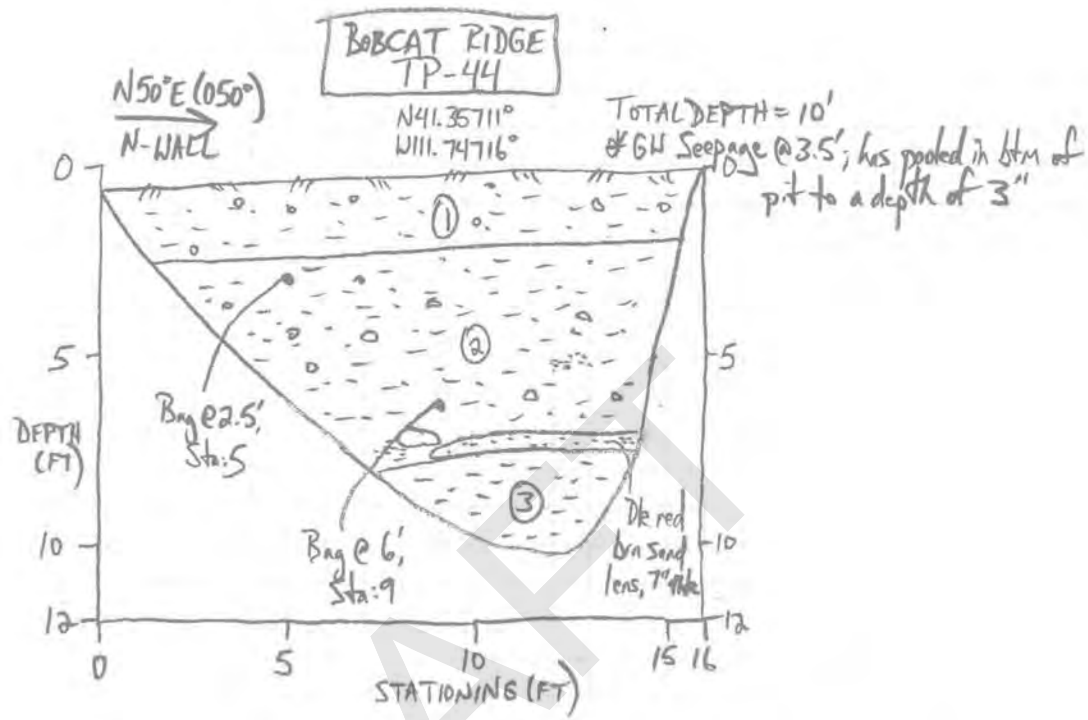

1" = 5'
H&V

DRAFT

LITHOLOGIC UNIT DESCRIPTIONS

1. A/B Soil Horizon: ~2' thick; dark yellowish brown (10YR 4/2) sandy lean CLAY with gravel (CL), loose to medium stiff, moist, low plasticity, massive; gravel and larger sized clasts comprise ~10% of the unit; clasts are subrounded to subangular medium gray (N5) to dark yellowish orange (10R 6/6) quartzite up to ~18" in diameter, though mode clast size is ~1-2"; abundant plant roots, sharp, irregular basal contact.

2. Shallow Landslide: ~5' thick; mottled light brownish gray (5YR 6/1) and moderate reddish orange (10R 6/6) sandy fat CLAY with gravel (CH), medium stiff, wet, moderate to high plasticity, massive; gravel and larger sized clasts comprise ~20% of the unit; clasts are subrounded to subangular quartzite as above up to 18" in diameter, though mode clast size is ~2-3"; few plant roots; has sandy lenses and pockets, some with MnO_2; possibly weathered Wasatch Formation.

3. Shear Plane: >3' thick; mottled light brownish gray (5YR 6/1) and dark yellowish orange (10YR 6/6) fat CLAY (CH), stiff, moist to wet, high plasticity, massive; devoid of clasts; appears similar to unit as seen in TP-43, except no slickensides, but very greasy feel when wet.

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TP-44 Log

Figure
A-45

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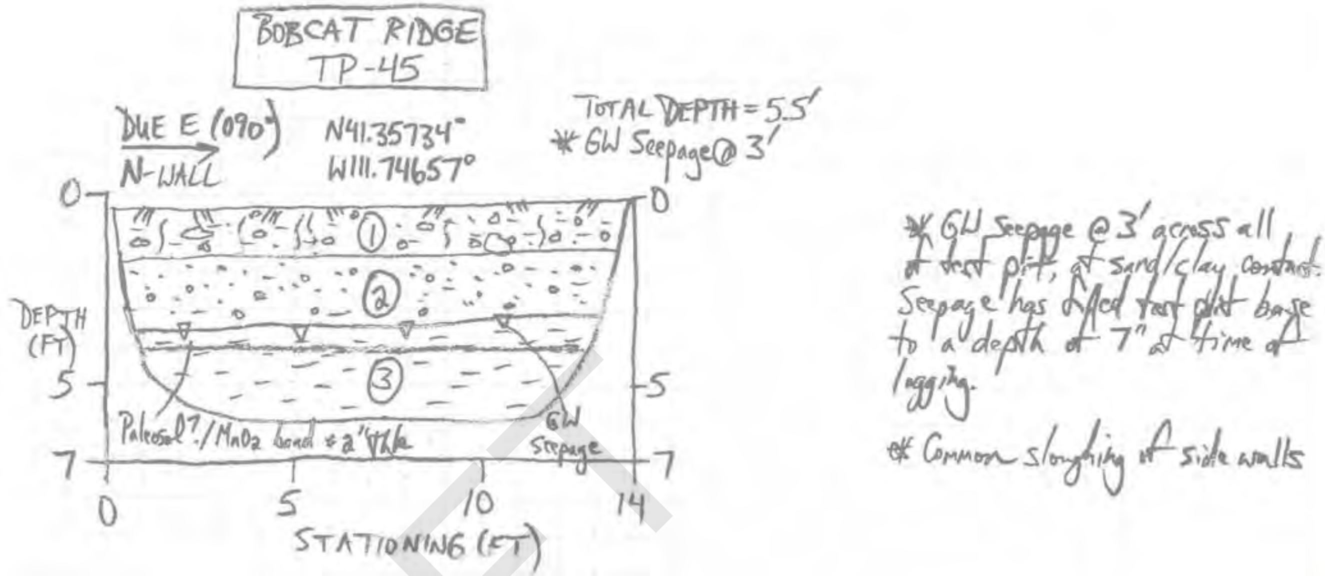
Date 6-8-18 by PED
Ckd by ________ on ________

1" = 5'
H&V



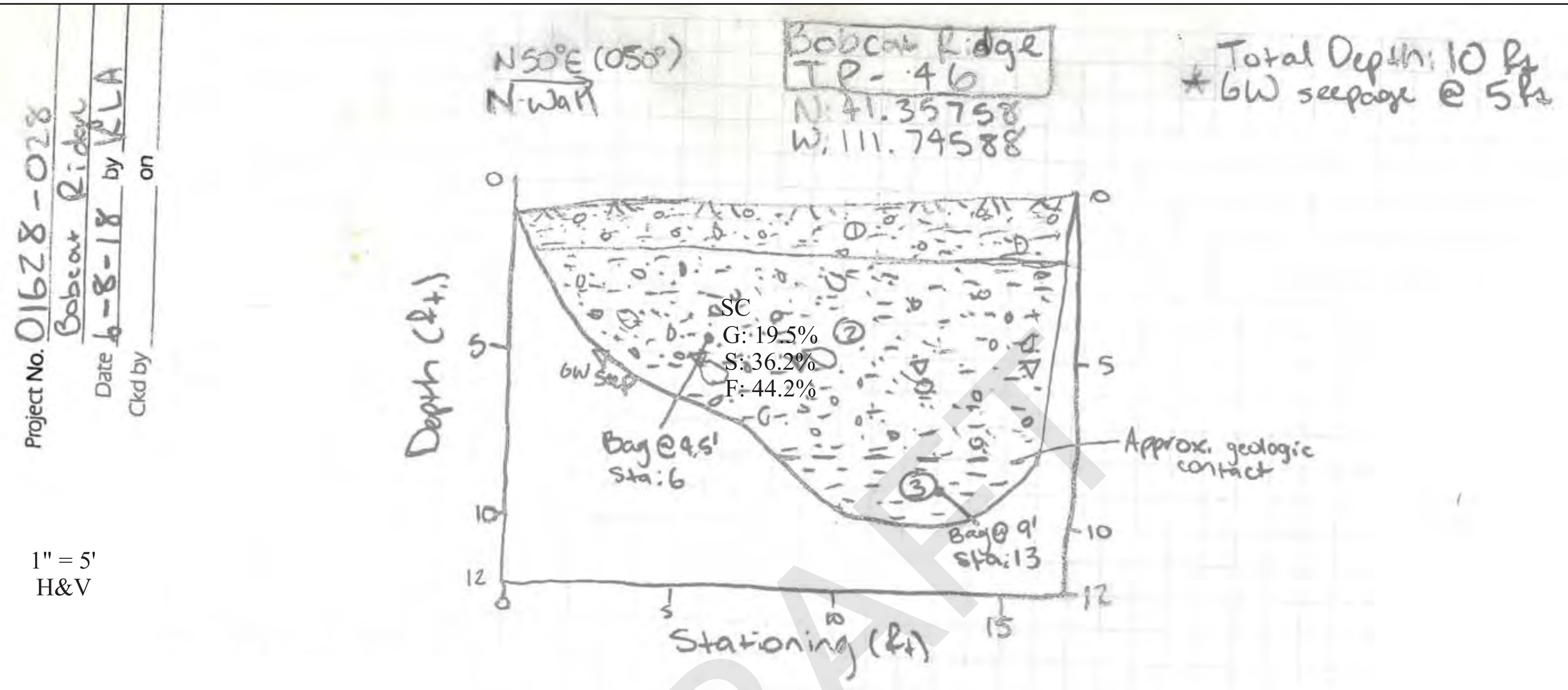
LITHOLOGIC UNIT DESCRIPTIONS

1. **A/B Soil Horizon:** ~1.5' thick; dark yellowish brown (10YR $\frac{4}{2}$) to grayish brown (5Y $\frac{3}{2}$) sandy lean CLAY with gravel (CL), loose to medium stiff, moist, low plasticity, massive; gravel and larger sized clasts comprise ~20-25% of the unit; clasts are subrounded to subangular pale yellowish orange (10R $\frac{8}{6}$) to medium gray (N5) quartzite up to ~2' in diameter, mode clast size is ~2'; may represent colluvial unit with topsoil matrix; abundant plant and tree roots; gradational, largely planar basal contact.

2. **Shallow Landslide:** ~1.5' thick; moderate yellowish brown (10YR $\frac{5}{4}$) sandy fat CLAY with gravel (CH), medium stiff, moist to wet, moderate plasticity fines, massive; gravel and larger sized clasts comprise ~15-20% of the unit; clasts are subrounded quartzite as above up to 4" in diameter, though mode clast size is ~1-2"; occasional plant roots; possible B-horizon or colluvial unit; sharp, largely planar basal contact.

3. **Shear Plane:** >2.5' thick; mottled dark yellowish orange (10YR $\frac{6}{6}$), light gray (N7) and light brownish gray (5YR $\frac{6}{1}$) fat CLAY (CH), stiff, wet, high plasticity, massive; devoid of clasts; very similar to what was seen in TP-41.

DRAFT



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LITHOLOGIC UNIT DESCRIPTIONS

1. **A/B Soil Horizon:** ~1.5-2' thick; pale brown (5YR 5/2) clayey SAND with gravel (SC), medium dense, moist, low plasticity, massive; gravel and larger sized clasts comprise ~5-10% of the unit; clasts are subrounded to subangular medium gray (N5) quartzite up to ~3" in diameter, mode clast size is ~1-2"; abundant plant roots; sharp, irregular basal contact.

2. **Shallow Landslide:** ~6' thick; light gray (N7) to pale yellowish orange (10YR 8/6) to moderate reddish orange (10R 6/6) clayey SAND with gravel (SC) gradational to sandy fat CLAY with gravel (CH), dense, moist to wet, moderate plasticity, massive; gravel and larger sized clasts comprise ~30% of the unit; clasts are subrounded to subangular medium gray (N5) to grayish pink (5R 8/2) quartzite up to ~6" in diameter, though mode clast size is ~1-3"; few plant roots; unknown character of basal contact.

3. **Wasatch Formation:** >2' thick; dark reddish brown (10R 3/4) sandy fat CLAY (CH), very stiff, moist, moderate plasticity, massive; devoid of clasts; common muscovite mica flakes; no slickensides observed; similar in character to basal unit of TP-52, with fine-grained brecciated appearance.

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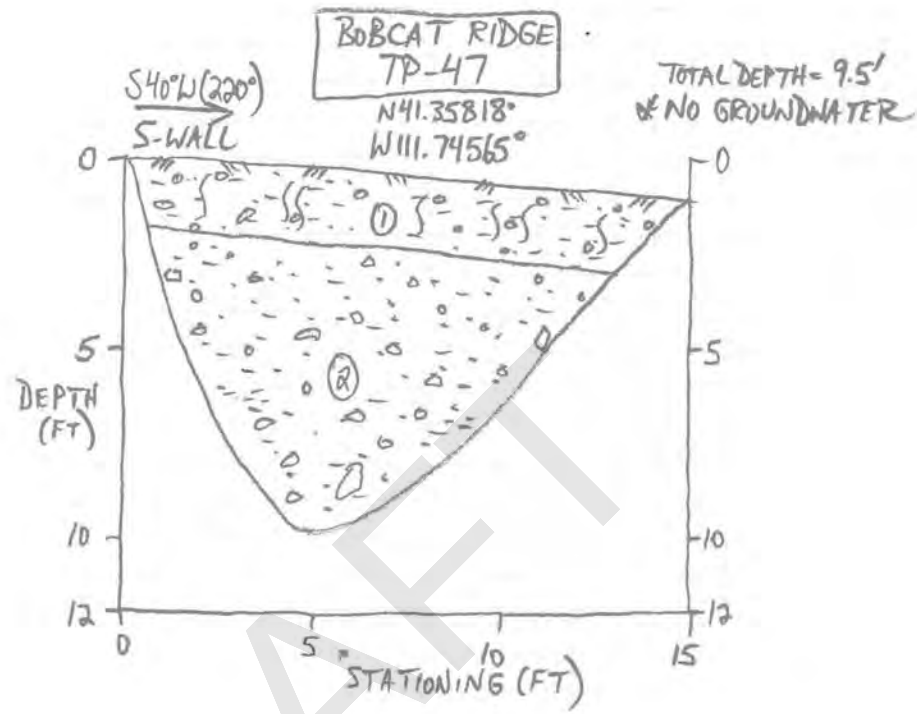
TP-46 Log

Figure

A-47

Project No. 01628-028
Date 6-8-18 by PEI
Ckd by on

1" = 5'
H&V



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LITHOLOGIC UNIT DESCRIPTIONS

1. A/B Soil Horizon: ~2' thick; dark yellowish brown (10YR $\frac{4}{2}$) sandy lean CLAY with gravel (CL), medium stiff, dry to slightly moist, low plasticity, massive; gravel and larger sized clasts comprise ~25-30% of the unit; clasts are subrounded to subangular pale yellowish orange (10R $\frac{8}{6}$) to medium gray (N5) quartzite up to ~8" in diameter, mode clast size is ~2-4"; abundant plant and tree roots; sharp, planar basal contact.

2. Wasatch Formation: >8' thick; dark reddish brown (10R $\frac{3}{4}$) clayey SAND with gravel (SC), dense, moist, moderate plasticity fines, massive; gravel and larger sized clasts comprise ~30-40% of the unit; clasts are subrounded to subangular quartzite as above up to ~2' in diameter, though mode clast size is ~3-4"; occasional small plant roots; occasional pockets of dark red fat clay, though no slickensides observed; unit is fairly homogeneous and poorly sorted; sand is fine- to medium-grained.

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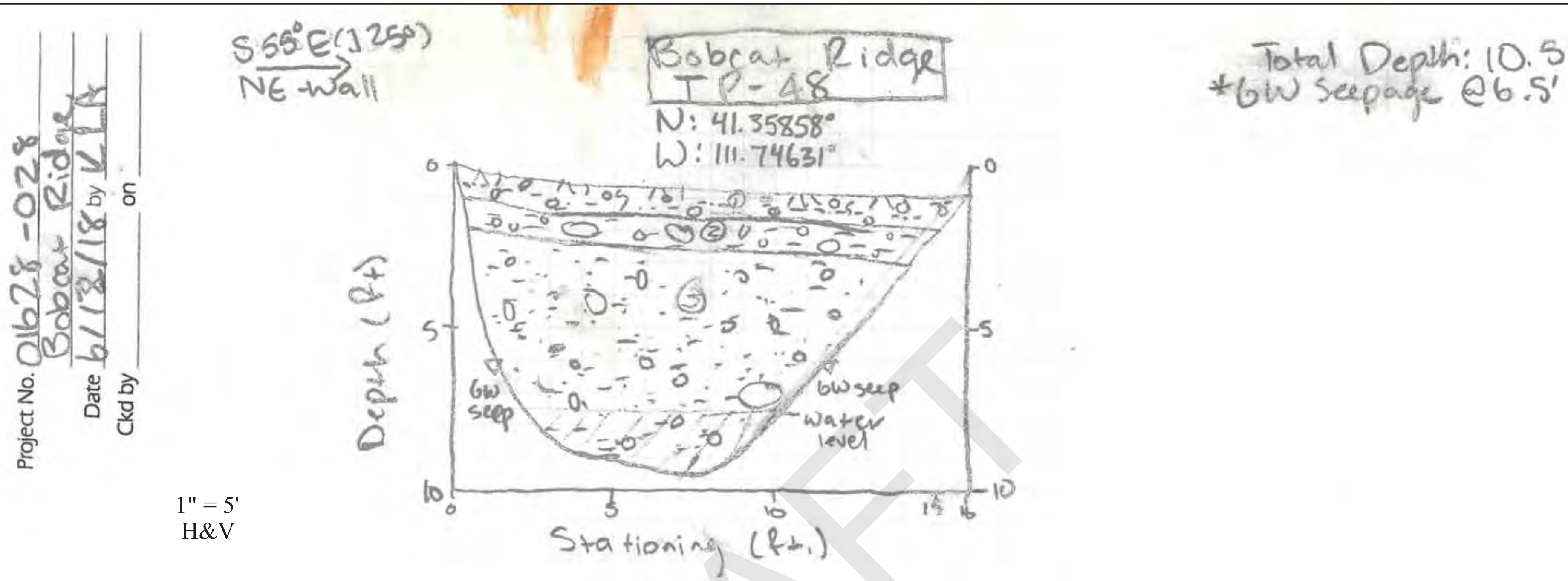
TP-47 Log

Figure A-48



1" = 5'
H&V

DRAFT

LITHOLOGIC UNIT DESCRIPTIONS

1. A/B Soil Horizon: ~1' thick; pale brown (5YR $\frac{5}{2}$) gravelly SILT (ML), loose, dry, low plasticity, massive; gravel and larger sized clasts comprise ~5-10% of the unit; clasts are subrounded to subangular medium gray (N5) quartzite up to ~4" in diameter, though mode clast size ~0.5-1"; abundant plant roots; gradational, irregular basal contact.

2. Colluvium: ~1' thick; moderate yellowish brown (10YR $\frac{5}{4}$) sandy lean CLAY with gravel (CL), medium stiff to loose, moist, low plasticity, massive; gravel and larger sized clasts comprise ~30-40% of the unit; clasts are subrounded to subangular quartzite as above up to 6" in diameter, though mode clast size is ~2-4"; common plant roots; sharp, planar basal contact.

3. Wasatch Formation: >7' thick; moderate reddish brown (10R $\frac{4}{6}$) mottled with yellowish gray (5Y $\frac{7}{2}$) clayey SAND with gravel (SC), dense, moist to wet, moderate plasticity fines, massive; gravel and larger sized clasts comprise ~20-30% of the unit; clasts are subrounded to subangular moderate reddish orange (10R $\frac{6}{6}$) to light gray (N7) quartzite up to 2' in diameter, though mode clast size is ~2-3"; no slickensides observed; minor muscovite mica grains; largely homogeneous.

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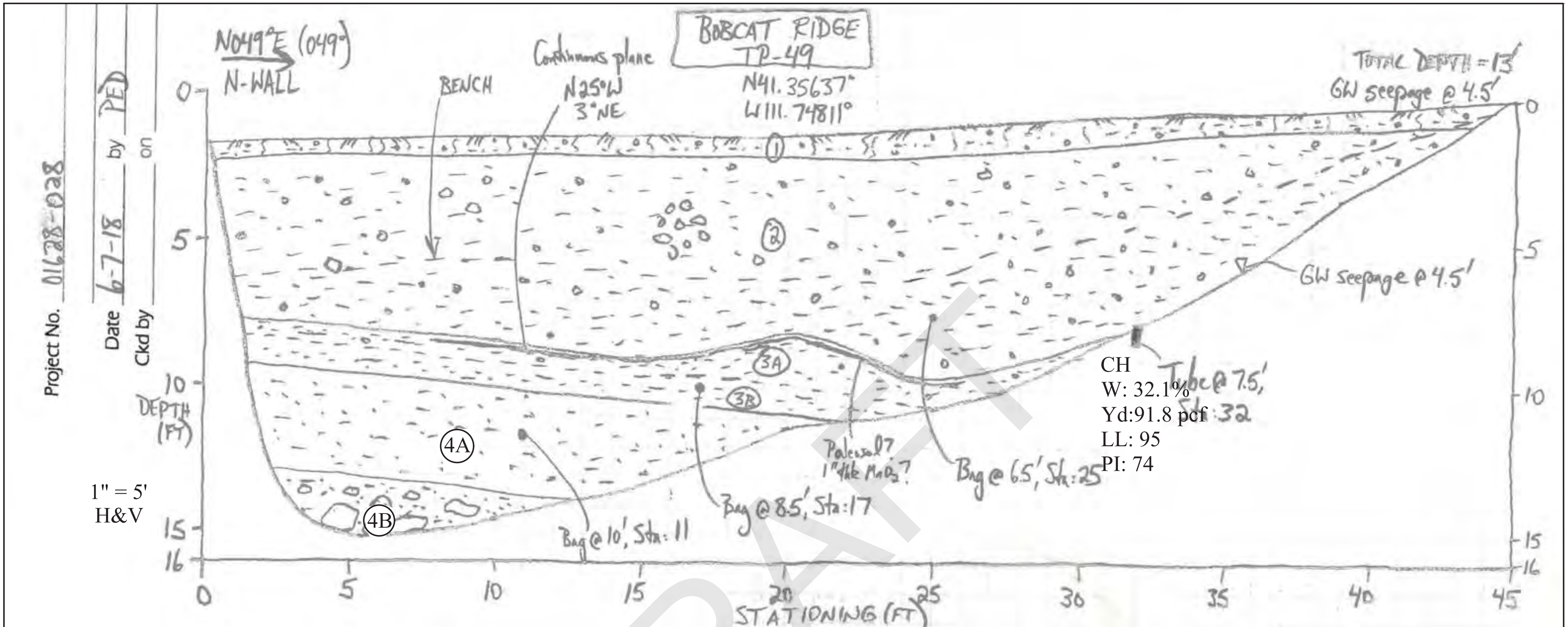
TP-48 Log

Figure

A-49



LITHOLOGIC UNIT DESCRIPTIONS

1. A/B Soil Horizon: ~6-12" thick; light brown (5YR $\frac{6}{4}$) sandy SILT with gravel (ML), medium stiff, dry, low plasticity, massive; gravel and larger sized clasts comprise ~15-20% of the unit; clasts are subrounded to subangular medium light gray (N6) to dark gray (N3) quartzite up to ~9" in diameter, though mode clast size ~0.5"; common plant roots; gradational, irregular basal contact.

2. Shallow Landslide: ~7' thick; mottled moderate reddish brown (10R $\frac{4}{6}$) and moderate reddish orange (10R $\frac{6}{6}$) sandy lean CLAY with gravel (CL), medium stiff, moist, moderate plasticity, massive; gravel and larger sized clasts comprise ~20-30% of the unit; clasts are subrounded to subangular quartzite as above up to 11" in diameter, though mode clast size is ~2"; highly heterogenous unit with organic and MnO2 smears; occasional small plant roots; becomes more clay-rich with depth; sharp, curvilinear basal contact.

3. Shear Plane: ~2' thick; 2 subunits.

a. ~6-8" thick; pale yellowish orange (10YR 8/6) fat CLAY with gravel (CH), medium stiff, moist, high plasticity, massive; gravel and larger sized clasts comprise ~5% of the unit; clasts are subrounded to subangular quartzite as above up to 3" in diameter; heavily slickensided with continuous plane observed ~2" below the top of the subunit; sharp, planar basal contact.

3. Shear Plane (continued)

b. ~14-16" thick; dark reddish brown (10R 3/4) fat CLAY (CH), stiff, moist, moderate to high plasticity, massive; common slickensides, but short and discontinuous; slickensides decrease with depth; gradational, planar basal contact.

4. Wasatch Formation: >6' thick; 2 subunits.

a. ~4' thick; dark reddish brown (10R 3/4) sandy lean CLAY (CL), very stiff, moist, moderate plasticity, massive; largely devoid of clasts; common light-colored quartzite sand grains give the unit a fine-grained brecciated appearance; glossy sheen in places, but no slickensides observed; appears like a weathered in-place, clay-rich lens of the Wasatch Formation; sharp, irregular basal contact.

b. >2' thick; dark reddish brown (10R 3/4) clayey SAND with gravel (SC), medium dense, moist, moderate to high plasticity fines, massive; gravel and larger sized clasts comprise ~30-40% of the unit; clasts are subrounded to subangular quartzite as above and minor dark yellowish orange (10YR 6/6) fine-grained sandstone; clasts are up to 18" in diameter, though mode size of ~1-2" in a wide range of clast sizes; heterogeneous, possibly alluvial subunit.

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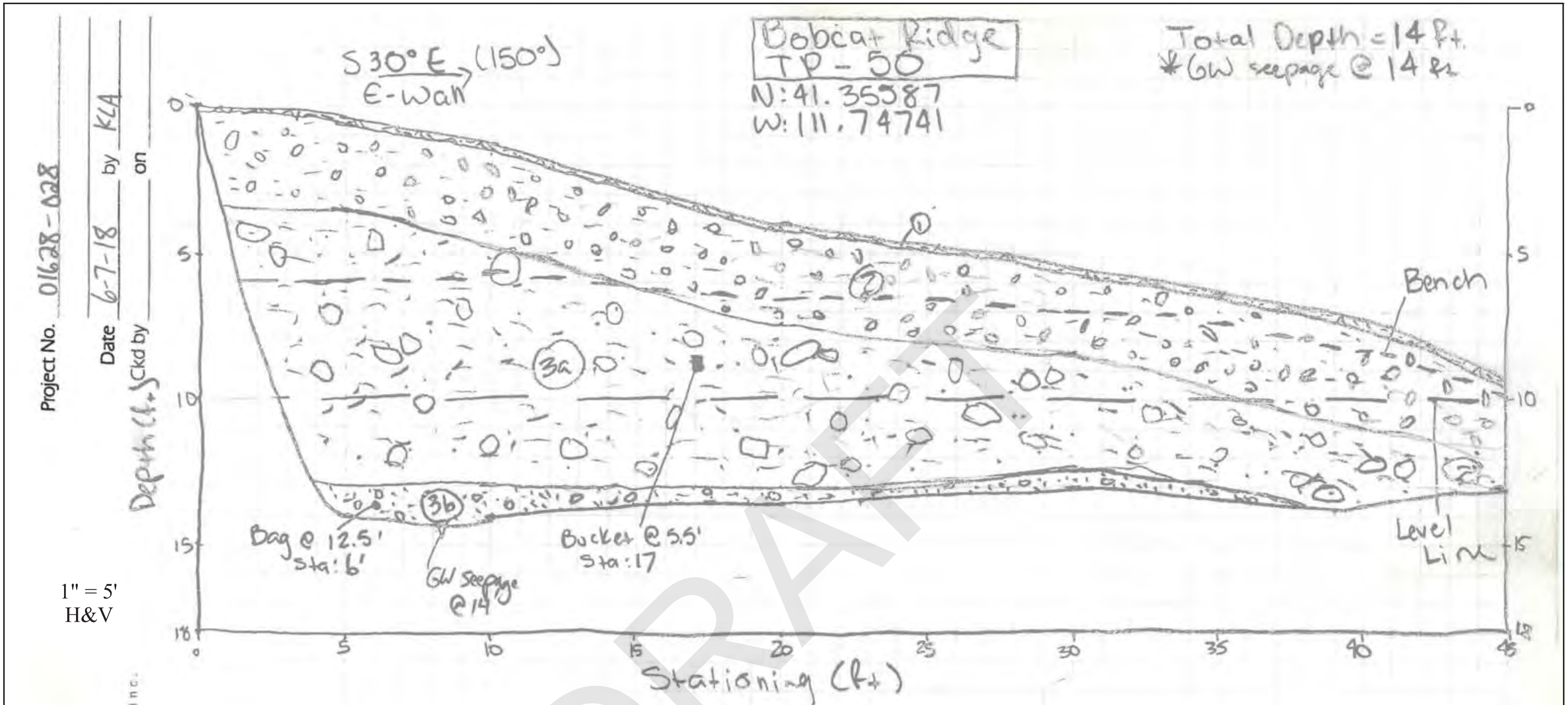
TP-49 Log

Figure

A-50



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LITHOLOGIC UNIT DESCRIPTIONS

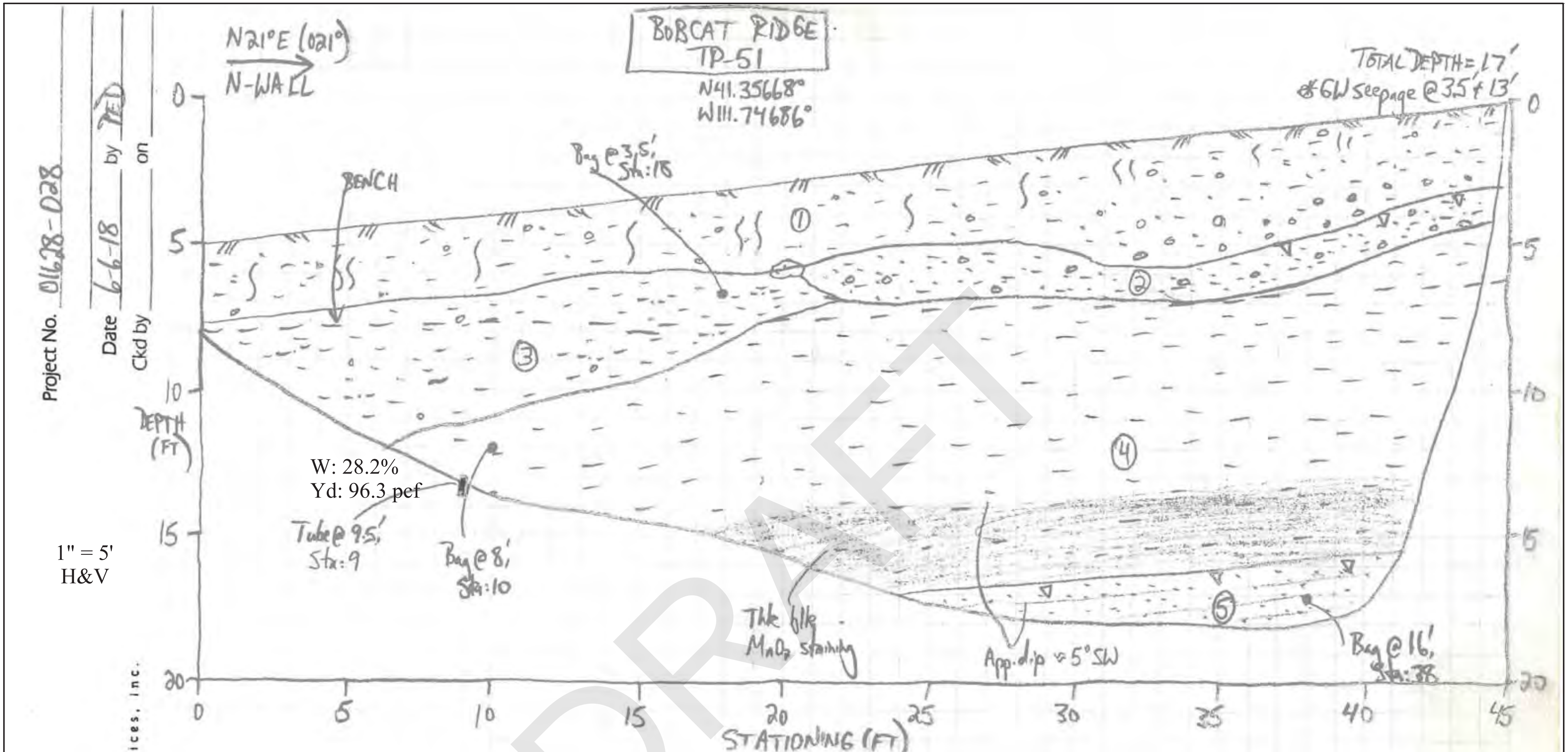
1. A/B Soil Horizon: ~2” thick; light brown (5YR $\frac{6}{4}$) gravelly SILT (ML), medium stiff to loose, dry, low plasticity, massive; gravel and larger sized clasts comprise ~30-40% of the unit; clasts are subrounded to subangular moderate reddish orange (10R $\frac{6}{6}$) to medium gray (N5) quartzite up to ~18” in diameter at the surface, though mode clast size ~3-5”; abundant plant roots; gradational, irregular basal contact.

2. Colluvium: ~2-3' thick; dark yellowish brown (10YR $\frac{4}{2}$) lean CLAY with gravel (CL) gradational to clayey GRAVEL (GC), medium stiff, moist, low to moderate plasticity, massive; gravel and larger sized clasts comprise ~40-60% of the unit; clasts are subrounded to subangular quartzite as above up to 1' in diameter, though mode clast size is ~3-5”; common plant roots; gradational, irregular basal contact.

3. Wasatch Formation: >10' thick; 2 subunits.

a. ~4-5' thick; pale reddish brown (10R $\frac{5}{4}$) to moderate reddish orange (10R $\frac{6}{6}$) to dark yellowish brown (10YR $\frac{4}{2}$) clayey SAND with gravel (SC) gradational to sandy lean CLAY (CL), dense to very dense, moist, moderate plasticity fines, massive; gravel and larger sized clasts comprise ~30-40% of the subunit; clasts are subrounded to subangular quartzite as above with minor pale yellowish orange (10YR $\frac{8}{6}$) to moderate reddish orange (10R $\frac{6}{6}$) sandstone; clasts are up to 2' in diameter, though mode clast size is ~6”.

b. >1' thick; pale reddish brown (10R $\frac{5}{4}$) to moderate reddish orange (10R $\frac{6}{6}$) well-graded SAND with gravel (SW), dense, moist, moderate plasticity fines, massive; gravel and larger sized clasts comprise ~20-30% of the subunit; clasts are quartzite and sandstone as above up to 6” in diameter, though mode clast size ~1-3”; sand is very fine to fine-grained.



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LITHOLOGIC UNIT DESCRIPTIONS

1. A/B Soil Horizon: ~2-3.5' thick; grayish brown (5Y $\frac{3}{2}$) sandy lean CLAY with gravel (CL), medium stiff, moist, moderate plasticity, massive; gravel and larger sized clasts comprise ~5-10% of the unit; clasts are subrounded to subangular medium light gray (N6) to pale yellowish orange (10YR $\frac{8}{6}$) quartzite up to ~13" in diameter, though mode clast size ~1"; abundant plant and tree roots; sharp, highly irregular basal contact.

2. Shallow Landslide 1: ~2' thick; medium light gray (N6) to light brownish gray (5YR $\frac{6}{1}$) clayey SAND with gravel (SC), medium dense to loose, wet and seeping groundwater, moderate plasticity fines, massive; gravel and larger sized clasts comprise ~10-20% of the unit; clasts are subrounded to subangular quartzite as above up to 6" in diameter, though mode clast size is ~1-2"; occasional small plant roots; thin organic-rich layer formed on basal contact.

3. Shallow Landslide 2: ~5' thick; dark yellowish orange (10YR $\frac{6}{6}$) silty fat CLAY with gravel (CH), stiff, moist, high plasticity, massive; gravel and larger sized clasts comprise ~10% of the unit; clasts are subrounded to subangular quartzite as above up to 4" in diameter, though mode clast size of ~2"; occasional small discontinuous slickensides and poorly-defined slide plane along basal contact; highly heterogenous unit; gradational, irregular basal contact.

4. Shear Plane: ~9' thick; moderate red (5R $\frac{5}{4}$) to moderate reddish brown (10R $\frac{4}{6}$) to black (N1) fat CLAY with gravel (CH), very stiff, moist, moderate to high plasticity, possibly thickly bedded; gravel and larger sized clasts comprise ~3% of unit; clasts are quartzite as above up to 3" in diameter; not as fat as unit 3 but similar except for fewer slickensides; abundant black MnO2 smear in matrix and along fractures throughout unit; basal ~3' of unit is covered black in MnO2 staining; sharp, planar basal contact.

5. Wasatch Formation: >3' thick; moderate red (5R $\frac{5}{4}$) clayey SAND (SC), medium dense, wet and seeping groundwater, low to moderate plasticity fines, finely bedded; sand is fine- to medium-grained; occasional MnO2 along bedding planes; devoid of clasts.

* Test pit walls constantly sloughing in during the course of logging, causing significant wall failures.

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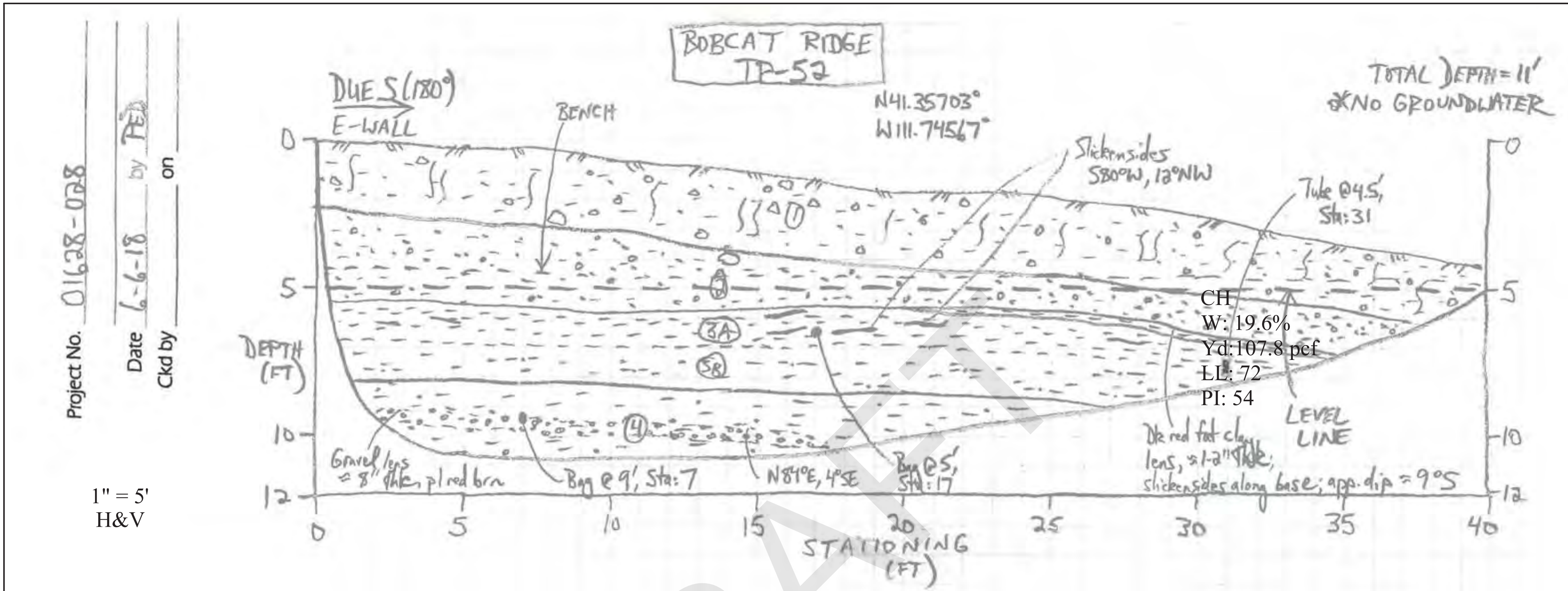
Weber County, Utah

TP-51 Log

Figure

A-52



LITHOLOGIC UNIT DESCRIPTIONS

1. A/B Soil Horizon: ~2.5' thick; grayish brown (5Y $\frac{3}{2}$) sandy lean CLAY with gravel (CL), medium stiff, moist to slightly moist, low plasticity, massive; gravel and larger sized clasts comprise ~10-15% of the unit; clasts are subrounded to subangular medium gray (N5) to dark yellowish orange (10YR $\frac{6}{6}$) quartzite up to 7” in diameter, though mode clast size ~2-3”; abundant plant and tree roots; sharp, irregular basal contact.

2. Shallow Landslide: ~2-3' thick; moderate reddish brown (10R $\frac{4}{6}$) to dark reddish brown (10R $\frac{3}{4}$) sandy lean CLAY with gravel (CL) gradational to clayey SAND with gravel (SC), stiff, moist, moderate plasticity, massive; gravel and larger sized clasts comprise ~10% of the unit; clasts are subrounded to subangular quartzite as above up to 6” in diameter, though mode clast size is ~1-2”; occasional small plant roots; sharp, irregular basal contact exhibited by a thin dark red fat clay in the southern end of test pit.

* Excavator noted hard digging at bottom of test pit.

3. Shear Plane: >2.5' thick; 2 subunits.

- **a.** ~1-1.5' thick; grayish red (10R 4/2) to medium light gray (N6) fat CLAY (CH), stiff, moist, high plasticity, massive; devoid of clasts; common slickensides, though discontinuous; slickensides appear to be developed along old bedding planes, and these appear to dip mainly upslope to the north; few 1 mm pinholes; common blocky texture in places; gradational, irregular basal contact.
- **b.** ~1-1.5' thick; mottled moderate reddish brown (10R 4/6) and medium light gray (N6) silty fat CLAY (CH), very stiff, slightly moist, moderate plasticity, massive; devoid of clasts; blocky texture; occasional 1 mm pinholes; no slickensides observed; sharp, irregular basal contact.

4. Wasatch Formation: >3' thick; dark reddish brown (10R $\frac{3}{4}$) to pale reddish brown (10R $\frac{5}{4}$) fat CLAY (CH), very stiff, moist, moderate to high plasticity, thickly bedded; gravel and larger sized clasts comprise ~30-40% within gravel lenses, otherwise ~5% of the unit; clasts are subangular to subrounded dark yellowish orange (10YR $\frac{6}{6}$) to pale yellowish orange (10YR 8/6) to black (N1) quartzite, sandstone and dolomite; clasts are all <0.5” in diameter; unit gives a finely brecciated appearance; no slickensides observed.

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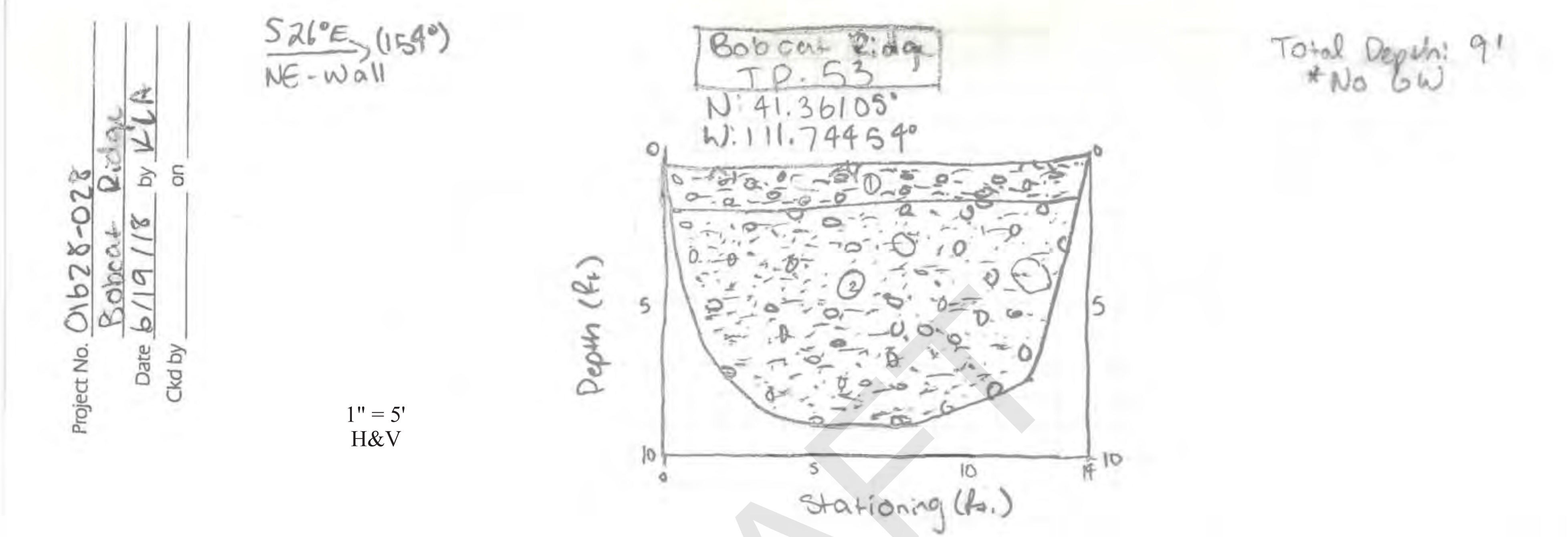
TP-52 Log

Figure

A-53



LITHOLOGIC UNIT DESCRIPTIONS

1. Undocumented Fill: ~1.5' thick; light brown (5YR $\frac{6}{4}$) silty lean CLAY with gravel (CL), medium stiff to stiff, dry to slightly moist, low plasticity, massive; gravel and larger sized clasts comprise ~20-25% of the unit; clasts are subrounded to angular moderate reddish orange (10R $\frac{6}{6}$) to medium gray (N5) to dark gray (N3) quartzite, sandstone, and dolomite; clasts are up to 2' in diameter at the surface and have a mode size of ~1"; abundant tree roots and wood fragments; sharp, planar basal contact.

2. Wasatch Formation: >7.5' thick; moderate reddish orange (10R $\frac{6}{6}$) to dark yellowish brown (10YR $\frac{4}{2}$) clayey SAND with gravel (SC) gradational to sandy lean CLAY with gravel (CL), medium dense to dense, moist to wet, low plasticity fines, massive; gravel and larger sized clasts comprise ~30-35% of the unit; clasts are subrounded to subangular moderate reddish orange (10R $\frac{6}{6}$) to very pale orange (10YR $\frac{8}{2}$) to grayish purple (5P $\frac{4}{2}$) quartzite with minor moderate reddish orange (10R $\frac{6}{6}$) sandstone; clasts are up to 1.5' in diameter, though mode clast size is ~1-3"; occasional tree and plant roots; traces of lean clay.

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TP-53 Log

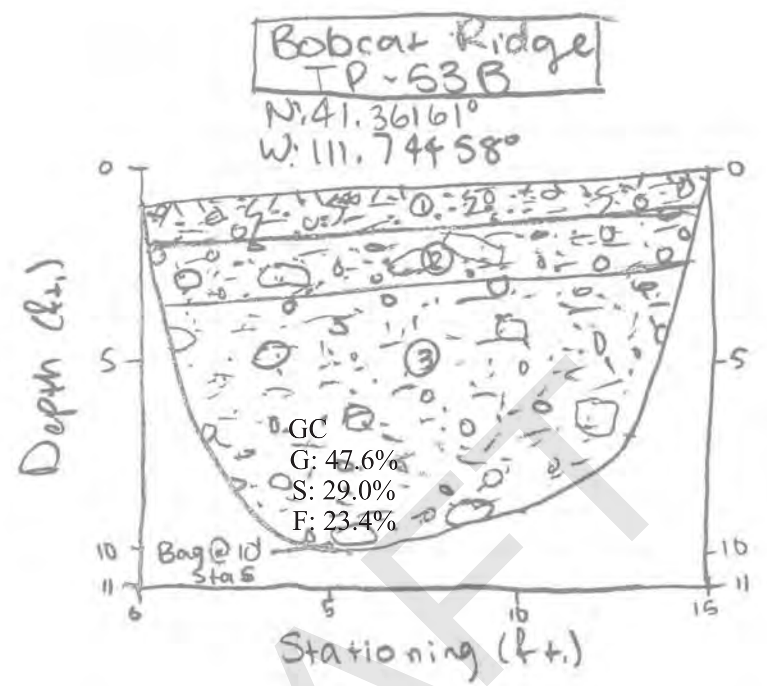
Figure A-54

Project No. 01628-028 Bobcat Ridge

Date 6/19/18 by KLP

Ckd by ______ on ______

S22°E (158°)
E-wall



Total Depth: 10'
* NO GW

1" = 5'
H&V

LITHOLOGIC UNIT DESCRIPTIONS

1. A/B Soil Horizon: ~1' thick; light brown (5YR $\frac{6}{4}$) sandy lean CLAY with gravel (CL), loose to medium stiff, dry, low plasticity, massive; gravel and larger sized clasts comprise ~10-20% of the unit; clasts are subrounded to subangular light brown (5YR $\frac{6}{4}$) to medium gray (N5) quartzite up to ~4" in diameter, though mode clast size ~0.5-1"; abundant plant and tree roots; gradational, irregular basal contact.

2. Colluvium: ~1.5' thick; light brown (5YR $\frac{6}{4}$) sandy lean CLAY with gravel (CL), loose to medium stiff, slightly moist to moist, low plasticity, massive; gravel and larger sized clasts comprise ~30% of the unit; clasts are subrounded to subangular quartzite as above up to 2" in diameter, though mode clast size is ~1-2"; topsoil matrix; abundant plant roots; sharp, planar basal contact.

3. Wasatch Formation: >7' thick; moderate reddish orange (10R $\frac{6}{6}$) to dark yellowish brown (10YR $\frac{4}{2}$) clayey SAND with gravel (SC), dense, moist, low plasticity fines, massive; gravel and larger sized clasts comprise ~30-35% of the unit; clasts are subrounded to subangular moderate reddish orange (10R $\frac{6}{6}$) to very pale orange (10YR $\frac{8}{2}$) to grayish purple (5P $\frac{4}{2}$) quartzite with minor moderate reddish orange (10R $\frac{6}{6}$) sandstone; clasts are up to 1.5' in diameter, though mode clast size is ~1-3"; occasional tree and plant roots; traces of lean clay.

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Weber County, Utah

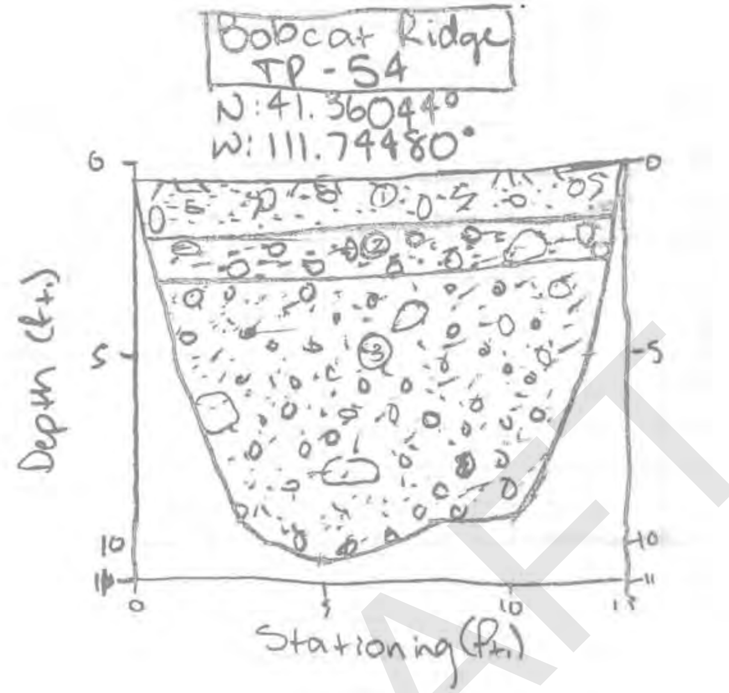
TP-53B Log

Figure A-55

Project No. 01628-028
Bobcat Ridge
Date 6/19/18 by KLA
Ckd by ______ on ______

S35°E (145°)
NE-wall

Total Depth: 10.5'
*No GW encountered



1" = 5'
H&V

DRAFT

LITHOLOGIC UNIT DESCRIPTIONS

1. **A/B Soil Horizon:** ~1.5' thick; light brown (5YR $\frac{6}{4}$) sandy lean CLAY with gravel (CL), loose to medium stiff, slightly moist, low plasticity, massive; gravel and larger sized clasts comprise ~20-25% of the unit; clasts are subrounded to subangular light brown (5YR $\frac{6}{4}$) to medium gray (N5) quartzite up to 4" in diameter, though mode clast size ~0.5-1"; abundant plant and tree roots; gradational, irregular basal contact.

2. **Colluvium**: ~1' thick; light brown (5YR $\frac{6}{4}$) sandy lean CLAY with gravel (CL), loose to medium stiff, moist, low plasticity fines, massive; gravel and larger sized clasts comprise ~30% of the unit; clasts are subrounded to subangular quartzite as above up to 2" in diameter, though mode clast size is ~1-2"; topsoil matrix; abundant plant roots; sharp, planar basal contact.

3. **Wasatch Formation**: >7' thick; moderate reddish orange (10R $\frac{6}{6}$) dark yellowish brown (10YR $\frac{4}{2}$) gravelly SAND (SW), medium dense to dense, moist, low plasticity fines, massive; gravel and larger sized clasts comprise ~30-35% of the unit; clasts are subrounded to subangular moderate reddish orange (10R $\frac{6}{6}$) to very pale orange (10YR $\frac{8}{2}$) to grayish purple (5P $\frac{4}{2}$) quartzite with minor moderate reddish orange (10R $\frac{6}{6}$) sandstone; clasts are up to 1.5' in diameter, though mode clast size is ~1-3"; occasional tree and plant roots; traces of lean clay.

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TP-54 Log

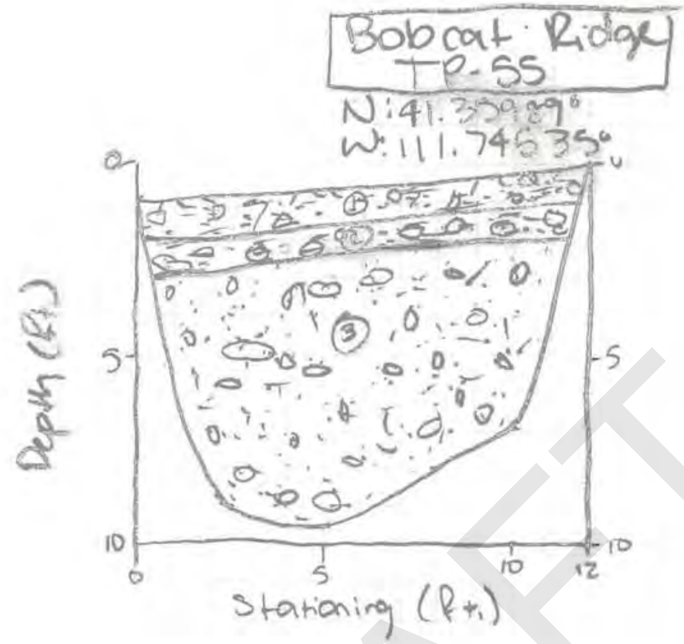
Figure

A-56

Project No. 01628-028 Bobcat Ridge
Date 6/19/18 by KLA
Ckd by ______ on ______

S29°E (161°)
E wall

Total Depth: 9.5'
* No GW seepage



1" = 5'
H&V

LITHOLOGIC UNIT DESCRIPTIONS

1. **A/B Soil Horizon:** ~1' thick; light brown (5YR $\frac{6}{4}$) sandy lean CLAY with gravel (CL), loose to medium stiff, slightly moist, low plasticity, massive; gravel and larger sized clasts comprise ~20-25% of the unit; clasts are subrounded to subangular light brown (5YR $\frac{6}{4}$) to medium gray (N5) quartzite up to 4" in diameter, though mode clast size ~0.5-1"; abundant plant and tree roots; gradational, irregular basal contact.

2. **Colluvium**: ~1' thick; light brown (5YR $\frac{6}{4}$) sandy lean CLAY with gravel (CL), loose to medium stiff, moist, low plasticity fines, massive; gravel and larger sized clasts comprise ~30% of the unit; clasts are subrounded to subangular quartzite as above up to 2" in diameter, though mode clast size is ~1-2"; topsoil matrix; abundant plant roots; sharp, planar basal contact.

3. **Wasatch Formation**: >7' thick; moderate reddish orange (10R $\frac{6}{6}$) to dark yellowish brown (10YR $\frac{4}{2}$) gravelly SAND (SW), medium dense to dense, moist, low plasticity fines, massive; gravel and larger sized clasts comprise ~30-35% of the unit; clasts are subrounded to subangular moderate reddish orange (10R $\frac{6}{6}$) to very pale orange (10YR $\frac{8}{2}$) to grayish purple (5P $\frac{4}{2}$) quartzite with minor moderate reddish orange (10R $\frac{6}{6}$) sandstone; clasts are up to 1.5' in diameter, though mode clast size is ~1-3"; occasional tree and plant roots; traces of lean clay.

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TP-55 Log

Figure A-57

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.

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KEY TO SOIL SYMBOLS AND TERMINOLOGY

Project No. **01628-028**

Engr. **DAG**

Drafted By **DAG**

Date **July 2018**

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Figure A-58

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

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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. 01628-028
Engr. DAG
Drafted By DAG
Date July 2018

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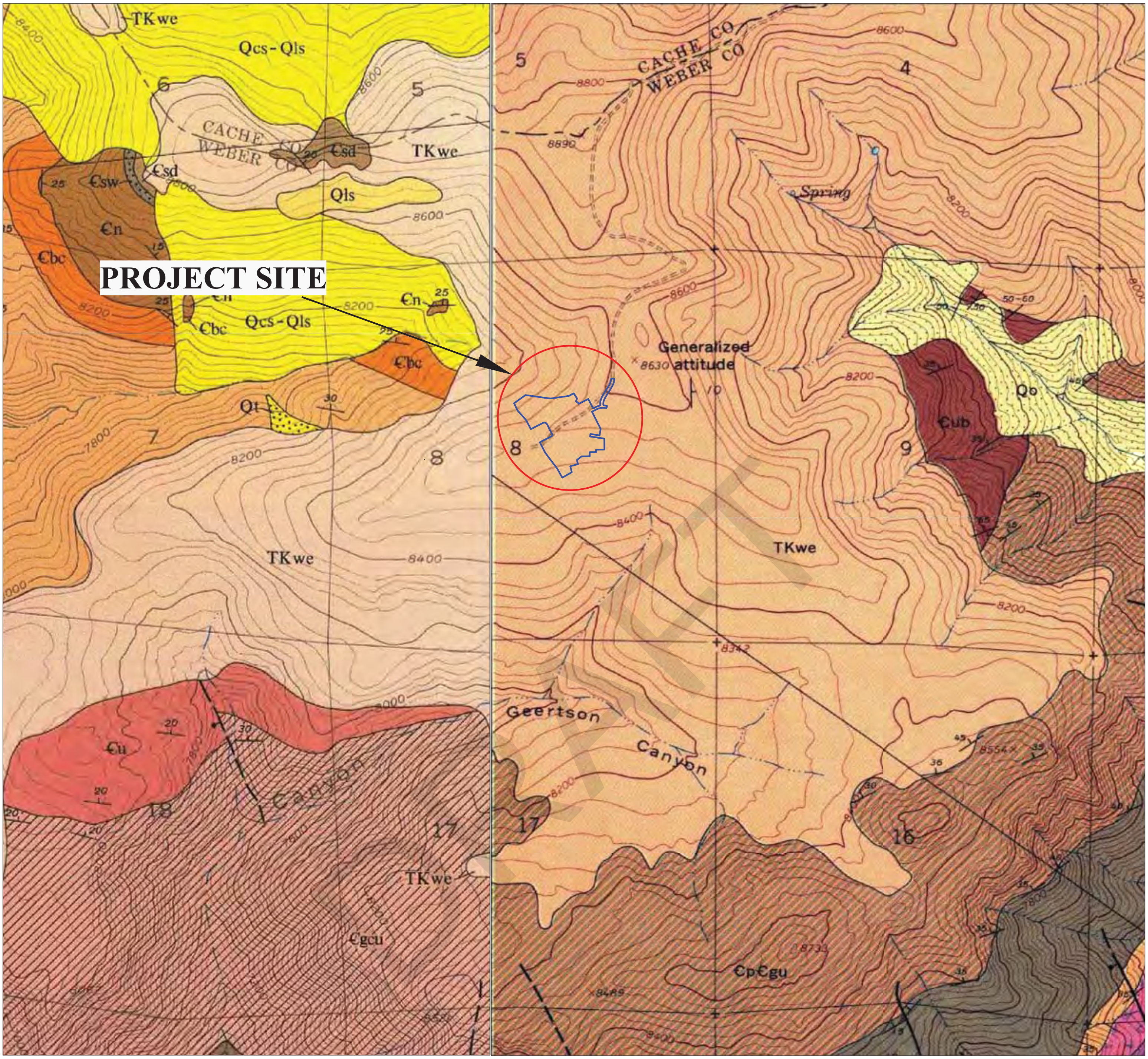
Intermountain Geo-Environmental Services, Inc.

Figure A-59



Base Maps:

-USGS *Huntsville Quadrangle,* 1:24,000 scale, map GQ-1503, Sorensen and Crittenden (1979)

-USGS *Brown's Hole Quadrangle,* 1:24,000 scale, map GQ-968, Crittenden (1979)

N

0 1000 2000
FEET

1" = 2000'

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Geotechnical and Geologic Hazards Assessment
Bobcat Ridge Subdivision
Summit Powder Mountain Resort
Weber County, Utah

Regional Geology Map 1

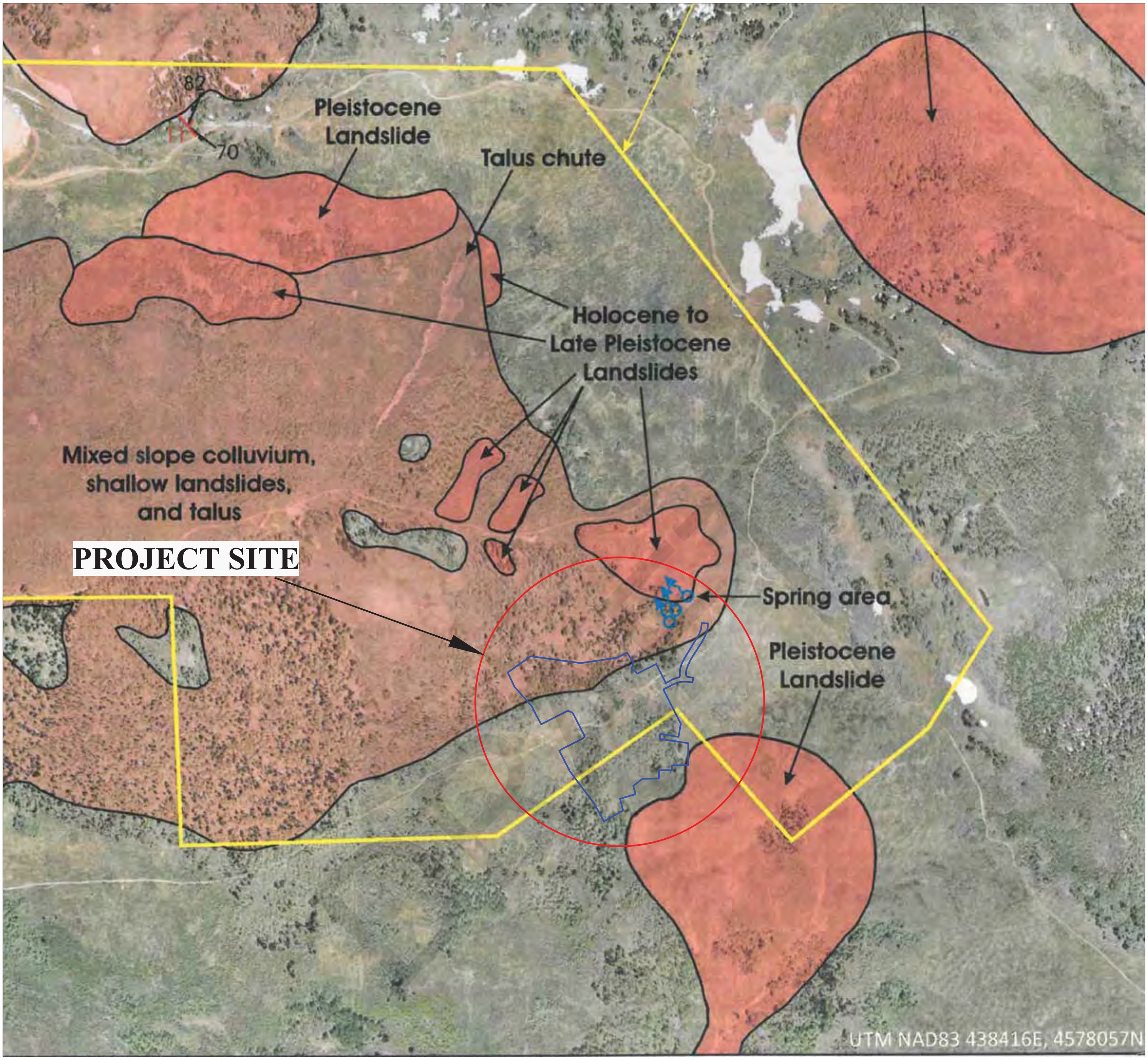
Figure

A-60a

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

DRAFT



Base Map:

-Western Geologic (2012)
Geologic Hazards Reconnaissance Report,
Figure 3

N

0 500 1000
FEET
1" = 1000'

UTAH
QUADRANGLE LOCATION

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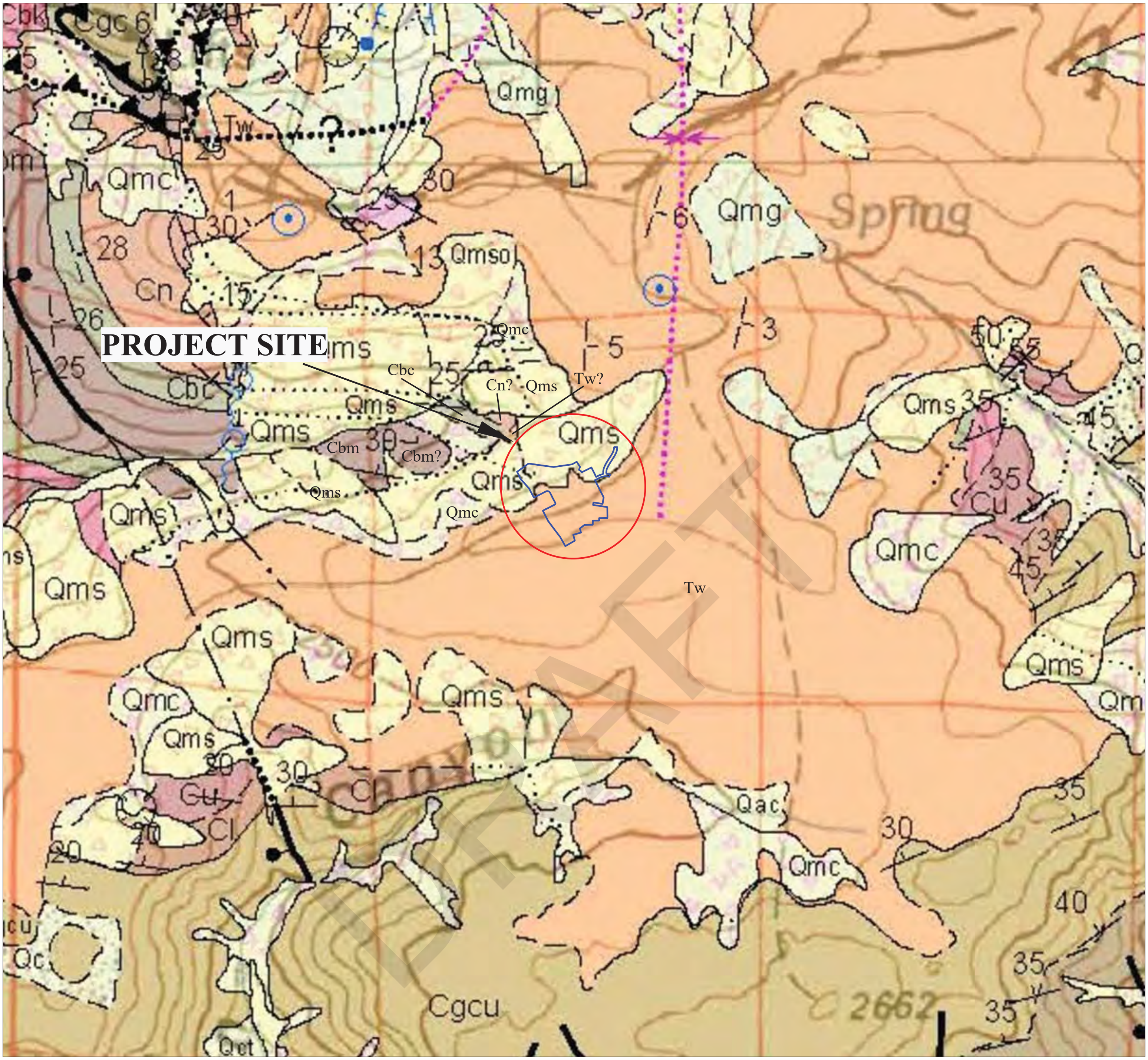
Geotechnical and Geologic Hazards Assessment
Bobcat Ridge Subdivision
Summit Powder Mountain Resort
Weber County, Utah

Regional Geology Map 2

Figure

A-61



Base Map:

-UGS *Ogden 30'x60' Geologic Quadrangle*, 1:62,500 scale, map OFR-635DM, Coogan and King (2016).

N

0 1000 2000
FEET

1" = 2000'

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Geotechnical and Geologic Hazards Assessment
Bobcat Ridge Subdivision
Summit Powder Mountain Resort
Weber County, Utah

Regional Geology Map 3

Figure

A-62a

LEGEND

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

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

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

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).

DRAFT

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.

Along the South Fork Ogden River, Wasatch strata are mostly pebble, cobble, and boulder conglomerate with a matrix of smaller gravel, sand, and silt in the Browns Hole quadrangle, and coarse-grained sandstone to granule conglomerate as well as siltstone and mudstone to the east in the Causey Dam quadrangle; note thinning to east away from source area. The Wasatch weathers to boulder-covered dip(?) slopes north of the South Fork Ogden River, for example in Evergreen Park. Along the South Fork, the Wasatch Formation is separated from the underlying Hams Fork Member of the Evanston Formation by an angular unconformity of a few degrees, with the Hams Fork containing less siltstone and mudstone than the Wasatch and having a lighter color.

The Herd Mountain surface is developed on the Wasatch Formation at elevations of 7600 to 8600 feet (2300-2620 m) in the Bybee Knoll quadrangle and in remnants in the Huntsville, Browns Hole, and Sharp Mountain quadrangles. The origin of this boulder-strewn surface is debated (see Eardley, 1944; Hafen, 1961; Mullens, 1971). Eardley's (1944) Herd Mountain surface is flat lying or gently east dipping, about the same as the underlying Wasatch Formation, and is strewn with quartzite boulders to pebbles that King thinks are residual and colluvial deposits of uncertain age that were derived from the Wasatch Formation. The other characteristic of this surface is the presence of pimple mounds and, given the elevations of greater than about 7500 feet (2300 m), possible periglacial patterned ground. Photogrammetric dips on the Wasatch Formation under the surface are nearly flat ($<3^{o}$) and an apparent angular unconformity is present in the Wasatch since dips on older Wasatch strata are greater than 3 degrees. King mapped this unconformity as a marker bed, but Coogan does not agree that this is an unconformity.

DRAFT

LEGEND

Cn, Cn? **Nounan Formation (Upper Cambrian)** – Medium-gray to dark-gray, very thick to thick-bedded, light to medium gray and tan-weathering, typically cliff forming, variably sandy and silty dolomite and lesser limestone, with crude laminae to partings and mottling of sandstone and siltstone that weather tan or reddish; little sandstone and siltstone in more resistant lower part; about 600 to 1150 feet (180-350 m) thick.

The Nounan Formation thickness range in our map area is based on numerous studies. It is about 800 feet (245 m) thick in the Huntsville quadrangle, using Coogan's mapping of about 300 feet (90 m) each of the Blacksmith and Langston Formations; about 900- and 999-foot (275 and 300 m) thicknesses reported at the South Fork Little Bear River in the James Peak quadrangle (Ezell, 1953; Gardiner, 1974; respectively) and 1145 feet (350 m) thick at Sharp Mountain (Hafen, 1961). To the east the Nounan thins southward from 1025 feet (312.5 m) thick in the Curtis Ridge quadrangle (Hansen, 1964) to 800 feet (245 m) thick in Sugar Pine Canyon (Creek) in the Dairy Ridge quadrangle (Gardiner, 1974; Coogan, 2006a) to 675 feet (205 m) thick in the Horse Ridge quadrangle (Coogan, 2006b). The Nounan is about 630 feet (190 m) thick in the Causey Dam quadrangle (Mullens, 1969), possibly the "average" of the 571 feet (174 m) and 696 feet (210 m) measured by Rigo (1968, aided by Mullens) and Gardiner (1974), respectively, on Baldy Ridge in the quadrangle, with Gardiner's (1974) thickness more closely matching Mullens' (1969) mapped thickness. So the Nounan thins to the south and east over the Tooele arch (see Hintze, 1959).

Williams (1948) reported that the Nounan was Late Cambrian in age, using unpublished fossil collections (in part from Maxey, 1941). In the Wellsville Mountains north of our map, Oviatt (1986) reported the upper Nounan was Dresbachian (Late Cambrian) in age based on *Dunderbergia*(?) and *Crepicephalus* zone trilobite fauna.

Cbc, Cbc?

Calls Fort Shale Member (Middle Cambrian) – Brown-weathering, slope-forming, olive-gray to tan-gray, thin bedded, shale and micaceous argillite with minor, thin-bedded, dark-gray, silty limestone; *Bolaspidella* sp. trilobite fossils reported by Rigo (1968, USGS No. 5965-CO) in the Causey Dam quadrangle; 75 to 125 feet (23-40 m) thick on the leading edge of the Willard thrust sheet (Coogan, 2006a-b; see Rigo, 1968, aided by Mullens), 100 to 120 feet (30-35 m) thick in Causey Dam quadrangle (King this report), and about 400 feet (120 m) thick in Huntsville quadrangle (King this report).

Cbm, Cbm?

Middle limestone member (Middle Cambrian) – Dark to medium-gray, thick- to thin-bedded, argillaceous limestone with tan-, yellow-, and red-weathering, wavy, silty layers and partings; contains subordinate olive-gray and tan-gray, thin-bedded, shale and micaceous argillite; typically forms "rib" or cliff between less resistant shale members; on leading edge of Willard thrust sheet, thickens southward from 425 feet (130 m) along Sugar Pine Creek, Dairy Ridge quadrangle, to 850 feet (260 m) along Sawmill Canyon, Horse Ridge quadrangle (Coogan, 2006a-b), and 548 feet (167 m) thick at Baldy Ridge section (Rigo, 1968, aided by Mullens) in Causey Dam or Horse Ridge quadrangle, but may be faulted, since about 400 feet (120 m) thick on flanks of Baldy and Knighton Ridges (King this report); 680 feet (200 m) thick in Huntsville quadrangle (Coogan, this report).

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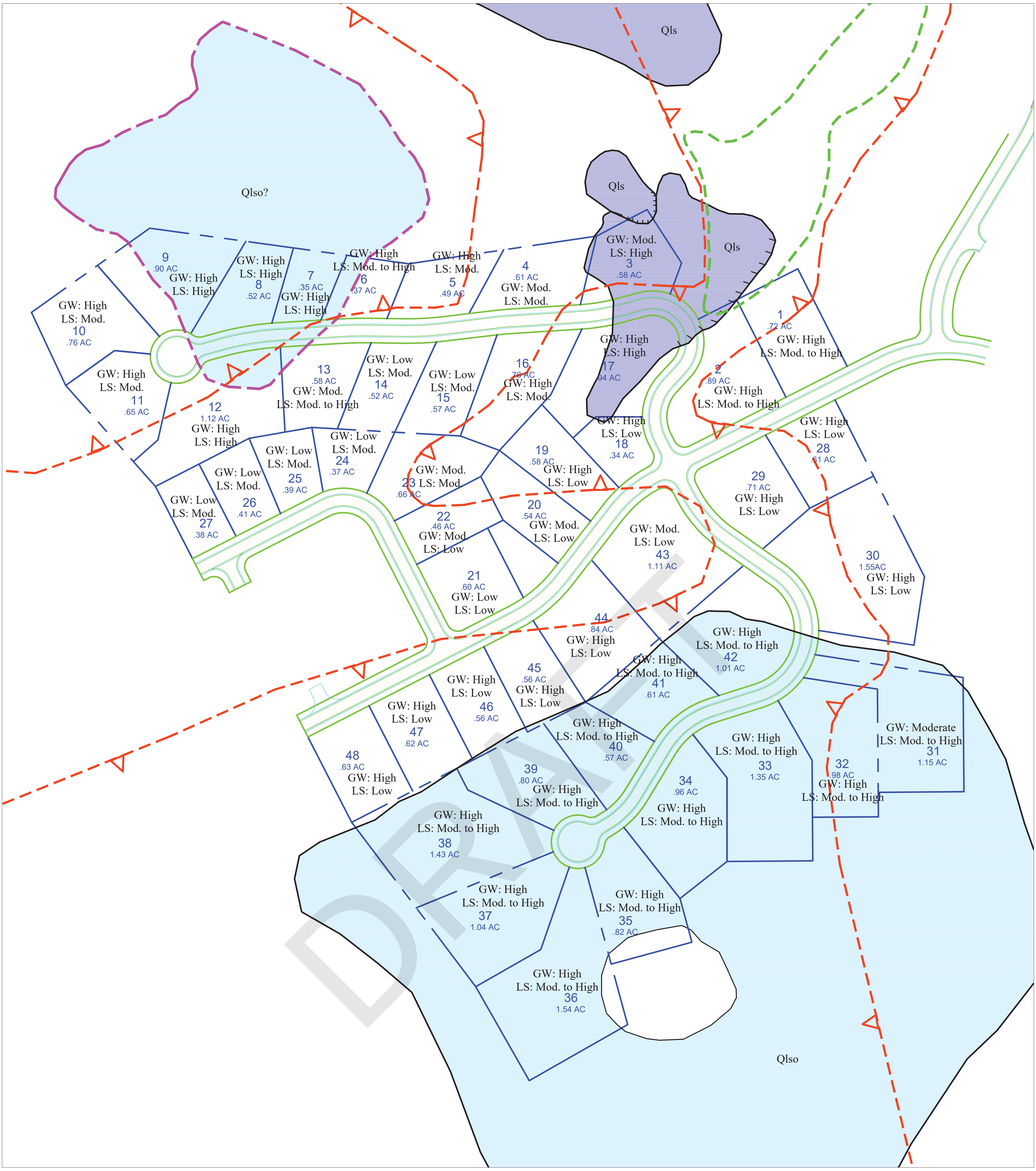

Basemap:

-Bobcat Ridge Preliminary Plat, provided by Talisman Civil Consultants, dated 7-12-2018

*All Geologic Contacts Approximate

N

0 100 200
FEET
1" = 200'

LEGEND

- Qls — Landslide Deposit (Holocene-aged)
- Qlso — Older landslide deposit (Pleistocene-aged)
- Area of Standing Water
- Project Boundary
- Deeper clay seam area; possible older landslide
- Landslide Scarp
- Area of Shallow Groundwater (<10' below existing grade) Triangle points in direction of groundwater

GW: Shallow Groundwater Hazard
LS: Landslide Hazard

IGES®
Project No: 01628-028

Geotechnical and Geologic Hazards Assessment
Bobcat Ridge Subdivision
Summit Powder Mountain Resort
Weber County, Utah

Geologic Hazard Classification Map

Figure
A-63

APPENDIX B

DRAFT

Water Content and Unit Weight of Soil

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

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Project: **Bobcat Ridge**
No: **01628-028**
Location: Powder Mountain, Weber Co., UT
Date: 7/6/2018
By: BRR/JP

Sample Info.	Boring No.	TP-2	TP-5	TP-6	TP-8	TP-12	TP-24	TP-34	TP-37
	Station	7	30	5	6	10	6.5	13	4
	Depth	12.0'	8.0'	3.5'	12.0'	10.0'	3.0'	10.0'	9.0'
	Split	No	Yes	No	No	No	No	Yes	No
	Split sieve		3/8"					3/8"	
	Total sample (g)		4007.14					4125.79	
	Moist coarse fraction (g)		1633.40					1070.99	
	Moist split fraction (g)		2373.74					3054.80	
	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)		2456.50					1806.74	
	Dry soil + tare (g)		2388.17					1790.75	
	Tare (g)		882.10					171.27	
	Water content (%)		4.5					1.0	
Split Fraction	Wet soil + tare (g)	457.31	468.03	375.85	362.12	541.14	674.08	407.42	548.46
	Dry soil + tare (g)	347.13	432.66	328.07	296.91	459.62	562.49	383.89	486.81
	Tare (g)	127.01	160.24	127.49	152.69	121.87	127.69	171.27	151.56
	Water content (%)	50.1	13.0	23.8	45.2	24.1	25.7	11.1	18.4
	Water Content, w (%)	**50.1**	**9.4**	**23.8**	**45.2**	**24.1**	**25.7**	**8.3**	**18.4**
	Dry Unit Wt., γ_d (pcf)								

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Entered by:___________
Reviewed:___________

Water Content and Unit Weight of Soil

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

IGES
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Project: **Bobcat Ridge**
No: **01628-028**
Location: Powder Mountain, Weber Co., UT
Date: 7/9/2018
By: BSS

Sample Info.	Boring No.	TP-41	TP-51						
	Station:	26	9						
	Depth:	6.0'	9.5'						
Unit Weight Info.	Sample height, H (in)	4.881	4.655						
	Sample diameter, D (in)	2.411	2.401						
	Sample volume, V (ft^3)	0.0129	0.0122						
	Mass rings + wet soil (g)	868.74	924.96						
	Mass rings/tare (g)	246.42	242.28						
	Moist soil, Ws (g)	622.32	682.68						
	Moist unit wt., γ_m (pcf)	106.39	123.40						
Water Content	Wet soil + tare (g)	749.68	808.67						
	Dry soil + tare (g)	571.42	658.80						
	Tare (g)	127.89	126.48						
Water Content, w (%)		**40.2**	**28.2**						
Dry Unit Wt., γ_d (pcf)		**75.9**	**96.3**						
Comments:		Sample was disturbed, and contained air voids.							

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Reviewed:___________

Liquid Limit, Plastic Limit, and Plasticity Index of Soils
(ASTM D4318)

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Project: Bobcat Ridge
No: 01628-028
Location: Powder Mountain, Weber Co., UT
Date: 7/3/2018
By: BRR

Boring No.: TP-1
Station: 16
Depth: 4.0'
Description: Reddish brown fat clay

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

Preparation method: Wet
Liquid limit test method: Multipoint
Screened over No.40: Yes
Larger particles removed: Wet sieved
Approximate maximum grain size: No.10
Estimated percent retained on No.40: Not requested
As-received water content (%): Not requested

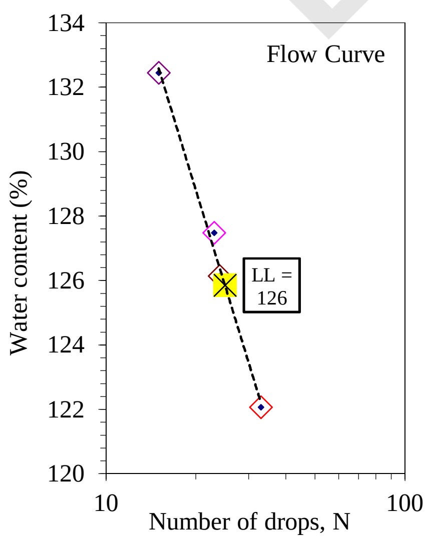
Plastic Limit

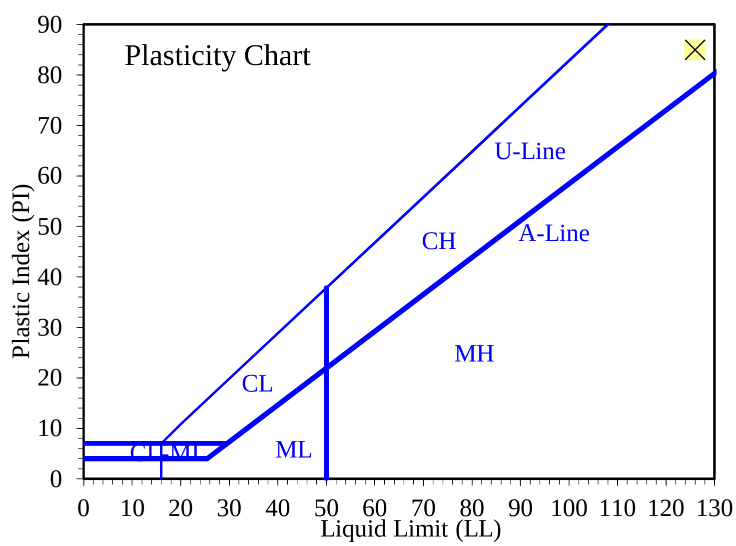
Determination No	1	2				
Wet Soil + Tare (g)	12.57	13.70				
Dry Soil + Tare (g)	10.77	11.76				
Water Loss (g)	1.80	1.94				
Tare (g)	6.42	7.08				
Dry Soil (g)	4.35	4.68				
Water Content, w (%)	41.38	41.45				

Liquid Limit

Determination No	1	2	3	4		
Number of Drops, N	33	23	15	24		
Wet Soil + Tare (g)	13.42	13.55	14.07	13.52		
Dry Soil + Tare (g)	10.10	10.07	10.11	9.90		
Water Loss (g)	3.32	3.48	3.96	3.62		
Tare (g)	7.38	7.34	7.12	7.03		
Dry Soil (g)	2.72	2.73	2.99	2.87		
Water Content, w (%)	122.06	127.47	132.44	126.13		
One-Point LL (%)		126		126		

Liquid Limit, LL (%)	**126**
Plastic Limit, PL (%)	**41**
Plasticity Index, PI (%)	**85**





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Liquid Limit, Plastic Limit, and Plasticity Index of Soils

(ASTM D4318)

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Project: **Bobcat Ridge**
No: **01628-028**
Location: Powder Mountain, Weber Co., UT
Date: 7/10/2018
By: BRR

Boring No.: **TP-2**
Station: **7**
Depth: **12.0'**
Description: Light brown fat 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: No.4
Estimated percent retained on No.40: Not requested
As-received water content (%): 50.1

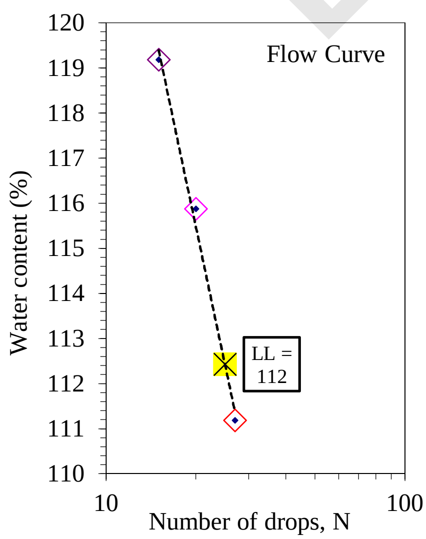
Plastic Limit

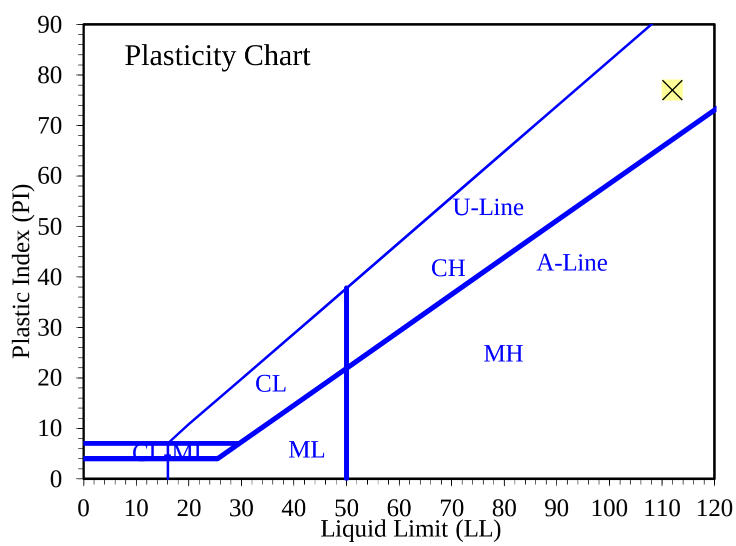
Determination No	1	2				
Wet Soil + Tare (g)	13.65	14.08				
Dry Soil + Tare (g)	11.97	12.27				
Water Loss (g)	1.68	1.81				
Tare (g)	7.09	7.08				
Dry Soil (g)	4.88	5.19				
Water Content, w (%)	34.43	34.87				

Liquid Limit

Determination No	1	2	3			
Number of Drops, N	27	20	15			
Wet Soil + Tare (g)	14.03	13.92	13.48			
Dry Soil + Tare (g)	10.35	10.27	10.00			
Water Loss (g)	3.68	3.65	3.48			
Tare (g)	7.04	7.12	7.08			
Dry Soil (g)	3.31	3.15	2.92			
Water Content, w (%)	111.18	115.87	119.18			
One-Point LL (%)	112	113				

Liquid Limit, LL (%)	**112**
Plastic Limit, PL (%)	**35**
Plasticity Index, PI (%)	**77**





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Liquid Limit, Plastic Limit, and Plasticity Index of Soils

(ASTM D4318)

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Project: Bobcat Ridge
No: 01628-028
Location: Powder Mountain, Weber Co., UT
Date: 7/10/2018
By: DKS/BRR

Boring No.: TP-3
Station: 26
Depth: 9.5'
Description: Reddish brown fat clay

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

Preparation method: Wet
Liquid limit test method: Multipoint
Screened over No.40: No
Larger particles removed: Mixed on glass plate
Approximate maximum grain size: No.40
Estimated percent retained on No.40: Not requested
As-received water content (%): Not requested

Plastic Limit

Determination No	1	2				
Wet Soil + Tare (g)	14.02	13.42				
Dry Soil + Tare (g)	12.17	11.74				
Water Loss (g)	1.85	1.68				
Tare (g)	7.01	7.07				
Dry Soil (g)	5.16	4.67				
Water Content, w (%)	35.85	35.97				

Liquid Limit

Determination No	1	2	3			
Number of Drops, N	35	29	18			
Wet Soil + Tare (g)	16.77	14.35	14.64			
Dry Soil + Tare (g)	12.39	10.95	11.01			
Water Loss (g)	4.38	3.40	3.63			
Tare (g)	7.37	7.11	7.06			
Dry Soil (g)	5.02	3.84	3.95			
Water Content, w (%)	87.25	88.54	91.90			
One-Point LL (%)		90				

Liquid Limit, LL (%)	**90**
Plastic Limit, PL (%)	**36**
Plasticity Index, PI (%)	**54**

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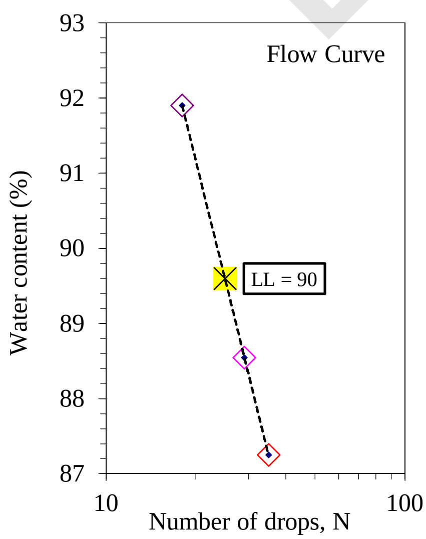

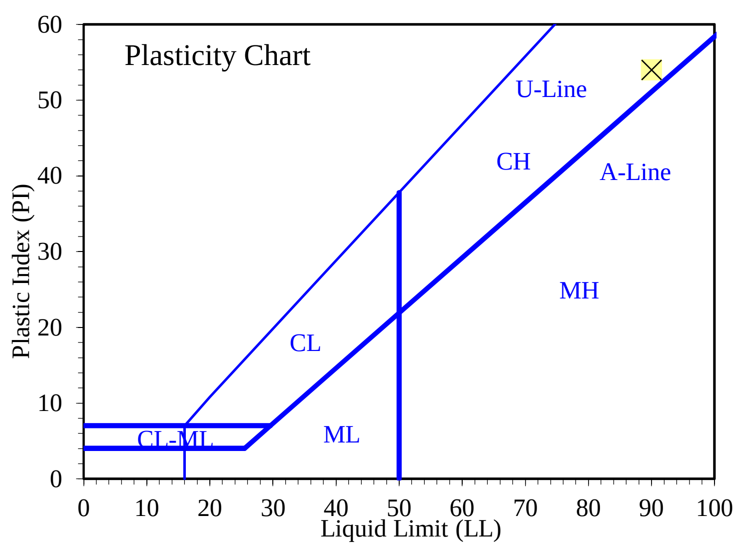

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Liquid Limit, Plastic Limit, and Plasticity Index of Soils

(ASTM D4318)

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Project: Bobcat Ridge
No: 01628-028
Location: Powder Mountain, Weber Co., UT
Date: 7/5/2018
By: BRR

Boring No.: TP-6
Station: 5
Depth: 3.5'
Description: Reddish brown fat 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: Not requested
As-received water content (%): 23.8

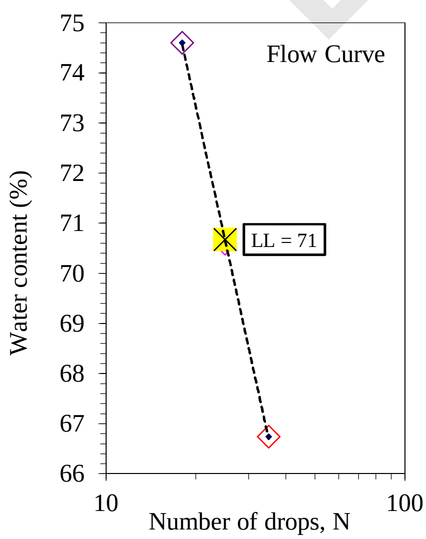
Plastic Limit

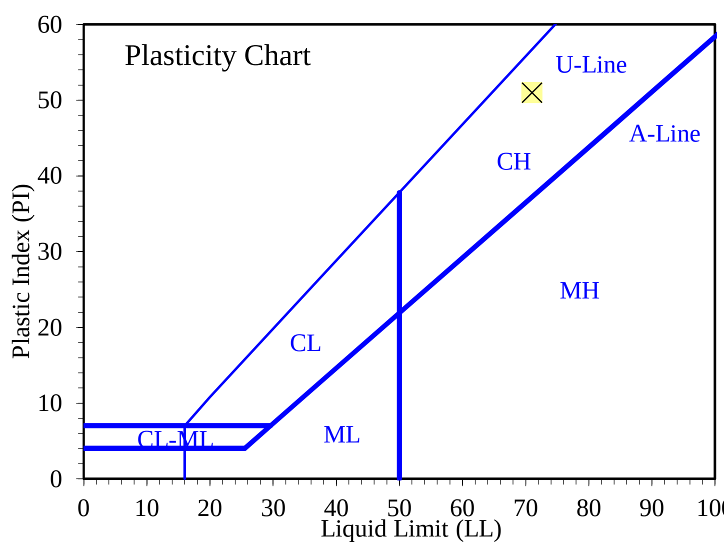
Determination No	1	2				
Wet Soil + Tare (g)	13.60	13.52				
Dry Soil + Tare (g)	12.51	12.46				
Water Loss (g)	1.09	1.06				
Tare (g)	7.04	7.08				
Dry Soil (g)	5.47	5.38				
Water Content, w (%)	19.93	19.70				

Liquid Limit

Determination No	1	2	3			
Number of Drops, N	35	25	18			
Wet Soil + Tare (g)	14.78	14.01	13.62			
Dry Soil + Tare (g)	11.71	11.25	10.83			
Water Loss (g)	3.07	2.76	2.79			
Tare (g)	7.11	7.34	7.09			
Dry Soil (g)	4.60	3.91	3.74			
Water Content, w (%)	66.74	70.59	74.60			
One-Point LL (%)		71				

Liquid Limit, LL (%)	**71**
Plastic Limit, PL (%)	**20**
Plasticity Index, PI (%)	**51**





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Liquid Limit, Plastic Limit, and Plasticity Index of Soils

(ASTM D4318)

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Project: Bobcat Ridge
No: 01628-028
Location: Powder Mountain, Weber Co., UT
Date: 7/6/2018
By: DKS

Boring No.: TP-8
Station: 6
Depth: 12.0'
Description: Light brown fat 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 (%): 45.2

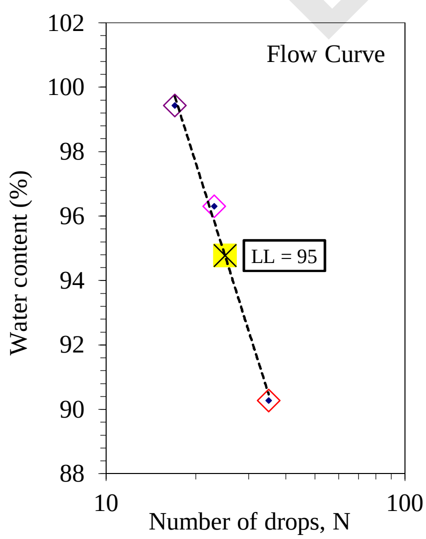
Plastic Limit

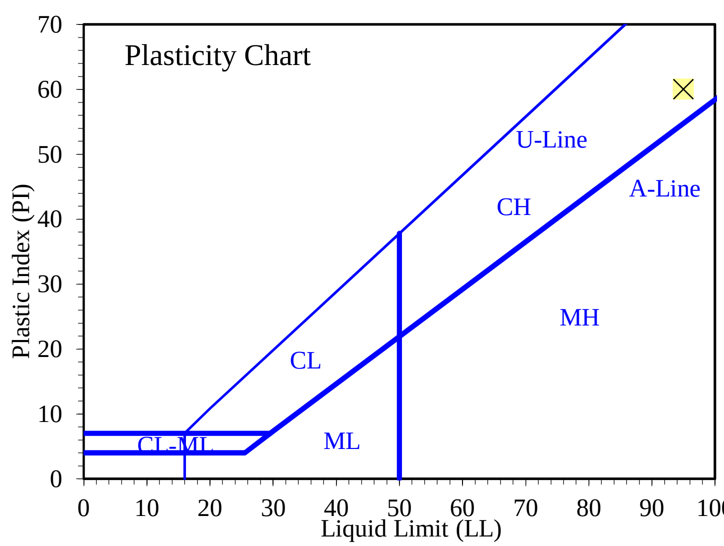
Determination No	1	2				
Wet Soil + Tare (g)	14.36	15.35				
Dry Soil + Tare (g)	12.47	13.21				
Water Loss (g)	1.89	2.14				
Tare (g)	7.09	7.07				
Dry Soil (g)	5.38	6.14				
Water Content, w (%)	35.13	34.85				

Liquid Limit

Determination No	1	2	3			
Number of Drops, N	35	23	17			
Wet Soil + Tare (g)	17.61	18.45	17.61			
Dry Soil + Tare (g)	12.60	12.99	12.33			
Water Loss (g)	5.01	5.46	5.28			
Tare (g)	7.05	7.32	7.02			
Dry Soil (g)	5.55	5.67	5.31			
Water Content, w (%)	90.27	96.30	99.44			
One-Point LL (%)		95				

Liquid Limit, LL (%)	**95**
Plastic Limit, PL (%)	**35**
Plasticity Index, PI (%)	**60**





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Liquid Limit, Plastic Limit, and Plasticity Index of Soils

(ASTM D4318)

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Project: **Bobcat Ridge**
No: **01628-028**
Location: Powder Mountain, Weber Co., UT
Date: 7/6/2018
By: DKS

Boring No.: **TP-12**
Station: **10**
Depth: **10.0'**
Description: Reddish brown fat 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: No.4
Estimated percent retained on No.40: Not requested
As-received water content (%): 24.1

Plastic Limit

Determination No	1	2				
Wet Soil + Tare (g)	15.45	15.23				
Dry Soil + Tare (g)	14.26	14.14				
Water Loss (g)	1.19	1.09				
Tare (g)	6.48	7.07				
Dry Soil (g)	7.78	7.07				
Water Content, w (%)	15.30	15.42				

Liquid Limit

Determination No	1	2	3			
Number of Drops, N	35	22	17			
Wet Soil + Tare (g)	17.59	20.42	16.79			
Dry Soil + Tare (g)	13.41	15.01	12.81			
Water Loss (g)	4.18	5.41	3.98			
Tare (g)	7.15	7.30	7.35			
Dry Soil (g)	6.26	7.71	5.46			
Water Content, w (%)	66.77	70.17	72.89			
One-Point LL (%)		69				

Liquid Limit, LL (%)	**69**
Plastic Limit, PL (%)	**15**
Plasticity Index, PI (%)	**54**

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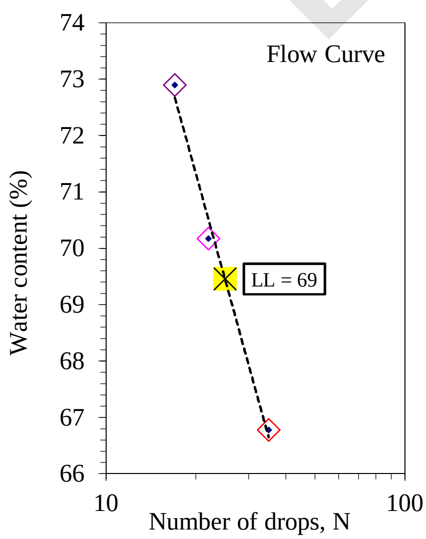

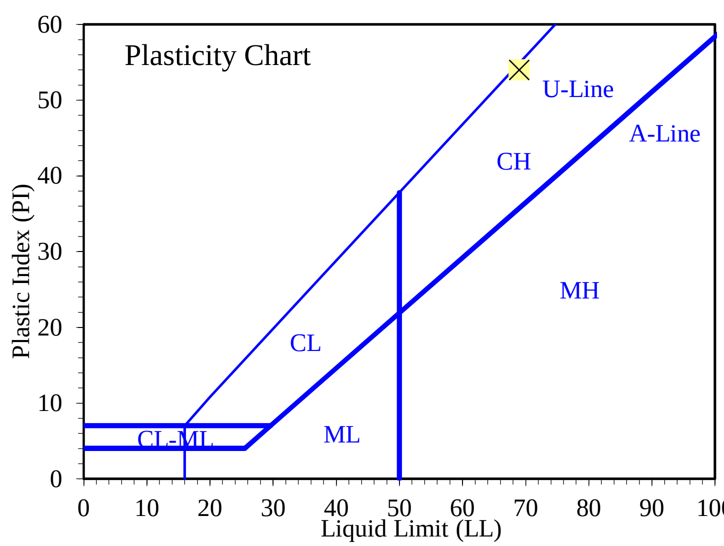

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Liquid Limit, Plastic Limit, and Plasticity Index of Soils

(ASTM D4318)

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Project: Bobcat Ridge
No: 01628-028
Location: Powder Mountain, Weber Co., UT
Date: 7/11/2018
By: BRR

Boring No.: TP-21
Station: 5
Depth: 5.5'
Description: Reddish brown lean clay

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

Preparation method: Wet
Liquid limit test method: Multipoint
Screened over No.40: Yes
Larger particles removed: Wet sieved
Approximate maximum grain size: No.10
Estimated percent retained on No.40: Not requested
As-received water content (%): Not requested

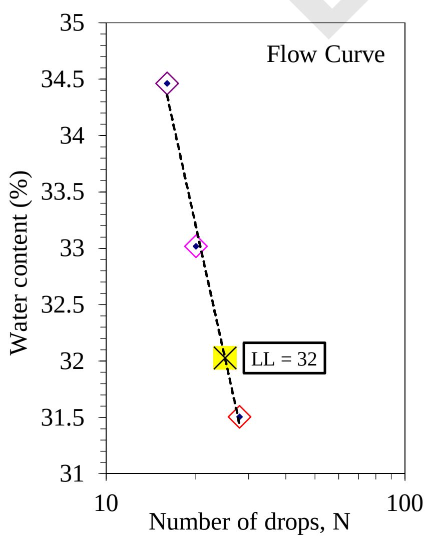
Plastic Limit

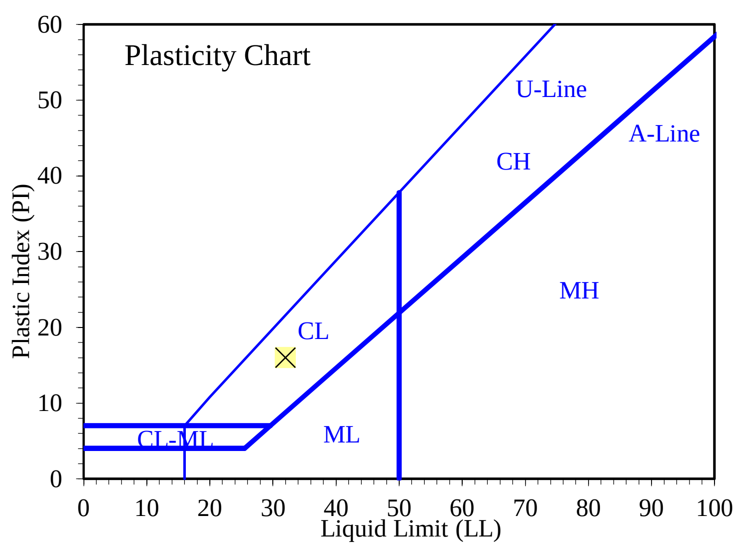
Determination No	1	2				
Wet Soil + Tare (g)	15.02	14.50				
Dry Soil + Tare (g)	13.90	13.46				
Water Loss (g)	1.12	1.04				
Tare (g)	7.05	7.07				
Dry Soil (g)	6.85	6.39				
Water Content, w (%)	16.35	16.28				

Liquid Limit

Determination No	1	2	3			
Number of Drops, N	28	20	16			
Wet Soil + Tare (g)	14.46	15.51	13.79			
Dry Soil + Tare (g)	12.68	13.43	12.06			
Water Loss (g)	1.78	2.08	1.73			
Tare (g)	7.03	7.13	7.04			
Dry Soil (g)	5.65	6.30	5.02			
Water Content, w (%)	31.50	33.02	34.46			
One-Point LL (%)	32	32				

Liquid Limit, LL (%)	**32**
Plastic Limit, PL (%)	**16**
Plasticity Index, PI (%)	**16**





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Liquid Limit, Plastic Limit, and Plasticity Index of Soils
(ASTM D4318)

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Project: Bobcat Ridge
No: 01628-028
Location: Powder Mountain, Weber Co., UT
Date: 7/11/2018
By: BRR

Boring No.: TP-22
Station: 18
Depth: 10.5'
Description: Reddish brown fat clay

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

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

Plastic Limit

Determination No	1	2				
Wet Soil + Tare (g)	13.34	13.96				
Dry Soil + Tare (g)	12.23	12.75				
Water Loss (g)	1.11	1.21				
Tare (g)	6.44	6.43				
Dry Soil (g)	5.79	6.32				
Water Content, w (%)	19.17	19.15				

Liquid Limit

Determination No	1	2	3			
Number of Drops, N	30	24	17			
Wet Soil + Tare (g)	13.43	13.86	13.17			
Dry Soil + Tare (g)	10.73	10.88	10.55			
Water Loss (g)	2.70	2.98	2.62			
Tare (g)	7.06	7.08	7.34			
Dry Soil (g)	3.67	3.80	3.21			
Water Content, w (%)	73.57	78.42	81.62			
One-Point LL (%)	75	78				

Liquid Limit, LL (%)	**77**
Plastic Limit, PL (%)	**19**
Plasticity Index, PI (%)	**58**

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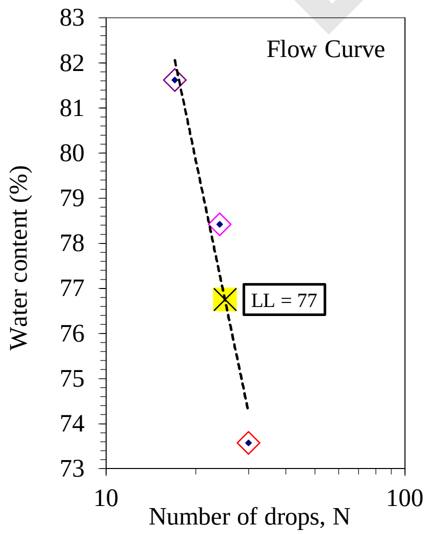

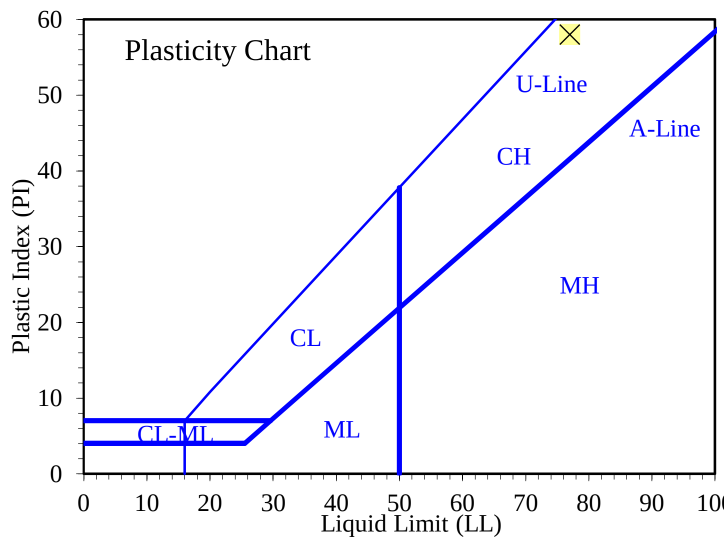

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Liquid Limit, Plastic Limit, and Plasticity Index of Soils

(ASTM D4318)

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Project: Bobcat Ridge
No: 01628-028
Location: Powder Mountain, Weber Co., UT
Date: 7/10/2018
By: BRR
Grooving tool type: Plastic
Liquid limit device: Mechanical
Rolling method: Hand

Boring No.: TP-24
Station: 6.5
Depth: 3.0'
Description: Reddish brown fat clay

Preparation method: Wet
Liquid limit test method: Multipoint
Screened over No.40: Yes
Larger particles removed: Wet sieved
Approximate maximum grain size: 1-1/2"
Estimated percent retained on No.40: Not requested
As-received water content (%): 25.7

Plastic Limit

Determination No	1	2				
Wet Soil + Tare (g)	13.32	13.29				
Dry Soil + Tare (g)	12.21	12.21				
Water Loss (g)	1.11	1.08				
Tare (g)	7.10	7.13				
Dry Soil (g)	5.11	5.08				
Water Content, w (%)	21.72	21.26				

Liquid Limit

Determination No	1	2	3			
Number of Drops, N	35	26	16			
Wet Soil + Tare (g)	13.29	13.66	14.34			
Dry Soil + Tare (g)	11.03	11.35	11.54			
Water Loss (g)	2.26	2.31	2.80			
Tare (g)	7.07	7.47	7.15			
Dry Soil (g)	3.96	3.88	4.39			
Water Content, w (%)	57.07	59.54	63.78			
One-Point LL (%)		60				

Liquid Limit, LL (%)	**60**
Plastic Limit, PL (%)	**21**
Plasticity Index, PI (%)	**39**

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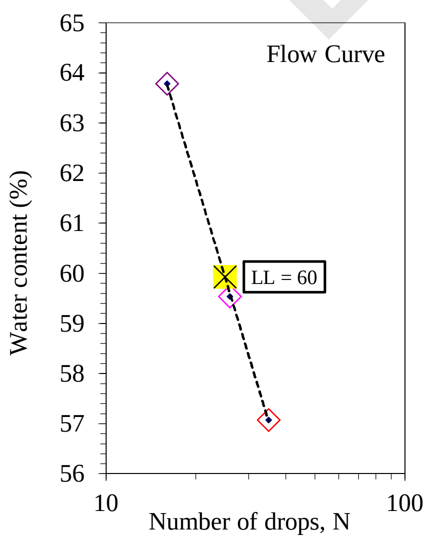

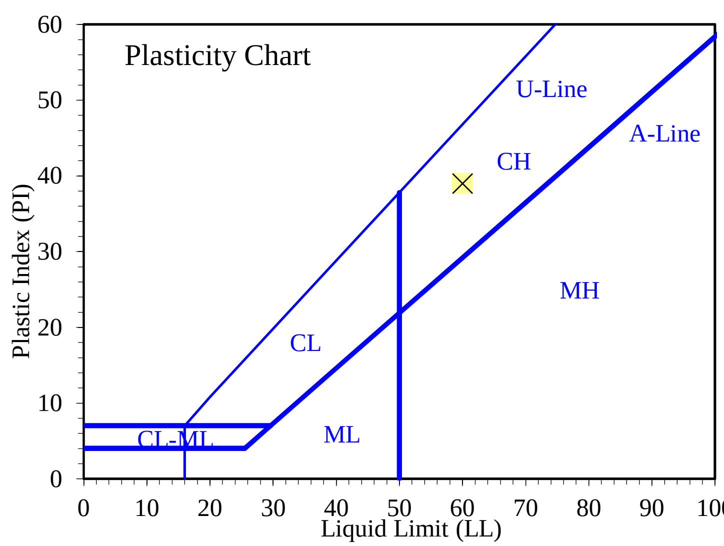

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Liquid Limit, Plastic Limit, and Plasticity Index of Soils
(ASTM D4318)

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Project: Bobcat Ridge
No: 01628-028
Location: Powder Mountain, Weber Co., UT
Date: 7/5/2018
By: BRR

Boring No.: TP-37
Station: 4
Depth: 9.0'
Description: Reddish brown fat clay

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

Preparation method: Wet
Liquid limit test method: Multipoint
Screened over No.40: Yes
Larger particles removed: Wet sieved
Approximate maximum grain size: No.4
Estimated percent retained on No.40: Not requested
As-received water content (%): 18.4

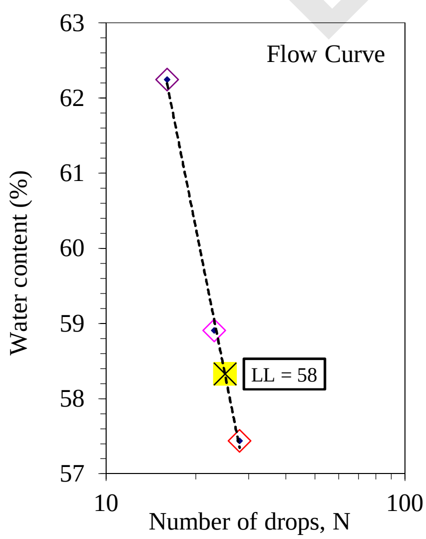
Plastic Limit

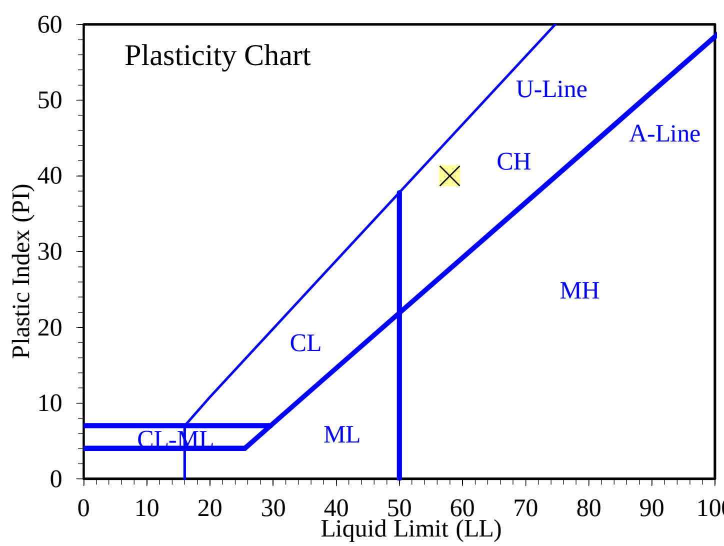
Determination No	1	2				
Wet Soil + Tare (g)	13.50	14.51				
Dry Soil + Tare (g)	12.53	13.39				
Water Loss (g)	0.97	1.12				
Tare (g)	7.14	7.08				
Dry Soil (g)	5.39	6.31				
Water Content, w (%)	18.00	17.75				

Liquid Limit

Determination No	1	2	3			
Number of Drops, N	28	23	16			
Wet Soil + Tare (g)	15.46	13.76	14.19			
Dry Soil + Tare (g)	12.37	11.28	11.47			
Water Loss (g)	3.09	2.48	2.72			
Tare (g)	6.99	7.07	7.10			
Dry Soil (g)	5.38	4.21	4.37			
Water Content, w (%)	57.43	58.91	62.24			
One-Point LL (%)	58	58				

Liquid Limit, LL (%)	**58**
Plastic Limit, PL (%)	**18**
Plasticity Index, PI (%)	**40**





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Liquid Limit, Plastic Limit, and Plasticity Index of Soils

(ASTM D4318)

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Project: Bobcat Ridge
No: 01628-028
Location: Powder Mountain, Weber Co., UT
Date: 7/12/2018
By: BRR

Boring No.: TP-40
Station: 14
Depth: 5.5'
Description: Reddish brown fat 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: No.40
Estimated percent retained on No.40: Not requested
As-received water content (%): Not requested

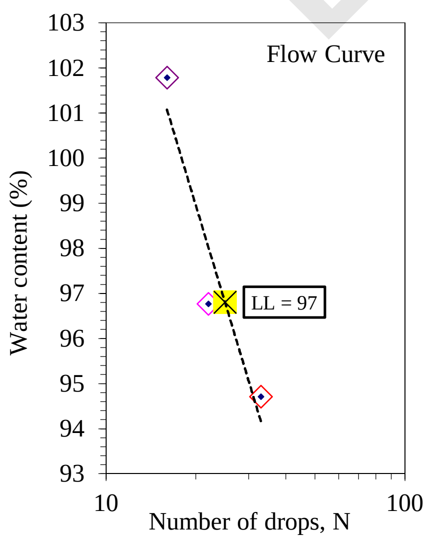
Plastic Limit

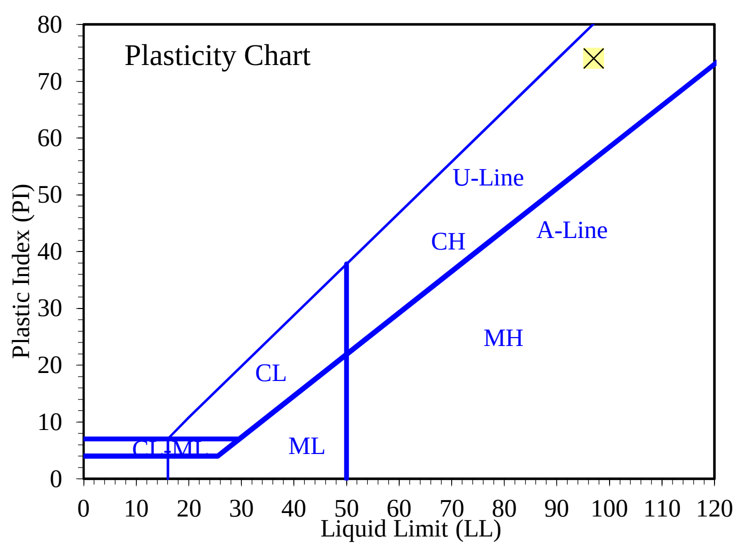
Determination No	1	2				
Wet Soil + Tare (g)	14.00	14.11				
Dry Soil + Tare (g)	12.71	12.81				
Water Loss (g)	1.29	1.30				
Tare (g)	7.05	7.06				
Dry Soil (g)	5.66	5.75				
Water Content, w (%)	22.79	22.61				

Liquid Limit

Determination No	1	2	3			
Number of Drops, N	33	22	16			
Wet Soil + Tare (g)	13.58	12.51	12.77			
Dry Soil + Tare (g)	10.54	9.82	9.91			
Water Loss (g)	3.04	2.69	2.86			
Tare (g)	7.33	7.04	7.10			
Dry Soil (g)	3.21	2.78	2.81			
Water Content, w (%)	94.70	96.76	101.78			
One-Point LL (%)		95				

Liquid Limit, LL (%)	**97**
Plastic Limit, PL (%)	**23**
Plasticity Index, PI (%)	**74**





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Liquid Limit, Plastic Limit, and Plasticity Index of Soils

(ASTM D4318)

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Project: Bobcat Ridge
No: 01628-028
Location: Powder Mountain, Weber Co., UT
Date: 7/12/2018
By: BRR

Boring No.: TP-49
Station: 32
Depth: 7.5'
Description: Reddish brown fat clay

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

Preparation method: Wet
Liquid limit test method: Multipoint
Screened over No.40: Yes
Larger particles removed: Wet sieved
Approximate maximum grain size: No.4
Estimated percent retained on No.40: Not requested
As-received water content (%): Not requested

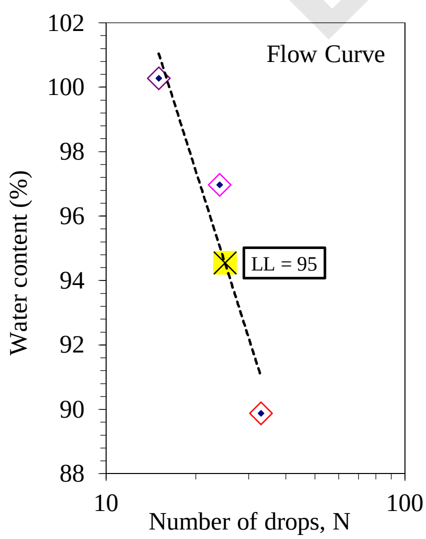
Plastic Limit

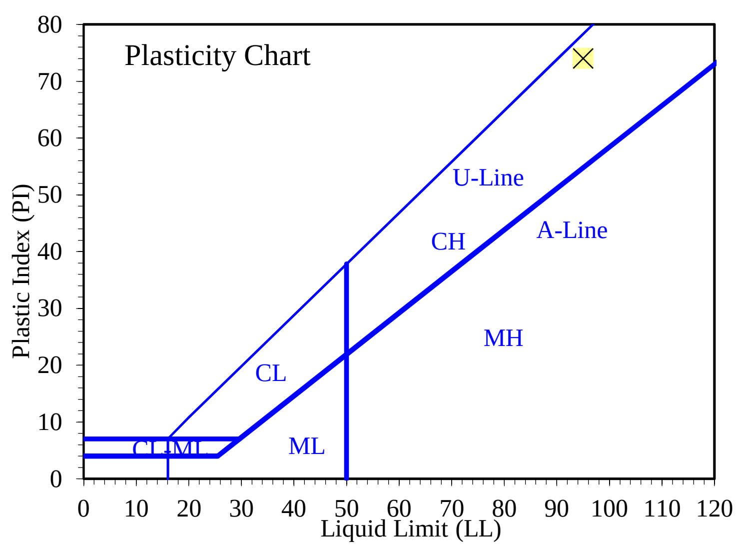
Determination No	1	2				
Wet Soil + Tare (g)	13.33	14.42				
Dry Soil + Tare (g)	12.16	13.16				
Water Loss (g)	1.17	1.26				
Tare (g)	6.43	7.12				
Dry Soil (g)	5.73	6.04				
Water Content, w (%)	20.42	20.86				

Liquid Limit

Determination No	1	2	3			
Number of Drops, N	33	24	15			
Wet Soil + Tare (g)	12.94	13.55	14.47			
Dry Soil + Tare (g)	10.19	10.35	10.77			
Water Loss (g)	2.75	3.20	3.70			
Tare (g)	7.13	7.05	7.08			
Dry Soil (g)	3.06	3.30	3.69			
Water Content, w (%)	89.87	96.97	100.27			
One-Point LL (%)		96				

Liquid Limit, LL (%)	**95**
Plastic Limit, PL (%)	**21**
Plasticity Index, PI (%)	**74**





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Liquid Limit, Plastic Limit, and Plasticity Index of Soils

(ASTM D4318)

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Project: Bobcat Ridge
No: 01628-028
Location: Powder Mountain, Weber Co., UT
Date: 7/11/2018
By: BRR

Boring No.: TP-52
Station: 31
Depth: 4.5'
Description: Reddish brown fat clay

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

Preparation method: Wet
Liquid limit test method: Multipoint
Screened over No.40: Yes
Larger particles removed: Wet sieved
Approximate maximum grain size: No.10
Estimated percent retained on No.40: Not requested
As-received water content (%): Not requested

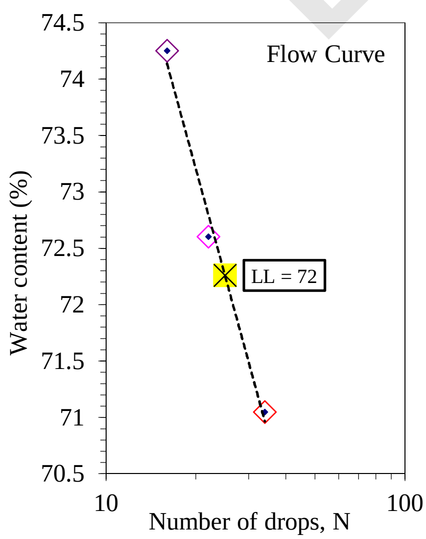
Plastic Limit

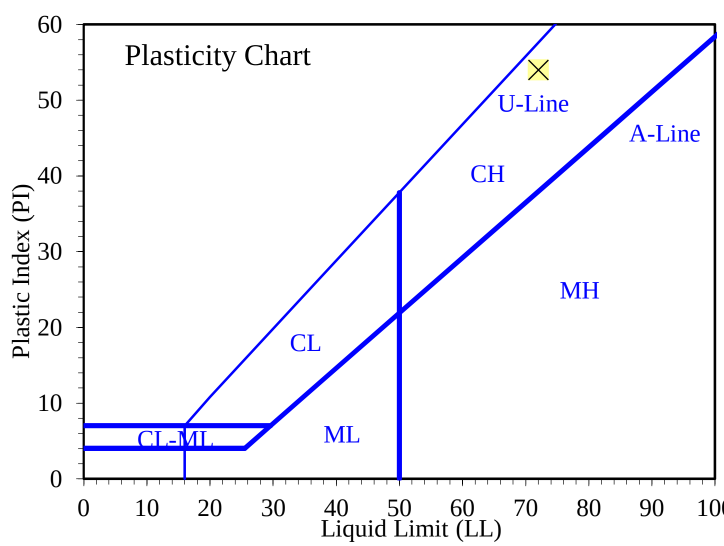
Determination No	1	2				
Wet Soil + Tare (g)	14.37	13.94				
Dry Soil + Tare (g)	13.27	12.90				
Water Loss (g)	1.10	1.04				
Tare (g)	7.08	7.05				
Dry Soil (g)	6.19	5.85				
Water Content, w (%)	17.77	17.78				

Liquid Limit

Determination No	1	2	3			
Number of Drops, N	34	22	16			
Wet Soil + Tare (g)	14.41	13.38	14.09			
Dry Soil + Tare (g)	11.49	10.73	11.12			
Water Loss (g)	2.92	2.65	2.97			
Tare (g)	7.38	7.08	7.12			
Dry Soil (g)	4.11	3.65	4.00			
Water Content, w (%)	71.05	72.60	74.25			
One-Point LL (%)		71				

Liquid Limit, LL (%)	**72**
Plastic Limit, PL (%)	**18**
Plasticity Index, PI (%)	**54**





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

(ASTM D6913)

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Project: Bobcat Ridge
No: 01628-028
Location: Powder Mountain, Weber Co., UT
Date: 7/11/2018
By: DKS/BSS

Boring No.: TP-1
Station: 22
Depth: 10.0'
Description: Light brown clay

Split:	Yes	
Split sieve:	3/8"	
	Moist	Dry
Total sample wt. (g):	21043.2	18752.19
+3/8" Coarse fraction (g):	15.29	13.62
-3/8" Split fraction (g):	283.27	252.43
Split fraction:	0.999	

Water content data	C.F.(+3/8")	S.F.(-3/8")
Moist soil + tare (g):	3320.36	402.89
Dry soil + tare (g):	2991.11	372.05
Tare (g):	310.48	119.62
Water content (%):	12.3	12.2

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"	11.01	19	99.9
3/8"	13.62	9.5	99.9 ←Split
No.4	0.00	4.75	99.9
No.10	1.82	2	99.2
No.20	4.17	0.85	98.3
No.40	5.89	0.425	97.6
No.60	7.01	0.25	97.2
No.100	8.26	0.15	96.7
No.140	9.19	0.106	96.3
No.200	10.85	0.075	95.6

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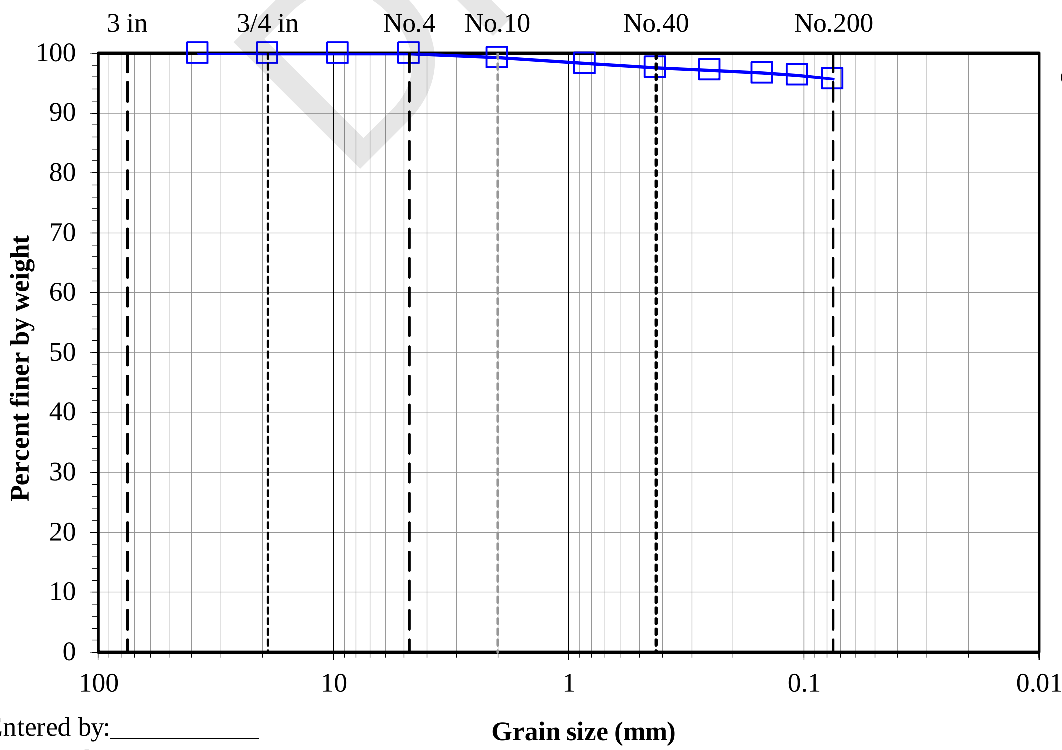

Gravel (%): 0.1
Sand (%): 4.3
Fines (%): 95.6

Entered by:___________
Reviewed:___________

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

(ASTM D6913)

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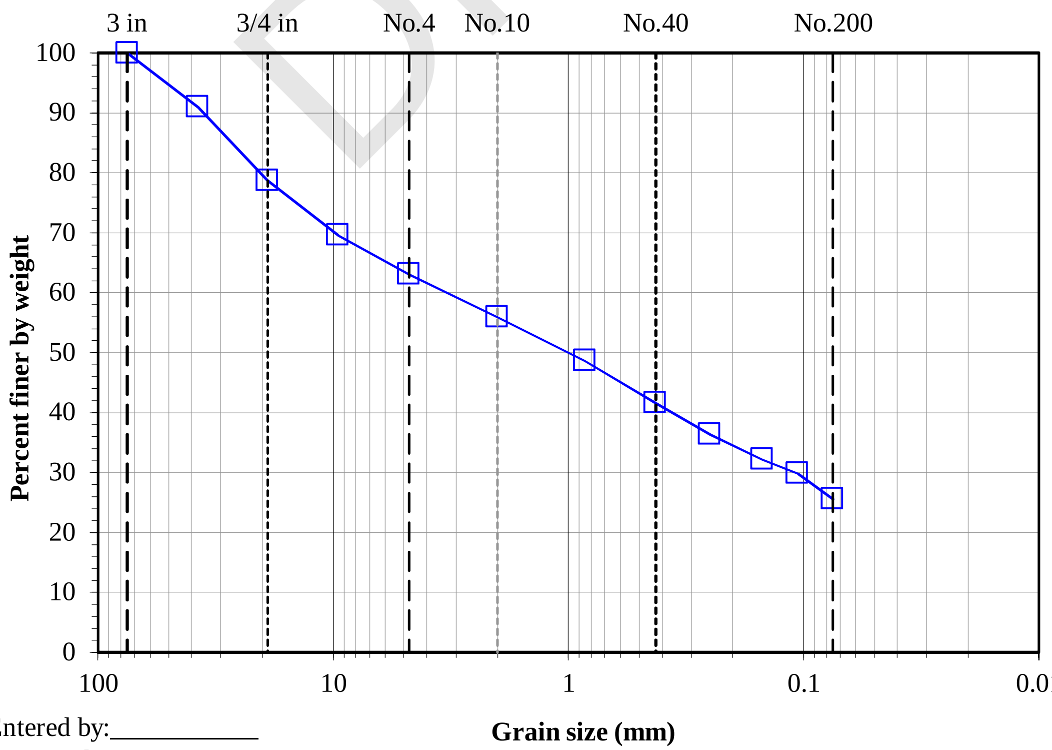
Project: Bobcat Ridge
No: 01628-028
Location: Powder Mountain, Weber Co., UT
Date: 7/11/2018
By: DKS/BSS

Boring No.: TP-3
Station: 27
Depth: 6.5'
Description: Reddish brown clayey sand with gravel

Split:	Yes	
Split sieve:	3/8"	
	Moist	Dry
Total sample wt. (g):	26496.2	24325.00
+3/8" Coarse fraction (g):	7772.9	7401.90
-3/8" Split fraction (g):	309.83	280.04
Split fraction:	0.696	

Water content data	C.F.(+3/8")	S.F.(-3/8")
Moist soil + tare (g):	9906.1	433.02
Dry soil + tare (g):	9511.0	403.23
Tare (g):	1627.5	123.19
Water content (%):	5.0	10.6

Sieve	Accum. Wt. Ret. (g)	Grain Size (mm)	Percent Finer
8"	-	200	-
6"	-	150	-
4"	-	100	-
3"	-	75	100.0
1.5"	2198.0	37.5	91.0
3/4"	5178.5	19	78.7
3/8"	7401.9	9.5	69.6 ←Split
No.4	26.27	4.75	63.0
No.10	55.08	2	55.9
No.20	84.35	0.85	48.6
No.40	112.67	0.425	41.6
No.60	133.66	0.25	36.4
No.100	150.39	0.15	32.2
No.140	159.88	0.106	29.9
No.200	177.20	0.075	25.5



Gravel (%): 37.0
Sand (%): 37.5
Fines (%): 25.5

Entered by:___________
Reviewed:___________

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

(ASTM D6913)

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Project: Bobcat Ridge
No: 01628-028
Location: Powder Mountain, Weber Co., UT
Date: 7/11/2018
By: JP

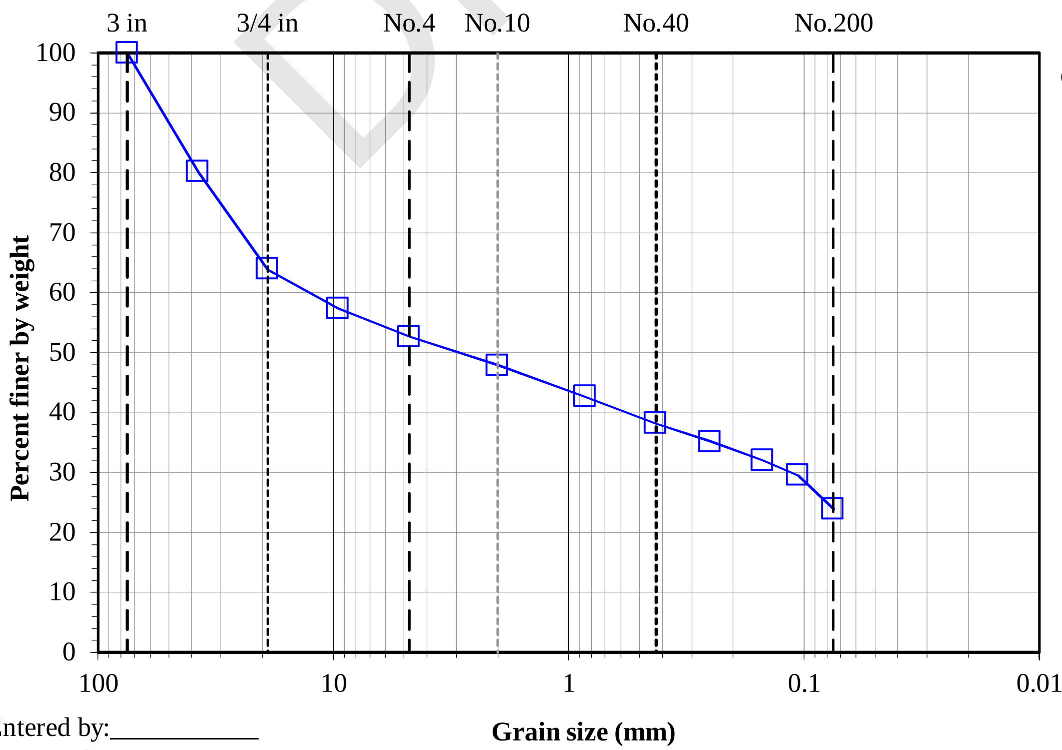
Boring No.: TP-5
Station: 30
Depth: 8.0'
Description: Brown clayey gravel with sand

Split:	Yes	
Split sieve:	3/8"	
	Moist	Dry
Total sample wt. (g):	4007.14	3663.47
+3/8" Coarse fraction (g):	1633.40	1562.51
-3/8" Split fraction (g):	307.79	272.42
Split fraction:	0.573	

Water content data	C.F.(+3/8")	S.F.(-3/8")
Moist soil + tare (g):	2456.50	468.03
Dry soil + tare (g):	2388.17	432.66
Tare (g):	882.10	160.24
Water content (%):	4.5	13.0

Sieve	Accum. Wt. Ret. (g)	Grain Size (mm)	Percent Finer	
8"	-	200	-	
6"	-	150	-	
4"	-	100	-	
3"	-	75	100.0	
1.5"	726.92	37.5	80.2	
3/4"	1322.88	19	63.9	
3/8"	1562.51	9.5	57.3	←Split
No.4	22.24	4.75	52.7	
No.10	45.10	2	47.9	
No.20	69.84	0.85	42.6	
No.40	91.08	0.425	38.2	
No.60	105.62	0.25	35.1	
No.100	120.36	0.15	32.0	
No.140	132.19	0.106	29.5	
No.200	158.96	0.075	23.9	

DRAFT



Gravel (%): 47.3
Sand (%): 28.8
Fines (%): 23.9

Entered by:___________
Reviewed:___________

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

(ASTM D6913)

IGES
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Project: Bobcat Ridge
No: 01628-028
Location: Powder Mountain, Weber Co., UT
Date: 7/11/2018
By: EH/JP

Boring No.: TP-9
Station: 12
Depth: 8.0'
Description: Reddish brown clayey gravel with sand

Split:	Yes	
Split sieve:	#4	
	Moist	Dry
Total sample wt. (g):	3345.81	3087.15
+#4 Coarse fraction (g):	1576.79	1516.44
-#4 Split fraction (g):	221.41	196.59
Split fraction:	0.509	

Water content data	C.F.(+#4)	S.F.(-#4)
Moist soil + tare (g):	1800.26	345.11
Dry soil + tare (g):	1739.91	320.29
Tare (g):	223.47	123.70
Water content (%):	4.0	12.6

Sieve	Accum. Wt. Ret. (g)	Grain Size (mm)	Percent Finer	
8"	-	200	-	
6"	-	150	-	
4"	-	100	-	
3"	-	75	100.0	
1.5"	201.06	37.5	93.5	
3/4"	821.43	19	73.4	
3/8"	1280.65	9.5	58.5	
No.4	1516.44	4.75	50.9	←Split
No.10	21.41	2	45.3	
No.20	41.74	0.85	40.1	
No.40	58.64	0.425	35.7	
No.60	69.55	0.25	32.9	
No.100	80.26	0.15	30.1	
No.140	88.56	0.106	28.0	
No.200	100.50	0.075	24.9	

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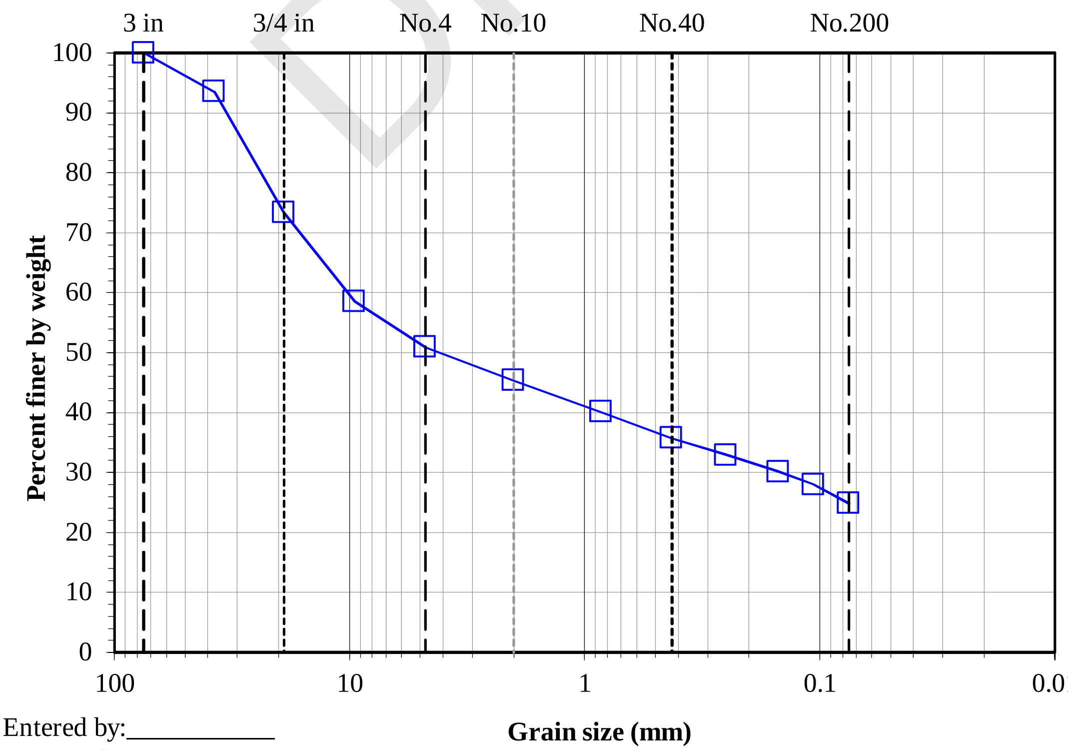


Gravel (%): 49.1
Sand (%): 26.0
Fines (%): 24.9

Entered by:___________
Reviewed:___________

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

(ASTM D6913)

© IGES 2004, 2018

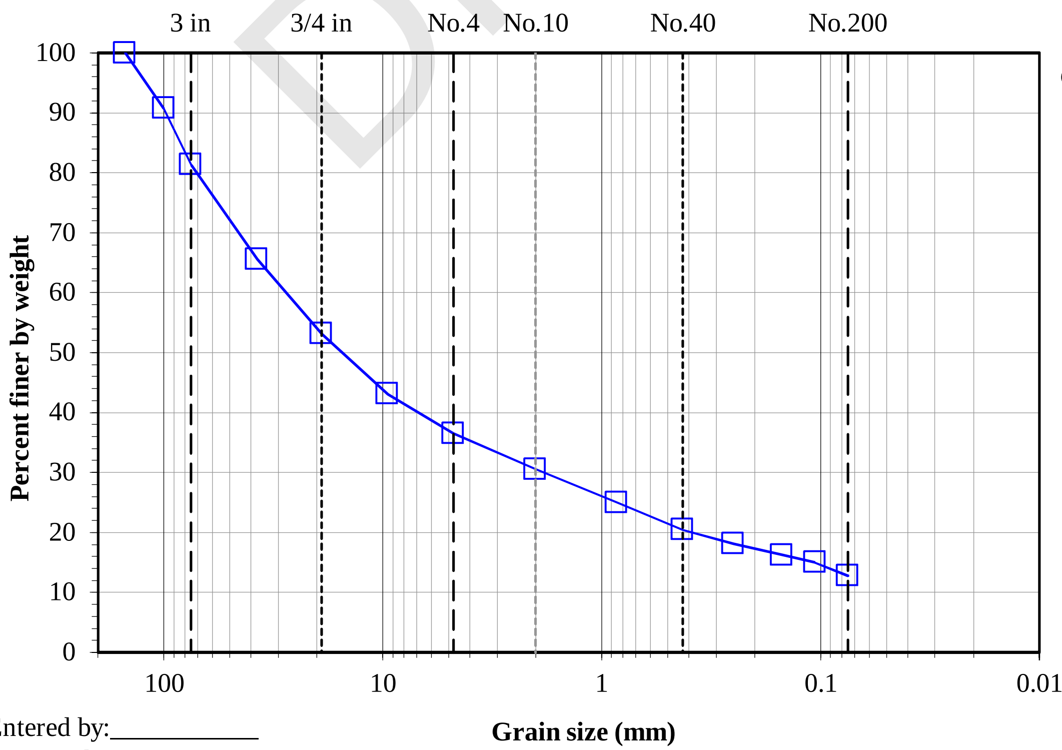
Project: Bobcat Ridge
No: 01628-028
Location: Powder Mountain, Weber Co., UT
Date: 7/11/2018
By: DKS/BSS

Boring No.: TP-17
Station: 19.5
Depth: 5.0'
Description: Reddish brown clayey gravel with sand

Split:	Yes	
Split sieve:	3/8"	
	Moist	Dry
Total sample wt. (g):	29867.3	28605.59
+3/8" Coarse fraction (g):	16499.6	16285.86
-3/8" Split fraction (g):	507.17	467.41
Split fraction:	0.431	

Water content data	C.F.(+3/8")	S.F.(-3/8")
Moist soil + tare (g):	5786.0	700.76
Dry soil + tare (g):	5718.0	661.00
Tare (g):	536.7	193.59
Water content (%):	1.3	8.5

Sieve	Accum. Wt. Ret. (g)	Grain Size (mm)	Percent Finer	
8"	-	200	-	
6"	-	150	100.0	
4"	2648.9	100	90.7	
3"	5348.1	75	81.3	
1.5"	9847.1	37.5	65.6	
3/4"	13406.2	19	53.1	
3/8"	16285.9	9.5	43.1	←Split
No.4	71.26	4.75	36.5	
No.10	135.91	2	30.5	
No.20	196.50	0.85	25.0	
No.40	245.62	0.425	20.4	
No.60	270.94	0.25	18.1	
No.100	291.25	0.15	16.2	
No.140	305.06	0.106	15.0	
No.200	328.60	0.075	12.8	



Gravel (%): 63.5
Sand (%): 23.7
Fines (%): 12.8

Entered by:___________
Reviewed:___________

DRAFT

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

(ASTM D6913)

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Project: Bobcat Ridge
No: 01628-028
Location: Powder Mountain, Weber Co., UT
Date: 7/11/2018
By: DKS/JP

Boring No.: TP-20
Station: 26
Depth: 9.0'
Description: Reddish brown clayey gravel with sand

Split:	Yes	
Split sieve:	3/8"	
	Moist	Dry
Total sample wt. (g):	29065.99	26751.34
+3/8" Coarse fraction (g):	11853.2	11342.34
-3/8" Split fraction (g):	341.91	306.08
Split fraction:	0.576	

Water content data	C.F.(+3/8")	S.F.(-3/8")
Moist soil + tare (g):	13882.9	564.14
Dry soil + tare (g):	13344.8	528.31
Tare (g):	1397.5	222.23
Water content (%):	4.5	11.7

Sieve	Accum. Wt. Ret. (g)	Grain Size (mm)	Percent Finer	
8"	-	200	-	
6"	-	150	100.0	
4"	1729.8	100	93.5	
3"	3761.7	75	85.9	
1.5"	5754.0	37.5	78.5	
3/4"	8907.3	19	66.7	
3/8"	11342.3	9.5	57.6	←Split
No.4	52.01	4.75	47.8	
No.10	112.08	2	36.5	
No.20	167.63	0.85	26.1	
No.40	189.15	0.425	22.0	
No.60	199.95	0.25	20.0	
No.100	208.87	0.15	18.3	
No.140	214.35	0.106	17.3	
No.200	223.02	0.075	15.6	

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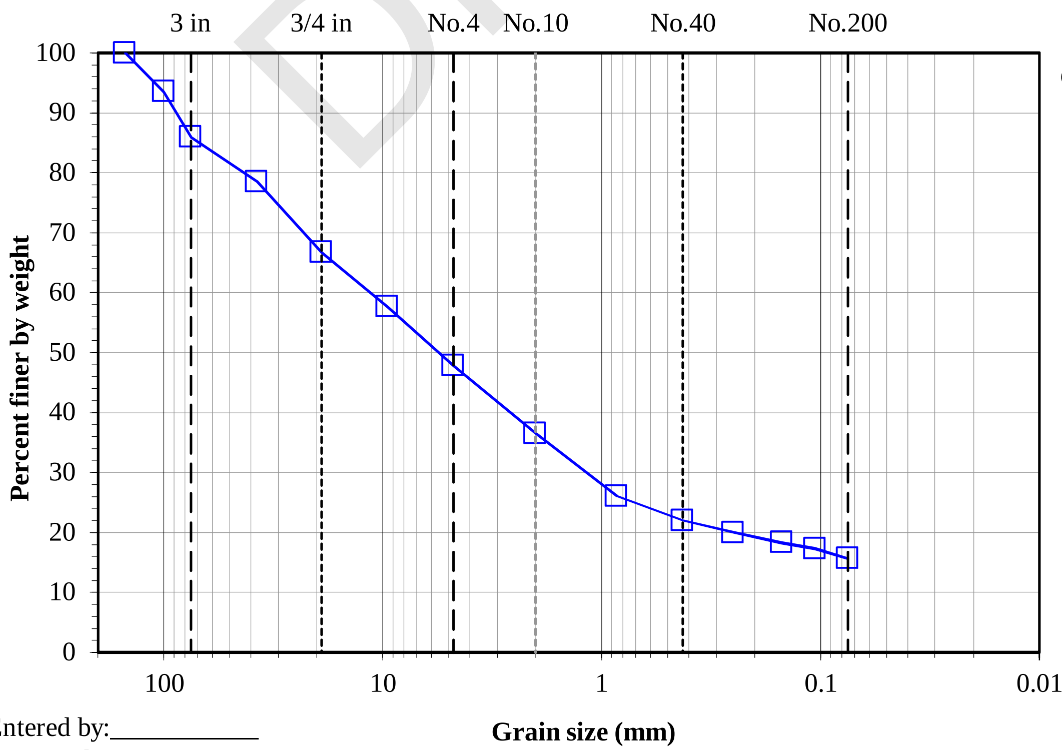

Gravel (%): 52.2
Sand (%): 32.2
Fines (%): 15.6

Entered by:___________
Reviewed:___________

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

(ASTM D6913)

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Project: Bobcat Ridge
No: 01628-028
Location: Powder Mountain, Weber Co., UT
Date: 7/11/2018
By: JP

Boring No.: TP-26
Station: 20
Depth: 5.5'
Description: Reddish brown clayey sand

Split:	No	
	Moist	Dry
Total sample wt. (g):	418.47	366.04
Split fraction:	1.000	

Water content data

Moist soil + tare (g):	-	583.85
Dry soil + tare (g):	-	531.42
Tare (g):	-	165.38
Water content (%):	0.0	14.3

Sieve	Accum. Wt. Ret. (g)	Grain Size (mm)	Percent Finer
8"	-	200	-
6"	-	150	-
4"	-	100	-
3"	-	75	-
1.5"	-	37.5	-
3/4"	-	19	-
3/8"	-	9.5	100.0
No.4	0.02	4.75	100.0
No.10	0.84	2	99.8
No.20	5.52	0.85	98.5
No.40	48.22	0.425	86.8
No.60	120.91	0.25	67.0
No.100	182.00	0.15	50.3
No.140	204.57	0.106	44.1
No.200	226.62	0.075	38.1

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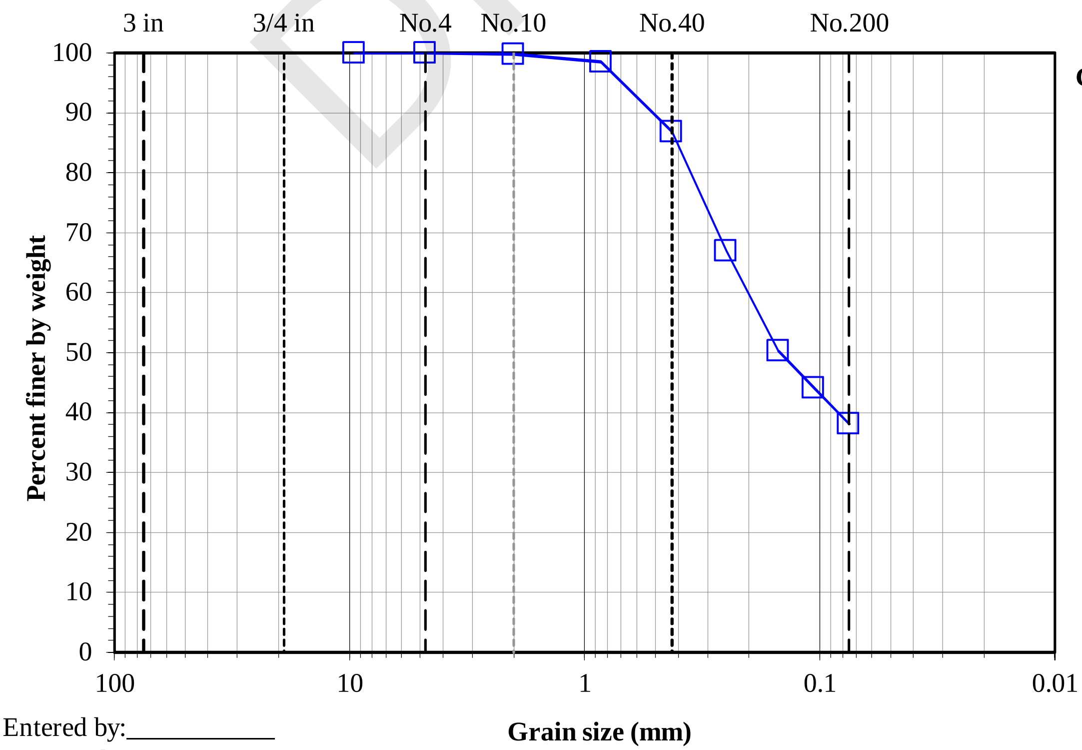

Gravel (%): 0.0
Sand (%): 61.9
Fines (%): 38.1

Entered by:___________
Reviewed:___________

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

(ASTM D6913)

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Project: Bobcat Ridge
No: 01628-028
Location: Powder Mountain, Weber Co., UT
Date: 7/11/2018
By: JP

Boring No.: TP-34
Station: 13
Depth: 10.0'
Description: Reddish brown clayey sand with gravel

Split:	Yes	
Split sieve:	3/8"	
	Moist	Dry
Total sample wt. (g):	4125.79	3800.12
+3/8" Coarse fraction (g):	1008.38	993.32
-3/8" Split fraction (g):	236.15	212.62
Split fraction:	0.739	

Water content data	C.F.(+3/8")	S.F.(-3/8")
Moist soil + tare (g):	1806.74	407.42
Dry soil + tare (g):	1790.75	383.89
Tare (g):	735.75	171.27
Water content (%):	1.5	11.1

Sieve	Accum. Wt. Ret. (g)	Grain Size (mm)	Percent Finer	
8"	-	200	-	
6"	-	150	-	
4"	-	100	-	
3"	-	75	100.0	
1.5"	137.37	37.5	96.4	
3/4"	506.12	19	86.7	
3/8"	993.32	9.5	73.9	←Split
No.4	29.29	4.75	63.7	
No.10	52.03	2	55.8	
No.20	70.73	0.85	49.3	
No.40	94.91	0.425	40.9	
No.60	116.40	0.25	33.4	
No.100	132.09	0.15	28.0	
No.140	137.93	0.106	25.9	
No.200	144.40	0.075	23.7	

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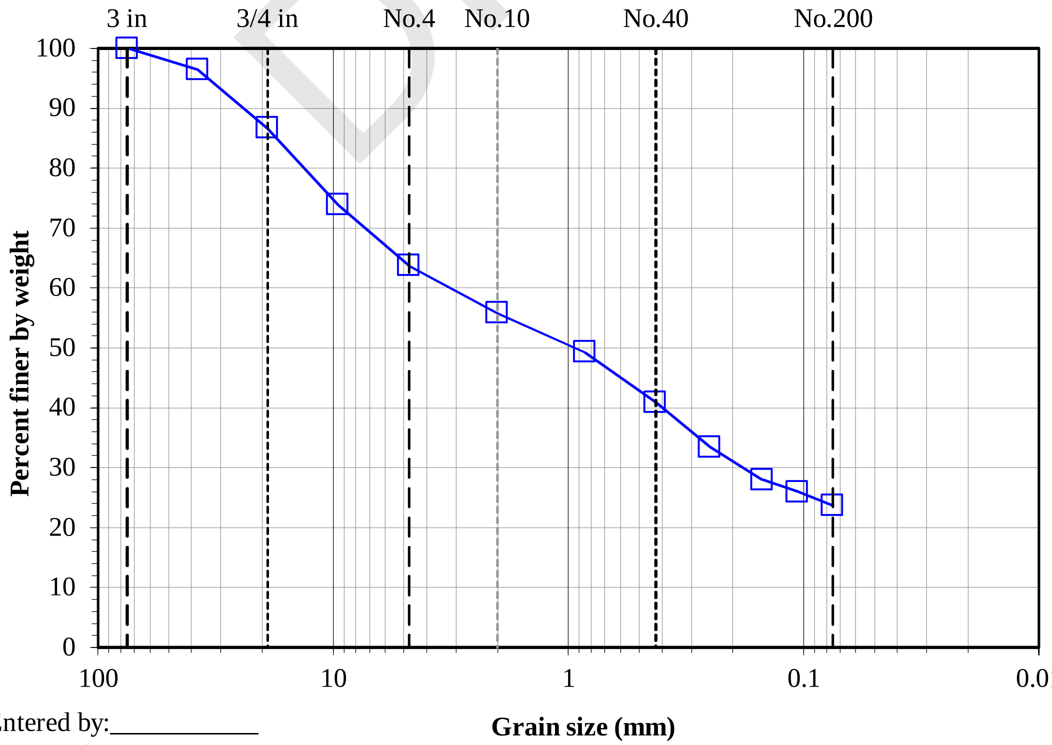

Gravel (%): 36.3
Sand (%): 40.0
Fines (%): 23.7

Entered by:___________
Reviewed:___________

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

(ASTM D6913)

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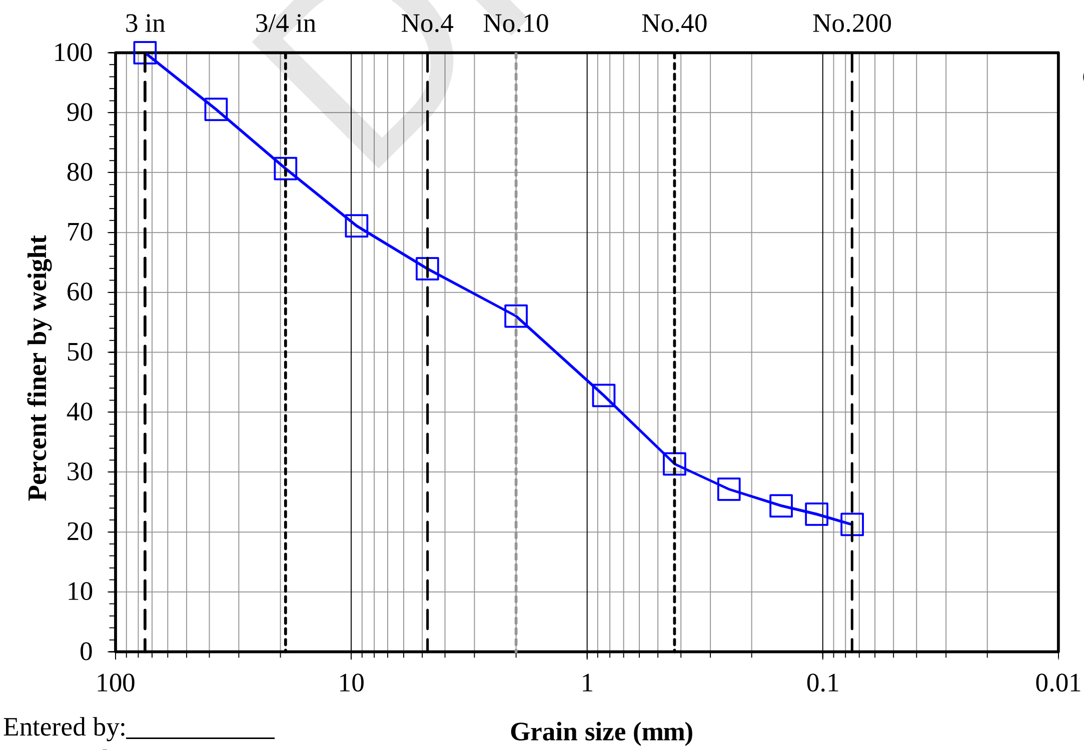
Project: Bobcat Ridge
No: 01628-028
Location: Powder Mountain, Weber Co., UT
Date: 7/12/2018
By: JP/BSS

Boring No.: TP-36
Station: 7
Depth: 6.0'
Description: Reddish brown clayey sand with gravel

	Moist	Dry
Split:	Yes	
Split sieve:	3/8"	
Total sample wt. (g):	21656.2	20588.48
+3/8" Coarse fraction (g):	6108.8	5953.35
-3/8" Split fraction (g):	317.17	298.56
Split fraction:	0.711	

Water content data	C.F.(+3/8")	S.F.(-3/8")
Moist soil + tare (g):	3078.02	427.03
Dry soil + tare (g):	3018.56	409.21
Tare (g):	741.46	123.33
Water content (%):	2.6	6.2

Sieve	Accum. Wt. Ret. (g)	Grain Size (mm)	Percent Finer	
8"	-	200	-	
6"	-	150	-	
4"	-	100	-	
3"	-	75	100.0	
1.5"	1945.7	37.5	90.5	
3/4"	3983.0	19	80.7	
3/8"	5953.3	9.5	71.1	←Split
No.4	30.07	4.75	63.9	
No.10	63.12	2	56.1	
No.20	118.75	0.85	42.8	
No.40	166.79	0.425	31.4	
No.60	184.66	0.25	27.1	
No.100	196.31	0.15	24.3	
No.140	202.03	0.106	23.0	
No.200	209.37	0.075	21.2	



Gravel (%): 36.1
Sand (%): 42.7
Fines (%): 21.2

Entered by:___________
Reviewed:___________

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

(ASTM D6913)

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Project: Bobcat Ridge
No: 01628-028
Location: Powder Mountain, Weber Co., UT
Date: 7/11/2018
By: BSS/JP

Boring No.: TP-46
Station: 6
Depth: 4.5'
Description: Reddish brown clayey sand with gravel

Split:	Yes	
Split sieve:	3/8"	
	Moist	Dry
Total sample wt. (g):	3948.41	3469.56
+3/8" Coarse fraction (g):	505.32	492.31
-3/8" Split fraction (g):	323.29	279.55
Split fraction:	0.858	

Water content data	C.F.(+3/8")	S.F.(-3/8")
Moist soil + tare (g):	834.67	451.21
Dry soil + tare (g):	820.60	407.47
Tare (g):	288.36	127.92
Water content (%):	2.6	15.6

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"	301.04	19	91.3	
3/8"	492.31	9.5	85.8	←Split
No.4	17.42	4.75	80.5	
No.10	32.99	2	75.7	
No.20	55.26	0.85	68.8	
No.40	81.86	0.425	60.7	
No.60	100.45	0.25	55.0	
No.100	115.34	0.15	50.4	
No.140	123.33	0.106	48.0	
No.200	135.51	0.075	44.2	

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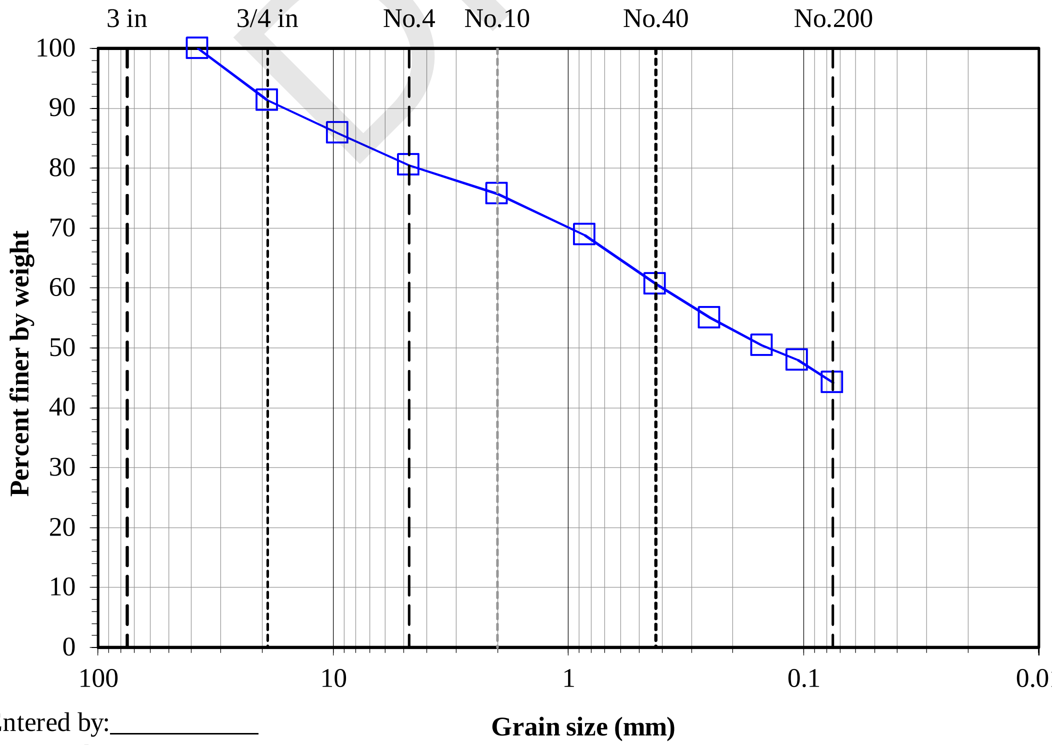

Gravel (%): 19.5
Sand (%): 36.2
Fines (%): 44.2

Entered by:___________
Reviewed:___________

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

(ASTM D6913)

© IGES 2004, 2018

Project: Bobcat Ridge
No: 01628-028
Location: Powder Mountain, Weber Co., UT
Date: 7/11/2018
By: BSS/JP

Boring No.: TP-53B
Station: 5
Depth: 10.0'
Description: Reddish brown clayey gravel with sand

Split:	Yes	
Split sieve:	3/8"	
	Moist	Dry
Total sample wt. (g):	3414.3	3267.89
+3/8" Coarse fraction (g):	1321.2	1307.57
-3/8" Split fraction (g):	512.48	479.97
Split fraction:	0.600	

Water content data	C.F.(+3/8")	S.F.(-3/8")
Moist soil + tare (g):	1536.56	654.21
Dry soil + tare (g):	1522.93	621.70
Tare (g):	215.34	141.73
Water content (%):	1.0	6.8

Sieve	Accum. Wt. Ret. (g)	Grain Size (mm)	Percent Finer	
8"	-	200	-	
6"	-	150	-	
4"	-	100	-	
3"	-	75	100.0	
1.5"	419.0	37.5	87.2	
3/4"	825.5	19	74.7	
3/8"	1307.6	9.5	60.0	←Split
No.4	60.48	4.75	52.4	
No.10	111.71	2	46.0	
No.20	160.12	0.85	40.0	
No.40	202.97	0.425	34.6	
No.60	231.14	0.25	31.1	
No.100	253.89	0.15	28.3	
No.140	267.98	0.106	26.5	
No.200	292.82	0.075	23.4	

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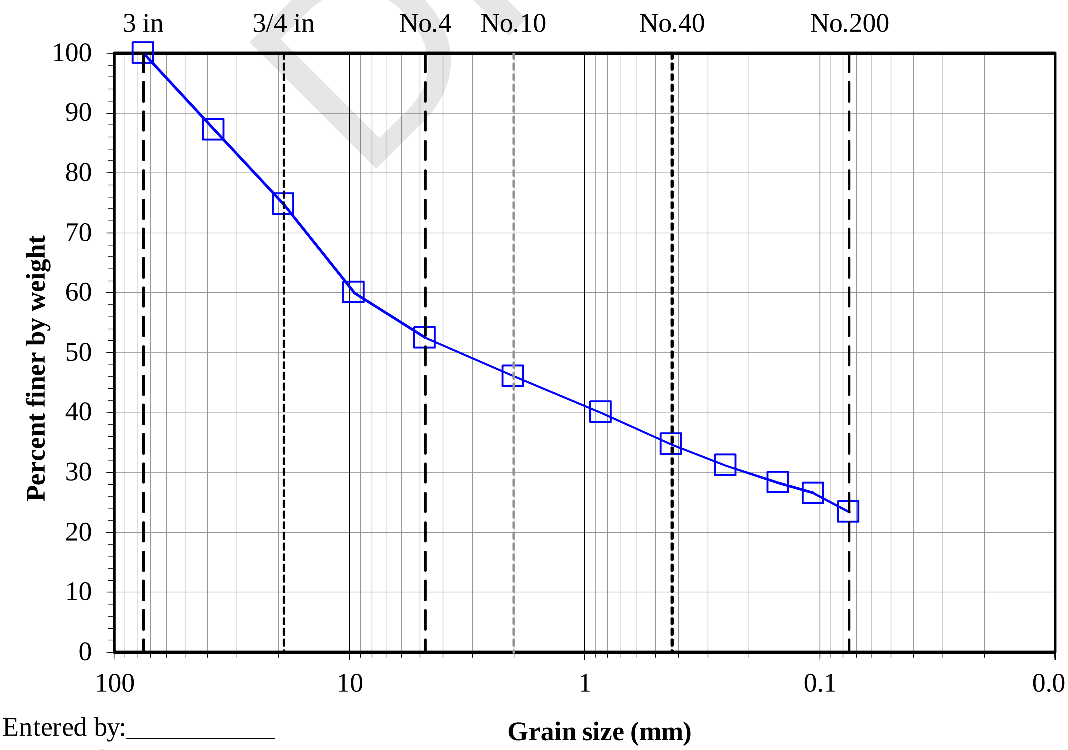

Gravel (%): 47.6
Sand (%): 29.0
Fines (%): 23.4

Entered by:___________
Reviewed:___________

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

(ASTM D1140)

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Project: Bobcat Ridge
No: 01628-028
Location: Powder Mountain, Weber Co., UT
Date: 7/10/2018
By: BRR/EH/BSS

Sample Info.	Boring No.	TP-1	TP-3	TP-6	TP-8	TP-13	TP-39		
	Station	16	26	5	6	5	21		
	Depth	4.0'	9.5'	3.5'	12.0'	4.5'	6.5'		
	Split	No	No	No	No	Yes	Yes		
	Split Sieve*					3/8"	3/8"		
	Method	B	B	B	B	B	B		
	Specimen soak time (min)	490	430	260	270	430	280		
	Moist total sample wt. (g)	186.88	154.45	248.36	209.43	3811.2	21189.6		
	Moist coarse fraction (g)					1067.6	5546.4		
	Moist split fraction + tare (g)					567.48	595.03		
	Split fraction tare (g)					208.41	213.89		
	Dry split fraction (g)					350.97	341.92		
	Dry retained No. 200 + tare (g)	137.99	146.80	159.02	163.83	420.56	387.12		
	Wash tare (g)	127.90	128.58	127.49	152.69	208.41	213.89		
	No. 200 Dry wt. retained (g)	10.09	18.22	31.53	11.14	212.15	173.23		
	Split sieve* Dry wt. retained (g)					1060.17	5455.31		
	Dry total sample wt. (g)	121.96	103.12	200.58	144.22	3741.85	19488.80		
Coarse Fraction	Moist soil + tare (g)					1235.24	4110.12		
	Dry soil + tare (g)					1227.78	4047.72		
	Tare (g)					167.61	310.46		
	Water content (%)					0.70	1.67		
Split Fraction	Moist soil + tare (g)	314.78	283.03	375.85	362.12	567.48	595.03		
	Dry soil + tare (g)	249.86	231.70	328.07	296.91	559.38	555.81		
	Tare (g)	127.90	128.58	127.49	152.69	208.41	213.89		
	Water content (%)	53.23	49.78	23.82	45.22	2.31	11.47		
	Percent passing split sieve* (%)					**71.7**	**72.0**		
	Percent passing No. 200 sieve (%)	**91.7**	**82.3**	**84.3**	**92.3**	**28.3**	**35.5**		

DRAFT

Entered by:___________
Reviewed:___________

Unconfined Compressive Strength of Cohesive Soils

(ASTM D2166)

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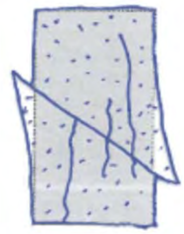
Project: **Bobcat Ridge**
No: **01628-028**
Location: Powder Mountain, Weber Co., UT
Date: 7/11/2018
By: EH

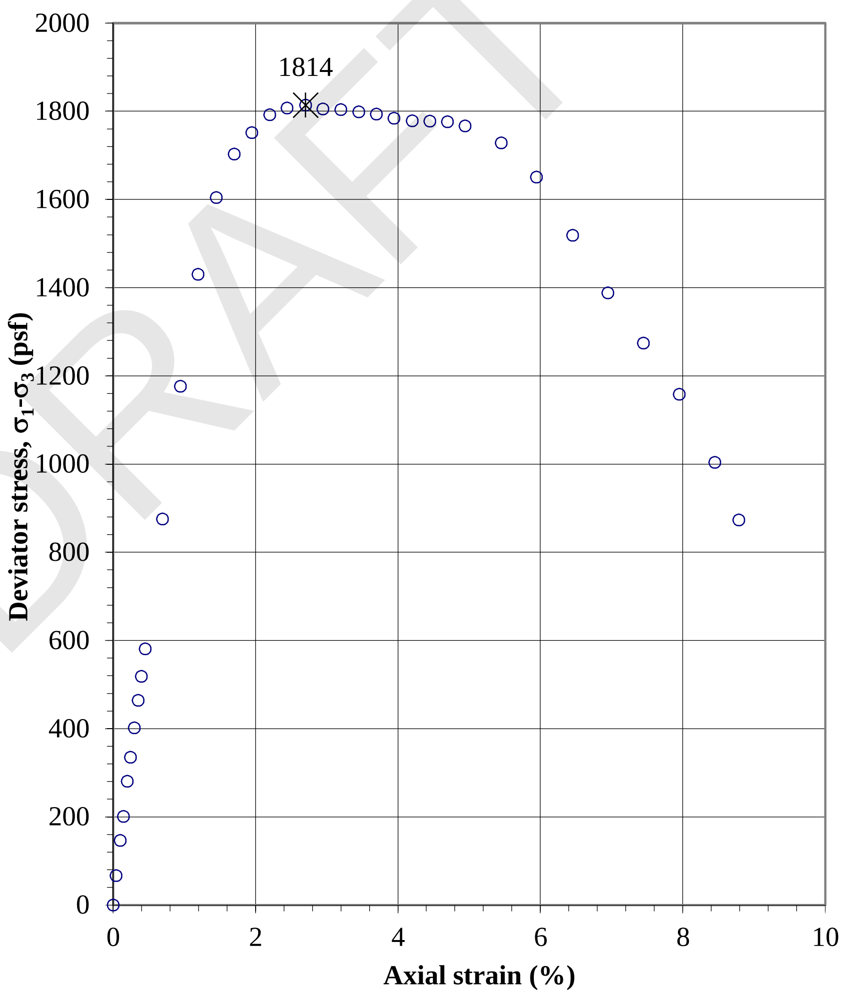
Boring No.: **TP-22**
Station: **18**
Depth: **10.5'**
Sample Description: Reddish brown fat clay
Sample type: Undisturbed

Specific gravity, Gs	2.70	Assumed
Sample height, H (in.)	5.444	
Sample diameter, D (in.)	2.414	
Sample volume, V (ft^3)	0.0144	
Wt. rings + wet soil (g)	793.30	
Wt. rings/tare (g)	0.00	
Moist soil, Ws (g)	793.30	
Moist unit wt., γ_m (pcf)	121.3	
Dry unit wt., γ_d (pcf)	**96.1**	
Saturation (%)	93.5	
Void ratio, *e*	0.76	



Wet soil + tare (g)	694.50
Dry soil + tare (g)	576.07
Tare (g)	124.45
Water content, w (%)	**26.2**
Strain rate (%/min)	2.0
Strain at failure, ε_f (%)	2.70
Deviator stress at failure, $(\sigma_1\text{-}\sigma_3)_f$ (psf)	1814
Shear stress at failure, $q_f = (\sigma_1\text{-}\sigma_3)_f/2$ (psf)	907

Axial Strain (%)	σ_d $\sigma_1\text{-}\sigma_3$ (psf)	Q 1/2 σ_d (psf)
0.00	0.0	0.0
0.04	67.2	33.6
0.10	146.8	73.4
0.14	201.2	100.6
0.20	280.7	140.4
0.24	335.0	167.5
0.30	401.8	200.9
0.35	464.3	232.2
0.40	518.4	259.2
0.45	580.8	290.4
0.69	875.3	437.7
0.95	1176.6	588.3
1.19	1430.6	715.3
1.45	1604.5	802.3
1.70	1703.2	851.6
1.95	1751.9	876.0
2.20	1792.1	896.1
2.45	1807.5	903.8
2.70	1814.3	907.2
2.95	1805.1	902.6
3.20	1803.9	902.0
3.45	1798.6	899.3
3.70	1793.4	896.7
3.94	1784.1	892.1
4.20	1778.7	889.4
4.45	1777.6	888.8
4.70	1776.4	888.2
4.94	1767.1	883.6
5.45	1728.6	864.3
5.94	1651.1	825.6
6.45	1519.0	759.5
6.95	1388.4	694.2
7.45	1274.6	637.3
7.95	1158.0	579.0
8.45	1004.1	502.1
8.79	873.0	436.5



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Unconfined Compressive Strength of Cohesive Soils

(ASTM D2166)

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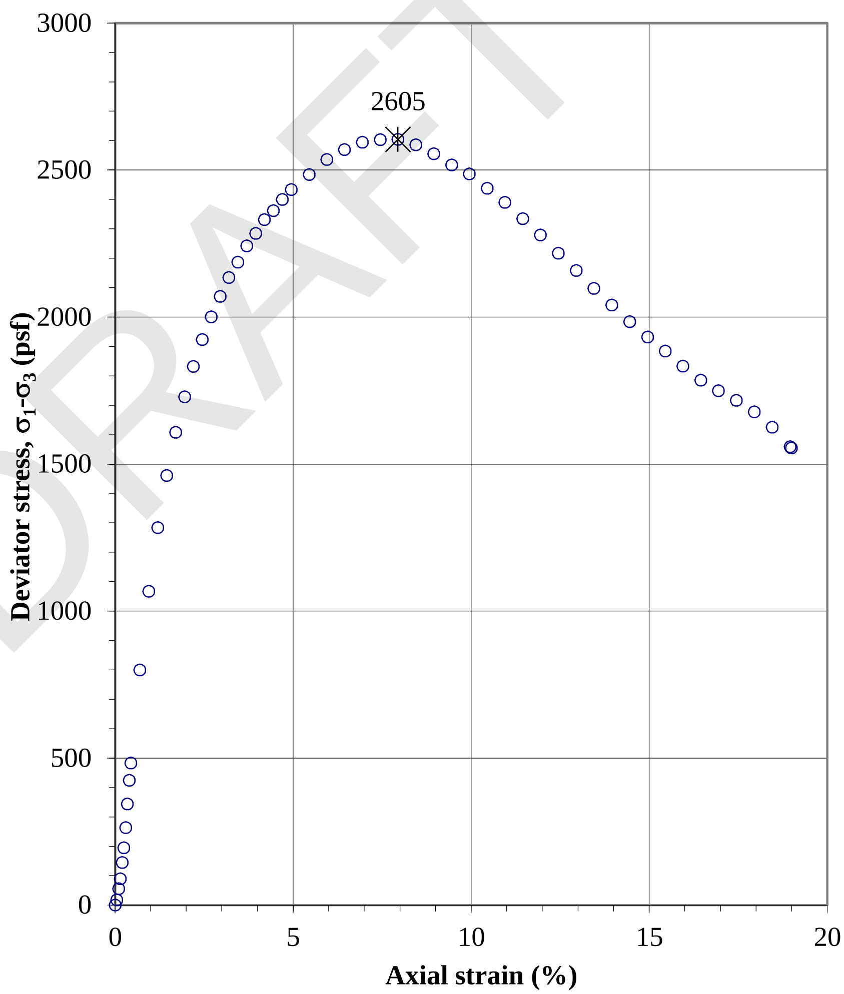
Project: Bobcat Ridge
No: 01628-028
Location: Powder Mountain, Weber Co., UT
Date: 7/11/2018
By: EH

Boring No.: TP-40
Station: 14
Depth: 5.5'
Sample Description: Reddish brown clay
Sample type: Undisturbed

Specific gravity, Gs	2.70	Assumed
Sample height, H (in.)	4.573	
Sample diameter, D (in.)	2.397	
Sample volume, V (ft^3)	0.0119	
Wt. rings + wet soil (g)	638.06	
Wt. rings/tare (g)	0.00	
Moist soil, Ws (g)	638.06	
Moist unit wt., γ_m (pcf)	117.8	
Dry unit wt., γ_d (pcf)	**91.4**	
Saturation (%)	92.0	
Void ratio, *e*	0.85	

Wet soil + tare (g)	526.88
Dry soil + tare (g)	437.61
Tare (g)	128.40
Water content, w (%)	**28.9**
Strain rate (%/min)	2.0
Strain at failure, ε_f (%)	7.94
Deviator stress at failure, $(\sigma_1-\sigma_3)_f$ (psf)	2605
Shear stress at failure, $q_f = (\sigma_1-\sigma_3)_f/2$ (psf)	1302

Axial Strain (%)	σ_d $\sigma_1-\sigma_3$ (psf)	Q 1/2 σ_d (psf)
0.00	0.0	0.0
0.05	17.0	8.5
0.10	55.3	27.6
0.15	89.2	44.6
0.20	144.5	72.2
0.25	195.4	97.7
0.30	263.3	131.6
0.35	343.8	171.9
0.40	424.3	212.1
0.44	483.5	241.7
0.70	799.6	399.8
0.95	1067.6	533.8
1.20	1283.8	641.9
1.45	1460.9	730.4
1.70	1607.8	803.9
1.95	1728.8	864.4
2.20	1832.6	916.3
2.45	1923.2	961.6
2.70	2001.0	1000.5
2.95	2070.0	1035.0
3.20	2134.6	1067.3
3.45	2186.4	1093.2
3.70	2242.0	1121.0
3.95	2285.0	1142.5
4.20	2331.9	1165.9
4.44	2362.2	1181.1
4.70	2400.3	1200.1
4.95	2434.2	1217.1
5.45	2485.3	1242.6
5.95	2535.7	1267.8
6.44	2569.4	1284.7
6.95	2594.6	1297.3
7.45	2603.7	1301.8
7.94	2604.8	1302.4
8.45	2585.8	1292.9
8.95	2555.4	1277.7
9.45	2517.5	1258.7
9.95	2487.6	1243.8
10.45	2438.7	1219.3
10.95	2390.3	1195.1
11.45	2334.6	1167.3
11.95	2279.4	1139.7
12.45	2217.1	1108.5
12.95	2159.1	1079.5
13.45	2098.0	1049.0
13.95	2041.1	1020.5
14.45	1984.7	992.3
14.95	1932.4	966.2
15.45	1884.3	942.1
15.95	1833.0	916.5
16.45	1785.7	892.8
16.95	1749.5	874.7
17.45	1717.1	858.5
17.95	1677.8	838.9
18.45	1625.1	812.5
18.95	1559.0	779.5
18.99	1554.7	777.3



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Unconfined Compressive Strength of Cohesive Soils

(ASTM D2166)

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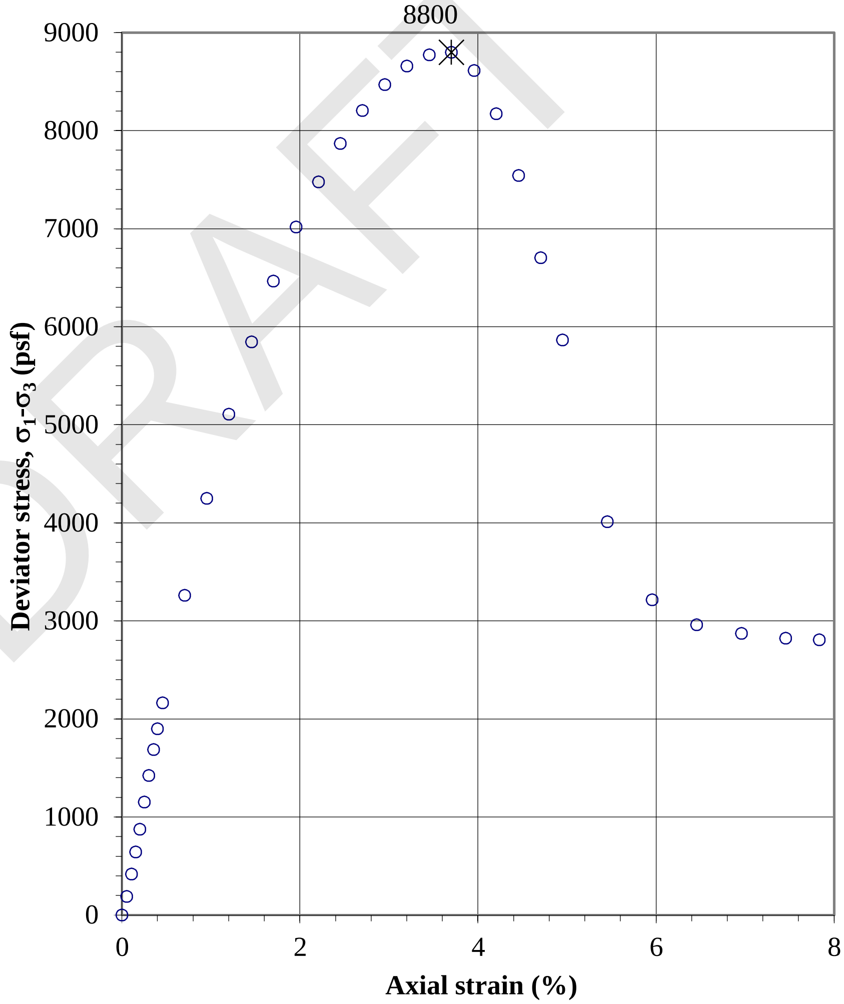
Project: Bobcat Ridge
No: 01628-028
Location: Powder Mountain, Weber Co., UT
Date: 7/11/2018
By: EH

Boring No.: TP-52
Station: 31
Depth: 4.5'
Sample Description: Reddish brown fat clay
Sample type: Undisturbed

Specific gravity, Gs	2.70	Assumed
Sample height, H (in.)	5.816	
Sample diameter, D (in.)	2.380	
Sample volume, V (ft^3)	0.0150	
Wt. rings + wet soil (g)	876.40	
Wt. rings/tare (g)	0.00	
Moist soil, Ws (g)	876.40	
Moist unit wt., γ_m (pcf)	129.0	
Dry unit wt., γ_d (pcf)	**107.8**	
Saturation (%)	93.8	
Void ratio, *e*	0.57	

Wet soil + tare (g)	598.28
Dry soil + tare (g)	520.85
Tare (g)	126.66
Water content, w (%)	**19.6**
Strain rate (%/min)	2.0
Strain at failure, ε_f (%)	3.70
Deviator stress at failure, $(\sigma_1-\sigma_3)_f$ (psf)	8800
Shear stress at failure, $q_f = (\sigma_1-\sigma_3)_f/2$ (psf)	4400

Axial Strain (%)	σ_d $\sigma_1-\sigma_3$ (psf)	Q 1/2 σ_d (psf)
0.00	0.0	0.0
0.05	190.0	95.0
0.11	418.7	209.4
0.15	643.0	321.5
0.20	875.6	437.8
0.25	1151.1	575.5
0.30	1422.1	711.0
0.36	1688.4	844.2
0.40	1898.6	949.3
0.45	2164.3	1082.1
0.70	3261.9	1630.9
0.95	4251.0	2125.5
1.20	5106.9	2553.4
1.45	5847.4	2923.7
1.70	6465.5	3232.7
1.95	7016.0	3508.0
2.21	7479.1	3739.5
2.45	7868.8	3934.4
2.70	8205.3	4102.6
2.95	8468.5	4234.2
3.20	8659.4	4329.7
3.45	8773.8	4386.9
3.70	8800.1	4400.0
3.96	8613.5	4306.7
4.20	8171.8	4085.9
4.46	7541.5	3770.7
4.71	6704.4	3352.2
4.95	5863.8	2931.9
5.45	4010.4	2005.2
5.96	3213.8	1606.9
6.45	2959.9	1479.9
6.96	2873.2	1436.6
7.46	2823.6	1411.8
7.83	2806.5	1403.2



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Unconsolidated-Undrained Triaxial Compression Test on Cohesive Soils

(ASTM D2850)

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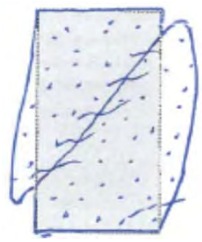
Project: Bobcat Ridge
No: 01628-028
Location: Powder Mountain, Weber Co., UT
Date: 7/11/2018
By: EH

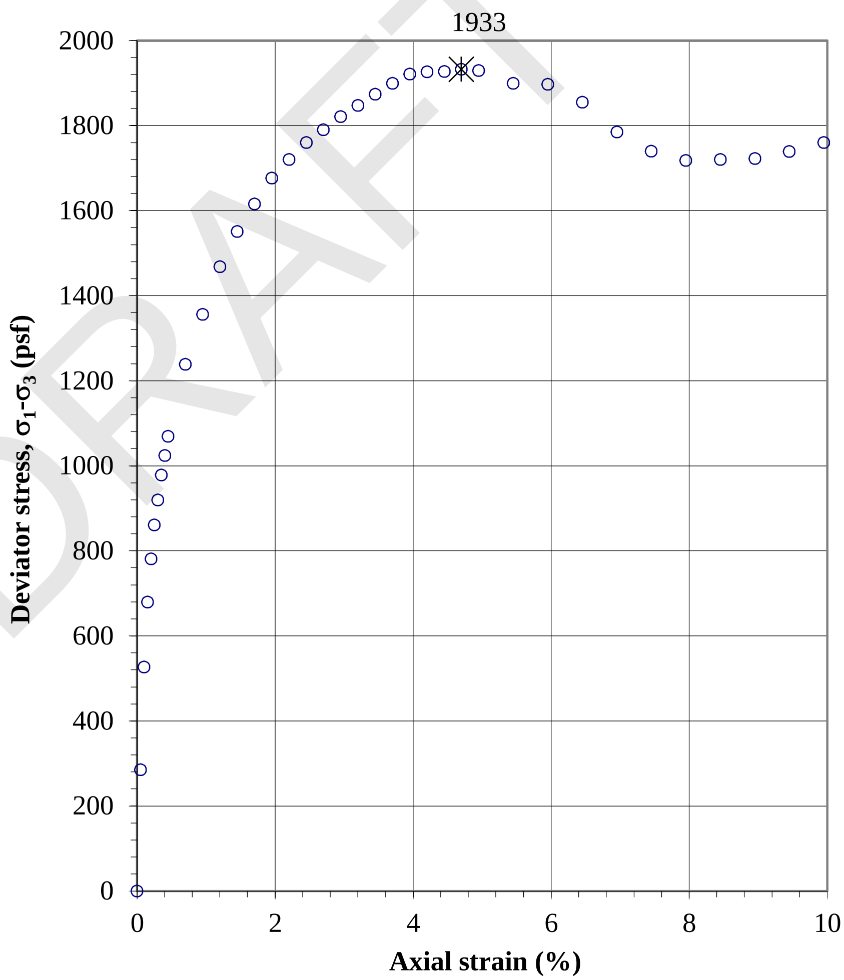
Boring No.: TP-49
Station: 32
Depth: 7.5'
Sample Description: Reddish brown clay
Sample type: Undisturbed

Specific gravity, Gs	2.85	Assumed
Sample height, H (in.)	5.257	
Sample diameter, D (in.)	2.398	
Sample volume, V (ft^3)	0.0137	
Wt. rings + wet soil (g)	755.82	
Wt. rings/tare (g)	0.00	
Moist soil, Ws (g)	755.82	
Moist unit wt., γ_m (pcf)	121.3	
Dry unit wt., γ_d (pcf)	**91.8**	
Saturation (%)	97.2	
Void ratio, *e*	0.94	



Wet soil + tare (g)	232.34
Dry soil + tare (g)	205.55
Tare (g)	122.18
Water content, w (%)	**32.1**
Confining stress, σ_3 (psf)	600
Shear rate (in/min)	0.0158
Strain at failure, ε_f (%)	4.70
Deviator stress at failure, $(\sigma_1-\sigma_3)_f$ (psf)	1933
Shear stress at failure, $q_f = (\sigma_1-\sigma_3)_f/2$ (psf)	966

Axial Strain (%)	σ_d $\sigma_1-\sigma_3$ (psf)	Q 1/2 σ_d (psf)
0.00	0.0	0.0
0.05	285.0	142.5
0.10	527.1	263.5
0.15	679.6	339.8
0.20	781.0	390.5
0.25	861.0	430.5
0.30	919.6	459.8
0.35	978.2	489.1
0.40	1024.0	512.0
0.45	1069.8	534.9
0.70	1238.6	619.3
0.95	1355.9	677.9
1.20	1468.4	734.2
1.45	1550.9	775.4
1.70	1616.2	808.1
1.95	1676.9	838.4
2.20	1720.7	860.3
2.45	1760.0	880.0
2.70	1790.8	895.4
2.95	1821.4	910.7
3.20	1847.7	923.8
3.45	1873.8	936.9
3.70	1899.8	949.9
3.95	1921.4	960.7
4.20	1926.7	963.3
4.45	1927.7	963.8
4.70	1932.8	966.4
4.95	1929.7	964.8
5.45	1899.3	949.6
5.95	1897.2	948.6
6.45	1855.0	927.5
6.95	1785.4	892.7
7.45	1740.0	870.0
7.95	1718.5	859.2
8.45	1720.6	860.3
8.95	1722.4	861.2
9.45	1739.5	869.7
9.95	1760.1	880.0
10.45	1753.6	876.8



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Direct Shear Test for Soils Under Drained Conditions

(ASTM D3080)

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Project: Bobcat Ridge
No: 01628-028
Location: Powder Mountain, Weber Co., UT
Date: 7/9/2018
By: EH

Boring No.: TP-3
Station: 26
Depth: 9.5'
Sample Description: Reddish brown and grey elastic silt
Sample type: Undisturbed-trimmed from thin-wall

Test type: Inundated
Lateral displacement (in.): 0.3
Shear rate (in./min): 0.0003
Specific gravity, Gs: 2.70 Assumed

	Sample 1		Sample 2		Sample 3	
Nominal normal stress (psf)	4000		2000		1000	
Peak shear stress (psf)	1916		1370		860	
Lateral displacement at peak (in)	0.142		0.097		0.302	
Load Duration (min)	277		278		289	
	Initial	Pre-shear	Initial	Pre-shear	Initial	Pre-shear
Sample height (in)	0.998	0.960	1.002	0.965	0.995	0.980
Sample diameter (in)	2.427	2.427	2.413	2.413	2.419	2.419
Wt. rings + wet soil (g)	169.07	168.22	172.06	170.66	168.25	168.88
Wt. rings (g)	41.98	41.98	44.83	44.83	42.05	42.05
Wet soil + tare (g)	283.03		283.03		283.03	
Dry soil + tare (g)	231.70		231.70		231.70	
Tare (g)	128.58		128.58		128.58	
Water content (%)	49.8	48.8	49.8	48.1	49.8	50.5
Dry unit weight (pcf)	70.0	72.7	70.6	73.3	70.2	71.3
Void ratio, e, for assumed Gs	1.41	1.32	1.39	1.30	1.40	1.36
Saturation (%)*	95.5	100.0	96.9	100.0	95.9	100.0

ϕ' (deg)	19
c' (psf)	587

Average of 3 samples	Initial	Pre-shear
Water content (%)	49.8	49.1
Dry unit weight (pcf)	70.3	72.4

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

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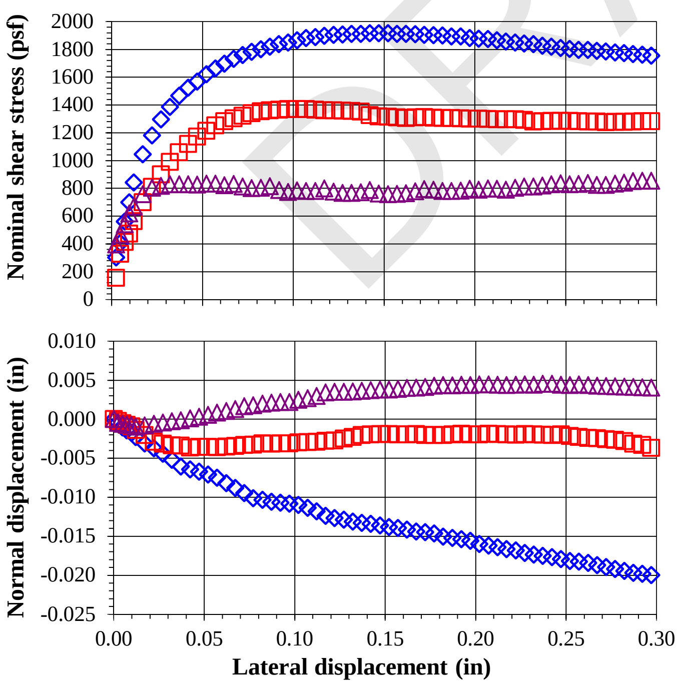

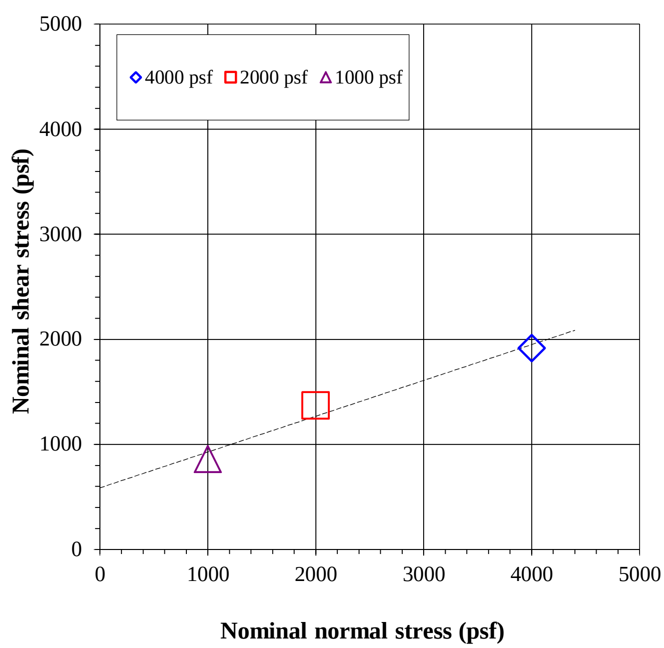

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Direct Shear Test for Soils Under Drained Conditions

(ASTM D3080)

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Project: Bobcat Ridge
No: 01628-028
Location: Powder Mountain, Weber Co., UT

Boring No.: TP-3
Station: 26
Depth: 9.5'

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Nominal normal stress = 4000 psf			Nominal normal stress = 2000 psf			Nominal normal stress = 1000 psf		
Lateral Displacement (in.)	Nominal Shear Stress (psf)	Normal Displacement (in.)	Lateral Displacement (in.)	Nominal Shear Stress (psf)	Normal Displacement (in.)	Lateral Displacement (in.)	Nominal Shear Stress (psf)	Normal Displacement (in.)
0.000	-10	0.000	0.000	-2	0.000	0.000	-1	0.000
0.002	302	0.000	0.002	155	0.000	0.002	396	0.000
0.005	407	-0.001	0.005	327	-0.001	0.005	465	-0.001
0.007	560	-0.001	0.007	412	-0.001	0.007	539	-0.001
0.010	698	-0.002	0.010	473	-0.001	0.010	620	-0.001
0.012	842	-0.002	0.012	564	-0.001	0.012	667	-0.001
0.017	1046	-0.003	0.017	700	-0.002	0.017	757	-0.001
0.022	1182	-0.004	0.022	809	-0.003	0.022	803	-0.001
0.027	1297	-0.004	0.027	901	-0.003	0.027	816	0.000
0.032	1386	-0.005	0.032	991	-0.003	0.032	829	0.000
0.037	1468	-0.006	0.037	1060	-0.003	0.037	829	0.000
0.042	1525	-0.006	0.042	1118	-0.004	0.042	828	0.000
0.047	1568	-0.007	0.047	1171	-0.004	0.047	827	0.000
0.052	1622	-0.007	0.052	1213	-0.004	0.052	832	0.001
0.057	1663	-0.007	0.057	1252	-0.004	0.057	832	0.001
0.062	1698	-0.008	0.062	1282	-0.004	0.062	822	0.001
0.067	1732	-0.009	0.067	1303	-0.003	0.067	831	0.001
0.072	1760	-0.009	0.072	1321	-0.003	0.072	811	0.002
0.077	1783	-0.010	0.077	1340	-0.003	0.077	800	0.002
0.082	1801	-0.010	0.082	1354	-0.003	0.082	803	0.002
0.087	1821	-0.011	0.087	1362	-0.003	0.087	814	0.002
0.092	1839	-0.011	0.092	1366	-0.003	0.092	788	0.002
0.097	1849	-0.011	0.097	1370	-0.003	0.097	773	0.002
0.102	1867	-0.011	0.102	1370	-0.003	0.102	785	0.002
0.107	1883	-0.011	0.107	1370	-0.003	0.107	779	0.003
0.112	1890	-0.012	0.112	1366	-0.003	0.112	781	0.003
0.117	1898	-0.012	0.117	1362	-0.003	0.117	798	0.003
0.122	1906	-0.013	0.122	1361	-0.003	0.122	774	0.004
0.127	1908	-0.013	0.127	1359	-0.002	0.127	765	0.004
0.132	1913	-0.013	0.132	1356	-0.002	0.132	767	0.004
0.137	1913	-0.013	0.137	1352	-0.002	0.137	770	0.004
0.142	1916	-0.013	0.142	1326	-0.002	0.142	786	0.004
0.147	1916	-0.014	0.147	1317	-0.002	0.147	763	0.004
0.152	1916	-0.014	0.152	1315	-0.002	0.152	756	0.004
0.157	1913	-0.014	0.157	1311	-0.002	0.157	760	0.004
0.162	1913	-0.014	0.162	1306	-0.002	0.162	764	0.004
0.167	1911	-0.014	0.167	1311	-0.002	0.167	779	0.004
0.172	1906	-0.014	0.172	1312	-0.002	0.172	794	0.004
0.177	1903	-0.015	0.177	1309	-0.002	0.177	789	0.004
0.182	1901	-0.015	0.182	1306	-0.002	0.182	780	0.004
0.187	1893	-0.015	0.187	1305	-0.002	0.187	781	0.004
0.192	1893	-0.015	0.192	1303	-0.002	0.192	782	0.004
0.197	1883	-0.016	0.197	1302	-0.002	0.197	796	0.004
0.202	1878	-0.016	0.202	1301	-0.002	0.202	790	0.004
0.207	1875	-0.016	0.207	1299	-0.002	0.207	799	0.004
0.212	1867	-0.016	0.212	1296	-0.002	0.212	795	0.004
0.217	1857	-0.017	0.217	1296	-0.002	0.217	790	0.004
0.222	1849	-0.017	0.222	1296	-0.002	0.222	802	0.004
0.227	1842	-0.017	0.227	1293	-0.002	0.227	812	0.004
0.232	1839	-0.017	0.232	1280	-0.002	0.232	811	0.004
0.237	1826	-0.018	0.237	1283	-0.002	0.237	820	0.005
0.242	1819	-0.018	0.242	1286	-0.002	0.242	830	0.005
0.247	1811	-0.018	0.247	1286	-0.002	0.247	836	0.004
0.252	1803	-0.018	0.252	1285	-0.002	0.252	829	0.004
0.257	1798	-0.018	0.257	1282	-0.002	0.257	831	0.004
0.262	1796	-0.018	0.262	1280	-0.002	0.262	837	0.004
0.267	1791	-0.019	0.267	1281	-0.002	0.267	825	0.004
0.272	1785	-0.019	0.272	1276	-0.003	0.272	823	0.004
0.277	1778	-0.019	0.277	1279	-0.003	0.277	833	0.004
0.282	1775	-0.019	0.282	1278	-0.003	0.282	841	0.004
0.287	1768	-0.020	0.287	1280	-0.003	0.287	851	0.004
0.292	1762	-0.020	0.292	1282	-0.003	0.292	855	0.004
0.297	1755	-0.020	0.297	1283	-0.004	0.297	855	0.004
0.301	1755	-0.020	0.301	1285	-0.004	0.302	860	0.004

Direct Shear Test for Soils Under Drained Conditions

(ASTM D3080)

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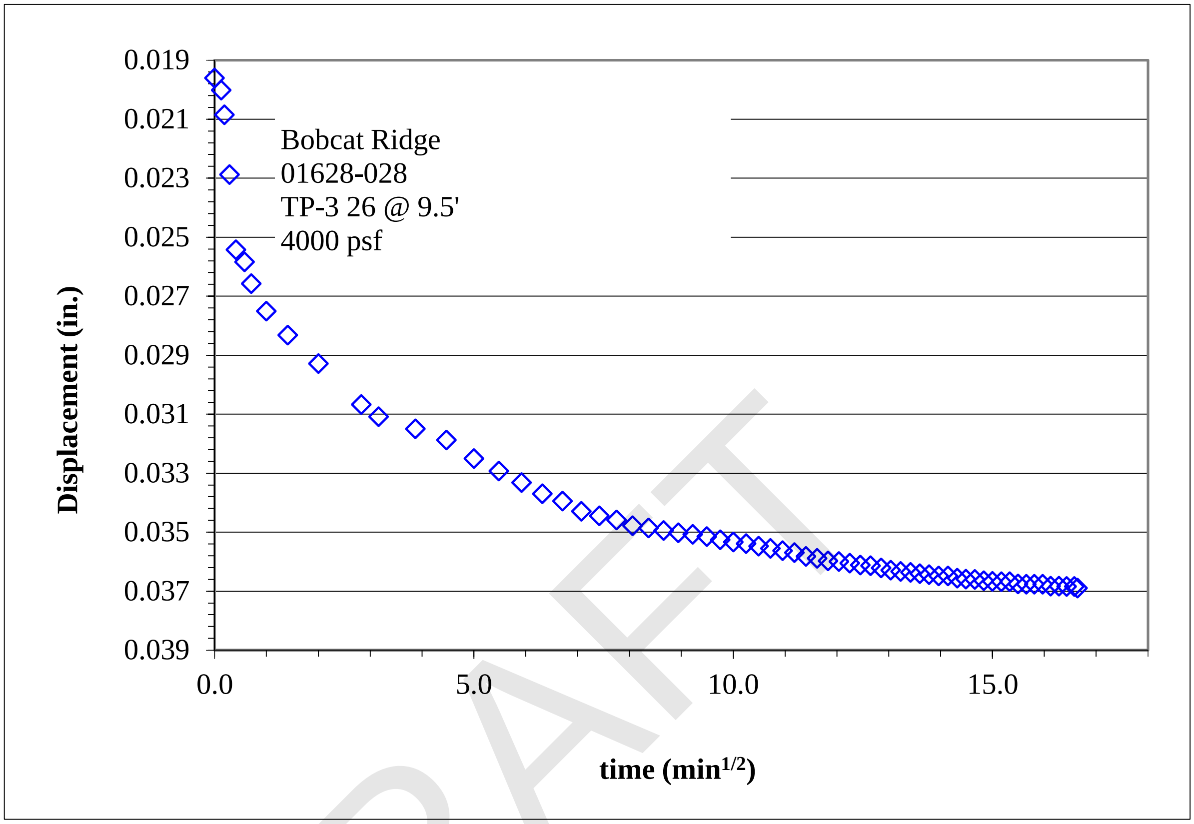
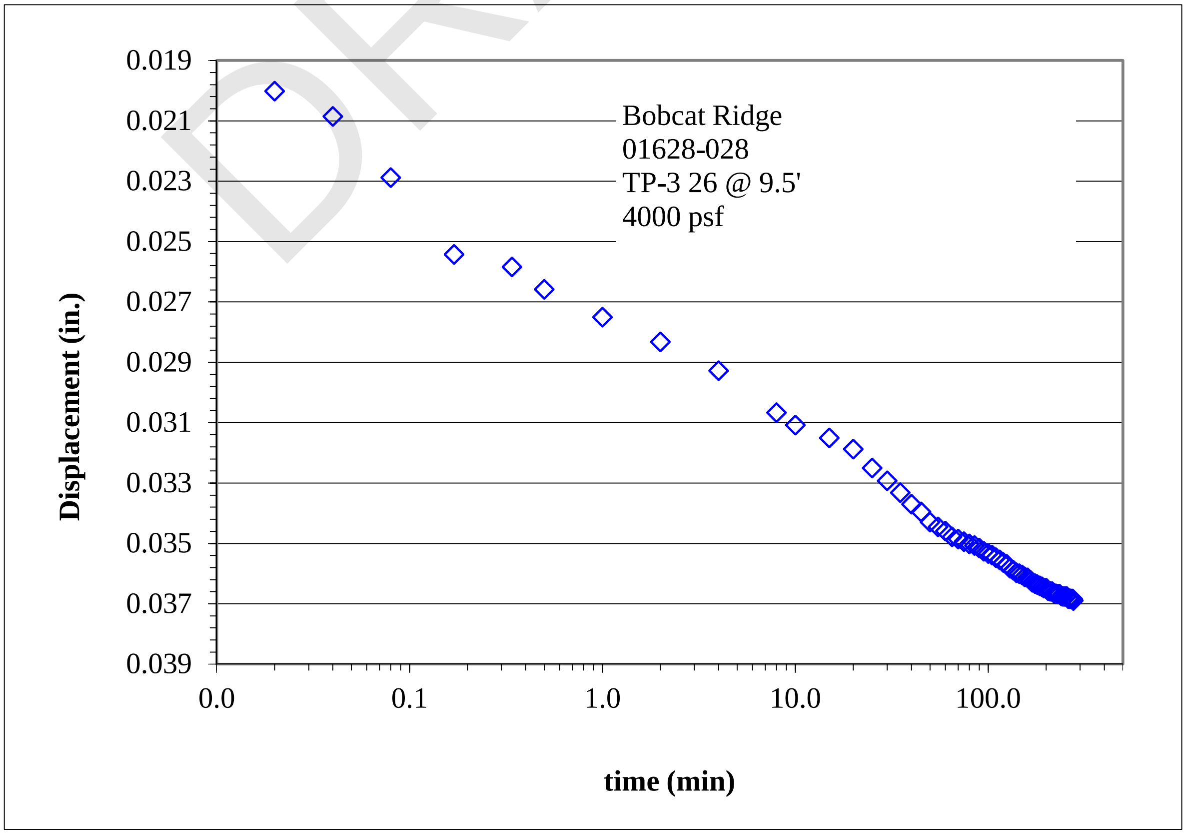
Project: Bobcat Ridge
No: 01628-028
Location: Powder Mountain, Weber Co., UT

Boring No.: TP-3
Station: 26
Depth: 9.5'





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Direct Shear Test for Soils Under Drained Conditions

(ASTM D3080)

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Project: Bobcat Ridge
No: 01628-028
Location: Powder Mountain, Weber Co., UT
Date: 7/11/2018
By: EH

Boring No.: TP-9
Station: 12
Depth: 8.0'
Sample Description: Reddish brown clayey sand
Sample type: Arbitrary remold

Test type: Inundated
Lateral displacement (in.): 0.3
Shear rate (in./min): 0.0010
Specific gravity, Gs: 2.70 Assumed

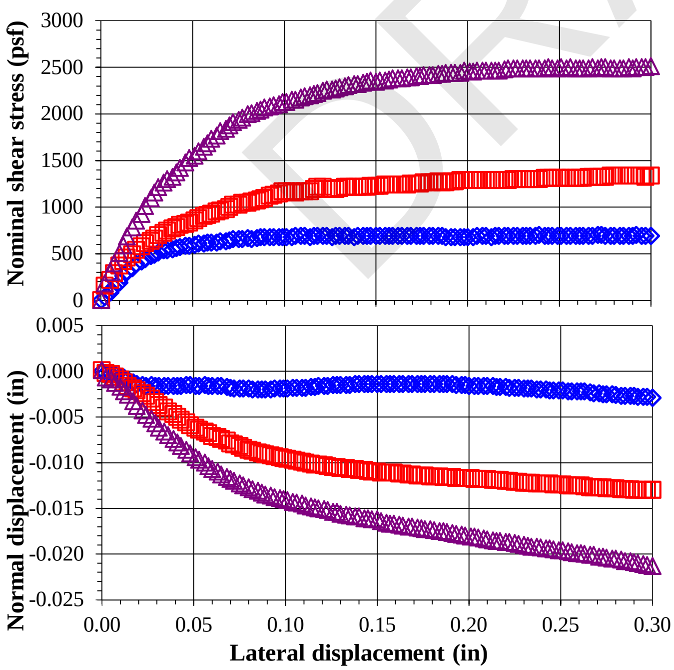
	Sample 1		Sample 2		Sample 3	
Nominal normal stress (psf)	1000		2000		4000	
Peak shear stress (psf)	703		1336		2512	
Lateral displacement at peak (in)	0.239		0.278		0.300	
Load Duration (min)	360		4245		4500	
	Initial	Pre-shear	Initial	Pre-shear	Initial	Pre-shear
Sample height (in)	0.996	0.984	0.999	0.979	0.997	0.976
Sample diameter (in)	2.424	2.424	2.412	2.412	2.414	2.414
Wt. rings + wet soil (g)	198.03	203.99	199.96	205.23	199.50	204.63
Wt. rings (g)	42.72	42.72	45.63	45.63	45.11	45.11
Wet soil + tare (g)	345.11		345.11		345.11	
Dry soil + tare (g)	320.29		320.29		320.29	
Tare (g)	123.70		123.70		123.70	
Water content (%)	12.6	16.9	12.6	16.5	12.6	16.4
Dry unit weight (pcf)	114.3	115.6	114.4	116.6	114.4	116.8
Void ratio, e, for assumed Gs	0.47	0.46	0.47	0.44	0.47	0.44
Saturation (%)*	71.8	100.0	71.9	100.0	72.1	100.0

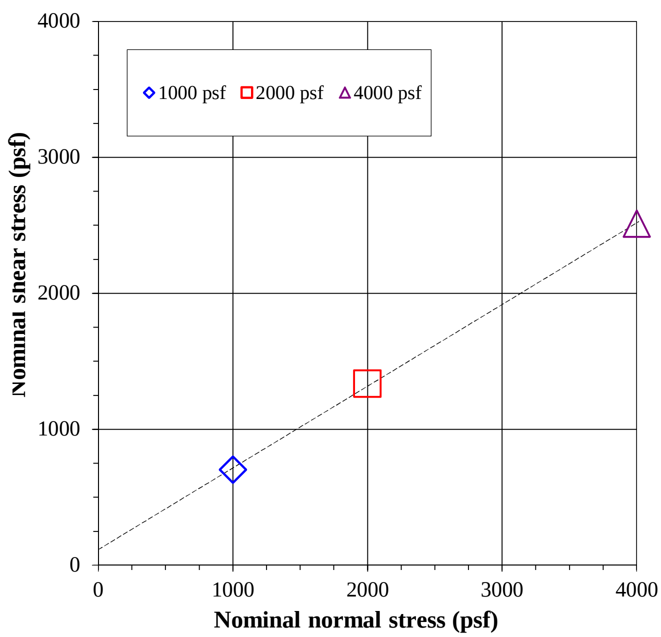
ϕ' (deg)	31
c' (psf)	115

Average of 3 samples	Initial	Pre-shear
Water content (%)	12.6	16.6
Dry unit weight (pcf)	114.4	116.4

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

DRAFT





Comments:
Sample screened on No. 4 sieve and remolded to estimated 90% of maximum dry density at in-situ moisture content.

Entered by:___________
Reviewed:___________

Direct Shear Test for Soils Under Drained Conditions

(ASTM D3080)

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Project: Bobcat Ridge
No: 01628-028
Location: Powder Mountain, Weber Co., UT

Boring No.: TP-9
Station: 12
Depth: 8.0'

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
0.002	36	0.000	0.002	157	0.000	0.002	180	-0.001
0.005	83	0.000	0.005	217	0.000	0.005	300	-0.001
0.007	143	0.000	0.007	289	-0.001	0.007	397	-0.001
0.010	191	-0.001	0.010	373	-0.001	0.010	505	-0.002
0.012	262	-0.001	0.012	421	-0.001	0.012	589	-0.002
0.014	310	-0.001	0.014	457	-0.002	0.014	685	-0.003
0.017	346	-0.001	0.017	494	-0.002	0.017	781	-0.003
0.019	393	-0.001	0.019	542	-0.002	0.019	853	-0.004
0.022	417	-0.002	0.022	578	-0.002	0.022	925	-0.004
0.024	441	-0.002	0.024	614	-0.003	0.024	1010	-0.005
0.027	477	-0.002	0.027	638	-0.003	0.027	1094	-0.005
0.029	489	-0.002	0.029	662	-0.003	0.029	1154	-0.006
0.031	513	-0.002	0.031	698	-0.004	0.031	1214	-0.006
0.034	536	-0.002	0.034	722	-0.004	0.034	1262	-0.007
0.036	536	-0.002	0.036	746	-0.004	0.036	1298	-0.007
0.039	548	-0.002	0.039	771	-0.005	0.039	1322	-0.007
0.041	560	-0.002	0.041	783	-0.005	0.041	1370	-0.008
0.043	572	-0.002	0.043	807	-0.005	0.043	1418	-0.008
0.046	584	-0.002	0.046	819	-0.006	0.046	1478	-0.009
0.048	584	-0.002	0.048	831	-0.006	0.048	1526	-0.009
0.051	596	-0.002	0.051	855	-0.006	0.051	1550	-0.009
0.053	608	-0.002	0.053	879	-0.006	0.053	1599	-0.010
0.056	608	-0.002	0.056	903	-0.007	0.056	1647	-0.010
0.058	620	-0.002	0.058	915	-0.007	0.058	1683	-0.010
0.060	620	-0.002	0.060	927	-0.007	0.060	1731	-0.011
0.063	620	-0.002	0.063	951	-0.007	0.063	1767	-0.011
0.065	632	-0.002	0.065	963	-0.007	0.065	1815	-0.011
0.068	632	-0.002	0.068	975	-0.008	0.068	1839	-0.012
0.070	644	-0.002	0.070	999	-0.008	0.070	1875	-0.012
0.072	656	-0.002	0.072	1023	-0.008	0.072	1911	-0.012
0.075	656	-0.002	0.075	1023	-0.008	0.075	1935	-0.012
0.077	656	-0.002	0.077	1047	-0.008	0.077	1959	-0.013
0.080	668	-0.002	0.080	1047	-0.009	0.080	1995	-0.013
0.082	656	-0.002	0.082	1059	-0.009	0.082	2007	-0.013
0.085	668	-0.002	0.085	1071	-0.009	0.085	2031	-0.013
0.087	679	-0.002	0.087	1084	-0.009	0.087	2043	-0.013
0.089	679	-0.002	0.089	1096	-0.009	0.089	2067	-0.014
0.092	679	-0.002	0.092	1120	-0.009	0.092	2079	-0.014
0.094	679	-0.002	0.094	1132	-0.009	0.094	2091	-0.014
0.097	679	-0.002	0.097	1144	-0.009	0.097	2103	-0.014
0.099	679	-0.002	0.099	1168	-0.010	0.099	2127	-0.014
0.101	679	-0.002	0.101	1168	-0.010	0.101	2127	-0.014
0.104	679	-0.002	0.104	1168	-0.010	0.104	2151	-0.014
0.106	691	-0.002	0.106	1156	-0.010	0.106	2151	-0.014
0.109	691	-0.002	0.109	1168	-0.010	0.109	2175	-0.015
0.111	691	-0.002	0.111	1168	-0.010	0.111	2187	-0.015
0.114	679	-0.002	0.114	1168	-0.010	0.114	2200	-0.015
0.116	691	-0.002	0.116	1192	-0.010	0.116	2212	-0.015
0.118	691	-0.002	0.118	1216	-0.010	0.118	2224	-0.015
0.121	691	-0.002	0.121	1216	-0.010	0.121	2248	-0.015
0.123	691	-0.002	0.123	1192	-0.010	0.123	2260	-0.015
0.126	679	-0.002	0.126	1192	-0.011	0.126	2260	-0.015
0.128	691	-0.002	0.128	1192	-0.011	0.128	2272	-0.015
0.130	691	-0.002	0.130	1204	-0.011	0.130	2284	-0.016
0.133	691	-0.002	0.133	1216	-0.011	0.133	2296	-0.016
0.135	691	-0.002	0.135	1216	-0.011	0.135	2308	-0.016
0.138	679	-0.001	0.138	1216	-0.011	0.138	2320	-0.016
0.140	691	-0.001	0.140	1216	-0.011	0.140	2320	-0.016
0.143	691	-0.001	0.143	1216	-0.011	0.143	2332	-0.016
0.145	691	-0.001	0.145	1216	-0.011	0.145	2344	-0.016
0.147	691	-0.001	0.147	1228	-0.011	0.147	2356	-0.016
0.150	691	-0.001	0.150	1228	-0.011	0.150	2344	-0.016
0.152	691	-0.001	0.152	1228	-0.011	0.152	2356	-0.016
0.155	691	-0.001	0.155	1240	-0.011	0.155	2356	-0.017

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Direct Shear Test for Soils Under Drained Conditions

(ASTM D3080)

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Project: **Bobcat Ridge**
No: **01628-028**
Location: Powder Mountain, Weber Co., UT

Boring No.: **TP-9**
Station: **12**
Depth: **8.0'**

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	691	-0.001	0.157	1240	-0.011	0.157	2368	-0.017
0.159	691	-0.001	0.159	1240	-0.011	0.159	2380	-0.017
0.162	691	-0.001	0.162	1240	-0.011	0.162	2380	-0.017
0.164	691	-0.001	0.164	1240	-0.011	0.164	2380	-0.017
0.167	691	-0.001	0.167	1240	-0.011	0.167	2392	-0.017
0.169	691	-0.001	0.169	1252	-0.011	0.169	2392	-0.017
0.172	691	-0.001	0.172	1252	-0.011	0.172	2404	-0.017
0.174	691	-0.001	0.174	1252	-0.011	0.174	2404	-0.017
0.176	691	-0.001	0.176	1264	-0.011	0.176	2416	-0.017
0.179	691	-0.001	0.179	1264	-0.012	0.179	2416	-0.017
0.181	691	-0.001	0.181	1264	-0.012	0.181	2416	-0.017
0.184	691	-0.001	0.184	1276	-0.012	0.184	2428	-0.018
0.186	691	-0.001	0.186	1264	-0.012	0.186	2428	-0.018
0.188	679	-0.001	0.188	1264	-0.012	0.188	2440	-0.018
0.191	679	-0.001	0.191	1276	-0.012	0.191	2440	-0.018
0.193	679	-0.002	0.193	1276	-0.012	0.193	2440	-0.018
0.196	679	-0.002	0.196	1288	-0.012	0.196	2440	-0.018
0.198	679	-0.002	0.198	1288	-0.012	0.198	2464	-0.018
0.200	679	-0.002	0.201	1288	-0.012	0.201	2452	-0.018
0.203	679	-0.002	0.203	1288	-0.012	0.203	2452	-0.018
0.205	691	-0.002	0.205	1288	-0.012	0.205	2464	-0.018
0.208	691	-0.002	0.208	1288	-0.012	0.208	2464	-0.018
0.210	691	-0.002	0.210	1288	-0.012	0.210	2464	-0.018
0.213	679	-0.002	0.213	1288	-0.012	0.213	2464	-0.019
0.215	691	-0.002	0.215	1288	-0.012	0.215	2464	-0.019
0.217	691	-0.002	0.217	1288	-0.012	0.217	2464	-0.019
0.220	691	-0.002	0.220	1288	-0.012	0.220	2476	-0.019
0.222	691	-0.002	0.222	1288	-0.012	0.222	2488	-0.019
0.225	691	-0.002	0.225	1300	-0.012	0.225	2488	-0.019
0.227	691	-0.002	0.227	1300	-0.012	0.227	2488	-0.019
0.230	691	-0.002	0.230	1300	-0.012	0.230	2488	-0.019
0.232	691	-0.002	0.232	1300	-0.012	0.232	2488	-0.019
0.234	691	-0.002	0.234	1300	-0.012	0.234	2488	-0.019
0.237	691	-0.002	0.237	1300	-0.012	0.237	2488	-0.019
0.239	703	-0.002	0.239	1300	-0.012	0.239	2488	-0.019
0.242	691	-0.002	0.242	1312	-0.012	0.242	2488	-0.019
0.244	691	-0.002	0.244	1312	-0.012	0.244	2500	-0.019
0.246	691	-0.002	0.246	1312	-0.012	0.246	2488	-0.020
0.249	691	-0.002	0.249	1312	-0.012	0.249	2488	-0.020
0.251	691	-0.002	0.251	1312	-0.012	0.251	2500	-0.020
0.254	691	-0.002	0.254	1312	-0.013	0.254	2488	-0.020
0.256	691	-0.002	0.256	1312	-0.013	0.256	2500	-0.020
0.259	691	-0.002	0.259	1312	-0.013	0.259	2488	-0.020
0.261	691	-0.002	0.261	1312	-0.013	0.261	2488	-0.020
0.263	691	-0.002	0.263	1312	-0.013	0.263	2488	-0.020
0.266	691	-0.002	0.266	1324	-0.013	0.266	2488	-0.020
0.268	691	-0.002	0.268	1324	-0.013	0.268	2500	-0.020
0.271	703	-0.002	0.271	1324	-0.013	0.271	2488	-0.020
0.273	703	-0.003	0.273	1324	-0.013	0.273	2500	-0.020
0.275	691	-0.003	0.275	1324	-0.013	0.275	2500	-0.020
0.278	691	-0.003	0.278	1336	-0.013	0.278	2488	-0.021
0.280	691	-0.003	0.280	1336	-0.013	0.280	2488	-0.021
0.283	691	-0.003	0.283	1336	-0.013	0.283	2488	-0.021
0.285	691	-0.003	0.285	1336	-0.013	0.285	2488	-0.021
0.288	691	-0.003	0.288	1336	-0.013	0.288	2500	-0.021
0.290	691	-0.003	0.290	1336	-0.013	0.290	2488	-0.021
0.292	703	-0.003	0.292	1336	-0.013	0.292	2500	-0.021
0.295	691	-0.003	0.295	1336	-0.013	0.295	2500	-0.021
0.297	691	-0.003	0.297	1324	-0.013	0.297	2500	-0.021
0.300	691	-0.003	0.300	1336	-0.013	0.300	2512	-0.021
0.300	691	-0.003	0.300	1336	-0.013	0.300	2512	-0.021

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Direct Shear Test for Soils Under Drained Conditions

(ASTM D3080)

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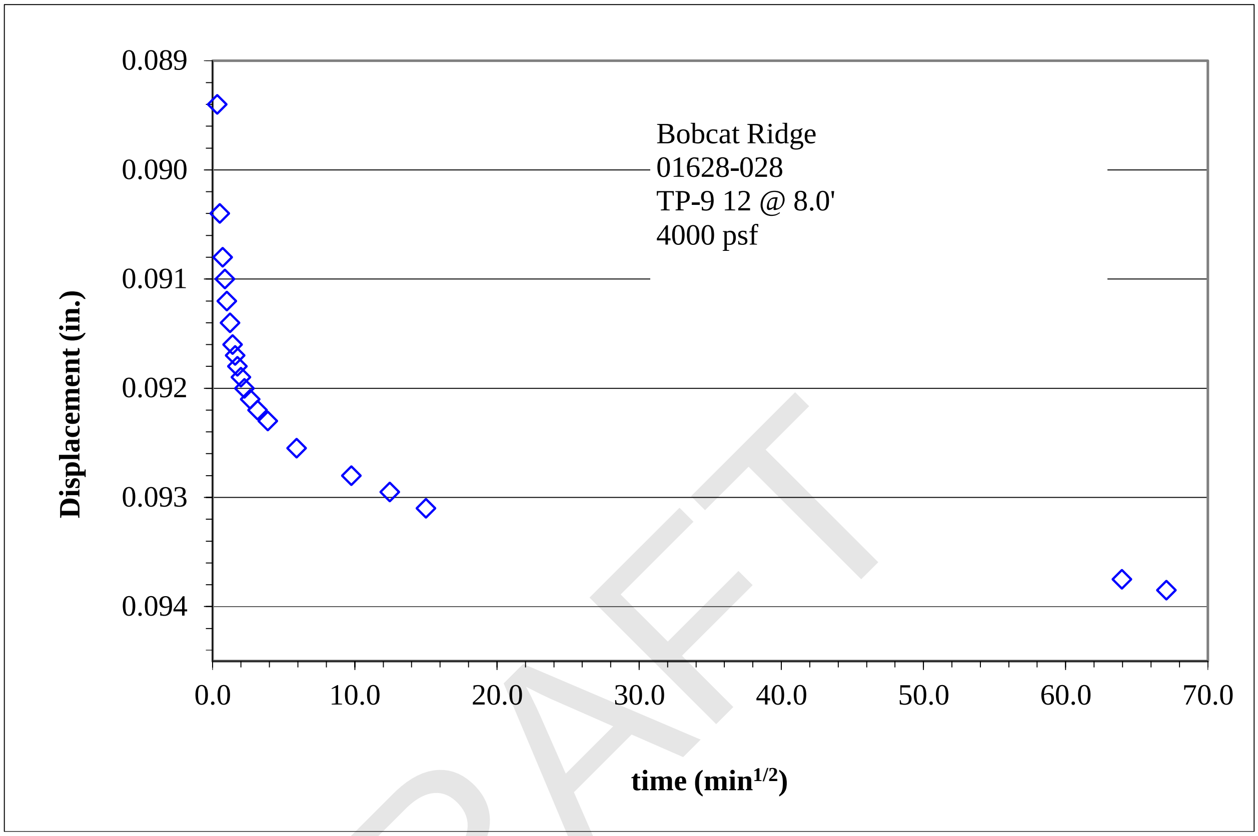
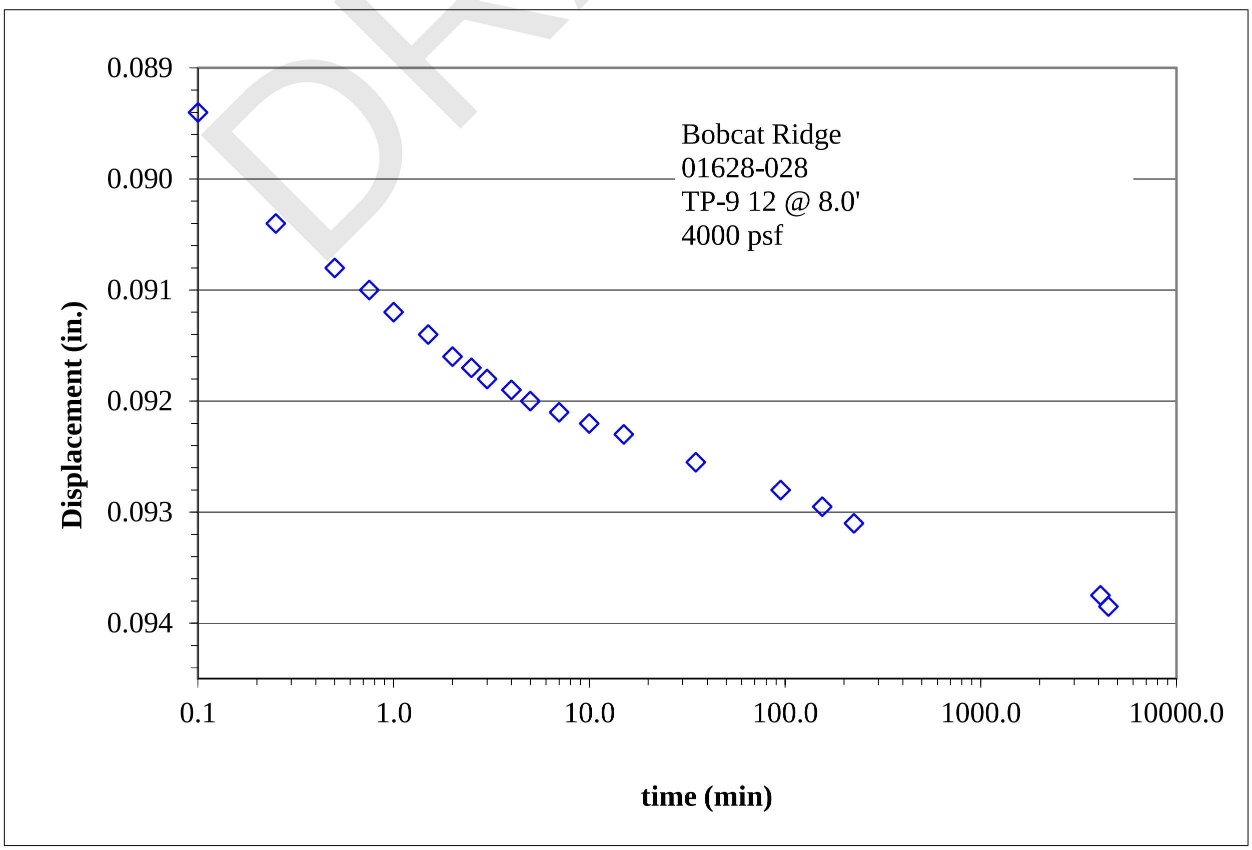
Project: Bobcat Ridge
No: 01628-028
Location: Powder Mountain, Weber Co., UT

Boring No.: TP-9
Station: 12
Depth: 8.0'





DRAFT

Direct Shear Test for Soils Under Drained Conditions

(ASTM D3080)

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Project: Bobcat Ridge
No: 01628-028
Location: Powder Mountain, Weber Co., UT
Date: 7/9/2018
By: EH

Boring No.: TP-21
Station: 5
Depth: 5.5'
Sample Description: Reddish brown sandy clay
Sample type: Undisturbed-trimmed from thin-wall

Test type: Inundated
Lateral displacement (in.): 0.3
Shear rate (in./min): 0.0009
Specific gravity, Gs: 2.70 Assumed

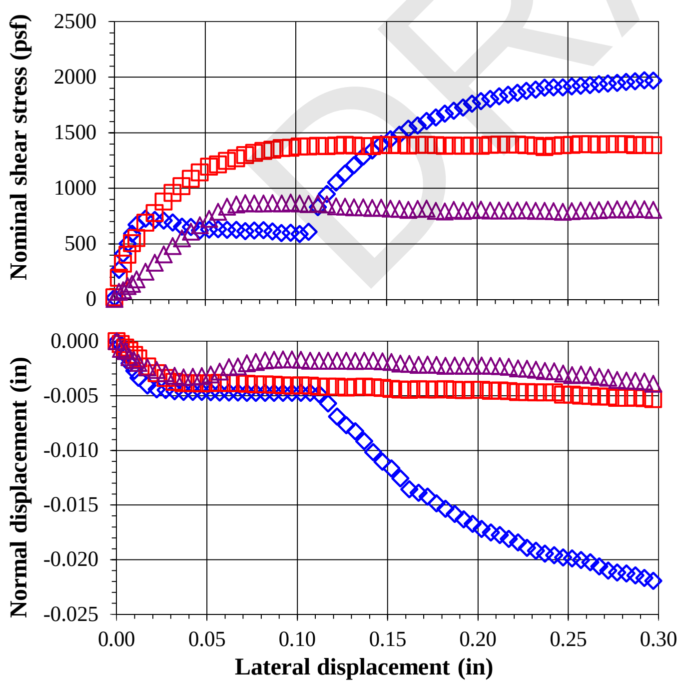
	Sample 1		Sample 2		Sample 3	
Nominal normal stress (psf)	3000		2000		1000	
Peak shear stress (psf)	1977		1397		872	
Lateral displacement at peak (in)	0.300		0.262		0.097	
Load Duration (min)	184		200		215	
	Initial	Pre-shear	Initial	Pre-shear	Initial	Pre-shear
Sample height (in)	0.996	0.998	0.997	0.958	0.999	0.965
Sample diameter (in)	2.424	2.424	2.414	2.414	2.412	2.412
Wt. rings + wet soil (g)	194.62	203.61	200.08	204.16	199.56	204.44
Wt. rings (g)	42.72	42.72	45.11	45.11	45.63	45.63
Wet soil + tare (g)	314.59		314.59		314.59	
Dry soil + tare (g)	294.24		294.24		294.24	
Tare (g)	123.63		123.63		123.63	
Water content (%)	11.9	18.6	11.9	14.9	11.9	15.5
Dry unit weight (pcf)	112.5	112.2	115.6	120.2	114.8	118.8
Void ratio, e, for assumed Gs	0.50	0.50	0.46	0.40	0.47	0.42
Saturation (%)*	64.6	100.0	70.3	100.0	68.7	100.0

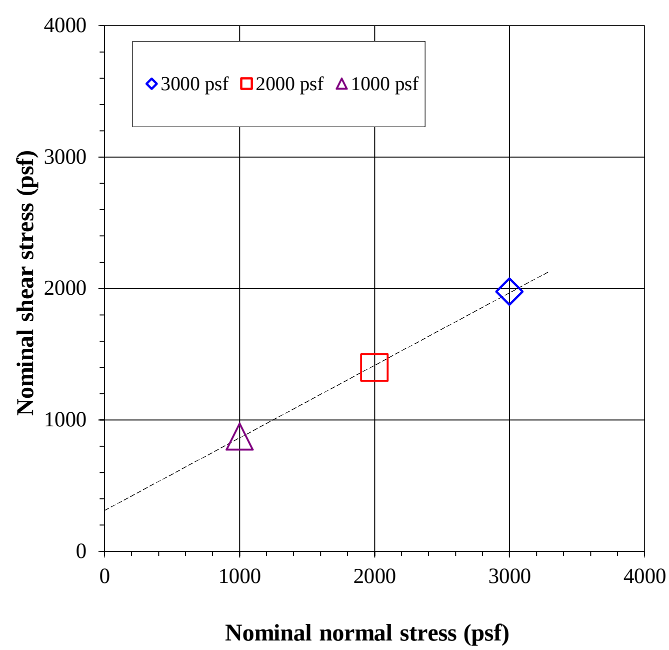
ϕ' (deg)	29
c' (psf)	311

Average of 3 samples	Initial	Pre-shear
Water content (%)	11.9	16.3
Dry unit weight (pcf)	114.3	117.1

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

DRAFT





Comments:
Specimens contain gravel that may have influenced the behavior of specimen S1.

Entered by:___________
Reviewed:___________

Direct Shear Test for Soils Under Drained Conditions

(ASTM D3080)

© IGES 2009, 2018

Project: Bobcat Ridge
No: 01628-028
Location: Powder Mountain, Weber Co., UT

Boring No.: TP-21
Station: 5
Depth: 5.5'

Nominal normal stress = 3000 psf			Nominal normal stress = 2000 psf			Nominal normal stress = 1000 psf		
Lateral Displacement (in.)	Nominal Shear Stress (psf)	Normal Displacement (in.)	Lateral Displacement (in.)	Nominal Shear Stress (psf)	Normal Displacement (in.)	Lateral Displacement (in.)	Nominal Shear Stress (psf)	Normal Displacement (in.)
0.000	15	0.000	0.000	19	0.000	0.000	4	0.000
0.002	267	0.000	0.002	195	0.000	0.002	68	-0.001
0.005	410	-0.001	0.005	320	-0.001	0.005	81	-0.001
0.007	503	-0.002	0.007	402	-0.001	0.007	118	-0.001
0.010	592	-0.003	0.010	505	-0.001	0.010	139	-0.002
0.012	672	-0.003	0.012	551	-0.002	0.012	180	-0.002
0.017	728	-0.004	0.017	689	-0.002	0.017	249	-0.002
0.022	715	-0.004	0.022	777	-0.003	0.022	328	-0.003
0.027	710	-0.004	0.027	880	-0.003	0.027	405	-0.003
0.032	692	-0.005	0.032	957	-0.004	0.032	479	-0.003
0.037	654	-0.005	0.037	1018	-0.004	0.037	548	-0.003
0.042	651	-0.005	0.042	1085	-0.004	0.042	610	-0.003
0.047	621	-0.005	0.047	1142	-0.004	0.047	666	-0.003
0.052	628	-0.005	0.052	1194	-0.004	0.052	725	-0.003
0.057	631	-0.005	0.057	1215	-0.004	0.057	787	-0.003
0.062	626	-0.005	0.062	1245	-0.004	0.062	834	-0.002
0.067	626	-0.005	0.067	1269	-0.004	0.067	853	-0.002
0.072	615	-0.005	0.072	1297	-0.004	0.072	866	-0.002
0.077	621	-0.005	0.077	1317	-0.004	0.077	861	-0.002
0.082	623	-0.005	0.082	1336	-0.004	0.082	861	-0.002
0.087	613	-0.005	0.087	1346	-0.004	0.087	866	-0.002
0.092	598	-0.005	0.092	1360	-0.004	0.092	864	-0.002
0.097	600	-0.005	0.097	1365	-0.004	0.097	872	-0.002
0.102	590	-0.005	0.102	1375	-0.004	0.102	861	-0.002
0.107	610	-0.005	0.107	1377	-0.004	0.107	857	-0.002
0.112	831	-0.005	0.112	1381	-0.004	0.112	862	-0.002
0.117	949	-0.006	0.117	1379	-0.004	0.117	853	-0.002
0.122	1054	-0.007	0.122	1384	-0.004	0.122	835	-0.002
0.127	1133	-0.008	0.127	1389	-0.004	0.127	833	-0.002
0.132	1208	-0.008	0.132	1385	-0.004	0.132	829	-0.002
0.137	1287	-0.009	0.137	1380	-0.004	0.137	827	-0.002
0.142	1341	-0.010	0.142	1379	-0.004	0.142	824	-0.002
0.147	1398	-0.011	0.147	1389	-0.004	0.147	825	-0.002
0.152	1441	-0.012	0.152	1387	-0.004	0.152	816	-0.002
0.157	1482	-0.013	0.157	1390	-0.004	0.157	813	-0.002
0.162	1536	-0.014	0.162	1385	-0.004	0.162	806	-0.002
0.167	1567	-0.014	0.167	1390	-0.004	0.167	813	-0.002
0.172	1605	-0.014	0.172	1389	-0.004	0.172	816	-0.002
0.177	1639	-0.015	0.177	1386	-0.004	0.177	797	-0.002
0.182	1674	-0.015	0.182	1382	-0.004	0.182	790	-0.002
0.187	1698	-0.016	0.187	1385	-0.004	0.187	804	-0.002
0.192	1726	-0.016	0.192	1382	-0.004	0.192	797	-0.002
0.197	1762	-0.017	0.197	1385	-0.004	0.197	801	-0.002
0.202	1785	-0.017	0.202	1382	-0.004	0.202	808	-0.002
0.207	1805	-0.018	0.207	1391	-0.005	0.207	799	-0.002
0.212	1828	-0.018	0.212	1393	-0.005	0.212	799	-0.002
0.217	1844	-0.018	0.217	1393	-0.005	0.217	798	-0.002
0.222	1859	-0.018	0.222	1393	-0.005	0.222	798	-0.002
0.227	1877	-0.019	0.227	1386	-0.005	0.227	803	-0.003
0.232	1890	-0.019	0.232	1382	-0.005	0.232	796	-0.003
0.237	1905	-0.019	0.237	1371	-0.005	0.237	797	-0.003
0.242	1908	-0.020	0.242	1381	-0.005	0.242	792	-0.003
0.247	1910	-0.020	0.247	1386	-0.005	0.247	788	-0.003
0.252	1918	-0.020	0.252	1391	-0.005	0.252	794	-0.003
0.257	1923	-0.020	0.257	1395	-0.005	0.257	799	-0.003
0.262	1928	-0.020	0.262	1397	-0.005	0.262	799	-0.003
0.267	1939	-0.021	0.267	1393	-0.005	0.267	803	-0.003
0.272	1944	-0.021	0.272	1397	-0.005	0.272	809	-0.003
0.277	1949	-0.021	0.277	1397	-0.005	0.277	811	-0.004
0.282	1959	-0.021	0.282	1395	-0.005	0.282	808	-0.004
0.287	1964	-0.021	0.287	1386	-0.005	0.287	814	-0.004
0.292	1972	-0.022	0.292	1390	-0.005	0.292	812	-0.004
0.297	1969	-0.022	0.297	1388	-0.005	0.297	804	-0.004
0.300	1977	-0.022	0.300	1389	-0.005	0.301	803	-0.004

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Direct Shear Test for Soils Under Drained Conditions

(ASTM D3080)

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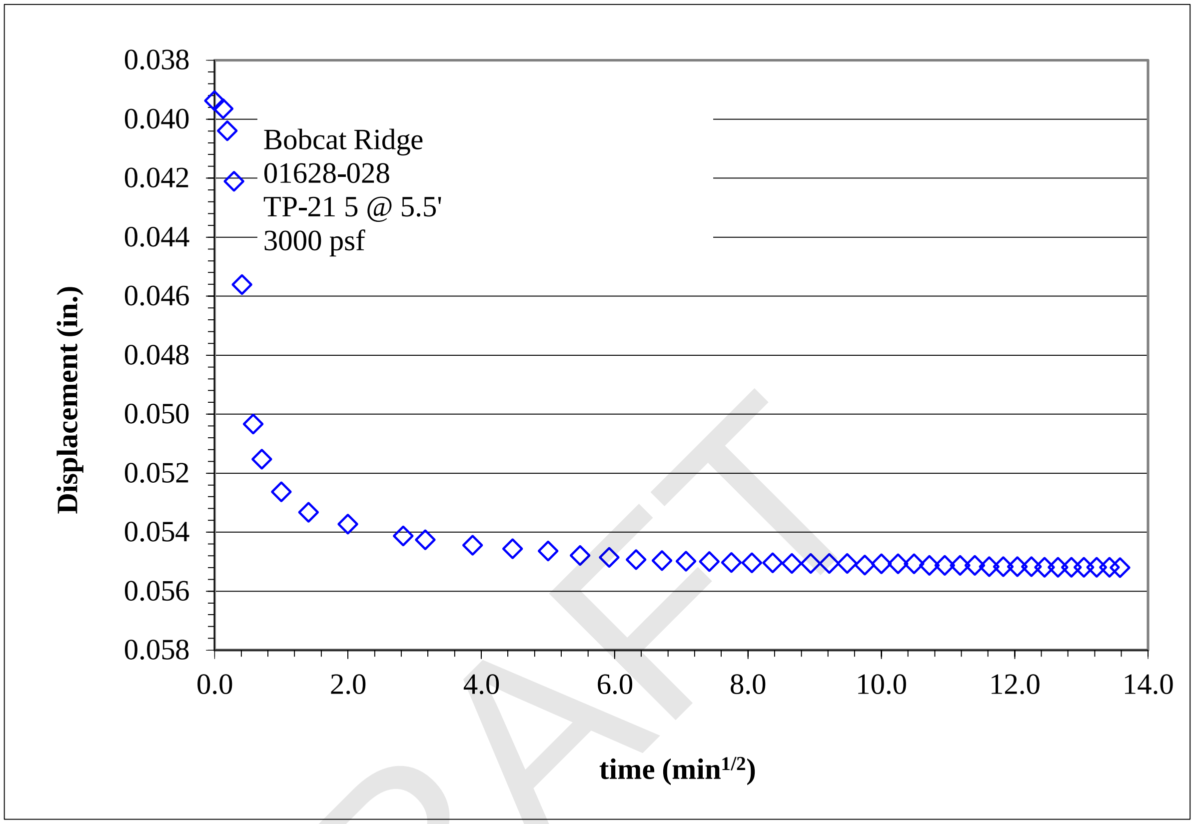
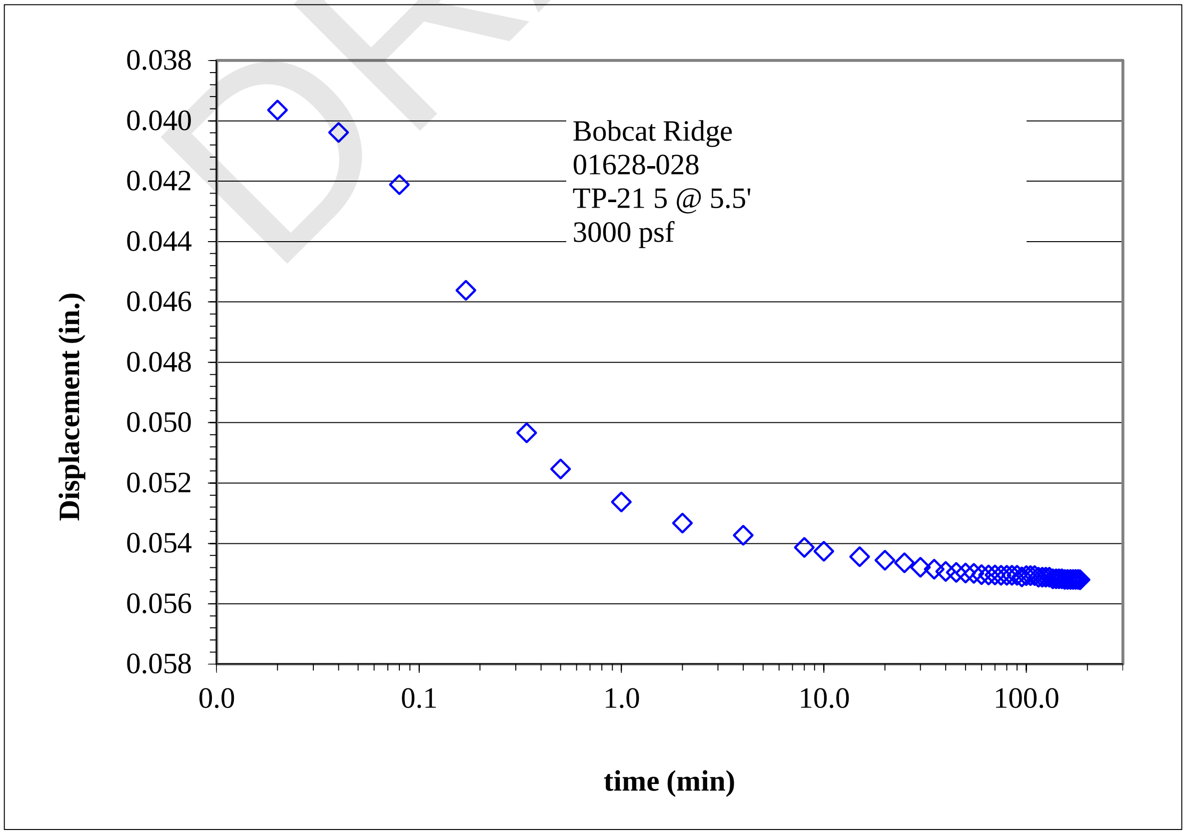
Project: Bobcat Ridge
No: 01628-028
Location: Powder Mountain, Weber Co., UT

Boring No.: TP-21
Station: 5
Depth: 5.5'





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Torsional Ring Shear Test to Determine Drained Residual Shear Strength of Cohesive Soils (ASTM 6467)

© IGES 2007, 2018

Project: **Bobcat Ridge**
No: **01628-028**
Location: Powder Mountain, Weber Co., UT
Date: 7/20/2018
By: NB

Boring No.: **TP-1**
Station: **16**
Depth: **4.0'**
Sample Description: Reddish brown fat clay
Engineering Classification: CH

Sample preparation: Screened over No.40 / remolded near liquid limit
Test type: Residual
Ring friction remarks: Modified upper platen
Ring shear device: Bromhead type, WF 25850 #1
Sample presheared: Yes
Failure surface location: Near top

inner/outter/avg. dia. (mm)	70	100	85
inner/outter/avg. radii (mm)	35	50	42.5
Thickness (mm)/area (cm^2):	5	40.1	

LL (%):	126	CF [a] (%):	N/A
PL (%):	41	Gs assum.:	2.8
		% Finer No. 200 (tested sample):	94.3

LL, PL = liquid and plastic limits, respectively
[a]CF = %<0.002 mm and passing No. 10

	τ stress	σ stress	Horz. def	Vert. def
Units:	(psf)	(psf)	(deg.)	(in)
Conversion:	20885.434	2048.2	1	3.94E-05

	Sample 1 Initial	Final
Sample thickness (mm)	5.00	2.73
Wt. container + wet soil (g)	622.38	
Wt. container (g)	593.32	
Wet soil + tare (g)	16.11	25.68
Dry soil + tare (g)	11.10	20.11
Tare (g)	7.06	12.72
Water content (%)	124.0	75.4
Dry density (g/cm^3)	0.65	1.19
Saturation (%)	104.5	155.3

	Sample 1
Normal load on lever arm (kg)	2
Conversion factor (kg/cm^2) to (psf):	2048.1614
Residual deformation (deg.)	175.7
Normal stress (psf)	1023
Residual shear stress (psf)	263
Peak shear stress (psf)	411
Secant residual friction angle (deg)	14.4
Secant peak friction angle (deg)	21.9

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Entered by:___________
Reviewed:___________

<u>Torsional Ring Shear Test to Determine Drained Residual Shear Strength of Cohesive Soils</u> (*ASTM 6467*)

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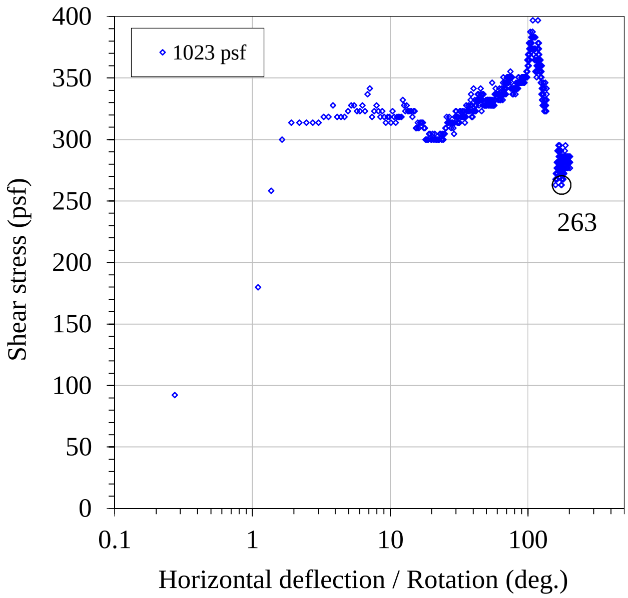
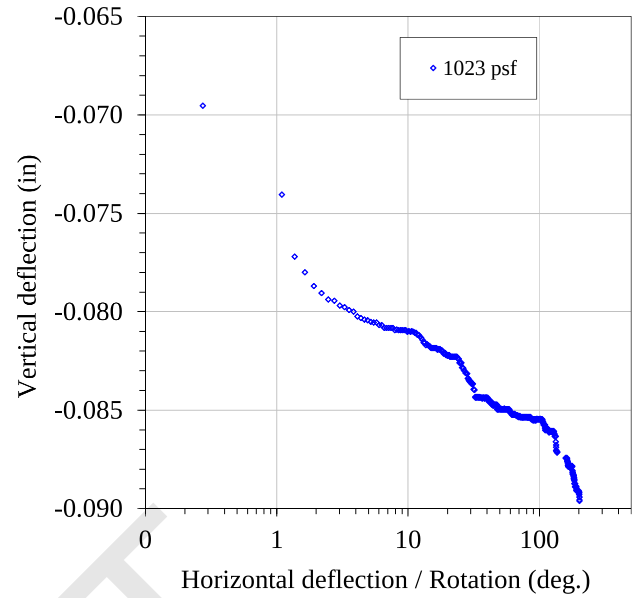
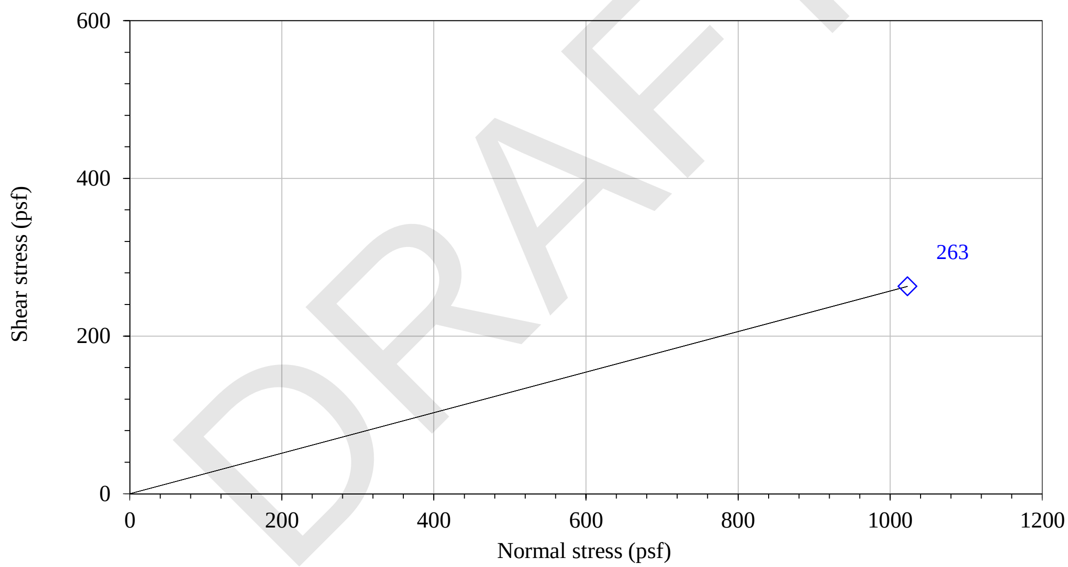
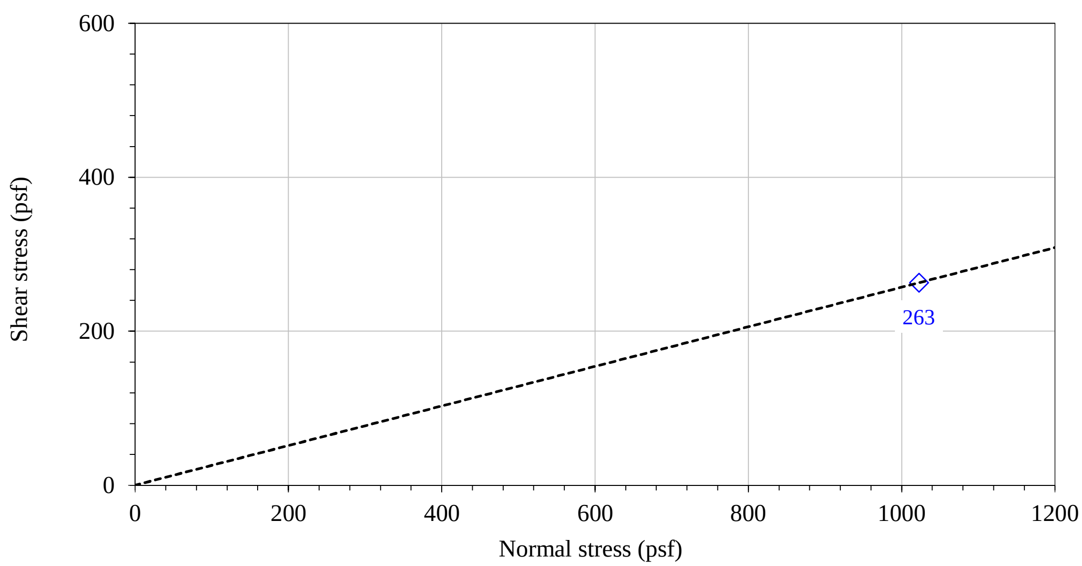




*Horizontal deflection (in) = Degrees rotation * 0.0292*



DRAFT



Minimum Laboratory Soil Resistivity, pH of Soil for Use in Corrosion Testing, and Ions in Water by Chemically Suppressed Ion Chromatography *(AASHTO T 288, T 289, ASTM D4327, and C1580)*

© IGES 2014, 2018

Project: **Bobcat Ridge**
No: **01628-028**
Location: Powder Mountain, Weber Co., UT
Date: 7/9/2018
By: JP

Sample info.	Boring No.	TP-25							
	Station	4							
	Depth	3.0'							
Water content data	Wet soil + tare (g)	72.31							
	Dry soil + tare (g)	67.90							
	Tare (g)	37.23							
	Water content (%)	14.4							
Chem. data	pH	4.21							
	Soluble chloride* (ppm)	18.9							
	Soluble sulfate** (ppm)	<5.80							
Resistivity data	Pin method	2							
	Soil box	Miller Small							
		Approximate Soil condition (%)	Resistance Reading (Ω)	Soil Box Multiplier (cm)	Resistivity (Ω-cm)	Approximate Soil condition (%)	Resistance Reading (Ω)	Soil Box Multiplier (cm)	Resistivity (Ω-cm)
		As Is	5708	0.67	3824				
		+3	2670	0.67	1789				
		+6	1750	0.67	1173				
		+9	1460	0.67	978				
		+12	1496	0.67	1002				
	Minimum resistivity (Ω-cm)	**978**							

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* Performed by AWAL using EPA 300.0

** Performed by AWAL using ASTM C1580

Entered by:___________

Reviewed:___________

APPENDIX C

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USGS Design Maps Detailed Report

2012/2015 International Building Code (41.3578°N, 111.7496°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 = 0.814 g
From Figure 1613.3.1(2) [2]	S_1 = 0.270 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

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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				
	$S_S \leq 0.25$	$S_S = 0.50$	$S_S = 0.75$	$S_S = 1.00$	$S_S \geq 1.25$
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 = 0.814 g, F_a = 1.075

TABLE 1613.3.3(2)
VALUES OF SITE COEFFICIENT F_v

Site Class	Mapped Spectral Response Acceleration at 1–s Period				
	$S_1 \leq 0.10$	$S_1 = 0.20$	$S_1 = 0.30$	$S_1 = 0.40$	$S_1 \geq 0.50$
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 = 0.270 g, F_v = 1.530

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Equation (16-37):	$S_{MS} = F_a S_S = 1.075 \times 0.814 = 0.874$ g
Equation (16-38):	$S_{M1} = F_v S_1 = 1.530 \times 0.270 = 0.413$ g

Section 1613.3.4 — Design spectral response acceleration parameters

Equation (16-39):	$S_{DS} = ⅔ S_{MS} = ⅔ \times 0.874 = 0.583$ g
Equation (16-40):	$S_{D1} = ⅔ S_{M1} = ⅔ \times 0.413 = 0.275$ g

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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} = 0.583 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} = 0.275 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

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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

USGS Design Maps Summary Report

User–Specified Input

Report Title	Bobcat Fri July 20, 2018 20:16:05 UTC
Building Code Reference Document	2012/2015 International Building Code (which utilizes USGS hazard data available in 2008)
Site Coordinates	41.3578°N, 111.7496°W
Site Soil Classification	Site Class C – “Very Dense Soil and Soft Rock”
Risk Category	I/II/III

USGS–Provided Output

S_S =	0.814 g	S_{MS} =	0.874 g	S_{DS} =	0.583 g
S_1 =	0.270 g	S_{M1} =	0.413 g	S_{D1} =	0.275 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.

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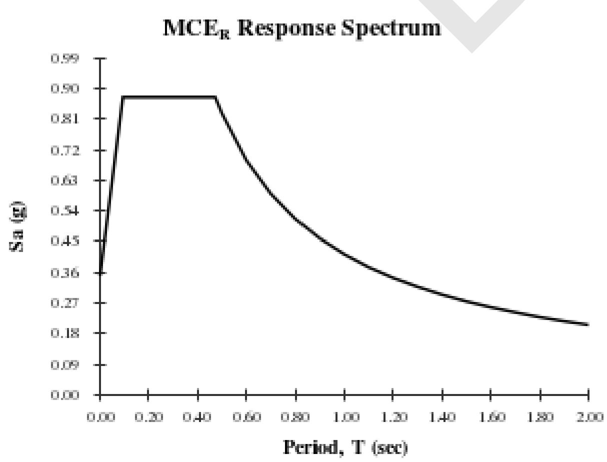

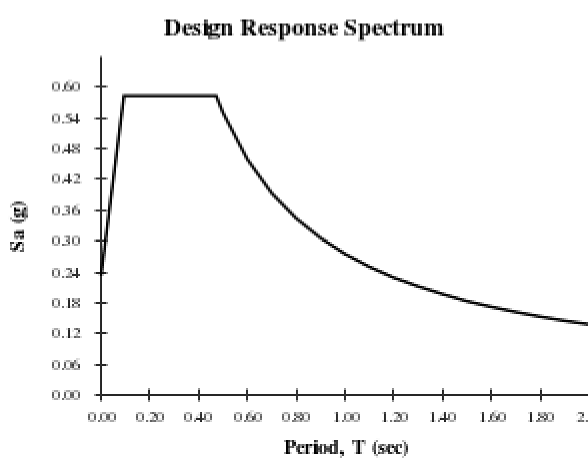

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APPENDIX D

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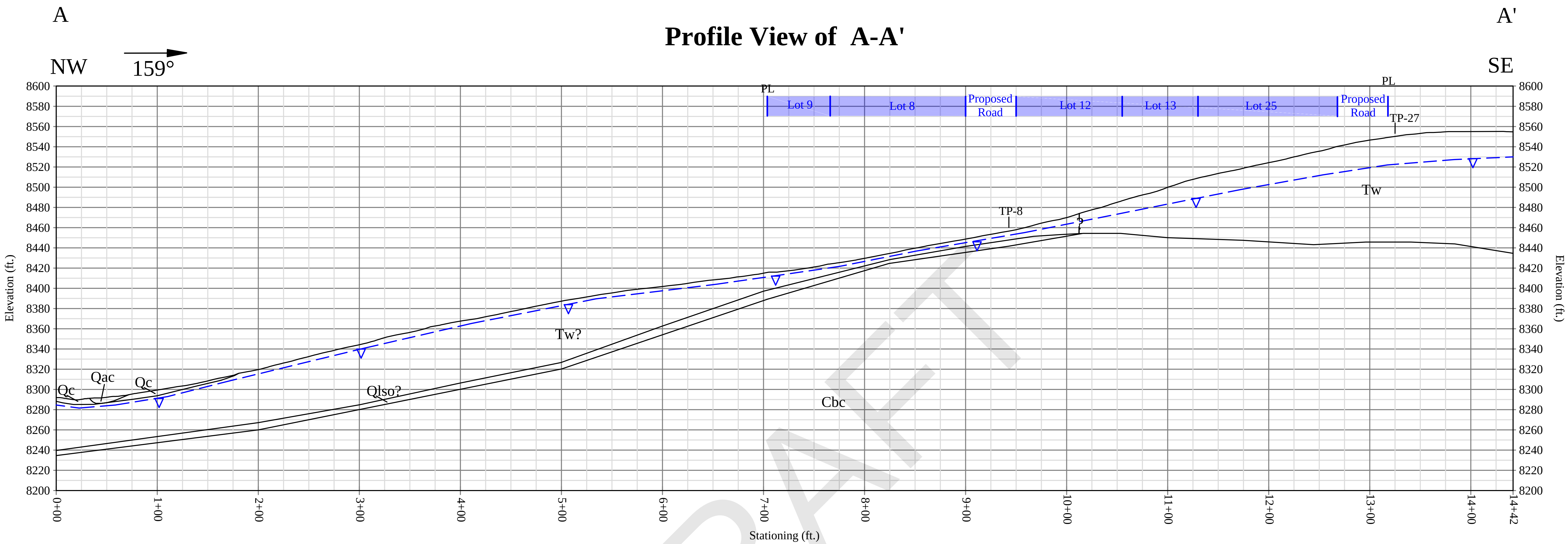

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LEGEND

Qac	Alluvial and Colluvial Deposits	Qlso?	Deeper Clay Seam; possible older landslide slide plane		
Qc	Colluvium	Tw	Wasatch Formation; queried where possible older landslide deposits	Cbc	Calls Fort Shale Member of Bloomington Formation

*All Geologic Contacts Approximate

Groundwater (perched)

0 100 200
FEET
1" = 100'

IGES®

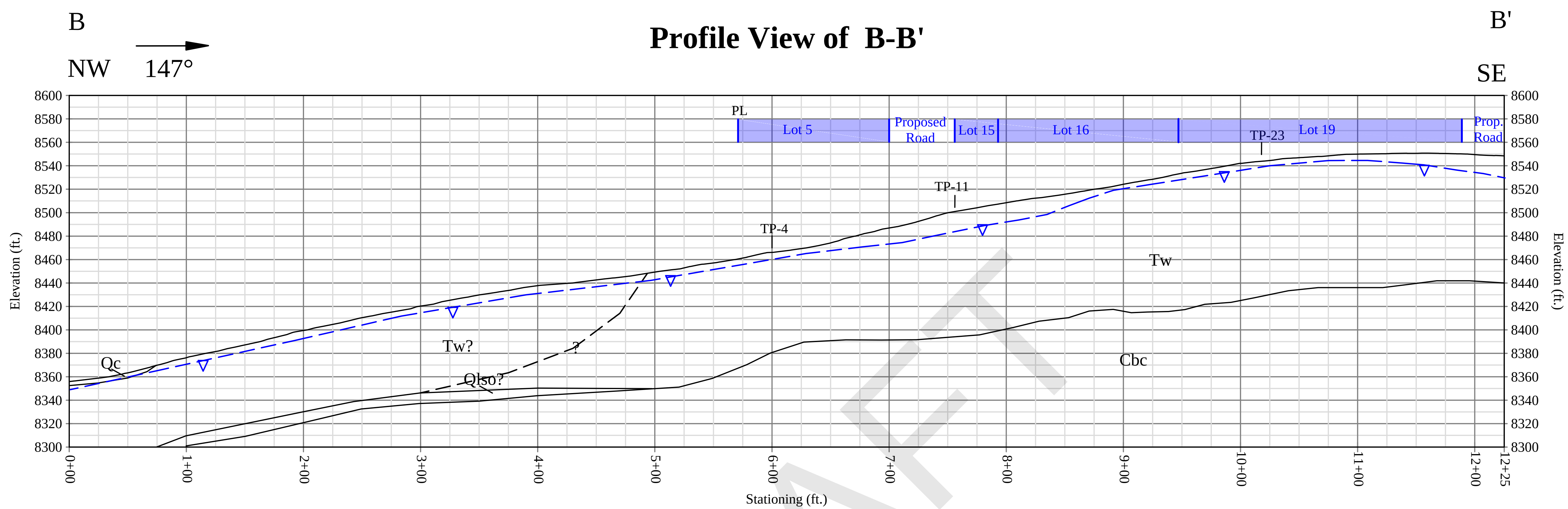
Project No: 01628-028

Geotechnical and Geologic Hazards Assessment
Bobcat Ridge Subdivision
Summit Powder Mountain Resort
Weber County, Utah

Cross Section A-A'

Figure

D-1



LEGEND

Qac Alluvial and Colluvial Deposits

Qlso? Deeper Clay Seam; possible older landslide deposit

Qc Colluvium

Tw Wasatch Formation; queried where possible older landslide deposits

Cbc Calls Fort Shale Member of Bloomington Formation

Groundwater (perched)

*All Geologic Contacts Approximate

0 100 200 FEET

1" = 100'

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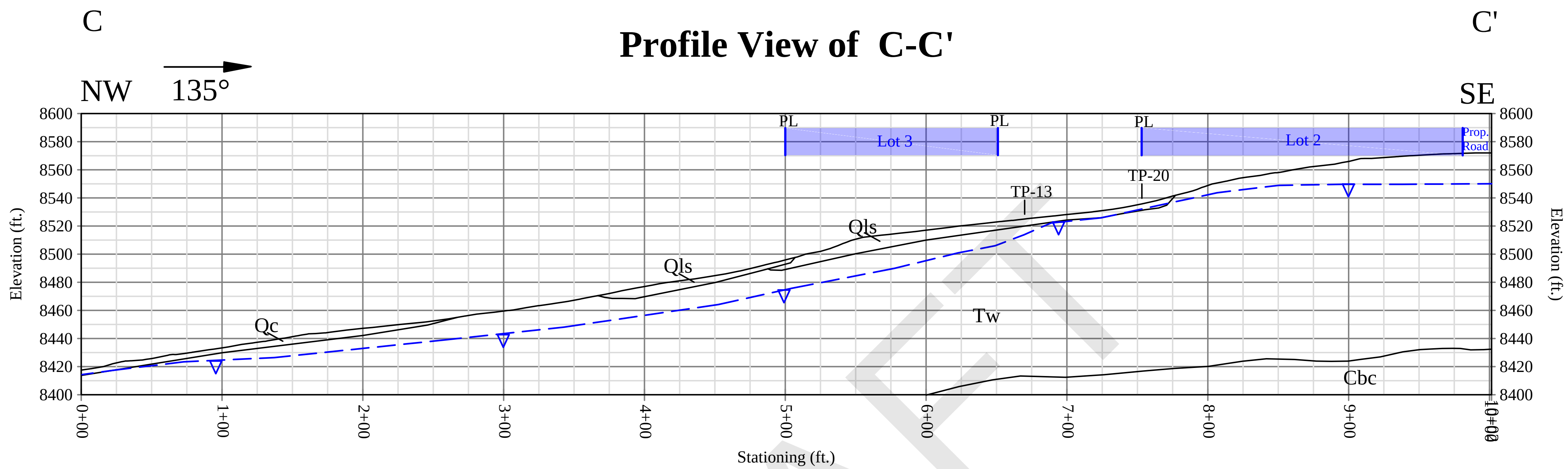
Project No: 01628-028

Geotechnical and Geologic Hazards Assessment
Bobcat Ridge Subdivision
Summit Powder Mountain Resort
Weber County, Utah

Cross Section B-B'

Figure D-2



LEGEND

Qac	Alluvial and Colluvial Deposits	Qls	Landslide Deposits (Holocene-aged)		
Qc	Colluvium	Tw	Wasatch Formation; queried where possible older landslide deposits	Cbc	Calls Fort Shale Member of Bloomington Formation

*All Geologic Contacts Approximate

Groundwater (perched)

0 100 200 FEET

1" = 100'

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Geotechnical and Geologic Hazards Assessment
Bobcat Ridge Subdivision
Summit Powder Mountain Resort
Weber County, Utah

Cross Section C-C'

Figure D-3

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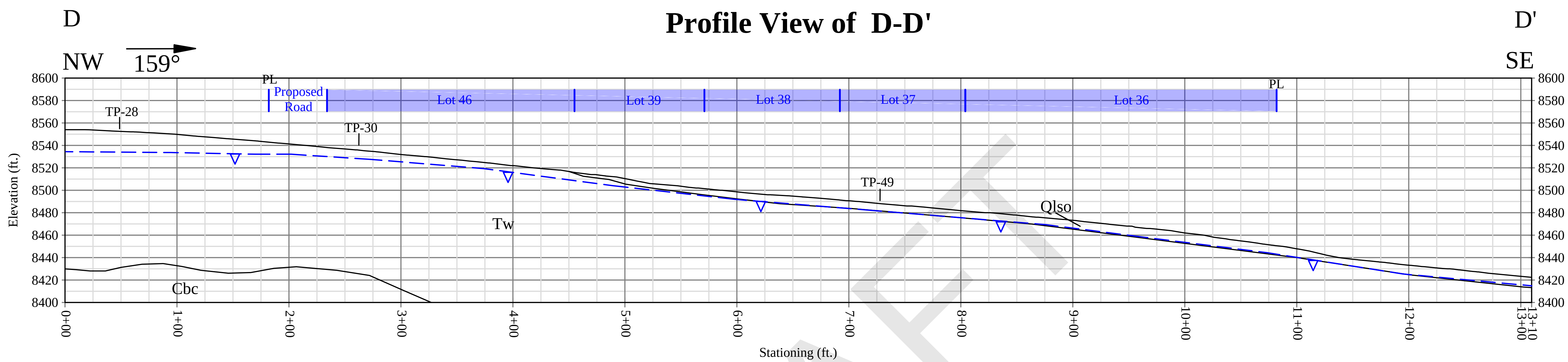

LEGEND

Qac	Alluvial and Colluvial Deposits	Qlso	Older Landslide Deposits (Pleistocene-aged)		
Qc	Colluvium	Tw	Wasatch Formation; queried where possible older landslide deposits	Cbc	Calls Fort Shale Member of Bloomington Formation

*All Geologic Contacts Approximate

Groundwater (perched)

0 100 200
FEET

1" = 100'

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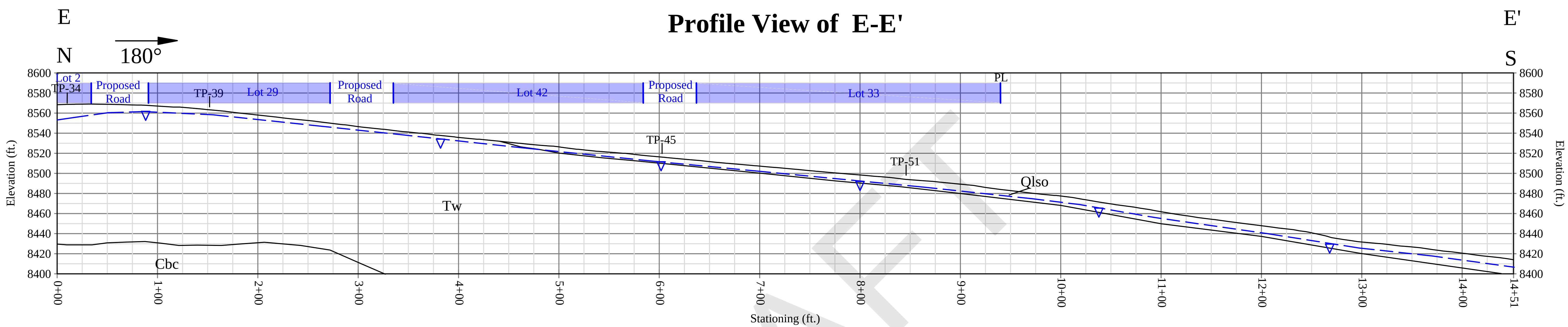
Project No: 01628-028

Geotechnical and Geologic Hazards Assessment
Bobcat Ridge Subdivision
Summit Powder Mountain Resort
Weber County, Utah

Cross Section D-D'

Figure D-4



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LEGEND

Qac	Alluvial and Colluvial Deposits	Qlso	Older Landslide Deposits (Pleistocene-aged)		
Qc	Colluvium	Tw	Wasatch Formation; queried where possible older landslide deposits	Cbc	Calls Fort Shale Member of Bloomington Formation

Groundwater (perched)

*All Geologic Contacts Approximate

0 100 200
FEET

1" = 100'

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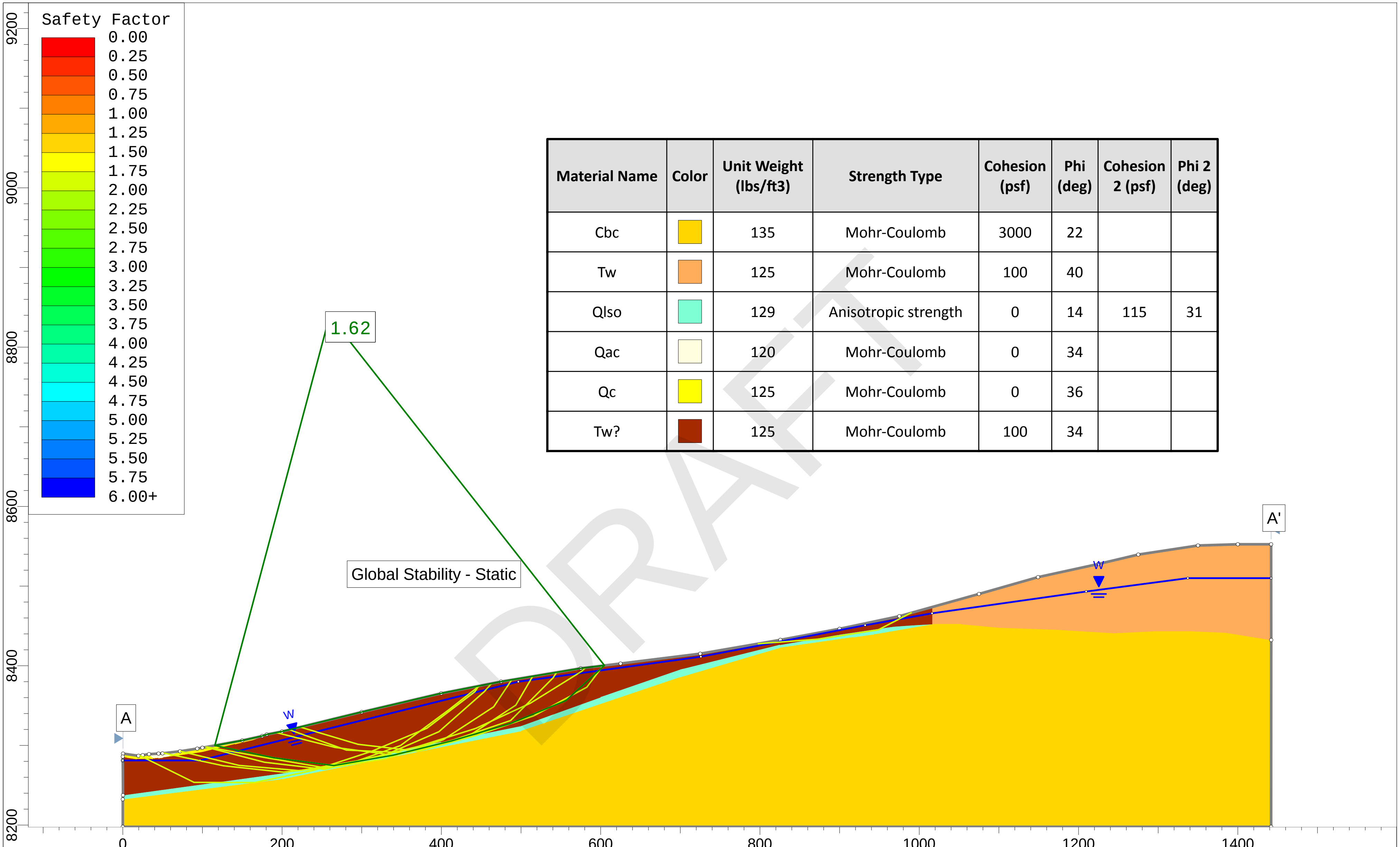
Project No: 01628-028

Geotechnical and Geologic Hazards Assessment
Bobcat Ridge Subdivision
Summit Powder Mountain Resort
Weber County, Utah

Cross Section E-E'

Figure

D-5



Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Cohesion 2 (psf)	Phi 2 (deg)
Cbc		135	Mohr-Coulomb	3000	22		
Tw		125	Mohr-Coulomb	100	40		
Qlso		129	Anisotropic strength	0	14	115	31
Qac		120	Mohr-Coulomb	0	34		
Qc		125	Mohr-Coulomb	0	36		
Tw?		125	Mohr-Coulomb	100	34		

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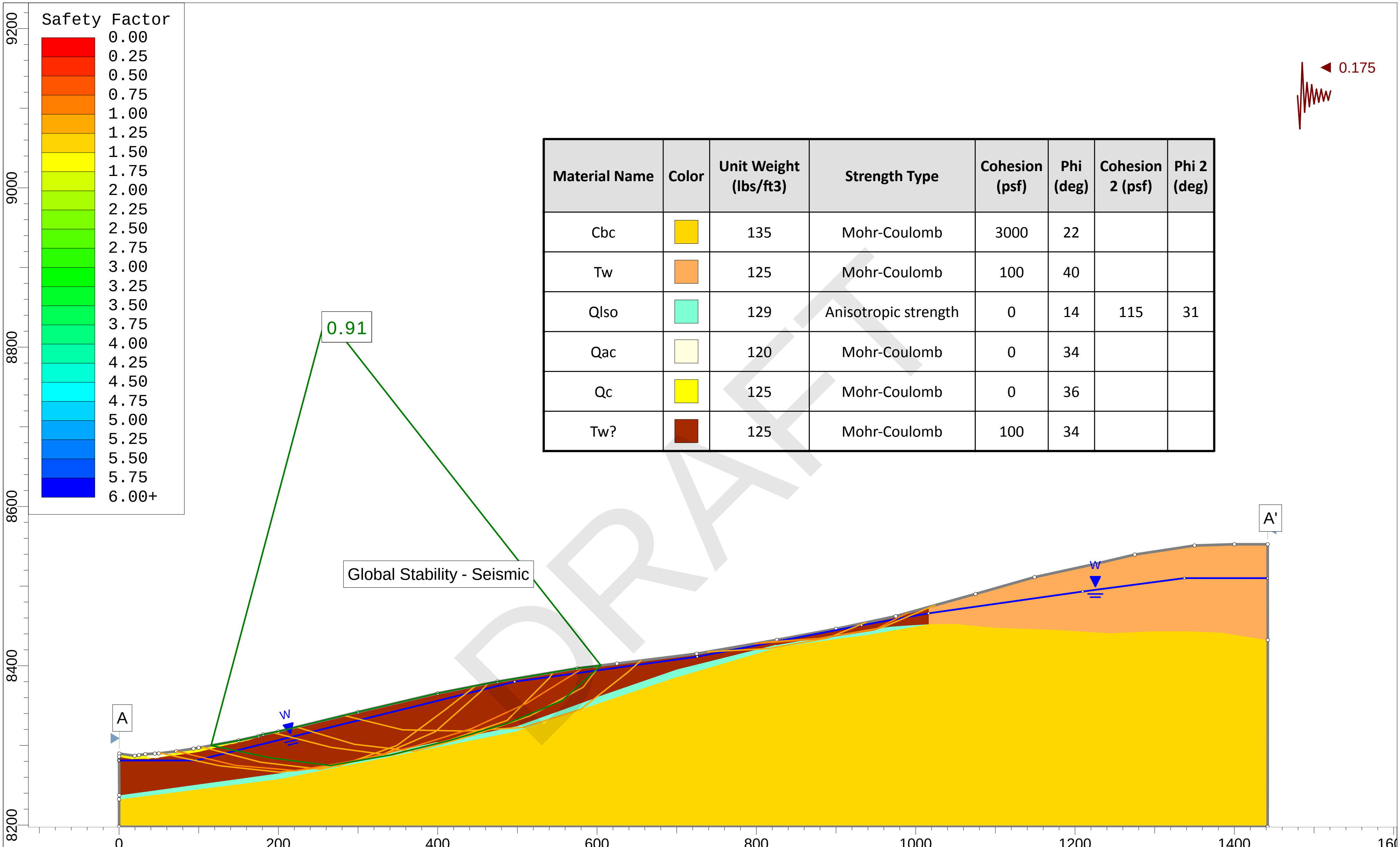
SLIDEINTERPRET 8.008

Project	Bobcat Ridge		
Analysis Description	A-A' 01628-028		
Drawn By EBF	*Scale* 1:2000	*Company*	IGES Inc
Date 7/20/2018		*File Name*	A-A'.slim



Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Cohesion 2 (psf)	Phi 2 (deg)
Cbc		135	Mohr-Coulomb	3000	22		
Tw		125	Mohr-Coulomb	100	40		
Qlso		129	Anisotropic strength	0	14	115	31
Qac		120	Mohr-Coulomb	0	34		
Qc		125	Mohr-Coulomb	0	36		
Tw?		125	Mohr-Coulomb	100	34		

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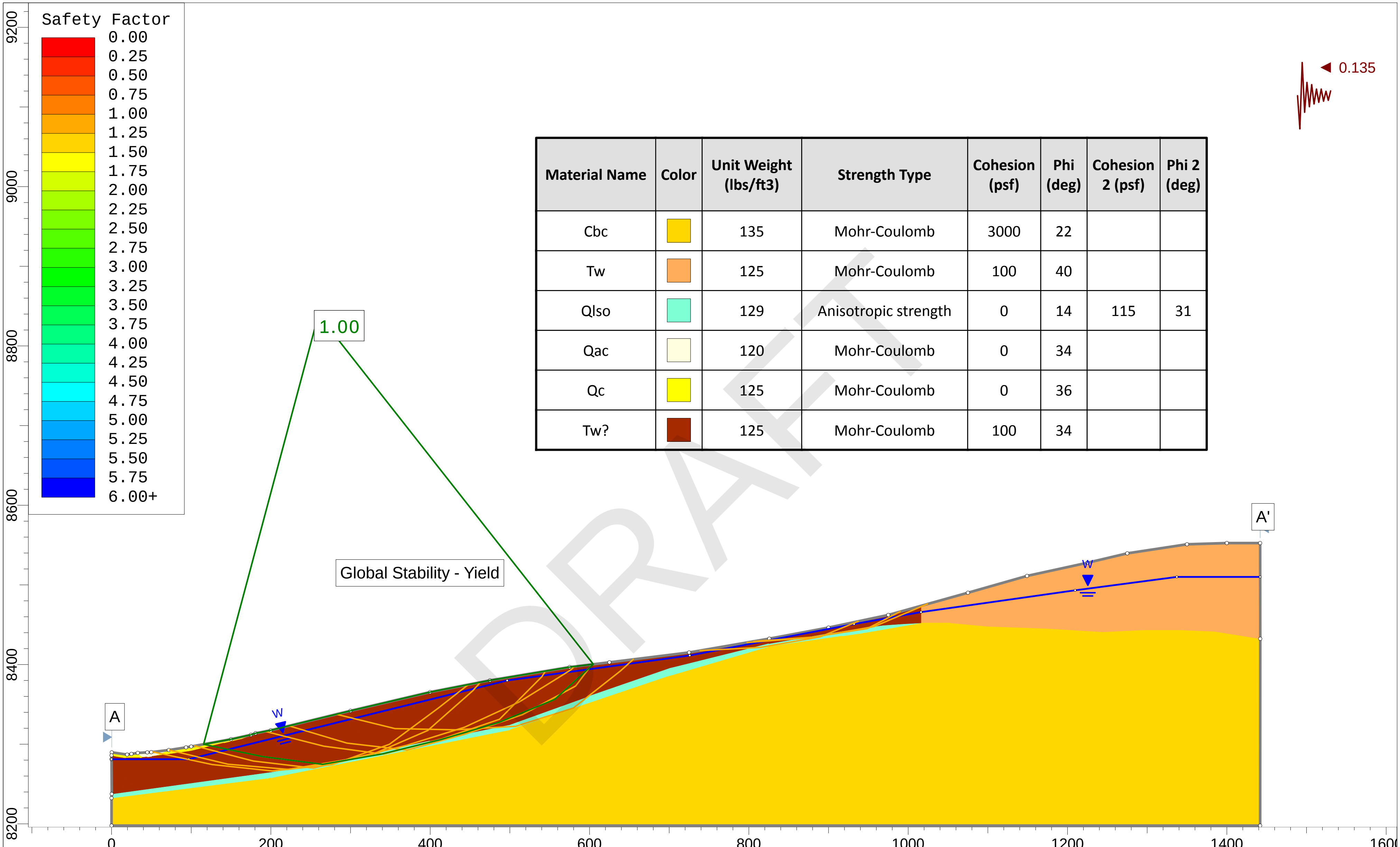
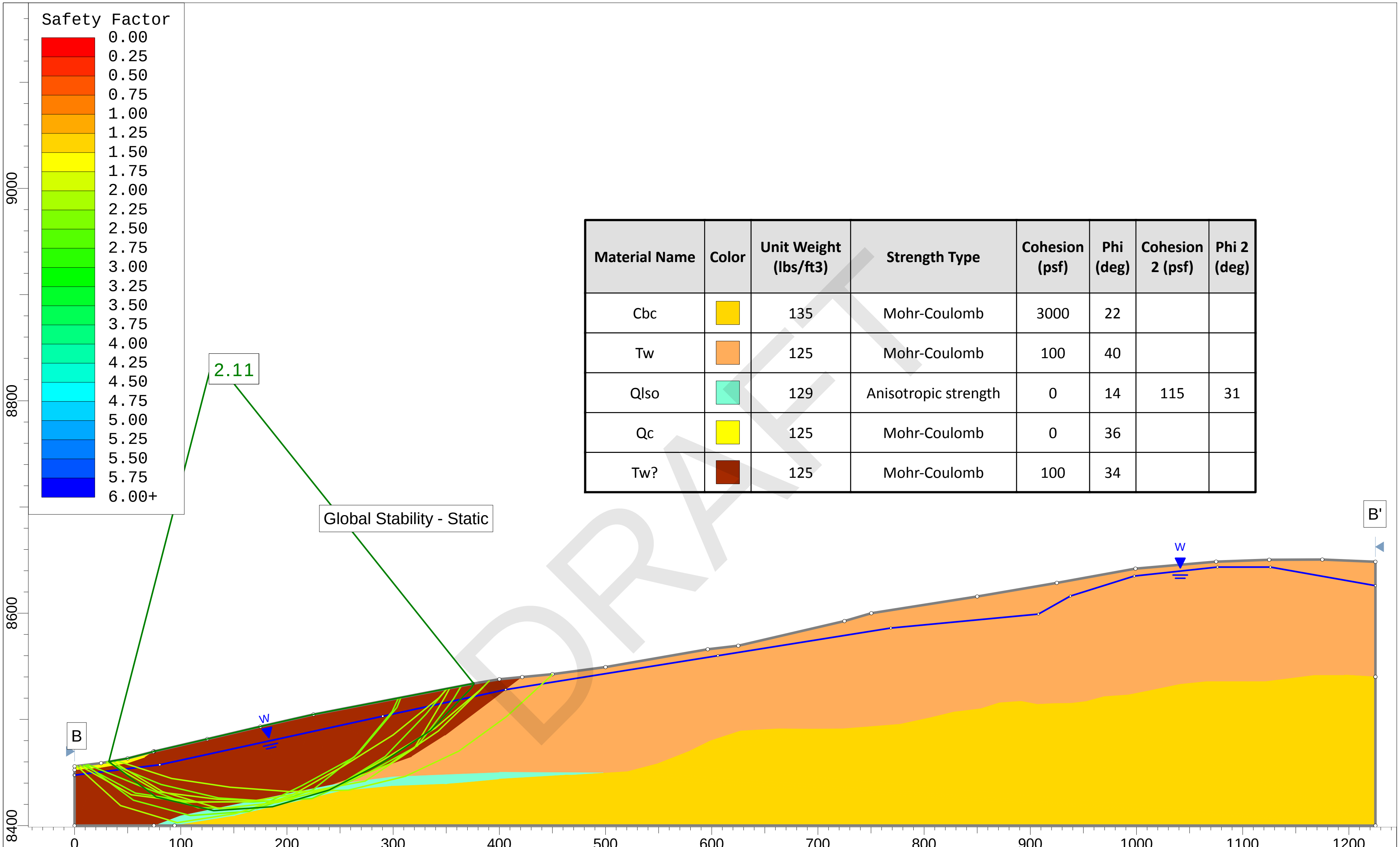
SLIDEINTERPRET 8.008

Project	Bobcat Ridge
Analysis Description	A-A' 01628-028
Drawn By	EBF
Scale	1:2000
Company	IGES Inc
Date	7/20/2018
File Name	A-A'.slim



Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Cohesion 2 (psf)	Phi 2 (deg)
Cbc		135	Mohr-Coulomb	3000	22		
Tw		125	Mohr-Coulomb	100	40		
Qlso		129	Anisotropic strength	0	14	115	31
Qac		120	Mohr-Coulomb	0	34		
Qc		125	Mohr-Coulomb	0	36		
Tw?		125	Mohr-Coulomb	100	34		

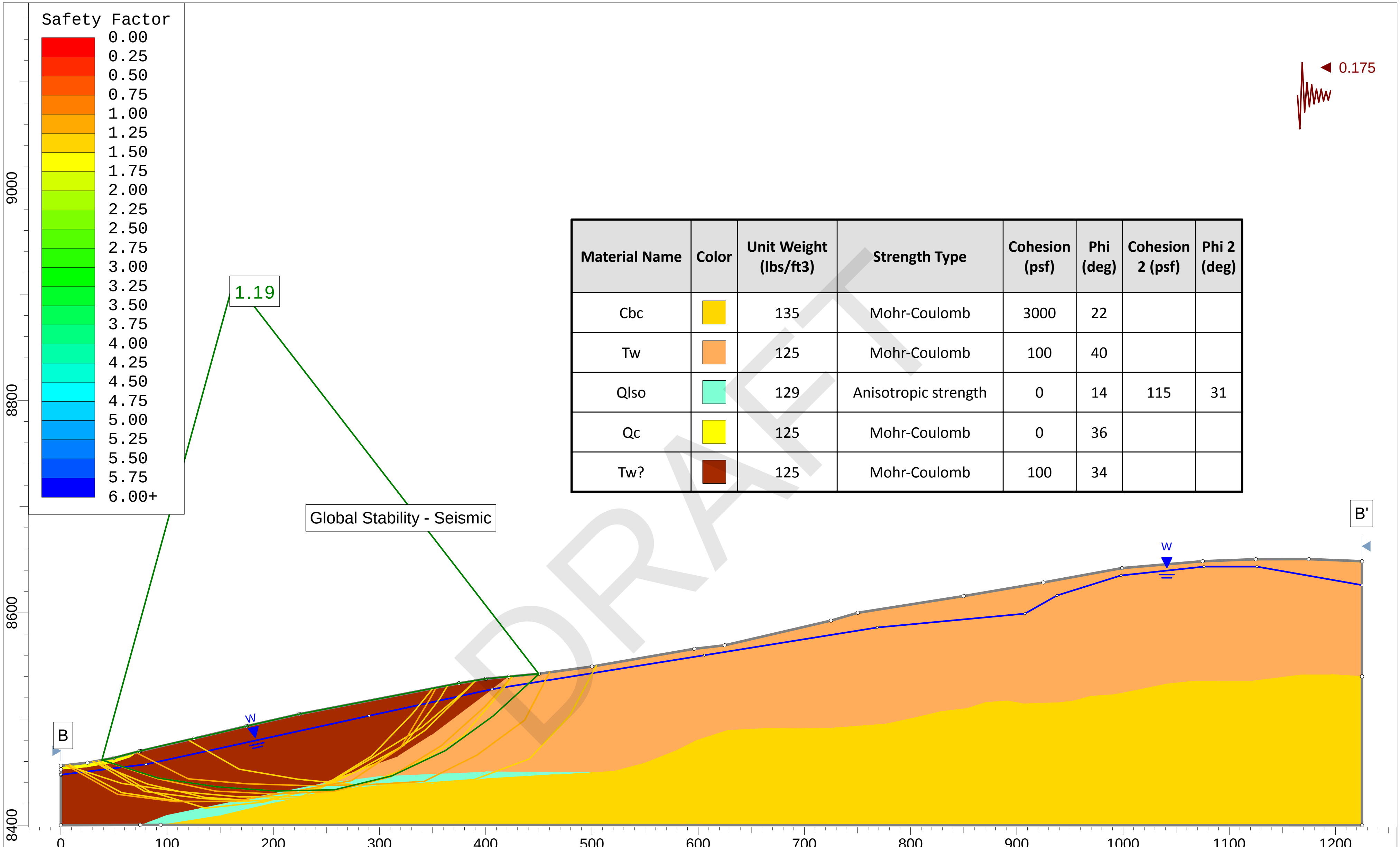
IGES®	*Project* Bobcat Ridge		
	Analysis Description A-A' 01628-028		
	Drawn By EBF	*Scale* 1:2000	*Company* IGES Inc
SLIDEINTERPRET 8.008	*Date* 7/20/2018		*File Name* A-A'.slim



Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Cohesion 2 (psf)	Phi 2 (deg)
Cbc		135	Mohr-Coulomb	3000	22		
Tw		125	Mohr-Coulomb	100	40		
Qlso		129	Anisotropic strength	0	14	115	31
Qc		125	Mohr-Coulomb	0	36		
Tw?		125	Mohr-Coulomb	100	34		

Project	Bobcat Ridge
Analysis Description	B-B' 01628-028
Drawn By	EBF
Scale	1:1500
Company	IGES Inc
Date	7/20/2018
File Name	B-B'.slim

SLIDEINTERPRET 8.008



Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Cohesion 2 (psf)	Phi 2 (deg)
Cbc		135	Mohr-Coulomb	3000	22		
Tw		125	Mohr-Coulomb	100	40		
Qlso		129	Anisotropic strength	0	14	115	31
Qc		125	Mohr-Coulomb	0	36		
Tw?		125	Mohr-Coulomb	100	34		

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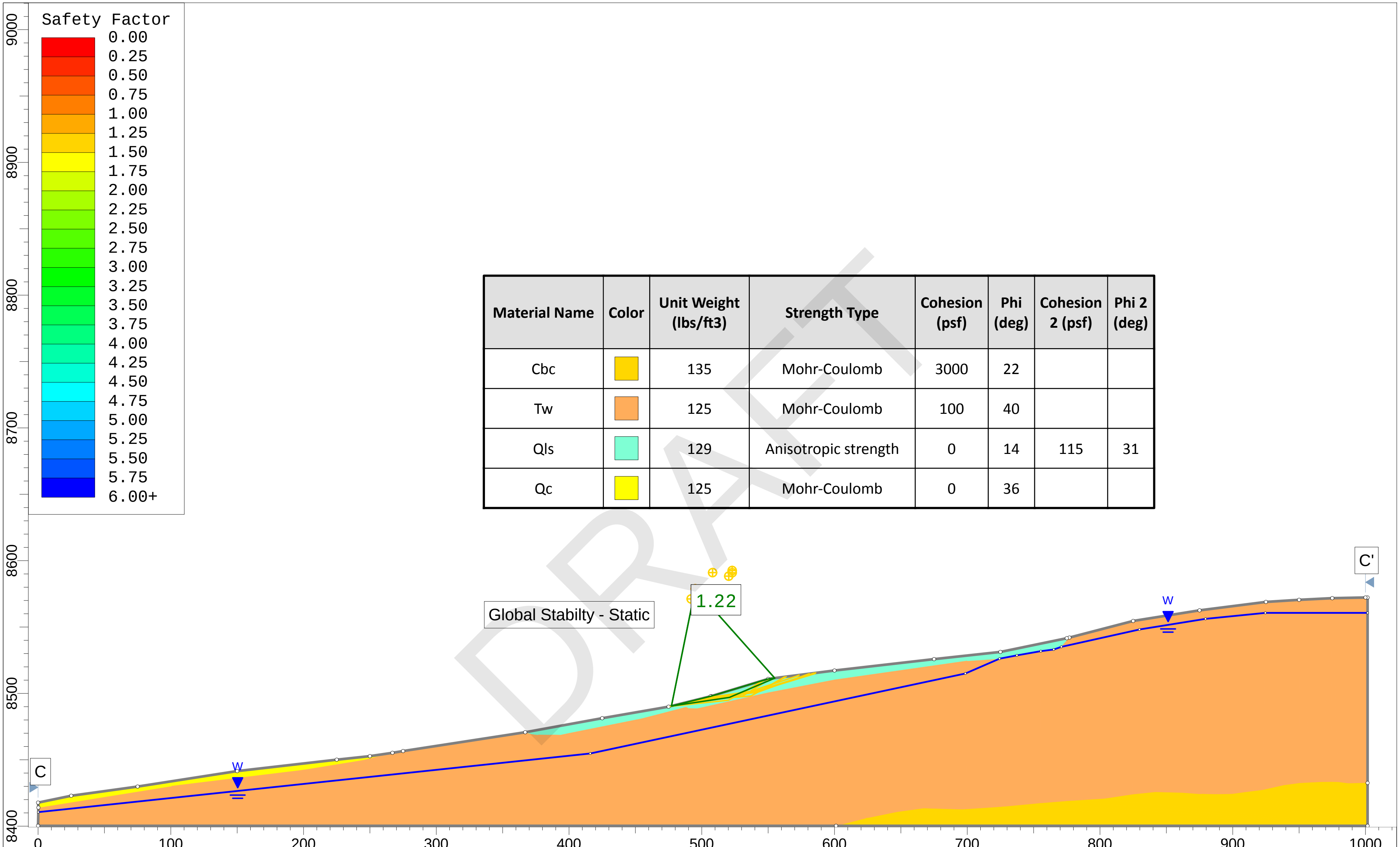
SLIDEINTERPRET 8.008

Project	Bobcat Ridge
Analysis Description	B-B' 01628-028
Drawn By	EBF
Scale	1:1500
Company	IGES Inc
Date	7/20/2018
File Name	B-B'.slim



Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Cohesion 2 (psf)	Phi 2 (deg)
Cbc		135	Mohr-Coulomb	3000	22		
Tw		125	Mohr-Coulomb	100	40		
Qls		129	Anisotropic strength	0	14	115	31
Qc		125	Mohr-Coulomb	0	36		

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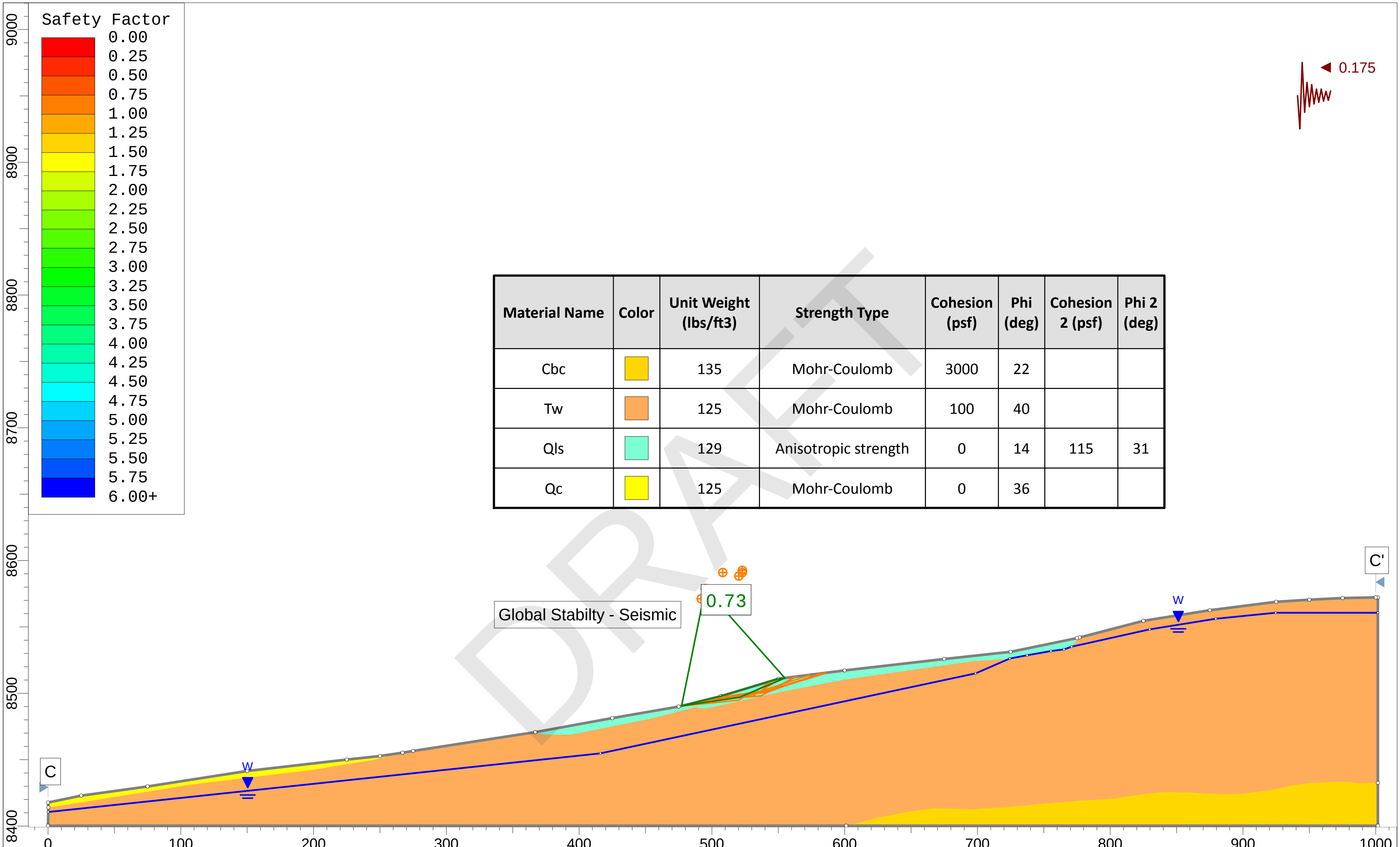
SLIDEINTERPRET 8.008

Project	Bobcat Ridge
Analysis Description	C-C' 01628-028
Drawn By	EBF
Scale	1:1200
Company	IGES Inc
Date	7/20/2018
File Name	C-C'.slim



Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Cohesion 2 (psf)	Phi 2 (deg)
Cbc		135	Mohr-Coulomb	3000	22		
Tw		125	Mohr-Coulomb	100	40		
Qls		129	Anisotropic strength	0	14	115	31
Qc		125	Mohr-Coulomb	0	36		

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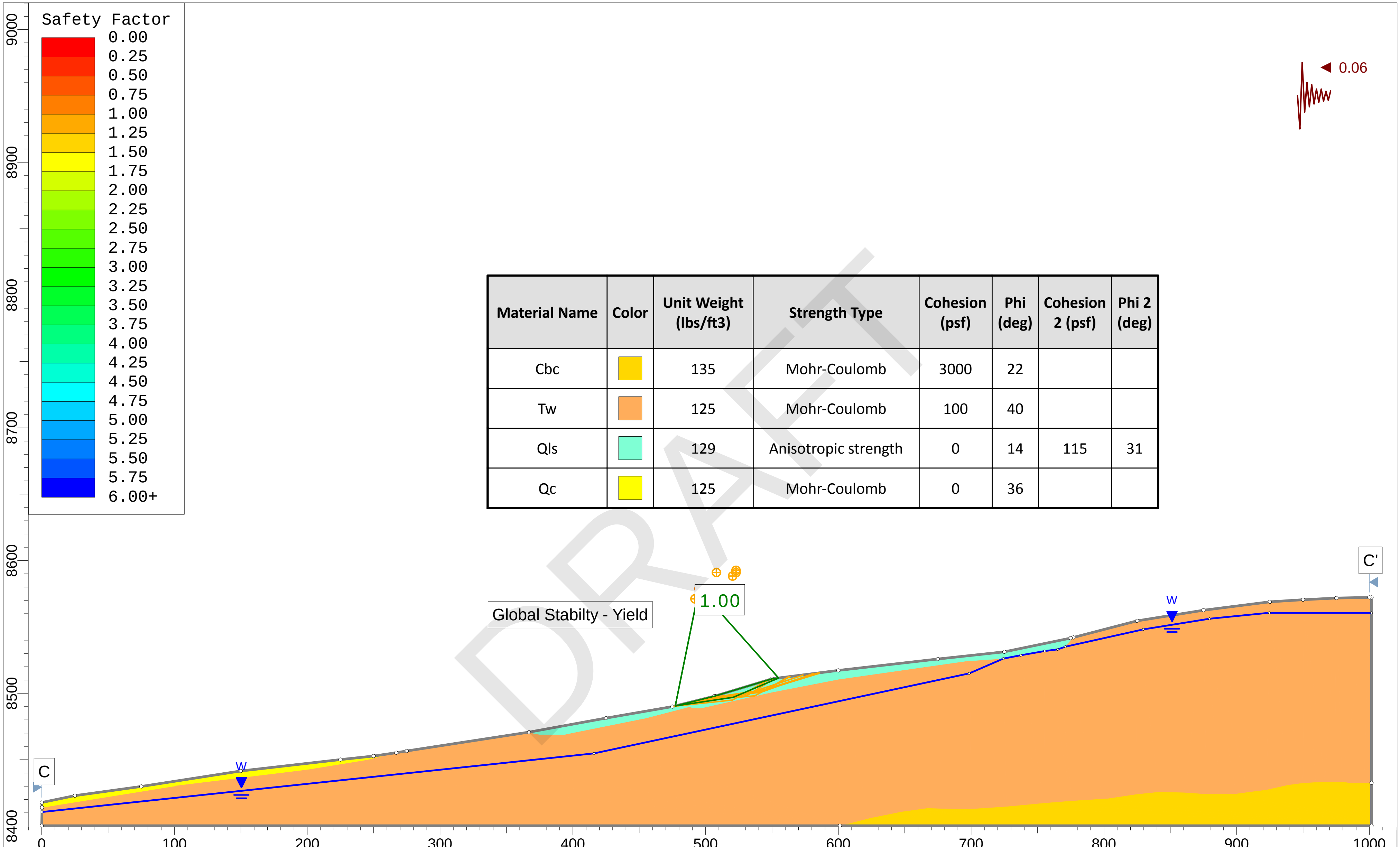
SLIDEINTERPRET 8.008

Project	Bobcat Ridge		
Analysis Description	C-C' 01628-028		
Drawn By EBF	*Scale* 1:1200	*Company* IGES Inc	
Date 7/20/2018		*File Name* C-C'.slim	



Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Cohesion 2 (psf)	Phi 2 (deg)
Cbc		135	Mohr-Coulomb	3000	22		
Tw		125	Mohr-Coulomb	100	40		
Qls		129	Anisotropic strength	0	14	115	31
Qc		125	Mohr-Coulomb	0	36		

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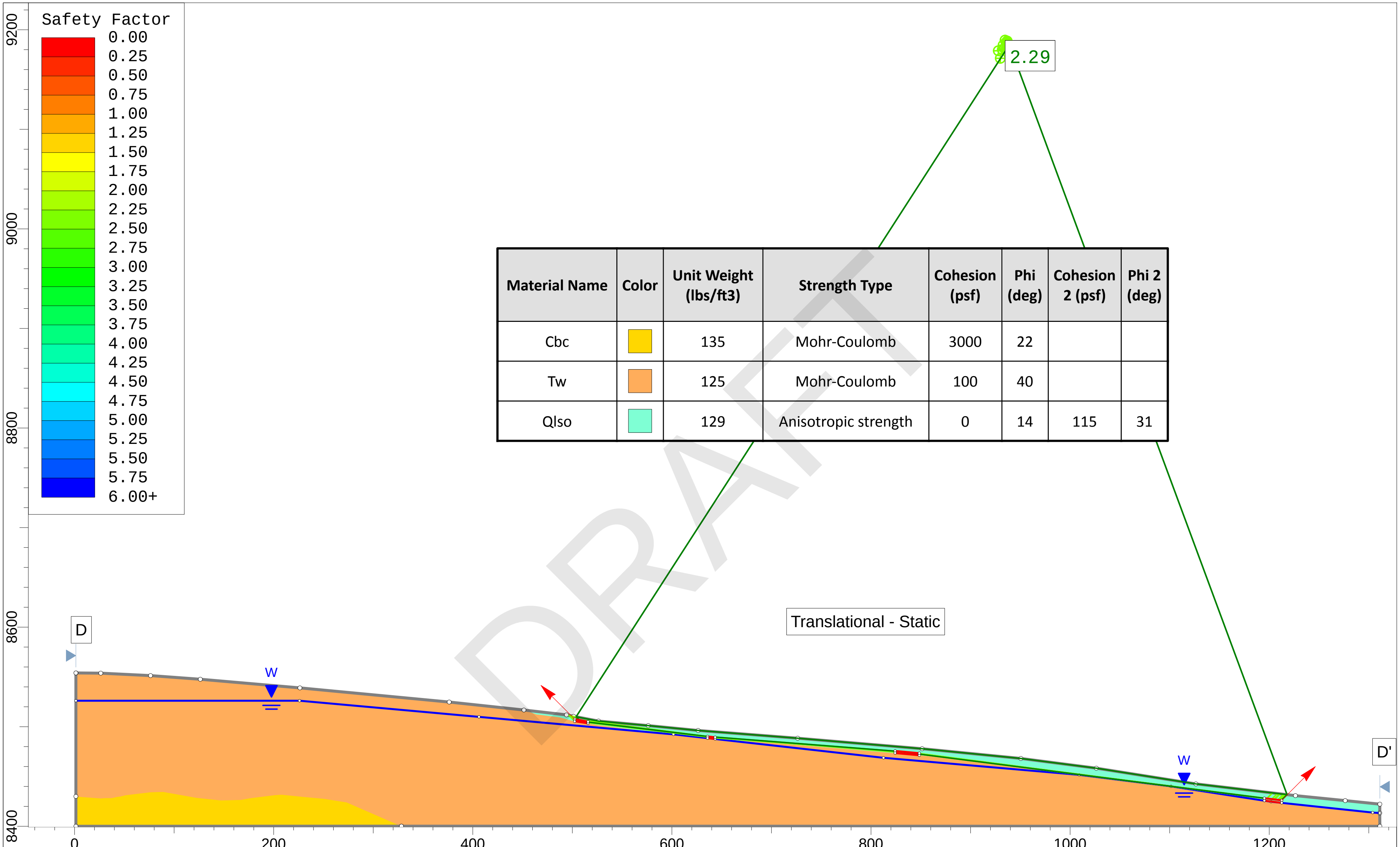
SLIDEINTERPRET 8.008

Project	Bobcat Ridge		
Analysis Description	C-C' 01628-028		
Drawn By EBF	*Scale* 1:1200	*Company*	IGES Inc
Date	7/20/2018	*File Name*	C-C'.slim



Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Cohesion 2 (psf)	Phi 2 (deg)
Cbc		135	Mohr-Coulomb	3000	22		
Tw		125	Mohr-Coulomb	100	40		
Qlso		129	Anisotropic strength	0	14	115	31

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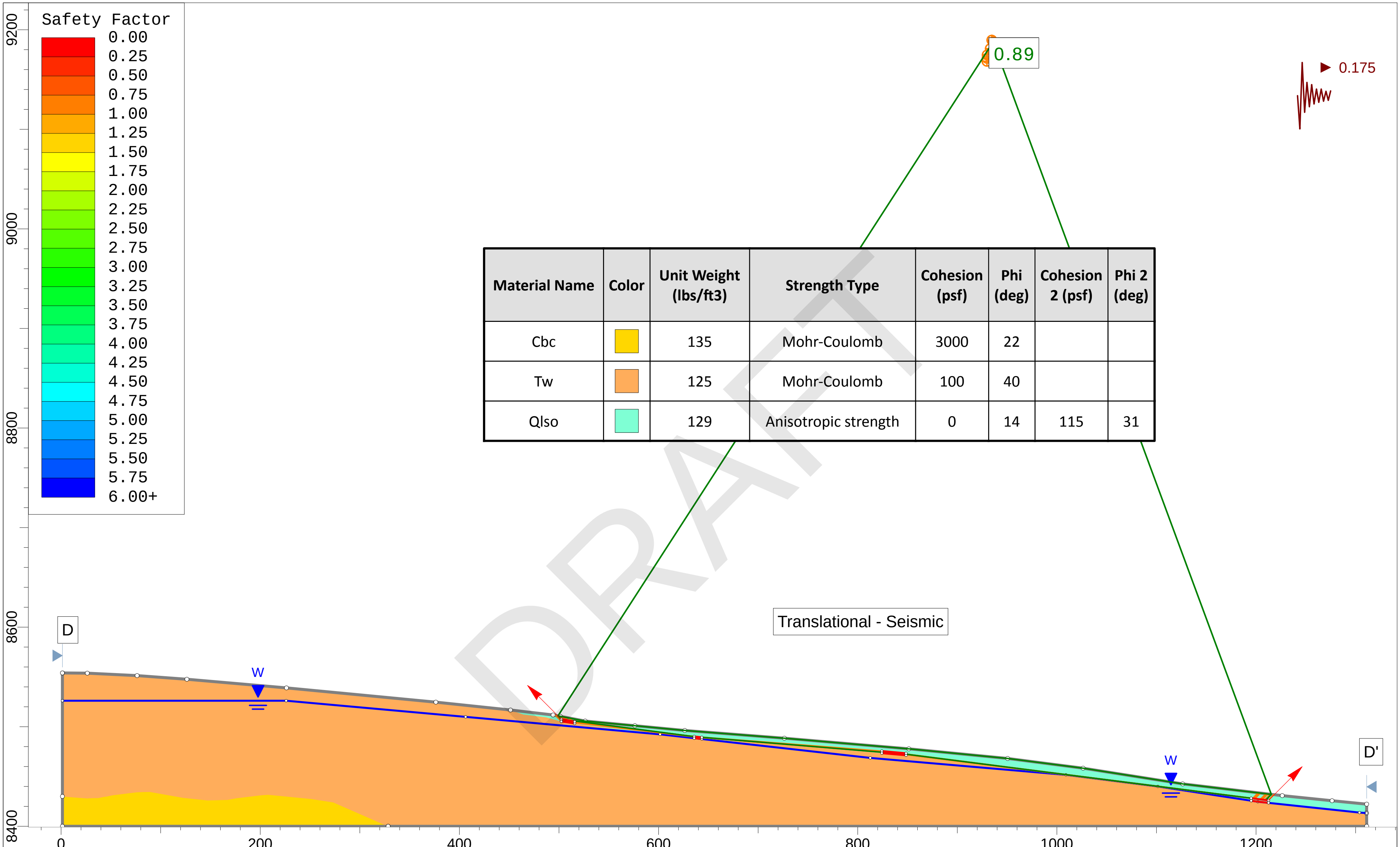
Project	Bobcat Ridge		
Analysis Description	D-D' 01628-028		
Drawn By EBF	*Scale* 1:1600	*Company*	IGES Inc
Date 7/20/2018		*File Name*	D-D'.slim



Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Cohesion 2 (psf)	Phi 2 (deg)
Cbc		135	Mohr-Coulomb	3000	22		
Tw		125	Mohr-Coulomb	100	40		
Qlso		129	Anisotropic strength	0	14	115	31

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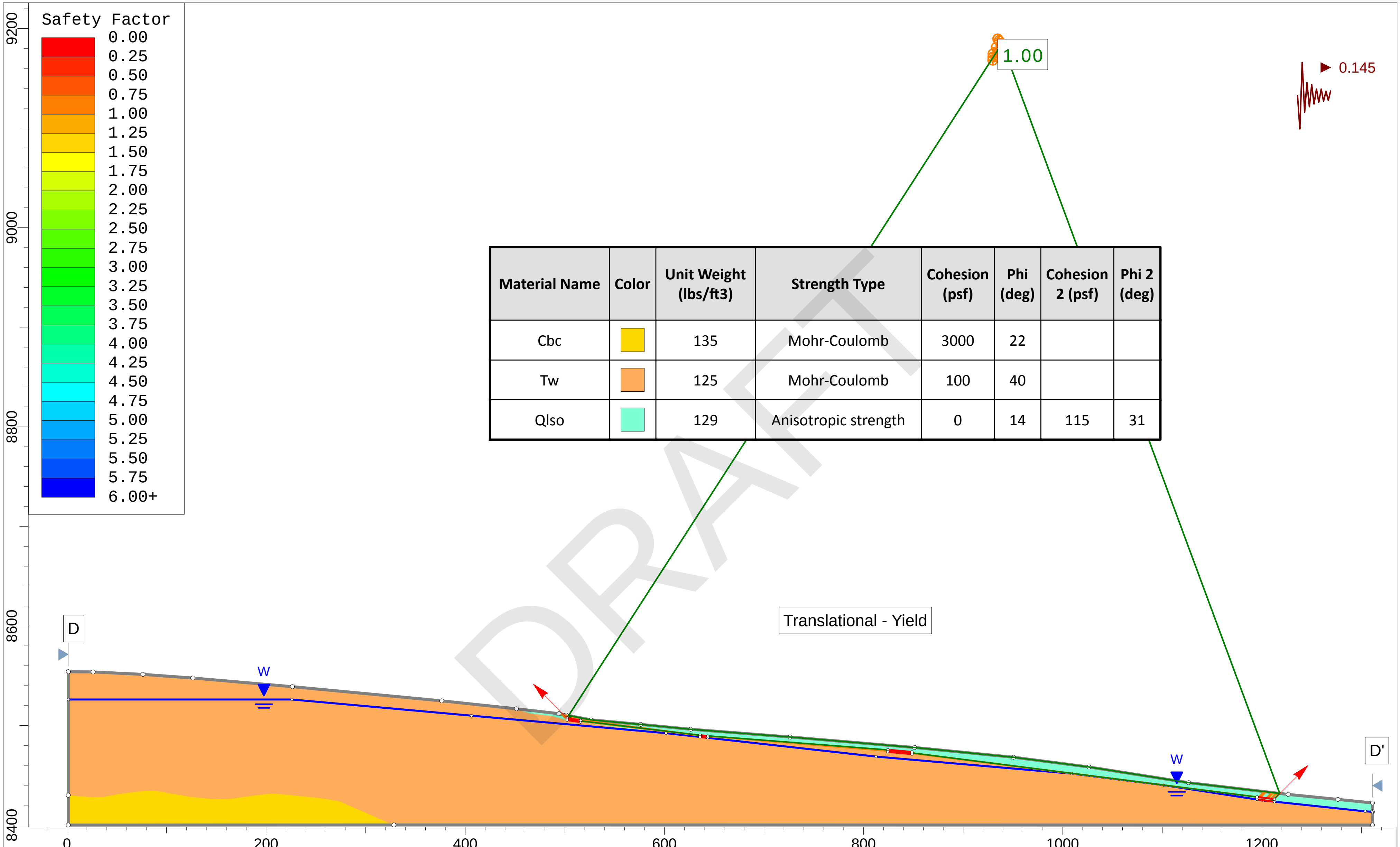
Project	Bobcat Ridge		
Analysis Description	D-D' 01628-028		
Drawn By	EBF	*Scale*	1:1600
Company	IGES Inc		
Date	7/20/2018	*File Name*	D-D'.slim



Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Cohesion 2 (psf)	Phi 2 (deg)
Cbc		135	Mohr-Coulomb	3000	22		
Tw		125	Mohr-Coulomb	100	40		
Qlso		129	Anisotropic strength	0	14	115	31

Project	Bobcat Ridge		
Analysis Description	D-D' 01628-028		
Drawn By	EBF	*Scale*	1:1600
Company	IGES Inc		
Date	7/20/2018	*File Name*	D-D'.slim

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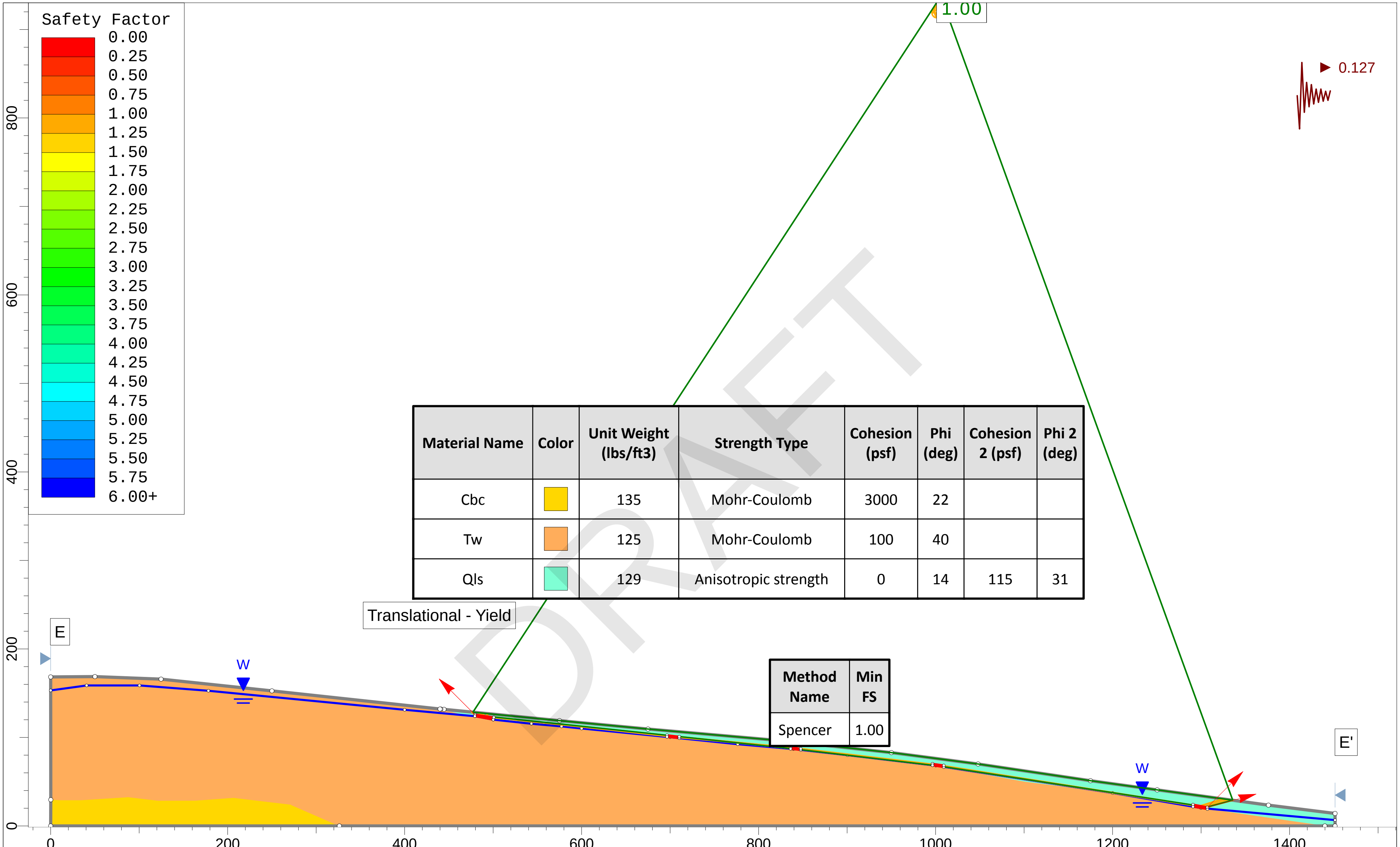

Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Cohesion 2 (psf)	Phi 2 (deg)
Cbc		135	Mohr-Coulomb	3000	22		
Tw		125	Mohr-Coulomb	100	40		
Qls		129	Anisotropic strength	0	14	115	31

Method Name	Min FS
Spencer	1.00

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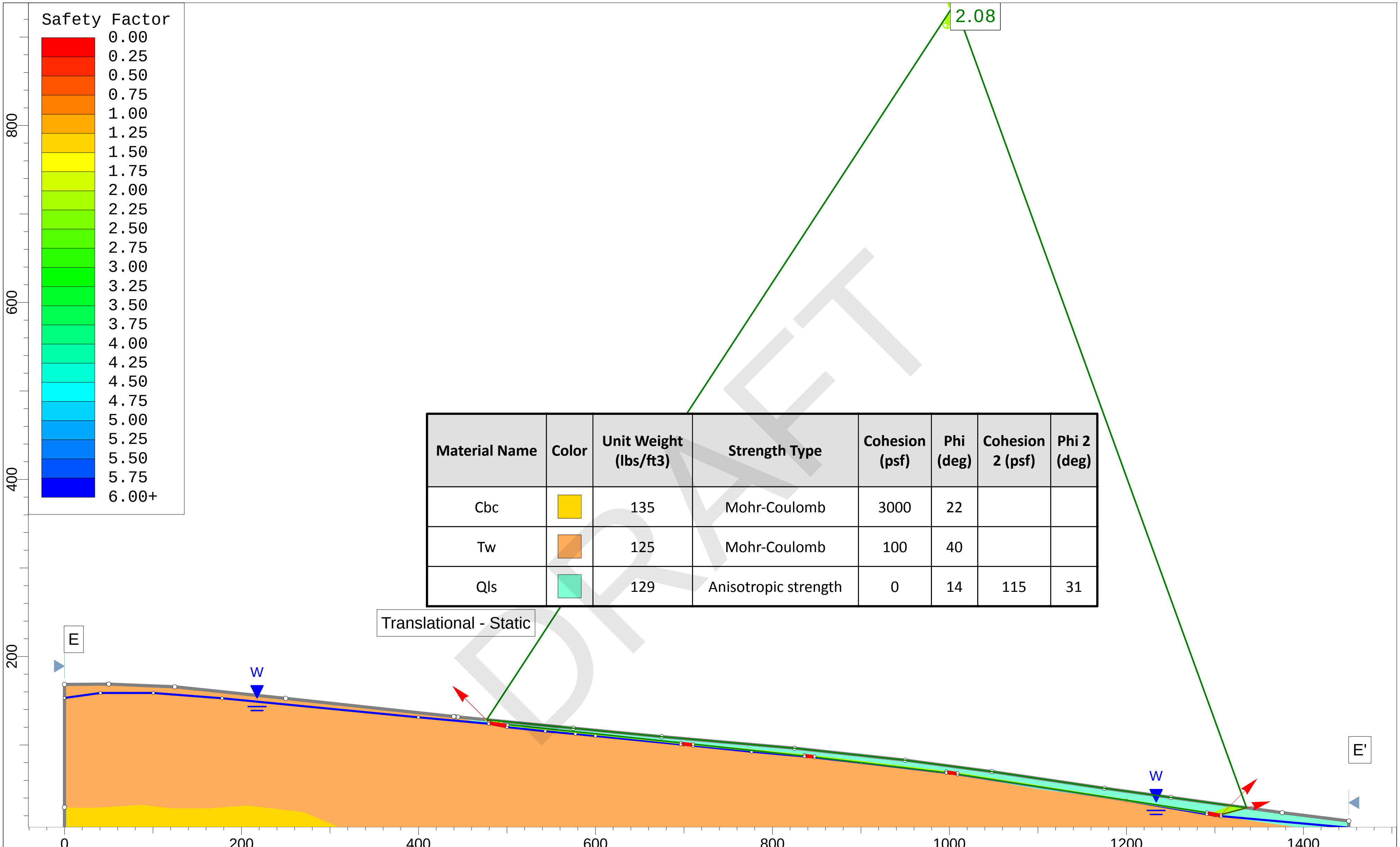
Project	Bobcat Ridge		
Analysis Description	E-E' 01628-028		
Drawn By EBF	*Scale* 1:1800	*Company*	IGES Inc
Date	7/20/2018	*File Name*	E-E'.slim



Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Cohesion 2 (psf)	Phi 2 (deg)
Cbc		135	Mohr-Coulomb	3000	22		
Tw		125	Mohr-Coulomb	100	40		
Qls		129	Anisotropic strength	0	14	115	31

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SLIDEINTERPRET 8.008

Project	Bobcat Ridge		
Analysis Description	E-E' 01628-028		
Drawn By EBF	*Scale* 1:1800	*Company*	IGES Inc
Date	7/20/2018	*File Name*	E-E'.slim

Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Cohesion 2 (psf)	Phi 2 (deg)
Cbc		135	Mohr-Coulomb	3000	22		
Tw		125	Mohr-Coulomb	100	40		
Qls		129	Anisotropic strength	0	14	115	31

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SLIDEINTERPRET 8.008

Project	Bobcat Ridge		
Analysis Description	E-E' 01628-028		
Drawn By EBF	*Scale* 1:1800	*Company*	IGES Inc
Date 7/20/2018		*File Name*	E-E'.slim

Simplified Procedure for Estimating Earthquake Induced Deviatoric Slope Displacements
by Jonathan D. Bray and Thaleia Travasarou
Journal of Geotechnical and Geonvironmental Engineering, ASCE, V. 133(4), pp. 381-392, April 2007

SEE NOTES BELOW FOR GUIDANCE IN THE USE OF SPREADSHEET

Input Parameters			
Yield Coefficient (ky)	0.135		Based on pseudostatic analysis
Initial Fundamental Period (Ts)	0.43	seconds	1D: Ts=4H/Vs 2D: Ts=2.6H/Vs
Degraded Period (1.5Ts)	0.64	seconds	
Moment Magnitude (Mw)	7.0		
Spectral Acceleration (Sa(1.5Ts))	0.25	g	

Additional Input Parameters		
Probability of Exceedance #1 (P1)	84	%
Probability of Exceedance #2 (P2)	50	%
Probability of Exceedance #3 (P3)	16	%
Displacement Threshold (d_threshold)	5	cm

Intermediate Calculated Parameters			
Non-Zero Seismic Displacement Est (D)	2.14	cm	eq. (5) or (6)
Standard Deviation of Non-Zero Seismic D	0.66		

Results			
Probability of Negligible Displ. (P(D=0))	0.41		eq. (3)
D1	<1	cm	calc. using eq. (7)
D2	1.1	cm	calc. using eq. (7)
D3	3.2	cm	calc. using eq. (7)
P(D>d_threshold)	0.06		eq. (7)

Notes
1. Values highlighted in blue are input parameters, and results are presented in the table with the yellow heading.
2. Probability of Exceedance is the desired probability of exceeding a particular displacement value.
3. Displacements D1, D2, and D3 correspond to P1, P2, and P3, respectively.
   (e.g., the probability of exceeding displacement D1 is P1)
4. The 16%, 50%, and 84% percentile displacement values at selected ky values are shown to the right.
5. Calculated seismic displacements are due to deviatoric deformation only (add in volumetrically induced movement).
6. ky may range between 0.01 and 0.5, Ts between 0 and 2 s, Sa between 0.002 and 2.7 g, M between 4.5 and 9
7. Rigid slope is assumed for Ts < 0.05 s
8. When a value for D is not calculated, D is < 1cm
9. ky may be estimated using the simplified equations shown below.
10. Examples of how Ts is estimated are shown below.
11. Vs = weighted avg. shear wave velocity for the sliding mass, e.g., for 2 layers, Vs = [(h1)(Vs1) + (h2)(Vs2)]/(h1 + h2)

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SECTION A-A'

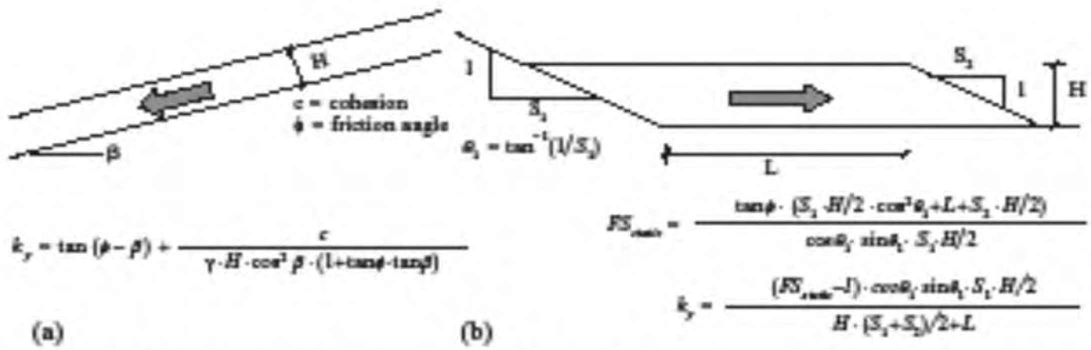

Fig. 14.1. Simplified estimates of the yield coefficient: (a) shallow sliding and (b) deep sliding

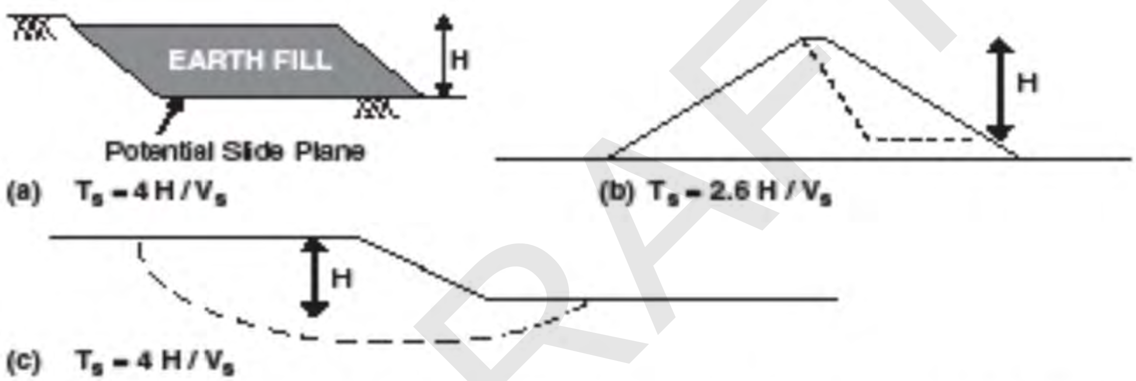

Fig. 14.4. Estimating the initial fundamental period of potential sliding blocks

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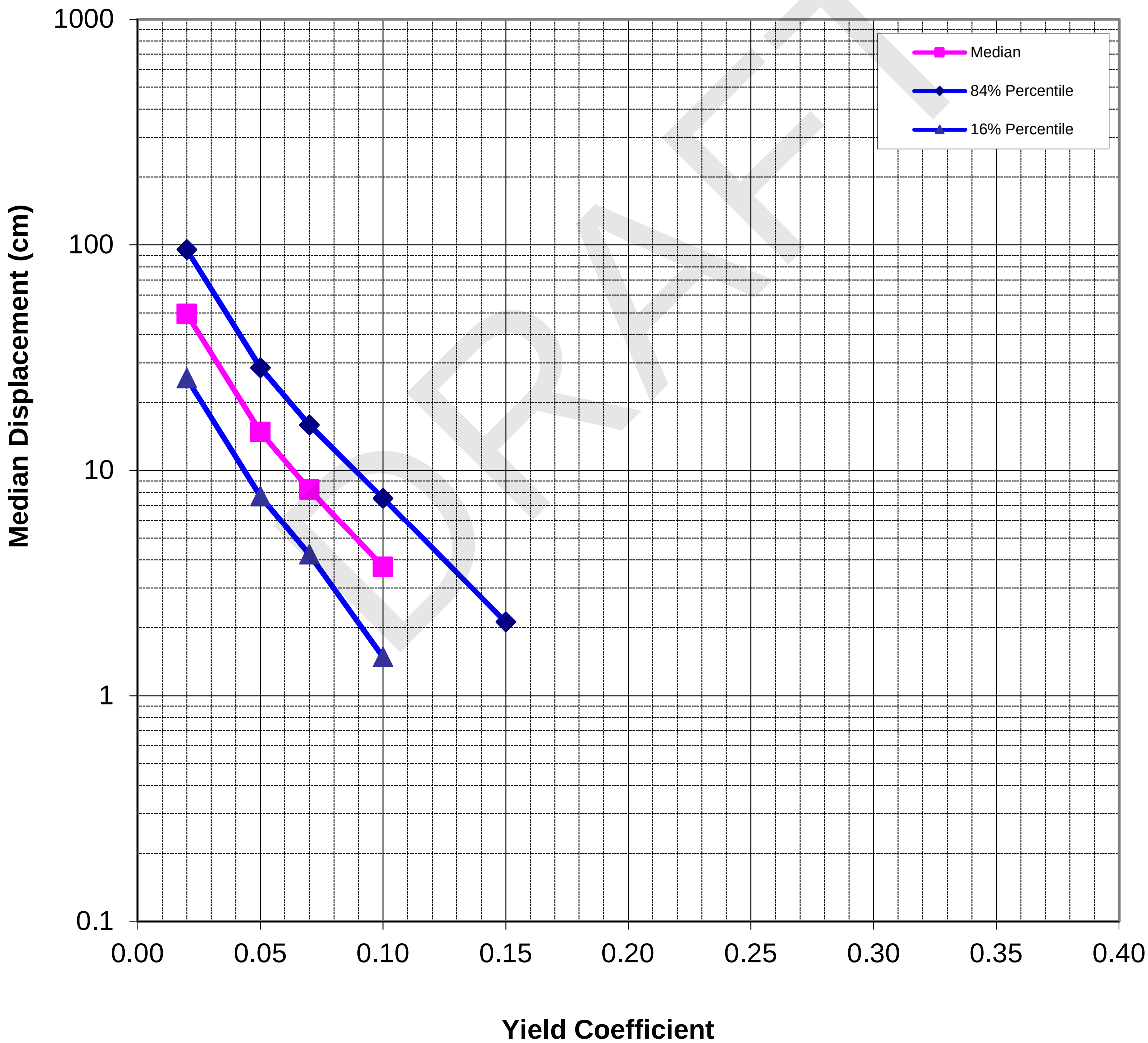
Figures from Bray, J.D. (2007) “Chapter 14: Simplified Seismic Slope Displacement Procedures,” Earthquake Geotechnical Engineering, 4th Inter. Conf. on Earthquake Geotechnical Engineering - Invited Lectures, in Geotechnical, Geological, and Earthquake Engineering Series, Vol. 6, Pitilakis, Kyriazis D., Ed., Springer, Vol. 6, pp. 327-353.

Simplified Procedure for Estimating Earthquake Induced Deviatoric Slope Displacements
by Jonathan D. Bray and Thaleia Travasarou
Journal of Geotechnical and Geonvironmental Engineering, Vol 133, No. 4, pp. 381-392, April 2007

Dependence on ky

ky	P(D="0")	D (cm)	Dmedian (cm)	D-84% (cm)	D-16% (cm)
0.020	0.00	49.5	49.5	95.3	25.7
0.05	0.00	14.8	14.8	28.6	7.7
0.07	0.01	8.3	8.2	15.9	4.2
0.1	0.11	4.1	3.7	7.5	1.5
0.15	0.56	1.7	<1	2.1	<1
0.2	0.87	0.8	<1	<1	<1
0.3	0.99	0.3	<1	<1	<1
0.4	1.00	0.1	<1	<1	<1



Simplified Procedure for Estimating Earthquake Induced Deviatoric Slope Displacements
by Jonathan D. Bray and Thaleia Travasarou
Journal of Geotechnical and Geonvironmental Engineering, Vol 133, No. 4, pp. 381-392, April 2007

SECTION C-C'

Simplified Procedure for Estimating Earthquake Induced Deviatoric Slope Displacements
by Jonathan D. Bray and Thaleia Travasarou
Journal of Geotechnical and Geonvironmental Engineering, ASCE, V. 133(4), pp. 381-392, April 2007

SEE NOTES BELOW FOR GUIDANCE IN THE USE OF SPREADSHEET

Input Parameters			
Yield Coefficient (ky)	0.06		Based on pseudostatic analysis
Initial Fundamental Period (Ts)	0.07	seconds	1D: Ts=4H/Vs 2D: Ts=2.6H/Vs
Degraded Period (1.5Ts)	0.10	seconds	
Moment Magnitude (M_w)	7.0		
Spectral Acceleration (Sa(1.5Ts))	0.25	g	

Additional Input Parameters		
Probability of Exceedance #1 (P1)	84	%
Probability of Exceedance #2 (P2)	50	%
Probability of Exceedance #3 (P3)	16	%
Displacement Threshold (d_threshold)	5	cm

Intermediate Calculated Parameters			
Non-Zero Seismic Displacement Est (D)	6.36	cm	eq. (5) or (6)
Standard Deviation of Non-Zero Seismic D	0.66		

Results			
Probability of Negligible Displ. (P(D=0))	0.01		eq. (3)
D1	3.3	cm	calc. using eq. (7)
D2	6.3	cm	calc. using eq. (7)
D3	12.2	cm	calc. using eq. (7)
P(D>d_threshold)	0.64		eq. (7)

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Notes

1. Values highlighted in blue are input parameters, and results are presented in the table with the yellow heading.
2. Probability of Exceedance is the desired probability of exceeding a particular displacement value.
3. Displacements D1, D2, and D3 correspond to P1, P2, and P3, respectively.
   (e.g., the probability of exceeding displacement D1 is P1)
4. The 16%, 50%, and 84% percentile displacement values at selected ky values are shown to the right.
5. Calculated seismic displacements are due to deviatoric deformation only (add in volumetrically induced movement).
6. ky may range between 0.01 and 0.5, Ts between 0 and 2 s, Sa between 0.002 and 2.7 g, M between 4.5 and 9
7. Rigid slope is assumed for Ts < 0.05 s
8. When a value for D is not calculated, D is < 1cm
9. ky may be estimated using the simplified equations shown below.
10. Examples of how Ts is estimated are shown below.
11. Vs = weighted avg. shear wave velocity for the sliding mass, e.g., for 2 layers, Vs = [(h1)(Vs1) + (h2)(Vs2)]/(h1 + h2)

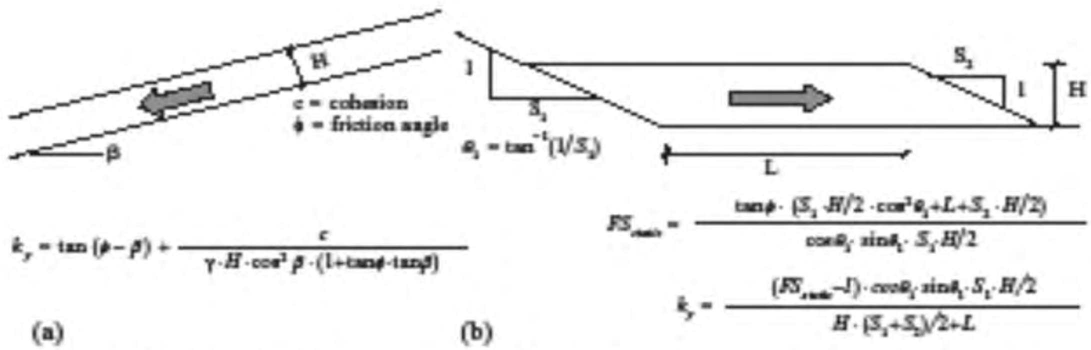

Fig. 14.1. Simplified estimates of the yield coefficient: (a) shallow sliding and (b) deep sliding

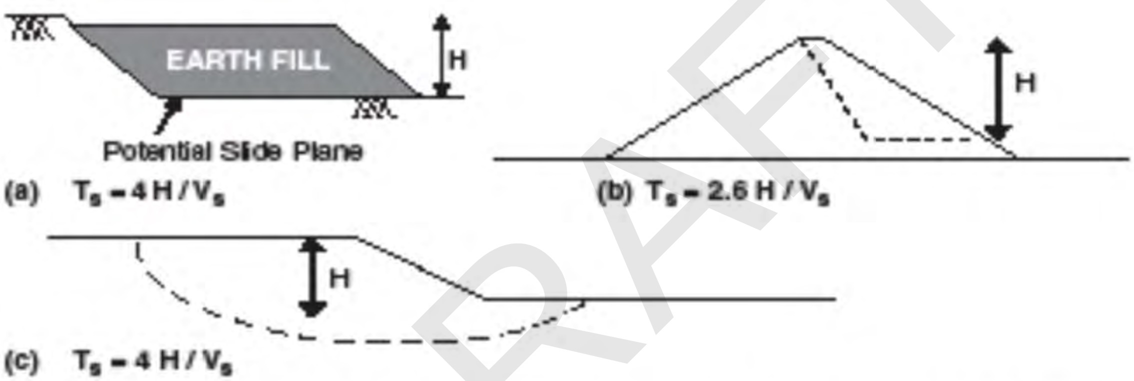

Fig. 14.4. Estimating the initial fundamental period of potential sliding blocks

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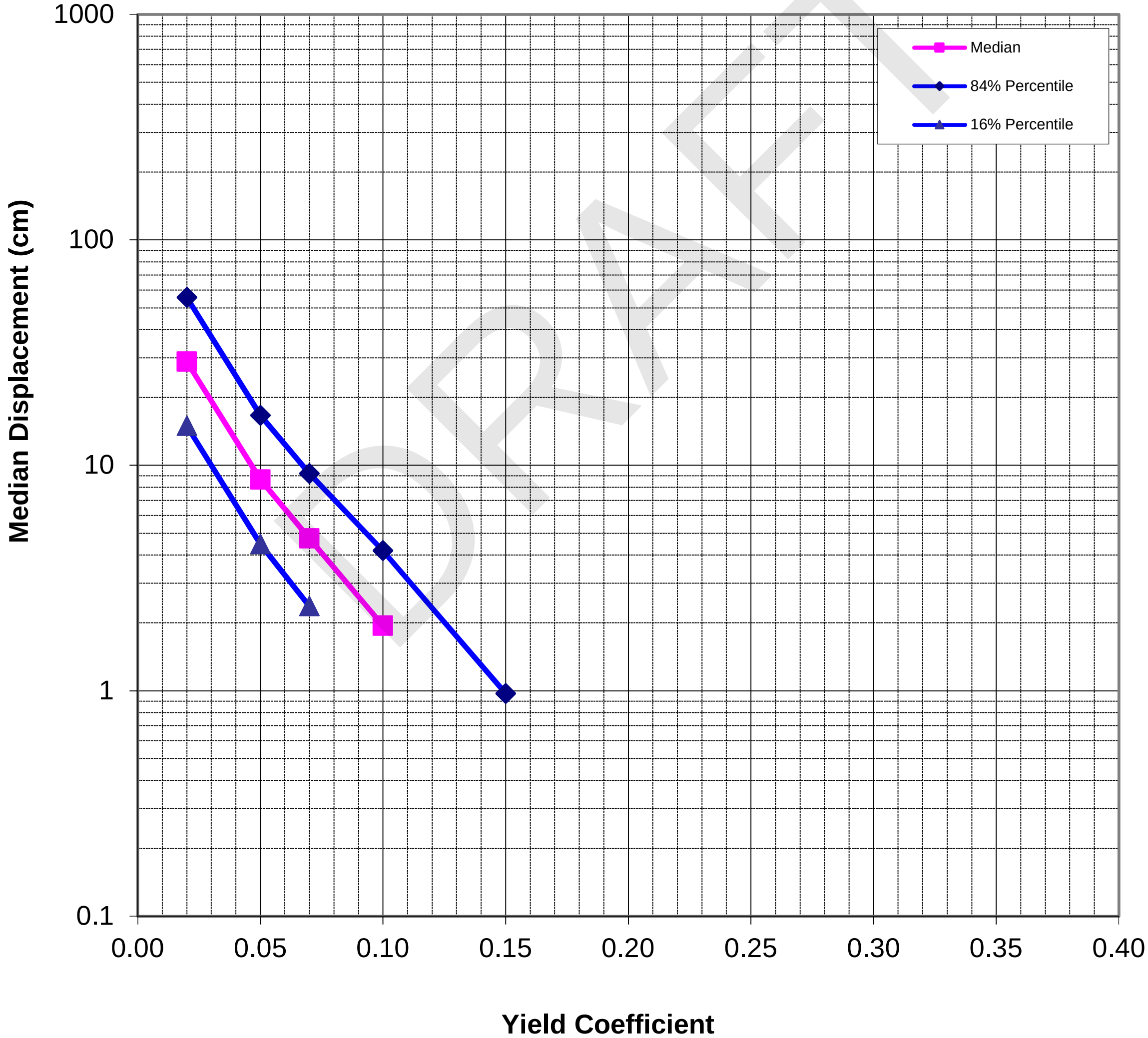
Figures from Bray, J.D. (2007) “Chapter 14: Simplified Seismic Slope Displacement Procedures,” Earthquake Geotechnical Engineering, 4th Inter. Conf. on Earthquake Geotechnical Engineering - Invited Lectures, in Geotechnical, Geological, and Earthquake Engineering Series, Vol. 6, Pitilakis, Kyriazis D., Ed., Springer, Vol. 6, pp. 327-353.

SECTION C-C'

Dependence on ky

ky	P(D="0")	D (cm)	Dmedian (cm)	D-84% (cm)	D-16% (cm)
0.020	0.00	28.8	28.8	55.6	15.0
0.05	0.00	8.6	8.6	16.7	4.5
0.07	0.02	4.8	4.7	9.2	2.4
0.1	0.20	2.4	1.9	4.2	<1
0.15	0.68	1.0	<1	1.0	<1
0.2	0.92	0.5	<1	<1	<1
0.3	1.00	0.2	<1	<1	<1
0.4	1.00	0.1	<1	<1	<1



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Journal of Geotechnical and Geonvironmental Engineering, Vol 133, No. 4, pp. 381-392, April 2007

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Journal of Geotechnical and Geonvironmental Engineering, ASCE, V. 133(4), pp. 381-392, April 2007

SEE NOTES BELOW FOR GUIDANCE IN THE USE OF SPREADSHEET

Input Parameters			
Yield Coefficient (ky)	0.145		Based on pseudostatic analysis
Initial Fundamental Period (Ts)	0.05	seconds	1D: Ts=4H/Vs 2D: Ts=2.6H/Vs
Degraded Period (1.5Ts)	0.07	seconds	
Moment Magnitude (Mw)	7.0		
Spectral Acceleration (Sa(1.5Ts))	0.25	g	

Additional Input Parameters		
Probability of Exceedance #1 (P1)	84	%
Probability of Exceedance #2 (P2)	50	%
Probability of Exceedance #3 (P3)	16	%
Displacement Threshold (d_threshold)	5	cm

Intermediate Calculated Parameters			
Non-Zero Seismic Displacement Est (D)	2.47	cm	eq. (5) or (6)
Standard Deviation of Non-Zero Seismic D	0.66		

Results			
Probability of Negligible Displ. (P(D=0))	0.65		eq. (3)
D1	<1	cm	calc. using eq. (7)
D2	<1	cm	calc. using eq. (7)
D3	2.7	cm	calc. using eq. (7)
P(D>d_threshold)	0.05		eq. (7)

Notes

1. Values highlighted in blue are input parameters, and results are presented in the table with the yellow heading.
2. Probability of Exceedance is the desired probability of exceeding a particular displacement value.
3. Displacements D1, D2, and D3 correspond to P1, P2, and P3, respectively.
   (e.g., the probability of exceeding displacement D1 is P1)
4. The 16%, 50%, and 84% percentile displacement values at selected ky values are shown to the right.
5. Calculated seismic displacements are due to deviatoric deformation only (add in volumetrically induced movement).
6. ky may range between 0.01 and 0.5, Ts between 0 and 2 s, Sa between 0.002 and 2.7 g, M between 4.5 and 9
7. Rigid slope is assumed for Ts < 0.05 s
8. When a value for D is not calculated, D is < 1cm
9. ky may be estimated using the simplified equations shown below.
10. Examples of how Ts is estimated are shown below.
11. Vs = weighted avg. shear wave velocity for the sliding mass, e.g., for 2 layers, Vs = [(h1)(Vs1) + (h2)(Vs2)]/(h1 + h2)

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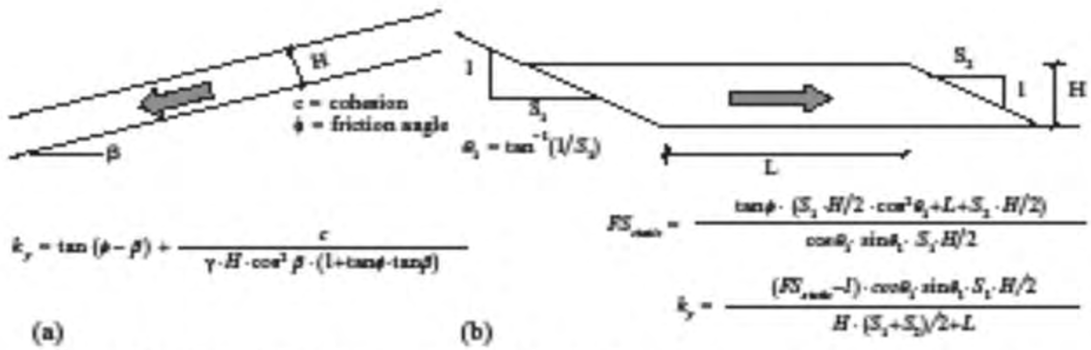

Fig. 14.1. Simplified estimates of the yield coefficient: (a) shallow sliding and (b) deep sliding

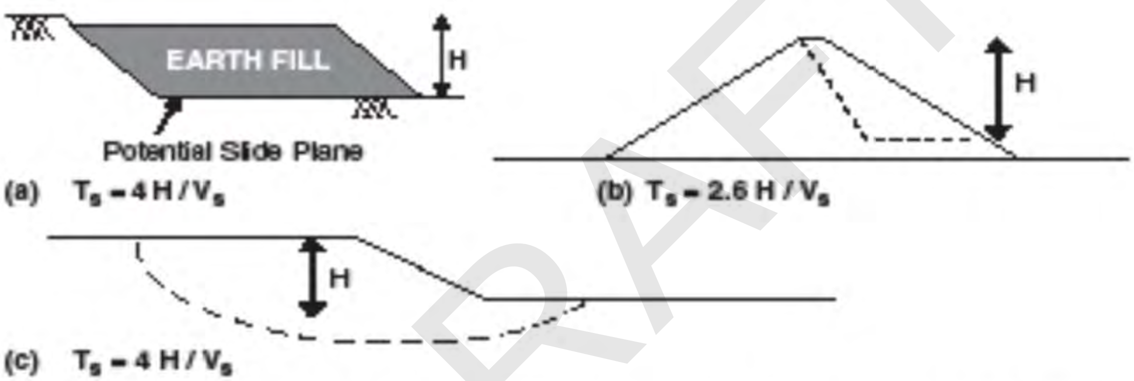

Fig. 14.4. Estimating the initial fundamental period of potential sliding blocks

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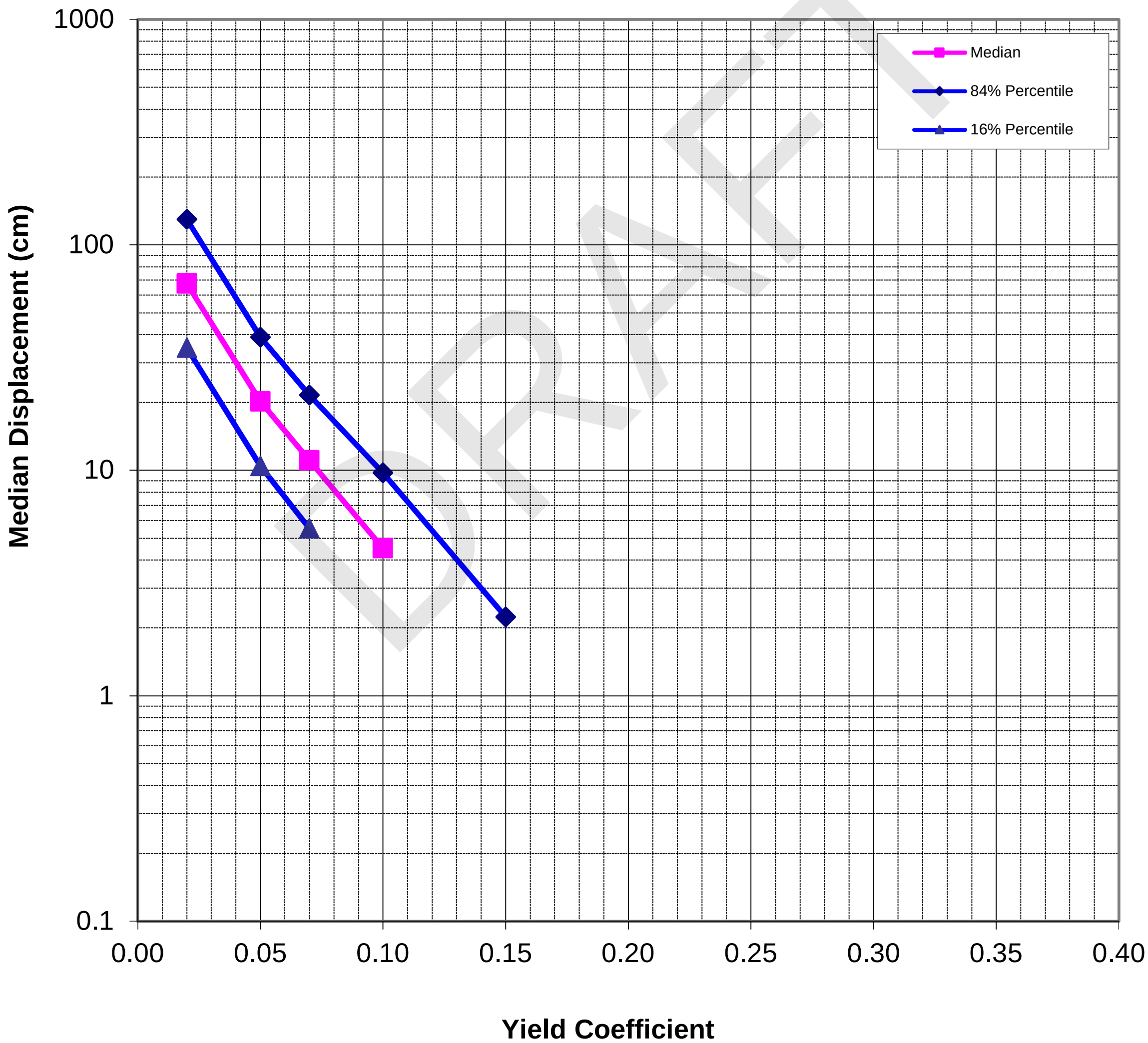
Figures from Bray, J.D. (2007) “Chapter 14: Simplified Seismic Slope Displacement Procedures,” Earthquake Geotechnical Engineering, 4th Inter. Conf. on Earthquake Geotechnical Engineering - Invited Lectures, in Geotechnical, Geological, and Earthquake Engineering Series, Vol. 6, Pitilakis, Kyriazis D., Ed., Springer, Vol. 6, pp. 327-353.

SECTION D-D'

Dependence on ky

ky	P(D="0")	D (cm)	Dmedian (cm)	D-84% (cm)	D-16% (cm)
0.020	0.00	67.4	67.4	130.0	35.0
0.05	0.00	20.2	20.2	39.0	10.5
0.07	0.02	11.3	11.1	21.5	5.5
0.1	0.20	5.6	4.5	9.7	<1
0.15	0.69	2.3	<1	2.2	<1
0.2	0.92	1.1	<1	<1	<1
0.3	1.00	0.4	<1	<1	<1
0.4	1.00	0.2	<1	<1	<1



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Journal of Geotechnical and Geonvironmental Engineering, ASCE, V. 133(4), pp. 381-392, April 2007

SEE NOTES BELOW FOR GUIDANCE IN THE USE OF SPREADSHEET

Input Parameters			
Yield Coefficient (ky)	0.127		Based on pseudostatic analysis
Initial Fundamental Period (Ts)	0.05	seconds	1D: Ts=4H/Vs 2D: Ts=2.6H/Vs
Degraded Period (1.5Ts)	0.07	seconds	
Moment Magnitude (Mw)	7.0		
Spectral Acceleration (Sa(1.5Ts))	0.25	g	

Additional Input Parameters		
Probability of Exceedance #1 (P1)	84	%
Probability of Exceedance #2 (P2)	50	%
Probability of Exceedance #3 (P3)	16	%
Displacement Threshold (d_threshold)	5	cm

Intermediate Calculated Parameters			
Non-Zero Seismic Displacement Est (D)	3.35	cm	eq. (5) or (6)
Standard Deviation of Non-Zero Seismic D	0.66		

Results			
Probability of Negligible Displ. (P(D=0))	0.48		eq. (3)
D1	<1	cm	calc. using eq. (7)
D2	1.0	cm	calc. using eq. (7)
D3	4.7	cm	calc. using eq. (7)
P(D>d_threshold)	0.14		eq. (7)

Notes

1. Values highlighted in blue are input parameters, and results are presented in the table with the yellow heading.
2. Probability of Exceedance is the desired probability of exceeding a particular displacement value.
3. Displacements D1, D2, and D3 correspond to P1, P2, and P3, respectively.
   (e.g., the probability of exceeding displacement D1 is P1)
4. The 16%, 50%, and 84% percentile displacement values at selected ky values are shown to the right.
5. Calculated seismic displacements are due to deviatoric deformation only (add in volumetrically induced movement).
6. ky may range between 0.01 and 0.5, Ts between 0 and 2 s, Sa between 0.002 and 2.7 g, M between 4.5 and 9
7. Rigid slope is assumed for Ts < 0.05 s
8. When a value for D is not calculated, D is < 1cm
9. ky may be estimated using the simplified equations shown below.
10. Examples of how Ts is estimated are shown below.
11. Vs = weighted avg. shear wave velocity for the sliding mass, e.g., for 2 layers, Vs = [(h1)(Vs1) + (h2)(Vs2)]/(h1 + h2)

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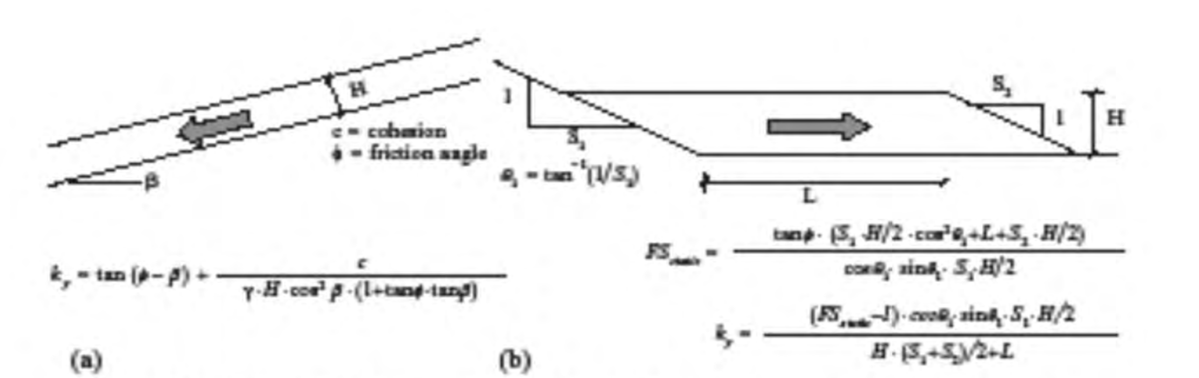

Fig. 14.1. Simplified estimates of the yield coefficient: (a) shallow sliding and (b) deep sliding

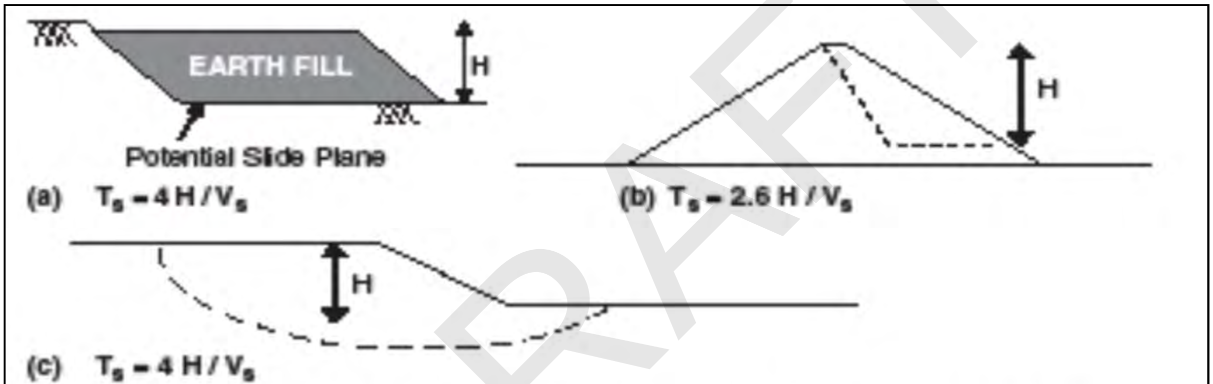

Fig. 14.4. Estimating the initial fundamental period of potential sliding blocks

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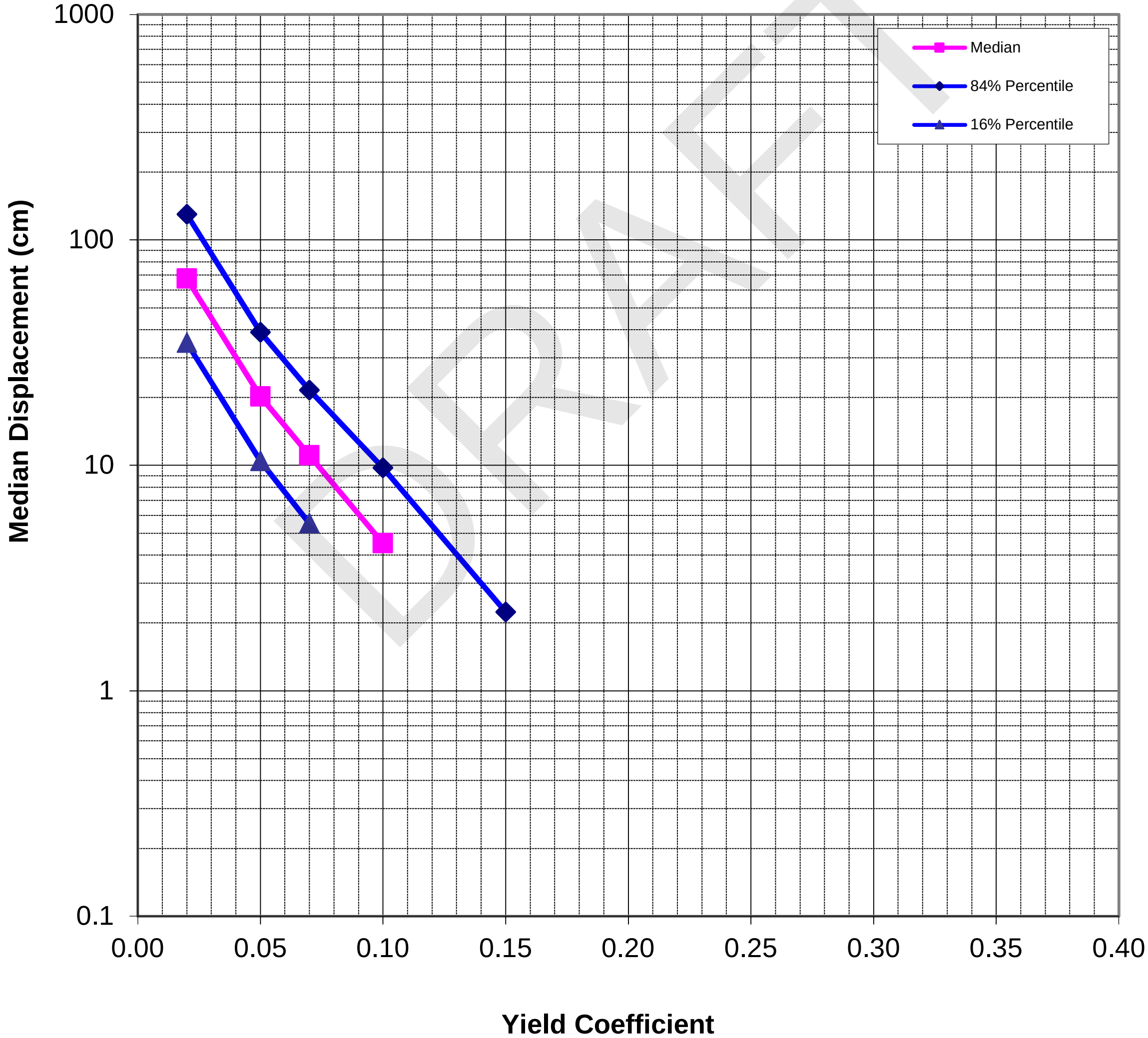
Figures from Bray, J.D. (2007) “Chapter 14: Simplified Seismic Slope Displacement Procedures,” Earthquake Geotechnical Engineering, 4th Inter. Conf. on Earthquake Geotechnical Engineering - Invited Lectures, in Geotechnical, Geological, and Earthquake Engineering Series, Vol. 6, Pitilakis, Kyriazis D., Ed., Springer, Vol. 6, pp. 327-353.

SECTION E-E'

Dependence on ky

ky	P(D="0")	D (cm)	Dmedian (cm)	D-84% (cm)	D-16% (cm)
0.020	0.00	67.4	67.4	130.0	35.0
0.05	0.00	20.2	20.2	39.0	10.5
0.07	0.02	11.3	11.1	21.5	5.5
0.1	0.20	5.6	4.5	9.7	<1
0.15	0.69	2.3	<1	2.2	<1
0.2	0.92	1.1	<1	<1	<1
0.3	1.00	0.4	<1	<1	<1
0.4	1.00	0.2	<1	<1	<1



Simplified Procedure for Estimating Earthquake Induced Deviatoric Slope Displacements
by Jonathan D. Bray and Thaleia Travasarou
Journal of Geotechnical and Geonvironmental Engineering, Vol 133, No. 4, pp. 381-392, April 2007

APPENDIX E

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Bobcat Ridge Table of Lots

Lot No.	Est. Depth to Groundwater (ft)	*Estimated Min. OX (ft)	Recommendations
Lot 1	8-9	n/a	Southern half of lot – no special requirements Northern half of lot – development currently not recommended due to shallow groundwater and proximity to landslide scarp to the north; may be developable pending additional subsurface investigation and analysis and the development of an appropriate hazard mitigation plan, but would likely be an on-grade structure (no basement).
Lot 2	>10 (south) 4-10 (north)	n/a	Southern half of lot – no special requirements Northern half of lot – development currently not recommended due to shallow groundwater and proximity to landslide scarp to the north; may be developable pending additional subsurface investigation and analysis and the development of an appropriate hazard mitigation plan, but would likely be an on-grade structure (no basement).
Lot 3	>13	6-8	Over-excavate (OX) below landslide deposits across entire building footprint.
Lot 4	>10.5	n/a	No special requirements.
Lot 5	12	n/a	No special requirements – basement depth may be limited due to shallow groundwater, identified at approximately 12 feet below existing grade.
Lot 6	9-10	n/a	East half of lot - No special requirements – basement depth may be limited due to shallow groundwater, identified at approximately 9 to 10 feet below existing grade. West half of lot - development currently not recommended pending additional subsurface investigation and analysis and the development of an appropriate hazard mitigation plan, or significant remedial earthwork to mitigate the landslide hazard for this area.
Lot 7	7	n/a	Development currently not recommended pending additional subsurface investigation and/or analysis - significant remedial earthwork to mitigate the landslide hazard for this area should be anticipated.
Lot 8	8-10	n/a	Development currently not recommended pending additional subsurface investigation and/or analysis - significant remedial earthwork to mitigate the landslide hazard for this area should be anticipated.
Lot 9	5	n/a	Development currently not recommended pending additional subsurface investigation and/or analysis - significant remedial earthwork to mitigate the landslide hazard for this area should be anticipated.
Lot 10	~6-10	n/a	Probable shallow groundwater; on-grade structure recommended (no basement) unless lot-specific data indicates favorable groundwater depth within the building footprint.
Lot 11	11	n/a	No special requirements – basement depth may be limited due to shallow groundwater, identified at approximately 11 feet below existing grade.
Lot 12	~10	n/a	The northern 1/5th of this lot is within landslide deposit (Qlso?); recommend a minimum structural set-back of 30 feet from the limits of the landslide. Basement depth may be limited due to shallow groundwater, estimated at approximately 10 feet below existing grade.

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Lot No.	Est. Depth to Groundwater (ft)	*Estimated Min. OX (ft)	Recommendations
Lot 13	>16	n/a	The northwestern corner of this lot is within landslide deposit (Qlso?); recommend a minimum structural set-back of 20 feet from the limits of the landslide.
Lot 14	>16	n/a	No special requirements.
Lot 15	>10.5	n/a	No special requirements.
Lot 16	10-15	n/a	No special requirements. The depth of basement may be limited on the eastern half of the lot due to shallow groundwater.
Lot 17	4	5-6	Probable shallow groundwater; on-grade structure recommended (no basement), possible temporary dewatering could be needed during construction. Over-excavate below landslide deposits across entire building footprint.
Lot 18	6-7	n/a	Probable shallow groundwater; on-grade structure recommended (no basement).
Lot 19	6-7	n/a	Probable shallow groundwater; on-grade structure recommended (no basement).
Lot 20	11	n/a	Possible shallow groundwater in northwest ~1/3 of lot that may limit basement depth in this area, otherwise no special requirements.
Lot 21	>12	n/a	No special requirements.
Lot 22	>12	n/a	Possible shallow groundwater at northeast corner of lot that may limit basement depth in this area, otherwise no special requirements.
Lot 23	12	n/a	No special requirements – basement depth may be limited due to shallow groundwater, identified at approximately 12 feet below existing grade.
Lot 24	>16	n/a	No special requirements.
Lot 25	>16	n/a	No special requirements.
Lot 26	>10.5	n/a	No special requirements.
Lot 27	>10.5	n/a	No special requirements.
Lot 28	6.5 (west)	n/a	Shallow groundwater on western 1/3rd of lot; on-grade structure recommended unless structure is placed outside of western 1/3rd of lot.
Lot 29	10	n/a	No special requirements – basement depth may be limited due to shallow groundwater, identified at approximately 10 feet below existing grade.
Lot 30	8 (western half) >9.5 (eastern half)	n/a	Western half of lot – on-grade structure (no basement) recommended due to shallow groundwater. Eastern half of lot - basement depth may be limited due to shallow groundwater.
Lot 31	>11	9	Over-excavate below landslide deposits across entire building footprint.
Lot 32	6-9	12	Over-excavate below landslide deposits across entire building footprint. Probable temporary dewatering needed during over-excavation. On-grade structure recommended (no basement).
Lot 33	3-4	16	Over-excavate below landslide deposits across entire building footprint. Significant temporary dewatering needed during over-excavation. On-grade structure recommended (no basement).
Lot 34	3-4	16	Over-excavate below landslide deposits across entire building footprint. Significant temporary dewatering needed during over-excavation. On-grade structure recommended (no basement).

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Lot No.	Est. Depth to Groundwater (ft)	*Estimated Min. OX (ft)	Recommendations
Lot 35	4-5	12	Over-excavate below landslide deposits across entire building footprint. Probable temporary dewatering needed during over-excavation. On-grade structure recommended (no basement).
Lot 36	5-12	12-16	Over-excavate below landslide deposits across entire building footprint. Probable temporary dewatering needed during over-excavation. On-grade structure recommended (no basement).
Lot 37	5	10-12	Over-excavate below landslide deposits across entire building footprint. Probable temporary dewatering needed during over-excavation. On-grade structure recommended (no basement).
Lot 38	4-6	10-12	Over-excavate below landslide deposits across entire building footprint. Probable temporary dewatering needed during over-excavation. On-grade structure recommended (no basement).
Lot 39	3-4	9-11	Over-excavate below landslide deposits across entire building footprint. Probable temporary dewatering needed during over-excavation. On-grade structure recommended (no basement).
Lot 40	3-4	9-11	Over-excavate below landslide deposits across entire building footprint. Probable temporary dewatering needed during over-excavation. On-grade structure recommended (no basement).
Lot 41	5-6	11-13	Over-excavate below landslide deposits across entire building footprint. Probable temporary dewatering needed during over-excavation. On-grade structure recommended (no basement).
Lot 42	5-6	9-11	Over-excavate below landslide deposits across entire building footprint. Probable temporary dewatering needed during over-excavation. On-grade structure recommended (no basement).
Lot 43	>12.5	n/a	No special requirements – possible shallow groundwater near/along southeast property boundary.
Lot 44	10 (southern half of lot)	n/a	No special requirements – possible shallow groundwater on the southern half of the property, which may limit the depth of basement on the southern half.
Lot 45	9	n/a	No special requirements – basement depth may be limited due to shallow groundwater, identified at approximately 9 feet below existing grade.
Lot 46	9	n/a	No special requirements – basement depth may be limited due to shallow groundwater, identified at approximately 9 feet below existing grade.
Lot 47	6	n/a	On-grade structure recommended (no basement) due to shallow groundwater.
Lot 48	6	n/a	On-grade structure recommended (no basement) due to shallow groundwater.

*Estimated minimum over-excavation below existing grade. Values are estimated based on current subsurface data – the actual depth of over-excavation may be more, or less, depending on the specific geologic conditions within the building footprint.

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