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GEOLOGIC AND GEOTECHNICAL ENGINEERING STUDY

Proposed Three Branch Ranch Residence

About 1700 South 9500 East
Huntsville, Weber County, Utah

CMT PROJECT NO. 21480

FOR:
Big Canyon Homes
791 North 100 East
Lehi, Utah 84003

February 12, 2024

CMT TECHNICAL SERVICES

February 12, 2024

Mr. Paul Berman
Big Canyon Homes
791 North 100 East
Lehi, Utah 84003

Subject: Geologic and Geotechnical Engineering Study
Proposed Three Branch Ranch Residence
About 1700 South 9500 East
Huntsville, Weber County, Utah
CMT Project No. 21480

Mr. Berman:

Submitted herewith is the report of our geologic and geotechnical engineering study for the subject site. This report contains the results of our findings and an interpretation of the results with respect to the available project characteristics. The report also contains recommendations to aid in the design and construction of the earth related phases of this project.

On December 14, 2023, CMT Technical Services (CMT) personnel were onsite and supervised excavation of four test pits to depths of 7.9 to 8.5 feet below the existing ground surface. Soil samples were obtained during the field operation and subsequently transported to our laboratory for further testing and observation. Conventional spread and/or continuous footings may be utilized to support the proposed structure, provided the recommendations in this report are followed. A detailed discussion of design and construction criteria is presented in this report. Slope stability cross sections were also measured across site slopes and analyzed for slope grading and wall design. A Professional Geologist also visited the site and conducted a review of the site geological and related geological hazard conditions.

We appreciate the opportunity to work with you at this stage of the project. CMT offers a full range of Geotechnical Engineering, Geological, Material Testing, Special Inspection services, and Phase I and II Environmental Site Assessments. With offices in Utah, Arizona, Idaho, Colorado, and Texas, our staff is capable of efficiently serving your project needs. If we can be of further assistance or if you have any questions regarding this project, please do not hesitate to contact us at (801) 590-0394.

Sincerely,
CMT Technical Services

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APPENDIX

1.0 INTRODUCTION

1.1 General

This report presents results of a geologic and geotechnical engineering study conducted by CMT Technical Services (CMT) for the proposed Three Branch Ranch residence in Huntsville, Utah. The property consists of a 126.62-acre parcel identified as Weber County Assessor parcel number 23-006-0030. However, not all of the property was evaluated given its size. Our study area focused on the location of the proposed residence as shown on site drawings prepared by Langvardt Design Group, dated August 2023. The study area is located in the Wasatch Range southeast of Ogden Valley in the NW1/4 Section 2, Township 5 North, Range 2 East (Salt Lake Base Line and Meridian). Elevation of the study area ranges between about 5,602 to 5,867 feet above mean sea level. The property and study area is located on **Figure 1, Vicinity Map**. Regional geology of the site and nearby area is shown on **Figure 2, Geologic Map**. A historical black and white air photo of the study area is shown on **Figure 3, 1958 Air Photo**. Locations of the test pits conducted for our subsurface investigation are shown on **Figure 4, Site Evaluation.** Slope-terrain information of the study area is shown on **Figure 5, Slope Analysis**. Site-specific surficial geology of the study area is shown on **Figure 6, Site-Specific Geology**.

1.2 Objectives, Scope and Authorization

The objectives and scope of our study were planned in discussions between Mr. Paul Berman of Big Canyon Homes and Andrew Harris of CMT, as outlined in our proposal dated December 8, 2023.

Our objectives and scope of work included:

1. Performing a site-specific geologic study, in accordance with Section 108-22 Natural Hazard Areas guidelines and standards of the Weber County Code of Ordinances (October 28, 2019), to assess whether all or parts of the site are exposed to natural hazards including, but not limited to: Surface-Fault Rupture, Landslides, Tectonic Subsidence, Rock Falls, Debris Flows, Liquefaction and Flooding.

2. Defining and evaluating site conditions, including: (a) a field program consisting of surficial observation, and the excavation, logging, and sampling of four test pits in the area of the proposed home to evaluate subsurface conditions; (b) a laboratory soils testing program; and (c) an office program consisting of data compilation and correlation, applicable engineering and geological analyses, and preparation of this report summarizing our findings.

The engineering geologic analyses and report sections herein have been conducted and prepared in accordance with Bowman and Lund (2020) and current generally accepted professional engineering geologic principles and practice in Utah. However, the surface of the site at the time of the field program was obscured by about a foot of snow that restricted surficial observations and access. This may affect CMT's ability to accurately assess the geologic hazards at the site.

1.3 Description of Proposed Construction

A single-family home is planned for construction at the site. The structure will likely be 1 to 3 levels above grade, constructed using conventional wood framing, founded on spread footings, and with a basement. Maximum continuous wall and column loads are anticipated to be 1 to 3 kips per lineal foot and 10 to 50 kips, respectively.

1.4 Executive Summary

Structures can be supported upon conventional spread and continuous wall foundations established on suitable natural soils or on structural fill extending to suitable natural soils. The most significant geotechnical/geological aspects of the site are:

1. The property is located in the Wasatch Range southeast of Ogden Valley and about 5 miles west of Herd Mountain. The study area is on northeast-facing slopes overlooking the Sheep Herd Creek floodplain. Sheep Herd Creek heads on the west side of Herd Mountain and then flows westward to its confluence with Bally Watts Creek. The latter then flows northward into Ogden Valley.

2. Parts of the study area are underlain by Pleistocene- to possibly Holocene-age alluvial fan deposits from a small, unnamed canyon to the south. The distal portion of the alluvial fan (furthest from the canyon mouth) is eroded and likely older than or contemporaneous with when Lake Bonneville occupied Ogden Valley. The proximal portion of the alluvial fan (closest to the canyon mouth) is younger. The proposed home is located in the older, distal portion of the alluvial fan on an eroded ridge. The drainage basin for the unnamed canyon south of the study area is small and the channel in the canyon is broad and indistinct. Bedrock in the canyon south of the study area is mapped as Mississippian-age Lodgepole Limestone. A small seasonal drainage flows along the eastern flank of the ridge toward Sheep Herd Creek.

3. The proposed home location is situated on a ridge that trends northeastward from the canyon mouth and dips at an overall gradient of about 11 percent (or about 9:1 horizontal:vertical, H:V). Steeper slopes bound the ridge on the northwest and southeast that show gradients between 15 to 25 percent.

4. The test pits conducted for our field investigation at the site exposed mainly sandy clay soils with no significant clasts or buried paleosols suggestive of Holocene debris flow deposition. A moderately thick topsoil layer was observed at the surface up to about 18 inches thick. No groundwater was observed in the test pits to their explored depths. A domestic water well is in the study area that was drilled in September 2023 on the ridge southwest of the proposed home. This well reportedly encountered about 140 feet of cobbly sand, gravel and clay deposits overlying bedrock of the Mississippian Lodgepole Limestone and Devonian Beirdneau Sandstone. Static groundwater in this well was at a depth of 50 feet. Given this and local topography, groundwater in the study area appears to be from 30 to 50 feet deep.

5. A slope stability analysis was completed across the home site along two separate cross sections as shown on **Figure 5 Slope Analysis**, provided in the appendix. The analysis concluded that the current slopes have adequate factors of safety (see section **6.0 Slope Stability**).

6. Foundations and floor slabs may be constructed on suitable undisturbed natural soils or on select structural/engineered fill which extends to natural soils.

A geotechnical engineer/geologist from CMT must be allowed to verify that all topsoil and undocumented fill materials have been completely removed from beneath proposed structures, and suitable natural soils encountered prior to the placement of structural fills, floor slabs, footings, foundations, or concrete flatwork.

In the following sections, detailed discussions pertaining to proposed construction, field exploration, the geologic setting and mapped hazards, geoseismic setting of the site, earthwork, foundations, lateral pressure and resistance, floor slabs, and subdrains are provided.

2.0 FIELD EXPLORATION

Subsurface soil conditions at the Project were explored by excavating four test pits at the locations shown on **Figure 4**. The test pits were excavated using a track-mounted excavator to depths of from 7.9 to 8.5 feet below the ground surface (bgs) for geologic/geotechnical logging and sampling. During the course of the excavation operations, a continuous log of the subsurface conditions encountered was maintained. Undisturbed tube, block and disturbed bulk samples of representative soils encountered in the test pits were obtained for subsequent laboratory testing and examination. The representative soil samples were sealed in plastic bags and containers prior to transport to the laboratory.

The collected samples were classified in the field based upon visual and textural examination in general accordance with ASTM D-2488. These classifications were supplemented by subsequent inspection and testing in our laboratory. The subsurface conditions encountered in the field exploration are discussed below in **Section 3.2**. Geologic logs of test pits TP-1 through TP-4 at a scale of 1-inch equals five feet (1:60) are provided on **Figures 7A through 7D, Geologic Test Pit Logs**. Geotechnical logs (measured sections) of the test pits are provided on **Figures 9 through 12, Geotechnical Test Pit Logs**. Sampling information, location, trend, and other pertinent data and observations are provided on the logs. Field classifications may differ somewhat from lab data. A Key to Symbols defining the terms and symbols used on the geotechnical test pit logs is provided on **Figure 13, Key to Symbols**.

When backfilling the test pit excavations, only minimal effort was made to compact the backfill and no compaction testing was performed. Thus, the backfill must be considered as non-engineered and settlement of the backfill in the test pits over time must be anticipated.

3.0 SITE CONDITIONS

3.1 Surface Conditions

The site conditions and geology were interpreted through an integrated compilation of data, including a review of literature and mapping from previous studies conducted in the area (Coogan and King, 2016); a limited onsite reconnaissance; and photogeologic analyses of GIS-registered 1958 aerial photography available from

NETROnline (**Figure 3)**, 1997 digital orthophoto quadrangle photography and 2006 high-resolution orthophotography available from the Utah Geospatial Resource Center, and recent aerial imagery from 2023 available from Google Earth™ (**Figure 4**); and GIS analyses of elevation and geo-processed 2020 Light Detection and Ranging (LIDAR) terrain data (**Figure 5**). Site-specific geology of the Project at a scale of 1 inch equals 100 feet (1:1,200) is shown on **Figure 6**. Unit labels and descriptions on **Figure 6** correspond to those provided in **Section 5.2**.

3.2 Subsurface Soils

Four test pits were excavated at the site to evaluate subsurface soil conditions, approximately located as shown on **Figure 4**. Stratigraphic interpretations and detailed unit descriptions are shown on the logs (**Figures 7A-D and 9 through 12**). A summary of the deposits in the test pits is provided in the table below. Test pit locations were measured using a hand-held GPS unit or mobile device and by trend and distance methods from known points. Geologic logging follows methodology in McCalpin (1996).

Exposure	Subsurface Soils
Test pit 1	Dark brown, brown and reddish-brown; stiff to very stiff; massive; sandy lean clay (CL) with no obvious clasts or buried paleosols.
Test pit 2	Brown to dark brown, stiff, massive, slightly moist, lean clay (CL) with sand and with no obvious clasts or buried paleosols.
Test pit 3	Sequence comprised of a lower (1) brown to dark reddish-brown, stiff to very stiff, massive, sandy clay (CL); and an upper (2) brown to dark brown, stiff to dense, massive, sandy clay to clayey sand (CL/SC) with fine to coarse gravel; no obvious clasts or buried paleosols in either unit.
Test pit 4	Brown to dark brown, stiff, massive, lean clay (CL) with sand and with no obvious clasts or buried paleosols.

3.3 Geologic Cross Section

Figure 8A, Cross Section A-A' shows one geologic cross section northeastward across the proposed home location following the ridge top. **Figure 8B, Cross Section B-B'** shows one geologic cross section eastward from the ridge top across the proposed home and a steep slope section below the home. The cross sections are at a scale of 1-inch equals 20 feet with no vertical exaggeration. Cross section locations are shown on **Figure 5**. The geology is based on subsurface data from the test pits, the regional and site-specific geologic mapping on **Figures 2 and 6**, and subsurface data from the drillers' log for onsite well southwest of the proposed home (**Figures 4 through 6** and **Section 3.4**). The topographic profile is based on geoprocessed LIDAR data from 2020. The LIDAR data provide a snapshot of topographic conditions at the time of acquisition; past, present and future surficial topography may vary. Units and contacts should be considered approximate and inferred, and variations should be expected at depth and laterally.

3.4 Groundwater

Slightly moist soils were observed in test pit TP-2, but no groundwater was encountered in the test pits conducted for our evaluation to their explored depths. The Utah Division of Water Rights indicates a domestic water well (WIN 448180) was drilled in September 2023 about 70 feet southwest of the proposed home, as located on **Figures 4 through 6**. The well reportedly encountered Pleistocene alluvium comprised of cobbly brown sandy clay to clayey sand from 0 to 55 feet bgs (unit Qaf, **Section 5.2**); cobbly brown to gray gravel with sand and clay between 55 to 140 feet bgs, which we infer to be Tertiary fanglomerate deposits (unit Thv, **Section 5.2**); and then bedrock of the Mississippian Lodgepole Limestone and Devonian Beirdneau Sandstone to its maximum depth of 660 feet (units Ml and Db, **Section 5.2**). Static groundwater in this well was reportedly at a depth of 50 feet bgs.

Based on local topography and data from the onsite well, we anticipate static groundwater in the study area is from 30 to 50 feet deep. Groundwater is deepest below the ridge top and shallowest in areas off the ridge. Groundwater depths at the site also likely vary seasonally from snowmelt runoff, annually from climatic fluctuations, and locally with topography and subsurface conditions. Such variations would be typical for the area. Groundwater may also be perched above less-permeable, clay-rich stratigraphic layers in the subsurface following spring snowmelt. The perched groundwater typically dries out over the summer depending on the hydraulic conductivity of the underlying and downslope surficial deposits. No springs or seeps suggestive of shallow groundwater conditions were observed at the site during our reconnaissance.

3.5 Site Subsurface Variations

Based on the results of the subsurface explorations and our experience, variations in the continuity and nature of subsurface conditions should be anticipated. Due to the heterogeneous characteristics of natural soils, care should be taken in interpolating or extrapolating subsurface conditions between or beyond the exploratory locations.

4.0 LABORATORY TESTING

4.1 General

Selected samples of the subsurface soils were subjected to various laboratory tests to assess pertinent engineering properties, as follows:

1. Moisture Content, ASTM D-2216, Percent moisture representative of field conditions
2. Atterberg Limits, ASTM D-4318, Plasticity and workability
3. Gradation Analysis, ASTM D-1140/C-117, Grain Size Analysis
4. One Dimension Consolidation, ASTM D-2435, Consolidation properties
5. Dry Density, ASTM D-2937, Dry unit weight representing field conditions
6. Direct Shear Test, ASTM D-3080, Shear strength parameters

Laboratory test results are presented on the geotechnical test pit logs (***Figures 9 through 12***) and in the following **Lab Summary Table**:

LAB SUMMARY TABLE

TEST PIT	DEPTH (feet)	SOIL CLASS	SAMPLE TYPE	MOISTURE CONTENT(%)	DRY DENSITY (pcf)	GRADATION			ATTERBERG LIMITS		
						GRAV.	SAND	FINES	LL	PL	PI
TP-1	2	CL	Block	25	89				49	22	27
	6	CL	Bag	17		0	9	91	33	17	16
TP-2	4	CL	Block	15	94						
TP-3	4	CL	Bag	13		20	23	57			
	8	CL	Block	18	95				39	17	22
TP-4	7	CL	Bag	12		1	8	91			

4.2 Consolidation Test

To provide data necessary for an assessment of potential settlement from structural loading, a consolidation test was performed on each of 2 representative samples of the subsurface clay soils encountered across the site. Based upon data obtained from the consolidation testing, the clay soils at this site are moderately over-consolidated, have moderate to slightly high compressibility under additional loading, and have a collapse/swell potential of less than 0.5% at a load of 1,000 psf when water was added. Detailed results of the tests are maintained within our files and can be transmitted to you, if so desired.

4.3 Direct Shear Test

To determine the shear strength of the natural soils encountered at the site, a laboratory direct shear test was performed on a carved ring sample of a near surface clay sample from test pit TP-3

During the direct shear test, the sample was evenly consolidated within the test ring, loaded, and saturated immediately after the load was applied. Loading was conducted at a slower rate to simulate saturated-drained condition. The results of the direct shear tests are presented in the following table:

DIRECT SHEAR RESULTS

Sample Location	Sample Depth (feet)	Unified Soils Classification	Sample Type	Natural Moisture Percent	Apparent Cohesion (psf)	Measured Internal Friction Angle (degrees)
TP-3	8	CL	Rings	18	510	23.7

5.0 ENGINEERING GEOLOGY

5.1 Seismotectonic Setting

The property is located in the Wasatch Range southeast of Ogden Valley and about 5 miles west of Herd Mountain. The study area is on northeast-facing slopes overlooking the Sheep Herd Creek floodplain. Sheep

Herd Creek heads on the west side of Herd Mountain and then flows westward to its confluence with Bally Watts Creek. The latter then flows northward into Ogden Valley.

Ogden Valley is a roughly 40-square mile back valley within the Wasatch Range described by Gilbert (1928) as a structural trough similar to Cache and Morgan Valleys to the north and south, respectively. The back valleys are in a transition zone between the Basin and Range and Middle Rocky Mountains provinces (Stokes, 1977, 1986). The Basin and Range is characterized by a series of generally north-trending elongate mountain ranges, separated by predominately alluvial and lacustrine sediment-filled valleys and typically bounded on one or both sides by major normal faults (Stewart, 1978). The boundary between the Basin and Range and Middle Rocky Mountains provinces is the prominent, west-facing escarpment along the Wasatch fault zone at the base of the Wasatch Range. Late Cenozoic normal faulting, a characteristic of the Basin and Range, began between about 17 and 10 million years ago in the Nevada (Stewart, 1980) and Utah (Anderson, 1989) portions of the province. The faulting is a result of a roughly east-west directed, regional extensional stress regime that has continued to the present (Zoback and Zoback, 1989; Zoback, 1989).

The site is also in the central portion of the Intermountain Seismic Belt (ISB), a generally north-south trending zone of historical seismicity along the eastern margin of the Basin and Range province extending from northern Arizona to northwestern Montana (Sbar and others, 1972; Smith and Sbar, 1974). At least 16 earthquakes of magnitude 6.0 or greater have occurred within the ISB since 1850; the largest of these earthquakes was a M 7.5 event in 1959 near Hebgen Lake, Montana. None of these earthquakes occurred along the Wasatch fault or other known late Quaternary faults (Arabasz and others, 1992; Smith and Arabasz, 1991). The closest event was the 1934 Hansel Valley (M 6.6) event north of the Great Salt Lake. The March 18, 2020 M 5.7 earthquake[1] near Magna, Utah reportedly showed a style, location, and slip depth consistent with an earthquake on the Wasatch fault system. Despite being less than magnitude 6.0, this earthquake damaged multiple buildings and was felt from southern Idaho to south-central Utah[2]. The University of Utah Seismograph Stations[3] indicates the Magna earthquake was weakly felt in Ogden Valley, with a peak acceleration of about 0.005 g and an instrument intensity of II-III (on a Roman numeral scale of I-X).

5.2 Surficial Geology

The Project is adjacent to the eastern base of a northwest-trending series of unnamed intermontane mountain peaks displaying about 800 to 1,400 feet of vertical relief (**Figure 1**). Coogan and King (2016) indicate the peaks are underlain by a thrust-faulted sequence of Paleozoic sedimentary bedrock, including the Mississippian Lodgepole Limestone and Devonian Beirdneau Sandstone and Hyrum Dolomite and (units Ml, Db and Dh, respectively; **Figure 2**). Coogan and King (2016) map surficial geology of the study area as undivided Holocene and Pleistocene mass wasting deposits (unit Qmc) on the west and east, undivided Holocene and Pleistocene alluvial fan deposits (unit Qaf) in the middle, and younger Holocene and Pleistocene alluvium (unit Qay) in the Sheep Herd Creek flood plain on the north (**Figure 2**). The alluvial fan deposits emanate from a small, unnamed

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[1] https://earthquake.usgs.gov/earthquakes/eventpage/uu60363602/executive
[2] https://www.ksl.com/article/46731630/
[3] https://earthquakes.utah.gov/magna-quake/#

canyon south of the study area. Based on subsurface data from the onsite well, Tertiary fangomerate deposits (unit Thv) may underlie the Pleistocene alluvium. This unit is found on **Figure 2** north and west of the study area.

Coogan and King (2016) describe surficial geologic units on **Figure 2** as follows:

> ***Qal, Qal1, Qal2, Qal2?*** – *Stream alluvium and flood-plain deposits (Holocene and uppermost Pleistocene)*. Sand, silt, clay, and gravel in channels, flood plains, and terraces typically less than 16 feet (5 m) above river and stream level; moderately sorted; unconsolidated; along the same drainage Qal2 is lower than Qat2 and has likely been subject to flooding, at least prior to dam building; present in broad plains along the Bear, Ogden, and Weber Rivers and larger tributaries like Deep, Cottonwood, East Canyon, Lost, and Saleratus Creeks, along Box Elder, Heiners, and Yellow Creeks, and in narrower plains of larger tributary streams; locally includes muddy, organic overbank and oxbow lake deposits; composition depends on source area, so in back valleys typically contains many quartzite cobbles recycled from the Wasatch Formation; mostly Holocene, but deposited after regression of Lake Bonneville from the late Pleistocene Provo shoreline; width in Morgan Valley is combined flood plain of Weber River and East Canyon and Deep Creeks; 6 to 20 feet (2-6 m) thick and possibly as much as 50 feet (15 m) along Weber River and thinner in the Kaysville quadrangle; greater thicknesses (>50 feet [15 m]) are reported in Morgan Valley (Utah Division of Water Rights, well drilling database), but likely include Lake Bonneville and older Pleistocene deposits.
>
> Suffixes 1 and 2 indicate ages where they can be separated, with 1 including active channels and 2 including low terraces 10 to 20 feet (3-6 m) above the Weber and Ogden Rivers, and the South Fork Ogden River that may have been in the flood plain prior to damming of these waterways. Qal2 queried in low terraces above Bear River, Saleratus Creek, and Dry Creek where deposits may not be in the flood plain.
>
> ***Qaf1, Qaf2, Qaf2?, Qafy, Qafy?*** – *Younger alluvial-fan deposits (Holocene and uppermost Pleistocene)*. Like undivided alluvial fans, but all of these fans are unconsolidated and should be considered active; height above present drainages is low and is within certain limits; generally less than 40 feet (12 m) thick; near former Lake Bonneville, fans are shown as Qafy where Qaf1 and Qaf2 cannot be separated, and all contain well-rounded recycled Lake Bonneville gravel. Younger alluvial fan deposits are queried where relative age is uncertain (see Qaf for details).
>
> Qaf1 fans are active because they impinge on and deflect present-day drainages. Qaf2 fans appear to underlie Qaf1 fans but may be active. Qafy fans are active, impinge on present-day floodplains, divert active streams, overlie low terraces, and/or cap alluvial deposits (Qap) related to the Provo and regressive shorelines. Therefore, Qafy fans are younger than the Provo shoreline and likely mostly Holocene in age, but may be as old as latest Pleistocene and may be partly older than Qaf1 fans.
>
> ***Qap, Qap?, Qab, Qab?, Qapb*** – *Lake Bonneville-age alluvium (upper Pleistocene)*. Like undivided alluvium but height above present drainages appears to be related to shorelines of Lake Bonneville and is within certain limits, and unconsolidated to weakly consolidated; alluvium labeled Qap and Qab is related to Provo (and slightly lower) and Bonneville shorelines of Lake Bonneville (at ~4800 to 4840 feet [1463-1475 m] and 5180 feet [1580 m] in Morgan Valley), respectively; suffixes partly based on heights above adjacent drainages near Morgan Valley (see tables 1 and 2); Qap is typically about 15 to 40 feet (5-12 m) above present adjacent drainages, but is locally 45 feet (12 m) above; Qapb is used where more exact age cannot

be determined, typically away from Lake Bonneville, or where alluvium of different ages cannot be shown separately at map scale; Qap is up to about 50 feet (15 m) thick, with Qapb and Qab, at least locally up to 40 and 90 feet (12 and 27 m) thick, respectively. Queried where classification or relative age uncertain (see Qa).

A prominent surface ("bench") is present on Qap and Qatp at about 4900 feet (1494 m) elevation and about 25 to 40 feet (8-12 m) above the Weber River in Morgan Valley and along the South Fork Ogden River.

In the Devils Slide quadrangle, the Qab that is mapped about 80 to 95 feet (24-29 m) above Round Valley and 40 to 50 feet (12-15 m) above adjacent drainages at the mouth of Geary Hollow appears unique. Based on heights above adjacent drainages, these deposits would be Qao (see table 1), but similar alluvial deposits to the east near Phil Shop Hollow have a Bonneville shoreline cut in them and are much thinner than 40 feet (12 m). The lack of a Bonneville shoreline, and small thickness and heights above drainages indicate the deposits could be a Bonneville shoreline fan-delta.

Qafo, Qafo? – *Older alluvial-fan deposits (mostly upper Pleistocene)*. Incised and at least locally dissected fans of mostly sand, silt, and gravel that is poorly bedded and poorly sorted; includes debris flows, particularly in drainages and at drainage mouths (fan heads); older fans are typically above the Bonneville shoreline, with an eroded bench at the shoreline; upstream and above the Bonneville shoreline, unit Qafo is topographically higher than fans graded to the Bonneville shoreline (Qafb), and is typically dissected; generally less than 60 feet (18 m) thick. In Mantua Valley, exposed thickness up to about 100 feet (30 m), but water wells (sections 26 and 27, T. 9 N., R. 1 W.) were still in gravelly to bouldery valley fill at depths of 505 and 467 feet (154 and 142 m), respectively, and red coloration that may indicate Wasatch Formation bedrock was not noted (see Bjorklund and McGreevy, 1973, p. 16).

Qafo queried where relative age is uncertain (see Qaf for details), for example in Mantua quadrangle where it is as high as Qafoe in Morgan Valley (see table 1). Qafo queried in East Canyon graben because the deposits are not dissected and some deposits mantle Qafoe (see also unit Qafm above), resulting in a reversal of relative height and only local incision. These irregular deposits are likely the result of salt movement in the East Canyon graben. Our Qafo is roughly shown to south by Bryant (1990) as Qgp (pediment gravel); farther south he showed Qoa (dissected alluvium) adjacent to the East Canyon fault, which may be the QTaf or Qafoe we mapped.

Amino-acid age estimates presented in Sullivan and Nelson (1992) imply Qafo north of Morgan considerably predates Lake Bonneville and is middle Pleistocene in age (>400 ka). However, the Bonneville shoreline is obscure on this fan, and soil-carbonate age estimates (>70-100 ka) and other amino acid age estimates (~98-155 ka) in Sullivan and others (1988) imply these older fans are related to Bull Lake glaciation (95,000 to 130,000 years old; see Chadwick and others, 1997; Phillips and others, 1997). As noted under Qao, Qafo deposits may contain two ages (levels) of alluvial surfaces that are not easily recognized in Morgan Valley but are recognized upstream in the Henefer and Lost Creek Valleys (Devils Slide quadrangle) and along the North and South Forks of Ogden River.

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 (is there supposed to be another letter on one of these 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.

Qay, Qa2, Qa2?, Qa3, Qa3?, Qa4, Qa4?, Qa4-5, Qa5, Qa6 – *Alluvium (Holocene and Pleistocene)*. Sand, silt, clay, and gravel in stream and alluvial-fan deposits that are not close to late Pleistocene Lake Bonneville and are geographically in the Huff Creek and upper Bear River drainages; variably sorted; variably consolidated; composition depends on source area; deposits lack fan shape of Qaf and are distinguished from terraces (Qat) based on upper surface sloping toward adjacent streams from sides of drainage, or are shown where fans and terraces are too small to show separately at map scale; Qay is at to slightly above present drainages and not incised by active drainages, so is the youngest unit; generally 6 to 20 feet (2-6 m) thick.

Age-number and letter suffixes on alluvium (undivided, channel, flood plain, terrace, and fan) that is not close to late Pleistocene Lake Bonneville are relative and only apply to the local drainage, with suffix 2 being the second youngest; the relative age is queried where age uncertain, generally due to the height not fitting into the typical order of surfaces. The various numbered deposits listed, Qa2 through Qa6, are 20 to 180 feet (6-55 m) above the Bear River, Saleratus Creek, and Yellow Creek. Qa5 and Qa3? are only used in stacked units (Qa5/Tfb and Qa3?/Tfb).

Qa, Qa? – *Alluvium, undivided (Holocene and Pleistocene)*. Sand, silt, clay, and gravel in stream and alluvial-fan deposits near late Pleistocene Lake Bonneville and are geographically in the Ogden and Weber River, and lower Bear River drainages; composition depends on source area; variably sorted; variably consolidated; deposits lack fan shape of Qaf and are distinguished from terraces (Qat) based on upper surface sloping toward adjacent streams from sides of drainage, or are shown where fans and terraces are too small to show separately at map scale; Qa with no suffix used where age uncertain or alluvium of different ages cannot be shown separately at map scale; Qa queried where relative age uncertain, generally due to height not fitting into ranges in table 1 and/or typical order of surfaces contradicts height-derived age (see following paragraphs); generally 6 to 20 feet (2-6 m) thick.

Where possible, alluvium is subdivided into relative ages, indicated by number and letter suffixes. This alluvium is listed and described separately below. The relative ages of alluvium, including terraces and fans, are in part based on deposit heights above present adjacent drainages in Morgan and Round Valleys, and this subdivision apparently works in and is applied in Ogden, Henefer, and Lost Creek Valleys and above the North, Middle, and South Forks of Ogden River (see table 1 and 2). Alluvial deposits mapped in the Henefer quadrangle (Coogan, 2010b) and Lost Creek drainage (Coogan, 2004a-c) were revised during mapping of the Devils Slide quadrangle (see table 2). Comparable alluvium along Box Elder Creek in the northwest part of the map area (Mantua quadrangle) seems to be slightly higher than in Morgan Valley.

Units Qa2, Qay, Qap, Qab, Qapb, Qao, and Qaoe described below are near Lake Bonneville. Their relative age is queried where age uncertain, generally due to height not fitting into ranges in table 1 and/or typical order of surfaces contradicts height-derived age.

***Qaf, Qaf?** – Alluvial-fan deposits, undivided (Holocene and Pleistocene)*. Mostly sand, silt, and gravel that is poorly bedded and poorly sorted and is near late Pleistocene Lake Bonneville and is geographically in the Ogden and Weber River, and lower Bear River drainages; variably consolidated; includes debris flows, particularly in drainages and at drainage mouths (fan heads); generally less than 60 feet (18 m) thick; in subsurface, about 100 feet (30 m) thick in section 22, T. 9 N., R. 1 W. northwest of Mantua, and about 150 feet (45 m) thick beneath Qac in sections 9 and 16, T. 9 N., R. 1 W. (Utah Division of Water Rights website). Qaf with no suffix used where age uncertain or for composite fans where portions of fans with multiple ages cannot be shown separately at map scale; toes of some fans have been removed by human disturbances, so their age cannot be determined, for example in Upper Weber Canyon. Qaf queried where relative age uncertain, generally due to height not fitting into ranges in table 1 and/or typical order of surfaces contradicts height-derived age (see following paragraphs).

Where possible, subdivided into relative ages, indicated by letter and number suffixes (like Qa and Qat suffixes). These alluvial fans near Lake Bonneville (Qaf1, Qaf2, Qafy, Qafp, Qafpb, Qafb, Qafm, Qafo, Qafoe) are listed and described separately below. Relative ages of these fans are partly based on heights above present drainages in Morgan Valley area, in this case at drainage-eroded edge of fan. This height-based subdivision apparently works in and is applied in Ogden, Henefer, and Lost Creek Valleys and above the North, Middle and South Forks of Ogden River (see tables 1 and 2) (note revisions from Coogan and King, 2006; King and others, 2008; Coogan, 2010a-b). Despite the proximity to Lake Bonneville, alluvial fans along and near Box Elder Creek in the northwest corner of the map area (Mantua quadrangle) do not fit into table 1 and overall appear to be higher than comparable fans in Morgan Valley. Their relative ages are queried where the age is uncertain, generally due to the height not fitting into the ranges in table 1 and/or the typical order of surfaces contradicts height-derived age.

***Qng** – Colluvial and residual gravel deposits (Holocene and Pleistocene)*. Poorly sorted pebble to boulder gravel in a matrix of silt and sand; gravel of uncertain origin, but probably includes colluvium and residuum, and at least locally glacial deposits (for example near Powder Mountain) and alluvium; mostly gravel-armored deposits on and near alluvial and colluvial deposits like units Qcg, QTay?, QTao?, and QTaf; locally on gravel-rich bedrock (Thv, Tcg, Tw, and Keh) and Paleozoic quartzite (Cgcu and Ct); typically have gently dipping upper surface; present on Durst Mountain, near high-level fans (QTaf) near head of Strawberry Creek (Snow Basin quadrangle), in northeast corner of Peterson quadrangle, and on benches above streams in east part of Peterson quadrangle; generally 6 to 20 feet (2-6 m) thick.

***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 (slope wash 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 slope wash 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).

***Thv, Thv?** – Fanglomerate of Huntsville area (Pliocene and/or Miocene)*. Typically dark-weathering, poorly to moderately consolidated, pebble to boulder gravel in brown to reddish-brown silt and sand; gravel and matrix reflect erosion of red Wasatch Formation, as well as Paleozoic and Precambrian rocks exposed on Durst Mountain; in contrast, where fanglomerate is next to Tintic Quartzite (Ct) exposures, clasts are mostly angular to subangular Tintic Quartzite, with less red matrix; overlies conglomeratic rocks (Tcy, Tcg) with angular unconformity, yet is folded with unit Tcy into syncline just west of faults bounding Durst Mountain; estimate 0 to 500 to possibly 1000 feet (0-150-300 m) thick on west flank of Durst Mountain, with upper estimate assuming unit not faulted or folded; several hundred feet of reddish-hued strata are exposed in graben on Durst Mountain but this graben fill may include unit Tcg. Unit Thv queried where may be underlying conglomerate (Tcy) and where poor exposures may actually be surficial deposits.

Our Thv unit is more age restricted than the Huntsville fanglomerate named by Eardley (1955). His unit included Holocene, Pleistocene, Pliocene, Miocene, and Oligocene(?) fanglomerates (our Qcg, Qng, QTaf, Thv, and Tcy units). The age of our Thv may overlap with the Salt Lake Formation.

***Tcg, Tcg?** – Unnamed Tertiary conglomeratic rocks (Oligocene?).* Characterized by rounded, cobble- to boulder-sized, quartzite-clast conglomerate with pebbles and less than 10 percent to more than 50 percent gray, tan, or reddish-gray to reddish-tan matrix; conglomerate clasts locally angular to subangular Tintic Quartzite and angular to rounded lower Paleozoic carbonate rocks; interbedded with tan, gray, and reddish-brown, pebble-bearing mudstone to sandstone and some claystone (altered tuff); most beds poorly indurated and poorly exposed; mudstone likely constitutes matrix of conglomeratic beds; in Morgan and Durst Mountain quadrangles, about 500 to 700 feet (150-210 m) thick and thickening northward to possibly 3000 feet (900 m), though faulting may make this estimate too large.

Reddish-hued Tcg strata mostly contain recycled Wasatch Formation clasts (quartzite and carbonate) with a distinct reddish patina in a reddish matrix. Some non-conglomeratic beds in Tcg look like gray upper Norwood Formation (Tn) and are locally tuffaceous, indicating the units are interbedded. Further, some Tcg pebble beds have carbonate and chert clasts (like the Norwood) and lesser quartzite clasts, and Tcg conglomerate includes rare altered tuff clasts from the Norwood Formation. Despite tuffaceous matrix, unit Tcg seems to be less prone to mass movements than Norwood strata.

Tn, Tn? – *Norwood Formation (lower Oligocene and upper Eocene)*. Typically light-gray to light-brown altered tuff (claystone), altered tuffaceous siltstone and sandstone, and conglomerate; unaltered tuff, present in type section south of Morgan, is rare; locally colored light shades of red and green; variable calcareous cement and zeolitization; involved in numerous landslides of various sizes; estimate 2000-foot *(600 m) thick in exposures on west side of Ogden Valley (based on bedding dip,* outcrop width, and topography). Norwood Formation queried where poor exposures may actually be surficial deposits. For detailed Norwood Formation information see description under heading "Sub-Willard Thrust - Ogden Canyon Area" since most of this unit is in and near Morgan Valley and covers the Willard thrust, Ogden Canyon, and Durst Mountain areas.

Ts – *Tertiary strata, undivided*. Only used in Ogden Canyon area where Norwood and Wasatch Formations are in landslide block [Qms?(Ts)] in Line Creek drainage, Peterson quadrangle, and below old fan (QTaf/Ts) near Maples recreation area (formerly campground), Snow Basin quadrangle; latter may be on or below the Willard thrust.

Keh, Keh? – *Hams Fork Member of Evanston Formation (Upper Cretaceous, Maastrichtian-Campanian)*. Light gray to tan conglomerate with lesser conglomeratic sandstone, and sandstone, with quartzite and chert clasts, as exposed along South Fork Ogden River; lower Hams Fork markedly coarsens to cobble conglomerate dominated by Cambrian and Neoproterozoic quartzite clasts (not mapped separately here, but mapped as Kehc to southeast); about 300 to 1000 feet (140-300 m) thick along South Fork Ogden River, thinning to west; thins to absence to north and west along regional angular unconformities. DeCelles and Cavazza (1999, figure 7A) showed a basal conglomerate as 66 feet (20 m) thick in the Causey Dam quadrangle. Unconformably truncated beneath Wasatch Formation and overlies Cretaceous Weber Canyon Conglomerate and Paleozoic rocks, with angular unconformity, along Right Fork South Fork Ogden River, indicating northern Causey Dam quadrangle, northwestern Horse Ridge, and western Dairy Ridge quadrangles were areas of high paleotopography (after Coogan, 2006a-b).

The age of the Hams Fork here is based on Mullens (1969; 1971, p. 13) note of Late Cretaceous pollen in a sample (D3971) that is from upper part of our Keh unit.

These South Fork Ogden River Keh exposures are not the same lithologically as those near Devils Slide, in the Lost Creek drainage, and in Echo Canyon; but these outcrops form a nearly continuous band down the South Fork and along the east flank of Durst Mountain to Devils Slide and other exposures to the east. The lithology of Keh along the east flank of Durst Mountain also differs from that in the other areas mentioned.

TRd – *Dinwoody Formation (Lower Triassic)*. Greenish-gray and tan, calcareous siltstone and silty limestone (Coogan, 2010a-b); about 250 feet (75 m) thick along Utah-Wyoming state line with variation that might be due to difficulty picking contact with lithologically similar upper Park City Formation.

About 260 feet (80 m) of Dinwoody was cut in the American Quasar Minnow Hill well (AMSTRAT log D-4952, API 43-033-30018). About 240 and 280 feet (73 and 85 m) of Dinwoody was cut in the Woodruff Narrows field in the Amoco 1-4H and Chevron-Amoco 1-32G wells, respectively (API 49-041-20289 and 49-041-20627, respectively, WOGCC), with the 1-4H well just east of the Ogden map area. South of Woodruff Narrows 265 feet (81 m) and 282 feet (86 m) of Dinwoody was cut in the Amoco Bradley and Chevron 1-35 wells, respectively (API 49-041-20509 and 49-041-20315, respectively, WOGCC), and about 250 feet (75 m) of Dinwoody was cut in the Amoco A-MF-Chev well (API 43-033-30011, Utah DOGM; AMSTRAT log D-4943). Farther south, in Yellow Creek field 290 feet (88 m) of Dinwoody was cut in the Celsius [Mtn Fuel] 4-36 well, (API 49-041-20578, WOGCC), and 220 feet (67 m) was cut in the Anschutz 14-33 well (King after API 43-043-30315, Utah DOGM well file). In the Cave Creek field about 250 and 210 feet (75 and 65 m) of Dinwoody was cut in the Champlin 846-Amoco A (API 43-043-30100), Utah DOGM well file) and Fawcett & Son wells (AMSTRAT log D-5672, API 43-043-30078), respectively. In the Anschutz Ranch (west) field, 205, 260, 245, and 304 feet (63, 79, 75, and 93 m) of Dinwoody was cut in the Anschutz 34-2, 10-27, Island Ranching D, and Anschutz 4-26 wells, respectively (API 43-043-30106, 43-043-30321, 43-043-30161, 43-043-30320, respectively, Utah DOGM).

PIPw, PIPwls, IPwl, PIPwu – *Weber Sandstone (Lower Permian and Pennsylvanian)*. Gray, well-cemented, quartzose sandstone with dolomite and siltstone in lower part; estimate 2600 feet (790 m) thick near Morgan (this report). Previously reported thicknesses (Eardley, 1944; Bissell and Childs, 1958; Mullens and Laraway, 1973) are likely from complexly folded strata and are likely across a back thrust. Equivalent to at least part of the Wells Formation. See Williams (1943, p. 598) for fossils. Likely at least partly non-marine eolian (see Fryberger, 1979).

On Durst Mountain, where possible and to show structure, the Weber is divided into a lower part (IPwl) with distinct regular bedding and an upper part (PIPwu) with less distinct bedding, and a marker limestone (PIPwls). The relationship of limestone marker (PIPwls) to the lower and upper units and the disconformity reported by Welsh and Bissell (1979, p. Y22) in the Weber is not known, though the marker appears to be in the upper unit. The lower Weber (IPwl) may be units 1-3 of Eardley (1944), Fusulina-bearing and older strata of Bissell and Childs (1958), or Desmoinesian and older strata of Welsh and Bissell (1979, p. Y18 and Y23). The disconformity of Welsh and Bissell (1979, p. Y22) may or may not be at the IPwl-PIPwu contact and may actually be the back thrust in the upper Weber (PIPwu) in the Devils Slide quadrangle.

Weber strata south of Sheep Herd Creek in the Durst Mountain quadrangle are separated from Mississippian strata to the north by Sheep Herd Creek such that a fault with 1000 to 3000 feet (300-900 m) of stratigraphic offset must be between these outcrops. The orientation of the fault is not known, but the Weber strata are displaced down relative to the Mississippian rocks.

Mh, Mhu – *Humbug Formation (Mississippian, Meramecian?)*. Interbedded carbonate and calcareous to dolomitic quartzose sandstone (see also Crittenden, 1959, p. 70, his unit 1). Roughly equivalent to lower Monroe Canyon Limestone and upper Little Flat Formation to north; interval to east is in an unconformity. Upper part is limestone with sandstone beds near base, about 400 feet (120 m) thick at Durst Mountain (Coogan and King, 2006). See Nohara (1966) for fossils.

Mde – *Deseret Limestone (Mississippian)*. Limestone, dolomite and sandstone, with dark, non-resistant phosphatic shale at base (Delle Phosphatic Member, Mded); about 500 feet (150 m) thick at Durst Mountain (Coogan and King, 2006). Deseret probably equivalent to most of Little Flat Formation (Mlf) mapped in Horse Ridge quadrangle.

***Ml** – Lodgepole Limestone (Mississippian, Osagean-Kinderhookian)*. Dark-gray, thin-bedded, lime micrite (mudstone) to wackestone; locally cherty; at least locally fossiliferous; about 650 feet (200 m) thick on Durst Mountain (Coogan and King, 2006). Structurally thickened to 1300 feet (395 m) in Howard Hollow, even thicker than the 900-foot (270 m) thickness on Willard thrust sheet (Coogan, 2006b).

The type Lodgepole is overlain by the Mission Canyon Limestone (Sando and Dutro, 1974), so, with the Delle marking the boundary between the Deseret and Gardison, this unit may better be called Gardison. In subsurface east of the Willard thrust, 764 feet (233 m) of Lodgepole was reportedly penetrated in the Champlin 432-Amoco C well in the Peck Canyon quadrangle (see API 043-29-30011, Utah DOGM well file) and, north of the map area near Randolph, Utah, about 740 feet (225 m) of Lodgepole was cut in the American Quasar Hoffman well, with an additional 45 feet (14 m) of shaly Cottonwood Canyon Member of Madison/Lodgepole and Leatham Formation (after AMSTRAT log D-4528, API 43-033-30001), with about 820 feet (250 m) of total Lodgepole reported in the Utah DOGM well file (API 43-033-30001). Well data from the Sohio Birch Creek, Sohio Sugarloaf, Marathon Hawk Springs, and American Quasar Putnam wells in the Birch Creek fold belt north of the map area indicate about 680 to 930 feet (210-280 m) of Lodgepole was cut (API 43-033-30042, 43-033-30043, 43-033-30028, and 43-033-30002, respectively, Utah DOGM), and the shaly Cottonwood Canyon Member of Madison/Lodgepole and Leatham Formation are likely present.

These shaly units (and their characteristic double spike on gamma-ray logs) are truncated and eliminated by an unconformity in the region (see references on Willard thrust sheet). On Durst Mountain, a basal recessive interval that is likely the Cottonwood Canyon Member of Lodgepole Limestone and the underlying Leatham Formation (Devonian) is not consistently mapped in the Lodgepole or underlying Beirdneau Formations (Coogan and others, 2015). The Leatham Formation, likely including the Cottonwood Canyon Member, is also exposed in the Crawford Mountains, west of the Crawford thrust and north of the map area (see descriptions in Sando and others, 1959; Sandburg and Gutchick, 1979; Ott, 1980).

***Db** – Beirdneau Sandstone (Devonian)*. Tan, reddish-tan, and yellowish-gray, calcareous to dolomitic sandstone, siltstone, some sandy dolomite and limestone, and lesser intraformational conglomerate; less resistant than adjacent units; brownish-gray dolomite resembling Hyrum Dolomite in middle part; about 200 to 300 feet (60-90 m) thick in Howard Hollow and on Durst Mountain (Coogan, 2006b; Coogan and King, 2006). Beirdneau-Hyrum contact may not be consistently mapped on Durst Mountain (Coogan and others, 2015).

The Beirdneau is typically called Three Forks Formation (Dtf) (Wyoming terminology) in subsurface. In the Birch Creek fold belt, Coogan (1992a, figure 33) showed an upper Darby about 400 feet (120 m) thick with a log signature like the Beirdneau/Three Forks, while the Sohio Birch Creek, Sohio Sugarloaf, Marathon Hawk Springs, and American Quasar Putnam wells apparently penetrated about 400 to 500 feet (120-150 m) of Three Forks (API 43-033-30042, 43-033-30043, 43-033-30028, and 43-033-30002, respectively, Utah DOGM well files). The Beirdneau is about 300 or 400 feet (90 or 120 m) thick in the American Quasar Hoffman well near Randolph, Utah (after API 43-033-30001, Utah DOGM and AMSTRAT log D-4528, respectively). To the south in the map area in the Amoco Deseret WIU well about 485 feet (148 m) of Beirdneau was cut (King after AMSTRAT log D-4948, API 43-029-30009) and 460 feet (140 m) was reportedly penetrated in Champlin 432-Amoco C well in the Peck Canyon quadrangle (API 043-29-30011, Utah DOGM well file).

***Dh** – Hyrum Dolomite (Upper and Middle Devonian)*. Dark- to medium-brownish-gray dolomite; weathers distinctive, chocolate-brown color and is typically more resistant than silty and sandy overlying Beirdneau and underlying Water Canyon Formations; estimate 0 to 675 feet (0-205 m) thick and absent in northwest part of our map area. This unit is "lower" Jefferson member of some previous workers.

In the Ogden map area, the Hyrum is thickest on the leading edge of the Willard thrust sheet, 500 to 675 feet (150 to 205 m) thick in the Horse and Dairy Ridge quadrangles (Coogan, 2006a-b) and is thicker yet north of our map area, for example 930 to 980 feet (280-300 m) thick along the Blacksmith Fork River (after Mullens and Izett, 1964; Eliason, 1969; Williams, 1971). The Hyrum is thinnest in the Mantua quadrangle and directly to the north (0 to 400 feet [0-120 m] thick) (King). The Hyrum is about 400 feet (120 m) thick near Causey Dam and in the Monte Cristo Peak area (King), with 400 to 435-foot (120-133 m) thicknesses reported near Causey Dam (Jefferson of Laraway, 1958). Hyrum strata are eroded in the Sharp Mountain area (Hafen, 1961) and covered in the James Peak quadrangle, so the thickness indeterminate. The Hyrum seems to thin to the south and west over Stansbury uplift (compare to Rigby, 1959).

A Middle Devonian age was assigned to the Hyrum based on fossils from the base (and possibly middle portion) of the formation in the Wellsville Mountains, Bear River Range, and West Hills in northern Utah (Williams, 1971; Oviatt, 1986). Fossils collected from the Hyrum a few miles north of the Paradise quadrangle, north of the Ogden map area (Williams, 1948, p. 1140) indicate a probable early Late Devonian age.

***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.

Cm, Cm? *– Maxfield Limestone (Middle Cambrian)*. From top down includes dolomite, limestone, argillaceous to silty limestone and calcareous siltstone and argillite, and basal limestone with argillaceous interval (see Yonkee and Lowe, 2004; King and others, 2008 for more member details); members mappable at 1:24,000 scale, but like Ophir Formation thicknesses highly variable due to deformation; total thickness about 600 to 900 feet (180-270 m) (King and others, 2008).

According to Yonkee and Lowe (2004), the Bathyuriscus sp., Elrathina sp., Peronopsis sp., and Ptychagnostus sp. trilobite fossils reported by Rigo (1968, USGS No. 5948-CO in the middle limestone of the Ophir Shale) in Ogden Canyon are in the basal limestone member of the Maxfield. Elrathia can be used as a proxy for the Middle Cambrian Bolaspidella zone (see Robison, 1976, figure 4) and this zone is in the Bloomington Formation shales on the Willard thrust sheet (see Oviatt, 1986; Jensen and King, 1996, table 2). This supports the Maxfield Limestone as partly equivalent to the Bloomington Formation, but leaves the Blacksmith Dolomite without an equivalent carbonate unit below the Willard thrust sheet. However, Rigo (1968) did not provide a usable sample location and the sample location is not on the map of Crittenden and Sorensen (1985b).

Co, Co? *– Ophir Formation (Middle Cambrian)*. Upper and lower brown-weathering, slope-forming, gray to olive-gray, variably calcareous and micaceous to silty argillite to slate with intercalated gray, silty limestone beds; middle ledge-forming, gray limestone; total thickness about 450 to 650 feet (140-200 m) (Sorensen and Crittenden, 1972) where likely less deformed, but highly deformed in most outcrops.

Rigo (1968, USGS No. 5947-CO) reported Ehmaniella sp., Alokistocare sp., and Zacanthoides sp. Trilobites from the lower member indicating an early Middle Cambrian age. These trilobites may be in the upper and, possibly, lower Ute Formation on the Willard thrust sheet (see unit Cu), leaving the Langston Formation and possibly the lower Ute Formation without lithologically equivalent strata below the Willard thrust sheet. The Ophir Formation is only subdivided north of Ogden Canyon to show structure.

Citations, tables, and figures in the above descriptions are not provided herein, but are in Coogan and King (2016). Descriptions of other units on Figure 2 that are not provided above are also available in Coogan and King (2016).

5.3 Seismic Hazards

5.3.1 Strong Ground Motions

Strong ground motion is likely to present a significant risk during moderate to large earthquakes located within a 60-mile radius of the Project area (Boore and others, 1993). Seismic sources include mapped active faults, as well as a random or “floating” earthquake source on faults not evident at the surface. The Utah Geological Survey Quaternary Fault Database (Black and others, 2003; 2020 update) shows numerous class A faults within 60 miles of the Project that may pose potential seismic sources. Strong ground motions originating from the Wasatch fault or other near-by seismic sources are capable of impacting the site. The Wasatch fault zone is considered active and capable of generating earthquakes as large as magnitude 7.3 (Arabasz and others, 1992).

5.3.2 Site Class

Utah has adopted the International Building Code (IBC) 2021. IBC 2021 determines the seismic hazard for a site based upon 2014 mapping of bedrock accelerations prepared by the USGS and the soil site class. The USGS values are presented on maps incorporated into the IBC code and are also available based on latitude and longitude coordinates (grid points). For site class definitions, IBC 2021 (Section 1613.3.2) refers to Chapter 20, Site Classification Procedure for Seismic Design, of ASCE[4] 7. This paragraph does not say what the site class is?

5.3.3 Seismic Design Category

The 2014 USGS mapping utilized by the IBC provides values of peak ground, short period and long period accelerations for the Site Class B/C boundary and the Maximum Considered Earthquake (MCE). This Site Class B boundary represents average bedrock values for the Western United States and must be corrected for local soil conditions. The Seismic Design Categories in the International Residential Code (IRC 2018 Table R301.2.2.1.1) are based upon the Site Class as addressed in the previous section. For Site Class D (Default) at grid coordinates of 41.202443 degrees north latitude and -111.698732 degrees west longitude, S_{DS} is 0.588 and the Seismic Design Category is null (see ASCE 7-16 Section 11.4.8). Site-modified peak ground acceleration (PGA_M) for the Project is 0.404 g, which is about 80 times the peak ground acceleration (0.005 g) reported in Ogden Valley from the March 18, 2020 M 5.7 Magna earthquake (**Section 5.1**).

5.3.4 Surface Faulting

Movement along faults at depth generates earthquakes. During earthquakes larger than Richter magnitude 6.5, ruptures along normal faults in the intermountain region generally propagate to the surface (Smith and Arabasz, 1991) as one side of the fault is uplifted and the other side down dropped. The resulting fault scarp has a near-vertical slope. The surface rupture may be expressed as a large singular rupture or several smaller ruptures in a broad zone. Ground displacement from surface fault rupture can cause significant damage or even collapse to structures located on an active fault.

No evidence of active faulting is mapped or was evident in the study area. The nearest active (Holocene-age) fault to the study area is the Weber segment of the Wasatch fault zone about 11.2 miles to the west. Surface faulting is not therefore considered to pose a risk to the Project.

5.3.5 Liquefaction

Liquefaction is a phenomenon whereby loose, saturated, granular soil units lose a significant portion of their shear strength due to excess pore water pressure buildup resulting from dynamic loading, such as that caused by an earthquake. Among other effects, liquefaction can result in densification of such deposits causing settlements of overlying layers after an earthquake as excess pore water pressures are dissipated. Horizontally continuous liquefied layers may also have a potential to spread laterally where sufficient slope or free-face

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[4] American Society of Civil Engineers

conditions exist. The primary factors affecting liquefaction potential of a soil deposit are: (1) magnitude and duration of seismic ground motions; (2) soil type and consistency; and (3) occurrence and depth to groundwater.

Liquefaction potential has not been studied or mapped for the Project area. Subsurface soils encountered consisted of clay with plasticity indices greater than 12 (typically considered not liquefiable). In our opinion, the soils we encountered suggest the risk from liquefaction to the proposed development is low.

Based on an onsite water well, groundwater in the study area is 30 to 50 feet deep.

5.3.6 Tectonic Subsidence

Subsidence may occur from warping, lowering, and tilting of a valley floor in conjunction with large-magnitude, surface-faulting earthquakes. Tectonic subsidence mainly impacts areas adjacent to and in close proximity to the downthrown side of normal faults (Lund, 1990). The study area is not located adjacent to or near any active earthquake faults and tectonic subsidence is not therefore considered to pose a risk to the proposed development.

5.4 Landslide and Slump Deposits

Landslides, slumps, and other mass movements are gravity-induced downslope movements of rock or soil. Such failures may be both deep and shallow seated. Deep-seated failures include rotational and translational slides and associated earthflows where the failure plane is more than 10 feet deep (Varnes, 1978; Cruden and Varnes, 1996). Landslides can develop in moderate to steep slopes where a slope has been disturbed, the head of a slope loaded, or where increased groundwater pore pressures result in driving forces within the slope exceeding restraining forces.

Mass wasting colluvium from shallow slumps and/or slope wash is mapped in the study area southeast and northwest of the proposed home (**Figure 6**), but no evidence for landsliding or recent or ongoing slope instability was observed in the area of the proposed home. Slope stability is discussed in **Section 6.0**.

5.5 Other Geologic Hazards

Other potential geologic hazards at the Project are addressed in the following subsections.

5.5.1 Sloping Surfaces

The proposed home is situated on a ridge that trends northeastward from the canyon mouth and dips at an overall gradient of about 11 percent (or about 9:1 horizontal:vertical, H:V). Moderate to steep slopes bound the ridge on the west and east that show gradients between 15 to 25 percent (shaded in yellow and red on **Figure 5**). Steepest slopes at the property are associated with the mountain front further south, but the current proposed development is about 300 feet northeast of the base of these slopes.

5.5.2 Alluvial Fan Flooding

Alluvial-fan flooding refers to a continuum of processes that includes debris slides, debris flows, debris floods, and flash flooding on alluvial fans (National Research Council, 1996). Debris flows and related sediment-enriched floods and flows are fast moving flow-type landslides comprised of a slurry of rock, mud, organic matter, and water that move down drainage-basin channels onto alluvial fans. Debris flow hazards are commonly associated with areas underlain by Holocene alluvial-fan deposits at the mouths of range-front drainages, such as those along the Wasatch Range. Evaluation of the need for mitigation of alluvial-fan flooding is a planning decision that weighs the existing and future hazard potential against what will be at risk and level of exposure. Both active and passive measures are typically employed to mitigate risk. Active measures (such as debris basins) are considered optimal to attenuate flows, but such strategies are typically deployed to protect subdivision-scale developments and are not always feasible. Passive measures (such as berms and routing channels) may be deployed for smaller-scale developments, but are not always effective and tend to increase risk to adjacent properties.

Parts of the study area are on a mapped alluvial fan on **Figure 6**. The distal portion of the alluvial fan (furthest from the canyon mouth) is eroded and subdued. Air photo evidence and the degree of soil development in the test pit exposures suggest this part of the fan is older than or contemporaneous with when Lake Bonneville occupied Ogden Valley about 18,000 years ago (unit Qafo, **Figures 3 through 6**). Environmental conditions during the Bonneville Lake cycle were wetter than presently. The proximal portion of the alluvial fan (closest to the canyon mouth) is upslope of the proposed home to the southwest. This portion shows vegetation and surficial geomorphology suggestive of younger deposition (unit Qafy, **Figures 3 through 6**). The drainage basin for the unnamed canyon south of the study area is relatively small (53.09 acres, **Figure 1**) and the canyon bottom is broad with an indistinct drainage channel (**Figure 5**). Bedrock in the drainage basin is mapped as Mississippian Lodgepole Limestone (**Figures 2 and 6**). No coarse deposits or buried paleosols suggestive of geologically recent debris flow deposition were exposed in the test pits at the Project (**Figures 7A-D**), and no surficial evidence for characteristic debris flow morphology (such as debris levees) was observed in the area of the proposed home.

Given all the above, debris flows and floods are not considered to pose a risk to the current proposed development. However, the risk from debris flows and floods will increase in the younger part of the alluvial fan further southwest. Additional subsurface exploration and a detailed debris flow hazard evaluation may be necessary if structures will be developed upslope (west) of our test pit TP-1 on the younger fan portion (unit Qafy) on **Figures 3 through 6**.

5.5.3 Stream Flooding Hazards

A small seasonal drainage flows in the bottom of the unnamed canyon south of the study area that has an indistinct channel based on LIDAR topography. The channel extends only a short distance from the canyon mouth before disappearing. A small seasonal drainage also flows along the eastern base of the ridge on which the proposed home is situated toward Sheep Herd Creek. This drainage heads at what appears to be a small, seasonal pond (**Figure 4**). No active drainages were observed crossing the study area and Federal Emergency Management Agency flood insurance rate mapping (Map Number 49057C0500F, effective 6/2/2015) shows the study area is in Zone X (Area of Minimal Flood Hazard).

Given the above, stream flooding is not considered to pose a risk to the proposed development. However, it is possible that the western part of the proposed home, which is in the broad swale west of the ridge top, could be impacted by muddy water from a future upslope debris flow as it dewaters. The site grading and drainage plan should ensure potential flooding in the swale is directed away from the home. Site hydrology and drainage should be addressed in the civil engineering design for the development in accordance with all applicable local government development guidelines. Care should be taken that proper surface drainage is maintained and that water is minimized in steep slope areas.

5.5.4 Rockfall Hazards

The Project is not located on or adjacent to steep slopes with bedrock source areas where rockfalls may originate. Given this, rockfalls are not considered to pose a risk to the proposed development.

6.0 SLOPE STABILITY

6.1 Input Parameters

The properties of the natural soils encountered in the test pits were estimated using laboratory testing, published correlations[5], and our experience with similar soils. Accordingly, the following parameters were used in the stability analyses:

Material	Internal Friction Angle (degrees)	Apparent Cohesion (psf)	Unit Weight (pcf)
Pleistocene alluvium	23.7	410	115
Tertiary fanglomerate	34**	150**	125**

** Estimated based on our experience with similar soils

The stability analyses provided are based on **Figures 8A, Cross Section A-A’** and **Figure 8B, Cross Section B-B’** and represent the existing slope conditions and do not include any future grading. No grading plans were provided. CMT must review future grading plans.

The pseudostatic coefficient for the seismic analyses was obtained by taking half of the modified peak ground acceleration (0.404g) queried for the site which resulted in a value of 0.202g.

6.2 Stability Analyses

We evaluated the global stability of the cross-sections A-A’ and B-B’ located as shown on **Figures 4**. The analysis was completed using the computer program *SLIDE* version 7.0. This program uses a limit equilibrium (Simplified Bishop) method for calculating factors of safety against sliding on an assumed failure surface and evaluates

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[5] U.S. Bureau of Reclamation, 1987, “Design Standards No. 13, Embankment Dams,” Denver, Colorado.

numerous potential failure surfaces, with the most critical failure surface identified as the one yielding the lowest factor of safety of those evaluated. Typically, the required minimum factors of safety are 1.5 for static conditions and 1.0 for seismic (pseudostatic) conditions.

A projected water (phreatic) surface was incorporated in the model approximately 50 feet below the ground surface based on nearby water well.

Typically, the required minimum factors of safety are 1.5 for static conditions and 1.0 for seismic (pseudostatic) conditions. The results of our analyses utilizing the estimated soil properties described previously, provides suitable stability for static and seismic conditions through the lot. The results of these analyses are graphically shown on **Figures 14 through 17 Stability Results**, provided in the appendix, and are summarized in the following table.

Slope Cross Section	Condition	Seismic Coefficient	Lowest Factor of Safety (F.S.)	Minimum Allowable F.S.
A-A’	Static	---	2.265	1.5
A-A’	Seismic	0.202	2.033	1.0
B-B’	Static	---	2.168	1.5
B-B”	Seismic	0.202	1.853	1.0

Slope movements or even failure can occur if the slope soils are undermined or become saturated. Any planned retaining walls must be properly engineered, including stability analyses. Proposed grading at the site must be reviewed by CMT prior to initiation of any construction in order to assess if our findings and recommendations remain applicable. Following grading at the site, we recommend the slope surface must be re-vegetated as soon as possible to limit erosion.

6.3 Site Drainage and Irrigation

Proper site drainage is important to maintaining slope stability at the site. The surface of the site should be graded to prevent the accumulation or ponding of surface water at the site. It is anticipated that little to no landscape watering will occur. Landscaping if/as incorporated at the site should be planned to utilize native, drought resistant plants that require minimal watering for establishment only.

7.0 SITE PREPARATION AND GRADING

7.1 General

Initial site preparation shall consist of the removal of surface vegetation, topsoil, any other deleterious materials, and loose/disturbed surface soils from beneath structures, pavements and exterior flatwork areas. Based upon the conditions observed in the test pits there is topsoil on the surface of the site which we estimated to be about 1 to 1.5 feet in thickness. When stripping and grubbing, topsoil should be distinguished by the apparent organic content and not solely by color; thus we estimate that topsoil stripping will need to include the upper about 8 to 12 inches.

Subsequent to stripping and subgrade preparation activities and prior to the placement of floor slabs, foundations, structural site grading fills, and exterior flatwork the exposed subgrade must be proof rolled by passing moderate-weight rubber tire-mounted construction equipment over the surface at least twice.

If excessively soft or otherwise unsuitable soils are encountered beneath footings, they must be completely removed. If removal depth required is greater than 2 feet below footings, CMT must be notified to provide further recommendations. In pavement, floor slab, and outside flatwork areas, excessively soft soils should be removed to a maximum depth of 2 feet and replaced with compacted granular structural fill.

The site should be examined by a CMT geotechnical engineer to assess that suitable natural soils have been exposed and/or properly prepared and that any deleterious materials, loose and/or disturbed soils have been removed, prior to placing site grading fills, footings, slabs, and pavements.

Fill placed over large areas to raise overall site grades can induce settlements in the underlying natural soils. If more than 4 feet of site grading fill is anticipated over the natural ground surface, we should be notified to assess potential settlements and provide additional recommendations as needed. These recommendations may include placement of the site grading fill far in advance to allow potential settlements to occur prior to construction or the monitoring of settlement following placement.

7.2 Temporary Excavations

Excavations deeper than 10 feet are not anticipated at the site. Groundwater was not encountered within the depths explored, about 7.5 to 8.5 feet at the time of our field explorations and is anticipated to be at a depth of about 30 to 50 feet based on an onsite well. Thus groundwater is not anticipated to affect excavations.

The natural soils encountered at this site consisted of clay. In clayey (cohesive) soils, temporary construction excavations not exceeding 4 feet in depth may be constructed with near-vertical side slopes. Temporary excavations up to 10 feet deep, above or below groundwater, may be constructed with side slopes no steeper than three-quarter horizontal to one vertical (0.75H:1V).

All excavations must be inspected periodically by qualified personnel. If any signs of instability or excessive sloughing are noted, immediate remedial action must be initiated. All excavations should be made following OSHA safety guidelines.

7.3 Fill Material

Structural fill is defined as all fill which will ultimately be subjected to structural loadings, such as imposed by footings, floor slabs, pavements, etc. Structural fill will be required as backfill over foundations and utilities, as site grading fill, and potentially as replacement fill below structures. All structural fill must be free of sod, rubbish, topsoil, frozen soil, and other deleterious materials.

Following are our recommendations for the various fill types we anticipate will be used at this site:

Fill Material Type	Description/Recommended Specification
Select Structural Fill	Placed below structures, flatwork and pavement. Imported structural fill should consist of well-graded sand/gravel mixture, with maximum particle size of 4 inches, a minimum 70% passing 3/4-inch sieve, a maximum 20% passing the No. 200 sieve, and a maximum Plasticity Index of 10.
Site Grading Fill	Placed over larger areas to raise the site grade. Sandy to gravelly soil, with a maximum particle size of 6 inches, a minimum 70% passing 3/4-inch sieve, and a maximum 40% passing No. 200 sieve.
Non-Structural Fill	Placed below non-structural areas, such as landscaping. On-site soils or imported soils, with a maximum particle size of 8 inches, including silt/clay soils not containing excessive amounts of degradable/organic material.
Stabilization Fill	Placed to stabilize soft areas prior to placing structural fill and/or site grading fill. Coarse angular gravels and cobbles 1 inch to 8 inches in size. May also use 1.5- to 2.0-inch gravel placed on stabilization fabric, such as Mirafi RS280i, or equivalent (see **Section 6.6**).

On-site soils may be reutilized as site grading fill if proper compaction can be achieved. However, please note that fine-grained soils are inherently more difficult to rework, are sensitive to changes in moisture content, and will require very close moisture control during placement and compaction. In addition, smaller lift placement and moderate to high compaction effort will be likely for fine grained soils. This will be very difficult, if not impossible, during wet and cold periods of the year and may not be economical for use as structural site grading fill but may more appropriately re-utilized in land scaped/non-structural areas.

All fill material should be approved by a CMT geotechnical engineer prior to placement.

7.4 Fill Placement and Compaction

The various types of compaction equipment available have their limitations as to the maximum lift thickness that can be compacted. For example, hand operated equipment is limited to lifts of about 4 inches and most “trench compactors” have a maximum, consistent compaction depth of about 6 inches. Large rollers, depending on soil and moisture conditions, can achieve compaction at 8 to 12 inches. The full thickness of each lift should be compacted to at least the following percentages of the maximum dry density as determined by ASTM D-1557 (or AASHTO[6] T-180) in accordance with the following recommendations:

Location	Total Fill Thickness (feet)	Minimum Percentage of Maximum Dry Density
Beneath an area extending at least 4 feet beyond the perimeter of structures, and below flatwork and pavement (applies to structural fill and site grading fill)	0 to 5 5 to 10	95 98
Site grading fill outside area defined above	0 to 5	92

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[6] American Association of State Highway and Transportation Officials

Location	Total Fill Thickness (feet)	Minimum Percentage of Maximum Dry Density
	5 to 10	95
Utility trenches within structural areas	--	96
In-situ Fill/replacement fill preparation below pavement areas	12 inches	95
Roadbase and subbase	-	96
Non-structural fill	0 to 5 5 to 10	90 92

Structural fills, including utility backfill, greater than 10 feet thick are not anticipated at the site. For best compaction results, we recommend that the moisture content for structural fill/backfill be within 2% of optimum. Field density tests should be performed on each lift as necessary to verify that proper compaction is being achieved.

7.5 Utility Trenches

For the bedding zone around the utility, we recommend utilizing sand bedding fill material that meets current APWA[7] requirements.

All utility trench backfill material below structurally loaded facilities (foundations, floor slabs, flatwork, parking lots/drive areas, etc.) should be placed at the same density requirements established for structural fill in the previous section.

Most utility companies and local governments are requiring Type A-1a or A-1b (AASHTO Designation) soils (sand/gravel soils with limited fines) be used as backfill over utilities within public rights of way, and the backfill be compacted over the full depth above the bedding zone to at least 96% of the maximum dry density as determined by AASHTO T-180 (ASTM D-1557).

Where the utility does not underlie structurally loaded facilities and public rights of way, natural soils may be utilized as trench backfill above the bedding layer, provided they are properly moisture conditioned and compacted to the minimum requirements stated above in **Section 6.4**.

7.6 Stabilization

To stabilize soft subgrade conditions (if encountered), a mixture of coarse, clean, angular gravels and cobbles and/or 1.5- to 2.0-inch clean gravel should be utilized, as indicated above in **Section 6.3**. This coarse material may be placed and worked into the soft soils until firm and non-yielding or the soft soils removed an additional, minimum of 18 inches, and backfilled with the clean stabilizing fill. A test area should be implemented to achieve a proper stabilization strategy. Often the amount of gravelly material can be reduced with the use of a geotextile

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[7] American Public Works Association

fabric such as Mirafi RS280i or equivalent. Its use will also help avoid mixing of the subgrade soils with the gravelly material. After excavating the soft/disturbed soils, the fabric should be spread across the bottom of the excavation and up the sides a minimum of 18 inches. Otherwise, it should be placed in accordance with the manufacturer's recommendation, including proper overlaps. The gravel material can then be placed over the fabric in compacted lifts as described above.

8.0 FOUNDATION RECOMMENDATIONS

The following recommendations have been developed on the basis of the previously described Project characteristics, including the maximum loads discussed in **Section 1.3**, the subsurface conditions observed in the field and the laboratory test data, and standard geotechnical engineering practice.

8.1 Foundation Recommendations

Based on our geotechnical engineering analyses, the proposed residence may be supported upon conventional spread and/or continuous wall foundations placed on suitable, undisturbed natural soils and/or on structural fill extending to suitable natural soils. Footings may then be designed using a net bearing pressure of 2,000 psf. The term "net bearing pressure" refers to the pressure imposed by the portion of the structure located above lowest adjacent final grade, thus the weight of the footing and backfill to lowest adjacent final grade need not be considered. The allowable bearing pressure may be increased by 1/2 for temporary loads such as wind and seismic forces.

We also recommend the following:

1. Exterior footings subject to frost should be placed at least 36 inches below final grade.
2. Interior footings not subject to frost should be placed at least 16 inches below grade.
3. Continuous footing widths should be maintained at a minimum of 18 inches.
4. Spot footings should be a minimum of 24 inches wide.

8.2 Installation

Under no circumstances shall the footings be established upon non-engineered fills, loose or disturbed soils, rubbish, construction debris, other deleterious materials, frozen soils, or within ponded water. If unsuitable soils are encountered, they must be completely removed and replaced with compacted structural fill.

Excavation bottoms should be examined by a geotechnical engineer from CMT to confirm that suitable bearing soils have been exposed **prior to placement of select structural fill and/or foundations**.
All structural fill should meet the requirements for such, and should be placed and compacted in accordance with **Section 6** above. The width of structural replacement fill below footings should be equal to the width of the footing plus 1 foot for each foot of fill thickness. For instance, if the footing width is 2 feet and the structural fill depth beneath the footing is 2 feet, the fill replacement width should be 4 feet, centered beneath the footing.

8.3 Estimated Settlement

Foundations designed and constructed in accordance with our recommendations could experience some settlement, but we anticipate that total settlements of footings founded as recommended above will not exceed 1 inch, with differential settlements on the order of 0.5 inches over a distance of 25 feet. We expect approximately 50% of the total settlement to initially take place during construction.

8.4 Lateral Resistance

Lateral loads imposed upon foundations due to wind or seismic forces may be resisted by the development of passive earth pressures and friction between the base of the footings and the supporting soils. In determining frictional resistance, a coefficient of 0.30 for natural clayey soils, or 0.40 for select structural fill may be utilized for design. Passive resistance provided by properly placed and compacted natural soil above the water table may be considered equivalent to a fluid with a density of 275 pcf. A combination of passive earth resistance and friction may be utilized if the passive component of the total is divided by 1.5.

9.0 LATERAL EARTH PRESSURES

We anticipate that below-grade walls up to 10 feet high might be constructed at this site. The lateral earth pressure values given below are for a backfill material that will consist of drained natural soils, clean of debris or deleterious materials, placed and compacted in accordance with the recommendations presented herein.

The lateral pressures imposed upon subgrade facilities will depend upon the relative rigidity and movement of the backfilled structure. Following are the recommended lateral pressure values, which also assume that the soil surface behind the wall is horizontal and that the backfill within 3 feet of the wall will be compacted with hand-operated compacting equipment.

CONDITION	STATIC (psf/ft)*	SEISMIC (psf)*
Active Pressure (wall is allowed to yield, i.e. move away from the soil, with a minimum 0.001H movement/rotation at the top of the wall, where "H" is the total height of the wall)	53	22
At-Rest Pressure (wall is not allowed to yield)	74	N/A
Passive Pressure (wall moves into the soil)	275	75

*Equivalent Fluid Pressure (applied at 1/3 Height of Wall)
*Equivalent Fluid Pressure (added to static and applied at 1/3 Height of Wall)

10.0 FLOOR SLABS

Floor slabs may be established upon suitable, undisturbed, natural soils, structural fill extending to suitable natural soils or properly prepared fills as outlined in section **6.0 Site Preparation** above. Under no circumstances shall floor slabs be established directly on any topsoil, loose or disturbed soils, sod, rubbish, construction debris, other deleterious materials, frozen soils, or within ponded water.

In order to facilitate curing of the concrete, we recommend that floor slabs be directly underlain by at least 4 inches of “roadbase/clean structural fill”. To help control normal shrinkage and stress cracking, the floor slabs may include the following features:

1. Adequate reinforcement for the anticipated floor loads
2. Frequent crack control joints; and
3. Non-rigid attachment of the slabs to foundation walls and bearing slabs.

11.0 DRAINAGE RECOMMENDATIONS

It is important to the long-term performance of foundations and floor slabs that water not be allowed to collect near the foundation walls and infiltrate into the underlying soils. We recommend the following:

1. All areas around structures should be sloped to provide drainage away from the foundations. Where possible we recommend a minimum slope of 4 inches in the first 10 feet away from the structure.

2. All roof drainage should be collected in rain gutters with downspouts designed to discharge at least 10 feet from the foundation walls or well beyond the backfill limits, whichever is greater.

3. Adequate compaction of the foundation backfill should be provided. We suggest a minimum of 90% of the maximum laboratory density as determined by ASTM D-1557. Water consolidation methods should not be used under any circumstances.

4. Landscape sprinklers should be aimed away from the foundation walls. The sprinkling systems should be designed with proper drainage and be well-maintained. Over watering should be avoided.

5. Other precautions may become evident during construction.

12.0 QUALITY CONTROL

We recommend that CMT be retained to as part of a comprehensive quality control testing and observation program. With CMT onsite we can help facilitate implementation of our recommendations and address, in a timely manner, any subsurface conditions encountered which vary from those described in this report. Without such a program CMT cannot be responsible for application of our recommendations to subsurface conditions which may vary from those described herein. This program may include, but not necessarily be limited to, the following:

12.1 Field Observations

Observations should be completed during all phases of construction such as site preparation, foundation excavation, structural fill placement and concrete placement.

12.2 Fill Compaction

Compaction testing by CMT is required for all structural supporting fill materials. Maximum Dry Density (Modified Proctor, ASTM D-1557) tests should be requested by the contractor immediately after delivery of any fill materials. The maximum density information should then be used for field density tests on each lift as necessary to ensure that the required compaction is being achieved.

12.3 Excavations

All excavation procedures and processes should be observed by a geotechnical engineer from CMT or their representative. In addition, for the recommendations in this report to be valid, all backfill and structural fill placed in trenches and all pavements should be density tested by CMT. We recommend that freshly mixed concrete be tested by CMT in accordance with ASTM designations.

13.0 LIMITATIONS

The recommendations provided herein were developed by evaluating the information obtained from the subsurface explorations and soils encountered therein. The exploration logs reflect the subsurface conditions only at the specific location at the particular time designated on the logs. Soil and ground water conditions may differ from conditions encountered at the actual exploration locations. The nature and extent of any variation in the explorations may not become evident until during the course of construction. If variations do appear, it may become necessary to re-evaluate the recommendations of this report after we have observed the variation.

Our professional services have been performed, our findings obtained, and our recommendations prepared in accordance with generally accepted geotechnical engineering principles and practices. This warranty is in lieu of all other warranties, either expressed or implied.

We appreciate the opportunity to be of service to you on this project. If we can be of further assistance or if you have any questions regarding this project, please do not hesitate to contact us at (801) 590-0394. To schedule materials testing, please call (801) 381-5141.

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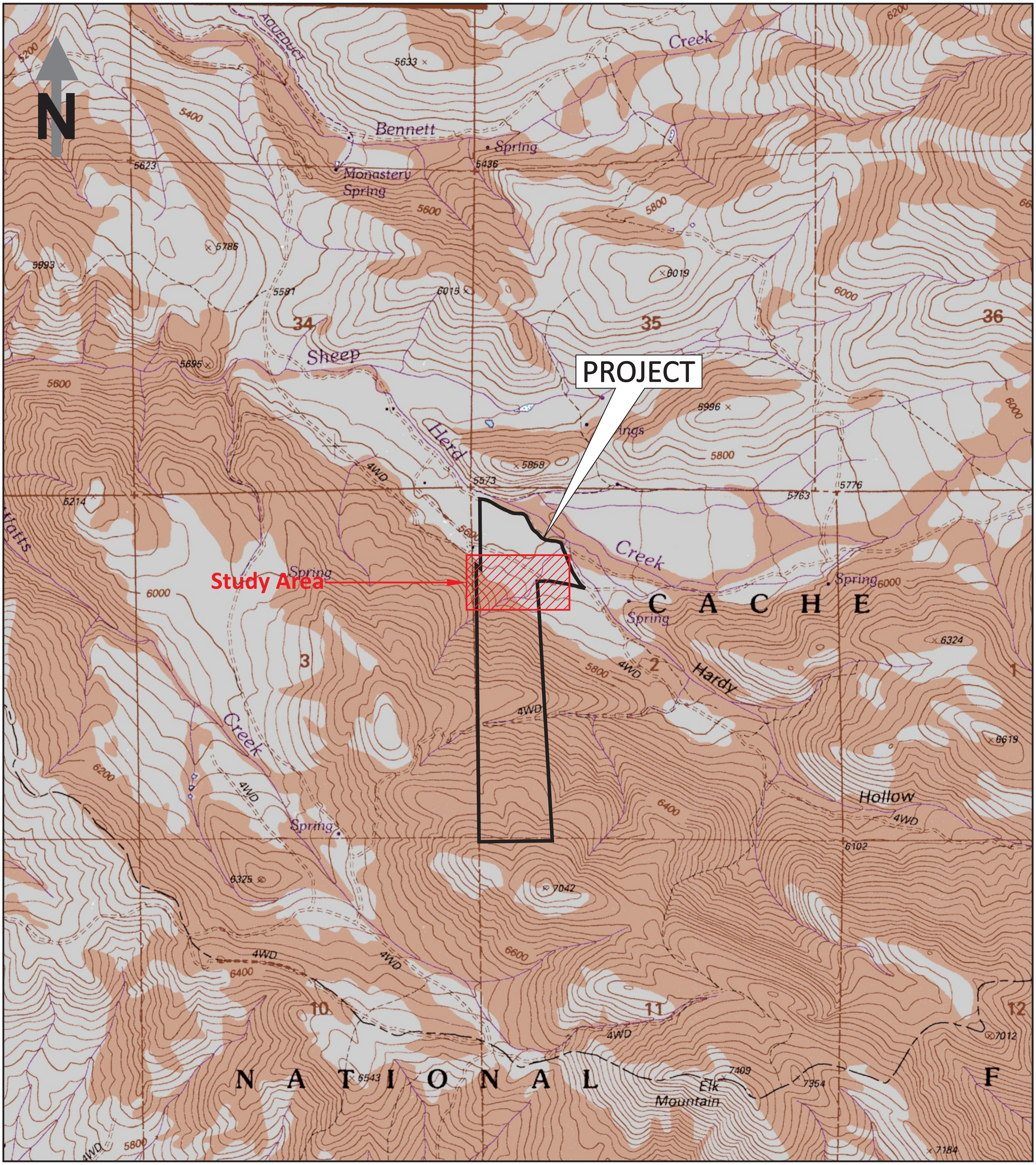
Zoback, M.L. and Zoback, M.D., 1989. Tectonic stress field of the conterminous United States: Boulder, Colorado, Geological Society of America Memoir, v. 172, p. 523-539.

APPENDIX

SUPPORTING
DOCUMENTATION



Base:
U.S.G.S. 7.5-Minute Series Topographic Map - Durst Mountain, 1998; Study area location NW1/4, Section 2, Township 5 North, Range 2 East (SLBM).

0 1000 ft 2000 ft

1:24,000 (1 inch equals 2000 feet)

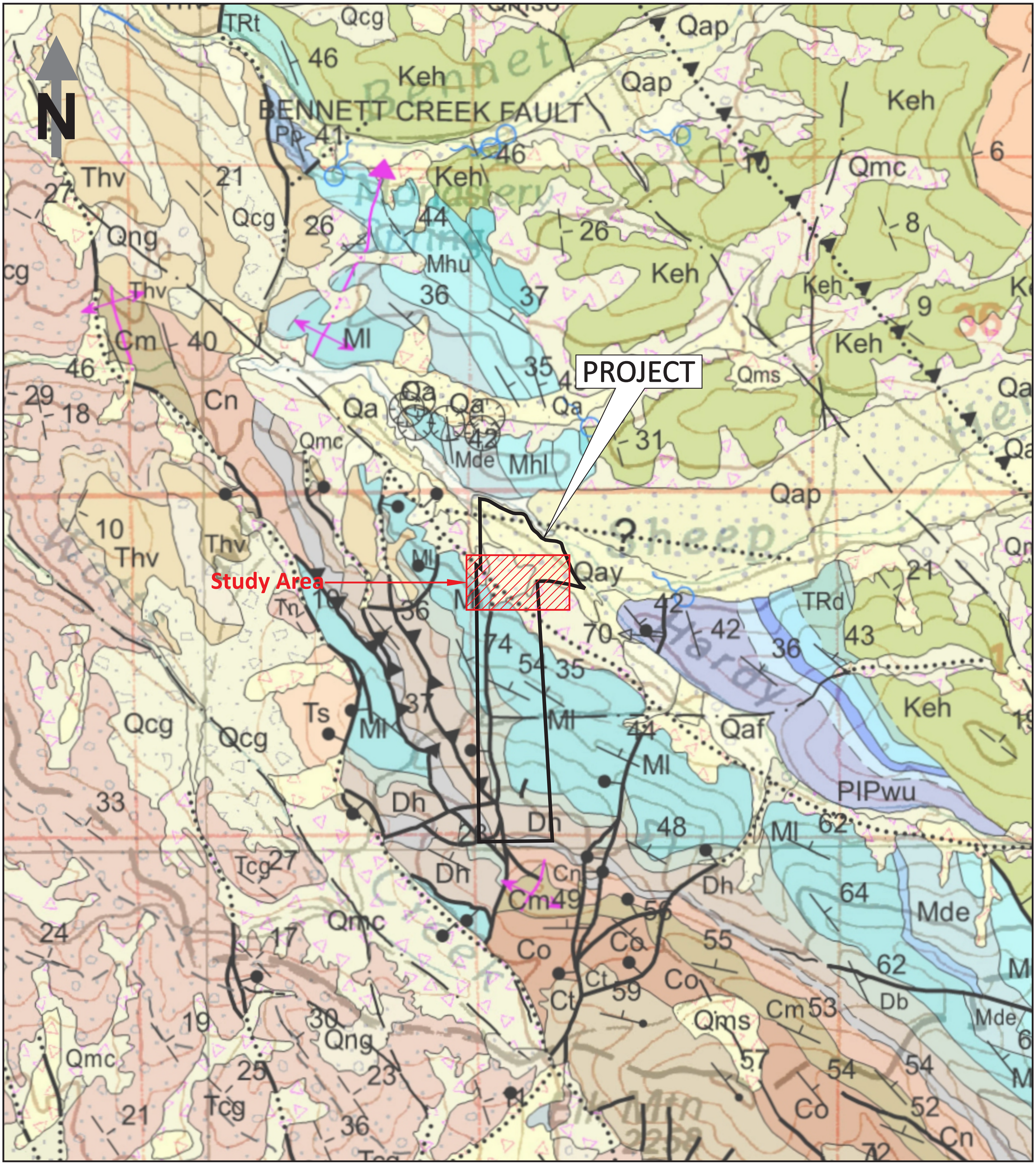
Proposed Three Branch Ranch Residence
About 1700 South 9500 East
Huntsville, Weber County, Utah

CMT TECHNICAL SERVICES

Vicinity Map

Date:	29-Jan-2024
Job #	21480

Figure
1



Base:
Coogan and King (2016). See report for descriptions of nearby surficial geologic units.

0 1000 ft 2000 ft

1:24,000 (1 inch equals 2000 feet)

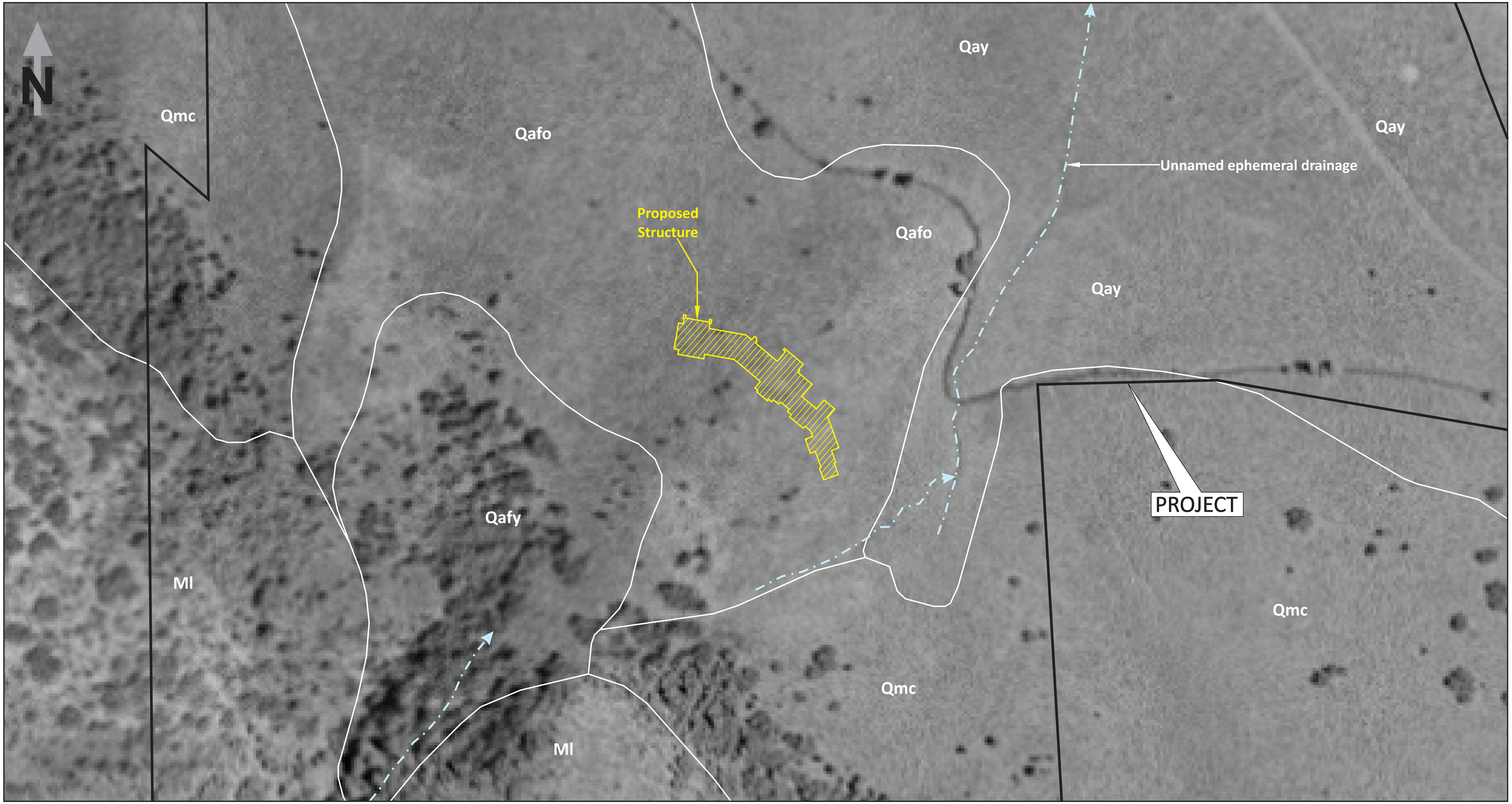
Proposed Three Branch Ranch Residence
About 1700 South 9500 East
Huntsville, Weber County, Utah

CMT TECHNICAL SERVICES

Geologic Map

Date:	29-Jan-2024
Job #	21480

Figure
2



Base:
U.S. Department of Agriculture frames 06-17 to 09-06 GIS-registered by and available from NETROnline.

0 100 ft 200 ft
1:1,200 (1 inch equals 100 feet)

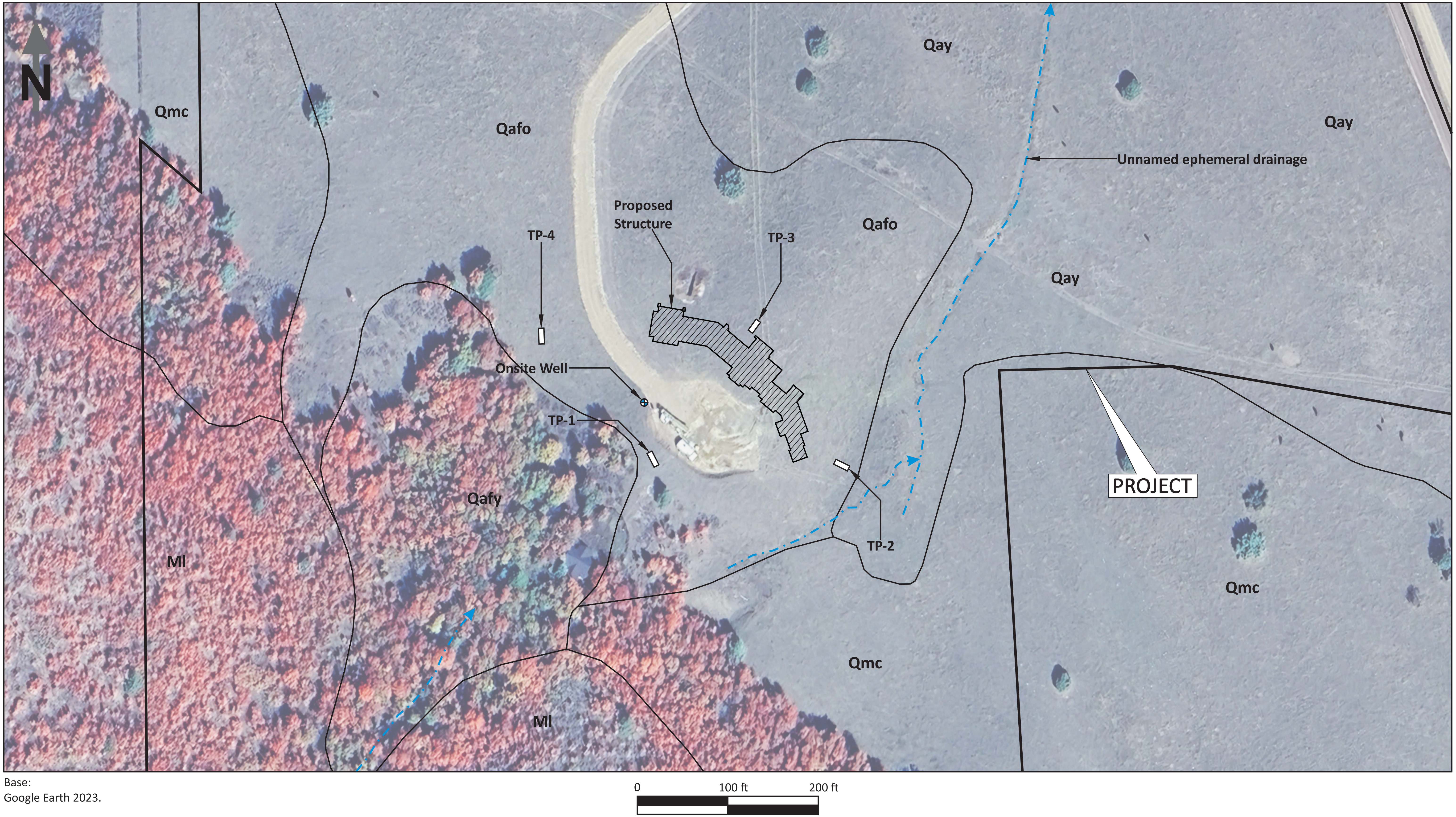
CMT TECHNICAL SERVICES

Proposed Three Branch Ranch Residence
About 1700 South 9500 East, Huntsville, Weber County, Utah

1958 Air Photo

Date:	29-Jan-2024
CMT No.:	21480

Figure
3



Base:
Google Earth 2023.

CMT TECHNICAL SERVICES

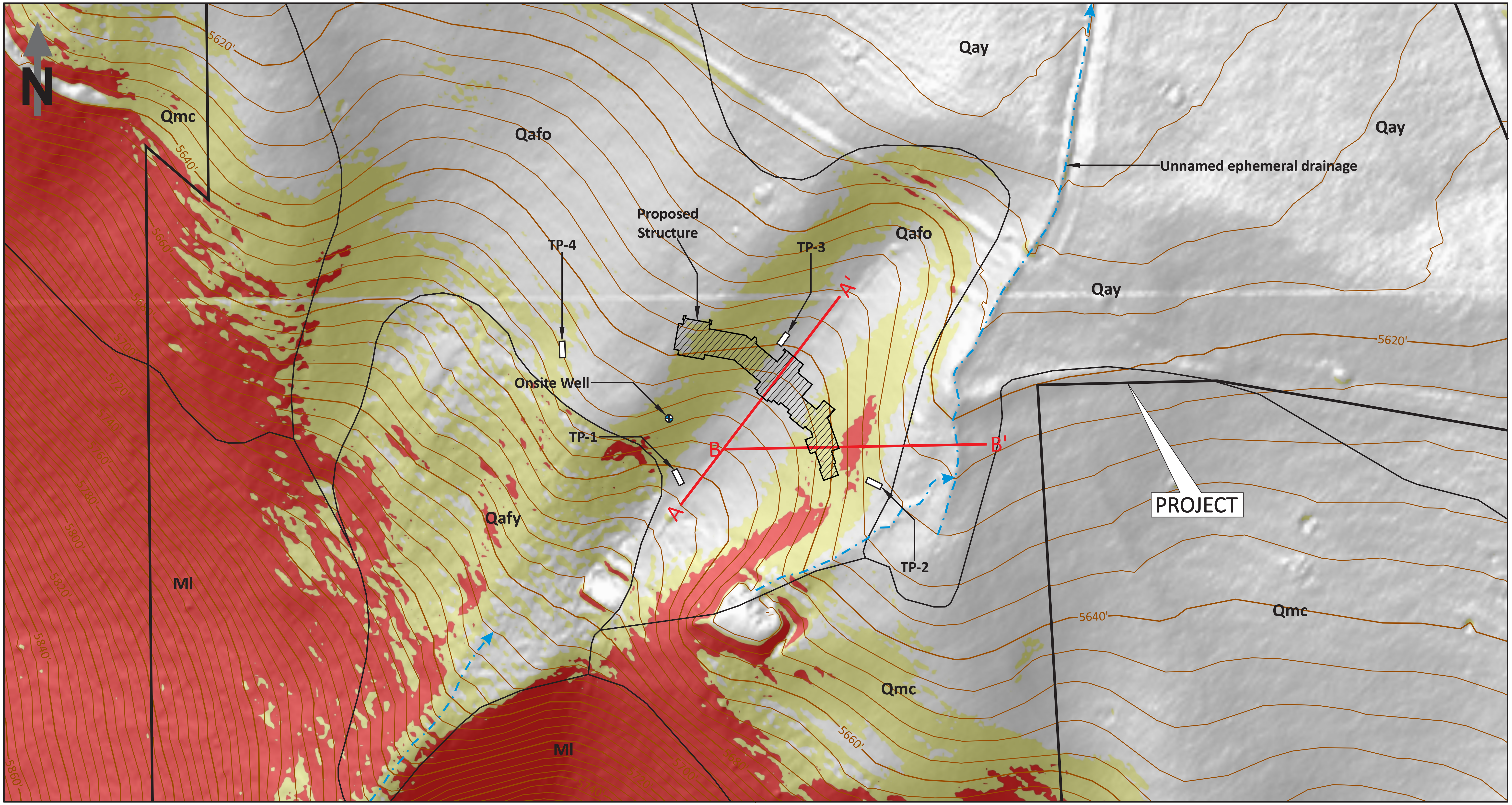
Proposed Three Branch Ranch Residence

About 1700 South 9500 East, Huntsville, Weber County, Utah

Site Evaluation

Date:	29-Jan-2024
CMT No.:	21480

Figure
4

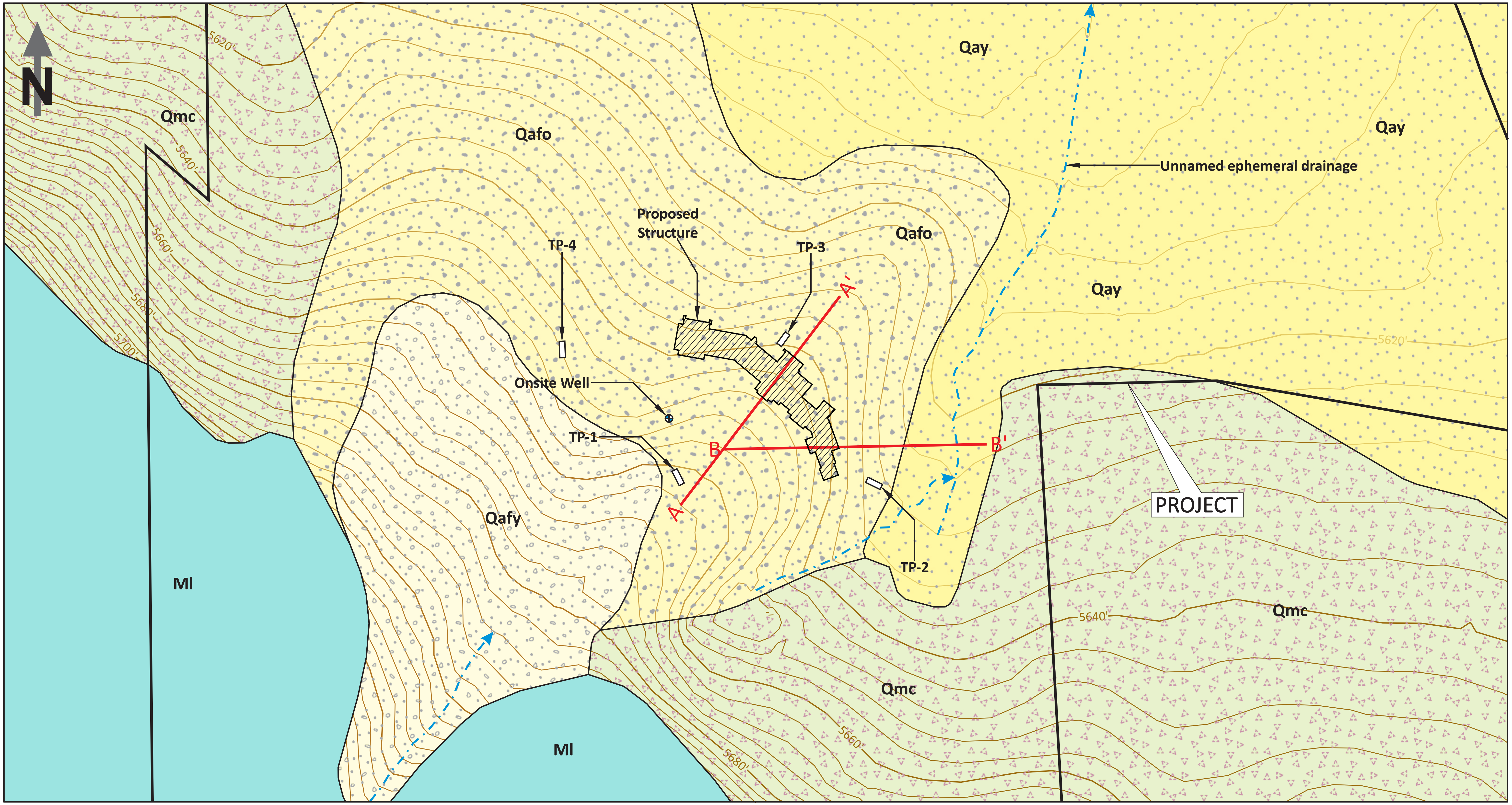


Base:
Utah Geospatial Resource Center 2013 LIDAR bare earth DEM, 50 centimeter resolution. Slopes <15% unshaded, 15-25% shaded in yellow, and >25% shaded in red. Contours generated by Global Mapper, 4 foot interval.

0 100 ft 200 ft

1:1,200 (1 inch equals 100 feet)

CMT TECHNICAL SERVICES	Proposed Three Branch Ranch Residence About 1700 South 9500 East, Huntsville, Weber County, Utah	Slope Analysis	Date:	2-Jan-2024	Figure 5
			CMT No.:	21480	

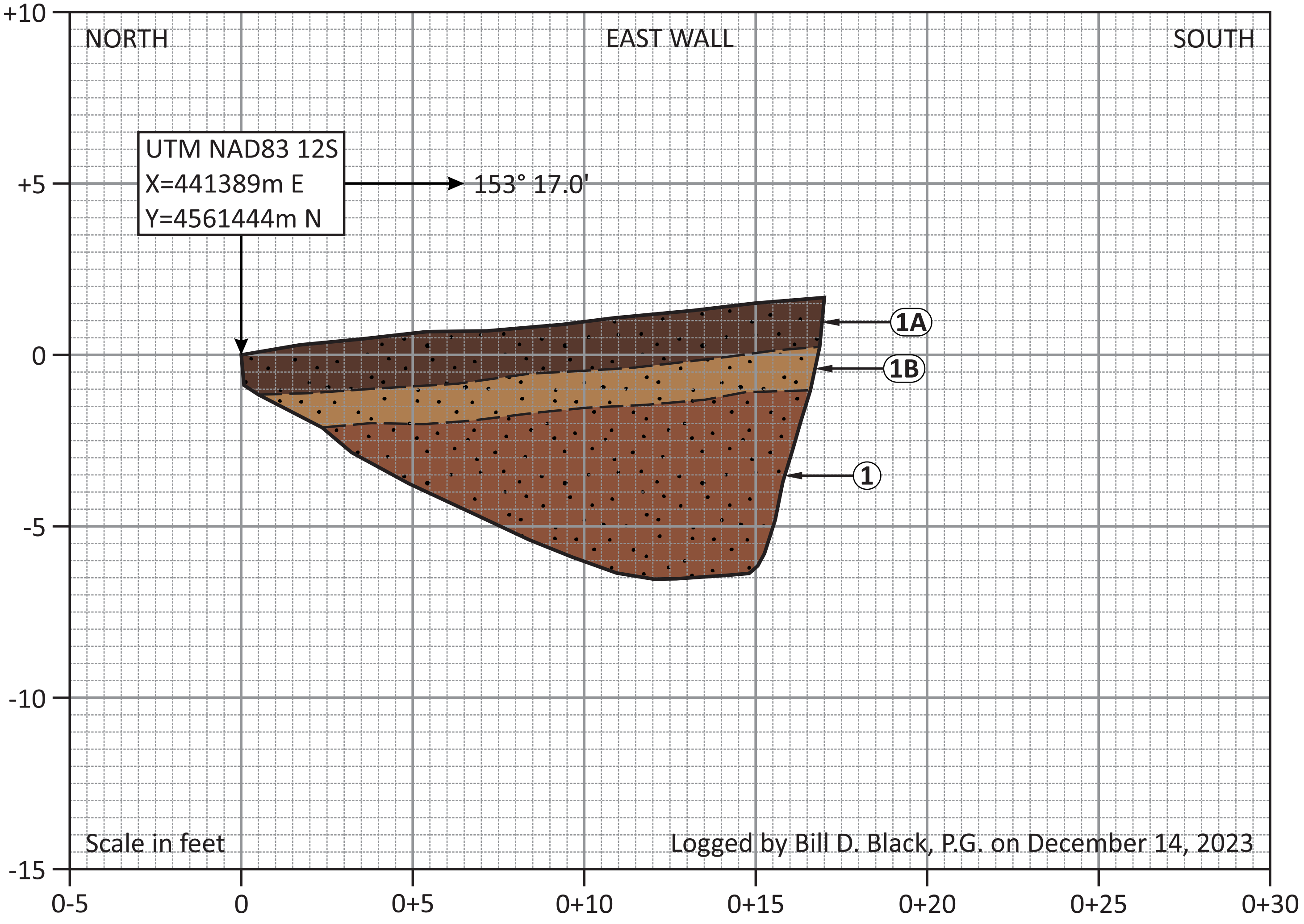


Source:
Modified from Coogan and King (2016).

1:1,200 (1 inch equals 100 feet)

CMT TECHNICAL SERVICES	Proposed Three Branch Ranch Residence About 1700 South 9500 East, Huntsville, Weber County, Utah	**Site-Specific Geology**	Date:	29-Jan-2024	Figure
			CMT No.:	21480	6

TEST PIT 1



Logged by Bill D. Black, P.G. on December 14, 2023

UNIT DESCRIPTIONS

Unit 1. *Pleistocene alluvium* - dark brown, brown and reddish-brown; stiff to very stiff; massive; sandy clay (CL) with no obvious clasts or buried paleosols; soil A and B horizons formed in unit (**1A** and **1B**).

Proposed Three Branch Ranch Residence
About 1700 South 9500 East
Huntsville, Weber County, Utah

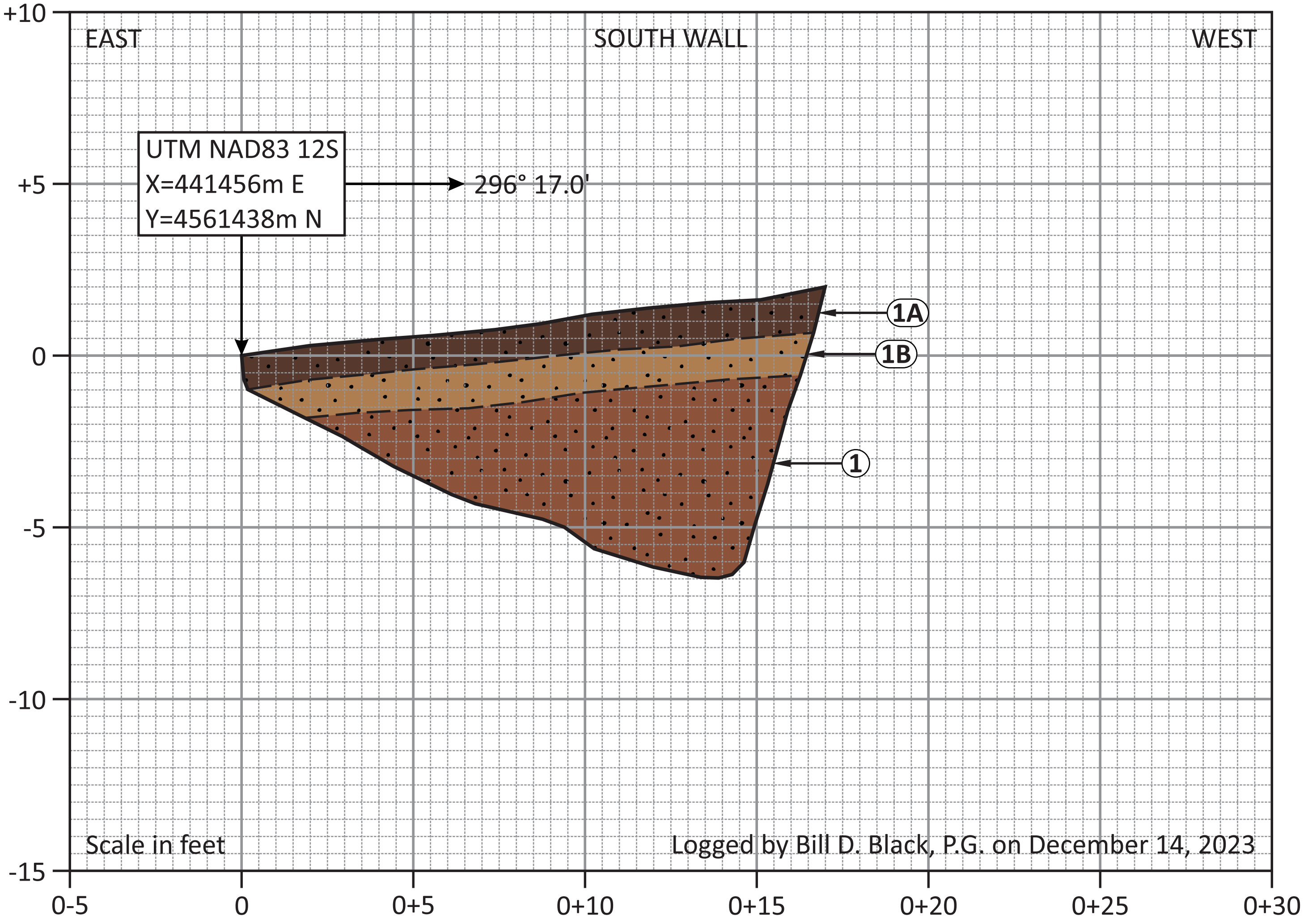
CMT TECHNICAL SERVICES

Geologic Log
Test Pit 1

Date:	12-Feb-2024
Job #	21480

Figure
7A

TEST PIT 2



UNIT DESCRIPTIONS

Unit 1. *Pleistocene alluvium* - brown to dark brown, stiff, massive, slightly moist, sandy clay (CL) with no obvious clasts or buried paleosols; soil A and B horizons formed in unit (**1A** and **1B**).

Proposed Three Branch Ranch Residence
About 1700 South 9500 East
Huntsville, Weber County, Utah

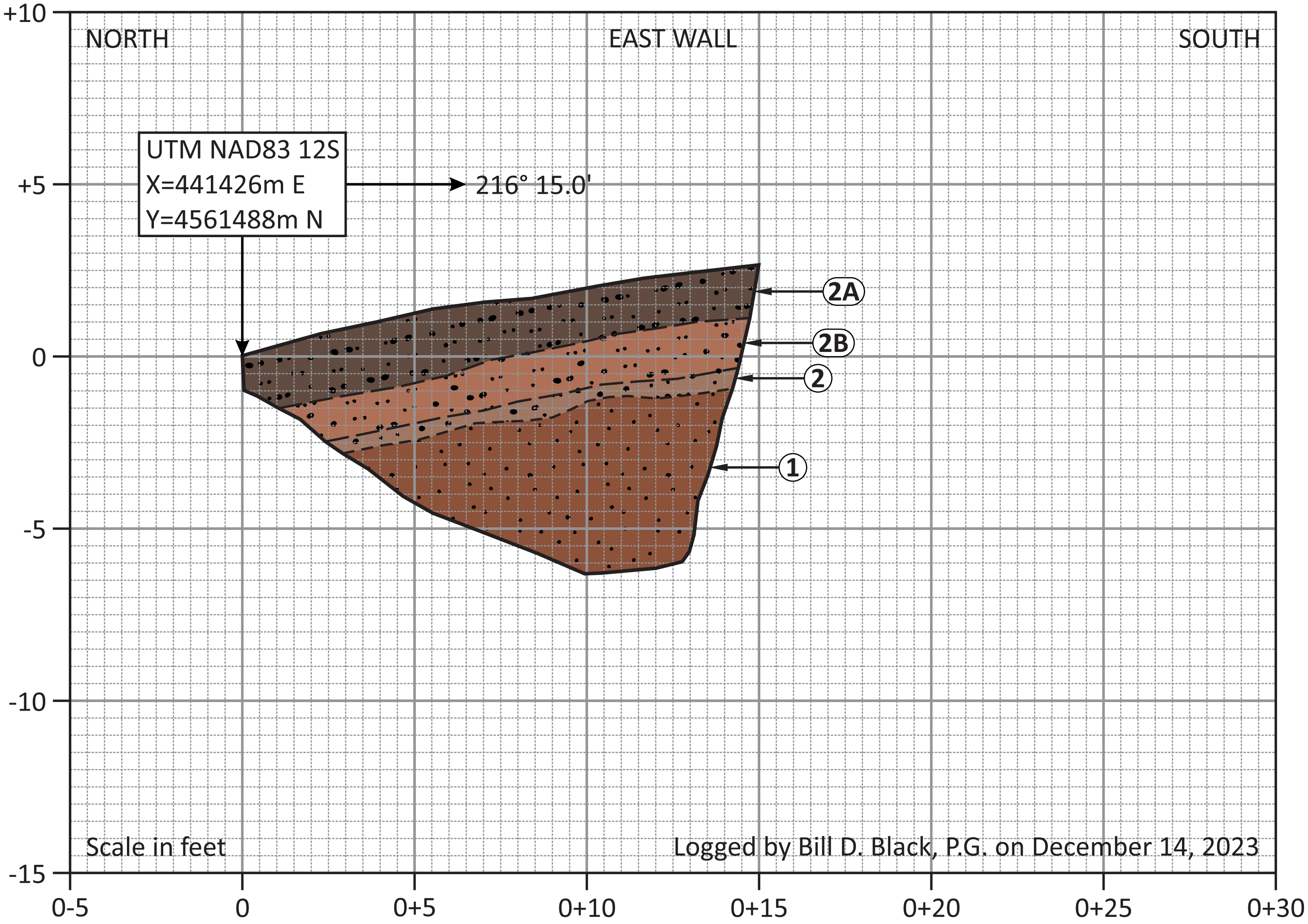
CMT TECHNICAL SERVICES

Geologic Log
Test Pit 2

Date:	12-Feb-2024
Job #	21480

Figure
7B

TEST PIT 3



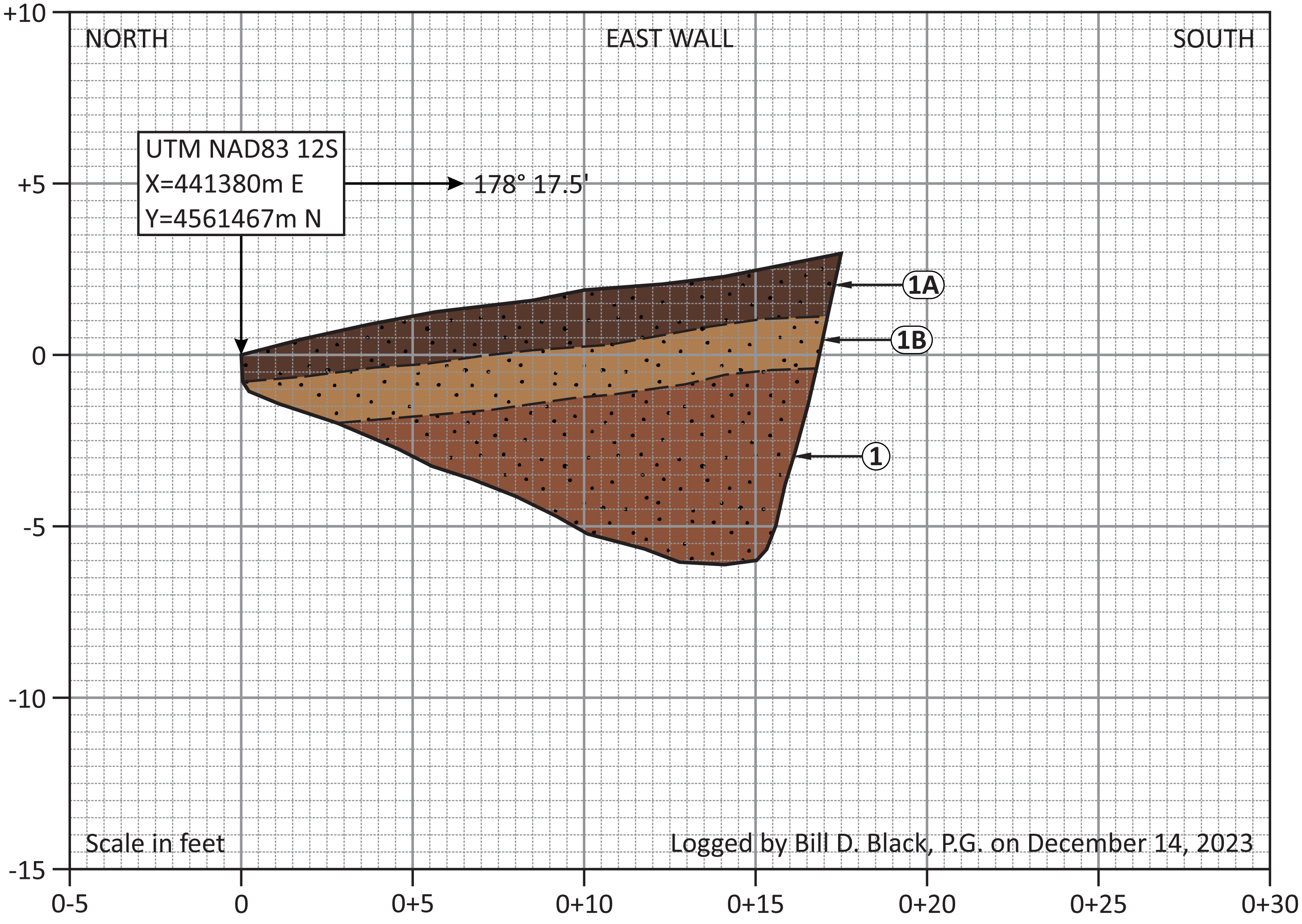
UNIT DESCRIPTIONS

Unit 1. *Older Pleistocene alluvium* - brown to dark reddish-brown, stiff to very stiff, massive, sandy clay (CL) with no obvious clasts or buried paleosols.

Unit 2. *Younger Pleistocene alluvium* - brown to dark brown, stiff to dense, massive, sandy clay to clayey sand (CL/SC) with fine to coarse gravel; no cobbles or buried paleosols; soil A and B horizons formed in unit (**2A** and **2B**).

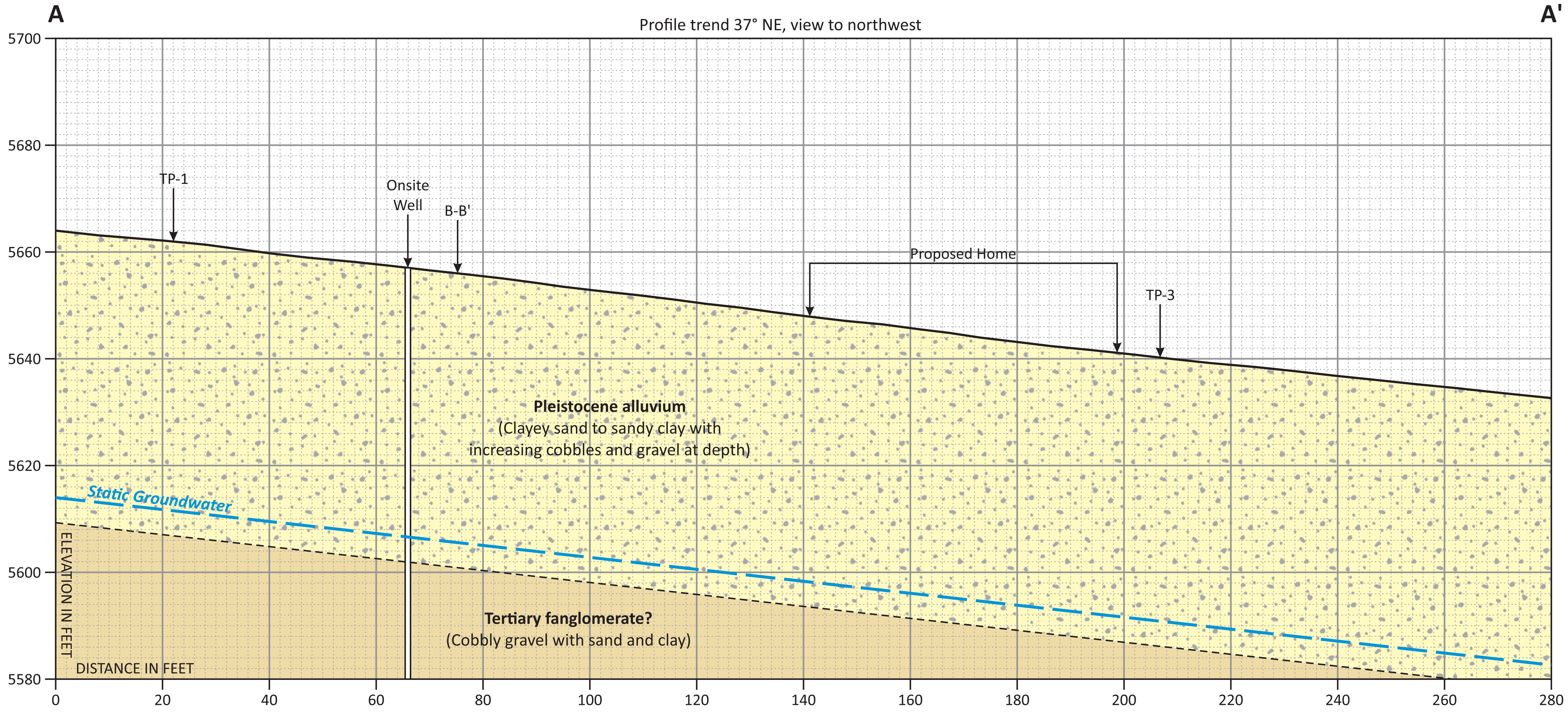
Proposed Three Branch Ranch Residence About 1700 South 9500 East Huntsville, Weber County, Utah	CMT TECHNICAL SERVICES		Figure 7C
	Geologic Log **Test Pit 3**	Date: 12-Feb-2024 Job # 21480	

TEST PIT 4



UNIT DESCRIPTIONS

Unit 1. *Pleistocene alluvium* - brown to dark brown, stiff, massive, sandy clay (CL) with no obvious clasts or buried paleosols, soil A and B horizons formed in unit (**1A** and **1B**).



Scale 1 inch equals 20 feet (1:240) with no vertical exaggeration. Profile based on geoprocessed LIDAR data from 2020. Contacts and units are inferred and approximate.

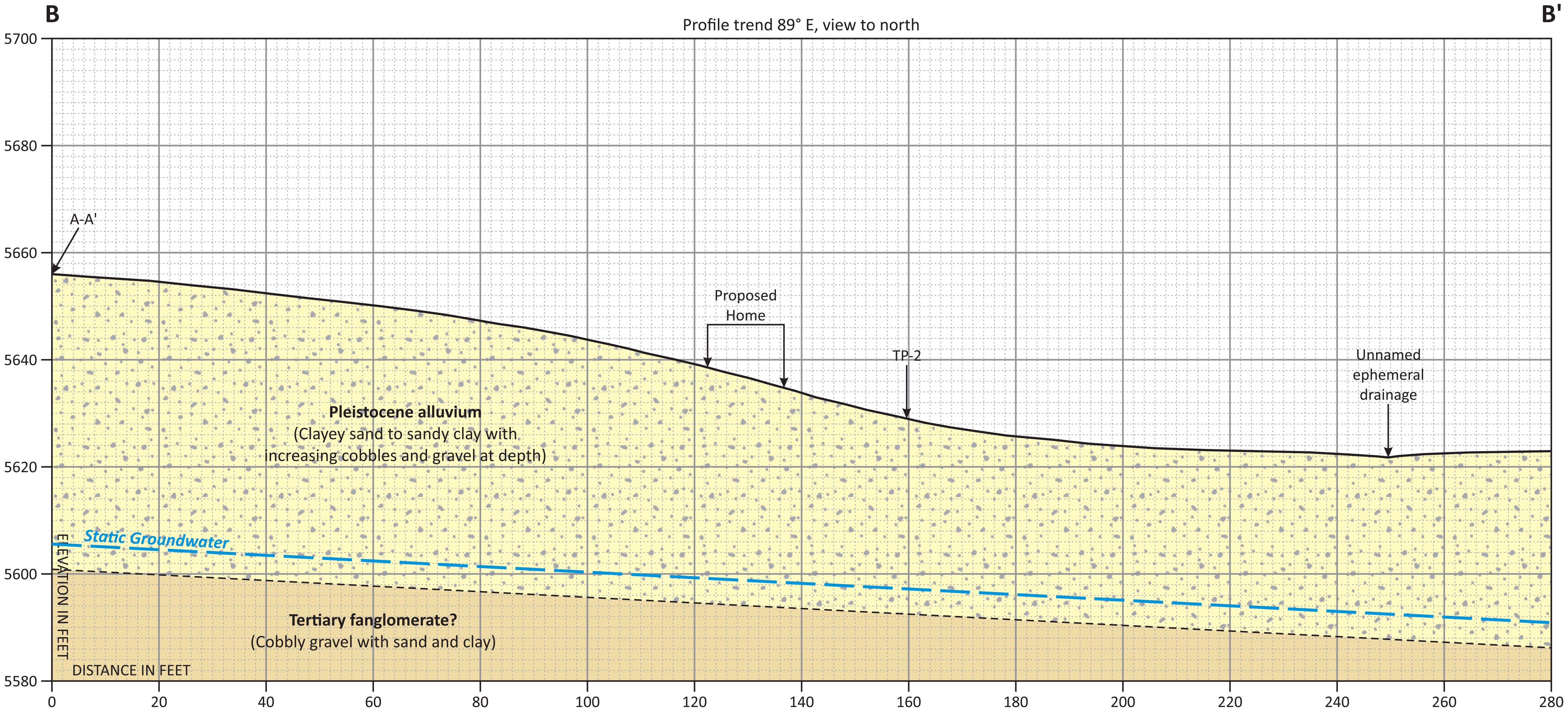
CMT TECHNICAL SERVICES

Proposed Three Branch Ranch Residence
About 1700 South 9500 East, Huntsville, Weber County, Utah

Cross Section A-A'

Date:	29-Jan-2024
CMT No.:	21480

Figure
8A



Scale 1 inch equals 20 feet (1:240) with no vertical exaggeration. Profile based on geoprocessed LIDAR data from 2020. Contacts and units are inferred and approximate.

CMT TECHNICAL SERVICES	**Proposed Three Branch Ranch Residence** About 1700 South 9500 East, Huntsville, Weber County, Utah	**Cross Section B-B'**	Date: 29-Jan-2024 CMT No.: 21480	Figure 8B

Three Branch Ranch Residence

About 1700 South 9500 East, Huntsville, Utah

Test Pit Log

TP-1

Total Depth: 7.5'
Water Depth: (see Remarks)

Date: 12/14/23
Job #: 21480

Depth (ft)	GRAPHIC LOG	Soil Description	Sample Type	Sample #	Moisture (%)	Dry Density(pcf)	Gradation Gravel %	Gradation Sand %	Gradation Fines %	Atterberg LL	Atterberg PL	Atterberg PI
0 – 1.5	⁘	Topsoil; dark brown sandy silty clay with roots and rootholes										
1.5 – 7.5	▨	Brown Silty CLAY (CL) with some sand, roots and rootholes slightly moist to moist, medium stiff (estimated)										
2			▮	1	25	89				49	22	27
4		stiff (estimated)	◣	2								
6			◣	3	17		0	9	91	33	17	16
7.5		END AT 7.5'										

Remarks: Groundwater not encountered during excavation.

Coordinates: 41.202196°, -111.698942°
Surface Elev. (approx): Not Given

Equipment: Mini Excavator
Excavated By: Owner Provided
Logged By: Carolina Olivera

CMT TECHNICAL SERVICES

Figure: 9

Three Branch Ranch Residence

About 1700 South 9500 East, Huntsville, Utah

Test Pit Log

TP-2

Total Depth: 8'
Water Depth: (see Remarks)

Date: 12/14/23
Job #: 21480

Depth (ft)	GRAPHIC LOG	Soil Description	Sample Type	Sample #	Moisture (%)	Dry Density(pcf)	Gradation			Atterberg		
							Gravel %	Sand %	Fines %	LL	PL	PI
0	⁘	Topsoil; dark brown sandy silty clay with roots and rootholes										
1	▨	Brown Sandy CLAY (CL) with roots and rootholes dry to slightly moist, stiff (estimated)										
2	▨		◢	4								
	▨	grades more sand										
3	▨											
4	▨	slightly moist to moist, medium stiff to stiff (estimated)	▮	5	15	94						
5	▨											
6	▨	medium stiff (estimated)	◢	6								
7	▨											
8		END AT 8'										
9												
10												
11												
12												
13												
14												

Remarks: Groundwater not encountered during excavation.

Coordinates: 41.202128°, -111.698341°
Surface Elev. (approx): Not Given

Equipment: Mini Excavator
Excavated By: Owner Provided
Logged By: Carolina Olivera

CMT TECHNICAL SERVICES

Figure:
10

Three Branch Ranch Residence

About 1700 South 9500 East, Huntsville, Utah

Test Pit Log

TP-3

Total Depth: 8.5'
Water Depth: (see Remarks)

Date: 12/14/23
Job #: 21480

Depth (ft)	GRAPHIC LOG	Soil Description	Sample Type	Sample #	Moisture (%)	Dry Density(pcf)	Gradation			Atterberg		
							Gravel %	Sand %	Fines %	LL	PL	PI
0	⁘	Topsoil; dark brown sandy silty clay with roots and rootholes										
1	⁘											
	▨	Brown Sandy CLAY (CL) with grael, some roots and rootholes dry to slightly moist, stiff to very stiff (estimated)										
2	▨		◢	7								
3	▨											
4	▨	stiff (estimated)	◢	8	13		20	23	57			
5	▨	grades more sand, no gravels, some thin roots and rootholes										
6	▨	slighlty moist to moist, medium (stiff)	◢	9								
7	▨											
8	▨		▮	10	18	95				39	17	22
		END AT 8.5'										
9												
10												
11												
12												
13												
14												

Remarks: Groundwater not encountered during excavation.

Coordinates: 41.202621°, -111.698617°
Surface Elev. (approx): Not Given

Equipment: Mini Excavator
Excavated By: Owner Provided
Logged By: Carolina Olivera

CMT TECHNICAL SERVICES

Figure:

11

Three Branch Ranch Residence

About 1700 South 9500 East, Huntsville, Utah

Test Pit Log

TP-4

Total Depth: 8'
Water Depth: (see Remarks)

Date: 12/14/23
Job #: 21480

Depth (ft)	GRAPHIC LOG	Soil Description	Sample Type	Sample #	Moisture (%)	Dry Density(pcf)	Gradation Gravel %	 Sand %	 Fines %	Atterberg LL	 PL	 PI
0	⁘	Topsoil; dark brown sandy silty clay with roots and rootholes										
1	⁘											
	▨	Brown Sandy Silty CLAY (CL) with roots and rootholes dry to slighlty moist, stiff to very stiff (estimated)										
2	▨	grades more sand with depth	◣	11								
3	▨											
4	▨											
5	▨	grades less sand										
6	▨	thin roots and rootholes slightly moist, stiff (estimated)	◣	12								
7	▨		◣	13	12		1	8	91			
8		END AT 8'										
9												
10												
11												
12												
13												
14												

Remarks: Groundwater not encountered during excavation.

Coordinates: 41.202394°, -111.699104°
Surface Elev. (approx): Not Given

Equipment: Mini Excavator
Excavated By: Owner Provided
Logged By: Carolina Olivera

CMT TECHNICAL SERVICES

Three Branch Ranch Residence

Key to Symbols

About 1700 South 9500 East, Huntsville, Utah

Date: 12/14/23

Job #: 21480

① Depth (ft)	② GRAPHIC LOG	③ Soil Description	④ Sample Type	⑤ Sample #	⑥ Moisture (%)	⑦ Dry Density(pcf)	⑧ Gradation			Atterberg		
							Gravel %	Sand %	Fines %	LL	PL	PI

COLUMN DESCRIPTIONS

Depth (ft.): Depth (feet) below the ground surface (including groundwater depth - see below right).

Graphic Log: Graphic depicting type of soil encountered (see below).

Soil Description: Description of soils, including Unified Soil Classification Symbol (see below).

Sample Type: Type of soil sample collected; sampler symbols are explained below-right.

Sample #: Consecutive numbering of soil samples collected during field exploration.

Moisture (%): Water content of soil sample measured in laboratory (percentage of dry weight).

Dry Density (pcf): The dry density of a soil measured in laboratory (pounds per cubic foot).

Gradation: Percentages of Gravel, Sand and Fines (Silt/Clay), obtained from lab test results of soil passing the No. 4 and No. 200 sieves.

Atterberg: Individual descriptions of Atterberg Tests are as follows:

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

PL = Plastic Limit (%): Water content at which a soil changes from liquid to plastic behavior.

PI = Plasticity Index (%): Range of water content at which a soil exhibits plastic properties (= Liquid Limit - Plastic Limit).

STRATIFICATION	
Description	**Thickness**
Seam	Up to ½ inch
Lense	Up to 12 inches
Layer	Greater than 12 in.
Occasional	1 or less per foot
Frequent	More than 1 per foot

MODIFIERS
Trace
<5%
Some
5-12%
With
> 12%

MOISTURE CONTENT
Dry: Absence of moisture, dusty, dry to the touch.
Moist: Damp / moist to the touch, but no visible water.
Wet: Visible water, usually soil below groundwater.

UNIFIED SOIL CLASSIFICATION SYSTEM (USCS)

MAJOR DIVISIONS			USCS SYMBOLS		TYPICAL DESCRIPTIONS
COARSE-GRAINED SOILS More than 50% of material is larger than No. 200 sieve size.	**GRAVELS** The coarse fraction retained on No. 4 sieve.	**CLEAN GRAVELS** (< 5% fines)	GW	●	Well-Graded Gravels, Gravel-Sand Mixtures, Little or No Fines
			GP	●	Poorly-Graded Gravels, Gravel-Sand Mixtures, Little or No Fines
		GRAVELS WITH FINES (≥ 12% fines)	GM	●	Silty Gravels, Gravel-Sand-Silt Mixtures
			GC	▨	Clayey Gravels, Gravel-Sand-Clay Mixtures
	SANDS The coarse fraction passing through No. 4 sieve.	**CLEAN SANDS** (< 5% fines)	SW	⁘	Well-Graded Sands, Gravelly Sands, Little or No Fines
			SP	⁘	Poorly-Graded Sands, Gravelly Sands, Little or No Fines
		SANDS WITH FINES (≥ 12% fines)	SM	⁘	Silty Sands, Sand-Silt Mixtures
			SC	▨	Clayey Sands, Sand-Clay Mixtures
FINE-GRAINED SOILS More than 50% of material is smaller than No. 200 sieve size.	**SILTS AND CLAYS** Liquid Limit less than 50%		ML	‖	Inorganic Silts and Sandy Silts with No Plasticity or Clayey Silts with Slight Plasticity
			CL	▨	Inorganic Clays of Low to Medium Plasticity, Gravelly Clays, Sandy Clays, Silty Clays, Lean Clays
			OL	▦	Organic Silts and Organic Silty Clays of Low Plasticity
	SILTS AND CLAYS Liquid Limit greater than 50%		MH	‖	Inorganic Silts, Micacious or Diatomacious Fine Sand or Silty Soils
			CH	▨	Inorganic Clays of High Plasticity, Fat Clays
			OH	▦	Organic Silts and Organic Clays of Medium to High Plasticity
HIGHLY ORGANIC SOILS			PT	⁙	Peat, Soils with High Organic Contents

Note: Dual Symbols are used to indicate borderline soil classifications (i.e. GP-GM, SC-SM, etc.).

SAMPLER SYMBOLS

◧	Block Sample
◩	Bulk/Bag Sample
⧗	Modified California Sampler 3.5" OD, 2.42" ID
⧗	D&M Sampler
▯	Rock Core
◩	Standard Penetration Split Spoon Sampler
▥	Thin Wall (Shelby Tube)

WATER SYMBOL

▽	Encountered Water Level
▼	Measured Water Level

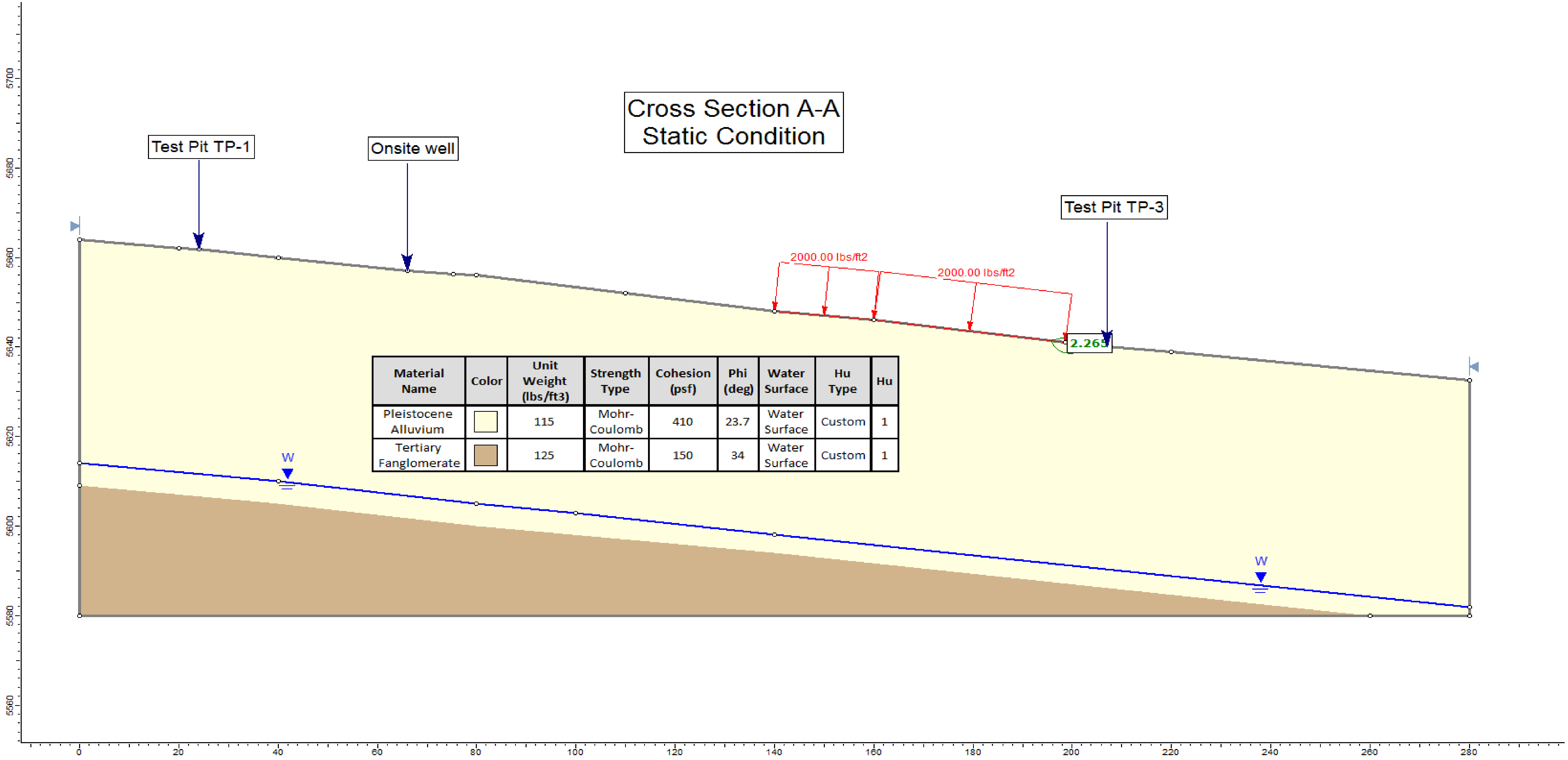
(see Remarks on Logs)

1. The results of laboratory tests on the samples collected are shown on the logs at the respective sample depths.
2. The subsurface conditions represented on the logs are for the locations specified. Caution should be exercised if interpolating between or extrapolating beyond the exploration locations.
3. The information presented on each log is subject to the limitations, conclusions, and recommendations presented in this report.

CMT TECHNICAL SERVICES

Figure:

13



Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Water Surface	Hu Type	Hu
Pleistocene Alluvium	🟨	115	Mohr-Coulomb	410	23.7	Water Surface	Custom	1
Tertiary Fanglomerate	🟫	125	Mohr-Coulomb	150	34	Water Surface	Custom	1

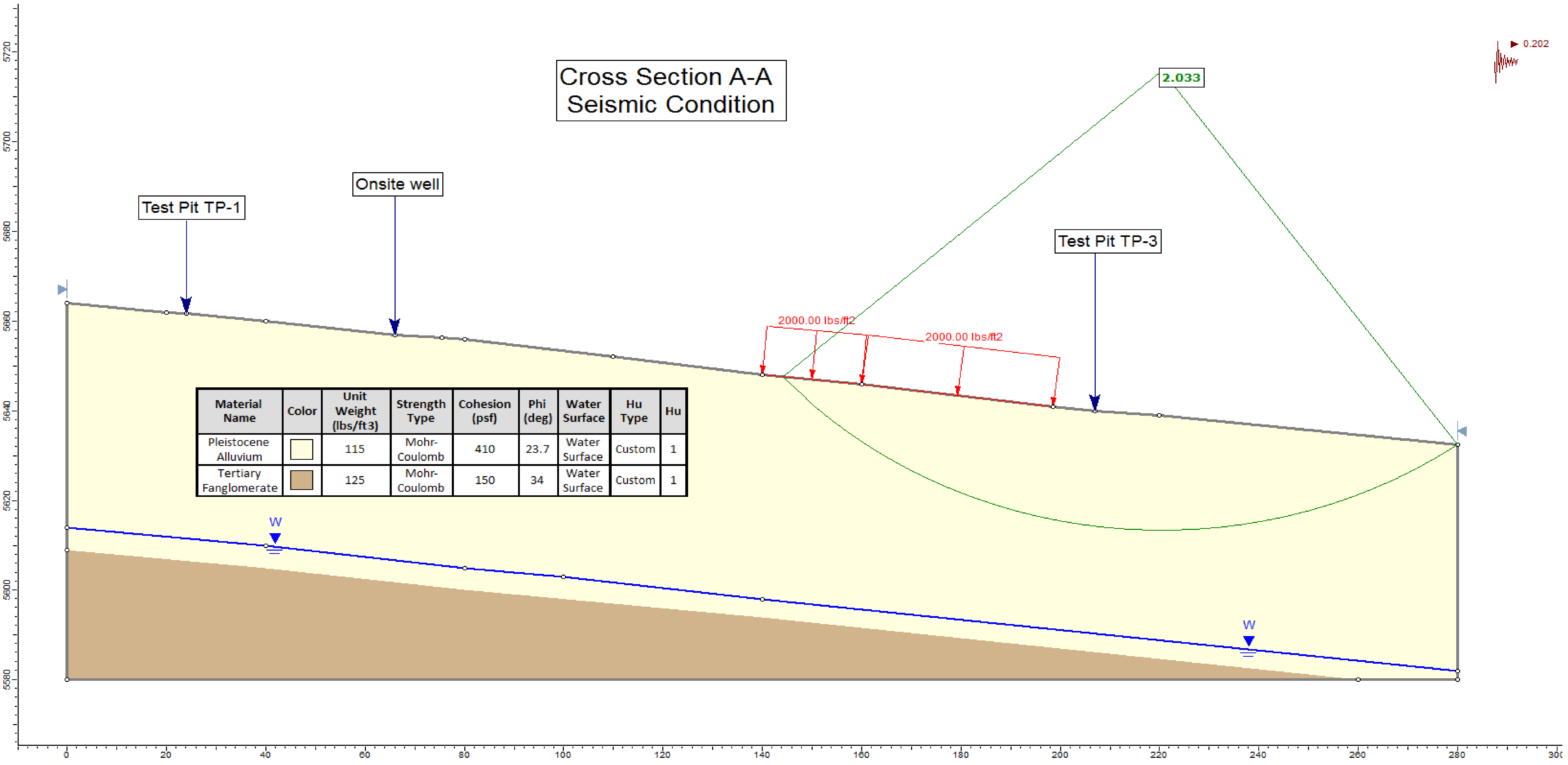
CMT TECHNICAL SERVICES

Three Branch Ranch Residence
About 1700 South 9500 East, Huntsville, Utah

Static A-A

Date:	8-Feb-2024
CMT No.:	21480

Figure:
14



Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Water Surface	Hu Type	Hu
Pleistocene Alluvium	⬜	115	Mohr-Coulomb	410	23.7	Water Surface	Custom	1
Tertiary Fanglomerate	🟫	125	Mohr-Coulomb	150	34	Water Surface	Custom	1

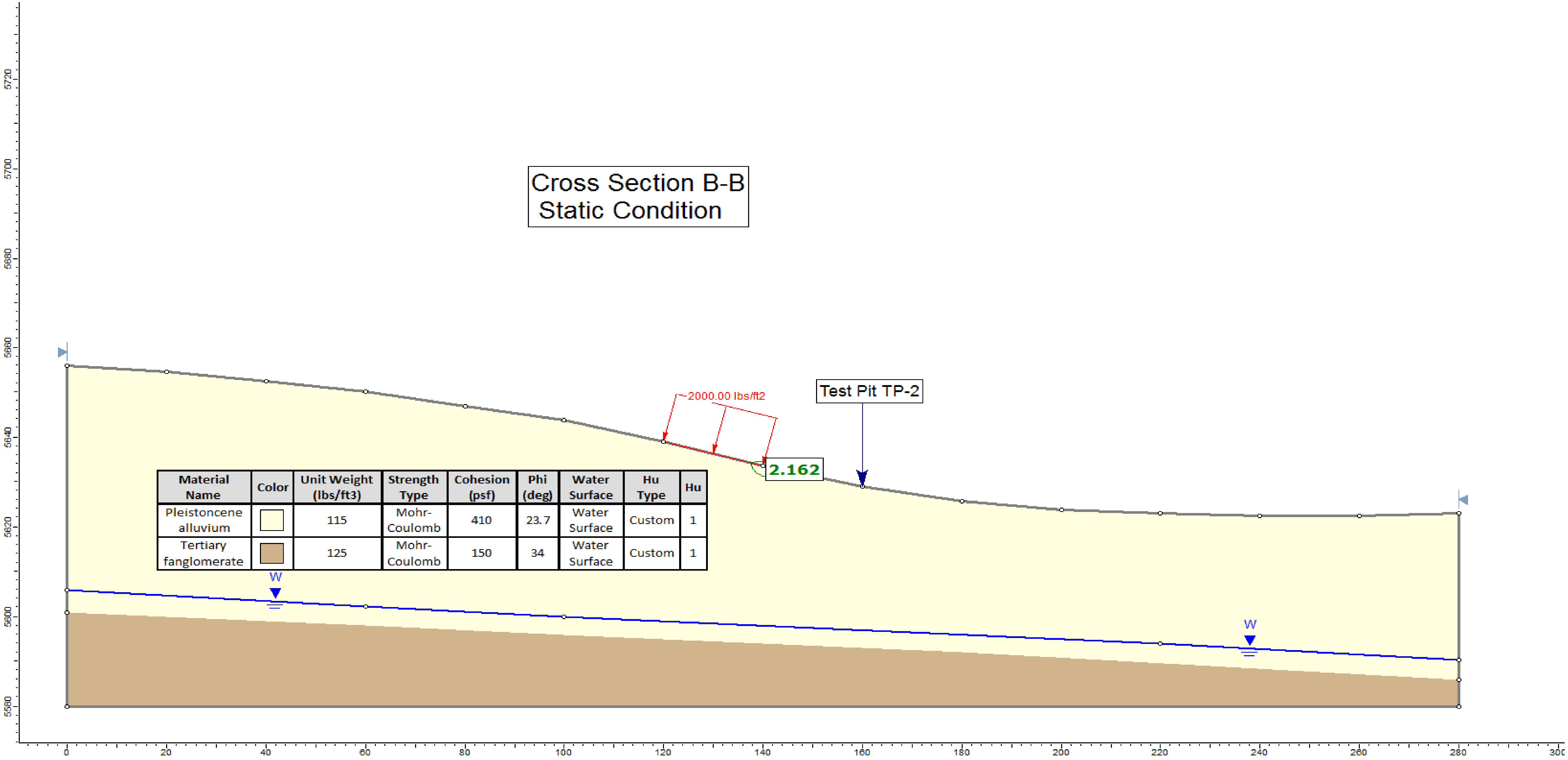
CMT TECHNICAL SERVICES

Three Branch Ranch
About 1700 South 9500 East, Huntsville, Utah

Seismic A-A

Date:	8-Feb-2024
CMT No.:	21480

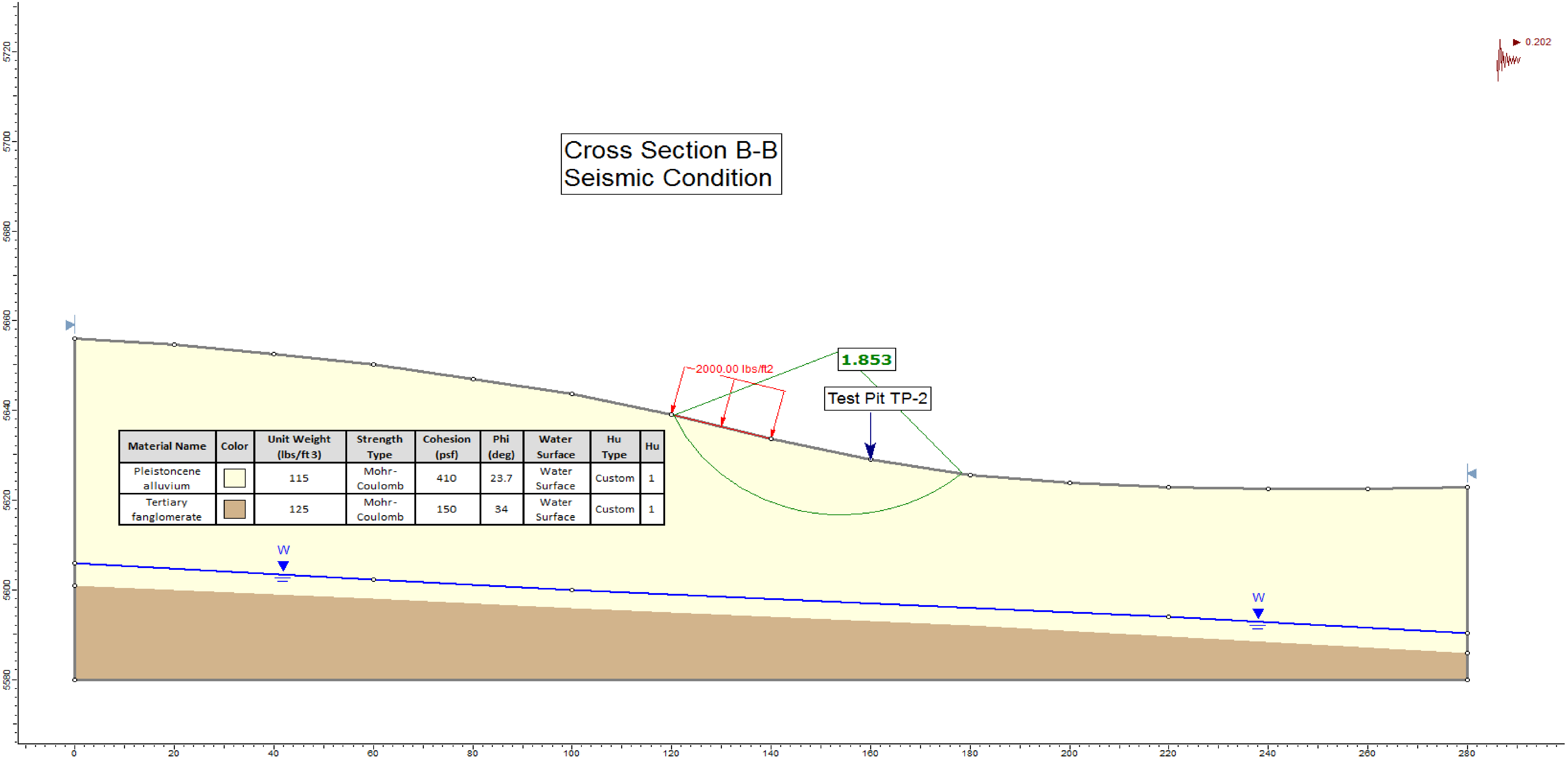
Figure:
15



Cross Section B-B
Static Condition

Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Water Surface	Hu Type	Hu
Pleistoncene alluvium	🟨	115	Mohr-Coulomb	410	23.7	Water Surface	Custom	1
Tertiary fanglomerate	🟫	125	Mohr-Coulomb	150	34	Water Surface	Custom	1

CMT TECHNICAL SERVICES	**Three Branch Ranch** About 1700 South 9500 East, Huntsville, Utah	**Static B-B**	Date:	8-Feb-2024	Figure: 16
			CMT No.:	21480	



Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Water Surface	Hu Type	Hu
Pleistoncene alluvium	🟨	115	Mohr-Coulomb	410	23.7	Water Surface	Custom	1
Tertiary fanglomerate	🟫	125	Mohr-Coulomb	150	34	Water Surface	Custom	1

CMT TECHNICAL SERVICES

Three Branch Ranch
About 1700 South 9500 East, Huntsville, Utah

Seismic B-B

Date:	8-Feb-2024
CMT No.:	21480

Figure:
17