REPORT

GEOLOGIC HAZARDS EVALUATION

PROPOSED WATER TANK
LEGACY MOUNTAIN DEVELOPMENT
SECTIONS 14 AND 23, TOWNSHIP 6 NORTH, RANGE 1 EAST
HUNTSVILLE, WEBER COUNTY, UTAH

Prepared for

Lewis Homes
3718 North Wolf Creek Drive
Eden, Utah 84310

December 11, 2020

Prepared by

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December 11, 2020

Lewis Homes
Eric Householder
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Letter of Transmittal: REPORT
Geologic Hazards Evaluation
Proposed Water Tank
Legacy Mountain Development
Sections 14 and 23, Township 6 North, Range 1 East
Huntsville, Weber County, Utah

Dear Mr. Householder:

Western Geologic & Environmental has completed a Geologic Hazards Evaluation for the proposed Legacy Mountain Development in Huntsville, Utah and submits the attached report for your review.

If you have any questions regarding this report, please contact us at (801) 359-7222.

Sincerely,
Western Geologic & Environmental LLC

LICENSED PROFESSIONAL GEOLOGIST
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WG&E Project No. 5563

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1.0 INTRODUCTION

This report presents the results of a geology and geologic hazards review and evaluation conducted by Western Geologic & Environmental LLC (Western Geologic) for a proposed water tank at the Legacy Mountain Development in Huntsville, Utah. The Legacy Mountain Development is located in southern Ogden Valley on generally northeast-facing slopes overlooking Pineview Reservoir in the Sections 14 and 23, Township 6 North, Range 1 East (Salt Lake Base Line and Meridian; Figure 1). The water tank, which will reportedly be about 80 feet in diameter and set 8 feet into the ground, is located in Weber County Assessor parcel number 20-035-0046 in the southwest part of the overall site about 650 feet north of Old Snow Basin Road. The location is at an elevation of about 5,795 feet above sea level. The Project setting is shown on Figure 1 – Project Location. Surficial geologic mapping for the Legacy Mountain Development and surrounding area is shown on Figure 2 – Regional Geologic Map. Site-specific geology, locations of nearby water wells, locations of test pits and geologic cross sections prepared for our prior evaluation, and the approximate water tank location (based on verbal discussions) are shown on Plate 1 – Site Evaluation and Geology. No formalized site plans were provided.

2.0 PURPOSE AND SCOPE

The purpose and scope of this investigation is to identify and interpret surficial geologic conditions at the site to identify potential risk from geologic hazards to the Project. This investigation is intended to: (1) provide preliminary geologic information and assessment of geologic conditions at the site; (2) identify potential geologic hazards that may be present and qualitatively assess their risk to the intended site use; and (3) provide recommendations for additional site- and hazard-specific studies or mitigation measures, as may be needed based on our findings. Such recommendations could require further multi-disciplinary evaluations, and/or may need design criteria that are beyond our professional scope. Our investigation was conducted concurrently with a geotechnical engineering study performed at the Project by Christensen Geotechnical.

2.1 Methodology

The following services were performed in accordance with the above-stated purpose and scope:

- A site reconnaissance conducted by an experienced certified engineering geologist to assess the site setting and look for adverse geologic conditions;

- Review of readily-available geologic maps, reports, and air photos;

- Logging of one walk-in test pit to assess subsurface conditions at the tank location, in addition to 25 test pit exposures previously excavated and logged at the inclusive site;

- Preparation of one geologic cross section based on geoprocessed LIDAR data, site-specific subsurface data, inferred conditions, and cross section F-F' previously prepared for our November 2020 report; and

- Evaluation of available data and preparation of this report, which presents the results of our study.

Western Geologic previously prepared a hazards evaluation for the proposed Legacy Mountain development dated November 20, 2020 that identified high-risk hazards from earthquake ground shaking and landslides. This report includes information provided in our prior report with regard to the water tank location, supplemented by additional subsurface data and observations. The engineering geology section of this report has been prepared in accordance with Bowman and Lund (2016) and current generally accepted professional engineering geologic principles and practice in Utah, and meets specifications provided in Chapter 27 of the Weber County Land Use Code within the above stated scope.

2.2 Limitations and Exceptions

This investigation was performed at the request of Lewis Homes (the Client) using the methods and procedures consistent with good commercial and customary practice designed to conform to acceptable industry standards. The analysis and recommendations submitted in this report are based upon the data obtained from site-specific observations and compilation of known geologic information. This information and the conclusions of this report should not be interpolated to adjacent properties without additional site-specific information. In the event that any changes are later made in the location of the proposed site, the conclusions and recommendations contained in this report shall not be considered valid unless the changes are reviewed and conclusions of this report modified or approved in writing by the engineering geologist.

This report has been prepared by the staff of Western Geologic for the Client under the professional supervision of the principal and/or senior staff whose seal(s) and signatures appear hereon. Neither Western Geologic, nor any staff member assigned to this investigation has any interest or contemplated interest, financial or otherwise, in the subject or surrounding properties, or in any entity which owns, leases, or occupies the subject or surrounding properties or which may be responsible for environmental issues identified during the course of this investigation, and has no personal bias with respect to the parties involved.

The information contained in this report has received appropriate technical review and approval. The conclusions represent professional judgment and are founded upon the findings of the investigations identified in the report and the interpretation of such data based on our experience and expertise according to the existing standard of care. No other warranty or limitation exists, either expressed or implied.

The investigation was prepared in accordance with the approved scope of work outlined in our proposal for the use and benefit of the Client; its successors, and assignees. It is based, in part, upon documents, writings, and information owned, possessed, or secured by the Client. Neither this report, nor any information contained herein shall be used or relied upon for any purpose by any other person or entity without the express written permission of the Client. This report is not for the use or benefit of, nor may it be relied upon by any other person or entity, for any purpose without the advance written consent of Western Geologic.

In expressing the opinions stated in this report, Western Geologic has exercised the degree of skill and care ordinarily exercised by a reasonable prudent environmental professional in the same community and in the same time frame given the same or similar facts and circumstances. Documentation and data provided by the Client, designated representatives of the Client or other interested third parties, or from the public domain, and referred to in the preparation of this assessment, have been used and referenced with the understanding that Western Geologic assumes no responsibility or liability for their accuracy. The independent conclusions represent our professional judgment based on information and data available to us during the course of this assignment. Factual information regarding operations, conditions, and test data provided by the Client or their representative has been assumed to be correct and complete. The conclusions presented are based on the data provided, observations, and conditions that existed at the time of the field exploration.

3.0 HYDROLOGY

The U.S. Geological Survey (USGS) topographic map of the Huntsville Quadrangle shows the Legacy Mountain Development is in southern Ogden Valley straddling Poison Hollow (on the west) and a tributary of Smith Creek (on the southeast), both of which flow into Ogden Valley and Pineview Reservoir (Figure 1). The proposed tank location is on an east-plunging ridge in the southwest part of the development. Pineview Reservoir is to the north. No active, perennial or ephemeral drainages are in the tank area.

The site is at the southern margin of Ogden Valley, which is dominated in the valley bottom by unconsolidated lacustrine and alluvial basin-fill deposits. Slopes in the site area are in weathered tuffaceous bedrock overlain by alluvium and colluvium from mixed sources, including landslides. The Utah Division of Water Rights Well Driller Database shows several water wells at the Project and in the vicinity that report static groundwater depths of 28 to 180 feet below the ground surface (Plate 1). The nearest well to the tank location is about 560 feet to the southeast (Plate 1). Groundwater is at an elevation of 5,656’ in this well based on the driller log. However, groundwater depths at the site likely vary seasonally from snowmelt runoff and annually from climatic fluctuations, and may also vary locally with subsurface conditions. Such variations would be typical for Ogden Valley. Perched conditions on less-permeable bedrock layers on the surface may be present in the area.

Avery (1994) indicates groundwater in Ogden Valley occurs under perched, confined, and unconfined conditions in the valley fill to depths of 750 feet or more. A well-stratified lacustrine silt layer forms a leaky confining bed in the upper part of the valley-fill aquifer. The aquifer below the confining beds is the principal aquifer, which is in primarily fluvial and alluvial-fan deposits. The principal aquifer is recharged from precipitation, seepage from surface water, and subsurface inflow from bedrock into valley fill along the valley margins (Avery, 1994). The confined aquifer is typically overlain by a shallow, unconfined aquifer recharged from surface flow and upward leakage. Groundwater flow is generally from the valley margins into the valley fill, and then toward the head of Ogden Canyon (Avery, 1994). Based on topography, we expect regional groundwater flow at the water tank site to be northward and eastward.

4.0 GEOLOGY

4.1 Surficial Geology

The water tank site is located on the southern margin of Ogden Valley, a sediment-filled intermontane valley within the Wasatch Range, a major north-south trending mountain range marking the eastern boundary of the Basin and Range physiographic province (Stokes; 1977, 1986). Regional surficial geology of the site is shown on Figure 2 at a scale of 1 inch equals 2,000 feet (1:24,000); site-specific geology is shown on Plate 1 at a scale of 1 inch equals 200 feet (1:2,400) based on the regional mapping and subsurface data from our investigation.

Coogan and King (2016) map the surficial geology of the water tank site on Figure 2 as bedrock of the Tertiary Norwood Formation. They describe surficial geologic units in the site area on Figure 2 as follows:

***Qa2, Qa2?, Qay** – Younger alluvium (mostly Holocene).* Like undivided alluvium, with Qay at to slightly above present drainages, unconsolidated, and not incised by active drainages; likely mostly Holocene in age and postdates late Pleistocene Provo shoreline of Lake Bonneville; height above present drainages is low and is within certain limits, with suffix 1 (not present on this map) being the youngest and being at to slightly (<10 feet [3 m]) above drainages and suffix 2 being slightly higher and older, with y suffix where ages 1 and 2 cannot be separated; Qa2 is up to about 20 feet (6 m) above drainage on south side of Round Valley indicating unit includes slightly older post Provo-shoreline alluvium; generally 6 to 20 feet (2-6 m) thick. Mapped as Qa2 (queried) where about 20 feet (6 m) above incised stream in Stephens Canyon (Devils Slide quadrangle).

***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.

***Qac** – Alluvium and colluvium (Holocene and Pleistocene).* Unsorted to variably sorted gravel, sand, silt, and clay in variable proportions; includes stream and fan alluvium, colluvium, and, locally, mass-movement deposits too small to show at map scale; typically mapped along smaller drainages that lack flat bottoms; more extensive east of Henefer where Wasatch Formation (Tw) strata easily weather to debris that “chokes” drainages; 6 to 20 feet (2-6 m) thick. Some deposits are “perched” on benches 80 feet (25 m) and more above present-day drainages like Left Fork Heiners Creek (Heiners Creek quadrangle) and Harris Canyon (Henefer quadrangle). In the Devils Slide quadrangle, some deposits are “perched” on benches about 60 to 130 feet (18-40 m) above Quarry Cottonwood Canyon indicating the alluvium is at least partly Lake Bonneville age and older (see Qab and Qao in tables 1 and 2).

***Qat, Qat2, Qaty, Qatp, Qatp?, Qatpb, Qato** – Stream-terrace alluvium (Holocene and Pleistocene).* Sand, silt, clay, and gravel in terraces above floodplains near late Pleistocene Lake Bonneville and are geographically in the Ogden and Weber River, and lower Bear River drainages; moderately sorted; variably consolidated; upper surfaces slope gently downstream; locally includes thin and small mass-movement and alluvial-fan deposits; where possible, subdivided into relative ages, indicated by number and letter suffixes, with 2 being the lowest/youngest terraces, typically about 10 to 20 feet (3-6 m) above adjacent flood plains; Qat with no suffix used where age unknown or age subdivisions of terraces cannot be shown separately at map scale; 6 to at least 20 feet (2-6+ m) thick, with Qatp 50 to 80 feet (15-24 m) thick in Mantua Valley.

Relative ages are largely from heights above adjacent drainages in Morgan and Round Valleys. 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 tables 1 and 2). Despite the proximity to Lake Bonneville, terraces along and near Box Elder Creek in the northwest corner of the Ogden map area (Mantua quadrangle) seem to be slightly higher than comparable terraces in Morgan Valley. Terraces labeled Qat2 are post-Lake Bonneville and are likely mostly Holocene in age. A terrace labeled Qaty is up to 20 feet (6 m) above the South Fork Ogden River, but may be related to the Provo or regressional shorelines. Terraces labeled Qatp are likely related to the Provo and slightly lower shorelines of Lake Bonneville (at and less than ~4820 feet [1470 m] in area), and with Qap form “benches” at about 4900 feet (1494 m) along the Weber River and South Fork Ogden River. Qato terraces pre-date Lake Bonneville. Relative age queried (Qatp?) where age is uncertain, generally due to height not fitting into ranges in table 1 and/or typical order of surfaces contradicts height-derived age.

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

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

Qmc – *Landslide and colluvial deposits, undivided (Holocene and Pleistocene).* Poorly sorted to unsorted clay- to boulder-sized material; mapped where landslide deposits are difficult to distinguish from colluvium (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).

Qafp, Qafp?, Qafb, Qafb?, Qafpb, Qafpb? – *Lake Bonneville-age alluvial-fan deposits (upper Pleistocene).* Like undivided alluvial fans, but height above present drainages appears to be related to shorelines of Lake Bonneville and is within certain limits (see table 1); these fans are inactive, unconsolidated to weakly consolidated, and locally dissected; fans labeled Qafp and Qafb are related to the Provo (and slightly lower) and Bonneville shorelines of late Pleistocene Lake Bonneville, respectively, while unit Qafpb is used where fans may be related to the Provo or Bonneville shoreline (for example Qafpb is ~40 feet [12 m] above Lost Creek Valley), or where fans of different ages cannot be shown separately at map scale; Qafp fans typically contain well-rounded, recycled Lake

Bonneville gravel and sand and are moderately well sorted; generally 10 to less than 60 feet (3-18 m) thick. Lake Bonneville-age fans are queried where relative age is uncertain (see Qaf for details); fans labeled Qafpb? are above the Bonneville shoreline and might be Qafo or like Qafm; see the note under Qao about two possible ages of older alluvium (Qao, Qato, and Qafo).

Most of the Lake Bonneville-age fans in the James Peak quadrangle are far from the Bonneville shoreline and their age is inferred from their stratigraphic relationship(s) to coeval Pinedale glacial outwash (see age equality in Table 3).

The channels (Qafp/Qdlb) on the Weber River delta and Lake Bonneville fines (Qafp on Qlfb) probably record scour and fill during the rapid drawdown of the lake as it fell from the Bonneville shoreline to the Provo shoreline.

***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.

***Ql, Ql?** – Lake Bonneville deposits, undivided (upper Pleistocene).* Silt, clay, sand, and cobbly gravel in variable proportions; mapped where grain size is mixed, deposits of different materials cannot be shown separately at map scale, or surface weathering obscures grain size and deposits are not exposed in scarps or construction cuts; thickness uncertain.

***Qlf, Qlf?, Qlfb, Qlfb?** – Fine-grained lacustrine deposits (Holocene and upper Pleistocene).* Mostly silt, clay, and fine-grained sand deposited near- and off-shore in Lake Bonneville; typically mapped as Qlf below the Provo shoreline (P) because older transgressive (Qlfb) deposits are indistinguishable from younger regressive deposits; mapped as Qlfb above the Provo shoreline because these deposits can only be related to the Bonneville shoreline (B) and transgression; grades upslope with more sand into Qls or Qlsp; typically eroded from shallow Norwood Formation in Ogden and Morgan Valleys and at least 12 feet (4 m) thick near Mountain Green. Qlf and Qlfb queried where grain size is uncertain.

In the Kaysville quadrangle, Qlf deposits that are below the Gilbert (G) shoreline are at least partly the same age as this shoreline (Holocene-latest Pleistocene) and post-date late Pleistocene Lake Bonneville. Qlf deposits below the Holocene (H) highstand shoreline are Holocene. Both ages of deposits are generally less than 15 feet (5 m) thick.

Deeper water fine-grained deposits overlie older shoreline and delta gravels (Qlf/Qdlb) at the mouths of several drainages along the Weber River. These gravels were deposited above the Provo shoreline during transgression of Lake Bonneville to the Bonneville shoreline (see unit Qdlb).

Qls, Qls?, Qlsp, Qlsb, Qlsb? *– Lake Bonneville sand (upper Pleistocene).* Mostly sand with some silt and gravel deposited nearshore below and near the Provo shoreline (Qlsp) and between the Provo and Bonneville shorelines (Qlsb); Qls mapped downslope from slope break below Provo shoreline beach deposits where thin Lake Bonneville regressional sand may overlie transgressional sand; grades downslope into unit Qlf with decreasing sand content and laterally with more gravel into units Qdlp, Qdlb, and upslope with more gravel into unit Qlgb; Qls and Qlsb queried where grain size or unit identification uncertain; may be as much as 75 feet (25 m) thick, and thickest near Ogden; typically less than 20 feet (6 m) thick in Morgan Valley; may include small deltas and deltas that lack typical delta shape.

Qla, Qla? *– Lake Bonneville lacustrine deposits and post- and pre-Lake Bonneville alluvial deposits, undivided (Holocene and upper? Pleistocene).* Mostly poorly sorted and poorly bedded sand, silt, and clay, with some gravel; mapped where Lake Bonneville deposits are reworked by later stream action or covered by thin stream and fan deposits, and where lake deposits are thin and overlie older alluvial deposits; unit queried where may be dominantly alluvium; deposits typically eroded from shallow Norwood Formation; mostly mapped near Bonneville shoreline; also mapped in Peterson quadrangle along upper Deep Creek above Bonneville shoreline where lake deposits seem to indicate landslide dam of creek; thickness uncertain.

Qao, Qao? *– Older alluvium (mostly upper Pleistocene).* Sand, silt, clay, and gravel above and likely older than the Bonneville shoreline; mapped on surfaces above Lake Bonneville-age alluvium (Qap, Qab, Qapb); deposits lack fan shape (Qaf) and are distinguished from terraces (Qat) based on upper surface sloping toward adjacent streams from sides of drainage; also shown where areas of fans and terraces are too small to show separately at map scale; composition depends on source area; at least locally up to 110 feet (34 m) thick. Queried where classification or relative age is uncertain (see Qa for details); for example near head of Saleratus Creek.

Older alluvium is likely older than Lake Bonneville and the same age as Qafo, so likely Bull Lake age, 95,000 to 130,000 years old (see Chadwick and others, 1997, and Phillips and others, 1997); see table 1 and note revision from Coogan and King (2006) and King and others (2008). From our work in the Henefer (Coogan, 2010b) and Devils Slide quadrangles and ages in Sullivan and Nelson (1992) and Sullivan and others (1988), older alluvium (Qao, Qafo, Qato) may encompass an upper (pre-Bull Lake) and lower (Bull Lake) alluvial surface that is not easily recognized in Morgan Valley (see tables 1 and 2).

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.

ZYp, ZYp? *– Formation of Perry Canyon (Neoproterozoic and possibly Mesoproterozoic).* Argillite to metagraywacke upper unit, middle meta-diamictite, and basal slate, argillite, and meta-sandstone; phyllitic at least south of Pineview Reservoir; due to overturned folding, only one diamictite unit (Adolph Yonkee, Weber State University, February 2, 2011, email communication) rather than two (see Crittenden and others, 1983); total thickness likely less than 2000 feet (600 m) (this report). Queried in knob west of North Fork Ogden River in North Ogden quadrangle because rock is quartzite that may be in this unit or the Papoose Creek Formation. The formation of Perry Canyon is prone to slope failures.

Balgord's (2011; Balgord and others, 2013) detrital zircon uranium-lead and lead-lead maximum depositional ages (~950-1030 Ma) on the basal mudstone unit straddle the Upper and Middle Proterozoic boundary, but other maximum ages (925 Ma) on this mudstone unit are Upper Proterozoic; her maximum ages on the upper unit are about 640, 660, and 690 Ma.

Lower part of formation not measured where thick in the Wasatch Range and stratigraphy not worked out, because upper and lower parts incompletely measured and at least locally the upper and lower parts in the Wasatch Range are lithologically indistinguishable. Unit ("member") thicknesses vary due to syndepositional faulting (see Balgord and others, 2013). The best stratigraphic section of the lower unit (ZYpm), volcanic unit (Zpb), and diamictite (Zpd) is 30 miles (50 km) to the southwest on Fremont Island in Great Salt Lake, but the base of ZYpm is not exposed (see Balgord, 2011, figure 14, p. 51; Balgord and others, 2013, figure 5). The Fremont Island section is likely in a different Proterozoic faulted basin; compare thicknesses and lithologies between Fremont Island and Willard Peak shown by Balgord (2011, Balgord and others (2013). Also, although both localities are shown on the Willard thrust sheet by Yonkee and Weil (2011), they may be on different thrust sheets. Therefore, the formal term Perry Canyon Formation is not used. Where possible divided into several lithosomes which have been called members.

Citations, tables, and/or figures referenced above are not provided herein but are in Coogan and King (2016).

4.2 Seismotectonic Setting

The water tank site is located at the southern margin of Ogden Valley, a roughly 40-square mile back valley described by Gilbert (1928) as a structural trough similar to Cache and Morgan Valleys to the north and south, respectively. The back valleys of the northern Wasatch Range are in a transition zone between the Basin and Range and Middle Rocky Mountains physiographic 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 marked by 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 back valleys are morphologically similar to valleys in the Basin and Range, but exhibit less structural relief (Sullivan and others 1988).

Ogden Valley occupies a structural trough created by up to 2,000 feet of vertical displacement on normal faults bounding the northeastern and southwestern margins of the valley. Based on the Utah Geological Survey Quaternary Fault Database (Black and others, 2003; January 2017 update), the Ogden Valley northeastern margin fault is about

4.6 miles to the northeast of the water tank site and the Ogden Valley southwestern margin fault about 0.2 miles to the west. Both faults were most-recently active more than 10,000 years ago (Sullivan and others, 1986). The nearest active (Holocene-age) fault to the water tank is the Weber segment of the Wasatch fault zone about 5.8 miles to the west.

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 north of Magna, Utah reportedly showed a style, location, and slip depth consistent with an earthquake on the Wasatch fault system (https://earthquake.usgs.gov/earthquakes/eventpage/uu60363602/executive). Despite being less than magnitude 6.0, this earthquake was felt from southern Idaho to south-central Utah and damaged multiple building (https://www.ksl.com/article/46731630/). The University of Utah Seismograph Stations (https://earthquakes.utah.gov/magna-quake/#) 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).

4.3 Lake Bonneville History

Lakes occupied nearly 100 basins in the western United States during late-Quaternary time, the largest of which was Lake Bonneville in northwestern Utah. The Bonneville basin consists of several topographically closed basins created by regional extension in the Basin and Range (Gwynn, 1980; Miller, 1990), and has been an area of internal drainage for much of the past 15 million years. Lake Bonneville consisted of numerous topographically closed basins, including the Salt Lake and Cache Valleys (Oviatt and others, 1992). Portions of Ogden Valley were inundated by Lake Bonneville at its highstand, including the northern part of the Project. The highest (Bonneville) shoreline is mapped on Plate 1 crossing the northern part of the Legacy Mountain Development (blue line and B).

Timing of events related to the transgression and regression of Lake Bonneville is indicated by calendar age estimates of significant radiocarbon dates in the Bonneville Basin (Oviatt, 2015). Approximately 30,000 years ago, Lake Bonneville began a slow transgression (rise) to its highest level of 5,160 to 5,200 feet above mean sea level. The lake rise eventually slowed as water levels approached an external basin threshold in northern Cache Valley at Red Rock Pass near Zenda, Idaho. Lake Bonneville reached the Red Rock Pass threshold and occupied its highest shoreline, termed the Bonneville beach, around 18,000 years ago. During the transgression and highstand, major drainages that emanate from within the Wasatch Range (such as the Weber River) formed large deltaic complexes in the lake at their canyon mouths. Headward erosion of the Snake River-Bonneville basin drainage divide then caused a catastrophic incision of the threshold and the lake level lowered by roughly 360 feet in fewer than two months (Jarrett and Malde, 1987; O’Conner, 1993).

Following the Bonneville flood, the lake stabilized and formed a lower shoreline referred to as the Provo shoreline between about 16,500 and 15,000 years ago. Climatic factors then caused the lake to regress rapidly from the Provo shoreline, and by about 13,000 years ago the lake had eventually dropped below historic levels of Great Salt Lake. Drainages that fed Lake Bonneville began downcutting through stranded deltaic complexes and near-shore deposits as the lake receded from the Provo shoreline. Oviatt and others (1992) deem this low stage the end of the Bonneville lake cycle. Great Salt Lake then experienced a brief transgression around 11,600 years ago to the Gilbert level at about 4,250 feet before receding to and remaining within about 20 feet of its historic average level (Lund, 1990).

5.0 SITE CHARACTERIZATION

5.1 Empirical Observations

On November 24, 2020, Bill D. Black, P.G. of Western Geologic conducted a reconnaissance of the water tank site. Weather at the time of the site visit was clear with a temperature of about 42 °F. The site was accessed via a newly graded dirt road that extends from Snow Basin Road.

The site is in southern Ogden Valley at the top of an east-plunging ridge overlooking Poison Hollow. Native vegetation in the area appeared to consist mainly of dense brush and trees. No active, perennial or intermittent drainages cross the site and no seeps or springs were observed in the site area. No evidence for recent or ongoing slope instability, characteristic debris flow features, significant bedrock outcrops, or other geologic hazards was observed.

5.2 Air Photo Observations

High-resolution orthophotography from 2012, bare earth LIDAR (Light Imaging Detection and Ranging) digital elevation mapping from 2016, and NAIP orthophotography from 2018 available from the Utah AGRC were reviewed to obtain information about the geomorphology of the Project area (Figures 3A-C). Site-specific surficial geologic mapping for the area is shown on Plate 1 and Figures 3A-C.

Figure 3B shows slopes at the Legacy Mountain Development vary in aspect and steepness, although the water tank is on the top of an east-trending ridge with relatively gentle slopes. The ridge overlooks and is at the head of Poison Hollow, which crosses the western part of the Legacy Mountain Development. Poison Hollow is underlain by a sequence of landslides of varying ages. The water tank site is at the crest of an eroded landslide scarp; deposits of the landslide are at lower elevations to the north. The ridge is underlain by Tertiary Norwood Formation bedrock. The trend of the ridge roughly mimics the regional bedrock strike. No evidence for other geologic hazards was observed on the air photos at the site.

5.3 Subsurface Investigation

Twenty-five test pits were excavated at the Legacy Mountain Development for our prior study, and one additional walk-in test pit (TP-26) was excavated and logged on November 24 to assess subsurface conditions in the area of the water tank. The test pit was logged by Bill D. Black, P.G. of Western Geologic concurrently with the Project geotechnical investigation conducted by Christensen Geotechnical. Locations of the new test pit and test pits conducted for our prior study are shown on Plate 1. Four test pits from our prior investigation are in the area of the proposed water tank, and the new test pit (TP-26, Plate 1) is in the tank footprint. Locations were measured using a hand-held GPS unit and by trend and distance methods, and the test pit was logged at a scale of 1-inch equals five feet (1:60) following methodology in McCalpin (1996). The test pit was digitally photographed at 5-foot intervals to document the exposures. The photos are not provided herein, but are available on request. The cover photo for this report shows a south-facing overview of TP-26.

Logs for test pits TP-16, TP-17, TP-18, and TP-19 from our prior study are provided on Figures 4A-B. A log of the new test pit (TP-26) is provided on Figure 4C. Stratigraphic interpretations, descriptions, and bedrock strike and dips (where measured) are provided on the logs. No groundwater was encountered in any of the test pit exposures to their explored depths. TP-26 exposed dense tuffaceous conglomerate to sandstone of the Tertiary Norwood Formation. Although the modern A-horizon soil had been removed by grading for the tank and access road, a laminated stage IV+ carbonate K horizon was evident in the bedrock. Lamina in the K horizon mimicked the slope aspect. No strike and dip could be measured in TP-26 due to a lack of distinct bedding, but other conglomerate exposures in test pits at the Legacy Mountain Development also lacked distinct bedding.

5.4 Cross Sections

Figure 5 shows one geologic cross section across critical slopes at the water tank site. The cross section is an extension of cross section F-F' from our prior report. The cross section is at a scale of 1 inch equals 100 feet with no vertical exaggeration. Location of the cross section is shown on Plate 1. Units and contacts are based on subsurface data from the test pits (Figures 4A-C) and/or the geologic mapping on Plate 1. The topographic profile is based on geoprocessed 2016 LIDAR data. The LIDAR data provides a snapshot of topographic conditions at the time it was acquired; 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. Schematic bedding dips were determined from http://app.visiblegeology.com/apparentDip.html based on the profile trend and average strike and dips measured in test pits along the profile or nearby. We recommend residual strengths be used in slope stability analyses for colluvial units shown with an asterisk on the cross section.

6.0 GEOLOGIC HAZARDS

Assessment of potential geologic hazards and the resulting risks imposed is critical in determining the suitability of the site for development. Table 1 below shows a summary of the geologic hazards reviewed at the site, as well as a relative (qualitative) assessment of risk to the Project for each hazard. A "high" hazard rating (H) indicates a hazard is present at the site (whether currently or in the geologic past) that is likely to pose significant risk and/or may require further study or mitigation techniques. A "moderate" hazard rating (M) indicates a hazard that poses an equivocal risk. Moderate-risk hazards may also require further studies or mitigation. A "low" hazard rating (L) indicates the hazard is not present, poses little or no risk, and/or is not likely to significantly impact the Project. Low-risk hazards typically require no additional studies or mitigation. We note that these hazard ratings represent a conservative assessment for the entire site and risk may vary in some areas. Careful selection of development areas can minimize risk by avoiding known hazard areas.

Table 1. *Geologic hazards summary for the water tank site.*

Hazard	H	M	L
Earthquake Ground Shaking	X		
Surface Fault Rupture			X
Liquefaction and Lateral-spread Ground Failure			X
Tectonic Deformation			X
Seismic Seiche and Storm Surge			X
Stream Flooding			X
Shallow Groundwater			X
Landslides and Slope Failures	X		
Debris Flows and Floods			X
Rock Fall			X
Problem Soil and Rock			X

6.1 Earthquake Ground Shaking

Ground shaking refers to the ground surface acceleration caused by seismic waves generated during an earthquake. 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; January 2017 update) shows numerous class A faults within 60 miles of the Project that may pose potential seismic sources.

The extent of property damage and loss of life due to ground shaking depends on factors such as: (1) proximity of the earthquake and strength of seismic waves at the surface (horizontal motions are the most damaging); (2) amplitude, duration, and frequency of ground motions; (3) nature of foundation materials; and (4) building design.

Based on 2018 IBC provisions and a risk category of IV, calculated seismic values for the site (centered on 41.240857° N, -111.815606° W) for a site class of C (soft rock) are:

Table 2A. *Seismic hazards summary.*

Type	Value
S_S	*0.892 g*
S_1	*0.316 g*
S_{MS} (F_a x S_S)	*1.07 g*
S_{M1} (F_v x S_1)	*0.474 g*
S_{DS} (2/3 x S_{MS})	*0.713 g*
S_{D1} (2/3 x S_{M1})	*0.316 g*
Site Coefficient, F_a	*= 1.2*
Site Coefficient, F_v	*= 1.5*
Peak Ground Acceleration, PGA	*= 0.395 g*

The site class should be confirmed by the Project geotechnical engineer. Given the above information, we rate the hazard from earthquake ground shaking as high. Earthquake ground shaking is a regional hazard common to all Wasatch Front areas. The hazard is mitigated by design and construction in accordance with the current adopted building code.

6.2 Surface Fault Rupture

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 surface faulting is mapped or was evident at the site. The nearest active (Holocene-age) fault to the water tank site is the Weber segment of the WFZ about 5.8 miles to the west. Given the above, the risk from surface faulting is low. No additional investigation regarding surface faulting appears needed given the site location and current paleoseismic information.

6.3 Liquefaction and Lateral-Spread Ground Failure

Liquefaction occurs when saturated, loose, cohesionless, soils lose their support capabilities during a seismic event because of the development of excessive pore pressure. Earthquake-induced liquefaction can present a significant risk to structures from bearing-capacity failures to structural footings and foundations, and can damage structures and roadway embankments by triggering lateral spread landslides. Earthquakes of Richter magnitude 5 are generally regarded as the lower threshold for liquefaction. Liquefaction potential at the site is a combination of expected seismic (earthquake ground shaking) accelerations, groundwater conditions, and presence of susceptible soils.

No subsurface soils susceptible to liquefaction are present at the water tank site or observed in TP-26. Based on this, we rate the risk from liquefaction as low. Weber County hazard mapping also shows the water tank site in an area of low liquefaction potential (code 1).

6.4 Tectonic Deformation

Tectonic deformation refers to subsidence from warping, lowering, and tilting of a valley floor that accompanies surface-faulting earthquakes on normal faults. Large-scale tectonic subsidence may accompany earthquakes along large normal faults (Lund, 1990). Tectonic subsidence is believed to mainly impact those areas immediately adjacent to the downthrown side of active normal faults.

The Project is not in close proximity to and on the downthrown side of any mapped active (Holocene) faults. Based on this, we rate the risk from tectonic subsidence as low.

6.5 Seismic Seiche and Storm Surge

Earthquake-induced seiche presents a risk to structures within the wave-oscillation zone along the edges of large bodies of water, such as the Great Salt Lake. Given the elevation of the subject property and distance from large bodies of water, we rate the risk from seismic seiches as low.

6.6 Stream Flooding

Stream flooding may be caused by direct precipitation, melting snow, or a combination of both. In much of Utah, floods are most common in April through June during spring snowmelt. High flows may be sustained from a few days to several weeks, and the potential for flooding depends on a variety of factors such as surface hydrology, site grading and drainage, and runoff.

No perennial, intermittent or ephemeral drainages are mapped crossing the site, were evident on air photos, or were observed during our reconnaissance. Federal Emergency Management Agency flood insurance rate mapping (Map Number 49057C0475F, effective 06/02/2015) classify the water tank site in "Zone X" (area of minimal flood hazard). Based on the above, the risk from stream flooding is low.

6.7 Shallow Groundwater

Given evidence discussed in the Hydrology Section above, groundwater at the water tank site is likely more than 100 feet deep. Although shallower levels may occur seasonally, as would be expected for an alpine environment, we do not anticipate that groundwater will pose a significant development constraint. We therefore rate the risk from shallow groundwater as low. However, groundwater is a significant trigger for slope instability. Care should therefore be taken that proper surface and subsurface drainage is maintained.

6.8 Landslides and Slope Failures

Slope stability hazards such as landslides, slumps, and other mass movements can develop along 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. Steep slopes underlain by landslide-prone bedrock (such as the Norwood Formation), slopes exhibiting prior failures, and deposits from landslides are particularly vulnerable to instability.

The water tank is on a ridge top at the crest of an eroded landslide scarp. Deposits from the landslide are in lower slopes in Poison Hollow to the north. Based on the exposure in TP-26, near-surface bedrock underlying the ridge appears to be conglomerate of the Tertiary Norwood Formation, which is a landslide-prone geologic unit. Given the above, we rate the risk from landsliding at the site as high. We recommend the Project geotechnical engineer evaluate stability of slopes at the site based on site-specific soil conditions and the data provided in this report. Recommendations should be provided to reduce the landslide hazard risk if factors of safety are determined to be unsuitable. Water, steep man-made cuts, and non-engineered fill materials are often major contributors to slope instability. Care should therefore also be taken to maintain proper site drainage, that site grading does not destabilize slopes at the site without prior geotechnical analysis and grading plans, and that water from man-made sources is minimized in potentially unstable slope areas.

6.9 Debris Flows

Debris flow hazards are typically associated with unconsolidated alluvial fan deposits at the mouths of large range-front drainages, such as those along the Wasatch Front. Debris flows have historically caused significant damage in the Wasatch Front area. The water tank site is not in an area subject to alluvial-fan flooding and no debris-flow channels, levees, or other debris-flow features were observed. We therefore rate the hazard from debris flows to the Project as low.

6.10 Rock Fall

No bedrock outcrops were observed at the site or in higher slopes that could present a source area for rock fall clasts. We therefore rate the hazard from rock falls to the Project as low.

6.11 Problem Soil and Rock

Surficial soils that contain certain clays can swell or collapse when wet. Based on subsurface data from TP-26 (Figure 4C), no soils likely susceptible to swelling or collapse appear to be present at the water tank site. The Project geotechnical engineer should evaluate site-specific soil conditions and provide recommendations for site grading, subgrade preparation, and footing and foundation design.

7.0 CONCLUSIONS AND RECOMMENDATIONS

Earthquake ground shaking and landslides pose a high relative geologic hazard risk to the water tank site. The hazard from ground shaking is common to all Wasatch Front areas. The following recommendations are provided with regard to the geologic characterizations in this report:

- ***Seismic Design*** **–** The water tank should be constructed to current adopted seismic design standards to reduce the risk of damage from earthquake ground shaking. The Project geotechnical engineer should confirm the ground-shaking hazard and provide appropriate seismic design parameters as needed.

- ***Geotechnical Considerations*** **–** The Project geotechnical engineer should address soil conditions at the site for use in the water tank design, site grading and drainage. The Project geotechnical engineer should also evaluate stability of slopes at the site, including providing recommendations for reducing the risk of landsliding if the factors of safety are deemed unsuitable. The stability evaluation should be based on site-specific geotechnical data, the geologic characterizations in this report, and the geologic characterizations in our prior report for the Legacy Mountain Development as they are applicable to the water tank site.

- ***Site Modifications and Drainage*** **–** No unplanned cuts should be made in the slopes at the site without prior geotechnical analyses, and proper surface and subsurface drainage should be maintained.

- ***Excavation Backfill*** **–** The water tank is located in the area of test pit TP-26. We recommend that all fill materials beneath the tank footprint be removed and the water tank be founded in native bedrock. We anticipate this will occur anyway given the explored depth of TP-26 and our understanding of the Project.

- ***Report Availability*** **–** This report should be made available to the Project geotechnical, civil and/or structural engineers so that they can assess design needs with regard to site-specific geologic conditions. The report should be referenced for information on technical data only as interpreted from observations and not as a warranty of conditions throughout the site. The report should be submitted in its entirety, or referenced appropriately, as part of any document submittal to a government agency responsible for planning decisions or geologic review. Incomplete submittals void the professional seals and signatures we provide herein. Although this report and the data herein are the property of the client, the report format is the intellectual property of Western Geologic and should not be copied, used, or modified without express permission of the authors.

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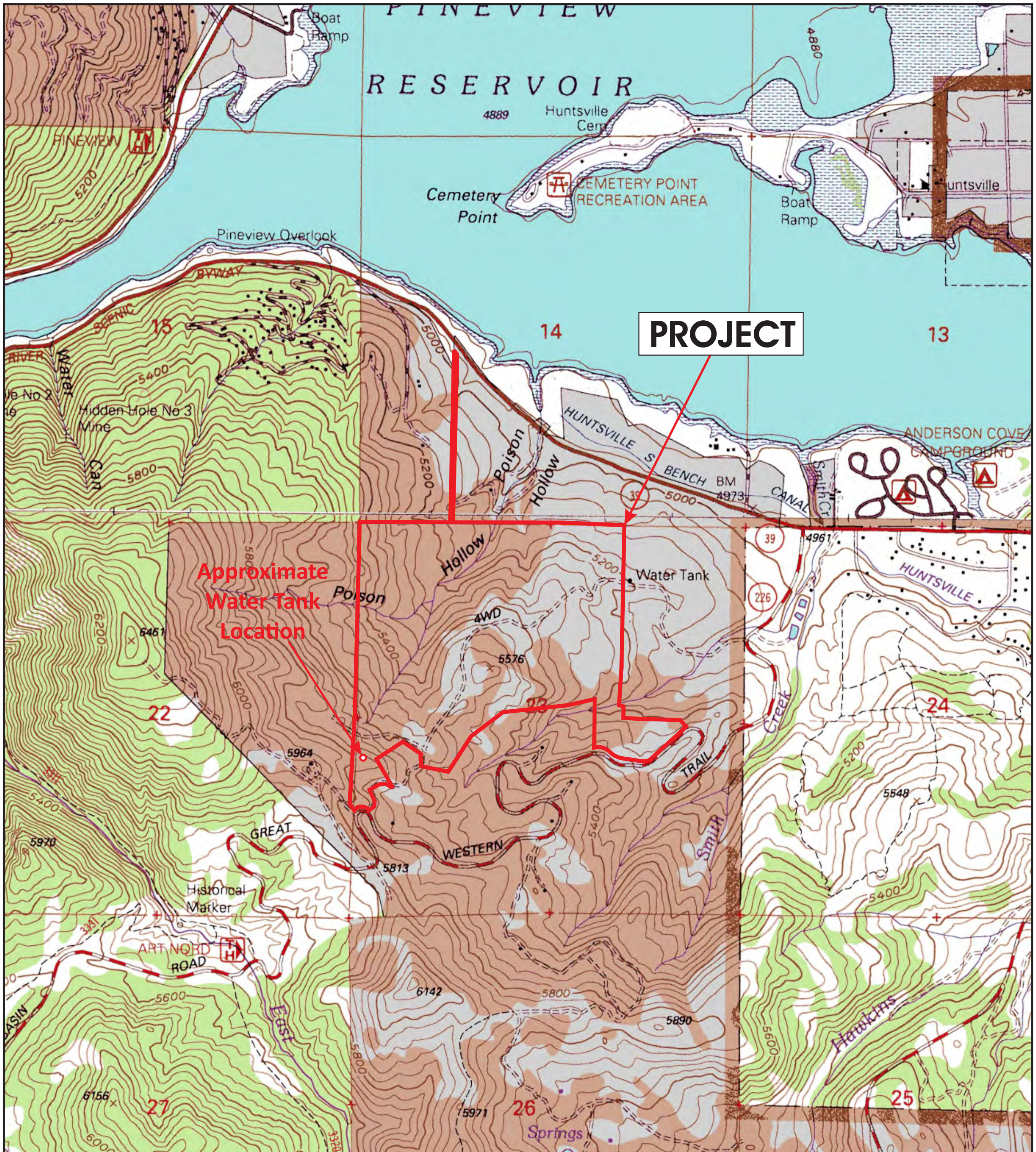
FIGURES



Source: U.S. Geological Survey 7.5 Minute Series Topographic Maps, Utah - Huntsville and Snow Basin, 1998.

Scale 1:24,000
(1 inch = 2000 feet)

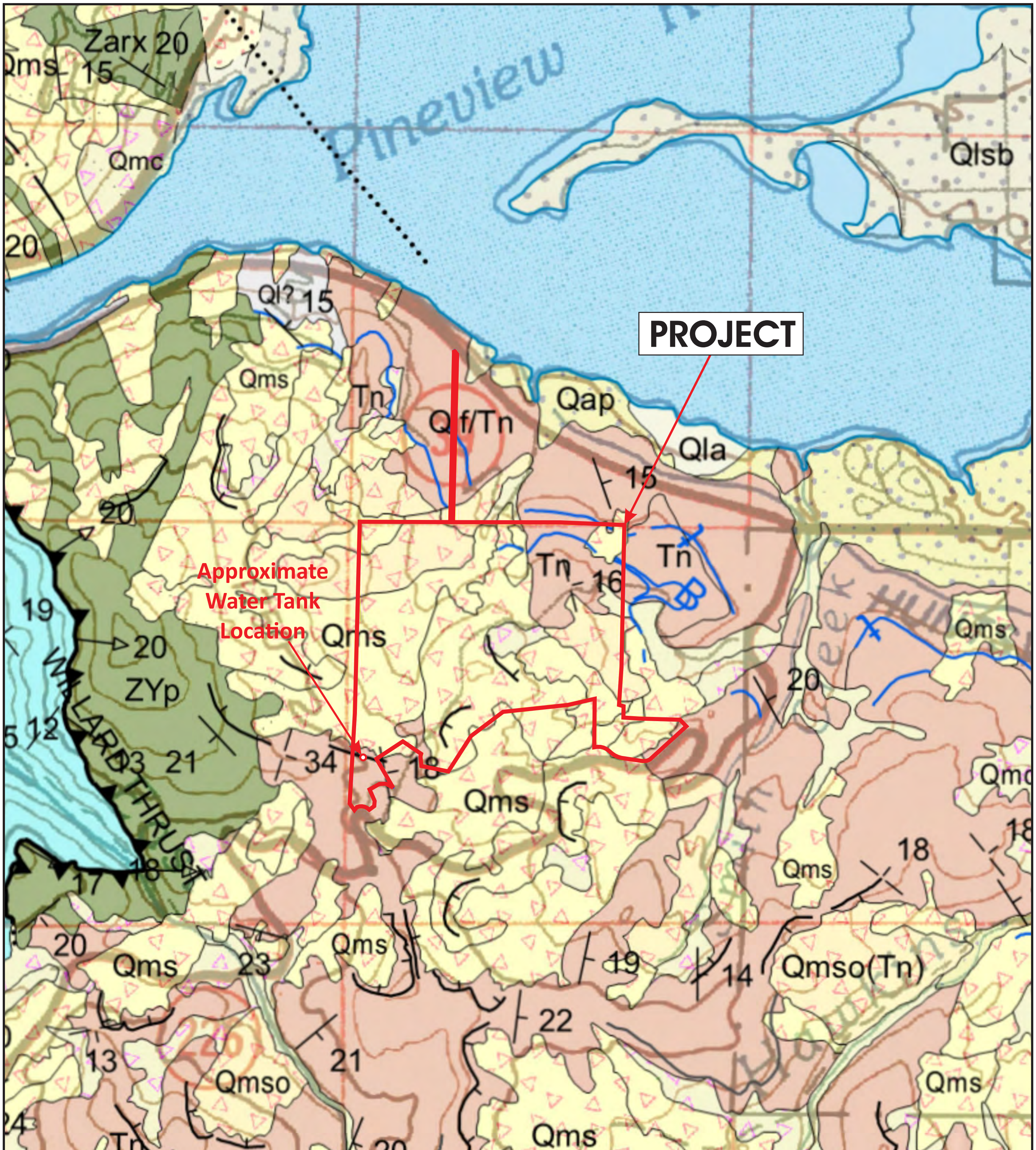
0 1000 2000 feet

LOCATION MAP

GEOLOGIC HAZARDS EVALUATION

Proposed Water Tank
Legacy Mountain Development
Sections 14 and 23, T. 6 N., R. 1 E.
Huntsville, Weber County, Utah

FIGURE 1



Source: Coogan and King (2016), original map scale 1:100,000. See text for explanation of nearby surficial geologic units.

WESTERN GEOLOGIC

N
W E
S

0 1000 2000 feet

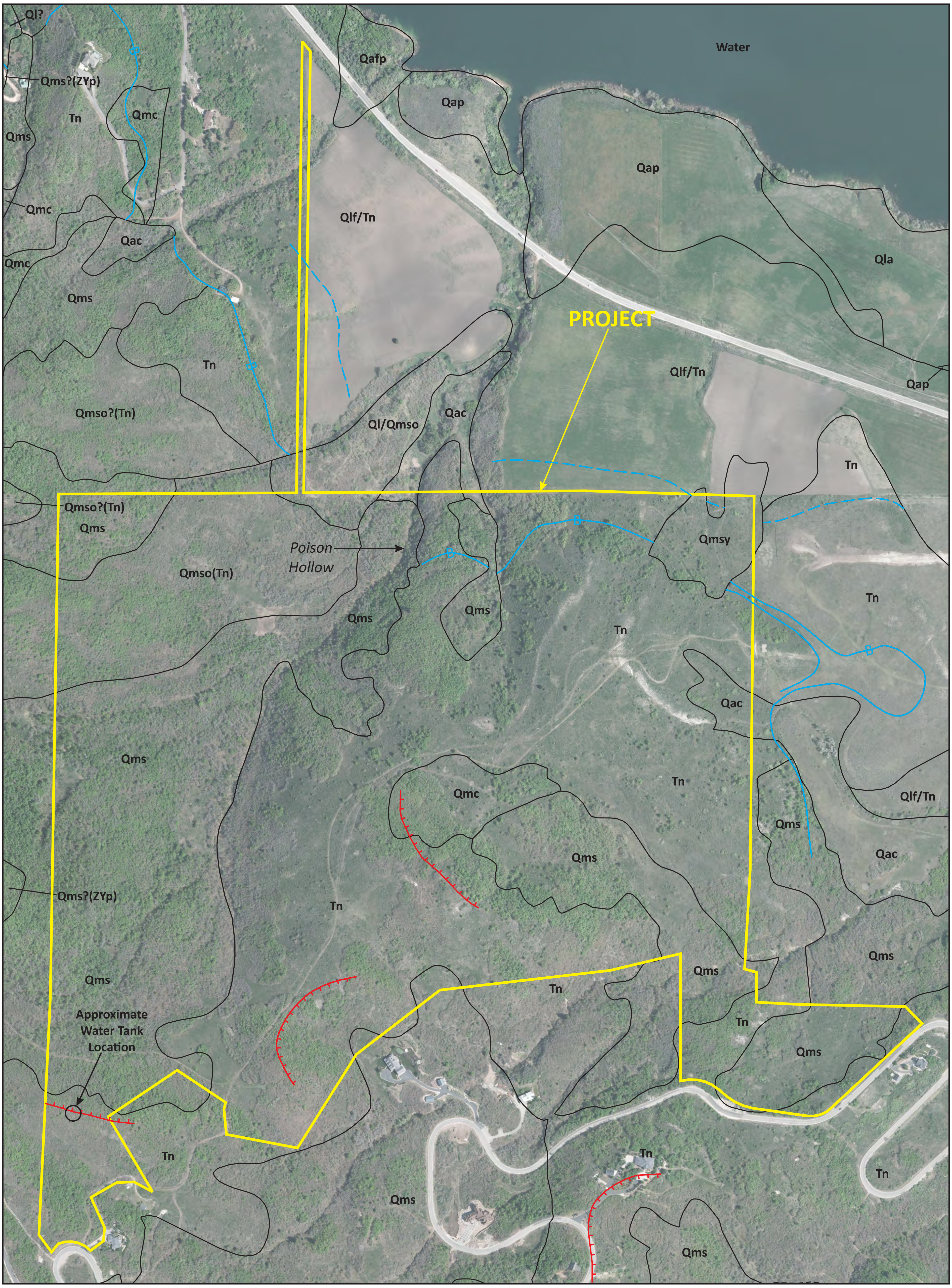
Scale 1:24,000
(1 inch = 2000 feet)

REGIONAL GEOLOGIC MAP

GEOLOGIC HAZARDS EVALUATION

Proposed Water Tank
Legacy Mountain Development
Sections 14 and 23, T. 6 N., R. 1 E.
Huntsville, Weber County, Utah

FIGURE 2



Source: Utah AGRC, 2012 High Resolution Orthophoto, 12.5 cm resolution.

0 500 1000 feet

Scale 1:6,000 (1 inch equals 500 feet)

N W E S

WESTERN GEOLOGIC

2012 AIR PHOTO

GEOLOGIC HAZARDS EVALUATION

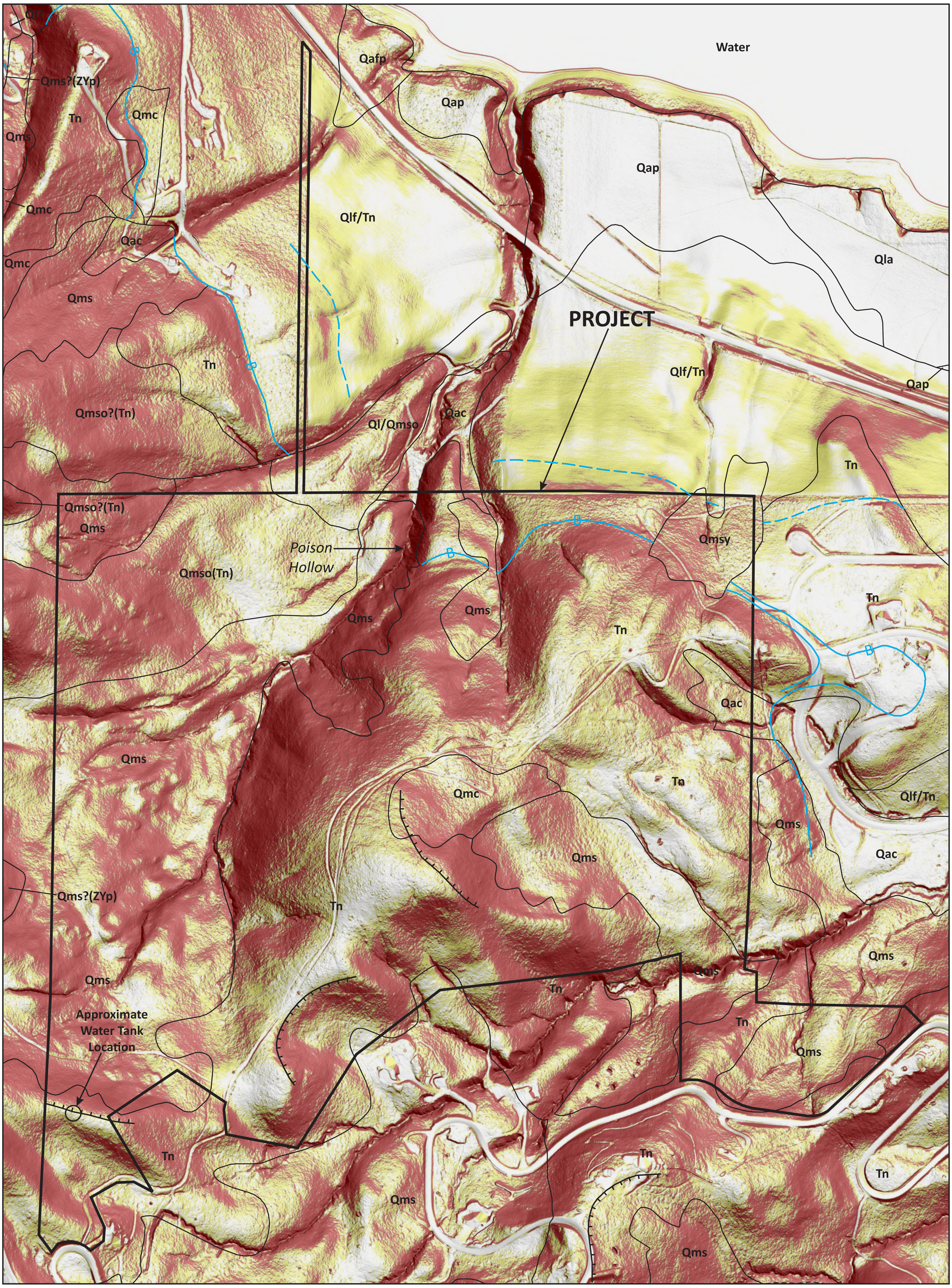
Proposed Water Tank

Legacy Mountain Development

Sections 14 and 23, T. 6 N., R. 1 E.

Huntsville, Weber County, Utah

FIGURE 3A



Source: Utah AGRC, 2016 LIDAR Bare Earth DEM, 50 cm resolution; slope gradients <15% unshaded, 15-25% in yellow, and >25% in red.

0 500 1000 feet
Scale 1:6,000 (1 inch equals 500 feet)

N W E S

WESTERN GEOLOGIC

LIDAR ANALYSIS

GEOLOGIC HAZARDS EVALUATION
Proposed Water Tank
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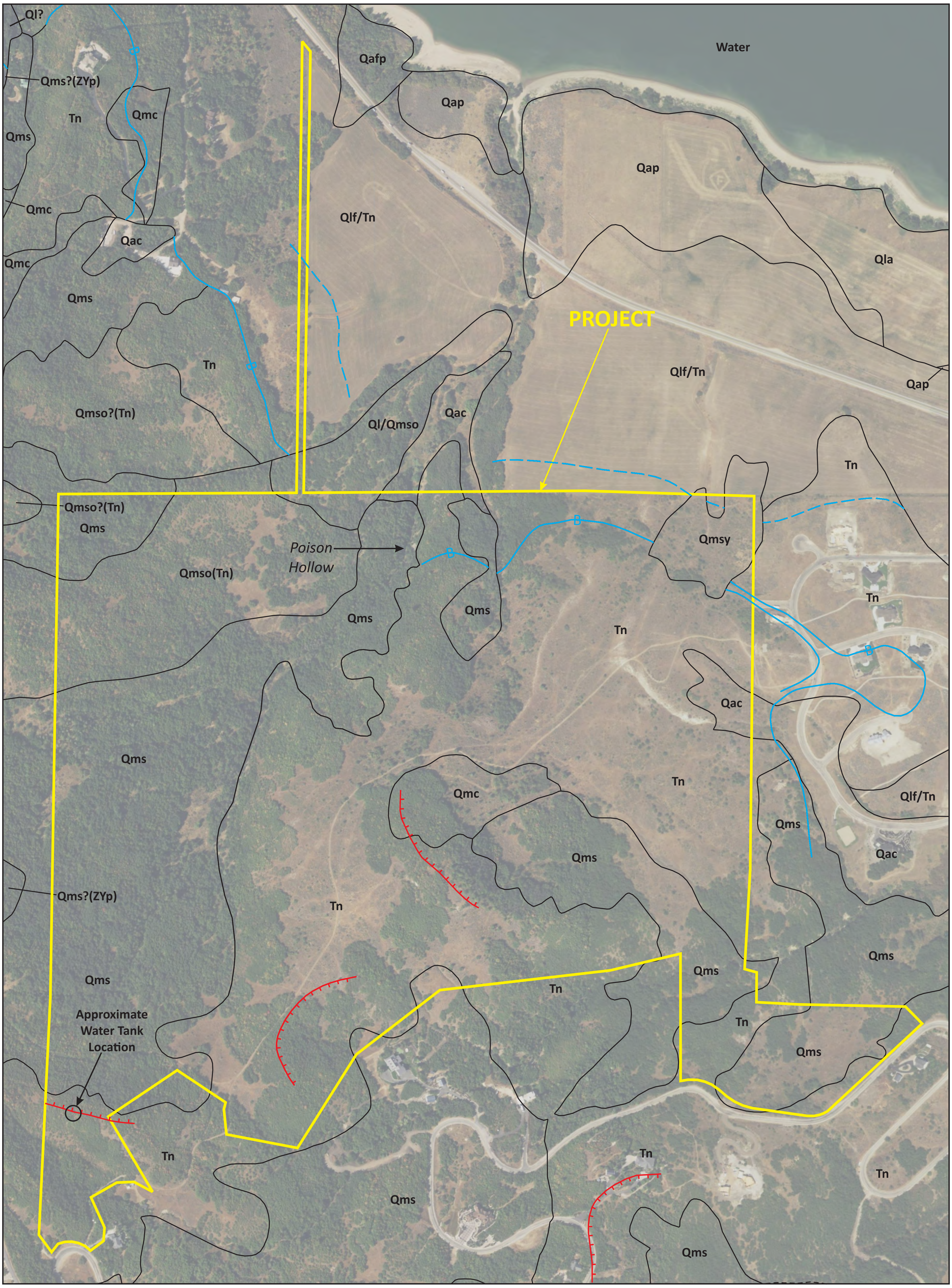
Huntsville, Weber County, Utah

FIGURE 3B



Source: Utah AGRC, 2018 NAIP orthophoto, 60 cm resolution.

0 500 1000 feet
Scale 1:6,000 (1 inch equals 500 feet)

N W E S

WESTERN GEOLOGIC

2018 AIR PHOTO

GEOLOGIC HAZARDS EVALUATION
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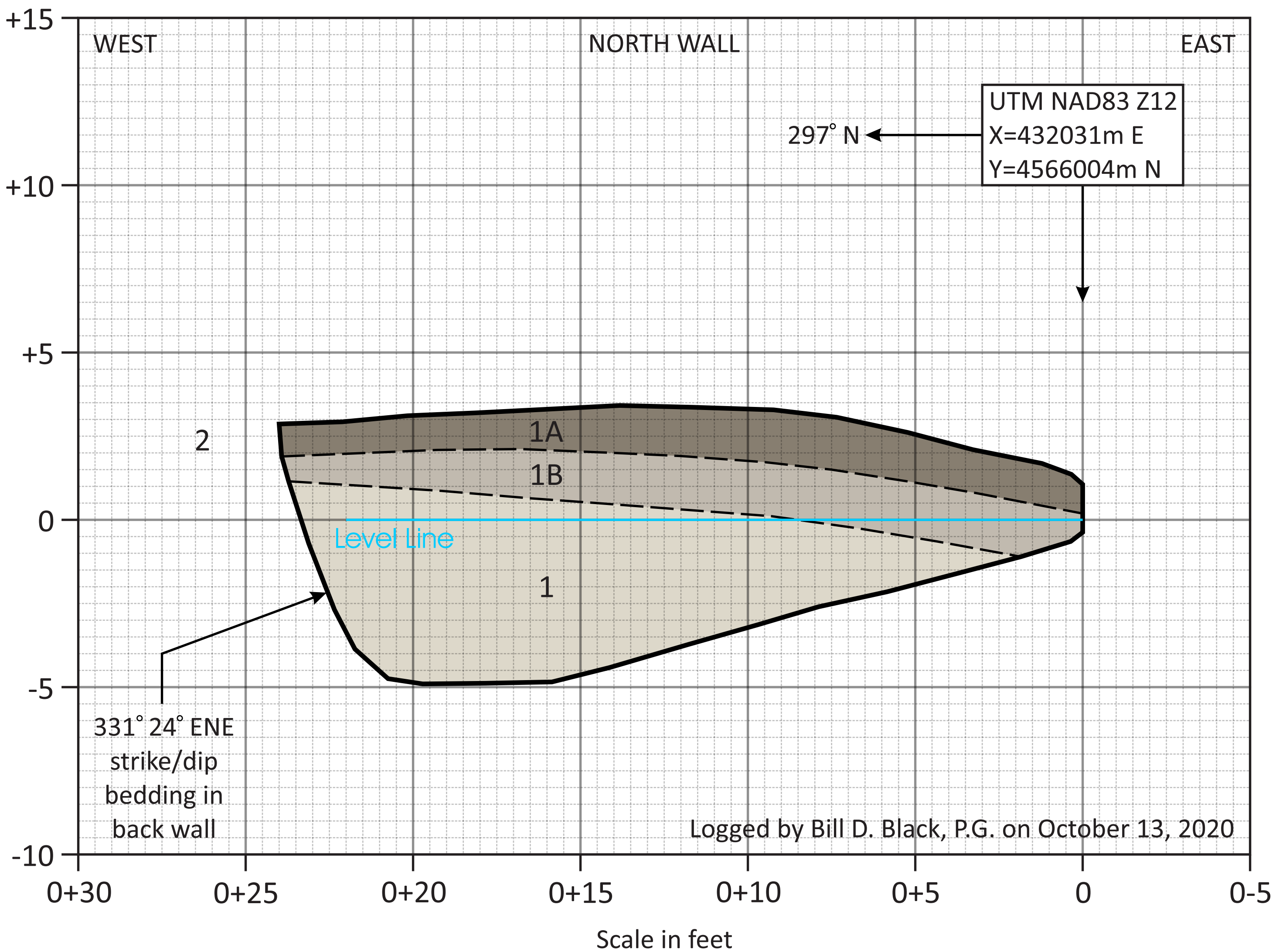
FIGURE 3C

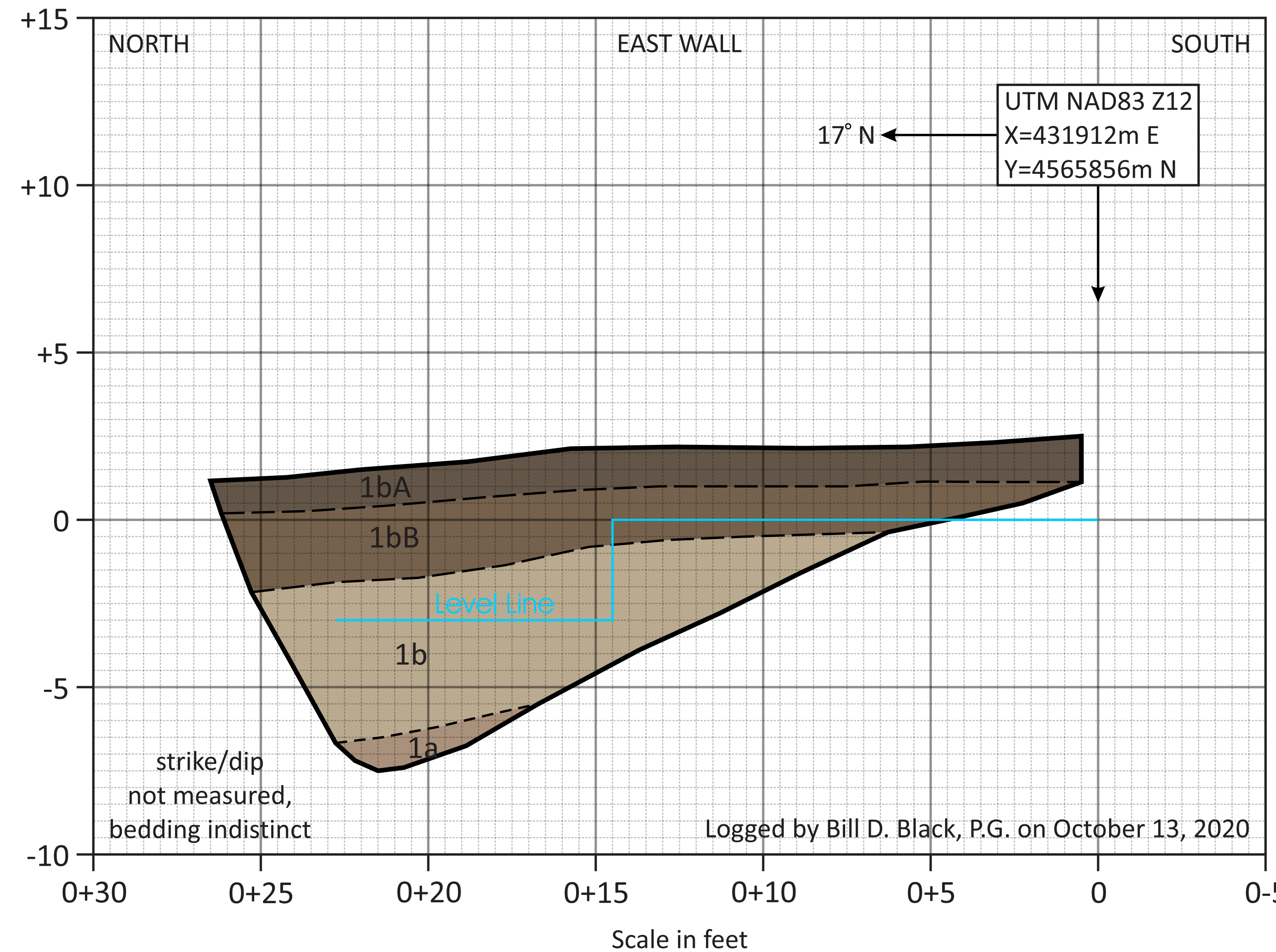
TEST PIT 16



UNIT DESCRIPTIONS

Unit 1. *Tertiary Norwood Formation* - weathered, brownish-olive-gray, high density, poorly to well bedded, tuffaceous clayey sandstone; A and B soil horizons formed at surface (units 1A and 1B).

TEST PIT 17



UNIT DESCRIPTIONS

Unit 1. *Tertiary Norwood Formation* - sequence of weathered tuffaceous bedrock comprised of a lower (1a) high density, massive to poorly bedded, conglomerate with a sandy clay matrix; and an upper (1b) brown to dark brown, high density, massive, sandy claystone with trace gravel; A and B soil horizons formed in unit 1b at surface (units 1bA and 1bB).

WESTERN GEOLOGIC

Scale 1 inch equals 5 feet with no vertical exaggeration

TEST PIT LOGS, SHEET 1

GEOLOGIC HAZARDS EVALUATION
Proposed Water Tank
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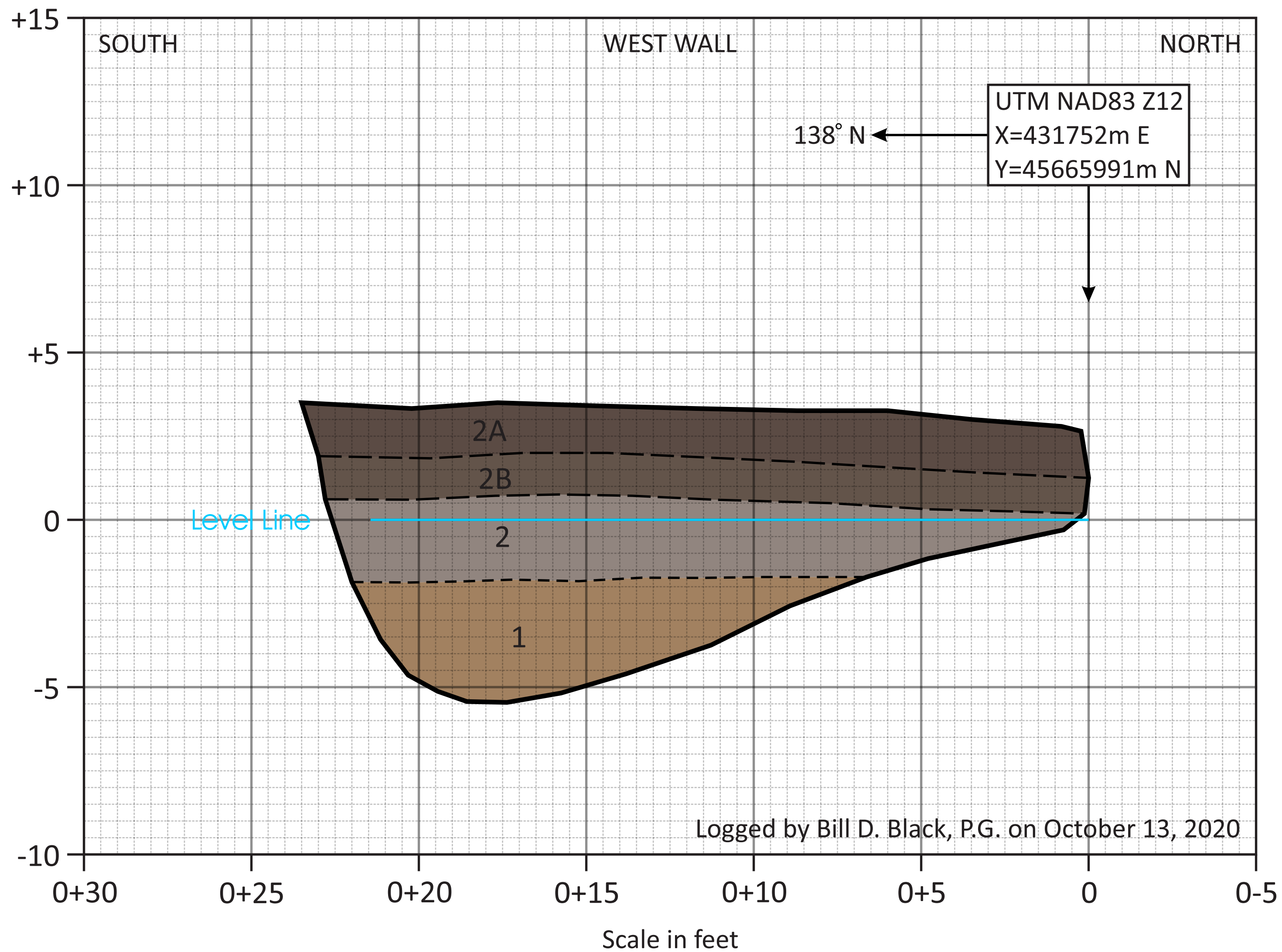
FIGURE 4A

TEST PIT 18

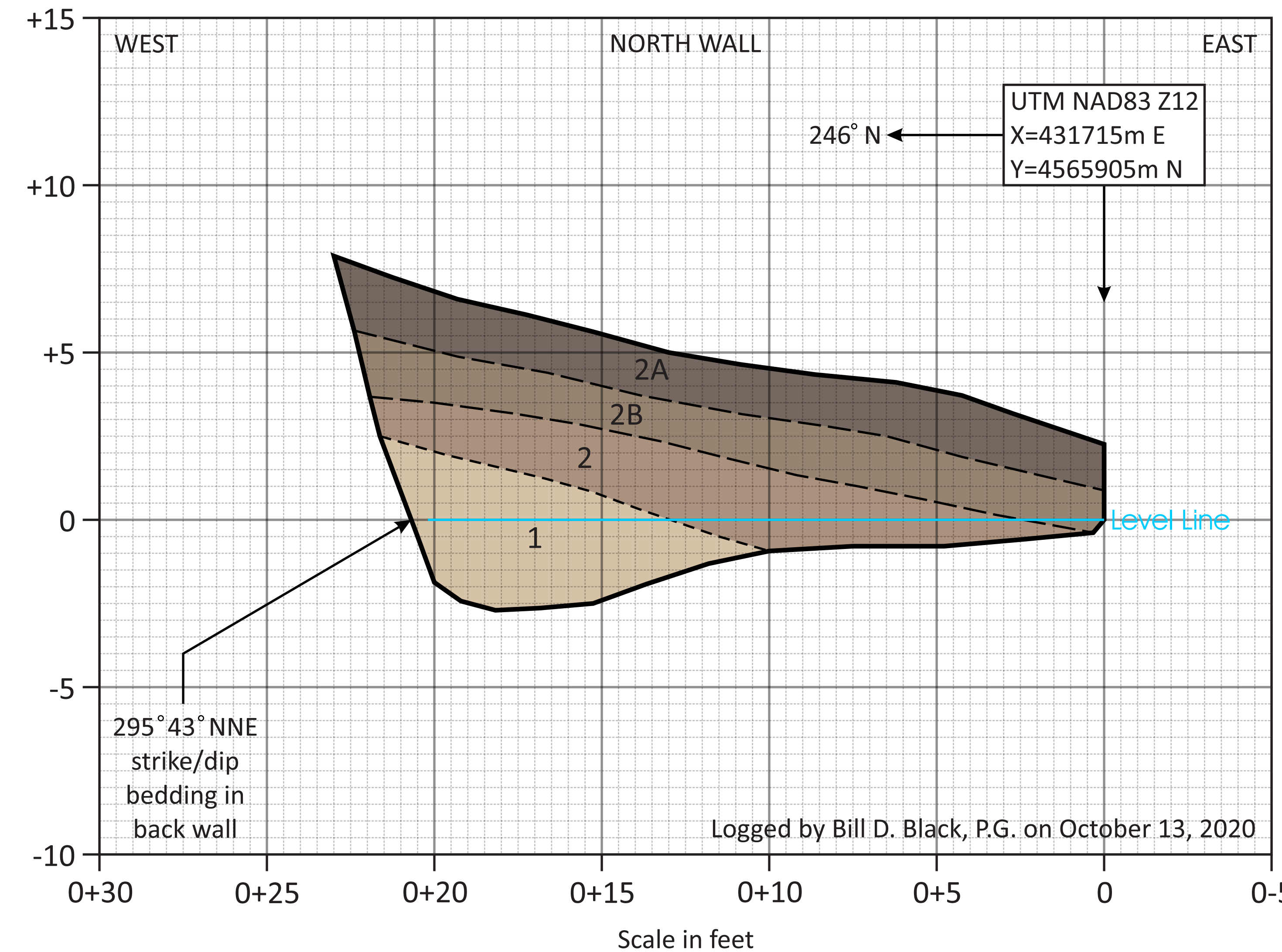


UNIT DESCRIPTIONS

Unit 1. *Late Pleistocene landslide colluvium* - yellowish-brown, high density, massive, lean to fat clay (CL/CH) with sand, trace gravel, and cobbles near trench floor.

Unit 2. *Late Pleistocene to early Holocene landslide colluvium* - brown to dark brown, moderate-high density, massive, sandy clay (CL) with trace gravel; A soil horizon and weak B horizon formed in unit 2 at surface (units 2A and 2B).

TEST PIT 19



UNIT DESCRIPTIONS

Unit 1. *Tertiary Norwood Formation?* - weathered, yellowish- to orange-brown, high density, well bedded, tuffaceous sandstone.

Unit 2. *Late Pleistocene to Holocene landslide colluvium* - brown to dark brown, moderate-high density, massive, sandy clay to clayey sand (CL/SM) with gravel; A and B soil horizons formed at surface (units 2A and 2B).

WESTERN GEOLOGIC

Scale 1 inch equals 5 feet with no vertical exaggeration

TEST PIT LOGS, SHEET 2

GEOLOGIC HAZARDS EVALUATION

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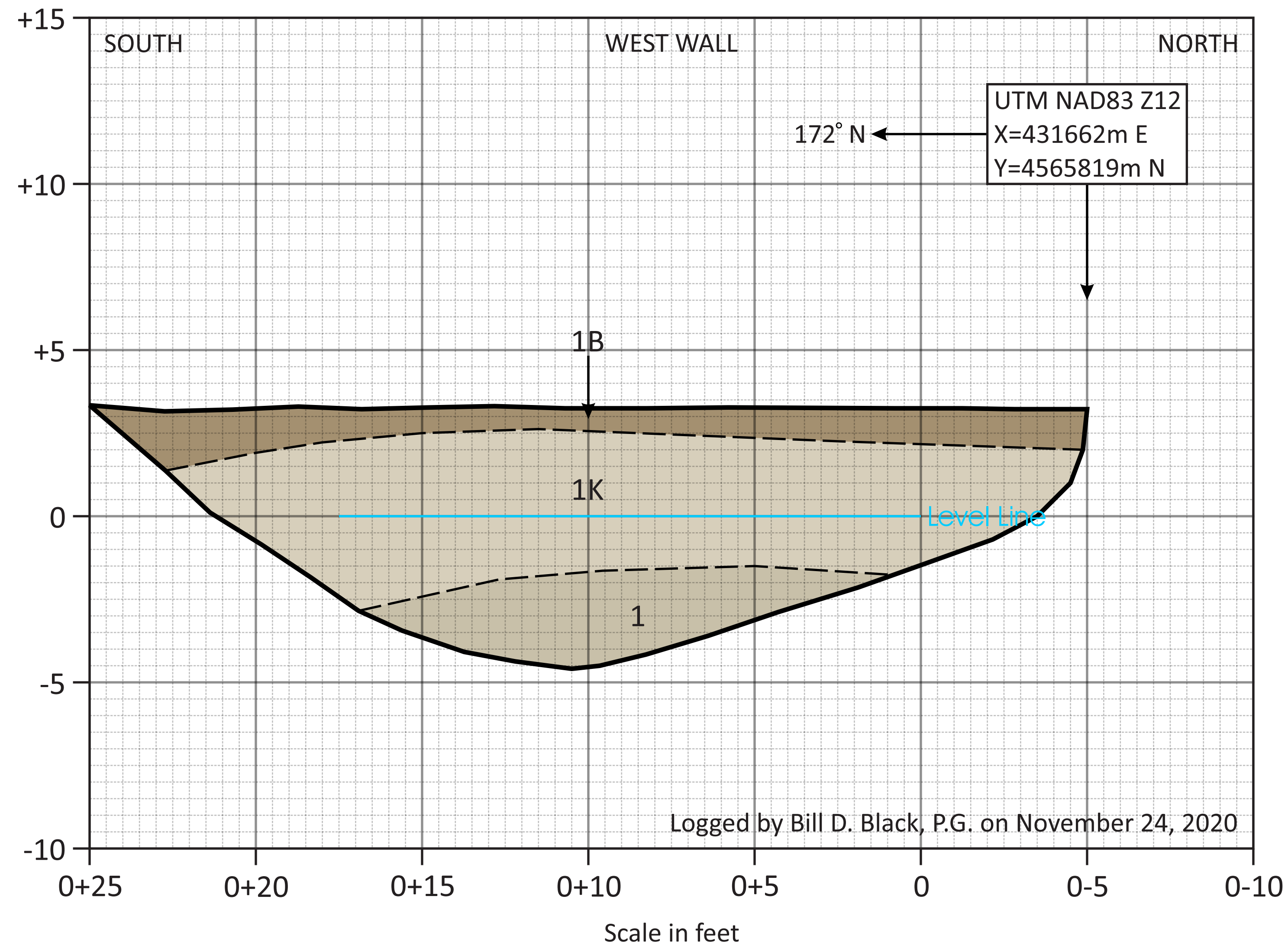
FIGURE 4B

TEST PIT 26



UNIT DESCRIPTIONS

Unit 1. *Tertiary Norwood Formation* - weathered, pale-brown to brown, dense, massive to poorly bedded, tuffaceous conglomerate to sandstone with quartzite clasts; bedding generally indistinct, no strike/dip measured; disturbed B horizon and stage IV+ K horizon formed in unit (units 1B and 1K), but A horizon removed due to surface disturbance.

WESTERN GEOLOGIC

Scale 1 inch equals 5 feet with no vertical exaggeration

TEST PIT LOGS, SHEET 3

GEOLOGIC HAZARDS EVALUATION
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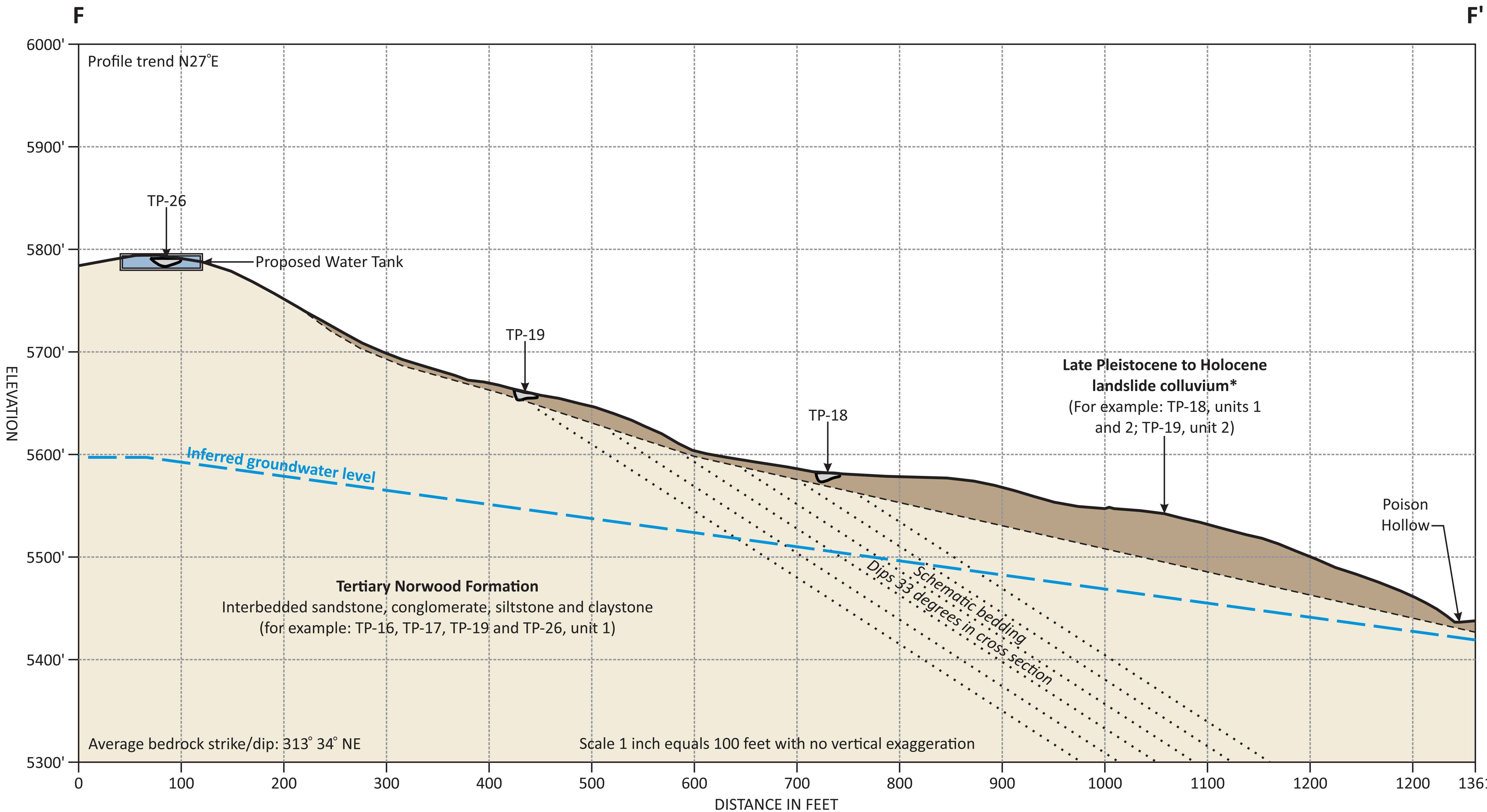
FIGURE 4C



Contacts are based on subsurface data and the surficial geologic mapping on Plate 1. Topographic profile determined by Global Mapper using 2016 LIDAR data. Inferred groundwater is based on reported depths in nearby wells. All contacts and groundwater (if shown) are approximate and may vary. Schematic bedding is based on average strike/dip, profile trend, and dips determined using http://app.visiblegeology.com/apparentDip.html.

WESTERN GEOLOGIC

CROSS SECTION F-F'

GEOLOGIC HAZARDS EVALUATION
Proposed Water Tank
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FIGURE 5

PLATES

Surficial geology modified from Coogan and King (2016). Contours generated by Global Mapper from 2016 LIDAR data, 4 foot interval.

0 200 400 feet
Scale 1:2,400 (1 inch equals 200 feet)

SITE EVALUATION AND GEOLOGY

GEOLOGIC HAZARDS EVALUATION
Proposed Water Tank
Legacy Mountain Development
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PLATE 1