

R E P O R T

GEOLOGIC HAZARDS EVALUATION PROPOSED OSPREY RANCH DEVELOPMENT 2050 HIGHWAY 150 EDEN, WEBER COUNTY, UTAH



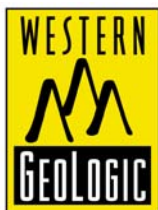
Prepared for

Lewis Homes
3718 North Wolf Creek Drive
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January 3, 2022

Prepared by

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January 3, 2022

Lewis Homes
Eric Householder
3718 North Wolf Creek Drive
Eden, Utah 84310

Letter of Transmittal: REPORT
Geologic Hazards Evaluation
Proposed Osprey Ranch Development
2050 Highway 150
Eden, Weber County, Utah

Dear Mr. Householder:

Western Geologic & Environmental has completed a Geologic Hazards Evaluation for the Proposed Osprey Ranch Development at 2050 Highway 150 in Eden, 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

Reviewed By:



Bill. D. Black, P.G.
Subcontract Geologist



Kevin J. Thomas, P.G.
Principal Geologist

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WG&E Project No. 5757

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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 the Proposed Osprey Ranch Development located at 2050 Highway 150 in Eden, Utah (Figure 1 – Project Location). The Project consists of several contiguous parcels comprising a total of about 598 acres. The Project is located in western Ogden Valley west and northwest of the north arm of Pineview Reservoir in all or parts of Sections 3, 4, 32 and 33, Township 7 North, Range 1 East (Salt Lake Base Line and Meridian; Figure 1). Elevation of the Project ranges between about 4,951 feet to 5,892 feet above sea level. Based on a Gardner Engineering site plan (preliminary plan sheet SP1 dated June 22, 2021), the Project is currently proposed for development of a water tank and a 67-lot residential subdivision with lot sizes of from 3.03 to 32.57 acres. The site plan is currently preliminary and no site grading or home locations are shown. The Project is currently undeveloped.

Western Geologic previously completed a geologic hazards evaluation for a 277-acre portion of the Project in October 2006 in conjunction with a geotechnical evaluation by Earthtec Testing and Engineering (Western Geologic, 2006). This portion of the overall Project was termed Moose Mountain Estates in 2006. Our report found high-risk geologic hazards at the proposed Moose Mountain Estates development from earthquake ground shaking, stream flooding, landslides, and radon. Data from this study was limited due to its age, but was reviewed to help prepare site-specific geologic mapping for the Project. Western Geologic also completed geologic hazards evaluations for the Beckstead Property located at about 1860 North Big Sky Drive (Western Geologic, 2018a) and the WAJ Enterprises Property located at about 2050 North Big Sky Drive (Western Geologic, 2018b) in October 2018. These properties are adjacent to the western boundary of the Project slightly north of the proposed onsite water tank location. Western Geologic (2018a) included two walk-in test pit exposures that were used to help prepare cross section R-R' (Figure 5R, Section 5.4). Test pit data from Western Geologic (2018b) was reviewed to also help prepare site-specific geologic mapping for the Project.

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 67 onsite walk-in test pits to assess subsurface conditions;
- Preparation of 18 geologic cross sections based on site-specific subsurface data and inferred conditions; and
- Evaluation of available data and preparation of this report, which presents the results of our study.

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. We do not include discussion of radon hazard potential, as recommended in Bowman and Lund (2016), because radon gas poses an environmental health hazard and indoor levels are heavily influenced by several post-construction, non-geologic factors. The hazard from radon should be evaluated by long-term testing following construction.

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 site is in western Ogden Valley between Nordic Valley and the north arm of Pineview Reservoir (Figure 1). Two perennial streams (Coal Hollow and Grover Hollow creeks, Figure 1) cross the Project, and several intermittent and ephemeral drainages also head within the Project, as identified on sheet DR1 in the June 22, 2021, Gardner Engineering preliminary plan set. There are also several small seasonal ponds at the Project and at least three reported spring areas. No springs are mapped on Figure 1 at the site. Both perennial streams were flowing at the time of our field investigation, although the ponds and intermittent drainages all appeared dry.

Ogden Valley is dominated in the valley bottom by unconsolidated lacustrine and alluvial basin-fill deposits. Slopes in the site area are mainly in weathered Tertiary-age tuffaceous bedrock overlain by a veneer of unconsolidated Quaternary alluvial and colluvial deposits. 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).

No site-specific groundwater information was available for the Project, but the Utah Department of Water Rights Well Driller's database shows five water wells near the eastern Project boundary (Figure 1). The drillers' logs for these wells report depths to static groundwater of from 25 to 50 feet, with a mean depth of 36.6 feet and a median depth of 30 feet. We anticipate groundwater conditions at the Project to be similar, though depths may vary locally with topography. Groundwater depths at the site also likely vary seasonally from snowmelt runoff and annually from climatic fluctuations, which would be typical for an alpine environment; and perched conditions above less-permeable, clay-rich bedrock layers are likely present in the subsurface that cause locally shallower groundwater levels. No groundwater was encountered in the test pits at the site, except for TP-11, although several test pits exposed evidence for past possible perched shallow groundwater (as discussed in Section 5.1). Given the above, our geologic cross sections (Section 5.4) assume groundwater is typically at a depth of around 30 feet, with a secondary perched groundwater zone in the upper 5 feet of weathered bedrock. We expect groundwater flow at the site to generally be to the northeast and east depending on topography.

4.0 GEOLOGY

4.1 Surficial Geology

The site is located on the western 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). Surficial geology of the site is mapped by Coogan and King (2016; Figure 2A) and McDonald (2020; Figure 2B). Coogan and King (2016) is a regional geologic map, whereas McDonald (2020) is a surficial geologic map for the Huntsville quadrangle. Both geologic maps indicate much of the Project is underlain by either landslide deposits of varying ages or Tertiary Norwood Formation bedrock. The Ogden Valley southwestern margin fault (aka West Ogden Valley fault) is also shown on both maps crossing the southwestern and western parts of the site, but is concealed beneath late Pleistocene- to Holocene-age unconsolidated sediments.

Coogan and King (2016) describe surficial geologic units in the site area on Figure 2A (from youngest to oldest) as follows:

Qh, Qh? – *Human disturbances (Historical)*. Mapped disturbances obscure original deposits or rocks by cover or removal; only larger disturbances that pre-date the 1984 aerial photographs used to map the Ogden 30 x 60- minute quadrangle are shown; includes engineered fill, particularly along Interstate Highways 80 and 84, the Union Pacific Railroad, and larger dams, as well as aggregate operations, gravel pits, sewage-treatment facilities, cement plant quarries and operations, brick plant and clay pit,

Defense Depot Ogden (Browning U.S. Army Reserve Center), gas and oil field operations (for example drill pads) including gas plants, and low dams along several creeks, including a breached dam on Yellow Creek.

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.

Qaf, Qafy, Qaf3, Qaf3?, Qaf4, Qaf4?, Qaf5 – *Alluvial-fan deposits (Holocene and Pleistocene)*. Mostly sand, silt, and gravel that is poorly bedded and poorly sorted and that is not close to late Pleistocene Lake Bonneville and is geographically in the Huff Creek and upper 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. 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.

Where possible, subdivided into relative ages, indicated by letter and number suffixes (like Qa and Qat suffixes) and relative ages only apply to the local drainage, with unit Qafy being the lowest (youngest) fans and unit 3 may or may not post-date Lake Bonneville. Relative ages of these fans are partly based on heights above present drainages at drainage-eroded edge of fan. The relative age is queried where the age is uncertain, generally due to the height not fitting into the typical order of surfaces. The various deposits listed, Qafy and Qaf3 through Qaf5, are 20 to 140 feet (6-40 m) above and west of Saleratus Creek, and also above Yellow Creek and the Bear River. Qafy fans are active, impinge on present-day floodplains, divert active streams, and overlie low terraces.

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).

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).

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.

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).

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.

Qmdf, Qmdf? – *Debris- and mud-flow deposits (Holocene and upper and middle? Pleistocene)*. Very poorly sorted, clay- to boulder-sized material in unstratified deposits characterized by rubbly surface and debris-flow levees with channels, lobes, and mounding; variably vegetated; in drainages typically form mounds, an indication of more viscous Qmdf, rather than being flat like unit Qac; Qmdf queried where may not

be mostly debris- and mud-flow deposits; many debris flows cannot be shown separately from alluvial fans at map scale; 0 to 40 feet (0-12 m) thick. Age(s) uncertain; deposits in drainages likely post-date the Provo shoreline of Lake Bonneville, while deposits above drainages, like north of the Right Hand Fork Peterson Creek, are likely as old as Bull Lake glaciation, but could pre-date Bull Lake glaciation and be middle Pleistocene.

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 regression sand may overlie transgression 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.

Qdlb, Qdlb? – *Transgressive and Bonneville-shoreline deltaic and lacustrine deposits (upper Pleistocene)*. Mostly sand, silty sand, and gravelly sand deposited near shore in Lake Bonneville; extensive at mouth of Weber Canyon; related to transgression to and occupation of the Bonneville shoreline with lacustrine deposits covering deltaic deposits; in Morgan Valley and near mouth of Coldwater Canyon (North Ogden quadrangle) contain more cobbles and overall more gravel; 0 to at least 40 feet (12 m) thick in Ogden and Morgan Valleys; about 400 feet (120 m) thick in bluff at the mouth of Weber Canyon. These deposits are prone to slope failures.

Qadb, Qadb? – *Transgressive and Bonneville-shoreline alluvial and deltaic deposits (upper Pleistocene)*. Cobbly gravel, sand, silt, and clay deposited above (subaerial) and in Lake Bonneville (subaqueous); typically mapped where shorelines are obscure, so that line cannot be drawn between alluvial fan and delta; include rounded to subangular clasts in a matrix of sand and silt with interbeds of sand and silt; mapped above the Provo shoreline and deposited as lake transgressed to and was at the Bonneville shoreline; typically better sorted delta and lake deposits over poorly sorted alluvial-fan deposits; Qadb prominent along Deep Creek (Morgan quadrangle) and Strawberry Creek (Snow Basin quadrangle); 0 to at least 40 feet (0-12+ m) thick.

Note that the Bonneville-shoreline fan-delta unit (Qadb), at 80 to 100 feet (24-30 m) above present drainages, is typically higher than the related alluvial units (Qab, Qafb) (see table 1). A fan-delta is built when an alluvial fan enters a lake or ocean, and includes both the fan and the delta.

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.

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.

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.

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.

Zpu, Zpu? – *Formation of Perry Canyon, Upper member (Neoproterozoic)*. Olive drab to gray, thin-bedded slate to argillite to phyllite to micaceous meta-siltstone to meta-graywacke to meta-sandstone in variable proportions such that unit looks like both the “greywacke-sandstone” and “mudstone” members of previous workers; unit identification based on underlying diamictite in Mantua quadrangle; rare meta-gritstone and meta-diamictite (actually conglomerate?); locally schistose; meta-sandstone contains poorly sorted lithic, quartz, and feldspar grains in silty to micaceous matrix; meta-sandstone is quartzose in outcrops on west margin of Mantua quadrangle (Crittenden and Sorensen, 1985a) and medial zone of sandstone is feldspathic east of Ogden Valley, where mapped and described as argillite member of Maple Canyon Formation by Crittenden (1972) and Sorensen and Crittenden (1979); thickness uncertain, but appears to be about 600 feet (180 m) thick on west flank of Grizzly Peak in the Mantua quadrangle and about 1000 feet (300 m) thick between Ogden Canyon and North Ogden divide. In Ogden Valley typically non-resistant and tan weathering such that gray to green to dark-gray fresh color is seldom seen except in cut slopes and excavations. This unit is prone to slope failures.

Zmcg, Zmcg? – *Maple Canyon Formation, Lower (green arkose) member (Neoproterozoic).* Grayish-green, fine-grained arkosic (feldspathic) meta-sandstone and sandy argillite (meta-graywacke), with local quartzite lenses up to 200 feet (60 m) thick; weathers darker gray to brown to greenish-gray and greenish-brown; 500 to 1000 feet (150-305 m) thick and lower thickness would eliminate the need for faulting in southwest part of Huntsville quadrangle. This unit is prone to slope failures.

McDonald (2020) describes surficial geologic units in the site area on Figure 2B (from youngest to oldest) as follows:

Qmsh – *Landslide deposits, historical (Holocene).* Poorly sorted clay- to boulder-sized material in slides, slumps, flows, and landslide complexes; generally characterized by hummocky topography, head, lateral, and/or internal scarps, and chaotic bedding in displaced blocks; composition depends on local sources; morphology becomes more subdued with increasing age and/or rate of movement; includes landslides having historical movement that has been observed, documented, or is apparent on aerial imagery; thickness highly variable.

Qaly – *Stream alluvium and floodplain deposits (Holocene to upper Pleistocene).* Poorly to moderately sorted, pebble to cobble gravel with a matrix of sand, silt, and clay in channels and floodplains and low terraces typically less than 10 feet (3 m) above modern channel level; angular to subangular grains; composition depends on source area; moderately sorted within beds; locally includes muddy overbank and organic-rich marsh deposits; present along the major valley-bottom streams including the North, Middle, and South Forks of the Ogden River, and Wolf Creek; 0 to 20 feet (0–6 m) thick.

Qat1 – *Stream terrace deposits (middle Holocene? to upper Pleistocene?).* Poorly to well sorted pebble to cobble gravel in a matrix of sand, silt and clay in terraces above modern streams and/or floodplains; subangular to subrounded grains; poorly to moderately bedded; typically about 5 to 10 feet (1–3 m) above modern channels; 0 to 10 feet (0–3 m) thick.

Qafy – *Younger alluvial-fan deposits (Holocene to upper Pleistocene).* Poorly to moderately sorted pebble to cobble gravel with silt, sand and minor clay matrix; angular to subangular grains; poorly to moderately bedded; composition depends on source area; includes debris flows, debris floods, and channel deposits on large alluvial fans notably at the mouth of Geertzen Canyon where a large, nearly 1.5-mile-wide (2.5 km) by over 1-mile-long (1.5 km) fan exists; elsewhere, smaller alluvial fans grade into active stream channels or lacustrine surfaces; the Geertzen Canyon fan contains abundant cobbles and boulders derived from Paleozoic quartzites and Paleogene conglomeratic surface deposits above and flanking the northeast margin of Ogden Valley; 0 to 30 feet (0–6 m) thick.

Qmsy – *Landslide deposits, younger (Holocene to upper Pleistocene?)* – Poorly sorted clay- to boulder-sized material in slides, slumps, flows, and landslide complexes; generally characterized by hummocky topography, head, lateral, and/or internal scarps, and chaotic bedding in displaced blocks; composition depends on local sources; morphology becomes more subdued with increasing age and/or rate of movement; morphology suggests likely post-Lake Bonneville movement with relatively sharp and pronounced landslide deformation features and may include parts that are historic and active; thickness highly variable.

Qla – *Lacustrine and alluvial deposits, undivided (Holocene to upper Pleistocene).* Poorly to moderately sorted silt, sand, clay, and gravel; subangular to rounded clasts; moderately to well-bedded; includes Lake Bonneville-age transgression deposits below and near the highstand shoreline and post-Bonneville stream alluvium overlain by, interbedded with, and/or reworked by streams; includes alluvial deposits aggraded to the Provo shoreline that are likely time equivalent to the overflowing and regressive phases of Lake Bonneville; 1 to 10 feet (0.3–3 m) thick.

Qac – *Alluvium and colluvium (Holocene to middle Pleistocene?).* Unsorted to variably sorted silt, sand, gravel, clay, cobble and boulder in variable proportions and roundness; includes stream and fan alluvium, colluvium, sheetwash deposits, and locally mass-movement deposits that are too small to map separately at map scale; typically mapped along drainages bounded by hillslopes where colluvium grades into alluvium without distinct break in slope and in smaller drainages lacking flat bottoms or too small to subdivide at map scale; 0 to 20 feet (0–6 m) thick.

Qms – *Landslide deposits, undifferentiated (Holocene to middle Pleistocene?).* Poorly sorted clay- to boulder-sized material in slides, slumps, flows, and landslide complexes; generally characterized by hummocky topography, head, lateral, and/or internal scarps, and chaotic bedding in displaced blocks; composition depends on local sources; morphology becomes more subdued with increasing age and/or rate of movement; mapped where relative age cannot be distinguished or where landslide complexes have portions with different ages and/or rates of activity; thickness highly variable.

Qmc – *Mass-movement and colluvial deposits, undivided (Holocene to middle Pleistocene?).* Poorly sorted to unsorted, mostly clay, silt, sand, gravel, cobble, and boulder; angular to rounded clasts; nonbedded; mapped on slopes where individual landslides, slumps, slope wash, and soil creep are difficult to distinguish from one another; often characterized by hummocky slopes composed of numerous slumps of various sizes and ages includes soil creep, sappy areas, talus, slope wash, and debris-flow deposits but lack clear landslide scarps and lateral margins to allow separate mapping; typically forms on slopes overlying clay-bearing, landslide prone bedrock units—notably Neogene volcanoclastics and argillic Proterozoic formations; 0 to 40 feet (0–12 m) thick.

Qafb – *Younger alluvial-fan deposits (upper Pleistocene).* Poorly sorted pebble to cobble gravel with silt, sand and minor clay matrix; angular to subangular grains; poorly to moderately bedded; composition depends on source area; includes debris

flows, debris floods, and channel deposits that grade into Lake Bonneville transgressive or highstand shoreline deposits or at a height above modern fan surfaces consistent with correlative deposits; 0 to 30 feet (0–6 m) thick.

Qls – *Lake Bonneville sand and gravel deposits (upper Pleistocene)*. Moderately to poorly sorted, moderately to well-bedded sand and gravel with silt and clay; subangular to rounded clasts; deposited in transgressive Lake Bonneville nearshore environments; includes thin clay and silt interbeds deposited off shore; may grade laterally into Qlf or Qdl; typically less than 20 feet (6 m) thick.

Qlf – *Lake Bonneville fine-grained deposits (upper Pleistocene)*. Moderately to well-sorted and moderately bedded to thinly laminated clay, silt, and sand deposited during the transgression and highstand of Lake Bonneville; rounded to well-rounded clasts; deposited in shallow to moderately deep water; typically overlies pre-Bonneville alluvium and may overlie middle Pleistocene Little Valley lake cycle (Scott and others, 1983; Oviatt and others, 1999) fine-grained deposits in the central part of the valley; 5 feet (2 m) thick or greater.

Qao – *Older alluvium (upper to middle Pleistocene?)*. Poorly to moderately sorted sand, silt, clay, and gravel on surfaces; subangular to subrounded grains; poorly to moderately bedded; deposits are typically isolated remnants in the valley or along valley margin drainages; located above and presumed older than Lake Bonneville-age alluvium and likely same age as Qafo but lacking alluvial-fan morphology; 10 to 50 feet (3–15 m) thick.

Qafo – *Older alluvial-fan deposits (upper to middle Pleistocene?)*. Poorly to moderately sorted pebble to cobble gravel with a matrix of silt, sand and clay; subangular to subrounded clasts; poorly bedded; fans are typically eroded and incised locally with isolated fan remnants, deposits may be somewhat lithified, and characterized by a reddish, clay-rich matrix; deposits are likely early to middle Pleistocene-age and may include deposits previously mapped as Huntsville Fanglomerate (Eardley, 1955; Lofgren, 1955; Coody, 1957) and may include deposits where fan age is uncertain, or for composite fans, where parts of fans with different ages cannot be shown separately at map scale; 10 to 50 feet (3–15 m) thick.

Qmso – *Landslide deposits, older (upper to middle Pleistocene?)* – Poorly sorted clay- to boulder-sized material in slides, slumps, flows, and landslide complexes; generally characterized by hummocky topography, head, lateral, and/or internal scarps, and chaotic bedding in displaced blocks; composition depends on local sources; morphology becomes more subdued with increasing age and/or rate of movement; mapped where deposits generally have a more subdued morphology and are likely early Holocene and Pleistocene in age; include very large complexes underlain by argillite-rich bedrock where entire hillsides appear to be part of a landslide complex but where defining their boundaries are often difficult; thickness highly variable.

BR – Rock (Tertiary to Precambrian). Mapping of bedrock structure and stratigraphy is beyond the scope of this project. Sorenson and Crittenden (1979) provide the most recent published 1:24,000-scale geologic map of the Huntsville quadrangle. Coogan and King (2016) performed a cursory revision of the bedrock of Sorenson and Crittenden (1979) in compiling the Ogden 30' x 60' quadrangle. For more information, refer to these maps and other maps and studies cited in the Previous Work section of this report.

Citations, tables, and figures above are not provided herein, but are in Coogan and King (2016) or McDonald (2020).

4.2 Seismotectonic Setting

The property is located at the western 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 (WFZ) 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 1986).

Ogden Valley occupies a structural trough created by up to 2,000 feet of vertical displacement on normal faults bounding the east and west sides of the valley. The Ogden Valley southwestern margin fault (aka West Ogden Valley fault) is mapped trending across the site slightly west of the proposed home. Coogan and King (2016) map the fault as concealed (Figure 2, dotted line) beneath Pleistocene- to Holocene-age alluvium in the area. Sullivan and others (1986) indicate the most recent movement on this fault is pre-Holocene. The nearest active (Holocene-age) fault to the site is the Weber section of the WFZ about 3.9 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

WFZ 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 Magna earthquake¹ reportedly showed a style, location, and slip depth consistent with an earthquake on the WFZ system. Despite being less than magnitude 6.0, this earthquake damaged multiple buildings and was felt from southern Idaho to south-central Utah². The University of Utah Seismograph Stations indicates the Magna earthquake³ 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). Sediments from Lake Bonneville are mapped in the northeast and southeast parts of the Project.

Timing of events related to the transgression and regression of Lake Bonneville are indicated in 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. Headward erosion of the Snake River-Bonneville basin drainage divide, possibly combined with landsliding in the threshold area, then caused a catastrophic incision that caused the lake level to lower by about 425 feet in less than a year (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 up to about 16,000 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. Oviatt and others (1992) deem this low stage the end of the Bonneville lake cycle. Great Salt Lake then experienced a brief transgression between 12,800 and 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; Oviatt, 2015). The highest Bonneville shoreline is mapped discontinuously in the eastern part of the Project on Figures 2A and 2B at an elevation of about 5,200 feet. Various sub-Bonneville transgressive shorelines are also mapped at lower elevations on Figures 2A and 2B.

¹ <https://earthquake.usgs.gov/earthquakes/eventpage/uu60363602/executive>

² <https://www.ksl.com/article/46731630/>

³ <https://earthquakes.utah.gov/magna-quake/#>

5.0 SITE CHARACTERIZATION

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 (Western Geologic, 2006, 2018a and 2018b; Coogan and King, 2016; and McDonald, 2020); excavation, logging and field interpretation of 67 test pits; field reconnaissance of the site in conjunction with the subsurface exploration; photogeologic analyses of 2012 high-resolution aerial imagery; and GIS analyses of geoprocessed 2016 LIDAR terrain data.

5.1 Subsurface Investigation

Sixty-seven walk-in test pits (short trenches) were excavated at the Project to assess subsurface conditions. The test pits were logged by Bill D. Black, P.G., of Western Geologic July 27 through August 6, and on November 22, 2021, concurrently with the Project geotechnical investigation conducted by Christensen Geotechnical. Locations of the test pits are shown on Plate 1. The test pit locations were measured using a hand-held GPS unit and by trend and distance methods. The test pits were logged at a scale of 1-inch equals five feet (1:60) following methodology in McCalpin (1996), and digitally photographed at 5-foot intervals to document the exposures. The photos are not provided herein, but are available on request. Logs of the test pits are provided on Figures 3A-3Z and Figures 4A-4H. Stratigraphic interpretations and descriptions are provided on the logs. Explored depth was limited in some test pits due to excavation refusal.

Except for TP-11, no groundwater was observed in the test pits to their explored depths. However, iron-oxide staining or highly weathered bedrock suggestive of seasonal perched groundwater was observed in TP-4, TP-15, and TP-36. Weathered bedrock was exposed in all of the test pits, except for TP-5, TP-9, TP-29, TP-37, TP-50 and TP-58. The bedrock was generally overlain by late Pleistocene mass wasting colluvium. Holocene mass wasting colluvium was observed in TP-2, TP-28, TP-29 and TP-30. Late Pleistocene to Holocene mixed alluvium and colluvium was observed in TP-37, TP-40 and TP-50.

5.2 Empirical Observations

On July 27 through August 6, and on November 22, 2021, Mr. Bill D. Black, P.G., of Western Geologic conducted a reconnaissance of the property to observe geomorphic and surficial conditions. Weather conditions varied. Due to the large Project size, steep slopes and heavy vegetation in some areas, not all areas of the Project were accessed or observable.

The site is on the western margin of Ogden Valley on slopes overlooking Ogden Valley. Native vegetation consists of mature trees, various brush, broadleaf weeds and grasses. Two perennial streams (Coal Hollow and Grover Hollow creeks) cross the Project, and several intermittent and ephemeral drainages also head within the Project. There are also several small seasonal ponds at the Project and at least three reported spring areas. Both perennial drainages were flowing at the time of our field investigation, although the ponds and intermittent drainages all appeared dry. Slopes at the site are steep and heavily

vegetated in some areas. Much of the site is typified by eroded landslide deposits overlying and encircling various weathered bedrock knobs and ridges. The landslide morphology appeared subdued. No evidence for recent or ongoing landslides or slope instability was observed. Except for the above and various areas of alluvial and colluvial deposition along Coal Hollow and Grover Hollow creeks, likely from seasonal floods, no evidence of other geologic hazards was observed.

5.3 Air Photo Observations

High-resolution color orthophotography from 2012 and bare earth DEM LIDAR imagery from 2016 were reviewed to obtain information about the geomorphology of the Project area. The 2012 aerial imagery and LIDAR analysis are provided on Plates 1 and 2 at a scale of 1 inch equals 400 feet (1:4,800). Surficial geology of the Project is shown on Plate 3 based on the mapping in Coogan and King (2016, Figure 2A), McDonald (2020, Figure 2B), and our onsite subsurface data, empirical observations, and air photo interpretation. Plate 2 shows slope steepness and aspect varies across at the site, though much of the site is on slopes gentler than 20 percent (5:1 horizontal to vertical; unshaded areas).

The Project is in an area underlain mainly by Tertiary-age Norwood Formation bedrock with a veneer of mass wasting colluvium from various pre- and post-Lake Bonneville landslides. Most of the landslide deposits likely predate when Lake Bonneville occupied Ogden Valley. Thickness of the colluvium varies, but is generally less than 10 feet. However, four Holocene-age landslide deposits are present in the southwest and north parts of the Project (unit Qmsy, Plates 1-3). TP-29 and TP-30 in one of these landslides showed evidence for multiple movement episodes. Coal Hollow and Grover Hollow creeks also flow across the Project. No alluvial fans are mapped at the site, but several areas of mixed alluvial and colluvial deposits are found along the creeks, likely from seasonal floods (unit Qac, Plates 1-3). We anticipate that these creeks are mainly transport and erosion zones for small debris flow and floods, with deposition principally in the alluvial fans (unit Qafy, Plates 1-3) in Ogden Valley east of the Project. The Ogden Valley southwestern margin fault crosses the southwest and west parts of the Project, but is concealed beneath late Pleistocene to Holocene surficial deposits and only approximately located (Plates 1-3, dotted bold line). Sullivan and others (1986) indicate the most recent movement on this fault is pre-Holocene. No evidence for other geologic hazards was observed on the air photos at the site or in the area.

5.4 Cross Sections

Figures 5A-5R show 18 geologic cross sections (A-A' through R-R'), as located on Plates 1-3, across various steep slopes at the site shown on Plate 2. Units and contacts are inferred based on subsurface data from the test pits (Figures 3A-Z and 4A-H), and the surficial geologic mapping on Plate 3. The topographic profiles are based on geoprocessed 2016 LIDAR data. The LIDAR data provide a snapshot of topographic conditions at the time of acquisition; past, present and future surficial topography may vary. Bedding dips were determined using <https://app.visiblegeology.com/apparentDip.html> based on the cross section trend and test pit strike/dip data. We caution that the cross sections are based on

limited subsurface data, particularly given the depth of exploration. Units and contacts should therefore be considered approximate and inferred, and variations should be expected at depth and laterally. Groundwater in the cross sections is inferred to be at a depth of about 30 feet (as discussed in Section 3.0), varying with topography. A perched groundwater zone is also shown in the upper 5 feet of the weathered bedrock.

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.

Table 1. *Geologic hazards summary.*

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		

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.

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, a site class of C (stiff soil), and a risk category of II, calculated seismic values for the site (centered on 41.296973° N, -111.839527° W) are summarized below:

Table 2. *Seismic hazards summary.*

Type	Value
S_s	0.984 g
S_1	0.352 g
$S_{Ms} (F_a \times S_s)$	1.18 g
$S_{M1} (F_v \times S_1)$	0.528 g
$S_{Ds} (2/3 \times S_{Ms})$	0.787 g
$S_{D1} (2/3 \times S_{M1})$	0.352 g
Seismic Design Category, SDC	<i>D</i>
Site Coefficient, F_a	= 1.2
Site Coefficient, F_v	= 1.5
Site-Modified Peak Ground Acceleration, PGA_M	= 0.524 g

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 of homes in accordance with the current adopted building code. The PGA_M for the site in Table 2 is more than 100 times that reportedly experienced in Ogden Valley (0.005 g) from the March 18, 2020 M 5.7 Magna earthquake.

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 active faults are mapped crossing the site or were observed during our reconnaissance or on air photos. The Ogden Valley southwestern margin fault is mapped crossing the southwestern and western parts of the Project, but is concealed and shows no evidence of Holocene activity (Sullivan and others, 1988). The Utah Geological Survey Quaternary Fault and Fold Database for Utah (Black and others, 2003) indicates the nearest active fault to the Project is the Weber section of the Wasatch fault zone 3.9 miles to the west. Given all the above, we rate the existing risk from surface faulting as low. No additional investigation regarding surface faulting appears needed given the proposed development 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 accelerations (earthquake ground shaking), groundwater conditions, and presence of susceptible soils.

Given subsurface soil conditions observed in the test pits (Figures 3A-3Z and 4A-4H) and the site-specific geologic mapping on Plate 3, we rate the risk from liquefaction as low. Weber County GIS mapping shows the site is in an area of very 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.

Federal Emergency Management Agency flood insurance rate mapping (Map Number 49057C0236F, effective on 06/02/2015; and 49057C0237F, effective 06/02/2015) classifies the Project in "Zone X" (areas of minimal flood hazards). However, two perennial drainages (Coal Hollow and Grover Hollow creeks) flow across the Project. Areas adjacent to these drainages may be subject to localized seasonal or flash flooding. Coal Hollow and Grover Hollow creeks are currently identified as drainages #4 and #5 on sheet DR1 in the June 22, 2021 Gardner Engineering preliminary plan set. The drainage plan overview shows a 50-foot setback around the creeks. Based on the FEMA mapping and current civil engineering design for the development, we rate the risk from stream flooding as low. Care should be taken that proper surface drainage is maintained.

6.7 Shallow Groundwater

Except for TP-11, no groundwater was encountered in the test pits at the site. However, several test pits exposed evidence for past possible perched shallow groundwater (as discussed in Section 5.1). Although no onsite groundwater information was found available, five water wells are near the eastern Project boundary (Figure 1). The drillers' logs for these wells report static groundwater depths of from 25 to 50 feet, with a mean depth of 36.6 feet and a median depth of 30 feet. We anticipate groundwater conditions at the Project to be similar, though depths may vary locally and seasonally from snowmelt runoff and annually from climatic fluctuations, which would be typical for an alpine environment. Our test pit data indicate perched conditions above less-permeable, clay-rich bedrock layers may also be locally present in the subsurface. Given all the above, we rate the risk from shallow groundwater as moderate. The Project geotechnical engineer should evaluate the need for a foundation drainage system to ensure that proper 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. Slopes exhibiting prior failures, and also deposits from large landslides, are particularly vulnerable to instability and reactivation.

The Project is in an area underlain mainly by Tertiary-age Norwood Formation bedrock with a veneer of mass wasting colluvium from various pre- and post-Lake Bonneville landslides. Much of the site is typified by eroded landslide deposits overlying and encircling various weathered bedrock knobs and ridges. The landslide morphology appeared subdued and no evidence for recent or ongoing landslides or slope instability was

observed. Colluvial thicknesses are shown on the test pit logs (Figures 3A-3Z and 4A-4H) and were generally less than 10 feet, except in TP-5, TP-9 and TP-29. Mixed alluvium and colluvium was also encountered in test pits TP-37 and TP-50 that extended below the depth of excavation. Four Holocene-age landslide deposits are also present in the southwest and north parts of the Project (unit Qmsy, Plates 1 and 3). Test pits TP-29 and TP-30 in one of these landslides showed evidence for multiple depositional events. Plate 2 shows slopes at the site vary in aspect and steepness, though much of the site appears to be on gentle slopes with a steepness less than 20 percent (unshaded). The young landslides originated in slopes exceeding 20 percent steepness.

Given the above, we rate the risk from landslides and slope instability as high. We recommend that slope stability be evaluated by the Project geotechnical engineer 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. We further recommend that: (1) no structures be constructed on a slope that shows an average gradient greater than 30 percent over a 50-foot span; (2) no structures be constructed on the young landslides (unit Qmsy) on Plates 1-3; and (3) a site-specific geologic and geotechnical assessment be conducted for structures that will be located on a slope that shows an average gradient greater than 20 percent over a 50-foot span. Water, steep man-made cuts, and non-engineered fill materials are often major contributors to slope instability. Care should 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.

Coal Hollow and Grover Hollow creeks flow across the Project. No onsite alluvial fans are mapped associated with these drainages, but several areas of mixed alluvial and colluvial deposits are mapped along the creeks that may be from seasonal floods (unit Qac, Plates 1-3) and test pit TP-50 near Coal Hollow creek (Plate 1) exposed mixed alluvium and colluvium that extended below the depth of excavation. We anticipate that these creeks are mainly transport and erosion zones for small debris flow and floods, with deposition locally along the creek and in the offsite alluvial fans (unit Qafy, Plates 1-3) downslope further east. Given that areas near the creeks are also in a 50-foot stream setback zone, the hazard from debris transport and erosion appears minimal. Given this, we rate the risk from debris flows and floods as low.

6.10 Rock Fall

No significant bedrock outcrops are at the site or in adjacent higher slopes that could present a source area for rock fall clasts, and no boulders likely from rock falls were observed at the site. Based on the above, we rate the hazard from rock falls as low.

6.11 Problem Soil and Rock

Clay-rich surficial soils and weathered bedrock possibly susceptible to a high degree of shrinking/swelling were observed in numerous test pits at the Project. Given the above, we rate the risk from problem soil and rock as high. Soil conditions and specific recommendations for site grading, subgrade preparation, and footing and foundation design should be provided in the Project geotechnical engineering evaluation.

7.0 CONCLUSIONS AND RECOMMENDATIONS

Earthquake ground shaking, landslides and slope stability, and problem soil and rock are identified as posing a high relative risk to the Project. Shallow groundwater also poses a moderate (equivocal) risk. The following recommendations are provided with regard to the geologic characterizations in this report:

- **Seismic Design** – All habitable structures developed at the property should be constructed to current adopted seismic building codes to reduce the risk of damage, injury, or loss of life from earthquake ground shaking. The Project geotechnical engineer should confirm the ground shaking hazard and provide appropriate seismic design parameters as needed. Earthquake ground shaking is a hazard that is common for all development along the Wasatch Front.
- **Geotechnical Evaluation** – A design-level geotechnical engineering study should be conducted prior to construction to assess soil foundation conditions, provide recommendations regarding subsurface drainage, and evaluate slope stability. The stability evaluation should be based on geologic characterizations in this report and site-specific geotechnical data, and provide recommendations for reducing the risk of landsliding if the factors of safety are deemed unsuitable.
- **Non-buildable Areas and Additional Investigations** – No structures should be constructed on a slope that shows an average gradient greater than 30 percent over a 50-foot span, or on the young landslides (unit Qmsy) on Plates 1-3. A site-specific geologic and geotechnical assessment should be conducted if any structure will be located on a slope that shows an average gradient greater than 20 percent over a 50-foot span.
- **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. We recommend that final site drainage and grading plans be reviewed by a licensed geologist and geotechnical engineer.
- **Excavation Backfill Considerations** – The test pits may be in areas where a structure could subsequently be placed. However, backfill may not have been replaced in the excavations in compacted layers. The fill could settle with time and upon saturation. Should structures be located in an excavated area, no footings or structure should be founded over the excavation unless the backfill has been removed and replaced with structural fill.
- **Hazard Disclosures and Report Availability** – All hazards identified as posing a high risk at the site should be disclosed to future buyers so that they may understand and be willing to accept any potential developmental challenges and/or risks posed by these hazards. This report should be made available to architects, building contractors, and in the event of a future property sale, real estate agents and potential buyers. The report should be referenced for information on technical data only as interpreted from

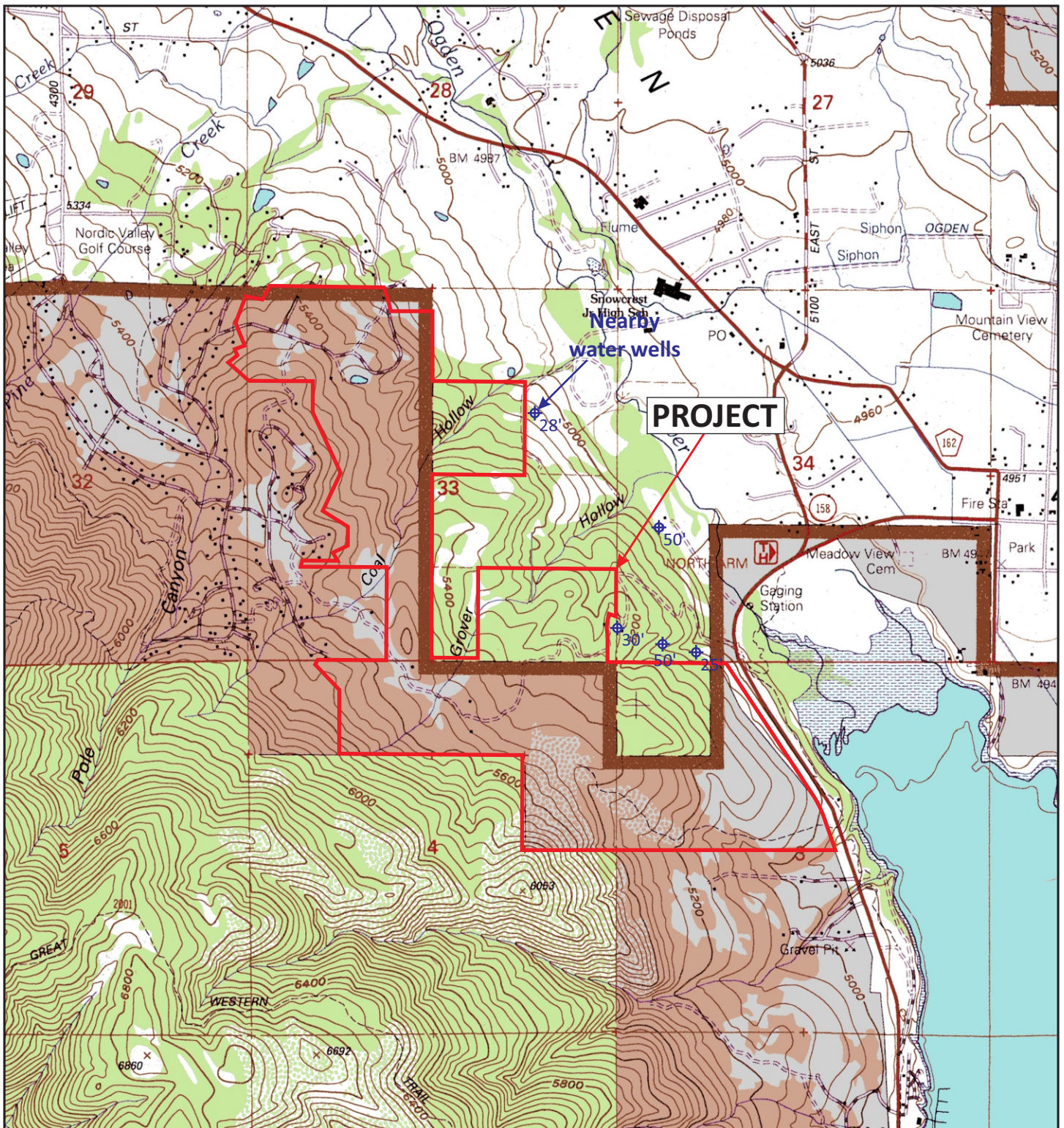
observations and not as a warranty of conditions throughout the site. The report should be submitted in its entirety, or referenced appropriately, as part of any document submittal to a government agency responsible for planning decisions or geologic review. Incomplete submittals void the professional 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.

8.0 REFERENCES

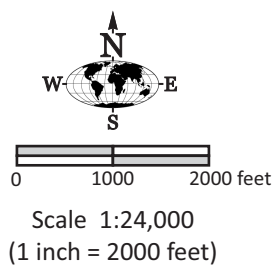
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FIGURES



Source: U.S. Geological Survey 7.5 Minute Series Topographic Maps, Utah - Huntsville, 1998; Project location Sections 3, 4, 32 and 33, Township 7 North, Range 1 East (SLBM).



LOCATION MAP

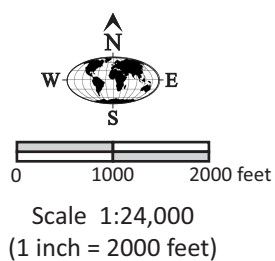
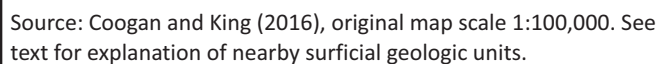
GEOLOGIC HAZARDS EVALUATION

Proposed Osprey Ranch Development

2050 Highway 150

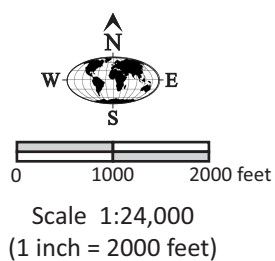
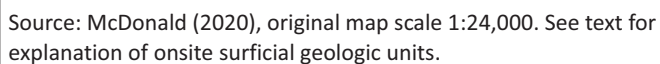
Eden, Weber County, Utah

FIGURE 1



GEOLOGIC HAZARDS EVALUATION

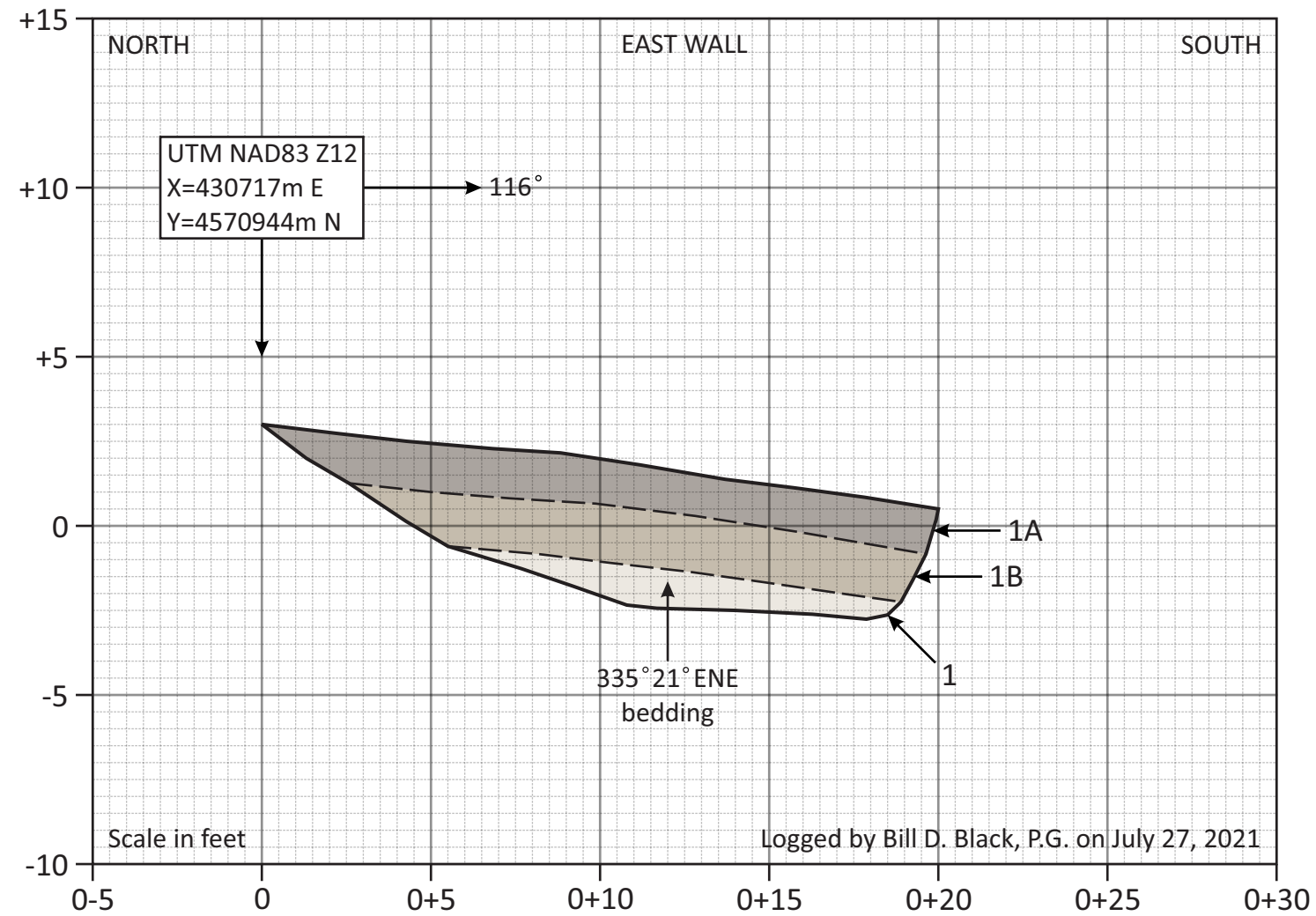
FIGURE 2A



GEOLOGIC HAZARDS EVALUATION

FIGURE 2B

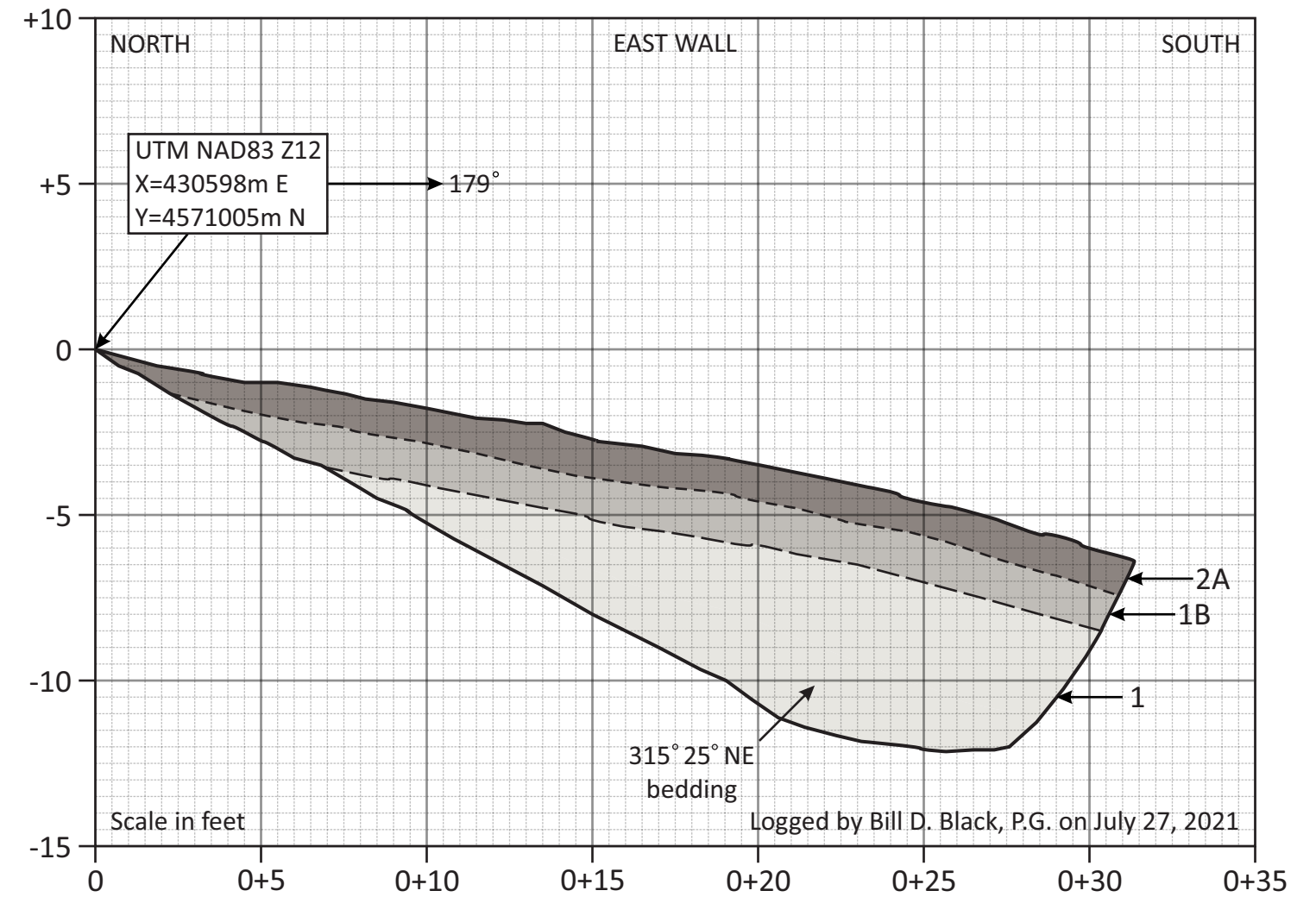
TEST PIT 1



UNIT DESCRIPTIONS

Unit 1. *Tertiary Norwood Formation* - light olive-brown, yellowish-brown and brown; strong to very strong; well bedded; weathered tuffaceous sandstone; A and B soil horizons formed in unit (1A and 1B).

TEST PIT 2



UNIT DESCRIPTIONS

Unit 1. *Tertiary Norwood Formation* - light brown to white, strong to very strong, well bedded, weathered tuffaceous sandstone grading upward to light olive-brown, poorly bedded siltstone; B horizon formed in unit (1B).

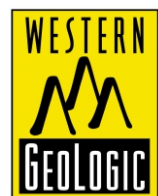
Unit 2. *Holocene mass wasting colluvium* - dark grayish-brown, medium dense to medium firm, massive, clayey sand to sandy clay (SC/CL) with gravel and cobbles; clasts subangular with stage II carbonate; soil A horizon formed in unit (2A); thickness about 1 feet.

TEST PIT LOGS, 1 AND 2

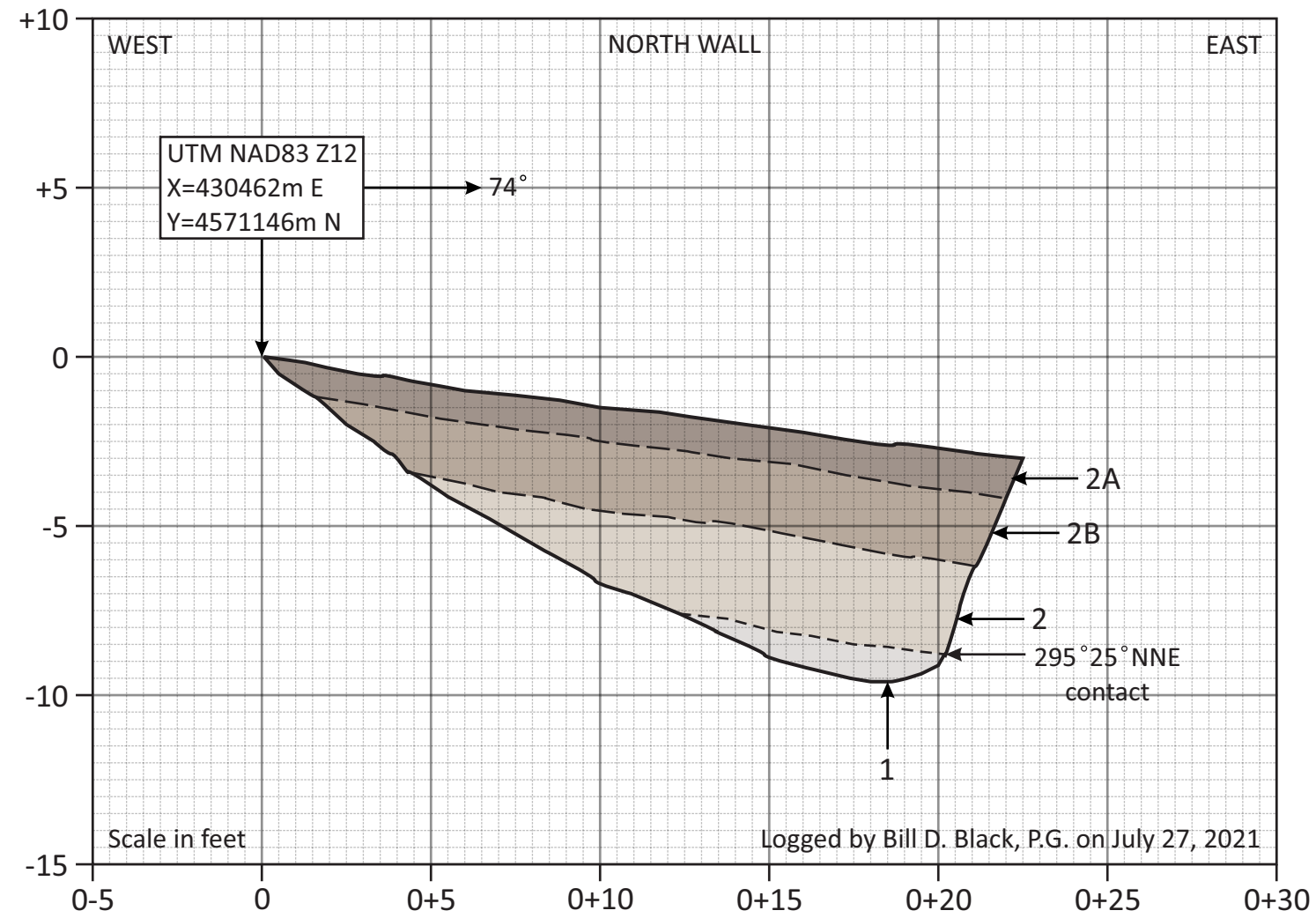
GEOLOGIC HAZARDS EVALUATION

Proposed Osprey Ranch Development
2050 Highway 150
Eden, Weber County, Utah

FIGURE 3A



TEST PIT 3

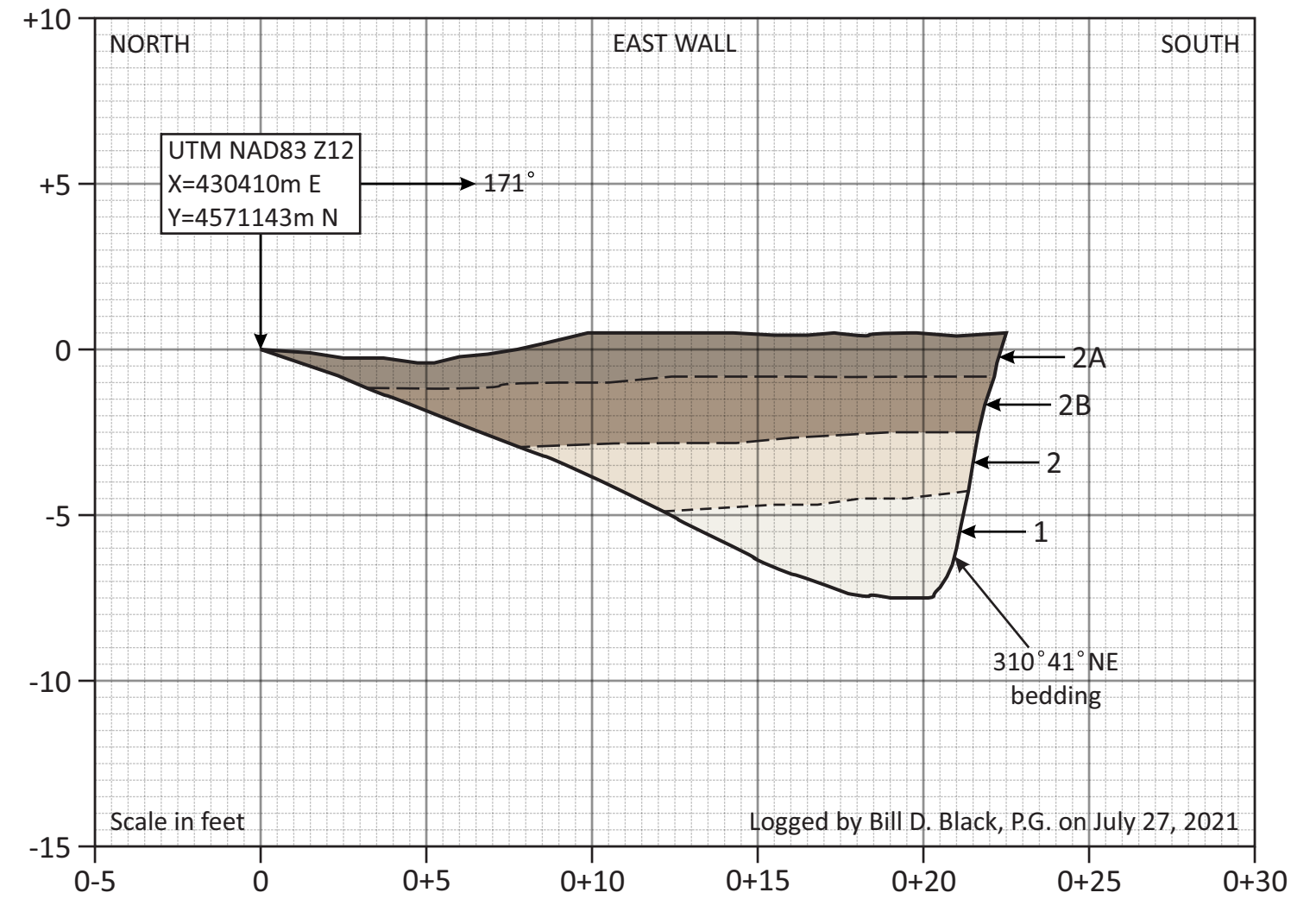


UNIT DESCRIPTIONS

Unit 1. *Tertiary Norwood Formation* - orange to olive-brown, strong, massive, weathered tuffaceous conglomerate.

Unit 2. *Late Pleistocene mass wasting colluvium* - brown to dark brown, dense to stiff, massive, clayey gravel to gravelly clay (GC/CL) with sand and trace cobbles; A and B horizons formed in unit (2A and 2B); about 6 feet thick.

TEST PIT 4



UNIT DESCRIPTIONS

Unit 1. *Tertiary Norwood Formation* - light brown to white, strong, well bedded, weathered siltstone.

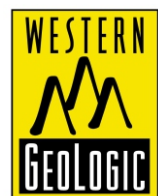
Unit 2. *Late Pleistocene mass wasting colluvium* - brown to dark grayish-brown, dense to stiff, massive, clayey gravel to gravelly clay (GC/CL) with cobbles along basal contact and near-surface cobbles and small boulders; clasts subangular with stage II carbonate; slight iron oxide staining along basal contact; A and B soil horizons formed in unit (2A and 2B); about 5 feet thick.

TEST PIT LOGS, 3 AND 4

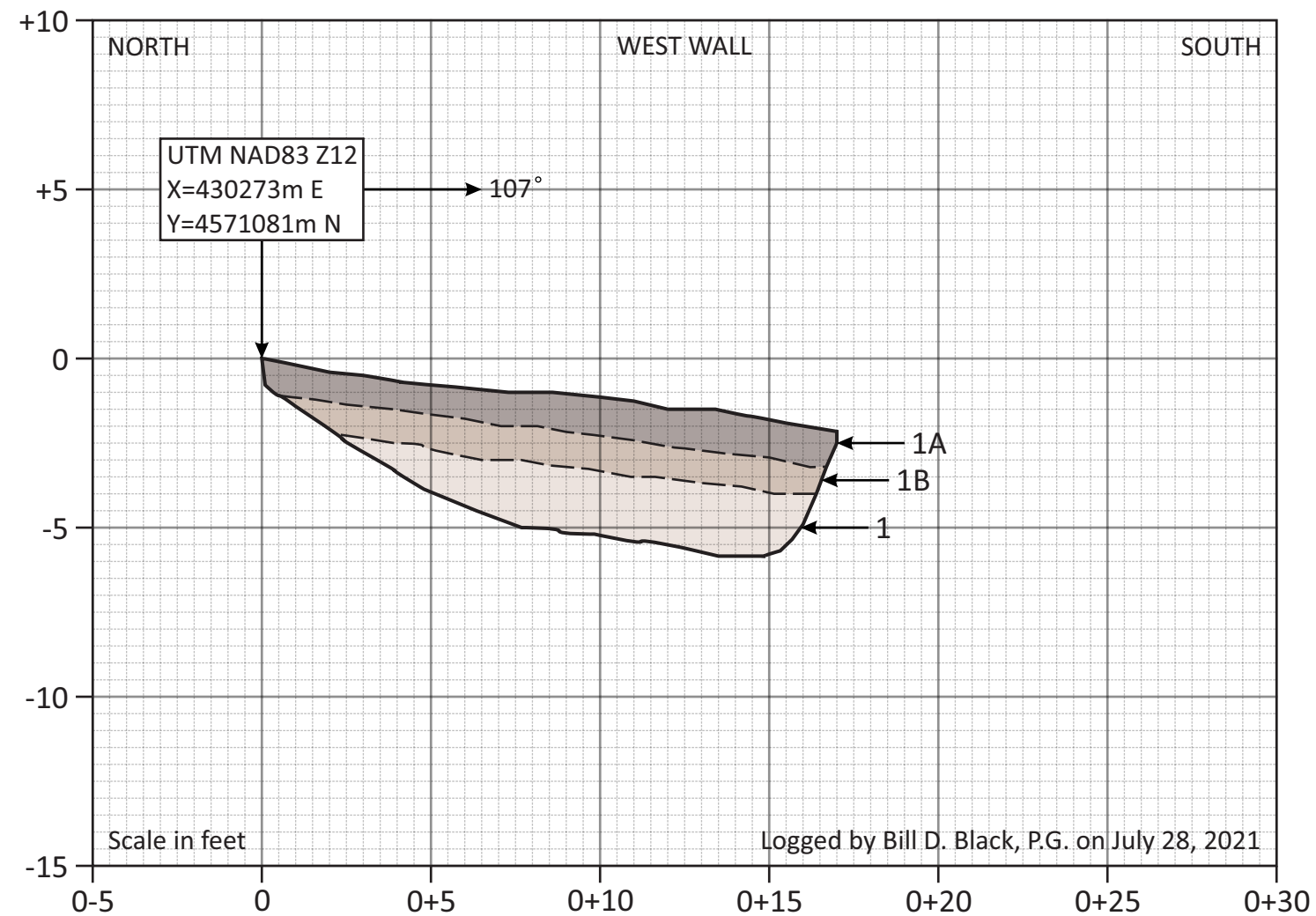
GEOLOGIC HAZARDS EVALUATION

Proposed Osprey Ranch Development
2050 Highway 150
Eden, Weber County, Utah

FIGURE 3B



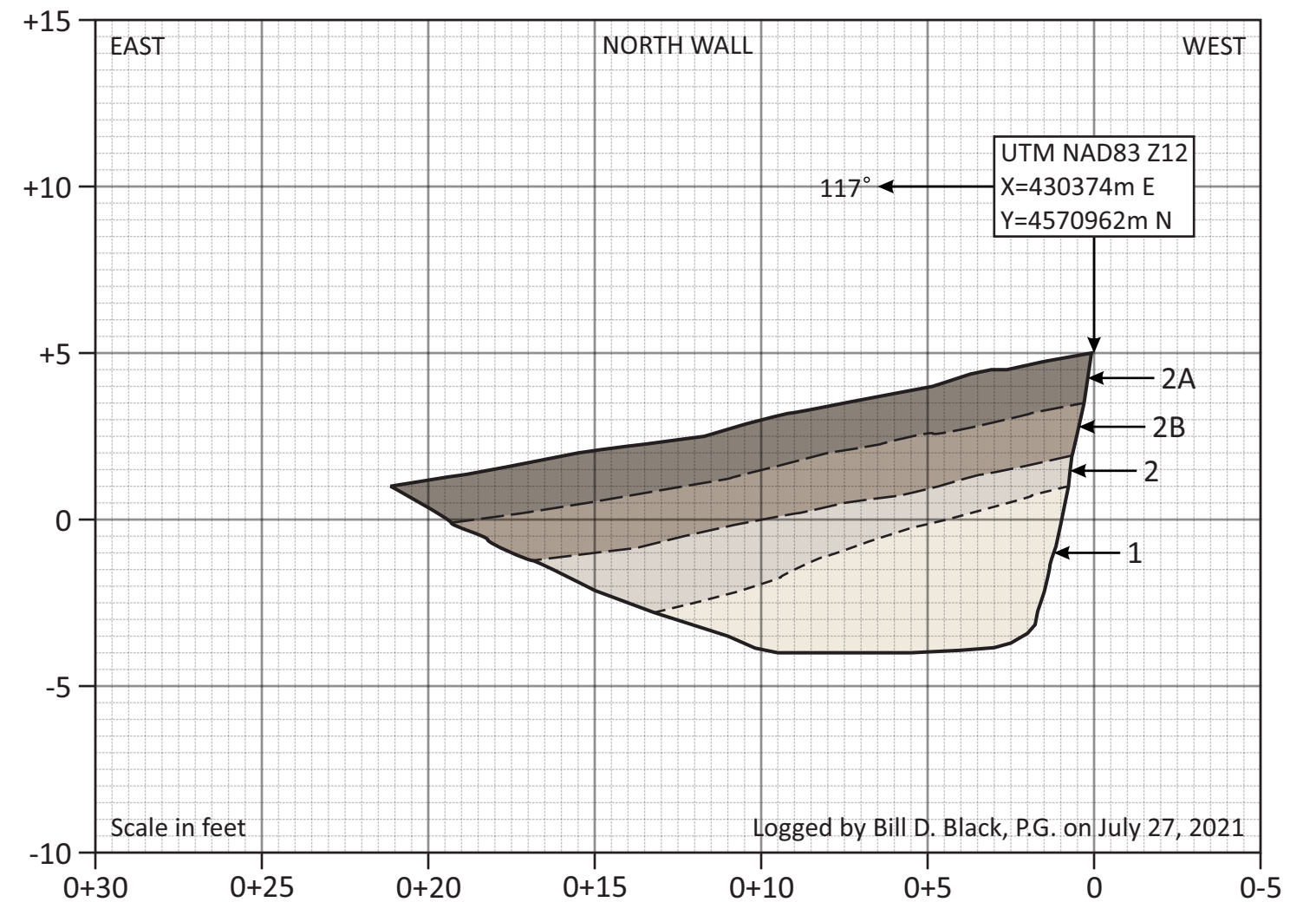
TEST PIT 5



UNIT DESCRIPTIONS

Unit 1. *Late Pleistocene mass wasting colluvium* - brown to dark grayish-brown, dense/stiff to very dense/stiff, massive, clayey gravel to gravelly clay (GC/CL); A and B soil horizons formed in unit (1A and 1B); thickness > 4 feet; refusal at test pit floor.

TEST PIT 6



UNIT DESCRIPTIONS

Unit 1. *Tertiary Norwood Formation* - grayish-brown to orange-brown, strong, massive, weathered tuffaceous conglomerate with round to subround cobbles.

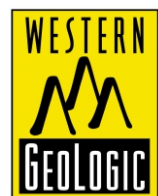
Unit 2. *Late Pleistocene mass wasting colluvium* - olive-brown to dark grayish-brown, stiff to dense, massive, clay with gravel (CL) in basal part grading upward to clayey gravel (GC) with sand, cobbles and rare small boulders; clasts subangular to subround with stage II carbonate; A and B soil horizons formed in unit (2A and 2B); about 4 to 5 feet thick.

TEST PIT LOGS, 5 AND 6

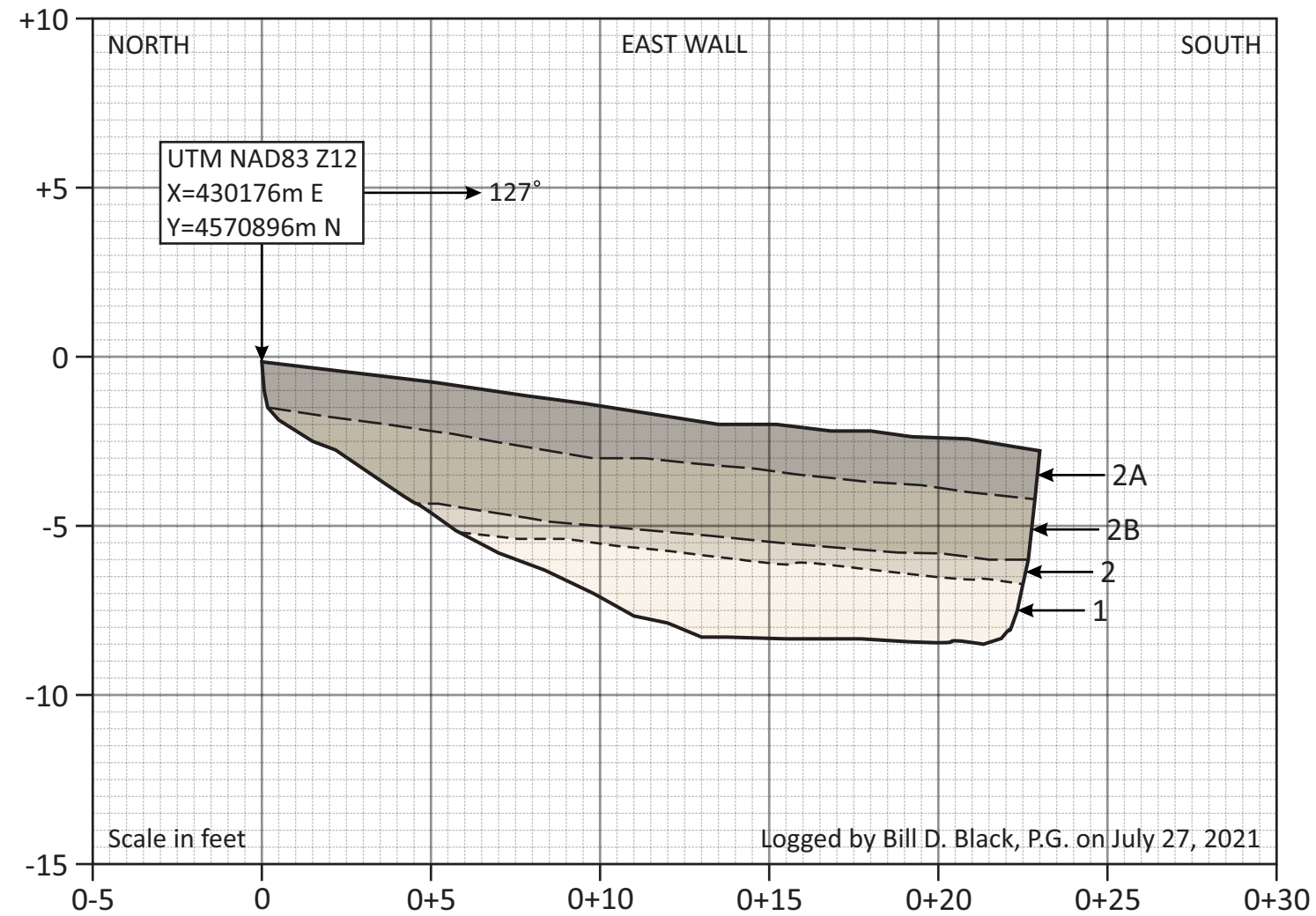
GEOLOGIC HAZARDS EVALUATION

Proposed Osprey Ranch Development
2050 Highway 150
Eden, Weber County, Utah

FIGURE 3C



TEST PIT 7

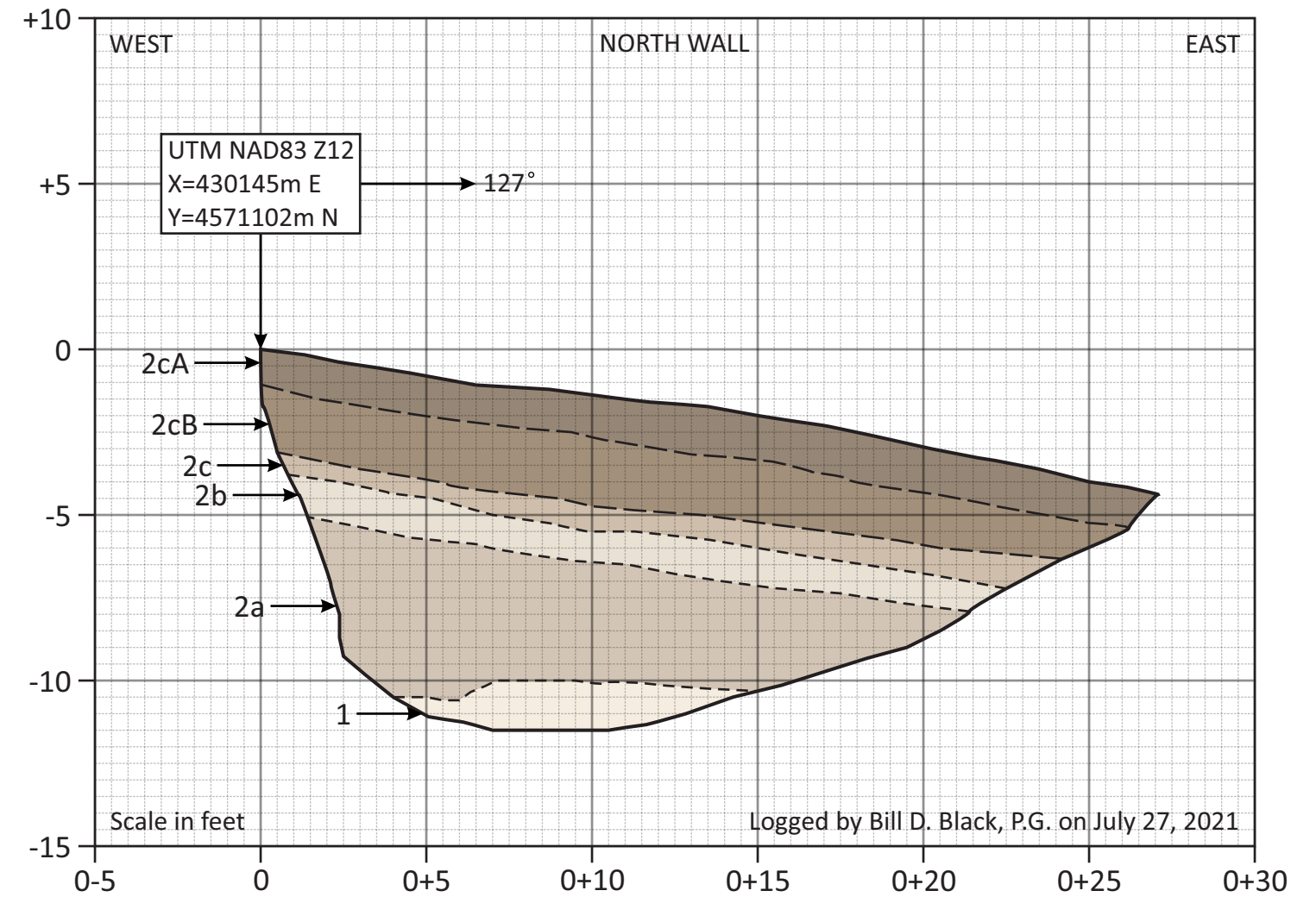


UNIT DESCRIPTIONS

Unit 1. *Tertiary Norwood Formation* - brownish-olive, orange-brown and light brown; strong; poorly bedded; weathered claystone in upper part overlying weathered tuffaceous conglomerate with subangular to subround cobbles.

Unit 2. *Late Pleistocene mass wasting colluvium* - brownish-olive to dark grayish-brown, stiff, massive, lean clay (CL) with sand; A and B soil horizons formed in unit (2A and 2B); about 4 feet thick.

TEST PIT 8



UNIT DESCRIPTIONS

Unit 1. *Tertiary Norwood Formation* - light orange-brown, strong, massive, weathered tuffaceous conglomerate.

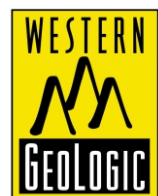
Unit 2. *Late Pleistocene mass wasting colluvium* - sequence of brown, brownish-gray, olive-brown and reddish-brown, stiff to dense, massive colluvium comprised of a lower (2a) lean clay (CL) with gravel; a middle (2b) gravelly clay to clayey gravel (CL/GC) with subangular cobbles; and an upper (2c) sandy clay (CL) with gravel and trace cobbles; A and B soil horizons formed in upper unit (2cA and 2cB); overall about 8.5 to 10 feet thick.

TEST PIT LOGS, 7 AND 8

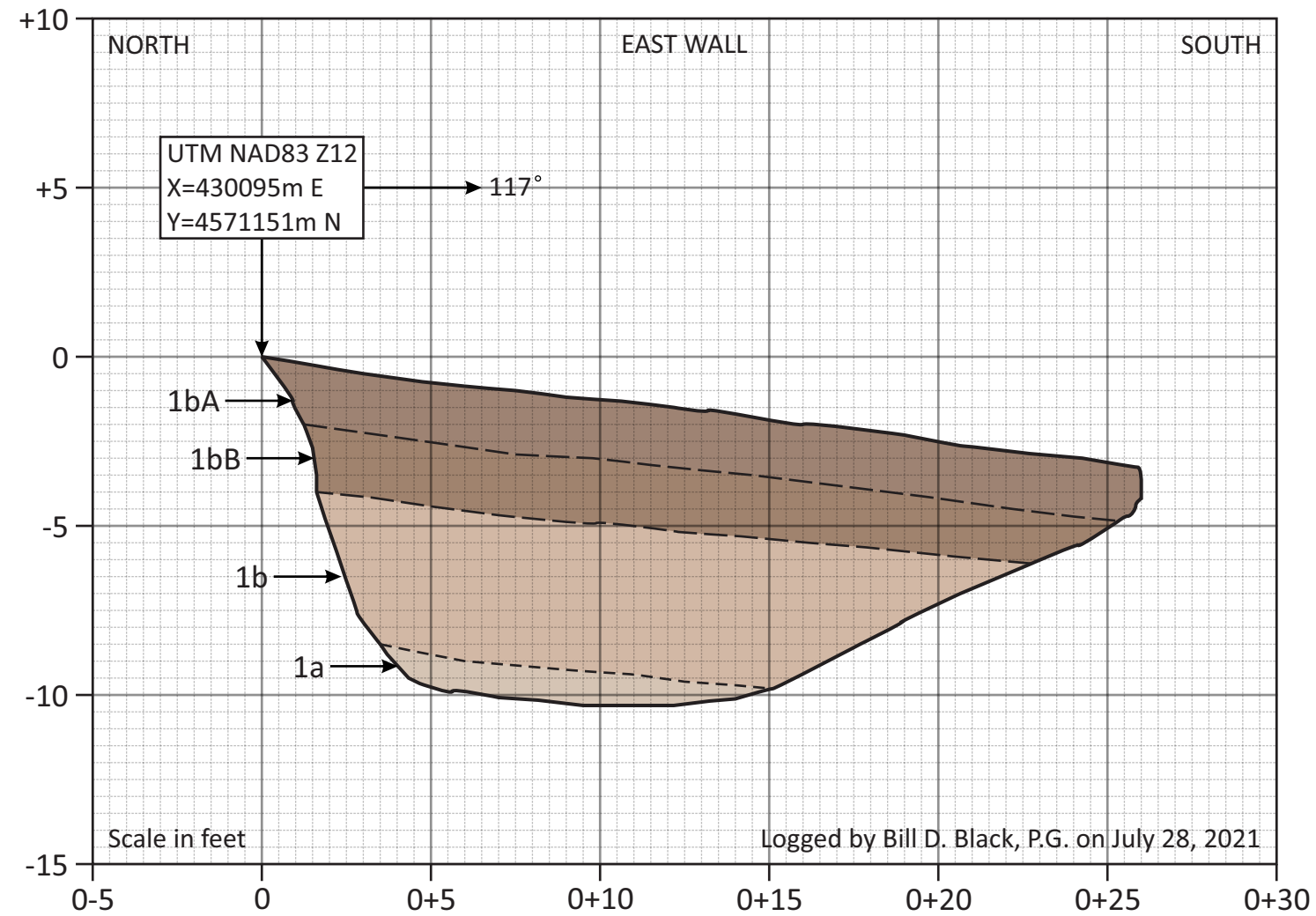
GEOLOGIC HAZARDS EVALUATION

Proposed Osprey Ranch Development
2050 Highway 150
Eden, Weber County, Utah

FIGURE 3D



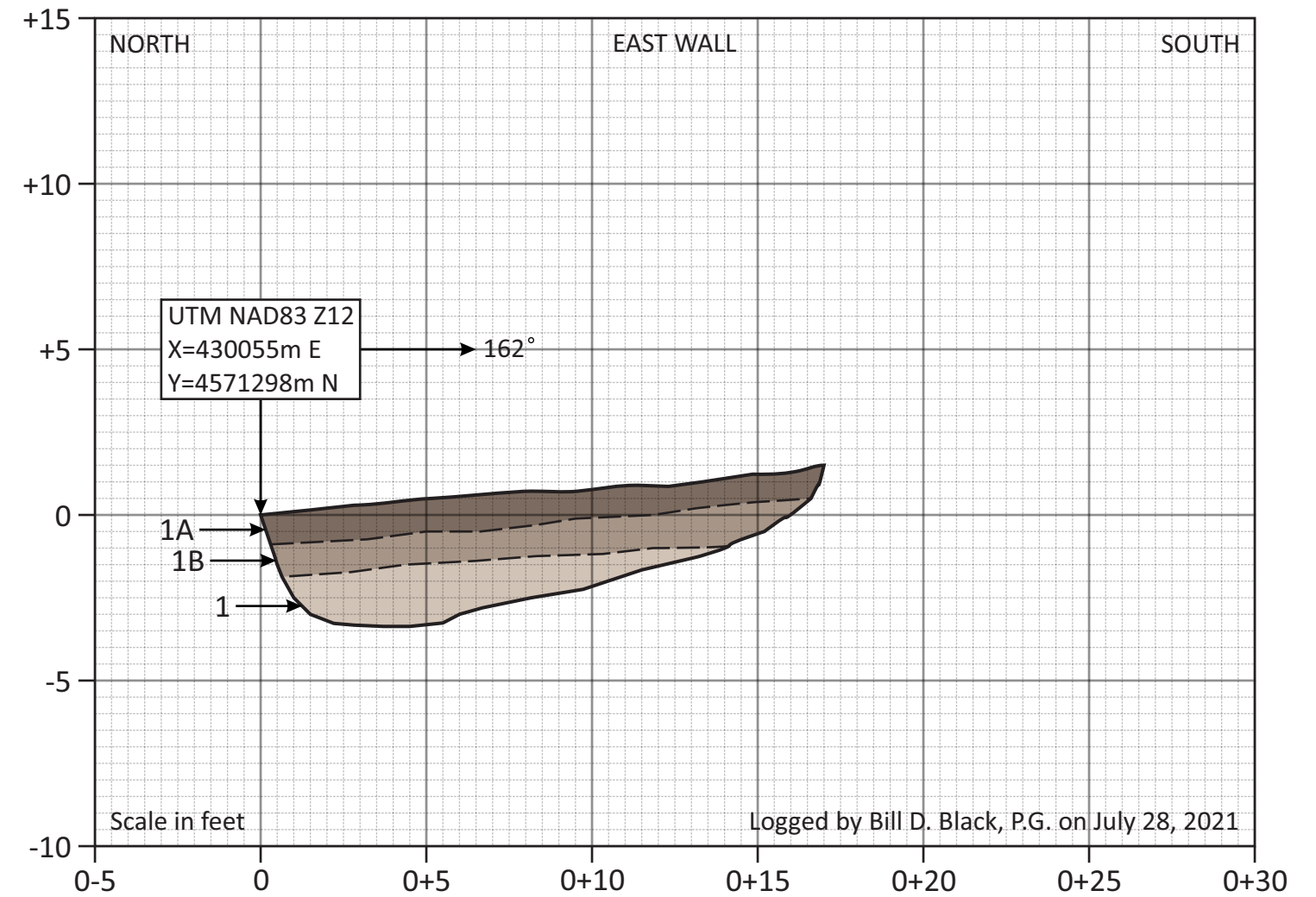
TEST PIT 9



UNIT DESCRIPTIONS

Unit 1. *Late Pleistocene mass wasting colluvium* - sequence comprised of a lower (1a) orange-brown, dense to stiff, massive, clayey gravel to gravelly clay (GC/CL); and an upper (1b) brown to dark grayish-brown, stiff, massive, clay (CL) with sand and gravel; A and B soil horizons formed in unit (1bA and 1bB); thickness > 9 feet.

TEST PIT 10



UNIT DESCRIPTIONS

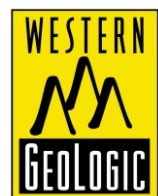
Unit 1. *Tertiary Norwood Formation* - orange-brown to dark grayish-brown, strong, massive, weathered tuffaceous conglomerate; A and B soil horizons formed in unit (1A and 1B); refusal at test pit floor.

TEST PIT LOGS, 9 AND 10

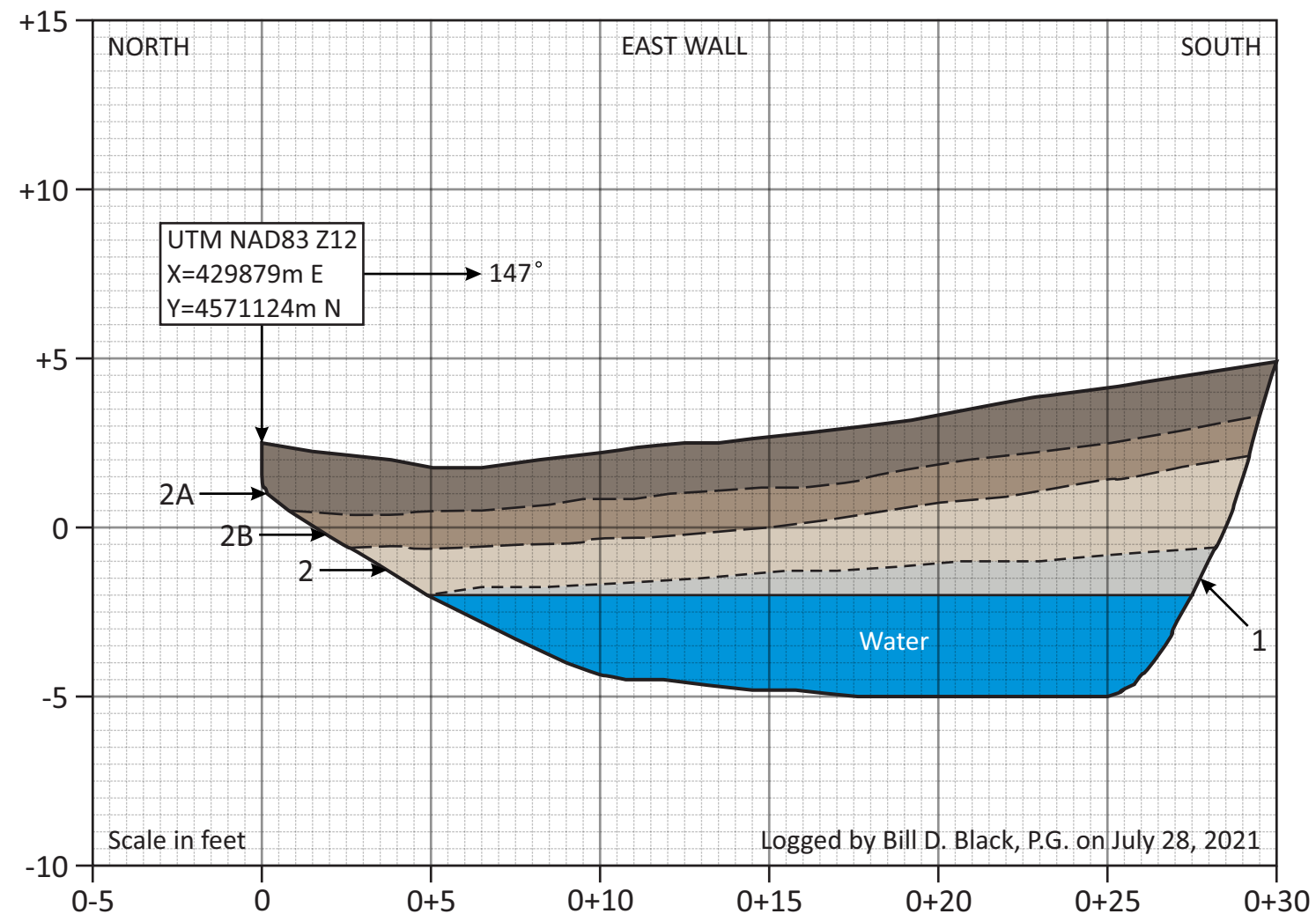
GEOLOGIC HAZARDS EVALUATION

Proposed Osprey Ranch Development
2050 Highway 150
Eden, Weber County, Utah

FIGURE 3E



TEST PIT 11

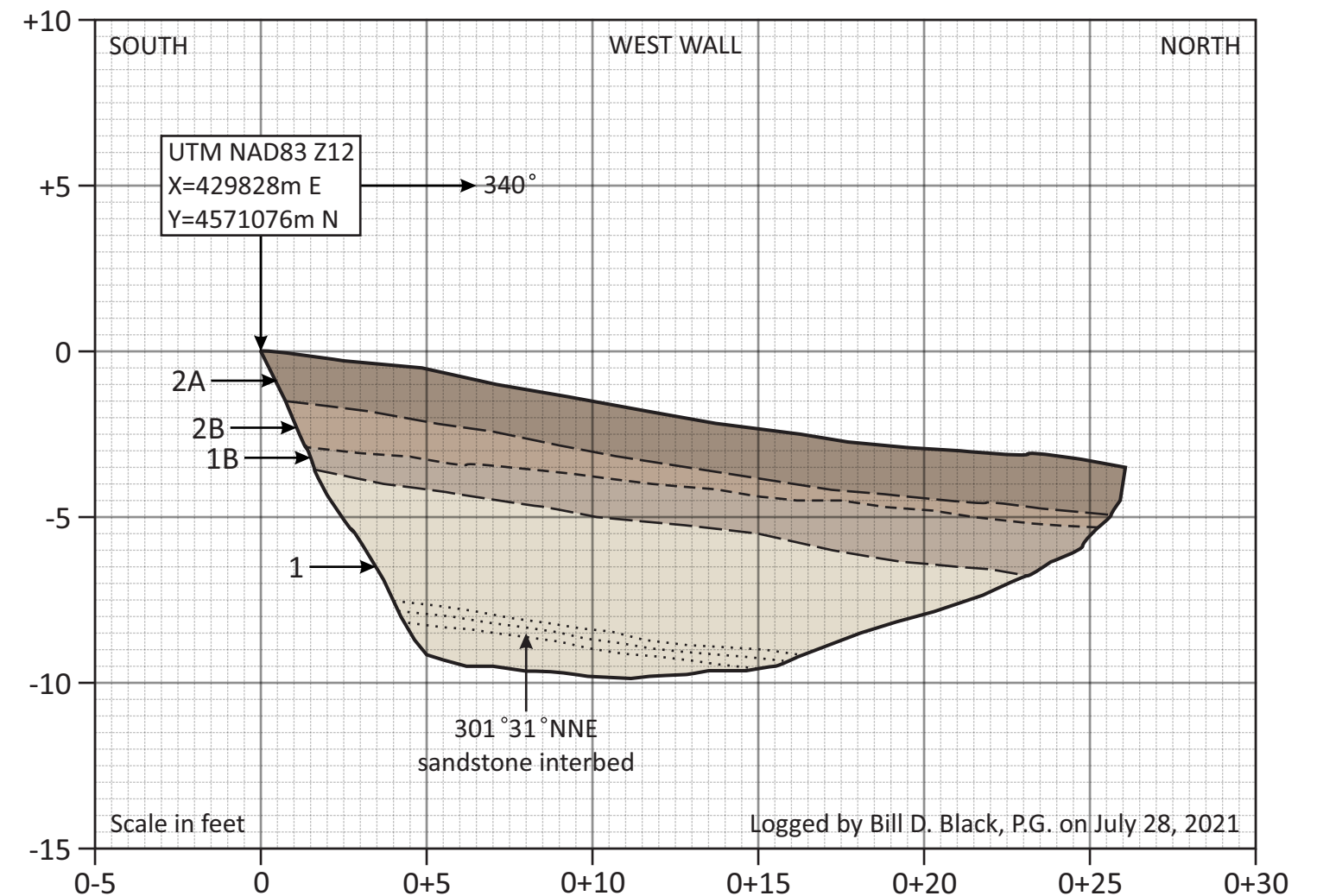


UNIT DESCRIPTIONS

Unit 1. *Tertiary Norwood Formation* - grayish-olive, dense, poorly bedded, strong, weathered tuffaceous sandstone; strike and dip not measured due to water.

Unit 2. *Late Pleistocene mass wasting colluvium* - orange-brown to dark grayish-brown, stiff, massive, lean clay (CL) with sand and gravel; A and B soil horizons formed in unit (2A and 2B); about 4 to 5 feet thick.

TEST PIT 12



UNIT DESCRIPTIONS

Unit 1. *Tertiary Norwood Formation* - light olive-brown, strong, poorly to well bedded, weathered claystone with iron oxide staining along bedding and sandstone interbeds up to 12 inches thick; B horizon formed in unit (1B).

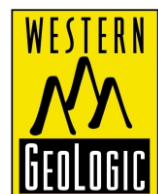
Unit 2. *Late Pleistocene mass wasting colluvium* - orange-brown to dark grayish-brown, dense, massive, clayey gravel (GC) with basal subangular cobbles with stage II carbonate; A and B soil horizons formed in unit (2A and 2B); about 2 to 3 feet thick.

TEST PIT LOGS, 11 AND 12

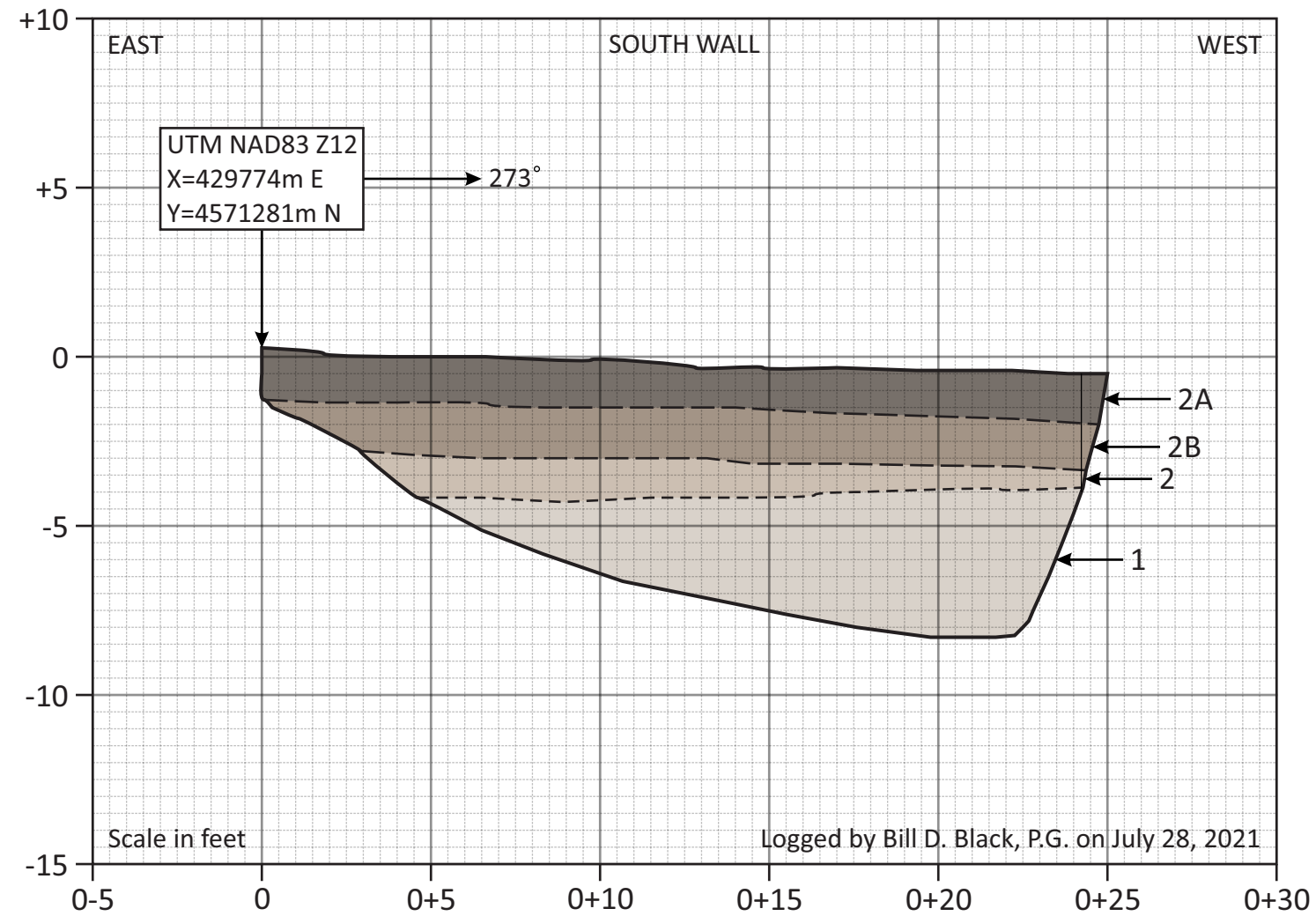
GEOLOGIC HAZARDS EVALUATION

Proposed Osprey Ranch Development
2050 Highway 150
Eden, Weber County, Utah

FIGURE 3F



TEST PIT 13

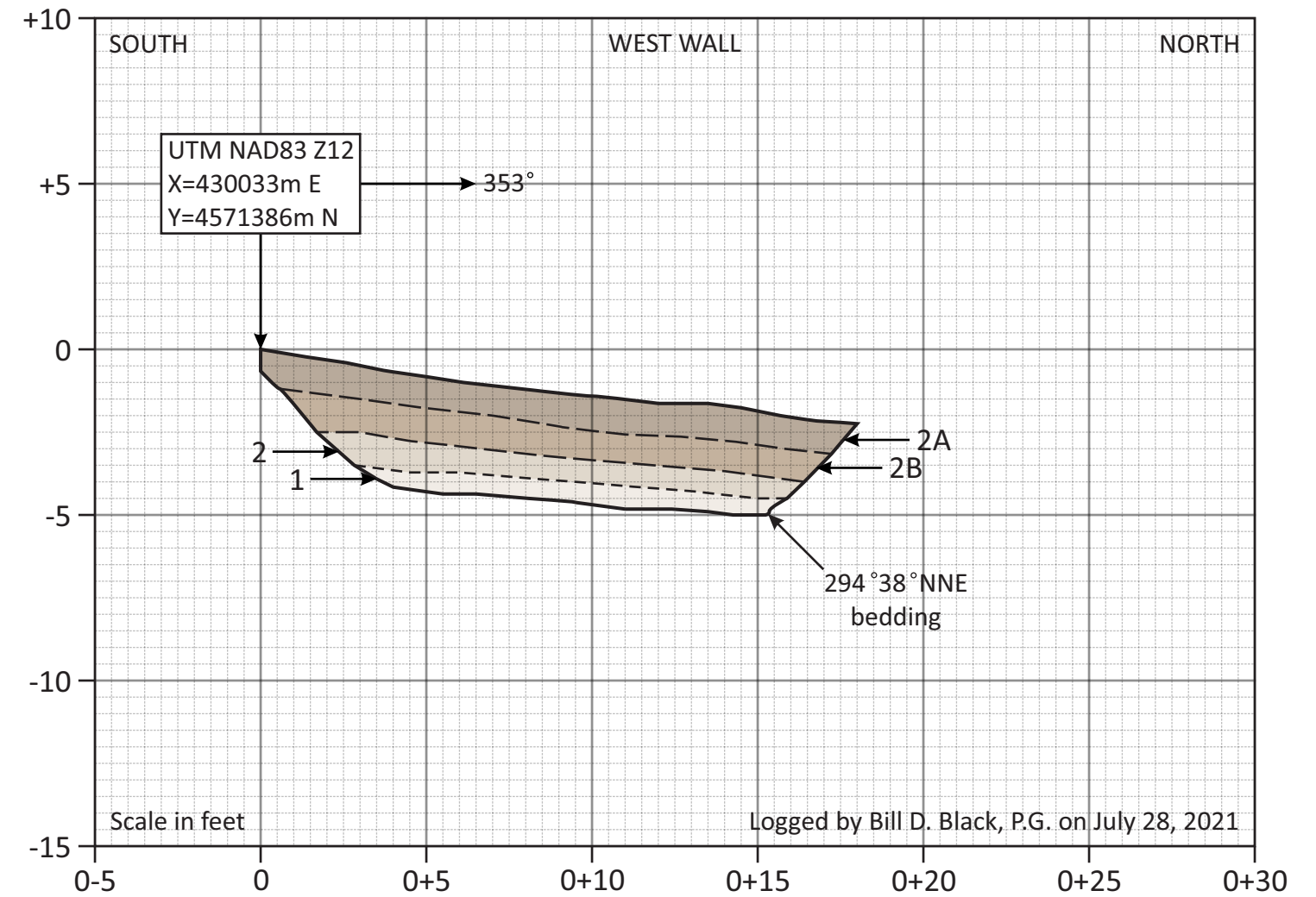


UNIT DESCRIPTIONS

Unit 1. *Tertiary Norwood Formation* - light orange-brown to light grayish-brown, moderately strong, weathered tuffaceous conglomerate; clasts subangular with stage II carbonate, carbonate stringers in lower part of unit.

Unit 2. *Late Pleistocene mass wasting colluvium* - dark brown to dark grayish-brown, stiff, massive, lean clay (CL) with sand and near-surface subangular to subround cobbles with stage II carbonate; A and B soil horizons formed in unit (2A and 2B); about 3.5 to 4 feet thick.

TEST PIT 14



UNIT DESCRIPTIONS

Unit 1. *Tertiary Norwood Formation* - light brownish-olive, strong to very strong, well bedded, laminated, weathered tuffaceous sandstone.

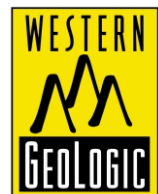
Unit 2. *Late Pleistocene mass wasting colluvium* - reddish-brown to dark grayish-brown, dense, massive, clayey gravel (GC) with sand and cobbles; clasts subangular to subround with stage II carbonate; A and B soil horizons formed in unit (2A and 2B); about 3 feet thick.

TEST PIT LOGS, 13 AND 14

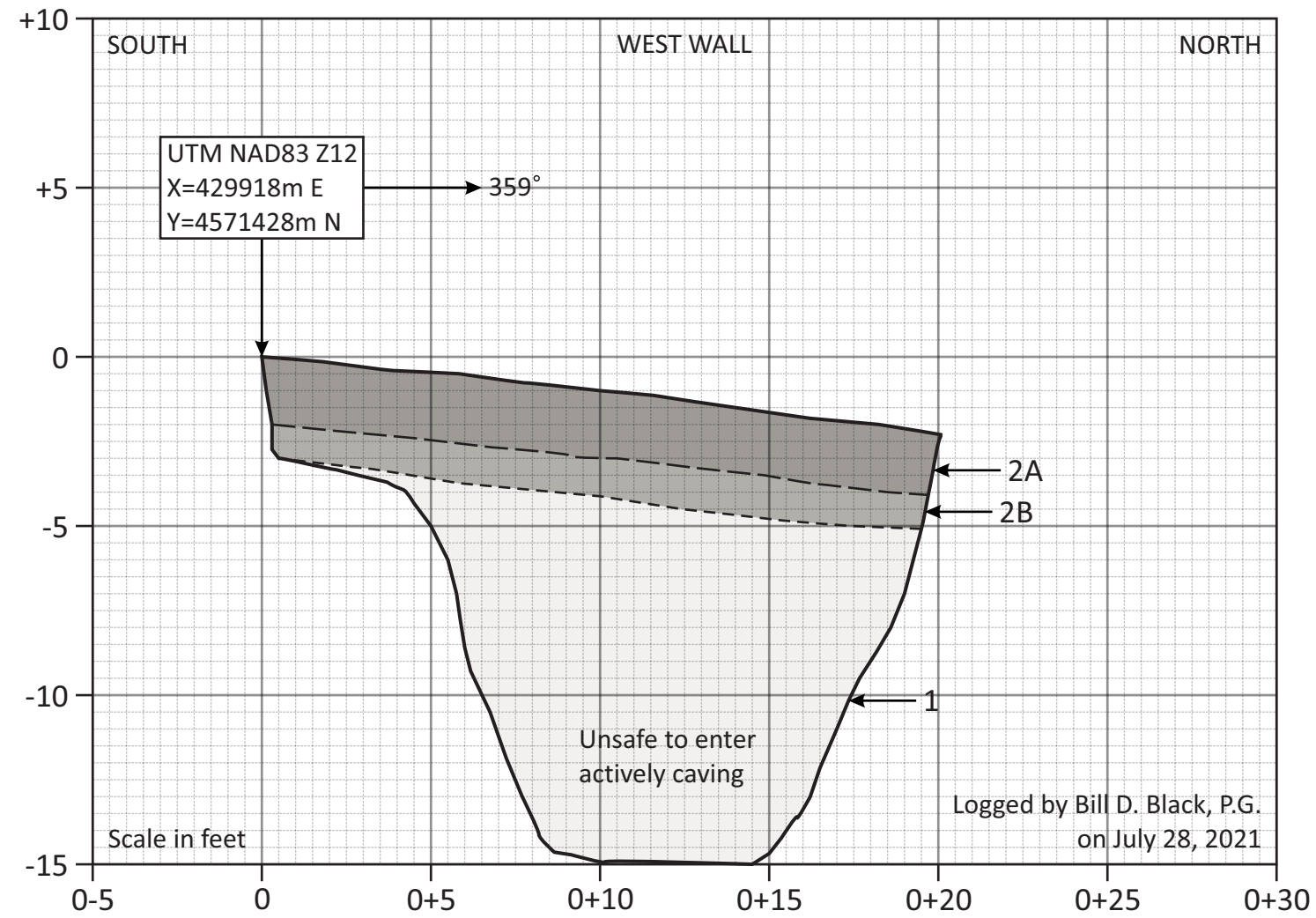
GEOLOGIC HAZARDS EVALUATION

Proposed Osprey Ranch Development
2050 Highway 150
Eden, Weber County, Utah

FIGURE 3G



TEST PIT 15

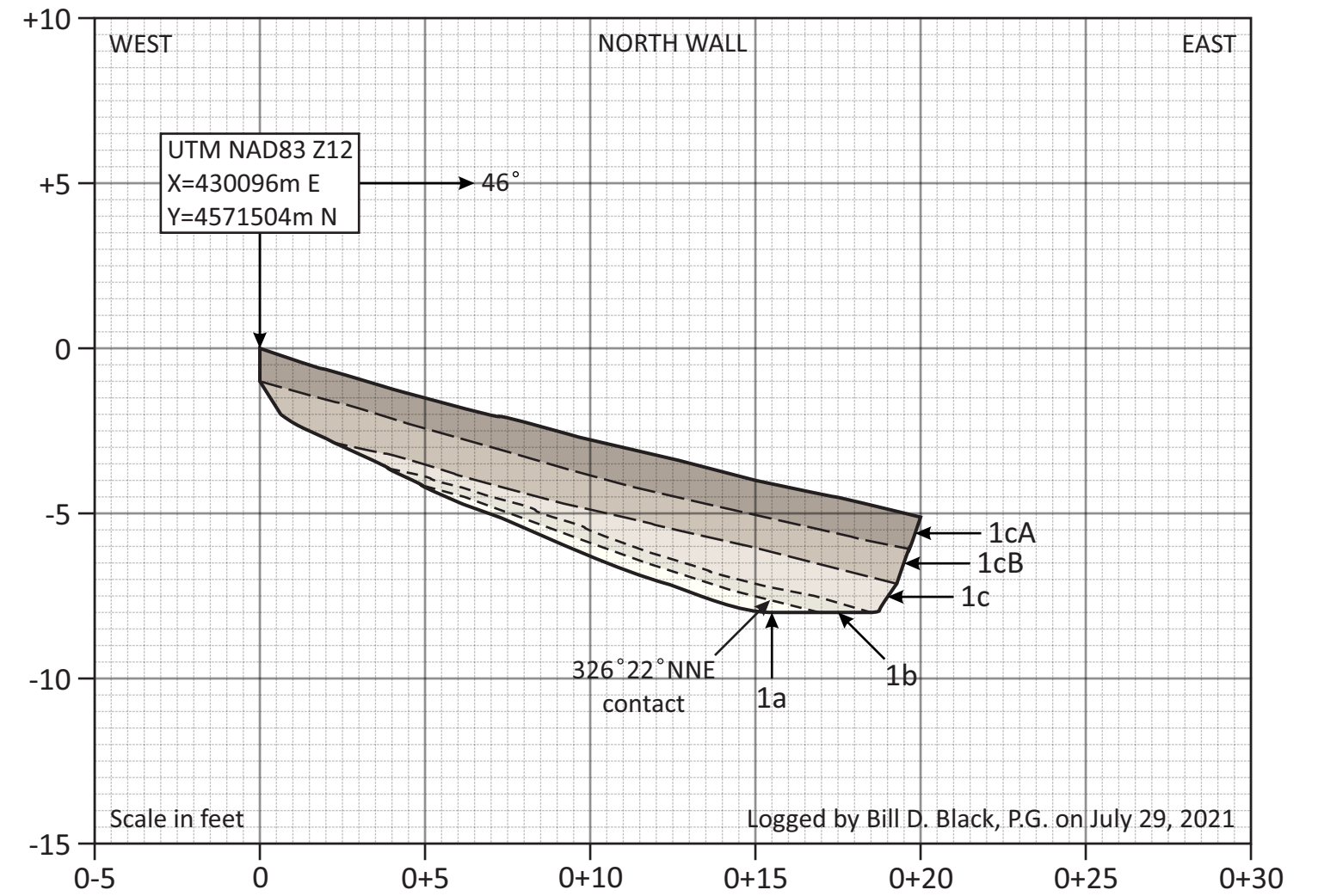


UNIT DESCRIPTIONS

Unit 1. *Tertiary Norwood Formation?* - light olive-brown to light grayish-olive, weak, highly fractured and weathered, poorly bedded, weathered claystone with brown banding.

Unit 2. *Late Pleistocene mass wasting colluvium* - dark grayish-brown to dark brownish-olive, stiff, massive, clay (CL) with sand, trace gravel and rare subangular to subround cobbles; A and B soil horizons formed in unit (2A and 2B); about 3 feet thick.

TEST PIT 16



UNIT DESCRIPTIONS

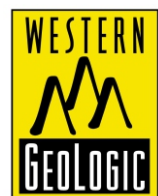
Unit 1. *Tertiary Norwood Formation* - sequence of interbedded, olive-brown to light brown, strong, well bedded, weathered bedrock comprised of a lower (1a) claystone, a middle (1b) tuffaceous sandstone, and an upper (1c) siltstone to claystone; A and B soil horizons formed in upper unit (1cA and 1cB).

TEST PIT LOGS, 15 AND 16

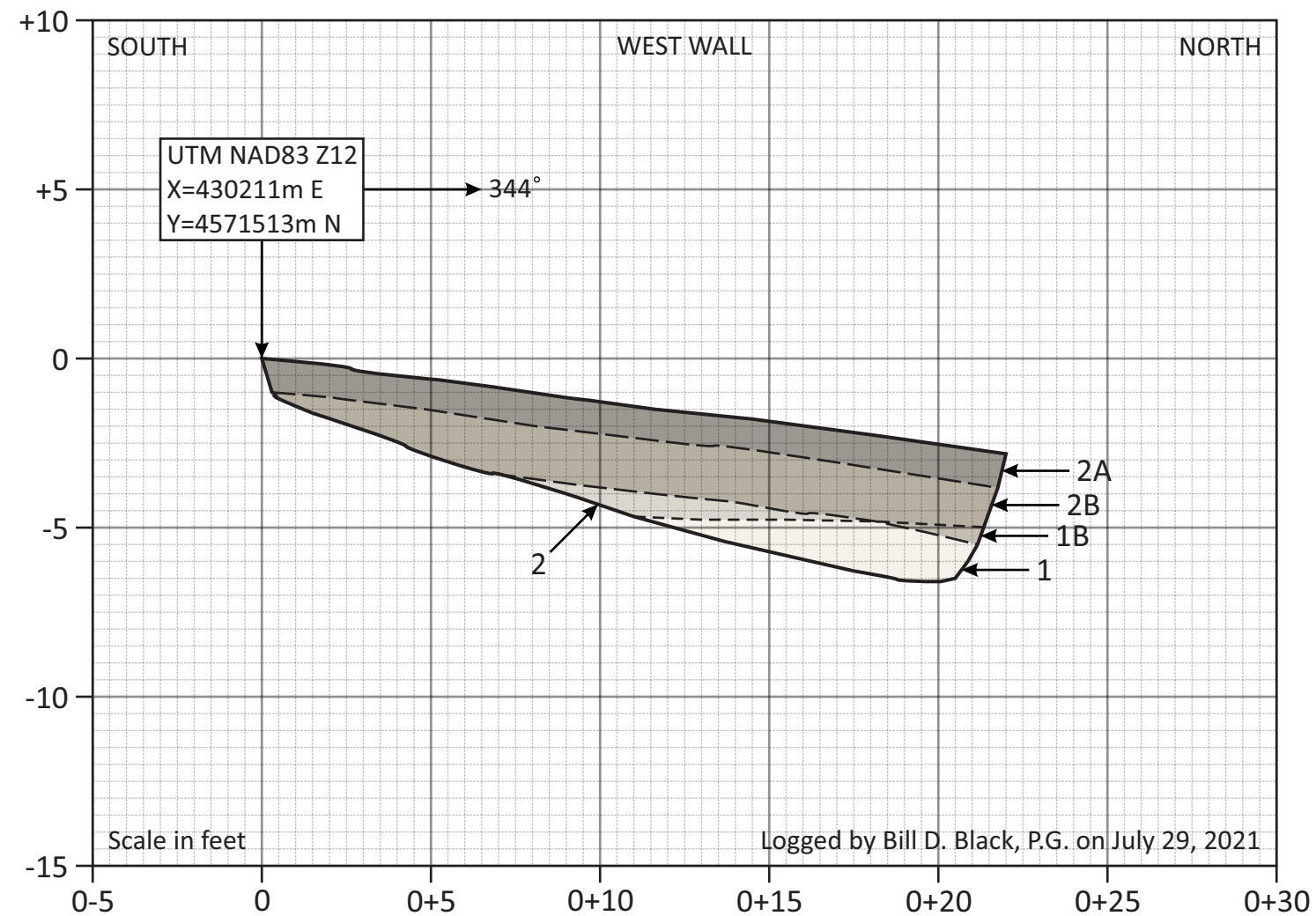
GEOLOGIC HAZARDS EVALUATION

Proposed Osprey Ranch Development
2050 Highway 150
Eden, Weber County, Utah

FIGURE 3H



TEST PIT 17

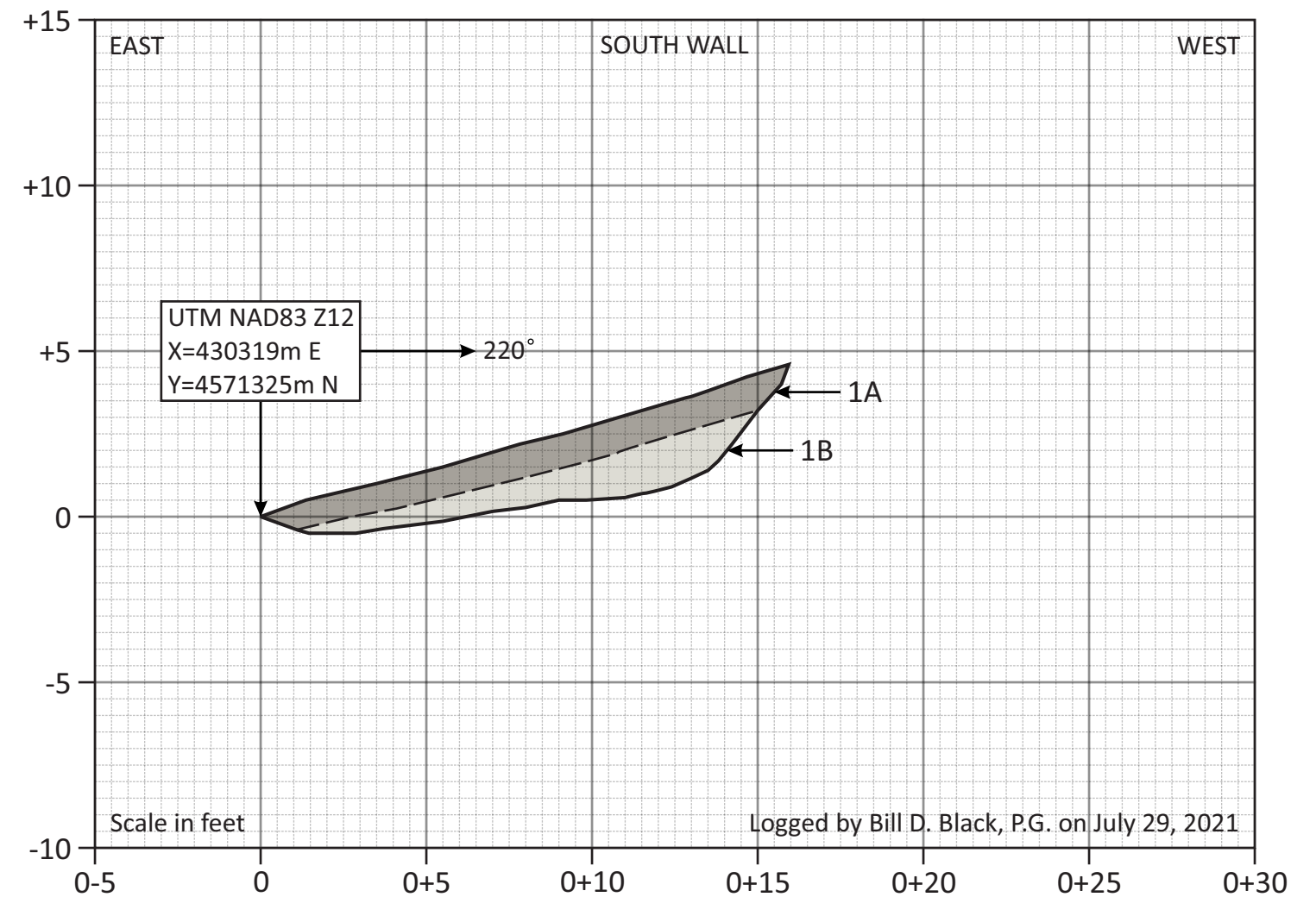


UNIT DESCRIPTIONS

Unit 1. *Tertiary Norwood Formation* - light olive-brown, strong, massive, weathered claystone; B soil horizon formed in unit (1B).

Unit 2. *Late Pleistocene mass wasting colluvium* - olive-brown to dark grayish-brown, stiff, massive, lean clay (CL) with sand; A and B soil horizons formed in unit (2A and 2B); about 2.5 to 3.5 feet thick.

TEST PIT 18



UNIT DESCRIPTIONS

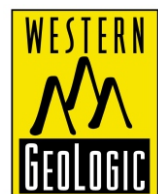
Unit 1. *Tertiary Norwood Formation* - brownish-white, very strong, well bedded, tuffaceous sandstone; refusal at test pit floor; exposure too shallow to observe base of B horizon or measure strike/dip; A and B soil horizons formed in unit (1A and 1B).

TEST PIT LOGS, 17 AND 18

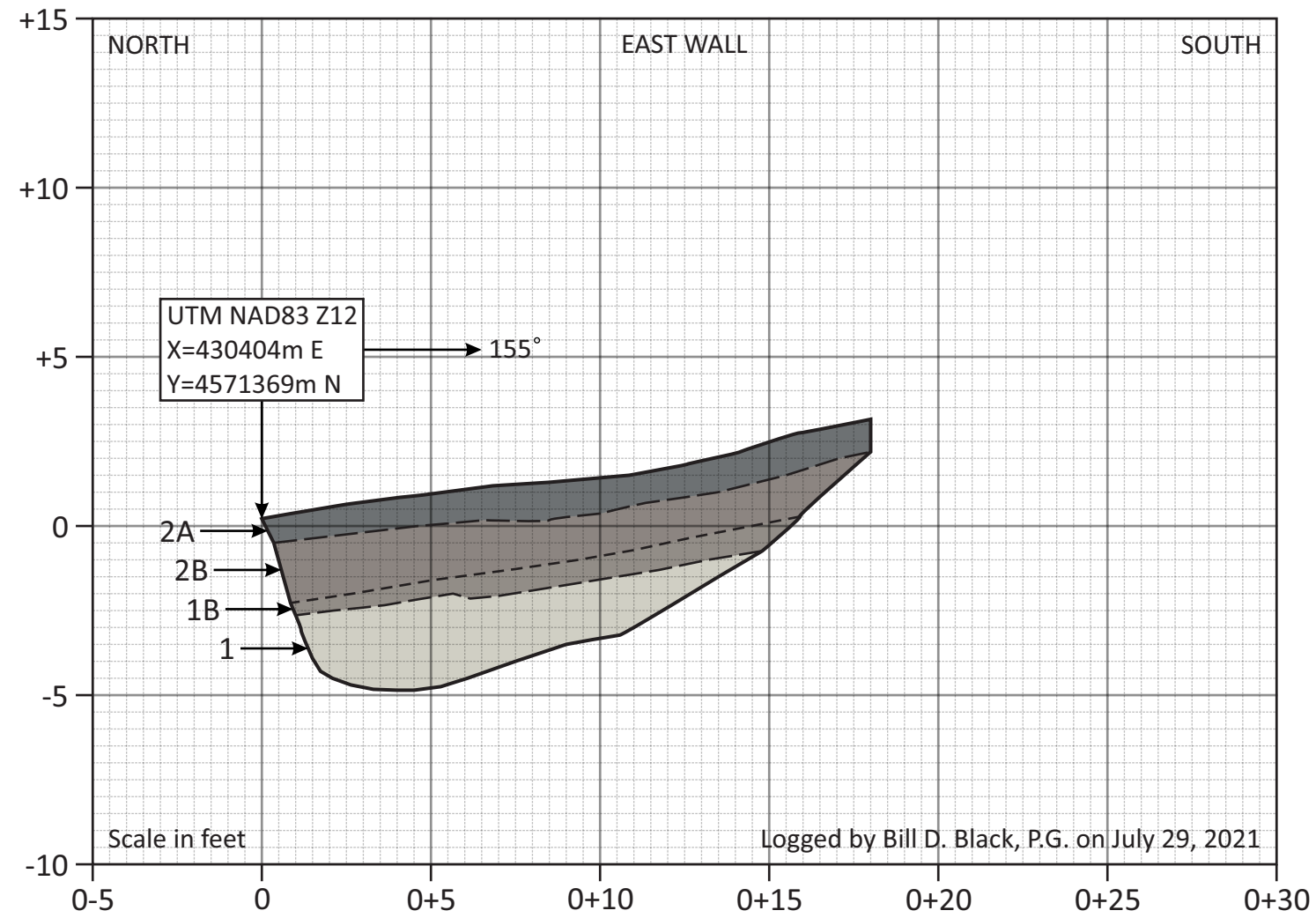
GEOLOGIC HAZARDS EVALUATION

Proposed Osprey Ranch Development
2050 Highway 150
Eden, Weber County, Utah

FIGURE 31



TEST PIT 19

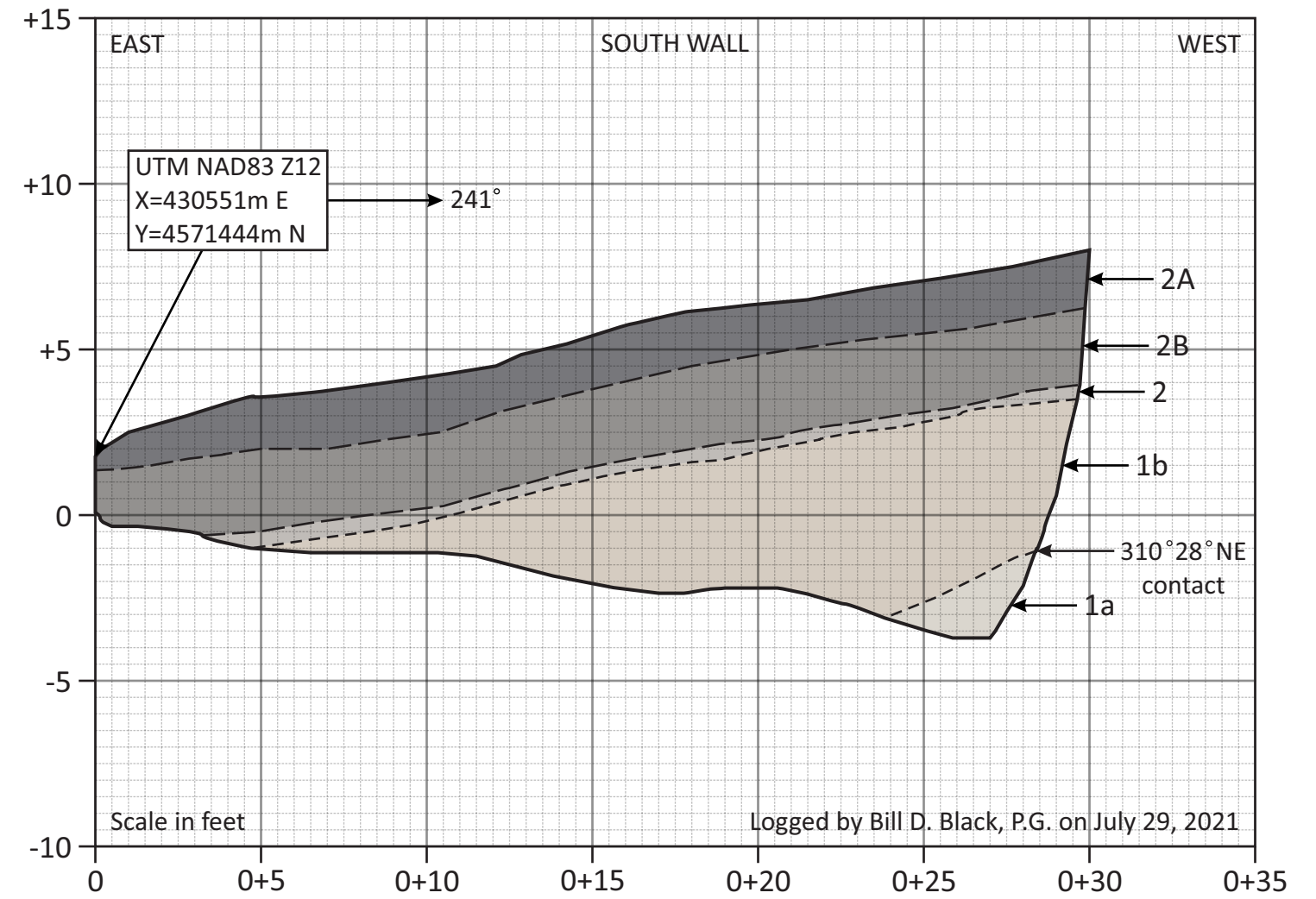


UNIT DESCRIPTIONS

Unit 1. *Tertiary Norwood Formation* - light olive-brown, strong, massive, weathered claystone; B soil horizon formed in unit (1B).

Unit 2. *Late Pleistocene mass wasting colluvium* - olive-brown to dark grayish-brown, stiff, massive, lean clay (CL) with sand; A and B soil horizons formed in unit (2A and 2B); about 3 feet thick.

TEST PIT 20



UNIT DESCRIPTIONS

Unit 1. *Tertiary Norwood Formation* - sequence of weathered bedrock comprised of a lower (1a) light grayish-olive, moderately strong, poorly bedded, siltstone to tuffaceous sandstone with carbonate; and an upper (1b) brownish-olive, strong, poorly bedded, claystone to tuffaceous conglomerate.

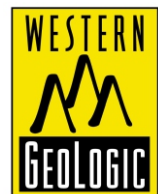
Unit 2. *Late Pleistocene to Holocene mixed alluvium and colluvium* - dark brown to dark grayish-brown, massive, stiff, lean clay (CL) with sand and gravel; A and B soil horizons formed in unit (2A and 2B); about 4 feet thick.

TEST PIT LOGS, 19 AND 20

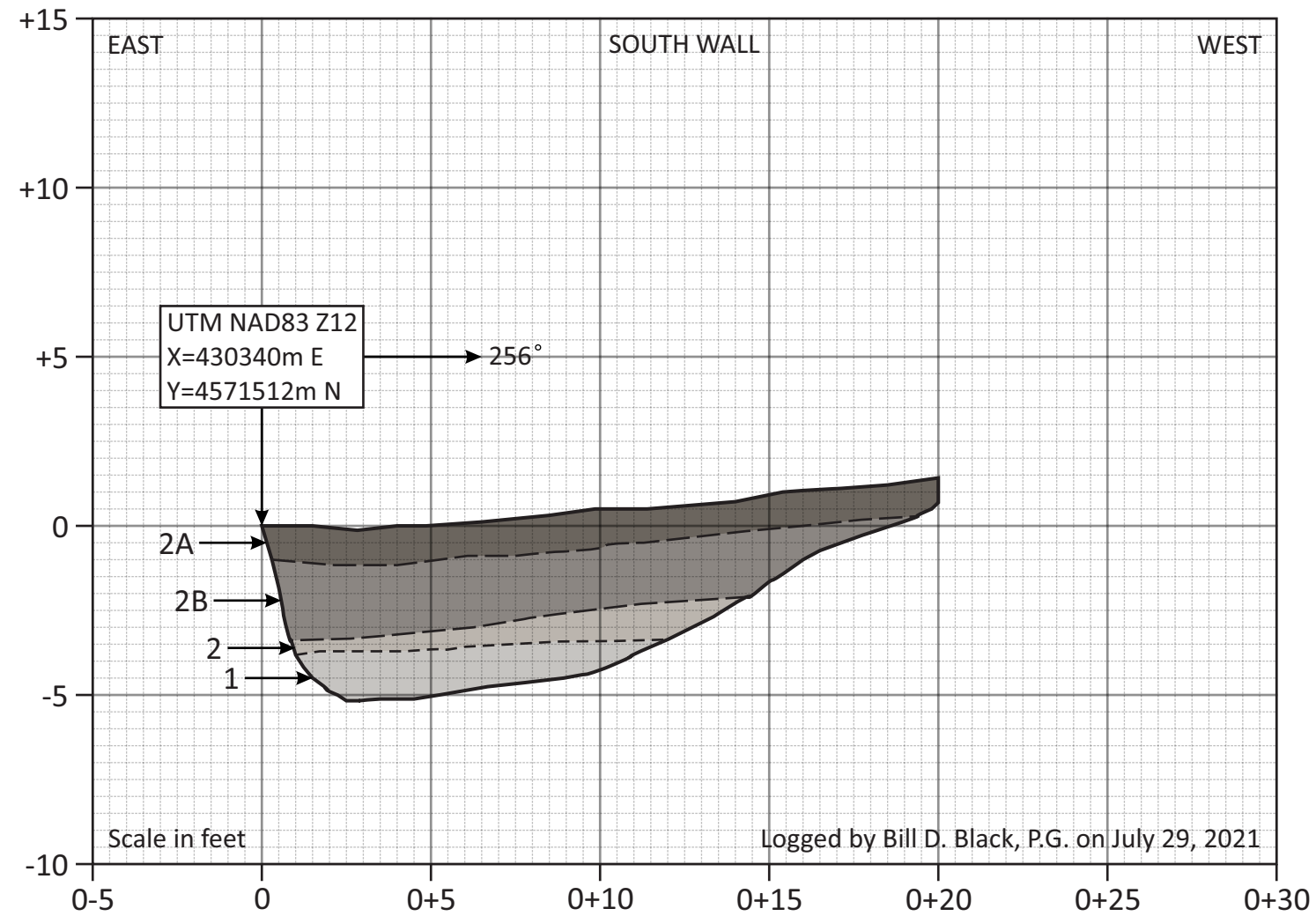
GEOLOGIC HAZARDS EVALUATION

Proposed Osprey Ranch Development
2050 Highway 150
Eden, Weber County, Utah

FIGURE 3J



TEST PIT 21

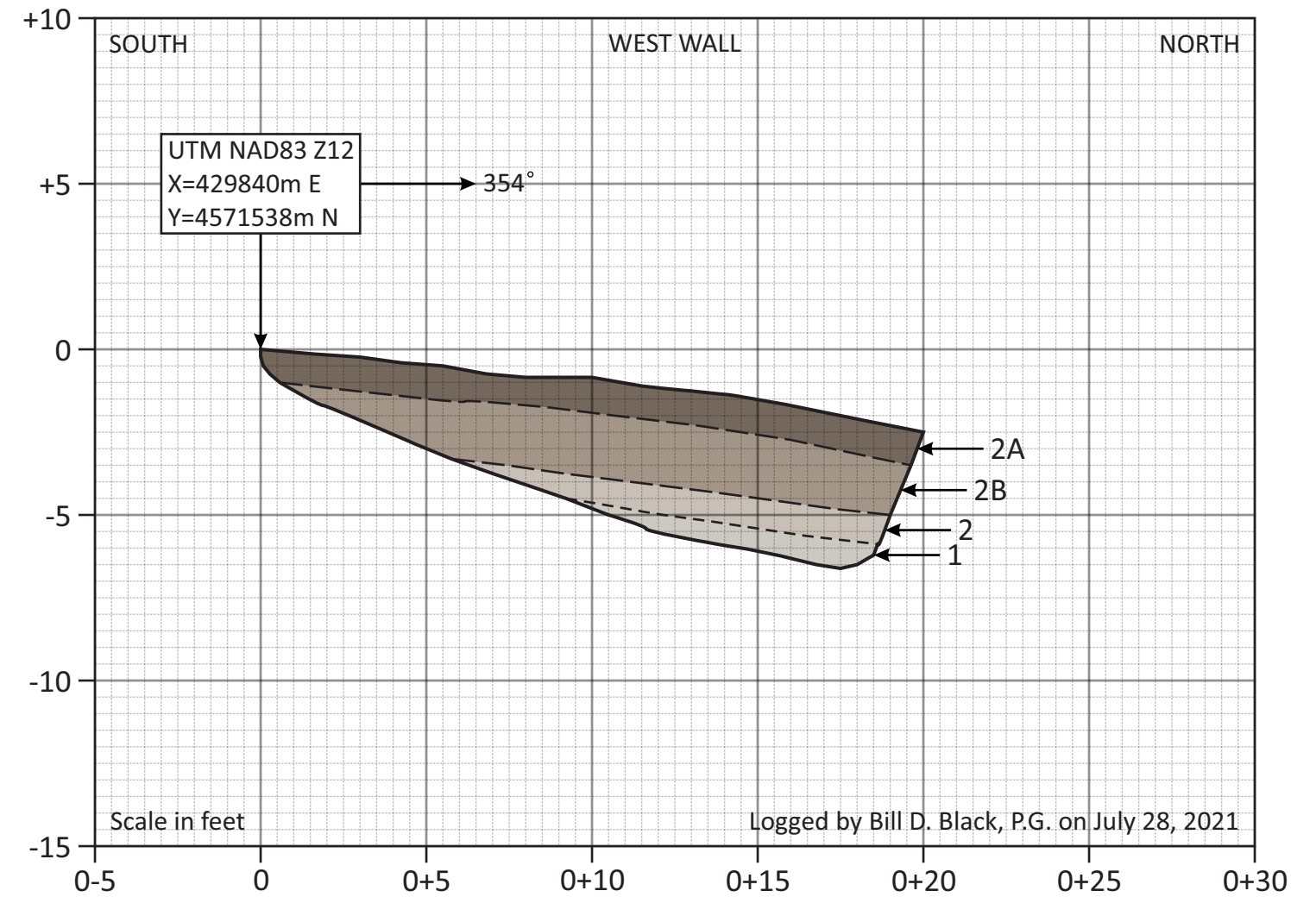


UNIT DESCRIPTIONS

Unit 1. *Tertiary Norwood Formation* - light olive-brown, strong, massive, weathered claystone.

Unit 2. *Late Pleistocene mass wasting colluvium* - olive-brown to dark grayish-brown, stiff, massive, lean clay (CL) with sand; A and B soil horizons formed in unit (2A and 2B); about 4 feet thick.

TEST PIT 22



UNIT DESCRIPTIONS

Unit 1. *Tertiary Norwood Formation* - light olive-brown to light grayish-olive, moderately strong, poorly bedded, weathered claystone.

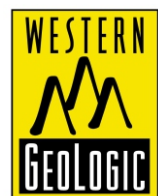
Unit 2. *Late Pleistocene mass wasting colluvium* - brown to dark grayish-brown, stiff, massive, clay (CL) with sand and subangular to subround cobbles with stage II carbonate; A and B soil horizons formed in unit (2A and 2B); about 4 feet thick.

TEST PIT LOGS, 21 AND 22

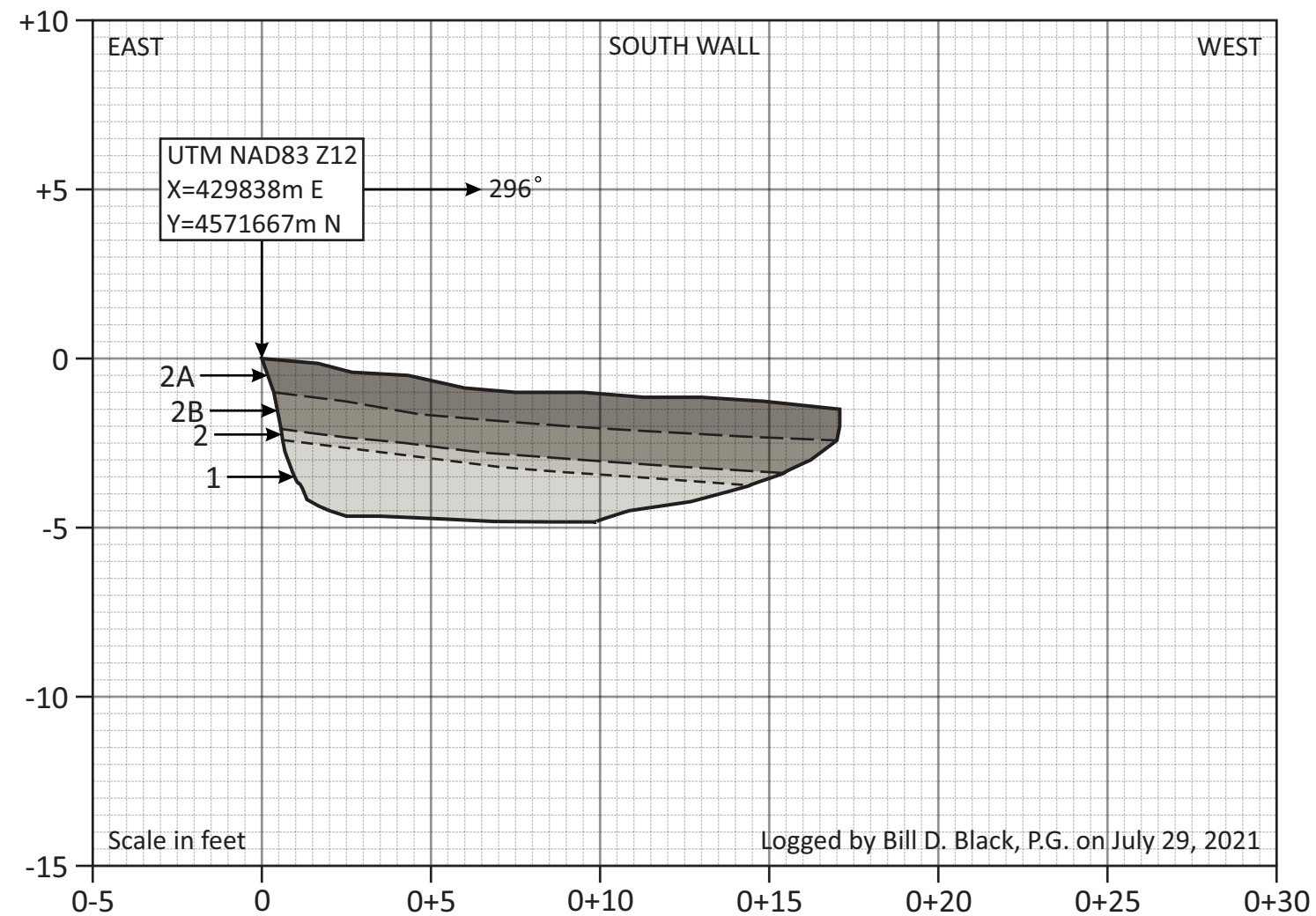
GEOLOGIC HAZARDS EVALUATION

Proposed Osprey Ranch Development
2050 Highway 150
Eden, Weber County, Utah

FIGURE 3K



TEST PIT 23

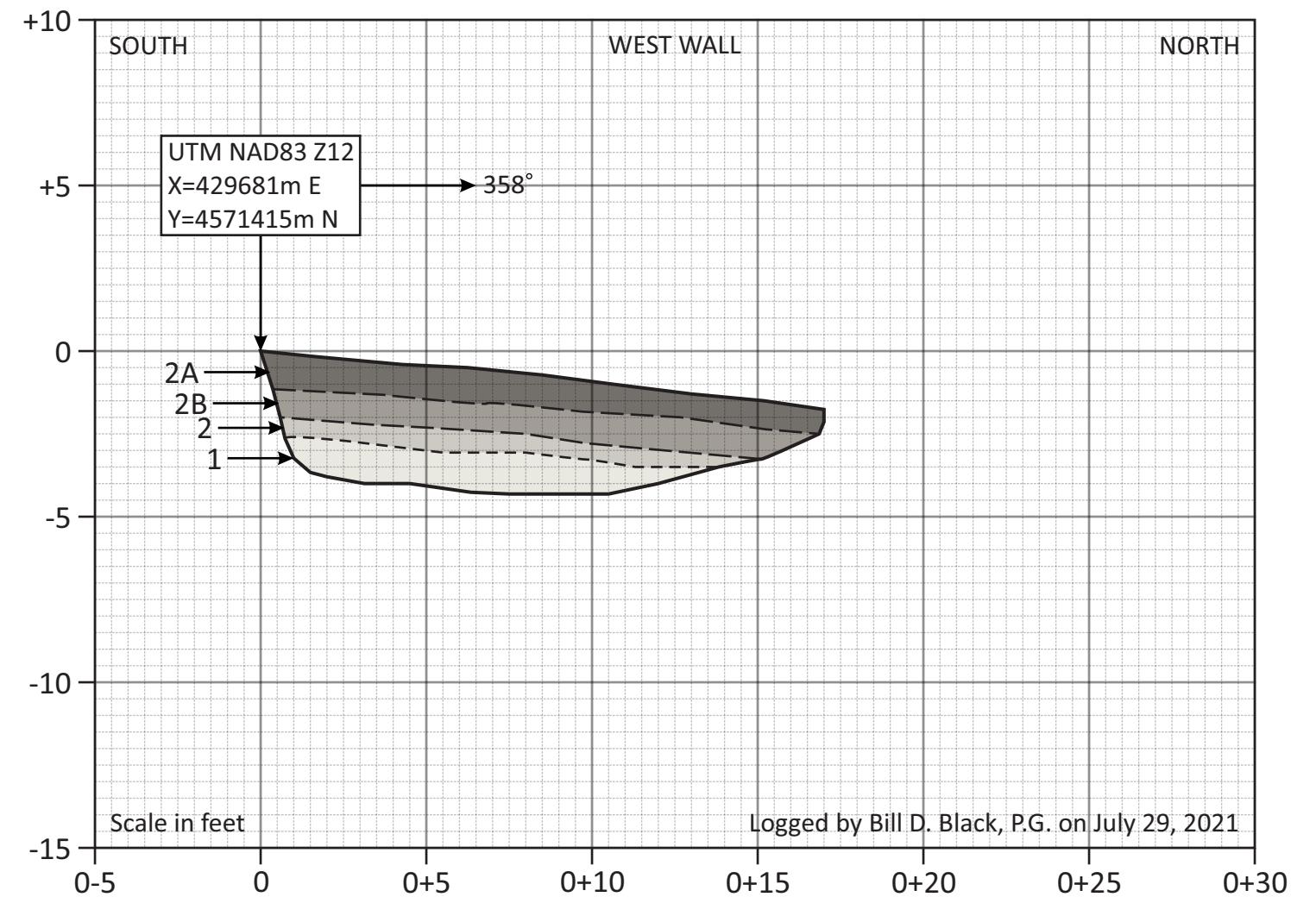


UNIT DESCRIPTIONS

Unit 1. *Tertiary Norwood Formation* - light grayish-brown, moderately strong, poorly bedded, weathered claystone.

Unit 2. *Late Pleistocene mass wasting colluvium* - dark grayish-brown, medium stiff, massive, lean clay (CL) with trace sand; A and B soil horizons formed in unit (2A and 2B); about 2 feet thick.

TEST PIT 24



UNIT DESCRIPTIONS

Unit 1. *Tertiary Norwood Formation* - light grayish-brown, moderately strong, poorly bedded, weathered claystone.

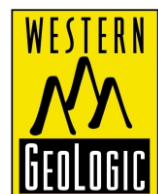
Unit 2. *Late Pleistocene to Holocene mixed alluvium and colluvium* - dark grayish-brown, medium stiff, massive, lean clay (CL) with trace sand; A and B soil horizons formed in unit (2A and 2B); about 2 to 3 feet thick.

TEST PIT LOGS, 23 AND 24

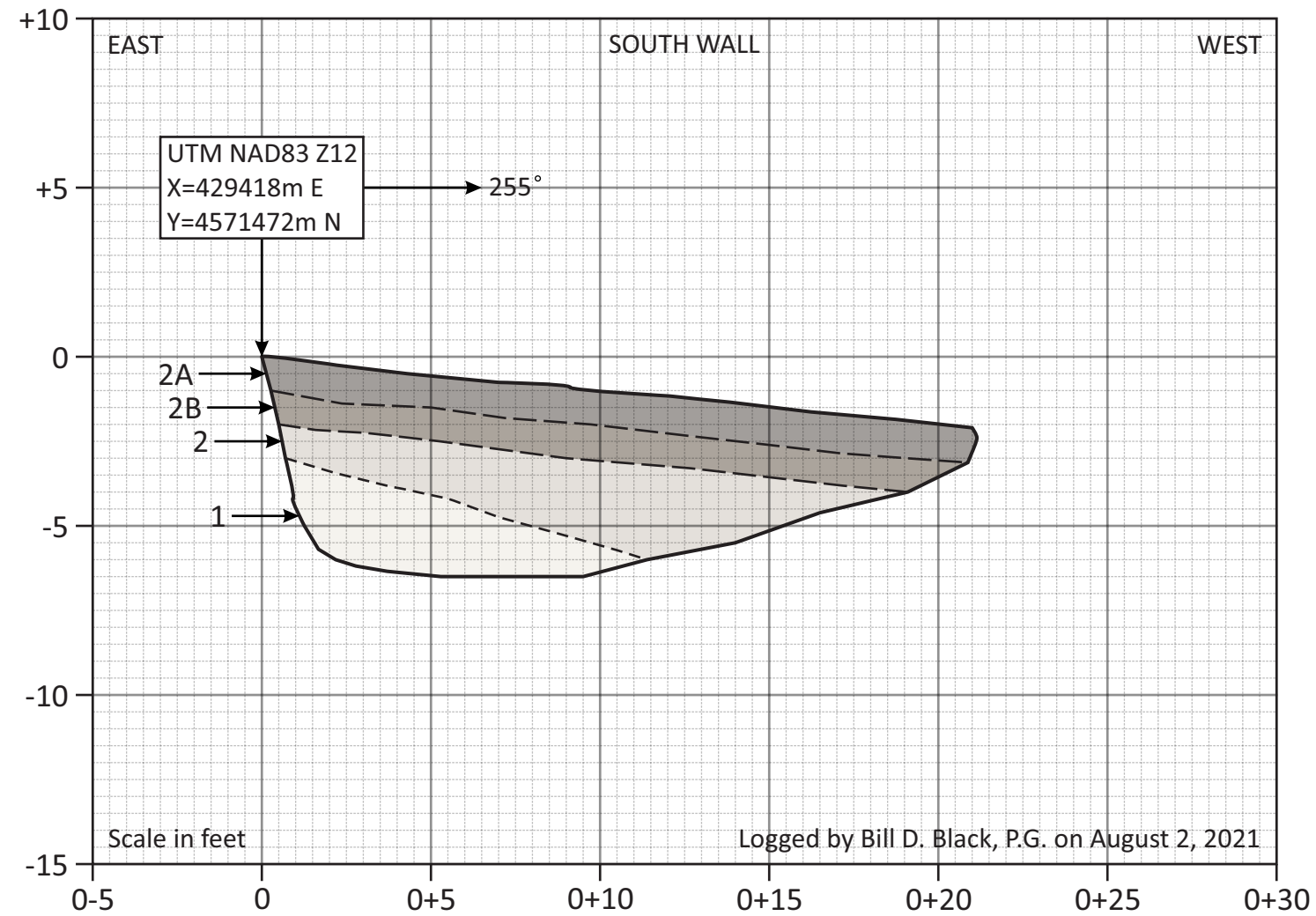
GEOLOGIC HAZARDS EVALUATION

Proposed Osprey Ranch Development
2050 Highway 150
Eden, Weber County, Utah

FIGURE 3L



TEST PIT 25

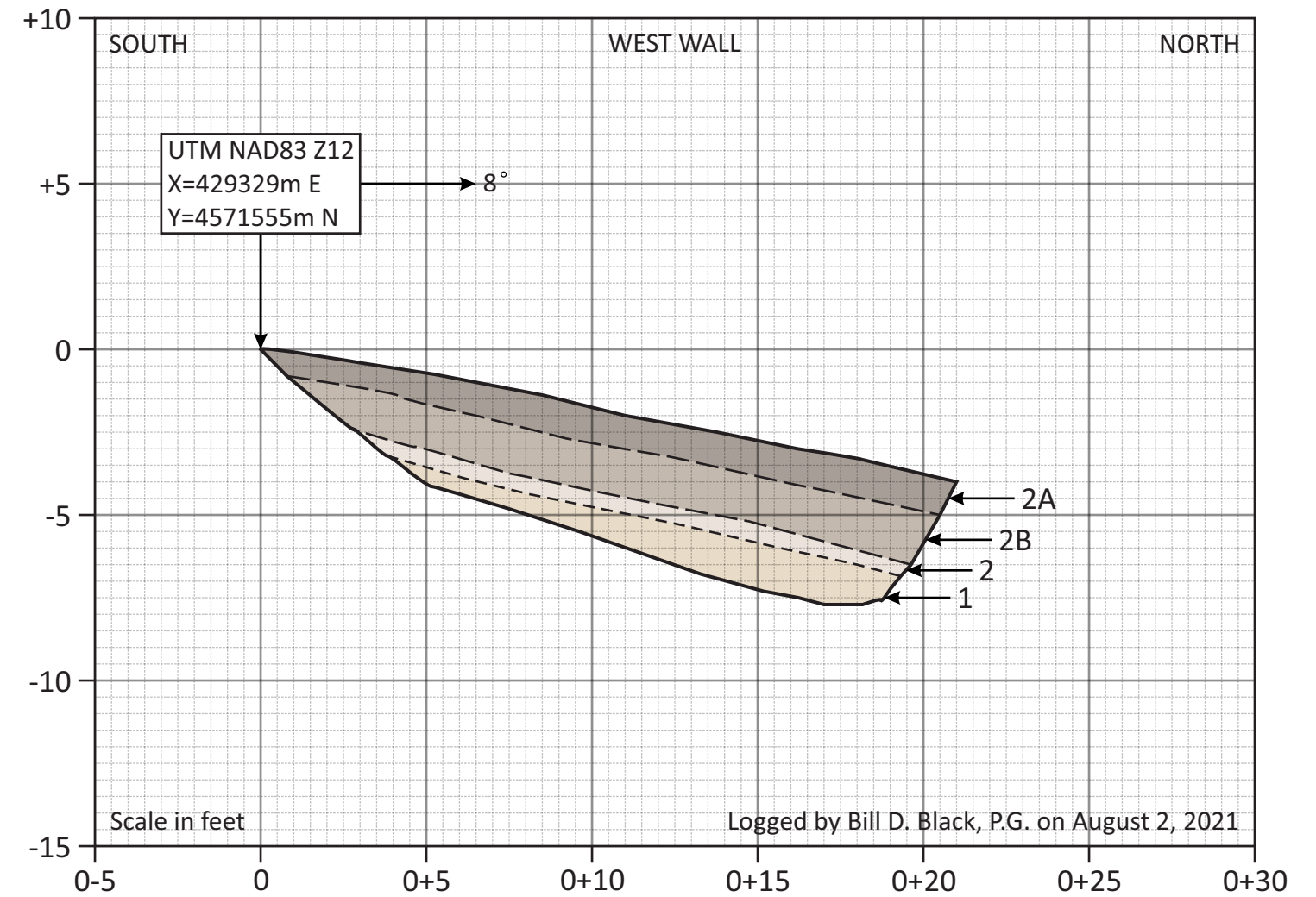


UNIT DESCRIPTIONS

Unit 1. *Tertiary Norwood Formation* - light grayish-olive-brown, strong, poorly bedded, weathered claystone.

Unit 2. *Late Pleistocene mass wasting colluvium* - brown to dark grayish-brown, stiff, massive, lean clay (CL) with sand and trace gravel; A and B soil horizons formed in unit (2A and 2B); about 3 to 5 feet thick.

TEST PIT 26



UNIT DESCRIPTIONS

Unit 1. *Tertiary Norwood Formation* - orange-brown, strong, massive, weathered pebble conglomerate.

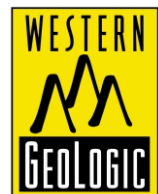
Unit 2. *Late Pleistocene mass wasting colluvium* - light brown to dark grayish-brown, stiff, massive, lean clay (CL) with sand and gravel; A and B soil horizons formed in unit (2A and 2B); about 3 feet thick.

TEST PIT LOGS, 25 AND 26

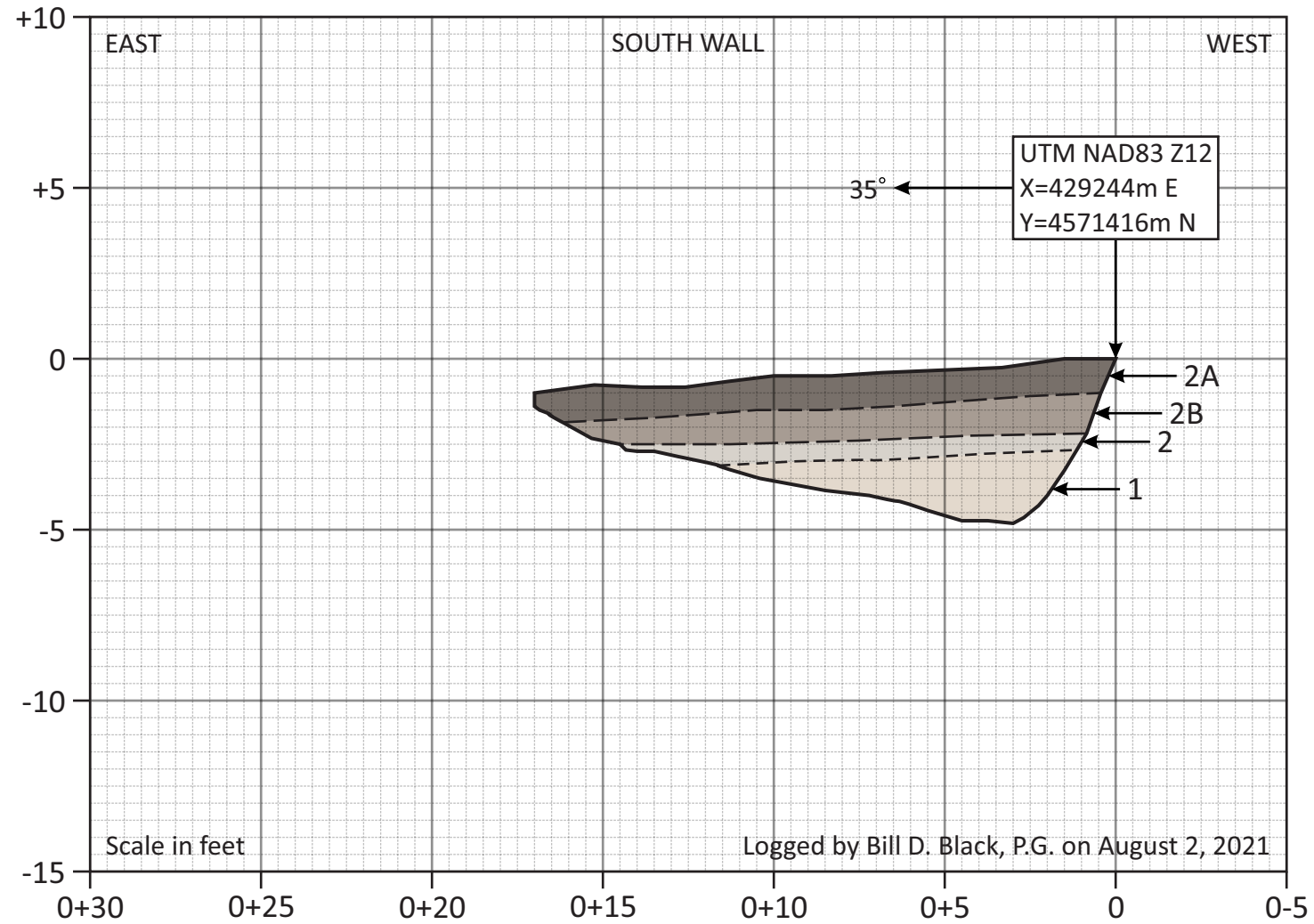
GEOLOGIC HAZARDS EVALUATION

Proposed Osprey Ranch Development
2050 Highway 150
Eden, Weber County, Utah

FIGURE 3M



TEST PIT 27

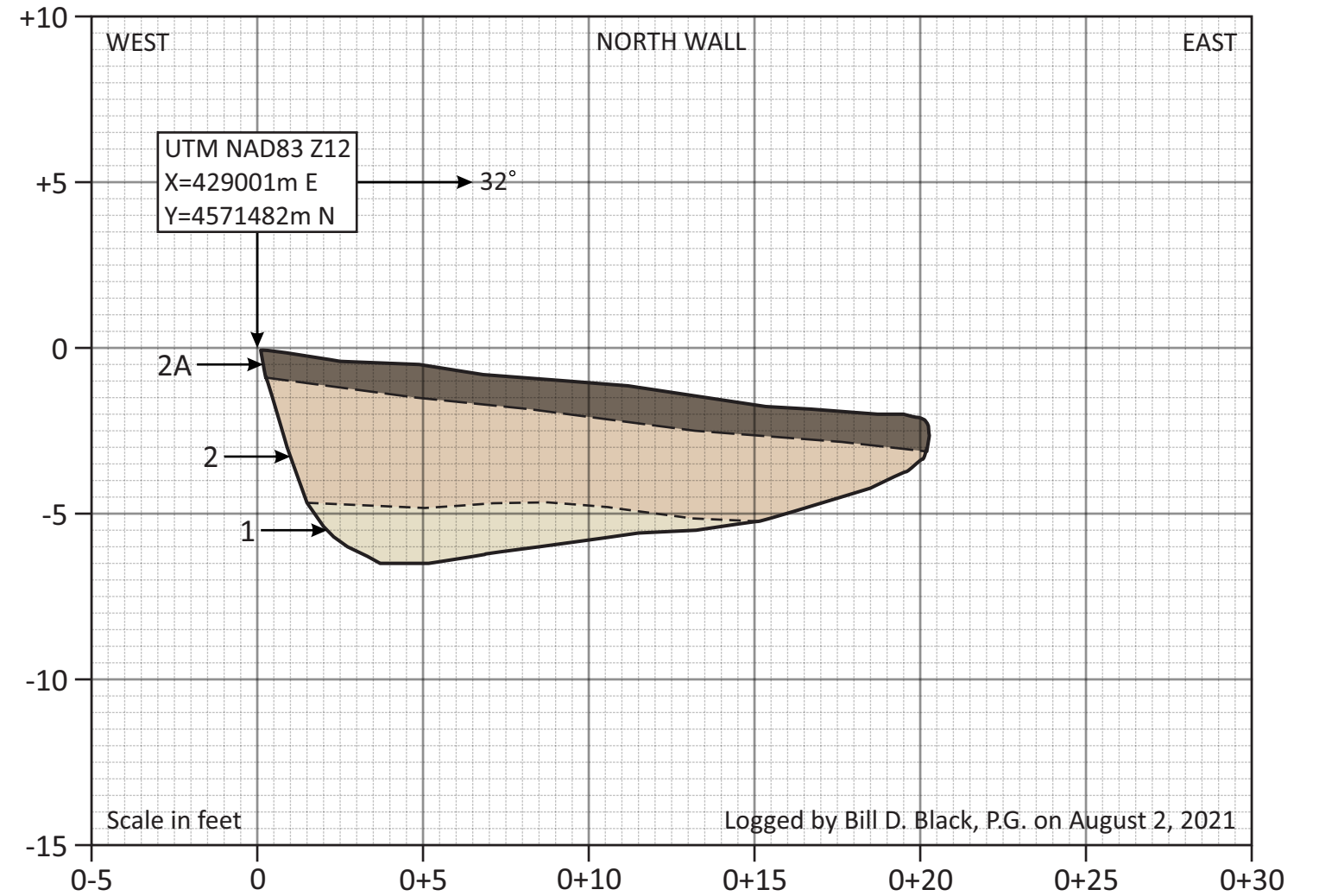


UNIT DESCRIPTIONS

Unit 1. *Tertiary Norwood Formation* - olive-brown, strong, poorly bedded, weathered claystone.

Unit 2. *Late Pleistocene mass wasting colluvium* - dark brown to dark grayish-brown, stiff, massive, lean clay (CL) with sand, gravel; and rare small subangular cobbles with stage II carbonate; A and B soil horizons formed in unit (2A and 2B); about 2.5 feet thick.

TEST PIT 28



UNIT DESCRIPTIONS

Unit 1. *Tertiary Norwood Formation* - light brown to olive-brown, strong, poorly bedded, weathered tuffaceous conglomerate with carbonate.

Unit 2. *Holocene mass wasting colluvium* - brown to dark grayish-brown, medium dense, massive, clayey gravel (GC) with sand and subangular to subround cobbles with stage II carbonate; A soil horizon formed in unit (2A); about 3.5 to 4.5 feet thick.



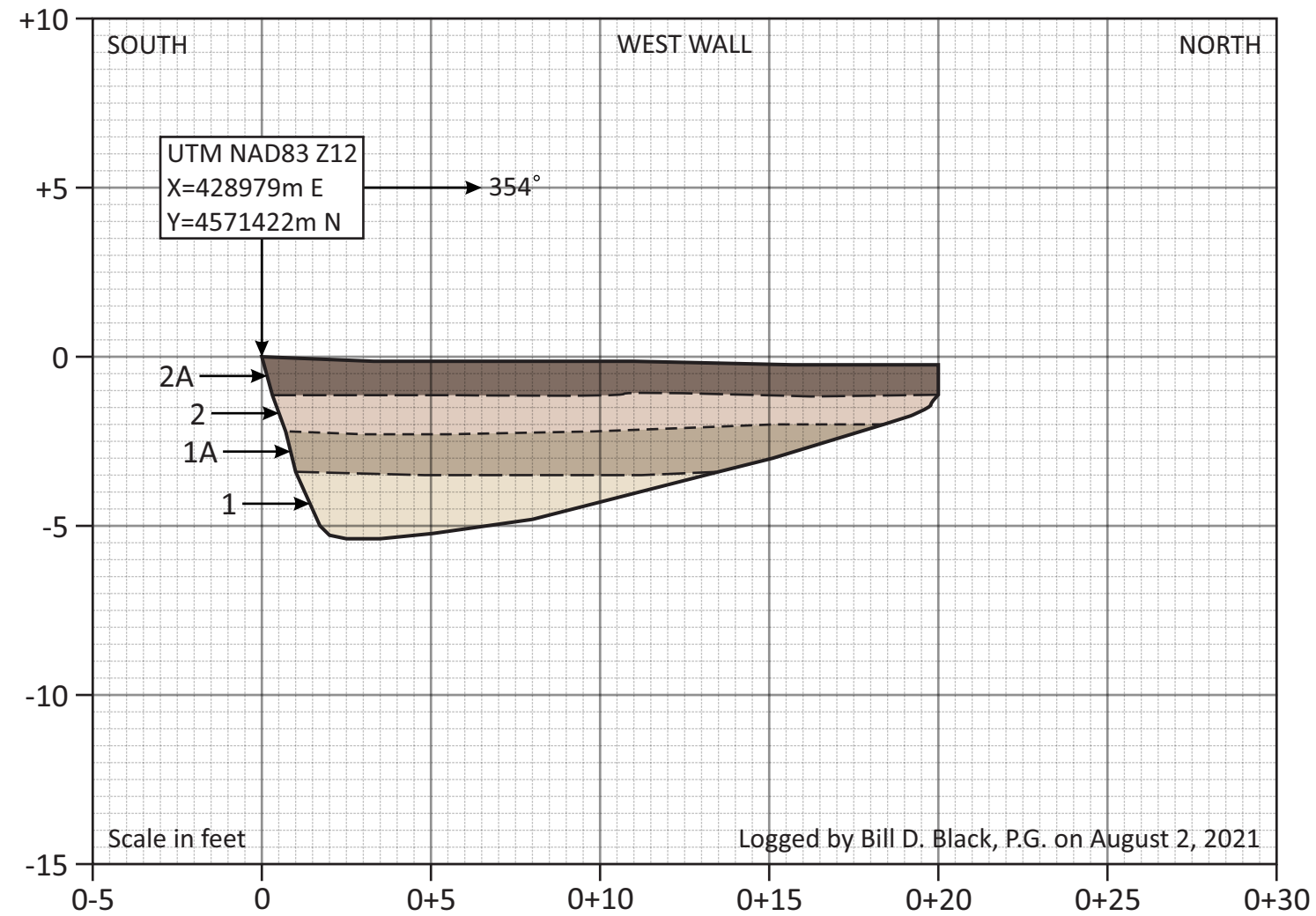
TEST PIT LOGS, 27 AND 28

GEOLOGIC HAZARDS EVALUATION

Proposed Osprey Ranch Development
2050 Highway 150
Eden, Weber County, Utah

FIGURE 3N

TEST PIT 29

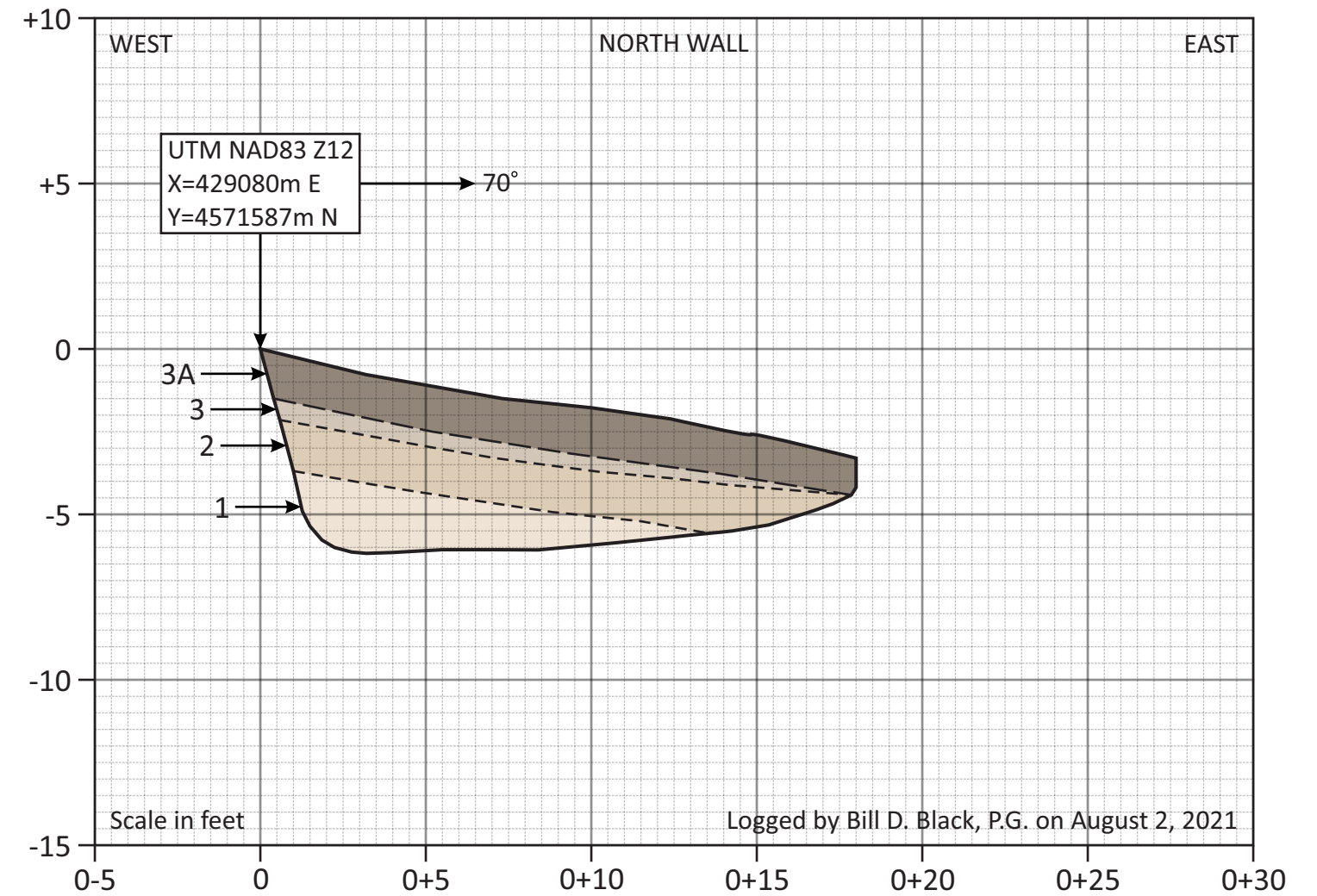


UNIT DESCRIPTIONS

Unit 1. *Holocene mass wasting colluvium* - grayish-brown to orange-brown, medium dense to dense, poorly bedded to massive, clayey gravel (GC) with sand, subround to angular cobbles with stage II carbonate and discontinuous organic-rich lamina; paleosol A horizon formed in unit (1A); thickness > 3 feet.

Unit 2. *Holocene mass wasting colluvium* - grayish-brown to dark grayish-brown, medium dense to dense, massive, clayey gravel (GC) with sand; A soil horizon formed in unit (2A); about 2 feet thick.

TEST PIT 30



UNIT DESCRIPTIONS

Unit 1. *Tertiary Norwood Formation* - brown, strong, poorly bedded, weathered claystone with orange-brown lamina.

Unit 2. *Holocene mass wasting colluvium* - brown, medium dense, massive, clayey gravel (GC) with sand and angular cobbles with stage II carbonate; clasts slightly imbricated; about 1.5 feet thick.

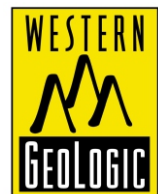
Unit 3. *Holocene mass wasting colluvium* - dark grayish-brown, dense to medium dense, massive, clayey gravel (GC); A soil horizon formed in unit (3A); about 2 feet thick.

TEST PIT LOGS, 29 AND 30

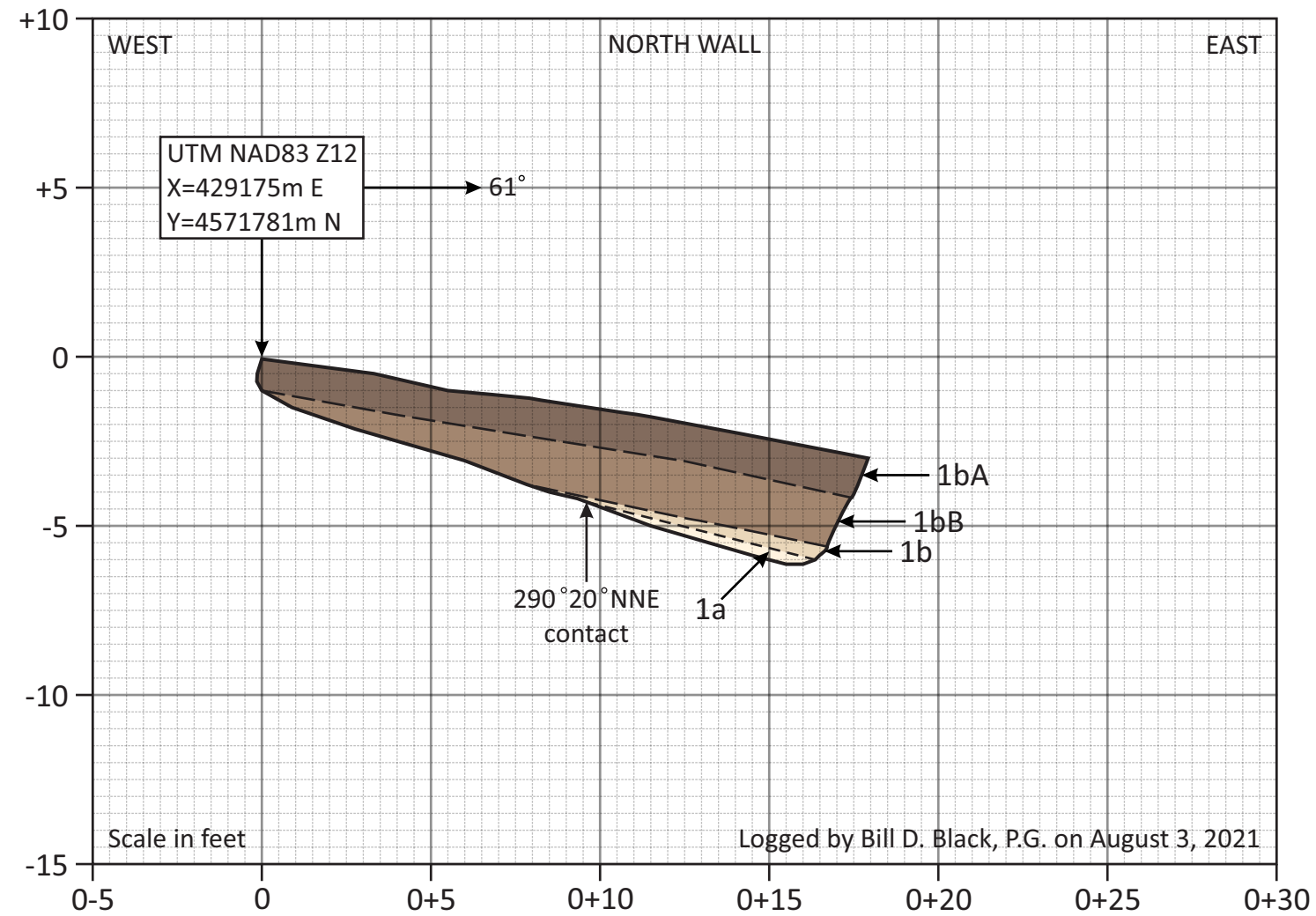
GEOLOGIC HAZARDS EVALUATION

Proposed Osprey Ranch Development
2050 Highway 150
Eden, Weber County, Utah

FIGURE 30



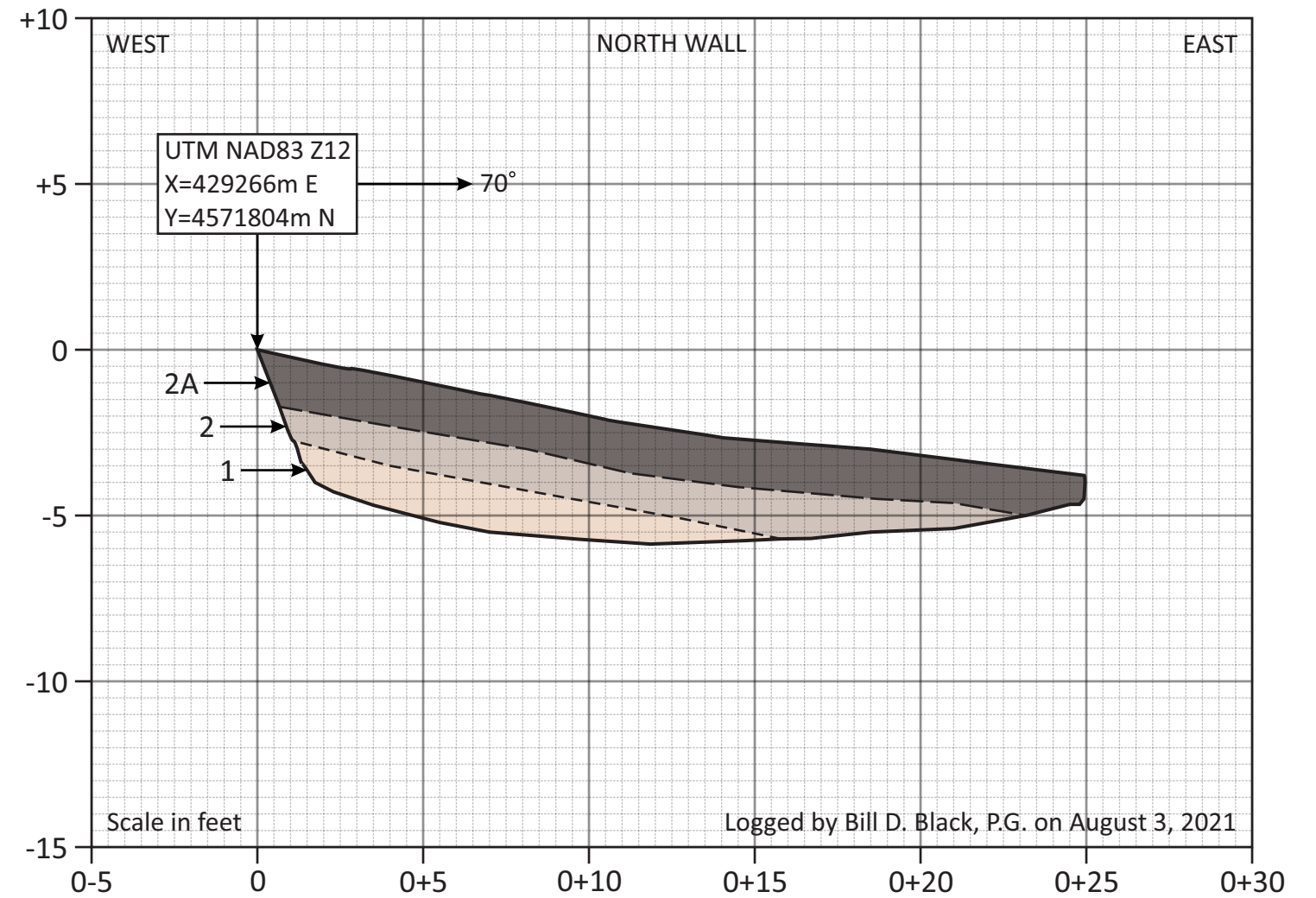
TEST PIT 31



UNIT DESCRIPTIONS

Unit 1. *Tertiary Norwood Formation* - sequence comprised of a lower (1a) light brown, strong to very strong, poorly bedded, weathered tuffaceous sandstone; and an upper (1b) light orange-brown to dark grayish-brown, moderately strong, poorly bedded to massive, weathered tuffaceous conglomerate; A and B soil horizons formed in unit (1bA and 1bB).

TEST PIT 32



UNIT DESCRIPTIONS

Unit 1. *Tertiary Norwood Formation* - orange to grayish-brown, strong, poorly bedded, weathered tuffaceous conglomerate.

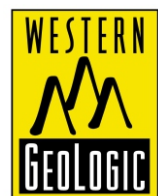
Unit 2. *Late Pleistocene? mass wasting colluvium* - brown to dark grayish-brown, medium dense, massive, clayey gravel (GC) with sand; A soil horizon formed in unit (2A), B horizon indistinct; about 2.5 feet thick.

TEST PIT LOGS, 31 AND 32

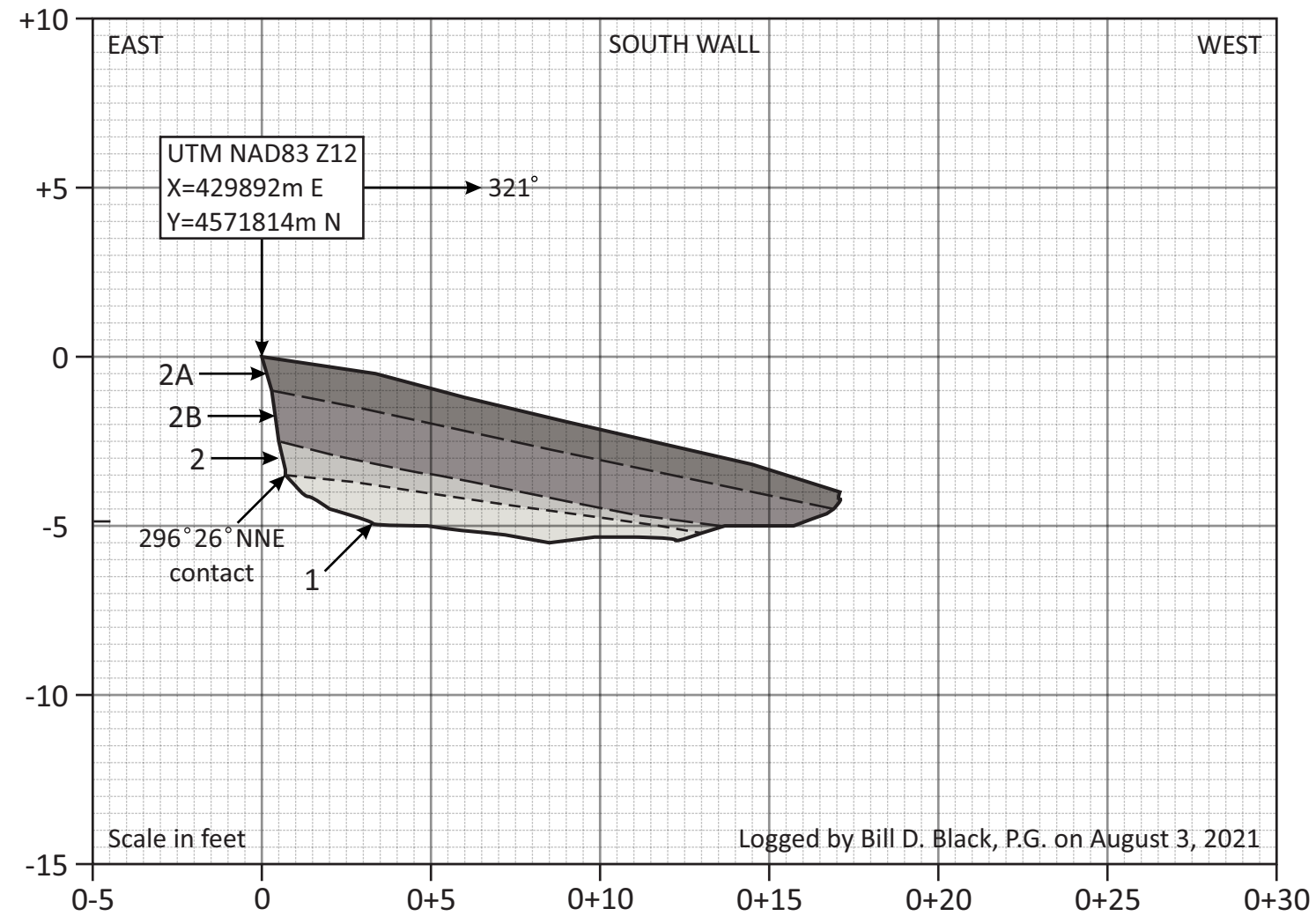
GEOLOGIC HAZARDS EVALUATION

Proposed Osprey Ranch Development
2050 Highway 150
Eden, Weber County, Utah

FIGURE 3P



TEST PIT 33

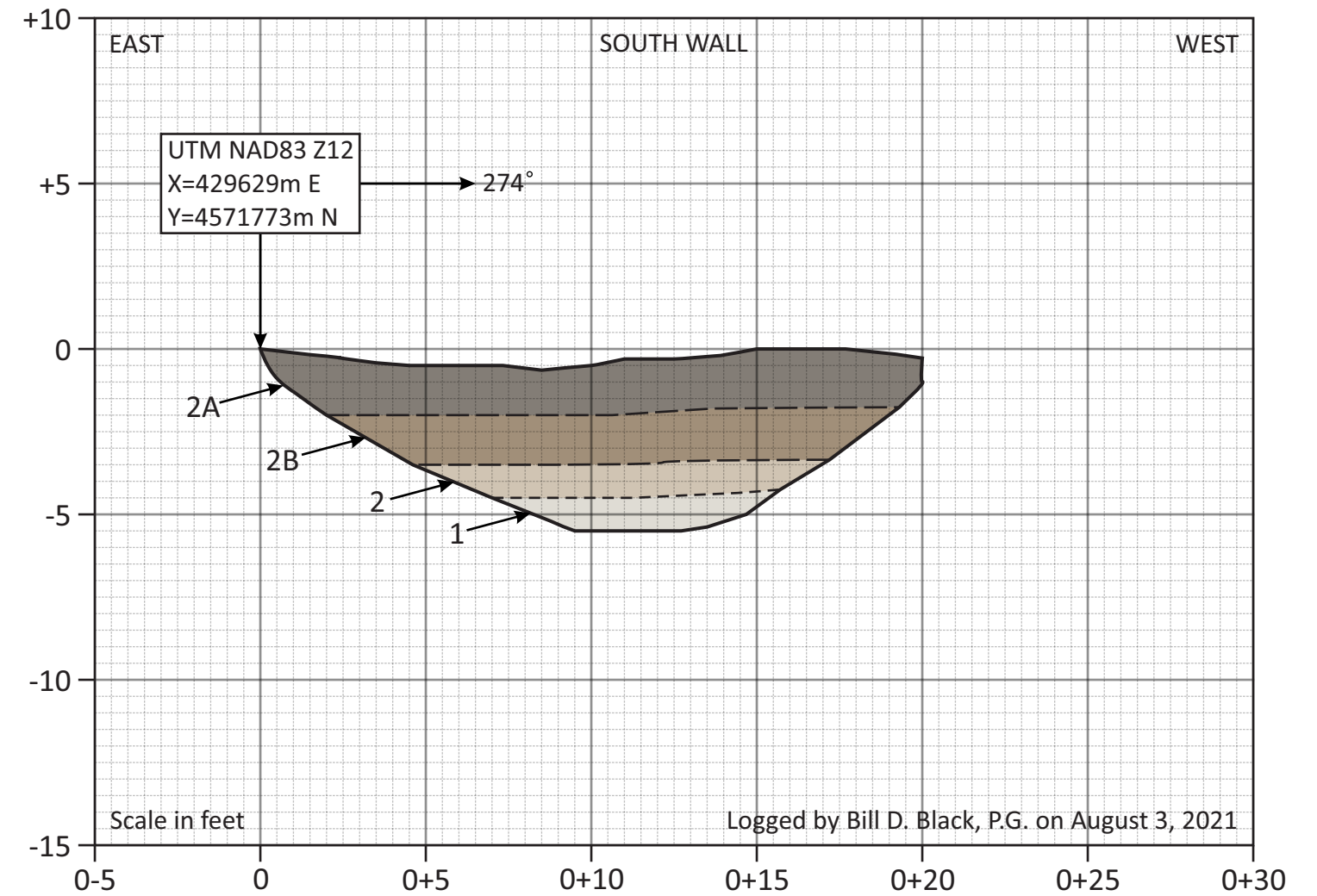


UNIT DESCRIPTIONS

Unit 1. *Tertiary Norwood Formation* - light brownish-gray, strong, well bedded weathered claystone.

Unit 2. *Late Pleistocene mass wasting colluvium* - grayish-brown to dark grayish-brown, stiff, massive, lean clay (CL) with sand, gravel and trace subangular cobbles with stage II carbonate; A and B soil horizons formed in unit (2A and 2B); about 3 feet thick.

TEST PIT 34



UNIT DESCRIPTIONS

Unit 1. *Tertiary Norwood Formation* - brown to light brown, strong, massive, weathered tuffaceous conglomerate.

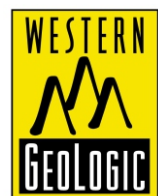
Unit 2. *Late Pleistocene mass wasting colluvium* - brown to dark grayish-brown, stiff to medium stiff, sandy to gravelly clay (CL) with trace cobbles; A and B soil horizons formed in unit (2A and 2B); about 4 feet thick.

TEST PIT LOGS, 33 AND 34

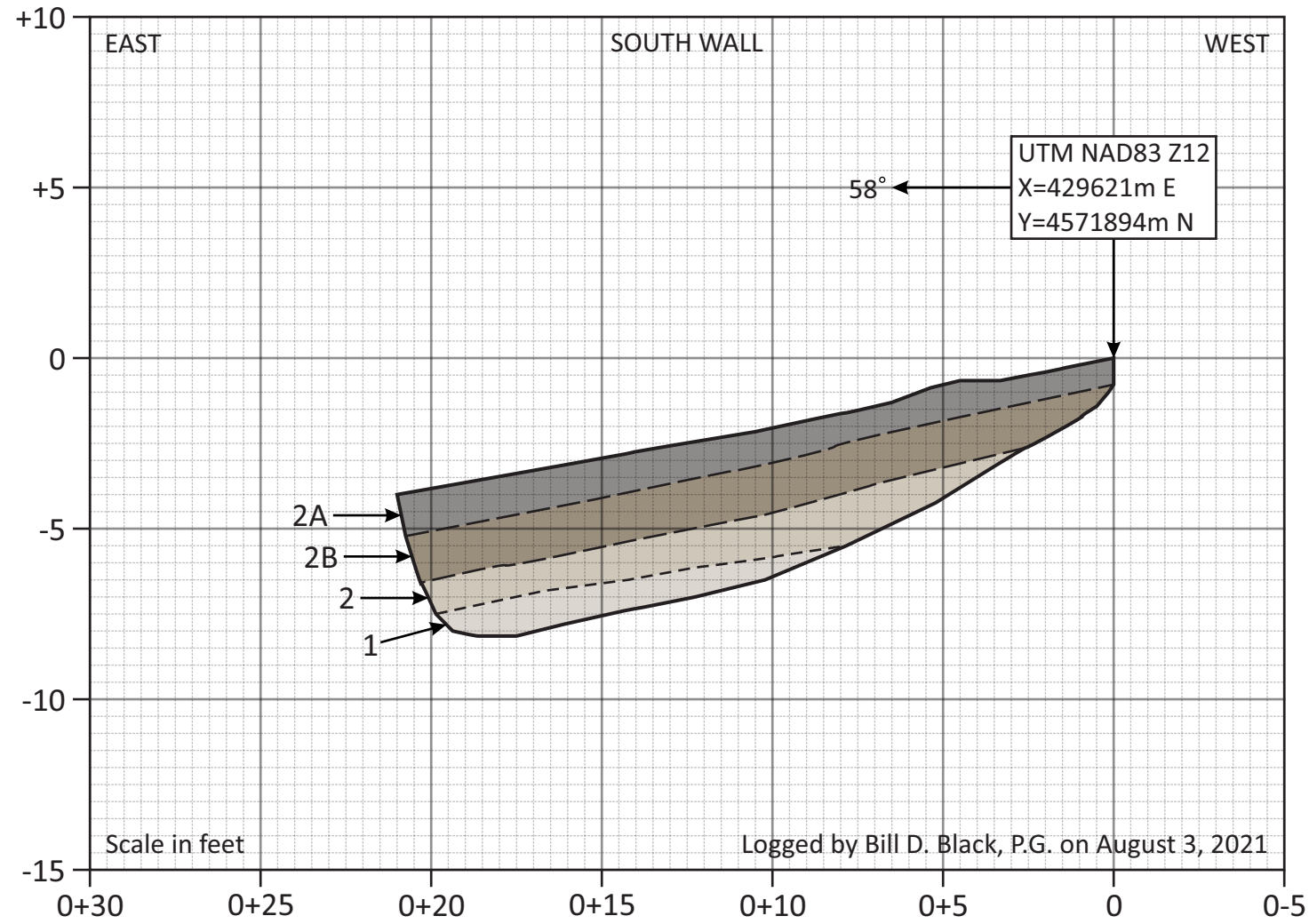
GEOLOGIC HAZARDS EVALUATION

Proposed Osprey Ranch Development
2050 Highway 150
Eden, Weber County, Utah

FIGURE 3Q



TEST PIT 35

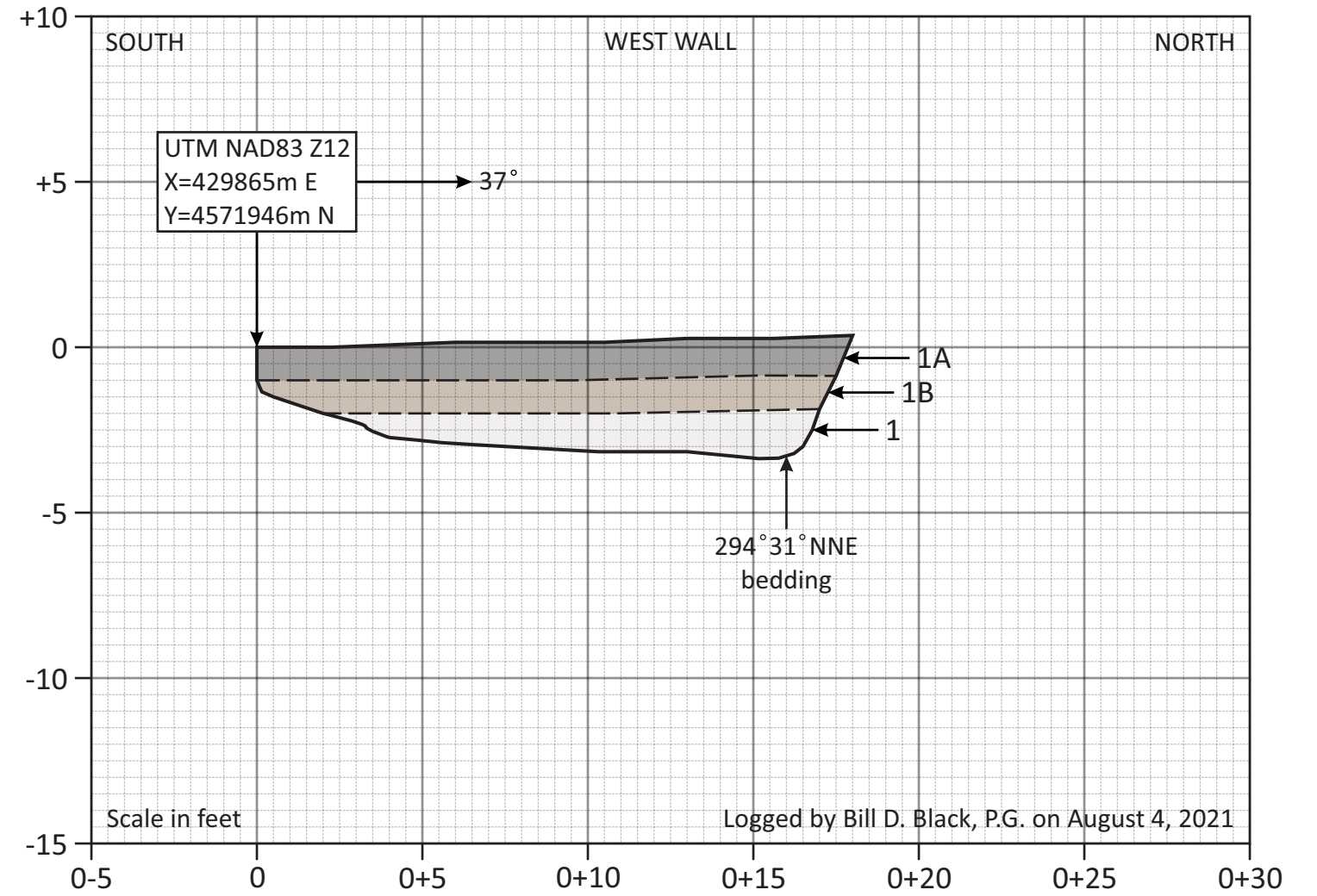


UNIT DESCRIPTIONS

Unit 1. *Tertiary Norwood Formation* - brown to light brown, strong, massive, weathered tuffaceous conglomerate.

Unit 2. *Late Pleistocene mass wasting colluvium* - brown to dark grayish-brown, stiff to medium stiff, sandy to gravelly clay (CL) with trace cobbles; A and B soil horizons formed in unit (2A and 2B); about 4 feet thick.

TEST PIT 36



UNIT DESCRIPTIONS

Unit 1. *Tertiary Norwood Formation* - light gray, strong to very strong, poorly bedded, weathered tuffaceous sandstone with iron-oxide staining along fractures; A and B soil horizons formed in unit (1A and 1B); refusal at test pit floor.

TEST PIT LOGS, 35 AND 36

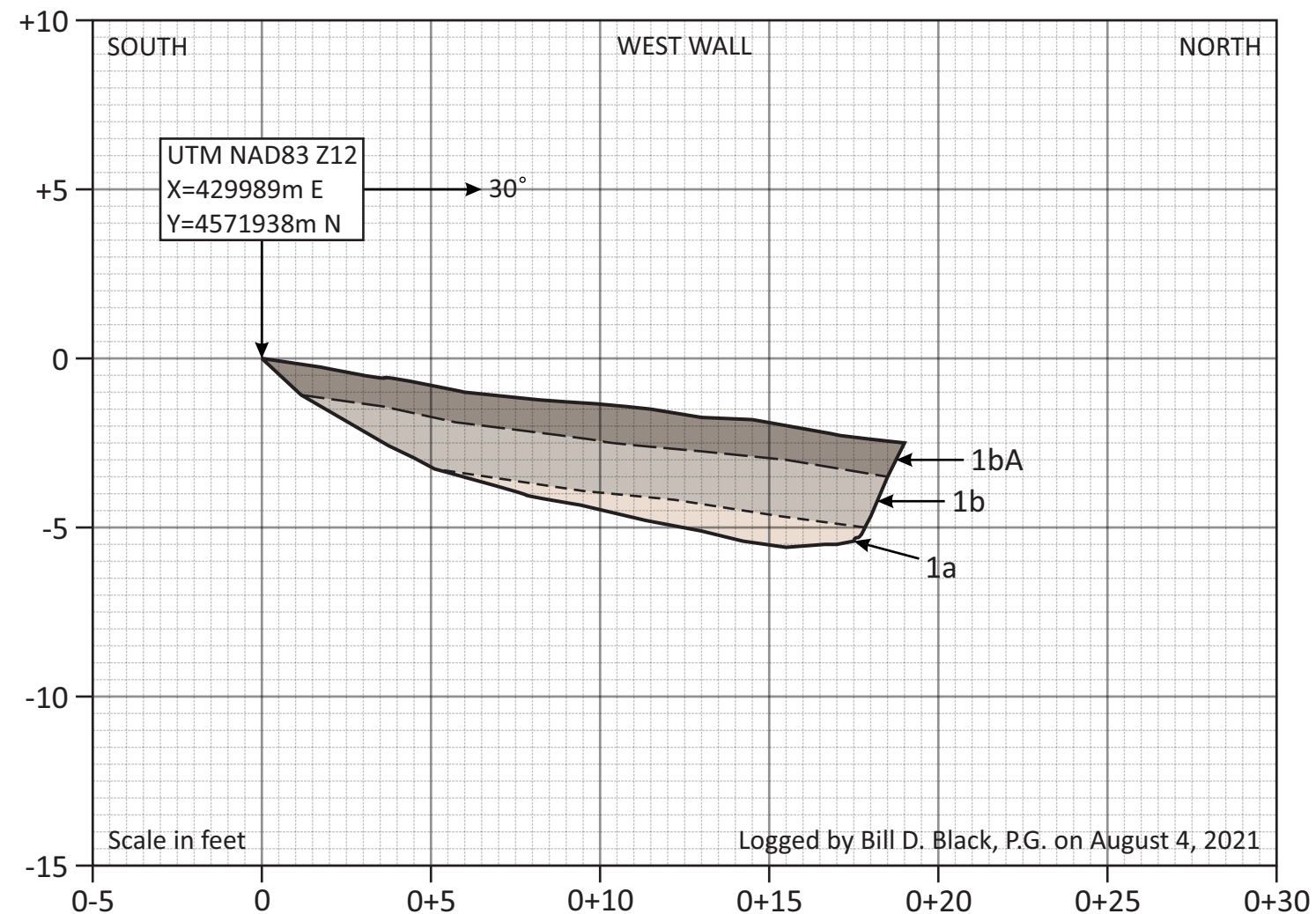
GEOLOGIC HAZARDS EVALUATION

Proposed Osprey Ranch Development
2050 Highway 150
Eden, Weber County, Utah

FIGURE 3R



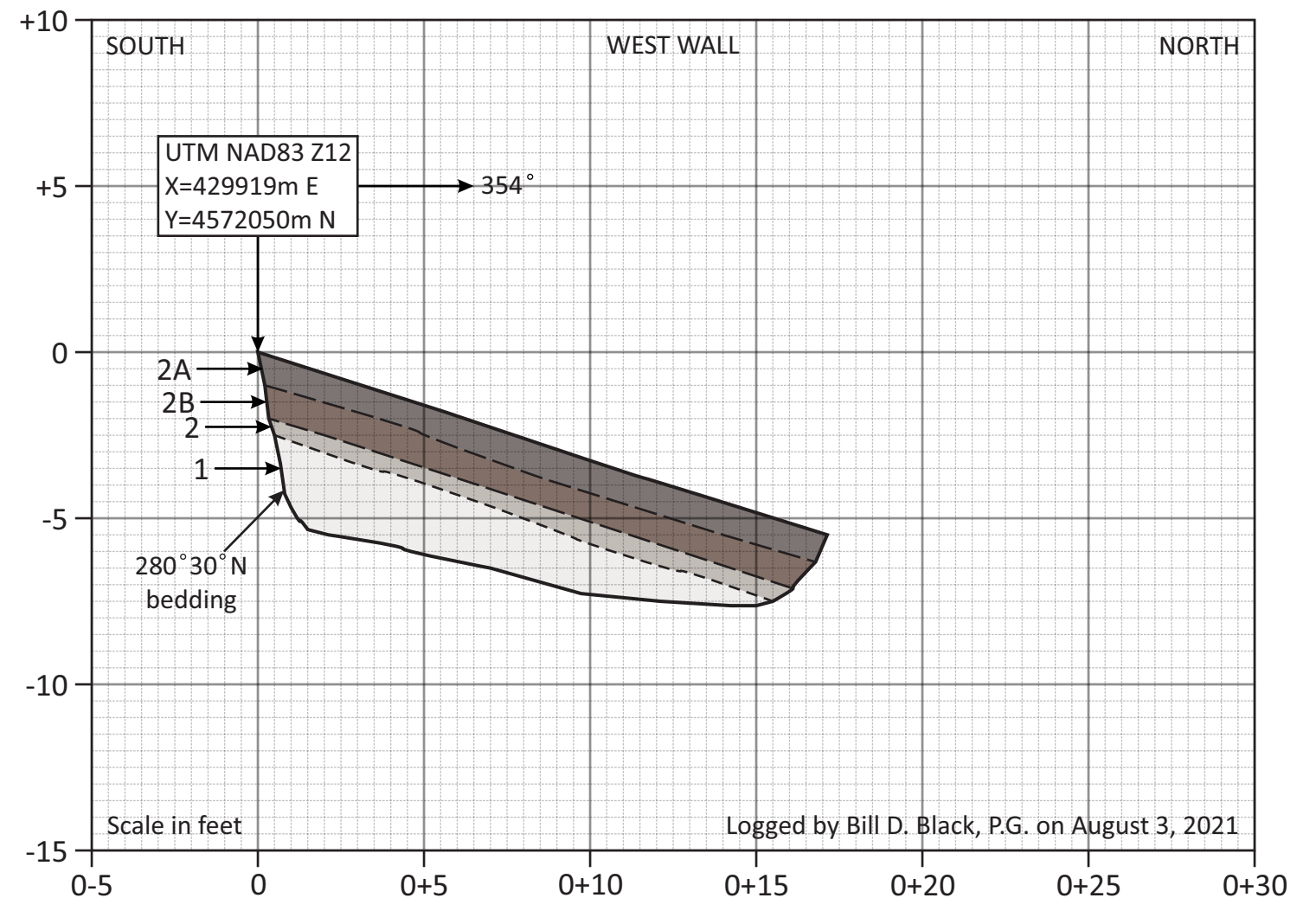
TEST PIT 37



UNIT DESCRIPTIONS

Unit 1. *Holocene mixed alluvium and colluvium* - sequence comprised of a lower (1a) matrix-supported, olive to orange-olive, dense, massive, clayey gravel (GC) with sand; and an upper (1b) clast-supported, dense, brown to dark brown, massive, gravel with clay (GW), sand, and subangular to subround cobbles and boulders with no carbonate; A soil horizon formed in upper unit (1bA); thickness > 3.5 feet.

TEST PIT 38



UNIT DESCRIPTIONS

Unit 1. *Tertiary Norwood Formation* - light grayish-olive, strong to very strong, well bedded, weathered tuffaceous sandstone.

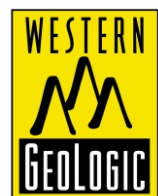
Unit 2. *Late Pleistocene mass wasting colluvium* - dark grayish-brown, stiff, massive, lean clay (CL) with sand and trace gravel; A and B soil horizons formed in unit (2A and 2B); about 2.5 feet thick.

TEST PIT LOGS, 37 AND 38

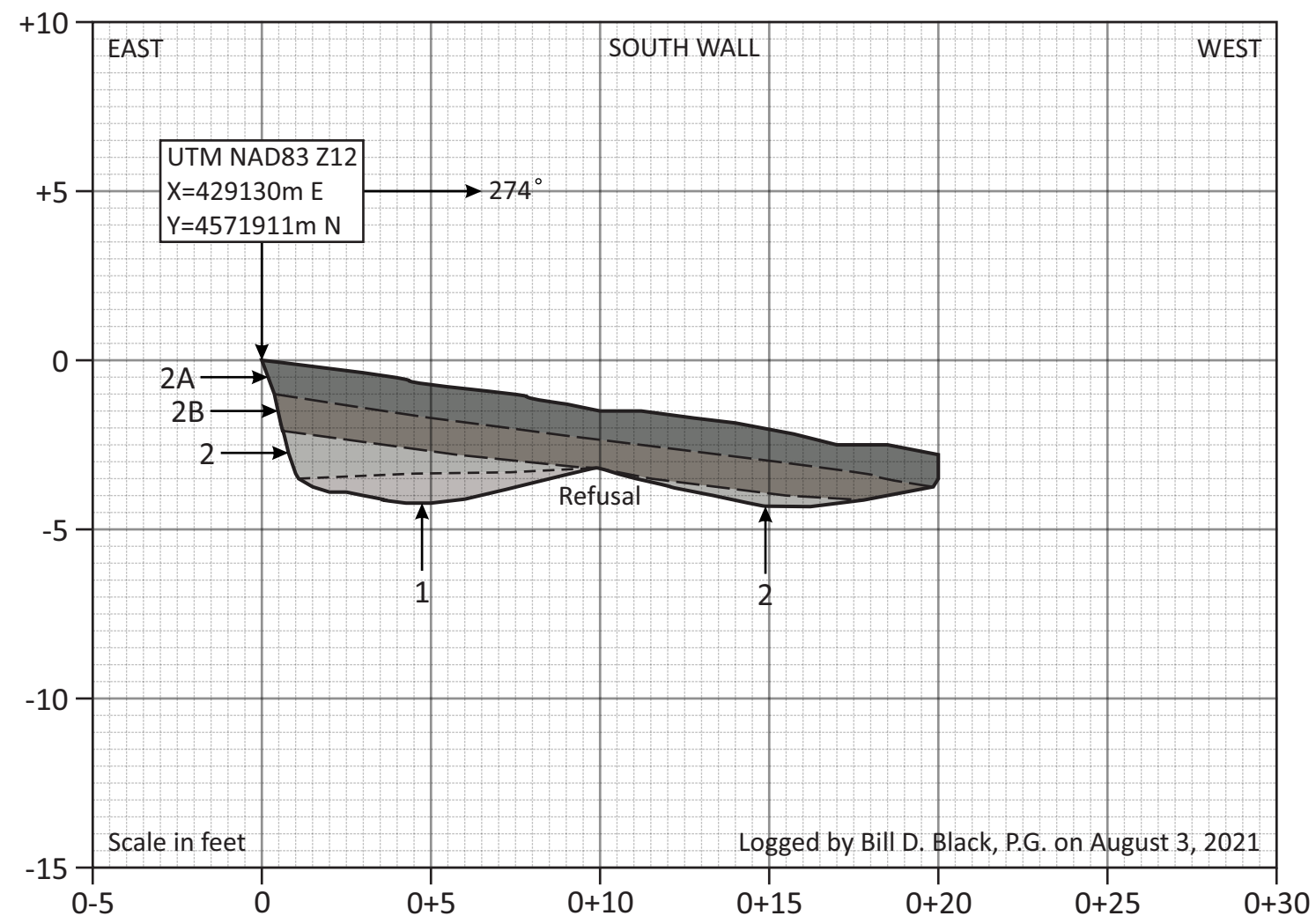
GEOLOGIC HAZARDS EVALUATION

Proposed Osprey Ranch Development
2050 Highway 150
Eden, Weber County, Utah

FIGURE 3S



TEST PIT 39

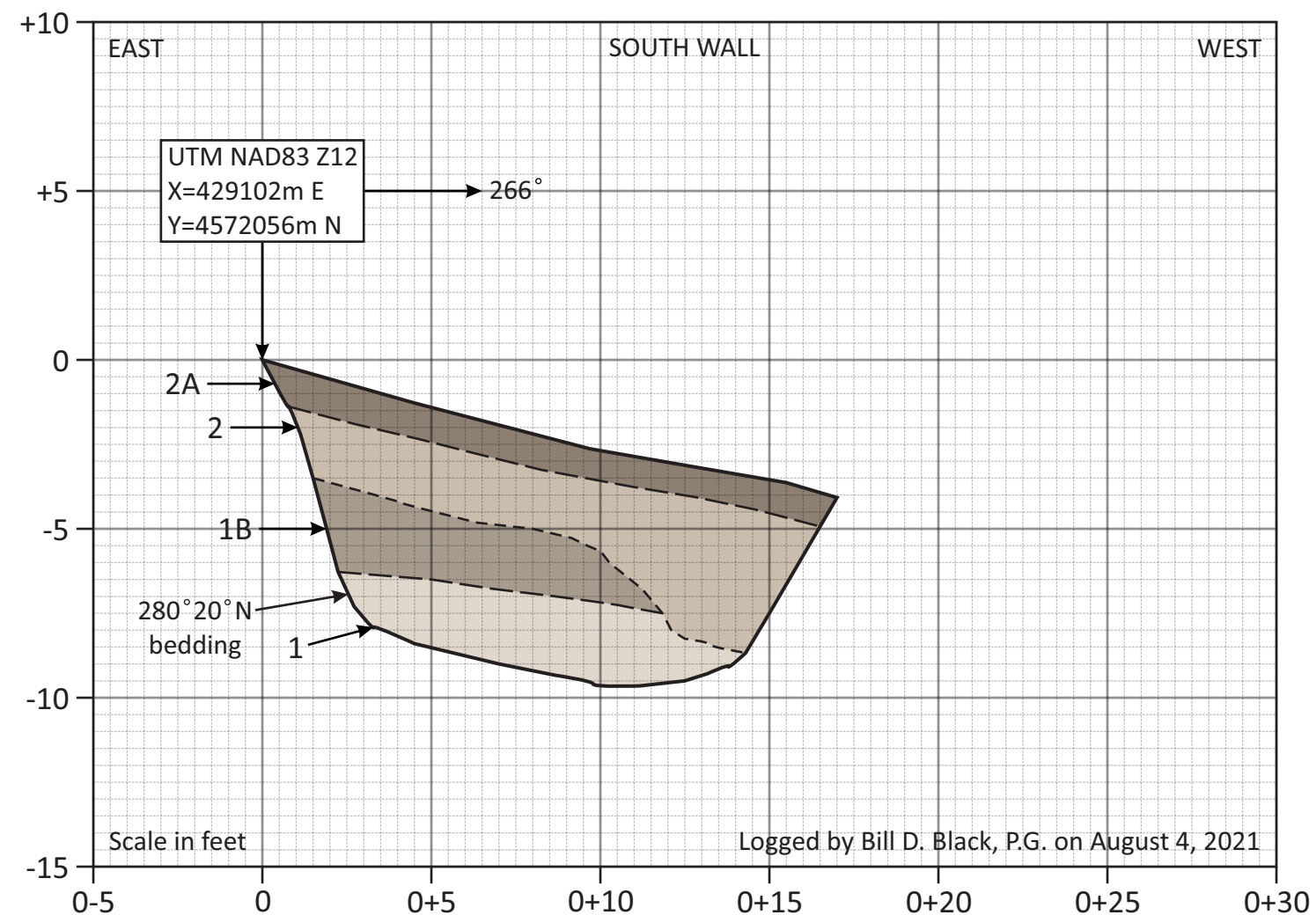


UNIT DESCRIPTIONS

Unit 1. *Tertiary Norwood Formation*- light gray to light brown, very strong, poorly bedded, weathered tuffaceous sandstone.

Unit 2. *Late Pleistocene tmass wasting colluvium* - reddish-brown to dark brown, massive, dense to medium dense, clayey gravel (GC) with sand and trace subangular cobbles with stage II carbonate; A and B soil horizons formed in unit (2A and 2B); about 1.5 to 3 feet thick.

TEST PIT 40



UNIT DESCRIPTIONS

Unit 1. *Tertiary Norwood Formation* - brown to grayish-brown, strong to medium strong, poorly bedded, weathered tuffaceous conglomerate with subangular to subround clasts with stage II carbonate; B soil horizon formed in unit (1B) but truncated by unit 2.

Unit 2. *Holocene mixed alluvium and colluvium?* - brown to dark grayish-brown, massive, medium dense, lean clay (CL) with sand and gravel; slightly vesicular; A soil horizon formed in unit (2A); about 3 to 5.5 feet thick.

TEST PIT LOGS, 39 AND 40

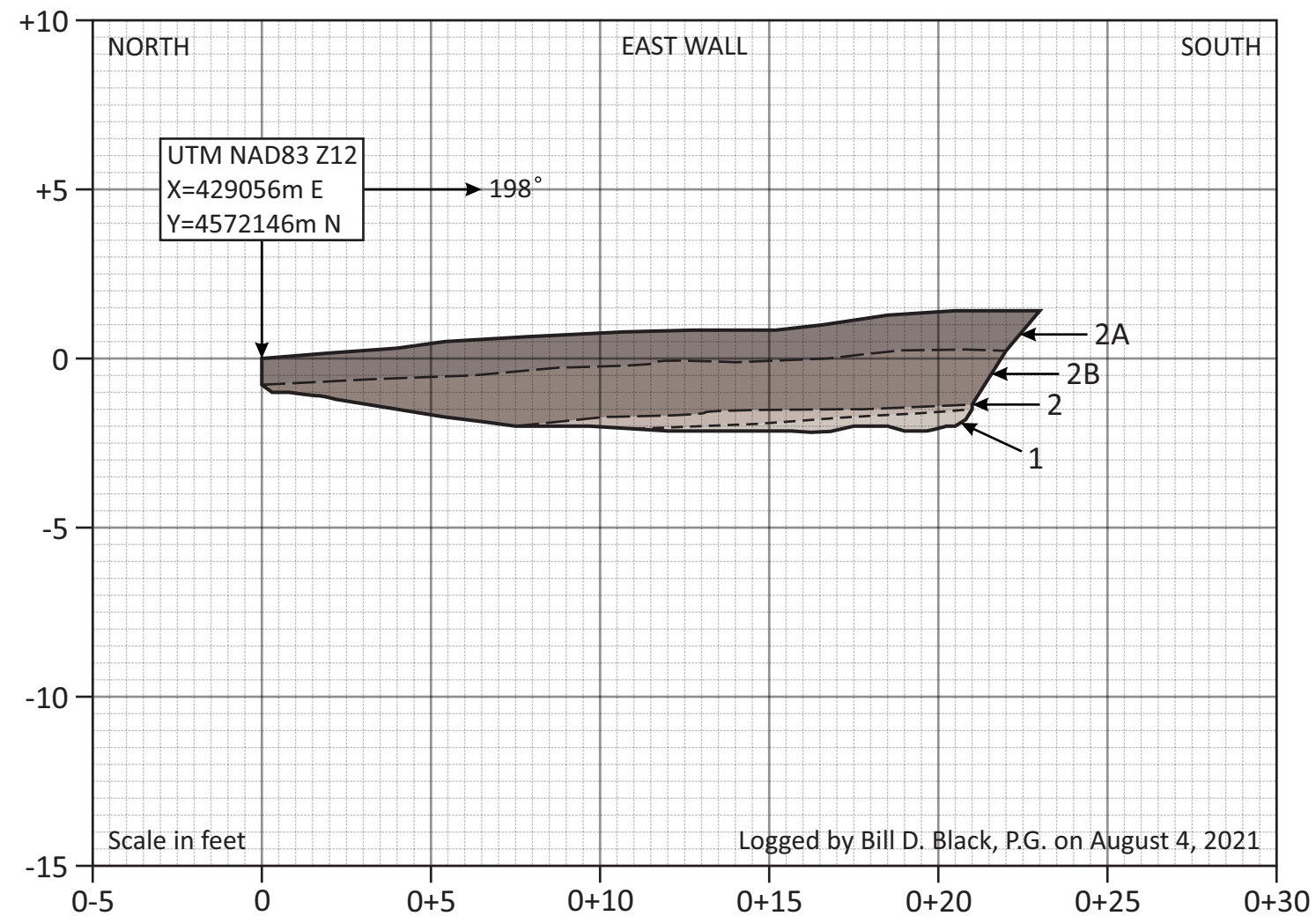
GEOLOGIC HAZARDS EVALUATION

Proposed Osprey Ranch Development
2050 Highway 150
Eden, Weber County, Utah

FIGURE 3T



TEST PIT 41

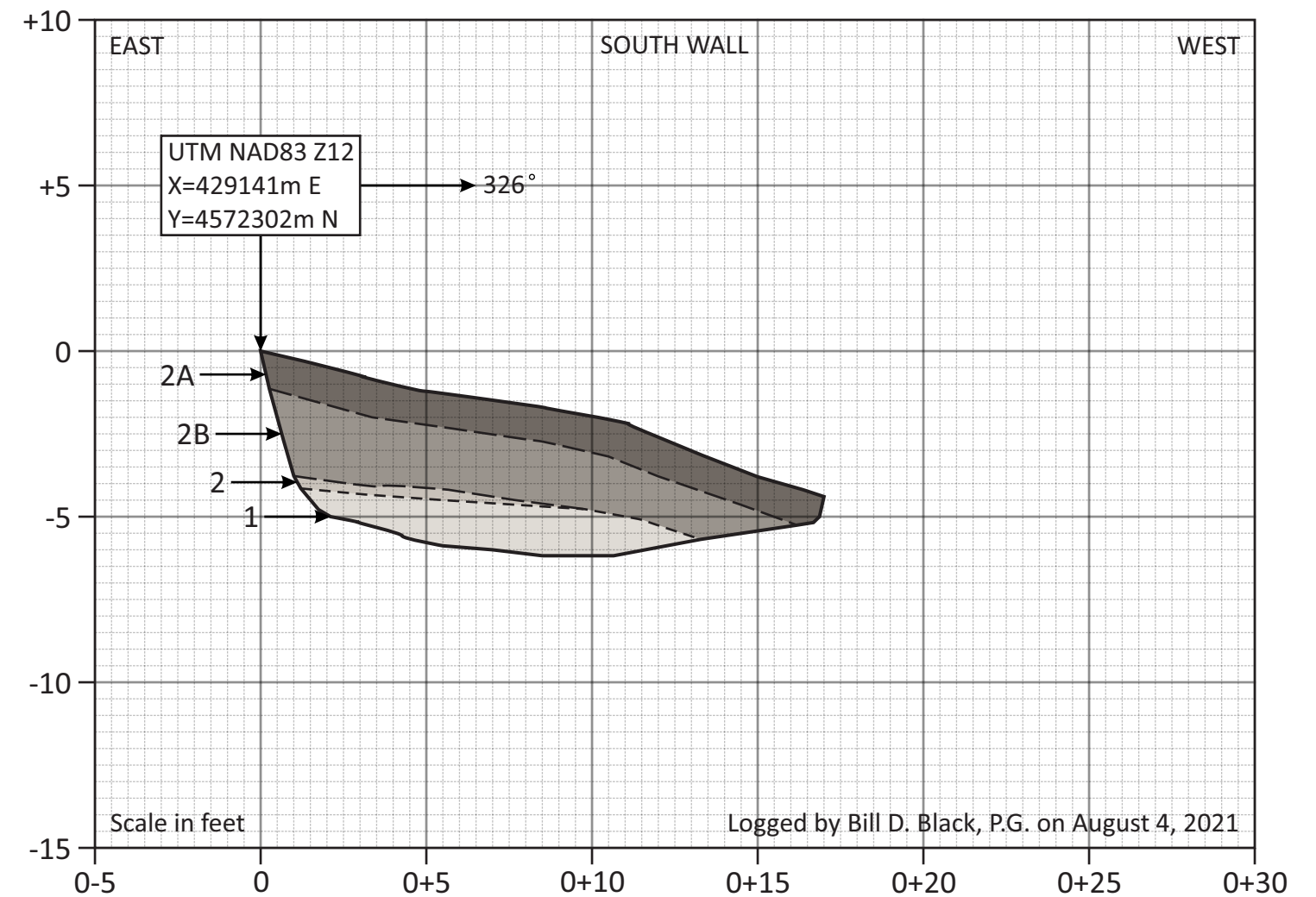


UNIT DESCRIPTIONS

Unit 1. *Tertiary Norwood Formation* - orange-brown, strong to very strong, massive to poorly bedded, weathered claystone; weak bedding dips to north.

Unit 2. *Late Pleistocene mass wasting colluvium* - grayish-brown to dark grayish-brown, stiff, massive, lean clay (CL) with sand and gravel; slightly vesicular; A and B soil horizons formed in unit (2A and 2B); about 3 feet thick.

TEST PIT 42



UNIT DESCRIPTIONS

Unit 1. *Tertiary Norwood Formation* - light olive-brown, strong, massive, weathered claystone.

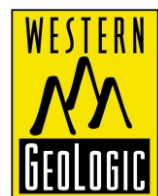
Unit 2. *Late Pleistocene mass wasting colluvium* - brown to dark grayish-brown, medium stiff, massive, sandy lean clay (CL) with gravel; contains blocks of unit 1 and discontinuous organic-enriched lamina and blocks; A and B soil horizons formed in unit (2A and 2B); 3 to 3.5 feet thick.

TEST PIT LOGS, 41 AND 42

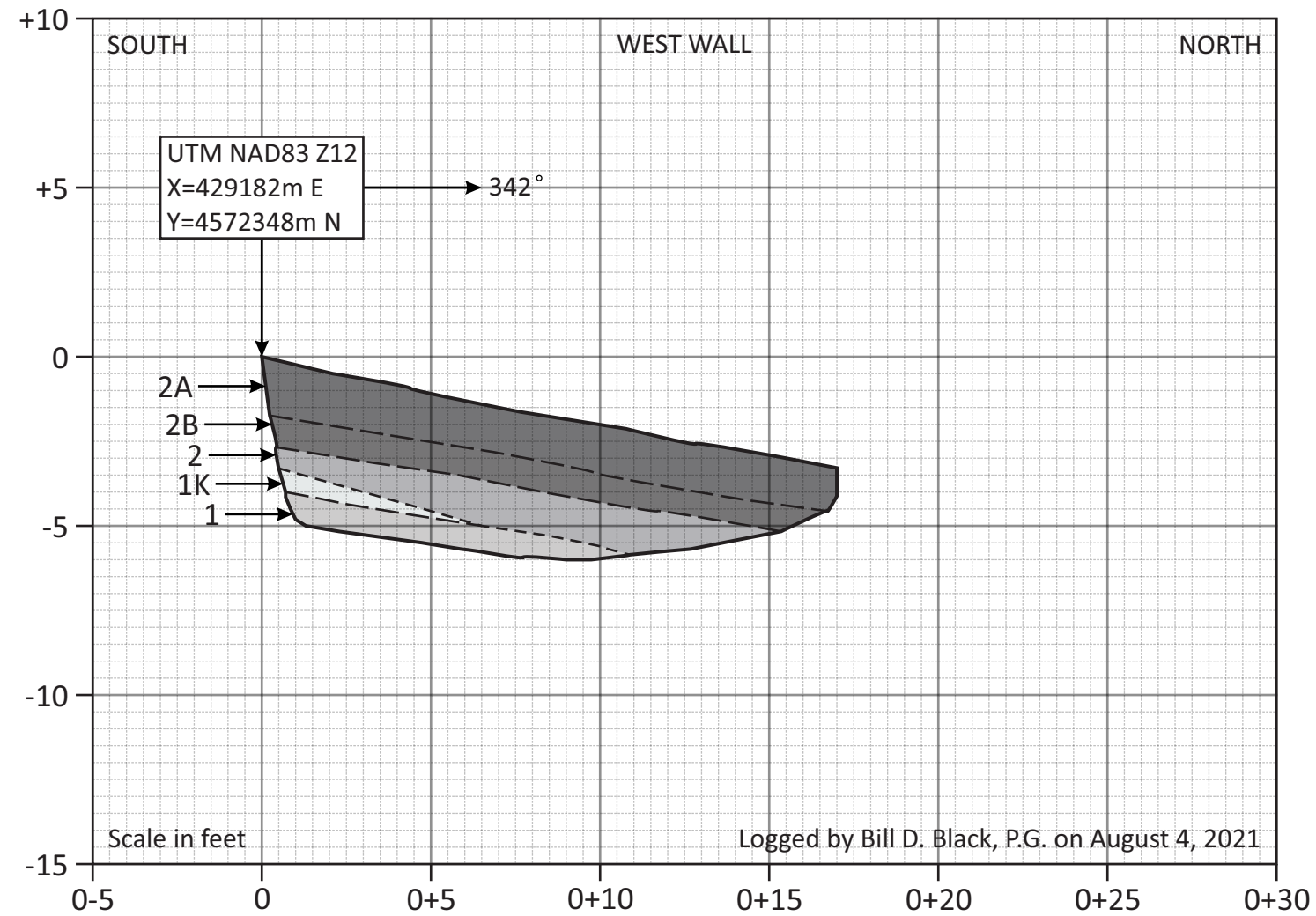
GEOLOGIC HAZARDS EVALUATION

Proposed Osprey Ranch Development
2050 Highway 150
Eden, Weber County, Utah

FIGURE 3U



TEST PIT 43

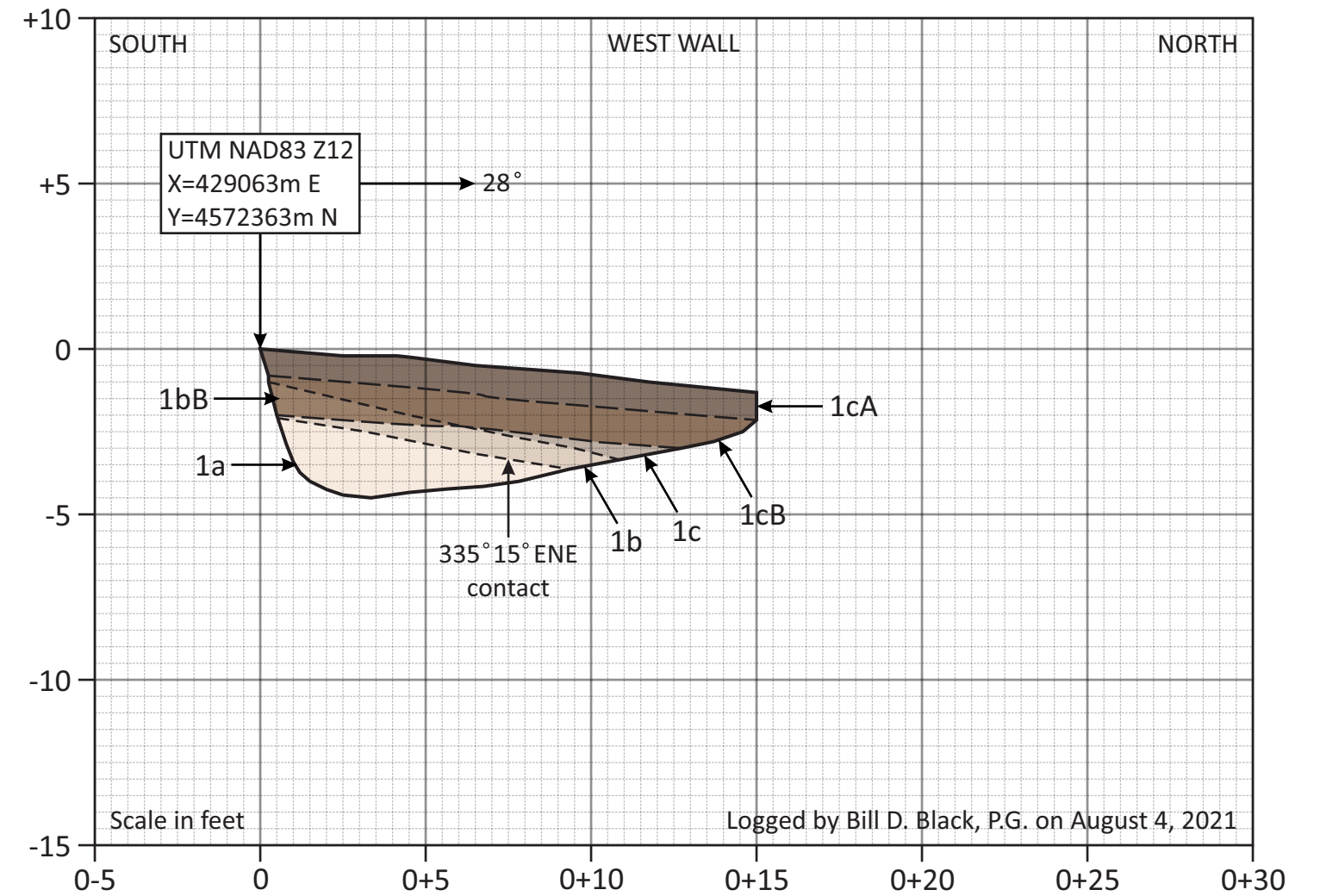


UNIT DESCRIPTIONS

Unit 1. *Tertiary Norwood Formation* - orange-brown, strong, poorly bedded, weathered tuffaceous conglomerate with topset carbonate and subangular to subround clasts; weak K soil horizon formed in unit (1K).

Unit 2. *Late Pleistocene mass wasting colluvium* - dark grayish-brown, medium dense/stiff to dense/stiff; clayey sand to sandy clay (SC/CL) with gravel and subround cobbles with stage II carbonate; A and B soil horizons formed in unit (2A and 2B); about 3.5 feet thick.

TEST PIT 44



UNIT DESCRIPTIONS

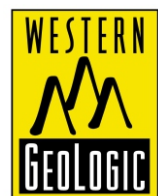
Unit 1. *Tertiary Norwood Formation* - sequence of weathered bedrock comprised of a lower (1a) light brown, strong, poorly bedded to massive, siltstone; a middle (1b) brownish-olive, strong, poorly bedded to massive, claystone; and an upper (1c) tuffaceous conglomerate; A and B soil horizons formed in unit (1bB, 1cB and 1cA).

TEST PIT LOGS, 43 AND 44

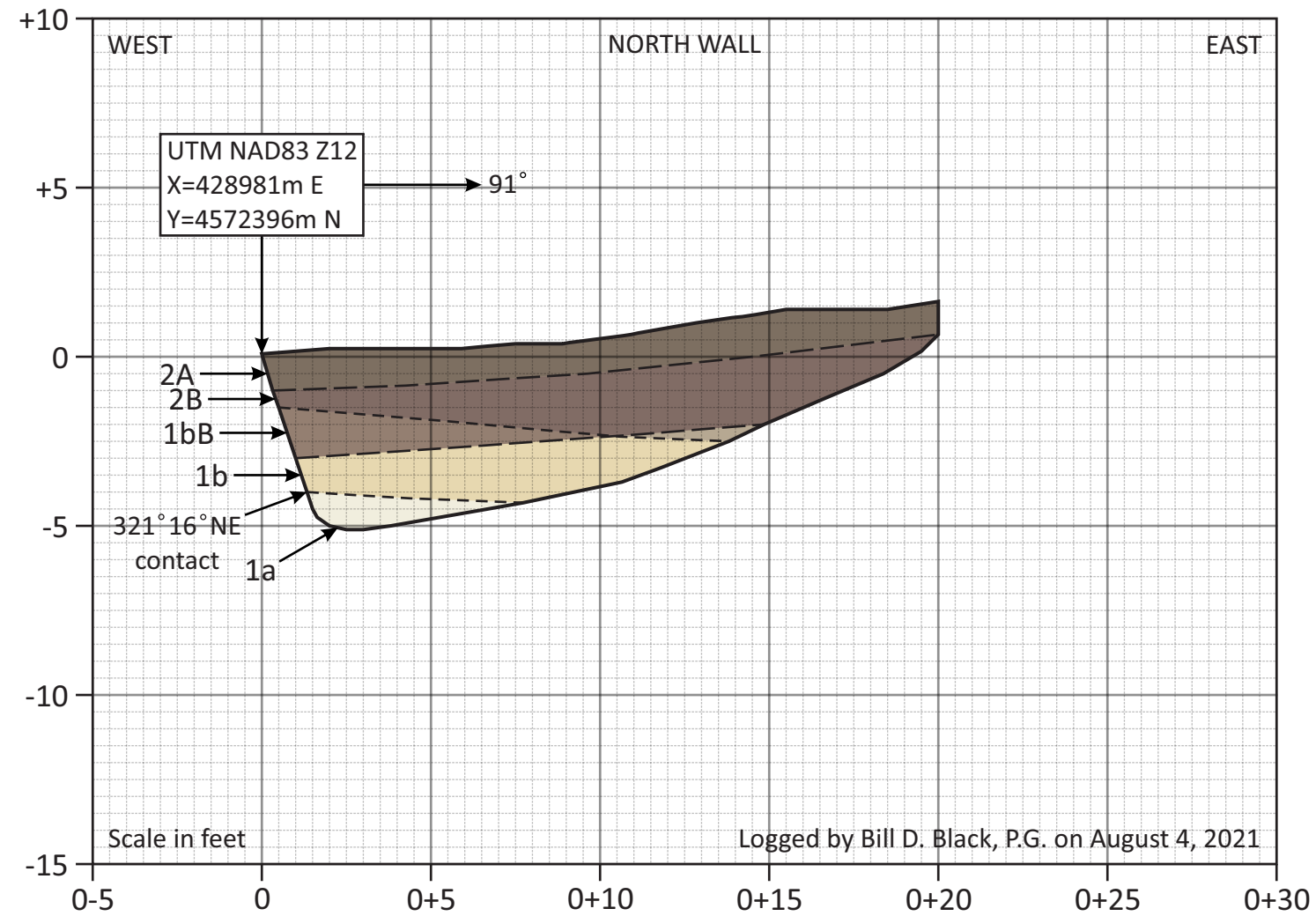
GEOLOGIC HAZARDS EVALUATION

Proposed Osprey Ranch Development
2050 Highway 150
Eden, Weber County, Utah

FIGURE 3V



TEST PIT 45

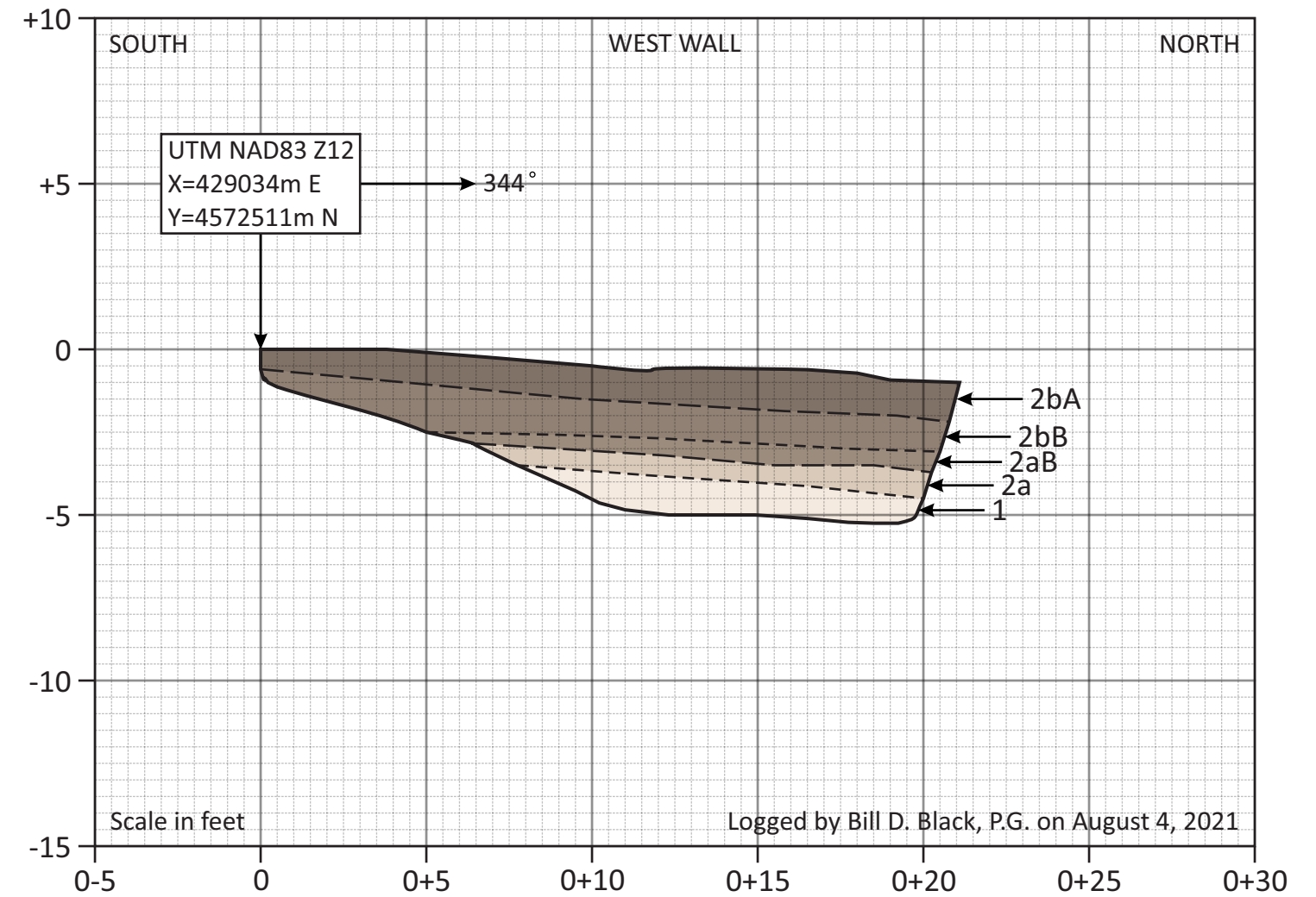


UNIT DESCRIPTIONS

Unit 1. *Tertiary Norwood Formation* - sequence of strong, weathered bedrock comprised of a lower (1a) olive-brown to light olive, thinly bedded siltstone to claystone; and an upper (1b) brownish-olive claystone; B soil horizon formed in upper unit (1bB).

Unit 2. *Late Pleistocene mass wasting colluvium* - dark grayish-brown, stiff, massive, lean clay (CL) with sand, gravel and subangular to subround cobbles with stage II carbonate; A and B soil horizons formed in unit (2A and 2B); about 1.5 to 3.5 feet thick.

TEST PIT 46



UNIT DESCRIPTIONS

Unit 1. *Tertiary Norwood Formation* - olive-brown, strong, massive, weathered claystone.

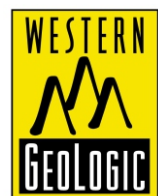
Unit 2. *Late Pleistocene mass wasting colluvium* - sequence of dense, massive colluvium comprised of a lower (2a) olive to brown, clayey gravel (GC) with sand and subangular cobbles with stage II carbonate; and an upper (2b) dark grayish-brown, clayey gravel (GC) with sand; A and B soil horizons formed in unit (2aB, 2bB and 2bA); overall about 3.5 feet thick.

TEST PIT LOGS, 45 AND 46

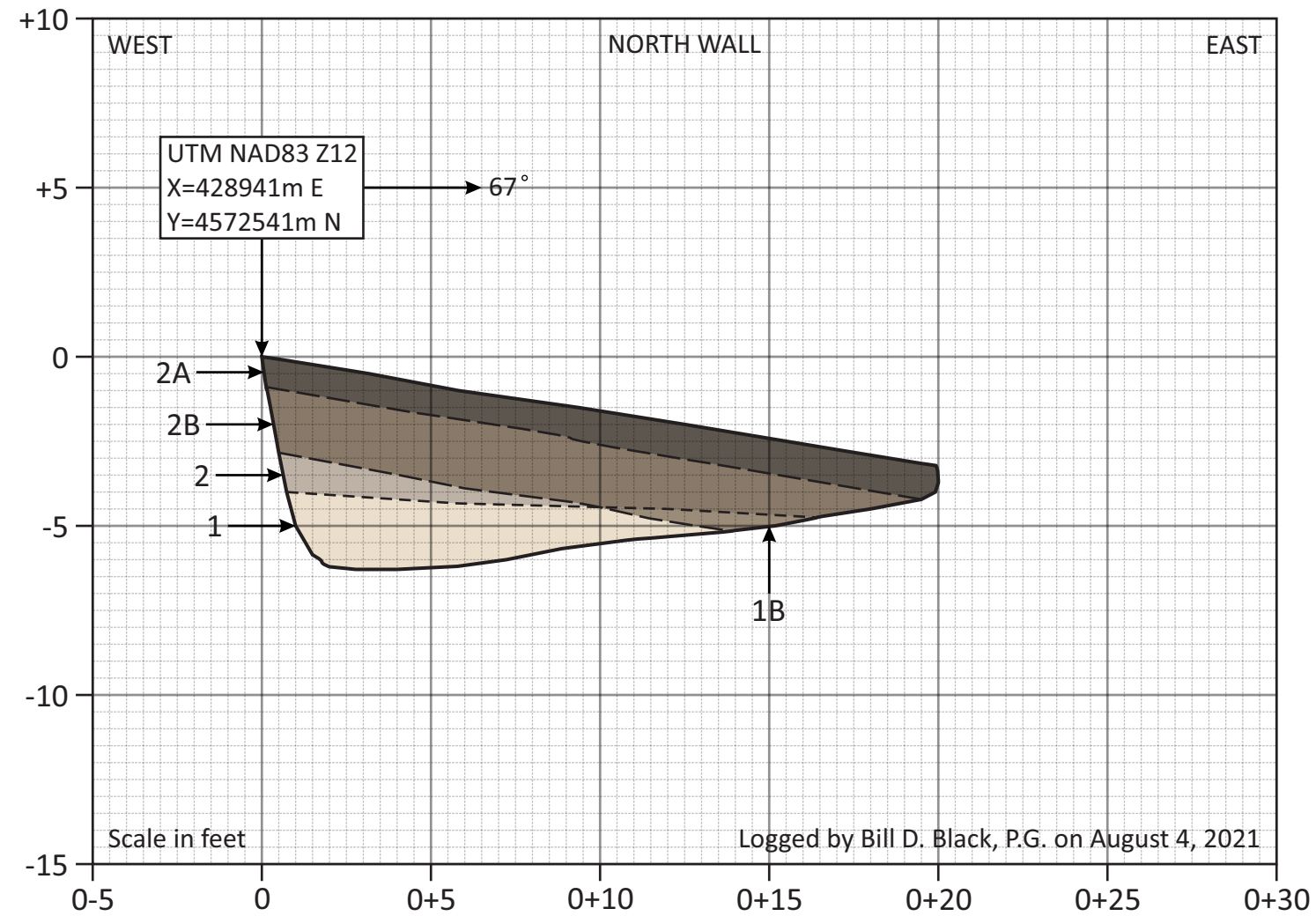
GEOLOGIC HAZARDS EVALUATION

Proposed Osprey Ranch Development
2050 Highway 150
Eden, Weber County, Utah

FIGURE 3W



TEST PIT 47

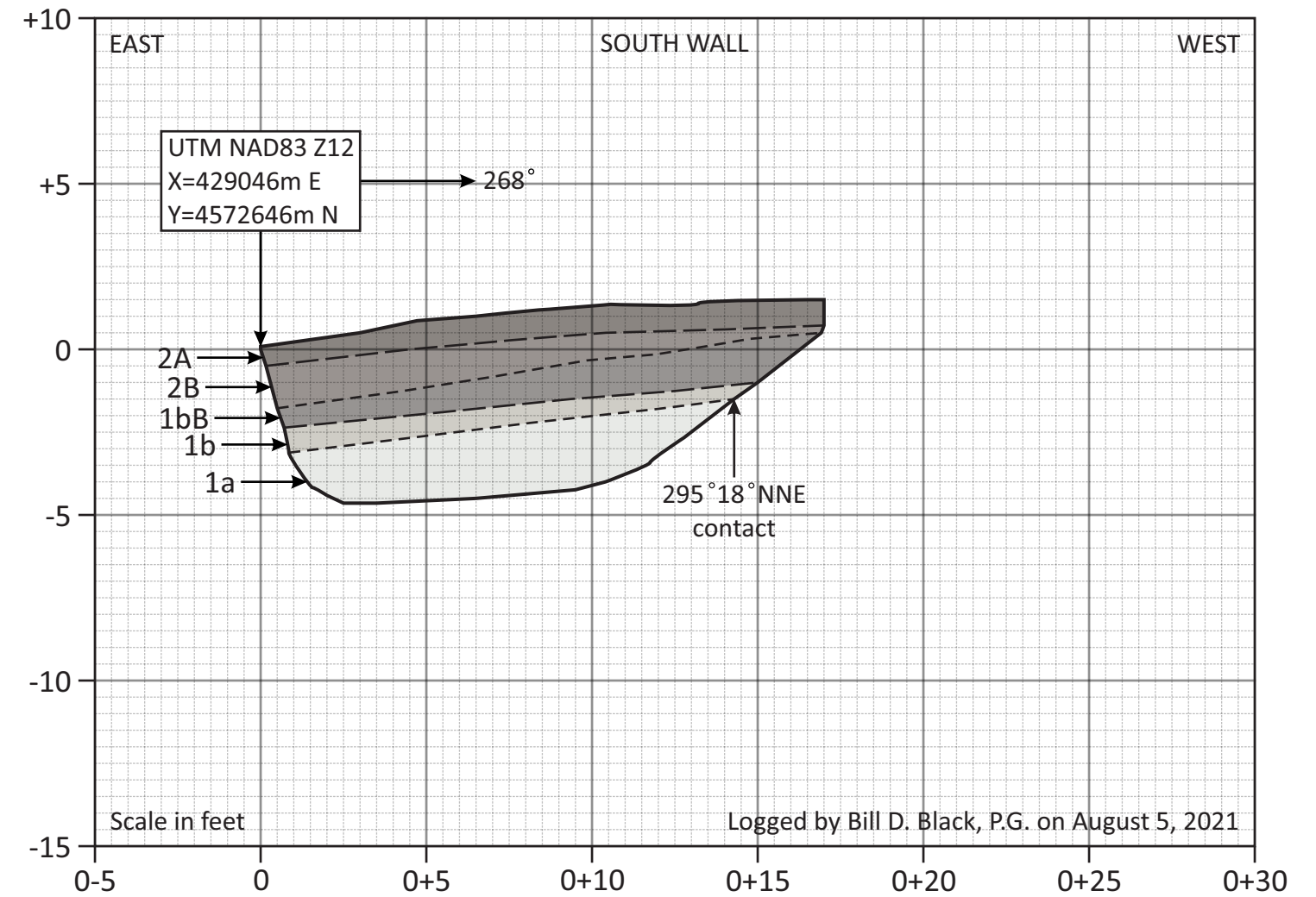


UNIT DESCRIPTIONS

Unit 1. *Tertiary Norwood Formation* - olive to light olive, strong, massive, weathered claystone with carbonate stringers in west test pit end; B soil horizon formed in unit (1B).

Unit 2. *Late Pleistocene mass wasting colluvium* - dark brown, stiff, massive, lean clay (CL) with sand and gravel; root penetrated; A and B soil horizons formed in unit (2A and 2B).; about 2 to 4 feet thick.

TEST PIT 48



UNIT DESCRIPTIONS

Unit 1. *Tertiary Norwood Formation* - sequence of brown, strong, poorly bedded to massive, weathered bedrock comprised of a lower (1a) claystone; and an upper (1b) matrix supported, tuffaceous conglomerate with subround to subangular clasts with stage II carbonate; B soil horizon formed in upper unit (1bB).

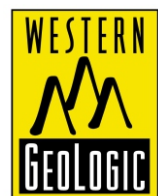
Unit 2. *Late Pleistocene mass wasting colluvium* - dark brown to dark grayish-brown, medium dense to dense, massive, clayey gravel (GC) with sand and subangular cobbles with stage II carbonate; A and B soil horizons formed in unit (2A and 2B); about 1 to 2 feet thick.

TEST PIT LOGS, 47 AND 48

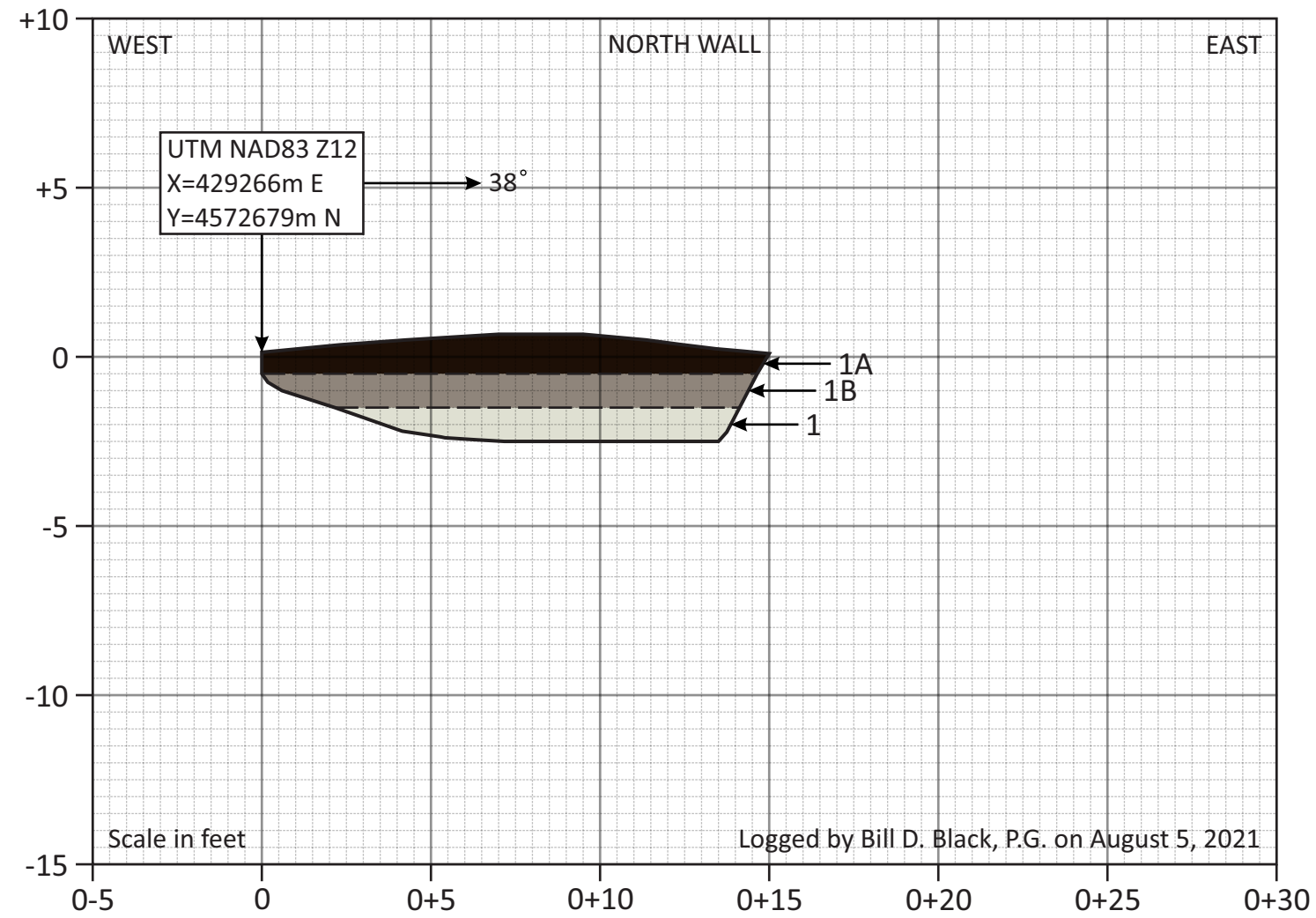
GEOLOGIC HAZARDS EVALUATION

Proposed Osprey Ranch Development
2050 Highway 150
Eden, Weber County, Utah

FIGURE 3X



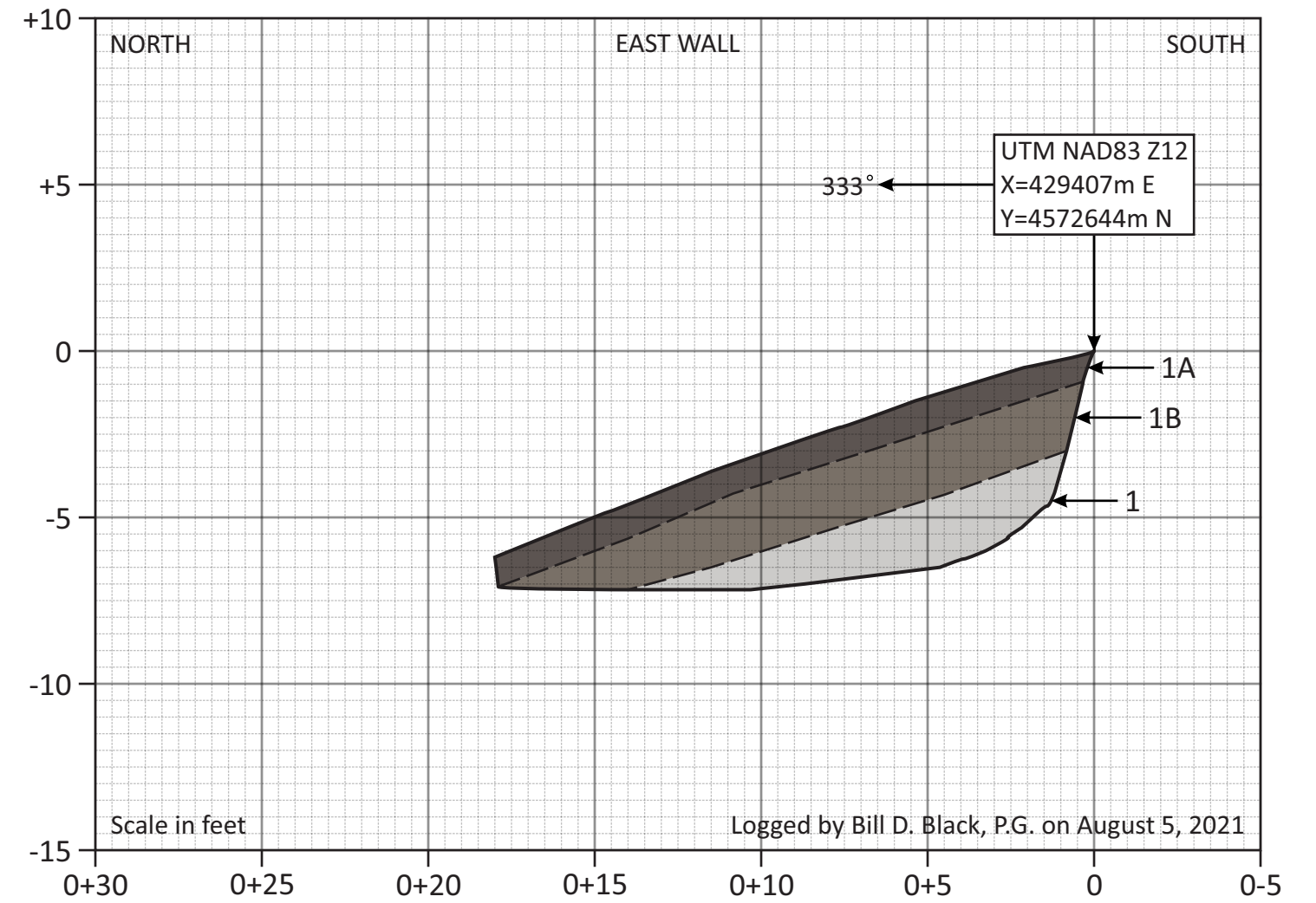
TEST PIT 49



UNIT DESCRIPTIONS

Unit 1. *Tertiary Norwood Formation* - light olive brown, strong, poorly bedded to massive, weathered siltstone; A and B soil horizons formed in unit (1A and 1B).

TEST PIT 50



UNIT DESCRIPTIONS

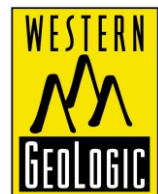
Unit 1. *Late Pleistocene to Holocene mixed alluvium and colluvium* - dark brown, stiff to very stiff, poorly bedded to massive, lean clay (CL) with sand, gravel and rare subround cobbles; contains discontinuous pebble gravel lenses; A and B soil horizons formed in unit (1A and 1B); thickness > 5 feet.

TEST PIT LOGS, 49 AND 50

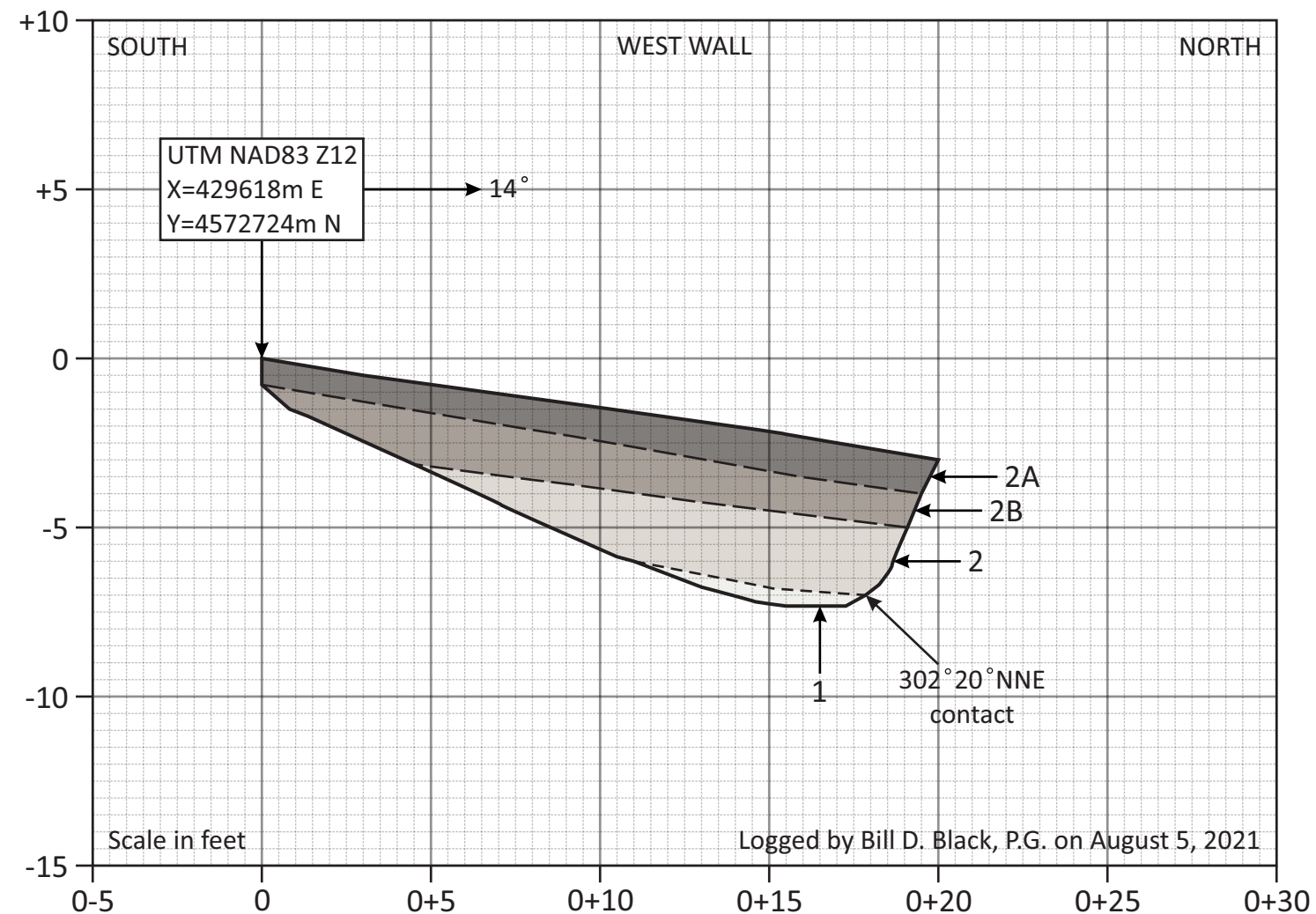
GEOLOGIC HAZARDS EVALUATION

Proposed Osprey Ranch Development
2050 Highway 150
Eden, Weber County, Utah

FIGURE 3Y



TEST PIT 51

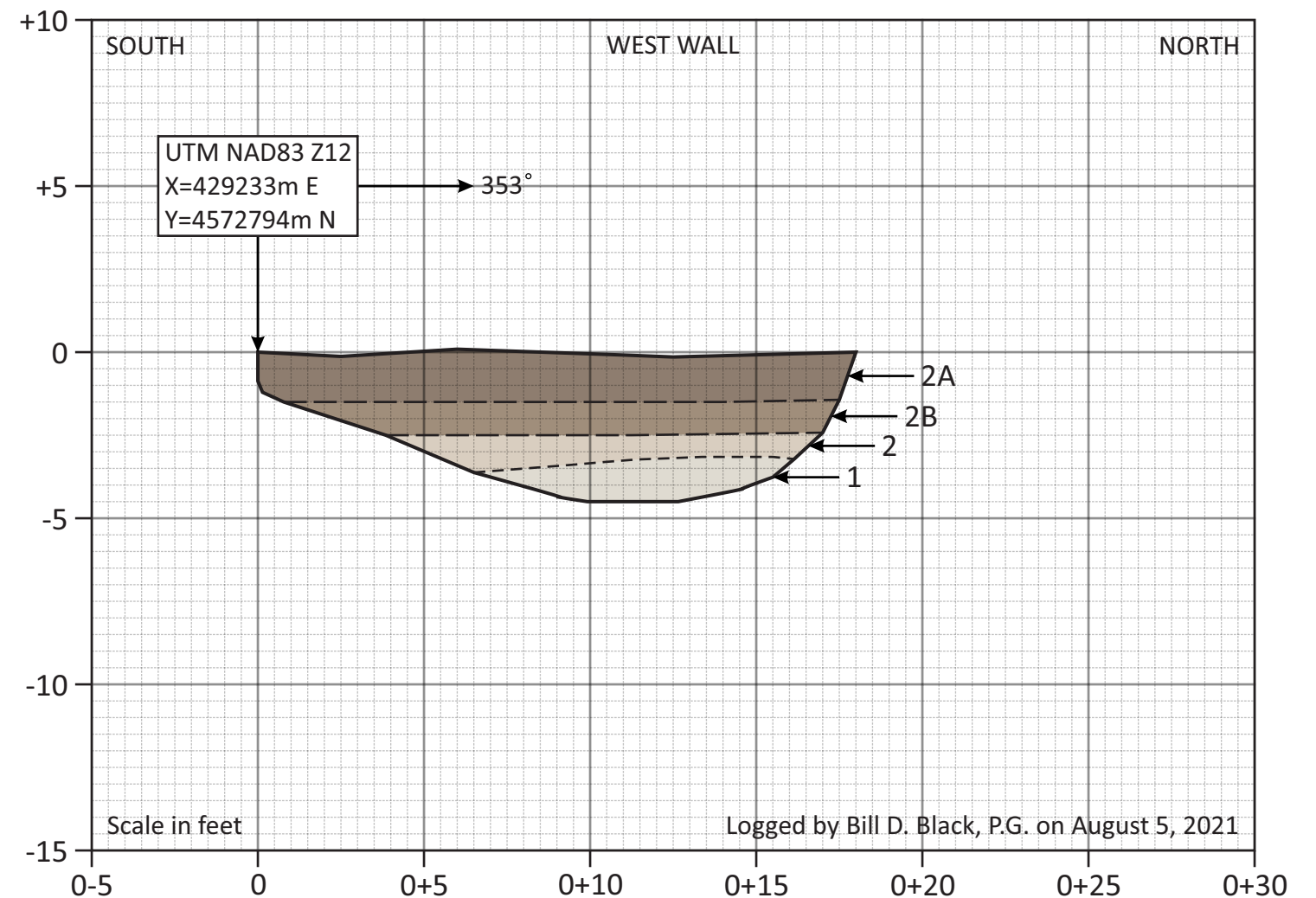


UNIT DESCRIPTIONS

Unit 1. *Tertiary Norwood Formation* - light brownish-olive, strong, poorly bedded, weathered siltstone.

Unit 2. *Late Pleistocene mass wasting colluvium* - yellowish-brown to dark grayish-brown, stiff, massive, lean clay (CL) with sand and siltstone clasts; A and B soil horizons formed in unit (2A and 2B); about 4.5 feet thick.

TEST PIT 52



UNIT DESCRIPTIONS

Unit 1. *Tertiary Norwood Formation* - light brownish-olive, strong, poorly bedded to thinly laminated, weathered siltstone.

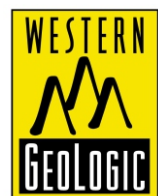
Unit 2. *Late Pleistocene mass wasting colluvium* - dark brown to dark grayish-brown, stiff to medium stiff, massive, lean clay (CL) with sand and gravel; A and B soil horizons formed in unit (2A and 2B); about 3 to 3.5 feet thick.

TEST PIT LOGS, 51 AND 52

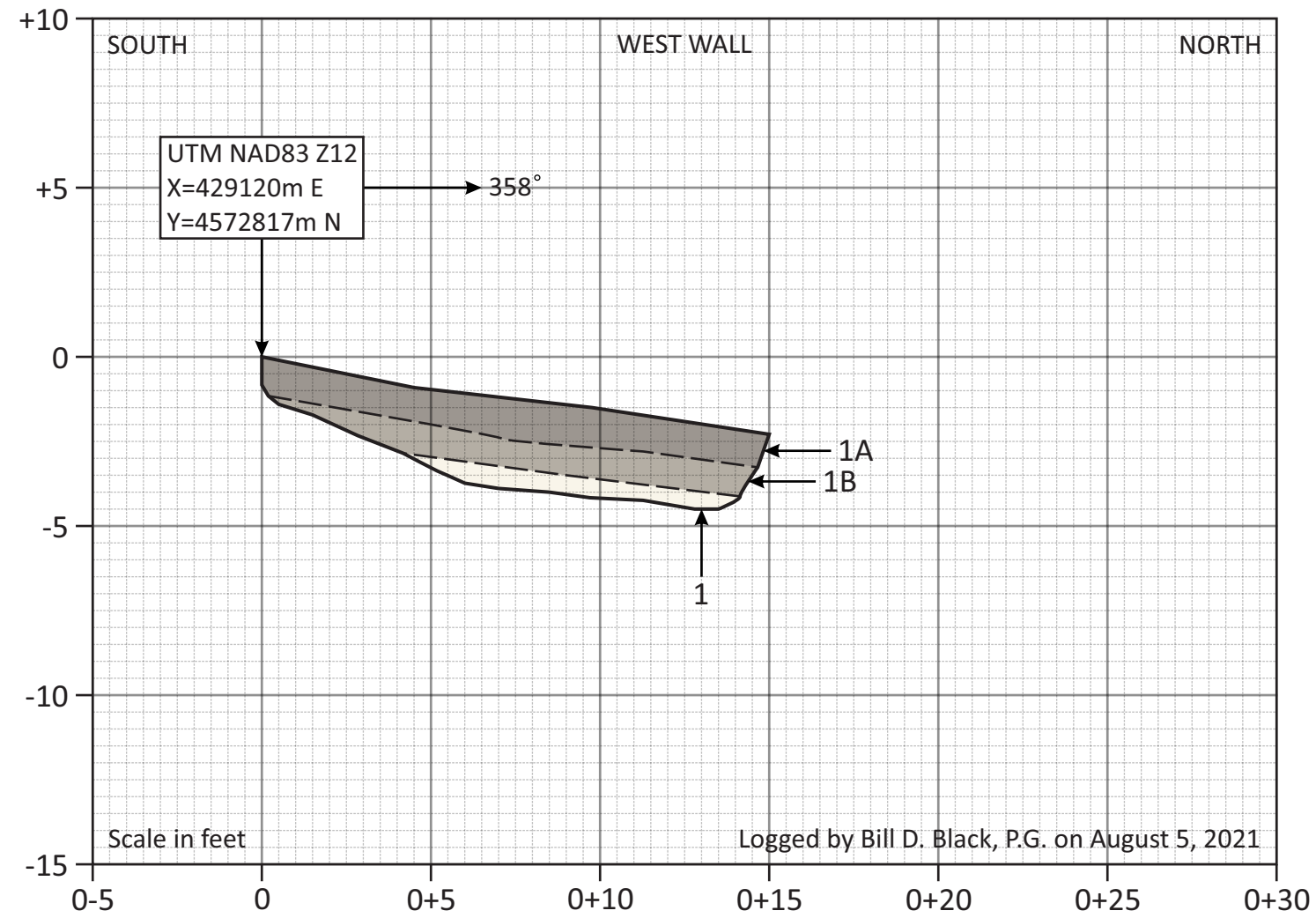
GEOLOGIC HAZARDS EVALUATION

Proposed Osprey Ranch Development
2050 Highway 150
Eden, Weber County, Utah

FIGURE 3Z



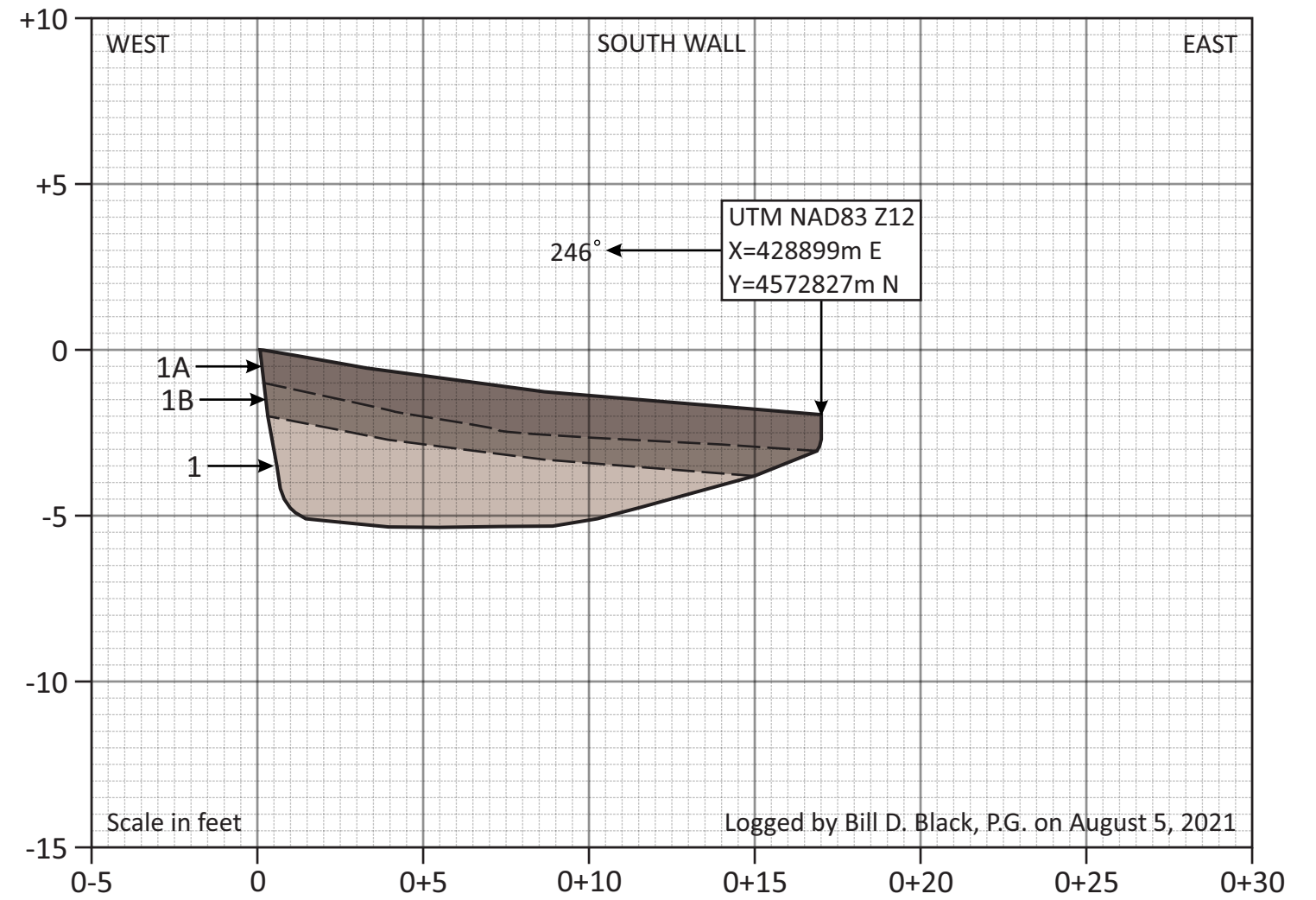
TEST PIT 53



UNIT DESCRIPTIONS

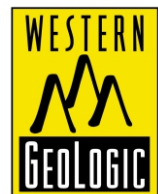
Unit 1. *Tertiary Norwood Formation* - light olive brown, strong, poorly bedded to massive, weathered siltstone; A and B soil horizons formed in unit (1A and 1B); refusal at test pit floor.

TEST PIT 54



UNIT DESCRIPTIONS

Unit 1. *Tertiary Norwood Formation* - dark olive to dark grayish-brown, strong, massive, weathered matrix-supported tuffaceous conglomerate; A and B soil horizons formed in unit (1A and 1B).



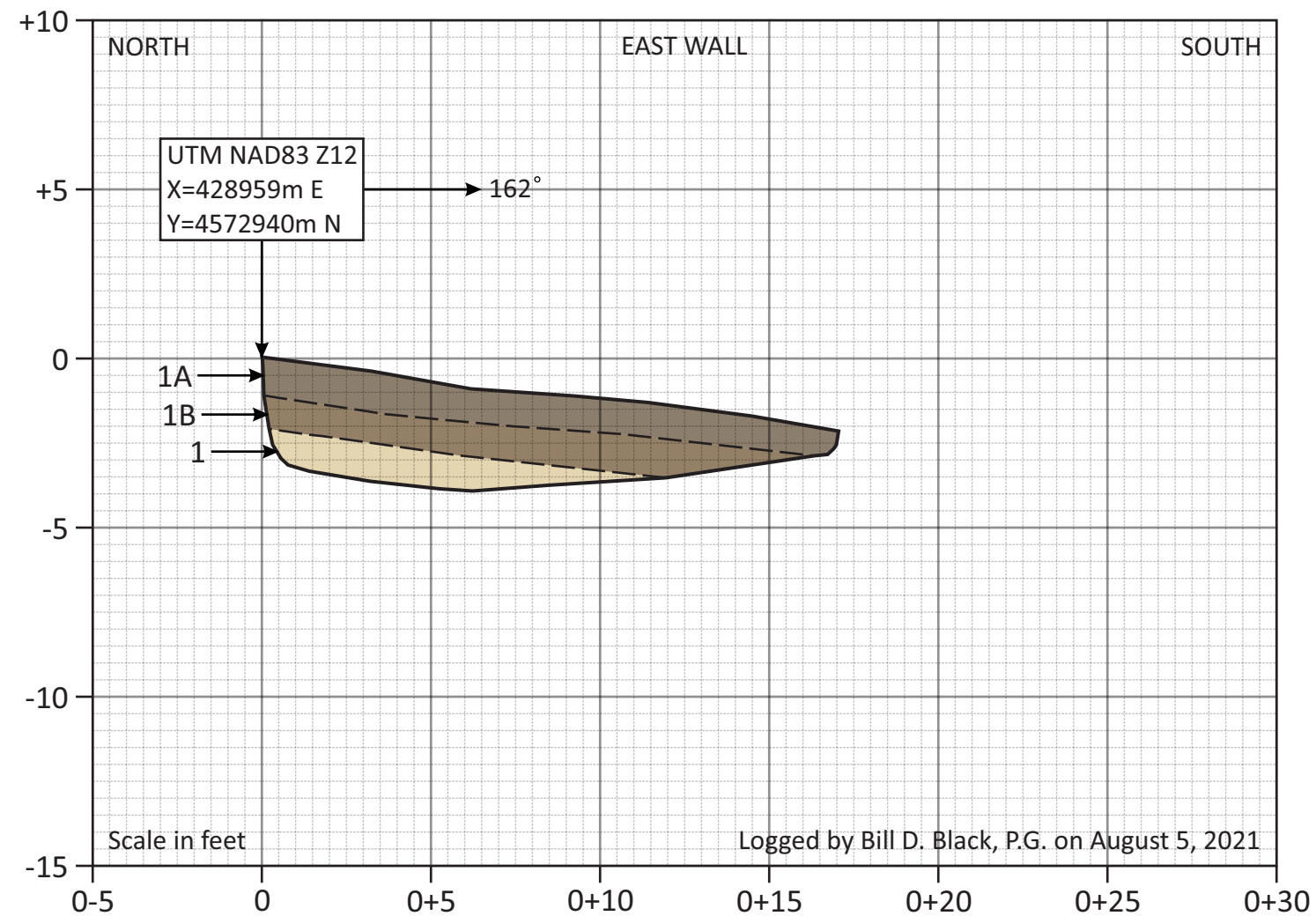
TEST PIT LOGS, 53 AND 54

GEOLOGIC HAZARDS EVALUATION

Proposed Osprey Ranch Development
2050 Highway 150
Eden, Weber County, Utah

FIGURE 4A

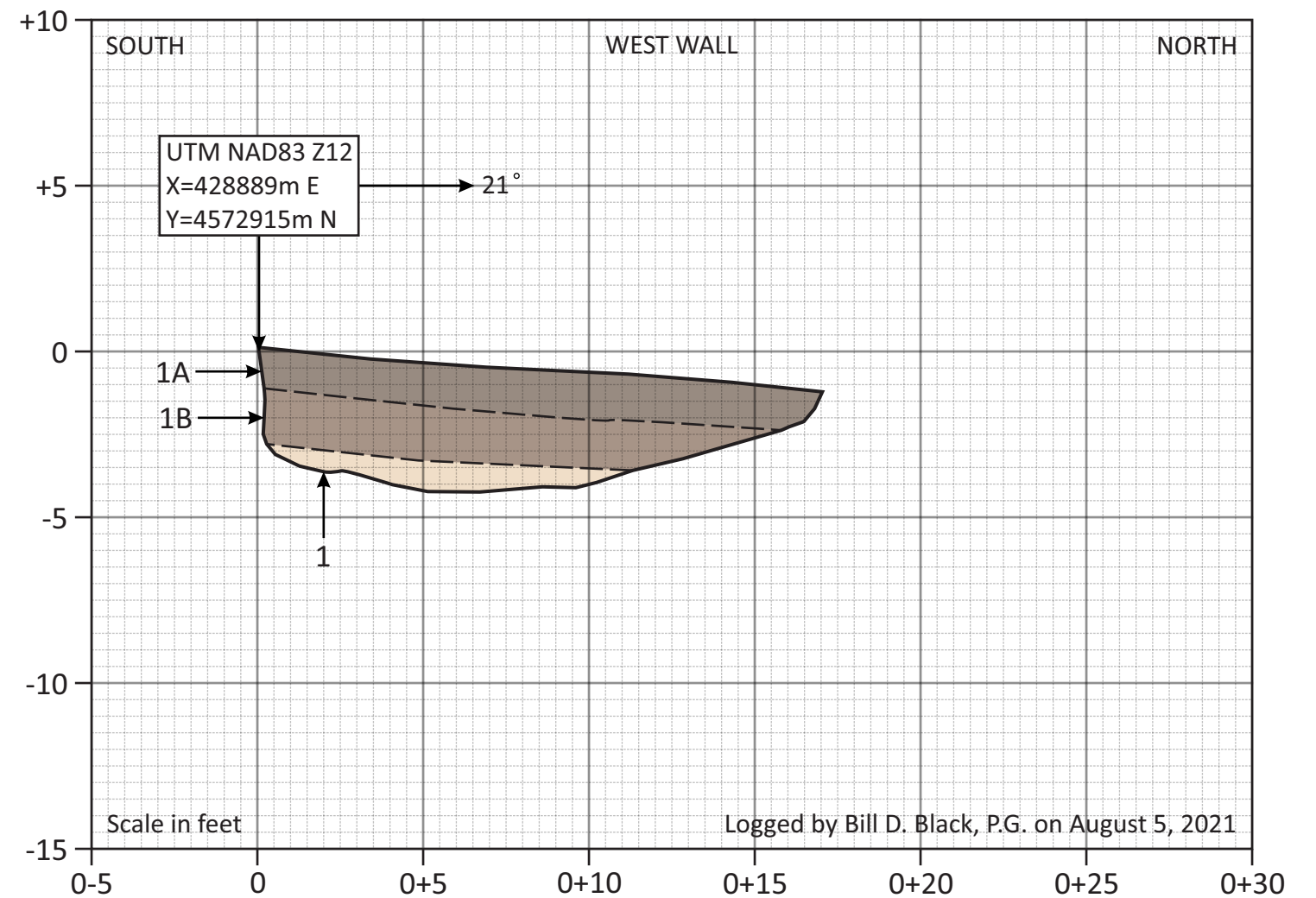
TEST PIT 55



UNIT DESCRIPTIONS

Unit 1. *Tertiary Norwood Formation* - reddish-brown to dark grayish-brown, strong, massive, weathered claystone grading to tuffaceous conglomerate in upper part; A and B soil horizons formed in unit (1A and 1B).

TEST PIT 56



UNIT DESCRIPTIONS

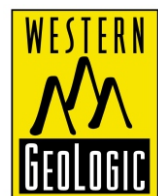
Unit 1. *Tertiary Norwood Formation* - brown to dark grayish-brown, strong, massive, weathered claystone with gravel in upper part; A and B soil horizons formed in unit (1A and 1B).

TEST PIT LOGS, 55 AND 56

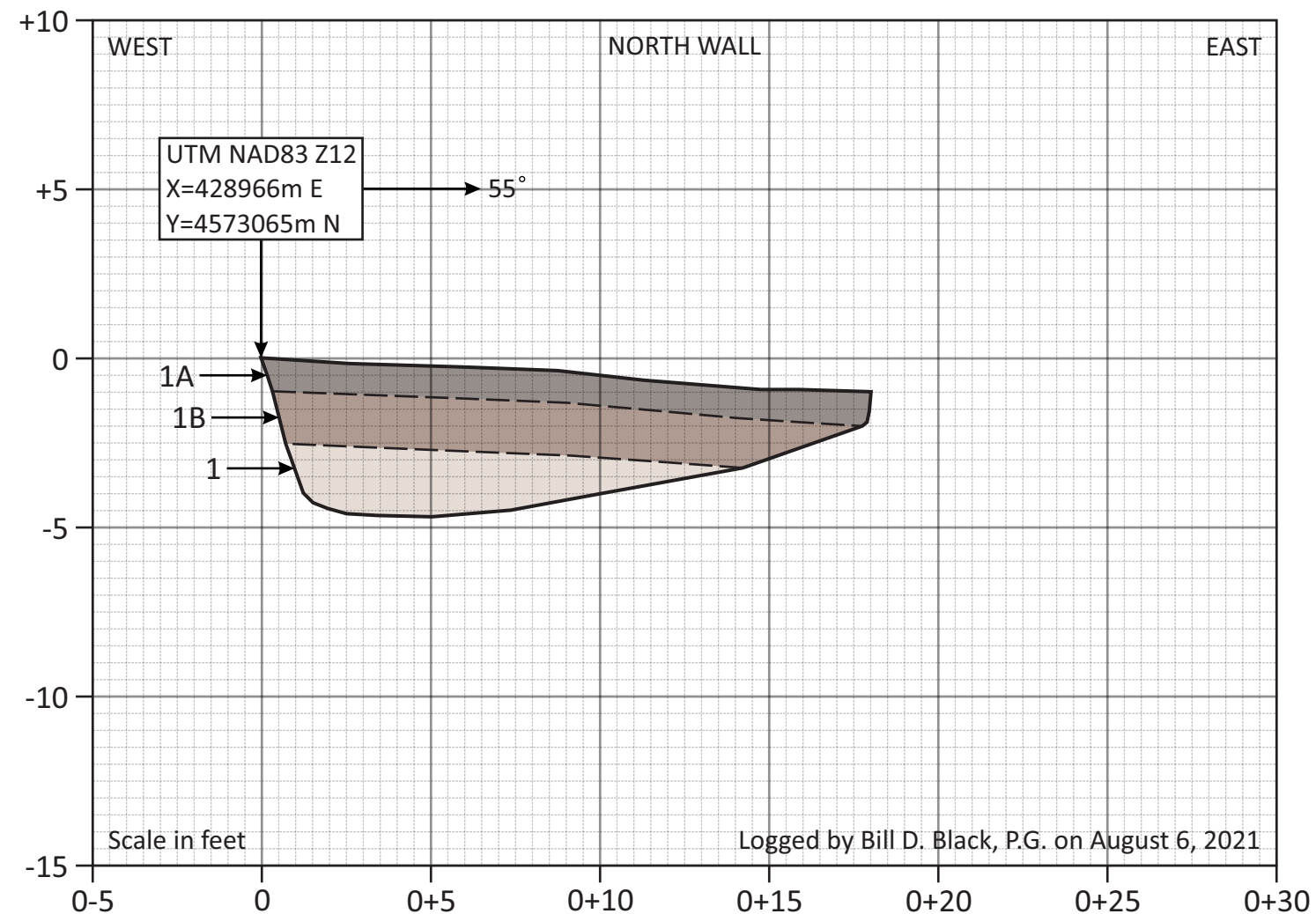
GEOLOGIC HAZARDS EVALUATION

Proposed Osprey Ranch Development
2050 Highway 150
Eden, Weber County, Utah

FIGURE 4B



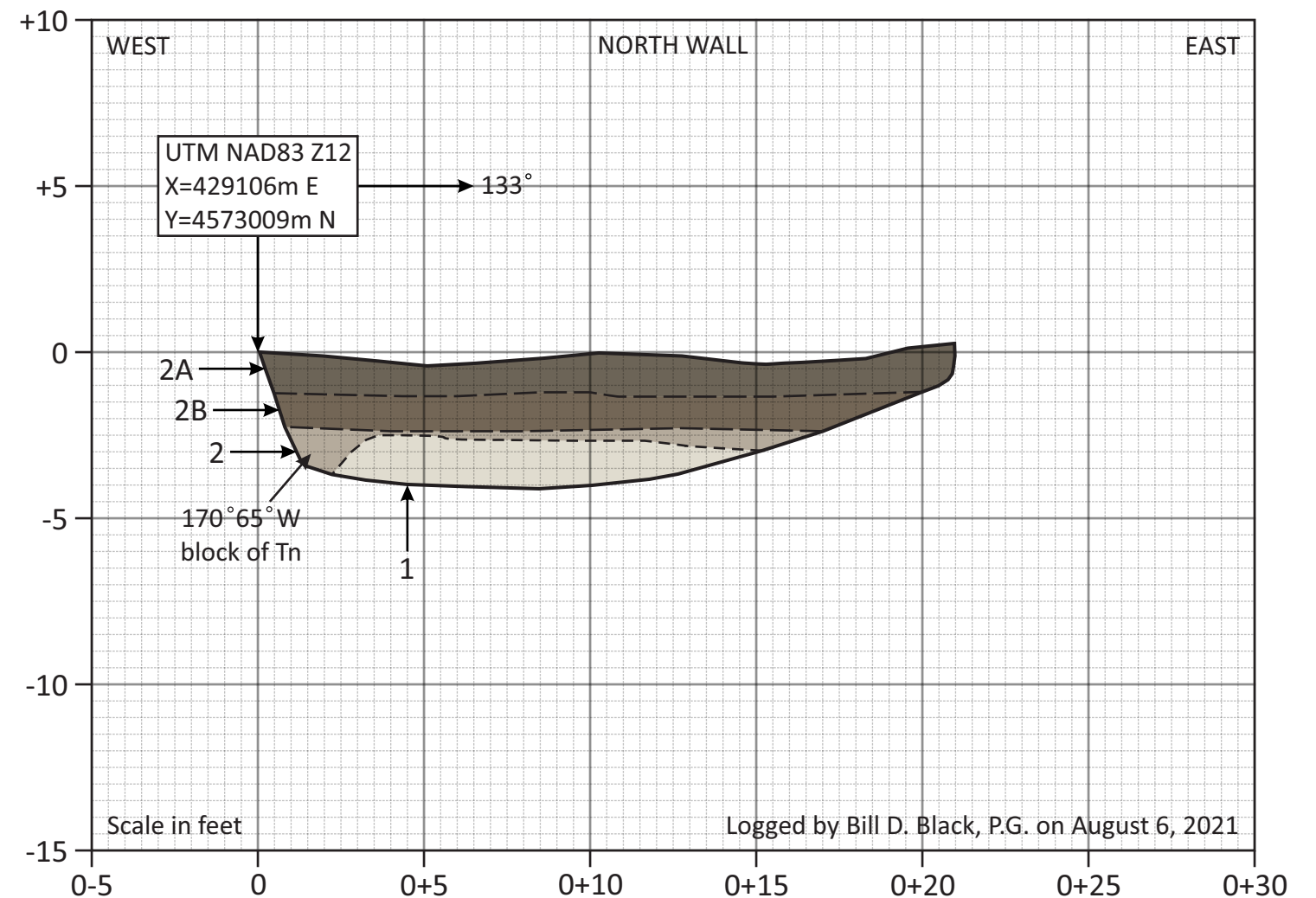
TEST PIT 57



UNIT DESCRIPTIONS

Unit 1. *Tertiary Norwood Formation* - light brown, orange-brown and dark brown; strong to very strong; massive, weathered claystone in lower part grading to tuffaceous conglomerate with subangular clasts with stage II carbonate in upper part; A and B soil horizons formed in unit (1A and 1B).

TEST PIT 58



UNIT DESCRIPTIONS

Unit 1. *Middle to late Pleistocene mass wasting colluvium* - light brown to light olive-brown; dense to very dense, massive, clayey sand (SC) with gravel and fractured tuffaceous sandstone blocks; thickness > 1.5 feet.

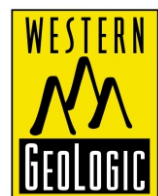
Unit 2. *Late Pleistocene mass wasting colluvium* - brown to dark grayish-brown, stiff, massive, lean clay (CL) with sand and gravel; A and B soil horizons formed in unit (2A and 2B); about 2.5 to 3.5 feet thick.

TEST PIT LOGS, 57 AND 58

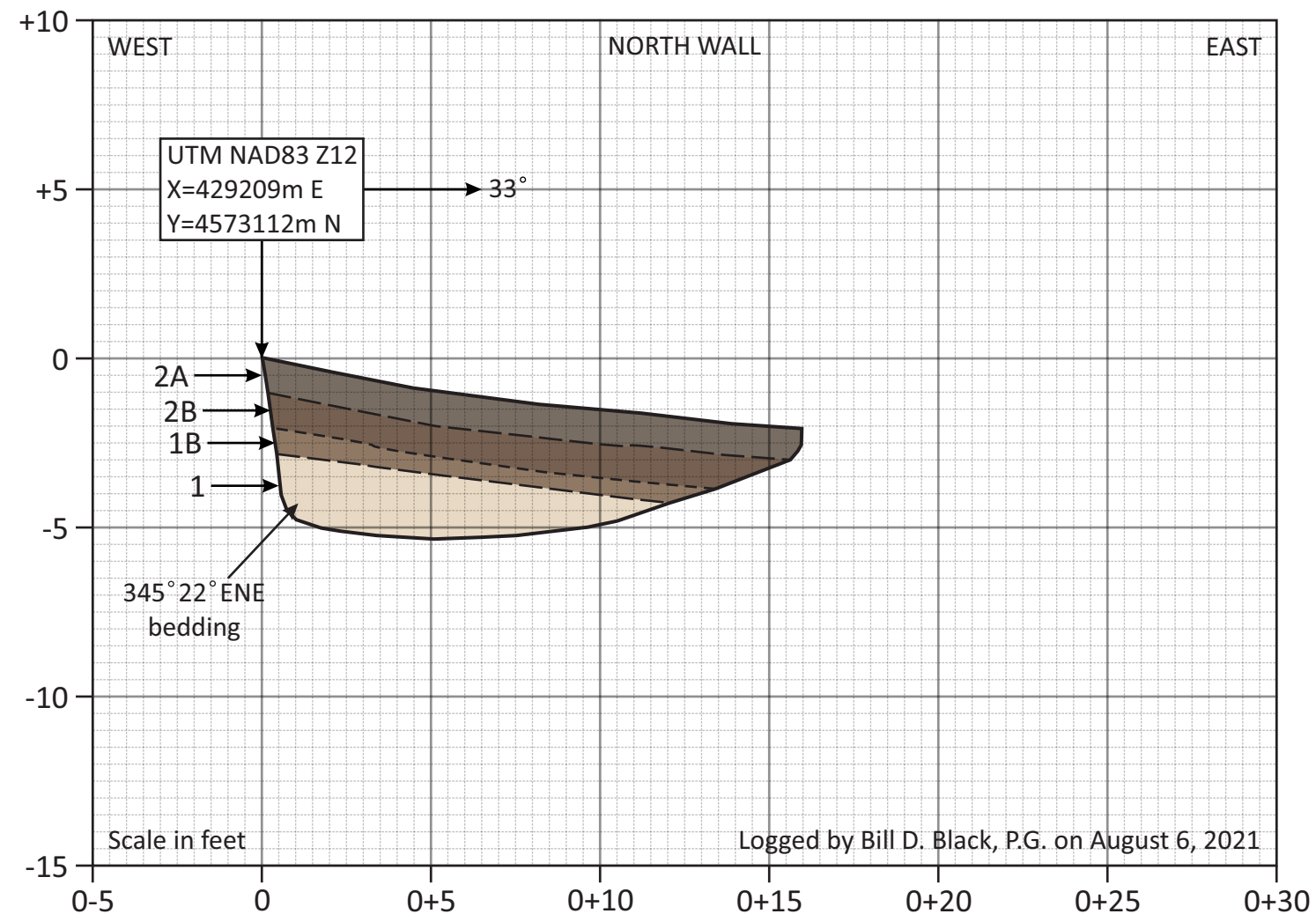
GEOLOGIC HAZARDS EVALUATION

Proposed Osprey Ranch Development
2050 Highway 150
Eden, Weber County, Utah

FIGURE 4C



TEST PIT 59

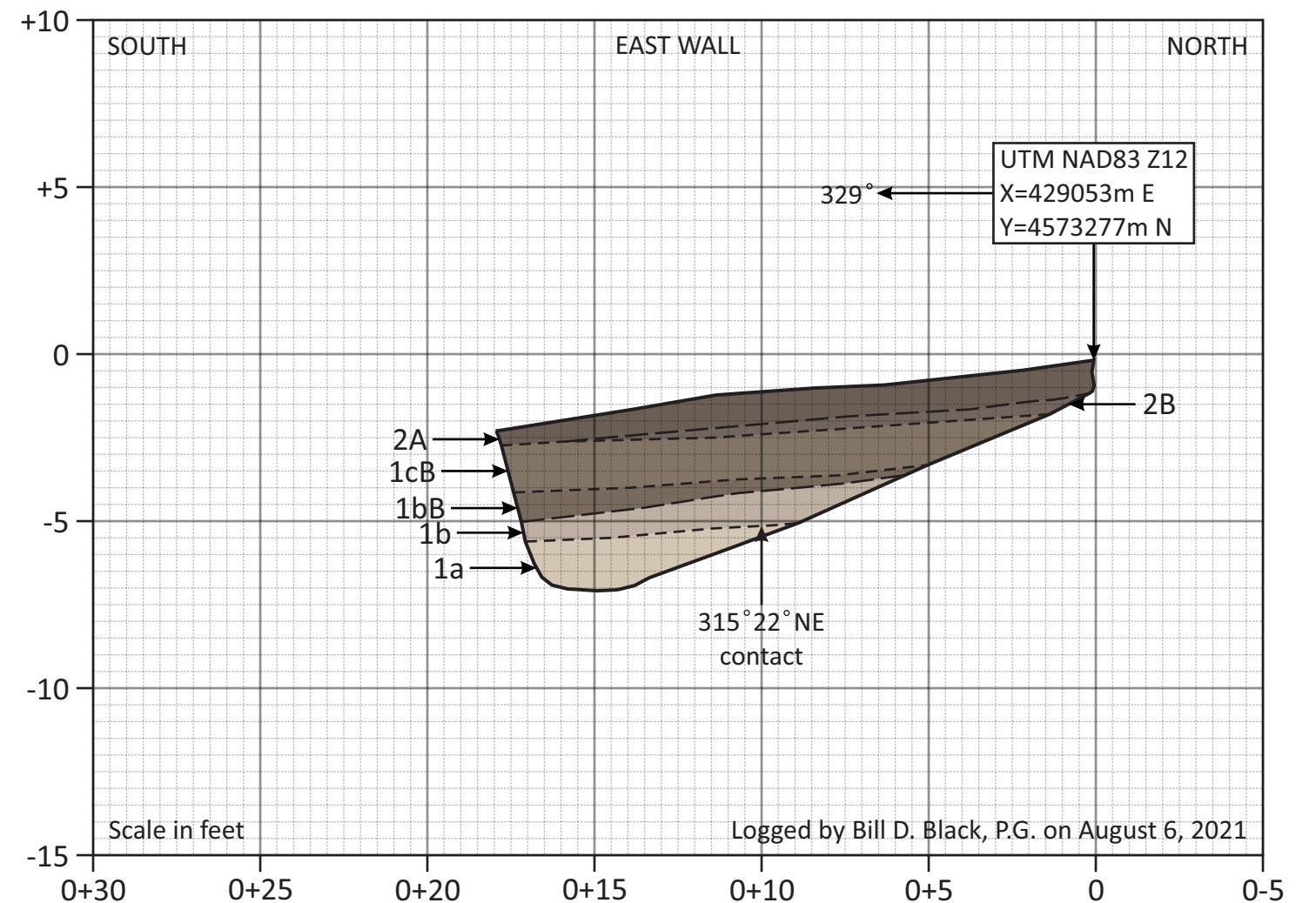


UNIT DESCRIPTIONS

Unit 1. *Tertiary Norwood Formation* - light brown, strong, poorly to well bedded, weathered tuffaceous sandstone with carbonate-enriched pebble interbeds; B soil horizon formed in unit (1B).

Unit 2. *Late Pleistocene mass wasting colluvium* - dark grayish-brown, stiff, massive, lean clay (CL) with sand and gravel; A and B soil horizons formed in unit (2A and 2B); about 2.5 feet thick.

TEST PIT 60



UNIT DESCRIPTIONS

Unit 1. *Tertiary Norwood Formation* - sequence of weathered bedrock comprised of a lower (1a) light brown, strong, massive, tuffaceous sandstone; a middle (1b) dark brown, strong to medium strong, tuffaceous conglomerate; and an upper (1c) light brownish-olive, medium strong, massive, claystone; B soil horizon formed in middle and upper units (1bB and 1cB).

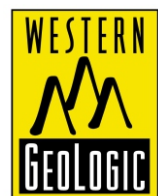
Unit 2. *Late Pleistocene mass wasting colluvium* - dark grayish-brown, medium dense, massive, clayey gravel (GC) with sand and angular to subangular cobbles with stage II carbonate; A and B soil horizons formed in unit (2A and 2B); about 0.5 to 1.5 feet thick.

TEST PIT LOGS, 59 AND 60

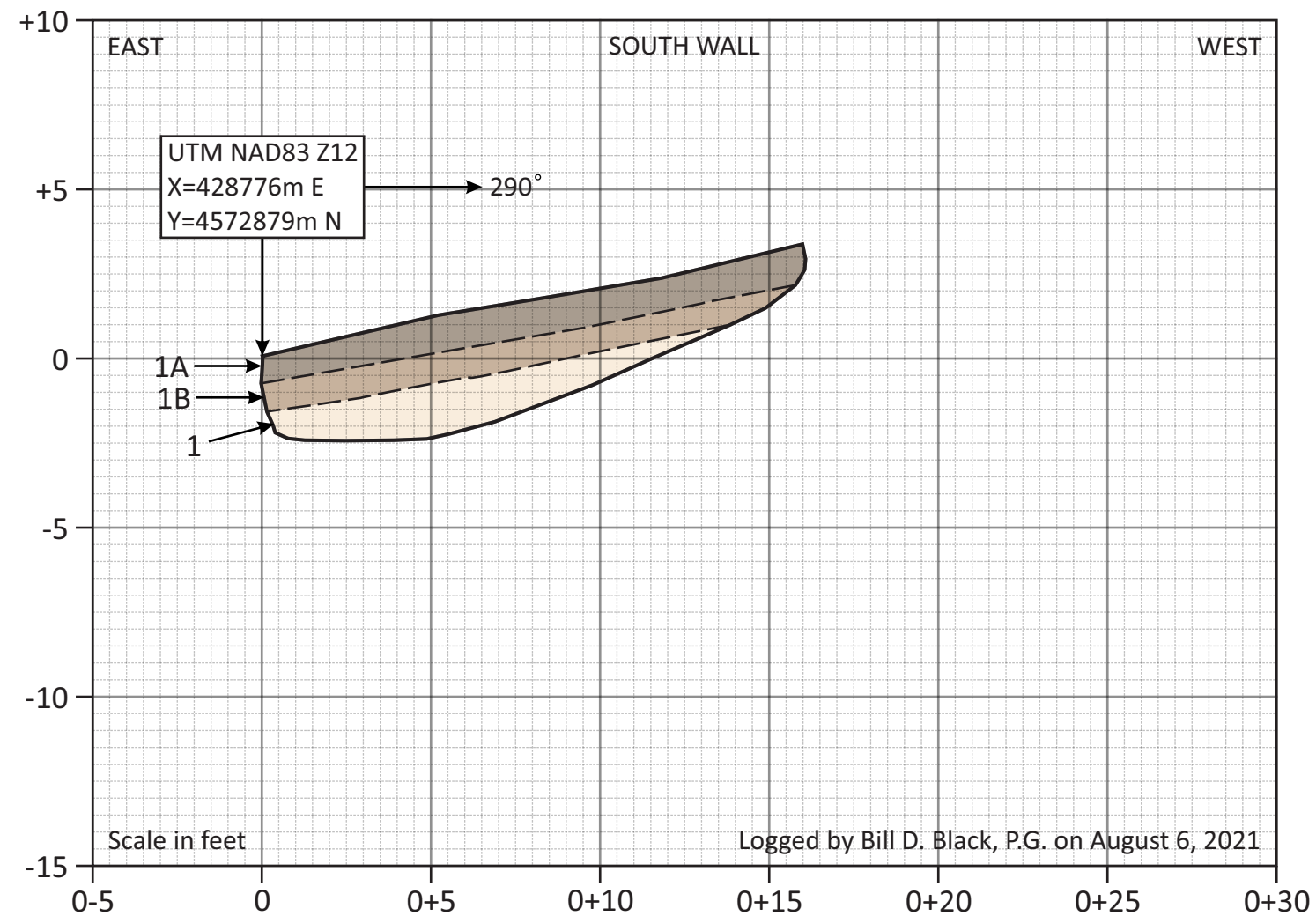
GEOLOGIC HAZARDS EVALUATION

Proposed Osprey Ranch Development
2050 Highway 150
Eden, Weber County, Utah

FIGURE 4D



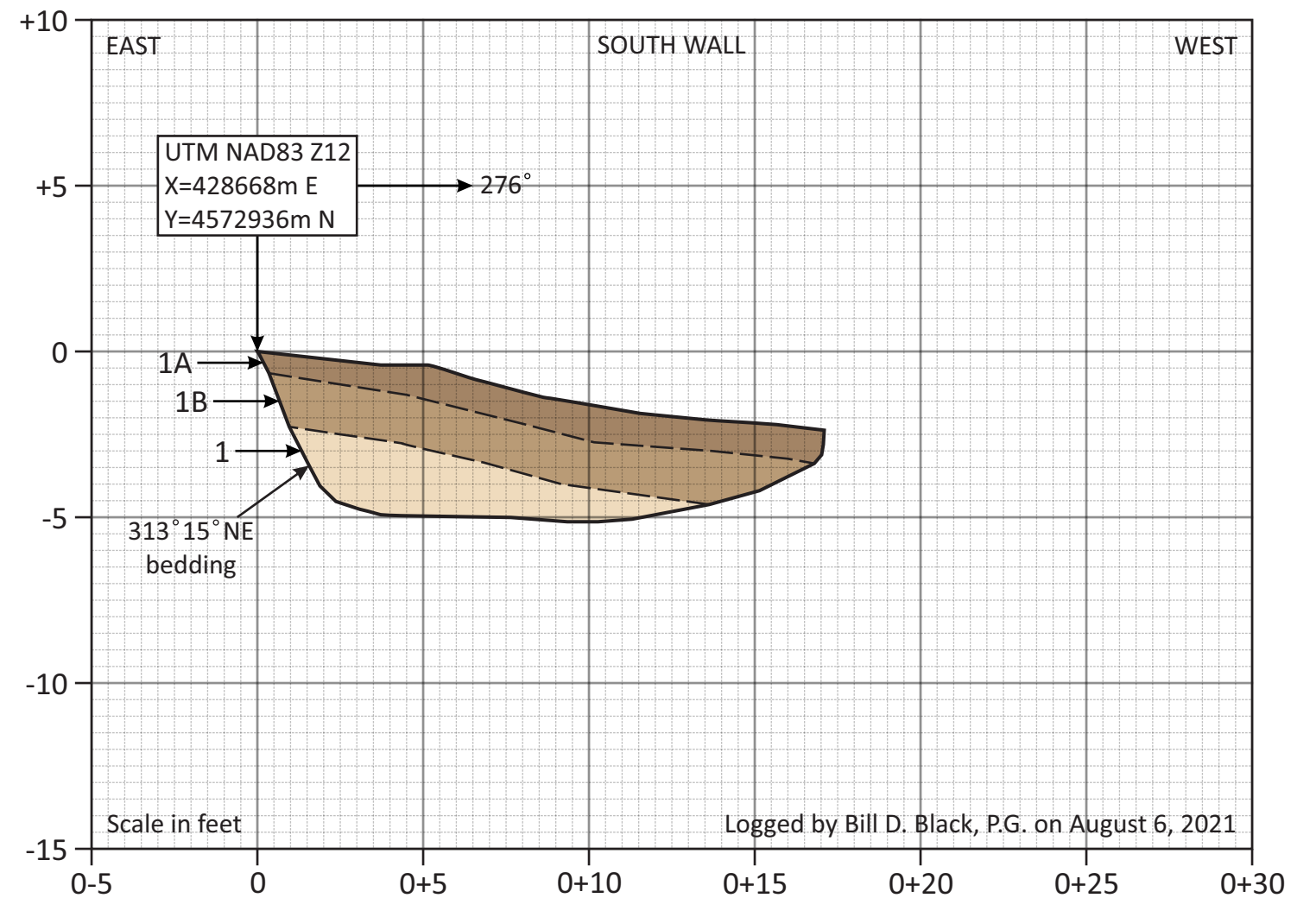
TEST PIT 61



UNIT DESCRIPTIONS

Unit 1. Tertiary Norwood Formation - light orange-brown to dark brown, strong, poorly bedded to massive, weathered tuffaceous conglomerate; A and B soil horizons formed in unit (1A and 1B).

TEST PIT 62



UNIT DESCRIPTIONS

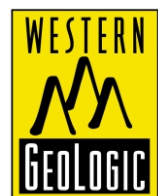
Unit 1. Tertiary Norwood Formation - orange-brown to brown, poorly bedded, strong, claystone to pebble conglomerate; A and B soil horizons formed in unit (1A and 1B).

TEST PIT LOGS, 61 AND 62

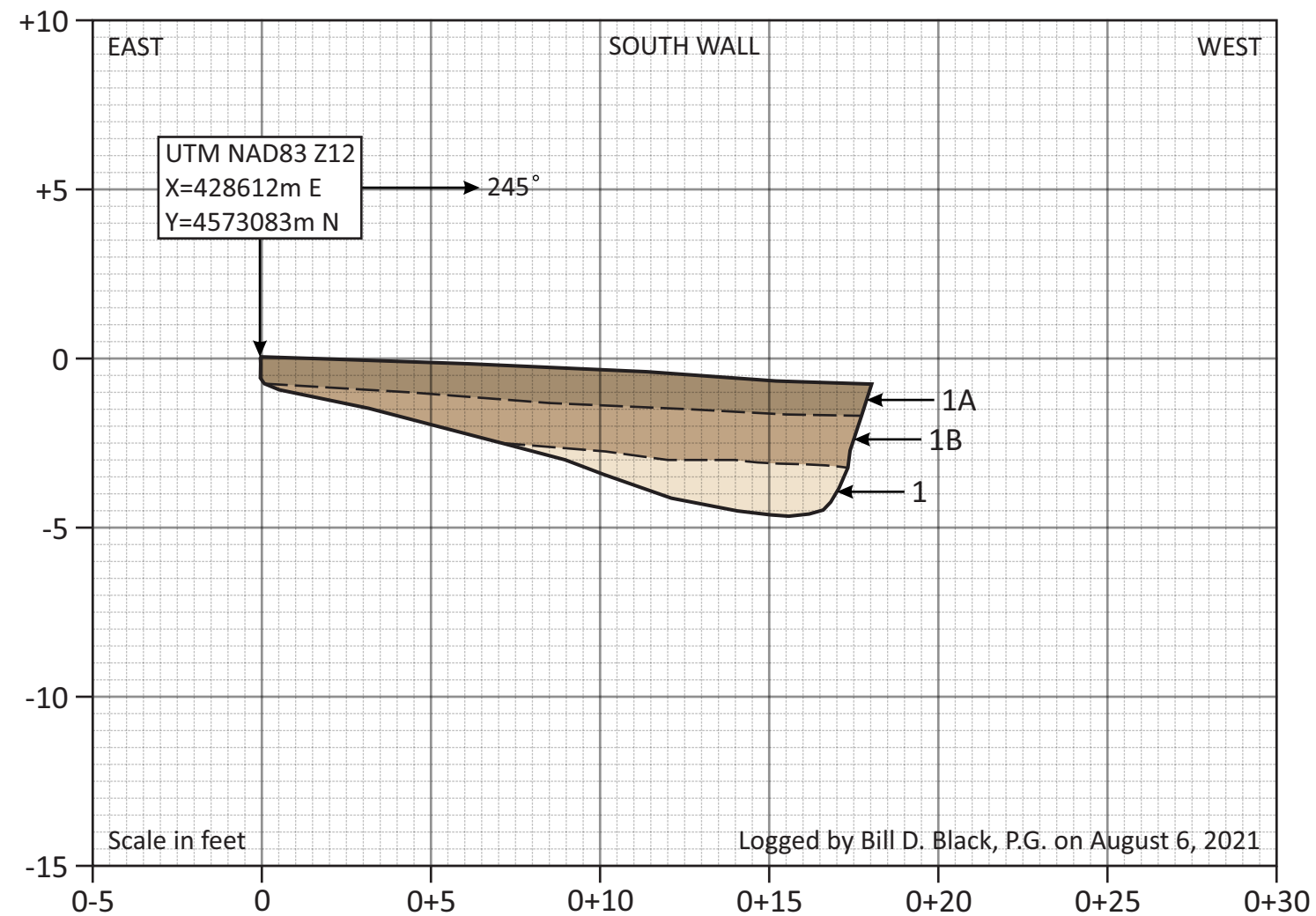
GEOLOGIC HAZARDS EVALUATION

Proposed Osprey Ranch Development
2050 Highway 150
Eden, Weber County, Utah

FIGURE 4E



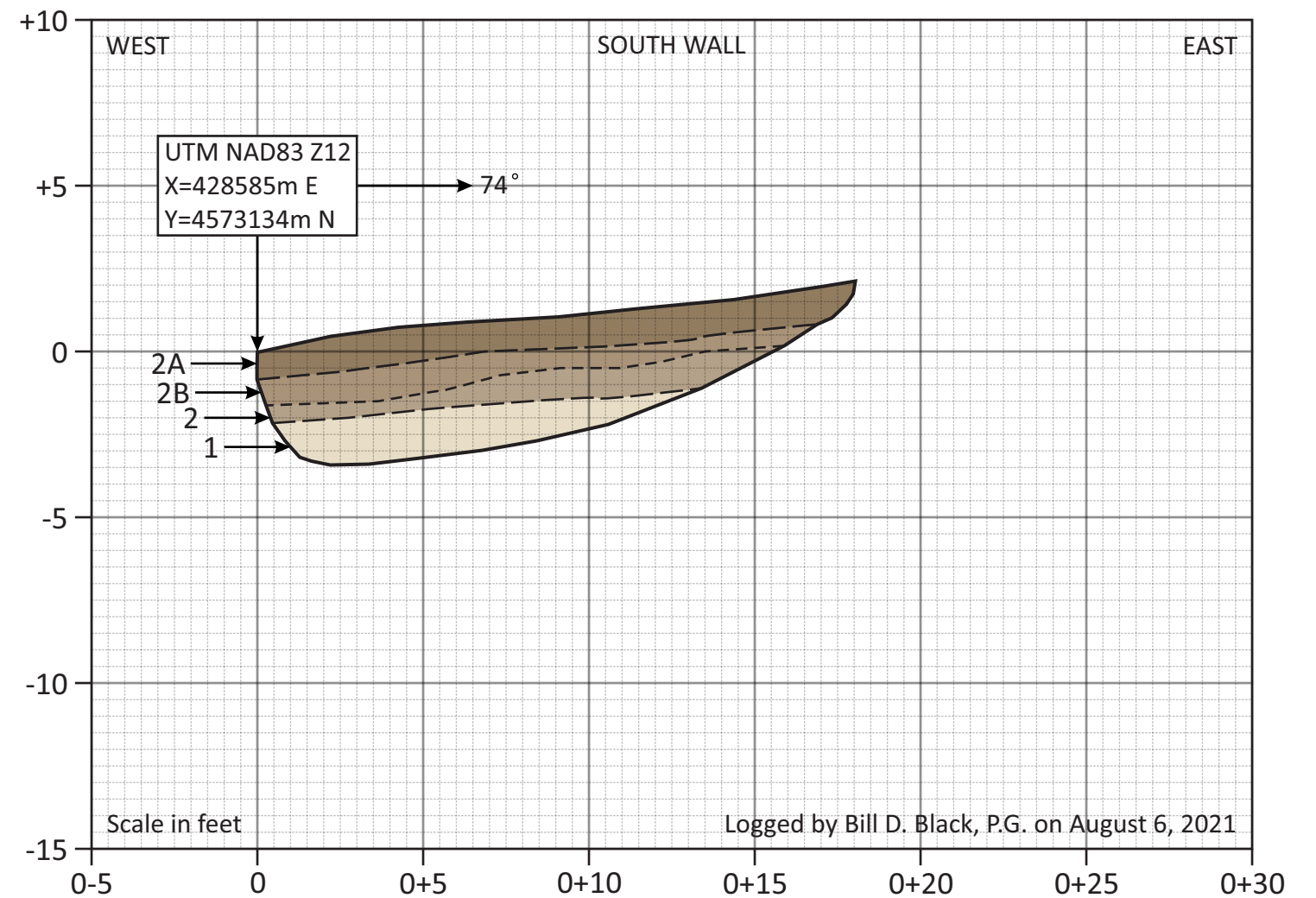
TEST PIT 63



UNIT DESCRIPTIONS

Unit 1. *Tertiary Norwood Formation* - orange-brown to dark brown, strong, massive, weathered tuffaceous conglomerate with subangular clasts with stage II carbonate; A and B soil horizons formed in unit (1A and 1B).

TEST PIT 64



UNIT DESCRIPTIONS

Unit 1. *Tertiary Norwood Formation* - olive-brown to orange-brown, strong, massive, weathered claystone grading upward to matrix-supported tuffaceous conglomerate; B soil horizon formed in unit (1B).

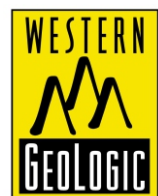
Unit 2. *Late Pleistocene mass wasting colluvium* - dark brown, dense, massive, clayey gravel (GC) with sand, trace subround to subangular cobbles with stage II carbonate in basal part of unit; A and B soil horizons formed in unit (2A and 2B); 1.5 to 2 feet thick.

TEST PIT LOGS, 63 AND 64

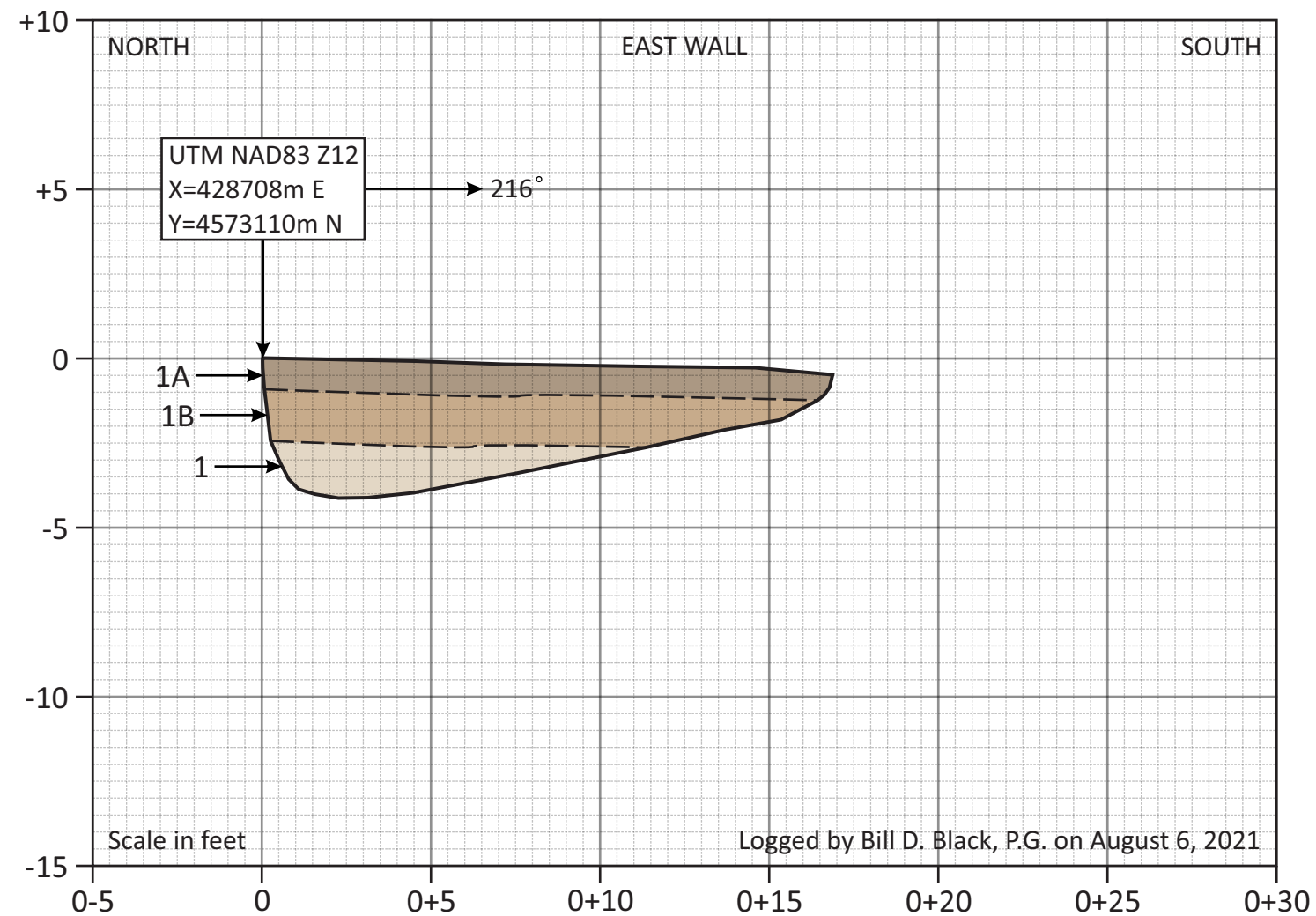
GEOLOGIC HAZARDS EVALUATION

Proposed Osprey Ranch Development
2050 Highway 150
Eden, Weber County, Utah

FIGURE 4F



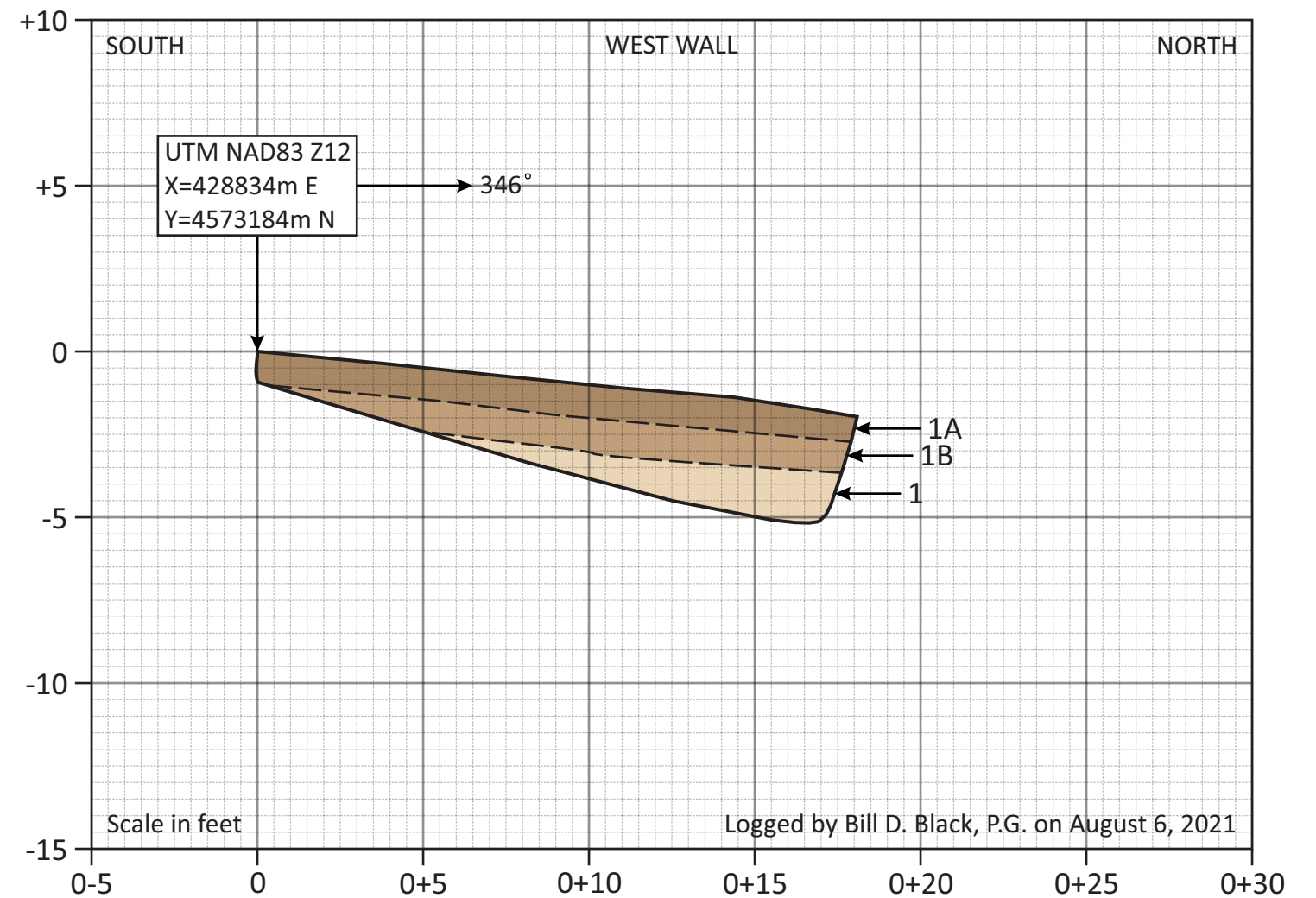
TEST PIT 65



UNIT DESCRIPTIONS

Unit 1. *Tertiary Norwood Formation* - reddish-brown to brown, strong, massive, weathered, matrix-supported tuffaceous conglomerate with subangular quartzite clasts with stage II carbonate; A and B soil horizons formed in unit (1A and 1B).

TEST PIT 66



UNIT DESCRIPTIONS

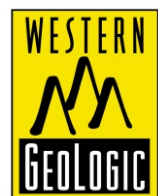
Unit 1. *Tertiary Norwood Formation*- brown to dark brown, strong to very strong, massive, weathered claystone; A and B soil horizons formed in unit (1A and 1B).

TEST PIT LOGS, 65 AND 66

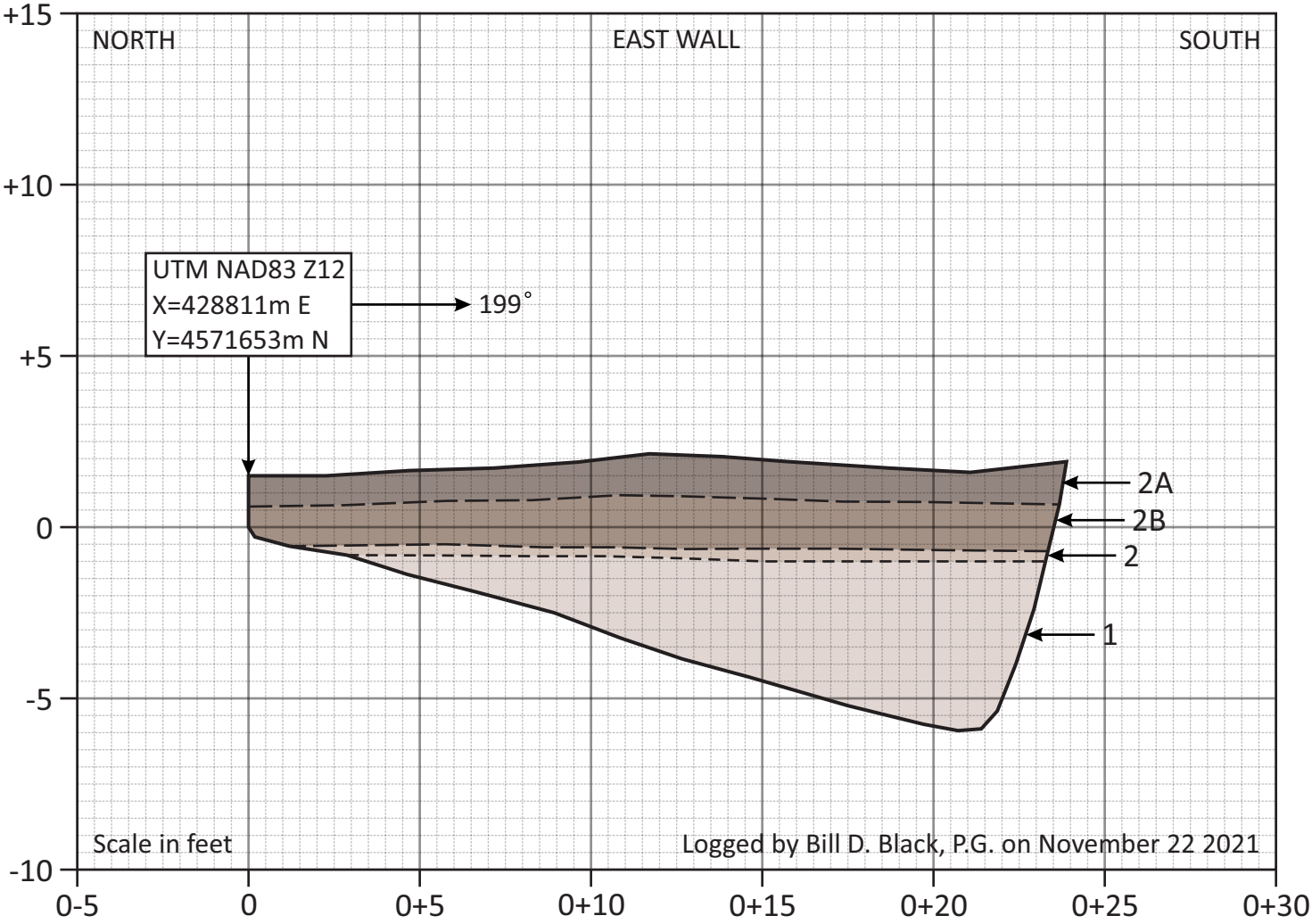
GEOLOGIC HAZARDS EVALUATION

Proposed Osprey Ranch Development
2050 Highway 150
Eden, Weber County, Utah

FIGURE 4G



TEST PIT 67

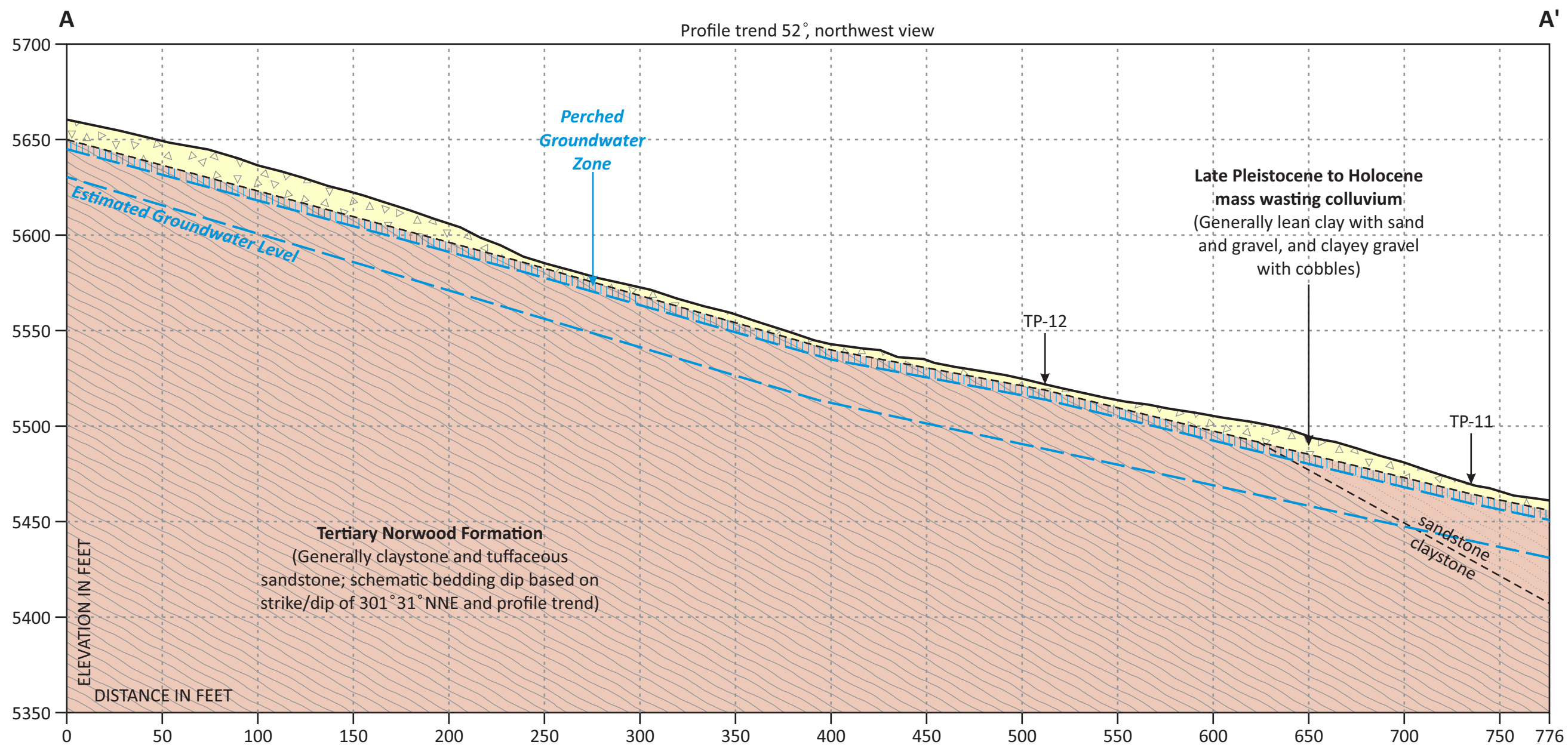


UNIT DESCRIPTIONS

- Unit 1.** *Tertiary Norwood Formation* - brown, orange-brown and light reddish-brown, strong to very strong, massive, weathered tuffaceous conglomerate.
- Unit 2.** *Late Pleistocene mass wasting colluvium* - reddish-brown to dark grayish-brown, medium dense, massive, clayey gravel (GC) with trace subangular cobbles with stage II carbonate; A and B soil horizons formed in unit (2A and 2B); about 2.5 to 3 feet thick.



TEST PIT LOG 67
GEOLOGIC HAZARDS EVALUATION Proposed Osprey Ranch Development 2050 Highway 150 Eden, Weber County, Utah
FIGURE 4H

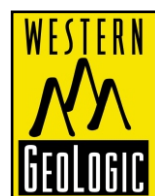


GEOLOGIC CROSS SECTION A-A'

GEOLOGIC HAZARDS EVALUATION

Proposed Osprey Ranch Development
2050 Highway 150
Eden, Weber County, Utah

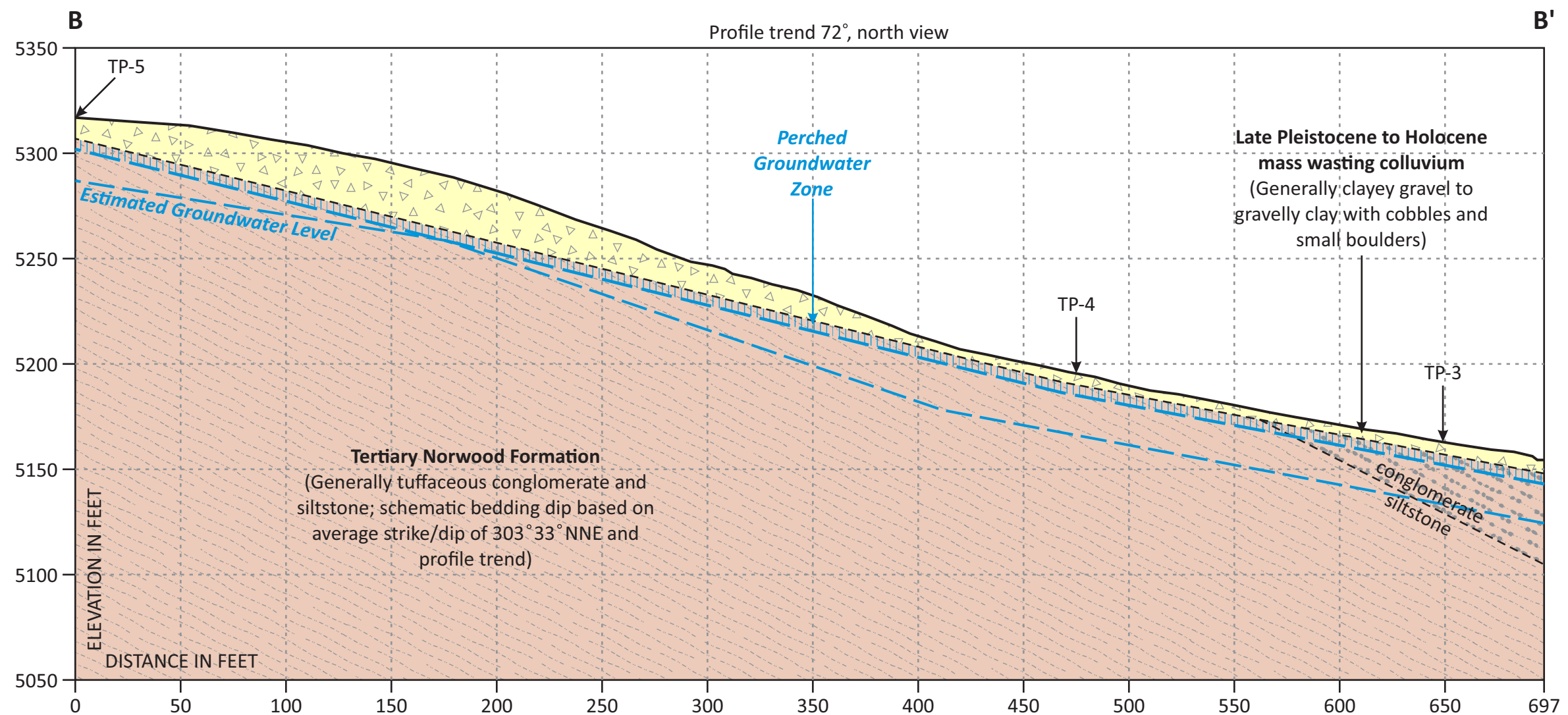
FIGURE 5A



Scale 1 inch equals 60 feet (1:720) with no vertical exaggeration.

All units and contacts are approximate and inferred based on available subsurface data; variations may occur laterally, at depth and within units.

Topographic profile based on geoprocessed 2016 LIDAR data.

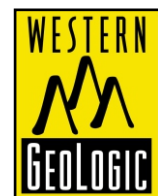


GEOLOGIC CROSS SECTION B-B'

GEOLOGIC HAZARDS EVALUATION

Proposed Osprey Ranch Development
2050 Highway 150
Eden, Weber County, Utah

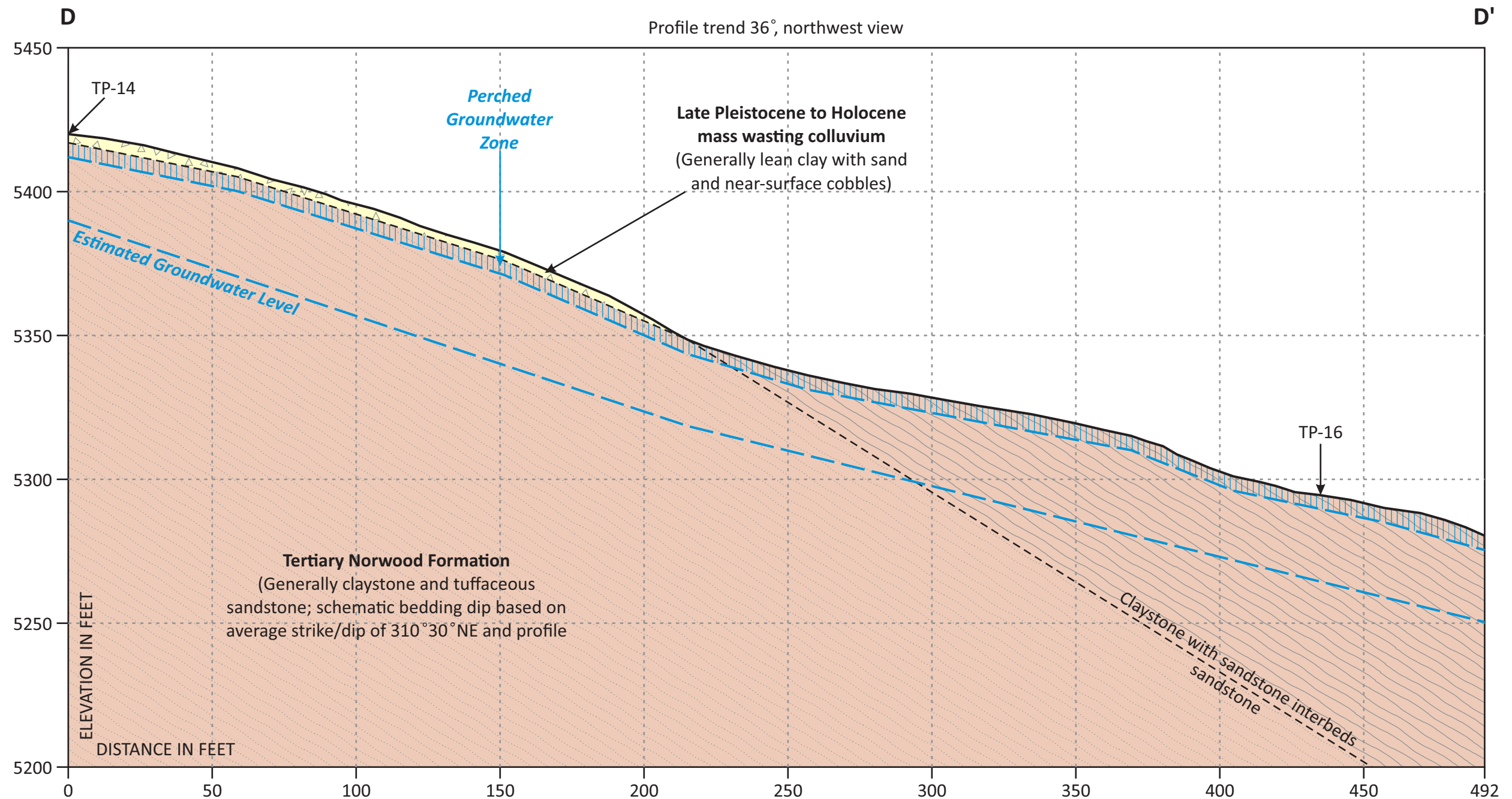
FIGURE 5B



Scale 1 inch equals 60 feet (1:720) with no vertical exaggeration.

All units and contacts are approximate and inferred based on available subsurface data; variations may occur laterally, at depth and within units.

Topographic profile based on geoprocessed 2016 LIDAR data.

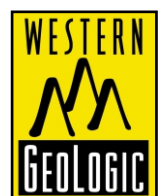


GEOLOGIC CROSS SECTION D-D'

GEOLOGIC HAZARDS EVALUATION

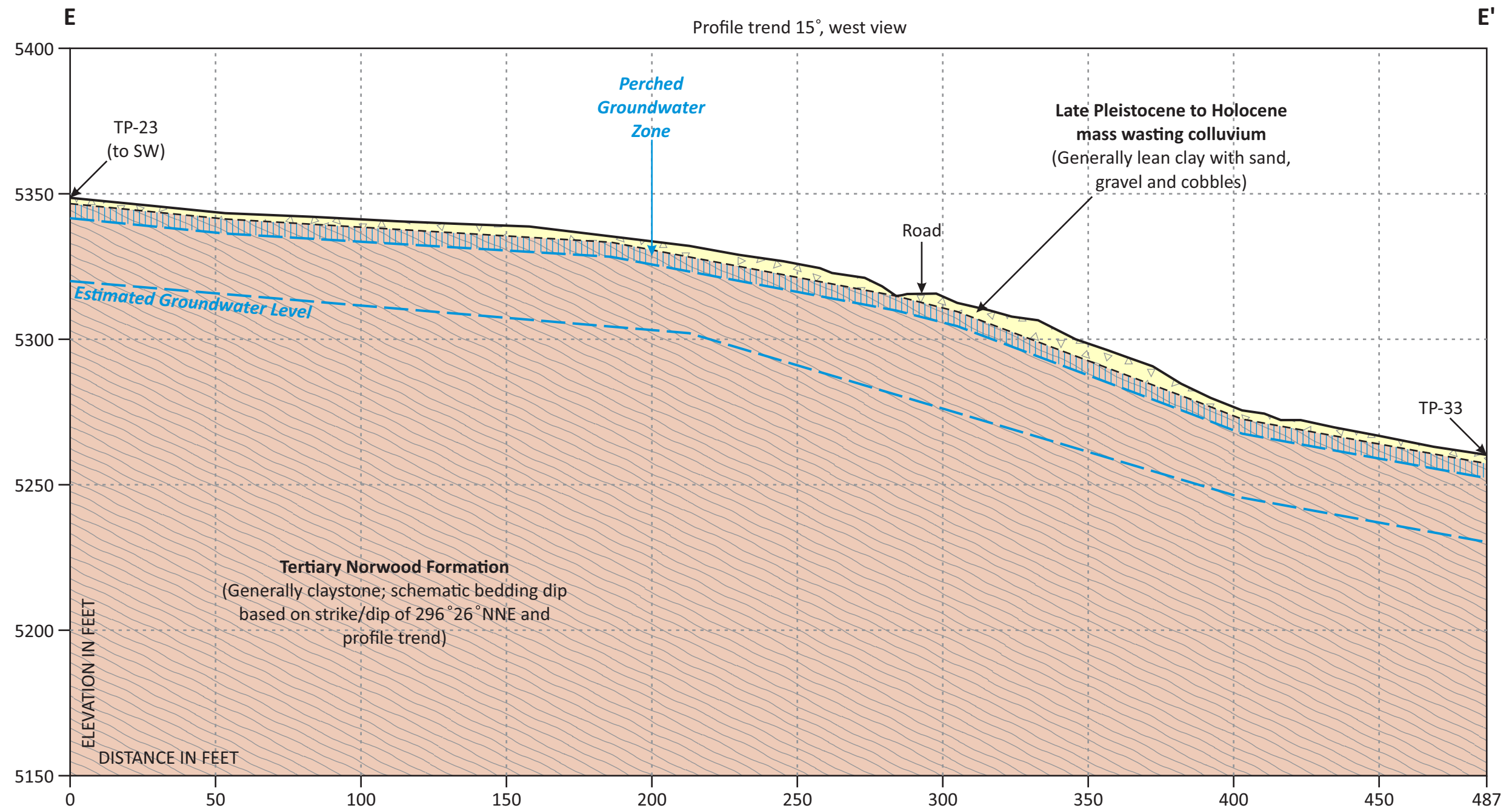
Proposed Osprey Ranch Development
2050 Highway 150
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FIGURE 5D



Scale 1 inch equals 40 feet (1:480) with no vertical exaggeration.

All units and contacts are approximate and inferred based on available subsurface data; variations may occur laterally, at depth and within units.
Topographic profile based on geoprocessed 2016 LIDAR data.

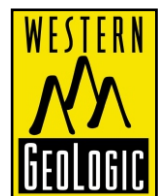


GEOLOGIC CROSS SECTION E-E'

GEOLOGIC HAZARDS EVALUATION

Proposed Osprey Ranch Development
2050 Highway 150
Eden, Weber County, Utah

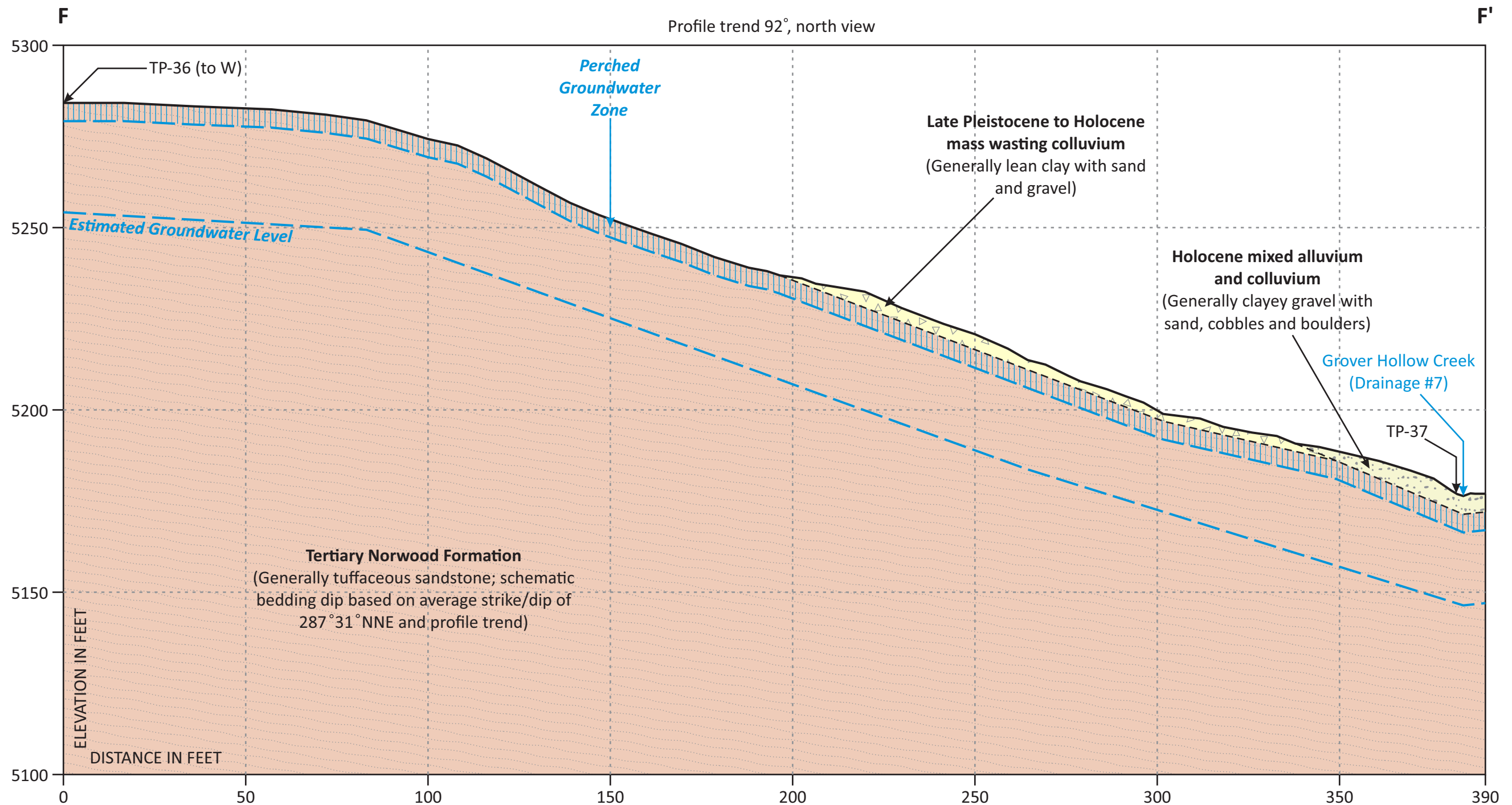
FIGURE 5E



Scale 1 inch equals 40 feet (1:480) with no vertical exaggeration.

All units and contacts are approximate and inferred based on available subsurface data; variations may occur laterally, at depth and within units.

Topographic profile based on geoprocessed 2016 LIDAR data.



GEOLOGIC CROSS SECTION F-F'

GEOLOGIC HAZARDS EVALUATION

Proposed Osprey Ranch Development
2050 Highway 150
Eden, Weber County, Utah

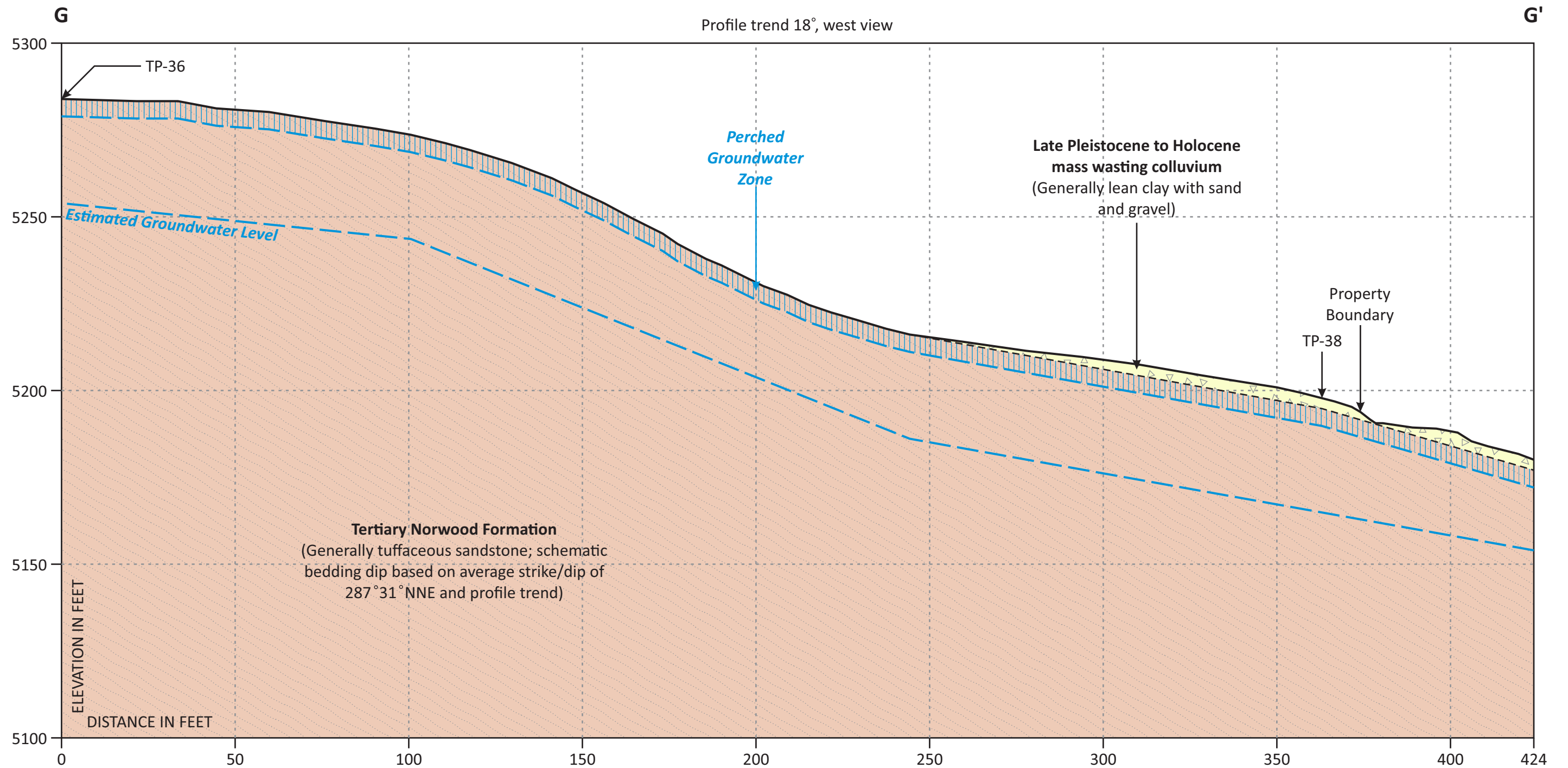
FIGURE 5F



Scale 1 inch equals 30 feet (1:360) with no vertical exaggeration.

All units and contacts are approximate and inferred based on available subsurface data; variations may occur laterally, at depth and within units.

Topographic profile based on geoprocessed 2016 LIDAR data.

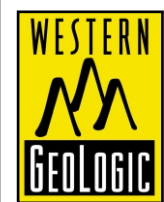


GEOLOGIC CROSS SECTION G-G'

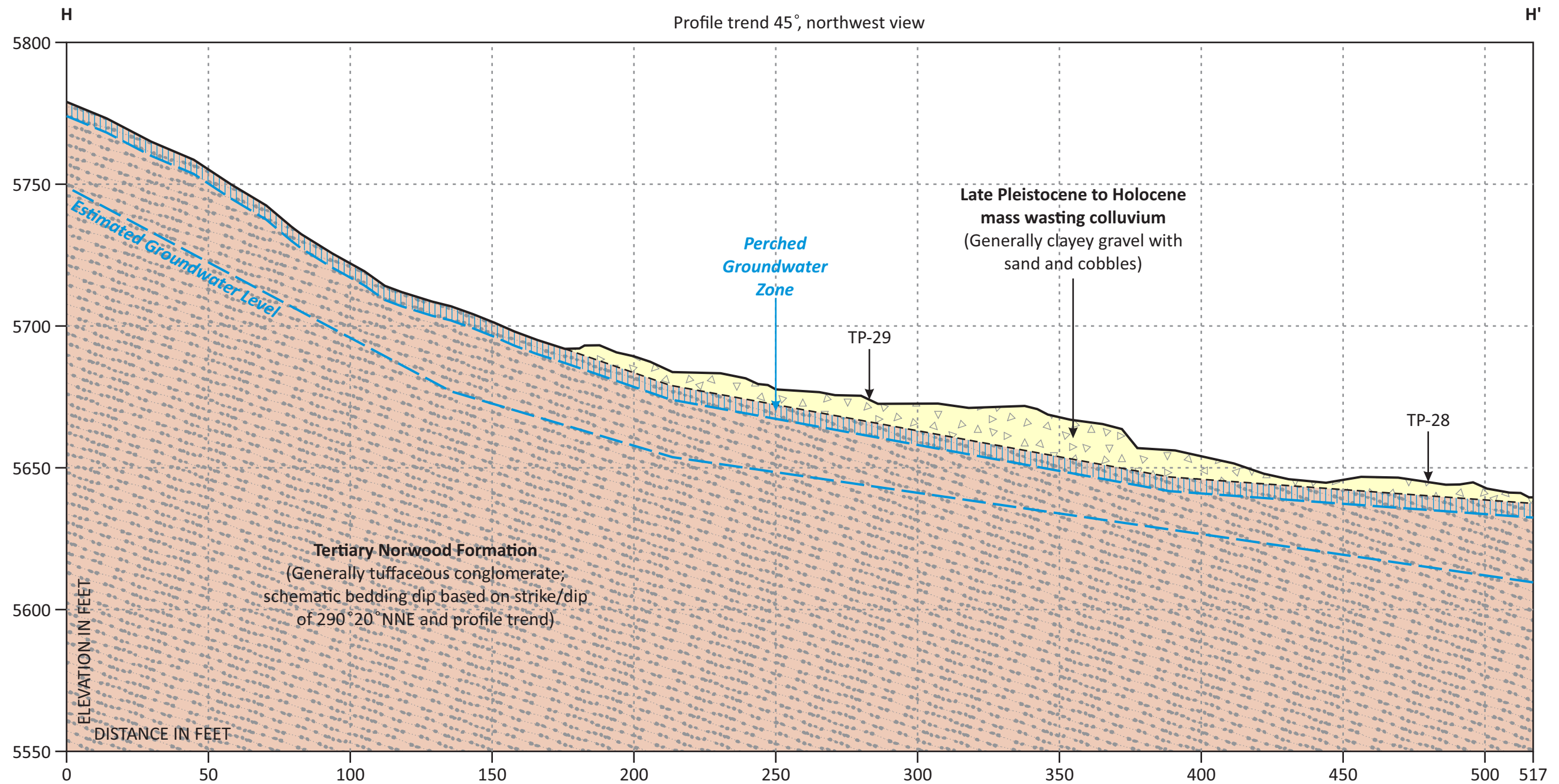
GEOLOGIC HAZARDS EVALUATION

Proposed Osprey Ranch Development
 2050 Highway 150
 Eden, Weber County, Utah

FIGURE 5G



Scale 1 inch equals 30 feet (1:360) with no vertical exaggeration.
 All units and contacts are approximate and inferred based on available subsurface data; variations may occur laterally, at depth and within units.
 Topographic profile based on geoprocessed 2016 LIDAR data.



GEOLOGIC CROSS SECTION H-H'

GEOLOGIC HAZARDS EVALUATION

Proposed Osprey Ranch Development
2050 Highway 150
Eden, Weber County, Utah

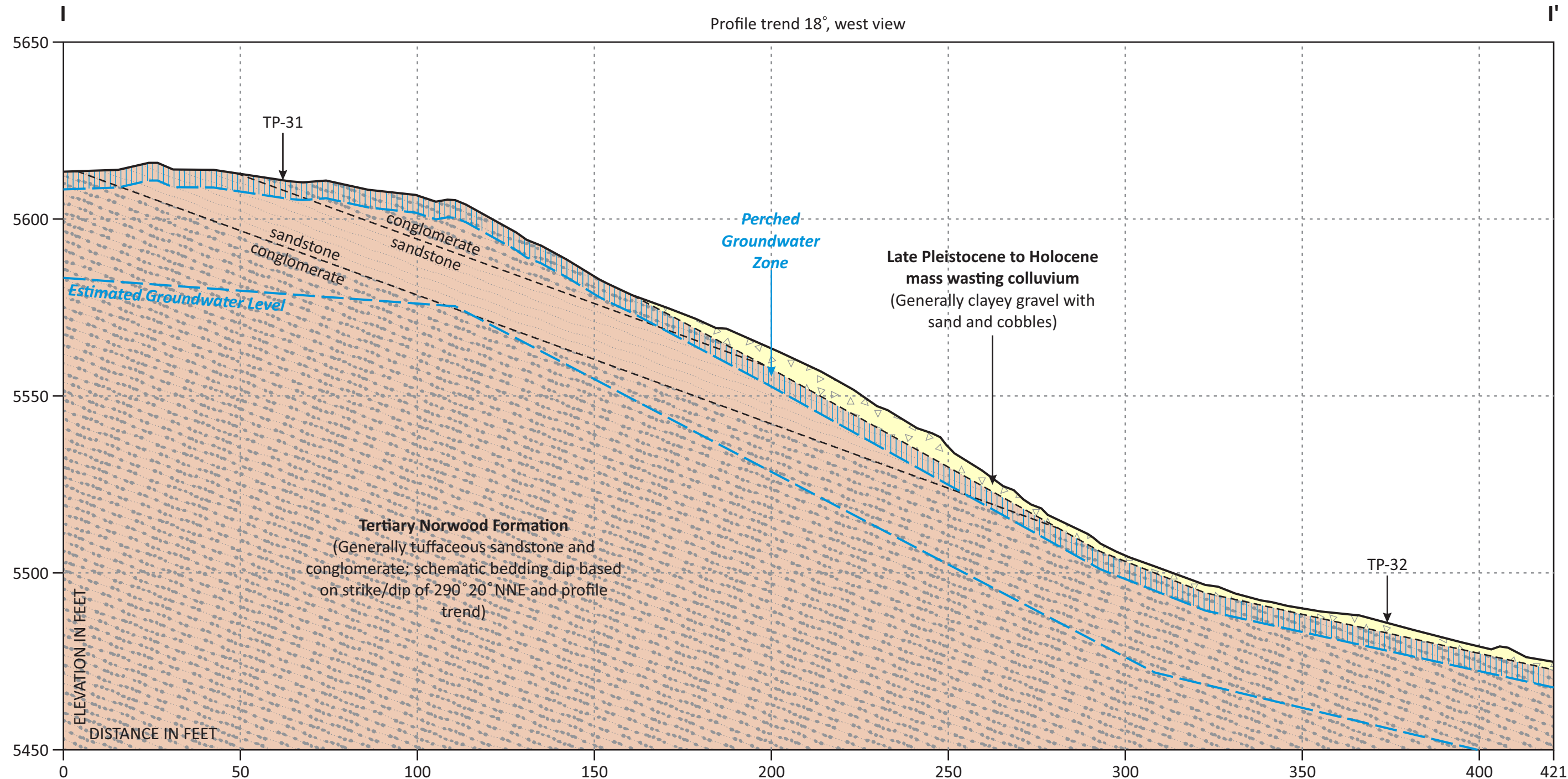
FIGURE 5H



Scale 1 inch equals 40 feet (1:480) with no vertical exaggeration.

All units and contacts are approximate and inferred based on available subsurface data; variations may occur laterally, at depth and within units.

Topographic profile based on geoprocessed 2016 LIDAR data.

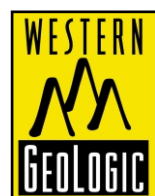


GEOLOGIC CROSS SECTION I-I'

GEOLOGIC HAZARDS EVALUATION

Proposed Osprey Ranch Development
2050 Highway 150
Eden, Weber County, Utah

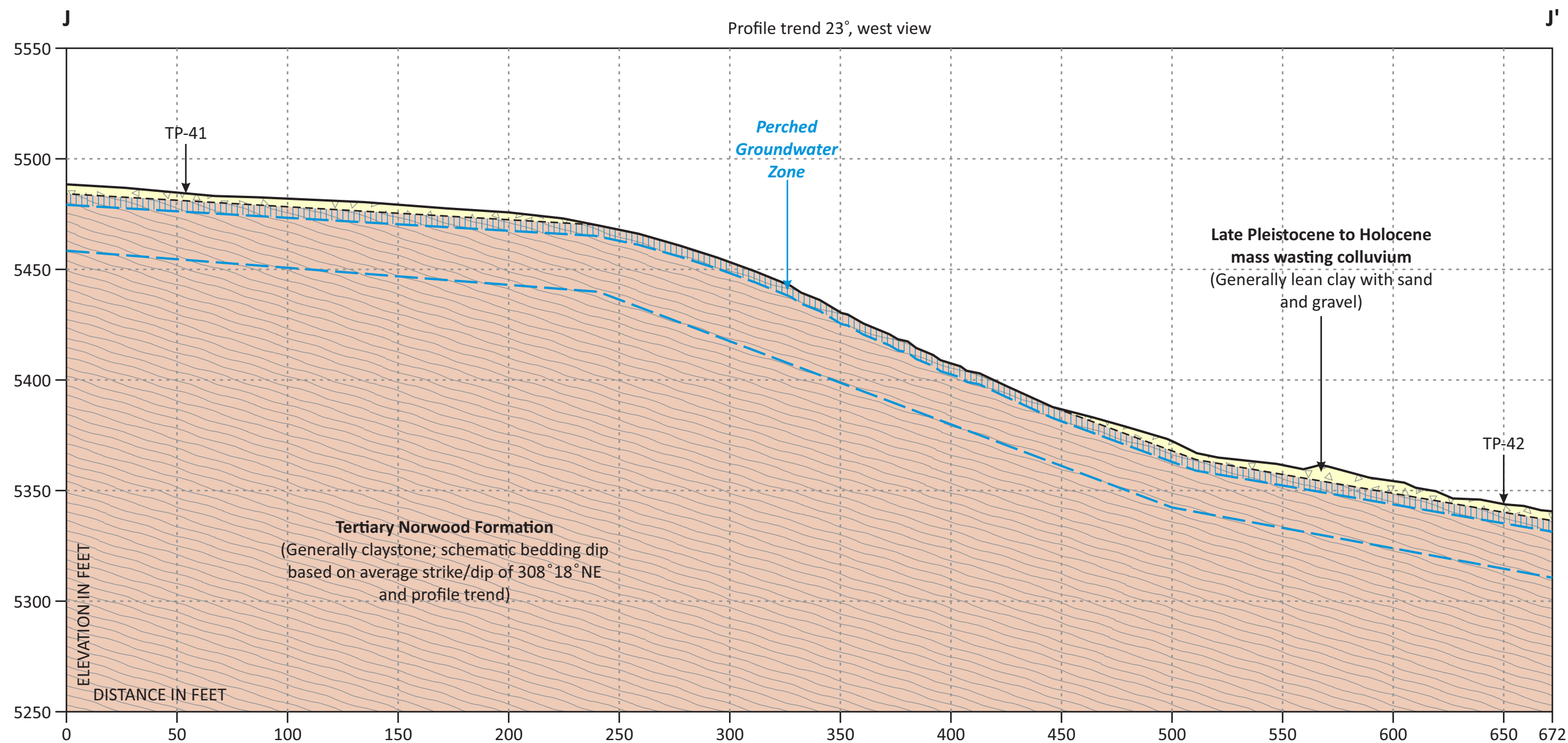
FIGURE 5I



Scale 1 inch equals 30 feet (1:360) with no vertical exaggeration.

All units and contacts are approximate and inferred based on available subsurface data; variations may occur laterally, at depth and within units.

Topographic profile based on geoprocessed 2016 LIDAR data.



GEOLOGIC CROSS SECTION J-J'

GEOLOGIC HAZARDS EVALUATION

Proposed Osprey Ranch Development
2050 Highway 150
Eden, Weber County, Utah

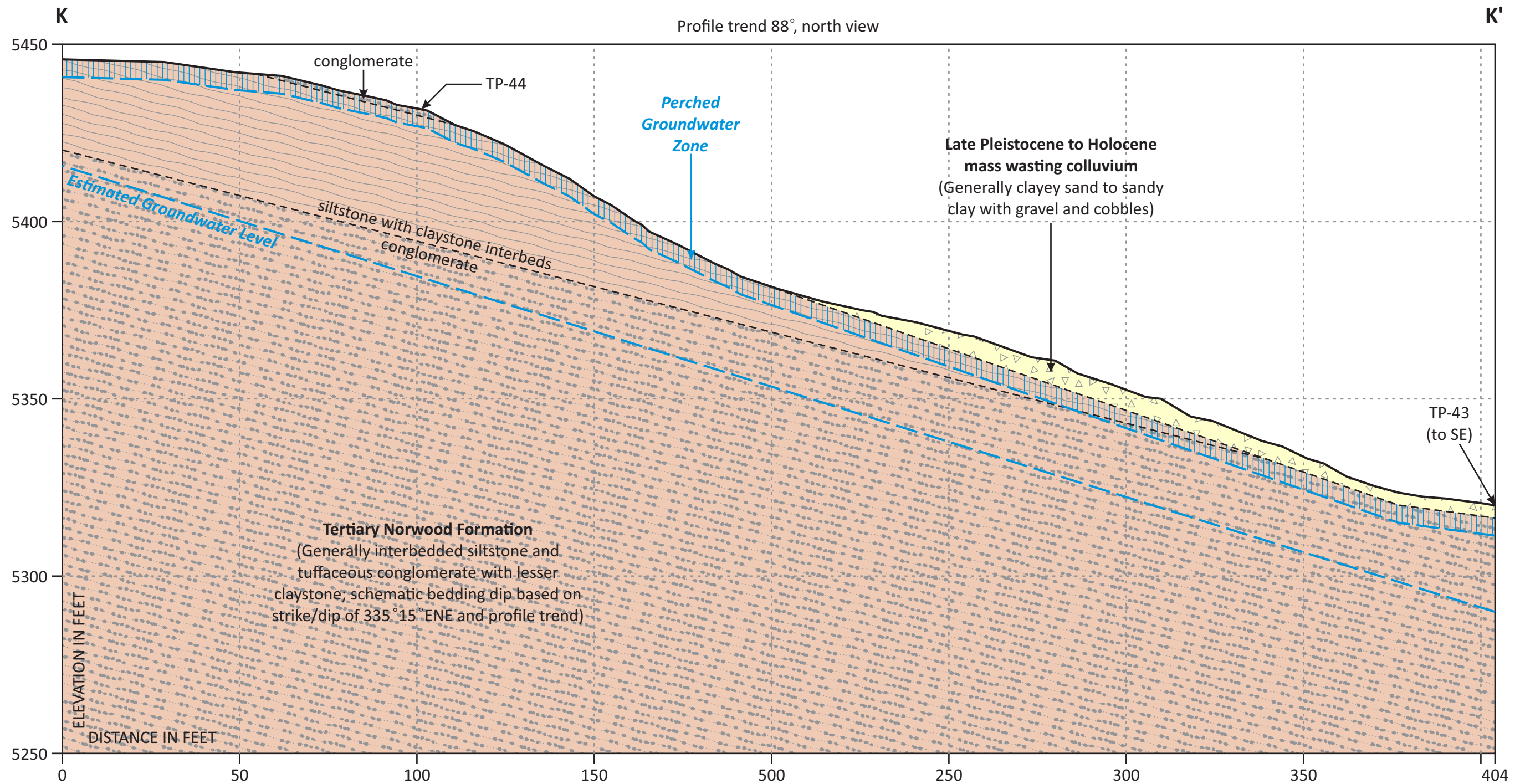
FIGURE 5J



Scale 1 inch equals 50 feet (1:600) with no vertical exaggeration.

All units and contacts are approximate and inferred based on available subsurface data; variations may occur laterally, at depth and within units.

Topographic profile based on geoprocessed 2016 LIDAR data.



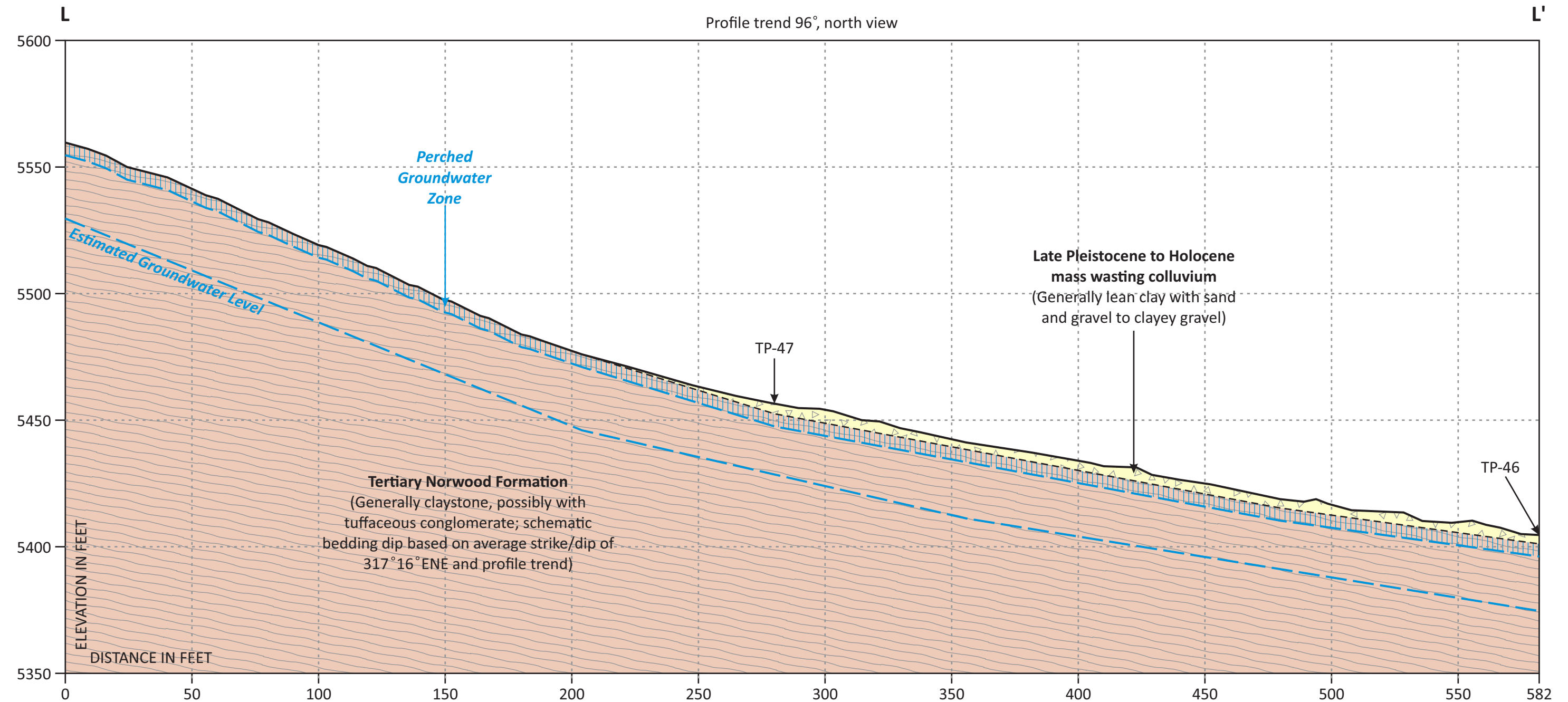
GEOLOGIC CROSS SECTION K-K'

GEOLOGIC HAZARDS EVALUATION
 Proposed Osprey Ranch Development
 2050 Highway 150
 Eden, Weber County, Utah

FIGURE 5K

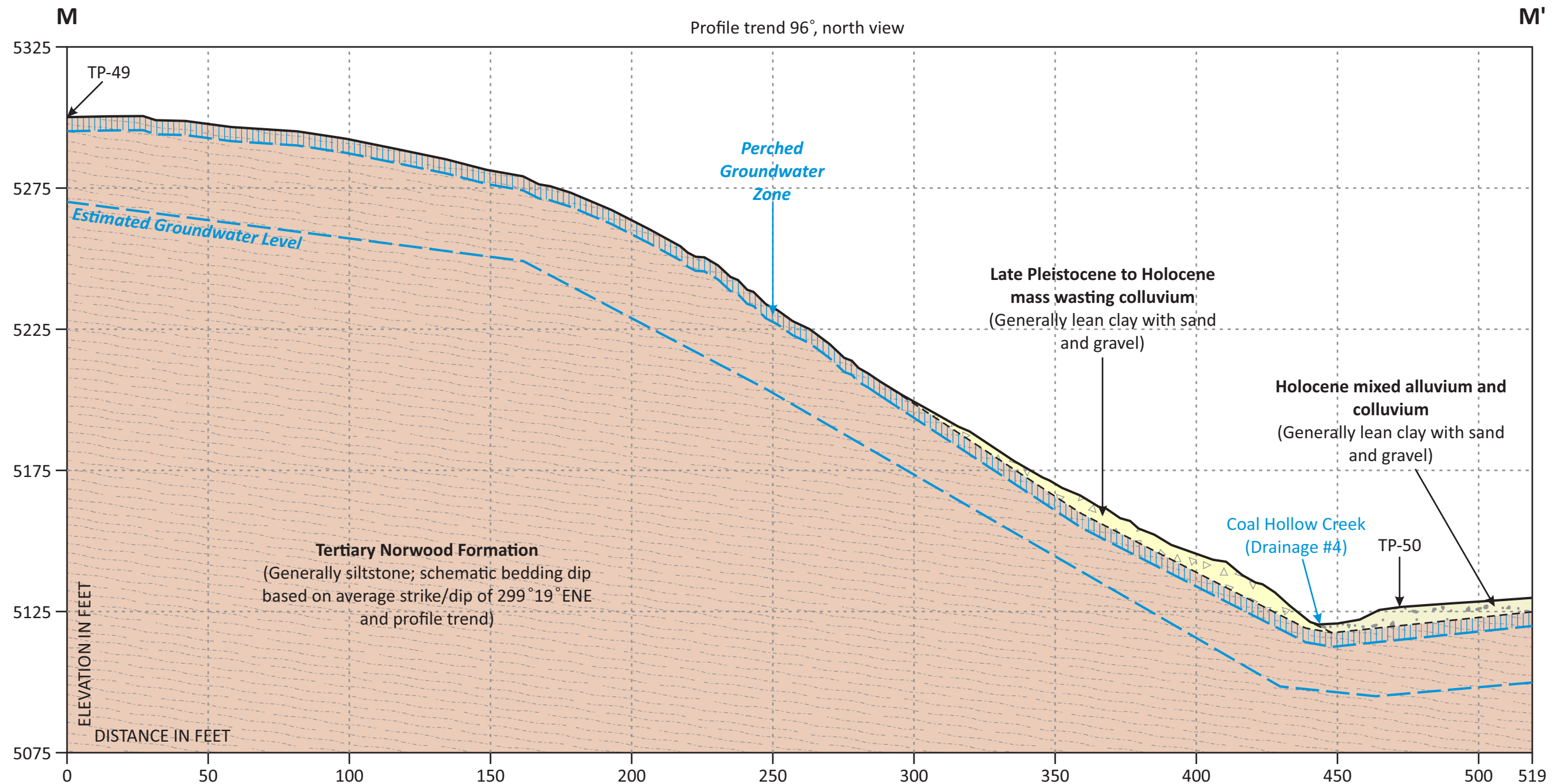


Scale 1 inch equals 30 feet (1:360) with no vertical exaggeration.
 All units and contacts are approximate and inferred based on available subsurface data; variations may occur laterally, at depth and within units.
 Topographic profile based on geoprocessed 2016 LIDAR data.



Scale 1 inch equals 40 feet (1:480) with no vertical exaggeration.
All units and contacts are approximate and inferred based on available subsurface data; variations may occur laterally, at depth and within units.
Topographic profile based on geoprocessed 2016 LIDAR data.

GEOLOGIC CROSS SECTION L-L'
GEOLOGIC HAZARDS EVALUATION Proposed Osprey Ranch Development 2050 Highway 150 Eden, Weber County, Utah
FIGURE 5L

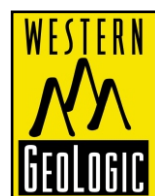


GEOLOGIC CROSS SECTION M-M'

GEOLOGIC HAZARDS EVALUATION

Proposed Osprey Ranch Development
2050 Highway 150
Eden, Weber County, Utah

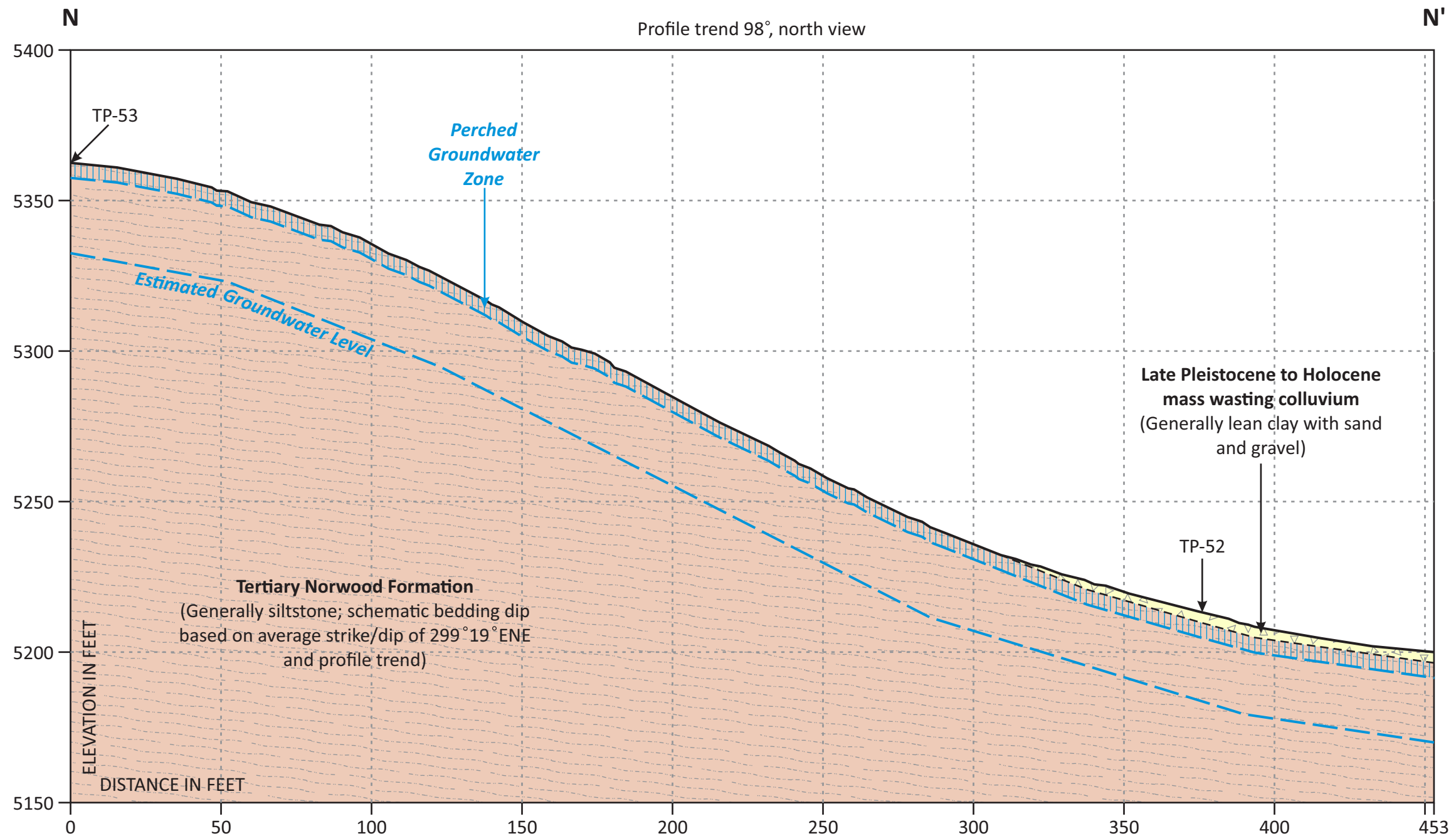
FIGURE 5M



Scale 1 inch equals 40 feet (1:480) with no vertical exaggeration.

All units and contacts are approximate and inferred based on available subsurface data; variations may occur laterally, at depth and within units.

Topographic profile based on geoprocessed 2016 LIDAR data.

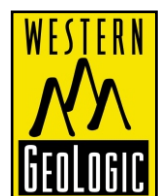


GEOLOGIC CROSS SECTION N-N'

GEOLOGIC HAZARDS EVALUATION

Proposed Osprey Ranch Development
2050 Highway 150
Eden, Weber County, Utah

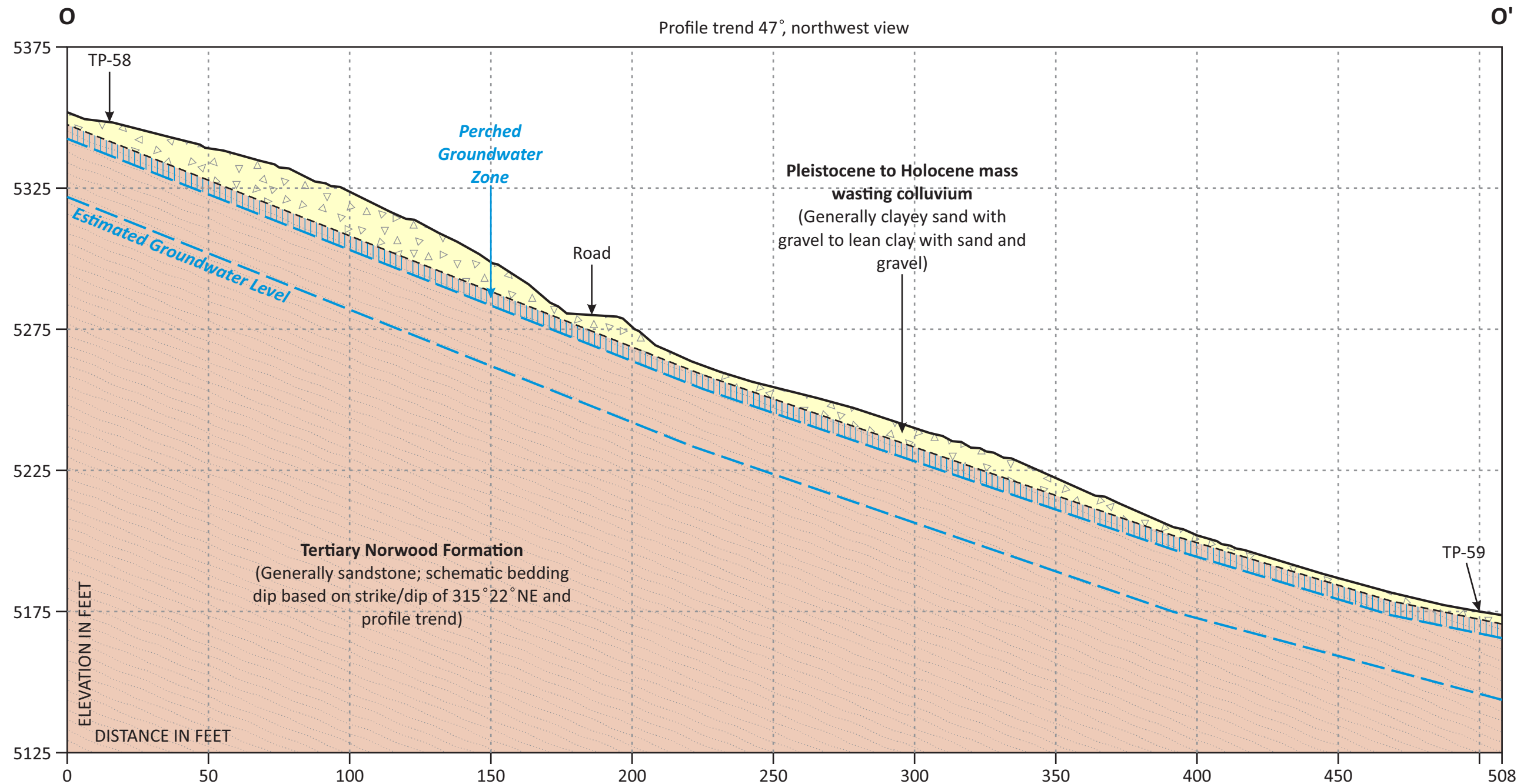
FIGURE 5N



Scale 1 inch equals 40 feet (1:480) with no vertical exaggeration.

All units and contacts are approximate and inferred based on available subsurface data; variations may occur laterally, at depth and within units.

Topographic profile based on geoprocessed 2016 LIDAR data.

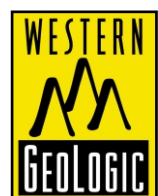


GEOLOGIC CROSS SECTION O-O'

GEOLOGIC HAZARDS EVALUATION

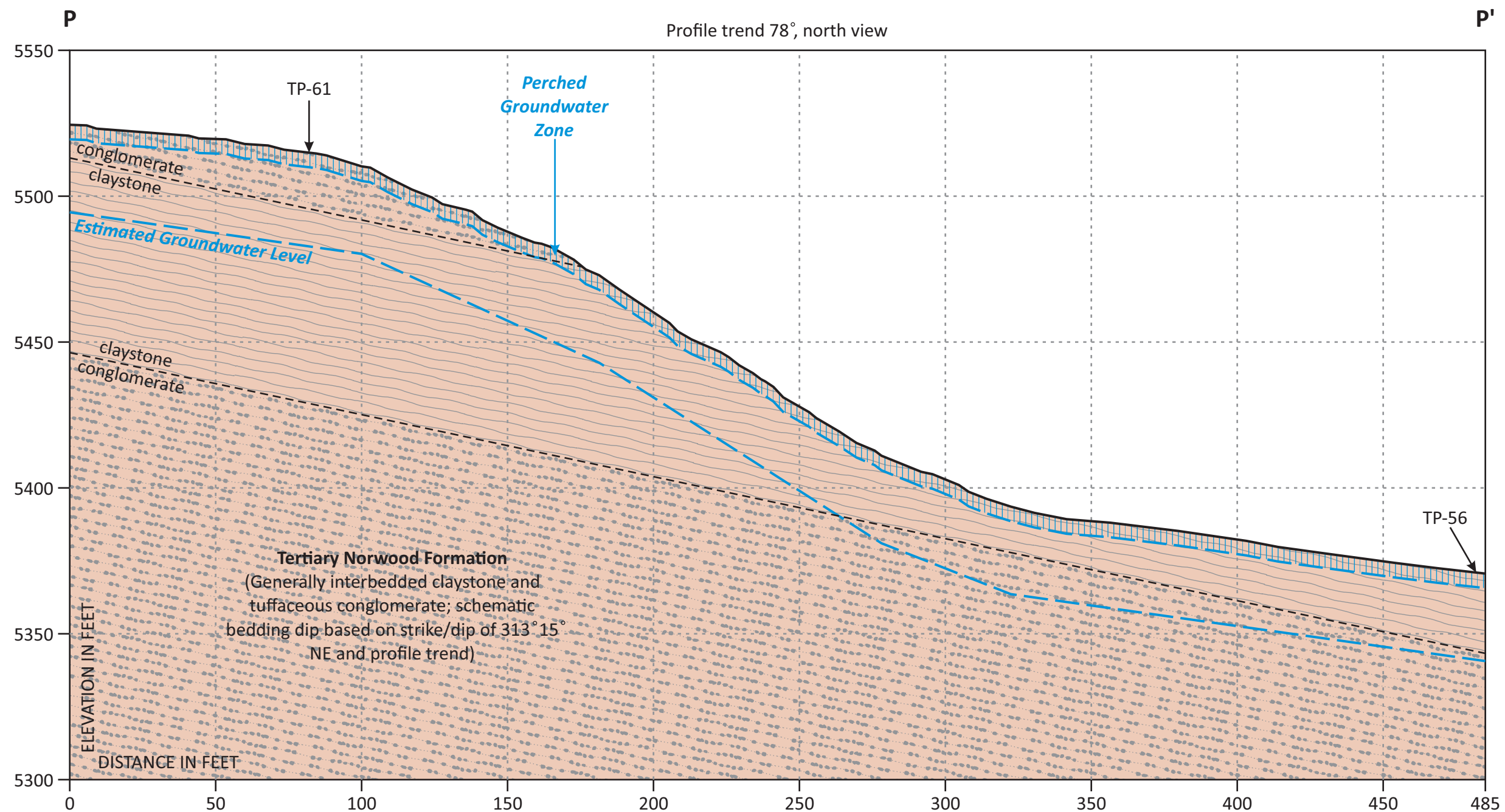
Proposed Osprey Ranch Development
2050 Highway 150
Eden, Weber County, Utah

FIGURE 50



Scale 1 inch equals 40 feet (1:480) with no vertical exaggeration.

All units and contacts are approximate and inferred based on available subsurface data; variations may occur laterally, at depth and within units.
Topographic profile based on geoprocessed 2016 LIDAR data.



GEOLOGIC CROSS SECTION P-P'

GEOLOGIC HAZARDS EVALUATION

Proposed Osprey Ranch Development
2050 Highway 150
Eden, Weber County, Utah

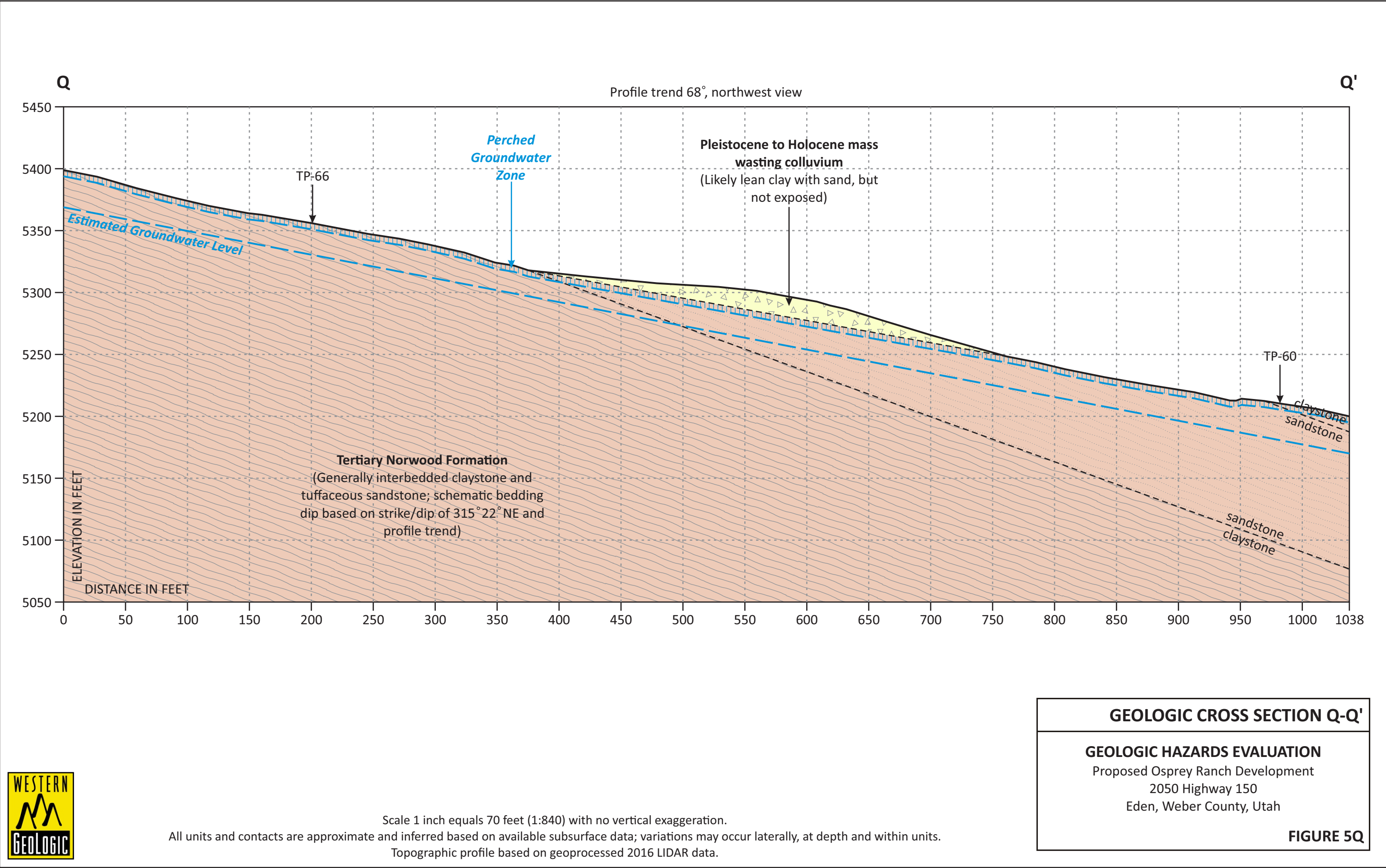
FIGURE 5P

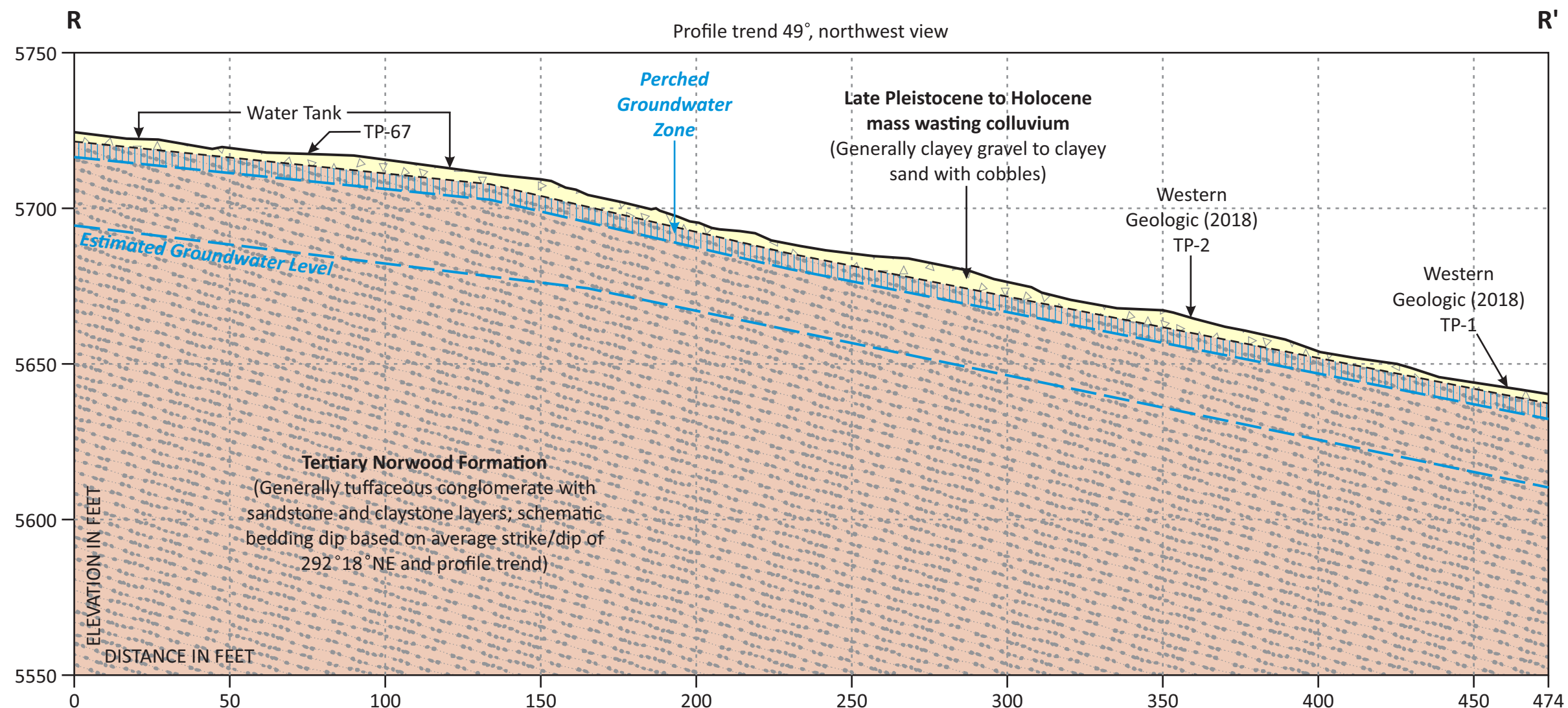


Scale 1 inch equals 40 feet (1:480) with no vertical exaggeration.

All units and contacts are approximate and inferred based on available subsurface data; variations may occur laterally, at depth and within units.

Topographic profile based on geoprocessed 2016 LIDAR data.





GEOLOGIC CROSS SECTION R-R'

GEOLOGIC HAZARDS EVALUATION

Proposed Osprey Ranch Development
2050 Highway 150
Eden, Weber County, Utah

FIGURE 5R



Scale 1 inch equals 40 feet (1:480) with no vertical exaggeration.

All units and contacts are approximate and inferred based on available subsurface data; variations may occur laterally, at depth and within units.

Topographic profile based on geoprocessed 2016 LIDAR data.

