GeoStrata Engineering & Geosciences
14425 S. Center Point Way, Bluffdale, Utah 84065 ~ T: (801) 501-0583 ~ F: (801) 501-0584

MEMORANDUM

PROFESSIONAL GEOLOGIST
4/24/15
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TIMOTHY J.
THOMPSON
LICENSED
STATE OF UTAH

To: **Matt Rasmussen**

From: **J. Scott Seal, P.E.**
Mark I. Christensen, P.E.
Timothy J. Thompson, P.G.

Date: **April 24, 2015**

Subject: **Review Response for Geological Review – 6472 and 6498 South Bybee Drive, Weber County Parcel Numbers: 07-753-0001 and 07-753-0002 Uintah, Utah, SBI Project Number 2-14-522**

GeoStrata has received review questions of our report titled **Geologic Hazards Assessment, Dauphine-Savory Piedmont Subdivision Lots 1R and 2R and adjacent 2-acre property, Weber County, Utah**, GeoStrata Job Number 910-001 and dated December 10, 2013. This report was prepared for Mr. Matt Rasmussen and submitted to Weber County for review. Mr. David B. Simon, P.G. of Simon Bymaster Inc. (SBI) prepared a review of our report. This memorandum was prepared in response to a series of review questions presented in a letter prepared by Mr. Simon and dated November 29, 2014.

<u>Review Questions – S.B.I.</u>

1. "The Table of contents indicate the report contains the following plates:

   Plate A-1, Site Vicinity Map
   Plate A-2, Site Exploration Map
   Plate A-3, Surficial Geology Map
   Plate A-4, Trench 1 Log
   Plate A-5, Trench 2 Log
   Plates B-3 and B-4, Test Pit Logs

   The title on Plates A-1 and A-2 is "Exploration Location Map." The title on Plates B-1 and B-2 is Lab Summary Report. SBI suggests Weber County request GeoStrata submit all plates with correct titles."

GeoStrata Response: GeoStrata has reviewed the referenced plates and has updated the incorrect title blocks. Updated versions of the plates have been produced and attached to the end of this letter. As part of this review, additional plates have been completed. The plates attached to the end of this letter are as follows;

Plate A-1, Site Vicinity Map
Plate A-2, Exploration Location Map
Plate A-3, Site Vicinity Geologic Map
Plate A-4, Site Vicinity Geologic Map Key (Key for Plate A-3)
Plate A-5, Site Specific Geologic Map
Plate A-6, Site Geologic Setback Map
Plate A-7, Hillshade 180° Sun-angle Map, with site boundaries and exploration locations.
Plate A-8, Hillshade 180° Sun-angle Map, without site boundaries and exploration locations.
Plate A-9, Hillshade 90° Sun-angle Map, with site boundaries and exploration locations.
Plate A-10, Hillshade 90° Sun-angle Map, without site boundaries and exploration locations.

Plate B-1 and B-2, Trench 1 Hand Log
Plate B-3 and B-4, Trench 3 Hand Log

2. "Plates B-1 and B-2, "Lab Summary Report," are presumably the logs of the trenches excavated at the site. It is standard of practice for trench logs to: a) contain both a vertical and horizontal scale, b) indicate the trench corresponding to the log, c) indicate the trench wall documented and, c) [sic] indicate the orientation of the trench (Salt Lake County, 20021, 2002b; Christenson and others, 2003; Draper City, 2007; McCalpin, 2009; Morgan County, 2010).

   Christenson and others (2003), state (page 8), "Some form of vertical and horizontal logging control must be used and shown on the log. The log should document all pertinent information from the trench, including geologic-unit contacts and descriptions, faults and other deformation features, and sample locations."

   SBI suggests Weber County request GeoStrata submit properly annotated trench logs.

GeoStrata Response: GeoStrata has reviewed the referenced trench logs and have added the requested information. Updated versions of the trench logs have been attached to the end of this letter as Plates B-1 to B-4. It should be noted that, at the request of the Client, the study area has been altered, and it is now requested that this report be prepared in order to assess residential building lots 1R and 2R only. As a result, Trench 2 as discussed in our 2013 report will not be included as it was excavated as part of an on-going study for the 2-acre portion of the property outside of residential building lots 1R and 2R. In addition, it should be noted that in order to assess the surficial fault rupture hazard on lot 2R, an additional trench (Trench 3) was completed. This trench has been included as Trench 3.

3. "Section 2.2, Project Description (p.2), states "…Proposed development, as currently planned, will consist of two to three residential building lots as well as associated roadways and landscaped areas. The subject property also includes a 2-acre portion that adjoins the two to three lots to the south… The project site is shown on the Site Vicinity Map included in the Appendix of this report (Plate 1). The Appendix also includes a Surficial Geology Map (Plate 2 and a Site Exploration Location Map (Plate 3)."

Building envelopes 1R and 2R are not delineated on any of the figures in the report. Also, the report did not contain Plates 1, 2, and 3.

SBI recommends Weber County request GeoStrata:

a. Submit a site plan, clearly delineating proposed building envelopes, particularly 1R and 2R.
b. Confirm that Plates 1, 2, and 3 are Plates A-1, A-2, and A-3.

GeoStrata Response: GeoStrata has reviewed the referenced plates and has added the requested data onto Plate A-2, Exploration Location Map. Plates 1, 2, and 3 were indeed intended to be Plates A-1, A-2, and A-3. This error has been corrected, and updated Appendix A Plates have been attached to the end of this letter.

4. "Section 2.1, Purpose and Scope of Work (p. 2), indicates GeoStrata reviewed and evaluated aerial photographs covering the site area. SBI suggests Weber County request GeoStrata provide the source, date, flight-line numbers, and scale of aerial photos used (Christenson, 2003).

GeoStrata Response: The following aerial photographs were reviewed as part of this investigation;

Source	Date	Flight-line Number	Scale
UGS	9/26/1937	10-AAJ3-49	Unknown
UGS	9/26/1937	10-AAJ3-50	Unknown
UGS	1970	WF2-5 141	1:12,000
UGS	1970	WF2-5 142	1:12,000
UGS	1970	WF2-15 210	1:6,000
UGS	1970	WF2-15 211	1:6,000
UGS	1970	WF2-15 212	1:6,000
UGS	1970	WF2-15 213	1:6,000
UGS	1970	WF2-15 214	1:6,000

In addition to the aerial photographs listed above, GeoStrata has also investigated hillshade maps produced using <1m Lidar data obtained from the AGRC. The UGS informed GeoStrata that reassessment of fault scarp location is underway using this data along the Wasatch Front. Based on our review of this Lidar data and our stereo aerial photography review, no visible lineations or other surface fault rupture related geomorphology was observed that would indicate the presence of surface fault ruptures on or adjacent to the subject site. As part of our review of the Lidar data , the following plates were produced and attached to the end of this report;

Plate A-7, Hillshade 180° Sun-angle Map, with site boundaries and exploration locations.
Plate A-8, Hillshade 180° Sun-angle Map, without site boundaries and exploration locations.

Plate A-9, Hillshade 90° Sun-angle Map, with site boundaries and exploration locations.
Plate A-10, Hillshade 90° Sun-angle Map, without site boundaries and exploration locations.

5. "Plate A-3, Geologic Map, is improperly referenced. For clarity, the correct reference is Yonkee, W.A. and Lowe, M., 2004, Geologic map of the Ogden 7.5 minute quadrangle, Utah Geological Survey Open-File Report M-200, 42 p., 2 pl., scale 1:24,000, which is in the consultant's references.

   The referenced geologic map in the south part of the property has two errors, regarding either the color and/or geologic unit designations. SBI contacted the Utah Geological Survey (UGS) about the apparent errors, which they confirmed are present on the map. The correct map, provided by the UGS, is attached.

GeoStrata Response: No map could be found as an attachment to the review document. As such, GeoStrata also contacted the UGS for a copy of the corrected version of the referenced map. The map provided to GeoStrata was identical to the map obtained from the UGS website, which was utilized in our 2013 investigation.

6. "Apparently Plate A-3, in the referenced report, was enlarged from Yonkee and Lowe (2004), which can be problematic, particularly when the limitations of enlarging a geologic map are not indicated. Yonkee and Lowe (2004) performed the mapping at a scale of 1:24,000 and the map is intended to be used at the scale of the publication. Plate A-3 is presented in the GeoStrata report at 1:6,000.

   Once enlarged, without reference, a level of detail is inherently implied, which is not factual. At the enlarged scale, significantly greater detail would be inherently expected, especially in regard to delineation of surficial deposits. Enlarging geologic maps in such a manner is fundamentally not sound geologic practice. Also, GeoStrata notes in the report areas where GeoStrata disagree with the geology shown on Plate A-3. It is standard of practice to include a site-specific geologic map (particularly for a site of several acres in size) (Salt Lake County, 2002a, 2002b; Christenson and others, 2003; Draper City, 2007; Morgan County, 2010). SBI recommends Weber County request the consultant submit a site-specific geologic map.

GeoStrata Response: The correct reference for Plate A-3 has been provided on the updated plate attached to this letter. Plate A-3 is also presented at the appropriate scale. GeoStrata has completed a site-specific geologic map based on our field observations and aerial photography review. The map has been attached to the end of this letter as Plate A-5.

7. "According to the geology depicted on Plate A-3, there is a landslide deposit at the south-center part of the south property boundary (unit Qms_1 on Plate A-3). SBI suggests Weber County request GeoStrata discuss the impacts of the landslide deposit on proposed development.

GeoStrata Response: The referenced landslide deposits (unit Qms_1) is located on the southern-most portion of the property, approximately 135 feet south of the buildable pad on lot 1R, and approximately 195 feet south of the buildable pad on lot 2R. The landslide deposit is mapped with an axis of movement oriented to the south, and is additionally separated from the proposed building pads by a small drainage. As such, it is it is our opinion that the mapped landslide will have no impact on the areas of proposed development on Lots R1 and R2.

8. "Throughout the report GeoStrata references alluvial fan deposits and debris flow deposits. SBI recommends Weber County request GeoStrata describe the general characteristics of the two deposits.

GeoStrata Response: GeoStrata has revisited the site since our original 2013 report was prepared, and determined that additional trenching and closer examination of the existing trenches was required. An additional trench (Trench 3) was excavated across the proposed building area of lot 2R and Trenches 1 and 2 were deepened, re-cleaned, and re-investigated. As a result of these additional investigations, we have updated our geologic interpretations of the sediment observed within the exploratory trenches. The updated interpretations are as follows;

Trench 1 Description:
Trench 1 was approximately 90 feet long, oriented approximately S80°W, and was excavated in order to assess the proposed building area of lot 1R for the presence of surface fault rupture hazards and debris flow potential within the buildable portion of the lot. The trench was excavated with a trackhoe to depths ranging from 8½ to 12 feet below the existing site grade. A hand log of the trench can be found on Plates B-1 and B-2. It should be noted that based on conversations with the Client, the area near the eastern portion of the trench contains a cut section completed several years prior to this investigation to aid in the construction of the roadway to the east. This cut is reflected in the eastern portion of our logs as the disappearance of Units 3 and 4 (see below for unit descriptions).

Sediments exposed in Trench 1 have been separated into four stratigraphic units and labeled Unit 1 through Unit 4. The oldest sediment observed at the bottom of the trench was designated as Unit 1, and was observed to persist for the full length of the trench. Unit 1 was observed to consist of silt and sand, and contained crude laminations 3 to 4 inches apart. The unit was weakly bedded, and contained significant iron staining. Unit 1 was interpreted as representing a lacustrine silt and sand deposit of Pleistocene-age. When referring to the geologic mapping completed by Yonkee and Lowe (2004), this deposit most closely matches the description given for Bonneville transgressive fine-grained deposits (Qlf_4), which are described as "Intervals of calcareous clay to silt, and intervals of rhythmically interbedded fine- to medium-sand and silt near mouth of Weber Canyon; deposited in deeper water environments, and as delta bottom set beds during transgression of Lake Bonneville".

Unit 2 was observed to span a length of approximately 57 feet, being first observed at approximately 33 feet from the eastern end of the trench and persisting to the western end of the trench. Unit 2 was observed to consist of massively bedded silt and sand with minor gravel and infrequent cobble. The gravel and cobbles were observed to be largely rounded to subrounded, were generally up to 3 inches in diameter with a maximum observed diameter of approximately 12-inches, and were contained within a matrix of silt and sand, although in several places the deposit was clast supported. The cobbles were weakly imbricated and indicated a flow to the west. Unit 2 was interpreted as representing Pleistocene-Holocene stream alluvium sourced by intermittent streams from the foothills of the Wasatch Mountains to the east. When referring to the geologic mapping completed by Yonkee and Lowe (2004), this deposit most closely matches the description given for stream alluvium (Qal), which are described as "mostly clast-supported, moderate- to well-sorted, pebble and cobble gravel, gravelly sand, and silty sand; deposited along modern channels and inactive beaches".

Unit 3 was observed to span the entire length of Trench 1 with the exception of an approximate 5 foot long segment where the sediment had been removed by human activities. Unit 3 was observed to consist of massively bedded sand and silt. This unit contained significant organics, and several areas contained relatively large root-balls which appeared to have destroyed the original depositional characteristics of the soil. Based on the silt/sand nature of the sediment, Unit 3 is interpreted as being Holocene-aged colluvium and alluvium deposits composed of re-worked Bonneville fine-grained deposits sourced from upslope of the site. When referring to the geologic mapping completed by Yonkee and Lowe (2004), this deposit most closely matches the description given for colluvium and alluvium, undivided (Qac), which is described as "Pebble to boulder gravel and clay – to boulder-rich diamiction; includes hillslope colluvium, small fans, stream alluvium, and small landslide deposits; mapped along some vegetated canyon areas in Wasatch Range".

Unit 4 was observed to span the entire length of Trench 1 with the exception of an approximate 20 foot long segment where the sediment had been removed by human activities. Unit 4 was observed to consist of massively bedded silt, sand, gravel, and trace cobble. This unit was dark brown to black in color, contained significant organics, and contained numerous relatively large root-balls. Based on our observations, Unit 4 is interpreted as being a Holocene-aged active soil profile with well-developed O, B, and C soil horizons.

Based on our observations, the oldest continuous material, Unit 1, was deposited by Bonneville Lake processes during the Pleistocene. As such, it is of proper age to preserve evidence of Holocene-aged movement along the Weber segment of the Wasatch Fault. No fault-related deformation was observed within any of the deposits observed in Trench 1. As such, it is our opinion that no active surface rupture faults are located underlying the proposed buildable area of Lot 1R

<u>Trench 2 Description:</u>
The trench was approximately 95 feet long, oriented approximately N80°W, and extended through the 2-acre property located adjacent to building lots 1R and 2R. The trench was excavated with a trackhoe to a depth of approximately 7½ to 12½ feet. Trench 2 was located to intersect any faults that trend through the proposed buildable portion of this area of investigation.

As per the Client's request, this report will focus only on the buildable portions of Lots 1R and 2R. The additional 2-acre portion investigated through the excavation of Trench 2 will be discussed in a future report.

Trench 3 Description:

The additional trench excavated as part of our updated 2014 investigation has been designated as Trench 3, and was located to assess the proposed buildable portion of residential building lot 2R. The mapped portion of Trench 3 was approximately 110 feet long, and was excavated to a depth of 5½ to 17½ feet. A hand log of the trench may be found attached to the end of this letter as Plates B-3 and B-4. The location of Trench 3 may be found on Plate A-2, Exploration Location Map. It should be noted that a relatively small area of human disturbance was encountered within the pathway of Trench 3.

Sediments exposed in Trench 3 have been separated into six stratigraphic units and labeled Unit 1 through Unit 5. The oldest sediment observed at the bottom of the trench was designated as Unit 1, and was observed in relatively limited portions near the eastern end of the trench. Unit 1 was observed to consist of moderately weathered, strong, closely fractured schist bedrock. When referring to the geologic mapping completed by Yonkee and Lowe (2004), this deposit most closely matches the description given for Early Proterozoic Metamorphic and Igneous Rocks, Muscovite-bearing schist (Xfs), which is described as "grey-brown, strongly foliated, schist to gneiss containing variable amounts of muscovite, biotite, quartz, and feldspar".

Unit 2 was observed to span an approximate 50 foot long section of the eastern portion of the trench. Unit 2 was observed to consist of thinly bedded course-grained sand and gravel. Occasional seams of this unit were moderately cemented. The gravels were subrounded to round, and largely clast supported. Measurements of the strike and dip of this unit ranged from S25°W to S51°E with Dips of 43° to 51°, respectively. Unit 3 was interpreted as representing Pleistocene-aged lacustrine gravel deposits. When referring to the geologic mapping completed by Yonkee and Lowe (2004), this deposit most closely matches the description given for Lacustrine gravel-bearing deposits associated with the transgressive phase of the Bonneville lake cycle (Qlg_4), which are described as "clast-supported, moderately to well-sorted, pebble to cobble gravel with some silt to sand in interfluve areas and away from mountain front; gravels contain rounded to subrounded clasts, and some subangular clasts derived from reworking of mass-wasting and alluvial fan deposits; Deposited in higher energy environments along shorelines and small fan deltas as Lake Bonneville was transgressing; grades westward away from shorelines into fine-grained lacustrine deposits (Qlf_4)".

Unit 3 was observed to persist for nearly the full length of the trench, with the exception of the western-most 20 feet. Unit 3 was observed to consist of silt and sand, and contained crude laminations 3 to 4 inches apart. The unit was weakly bedded, and contained significant iron staining. Unit 3 was interpreted as representing a lacustrine silt and sand deposit of Pleistocene-age, and correlates to Unit 1 observed in Trench 1. When referring to the geologic mapping completed by Yonkee and Lowe (2004), this deposit most closely matches the description given for Bonneville transgressive fine-grained deposits (Qlf_4), which are described as "Intervals of calcareous clay to silt, and intervals of rhythmically interbedded fine- to medium-sand and silt near mouth of Weber Canyon; deposited in deeper water environments, and as delta bottom set beds during transgression of Lake Bonneville".

Unit 4 was observed to persist for the full length of the trench, and was observed to consist of massively bedded sand and silt. This unit contained significant organics, and several areas contained relatively large root-balls which appeared to have destroyed the original depositional characteristics of the soil. Based on the silt/sand nature of the sediment, Unit 3 is interpreted as being Holocene-aged colluvium and alluvium deposits composed of re-worked Bonneville fine-grained deposits sourced from upslope of the site. When referring to the geologic mapping completed by Yonkee and Lowe (2004), this deposit most closely matches the description given for colluvium and alluvium, undivided (Qac), which is described as "Pebble to boulder gravel and clay – to boulder-rich diamiction; includes hillslope colluvium, small fans, stream alluvium, and small landslide deposits; mapped along some vegetated canyon areas in Wasatch Range".

Unit 5 was observed to persist for the full length of the trench, with the exception of an approximate 5-foot wide section where it had been removed by human activities. Unit 5 was observed to consist of massively bedded silt, sand, gravel, and trace cobble. This unit was dark brown to black in color, contained significant organics, and contained numerous relatively large root-balls. Based on our observations, Unit 4 is interpreted as being a Holocene-aged active soil profile with well-developed O, B, and C soil horizons.

Unit 6 was observed to persist for approximately 5 feet approximately 70 to 75 feet from the western end of the trench. Unit 6 was observed to consist of massively bedded silt, sand, gravel, and cobble. Based on conversations with the Client as well as on our field observations, Unit 6 is being interpreted as being historical fill soils associated with the construction of the unpaved roadway leading to the central portions of residential building lot 2R. This unit had a maximum thickness of approximately 18-inches.

Based on our observations, Units 1, 2 and 3 are of proper age to preserve evidence of Holocene-aged movement along the Weber segment of the Wasatch Fault. No fault-related deformation was observed within any of the deposits observed in Trench 3. As such, it is our opinion that no active surface rupture faults are located underlying the proposed buildable area of Lot 2R. Hand logs of the trenches showing our updated interpretations and additional explorations have been attached to the end of this letter as Plates B-1 to B-4.

9. "GeoStrata concluded "...Based on our field observations, residential building lot 1R is underlain by Holocene-aged alluvial fan deposits and is likely located near the distal or lateral portions of the fan….It is likely that Trench 2 is located in a more active channel, whereas Trench 1 is located in a distal edge of the fan, and experiences fewer debris flow events…Both of the test pits located on building lot 2R contained 5 stacked debris flow/fluvial flooding events, indicating that they are located in a relatively high energy portion of the channel…Based on the presence of mapped and observed past alluvial fan

deposits on the subject site, the site does have the potential to be impacted by future alluvial fan flooding and debris flows."

Alluvial fans are the primary sites of debris-flow deposition. The debris-flow hazard depends on the site location on an alluvial fan (Giraud, 2005). SBI suggests Weber County request GeoStrata delineate the alluvial fan and active channel(s) on the site-specific geologic map.

GeoStrata Response: GeoStrata has completed the requested map and has attached it to the end of this letter as Plate A-5. It should be noted that after additional observations of the pre-existing and new exploratory trenches, it is interpreted that the alluvial fan sediment is largely confined to the channel located to the south of Trenches 1 and 3. The test pits completed previously by GeoStrata as part of our 2013 investigation were excavated within the channel and encountered stacked debris and hyper-concentrated flows. These deposits were not observed in trenches 1 or 3. Mapping completed by Yonkee and Lowe (2004) suggests that the active alluvial fan associated with the observed channel is located down-slope from the subject site. GeoStrata understand that a separate hydrological study has been completed by another firm for the subject site. As part of that study, we understand that a setback has been delineated from either side of the channel. GeoStrata has included this setback on our site-specific geologic map (Plate A-5) and on our Site Geologic Setback Map (Plate A-6).

10. "In Section 5.2.1, Trench 1 Description, (p. 7), GeoStrata states: "…A hand log of the trench can be found on Plates 4 through 11."

    SBI recommends Weber County request GeoStrata provide Plates 4 through 11, which were not included in the December 10, 2003 [sic, 2013] GeoStrata report.

GeoStrata Response: GeoStrata has updated the requested plates with the proper plate numbering system. However, based on our updated investigation, our trench logs have been altered from their 2013 form. In addition, the property containing Trench 2 is no longer being considered for development at this time. As a result the logs of Trench 2 will not be necessary for this investigation. A hand log of Trench 1 and Trench 3 may be found attached to this letter as Plates B-1 to B-4.

11. "On page 9, (5.2.1 Trench 1 Description), page 11 (5.2.2 Trench 2 Description), page 13 (5.2.3 Test Pit 1 Description), and page 15 (5.2.4 Test Pit 2 Description), the Consultant states "…The presence of well-developed O, B, and C topsoil horizons suggests that the current site geomorphology has been established for a relatively long time."

    Consistent with long-established, geologic standards-of-practice (Birkeland, 1999), it is appropriate to document soil-stratigraphic development by providing at least one, representative, standard soil-profile measurement and description. It would assist the review process if GeoStrata would provide their soil-profile measurement and description. SBI suggests Weber County request GeoStrata submit their soil-profile measurement, indicate the location of the profile on the site-specific geologic map, and clarify what is meant by "…a relatively long time."

GeoStrata Response: GeoStrata is not using the topsoil profile to indicate the age of the sediment, and has removed any verbiage that may have suggested such. As a result, it is not considered necessary that GeoStrata conduct a soil profile measurement and description. To inquire as the nature of "standard of care" in the region, GeoStrata contacted Mr. Bill Black of Western Geologic, who reported that he does not consider such a requirement to be within the "standard of care". He further stated that a soil specialist should be retained should a soil-profile measurement be necessary. Permission was received by Mr. Black to summarize the conversation.

12. In Section 6.1 Surface Rupture Hazard (P. 16), GeoStrata states: "GeoStrata conducted a surface fault rupture hazard assessment across building lot 1R as well as on adjacent 2-acre parcel to assess these residential lots for surface fault rupture hazards. Trenching was not completed on building lot 2R as it is located outside of the surficial faulting special study zone. …Plate A-2 also shows the surface fault rupture hazard special study area as determined by GeoStrata utilizing a distance of 500 feet from the reported location of the Weber segment. This distance of 250 feet is recommended by Christensen [sic Christenson] and others (2003) for the upthrown side of the fault. Since the location of the fault was reported by Nelson and Personius (1993) on a larger and less accurate scale, GeoStrata used the location as reported by Yonkee and Lowe (2004) to assess the special study area in an attempt to be more conservative."

    In the executive summary and in Section 3.3 (Subsurface Investigation), page 4, GeoStrata states "…two exploratory test pits were excavated on building lot 2R."

    Christenson and others (2003), recommend, for well-defined faults, a special study area 500 feet wide on the downthrown side and 250 feet wide on the upthrown side. The two test pits, as shown on Figure A-2 of the December 10, 2013, GeoStrata report, are located between two north-south trending, normal faults (downthrown to the west). According to Plates A-2 and A-3 of the December 10, 2013, GeoStrata report, the test pits are about 90 feet from the east fault and 125 feet from the west fault, well within this special study area recommended in Christenson and others (2003).

    Also, Plate A-2 in the December 10, 2013 GeoStrata report does not depict the surface-fault-rupture hazard special study area as determined by GeoStrata, utilizing a distance of 500 feet from the reported location of the "Weber segment"

    SBI recommends Weber County request:

a. GeoStrata submit Plate A-2 depicting the surface fault rupture hazard special study area as determined by GeoStrata utilizing a distance of 500 feet from the reported location of the Weber segment.

b. Clarify why building lot 2R was not included in their surface-fault-rupture hazard study.

GeoStrata Response: Upon review, it does indeed appear that residential building lot 2R should be included within the surface-fault-rupture hazard study zone as per Christenson and others (2003). As a result, GeoStrata has excavated an additional trench (Trench 3) in order to assess the proposed building pad of building Lot 2R. Our observations of Trench 3 are discussed as a response to review comment 8. A map showing the areas assessed by our investigatory trenches is included as Plate A-6, Site Geologic Setback Map.

13. On page 9 (Section 5.2.1 Trench 1 Description), GeoStrata states: "It is our opinion that the oldest continuous material, Unit 2 was deposited at some point in the Holocene, and considering the depth of the trench it is believed that the sediments are of an age to preserve evidence of Holocene-aged movement along the Weber segment of the Wasatch Fault. No fault-related deformation was observed within any of the deposits observed in Trench 1. It is our opinion that no active surface rupture faults are located within the limits of the area exposed in Trench 1."

    On page 11 (Section 5.2.2 Trench 2 Description), GeoStrata states: "It is our opinion that the oldest material, Unit 1, was deposited at some point in the Holocene, and considering the depth of the trench it is believed that the sediments are of an age to preserve evidence of Holocene-aged movement along the Weber segment of the Wasatch Fault. No fault related deformation was observed within any of the deposits observed in Trench 2. It is our opinion that no active surface rupture faults are located within the limits of the area exposed in Trench 2."

    On page 16 (6.1 Surface Rupture Hazard), GeoStrata states: "It should be noted that while it is our opinion that the sediments observed within the trenches are of proper age to preserve evidence of recent seismic event, no age testing was completed as part of this investigation. As such, there remains the possibility that the sediments are upper Holocene-aged, and not of proper age to preserve fault movement. The trenches excavated as part of this investigation were advanced to the maximum practical depth," (italics added).

    GeoStrata states that it is their "opinion" that the oldest continuous material in the trenches were deposited at some time in the Holocene, and, considering the depth of the trenches, it is their belief that the age of the sediments is sufficient to preserve evidence of Holocene-aged movement along the Weber segment of the Wasatch Fault.

    GeoStrata subsequently expresses uncertainly in whether or not the trenches were excavated to a sufficient depth to observe Holocene-aged faulting and that the trenches excavated to the maximum practical depth. The two trenches excavated by GeoStrata ranged from 5 to 10 feet in depth and from 6 to 9 feet in depth, respectively; less than the practical depth limit of trenching, generally considered 15 to 20 feet (in most cases). Trenches must extend at least through sediments inferred to be older than several fault recurrence intervals.

    SBI recommends Weber County request GeoStrata provide:

a. The location of the trenches and test pits on a site plan.

b. Data to support their opinion that the oldest continuous sediments in the trenches were deposited at some time in the Holocene and the sediments are of an age to preserve evidence of at least the last two surface fault rupture earthquakes (Nelson and others, 2006).
c. An explanation for their interpretation that the depth of the two trenches was within the practical limit of excavation.
d. Additional quantitative data regarding the age of sediments exposed in the trenches.
e. Recommendations that reflect their inherent uncertainties regarding the age of sediments exposed in the trenches.

Christenson and others (2003), state:

a. Depth of Excavation (page 7): "For suspected Holocene faults, trenches should extend through all unfaulted Holocene deposits and artificial fill to determine whether a fault has been active during Holocene time. However, an early Holocene fault may be concealed by unfaulted younger Holocene deposits and not be encountered within the practical depth limit of trenching, generally 15 to 20 feet (5-6 meters) in most cases. For such trenches exposing unfaulted Holocene deposits where pre-Holocene deposits are below the practical depth of trenching, the practical limitations of the trenching should be acknowledged in the report and uncertainties should be reflected in the conclusions and recommendations. In cases where an otherwise well-defined Holocene fault is buried too deeply at a particular site to be exposed in trenches, the uncertainty in its location can be addressed by increasing setback distances along a project trace. Borehole or geoprobe samples and cone penetrometer soundings with precise vertical control may help extend the depth of investigation.

b. Trench Logging and Interpretation (page 8): "…The engineering geologist interprets the ages of sediments exposed in the trench and, when necessary, obtains samples for radiocarbon or other age determinations to constrain the age of most recent surface fault rupture. In the Lake Bonneville basin of northwestern Utah, the relation of deposits to latest Pleistocene Bonneville lake-cycle sediments is commonly used to infer ages of sediments, and thus estimate ages of surface-faulting events. Unfaulted Bonneville lake cycle sediments in a trench therefore provide evidence that Holocene faulting has not occurred at that site. Outside the Lake Bonneville basin and in the Lake Bonneville basin but above the highest shoreline, determining the age of surficial deposits is generally less straightforward and commonly requires advanced knowledge of location Quaternary stratigraphy and geomorphology, and familiarity with appropriate geochronologic techniques. At sites lacking deposits of known and sufficiently old ages, particularly to assess Holocene activity, radiocarbon or other age determinations of deposits that contrain the age of the most recent surface faulting event may be required (McCalpin, 1996).

GeoStrata Response: GeoStrata has created an updated site plan showing the proposed buildable portions of residential lots 1R and 2R as well as the locations of our explorations (both trenches and test pits). This site plan has been attached to the end of this letter as Plate A-2.

Upon further review of the exploratory trenches, both pre-existing and new, it is the opinion of GeoStrata that the oldest sediment exposed in both trenches 1 and 3 consist of Pleistocene-aged lacustrine deposits. Reasoning behind our interpretations is given in our descriptions of the updated trenches which are given as a response to comment 8. Pleistocene-aged sediments will by nature be old enough to preserve evidence of Holocene-aged fault movement along the Weber Segment of the Wasatch fault zone.

The term "practical limit of excavation" was applied to the equipment and space available with which to excavate the trenches. In additional conversations with the Client, it was determined that, although not preferred, additional vegetation could be disrupted in order to excavate to greater depths. As a result, the existing trenches (Trenches 1 and 2) were advanced an additional 2 to 3 feet, which is the maximum practical depth of the equipment available. This additional depth revealed Pleistocene-aged lacustrine sediment within the bottoms of both these trenches. Due to the portions of Trench 3 being located on the crest of a slope, depths up to 17 feet could be obtained in this area.

GeoStrata understands the desire to obtain more quantitative age of sediments when it was thought that only Holocene-aged sediments were observed within the trench. With the exposure of Pleistocene-aged lacustrine sediments within the bottom of each of the trenches, it is no longer considered necessary to obtain soil ages, as these Pleistocene-aged deposits are by nature of sufficient age to preserve Holocene-aged surficial movement.

With the exposure of Pleistocene-aged sediment, it is no longer considered necessary to apply additional recommendations due to the uncertainties regarding the age of sediments exposed in trenches.

14. The December 10, 2013, GeoStrata report States:

a. In Section 6.2 Alluvial Fan Flooding/Debris Flow (page 17): "Study of the Broad Hollow drainage basin and the entire alluvial fan deposit were outside the scope of this investigation."
b. In Section 6.2 Alluvial Fan Flooding/Debris Flow (page 18P): "Based on our observations the average debris flow event appears to deposit 5 to 6 feet of sediment. This value should be verified through the completion of a formal debris flow analysis."

SBI recommends Weber County request the applicant submit a debris flow analysis for the subject property as recommended by GeoStrata.

GeoStrata Response: GeoStrata has been informed that a hydrological study has been completed for the site, and that recommendations concerning site grading to reduce the potential for the site to be impacted by alluvial fan flooding/debris flow have been given in reports completed by others. All recommendations presented in these reports should be incorporated into the design of the project.

Closure

The conclusions and recommendations contained in this memorandum which include professional opinions and judgments, are based on the information available to us at the time of our evaluation, the results of our field observations, our limited subsurface exploration and our understanding of the proposed site development. This memorandum was prepared in accordance with the generally accepted standard of practice at the time the report was written. No other warranty, expressed or implied, is made. Development of property in the immediate vicinity of active faults involves a certain level of inherent risk.

This memorandum was written for the exclusive use of Matt Rasmussen and only for the proposed project described herein. It is the Client's responsibility to see that all parties to the project including the Designer, Contractor, Subcontractors, etc. are made aware of this memorandum in its entirety. We are not responsible for the technical interpretations by others of the information described or documented in this memorandum. The use of information contained in this memorandum for bidding purposes should be done at the Contractor's option and risk.

0 750 1,500 3,000 4,500 6,000 Feet

N

1:24,000

Base Map: Utah AGRC Hybrid Basemap

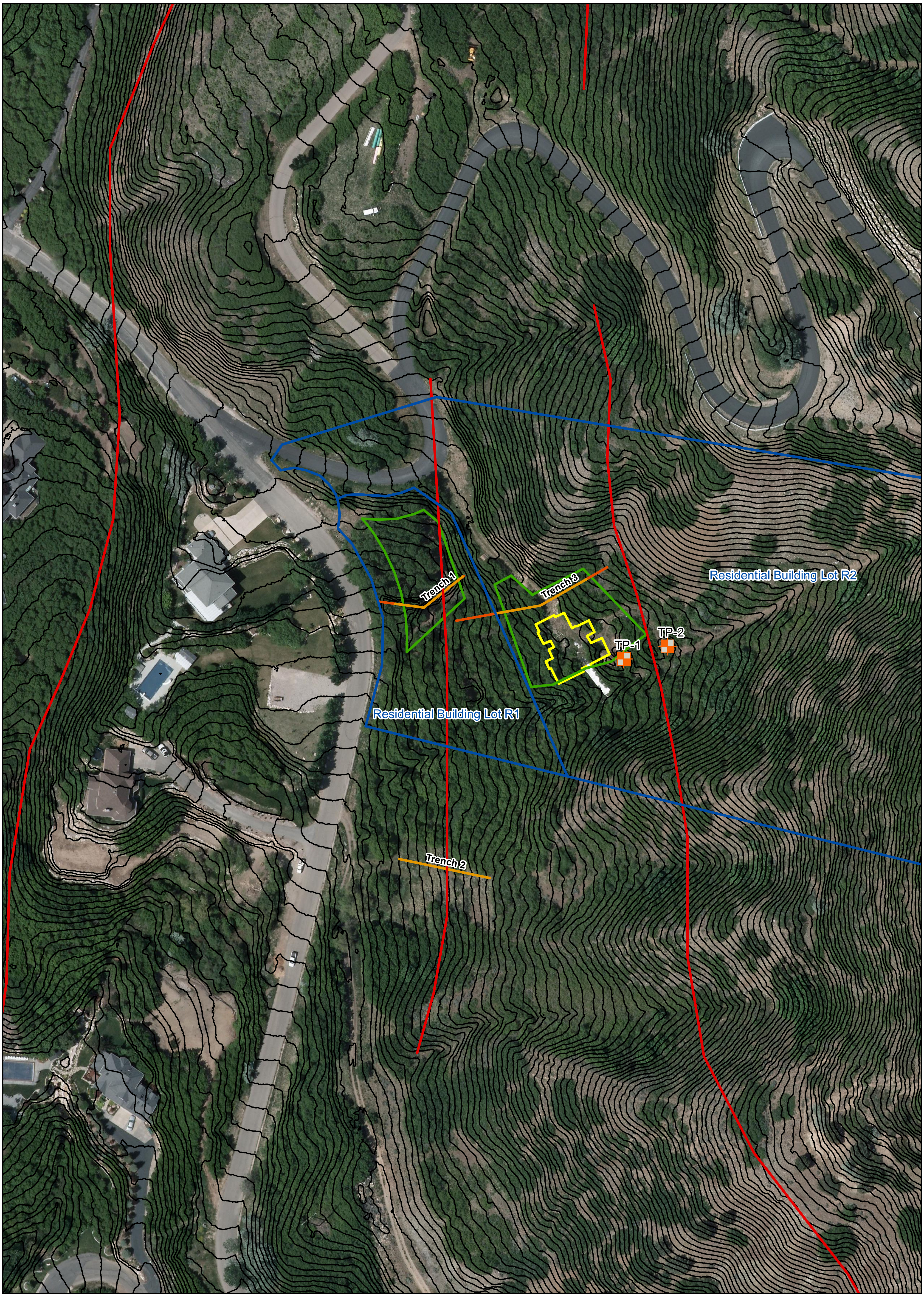
All Locations are Approximate

GeoStrata

Matt Rassmusen
Dauphine-Savory Piedmont Subdivision
South Weber, Utah
Project Number: 910-001

Site Vicinity Map

Plate A-1



Legend

- Site Boundary
- Fault
- Logged Portion of Trench
- Excavated Trench
- Test Pit
- Buildable Area
- Proposed Building

0 25 50 100 150 200 Feet

1:1,200

Base Map: 2012 HRO 6 inch Orthophotography obtained from the State of Utah AGRC.

All Locations are Approximate

N

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Matt Rassmusen
Dauphine-Savory Piedmont Subdivision
South Weber, Utah
Project Number: 910-001

Exploration Location Map

Plate A-2

Legend

Site Boundary

Geologic Unit descriptions provided on plate A-4

1:24,000

Base Map: Yonkee, W.A. and Lowe, M., 2004,
Geologic map of the Ogden 7.5 minute quadrangle, Utah
Geological Survey Open-File Report M-200, 42p., 2pl., scale 1:24,000

All Locations are Approximate

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Dauphine-Savory Piedmont Subdivision
South Weber, Utah
Project Number: 910-001

Geologic Map

Plate A-3

Quaternary Surficial Deposits

Units are subdivided based on dominant process (l- lacustrine, d- deltaic, a- alluvial, m- mass wasting, g- glacial), and on relative age (1- Holocene (younger), 2- Holocene (older), 3- Lake Bonneville regressive, 4- Lake Bonneville transgressive, and 5- pre-Lake Bonneville).
Units with form X/Y indicates thin (generally less than 3 meters [10 ft] thick) deposits of X overlying deposits of Y.

Qlg$_3$ Lacustrine gravel-bearing deposits, Bonneville regressive– *Clast-supported, moderately to well-sorted, pebble to cobble gravel and gravelly sand, interlayered with some silt and sand; deposited and reworked in higher energy environments along the Provo and regressive shorelines near the mountain front; mapped at elevations below Provo shoreline; thickness less than 6 meters (20 ft).*

Qlf$_3$ Lacustrine fine-grained deposits, Bonneville regressive– *Medium sand to silt deposited and reworked in moderate-energy environments near and below Provo shoreline away from mountain front in southern part of quadrangle; also includes calcareous clay, silt, and fine sand deposited in deeper water environments in the subsurface within western part of quadrangle; thickness of deposits near shoreline generally less than 6 meters (20 ft).*

Qlg$_4$ Lacustrine gravel-bearing deposits, Bonneville transgressive– *Clast-supported, moderately to well-sorted, pebble to cobble gravel, with some silt to sand in interfluve areas and away from mountain front; gravels contain rounded to subrounded clasts, and some subangular clasts derived from reworking of mass-wasting and alluvial-fan deposits; deposited in higher energy environments along shorelines and small fan deltas as Lake Bonneville was transgressing; grades westward away from shorelines into fine-grained lacustrine deposits (Qlf$_4$); total thickness locally as much as 60 meters (200 ft).*

Qlf$_4$ Lacustrine fine-grained deposits, Bonneville transgressive– *Intervals of calcareous clay to silt, and intervals of rhythmically interbedded fine to medium sand and silt near mouth of Weber Canyon; deposited in deeper water environments, and as delta bottomset beds during transgression of Lake Bonneville; total thickness, including subsurface deposits, locally as much as 150 meters (500 ft).*

Qd$_3$ Deltaic deposits, Bonneville regressive– *Main part of unit includes foreset beds of rhythmically interlayered, gently inclined, fine to medium sand and silt, and topset beds of clast-supported, moderately to well-sorted, pebble and cobble gravel and gravelly sand; gravels contain rounded to subrounded clasts; deposited when Lake Bonneville was at and regressing from Provo shoreline; forms large, gently westward-inclined surface that was locally reworked along regressive shorelines; total thickness locally as much as 30 meters (100 ft). Unit also includes moderately to well-sorted, pebble and cobble gravel in smaller terraces more than 30 meters (100 ft) above modern stream level that are graded to delta deposits and shorelines above the Gilbert level; exposed thickness of terrace gravels up to 6 meters (20 ft).*

Qd$_4$ Deltaic deposits, Bonneville transgressive– *Topset beds of clast-supported, moderately to well-sorted, pebble gravel and gravelly sand; contains abundant subrounded to rounded basement clasts; deposited as Lake Bonneville was near a transgressive shoreline at an elevation of about 1,520 meters (5,000 ft); thickness of topset beds 2 to 4 meters (7 - 13 ft).*

Qal Stream alluvium, undivided– *Mostly clast-supported, moderate- to well-sorted, pebble and cobble gravel, gravelly sand, and silty sand; deposited along modern channels and inactive benches; mapped where active channels and benches are too narrow to map separately; exposed thickness less than 12 meters (40 ft).*

Qal$_1$ Younger stream alluvium, Holocene– *Clast-supported, moderate- to well-sorted, pebble and cobble gravel, gravelly sand, and silty sand; deposited along modern channels and flood plains; mapped where fluvial processes are currently or episodically active; exposed thickness less than 6 meters (20 ft).*

Qal$_2$ Older stream alluvium, Holocene– *Clast-supported, moderately to well-sorted, pebble and cobble gravel, gravelly sand, and silty sand; deposited along inactive flood plains and terraces 3 to 9 meters (10-30 ft) above modern stream level; mapped where fluvial processes are generally no longer active; exposed thickness less than 6 meters (20 ft).*

Qat$_2$ Older alluvial terrace deposits, Holocene– *Clast-supported, moderately to well-sorted, pebble and cobble gravel and gravelly sand; contains subangular to rounded clasts; forms terraces 9 to 15 meters (30-50 ft) above modern stream level that appear graded to base levels below the Gilbert shoreline; exposed thickness less than 6 meters (20 ft).*

Qag$_4$ Alluvial gravel of Ogden Canyon–*Clast-supported, moderately sorted, pebble to boulder alluvial gravel, with some lacustrine sand layers at top of unit; gravel contains angular to subrounded clasts and is weakly to strongly cemented by calcite; present in small erosional remnants along Ogden Canyon; original thickness as much as 60 meters (200 ft).*

Qaf Alluvial-fan deposits, undivided– *Mixture of clast-supported, moderately sorted, pebble to cobble gravel and sand deposited by streams, and matrix-supported, poorly sorted, pebble to boulder gravel to diamicton deposited by debris flows; mapped where deposits lack cross-cutting relations and relative age is uncertain; exposed thickness less than 9 meters (30 ft).*

Qaf$_1$ Younger alluvial-fan deposits, Holocene– *Mixture of gravel and sand deposited by streams, and diamicton deposited by debris flows; forms fans having distinct levees and channels at mouths of mountain-front canyons; exposed thickness less than 6 meters (20 ft).*

Qaf$_2$ Older alluvial-fan deposits, Holocene– *Mixture of gravel and sand deposited by streams, and diamicton deposited by debris flows; forms fans with poorly preserved levees that are slightly incised by modern stream channels; exposed thickness less than 6 meters (20 ft).*

Qaf$_3$ Alluvial-fan deposits, Bonneville regressive– *Mixture of gravel and sand deposited by streams, and diamicton deposited by debris flows; contains mostly angular to subrounded clasts plus some recycled, well-rounded lacustrine clasts; forms fans having subdued morphology that are graded to the Provo or other regressive shorelines and are incised by modern stream channels; exposed thickness less than 9 meters (30 ft).*

Qaf$_4$ Alluvial-fan deposits, Bonneville transgressive– *Mixture of gravel deposited by streams and diamicton deposited by debris flows; gravel contains mostly angular to subrounded clasts; locally weakly cemented with calcite; fans have subdued morphology, display top surfaces graded to the Bonneville shoreline, and are deeply incised by modern stream channels; total thickness of some composite fans as much as 60 meters (200 ft).*

Qms Landslide deposits, undivided– *Unsorted, unstratified deposits of angular boulders, sand, silt, clay, and bedrock blocks; deposits generally found on steeper slopes that are covered by thick vegetation and display hummocky topography; deposits formed by single to multiple slides, slumps, and flows; mapped where lack of cross-cutting relations prevents relative age determination; querried where hummocky topography is more subdued; thickness uncertain.*

Qms$_1$ Younger landslide deposits, Holocene– *Unsorted, unstratified mixtures of gravel, sand, silt, and clay redeposited by slides, slumps, and flows; deposits display distinctly hummocky topography and fresh scarps, and are currently or have been recently active; many of these deposits are within older slide complexes.*

Qms$_2$ Older landslide deposits, Holocene– *Unsorted, unstratified mixtures of mostly sand, silt, and clay redeposited by single to multiple slides, slumps, and flows; deposits display hummocky topography but lack fresh scarps and are mostly inactive; deposits found mostly along moderate slopes where rivers and streams have incised into finer grained lacustrine and deltaic deposits; unit also includes slides of boulder-rich diamicton that reactivated parts of older slide complexes in the Wasatch Range.*

Qms$_3$ Landslide deposits, Bonneville regressive– *Mixture of silt, fine sand, and minor gravel redeposited in a flow slide and lateral spread as a result of liquefaction, probably during large earthquake(s); deposits display disrupted bedding, landslide-related lineaments and scarps, and hummocky topography; one large deposit is present in the quadrangle and formed after regression from the Provo level but before major downcutting by streams.*

Qms$_5$ Landslide deposits, pre-Bonneville to Bonneville transgressive– *Unsorted, unstratified deposits of angular boulders, sand, silt, clay, and bedrock blocks; deposited by multiple slides, slumps, and flows; parts of these slides are covered by Lake Bonneville deposits and reworked along the Bonneville shoreline, and parts of some slides are interlayered with Bonneville-transgressive lacustrine deposits.*

Qmf Debris-flow deposits, undivided– *Matrix- to clast-supported cobble and boulder gravel, with variable amounts of sand, silt, and clay matrix; surfaces variably rubbly and commonly have levees and channels; includes multiple events graded to various levels above modern channels; unit grades into alluvial fans at mouths of canyons, and into colluvium, talus, and slide deposits at higher elevations in source areas; thickness probably less than 9 meters (30 ft).*

Qmt Talus– *Deposits of angular pebble to boulder fragments with little or no matrix and little to no vegetation cover, which have accumulated at bases of some steep bedrock slopes and cliffs; thickness uncertain in most areas, but probably less than 15 meters (50 ft).*

Qma Avalanche deposits– *Diamicton and vegetative debris that have accumulated from repeated avalanches along moderately steep, northerly facing chutes at higher elevations; only one relatively large deposit mapped.*

Qc Colluvium– *Weakly to non-layered, variably sorted, matrix- to clast-supported, pebble to boulder gravel and diamicton of local origin; contains angular to subangular clasts in variable amounts of clay, silt, and sand matrix; deposits formed mostly by creep and slope wash, also includes small landslides, talus, debris cones, minor alluvium, and small bedrock exposures; found mostly along vegetated slopes in Wasatch Range, and locally covering scarps along the Wasatch fault zone; thickness probably less than 15 meters (50 ft) in most areas.*

Qac Colluvium and alluvium, undivided– *Pebble to boulder gravel and clay- to boulder-rich diamicton; includes hillslope colluvium, small fans, stream alluvium, and small landslide deposits; mapped along some vegetated canyon areas in Wasatch Range; thickness probably less than 15 meters (50 ft) in most areas.*

Qgr Rock-glacier deposits– *Bouldery debris with little or no matrix; displays hummocky forms with cross-slope ridges and little or no vegetation; present near bases of some cirque headwalls at higher elevations near Mount Ogden.*

Qgt$_y$ Glacial till, younger– *Boulders to pebbles in sparse sandy to silty matrix; displays distinct moraine crests and limited soil development; present in upper part of cirque basin northeast of Mount Ogden.*

Qgt$_o$ Glacial till, older– *Boulders to pebbles in variable amounts of sandy to silty matrix; displays more subdued moraine crests and greater soil development compared to younger till; present within cirque basins near Mount Ogden; probably late Pinedale age (about 25 to 10 ka).*

Qf Artificial fill– *Excavated and reworked debris; only larger areas mapped along rail and roadways in Weber Canyon, and near an abandoned landfill.*

Basin Fill

Qb Quaternary basin fill– *Weakly to non-consolidated mixture of alluvial and lacustrine clay, silt, sand, gravel, marl, and thin tuffaceous layers; includes two thicker, gravel-bearing zones corresponding to the Sunset and Delta aquifers; shown only on cross sections; up to 400 meters (1,300 ft) thick.*

Tb Late Tertiary basin fill– *Weakly to strongly consolidated mixture of conglomerate, sandstone, mudstone, tuffaceous sandstone, tuff, and lacustrine limestone; only shown on cross sections; up to 2,400 meters (8,000 ft) thick.*

Tertiary Igneous Rocks

Td Tertiary igneous dikes– *Dark colored, non-foliated dikes composed of altered hornblende, biotite, and feldspar phenocrysts in a fine-grained, highly altered matrix; interpreted to be Tertiary age.*

Cretaceous Altered and Deformed Rocks

Kc Chloritic gneiss, cataclasite, and mylonite– *Dark- to gray-green, variably fractured and altered gneiss, intensely fractured cataclasite, and mylonite to phyllonite with micaceous cleavage; derived by greenschist-facies alteration and varying degrees of cataclastic and plastic deformation that overprinted protoliths from the Farmington Canyon Complex; contains variable amounts of fine-grained, recrystallized chlorite, muscovite, and epidote; found within shear zones and along the Ogden floor thrust.*

Kfx Imbricated fault rocks– *Intensely deformed, complexly imbricated fault-zone rocks derived from a mixture of Farmington Canyon Complex and Cambrian sedimentary rock protoliths; contains fault-bounded slices of limestone and shale with intense cleavage and tight folds, and mixed cataclasite to mylonite; mapped along parts of the Ogden floor thrust.*

K(?)q Quartz veins and pods– *Veins and pods of quartz with minor chlorite, epidote, muscovite, and hematite; veins and pods cross cut gneissic foliation and are locally associated with chlorite alteration within rocks of the Farmington Canyon Complex; only larger bodies mapped; interpreted to be mostly related to Cretaceous alteration.*

Paleozoic Sedimentary Rocks

Mg Gardison Limestone– *Ledge- to cliff-forming, medium- to dark-gray, thin- to thick-bedded, fossiliferous limestone to dolomitic limestone; contains local chert lenses and widespread fragments of fossil corals, crinoids, and brachiopods; top not exposed in quadrangle but about 200 meters (660 ft) thick in nearby areas.*

Db Beirdneau Formation– *Overall slope-forming, yellow- to red- to light-gray, interlayered, sandy to silty dolomite and limestone, fine- to medium-grained sandstone, shale, flat-pebble conglomerate, and sedimentary breccia; uppermost part consists of argillaceous limestone and shale; about 50 to 100 meters (170-330 ft) thick, but thickness varies due to widespread minor faulting and folding.*

Dhw Hyrum Dolomite and Water Canyon Formation, undivided– *Hyrum consists of ledge-forming, medium- to dark-gray, medium- to thick-bedded, dolomite and minor silty limestone; Water Canyon consists of slope-forming, light- to yellow-gray, sandy to silty dolomite; unit is about 50 to 100 meters (170-330 ft) thick.*

Of Fish Haven Dolomite– *Cliff-forming, medium- to dark-gray, medium- to thick-bedded, slightly fossiliferous dolomite; about 40 to 80 meters (130-260 ft) thick.*

Og Garden City Formation– *Ledge- and slope-forming, tan to light-gray, thin- to thick-bedded, silty dolomite, dolomite, silty limestone, and siltstone; has well-layered appearance; some layers are slightly fossiliferous and some layers contain siltstone-filled cracks; about 60 to 120 meters (200-400 ft) thick, but thickness varies due to widespread minor faulting.*

Ꞓsn St. Charles and Nounan Formations, undivided– *St. Charles consists mostly of cliff-forming, light- to dark-gray, massive-weathering dolomite, with a thin interval of sandy dolomite and sandstone corresponding to the Worm Creek Quartzite Member at its base; Nounan consists of cliff-forming, light- to dark-gray, massive-weathering, dolomite and minor silty dolomite with local twiggy structures; unit is about 300 to 450 meters (1,000-1,500 ft) thick.*

Ꞓb Bloomington Formation– *Slope-forming, orange-gray to brown, thin-bedded, interlayered, shaley limestone, shale, fine-grained limestone with abundant orange-weathering silty ribbons, flat-pebble conglomerate, oncolitic limestone, and oolitic limestone; about 30 to 60 meters (100-200 ft) thick, but thickness varies due to widespread minor faulting.*

Ꞓm Maxfield Formation, undivided– *Total thickness about 180 to 300 meters (600-1000 ft), but total thickness and thicknesses of individual members vary due to widespread deformation.*

Ꞓmu Upper limestone and dolomite member– *Upper part consists mostly of cliff-forming, light- to dark-gray, medium- to thick-bedded, dolomite, oolitic dolomite, and minor limestone, with widespread twiggy structures; lower part consists mostly of ledge-forming, light- to medium-gray, thin- to thick-bedded, oolitic limestone, fine-grained limestone with yellow-weathering silty ribbons, and minor dolomite; distinctive interval of interlayered dark-gray cherty dolomite and light-gray boundstone found near top of the member; about 100 to 150 meters (330-500 ft) thick.*

Ꞓma Middle argillaceous limestone member– *Overall slope-forming, overall brown to orange-gray, thin- to medium-bedded, interlayered, argillaceous limestone with black, clay-filled cracks, shale with limestone nodules, fine-grained limestone with orange-weathering silty ribbons, oolitic limestone, oncolitic limestone, and flat-pebble conglomerate; about 40 to 80 meters (130-260 ft) thick.*

Ꞓml Lower limestone member– *Ledge-forming, light- to medium-gray, thin- to medium-bedded limestone with abundant orange-weathering silty ribbons and minor oolitic limestone; thin interval of shaley limestone near middle of member separates upper and lower ledges; about 40 to 80 meters (130-260 ft) thick.*

Ꞓo Ophir Shale, undivided– *Total thickness of about 90 to 200 meters (300-700 ft), but total thickness and thicknesses of individual members vary widely due to intense deformation.*

Ꞓou Upper shale member– *Slope-forming, gray-brown to olive-drab, variably calcareous, silty to micaceous shale (or argillite), with some thin, silty limestone beds; generally poorly exposed and strongly deformed; probably about 40 to 80 meters (130-260 ft) thick.*

Ꞓom Middle limestone member– *Ledge-forming, light- to medium-gray, thin- to medium-bedded limestone with abundant orange-weathering silty ribbons and minor oolitic limestone; probably about 6 to 20 meters (20-70 ft) thick.*

Ꞓol Lower shale member– *Slope-forming, brown- to olive-drab, silty to micaceous shale (or argillite), with some fine-grained sandstone layers at base; generally poorly exposed and strongly deformed; probably about 40 to 100 meters (130-330 ft) thick.*

Ꞓt Tintic Quartzite– *Main part of formation consists of cliff-forming, white to tan, thin- to thick-bedded, quartz-rich, well-cemented sandstone (orthoquartzite) with some lenses of quartz-pebble conglomerate and thin layers of argillite; argillite intervals increase in abundance and quartz pebbles decrease in abundance toward the top of the formation; basal part of the formation consists of heterogeneous mixture of green to purple to tan, arkosic sandstone, quartz-pebble conglomerate, and micaceous siltstone; about 400 to 450 meters (1,300-1,500 ft) thick.*

Early Proterozoic Metamorphic and Igneous Rocks

Xf Farmington Canyon Complex, undivided– *Shown only on cross sections.*

Units exposed in footwall of Ogden floor thrust

Xfgf Granitic gneiss of Ogden footwall– *Light- to pink-gray, moderately to strongly foliated, hornblende-bearing granitic gneiss; unit also contains widespread, variably deformed pegmatitic dikes and some pods of amphibolite.*

Xfh Hornblende-plagioclase gneiss– *Dark-gray to black, moderately to strongly foliated, hornblende-plagioclase gneiss, with minor garnet, quartz, and biotite in some layers; garnet grains up to 2.5 centimeters (1 inch) in size.*

Xfs Muscovite-bearing schist– *Gray-brown, strongly foliated, schist to gneiss containing variable amounts of muscovite, biotite, quartz, and feldspar, with minor garnet in some layers; muscovite grains are up to 2.5 centimeters (1 inch) in size; unit also contains some thin layers of hornblende-plagioclase gneiss.*

Units exposed in hanging wall of Ogden floor thrust

Xfa Meta-gabbro and amphibolite– *Black to green-black, non- to strongly foliated, pyroxene-bearing meta-gabbro to amphibolite with varying amounts of plagioclase; forms pods in granitic gneiss but only larger bodies mapped.*

Xfgh Granitic gneiss of Ogden hanging wall– *Light- to pink-gray, moderately to strongly foliated, fine- to medium-grained, hornblende-bearing granitic gneiss with rare orthopyroxene; gneiss is locally fractured and displays red hematite alteration; gneiss cut by variably deformed, light-colored pegmatitic dikes; unit also contains small pods of meta-gabbro and amphibolite; gradational contacts with migmatitic gneiss.*

Xfm Migmatitic gneiss– *Medium- to light-pink-gray, strongly foliated and layered, migmatitic, quartzo-feldspathic gneiss with widespread garnet and biotite; gneiss cut by widespread, variably deformed, pegmatitic dikes; unit also contains widespread amphibolite layers, granitic gneiss bands, and some thin layers of biotite-rich schist; gradational contacts with granitic gneiss.*

Xfb Biotite-rich schist– *Medium-gray to dark-brown, strongly foliated, biotite-rich schist with widespread garnet and sillimanite; displays alternating biotite-rich and quartz-feldspar-rich bands that are rotated into complex fold patterns; schist cut by variably deformed, garnet-bearing pegmatite dikes; unit also contains some thin layers of amphibolite, quartz-rich gneiss, and granitic gneiss; gradational contacts with migmatitic gneiss.*

Xfq Quartz-rich gneiss– *Milky- to green-white, quartz gneiss with lesser amounts of plagioclase and chrome-green mica; locally contains thin layers of biotite-rich schist and amphibolite.*

Xfu Meta-ultramafic and mafic rocks– *Dark-green to black, variably foliated, pyroxene-, amphibole-, and olivine-bearing ultramafic rock, hornblendite, and amphibolite.*

MAP AND CROSS-SECTION SYMBOLS

- Contact--*Dashed where location approximate; dotted where concealed.*
- Scratch Contact--*Used between subunits and combined unit.*
- Normal Fault--*Dashed where location approximate; dotted where concealed; solid bar and ball on downthrown side; arrows show relative movement on cross section.*
- Normal Fault--*Concealed; inferred and delineated from geophysical data; open ball and bar on downthrown side; arrows show relative movement on cross section.*
- U / D Steeply Dipping Fault--*High-angle fault with normal apparent stratigraphic throw; actual offset may be more complex; dashed where location approximate; dotted where concealed; U and D show up and down on throw.*
- Thrust Fault--*Dotted where concealed; teeth on upper plate; arrows show relative movement on cross section.*
- Lineament--*Related to liquefaction and possible ground cracks in Qms$_3$*
- Quartz veins related to K(?)q.
- Moraine Crests
- Landslide Scarp
- Erosional Scarp--*Related to river terraces incised into Lake Bonneville delta along Weber River.*
- Fold Axial Traces--*Location approximate; dotted where concealed.*
  - anticline
  - syncline

- Strike and Dip of bedding
  - 35 inclined
  - 85 overturned
- 45f Trend and Plunge of minor fold
- 75c Strike and Dip of cleavage
- 45 Strike and Dip of high-grade metamorphic foliation
- 55p Trend and Plunge of mineral lineation
- X Prospect Pit
- Gravel Pit
- Shorelines
  - X Regressive shoreline of Lake Bonneville
  - P Provo shoreline of Lake Bonneville
  - B Bonneville shoreline of Lake Bonneville
  - Y Transgressive shoreline of Lake Bonneville

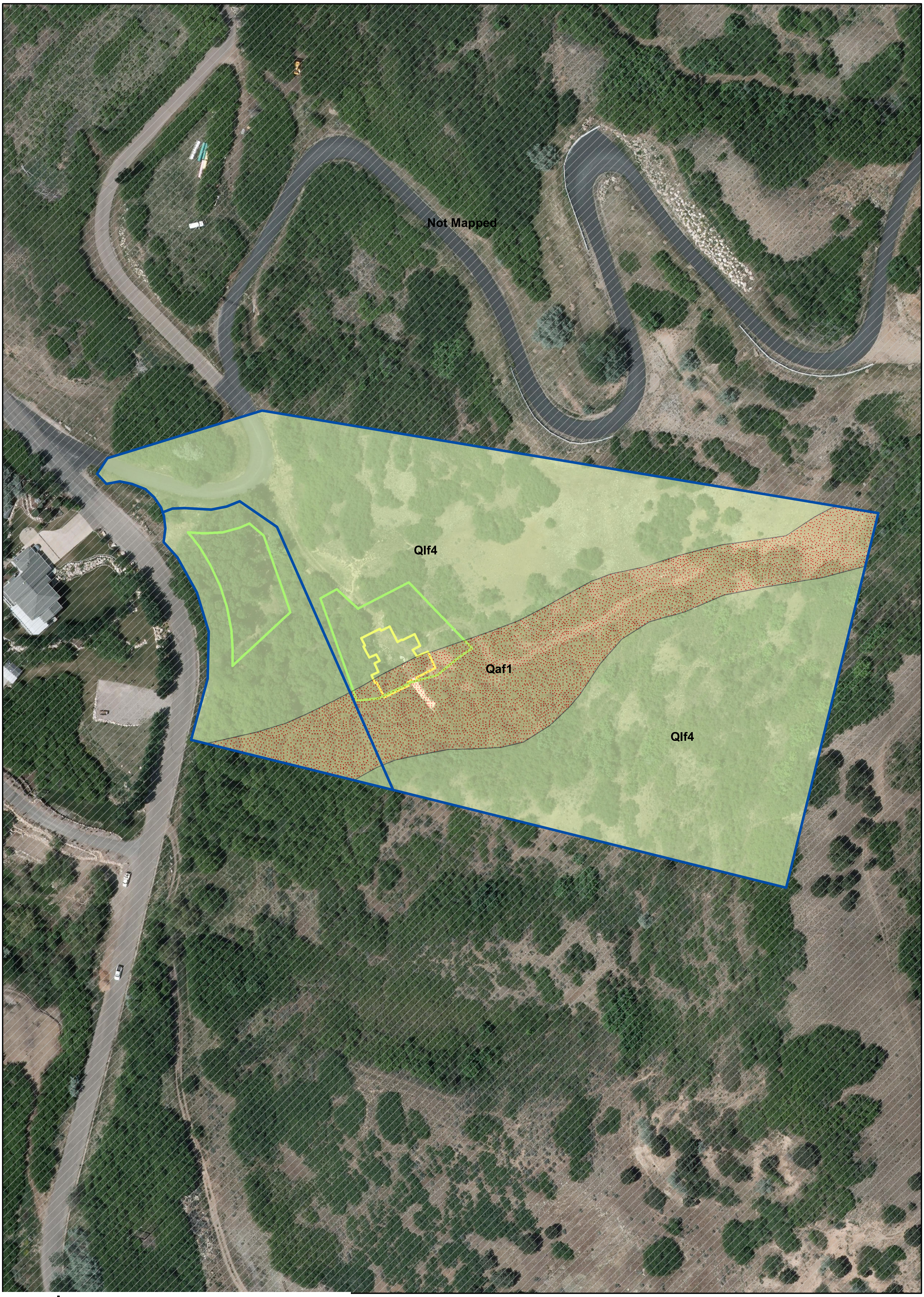
Yonkee, W.A. and Lowe, M., 2004, Geologic map of the Ogden 7.5 minute quadrangle, Utah Geological Survey Open-File Report M-200, 42p., 2pl., scale 1:24,000

GeoStrata

Description of Geologic Map Units

Matt Rassmusen
Dauphine-Savory Piedmont Subdivision
South Weber, UT
Project Number: 910-001

Plate A - 4



Legend

- Site Boundary
- Not Mapped
- Qaf1 - Younger alluvial fan deposits
- Qlf4 - lacustrine fine-grained deposits, Bonneville transgressive
- Proposed Buildable Area
- Proposed Building

0 25 50 100 150 200 Feet

1:1,200

Base Map: 2012 HRO 6 inch Orthophotography obtained from the State of Utah AGRC.

All Locations are Approximate

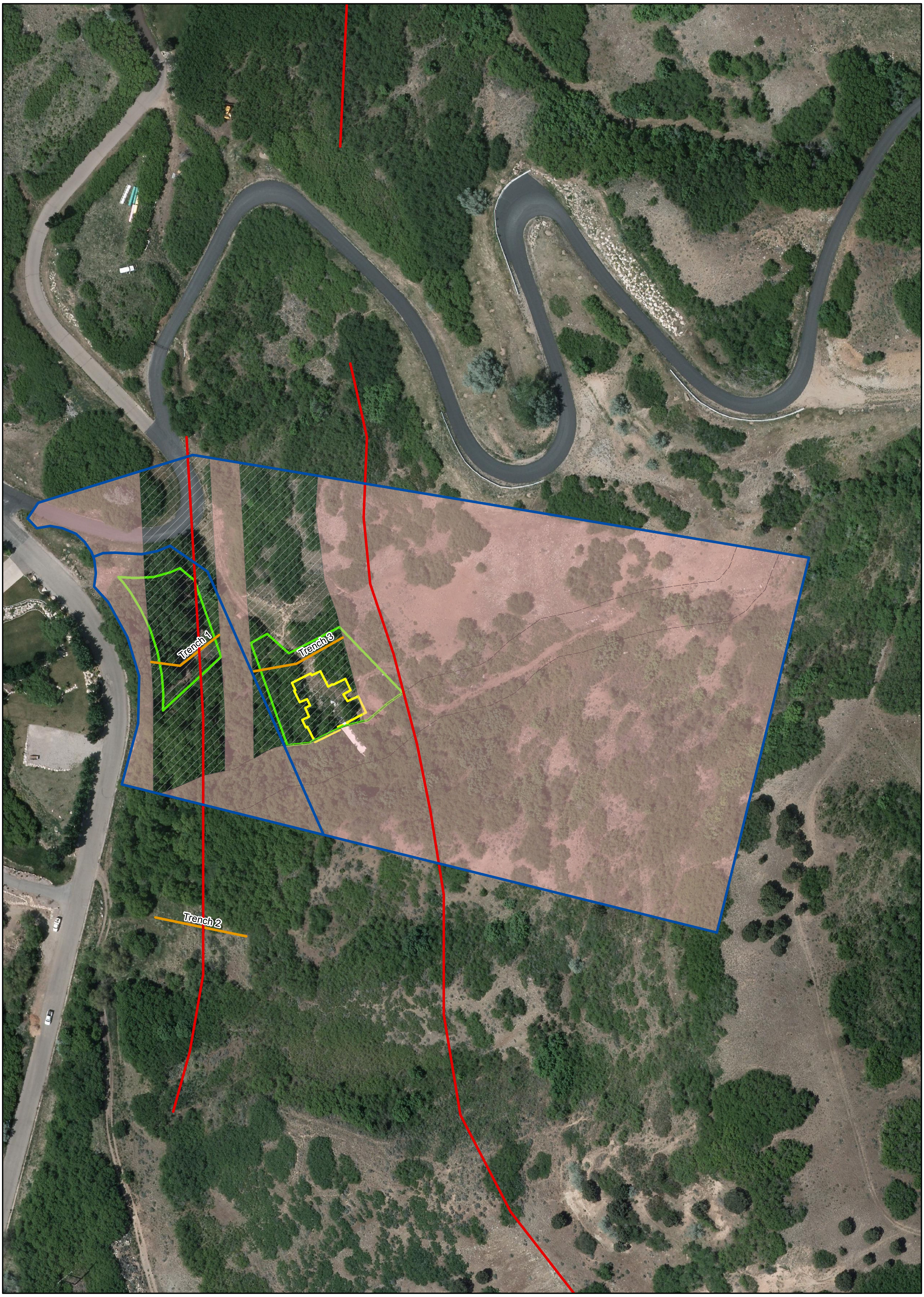
N

GeoStrata

Matt Rassmusen
Dauphine-Savory Piedmont Subdivision
South Weber, Utah
Project Number: 910-001

Site Geologic Setback Map

Plate A-6



Site Boundary
Fault
Logged Portion of Trench
Buildable Area
Non-Buildable Area
Drainage Setback
Proposed Buildable Area
Proposed Building Footprint

0 25 50 100 150 200 Feet

1:1,200

Base Map: 2012 HRO 6 inch Orthophotography obtained from the State of Utah AGRC.

All Locations are Approximate

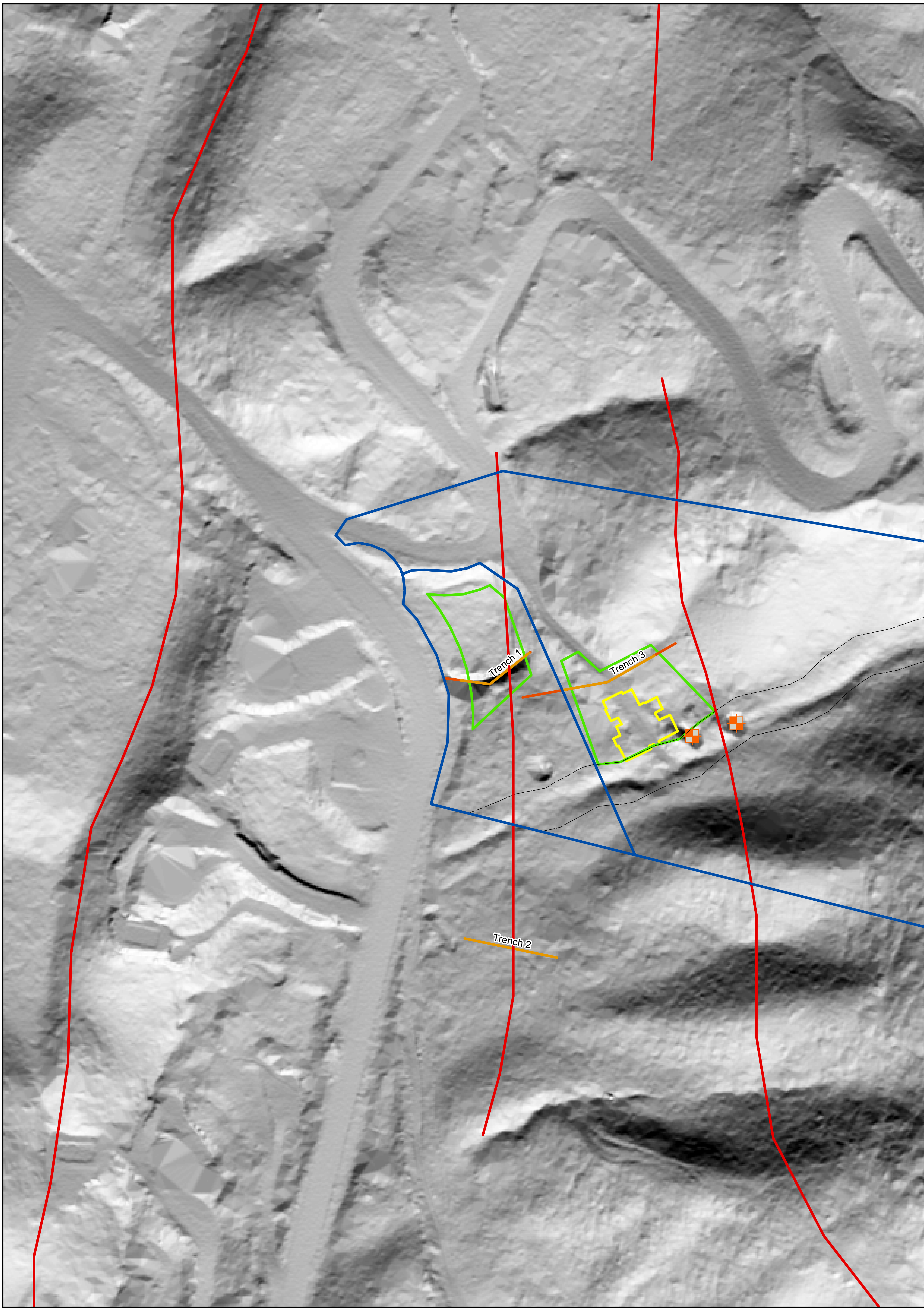
N

GeoStrata

Matt Rassmusen
Dauphine-Savory Piedmont Subdivision
South Weber, Utah
Project Number: 910-001

Site Geologic Setback Map

Plate A-6



Site Boundary
Fault
Logged Portion of Trench
Drainage Setback
Excavated Trench
Test Pit
Proposed Buildable Area
Proposed Building Footprint

0 25 50 100 150 200 Feet

1:1,200

Base Map: 2012 HRO 6 inch Orthophotography obtained from the State of Utah AGRC.

All Locations are Approximate

N

GeoStrata

Matt Rassmusen
Dauphine-Savory Piedmont Subdivision
South Weber, Utah
Project Number: 910-001

Hillshade 180

Plate A-7

0 25 50 100 150 200 Feet

1:1,200

Base Map: 2012 HRO 6 inch Orthophotography obtained from the State of Utah AGRC.

All Locations are Approximate

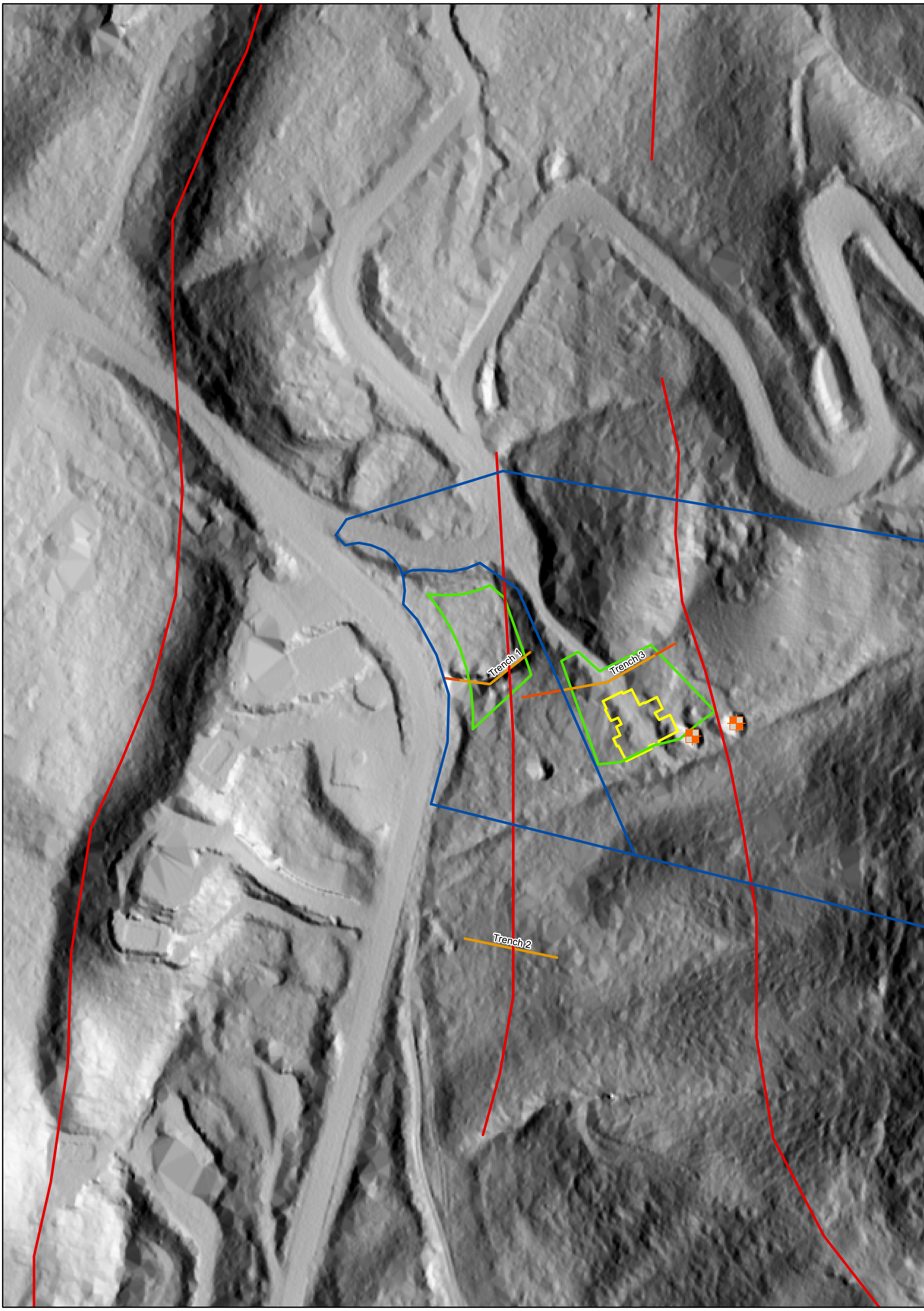
N

GeoStrata

Matt Rassmusen
Dauphine-Savory Piedmont Subdivision
South Weber, Utah
Project Number: 910-001

Hillshade 180

Plate A-8



0 25 50 100 150 200 Feet

1:1,200

Base Map: 2012 HRO 6 inch Orthophotography obtained from the State of Utah AGRC.

All Locations are Approximate

- Site Boundary
- Fault
- Logged Portion of Trench
- Excavated Trench
- Test Pit
- Proposed Buildable Area
- Proposed Building Footprint

N

GeoStrata

Matt Rassmusen
Dauphine-Savory Piedmont Subdivision
South Weber, Utah
Project Number: 910-001

Hillshade 90

Plate A-9

1:1,200

Base Map: 2012 HRO 6 inch Orthophotography obtained from the State of Utah AGRC.

All Locations are Approximate

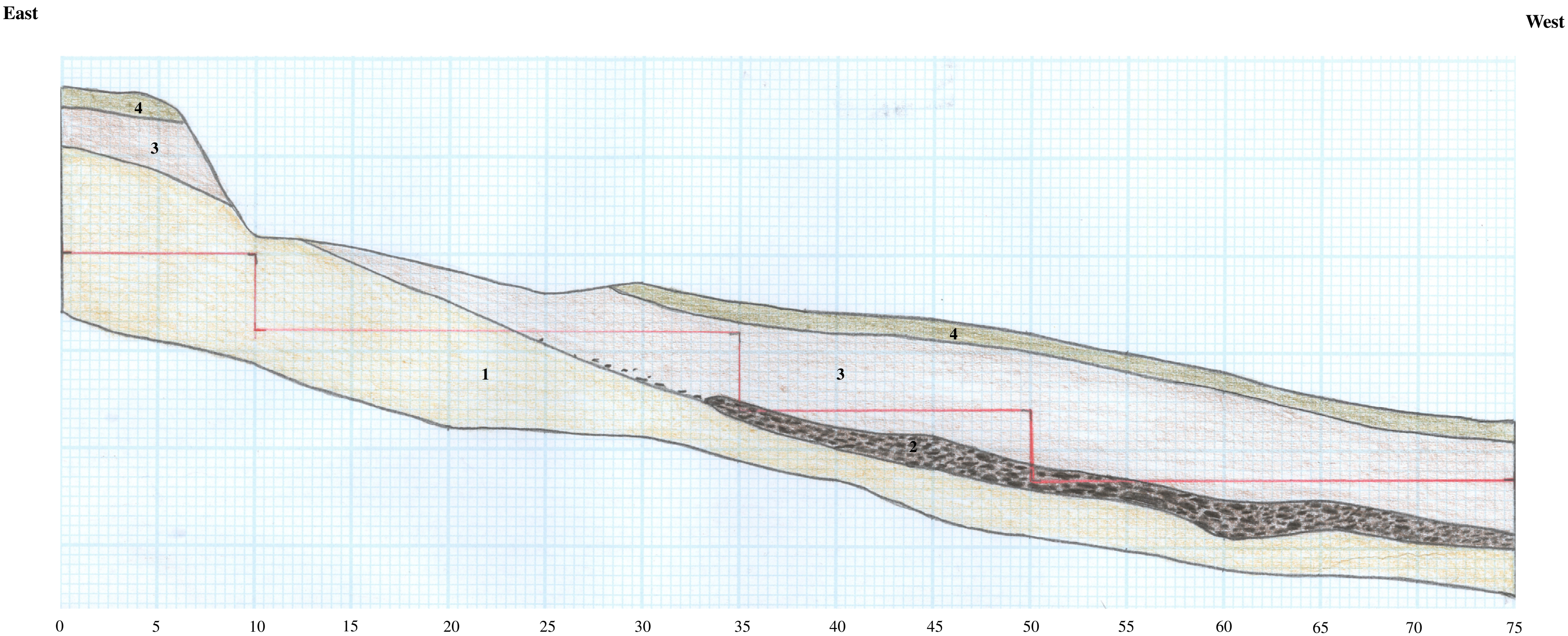
GeoStrata

Matt Rassmusen
Dauphine-Savory Piedmont Subdivision
South Weber, Utah
Project Number: 910-001

Hillshade 90

Plate A-9

TRENCH 1 SOUTH WALL



Distance (ft)

1 inch = 5 feet
Horizontal Scale = Vertical Scale

Trench 1 Legend
Unit 1 - Pleistocene-Aged Lacustrine Fine-Grained Deposits, Transgressive Bonneville
Unit 2 – Pleistocene/Holocene-Aged Stream Alluvium Deposits
Unit 3 - Holocene-Aged Colluvium and Alluvium
Unit 4 – Holocene-Aged Topsoil

logged by T. Thompson

Fault Study
Dauphine-Savory Piedmont Subdivision
Ogden, Utah
Project Number: 910-001

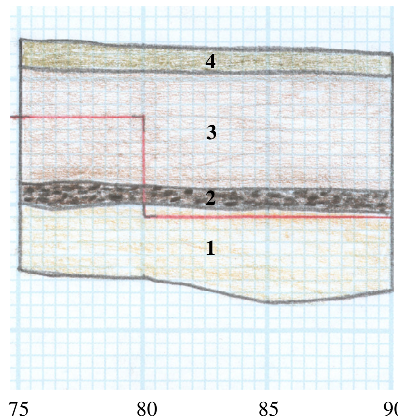
Trench 1 South Wall Trench Log
0 to 75 Feet

GeoStrata

Plate B-1

TRENCH 1 SOUTH WALL

East **West**



Distance (ft)

1 inch = 5 feet
Horizontal Scale = Vertical Scale

Trench 1 Legend
Unit 1 - Pleistocene-Aged Lacustrine Fine-Grained Deposits, Transgressive Bonneville
Unit 2 – Pleistocene/Holocene-Aged Stream Alluvium Deposits
Unit 3 - Holocene-Aged Colluvium and Alluvium
Unit 4 – Holocene-Aged Topsoil

logged by T. Thompson

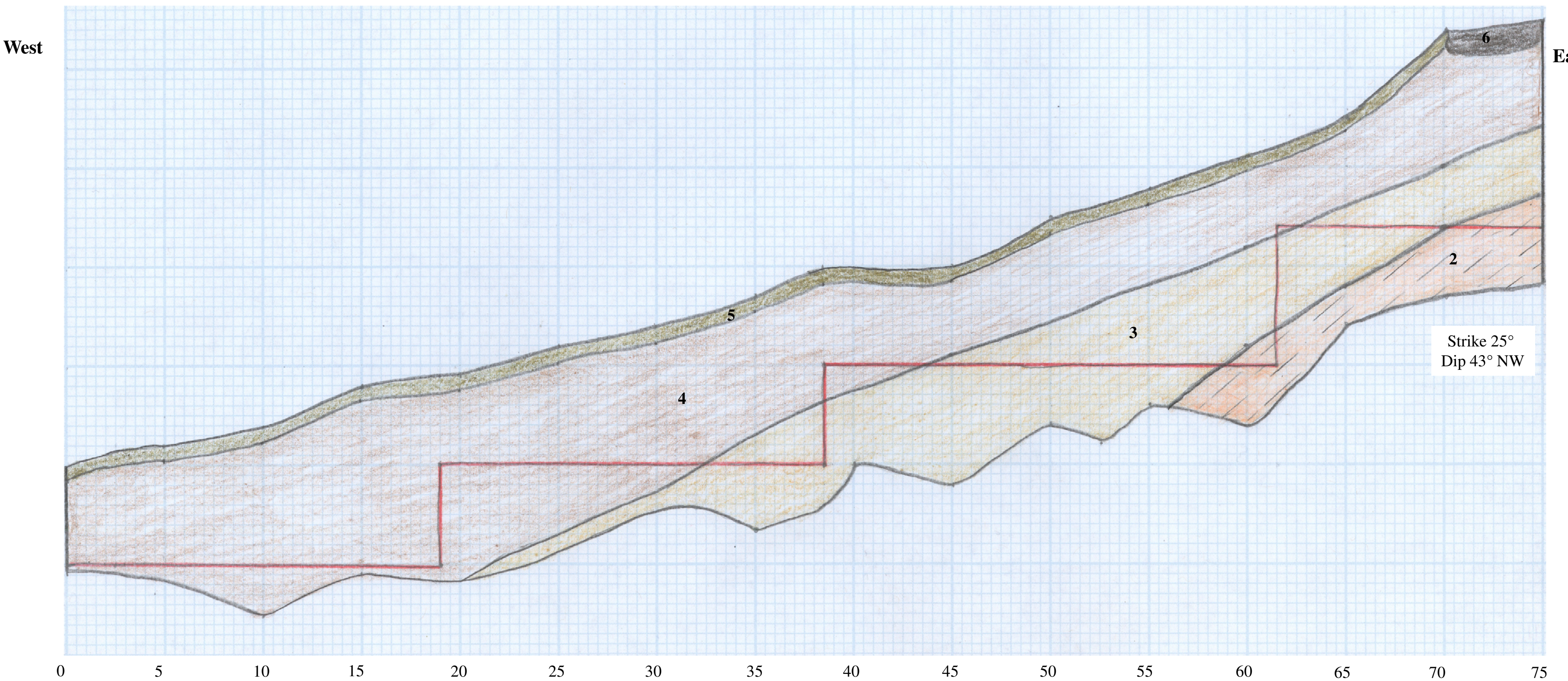
Fault Study
Dauphine-Savory Piedmont Subdivision
Ogden, Utah
Project Number: 910-001

Trench 1 South Wall Trench Log
75 to 90 Feet

GeoStrata

Plate B-2

TRENCH 3 NORTH WALL



Distance (ft)

1 inch = 5 feet
Horizontal Scale = Vertical Scale

Trench 3 Legend
Unit 1 – BEDROCK - Early Proterozoic Metamorphic and Igneous Rocks
Unit 2 – Pleistocene-Aged Lacustrine Gravel Deposits, Transgressive Bonneville
Unit 3 – Pleistocene-Aged Lacustrine Fine-Grained Deposits, Transgressive Bonneville
Unit 4 – Holocene-Aged Colluvium and Alluvium
Unit 5 – Holocene-Aged Topsoil
Unit 6 – Holocene-Aged Historical Fill Soils

logged by T. Thompson

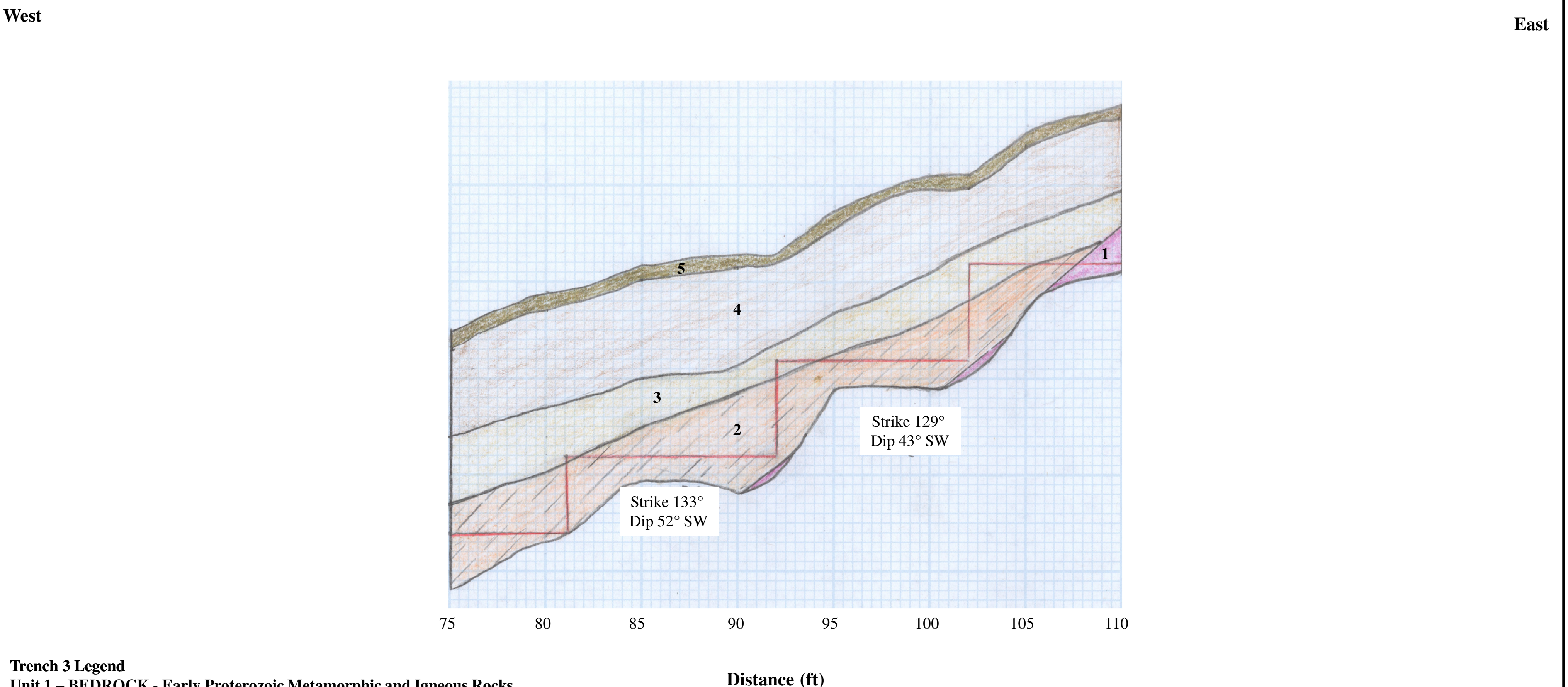
Fault Study
Dauphine-Savory Piedmont Subdivision
Ogden, Utah
Project Number: 910-001

Trench 3 North Wall Trench Log
0 to 75 Feet

GeoStrata

Plate
B-3

TRENCH 3 NORTH WALL



Trench 3 Legend
Unit 1 – BEDROCK - Early Proterozoic Metamorphic and Igneous Rocks
Unit 2 – Pleistocene-Aged Lacustrine Gravel Deposits, Transgressive Bonneville
Unit 3 – Pleistocene-Aged Lacustrine Fine-Grained Deposits, Transgressive Bonneville
Unit 4 – Holocene-Aged Colluvium and Alluvium
Unit 5 – Holocene-Aged Topsoil
Unit 6 – Holocene-Aged Historical Fill Soils

logged by T. Thompson

Fault Study
Dauphine-Savory Piedmont Subdivision
Ogden, Utah
Project Number: 910-001

Trench 3 North Wall Trench Log
75 to 110 Feet

Plate
B-4