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November 29, 2014

Ms. Dana Shuler
Weber County Engineering Department
c/o: Mr. Alan Taylor
Taylor Geotechnical
2650 North 180 East
Lehi, Utah 84043

Subject: Geologic Review
6472 and 6498 South Bybee Drive
Weber County Parcel Numbers: 07-753-0001 and 07-753-0002
Uintah, Utah
SBI Project No: 2-14-522

Report: GeoStrata Report: Geologic Hazards Assessment, Dauphine-Savory Piedmont Subdivision Lots 1R and 2R and adjacent 2-acre property, Weber County, Utah (GeoStrata Job No. 910-001), dated December 10, 2013: Prepared for: Matt Rasmussen, 2927 Melanie Lane, Ogden, UT 84403.

Geologic Review Status: ***INCOMPLETE***

Dear Ms. Shuler,

At your request, SBI reviewed the above referenced December 10, 2013, GeoStrata report. The purpose of SBI's review is to evaluate whether or not the GeoStrata documents adequately address geologic conditions at the site, consistent with concerns for public health, safety, and welfare; reasonable professional standards-of-care, and; the Weber County municipal code of ordinances. A field review of trenches and trench logs was not performed by SBI.

SBI recommends Weber County not consider the referenced GeoStrata report complete from a geologic perspective until GeoStrata addresses the items listed under SBI Recommendations.

GeoStrata Conclusions

GeoStrata conclusions follow.

1. GeoStrata conducted a surface fault rupture hazard assessment across building lot 1R as well as on the adjacent 2-acre parcel to assess these residential lots for surface fault rupture hazards.

2. Trenching was not completed on building lot 2R as it is located outside of the surficial faulting special study zone.

3. The western lots were selected for surface fault rupture hazard assessment because these two lots are located closest to the mapped location of the Weber segment of the Wasatch fault zone. Plate A-2 show the mapped locations of the Weber segment of the Wasatch fault zone as reported by Yonkee and Lowe (2004) and by Nelson and Personius (1993). 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 Christiansen and others (2003) for the upthrown side of the fault.

4. 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.

5. The fault mapped by Yonkee and Lowe (2004) was not observed in the trenches excavated by GeoStrata.

6. It is the opinion of GeoStrata that the fault mapped by Yonkee and Lowe (2004) is located to the west of our exploration trenches.

7. Based on the lack of any observed faulting in the Holocene-aged alluvial fan deposits observed at the bottom of both our exploratory trenches, it is our opinion that no active surface fault rupture-related deformation underlies the areas of the western two residential lots where the two trenches were excavated and observed.

8. 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.

9. 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.

10. The finer grained nature of the sediments observed in Trench 1 suggests that the area surrounding Trench 1 does not experience as many high energy events, with only one to two packets of debris flow sediment being observed.

11. Our observations suggest that the adjacent 2-acre property containing Trench 2 experiences higher energy events, with 5 to 6 stacked debris flow packets being observed within our excavation.

12. The debris flows likely originated from Broad Hollow drainage located to the east of the subject lots.

13. Based on these observations, 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.

14. 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. It is our recommendation that mitigation of alluvial fan flooding and debris flow hazards be designed prior to development of the site and implemented as part of construction. Given the location of Broad Hollow, alluvial fan flooding and debris flows affecting the site would come from the east to northeast.

15. Study of the Broad Hollow drainage basin and the entire alluvial fan deposit were outside the scope of this investigation.

16. Proper site grading and drainage planning will greatly reduce the potential for future alluvial fan flooding/debris flow events from impacting the proposed development, however, it is likely that further remediation for this property and adjoining properties, such as a catchment basin at the canyon mouth or redirecting berm will be required to properly minimize the potential for future impacts from alluvial fan flooding/debris flow events.

17. Based on observations made at the time of our investigation, the property owner has constructed a catchment up-gradient from the proposed development. While this basin will aid in reducing the potential for debris flow events from impacting the property, it remains a possibility that large events will surpass the volume of the basin, and as such it is recommended that strategic grading be implemented to create deflection berms and a break in slope away from each residence with slopes great enough and slope heights sufficient to allow alluvial fan

flooding/debris flow events from the east and northeast directions to flow around each residence.

18. These are likely the most feasible forms of mitigation available to the property owner at this time. 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 Recommendations

SBI recommends Weber County not consider the referenced GeoStrata report complete from a geologic perspective until GeoStrata addresses the following items:

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

   Plate A-1, Site Vicinity Map
   Plate A-2, Exploration Location Map
   Plate A-3, Surficial Geology Map
   Plate B-1, Trench 1 Log
   Plate B-2, 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.

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) indicate the orientation of the trench (Salt Lake County, 2002a, 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.

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 landscape 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.

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).

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 included 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.

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 regards 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.

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.

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

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 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.

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, GeoStrata report.

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."

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 the 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 Christiansen [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 the 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.

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 uncertainty in whether or not the trenches were excavated to a sufficient depth to observe Holocene-age 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 were 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 m) 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 projected 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 local 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 constrain the age of the most recent surface faulting event may be required (McCalpin, 1996).

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 18): "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.

Closure

Comments and recommendations in this review are based on data presented in the referenced Consultant's report. SBI accordingly provides no warranty that the data in the Consultant's report or any other referenced reports are correct or accurate. SBI has not performed an independent site evaluation. Comments and recommendations presented herein are provided to aid Weber County in reducing risks from geologic hazards and to protect public health, safety, and welfare. There is no other warranty, either express or implied.

All services performed by SBI for this review were provided for the exclusive use and benefit of Weber County; no other person or entity may or is entitled to use or rely upon any of the information or reports generated by SBI as a result of this review.

Should you have any questions, please feel free to contact the undersigned. The opportunity to be of service to Weber County is appreciated.

Very truly yours,

SBI

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References Cited

Birkeland, P.W., 1999, Soils and geomorphology, third edition: Oxford University Press, Inc., New York, New York, 430 p.

Bowman, S. D., Beisner, K., and Unger, C. 2009, Compilation of 1970s Woodward-Lundgren & Associates Wasatch fault investigation reports and oblique aerial photography, Wasatch Front and Cache Valley, Utah and Idaho: Utah Geological Survey Open file report OFR-548, 9 DVD set, 3 p, 6 plates.

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Draper City, 2007, Chapter 9-19 Geologic hazard ordinance of Title 9 Land use and development code for Draper City, adopted December 11, 2007.

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Nelson, A.R., and Personius, S.F., 1993, Surficial geologic map of the Weber segment, Wasatch fault zone, Weber and Davis Counties, Utah: U.S. Geological Survey Miscellaneous Field Studies Map MF-2199, scale: 1:50,000.

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Salt Lake County, 2002, Minimum standards for surface fault rupture hazard studies, Appendix A, Geologic hazards ordinance, Chapter 19.75 of the Salt Lake County zoning code of ordinances, adopted July 2002: Salt Lake County Planning and Development Services Division, 2001 South State Street, Suite N3700, Salt Lake City, Utah, 84190-4200, 9p.

AERIAL PHOTOGRAPHS

SOURCE	DATE	FLIGHT	PHOTOGRAPHS	SCALE
Farm Service Agency	1937	10-AAJ	3-16, 3-7, 3-50, 3-51	1:20,000
Bowman and others, 2009	1971	WF1-6	055, 056, 057	1:12,000
		WF2-5	141, 142, 143	1:12,000
		WF2-15	208, 209, 210, 211, 212, 213	1:6,000