



Staff Report for Administrative Approval
Hillside Review – Notice of Conditional Approval
Weber County Planning Division

Synopsis

Application Information

Application Request: Consideration and action on a request to approve a Hillside Review for the Mariani residence located on Lot 5 in the Big Sky No. 1 Subdivision.
Applicant: David and Gayle Mariani
File Number: HSR 2016-09

Property Information

Approximate Address: 2337 Panorama Circle Liberty, UT 84310
Project Area: 1.05 acres
Zoning: FV-3
Existing Land Use: Vacant
Proposed Land Use: Single Family Residence
Parcel ID: 22-042-0002
Township, Range, Section: 7N, 1E, 33

Adjacent Land Use

North: Residential	South: Residential
East: Residential	West: Residential

Staff Information

Report Presenter: Ronda Kippen
rkippen@co.weber.ut.us
 801-399-8768
Report Reviewer: RG

Applicable Ordinances

- Weber County Land Use Code Title 108 (Standards) Chapter 14 (Hillside Development Review)
- Weber County Land Use Code Title 104 (Zones) Chapter 27 (Natural Hazards Overlay District)

Background

It was determined during the building permit review process by the County Engineering Division that due to the potential of a geologic hazard being located on the site, the property would be subject to a Hillside Review. The property owner hired Western GeoLogic and GSH Geotechnical, Inc. to perform the required geologic and geotechnical investigation to determine if there is a geologic hazard located on the site in order to better design the home for safety purposes. Information related to the construction of the dwelling including a site plan, landscape plans, grading plans, the geologic and geotechnical reports, were distributed to the Hillside Review Board for comment. The plans have been reviewed and conditionally approved by all applicable review agencies.

Planning Division Review

The Planning Division Staff has determined that the requirements and standards provided by the Hillside Review Chapter have been met for the excavation and construction of the dwelling. The following submittals were required:

1. Proposed Building Plans including site plan, grading plan and landscape plan (see Exhibit A)
2. Geotechnical and Geologic Investigation Report (see Exhibit B)
3. Utah Pollution Discharge Elimination system (UPDES) Permit with Storm water Pollution Prevention Plan (See Building Permit Application Packet for UPDES and SWPPP)

Weber County Hillside Review Board comments

The Weber County Hillside Review Board, on this particular application, made comments related to the following:

Weber County Engineering Division: The Engineering Division granted approval on August 30, 2016. The approval is subject

to the applicant following all recommendations found in the applicable Geotechnical and Geological Investigation Reports and based on the following conditions:

1. Geologic staff must be on site to observe and test during site preparation and earthwork.
2. GSH must review the final grading plans for the project prior to initiation of any construction.
3. Surface drainage at the crest and toe of slopes, as well as on the uphill side of structures shall be diverted to keep from raising groundwater levels.

Subsequent recommendations may be necessary if additional geologic hazards are exposed during the excavation and construction phase of the dwelling.

Weber Fire District: The Fire district granted approval on October 19, 2016 subject to the following comments:

1. Provide a temporary address marker at the building site during construction.
2. Fire Access via Driveways: Driveways serving no more than 5 residences shall have a minimum clear width of 16 feet with a minimum of 12 feet of drive-able surface (measured from face of curb to face of curb) and a vertical clearance of 13 foot 6 inches and shall be capable of supporting a 75,000 pound load. Driveways in excess of 150 feet shall be provided with turn-arounds. Driveways exceeding 200 feet in length and less than 20 feet in width shall be provided with turnouts in addition to turnarounds. (See driveways- 2006 Wildland Urban Interface Code used as a reference for residential driveway requirements exceeding 150 feet in length). Roads and driveways shall also comply with City/County standards as applicable. In cases of differing requirements, contact the Fire Marshal for clarification.
3. All roads shall be designed, constructed, surfaced and maintained so as to provide an all-weather driving surface.
4. Fire access roads for this project shall be completed and approved prior to any combustible construction. Temporary roads shall meet the same requirements for height, width and imposed loads as permanent roads.
5. All required fire hydrants and water systems shall be installed, approved and fully functional prior to any combustible construction.

This review does not relieve the owner, contractor and/or developer from compliance with any and all applicable codes and standards. Any change or revision of this plan will render this review void and will require submittal of the new or revised layout for fire department review.

Weber County Building Inspection Department: The Building Inspection Department granted approval on October 18, 2016 based on the following conditions:

1. The geologist and geotechnical engineer will need to approve the soils prior to placement of footings.
2. Provide an acknowledgement from the Structural Engineer of the study

Weber-Morgan Health Department: The Health Department has reviewed the proposal and has made the following comment:

“As part of the hillside review process our office has commonly placed the burden on the applicant to show that a code compliant onsite wastewater treatment system may be installed on the property. The parcel has been deemed suitable for the installation of a packed bed media system using a design application rate of 0.35 gallon/day/sq foot with a maximum trench depth of 24 below original grade. The system may also be designed utilizing a drip irrigation drain field post packed bed media treatment system if desired.

No drain field may be installed on sloped in excess of 25%, and excavating to create slopes less than 25% by removal of topsoil may remove all permissible soils and should not be done before submittal and approval of a grading plan to our office.

As part of the hillside review what must be submit to our office is the location of a reasonably sized original and replacement septic drain field utilizing the aforementioned application rate, and the number of bedroom of which the system is being designed. If grading is required to accomplish the required footprint of the original and replacement septic drain field then a grading plan showing initial and post grading will be required.

Please refer to the Utah Administrative code R317-4 and the Weber-Morgan Health Department Onsite Wastewater System Regulation for all system requirements”

The applicant will need to address and meet all of the Weber-Morgan Health Department concerns prior to receiving approval of a building permit for Lot 5. The Hillside Review approval will be subject to and conditioned upon receiving approval from the Weber-Morgan Health Department.

Weber County Planning Division: The Planning Division staff is recommending approval subject to the applicant complying with all Board requirements and conditions. This approval is also subject to the applicant strictly adhering to the recommendations outlined in the geologic report by Western GeoLogic dated June 9, 2016 and the geotechnical report by GSH Job No. 2104-01N-16 dated July 15, 2016 including the following recommendations:

- All excavation shall be observed by a Western GeoLogic and GSH representative to assess the exposed foundation soils, to evaluate the site and to ensure that the recommendations presented in the Geotechnical and Geological Report have been compiled with.
- Western GeoLogic recommends that proper drainage is maintained to ensure the slope stability is not destabilized.
- Mass movement/landslide deposits must be removed in their entirety from beneath the proposed home and extending a minimum of 10 feet outside the home area. If this is not feasible, GSH must be contacted to provide additional recommendations for foundation support.
- A subdrain system must be installed upslope of the home and near the head of the mass movement deposit soils below the home to reduce the potential for surface water infiltration
- The on-site soils are not appropriate to be used as structural site grading fill; however, they may be used as general grading fill in landscape areas.
- A geotechnical engineer from GSH will need to verify that all mass movement deposit soils, fill material (if encountered) and topsoil/disturbed soils have been completely removed and suitable natural soils encountered prior to the placement of structural site grading fills, floor slabs, foundations, or rigid pavements.
- It is the client's responsibility to ensure that all designers, contractors and subcontractors are aware of these reports and that a representative from Western GeoLogic and GSH will be onsite during construction to ensure that all conditions and recommendations will be implemented.

Planning Division Recommendations

Based on site inspections and review agency comments, the Planning Division Staff has determined that it is necessary to impose additional requirements and conditions as part of approving HSR #2016-09. The recommendation for approval is subject to adherence to all review agencies conditions and based on the following conditions:

1. The geologist and geotechnical engineer will need to approve the soils prior to placement of footings.
2. A signed statement from the Structural Engineer must be provided to the Building Official acknowledging the study.
3. GSH must review the final grading plans for the project prior to initiation of any construction. A letter from GSH approving the final grading plans shall be provided to the Weber County Engineering Division.
4. All site preparation, earthwork and excavation shall be observed by a Western GeoLogic and GSH representative to assess the exposed foundation soils, to evaluate the site and to ensure that the recommendations presented in the Geotechnical and Geological Report have been compiled with.
5. Mass movement/landslide deposits must be removed in their entirety from beneath the proposed home and extending a minimum of 10 feet outside the home area. If this is not feasible, GSH must be contacted to provide additional recommendations for foundation support.
6. A subdrain system must be installed upslope of the home and near the head of the mass movement deposit soils below the home to reduce the potential for surface water infiltration
7. The on-site soils are not appropriate to be used as structural site grading fill; however, they may be used as general grading fill in landscape areas.
8. A geotechnical engineer from GSH will need to verify that all mass movement deposit soils, fill material (if encountered) and topsoil/disturbed soils have been completely removed and suitable natural soils encountered prior to the placement of structural site grading fills, floor slabs, foundations, or rigid pavements.
9. It is the client's responsibility to ensure that all designers, contractors and subcontractors are aware of these reports and that a representative from Western GeoLogic and GSH will be onsite during construction to ensure that all conditions and recommendations will be implemented.
10. All conditions and requirements of the Weber-Morgan Health Department will be addressed prior to receiving an approved building permit.

The recommendation is based on the following findings:

1. The application was submitted and with the required conditions, has been deemed complete.
2. The requirements and standards found in the Hillside Development Review Procedures and Standards Chapter have been met or will be met based on the outlined conditions during the excavation and construction phase

- of the dwelling.
3. The Hillside Review Board members reviewed the application individually and have provided their comments.
 4. The applicant has met or will meet, as part of the building permit process and/or during the excavation and construction phase of the dwelling, the requirements and conditions set forth by the Hillside Review Board. The Planning Division Staff has determined that the proposed improvements have been sited within the required setbacks for the FV-3 zone.

Administrative Approval

Administrative approval of Lot 5 in the Big Sky No. 1 Subdivision (HR#2016-09), is hereby granted based upon its compliance with the Weber County Land Use Code. This approval is subject to the requirements of applicable review agencies and is based on the recommendations, conditions and findings listed in this staff report.

Date of Administrative Approval: 11/17/16


Rick Grover
Weber County Planning Director

Exhibits

- A. Proposed Site and Building Plans
- B. Geotechnical and Geologic Investigation Report

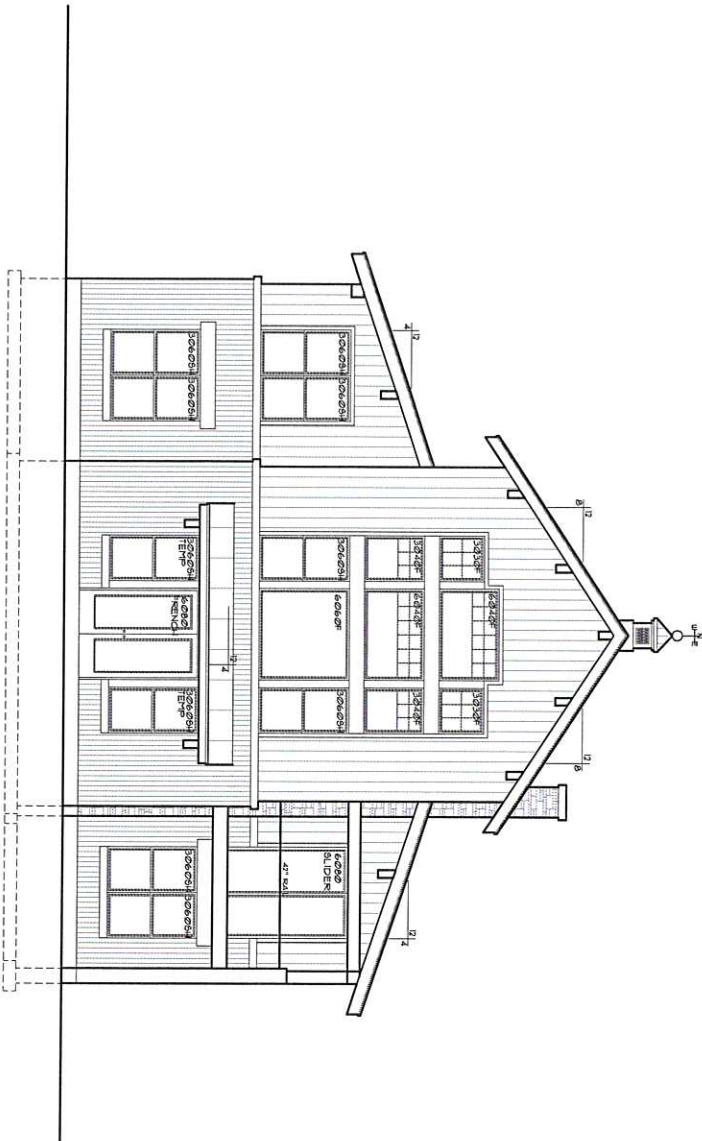
Map 1



Exhibit A-Site & Building Plans

A

REAR ELEVATION
SCALE: 1/8" = 1'-0"



THIS PLAN SHALL NOT BE USED FOR CONSTRUCTION WITHOUT THE APPROVAL OF THE ARCHITECT. ANY CHANGES TO THIS PLAN SHALL BE MADE BY THE ARCHITECT. THE ARCHITECT SHALL BE RESPONSIBLE FOR THE ACCURACY OF THE INFORMATION PROVIDED HEREON. THE ARCHITECT SHALL NOT BE RESPONSIBLE FOR THE ACCURACY OF THE INFORMATION PROVIDED BY OTHER SOURCES.

ALL RIGHTS RESERVED

PROJECT NAME: MARIANI RESIDENCE

LOCATION INFO: LOT # 5, SUBDIVISION BIG SKY ESTATES, COUNTY WEBER, STATE UTAH

CLIENT NAME: DAVE & GAYLE MARIANI

PLAN NAME: CUSTOM

ORIGINAL RELEASE: MAY 17, 2016

REVISION DATES: XXXXXXXXXX, XXXXXXXXXX, XXXXXXXXXX

DATE: 11/11/2016

428 S. LEGEND HILSDEN, 2000

07500 S. LEGEND HILSDEN, 2000

801.217.3122

ATTENTION: 11 of 8

DESIGN

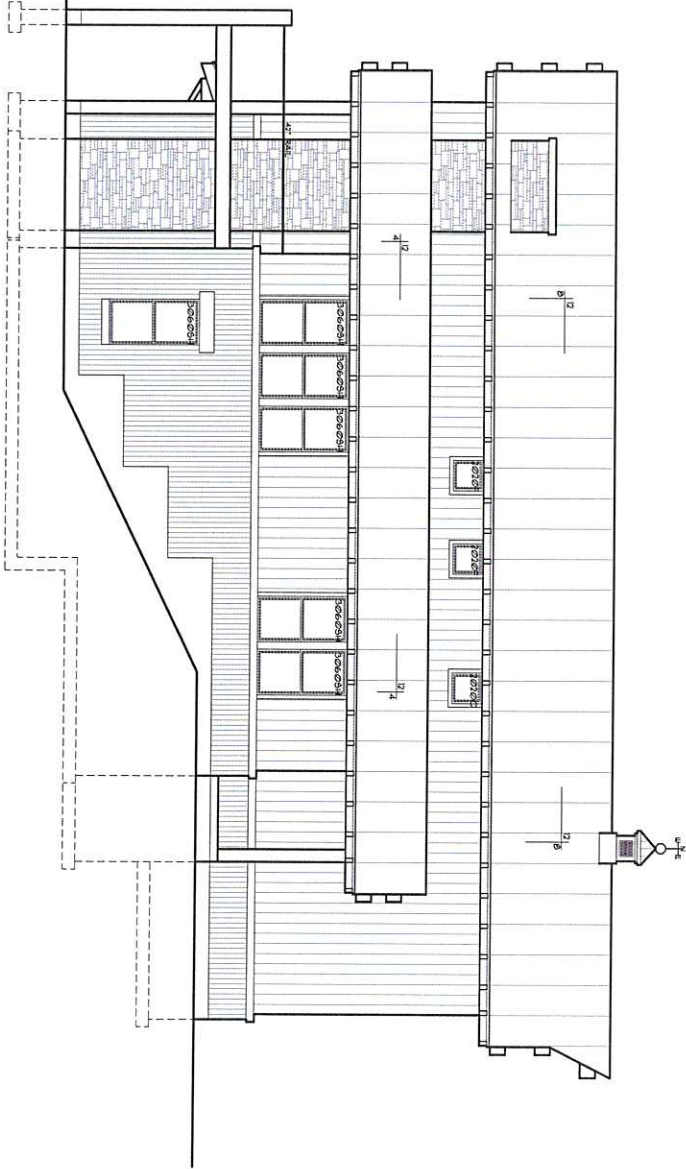
REAR ELEVATION

A2 | 2

PAGE 6 OF 25

Exhibit A-Site & Building Plans

A LEFT SIDE ELEVATION
SCALE: 1/8" = 1'-0"



DESIGN

MARSH, LESTER & ASSOCIATES, ARCHITECTS
 801 S. LEGION BLVD., SUITE 200
 SALT LAKE CITY, UT 84143
 801.217.3722

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PROJECT NAME:
 MARIANI
 RESIDENCE

LOCATION INFO:
 LOT #
 SUBDIVISION
 BIG SKY ESTATES

COUNTY:
 WEBER
STATE:
 UTAH

CLIENT NAME:
 DAVE & GAYLE
 MARIANI

PLAN NAME:
 CUSTOM

ORIGINAL RELEASE:
 MAY 17, 2016

REVISION DATES
 XXXXXXXXXX
 XXXXXXXXXX
 XXXXXXXXXX
 XXXXXXXXXX

**LEFT
 ELEVATION**

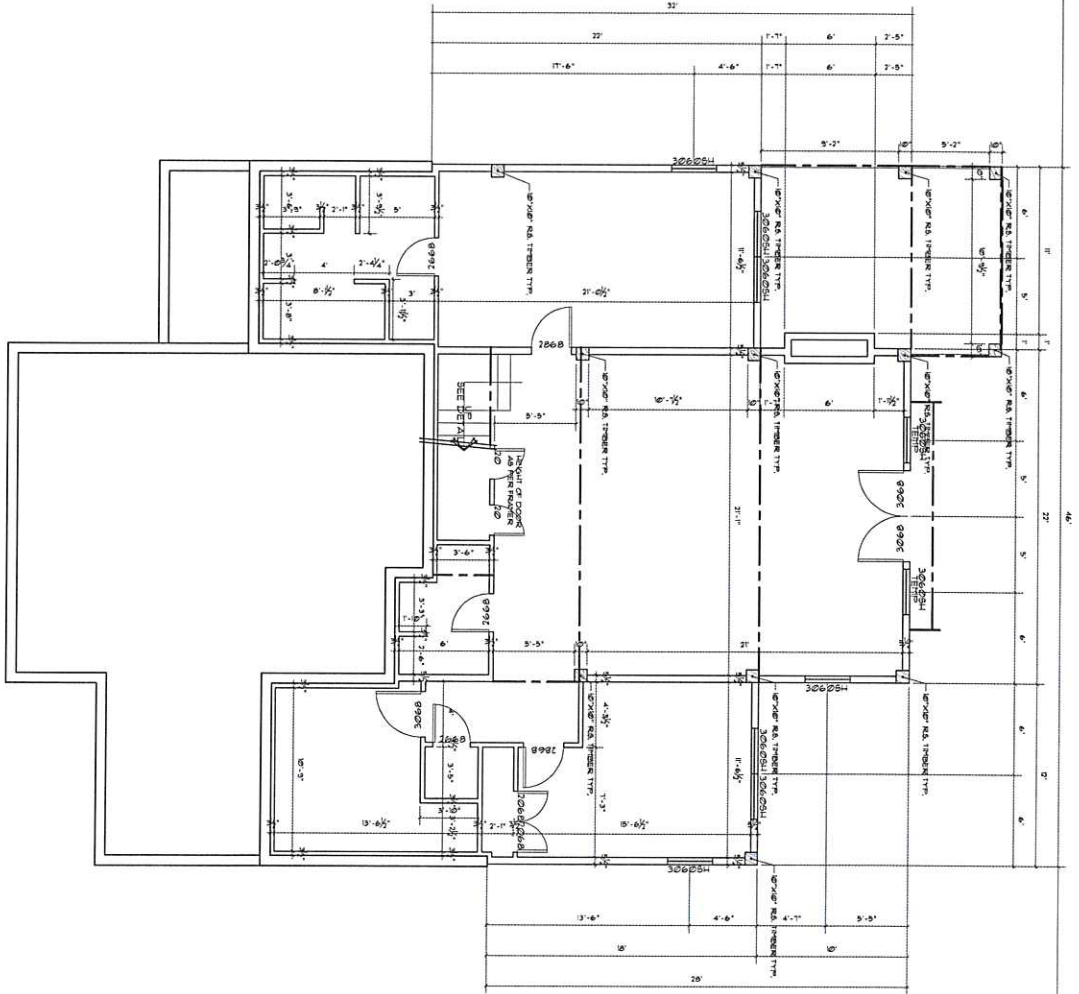
A2 | 3

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Exhibit A-Site & Building Plans

A

BASEMENT WALL FRAMING PLAN
SCALE: 1/8" = 1'-0"



DESIGN

1481 S. LEGION HILLS DR., #200
ALBANY, UTAH 84003
801.271.3322

ATTENTION

15
MARIANI RESIDENCE

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PROJECT NAME:
MARIANI RESIDENCE

LOCATION INFO:
LOT # 5
DIVISION
BIG SKY ESTATES
COUNTY WEBER
STATE UTAH

CLIENT NAME:
DAVE & GAYLE MARIANI

PLAN NAME:
CUSTOM

ORIGINAL RELEASE:
MAY 17, 2016

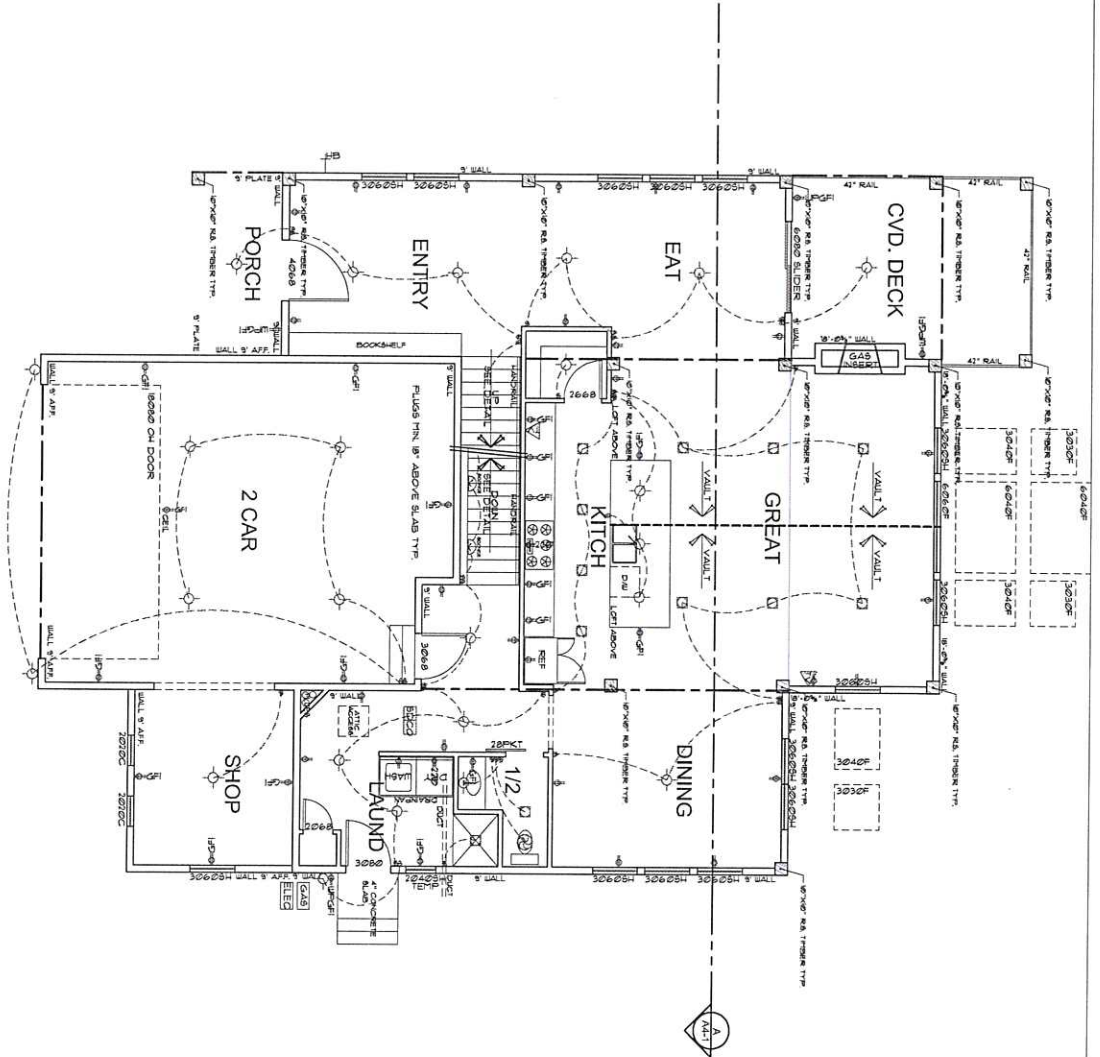
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BASEMENT WALL FRAMING PLAN

A3 | 2

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ELECTRICAL SCHEDULE

⊕	CELING MOUNTED RECESSED
⊕	WALL MOUNTED RECESSED
⊕	RECESSED FLOOR CANOP LIGHT
⊕	GRILL AIRFLOW RECESSED LIGHT
⊕	LARGE AIRFLOW RECESSED LIGHT
⊕	EXTERIOR RECESSED FLOOD LIGHT
⊕	RECESSED AS REFR COVER
⊕	FLOORSINK LIGHT
⊕	FLOOR HALL OR STAIR LIGHT
⊕	TRACK LIGHTS
⊕	CEILING FAN W/ LIGHT
⊕	CEILING FAN
⊕	EXHAUST FAN
⊕	EXHAUST FAN W/ LIGHT
⊕	EXHAUST FAN W/ HEATER
⊕	PROBE DETECTOR SMART DIAGNOSE
⊕	CARBON MONOXIDE DETECTOR
⊕	120 VOLT DIMMER OUTLET
⊕	120 VOLT 1/2" DIMMER FLOOR WALL INTERMEDIATE
⊕	120 VOLT 1/2" DIMMER 2" FLOOR OUTLET
⊕	TELEVISION CABLE JACK
⊕	TELEVISION CABLE JACK (CAN BE SHOWN W/ FLOOR OUTLET)
⊕	NORMAL SWITCH

WINDOW TYPE NOTE
 THE WINDOW TYPES SHOWN ON THIS PLAN ARE TO BE USED UNLESS OTHERWISE NOTED.
 W - 6" SINGLE HUNG F - ALUMINUM
 W - 6" DOUBLE HUNG F - ALUMINUM
 W - 6" CASING F - ALUMINUM

SHEETBOOK NOTE
 PROJECTOR OF THE STATE AND SPECIFIC REVISIONS TO THE PLAN SHALL BE INDICATED BY A CIRCLE WITH A NUMBER IN THE MIDDLE OF ANY LINE. THIS SPECIFICALLY INDICATED BY UNINTERRUPTED LINE ONLY. A CIRCLE WITH A NUMBER IN THE MIDDLE OF ANY LINE SHALL BE INDICATED BY A CIRCLE WITH A NUMBER IN THE MIDDLE OF ANY LINE.

DESIGN

DATE: 08/16/2016

PROJECT NAME: MARLANI RESIDENCE

LOCATION INFO: 5 SPURSON BIG SKY ESTATES WEBER UTAH

CLIENT NAME: DAVE & GAYLE MARLANI

PLAN NAME: CUSTOM

ORIGINAL RELEASE: MAY 17, 2016

REVISION DATES: XXXXXXXXXX
XXXXXXX
XXXXXXX

ATTENTION:

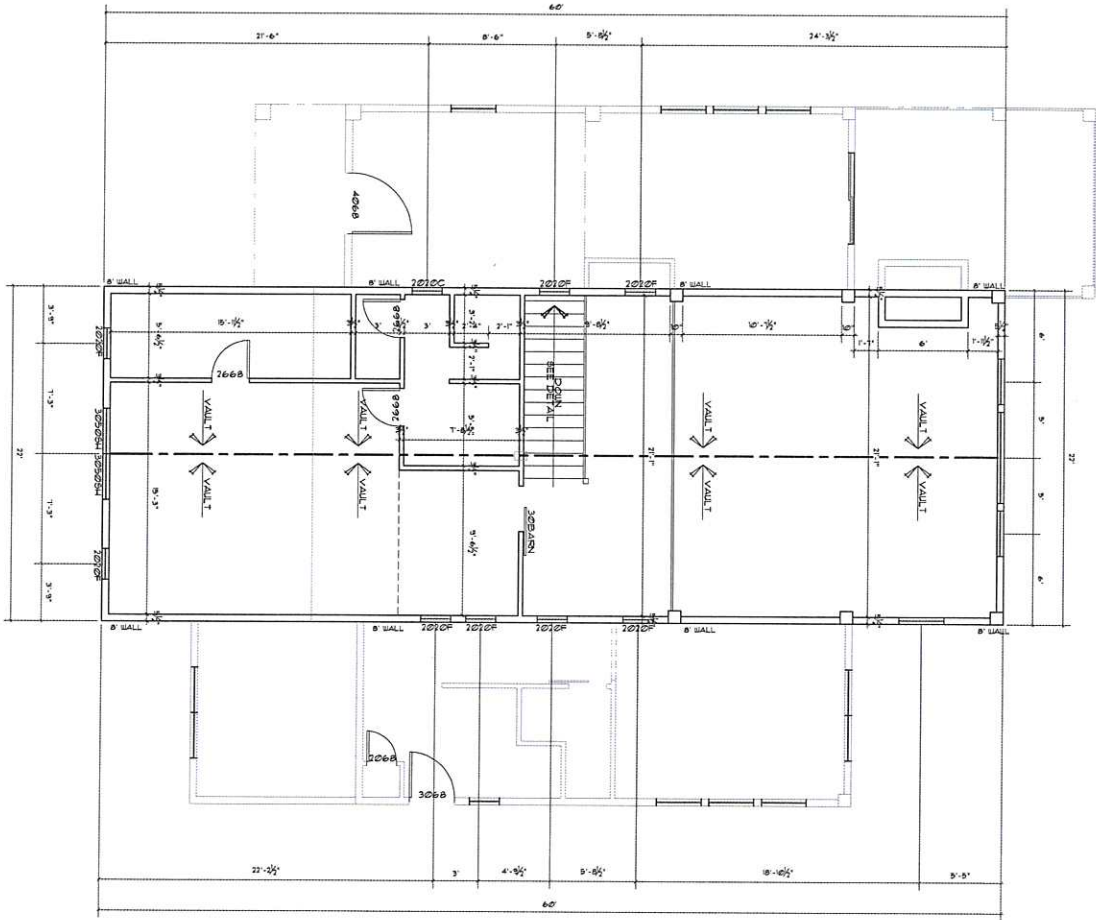
PLEASE REFER TO THE 2008 IBC FOR ALL ELECTRICAL REQUIREMENTS. THE ELECTRICAL SCHEDULE IS THE GOVERNING DOCUMENT FOR ALL ELECTRICAL WORK. ALL WORK SHALL BE IN ACCORDANCE WITH THE 2008 IBC AND ALL APPLICABLE CODES.

ALL RIGHTS RESERVED

Exhibit A-Site & Building Plans

A

UPPER FLOOR WALL FRAMING PLAN
SCALE: 1/8" = 1'-0"



DESIGN
1438 S. LEGEND HILLS DR. #200
SALT LAKE CITY, UT 84119
801.217.2222

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PROJECT NAME:
MARIANI
RESIDENCE

LOCATION INFO:
LOT #
5
DIVISION/
BIG SKY ESTATES
COUNTY
WEBER
STATE
UTAH

CLIENT NAME:
DAVE & GAYLE
MARIANI

PLAN NAME:
CUSTOM

ORIGINAL RELEASE:
MAY 17, 2018
REVISION DATES
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UPPER FLOOR
WALL FRAMING
PLAN

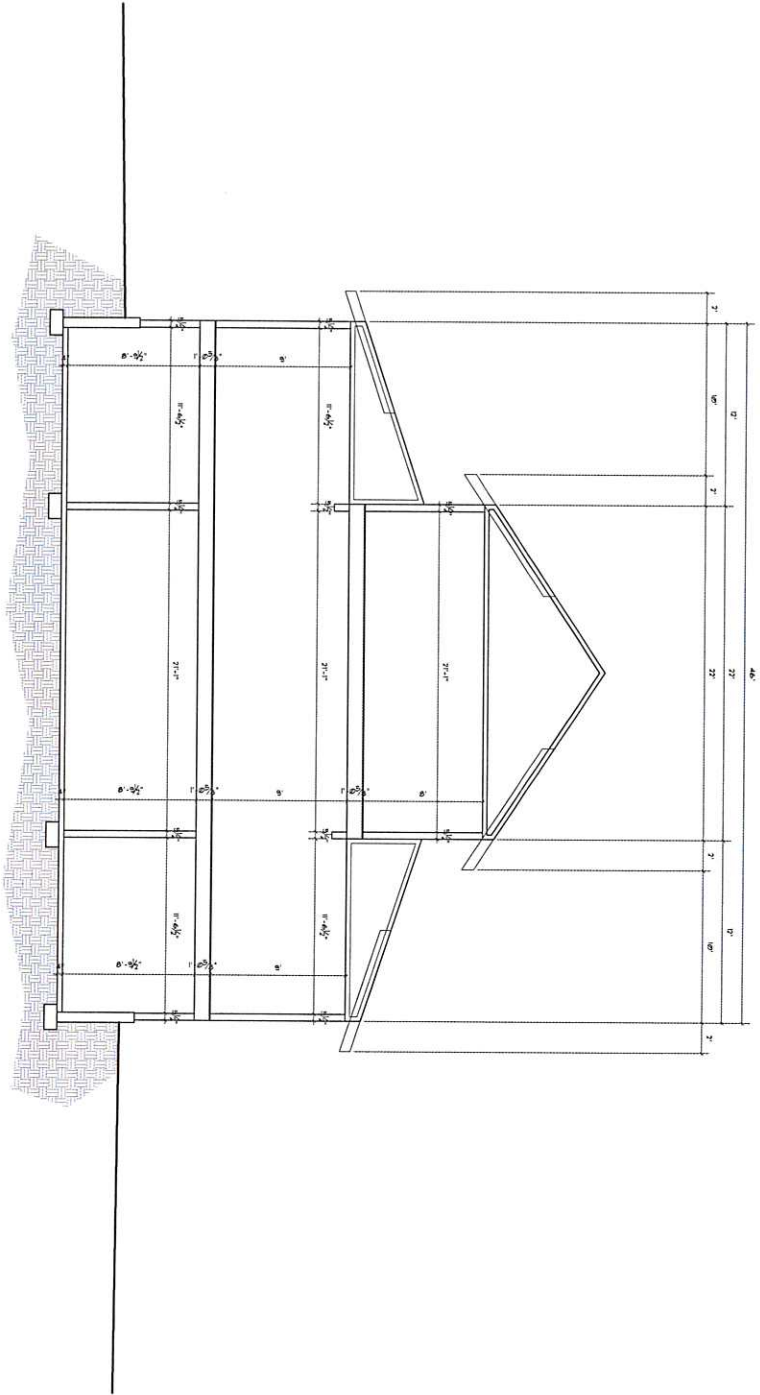
A3 | 6

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Exhibit A-Site & Building Plans

A

HOUSE SECTION 1
SCALE: 1/8" = 1'-0"



438 S. LEGEND HILLS DR., #200
CLARKFIELD, UTAH 84303
801.217.3121

ATTENTION
MEL DEBONO, PROJECT ARCHITECT
MARIANI RESIDENCE
2008
2008

PLEASE DO NOT SCALE THIS DRAWING
FOR THE CONSTRUCTION OF ANY
PARTS THEREOF. ALL DIMENSIONS
SHOWN ON THIS DRAWING SHALL
CONTROL OVER ANY DIMENSIONS
OBTAINED BY SCALING.

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PROJECT NAME:
MARIANI
RESIDENCE

LOCATION INFO:
LOT #
5

SUBDIVISION:
BIG SKY ESTATES

COUNTY:
WEBER
STATE:
UTAH

CLIENT NAME:
DAVE & GAYLE
MARIANI

PLAN NAME:
CUSTOM

ORIGINAL RELEASE:
MAY 17, 2018

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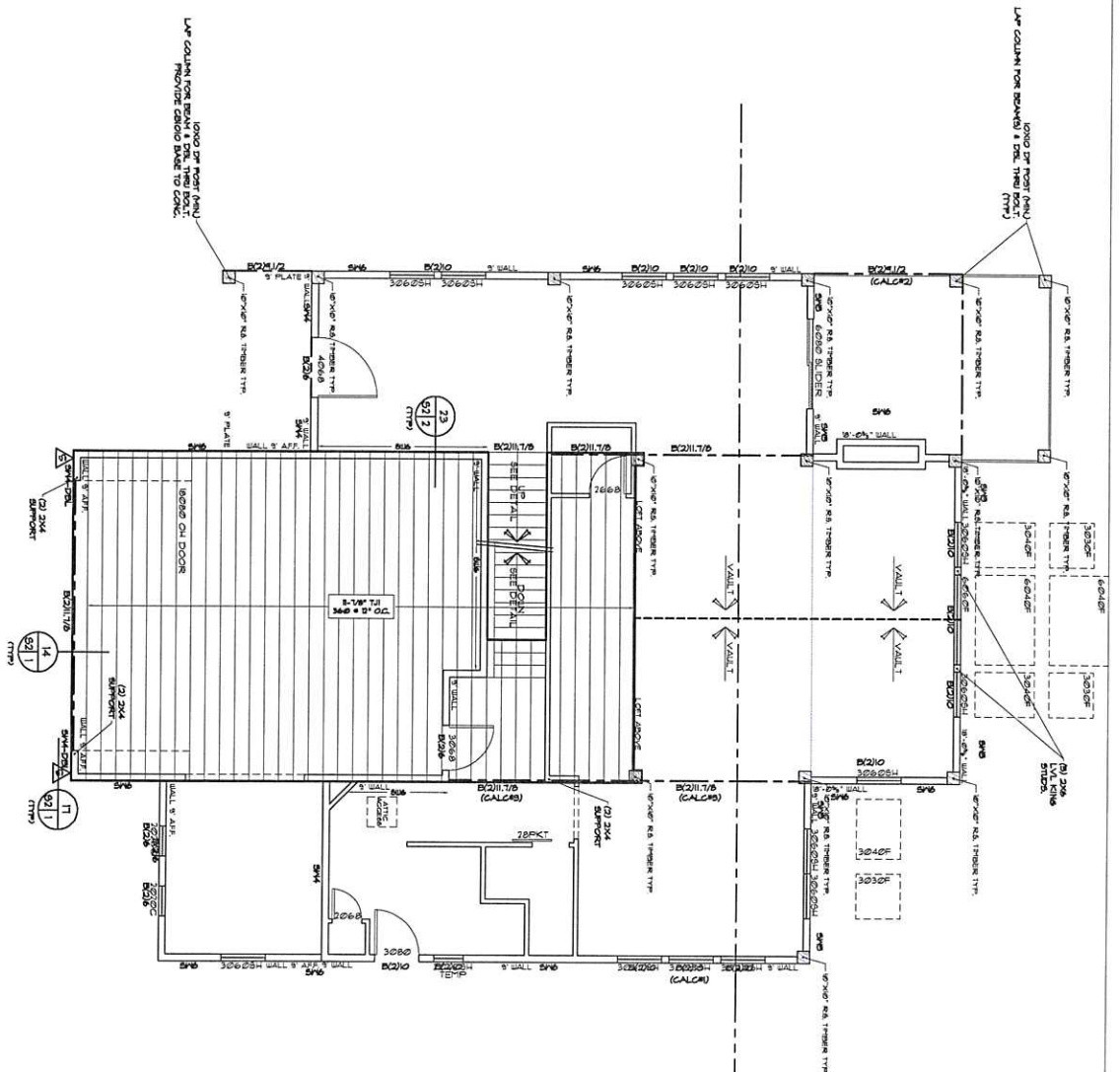
HOUSE SECTIONS

A4 | 1

PAGE 15 OF 25

Exhibit A-Site & Building Plans

A UPPER FLOOR FRAMING PLAN
SCALE: 1/8" = 1'-0"



VERTICAL FINISHING STRUC.
SEE SHEET S29 FOR ROOF FINISHING STRUC.
SEE SHEET S29 FOR ROOF FINISHING STRUC.
SEE SHEET S29 FOR ROOF FINISHING STRUC.

SEE SHEET S29 FOR ROOF FINISHING STRUC.
SEE SHEET S29 FOR ROOF FINISHING STRUC.
SEE SHEET S29 FOR ROOF FINISHING STRUC.
SEE SHEET S29 FOR ROOF FINISHING STRUC.

BEAM SCHEDULE EX	SEE NOTES 1,2,3,4,5	FIN. UNITS	TYPE
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B2197	21' 2" X 8" @ 20'	1	224
B2198	21' 2" X 8" @ 20'	1	224
B2199	21' 2" X 8" @ 20'	1	224
B2200	21' 2" X 8" @ 20'	1	224

DESIGN

148 S. LEGEND HALL DR. #200
SALT LAKE CITY, UT 84115
801.217.3120

ATTENTION
THIS SHEET IS PART OF THE 198D
CONSTRUCTION OF AN
INDUSTRIAL BUILDING. THE
OWNER SHALL BE RESPONSIBLE
FOR THE PROTECTION OF THE
DRAWING FROM ANY
UNAUTHORIZED REPRODUCTION.

© ALL RIGHTS RESERVED

PROJECT NAME:
MARIANI
RESIDENCE

LOCATION INFO:
3 SUPERSON
BIG SKY ESTATES
WEBER
STATE
UTAH

CLIENT NAME:
DAVE & GAYLE
MARIANI

PLAN NAME:
CUSTOM

ORIGINAL RELEASE:
MAY 17, 2018

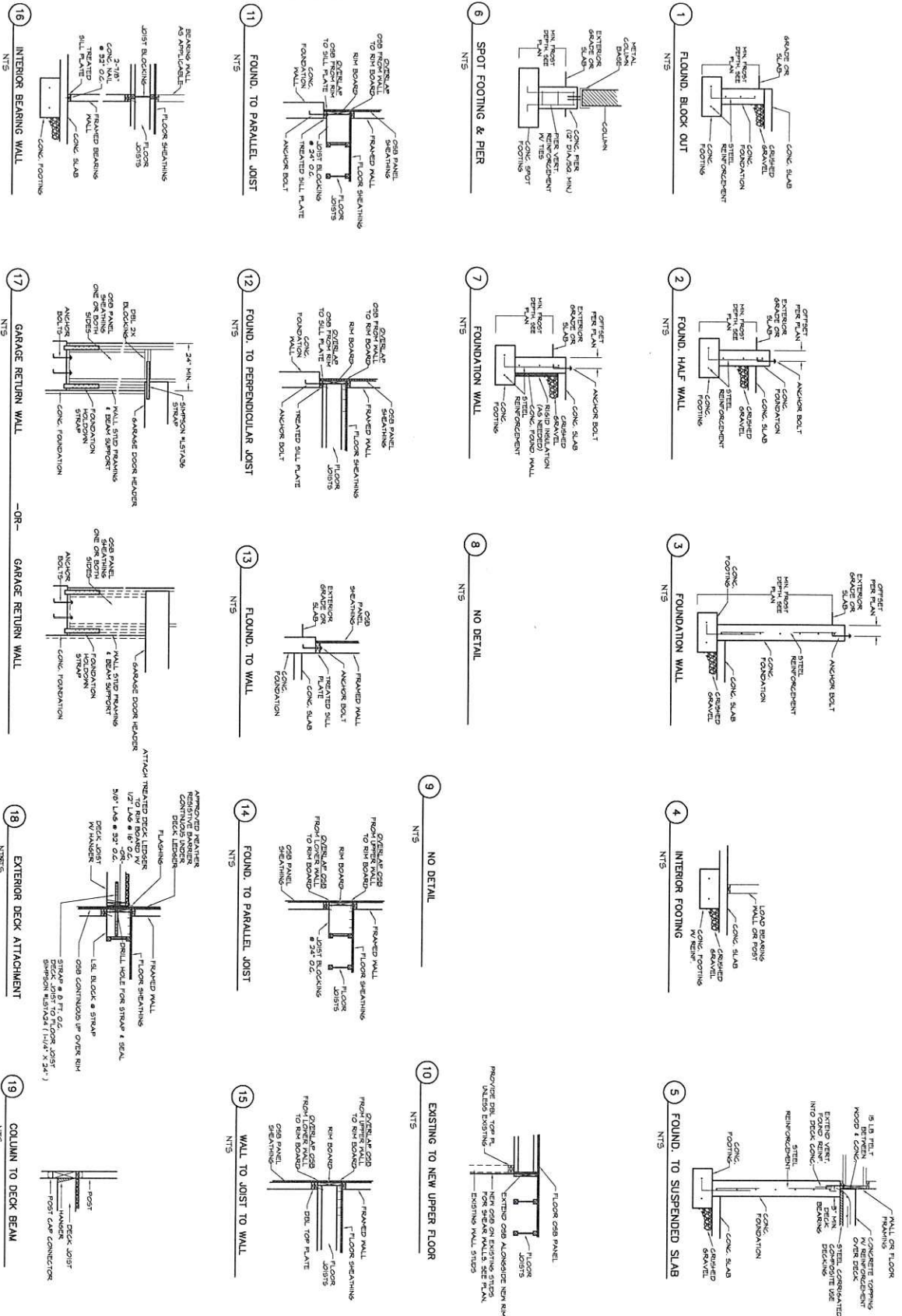
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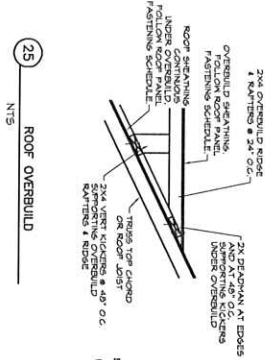
UPPER FLOOR FLOOR FRAMING PLAN

S1 | 3

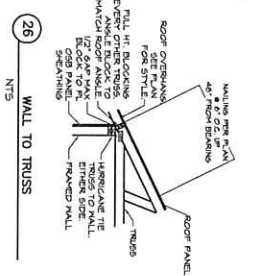
PAGE 21 OF 25

Exhibit A-Site & Building Plans

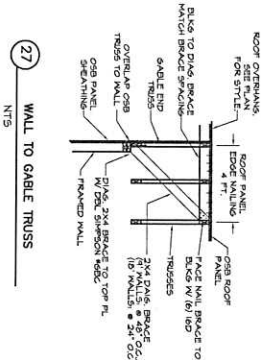




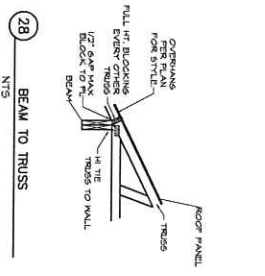
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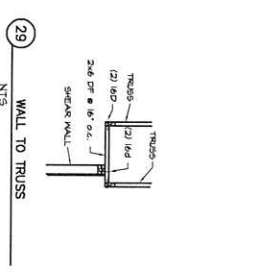
21 NO DETAIL
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22 NO DETAIL
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23 ATTIC TRUSS TO FLOOR
NTS



24 PORCH ROOF OVERHANG
NTS

25 ROOF OVERBUILD
NTS

26 WALL TO TRUSS
NTS

27 WALL TO GABLE TRUSS
NTS

28 BEAM TO TRUSS
NTS

29 WALL TO TRUSS
NTS

REPORT

GEOLOGIC HAZARDS EVALUATION

LOT 5 BIG SKY ESTATES NO. 1

2337 NORTH PANORAMA CIRCLE

LIBERTY, WEBER COUNTY, UTAH



Prepared for

Gayle Mariani
PO Box 1202
Eden, Utah 84310

June 9, 2016

Prepared by

Western Geologic, LLC
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June 9, 2016

Gayle Mariani
PO Box 1202
Eden, Utah 84310

SUBJECT: Geologic Hazards Evaluation
Lot 5 Big Sky Estates No. 1
2337 North Panorama Circle
Liberty, Weber County, Utah

Dear Ms. Mariani:

This report presents results of an engineering geology and geologic hazards review and evaluation conducted by Western GeoLogic, LLC (Western GeoLogic) for Lot 5 in the Big Sky Estates No. 1 Subdivision at 2337 North Panorama Circle in Liberty, Weber County, Utah (Figure 1 – Project Location). The site is at the margin of northwestern Ogden Valley at the eastern base of the Wasatch Range in the NW1/4 Section 33, Township 7 North, Range 1 East (Salt Lake Base Line and Meridian; Figure 1). Elevation of the site ranges from about 5,546 feet to 5,614 feet above sea level. It is our understanding that the current intended site use is for development of one residential home in the south-central part of the site.

PURPOSE AND SCOPE

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

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

- A site reconnaissance conducted by an experienced certified engineering geologist to assess the site setting and look for adverse geologic conditions;
- Excavation and logging of three test pits on April 28, 2016 to evaluate subsurface conditions at the property;

- Review of readily-available geologic maps, reports, and air photos; and
- Evaluation of available data and preparation of this report, which presents the results of our study.

The engineering geology section of this report has been prepared in accordance with current generally accepted professional engineering geologic principles and practice in Utah, and meets specifications provided in Chapter 27 of the Weber County Land Use Code.

HYDROLOGY

The U.S. Geological Survey (USGS) topographic map of the Huntsville Quadrangle shows the site is at the western margin of Ogden Valley between Pole Canyon and Coal Hollow Creeks, and is on southwest- to east-facing slopes slightly below a hilltop overlooking the southern end of Nordic Valley to the west (Figure 1). Pole Canyon Creek flows to the north about 560 feet west of the property. Nordic Valley Ski Area is about 0.8 miles to the northwest. No active drainages are shown crossing the site on Figure 1, and no springs or seeps were observed at the site or are shown in the site area on Figure 1.

The site is the western margin of Ogden Valley about 1.3 miles northwest of the north arm of Pineview Reservoir. The valley bottom to the east is dominated by unconsolidated lacustrine and alluvial basin-fill deposits, whereas slopes in the site area are mainly in weathered Tertiary-age tuffaceous bedrock and landslide colluvium from a complex series of overlapping failures since Late Pleistocene time. The Utah Division of Water Rights Well Driller Database shows one water well about 1,500 feet southwest of the property that has a reported depth to static groundwater of 50 feet, but no site-specific groundwater information was available and no groundwater was encountered in the boring conducted by GSH at the property to its explored depth of 29 feet. Given all the above, we anticipate the depth to the shallow aquifer at the Project is somewhere between 50 and 100 feet. However, groundwater depths at the site likely vary seasonally from snowmelt runoff and annually from climatic fluctuations. Such variations would be typical for an alpine environment. Perched conditions above less-permeable, clay-rich bedrock layers may also be present in the subsurface that could cause locally shallower groundwater levels.

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

GEOLOGY

Surficial Geology

The site is located on the northwestern margin of Ogden Valley, a sediment-filled intermontane valley within the Wasatch Range, a major north-south trending mountain range marking the eastern boundary of the Basin and Range physiographic province (Stokes; 1977, 1986). Surficial geology of the site is shown on unpublished, 1:24,000-scale, Utah Geological Survey (UGS) mapping from 2014 (Figure 2). The 2014 mapping is part of an ongoing surficial geologic mapping project for Ogden Valley that will be, in part, incorporated into an optimized update of Coogan and King (2001). The unpublished mapping was provided for this report since it represents the most-recent geologic information available for the area, although it will be replaced by the official optimized map.

Figure 2 shows the site in bedrock of the Norwood Formation (unit Tn, Figure 2). Descriptions of geologic units within 0.5 miles of the site from the adjoining Snow Basin Quadrangle (King and others, 2008) are as follows:

***Qaf** – Alluvial-fan deposits, undivided (Holocene and Pleistocene).* Mostly sand, silt, and gravel that is poorly bedded and poorly sorted; includes debris flows, particularly in drainages and at drainage mouths (fan heads); generally less than 60 feet (18 m) thick. Mapped where fan age uncertain or for composite fans where portions of fans with different ages cannot be shown separately at map scale.

***Qaf1, Qafy** – Younger alluvial-fan deposits (Holocene and uppermost Pleistocene) –* Mostly sand, silt, and gravel that is poorly bedded and poorly sorted; includes debris flows, particularly in drainages and at drainage mouths (fan heads); generally less than 40 feet (12 m) thick. Near late Pleistocene Lake Bonneville, deposits with suffixes 1 and y are younger than Lake Bonneville (mostly Holocene), are active, and impinge on present-day drainages like the Weber River and Cottonwood Creek; Qafy fans may be partly older than Qaf1 fans, and may be as old as uppermost Pleistocene Provo shoreline.

***Qmdf** – Debris- and mud-flow deposits (Holocene and uppermost Pleistocene).* Poorly sorted, clay- to boulder-sized material, typically with distinct natural lateral levees, channels, and lack of vegetation; older deposits can be vegetated; 0 to 40 feet (0-12 m) thick.

***Qms, Qms1, Qmsy, Qmso** – Landslide and slump deposits (Holocene and Pleistocene).* Poorly sorted clay- to boulder-sized material; locally includes flow deposits; generally characterized by hummocky topography, main and internal scarps, and chaotic bedding in displaced blocks; composition depends on local sources; morphology becomes more subdued with time and amount of water in deposits; Qms may be in contact with Qms when two different slide/slumps abut; locally, unit involved in slide/slump is shown in parentheses where a nearly intact block is visible; Qms and Qmso queried (?) where bedrock block may be in place;

thickness highly variable, boreholes in Rogers (1986) show thicknesses of about 20 to 30 feet (6-9 m) on small slides/flows. *Qms* without suffix is mapped where age uncertain (though likely Holocene and/or upper Pleistocene), where portions of slide/slump complexes have different ages but cannot be shown separately at map scale, or where boundaries between slides/slumps of different ages are not distinct. Estimated time of emplacement indicated by relative age number and letter suffixes with: 1 - likely emplaced in the last 80 to 150 years, mostly historical; y - post-Lake Bonneville in age and mostly pre-historic; and o - likely emplaced before Lake Bonneville transgression. Suffixes y (as well as 1) and o indicate probable Holocene and Pleistocene ages, respectively. *Qmso* typically mapped where rumped morphology typical of mass movements has been diminished and/or younger surficial deposits cover or cut *Qmso*. These older deposits are as unstable as other landslides and slumps, and are easily reactivated with the addition of water, be it irrigation or septic tank drain fields.

Qmc – Landslide and slump, and colluvial deposits, undivided (Holocene and Pleistocene). Mapped where landslides and slumps are difficult to distinguish from colluvium (slopewash and soil creep) and where mapping separate, small, intermingled areas of slides and slumps, and colluvial deposits is not possible at map scale; locally includes talus and debris flows; typically mapped where landslides and slumps are thin (“shallow”); also mapped where the blocky or rumped morphology that is characteristic of landslides and slumps has been diminished (“smoothed”) by slopewash and soil creep; composition depends on local sources; 0 to 40 feet (0-12 m) thick. These deposits are as unstable as other landslides and slumps units (*Qms*).

Qac – Alluvium and colluvium (Holocene and Pleistocene). Includes stream and fan alluvium, colluvium, and, locally, mass-movement deposits; 0 to 20 feet (0-6 m) thick.

Qls – Lake Bonneville sand (upper Pleistocene). Mostly sand with some silt and gravel deposited nearshore in Morgan Valley; typically less than 20 feet (6 m) thick, but thicker in “bench” east of Cottonwood Creek in southeast corner of Snow Basin quadrangle.

Qafp, Qafb, Qafo – Older alluvial-fan deposits (upper and middle(?) Pleistocene). Incised fans of mostly sand, silt, and gravel that is poorly bedded and poorly sorted; includes debris flows, particularly in drainages and at drainage mouths (fan heads); generally less than 60 feet (18 m) thick. Fans labeled *Qafp* and *Qafb* are graded to the Provo (and slightly lower) and Bonneville shorelines of late Pleistocene Lake Bonneville, respectively. Near Lake Bonneville, unit *Qafo* is older than (above and typically incised/eroded at) the Bonneville shoreline; upstream unit *Qafo* is topographically higher than fans graded to the Bonneville shoreline (*Qafb*). Elsewhere relative-age letters only apply to local drainages. Like *Qa* and *Qat* suffixes, ages are partly based on heights above present drainages (table 1), in this case heights at drainage-eroded edge of fan, with *Qafp* about 35 to 45 feet (10 to 12 m) above, *Qafb* 50 to 75 feet (15-23 m) above, and *Qafo* about 70 to 110 feet (20-35 m) above present drainages. Dates presented in Sullivan and Nelson (1992) imply

Qaf to southeast in Morgan quadrangle considerably predates Lake Bonneville and is middle Pleistocene in age (300-600 ka). This means these older fans could be related to Pokes Point lake cycle (at about 200 ka, after McCoy, 1987) (Kansan continental glaciation?, 300-400 ka) and/or pre Pokes Point (Nebraskan continental glaciation?, >500 ka); however, the Bonneville shoreline is obscure on this fan.

Tn – Norwood Formation (lower Oligocene and upper Eocene) - Typically light-gray to light brown, altered tuff (claystone), tuffaceous siltstone, sandstone, and conglomerate; locally colored light shades of red and green; variable calcareous cement and zeolitization, that is less common to south of Snow Basin quadrangle; zeolite marker beds mapped as an aid to recognizing geologic structure; locally includes landslides and slumps that are too small to show at map scale.

Upper Norwood Formation, as exposed on east margin of Snow Basin quadrangle and to east in Durst Mountain quadrangle, contains interbedded claystone (tuffaceous beds), fine- to coarse-grained sandstone, gray granule to small pebble conglomerate, with chert and carbonate clasts, as well as conglomerate interbeds with quartzite pebble clasts like those in unit Tcg; interbedded with more extensive quartzite-clast conglomerate, some mapped as Tcg, to east in Durst Mountain quadrangle (see Coogan and King, 2006); north of Wasatch Formation (Tw) knob on Snow Basin-Durst Mountain quadrangle boundary, the Norwood contains intermittent quartzite gravel (quartzite-richest exposures mapped as Tcg?); also, gravel-rich beds containing mostly chert and carbonate clasts are common north of the knob, and with quartzite-bearing beds, are involved in multiple landslides that obscure bedding and structure; these variations and disruptions make it difficult to map a consistent Tcg-Tn contact (see also unit Tcg description above and in Coogan and King, 2006); based on outcrop pattern, dip, and topography, Norwood is at least 7000 feet (2135 m) thick in Snow Basin quadrangle; it thins to the south, so is about 5000 feet (1525 m) thick north of Morgan, and only about 1500 feet (460 m) thick east of East Canyon Creek in the type area in Porterville quadrangle (Eardley, 1944) (not 2500+ feet [800+ m] inferred by Bryant and others, 1989, p. K6).

Zeolite beds mapped in the Norwood indicate a generally east-dipping homocline with minor faulting. A broad, north-south-oriented, doubly plunging syncline is superimposed on the homocline but the east limb of the syncline and companion anticline are obscured by landslide complexes. The common fold limb may dip steeply to the west. Also the zeolite beds become obscure to the east, due to the increased abundance of clastic sediment, making the zeolite beds thinner and less pure, and therefore less distinct. Norwood generally considered younger than the Fowkes Formation, but not well dated due to alteration. Corrected Norwood K-Ar ages are 38.4 Ma (sanidine) from Norwood type area (Evernden and others, 1964) and 39.3 Ma (biotite) from farther south in East Canyon (Mann, 1974), while Fowkes $^{40}\text{Ar}/^{39}\text{Ar}$ ages are 40.41 Ma and 38.78 Ma on biotite and hornblende, respectively, from Utah to east near Wyoming (Coogan and King, unpublished). To north in southern Cache Valley, basal part of unit similar to Fowkes and Norwood (“resting” on Wasatch and less than 600 feet [180 m] or about 1200 feet [260 m] thick) dated at 44.2 ± 1.7 Ma

and 48.6 ± 1.3 Ma K-Ar on hornblende and biotite, respectively (Smith, 1997; King and Solomon, 2008); though the biotite date is suspect, its age is similar to older dates on the Fowkes Formation in Wyoming, which are: 47.94 ± 0.17 Ma ($^{40}\text{Ar}/^{39}\text{Ar}$, sanidine) at the northeast end of the Crawford Mountains (Smith and others, 2008, p. 67), south of the Fowkes type area (see Oriol and Tracey, 1970); 49.1 Ma (biotite; recalculated; dated in 1977, but decay constant not reported, so may not need to be recalculated), reported as 47.9 ± 1.9 Ma by Nelson (1979) and likely from near the base of the Fowkes near Evanston, Wyoming (Nelson, 1973); and 48.9 Ma K-Ar (hornblende; recalculated) from the Fowkes type area near Leefe, Wyoming (47.7 ± 1.5 Ma, Oriol and Tracey, 1970). The Norwood is different in the southern Peterson and Morgan quadrangles, near the type area (see Eardley, 1944), where it contains extensive unaltered tuff (hence the name Norwood Tuff), has cut-and-fill structures (fluvial), and includes volcanic-clast conglomerate; in the Morgan quadrangle, it also contains local limestone and silica-cemented rocks. Unit referred to here as Norwood Formation, rather than Norwood Tuff, because the type area includes only part of the formation (see thickness in following paragraph), the Norwood contains many lithologies, and this emphasizes that it is not tuffaceous away from the type area.

Citations in the above unit descriptions are provided in King and others (2008).

Figure 2 shows several strike and dip measurements in Norwood Formation in the site area. Those shown in black were measured by the UGS, whereas those in purple are from U.S. Geological Survey (USGS) data (Jon King, Utah Geological Survey, verbal communication, February 29, 2016). The nearest measurement is about 750 feet south of the property and shows a strike/dip of $\text{N}46^\circ\text{W } 40^\circ \text{NE}$. Several additional measurements are to the east and southeast that show generally northwest-trending strikes and dips generally between about 27 to 46 degrees to the northeast. Norwood Formation bedrock in the area has average dips of about 30 to 45 degrees, although this unit has local depositional variations that may produce lower and higher dips within a relatively short distance (Jon King, Utah Geological Survey, verbal communication, February 29, 2016).

Seismotectonic Setting

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

has continued to the present (Zoback and Zoback, 1989; Zoback, 1989). The back valleys are morphologically similar to valleys in the Basin and Range, but exhibit less structural relief (Sullivan and others 1988).

Ogden Valley occupies a structural trough created by up to 2,000 feet of vertical displacement on normal faults bounding the east and west sides of the valley. The Ogden Valley southwestern margin fault and North Fork fault (Black and others, 2003) are shown on Figure 2 trending northwestward about 1,100 feet to the southwest and 4,150 feet to the northeast, respectively. The most recent movement on these faults is pre-Holocene (Sullivan and others, 1986). The faults are concealed where mantled by Late Pleistocene and Holocene surficial deposits (Figure 2, dashed and dotted bold lines). Norwood Formation mapped in the site area (Figure 2, unit Tn) likely represents an in-place faulted block preserved between the faults (Jon King, Utah Geological Survey, verbal communication, February 29, 2016).

The site is also situated near the central portion of the Intermountain Seismic Belt (ISB). The ISB is a north-south-trending zone of historical seismicity along the eastern margin of the Basin and Range province which extends for approximately 900 miles from northern Arizona to northwestern Montana (Sbar and others, 1972; Smith and Sbar, 1974). At least 16 earthquakes of magnitude 6.0 or greater have occurred within the ISB since 1850, with the largest of these events the M_s 7.5 1959 Hebgen Lake, Montana earthquake. However, none of these events have occurred along the Wasatch fault zone or other known late Quaternary faults in the region (Arabasz and others, 1992; Smith and Arabasz, 1991). The closest of these events to the site was the 1934 Hansel Valley (M_s 6.6) event north of the Great Salt Lake and south of the town of Snowville.

Lake Bonneville History

Lakes occupied nearly 100 basins in the western United States during late-Quaternary time, the largest of which was Lake Bonneville in northwestern Utah. The Bonneville basin consists of several topographically closed basins created by regional extension in the Basin and Range (Gwynn, 1980; Miller, 1990), and has been an area of internal drainage for much of the past 15 million years. Lake Bonneville consisted of numerous topographically closed basins, including the Salt Lake and Cache Valleys (Oviatt and others, 1992). Portions of Ogden Valley were inundated by Lake Bonneville at its highstand. Sediments from Lake Bonneville are not mapped at the site, but are shown at lower elevations to the east and northeast on Figure 2.

Timing of events related to the transgression and regression of Lake Bonneville is indicated by calendar age estimates of significant radiocarbon dates in the Bonneville Basin (Oviatt, 2015). Approximately 30,000 years ago, Lake Bonneville began a slow transgression (rise) to its highest level of 5,160 to 5,200 feet above mean sea level. The lake rise eventually slowed as water levels approached an external basin threshold in northern Cache Valley at Red Rock Pass near Zenda, Idaho. Lake Bonneville reached the Red Rock Pass threshold and occupied its highest shoreline, termed the Bonneville beach, around 18,000 years ago. During the transgression and highstand, major drainages that emanate from within the Wasatch Range (such as the Weber River) formed large deltaic complexes in the lake at

their canyon mouths. Headward erosion of the Snake River-Bonneville basin drainage divide then caused a catastrophic incision of the threshold and the lake level lowered by roughly 360 feet in fewer than two months (Jarrett and Malde, 1987; O’Conner, 1993). The Project is above the elevation for the lake highstand.

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

SITE CHARACTERIZATION

Empirical Observations

On April 28, 2016, Mr. Bill D. Black of Western GeoLogic conducted a reconnaissance of the property. Weather at the time of the site reconnaissance was partly cloudy with temperatures in the 50’s (°F). The site is at the western margin of Ogden Valley on heavily vegetated southwest-facing slopes slightly overlooking the upper (southern) part of Nordic Valley to the west. Pole Canyon Creek is in the valley bottom west of the site. Native vegetation appeared to consist of heavy oak brush and mature trees. No active streams or springs are mapped crossing the site or were observed, and no bedrock outcrops were evident at the site or in adjacent slopes.

Air Photo Observations

High-resolution orthophotography from 2012 and 1-meter bare earth DEM LIDAR from 2011 available from the Utah AGRC (Figures 3A and 3B) were reviewed to obtain information about the geomorphology of the site area. Several bedrock lineaments (presumably contacts between subunits in the Norwood Formation) are evident of Figures 3A and 3B that are obscured across the Project by what appears to be a small landslide. The landslide head is slightly north of the proposed home; the failure then widens and descends downslope to the southwest to about 85-90 feet southwest of the home. A slight bulge is evident on both the 2012 aerial photo and 2011 LIDAR image in the toe area (Figures 3A and 3B). We note that this bulge is not evident on the surveyed topography on Figure 3C, which may be just an anomaly of the surveying methodology. Morphology of the landslide appears subdued or obscured, suggesting it may be an older feature (possibly latest Pleistocene to early Holocene in age). No evidence of other geologic hazards were observed on the air photos in the site area.

Subsurface Investigation

Three test pits were excavated at the property in April 2016 to evaluate subsurface conditions. Test pit locations are shown on Figures 3A-3C, and were measured using a

hand-held GPS unit and trend and distance methods from known points. The test pits were logged at a scale of 1 inch equals 5 feet (1:60). Excavation was complicated in test pit 2 by dense bedrock, but no other complications were encountered. The test pit exposures were digitally photographed at five-foot intervals to document subsurface conditions. The photos are not provided herein, but are available on request.

Test pit 1 (Figure 4A) exposed a sequence of weathered Norwood Formation consisting of tuffaceous sandstone overlain by claystone and conglomerate (units 1-3, respectively). The contact between units 2 and 3 showed a strike/dip of N46°W 26° NE, which is similar to regional strike and dips. Units 1-3 in test pit 1 are in turn overlain by a shallow landslide and surficial alluvium and colluvium. The soil profile (A horizon and a well-developed Bt vertisol) suggests the landslide is likely early Holocene in age or older.

Test pit 2 (Figure 4B) exposed fractured and sheared sandstone bedrock (units 1 and 2) overlain by landslide colluvium (unit 3). Bedding in unit 1 near 9 feet horizontal (Figure 3B) showed a strike/dip of N50°W 30° NE, which suggests only a few degrees of backtilting and horizontal rotation. Many of the shears appeared to die out slightly above the trench floor, although several showed down-to-the-southwest displacements of up to several feet and continued below the test pit bottom. Trend of the shears ranged between N63° W to N76° W, generally similar to topographic contour trends.

Test pit 3 (Figure 4C) on the lateral margin of the slide (Figures 3A-C) exposed landslide colluvium overlying what we infer is in-place bedrock. The contact between units 1 and 2 (Figure 4C) showed a strike/dip of N40°W 26° NE, which is also similar to regional strike and dip measurements.

Cross Section

Figure 5 shows a cross section across the slope through the proposed home location at a scale of 1 inch equals 25 feet with no vertical exaggeration. The profile location is shown on Figure 3C (A-A', in blue). Units and contacts are inferred based on the subsurface data discussed above and our review of the log for the GSH boring in the northeastern part of the site (which is not reproduced herein). We use an overall dip of 26 degrees for contacts within the Norwood Formation, similar to the measurements in test pits 1 and 3. The profile trend generally matches the bedrock dip direction. We anticipate that the landslide exposed in the test pits likely originated as a shallow rotational slump in near-surface weathered claystone and sandstone bedrock in the area of test pit 1, and then propagated downslope as a translational block/slab failure through the underlying sandstone (Figure 5). The landslide does not appear to have caused a substantial amount of deformation, suggesting that it may not have moved very far and likely has a shallow failure plane that is only about 10-15 feet deep in the area of the proposed home (Figure 5). Given its failure mechanism, we would anticipate a slight bulge at the toe from thrusting, which is confirmed by the aerial photo and LIDAR image (Figures 3A-B). However, the surveyed topography shows no slope inflection in the toe area, and the slope also shows very little overall variance (Figure 5). This may be just an anomaly of the surveying (such as a lack of frequent and closely spaced data points).

GEOLOGIC HAZARDS

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

Table 1. Geologic hazards summary for Lot 5 Big Sky Estates No. 1.

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

Earthquake Ground Shaking

Ground shaking refers to the ground surface acceleration caused by seismic waves generated during an earthquake. Strong ground motion is likely to present a significant risk during moderate to large earthquakes located within a 60 mile radius of the project area (Boore and others, 1993). Seismic sources include mapped active faults, as well as a random or “floating” earthquake source on faults not evident at the surface. Mapped active faults within this distance include the East and West Cache fault zones; the Brigham City, Weber, Salt Lake, and Provo segments of the Wasatch fault zone; the East Great Salt Lake fault zone; the Morgan fault; the West Valley fault zone; the Oquirrh fault zone; and the Bear River fault zone (Black and others, 2003).

The extent of property damage and loss of life due to ground shaking depends on factors such as: (1) proximity of the earthquake and strength of seismic waves at the surface (horizontal motions are the most damaging); (2) amplitude, duration, and frequency of ground motions; (3) nature of foundation materials; and (4) building design (Costa and Baker, 1981). Based on 2012 IBC provisions, a site class of D (stiff soil), and a risk category of II, USGS calculated uniform-hazard and deterministic ground motion values with a 2% chance of exceedance in 50 years are as follows:

Table 2. Seismic hazards summary for Lot 5 Big Sky Estates No. 1.
(Home Location: 41.301155° N, -111.853500° W)

S_s	0.992 g
S_t	0.343 g
$S_{MS} (F_a \times S_s)$	1.095 g
$S_{M1} (F_v \times S_t)$	0.588 g
$S_{DS} (2/3 \times S_{MS})$	0.730 g
$S_{D1} (2/3 \times S_{M1})$	0.392 g
Site Coefficient, F_a	= 1.103
Site Coefficient, F_v	= 1.713

Although we present the values for site class D above, a site class of B (rock) or C (very stiff soil or soft rock) may be more appropriate if the home is founded in the underlying bedrock. However, the values do not show a significant difference. Given the above information, earthquake ground shaking poses a high risk to the site. The hazard from earthquake ground shaking can be adequately mitigated by design and construction of homes in accordance with appropriate building codes. The Project structural and/or geotechnical engineer, in conjunction with the developer, should confirm and evaluate the seismic ground-shaking hazard and provide appropriate seismic design parameters as needed.

Surface Fault Rupture

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

The nearest active fault to the site is the Weber segment of the WFZ about four miles to the west, and no evidence of active surface faulting is mapped or was evident at the site. Based on this, the hazard from surface faulting is rated as low.

Liquefaction and Lateral-spread Ground Failure

Liquefaction occurs when saturated, loose, cohesionless, soils lose their support capabilities during a seismic event because of the development of excessive pore pressure.

Earthquake-induced liquefaction can present a significant risk to structures from bearing-capacity failures to structural footings and foundations, and can damage structures and roadway embankments by triggering lateral spread landslides. Earthquakes of Richter magnitude 5 are generally regarded as the lower threshold for liquefaction. Liquefaction potential at the site is a combination of expected seismic (earthquake ground shaking) accelerations, groundwater conditions, and presence of susceptible soils.

No soils likely susceptible to liquefaction were observed in the test pit exposures at the site or were evident in the boring conducted by GSH. Based on this, the hazard from liquefaction and lateral spreading is rated as low.

Tectonic Deformation

Tectonic deformation refers to subsidence from warping, lowering, and tilting of a valley floor that accompanies surface-faulting earthquakes on normal faults. Large-scale tectonic subsidence may accompany earthquakes along large normal faults (Lund, 1990). Tectonic subsidence is believed to mainly impact those areas immediately adjacent to the downthrown side of a normal fault. No active faults are mapped in the site area. Based on this, the risk from tectonic subsidence is rated as low.

Seismic Seiche and Storm Surge

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

Stream Flooding

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

No active drainages are mapped crossing the site or were evident. Given this, the risk from stream flooding is low. Site hydrology and runoff should be addressed in the civil engineering design and grading plan for the Project.

Shallow Groundwater

No springs or seeps are shown on the topographic map for the site or were reported or observed, and no groundwater was encountered in the boring conducted by GSH. Given this, the depth to static groundwater is likely greater than 50 feet. Based on the above, we rate the risk from shallow groundwater as low. However, proper site drainage should be maintained so that groundwater does not pose a future risk of slope instability. It is also possible that groundwater levels may fluctuate seasonally and following snowmelt or rainstorms, and may be perched locally over less permeable bedrock layers. We note that some water was observed seeping along contact between units 2 and 3 in test pit 1 from recent rainfall. Unit 2 would be such an impermeable bedrock layer (claystone).

Landslides and Slope Failures

Slope stability hazards such as landslides, slumps, and other mass movements can develop along moderate to steep slopes where a slope has been disturbed, the head of a slope loaded, or where increased groundwater pore pressures result in driving forces within the slope exceeding restraining forces. Slopes exhibiting prior failures, and also deposits from large landslides, are particularly vulnerable to instability and reactivation.

A portion of the site, and particularly the area of the proposed home, is on what appears to be an older (late Pleistocene to early Holocene) landslide that is likely shallow and involved both shallow rotational and translational movement. Deformation from and colluvial deposits of the landslide are exposed in all the test pits at the site, although the low degree of deformation suggests it did not move very far. However, given the above we rate the risk from landsliding as high. We recommend stability of the slopes be evaluated in a geotechnical engineering evaluation prior to building based on site specific data and subsurface information included in this report. Recommendations for reducing the risk from landsliding should be provided if factors of safety are determined to be unsuitable. The stability evaluation should take into account possible perched groundwater and fluctuating seasonal levels. Care should also be taken that site grading does not destabilize slopes in this area without prior geotechnical analysis and grading plans, and that proper drainage is maintained.

Debris Flows

Debris flow hazards are typically associated with unconsolidated alluvial fan deposits at the mouths of large range-front drainages, such as those along the Wasatch Front. Debris flows have historically significant damage in the Wasatch Front area. The site is not in any mapped alluvial-fan deposits, and no evidence of debris-flow channels, levees, or other debris-flow features was observed. Based on the above, we rate the hazard from debris flows at the site as low.

Rock Fall

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

Swelling and Collapsible Soils

Surficial soils that contain certain clays can swell or collapse when wet. Given the subsurface soil conditions observed at the site, it is possible that clayey interbeds may be present in the subsurface that could pose a moderate risk from problem soils. A geotechnical engineering evaluation should therefore be performed to address soil conditions and provide specific recommendations for site grading, subgrade preparation, and footing and foundation design.

CONCLUSIONS AND RECOMMENDATIONS

Geologic hazards posing a high relative risk to the site are earthquake ground shaking and landslides. Problem soils also pose a moderate-risk hazard. The following recommendations are provided with regard to the geologic characterizations in this report:

- **Excavation Inspection** – To reduce the risk from landsliding, we recommend that the home be founded on underlying undeformed bedrock and that the foundation excavation be inspected by a licensed engineering geologist to confirm that no deformation is present, as well as to recognize any differing conditions that could affect the performance of the planned structure.
- **Geotechnical Investigation** - A design-level geotechnical engineering study should be conducted prior to construction to: (1) address soil conditions at the site for use in foundation design, site grading, and drainage; (2) provide recommendations regarding building design to reduce risk from seismic acceleration; and (3) evaluate stability of slopes at the site, including providing recommendations for reducing the risk of landsliding if the factors of safety are deemed unsuitable, based on the geologic characterizations provided in this report and site-specific geotechnical data. The stability evaluation should account for possible perched groundwater and seasonal fluctuations. It is our understanding that GSH is in the process of preparing a geotechnical report for the site. Our report should be provided to them to assist with their evaluation.
- **Excavation Backfill Considerations** - The test pits may be in areas where structures could subsequently be placed. However, backfill may not have been replaced in the test pits in compacted layers. The fill could settle with time and upon saturation. Should structures be located over an excavated area, no footings or structure should be founded over the excavations unless the backfill has been removed and replaced with structural fill, if the fill is to support a structure.
- **Availability of Report** - The report should be made available to architects, building contractors, and in the event of a future property sale, real estate agents and potential buyers. This report should be referenced for information on technical data only as interpreted from observations and not as a warranty of conditions throughout the site. The report should be submitted in its entirety, or referenced appropriately, as part of any document submittal to a government agency responsible for planning decisions or geologic review. Incomplete submittals void the professional seals and signatures we provide herein. Although this report and the data herein are the property of the client, the report format is the intellectual property of Western Geologic and should not be copied, used, or modified without express permission of the authors.

LIMITATIONS

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

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

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

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

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

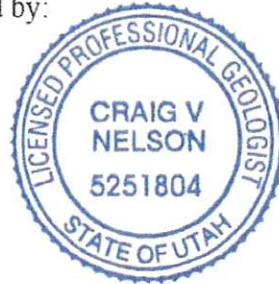
It has been a pleasure working with you on this project. Should you have any questions, please call.

Sincerely,
Western GeoLogic, LLC

Reviewed by:



Bill. D. Black, P.G.
Senior Engineering Geologist



A handwritten signature in blue ink that reads "Craig V. Nelson".

Craig V. Nelson, P.G.
Principal Engineering Geologist

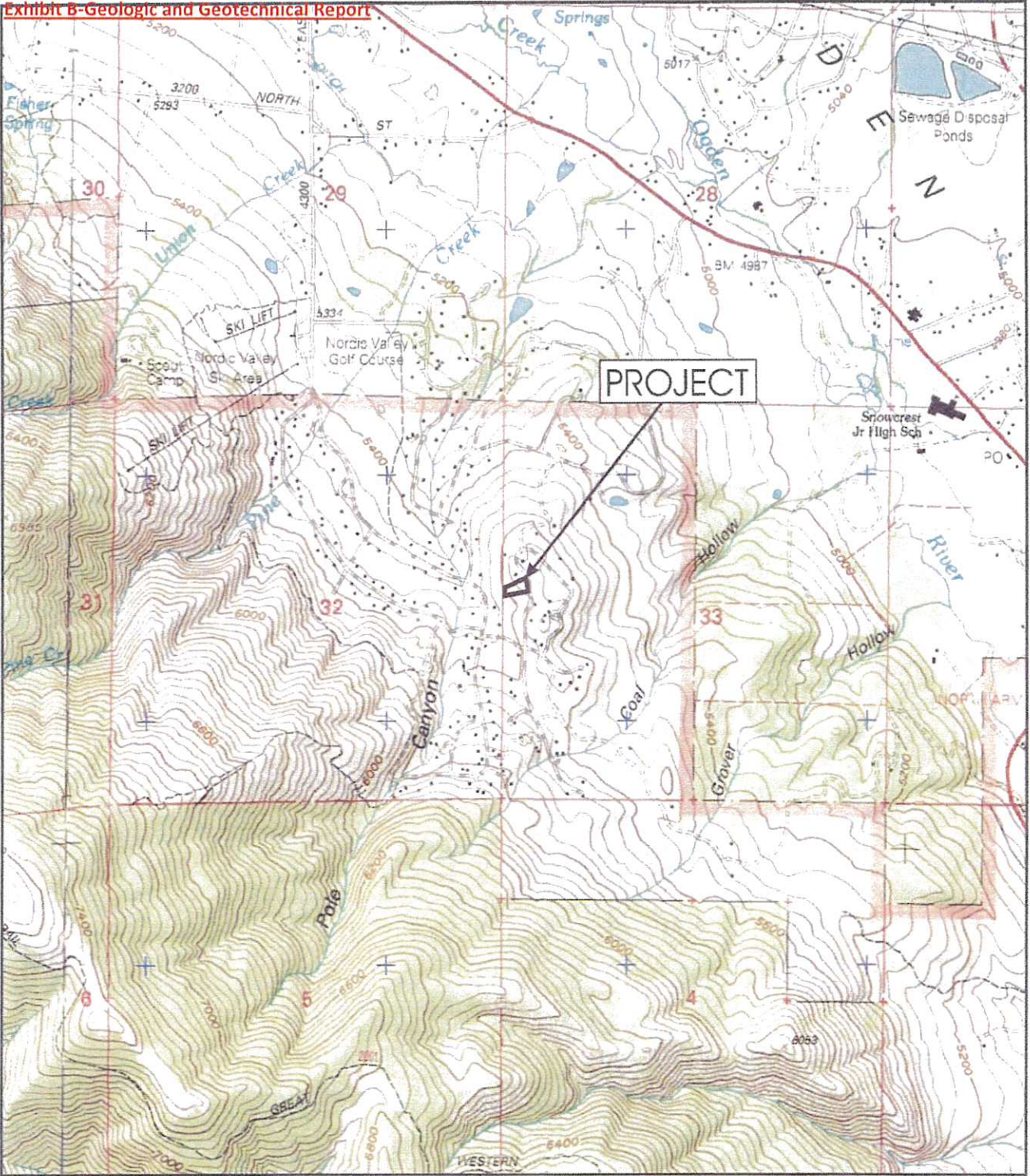
ATTACHMENTS

- Figure 1. Location Map (8.5"x11")
- Figure 2. Geologic Map (8.5"x11")
- Figure 3A. 2012 Air Photo (8.5"x11")
- Figure 3B. 2011 LIDAR Image (8.5"x11")
- Figure 3C. Site Plan (8.5"x11")
- Figure 4A-C. Test Pit Logs (three 8.5"x11" sheets)
- Figure 5. Cross Section (11"x17")

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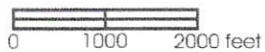
Source: U.S. Geological Survey 7.5 Minute Series Topographic Maps, Utah - Huntsville, 1998;
 Project location SW1/4, Section 33, T7N, R1E (SLBM); about 5,525 to 5,615 feet elevation (ASL).

LOCATION MAP

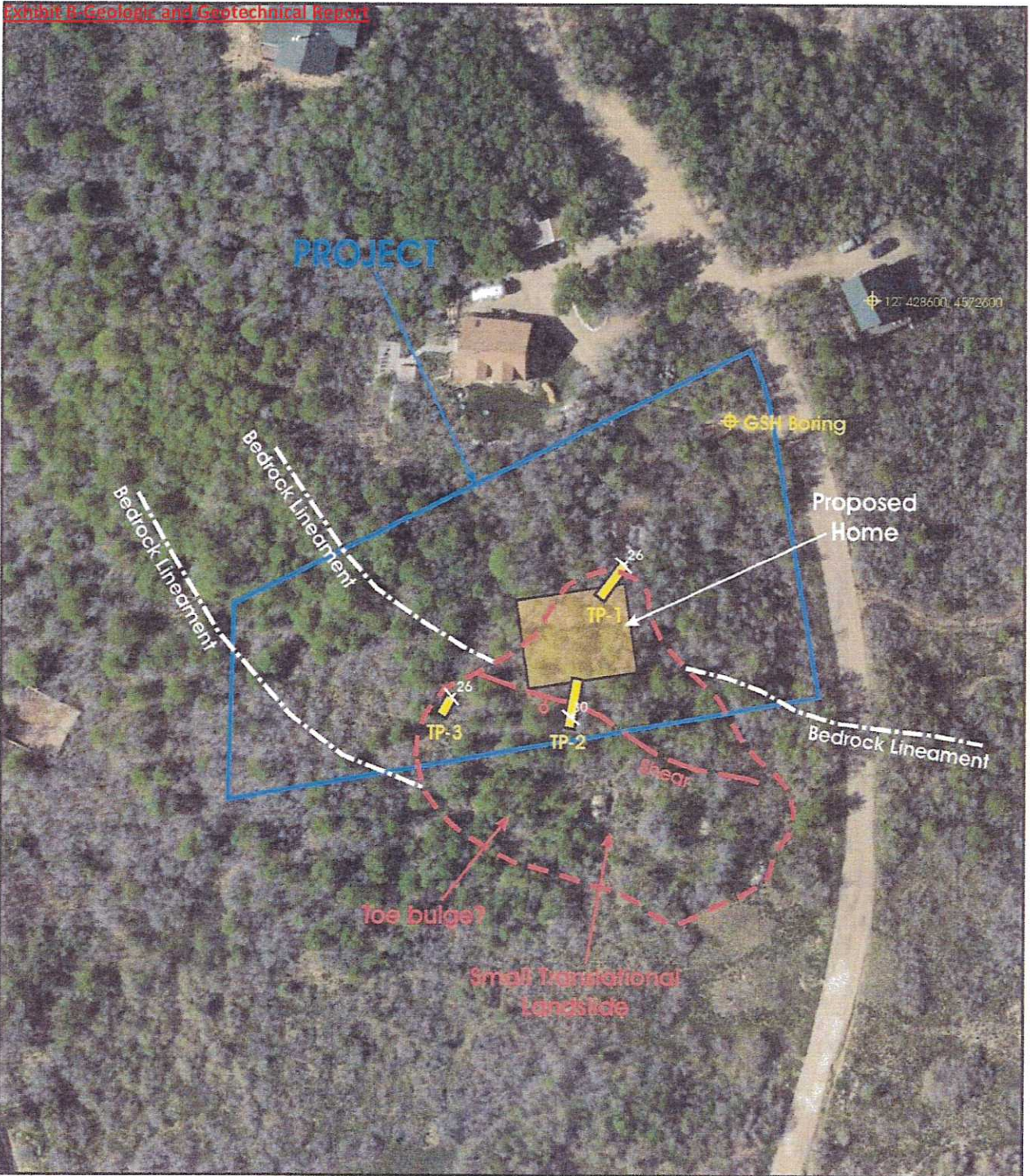
GEOLOGIC HAZARDS EVALUATION

Lot 5 Big Sky Estates No. 1
 2337 North Panorama Circle
 Liberty, Weber County, Utah

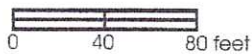
FIGURE 1



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



Source: Utah AGRC, 2012 High-Resolution Orthophoto, 6-inch resolution.



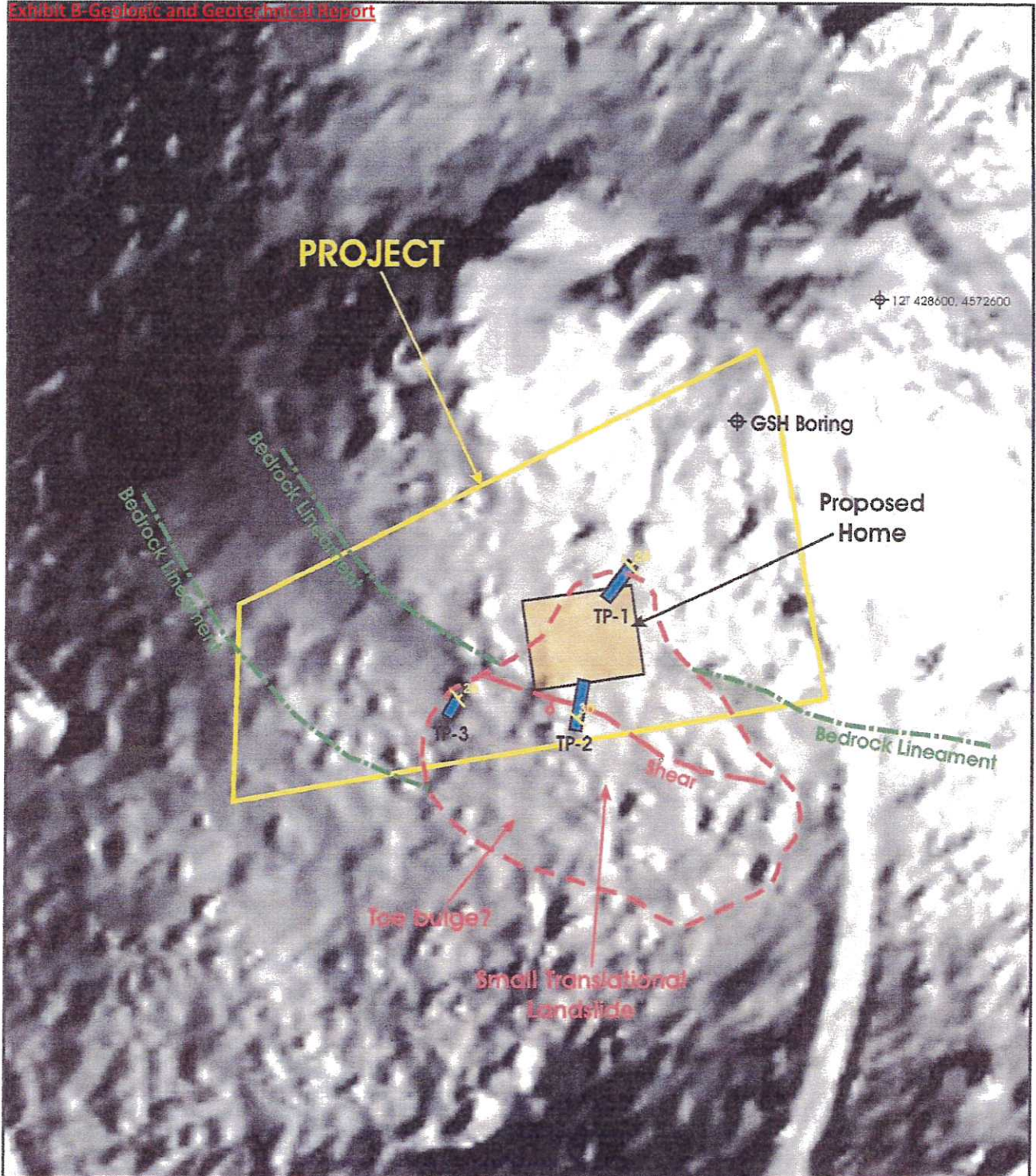
Scale 1:960
(1 inch = 80 feet)

2012 AERIAL PHOTO

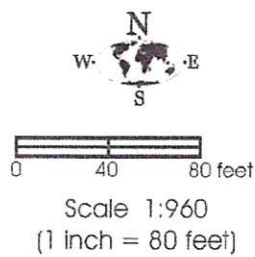
GEOLOGIC HAZARDS EVALUATION

Lot 5 Big Sky Estates No. 1
2337 North Panorama Circle
Liberty, Weber County, Utah

FIGURE 3A



Source: Utah AGRC, 2011 LIDAR Bare Earth DEM.

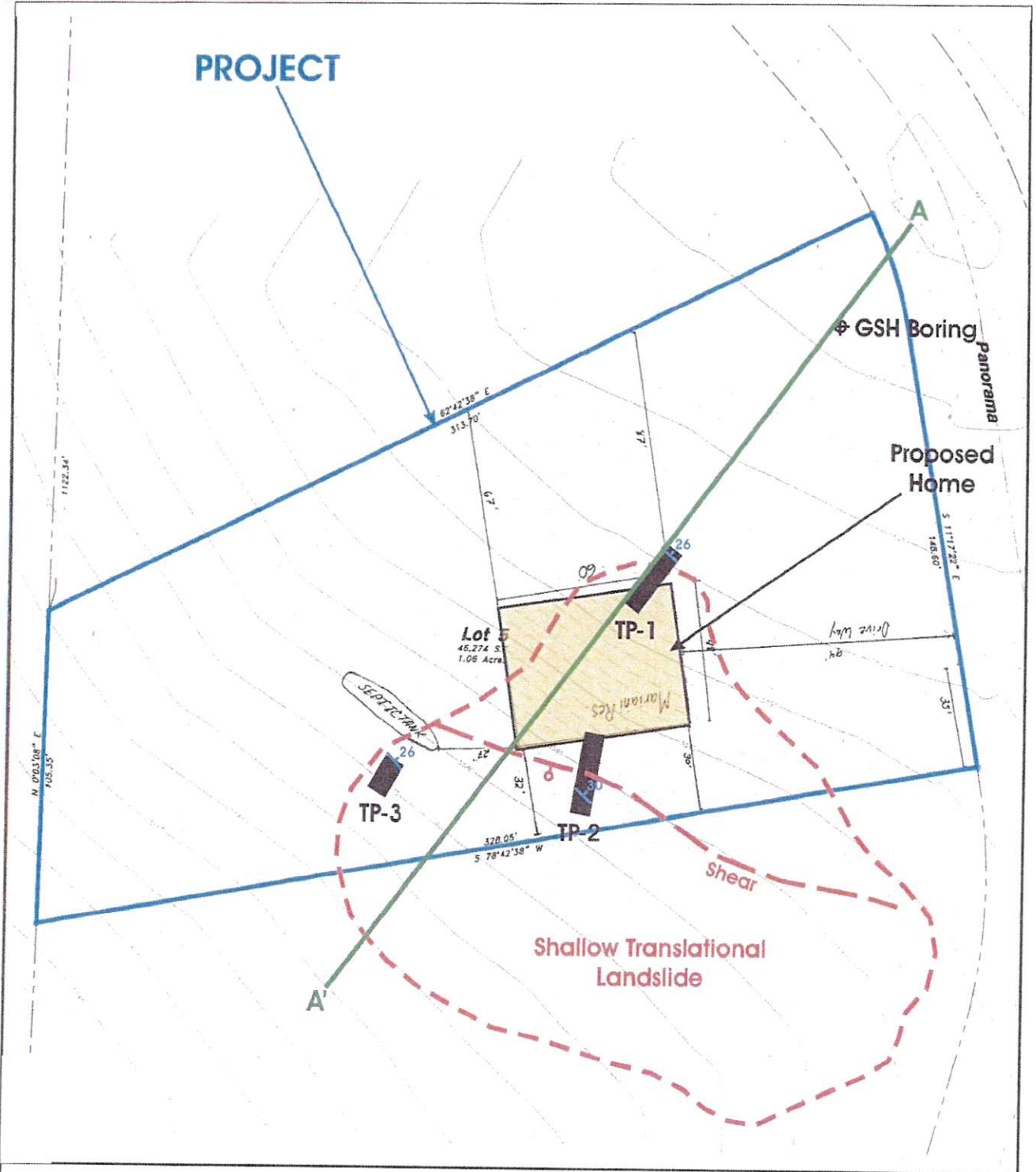


2011 LIDAR IMAGE

GEOLOGIC HAZARDS EVALUATION

Lot 5 Big Sky Estates No. 1
2337 North Panorama Circle
Liberty, Weber County, Utah

FIGURE 3B



SITE PLAN

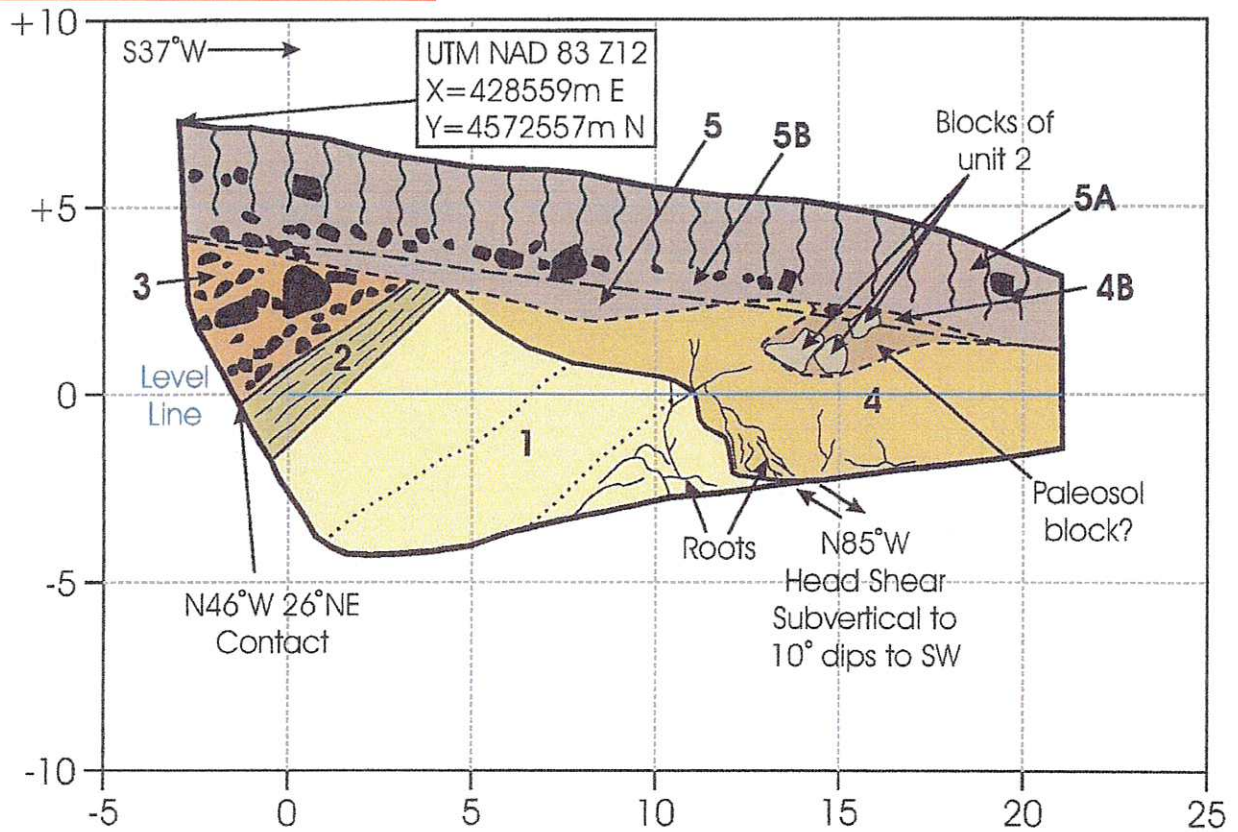
GEOLOGIC HAZARDS EVALUATION

Lot 5 Big Sky Estates No. 1
 2337 North Panorama Circle
 Liberty, Weber County, Utah

FIGURE 3C



Scale 1:600
 (1 inch = 50 feet)



UNIT DESCRIPTIONS

Unit 1. *Tertiary Norwood Formation* - Carbonate-enriched tuffaceous sandstone; slightly fractured, pale-brown, high density, well to poorly bedded, with zones of pale-olive brown clay and iron oxide along cleavage fractures.

Unit 2. *Tertiary Norwood Formation* - Olive, reddish-olive, well bedded, moist, moderate density, fat clay (CH).

Unit 3. *Tertiary Norwood Formation* - Weathered tuffaceous conglomerate comprised of reddish-brown, moderate density, clayey sandy gravel to gravelly sand (GW/SW) with subangular cobbles and boulders.

Unit 4. *Late Pleistocene to early Holocene landslide* - Low to moderate density, olive to orange, lean to fat clay (CL/CH) with blocks of tuffaceous sandstone and possibly paleosol A horizon; generally massive, but with weak, slope parallel, iron-oxide stringers in places.

4B. Bt vertisol formed in unit 4.

Unit 5. *Holocene alluvium and colluvium* - reddish-, orange-, and very-dark-brown, low to moderate density, massive, root-penetrated, clayey sand to sandy clay (SC/CL) with cobbles and trace boulders; likely mixed slope wash and colluvium from up-slope erosion.

5B. Bt vertisol formed in unit 5.

5A. Organic-rich modern A-horizon soil formed in unit 5.

TEST PIT 1 LOG

GEOLOGIC HAZARDS EVALUATION

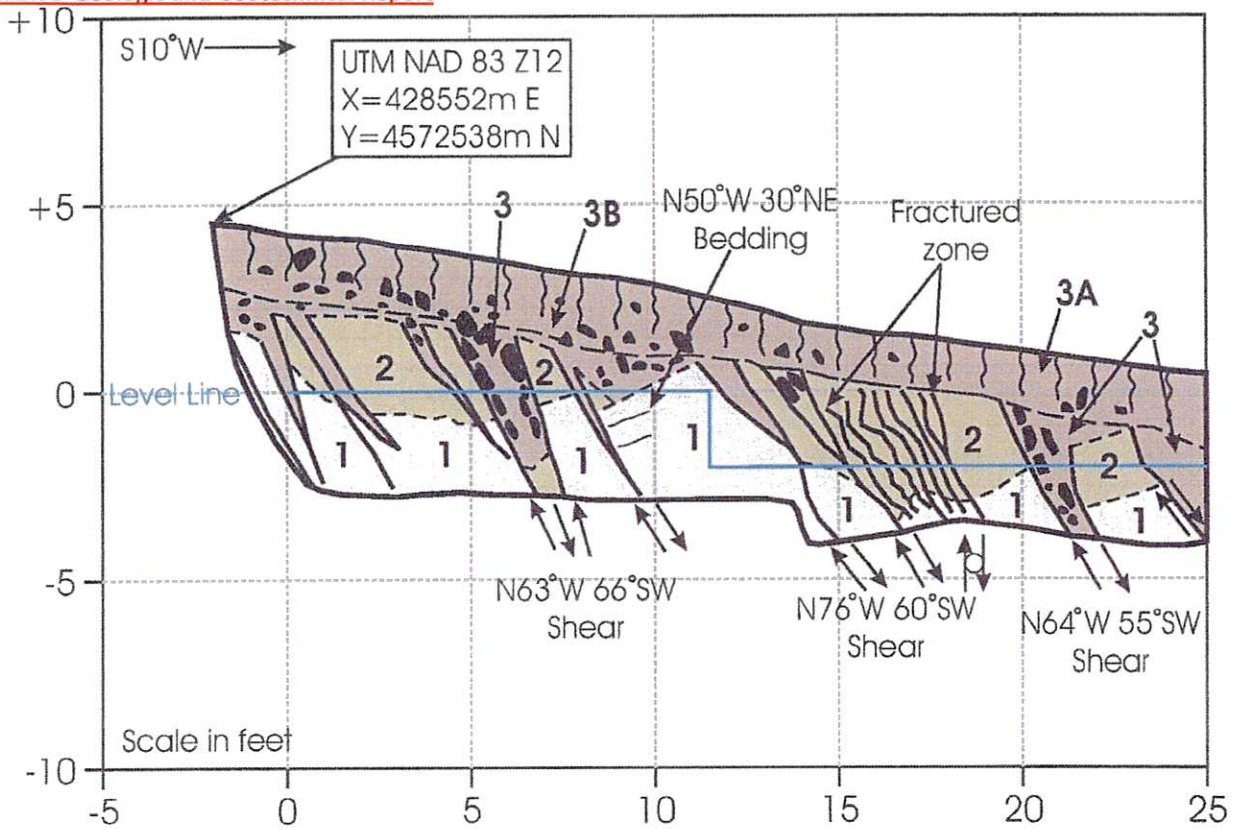
Lot 5 Big Sky Estates No. 1
2337 North Panorama Circle
Liberty, Weber County, Utah

FIGURE 4A



SCALE: 1 inch = 5 feet
(no vertical exaggeration)
East Wall Logged, North to South

Logged by Bill D. Black, P.G.
on April 28, 2016
Reviewed by
Craig V. Nelson, P.G.



UNIT DESCRIPTIONS

Unit 1. Tertiary Norwood Formation - Fractured, very dense, pale-gray, carbonate-enriched, well-bedded tuffaceous sandstone.

Unit 2. Tertiary Norwood Formation - Fractured, very dense, olive-gray, well-bedded tuffaceous sandstone with iron-oxide staining along cleavage faces.

Unit 3. Late Pleistocene to early Holocene landslide - Brown to dark brown, low to moderate density, massive, root-penetrated, clayey sand to sandy clay (SC/CL) with gravel, cobbles, and trace boulders.

3B. Bt vertisol horizon formed in unit 3.

3A. Organic-rich modern A horizon formed in unit 3.



SCALE: 1 inch = 5 feet
(no vertical exaggeration)
East Wall Logged, North to South

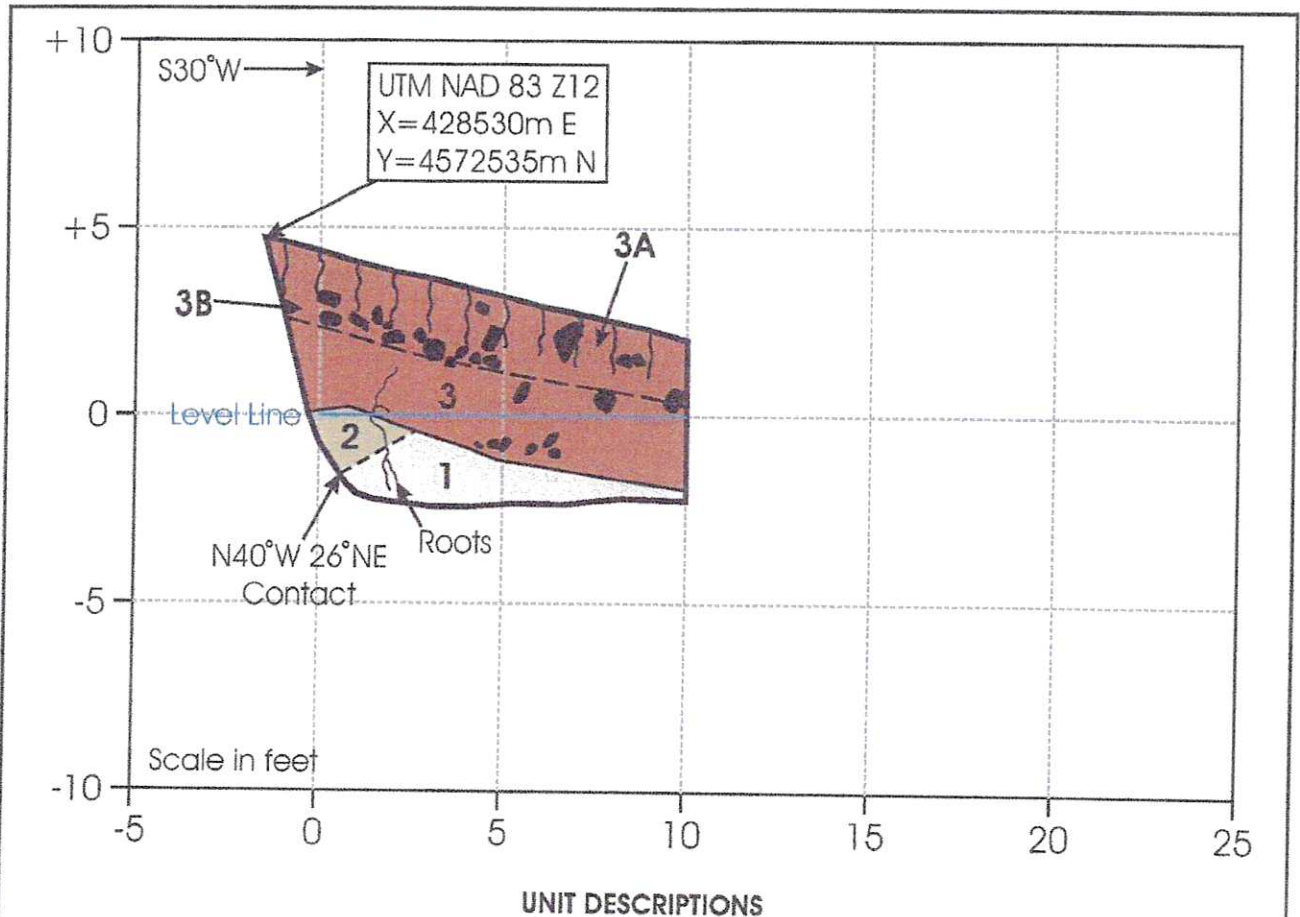
Logged by Bill D. Black, P.G.
on April 28, 2016
Reviewed by
Craig V. Nelson, P.G.

TEST PIT 2 LOG

GEOLOGIC HAZARDS EVALUATION

Lot 5 Big Sky Estates No. 1
2337 North Panorama Circle
Liberty, Weber County, Utah

FIGURE 4B



UNIT DESCRIPTIONS

Unit 1. Tertiary Norwood Formation - Fractured, very dense, pale-gray, carbonate-enriched, well-bedded tuffaceous sandstone.

Unit 2. Tertiary Norwood Formation - Fractured, very dense, olive-gray, well-bedded tuffaceous sandstone with iron-oxide staining along cleavage faces.

Unit 3. Late Pleistocene to early Holocene landslide - Brown to dark brown, low to moderate density, massive, root-penetrated, clayey sand to sandy clay (SC/CL) with gravel, cobbles, and trace boulders.

3B. Bt vertisol horizon formed in unit 3.

3A. Organic-rich modern A horizon formed in unit 3.



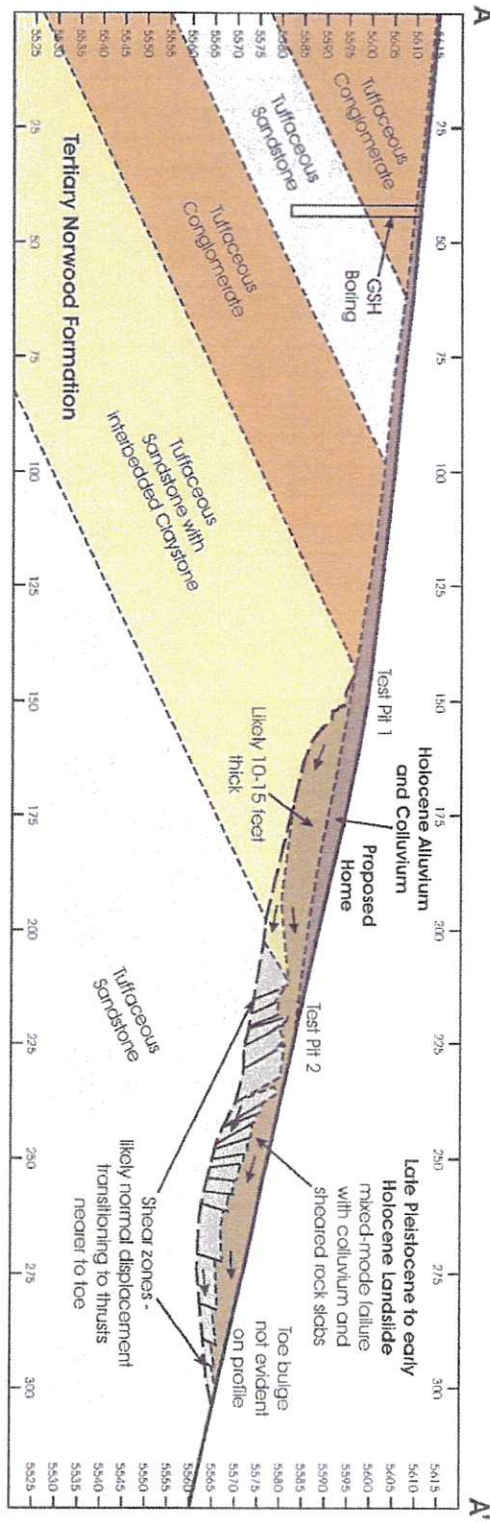
SCALE: 1 inch = 5 feet
(no vertical exaggeration)
East Wall Logged, North to South

Logged by Bill D. Black, P.G.
on April 28, 2016
Reviewed by
Craig V. Nelson, P.G.

TEST PIT 3 LOG

GEOLOGIC HAZARDS EVALUATION

Lot 5 Big Sky Estates No. 1
2337 North Panorama Circle
Liberty, Weber County, Utah



SCALE: 1 inch = 25 feet
 No vertical exaggeration
 Contacts based on subsurface data and are inferred in unexplored areas and/or depth

CROSS SECTION

GEOLOGIC HAZARDS EVALUATION
 Lot 5 Big Sky Estates No. 1
 2337 North Panorama Circle
 Liberty, Weber County, Utah

FIGURE 5



**REPORT
GEOTECHNICAL STUDY
LOT 5 BIG SKY ESTATES
2337 PANORAMA CIRCLE
NEAR LIBERTY, WEBER COUNTY, UTAH**

Submitted To:

Mr. and Mrs. Dave and Gayle Mariani
P.O. Box 1202
Eden, Utah

Submitted By:

GSH Geotechnical, Inc.
1596 West 2650 South
Ogden, Utah 84401

July 15, 2016

Job No. 2104-01N-16



July 15, 2016
Job No. 2104-01N-16

Mr. and Mrs. Dave and Gayle Mariani
P.O. Box 1202
Eden, Utah 84310

Re: Report
Geotechnical Study
Lot 5 Big Sky Estates
2337 Panorama Circle
Near Liberty, Weber County, Utah
(41.3012° N; 111.8535° W)

1. INTRODUCTION

1.1 GENERAL

This report presents the results of our geotechnical study performed for Lot 5 Big Sky Estates located at 2337 Panorama Circle near Liberty in Weber County, Utah. The general location of the site with respect to major roadways, as of 2014, is presented on Figure 1, Vicinity Map. A more detailed layout of the site showing the proposed improvements is presented on Figure 2, Site Plan. The locations of the test pits excavated and boring drilled in conjunction with this study are also presented on Figure 2.

1.2 OBJECTIVES AND SCOPE

The objectives and scope of our study were planned in discussions between Mr. and Mrs. Dave and Gayle Mariani and Mr. Andrew Harris of GSH Geotechnical, Inc. (GSH).

In general, the objectives of this study were to:

1. Define and evaluate the subsurface soil and groundwater conditions across the site.
2. Provide appropriate foundation, earthwork, and slope stability recommendations as well as geoseismic information to be utilized in the design and construction of the proposed home.



In accomplishing these objectives, our scope has included the following:

1. A field program consisting of the excavating, logging, and sampling of 3 test pits and 1 boring.
2. A laboratory testing program.
3. An office program consisting of the correlation of available data, engineering analyses, and the preparation of this summary report.

1.3 AUTHORIZATION

Authorization was provided by returning a signed copy of our Professional Services Agreement No. 16-0235N dated February 14, 2016.

1.4 PROFESSIONAL STATEMENTS

Supporting data upon which our recommendations are based are presented in subsequent sections of this report. Recommendations presented herein are governed by the physical properties of the soils encountered in the exploration test pits/boring, projected groundwater conditions, and the layout and design data discussed in Section 2, Proposed Construction, of this report. If subsurface conditions other than those described in this report are encountered and/or if design and layout changes are implemented, GSH must be informed so that our recommendations can be reviewed and amended, if necessary.

Our professional services have been performed, our findings developed, and our recommendations prepared in accordance with generally accepted engineering principles and practices in this area at this time.

2. PROPOSED CONSTRUCTION

The proposed project consists of constructing a single-family residence on Lot 5 Big Sky Estates near Liberty in Weber County, Utah. Construction will likely consist of reinforced concrete footings and basement/crawlspace foundation walls supporting 1 to 2 wood-framed levels above grade. Projected maximum column and wall loads are on the order of 10 to 25 kips and 1 to 3 kips per lineal foot, respectively.

Site development will require a moderate amount of earthwork in the form of site grading. We estimate in general that maximum cuts and fills to achieve design grades will be on the order of 2 to 8 feet. Larger cuts and fills may be required in isolated areas.



3. INVESTIGATIONS

3.1 FIELD PROGRAM

In order to define and evaluate the subsurface soil and groundwater conditions at the site, 1 boring was drilled to a depth of about 29.0 feet below existing grade. The boring was drilled using a truck-mounted drill rig equipped with hollow-stem augers, mud rotary, and coring. Additionally, 3 test pits were excavated to depths of about 7.0 to 11.0 feet below existing grade. The test pits were excavated using a track-mounted excavator. Test pit and boring locations are presented on Figure 2.

The field portion of our study was under the direct control and continual supervision of an experienced member of our geotechnical staff. During the course of the excavating and drilling operations, a continuous log of the subsurface soil conditions encountered was maintained. In addition, samples of the typical soils encountered were obtained and placed in sealed bags and plastic containers for subsequent laboratory testing and examination. The soils were classified in the field based upon visual and textural examination. These classifications have been supplemented by subsequent inspection and testing in our laboratory. Detailed graphical representation of the subsurface conditions encountered is presented on Figure 3A, Boring Log, and on Figures 4A through 4C, Test Pit Log. Soils were classified in accordance with the nomenclature described on Figure 5, Key to Boring Log (USCS) and on Figure 6, Key to Test Pit Log (USCS).

A 3.0-inch outside diameter, 2.42-inch inside diameter drive sampler (Dames & Moore) and a 2.0-inch outside diameter, 1.38-inch inside diameter drive sampler (SPT) were utilized in the subsurface soil sampling at select locations within the boring. The blow counts recorded on the boring logs were those required to drive the sampler 12 inches with a 140-pound hammer dropping 30 inches.

A 2.42-inch inside diameter thin-wall drive sampler was utilized in the subsurface sampling of the test pits at the site.

Following completion of drilling and excavation operations, one and one-quarter-inch diameter slotted PVC pipe was installed in boring B-1 and test pit TP-2 in order to provide a means of monitoring the groundwater fluctuations. The boring was backfilled with auger cuttings. Following completion of excavating and logging, each test pit was backfilled. Although an effort was made to compact the backfill with the trackhoe, backfill was not placed in uniform lifts and compacted to a specific density. Consequently, the backfill soils must be considered as non-engineered and settlement of the backfill with time is likely to occur.



3.2 LABORATORY TESTING

3.2.1 General

In order to provide data necessary for our engineering analyses, a laboratory testing program was performed. The program included moisture, density, Atterberg limits, partial gradations, consolidation, direct shear, and residual direct shear tests. The following paragraphs describe the tests and summarize the test data.

3.2.2 Moisture and Density

To provide index parameters and to correlate other test data, moisture and density tests were performed on selected samples. The results of these tests are presented on the boring log, Figure 3A, and on the test pit logs, Figure 4A through 4C.

3.2.3 Atterberg Limit Tests

To aid in classifying the soils, Atterberg limit tests were performed on samples of the fine-grained cohesive soils. Results of the test are tabulated on the following table:

Boring/ Test Pit No.	Depth (feet)	Liquid Limit (percent)	Plastic Limit (percent)	Plasticity Index (percent)	Soil Classification
B-1	2.5	25	17	8	SC
B-1	10.0	21	11	10	GC
B-1	19.0	33	22	11	SC
TP-2	2.5	Non-Plastic	Non-Plastic	Non-Plastic	SM
TP-3	3.0	72	38	34	MH

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3.2.4 Partial Gradation Tests

To aid in classifying the granular soils, partial gradation tests were performed. Results of the tests are tabulated below:

Boring/ Test Pit No.	Depth (feet)	Percent Passing No. 200 Sieve	Soil Classification
B-1	2.5	28	SC
B-1	10.0	14	GC
B-1	19.0	23	SC
TP-1	4.0	30	SC
TP-2	2.5	25	SM
TP-3	3.0	74	MH

3.2.5 Consolidation Tests

To provide data necessary for our settlement analyses, consolidation tests were performed on each of 2 representative samples of the fine grained soils encountered at the site. Based upon data obtained from the consolidation tests, the silty clay/clayey silt soils are moderately over-consolidated and will exhibit moderate strength and compressibility characteristics under the anticipated loadings. Detailed results of the test are maintained within our files and can be transmitted, at the client’s request.

3.2.6 Laboratory Direct Shear Test

To determine the shear strength of the soils encountered at the site, a laboratory direct shear test was performed on a sample of the site soils. The results of the test are tabulated below:

Test Pit/Boring No.	Depth (feet)	Soil Type	In-Situ Moisture Content (percent)	Dry Density (pcf)	Internal Friction Angle (degrees)	Apparent Cohesion (psf)
TP-1	4.0	SC	27	79	28	605
TP-3	6.0	MH	28	74	28	350



3.2.7 Laboratory Residual Direct Shear Test

To determine the residual shear strength of the soils encountered at the site, a laboratory residual direct shear test was performed on a sample of the site soils. The results of the test are tabulated on below:

Test Pit/Boring No.	Depth (feet)	Soil Type	In-Situ Moisture Content (percent)	Dry Density (pcf)	Internal Friction Angle (degrees)	Apparent Cohesion (psf)
TP-1	4.0	SC	27	79	16	275

4. SITE CONDITIONS

4.1 GEOLOGIC SETTING

A geologic hazards reconnaissance study¹ dated June 9, 2016 was prepared for the subject property by Western Geologic, LLC, and a copy of that report is included in the attached Appendix.

4.2 SURFACE

The subject property is a vacant, irregularly-shaped lot located at 2337 Panorama Circle near Liberty in Weber County, Utah. The topography of the site slopes downward to the west/southwest at grades of about 10H:1V (Horizontal:Vertical) to about 4H:1V (Horizontal:Vertical) with an overall change in elevation of about 145 feet across the site. Vegetation at the site consists primarily of native weeds, grasses, brush, and numerous mature trees, particularly over the slope area. The site is bordered on the north by residential development, on the west and south by undeveloped property, and on the east by Panorama Road followed by residential development.

4.3 SUBSURFACE SOIL

Subsurface conditions encountered at the test pit and boring locations varied slightly across the site. Topsoil and disturbed soils were observed in the upper 3 to 12 inches at the test pit and boring locations. Non-engineered fill extending about 1.0 foot below existing site grades was encountered at boring B-1. In test pit TP-3 and boring B-1, natural soils were observed beneath the non-engineered fill and topsoil/disturbed soils to the full depth penetrated, about 7.0 to 29.0 feet below surrounding grades and consisted of silty clay with varying fine to coarse sand content, fine sandy silt, fine to coarse sand with varying amounts of silt, weathered bedrock (weathered sandstone/claystone/siltstone), and occasional mixture of these soils. In test pits TP-1

¹ "Report, Geologic Hazards Evaluation, Lot 5 Big Sky Estates No.1, 2337 North Panorama Circle, Liberty, Weber County, Utah," Western Geologic, LLC, June 9, 2016.



and TP-2, mass movement soil deposits were encountered below the topsoil and disturbed soils extending to the full depth explored of about 10.0 to 11.0 feet below surrounding site grades. The mass movement deposits were comprised of a mixture of silty sand, clayey silt, silty clay, and degraded/weathered sandstone/siltstone.

The natural granular soils encountered were medium dense to very dense, slightly moist to moist, reddish-brown to brown to gray in color, and will generally exhibit moderately high strength and low compressibility characteristics under the anticipated vertical loading.

The natural silt/clay soils encountered were medium stiff to hard, slightly moist to moist, brown to gray in color, and will generally exhibit moderate strength and compressibility characteristics under the anticipated vertical loading.

For a more detailed description of the subsurface soils encountered, please refer to Figure 3A, Boring Log, and Figures 4A through 4C, Test Pit Log. The lines designating the interface between soil types on the test pit and boring logs generally represent approximate boundaries. In-situ, the transition between soil types may be gradual.

4.4 GROUNDWATER

Groundwater was not encountered in the test pits or boring at the time of our field exploration; however, water resulting from recent precipitation was observed seeping into the test pits at about 2 to 4 feet below existing site grades. Seasonal and longer-term groundwater fluctuations of 1 to 2 feet shall be anticipated. The highest seasonal levels will generally occur during the late spring and summer months. Landscape irrigation on this and surrounding areas may also create additional seasonal groundwater fluctuations. The limitations of landscape irrigation at the site are discussed further in Section 5.9, Site Irrigation, and measures to reduce infiltration of surface water at the site are discussed further in Section 5.8, Subdrains. The contractor must be prepared to dewater excavations as needed.

5. DISCUSSIONS AND RECOMMENDATIONS

5.1 SUMMARY OF FINDINGS

The results of our analyses indicate that the proposed structure may be supported upon conventional spread and/or continuous wall foundations established upon a minimum of 2 feet of granular structural fill extending to suitable natural soils. Under no circumstance should the proposed structure or associated structural fill be placed directly on mass movement/landslide deposits noted at the site. Mass movement/landslide deposits must be removed in their entirety from beneath the proposed home and extending a minimum of 10 feet outside the home area.

The most significant geotechnical aspects of the site are:

1. The surficial non-engineered fills encountered at boring B-1;
2. The proximity of the proposed structure to mass movement soil deposits; and

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3. Maintaining stability of the slope at the property.

Mass movement/landslide deposits must be removed in their entirety from beneath the proposed home and extending a minimum of 10 feet outside the home area. If this is not feasible, GSH must be contacted to provide additional recommendations for foundation support.

A subdrain system must be installed upslope of the home and near the head of the mass movement deposit soils below the home to reduce the potential for surface water infiltration, as discussed further within this report.

The on-site soils are not appropriate to be used as structural site grading fill, however, they may be used as general grading fill in landscape areas.

A geotechnical engineer from GSH will need to verify that all mass movement deposit soils, fill material (if encountered) and topsoil/disturbed soils have been completely removed and suitable natural soils encountered prior to the placement of structural site grading fills, floor slabs, foundations, or rigid pavements.

In the following sections, detailed discussions pertaining to earthwork, foundations, lateral pressure and resistance, floor slabs, slope stability, and the geoseismic setting of the site are provided.

5.2 EARTHWORK

5.2.1 Site Preparation

Initial site preparation will consist of the removal of surface vegetation, topsoil, and other deleterious materials from beneath an area extending out at least 3 feet from the perimeter of the proposed building, pavements, and exterior flatwork areas.

Additional site preparation will consist of the removal of existing non-engineered fills (if encountered) from an area extending out at least 3 feet from the perimeter of residential structures and 1 foot beyond rigid pavements. Mass movement/landslide deposits must be removed in their entirety from beneath the proposed home and extending a minimum of 10 feet outside the home area.

Non-engineered fills/disturbed soil may remain in asphalt pavement and sidewalk areas as long as they are free of deleterious materials and properly prepared. Below rigid pavements non-engineered fills/disturbed soils must be removed. Additionally, the surface of any existing engineered fills must be prepared prior to placing additional site grading fills.

Proper preparation shall consist of scarifying, moisture conditioning, and re-compacting the upper 12 inches to the requirements for structural fill. As an option to proper preparation and recompaction, the upper 12 inches of non-engineered fill (where encountered) may be removed and replaced with granular subbase over unfrozen proofrolled subgrade. Even with proper

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preparation, pavements established overlying non-engineered fills may encounter some long-term movements unless the non-engineered fills are completely removed.

It must be noted that from a handling and compaction standpoint, onsite soils containing high amounts of fines (silts and clays) are inherently more difficult to rework and are very sensitive to changes in moisture content requiring very close moisture control during placement and compaction. This will be very difficult, if not impossible, during wet and cold periods of the year. Additionally, the onsite soils are likely above optimum moisture content for compacting at present and would require some drying prior to recompacting.

Subsequent to stripping and prior to the placement of structural site grading fill, pavements, driveway, and parking slabs on grade, the prepared subgrade must be proofrolled by passing moderate-weight rubber tire-mounted construction equipment over the surface at least twice. If excessively soft or loose soils are encountered, they must be removed to a maximum depth of 2 feet and replaced with structural fill. Beneath footings, all loose and disturbed soils must be totally removed. Fill soils must be handled as described above.

Surface vegetation, debris, and other deleterious materials shall generally be removed from the site. Topsoil, although unsuitable for utilization as structural fill, may be stockpiled for subsequent landscaping purposes.

A representative of GSH must verify that suitable natural soils and/or proper preparation of existing fills have been encountered/met prior to placing site grading fills, footings, slabs, and pavements.

5.2.2 Excavations

For granular (cohesionless) soils, construction excavations above the water table, not exceeding 4 feet, shall be no steeper than one-half horizontal to one vertical (0.5H:1V). For excavations up to 10 feet, in granular soils and above the water table, the slopes shall be no steeper than one horizontal to one vertical (1H:1V). Excavations encountering saturated cohesionless soils will be very difficult and will require very flat sideslopes and/or shoring, bracing and dewatering. Excavations deeper than 10 feet are not anticipated at the site.

Temporary excavations up to 10 feet deep in fine-grained cohesive soils (if encountered), above or below the water table, may be constructed with sideslopes no steeper than one-half horizontal to one vertical (0.5H:1V).

To reduce disturbance of the natural soils during excavation, it is recommended that smooth edge buckets/blades be utilized.

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



5.2.3 Structural Fill

Structural fill will be required as site grading fill, as backfill over foundations and utilities, and possibly as replacement fill beneath some footings. All structural fill must be free of sod, rubbish, construction debris, frozen soil, and other deleterious materials.

Structural site grading fill is defined as fill placed over fairly large open areas to raise the overall site grade. The maximum particle size within structural site grading fill should generally not exceed 4 inches; although, occasional particles up to 6 to 8 inches may be incorporated provided that they do not result in “honeycombing” or preclude the obtainment of the desired degree of compaction. In confined areas, the maximum particle size should generally be restricted to 2.5 inches.

Only granular soils are recommended in confined areas such as utility trenches, below footings, etc. Generally, we recommend that all imported granular structural fill consist of a well-graded mixture of sands and gravels with no more than 20 percent fines (material passing the No. 200 sieve) and less than 30 percent retained on the 3/4 inch sieve. The plasticity index of import fine-grained soil shall not exceed 18 percent.

To stabilize soft subgrade conditions or where structural fill is required to be placed closer than 1.0 foot above the water table at the time of construction, a mixture of coarse gravels and cobbles and/or 1.5- to 2.0-inch gravel (stabilizing fill) should be utilized. It may also help to utilize a stabilization fabric, such as Mirafi 600X or equivalent, placed on the native ground if 1.5- to 2.0-inch gravel is used as stabilizing fill.

On-site soils are not recommended as structural fill but may be used as non-structural grading fill in landscape areas. Non-structural site grading fill is defined as all fill material not designated as structural fill and may consist of any cohesive or granular soils not containing excessive amounts of degradable material.

5.2.4 Fill Placement and Compaction

All structural fill shall be placed in lifts not exceeding 8 inches in loose thickness. Structural fills shall be compacted in accordance with the percent of the maximum dry density as determined by the ASTM² D-1557 (AASHTO³ T-180) compaction criteria in accordance with the table on the following page.

² American Society for Testing and Materials

³ American Association of State Highway and Transportation Officials

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Location	Total Fill Thickness (feet)	Minimum Percentage of Maximum Dry Density
Beneath an area extending at least 5 feet beyond the perimeter of the structure	0 to 10	95
Site Grading Fills outside area defined above	0 to 5	90
Site Grading Fills outside area defined above	5 to 10	95
Trench Backfill	--	96
Pavement granular base/subbase	--	96

Structural fills greater than 10 feet thick are not anticipated at the site.

Subsequent to stripping and prior to the placement of structural site grading fill, the subgrade shall be prepared as discussed in Section 5.2.1, Site Preparation, of this report. In confined areas, subgrade preparation shall consist of the removal of all loose or disturbed soils.

If utilized for stabilizing fill, coarse gravel and cobble mixtures should be end-dumped, spread to a maximum loose lift thickness of 15 inches, and compacted by dropping a backhoe bucket onto the surface continuously at least twice. As an alternative, the fill may be compacted by passing moderately heavy construction equipment or large self-propelled compaction equipment at least twice. Subsequent fill material placed over the coarse gravels and cobbles shall be adequately compacted so that the “fines” are “worked into” the voids in the underlying coarser gravels and cobbles.

5.2.5 Utility Trenches

All utility trench backfill material below structurally loaded facilities (flatwork, floor slabs, roads, etc.) shall be placed at the same density requirements established for structural fill. If the surface of the backfill becomes disturbed during the course of construction, the backfill shall be proofrolled and/or properly compacted prior to the construction of any exterior flatwork over a backfilled trench. Proofrolling may be performed by passing moderately loaded rubber tire-mounted construction equipment uniformly over the surface at least twice. If excessively loose or soft areas are encountered during proofrolling, they must be removed (to a maximum depth of 2 feet below design finish grade) and replaced with structural fill.

Most utility companies and City-County governments are now requiring that Type A-1-a/A-1-b (AASHTO Designation – basically granular soils with limited fines) soils be used as backfill over utilities. These organizations are also requiring that in public roadways the backfill over major utilities be compacted over the full depth of fill to at least 96 percent of the maximum dry



density as determined by the AASHTO T-180 (ASTM D-1557) method of compaction. We recommend that as the major utilities continue onto the site that these compaction specifications are followed.

Natural or imported silt/clay soils are not recommended for use as trench backfill, particularly in structurally loaded areas.

5.3 SLOPE STABILITY

5.3.1 Parameters

The properties of the soils at this site were estimated using the results of our laboratory testing, published correlations, and our experience with similar soils. Accordingly, we estimated the following parameters for use in the stability analyses:

Material	Internal Friction Angle (degrees)	Apparent Cohesion (psf)	Saturated Unit Weight (pcf)
Colluvium	28	250	115
Bedrock	29	400	120
Landslide	16	200	115

For the seismic analysis, a peak horizontal ground acceleration of 0.292 using IBC 2012 guidelines and adjusted for Site Class effects (for Site Class D soils) was obtained for site (grid) locations of 41.3012 degrees latitude (north) and 111.8535 degrees longitude (west). To model sustained accelerations at the site, one-half of this value is typically used. Accordingly, a value of 0.146 was used as the pseudostatic coefficient in the seismic analyses.

5.3.2 Stability Analyses

We evaluated the global stability of the existing slope using the computer program *SLIDE*. This program uses a limit equilibrium (Simplified Bishop) method for calculating factors of safety against sliding on an assumed failure surface and evaluates numerous potential failure surfaces, with the most critical failure surface identified as the one yielding the lowest factor of safety of those evaluated. We analyzed the following configuration based on cross-sections provided in the referenced geologic study (see geological study in appendix for cross-section information and location):

- Slopes between 10H:1V (Horizontal:Vertical) to 4H:1V (Horizontal:Vertical) with an overall change in elevation of about 145 feet across the site. To simulate the load imposed on the slope by the proposed home, a load of 1,500 psf was modeled over the proposed building area. In addition, a phreatic surface was included in our analyses to

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account for potential seasonal perched water and effluent water from the proposed on-site septic system.

Typically, the required minimum factors of safety are 1.5 for static conditions and 1.0 for seismic (pseudostatic) conditions. The results of our analyses indicate that the existing slope configurations analyzed will meet both these requirements provided our recommendations are followed (see Figures 7 and 8).

Slope movements or even failure can occur if the slope soils are undermined or become saturated. Groundwater was not encountered during the course of our field investigation; however saturation of the slope soils can adversely affect the stability of the slope. Measures must be implemented to reduce the potential for saturation of the soils at the site. Surface drainage at the bottom and top of the slope should be directed to prevent ponding at the toe or crest of the slope, and a cut-off drain on the slope above the home and at the head of the landslide deposit below the home is recommended to reduce the potential for infiltration of surface water at the site, as discussed further in Section 5.8, Subdrains. Landscape irrigation on this and surrounding areas may also create additional seasonal groundwater fluctuations. The limitations of landscape irrigation at the site are discussed further in Section 5.9, Site Irrigation. The property owner and the owner’s representatives should be made aware of the risks should these or other conditions occur that could saturate or erode/undermine the slope soils.

Changes to the grading at the site and any retaining walls must be properly engineered to maintain stability of the slopes. GSH must review the final grading plans for the project prior to initiation of any construction.

5.4 SPREAD AND CONTINUOUS WALL FOUNDATIONS

5.4.1 Design Data

The proposed structure may be supported upon conventional spread and continuous wall foundations established upon a minimum of 2 feet of structural fill extending to suitable natural soils. For design, the following parameters are provided:

Minimum Recommended Depth of Embedment for Frost Protection	- 30 inches
Minimum Recommended Depth of Embedment for Non-frost Conditions	- 15 inches
Recommended Minimum Width for Continuous Wall Footings	- 16 inches
Minimum Recommended Width for Isolated Spread Footings	- 24 inches



Recommended Net Bearing Pressure for Real Load Conditions	- 1,500 pounds per square foot
Bearing Pressure Increase for Seismic Loading	- 50 percent

The term “net bearing pressure” refers to the pressure imposed by the portion of the structure located above lowest adjacent final grade. Therefore, the weight of the footing and backfill to lowest adjacent final grade need not be considered. Real loads are defined as the total of all dead plus frequently applied live loads. Total load includes all dead and live loads, including seismic and wind.

5.4.2 Installation

Footings shall not be installed upon mass movement soil deposits, soft or disturbed soils, non-engineered fill, construction debris, frozen soil, or within ponded water. If the granular structural fill upon which the footings are to be established becomes disturbed, it shall be recompacted to the requirements for structural fill or be removed and replaced with structural fill.

The width of structural fill, where placed below footings, shall extend laterally at least 6 inches beyond the edges of the footings in all directions for each foot of fill thickness beneath the footings. For example, if the width of the footing is 2 feet and the thickness of the structural fill beneath the footing is 2.0 feet, the width of the structural fill at the base of the footing excavation would be a total of 4.0 feet, centered below the footing.

5.4.3 Settlements

Maximum settlements of foundations designed and installed in accordance with recommendations presented herein and supporting maximum anticipated loads as discussed in Section 2, Proposed Construction, are anticipated to be 1 inch or less.

Approximately 40 percent of the quoted settlement should occur during construction.

5.5 LATERAL RESISTANCE

Lateral loads imposed upon foundations due to wind or seismic forces may be resisted by the development of passive earth pressures and friction between the base of the foundations and the supporting soils. In determining frictional resistance, a coefficient of 0.40 should be utilized for foundations placed over granular structural fill. Passive resistance provided by properly placed and compacted granular structural fill above the water table may be considered equivalent to a fluid with a density of 300 pounds per cubic foot. Below the water table, this granular soil should be considered equivalent to a fluid with a density of 150 pounds per cubic foot.

A combination of passive earth resistance and friction may be utilized provided that the friction component of the total is divided by 1.5.



5.6 LATERAL PRESSURES

The lateral pressure parameters, as presented within this section, are for backfills which will consist of drained granular soil placed and compacted in accordance with the recommendations presented herein. The lateral pressures imposed upon subgrade facilities will, therefore, be basically dependent upon the relative rigidity and movement of the backfilled structure. For active walls, such as retaining walls which can move outward (away from the backfill), granular backfill may be considered equivalent to a fluid with a density of 35 pounds per cubic foot in computing lateral pressures. For more rigid walls (moderately yielding), generally not exceeding 8 feet in height, granular backfill may be considered equivalent to a fluid with a density of 45 pounds per cubic foot. The above values assume that the surface of the soils slope behind the wall is no steeper than 4 horizontal to 1 vertical and that the granular fill within 3 feet of the wall will be compacted with hand-operated compacting equipment.

For seismic loading, a uniform pressure shall be added. The uniform pressures based on different wall heights are provided in the following table:

Wall Height (feet)	Seismic Loading Active Case (psf)	Seismic Loading Moderately Yielding (psf)
4	25	55
6	40	85
8	55	115

5.7 FLOOR SLABS

Floor slabs may be established upon a minimum of 2 feet of structural fill extending to suitable natural soils. Under no circumstances shall floor slabs be established over mass movement deposit soils, non-engineered fills, loose or disturbed soils, sod, rubbish, construction debris, other deleterious materials, frozen soils, or within ponded water. In order to provide a capillary break and facilitate curing of the concrete, it is recommended that floor slabs be directly underlain by 4 inches of “free-draining” fill, such as “pea” gravel or three-quarters- to one-inch minus clean gap-graded gravel.

Settlement of lightly loaded floor slabs (average uniform pressure of 100 to 150 pounds per square foot or less) is anticipated to be less than 1/4 inch.

The tops of all floor slabs in habitable areas must be established at least 4 feet above the highest anticipated normal water level or 1.5 feet above the maximum groundwater level controlled by land drains.



5.8 SUBDRAINS

5.8.1 General

We recommend that the perimeter foundation subdrains and a cutoff drain above the home and near the head of the mass movement deposit soils be installed as indicated below.

5.8.2 Foundation Subdrains

Foundation subdrains should consist of a 4-inch diameter perforated or slotted plastic or PVC pipe enclosed in clean gravel. The invert of a subdrain should be at least 2 feet below the top of the lowest adjacent floor slab. The gravel portion of the drain should extend 2 inches laterally and below the perforated pipe and at least 1 foot above the top of the lowest adjacent floor slab. The gravel zone must be installed immediately adjacent to the perimeter footings and the foundation walls. To reduce the possibility of plugging, the gravel must be wrapped with a geotextile, such as Mirafi 140N or equivalent. Above the subdrain, a minimum 4-inch-wide zone of “free-draining” sand/gravel should be placed adjacent to the foundation walls and extend to within 2 feet of final grade. The upper 2 feet of soils should consist of a compacted clayey cap to reduce surface water infiltration into the drain. As an alternative to the zone of permeable sand/gravel, a prefabricated “drainage board,” such as Miradrain or equivalent, may be placed adjacent to the exterior below-grade walls. Prior to the installation of the footing subdrain, the below-grade walls should be dampproofed. The slope of the subdrain should be at least 0.3 percent. The gravel placed around the drain pipe should be clean 0.75-inch to 1.0-inch minus gap-graded gravel and/or “pea” gravel. The foundation subdrains can be discharged into the area subdrains, storm drains, or other suitable down-gradient location.

We recommend final site grading slope away from the structures at a minimum 2 percent for hard surfaces (pavement) and 5 percent for soil surfaces within the first 10 feet from the structures.

5.8.3 Cutoff Drain

To reduce potential infiltration of surface water and groundwater into the subsurface soils at the site, a cutoff drain should be installed upslope of the home and near the head of the mass movement deposit soils below the home. Final location of the required cutoff drains must be reviewed by GSH prior to construction. The drain should consist of a perforated 4-inch minimum diameter pipe wrapped in fabric and placed near the bottom of a minimum 24 inch wide trench excavated to a depth of at least 15 feet below existing grade or to competent bedrock and lined in filter fabric. The pipe should daylight at one or both ends of the drain and discharge to an appropriate drainage device or area. Clean gravel up to 2 inches in maximum size, with less than 10 percent passing the No. 4 sieve and less than 5 percent passing the No. 200 sieve, should be placed around the drain pipe. A fabric, such as Mirafi 140N or equivalent, should be placed between the clean gravel and the adjacent soils. A zone of clean gravel wrapped in fabric at least 24 inches wide should also extend above the drain, to within 2 feet of the ground surface, with



fabric placed over the top of the gravel. The upper 2 feet of soils should consist of a compacted clayey cap to reduce surface water infiltration into the drain.

5.9 SITE IRRIGATION

Proper site drainage is important to maintaining slope stability at the site. Saturation of soils at the site may result in slope movement or failure. Therefore, we recommend that no irrigation lines should be placed on the slope. Landscaping at the site should be planned to utilize drought resistant plants that require minimal watering. Plants or lawn may be placed on the slope, with plants watered using direct drip systems targeted only for each plant, and any lawn areas watered using sprinklers placed in a manner such that watering is a minimum of 30 feet back from the crest of the slope. Overwatering should be strictly avoided. The surface of the site should be graded to prevent the accumulation or ponding of surface water at the site. The property owner and the owner's representatives should be made aware of the risks should these or other conditions occur that could saturate or erode/undermine the slope soils.

To reduce the potential for saturation of the site soils, overwatering at the site should be strictly avoided. Watering at the site should be limited to a maximum equivalent rainfall of 0.5 inches per week. Irrigation at the site should be strictly avoided during periods of natural precipitation.

5.10 GEOSEISMIC SETTING

5.10.1 General

Utah municipalities have adopted the International Building Code (IBC) 2012. The IBC 2012 code determines the seismic hazard for a site based upon 2008 mapping of bedrock accelerations prepared by the United States Geologic Survey (USGS) and the soil site class. The USGS values are presented on maps incorporated into the IBC code and are also available based on latitude and longitude coordinates (grid points).

The structure must be designed in accordance with the procedure presented in Section 1613, Earthquake Loads, of the IBC 2012 edition.

5.10.2 Faulting

Based upon our review of available literature, no active faults are known to pass through the site. The nearest active fault is the Wasatch Fault Zone Weber Section, approximately 4.0 miles west of the site.

5.10.3 Soil Class

For dynamic structural analysis, the Site Class D – Stiff Soil Profile as defined in Chapter 20 of ASCE 7 (per Section 1613.3.2, Site Class Definitions, of IBC 2012) can be utilized.



5.10.4 Ground Motions

The IBC 2012 code is based on 2008 USGS mapping, which provides values of short and long period accelerations for the Site Class B boundary for the Maximum Considered Earthquake (MCE). This Site Class B boundary represents average bedrock values for the Western United States and must be corrected for local soil conditions. The following table summarizes the peak ground and short and long period accelerations for the MCE event and incorporates the appropriate soil amplification factor for a Site Class D soil profile. Based on the site latitude and longitude (41.3012 degrees north and -111.8535 degrees west, respectively), the values for this site are tabulated below:

Spectral Acceleration Value, T	Site Class B Boundary [mapped values] (% g)	Site Coefficient	Site Class D [adjusted for site class effects] (% g)	Design Values (% g)
Peak Ground Acceleration	39.7	$F_a = 1.103$	43.8	29.2
0.2 Seconds (Short Period Acceleration)	$S_S = 99.2$	$F_a = 1.103$	$S_{MS} = 109.4$	$S_{DS} = 72.9$
1.0 Second (Long Period Acceleration)	$S_1 = 34.8$	$F_v = 1.704$	$S_{M1} = 59.3$	$S_{D1} = 39.5$

5.10.5 Liquefaction

The site is located in an area that has been identified by the Utah Geologic Survey as having “very low” liquefaction potential. Liquefaction is defined as the condition when saturated, loose, finer-grained sand-type soils lose their support capabilities because of excessive pore water pressure which develops during a seismic event. Clay soils, even if saturated, will generally not liquefy.

Liquefaction of the site soils is not anticipated during the design seismic event due to the unsaturated nature of the site soils.

5.11 SITE OBSERVATIONS

As stated previously, prior to placement of foundations, floor slabs, pavements, and site grading fills, a geotechnical engineer from GSH must verify that all mass movement deposit soils, non-engineered fill materials, topsoil, and disturbed soils have been removed and/or properly prepared and suitable subgrade conditions encountered. Additionally, GSH must observe fill placement and verify in-place moisture content and density of fill materials placed at the site.

Exhibit B-Geologic and Geotechnical Report

Dave and Gayle Mariani
Job No. 2104-01N-16
Geotechnical Study – Lot 5 Big Sky Estates
July 15, 2016




5.12 CLOSURE

If you have any questions or would like to discuss these items further, please feel free to contact us at (801) 393-2012.

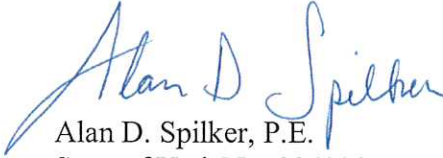
Respectfully submitted,

GSH Geotechnical, Inc.


Andrew M. Harris, P.E.
State of Utah No. 740456
Senior Geotechnical Engineer



Reviewed by:


Alan D. Spilker, P.E.
State of Utah No. 334228
Senior Geotechnical Engineer

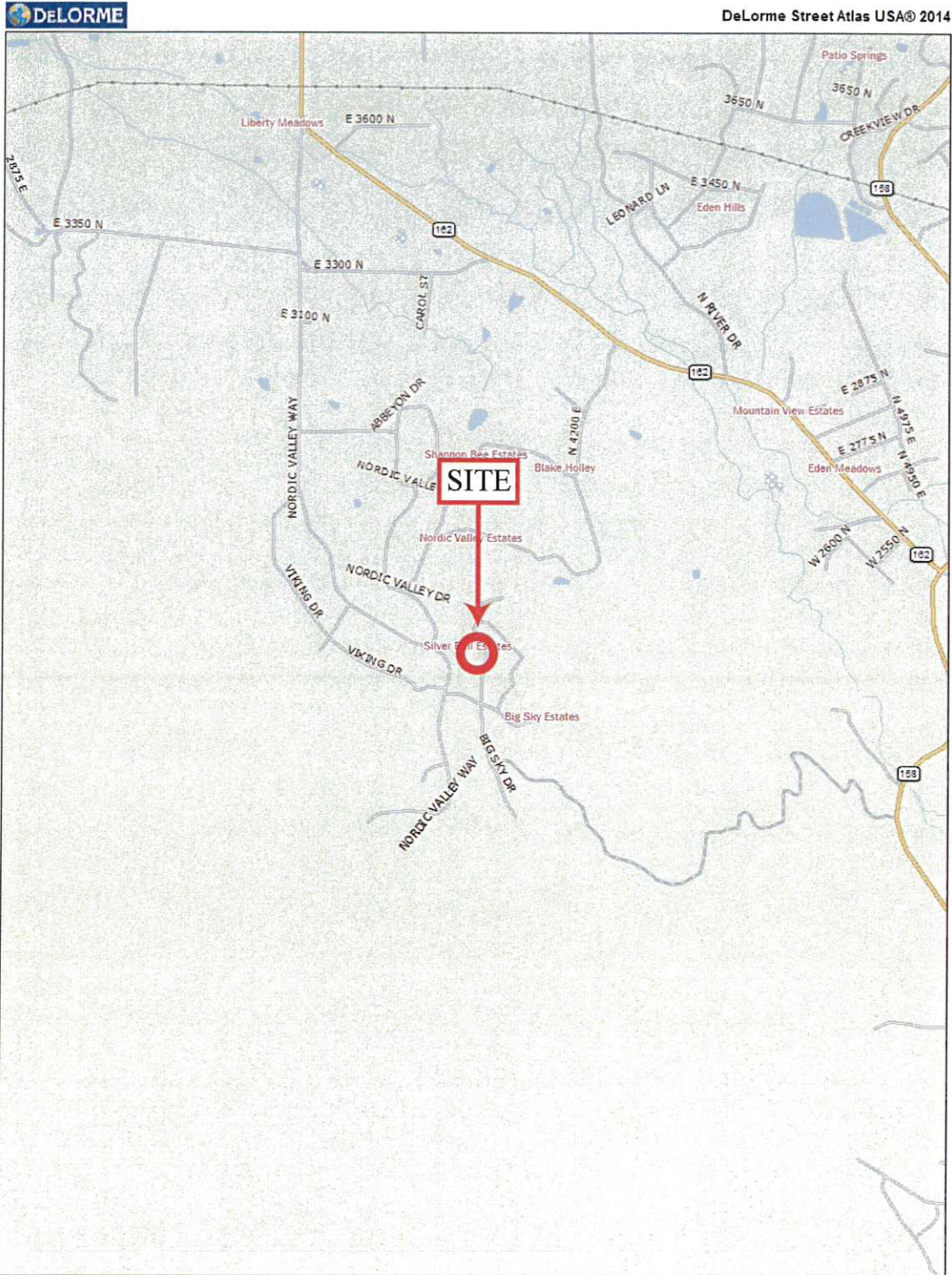
AMH/ADS:mmh

- Encl. Figure 1, Vicinity Map
- Figure 2, Site Plan
- Figures 3A Boring Log
- Figures 4A through 4C, Test Pit Logs
- Figure 5, Key to Boring Log (USCS)
- Figure 6, Key to Test Pit Log (USCS)
- Figures 7 and 8, Stability Results
- Appendix, Geologic Hazards Reconnaissance Study

Addressee (email)

Exhibit B-Geologic and Geotechnical Report

DAVE AND GAYLE MARIANI
JOB NO. 2104-01N-16



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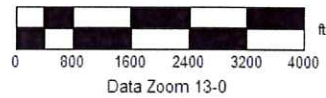
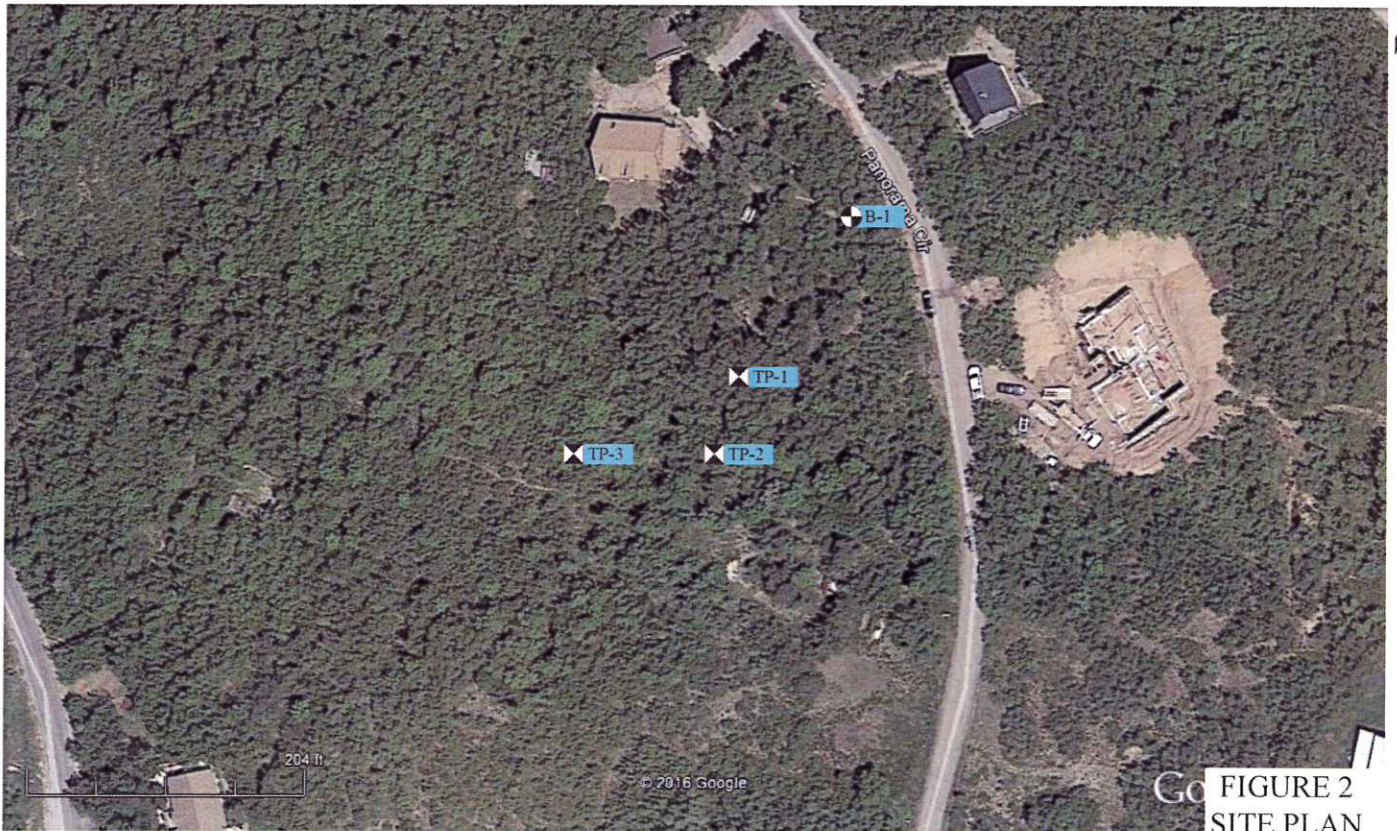


FIGURE 1

VICINITY MAP




REFERENCE:
DELORME STREET ATLAS



REFERENCE:
ADAPTED FROM AERIAL PHOTOGRAPH
DOWNLOADED FROM GOOGLE EARTH
IMAGERY DATE: JUNE 16, 2015


Go **FIGURE 2**
SITE PLAN
 **GSH**

Exhibit B-Geologic and Geotechnical Report

		<h1 style="text-align: center;">BORING LOG</h1> <p style="text-align: center;">Page: 1 of 2</p>				<h2 style="text-align: center;">BORING: B-1</h2>					
CLIENT: Dave and Gayle Mariani		PROJECT NUMBER: 2104-01N-16									
PROJECT: Lot 5 Big Sky Estates		DATE STARTED: 4/27/16				DATE FINISHED: 4/29/16					
LOCATION: 2337 Oanorama Circle, Near Liberty, Weber County, Utah		GSH FIELD REP.: CM/RG									
DRILLING METHOD/EQUIPMENT: 3-3/4" ID Hollow-Stem Auger		HAMMER: Automatic		WEIGHT: 140 lbs		DROP: 30"					
GROUNDWATER DEPTH: Not Encountered (4/29/16)		ELEVATION: ---									
WATER LEVEL	U S C S	DESCRIPTION	DEPTH (FT.)	BLOW COUNT	SAMPLE SYMBOL	MOISTURE (%)	DRY DENSITY (PCF)	% PASSING 200	LIQUID LIMIT (%)	PLASTICITY INDEX	REMARKS
		Ground Surface	0								slightly moist medium dense
	SM/ SC	SILTY/CLAYEY FINE TO COARSE SAND, FILL with some fine gravel; major roots (topsoil) to 12"; brown									
	FILL SC	CLAYEY FINE TO COARSE SAND with some fine gravel; brown		41	X	8		28	25	8	
			5	67	X	8	127				dense
		grades light gray		50/4"	X						very dense
	GC	CLAYEY FINE GRAVEL with fine to coarse sand; reddish-brown to gray	10	54	X	10		14	21	10	slightly moist dense
	SC	CLAYEY FINE TO COARSE SAND reddish-brown		50/2"	X						moist very dense
			15	50/12"	X	15		23	33	11	
	BR	SILTSTONE/SANDSTONE BEDROCK highly fractured; highly weathered; brownish-gray	20								
			25								


See Subsurface Conditions section in the report for additional information.

FIGURE 3A

		BORING LOG Page: 2 of 2				BORING: B-1					
CLIENT: Dave and Gayle Mariani		PROJECT NUMBER: 2104-01N-16									
PROJECT: Lot 5 Big Sky Estates		DATE STARTED: 4/27/16				DATE FINISHED: 4/29/16					
WATER LEVEL	U S C S	DESCRIPTION	DEPTH (FT.)	BLOW COUNT	SAMPLE SYMBOL	MOISTURE (%)	DRY DENSITY (PCF)	% PASSING 200	LIQUID LIMIT (%)	PLASTICITY INDEX	REMARKS
			25								
		End of Exploration at 29.0' No groundwater encountered at time of drilling Installed 1.25" diameter slotted PVC pipe to 19.0'	30								
			35								
			40								
			45								
			50								

See Subsurface Conditions section in the report for additional information.


FIGURE 3A
(continued)

		<h1>TEST PIT LOG</h1>					<h2>TEST PIT: TP-1</h2>			
CLIENT: Dave and Gayle Mariani		PROJECT NUMBER: 2104-01N-16								
PROJECT: Lot 5 Big Sky Estates		DATE STARTED: 4/29/16			DATE FINISHED: 4/29/16					
LOCATION: 2337 Oanorama Circle, Near Liberty, Weber County, Utah		GSH FIELD REP.: HRW								
EXCAVATING METHOD/EQUIPMENT: JCB 214S - Backhoe										
GROUNDWATER DEPTH: Not Encountered (4/29/16)		ELEVATION: ---								
WATER LEVEL	U S C S	DESCRIPTION	DEPTH (FT.)	SAMPLE SYMBOL	MOISTURE (%)	DRY DENSITY (PCF)	% PASSING 200	LIQUID LIMIT (%)	PLASTICITY INDEX	REMARKS
		Ground Surface	0							
	CL	SILTY CLAY with some fine sand; major roots (topsoil) to 6"; brown	0							moist medium stiff
	SC	CLAYEY FINE TO COARSE SAND brown	5		Ø		30			moist medium dense
			10							dense
		End of Exploration at 11.0' No significant sidewall caving No groundwater encountered at time of excavation	15							
			20							
			25							

See Subsurface Conditions section in the report for additional information.


FIGURE 4A

Exhibit B-Geologic and Geotechnical Report

		TEST PIT LOG				TEST PIT: TP-2				
CLIENT: Dave and Gayle Mariani		PROJECT NUMBER: 2104-01N-16								
PROJECT: Lot 5 Big Sky Estates		DATE STARTED: 4/29/16		DATE FINISHED: 4/29/16						
LOCATION: 2337 Oanorama Circle, Near Liberty, Weber County, Utah				GSH FIELD REP.: HRW						
EXCAVATING METHOD/EQUIPMENT: JCB 214S - Backhoe										
GROUNDWATER DEPTH: Not Encountered (4/29/16)						ELEVATION: ---				
WATER LEVEL	U S C S	DESCRIPTION	DEPTH (FT.)	SAMPLE SYMBOL	MOISTURE (%)	DRY DENSITY (PCF)	% PASSING 200	LIQUID LIMIT (%)	PLASTICITY INDEX	REMARKS
		Ground Surface	0							moist very stiff
	CL	SILTY CLAY with some fine sand; major roots (topsoil) to 8"; brown								
	SM/ ML	WEATHERED SILTSTONE/FINE SANDSTONE light gray				25	NP	NP		slightly moist hard
		grades claystone								
		End of Exploration at 10.0' No significant sidewall caving No groundwater encountered at time of excavation	10							
			15							
			20							
			25							

See Subsurface Conditions section in the report for additional information.

FIGURE 4B

		<h1>TEST PIT LOG</h1>					<h2>TEST PIT: TP-3</h2>			
CLIENT: Dave and Gayle Mariani		PROJECT NUMBER: 2104-01N-16								
PROJECT: Lot 5 Big Sky Estates		DATE STARTED: 4/29/16			DATE FINISHED: 4/29/16					
LOCATION: 2337 Oanorama Circle, Near Liberty, Weber County, Utah		GSH FIELD REP.: HRW								
EXCAVATING METHOD/EQUIPMENT: JCB 214S - Backhoe										
GROUNDWATER DEPTH: Not Encountered (4/29/16)		ELEVATION: ---								
WATER LEVEL	U S C S	DESCRIPTION	DEPTH (FT.)	SAMPLE SYMBOL	MOISTURE (%)	DRY DENSITY (PCF)	% PASSING 200	LIQUID LIMIT (%)	PLASTICITY INDEX	REMARKS
		Ground Surface	0							moist stiff
	CL	SILTY CLAY with some fine sand; major roots (topsoil) to 8"; brown								
	MH	SILSTONE BEDROCK light gray				74	72	34		very stiff slightly moist hard
		End of Exploration at 7.0' No significant sidewall caving No groundwater encountered at time of excavation								
			5							
			10							
			15							
			20							
			25							

See Subsurface Conditions section in the report for additional information.

FIGURE 4C

Exhibit B-Geologic and Geotechnical Report

CLIENT: Dave and Gayle Mariani
 PROJECT: Lot 5 Big Sky Estates
 PROJECT NUMBER: 2104-01N-16

KEY TO BORING LOG

WATER LEVEL	U S C S	DESCRIPTION	DEPTH (FT.)	BLOW COUNT	SAMPLE SYMBOL	MOISTURE (%)	DRY DENSITY (PCF)	% PASSING 200	LIQUID LIMIT (%)	PLASTICITY INDEX	REMARKS

① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨ ⑩ ⑪ ⑫

COLUMN DESCRIPTIONS

- ① **Water Level:** Depth to measured groundwater table. See symbol below.
- ② **USCS:** (Unified Soil Classification System) Description of soils encountered; typical symbols are explained below.
- ③ **Description:** Description of material encountered; may include color, moisture, grain size, density/consistency,
- ④ **Depth (ft.):** Depth in feet below the ground surface.
- ⑤ **Blow Count:** Number of blows to advance sampler 12" beyond first 6", using a 140-lb hammer with 30" drop.
- ⑥ **Sample Symbol:** Type of soil sample collected at depth interval shown; sampler symbols are explained below.
- ⑦ **Moisture (%):** Water content of soil sample measured in laboratory; expressed as percentage of dryweight of
- ⑧ **Dry Density (pcf):** The density of a soil measured in laboratory; expressed in pounds per cubic foot.
- ⑨ **% Passing 200:** Fines content of soils sample passing a No. 200 sieve; expressed as a percentage.

- ⑩ **Liquid Limit (%):** Water content at which a soil changes from plastic to liquid behavior.
- ⑪ **Plasticity Index (%):** Range of water content at which a soil exhibits plastic properties.
- ⑫ **Remarks:** Comments and observations regarding drilling or sampling made by driller or field personnel. May include other field and laboratory test results using the following abbreviations:

CEMENTATION:

Weakly: Crumbles or breaks with handling or slight finger pressure.
Moderately: Crumbles or breaks with considerable finger pressure.
Strongly: Will not crumble or break with finger pressure.

MODIFIERS:

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

MOISTURE CONTENT (FIELD TEST):

Dry: Absence of moisture, dusty, dry to the touch.
Moist: Damp but no visible water.
Saturated: Visible water, usually soil below water table.

Descriptions and stratum lines are interpretive; field descriptions may have been modified to reflect lab test results. Descriptions on the logs apply only at the specific boring locations and at the time the borings were advanced; they are not warranted to be representative of subsurface conditions at other locations or times.

MAJOR DIVISIONS		USCS SYMBOLS	TYPICAL DESCRIPTIONS
COARSE-GRAINED SOILS More than 50% of material is larger than No. 200 sieve size.	GRAVELS More than 50% of coarse fraction retained on No. 4 sieve.	CLEAN GRAVELS (little or no fines)	GW Well-Graded Gravels, Gravel-Sand Mixtures, Little or No Fines
		GRAVELS WITH FINES (appreciable amount of fines)	GP Poorly-Graded Gravels, Gravel-Sand Mixtures, Little or No Fines
	SANDS More than 50% of coarse fraction passing through No. 4 sieve.	CLEAN SANDS (little or no fines)	SW Well-Graded Sands, Gravelly Sands, Little or No Fines
		SANDS WITH FINES (appreciable amount of fines)	GM Silty Gravels, Gravel-Sand-Silt Mixtures
			GC Clayey Gravels, Gravel-Sand-Clay Mixtures
			SP Poorly-Graded Sands, Gravelly Sands, Little or No Fines
FINE-GRAINED SOILS More than 50% of material is smaller than No. 200 sieve size.	SILTS AND CLAYS Liquid Limit less than 50%	ML Inorganic Silts and Very Fine Sands, Rock Flour, Silty or Clayey Fine Sands or Clayey Silts with Slight Plasticity	
		CL Inorganic Clays of Low to Medium Plasticity, Gravelly Clays, Sandy Clays, Silty Clays, Lean Clays	
		OL Organic Silts and Organic Silty Clays of Low Plasticity	
	SILTS AND CLAYS Liquid Limit greater than 50%	MH Inorganic Silts, Micaceous or Diatomaceous Fine Sand or Silty Soils	
		CH Inorganic Clays of High Plasticity, Fat Clays	
		OH Organic Silts and Organic Clays of Medium to High Plasticity	
HIGHLY ORGANIC SOILS	PT Peat, Humus, Swamp Soils with High Organic Contents		

STRATIFICATION:

DESCRIPTION	THICKNESS
Seam	up to 1/8"
Layer	1/8" to 12"
Occasional: One or less per 6" of thickness	
Numerous; More than one per 6" of thickness	

TYPICAL SAMPLER GRAPHIC SYMBOLS

- Bulk/Bag Sample
- Standard Penetration Spilt Spoon Sampler
- Rock Core
- No Recovery
- 3.25" OD, 2.42" ID D&M Sampler
- 3.0" OD, 2.42" ID D&M Sampler
- California Sampler
- Thin Wall

WATER SYMBOL

- Water Level

Note: Dual Symbols are used to indicate borderline soil classifications.

FIGURE 5



Exhibit B-Geologic and Geotechnical Report

CLIENT: Dave and Gayle Mariani
 PROJECT: Lot 5 Big Sky Estates
 PROJECT NUMBER: 2104-01N-16

**KEY TO
TEST PIT LOG**

WATER LEVEL	U S C S	DESCRIPTION	DEPTH (FT.)	SAMPLE SYMBOL	MOISTURE (%)	DRY DENSITY (PCF)	% PASSING 200	LIQUID LIMIT (%)	PLASTICITY INDEX	REMARKS

① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨ ⑩ ⑪

COLUMN DESCRIPTIONS

- ① **Water Level:** Depth to measured groundwater table. See symbol below.
- ② **USCS:** (Unified Soil Classification System) Description of soils encountered; typical symbols are explained below.
- ③ **Description:** Description of material encountered; may include color, moisture, grain size, density/consistency,
- ④ **Depth (ft.):** Depth in feet below the ground surface.
- ⑤ **Sample Symbol:** Type of soil sample collected at depth interval shown; sampler symbols are explained below.
- ⑥ **Moisture (%):** Water content of soil sample measured in laboratory; expressed as percentage of dryweight of
- ⑦ **Dry Density (pcf):** The density of a soil measured in laboratory; expressed in pounds per cubic foot.
- ⑧ **% Passing 200:** Fines content of soils sample passing a No. 200 sieve; expressed as a percentage.
- ⑨ **Liquid Limit (%):** Water content at which a soil changes from plastic to liquid behavior.
- ⑩ **Plasticity Index (%):** Range of water content at which a soil exhibits plastic properties.
- ⑪ **Remarks:** Comments and observations regarding drilling or sampling made by driller or field personnel. May include other field and laboratory test results using the following abbreviations:

CEMENTATION:	MODIFIERS:	MOISTURE CONTENT (FIELD TEST):
Weakly: Crumbles or breaks with handling or slight finger pressure.	Trace <5%	Dry: Absence of moisture, dusty, dry to the touch.
Moderately: Crumbles or breaks with considerable finger pressure.	Some 5-12%	Moist: Damp but no visible water.
Strongly: Will not crumble or break with finger pressure.	With > 12%	Saturated: Visible water, usually soil below water table.

Descriptions and stratum lines are interpretive; field descriptions may have been modified to reflect lab test results. Descriptions on the logs apply only at the specific boring locations and at the time the borings were advanced; they are not warranted to be representative of subsurface conditions at other locations or times.

UNIFIED SOIL CLASSIFICATION SYSTEM (USCS)	MAJOR DIVISIONS		USCS SYMBOLS	TYPICAL DESCRIPTIONS	STRATIFICATION:
	DESCRIPTION	USCS SYMBOLS	TYPICAL DESCRIPTIONS	DESCRIPTION	THICKNESS
COARSE-GRAINED SOILS More than 50% of material is larger than No. 200 sieve size.	GRAVELS More than 50% of coarse fraction retained on No. 4 sieve.	CLEAN GRAVELS (little or no fines)	GW	Well-Graded Gravels, Gravel-Sand Mixtures, Little or No Fines	Seam up to 1/8"
		GRAVELS WITH FINES (appreciable amount of fines)	GP	Poorly-Graded Gravels, Gravel-Sand Mixtures, Little or No Fines	Layer 1/8" to 12"
	SANDS More than 50% of coarse fraction passing through No. 4 sieve.	CLEAN SANDS (little or no fines)	GM	Silty Gravels, Gravel-Sand-Silt Mixtures	Occasional: One or less per 6" of thickness
			GC	Clayey Gravels, Gravel-Sand-Clay Mixtures	Numerous; More than one per 6" of thickness
		SANDS WITH FINES (appreciable amount of fines)	SW	Well-Graded Sands, Gravelly Sands, Little or No Fines	
			SP	Poorly-Graded Sands, Gravelly Sands, Little or No Fines	
FINE-GRAINED SOILS More than 50% of material is smaller than No. 200 sieve size.	SILTS AND CLAYS Liquid Limit less than 50%	SM	Silty Sands, Sand-Silt Mixtures		
		SC	Clayey Sands, Sand-Clay Mixtures		
		ML	Inorganic Silts and Very Fine Sands, Rock Flour, Silty or Clayey Fine Sands or Clayey Silts with Slight Plasticity		
	SILTS AND CLAYS Liquid Limit greater than 50%	CL	Inorganic Clays of Low to Medium Plasticity, Gravelly Clays, Sandy Clays, Silty Clays, Lean Clays		
		OL	Organic Silts and Organic Silty Clays of Low Plasticity		
		MH	Inorganic Silts, Micaceous or Diatomaceous Fine Sand or Silty Soils		
SILTS AND CLAYS Liquid Limit greater than 50%	CH	Inorganic Clays of High Plasticity, Fat Clays			
	OH	Organic Silts and Organic Clays of Medium to High Plasticity			
	PT	Peat, Humus, Swamp Soils with High Organic Contents			

TYPICAL SAMPLER GRAPHIC SYMBOLS

- Bulk/Bag Sample
- Standard Penetration Split Spoon Sampler
- Rock Core
- No Recovery
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- 3.0" OD, 2.42" ID D&M Sampler
- California Sampler
- Thin Wall

WATER SYMBOL

- Water Level

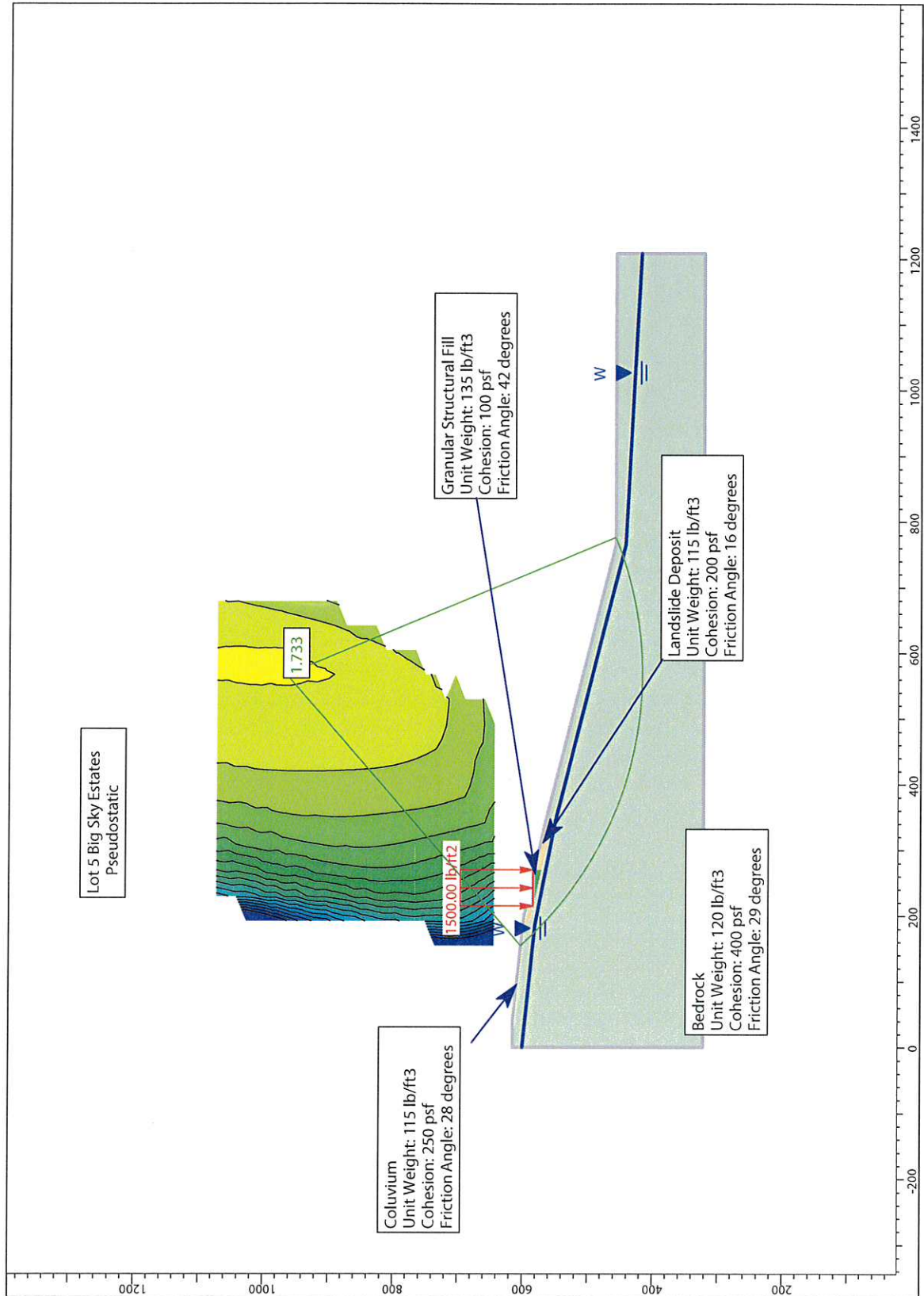
Note: Dual Symbols are used to indicate borderline soil classifications.

FIGURE 6



STABILITY RESULTS

LOT 5 BIG SKY ESTATES



PROJECT NO.: 2104-01N-16



FIGURE NO.: 7

STABILITY RESULTS

LOT 5 BIG SKY ESTATES

