July 26, 2021
Job No. 3361-002-21

Mr. Eric Ahern
Snowbasin Resort
3925 East Snowbasin Road
Huntsville, Utah 84317

Mr. Ahern:

RE: Geological and Geotechnical Reconnaissance
Proposed Middle Bowl Lift Re-Alignment
Snowbasin Resort
3925 East Snowbasin Road
Huntsville, Utah

1. INTRODUCTION

In response to your request, GSH Geotechnical, Inc (GSH) has prepared this geological and geotechnical reconnaissance report for the proposed Middle Bowl Lift re-alignment project, at Snowbasin Resort, Huntsville, Weber County, Utah. The location of the proposed re-alignment is shown on Figure 1, Vicinity Map, and Figure 2, Site Plan, provides aerial coverage of the site and detail of the current (2018) layout of the site vicinity.

The proposed re-alignment consists of an approximately 4,630-foot-long high-speed six-pack ski lift alignment, that covers part of Section 5, Township 5 North, Range 1 East, Salt Lake base and meridian. The site is located on the east side of the Mount Ogden-De Moisy Peak ridgeline crest of the Wasatch Mountains. The preliminary concept plans prepared by Ecosign Mountain Resort Planners Ltd., indicate the proposed re-alignment development is to include upper and lower terminal structures and 18 lift towers. The locations of the proposed alignment, terminals, and towers are shown on Figure 2. The proposed re-alignment will be built generally parallel but crossing the existing Middle Bowl lift alignment, with the Upper Terminal located slightly higher and to the southwest of the Needles Lodge structure.

Because the proposed re-alignment appears to be located in part on sloping areas in the vicinity of mapped landslide hazards, marginal soils, Quaternary faults and Federal Emergency Management Agency (FEMA) floodplain areas, Weber County is requesting that a geological site reconnaissance be performed to assess whether all or parts of the re-alignment project are exposed to the hazards that are included in the Weber County Code, Section 108-22 Natural Hazard Areas. These hazards include, but are not limited to: Surface-Fault Ruptures, Landslide, Tectonic Subsidence, Rock Fall, Debris Flows, Liquefaction Areas, Flood, or other Hazardous Areas.

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The purpose of this reconnaissance is to evaluate if the proposed re-alignment is outside or within areas identified as Natural Hazards Overlay District, and if within a hazard area, to recommend appropriate additional studies that comply with the purpose and intent of the Weber County Natural Hazards Area guidelines and standards in order to be "cleared" for building permit issuance by the county, as outlined by the Weber County Development Process packet as provided by the Weber County Building Inspection Department.

The objectives and scope of this study were discussed and presented to Mr. Eric Ahern, Director of Base Area Services of Snowbasin Resort, in our (GSH) Professional Services Agreement dated July 6, 2021, was signed by Mr. Davey Ratchford, General Manager of Snowbasin Resort July 9, 2021

The Objectives of this reconnaissance study are to:

1) Define potential geologic hazards and geotechnical conditions at the site.
2) Provide appropriate recommendations for geologic hazards, as well as foundations, earthwork, and geoseismic conditions.

In accomplishing the objectives, our Scope included the following:

1) Reconnaissance visit to the site for geological hazards and geotechnical conditions.
2) Summary report preparation.

1.2 AUTHORIZATION

Authorization was provided by Mr. Davey Ratchford by returning a signed copy of our Professional Services Agreements No. 21-0702 signed July 9, 2021.

1.3 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 and rock observed at the site, 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 geological and engineering principles and practices in this area at this time.

2. PROPOSED CONSTRUCTION

We understand that construction for the High Speed 6 Ski Lift is planned for the parcel. The proposed lift is to include upper and lower terminal structures and 18 lift towers. The proposed high speed 6 pack is an aerial lift that will span approximately 4,630 feet and will lift skiers approximately 1,165 feet in elevation.

2. INVESTIGATIONS

2.1 LITERATURE AND RESOURCE REVIEW

To evaluate the potential exposure of sites to geological hazards that impact sites or site improvements, Weber County has compiled a series of Geographic Information Systems (GIS) data mapping layers of geological hazard related information. These data may be queried on-line using the Weber County Geo-Gizmo web server application at:

http://www.co.weber.ut.us/gis/maps/gizmo/.

Using the Geo-Gizmo application, under the Engineering Layers category, is listed geological hazard related layers that may be toggled on and off to determine potential hazards exposure to sites in the county. These mapping layers include the following categories; *Quake Epicenters, FEMA Flood Zone Line, FEMA Base Flood Elevation, Wasatch Faults, Landslide Scarps, Geologic Faults, Faults, Quaternary Faults, FEMA Flood Zone, FEMA LOMR, Engineering Problems; Liquefaction Potential, Landslide, FEMA Letters of Map Change, and FEMA Flood Zones.* These layers have been compiled from the respective agencies including the Federal Emergency Management Agency (FEMA), the Utah Geological Survey (UGS), and the U.S. Geological Survey (USGS). These mapping layers consist of regional compilation hazards data but are not compiled at scales that are necessarily applicable for site specific usage and planning. When hazard layer data on the Geo-Gizmo are found to interact with Permit Applicant site improvement locations, Weber County Engineers and Planners will request that the Permit Applicant have a Professional Geologist Site Reconnaissance Review, such as presented herein, conducted for the site.

In addition to the Geo-Gizmo site screening, the Weber County Engineers and Planners rely on published UGS geological mapping (Coogan and King, 2016), that includes much of Weber County for determining if a site is located upon a potentially hazardous geological mapping unit, thus requiring a geological reconnaissance. This interactive "Weber County Geologic Map" may be viewed on-line at:

https://weber.maps.arcgis.com/apps/webappviewer/index.html?id=bd557ebafc0e4ed5847 1342bb03fdac5

Our preliminary review of the Geo-Gizmo indicated that the proposed re-alignment was near "*landslide*" hazard units that are mapped nearby according the UGS landslide database (Elliott and

Harty, 2010); however, the location did not show exposure to any of the other aforementioned hazard layer areas, Including; *Quaternary Faults* (USGS and UGS, 2006), and *FEMA Flood Zone* (FEMA, 2015).

The interactive Weber County Geologic Map (web map) shows the entire re-alignment spans ground codified (shaded red) as hazard by the web map, but our review of the "*Step by step directions to navigate the Weber County Geologic Website*" which lists the hazard area geologic units, at:

> https://webercountyutah.gov/inspection/documents/Step%20by%20step%20directions%20to%20navigate%20the%20Weber%20County%20Geologic%20Website.pdf

The step-by-step geologic unit listing indicates that only the listed geologic hazard units spanned by the re-alignment include: **Qmdf** - Debris- and mud-flow deposits (Holocene and upper and middle? Pleistocene) which would include debris-flow and debris-flood concerns; and **Qgp -** Pinedale glacial till and outwash (upper Pleistocene), which is a concern because Coogan and King (2016) have found that glacial deposits are prone to slope failures.

Our site-specific review consisted of a GIS data integration effort that included:

1. Reviews of previous mapping and literature pertaining to site and regional geology including Mulvey (1992), USGS and UGS (2016), Elliott and Harty (2010), King and others (2008), and Coogan and King (2016).

2. An analysis of vertical and stereoscopic aerial photography for the site including a 1963 1:15,840 scale black and white stereoscopic sequence; a 2001 1:15,840 scale color stereoscopic sequence; a 2012 5.0-inch digital HRO orthoimagery coverage, and a 2016 10.6 meter digital NAIP orthoimagery coverage of the site.

3. A GIS analysis using the QGIS® GIS platform to geoprocess and analyze 2006 2.0-meter LiDAR digital elevation data made available for the site by the Utah Automated Geographic Reference Center (AGRC). The GIS analysis included using the QGIS® platform Geospatial Data Abstraction Library (GDAL, 2013) Contour; the GRASS® (Geographic Resources Analysis Support System, 2013) r.slope and r.shaded.relief modules.

For the best site-specific documentation for this review, we relied on 1:100,000-scale geologic mapping by Coogan and King (2016), which provided the most up to date rendering of geological mapping for the site location, and 1:24,000-scale mapping by King and others (2008) was also used to support this review. The geological mapping for this review is provided on Figure 3, Geologic Mapping. Topographic, slope, and elevation data for this review was supported through the aforementioned LiDAR analysis, which is presented on Figure 4, LiDAR Analysis.

Site Evaluation

The site evaluation for the proposed development included the preliminary office procedures, outlined below, followed by a general field reconnaissance:

- A review of pertinent geological literature, mapping and data. from previous studies conducted in the area (Sorensen and Crittenden, 1979; Mulvey, 1992; USGS and UGS, 2016; Elliott and Harty, 2010; King and others, 2008; and Coogan and King, 2016), and seismic hazards information that was developed from United States Geologic Survey (USGS) databases (Peterson and others, 2014).

- A photogeologic analyses of vertical digital 2012 and 2018 orthoimagery shown on Figure 2, and the analysis of historical stereoscopic imagery flown in 1963 and 2001, and indexed as follows on Table 1:

Table 1
Stereoscopic Aerial Photograph Index

Year	Index	Scale	Color
1963	ELK_2-91	1:15840	B&W
1963	ELK_2-92	1:15840	B&W
2001	614190_1901-16	1:15840	Color
2001	614190_1901-17	1:15840	Color

- A GIS analyses of elevation and geoprocessed 2006 LiDAR terrain data as shown on Figure 4**,** LiDAR Analysis.

2.2 FIELD RECONNAISSANCE

A field reconnaissance of the general site area, including an on-ground visit to the site, was carried out July 13, 2021. The field reconnaissance was performed by GSH professionals: Dr. Greg Schlenker PG, Senior Geologist, Mr. Michael Huber PE, Senior Geotechnical Engineer, and Mr. Robert Gifford, PG, Project Geologist. The re-alignment span and each of the terminal and tower locations were inspected during this reconnaissance.

2.3 SLOPE ANALYSIS

Elevation data consisting of 2.0-meter 2006 LiDAR imagery was obtained from Utah Automated Geographic Reference Center (AGRC). These data were geo-processed using the QGIS® GIS platform, and using the r.slope, r.shaded.relief, and r.contour.level GRASS® (Geographic Resources Analysis Support System) modules, slope percentages, renderings and elevation contours were calculated for the site area.

Figure 4 presents the results of our slope analysis efforts. Shown on Figure 4 are the slope percentage gradients across the site. The calculated average slope gradient for the ground underlying the proposed lift is 34.9 percent. The threshold gradient for slope development restrictions according to the Weber County Section 108-14-3. (Weber County Code, 2021), includes slopes greater that 25 percent.

Topographic contour elevation lines were also calculated from the elevation data and are illustrated on Figure 4 with 2-foot intervals and 10-foot index contour intervals.

3. SITE CONDITIONS

3.1 SURFACE

As shown on Figures 1 and 2, the re-alignment area includes an established ski area with cleared ski and foot/bicycle trails and unpaved access/service roads. Elevation on the re-alignment ranges between 7563 feet on the east Lower Terminal area, to 8728 feet on the west Upper Terminal area. Slope gradients range from near-level to substantially steeper than the 30 percent. Overall, the re-alignment span slopes gently to moderately steeply down to the northeast. Surface vegetation consists of open areas of grasses, with weeds and underbrush, with areas of woody vegetation including clusters of aspen and fir trees. The ephemeral headwaters of Wheeler Creek emerge to the south of the site as shown on Figure 2 and flows generally to the northeast nearly parallel to the re-alignment.

The surface of the re-alignment is generally a series of stepping surfaces that have been formed through structural thrust faulting that occurred during the Cretaceous time, and late-Quaternary glacial erosion and deposition.

3.2 GEOLOGIC SETTING

The site is located on the eastern crest of Mount Ogden, which western flank comprises the Wasatch Front. The surficial geology of the site vicinity is the result of the uplift and exposure of older pre-Cambrian rocks which forms the crest of Mount Ogden east of the site. This exposure was the result of movement along high-angle faults during late Tertiary and Quaternary age (Bryant, 1988). Bounding the east foothill flank of Mount Ogden are mid Tertiary units of the Wasatch Formation and the Norwood Formation that ramp along the transition of the mountains to the foothills on the east. The Wasatch Front is marked by the Wasatch fault, which is 3.1 miles west of the site, and provides the basis of division between the Middle Rocky Mountain province on the east and the Basin and Range province on the west.

The Basin and Range province is characterized by approximately north-south trending valleys and mountain ranges that have been formed by extensional tectonics and displacement along normal faults, and extends from the Wasatch Range on the east to the Sierra Nevada Range on the west (Hunt, 1967). The Middle Rocky Mountain province is an assemblage of sedimentary, igneous, and metamorphic rocks that have been folded, faulted, and uplifted. Mountain building (tectonic) activity commenced about 30 million years ago (Oligocene epoch) and continues to the present.

The province is characterized by mountainous terrain with deep canyons and broad intervening basins, with temperate semi-arid to mesic climatic conditions (Hunt, 1967).

The surface of the Middle Bowl area is located upon older Precambrian and Paleozoic rocks that were thrusted from west to east roughly 80 million of years ago (Cretaceous Period), as part of what is called the Ogden Roof Thrust (Coogan and King, 2016). The thrusted rocks were locally covered approximately 20 to 30 million years ago by Tertiary volcanic deposits locally known as the Norwood Formation. Since the deposition of the Norwood Formation, orogenic mountain building processes have been occurring, resulting in the erosion and deposition of Quaternary age soils on the surface vicinity during the past 1.6 million years. More recently, between 30,000 BP to 12,000 BP, glacial ice accumulated upon the higher elevation peaks along the Wasatch Range, and subjected the terrain to glacial erosion and deposition, leaving eroded cirque valleys and depositional moraine features (Madsen and Currey, 1979). Since the regression of the ancient ice, stream erosion and incision of the mountain slopes has modified the glacial terrain features in the vicinity of the re-alignment site.

3.3 GEOLOGIC MAPPING

Figure 3 Geologic Mapping, shows the location of the site relative to integrated GIS overlays from the geological mapping prepared by King and others (2008), and Coogan and King (2016). A summary of the geological mapping units of the site and site vicinity is provided in relative age order as follows:

Qc – Colluvium (Holocene and Pleistocene) - Includes materials moved by slopewash and soil creep…

Qmsy - Younger landslide and slump deposits (Holocene) Poorly sorted clay- to boulder-sized material…

Qmdf – Debris- and mud-flow deposits (Holocene and upper and middle? Pleistocene) – Very poorly sorted, clay- to boulder-sized material in unstratified deposits characterized by rubbly surface and debris-flow levees with channels, lobes, and mounding...

Qmt – Talus (Holocene and Pleistocene**)** - Angular debris at the base of and on steep slopes…

Qmg –Mass-movement and glacial deposits, undivided (Holocene and Pleistocene) - poorly sorted clay, silt, sand, and gravel, to boulder-size materials…

Qgy – Qgmy - Younger glacial till and outwash (Holocene and upper Pleistocene)... till is non-stratified, poorly sorted clay, silt, sand, and gravel, to boulder-size materials...

Qgy/Ct- Younger glacial till and outwash (Holocene and upper Pleistocene), over **Ct - Tintic Quartzite** (Middle and Lower Cambrian)...

> **Qgp – Pinedale glacial till and outwash** (upper Pleistocene) – Pinedale-age (~12,000 to 30,000 years old)... till is non-stratified, poorly sorted clay, silt, sand, and gravel, to boulder size...
>
> **Cm - Maxfield Limestone** (Middle Cambrian) – From top down includes dolomite, limestone, argillaceous to silty limestone and calcareous siltstone and argillite, and basal limestone with argillaceous interval…with **Cml** representing the lower limestone member…
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> **Ophir Formation** (Middle Cambrian) – Upper and lower brown-weathering, slope-forming, gray to olive-gray, variably calcareous and micaceous to silty argillite to slate with intercalated gray, silty limestone beds; middle ledge-forming, gray limestone…with **Cou** representing the argillite member…
>
> **Ct - Tintic Quartzite** (Middle and Lower Cambrian) – Tan-weathering, cliff-forming, very well-cemented quartzite, with lenses and beds of quartz-pebble conglomerate, and lesser thin argillite layers; quartzite is tan, white, reddish-tan and pale-orange tan with abundant cross-bedding...

Summarily the geology of the site vicinity is the result of site formation processes beginning with structural thrust faulting during the Cretaceous time, and normal faulting and mountainous uplift which commenced during Oligocene time, and late-Pleistocene glacial erosion deposition, which has sculpted the present terrain of the re-alignment area. The bedding of the Cambrian rocks shown on Figure 3, are mapped as dipping northward and at an angle of 66 degrees on the east side of the Ogden Roof Thrust - thrust fault, and as dipping northeastward at an angle of 65 degrees on the west side of the Ogden Roof Thrust - thrust fault

4. DISCUSSIONS AND RECOMMENDATIONS

4.1 SUMMARY OF GEOLOGICAL FINDINGS

The engineering geology findings presented in this section pertain to the natural and geological hazards named in the Weber County Code, Section 108-22 Natural Hazard Areas. These hazards include, but are not limited to: Surface-Fault Ruptures, Landslide, Tectonic Subsidence, Rock Fall, Debris Flows, Liquefaction Areas, Flood, or other Hazardous Areas

4.1.1 Landsliding: From our analyses and reconnaissance, no features or surfaces identifiable as landsliding (Varnes, 1978) were found to impact the areas along the proposed re-alignment span. The nearest mapping unit classified as landslide consists of **Qmsy -** Younger landslide and slump deposits (Coogan and King, 2016) as occurring approximately 150 feet southeast of the Lower Terminal. The location of this landslide feature does not appear to impact proposed re-alignment.

4.1.2 Sloping Surfaces: The site vicinity slopes developed from our LiDAR Analysis range from level to well over 30 percent as shown on Figure 4. Slope percentage values for the average slope gradient for the ground underlying the proposed lift is 34.9 percent.

4.1.3 Geoseismic Setting: 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 (Peterson and others, 2014). The USGS values are presented on maps incorporated into the IBC code and are also available based on latitude and longitude coordinates (grid points).

Based on probabilistic estimates (Peterson and others, 2014) queried for the re-alignment, the expected peak horizontal ground acceleration on rock from a large earthquake with a 10 percent probability of exceedance in 50 years is 0.18*g,* and for a 2 percent probability of exceedance in 50 years is 0.48*g* for the west side of the re-alignment. For the east side of the re-alignment, the 10 percent probability of exceedance in 50 years is 0.18*g,* for a 2 percent probability of exceedance in 50 years is 0.45*g* for the eastside of the re-alignment.

The 10 percent probability of exceedance in 50 years event has a return period of 475 years, and the 0.18*g* acceleration for this event corresponds "strong" perceived shaking with "light" potential damage based on instrument intensity correlations. The 2 percent probability of exceedance in 50 years event has a return period of 2,475 years, and the 0.45*g* to 0.48*g* range of acceleration for this event corresponds "severe " perceived shaking with "moderate" potential damage based on instrument intensity correlations (Wald and others, 1999).

For dynamic structural analysis, the Site Class C – Very Dense Soil and Soft Rock Profile as defined in Chapter 20 of ASCE 7-16 (per Section 1613.3.2, Site Class Definitions, of IBC 2018) can be utilized.

The IBC 2018 code is based on USGS mapping, which provides values of short and long period accelerations for 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 – Stiff Soil Profile OR D – Default* Soil Profile OR C – Very Dense Soil and Soft Rock Soil Profile. Based on the site latitude and longitude (41.1970 degrees north and 111.8657 degrees west, respectively) and Risk Category I, the values for this site are tabulated on the following page.

Spectral Acceleration Value, T	Bedrock Boundary [mapped values] (% g)	Site Coefficient	Site Class C [adjusted for site class effects] (% g)	Design Values* (% g)
0.2 Seconds (Short Period Acceleration)	S_S = 102.7	F_a = 1.200	S_{MS} = 123.2	S_{DS} = 82.1
1.0 Second (Long Period Acceleration)	S_1 = 37.3	F_v = 1.500	S_{M1} = 56.0	S_{D1} = 37.3

4.1.4 Active Earthquake Faults: Based upon our review of available literature, no active Holocene age faults are known to pass through or immediately adjacent to the site. The nearest active (Holocene) fault is the Wasatch fault zone, Weber section (UT2351e), located 3.1 miles west of the re-alignment (Black and others, 2004). The Wasatch Fault Zone is considered capable of generating earthquakes as large as magnitude 7.3 (Arabasz and others 1992).

4.1.5 Liquefaction Potential Hazards: In conjunction with the ground shaking potential of large magnitude seismic events as discussed previously, certain soil units may also possess a potential for liquefaction during a large magnitude event. Liquefaction is a phenomenon whereby loose, saturated, granular soil units lose a significant portion of their shear strength due to excess pore water pressure buildup resulting from dynamic loading, such as that caused by an earthquake. Among other effects, liquefaction can result in densification of such deposits causing settlements of overlying layers after an earthquake as excess pore water pressures are dissipated. Horizontally continuous liquefied layers may also have a potential to spread laterally where sufficient slope or free-face conditions exist. The primary factors affecting liquefaction potential of a soil deposit are: (1) magnitude and duration of seismic ground motions; (2) soil type and consistency; and (3) occurrence and depth to groundwater.

Liquefaction potential hazards have not been studied or mapped for the Snowbasin area, as has occurred in other parts of northern Utah (Anderson and others, 1994). Liquefaction commonly occurs in saturated non-cohesive soils such as alluvium, which is not found on the proposed re-alignment; consequently the conditions susceptible to liquefaction do not appear to be present at the site.

4.1.6 Tectonic Subsidence is surface tilting subsidence that occurs along the boundaries of normal faults in response to surface-faulting earthquakes (Keaton, 1986). Because the site is not located in near proximity to active earthquake faults, tectonic subsidence hazards are not considered a risk to the site.

4.1.7 Alluvial Fan - Debris Flow Hazards: Alluvial fan debris flow processes including flash flooding and debris flow hazard: The nearest potential debris flow process deposits to the site are on-site units mapped as **Qmdf** – Debris- and mud-flow deposits, and occur on the east end of the re-alignment, including the Lower Terminal Location, and Tower T1 location as shown on

Figure 3**.** Based upon our reconnaissance observations, the surface and deposits observed at the Lower Terminal and Tower T1 locations appear to be glacial till deposits (**Qgp**), overlain by thin alluvial deposits (**Qmdf**) approximately one to one-and-a-half feet thick, and grading fills approximately one to two feet thick. Because the alluvial deposits were relatively fine, we consider the exposure to debris flow hazards to be Low for the Lower Terminal, and Tower T1 locations.

4.1.8 Flooding Hazards: No significant waterways pass in the vicinity of the re-alignment and flood insurance rate mapping by Federal Emergency Management Agency for the site vicinity has not been prepared for this area at this time (FEMA, 2015). Local sheet flow, slope wash, and seasonally perched soil water typical of sloping areas should be anticipated for the site and site improvements.

4.1.9 Rockfall and Avalanche Hazards: No talus deposits **(Qmt) w**ere observed in the vicinity of the Upper Terminal area where steep rock slopes stand above the re-alignment; thus, we consider exposure to rockfall hazards to be Low for the Upper Terminal area.

The Snowbasin Snow-Safety staff have indicated from their experience that the Upper Terminal area is not subject avalanche runout (Perla and Martinelli, 1976), and furthermore we understand the entire re-alignment area will be subject Snow-Safety control during winter operations.

4.2 SUMMARY OF GEOTECHNICAL FINDINGS

Based on our review of available information and site reconnaissance, the site is suitable for the proposed construction. Tower and terminal foundations may be constructed over suitable natural soils and/or bedrock. The most significant geotechnical aspects of the site are the presence of non-engineered fills near the base terminal area and areas where access roads form a cut-fill sequence in and over the natural soils/bedrock. Additionally, debris flow/mudflow deposits may exist based on geologic mapping in the base terminal location which may be comprised of hydro-collapsible soils. The reconnaissance indicated no collapsible soils which will be further confirmed during future footing excavation observations.

Prior to proceeding with construction, demolition and removal of the existing lift towers (if in conflict with the new alignment), foundations, associated debris, surface vegetation, root systems, topsoil, non-engineered fill, potentially collapsible soils, and any deleterious materials from beneath an area extending out at least 3 feet from the perimeter of the proposed foundation footprints is required. All existing utility locations should be reviewed to assess their impact on the proposed construction and abandoned and/or relocated as appropriate.

On-site non-engineered fill soils encountered were primarily granular. On-site granular soils, including existing non-engineered fills, may be re-utilized as structural site grading fill if they meet the criteria for such, which can be provided upon request.

A qualified representative from GSH must observe each foundation excavation to verify that all unsuitable soils have been removed and that suitable soils and or bedrock has been encountered prior to placing structural fill or constructing foundations. Specific recommendations for each excavation observation will be communicated during the site visit and formally within a letter documenting the observations and recommendations.

5. CONCLUSIONS

This report provides our assessment of potential geologic and geotechnical hazards in the vicinity of the re-alignment and the exposure of the re-alignment to the hazards that are included in the Weber County Code, Section 108-22 Natural Hazard Areas. These hazards include, but are not limited to: Surface-Fault Ruptures, Landslide, Tectonic Subsidence, Rock Fall, Debris Flows, Liquefaction Areas, Flood, or other Hazardous Areas.

Based upon the findings of this review, we believe that the proposed re- alignment is not adversely exposed to the geological hazards specified in the Section 108-22 Natural Hazard Areas of the Weber County Code (2021).

From a geological and geotechnical standpoint, it is our opinion that the re-alignment project be permitted to move forward with the appropriate geotechnical engineering support for the terminal and tower location foundation design and siting.

6. CLOSURE

If you have any questions or would like to discuss these items further, please feel free to contact us at (801) 685-9190.

Respectfully submitted,
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Encl. Figure 1, Vicinity Map
Figure 2, Aerial Coverage
Figure 3, Geologic Mapping
Figure 4, LiDAR Analysis

7. REFERENCES

Anderson, L.R., Keaton, J.R., and Bay, J.A., 1994, Liquefaction potential map for the northern Wasatch Front, Utah, complete technical report: Utah Geological Survey Contract Report 94-6, 150 p., 6 plates, scale 1:48,000.

Arabasz, W.J., Pechmann, J.C., and Brown, E.D., 1992, Observational seismology and the evaluation of earthquake hazards and risk in the Wasatch Front area, Utah, in Gori, P.L., and Hays, W.W., (eds.), Assessment of regional earthquake hazards and risk along the Wasatch Front, Utah: U.S. Geological Survey Professional Paper 1500-D, 36 p.

Black, B.D., DuRoss, C.B., Hylland, M.D., McDonald, G.N., and Hecker, S., compilers, 2004, Fault number 2351e, Wasatch fault zone, Weber section, in Quaternary fault and fold database of the United States: U.S. Geological Survey website, http://earthquakes.usgs.gov/hazards/qfaults, accessed 06/20/2016 02:49 PM.

Bryant, B.B., 1988, Geology of the Farmington Canyon Complex, Wasatch Mountains, Utah: USGS Professional Paper 1476, 54 p., 1 scale 1:50,000

Coogan, J.C., and King, J.K., 2016, Interim geologic map of the Ogden 30' x 60' quadrangle, Box Elder, Cache, Davis, Morgan, Rich, and Summit Counties, Utah, and Uinta County, Wyoming: Utah Geological Survey Open File Report 653DM, for use at 1:62,500 scale, 3 plates, 147 p.

Elliott, A.H., and Harty, K.M., 2010, Landslide Maps of Utah, Utah Geological Survey Map 246DM, 14 p., 46 plates, 1:100,000 scale

FEMA, 2015, Flood Insurance Rate Map, 2015 Weber County, Utah, Panel 49057C0475F, Scale 1 inch equals 1000 feet.

GDAL-SOFTWARE-SUITE, 2013, Geospatial data abstraction library. http://www.gdal.org/

GRASS-PROJECT, 2013. Geographic resource analysis support system. http://grass.osgeo.org/.

Keaton, J.R., 1986, Potential consequences of tectonic deformation along the Wasatch fault: Utah State University, Final Technical Report to the U.S. Geological Survey for the National Earthquake Hazards Reduction Program, Grant 14-08-0001-G0074, 23 p.

King, J.K., Yonkee, W.A., and Coogan, J.C., 2008, Interim geologic map of the Snow Basin and part of the Huntsville quadrangle, Davis, Morgan, and Weber Counties, Utah: Utah Geological Survey Open-File Report 536, scale 1:24,000.

Mulvey, W.E., 1992, Soil and rock causing engineering geologic problems in Utah: Utah Geological Survey Special Study 80, 23 p., scale 1:500,000.

Madsen, D.B., and Currey, D.R., 1979, Late Quaternary glacial and vegetation changes, Little Cottonwood Canyon area, Wasatch Mountains, Utah: Quaternary Research v. 12, p. 254-270.

Petersen, M.D., Moschetti, M.P., Powers, P.M., Mueller, C.S., Haller, K.M., Frankel, A.D., Zeng, Yuehua, Rezaeian, Sanaz, Harmsen, S.C., Boyd, O.S., Field, Ned, Chen, Rui, Rukstales, K.S., Luco, Nico, Wheeler, R.L., Williams, R.A., and Olsen, A.H., 2014, Documentation for the 2014 update of the United States national seismic hazard maps: U.S. Geological Survey Open-File Report 2014–1091, 243 p.

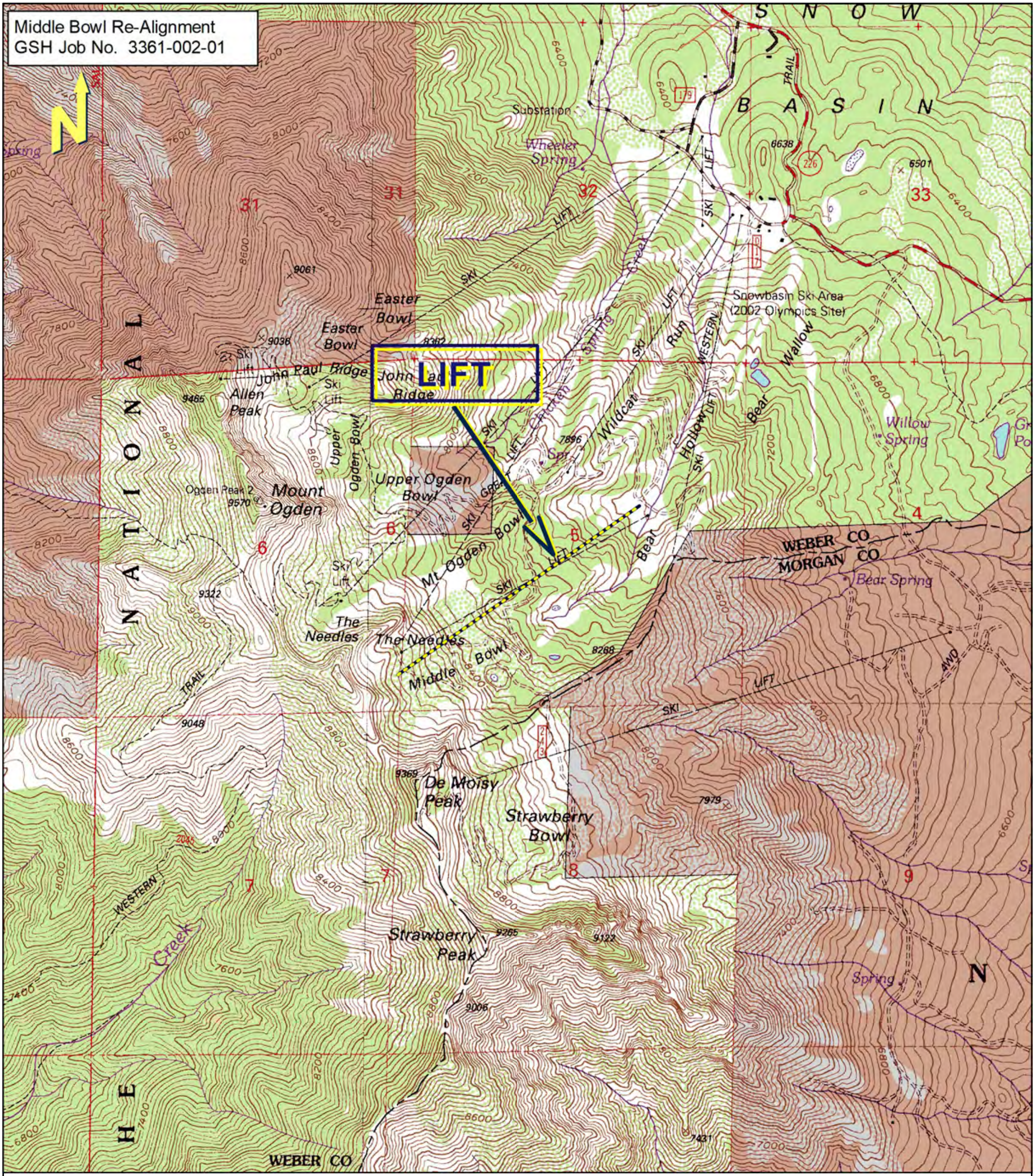
U.S. Geological Survey and Utah Geological Survey, 2006, Quaternary fault and fold database for the United States, from USGS web site: http//earthquakes.usgs.gov/hazards/qfaults/

Varnes, D.J., 1978, Slope movement types and processes, in Schuster, R.L., and Krizek, R.J., eds., Landslides—Analysis and control: National Research Council, Washington, D.C., Transportation Research Board, Special Report 176, p. 11–33

Wald, D.J., Quitoriano, V., Heaton, T.H., and Kanamori, H., 1999, Relationship between Peak Ground Acceleration, Peak Ground Velocity, and Modified Mercalli Intensity in California: Earthquake Spectra, v. 15, no. 3, p. 557-564

Weber County Code (2021), retrieved from:
https://www.municode.com/library/ut/weber_county/codes/code_of_ordinances

Weber County Inspection (2021), retrieved from:
http://www.webercountyutah.gov/inspection/documents/Development Process Packet.pdf



Base:
1998 7.5 Minute USGS Toporgraphic Maps
Titled Snowbasin, Utah, and Ogden, Utah.
from Utah AGRC; http://gis.utah.gov/

0 2000 4000 ft

1:24,000

FIGURE 1
VICINITY MAP

GSH

Middle Bowl Re-Alignment
GSH Job No. 3361-002-01

Explanation

Middle Bowl Lift Re-Alignment

Proposed Tower and Terminal Locations

Proposed Terminal Location

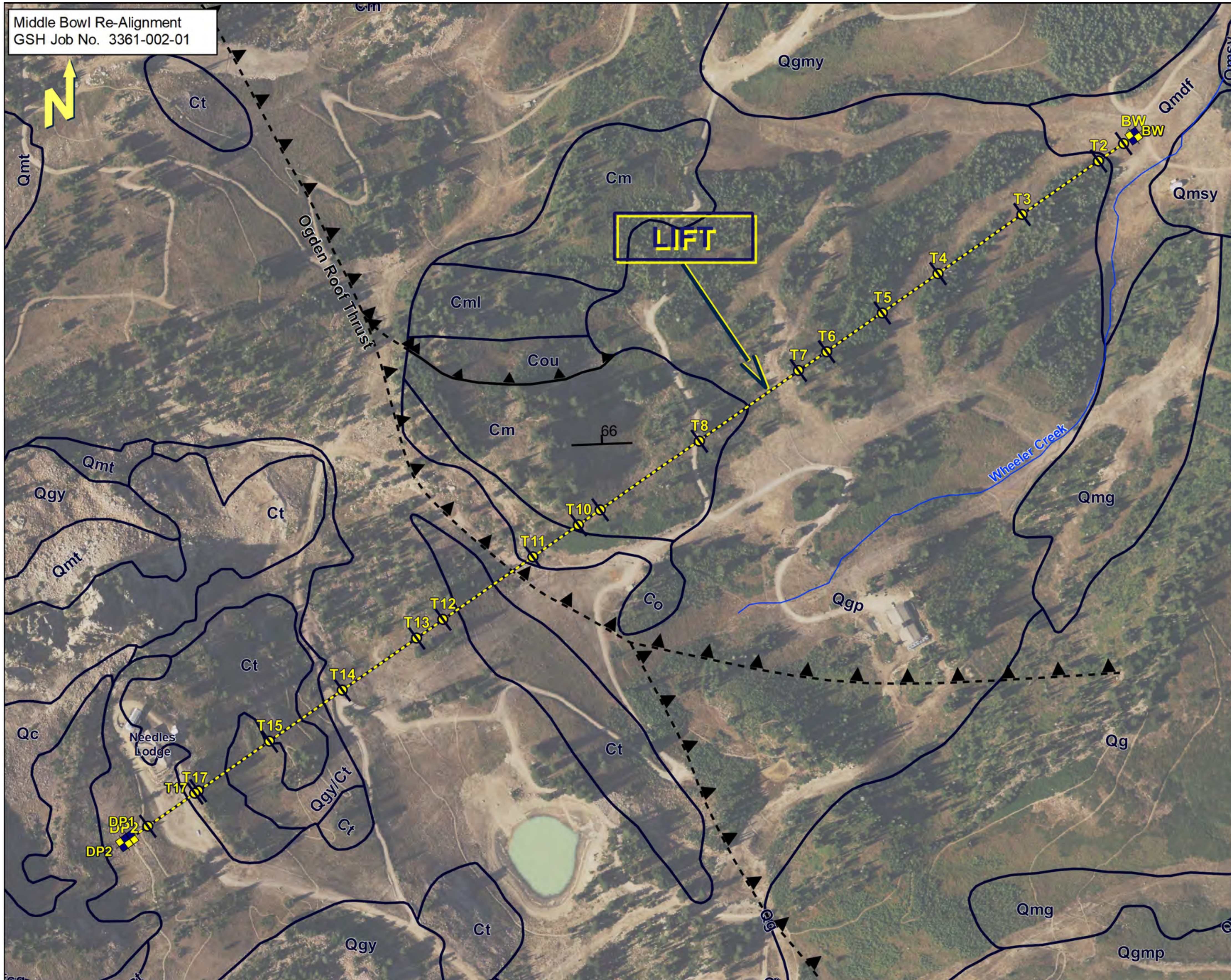
Proposed Tower Location

Base:
2018 0.6m NAIP Color Orthoimagery
from Utah AGRC; http://gis.utah.gov/

0 400 800 ft
1:4,800

FIGURE 2
AERIAL COVERAGE

GSH



Base:
2018 0.6m NAIP Color Orthoimagery
from Utah AGRC; http://gis.utah.gov/

0 400 800 ft

1:4,800

Geologic Classification

(after King and others, 2008; and Coogan and King, 2016)

Qc – Colluvium (Holocene and Pleistocene) - Includes materials moved by slopewash and soil creep…

Qmsy - Younger landslide and slump deposits (Holocene) Poorly sorted clay- to boulder-sized material…

Qmdf – Debris- and mud-flow deposits (Holocene and upper and middle? Pleistocene) – Very poorly sorted, clay- to boulder-sized material in unstratified deposits characterized by rubbly surface and debris-flow levees with channels, lobes, and mounding...

Qmt - Talus (Holocene and Pleistocene) - Angular debris at the base of and on steep slopes…

Qmg – Mass-movement and glacial deposits, undivided (Holocene and Pleistocene) - poorly sorted clay, silt, sand, and gravel, to boulder size materials…

Qgy – Qgmy - Younger glacial till and outwash (Holocene and upper Pleistocene)... till is non-stratified, poorly sorted clay, silt, sand, and gravel, to boulder size materials...

Qgy/Ct- Younger glacial till and outwash (Holocene and upper Pleistocene), over **Ct - Tintic Quartzite** (Middle and Lower Cambrian)...

Qgp – Pinedale glacial till and outwash (upper Pleistocene) – Pinedale-age (~12,000 to 30,000 years old)... till is non-stratified, poorly sorted clay, silt, sand, and gravel, to boulder size...

Cm - Maxfield Limestone (Middle Cambrian) – From top down includes dolomite, limestone, argillaceous to silty limestone and calcareous siltstone and argillite, and basal limestone with argillaceous interval...with **Cml** representing the lower limestone member…

Co – Ophir Formation (Middle Cambrian) – Upper and lower brown-weathering, slope-forming, gray to olive-gray, variably calcareous and micaceous to silty argillite to slate with intercalated gray, silty limestone beds; middle ledge-forming, gray limestone...with **Cou** representing the argillite member…

Ct - Tintic Quartzite (Middle and Lower Cambrian) – Tan-weathering, cliff-forming, very well-cemented quartzite, with lenses and beds of quartz-pebble conglomerate, and lesser thin argillite layers; quartzite is tan, white, reddish tan and pale-orange tan with abundant cross-bedding...

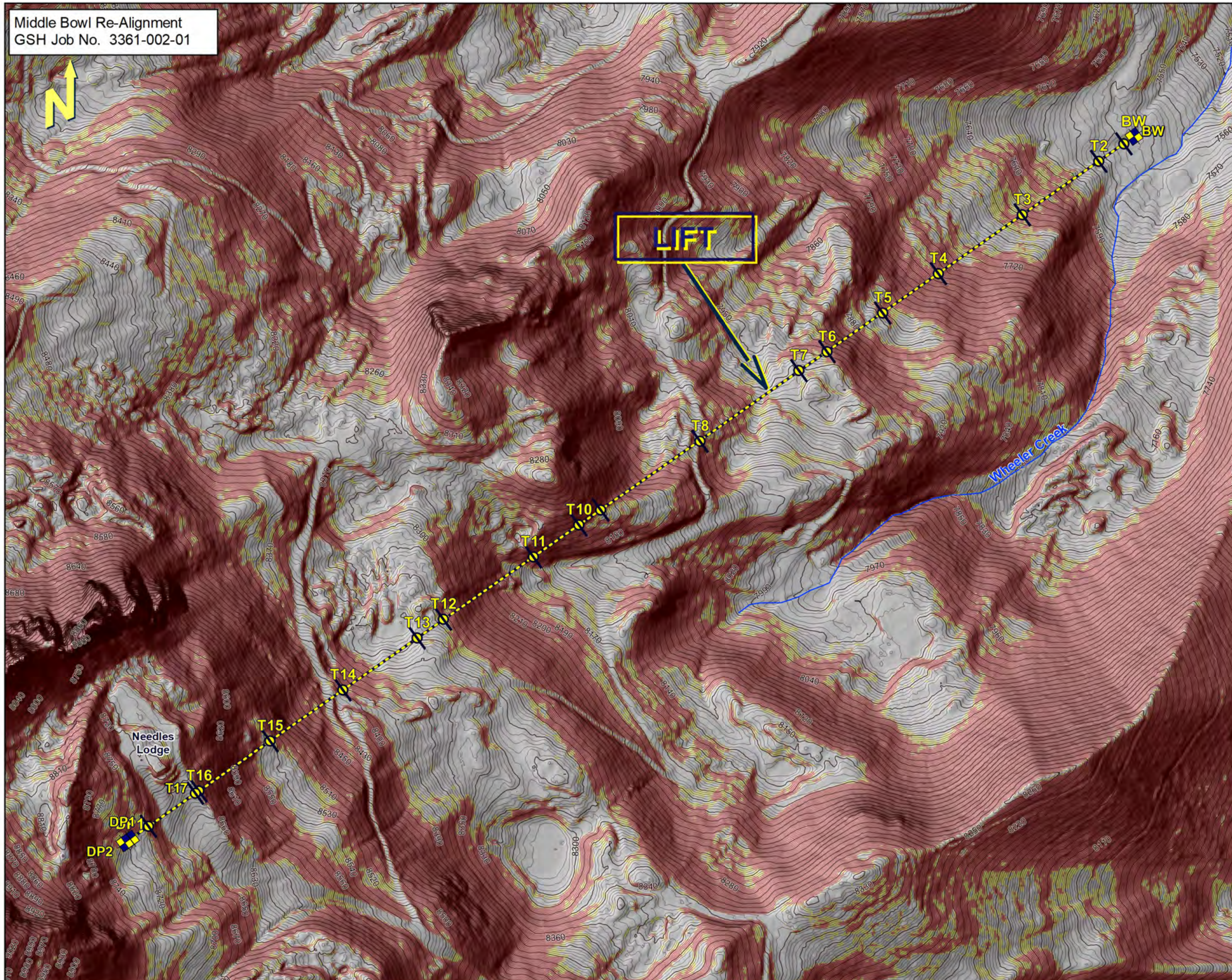
Thrust fault - well located

Thrust fault - concealed

Strike and dip of beds

FIGURE 3
GEOLOGIC MAPPING

GSH



Base:
2006 2.0 m LiDAR Imagery
from Utah AGRC; http://gis.utah.gov/

0 400 800 ft

1:4,800

Explanation

Slope Gradients

- 25 to 30 Percent Slopes
- Greater than 30 Percent Slopes
- Index Contour 10ft

FIGURE 4
LiDAR ANALYSIS