GCS Geoscience

Report Professional Geologist Site Reconnaissance and Review
Proposed 1500-foot Snowmaking Water Line Extension
Parcel #22-029-0008 Nordic Valley Ski Resort
Eden, Weber County, Utah

For:

Nordic Valley Resort LLC
3567 Nordic Valley Way
Eden, Utah 84310

By:

GCS Geoscience
554 South 7700 East Street
Huntsville, Utah 84317

October 19, 2018
GCS File No: 2018.33

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Nordic Valley Resort LLC
3567 Nordic Valley Way
Eden, Utah 84310

ATTN: Mr. Denzel Rowland

Subject: **Report**
Professional Geologist Site Reconnaissance and Review
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Parcel #22-029-0008 Nordic Valley Ski Resort
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In response to your request, GCS Geoscience (GCS) has prepared this Professional Geologist site reconnaissance review services for the above referenced improvements at Nordic Valley Resort. The affected parcel consists of an approximately 32.33-acre property that is part of the Nordic Valley Resort in Weber County, Utah, as shown on attached Figure 1. Figure 2 provides aerial coverage of the site and detail of the current (2014) layout of the site vicinity.

The parcel is generally open and presently developed for lift-served skiing. The existing facilities include an approximately 2770-foot long double chairlift (the Apollo Lift) that loads from a bottom terminal on an adjacent parcel, with a "Midway" loadout, and a top terminal located on the subject parcel. The subject parcel and surrounding properties are zoned by Weber County as Open Space Zone O-1, land-use zone. According to the Weber County Code of Ordinances *the purpose and intent of the open space zone is specifically intended to encourage the preservation of a natural environment in an otherwise urban setting; to hold for future generations open space in which plants and animals can be protected and studied; to inhibit erection of unnecessary buildings on a floodplain, on areas of severe slope, areas of fault line and rock slides; to provide suitable areas for recreation and relaxation, and to alleviate stream pollution.*

It is our understanding that resort intends to extend existing snowmaking water supply to the upper Apollo Lift area, above the Midway Loadout, as shown on Figure 2. The proposed extension is to consist of an approximately 1500-foot long buried four-inch diameter water supply pipeline, with three interval-spaced hydrants for snow gun hook-up. The water supply pipeline excavation will be four feet in depth and 18-inches wide during construction

Because the proposed improvements appear to be located in part on a hillslope area in the vicinity of mapped landslide hazards, marginal soils, and/or FEMA floodplain areas,

Weber County is requesting that a geological site reconnaissance be performed to assess whether all or parts of the site 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.

The purpose of this **Professional Geologist Site Reconnaissance Review** is to evaluate if the proposed improvements are 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.

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 recently 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 mapping may be viewed on-line at:

https://weber.maps.arcgis.com/apps/webappviewer/index.html?id=bd557ebafc0e4ed58471342bb03fdac5

Our preliminary review of the Geo-Gizmo web server indicated that the affected parcel area partially overlapped with area classified as Landslide layer, however our review of the Weber County Geologic Map indicated that the property is located upon a geological mapping unit designated as **Qms(**ZYp) – Mass movement deposits (Holocene and Pleistocene), a mapping unit that is considered potentially hazardous because of indications of past movement, thus requiring this reconnaissance and review.

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 and Sorensen and Crittenden (1979), Mulvey (1992), USGS and UGS (2016), Elliott and Harty (2010), King and McDonald (2014), and Coogan and King (2016).

2. An analysis of vertical and stereoscopic aerial photography for the site including a 1947 1:20,000 stereoscopic sequence, 2012 5.0 inch digital HRO coverage, and 2014 1.0 meter digital NAIP coverage of the site.

3. A GIS analysis using the QGIS® GIS platform to geoprocess and analyze 2011 1.0 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 geologic mapping by Coogan and King (2016), which provided the most up-to-date rendering of geological mapping for the site location. Supporting documentation by King and McDonald (2014), and Sorensen and Crittenden (1979) 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.

Review Findings

The site is located in Ogden Valley on the eastern flank of Lewis Peak. The valley is a northwest trending fault bounded graben structure, with the Wasatch Range comprising the western flank of the valley and the Bear River Range the eastern flank (Avery, 1995). Topographically the site is located on valley margin slopes positioned between Lewis Peak on the west and floodplains of the North Fork of the Ogden River on the east. The property is located on gentle to steep valley margin slopes at the base of

slopes that buttress Lewis Peak which rises to 8031 feet, approximately 3.1 miles southwest of the site.

The surface of the site is located upon a valley margin slopes formed on Precambrian and Paleozoic rocks that have been incised and eroded by past alluvial processes. The elevation of the proposed water line is roughly between 5824 feet at the bottom, and 6312 feet at the top as shown on Figure 4.

Geological Mapping:
Figure 3 shows the location of the site relative to GIS overlays including geological mapping drawn from Coogan and King (2016). A summary of the geological mapping of the site vicinity, as paraphrased from Coogan and King (2016), is provided as follows:

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...

Qafy Qaf - Alluvial-fan deposits (Holocene and Pleistocene) – Mostly sand, silt, and gravel that is poorly bedded and poorly...variably consolidated; includes debris flows, particularly in drainages and at drainage mouths (fan heads)...with unit **Qafy** being the lowest (youngest) fans and **Qaf** being undivided in age determination...

Qac - Alluvium and colluvium (Holocene and Pleistocene) – Unsorted to variably sorted gravel, sand, silt, and clay in variable proportions; includes stream and fan alluvium, colluvium, and, locally, mass-movement deposits...

Qms - Landslide deposits (Holocene and upper and middle? Pleistocene) – Poorly sorted clay- to boulder sized material; includes slides, slumps, and locally flows and floods...

Qms(ZYp) - Block landslide and possible block landslide deposits (Holocene and upper and middle? Pleistocene) – Jumbled mass of formation of Perry Canyon (ZYp) with blocks...

Zpu - Formation of Perry Canyon bedrock; Upper member (Neoproterozoic) – Olive drab to gray, thin-bedded slate to argillite to phyllite to micaceous meta-siltstone to meta-graywacke to meta-sandstone in variable proportions such that unit looks like both the "greywacke-sandstone" and "mudstone"...This unit is prone to slope failures...

Zpd - Formation of Perry Canyon bedrock; Diamictite member (Neoproterozoic) – Tan to gray weathering, gray to dark-gray meta-diamictite containing pebble to boulder-sized quartzite and granitoid (quartzo-feldspathic gneiss) clasts in dark-gray sandy (up to granule size) to micaceous argillite matrix...

In summary the surface of the site is located upon older Precambrian and Paleozoic rocks that were thrusted from west to east roughly 80 million of years ago, as part of what is called the Willard Thrust (Sorensen and Crittenden, 1979). 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. Most recently, in the past 19,000 to 15,000 years, ancient Lake Bonneville inundated parts of Ogden Valley leaving lake bed soil deposits, and adjusting the grade of alluvial soil deposition in the valley during and after the period of lake inundation (Currey and Oviatt, 1985).

Site Specific Geology:
Figure 3 indicates the proposed water line is located entirely upon **Qms(ZYp)** - Block landslide and possible block landslide deposits. These deposits consist of broken block structures comprised of Formation of Perry Canyon rocks (**Zpu** and **Zpd**) which abut the **Qms(ZYp)** deposits on the west, and likely underlie the block landslide deposits at depth. The **Qms(ZYp)** deposits are believed to have moved since the Holocene and upper and middle? Pleistocene time (Coogan and King, 2016). However, on the basis of the morphostratigraphic position of bounding **Qac** and **Qmdf** deposits, we believe the time of movement for the **Qms(ZYp)** deposits at the site to be no younger than middle Pleistocene age.

Normal faulting extending northwest across the site and the proposed water line alignment is shown on Figure 3. This fault structure is named in the U.S. Geological Survey Quaternary fault and fold database as the Ogden Valley southwestern margin faults (UT2375). The most recent movement on this fault is projected to be middle and late Quaternary age, greater than 750,000 years ago, and therefore is presently is not considered an active risk (Black and others, 1999).

Under present conditions no active geological processes appear to be occurring on proposed water line location.

Hazards Review:
In addition to the review and location query we searched for nearby or proximal classifications or conditions that could possibly present hazardous conditions to the site. A summary of this search is provided as follows:

1. **Landsliding:** The nearest active landslide units are mapped as **Qms** deposits by Coogan and King (2016), and are located approximately 760 feet to the northwest of the site, as shown on Figure 3. This **Qms** unit appears to slope away from the site, and is not expected to impact the proposed improvements in the future.

2. **Alluvial fan debris flow processes** including flash flooding and debris flow hazard: The nearest potential debris flow process deposits to the site are mapped as **Qmdf** by Coogan and King (2016), and occur along the Union Creek drainage approximately 900 feet north of the site, and These deposits occupy lower ground and are sufficiently separated from the proposed water line, thus are not considered a potential impact to the site.

3. **Surface fault rupture hazards, strong earthquake ground motion, tectonic subsidence and liquefaction potential:**

   Surface fault rupture hazards: The nearest active (Holocene) earthquake fault to the site is the Weber section of the Wasatch fault zone (UT2351E) which is located 3.0 miles west of the site, thus fault rupture hazards are not considered present on the site (Black and others, 2004). The Ogden Valley North Fork fault (UT2375) is shown to cross the site and proposed water line alignment, however the most recent movement along this fault is estimated to be pre-Holocene (>15,000 ybp), and therefore is presently is not considered an active risk (Black and others, 1999). Active earthquake faults are generally considered to be faults which have disrupted the ground surface within the past 11,000 years of earth history (the Holocene epoch). Implied with this definition is that such faults are likely to disrupt the ground surface in the relatively near future (Lund and others, 2016).

   Strong earthquake ground motion originating from the Wasatch fault or other near-by seismic sources is capable of impacting the site. The Wasatch fault zone is considered active and capable of generating earthquakes as large as magnitude 7.3 (Arabasz and others, 1992). Based on probabilistic estimates (Peterson, and others, 2008) queried for the site, the expected peak horizontal ground acceleration on rock from a large earthquake with a ten-percent probability of exceedance in 50 years is as high as 0.18*g*, and for a two-percent probability of exceedance in 50 years is as high as 0.42*g* for the site.

   The ten-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 two-percent probability of exceedance in 50 years event has a return period of 2475 years, and the 0.42*g* acceleration for this event corresponds "severe" perceived shaking with "moderate to heavy" potential damage based on instrument intensity correlations (Wald and others, 1999).

   Future ground accelerations greater than these are possible but will have a lower probability of occurrence.

   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.

Liquefaction potential hazards: In conjunction with strong earthquake ground motion 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 Ogden Valley 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 alignment, consequently the conditions susceptible to liquefaction do not appear to be present at the site.

4. **Rockfall and avalanche hazards**: The site is over a mile from steep slope areas where such hazards may originate.

5. **Flooding:** No significant water ways pass in the vicinity of the site and flood insurance rate mapping by Federal Emergency Management Agency for the site vicinity indicates that the site is outside the 100-year Flood Zone (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.

6. **Sloping surfaces:** The site vicinity slope gradients developed from our LiDAR analysis range from level to well over 50-percent as shown on Figure 4. Within the property area slope gradients are moderate to steep. On Figure 4, the site slopes are shown to slope moderately to steeply to the northeast. The calculated average slope for the parcel is 40.2 percent, and 35.4 percent for the proposed water line alignment.

Site Reconnaissance

The proposed water line alignment was reconnoitered on October 15, 2018. The alignment was accessed from resort parking lot on Nordic Valley Way on the west side of the site. The surface of the alignment consists of a moderate to steep slope down to the northeast sloping surface. Cover vegetation on the site consisted of dormant fescue and tall bunch grass, with few curly dock individuals, and the wooded areas off

the alignment were occupied by scrub oak, maple and fir trees. The soils observed on the surface of the site appeared to be silty clay and sandy silts with angular gravel and cobbles. The top and bottom ends and intersection points of the proposed alignment were staked and the locations were observed during our visit. Lineal soil lobes approximately a foot in height, oriented perpendicular to the slope were observed on the steeper sloping parts of the alignment. The soil lobes are likely the result of seasonal near surface soil creep, typical for steep open slope areas. During the reconnaissance no conditions of imminent geologic hazards were observed at the site.

Conclusions

Based upon the findings of this review we believe that the proposed water line alignment is not adversely exposed to the geological hazards specified in the Section 108-22 Natural Hazard Areas of the Weber County Code (2018).

The proposed water line is to be constructed four feet below the surface, which should be adequately deep enough to avoid the influence of frost and the action of seasonal near surface soil creep.

Limitations

Our services were limited to the scope of work discussed in the introduction section of this report. The results provided by this study are limited to geological hazards included in the Weber County Code, Section 108-22 Natural Hazard Areas (Weber County, 2018). The reporting provided here is not based upon any subsurface observations, and should in no way preclude the results of a geotechnical engineering soils and groundwater studies for foundations, earthwork, and geoseismic design prepared by a professional engineer licensed in the State of Utah.

Although risk can never be eliminated, more detailed and extensive studies yield more information, which may help understand and manage the level of risk. The recommendations contained in this report are based on our site observations, available data, probabilities, and our understanding of the facilities investigated. This report was prepared in accordance with the generally accepted standard of practice at the time the report was written. No warranty, express or implied, is made.

This report may be used only by the client and only for the purposes stated within a reasonable time from its issuance. The regulatory requirements and the "state of practice" can and do change from time to time, and the conclusions presented herein may not remain current. Based on the intended use of the report, or future changes to design, GCS Geoscience may require that additional work be performed and that an updated report be issued. Non-compliance with any of these requirements by the client or anyone else, unless specifically agreed to in advance by GCS Geoscience in writing will release GCS Geoscience from any liability resulting from the use of this report by any unauthorized party.

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We appreciate the opportunity to work with you on this project and look forward to assisting you in the future. If you have any questions or need additional information on this or other reporting, please contact the undersigned at (801) 745-0262 or (801) 458-0207.

Respectfully submitted,

GCS Geoscience

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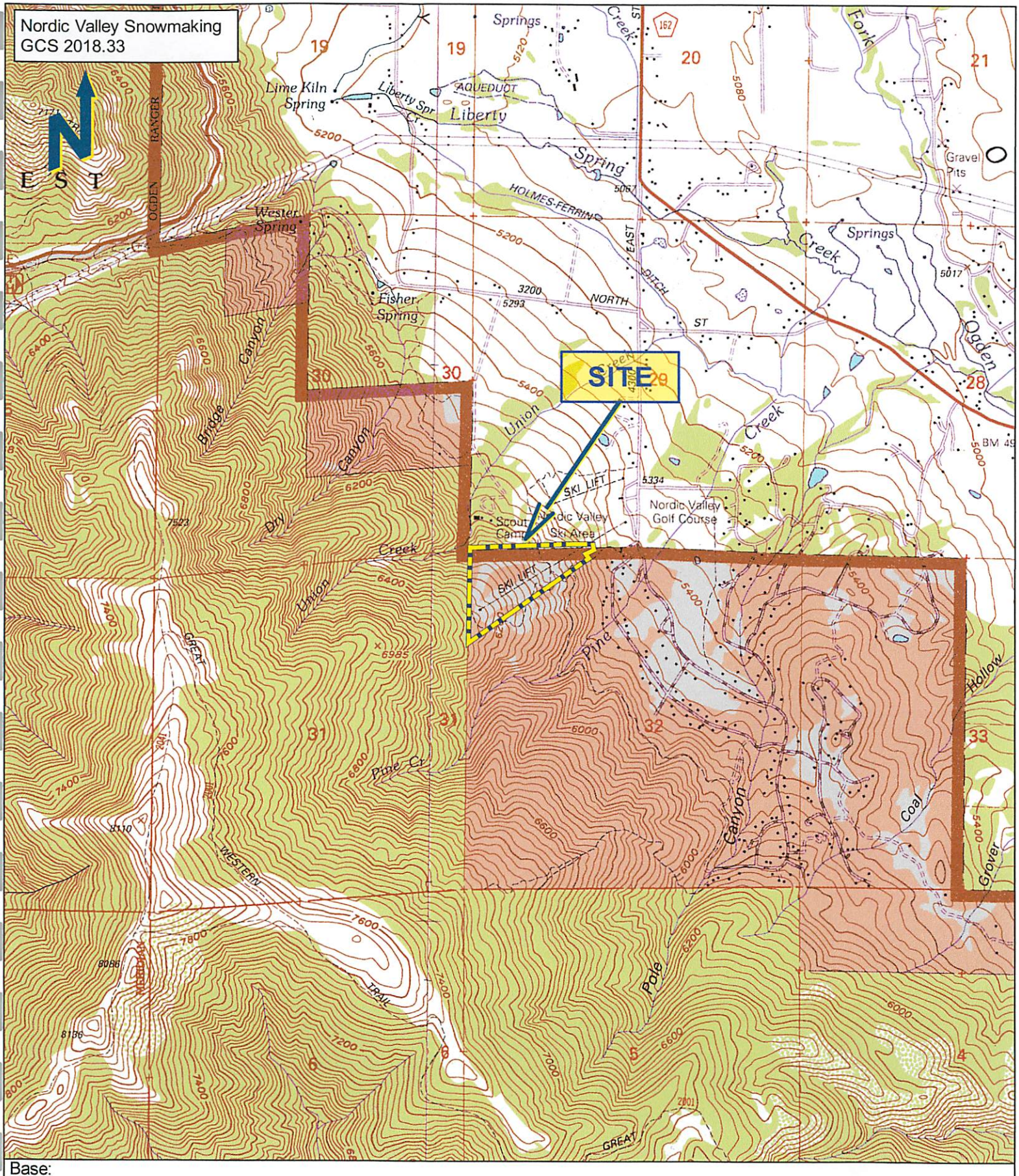
Encl. Figure 1, Site Vicinity Map
Figure 2, Aerial Coverage
Figure 3, Geologic Mapping
Figure 4, LiDAR Analysis



Base:
1998 USGS 7.5 Minute topographic maps titled "Huntsville, Utah" and North Ogden, Utah, from Utah AGRC; http://gis.utah.gov/

0 2000 4000 ft

1:24,000

FIGURE 1
SITE VICINITY MAP

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Base:
2014 1.0m NAIP Color Orthoimagery,
from Utah AGRC; http://gis.utah.gov/

0 400 800 ft

1:4,800

FIGURE 2
AERIAL COVERAGE

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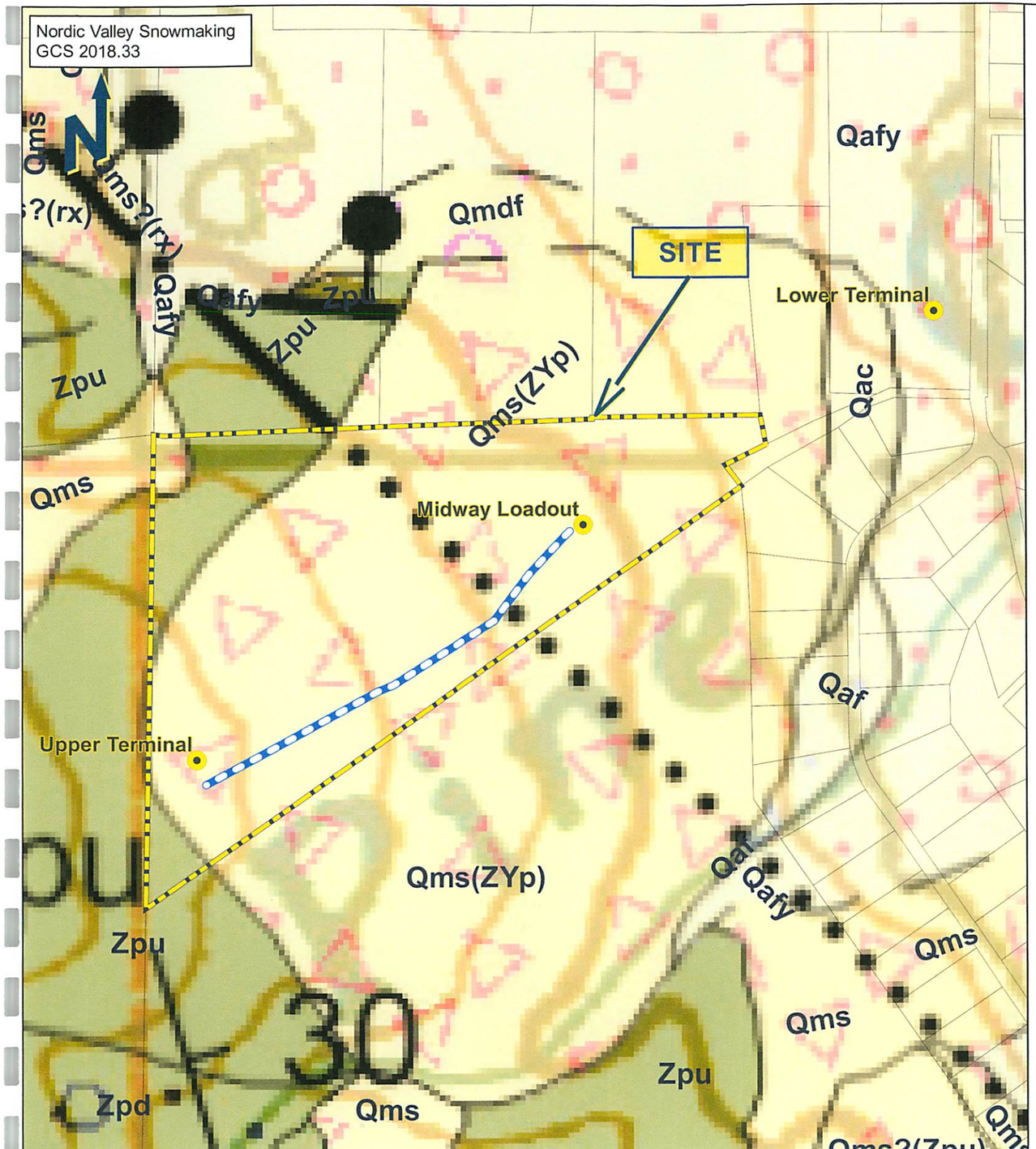

Geology (after Coogan and King, 2016)

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...

Qafy Qaf - Alluvial-fan deposits (Holocene and Pleistocene) – Mostly sand, silt, and gravel that is poorly bedded and poorly...variably consolidated; includes debris flows, particularly in drainages and at drainage mouths (fan heads)...with unit Qafy being the lowest (youngest) fans and Qaf being undivided in age determination...

Qac - Alluvium and colluvium (Holocene and Pleistocene) – Unsorted to variably sorted gravel, sand, silt, and clay in variable proportions; includes stream and fan alluvium, colluvium, and, locally, mass-movement deposits...

Qms - Landslide deposits (Holocene and upper and middle? Pleistocene) – Poorly sorted clay- to boulder sized material; includes slides, slumps, and locally flows and floods...

Qms(ZYp) - Block landslide and possible block landslide deposits (Holocene and upper and middle? Pleistocene) – Jumbled mass of formation of Perry Canyon (ZYp) with blocks...

Zpu - Formation of Perry Canyon bedrock; Upper member (Neoproterozoic) – Olive drab to gray, thin-bedded slate to argillite to phyllite to micaceous meta-siltstone to meta-graywacke to meta-sandstone in variable proportions such that unit looks like both the "greywacke-sandstone" and "mudstone"...This unit is prone to slope failures...

Zpd - Formation of Perry Canyon bedrock; Diamictite member (Neoproterozoic) – Tan to gray weathering, gray to dark-gray meta-diamictite containing pebble to boulder-sized quartzite and granitoid (quartzo-feldspathic gneiss) clasts in dark-gray sandy (up to granule size) to micaceous argillite matrix...

Normal Fault Bar on downthrown dashed where concealed

Strike and Dip Long bar represents strike axis, numerical value equals dip angle

FIGURE 3
GEOLOGIC MAPPING
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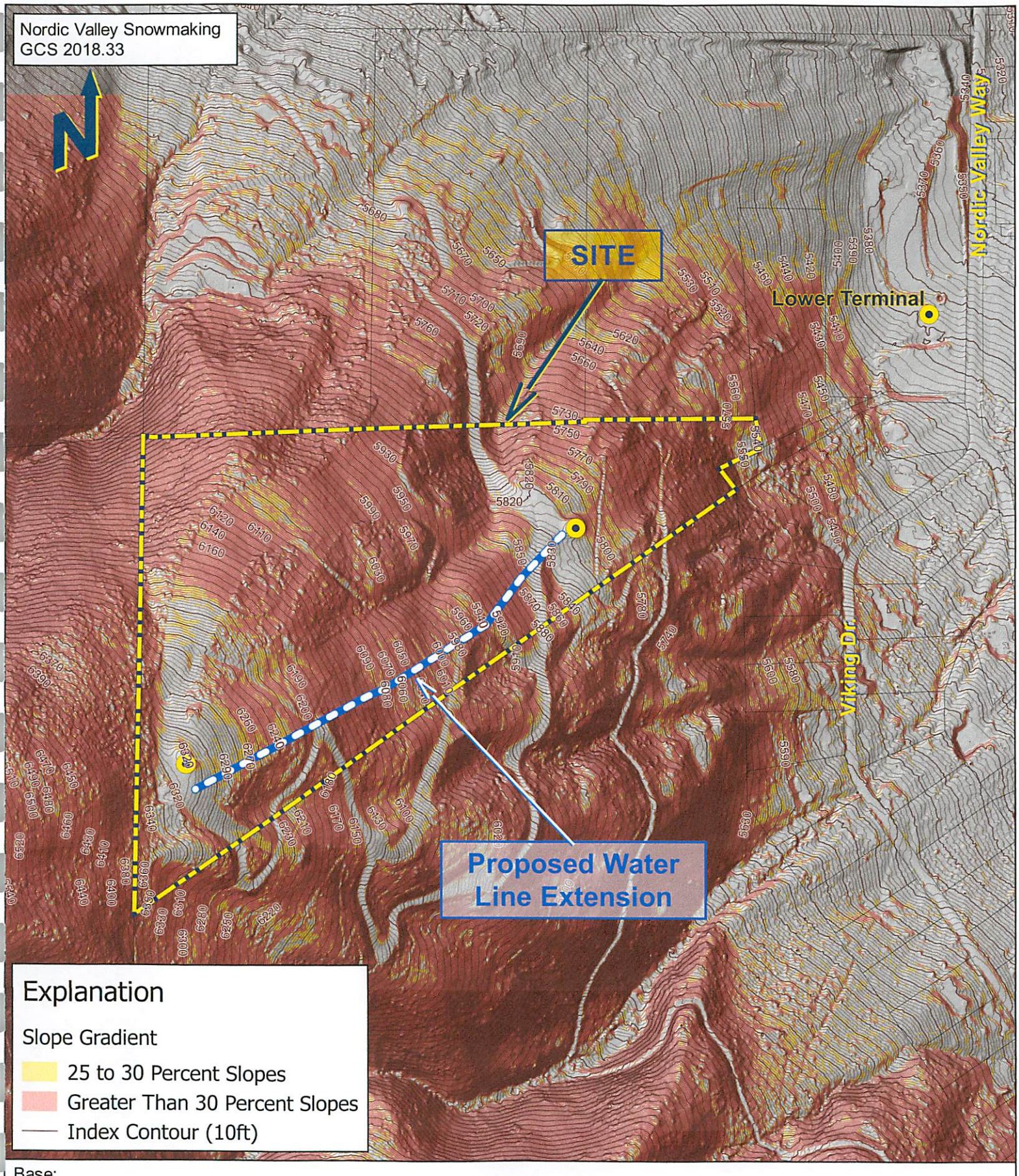

Base:
2014 1.0m NAIP Color Orthoimagery,
from Utah AGRC; http://gis.utah.gov/

0 400 800 ft

1:4,800

FIGURE 4
LiDAR ANALYSIS

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