

May 4, 2018
(Revised May 7, 2018)

Northwoods Condominium Association
600 Vail Valley Drive
Vail, Colorado 81657

Subject: Engineering Consultation
Golden Peak Improvements Project
Vail Ski Area
Vail, Colorado
Project No. GS06142.000-145

Introduction

CTL/Thompson, Inc. provided a letter (dated June 14, 2017) with our observations regarding geologic and geologic hazards observations of the slopes and ski area property above Northwoods Condominiums. Subsequent to our letter, the United States Forest Service (USFS) released the Draft Environmental Impact Statement (DEIS) for the Golden Peak Improvements Project for public comment. The document was compiled by SE Group Inc. for Vail Ski Area and the USFS. The Golden Peak Improvements Project will include a new surface lift, Men's Super G, Women's Downhill, mogul and skier cross courses. Lift operating shacks, race start buildings, and maintenance buildings are proposed. Significant tree clearing, and new snowmaking capacity would be required. The planned mogul course would be located above Northwoods Condominiums. Photographs are provided in Appendix A.

Summary

Our current engineering consultation included a review of documents to judge the increase in risk to Northwoods from flooding, mudflow or instability of slopes due to construction of the Golden Peak project above the site. This letter reiterates our interpretation of geology and geologic hazard observations, describes the project documents we reviewed, and discusses our opinions about the impact of the development on geologic hazards that could affect Northwoods. Our concerns regarding the improvement as currently planned include:

- Development that increases runoff towards Northwoods will increase the existing substantial risk of flood, mudflood and mudflow;
- The mogul course is the component of the proposed development that is likely to adversely affect Northwoods. Tree clearing, surface grading



changes, new high-pressure water lines, and additional manmade snow are planned for this project feature. These changes will increase the volume of runoff and potential sediment loads, especially when spring rain events coincide with snowmelt. We believe some of the additional runoff will be towards Northwoods. Increases in subsurface water are also likely to result in this area;

- The geologic hazard evaluation by other consultants was limited to relatively large-scale, deep-seated landslides within the project boundaries. Potential for other mechanisms, such as flood, mudflood and mudflow were not evaluated. The extent of the study is described as the proposed improvements area and nearby areas that could be affected by runoff and infiltration from the improvements. The potential of increased risk to Northwoods was not evaluated; and
- Snowmaking operations typically result in concentrated areas of snow, as well as snow stockpiles. This results in a large volume of potential runoff water in spring and summer months. We are concerned about the snow management programs effect on potential runoff that would affect Northwoods.

Site Geology

The Northwoods Condominiums includes 71 residential units in seven wood-framed, multi-level structures situated on gently to moderately sloping ground between the base of a steep, north-facing mountain side and Gore Creek. Vail Ski Area operations have historically been present on the gentler slopes above and generally west of Northwoods. The project is about 40 years old. The south sides of the buildings have narrow landscaped areas that are cut into the hillside. Slopes are retained with multi-tiered, rock-filled wire baskets (gabions). We noted several incised drainages a few to about 10 feet wide that run down and off the hillside onto the Northwoods property.

The gentle slopes adjacent to Gore Creek are a bouldery sand and gravel terrace deposit associated with post-glacial deposition and the steeper south portion is underlain by a colluvial soil formed by slopewash from the hill above. The colluvium probably overlies the terrace deposits at the Northwoods Condominiums and covers bedrock above the site.

Geologic mapping of the Vail East Quadrangle (USGS Map MF-2375, 2003) shows the surficial and bedrock geology of the area. The upper part of the steep slope above the northside include exposed limestone beds from the Pennsylvanian-age Robinson Limestone member of the Minturn Formation. The limestone bedrock forms at least one cliff below the existing buried water tank located directly above the western Northwoods buildings. Strike and dip measurements shown on the USGS Map indicate the Robinson Limestone strikes about north



with a west dip of about 22 degrees. The Minturn Formation contains thick gray limestone beds with softer reddish-brown sandstone, conglomerate and shale lenses between. We noted only limestone outcrops above the Northwoods property.

Geologic Hazards

The natural slope above Northwoods is very steep, nearly 100 percent overall or about 1H:1V, formed by glacial scouring of the Gore Creek Valley in the past one-half million years. This area is largely tree-covered with evidence of erosion and shallow slumps. Slopes on the ski runs to the south average about 40 percent down to the northwest. This slope is about the same as the bedrock dip. We noted man-made drainage swales and partially buried pipes in the area of the ski run and buried water tank.

From a large-scale perspective, slopes appear to be stable above the Northwoods property. This is largely due to the strength of the limestone bedrock layers. The colluvial soils above the bedrock are erosion-prone and subject to shallow failures that include slumps, as well as mudflood and mudflow. Drainage courses that are currently incised into the slope appear to transport surface flow toward the Northwoods property.

Development that increases runoff toward Northwoods will increase the existing substantial risk of flood, mudflood and mudflow exposure. These risks can be reduced by careful-management of surface grading and potential construction of subsurface drain systems. Grading changes that direct ski area runoff west and east of (away from) Northwoods would substantially reduce exposure of the property to these hazards. Combining this approach with interceptor drains would be a positive method to mitigate excessive soil saturation.

Documents Reviewed

As part of our engineering analysis for this geotechnical consultation, we reviewed several documents that are part of the DEIS. The documents reviewed are listed below.

1. Geology and Geologic Hazards of the Proposed Golden Peak Race Training Area, Vail Resort, Summit County, Colorado, (Revised Final Report), GEO-HAZ Consulting, Inc. Job No. 2173, dated January 30, 2018
2. Soils Specialist Report, Vail Ski Resort – Golden Peak Improvements, White River National Forest, Eagle County, Colorado, Buscher Soil & Environmental Consulting, Inc., Western Ecological Resource, Inc., dated December 2017



3. Water Resources Specialist Report, Golden Peak Improvements, Eagle-Holy Cross Ranger District, White River National Forest, Eagle County, Colorado, Leonard Rice Engineers, Inc., dated February 9, 2018

GEO-HAZ Consulting Report

GEO-HAZ prepared the geologic and geotechnical report for Leonard Rice Engineers (LRE) and SE Group Inc. GEO-HAZ characterized the bedrock and surficial geology, re-evaluated past landslide mapping utilizing recent satellite imagery and a field reconnaissance, and evaluated global stability and the potential effect of the planned improvements. This work provided guidance for LRE to develop the drainage management plan.

The major landslide feature evaluated is an existing old landslide deposit referred to as the "Big Slide". The landslide deposit is located near the center of the improvement project area. The lower part of the east flank and toe of the deposit is just southwest of the planned mogul course. The toe of the landslide deposit is about 1200 feet south of Northwoods. GEO-HAZ determined that tree clearing, additional snowmaking, and building and road construction would not significantly affect the existing stability of the landslide deposit.

The bedrock in the vicinity of the mogul course is described as being the Robinson Limestone member of the Minturn Formation. The surface soils are described as Quaternary colluvium. No areas of unstable slopes were identified in the area of the planned mogul course.

GEO-HAZ did not evaluate the potential effect of the planned tree clearing and increased moisture from snowmaking on the slopes above Northwoods. The mogul course and trail is described as extending northwest down to the crest of a bedrock ridge, which is stable and shows no signs of past slope stability.

Western Ecological Resources Report

The purpose of the soils specialist report by Western Ecological Resources (WER) was to confirm soil types and measure thicknesses of organic and surface soil mineral horizons. Soil types were defined according to the United States Department of Agriculture (USDA) classification system. The soil within the mogul course area is identified as Map Unit 385D: Scout-Rock outcrop-Hechtman. A characterization of this soil type from the report is shown below.

Hechtman soils are shallow (less than 20 inches) to bedrock, somewhat excessively drained, and formed in colluvium and residuum from sedimentary rocks of the Minturn Formation. Two descriptions were made of the Hechtman soil (GP3 and GP6). Profile GP6 contained fewer rock fragments than typically



occurs in the Hechtman soils. Within the Analysis Area, the Hechtman soils generally have a loam surface layer and below is gravelly or very gravelly loam to bedrock. They have low available water capacity and are strongly acid to moderately acid (pH 5.1 to 6.0). Runoff is rapid and permeability is moderately rapid.

Evaluation of the soils were limited to the thin mantle of organic and surface mineral horizons. WER judged the soils have a moderate erosion potential.

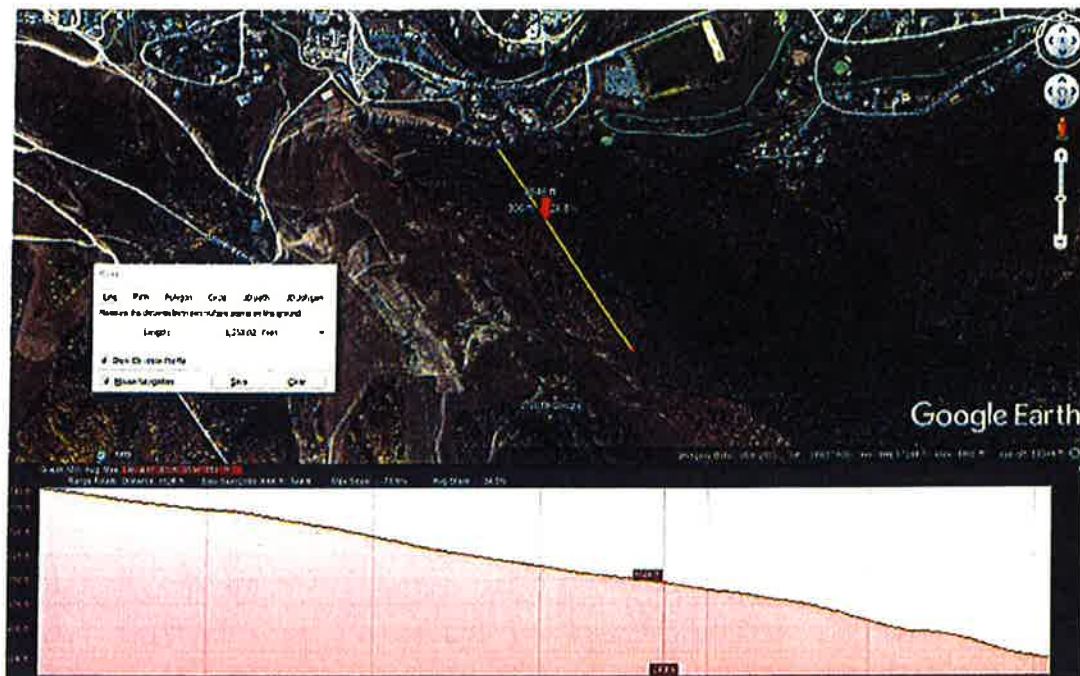
Leonard Rice Engineers Report

Leonard Rice Engineers (LRE) produced a water resources specialist report for the Golden Peak Improvements project. The Drainage Management Plan addresses strategies to avoid and minimize potential impacts to areas where there may be slope stability problems. The plan identifies drainage improvements needed to mitigate potential adverse impacts from changes to surface and subsurface water flows. Drainage improvements are mostly concerned with not increasing the water available to the older, deep-seated "Big Slide" features. Drainage improvements related to the mogul course are new water bars, enlargement and improvements to an existing channel and installation of a new culvert. Construction-level details are not provided.

We believe drainage basin GP-2C shown on the plans we reviewed may extend into basin GC-1B and north towards the Town of Vail. Analysis by LRE determined that within drainage basin GP-2C (mogul course) the area covered by snowmaking will change from 7.7 acres to 13.0 acres (59% increase) and water usage will change from 16.5 acre-feet to 24.5 acre-feet (67%). Tree cleared area will change from 18.0 acres to 30.6 acres (59%). The above changes will result in increases in total runoff and peak runoff flow.

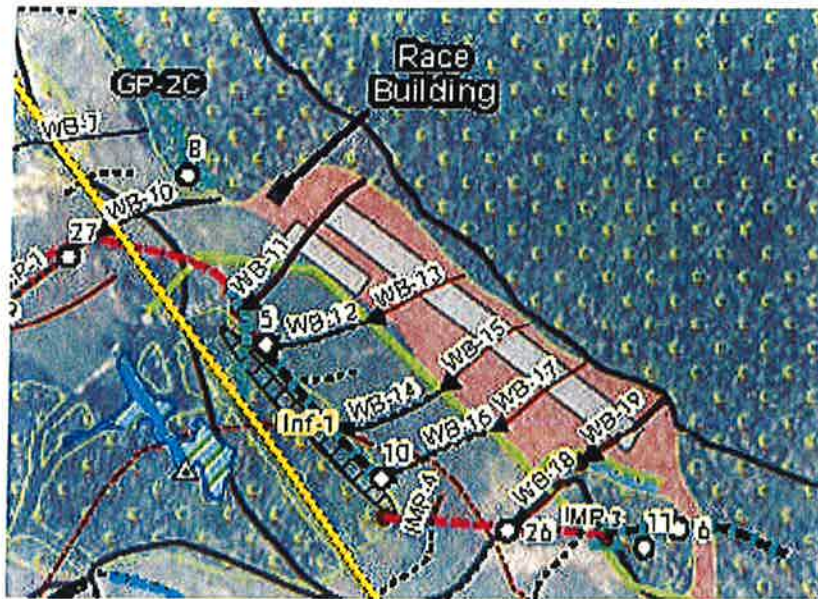
Opinions and Recommendations

Our document review indicates that the potential volume and flow rate of water directed toward the slopes above Northwoods has not been analyzed. The amount of water and sediment loads may be significant, especially if the Golden Peak features are constructed as proposed. A profile of the slope from the bottom of the mogul course to the ridge top above Northwoods is shown below.



This slope profile, generated with Google Earth, indicates that surface and subsurface water at the base of the mogul course is likely to travel to the slopes directly above the Northwoods property. Tree clearing, reshaped surface grades, and additional manmade snow required for the course is likely to increase the amount of surface runoff and subsurface water to the slope directly above Northwoods. This could increase driving forces for slope failures and sediment loads resulting in mudfloods and mudflows.

Drainage improvements related to basin GP-2G and the mogul course are indicated on the photograph below. New water bars (i.e., ditches) WB-11, WB-13, WB-15, WB-17 and WB-19 are proposed to be built. Existing water bars WB-7, WB-10, WB-12, WB-14 and WB-16 would be improved and enlarged. The existing drainage channel IMP-3 would be enlarged with enhanced erosion control.



The planned drainage improvements are positive, but not designed with the intent of mitigating risk of landslides, mudfloods, and mudflows that could affect Northwoods. Considering that a substantial degree of risk from flooding and mudflow currently exists and mogul course construction could increase the risk, we recommend this risk be evaluated. We can provide evaluation of the potential flood, mudflow and slope stability risks for the Northwoods HOA if desired. Potential mitigation may range from not constructing the mogul course, moving of the planned mogul course, or construction of berms, lined detention ponds and subsurface drains.

CTL/Thompson, Inc. provided engineering consultation regarding a mudflow that caused significant damage to a building adjacent to another ski area. A source of water triggering the mudflow was stockpiles of snow remaining from snowmaking operations required for winter sports competitions, including skiing and snowboarding. The additional snow exacerbated natural surface and subsurface water volumes. This combined with a heavy spring rainfall event and contributed to the mudflow. Due to the mudflow, the ski area implemented changes to snow removal and maintenance programs to mitigate the potential for similar mudflow events in the future. We believe it is critical that Vail develop a plan to manage snowmelt from the mogul course, if it is constructed.



We appreciate the opportunity to work with you on this project.
CTL/Thompson, Inc. is available to discuss the contents of this letter.

Very truly yours,

CTL | THOMPSON, INC.


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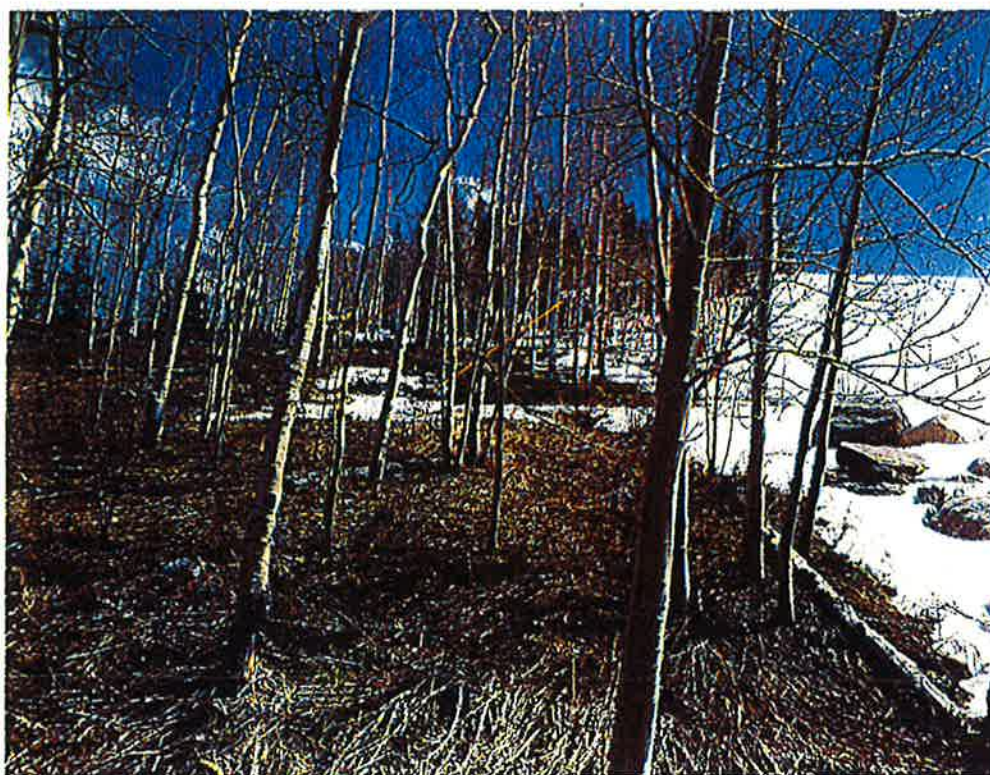
Buried Water Tank Above Northwoods



Crest of Slope Above Northwoods



Incised Drainage Channel Above Northwoods



Proposed Mogul Course Location



Ski Trial/Mogul Course Boundary



Golden Peak Improvement Area (left of existing ski run)