SNOW AVALANCHE HAZARD EVALUATION
LOT 9, BLOCK 5, WARM SPRINGS VALLEY SUBDIVSION, 219 HILLSIDE DR.
LOCATED WITHIN SECTION 11, T. 4 N., R.17 E., B.M.,
CITY OF KETCHUM, BLAINE COUNTY, IDAHO

Prepared for
Paramount Property Development, LLC.

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P.O. Box 2037
Ketchum, Idaho 83340

This report will attempt to delineate the potential avalanche danger at the study site by correlating key data, both quantitatively and intuitively, to show runout distances and destructive power within the limits of the avalanche hazard forecasting art. The avalanche hazard areas in this study are considered by Alpine Enterprises, Inc., the City of Ketchum, the owners and their planners to be reasonable for regulatory purposes. However, neither Alpine Enterprises, Inc., the City of Ketchum, nor the owners or their planners represents, warrants or implies that areas outside of the designated avalanche zones are safe and free from avalanches or avalanche danger. The effects of natural and artificial hazards other than snow are not discussed in this report.

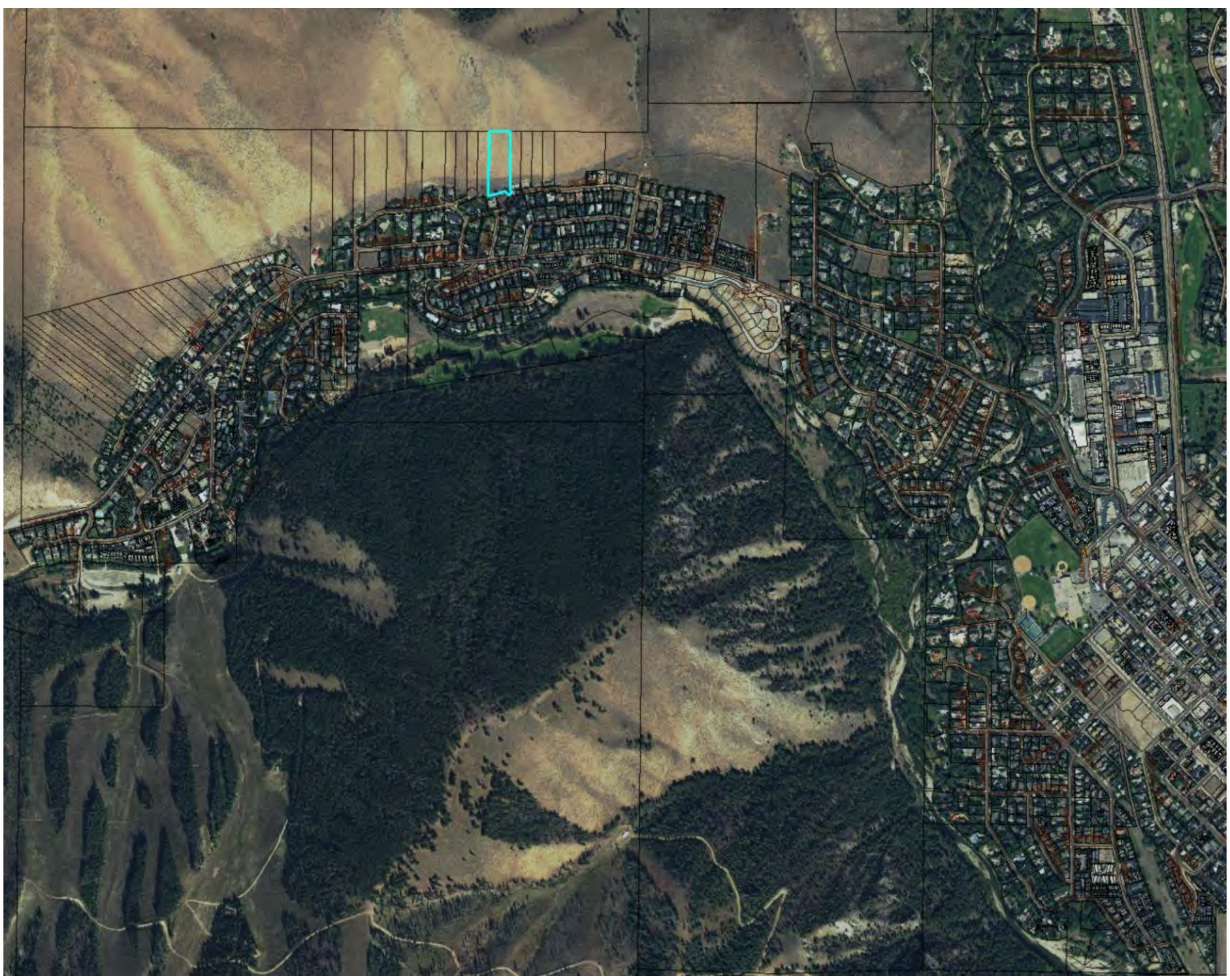


Figure 1 - Vicinity Map (Image Not to Scale)

The purpose of this study is to discuss the potential Snow Avalanche Hazard for a proposed new residence on Lot 9, Block 5, Warm Springs Valley Subdivision located at 219 Hillside Drive, City of Ketchum, Idaho. This discussion applies only to this Lot and should not be used for other areas. The subject property is located within a portion of Section 11, Township 4 North, Range 17 East, Boise Meridian, Blaine County, Idaho. The geographic position is roughly 43^0 41'33.7" North Latitude, and 114^0 23'27.2" West Longitude. Elevations range from approximately 5880 feet on the valley floor, to about 6600 feet on top of a ridge that may affect the general area. Downtown Ketchum, Idaho, lies approximately 1.5 miles Southeasterly of the study site. Topographic maps used in the calculations come from a Site Plan produced by Alpine Enterprises Inc. using site specific data, Blaine County GIS LiDAR and Parcel Data.

Field inspections and avalanche observations of the general area have taken place from circa 1980 through 2022, and field inspections of the site took place in May of 2022.

AVALANCHE CHARACTERISTICS

The following discussion is to help the reader better understand conditions that may lead to an avalanche event. The difference between grade in percent and inclination in degrees should be noted. Percent grade is calculated by the vertical rise divided by the horizontal distance. Inclination in degrees is calculated by taking the arc-tangent of the grade in percent. A four to one slope = 25% = 14^0. Avalanches are generally divided into three areas: a starting zone, a track, and a runout zone. In general, an open slope with an inclination over 27^0 that receives large amounts of snow can be considered a potential starting zone. Once the snow is set in motion, a slope angle of 17^0 is all that is required to keep the snow moving through the track, although 22^0 - 35^0 is a more typical track angle. The runout zone is where the slide starts losing momentum and the debris finally comes to rest. Runouts may begin when the slope angle flattens to 10^0 and some will continue across flats and even uphill.

Avalanches may be put into two general types: loose snow, and slabs. These two may be further subdivided into wet and dry. Loose snow slides occur when individual snow grains, due to a lack of cohesiveness, reach their angle of repose and slide down the hill in a generally harmless repositioning, known as a sluff. Wet snow sluffs, although slow moving, may present a hazard due to the sheer mass involved. This type of slide usually occurs in the springtime when factors such as high temperatures, warm winds, rain, and solar radiation create a melt-water saturated snowpack which slides on the ground. Slushflows have been documented on slopes as shallow as 3°, but these are rare occurrences and can generally be disregarded for land planning purposes. On slopes steeper than 50^0, loose snow sluffs occur almost continually during storms, thus preventing accumulations that could become hazardous.

Slab avalanches occur involving entire layers in the snowpack and have the potential to become extremely dangerous. The most common type of slab avalanche occurs when large amounts of wind deposited snow accumulate on a slope into a cohesive slab, sitting on top of a weaker layer. With an appropriate trigger, this slab layer will fracture into blocks of snow and begin moving rapidly down the hill, picking up momentum and entraining more snow as it propagates. The slide moves on a bed surface, which may be a deeper layer of snow or the ground. Structural instability in the snowpack occurs due to many factors, some of which are: heavy amounts of snowfall, extreme air temperature changes, a temperature gradient through the layers that forms weak crystals, rainfall, or an ice crust layer.

AVALANCHE ZONING

The City of Ketchum uses roughly the same zoning plan that was developed in Switzerland over 60 years ago. The main difference in the two systems is the "return period" factor. Avalanches have been documented for centuries in Europe, while Blaine County still lacks actual records of occurrences. The best available evidence is talking to long time area residents, old newspaper articles, and terrain analysis with personal observations and records.

This report will use the three color (or three zone) system. The three zones are defined as follows:

RED (High Hazard) Zone. This area includes terrain where avalanches are expected that have (a) an impact pressure of 30 kPa (600 Lb/Ft^2) or greater with a return period up to 300 years, and/or (b) a return period of 30 years or less regardless of impact pressure. Buildings, roads and winter parking are generally not allowed in the Red Zone (except in the City of Ketchum).

BLUE (Low Hazard) Zone. This area is the transition zone between high hazard and no hazard zones. Avalanches are expected with impact pressures of less than 30 kPa (600 Lb/Ft^2) and return periods between 30 and 300 years.

WHITE (No Hazard) Zone. This area includes terrain with very infrequent small slides and the potential for less than 3 kPa (60 Lb/Ft^2) from the air blast of a Very Large Avalanche.

The avalanche path modeled in this study that could affect the site and the proposed structure lie within the Red and Blue Hazard Zones and it's size classification is between Medium and Large.

Please refer to Ketchum Municipal Code, Chapter 17.92 Avalanche Zone District for further Conditions and Restrictions, as it is subject to change.

It is generally regarded that it is not economically feasible to build wood frame structures capable of withstanding pressures greater than 10 kPa (200 Lb/Ft^2), so reinforced concrete structures may be the most logical direct protection alternative. In some cases, avalanche mitigation structures such as catching dams or deflecting berms may be more suitable. Any structure that encourages gatherings of people such as schools, churches, and hotels, should not be allowed.

HISTORY

The Sun Valley area has seen man's activities since the late 1800's, but a detailed history of avalanche activity has not been kept. Personal observations, videos, photos, old newspaper articles and interviews with long time area residents recall that avalanches have occurred regularly in some locations in the Warm Springs area. In my brief 40 years living in Ketchum, I have observed numerous avalanches in this area, but never at this particular site.

A former Blaine County Planning and Zoning Administrator recalled stories of a storm in the early 1930's when "it snowed 2 feet, and then rained hard on the new snow, and nearly everything slid." A similar report from the early 1900's reports the same conditions.

The circa 1978 Avalanche Maps by Norman A. Wilson and Arthur I. Mears that were used as the basis for Ketchum's Avalanche Overlay both show the subject property to be in a Red Zone. These maps were produced before most of the development occurred in the area and were before Avalanche Dynamics Software and LiDAR mapping were available.

Figure 2 - This photo shows a January 2004 event at the intersection of Sage Road and Skiway Drive and is similar to what could be expected at the site.

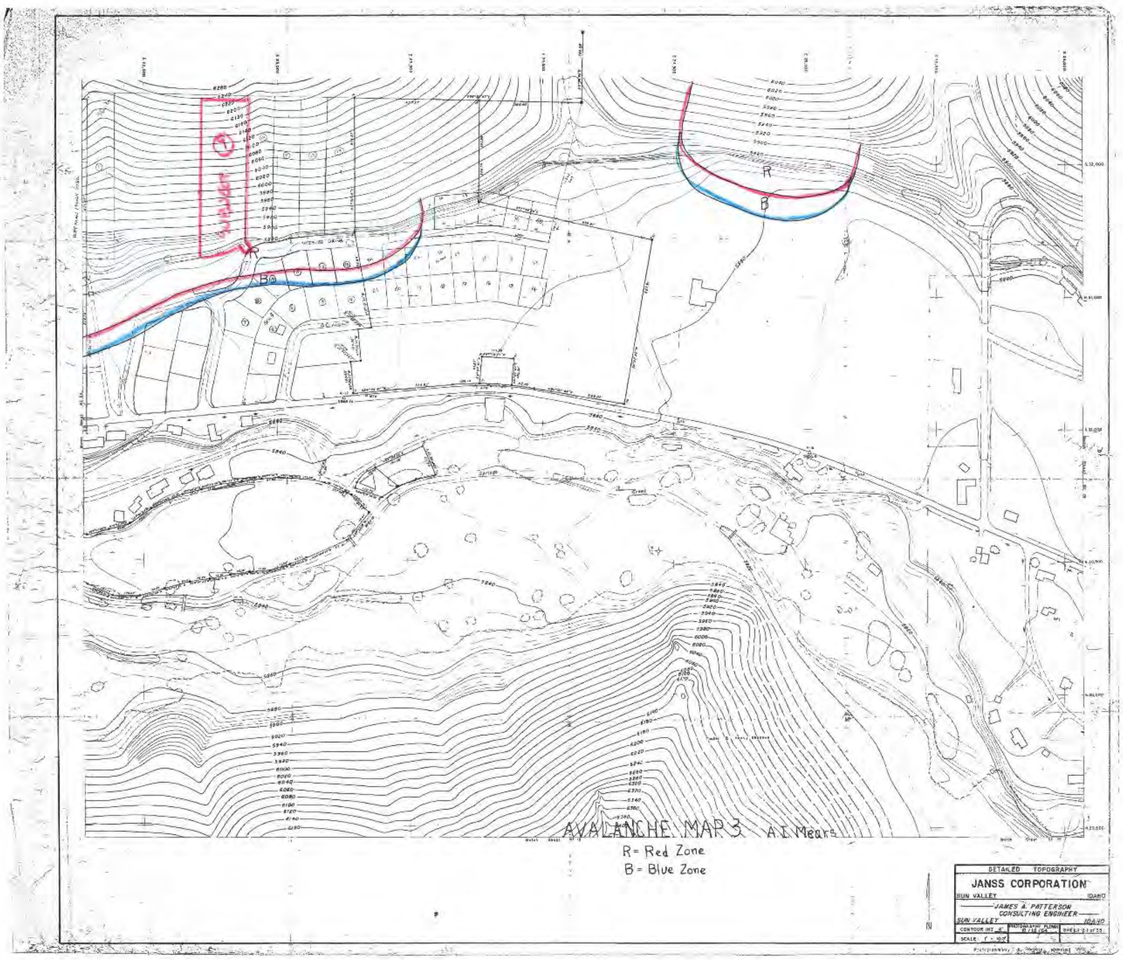


Figure 3 - Mears Avalanche Map 3 – Circa 1978

<u>SITE ANALYSIS</u>

The best method for determining avalanche runout distance (which is of primary importance to man and his activities) is a long (300 year) history of past events at the site. If this is not available, the next step is to look for damage to trees and other vegetation along the track and runout zone. This particular site does not lend itself to dendrochronology, as there are only grasses and sage that have been changed by the Castle Rock Fire Backburn.

The next step is terrain analysis and applying statistical methods developed by mapping hundreds of avalanches around the world and comparing these figures to a local data set to determine runout distance. These results are compared with accepted avalanche dynamics modeling software, RAMMS: AVALANCHE (RApid Mass Movement Simulation), developed by the Swiss Federal Institute for Snow and Avalanche Research to calculate approximate flow depths, velocities, pressures, and potential impact forces that may be expected. Both the Statistical and Dynamic Models are used in this report with the RAMMS model taking precedence as it shows velocities, pressures, and flow depths along the path and the lateral extents.

Blaine County is typically under the influence of Intermountain climatic factors, which usually results in a comparatively shallow snowpack, and cold temperatures; perfect conditions for creating the usual and expected temperature gradient layers (T. G., Kinetic, Facets or "sugar snow") resulting in a weak snowpack structure. This fact, coupled with occasional large Pacific storms, and the necessary terrain characteristics, result in the occasional avalanches that are observed.

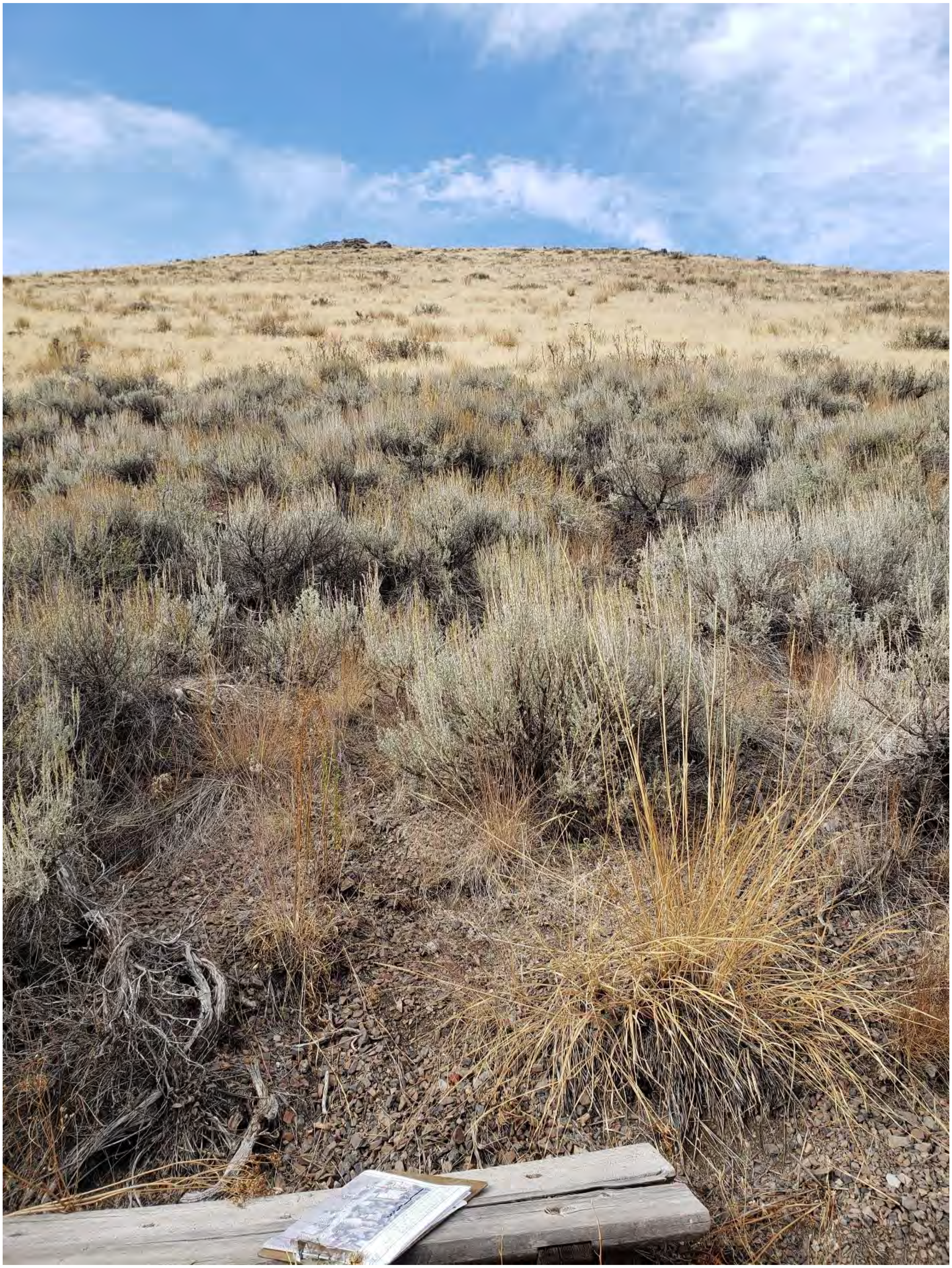


Figure 4 - Looking Uphill from Proposed Building Site.

The slope above the site is a broad unconfined face lying at a typical slope angle of around 33 degrees. The slope does not lend itself to deep snow loading as typical on the Westerly side of many of the channelized paths in the Warm Springs area.

LAND PLANNING RECOMMENDATIONS

Please refer to the attached 1" = 50’, 1” = 10’, and Avalanche Forces "Snow Avalanche Hazard Study Showing Lot 9, Block 5 Warm Springs Valley Subdivision” maps by Alpine Enterprises Inc. for the following discussion.

The Red Zone shown will affect most of the proposed structure, while a portion of the proposed structure and driveway lie in the Blue Zone that stops before it reaches Hillside Drive.

We have worked with the Developer, his Designers and Structural Engineer to make this an avalanche aware design from the inception. An important aspect of the design is to be deflection neutral and act as a mitigation structure to add an element of safety to the existing down path residences.

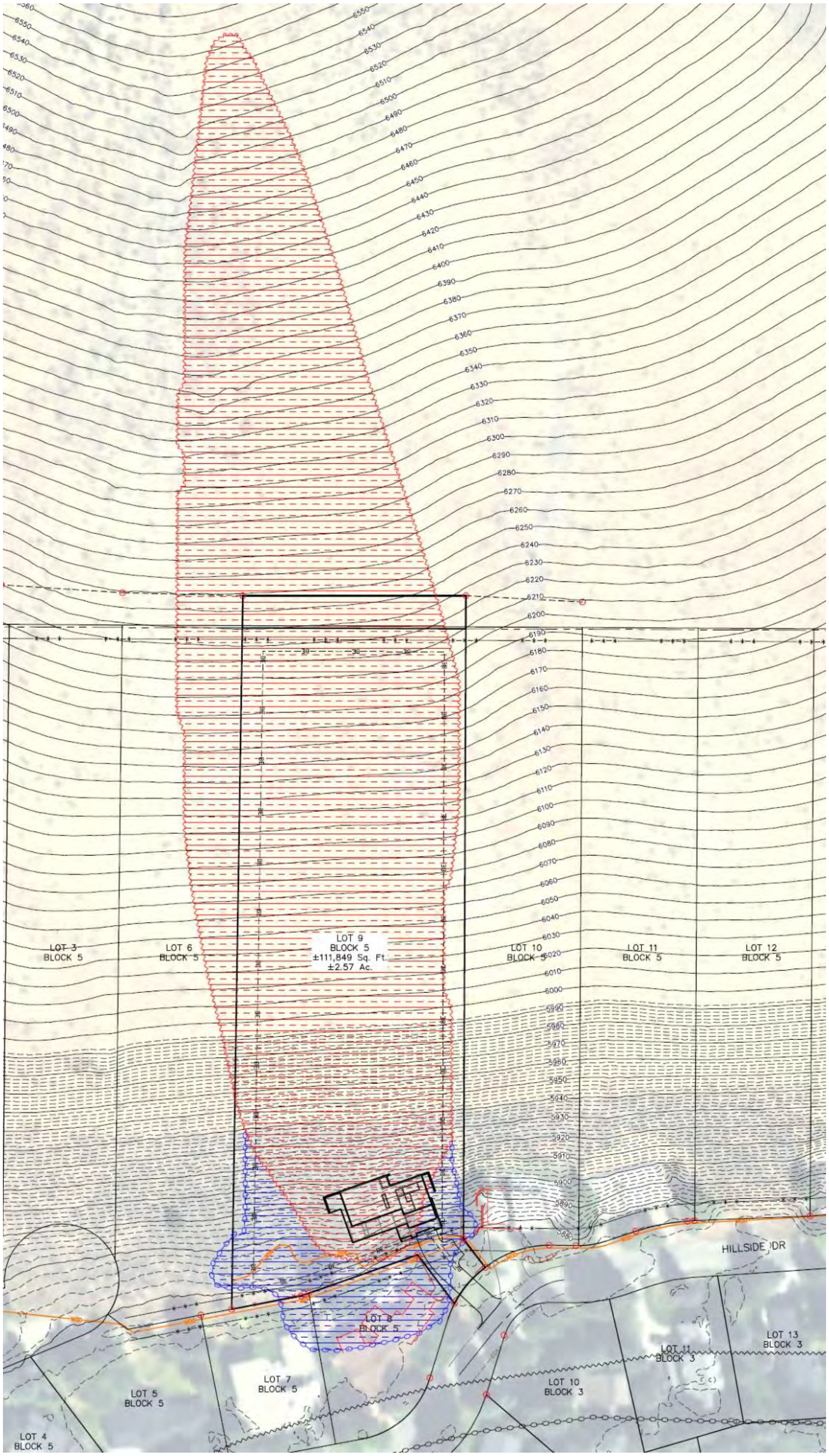


Figure 5 – A 2022 Avalanche Hazard Zoning Map showing the subject property, 129 Hillside Dr.

This report should be considered site specific in that avalanche forces and return periods at this site should not be applied to other sites.

The Sawtooth Avalanche Center maintains a daily avalanche hazard forecast during winter months on the internet at SawtoothAvalanche.com that should be referred to frequently, and official warnings should be heeded during periods of high hazard. A daily subscription via email is also available.

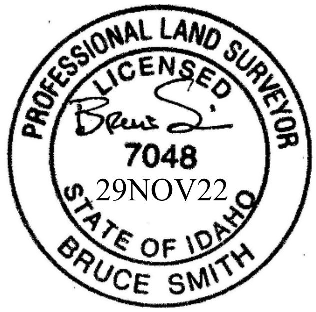
As Pete Schaerer suggests in The Handbook of Snow, "the technical work required to identify dangerous zones can be carried out with reasonable accuracy using the procedures outlined above. Determination of acceptable risk and the enforcement of building restriction are political and legal matters."

In conclusion, it is recommended that structures in this area be carefully positioned, oriented, and designed; and that the residents of this area possess at least a basic knowledge of conditions that may lead to an avalanche event, and use this knowledge to protect themselves, family, visitors, structures, the public, and property. As long as the City allows development in the High Hazard Zones, we do feel that the owners have a vested right to responsibly develop this property. Dwelling in this area may be considered an acceptable risk for those who are aware of the hazard, have a basic understanding of conditions that could result in an avalanche event, and are willing to accept the occasional risk. The Developer, Owner, and the City should be aware of, and willing to accept, all possible legal, moral, financial, political, ethical, and safety consequences that may result from structures being located within High Avalanche Hazard Zones.

Respectfully submitted,

Bruce Smith, PLS 7048, Idaho

Alex Nelson, PE 19275, Idaho



Alpine Enterprises, Inc.

Ketchum, Idaho

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NGI CALCULATIONS

Client/Site	WarmSpringsValleySub_Blk5Lt9	
Date	6/20/2022	
Input Parameters (yellow):	**Horizontal Distance**	**Elevation**
Avalanche Path Profile	**(X) (ft)**	**(Y) (ft)**
Top of starting zone (X_1, Y_1)	**0**	6565
10° point (X_β, Y_β)	1080	5875
θ, slope angle (°) top 100 m (vert.)		31.60
Calculated Parameters (green and red):		
β, ave. slope < to 10° point		32.574
H, vert. distance (0,0 to end parabola (ft)		210.312

X_r (ft)	**dX (ft)**	**dX + 1SD (ft)**	
1,216	136	208	**Equation 2**
1,237	157	236	**Equation 3**
1,358	278	370	**Equation 3B**
1,147	67	189	**Equation 5**
1,377	297	385	**Equation 7**
Mean	**187**	**278**	**All Equations**
Mean	**194**	**288**	**All Equations except Eq. 3**

Figure 6 - NGI Calculation Sheet

RAMMS ::AVALANCHE DATA

Avalanche simulations were run for five different circumstances. Path R5_T300 represents the 300-Year Event that is considered to be an accurate representation of the potential design event. Existing vegetation and structures were ignored due to uncertainties in future site conditions.

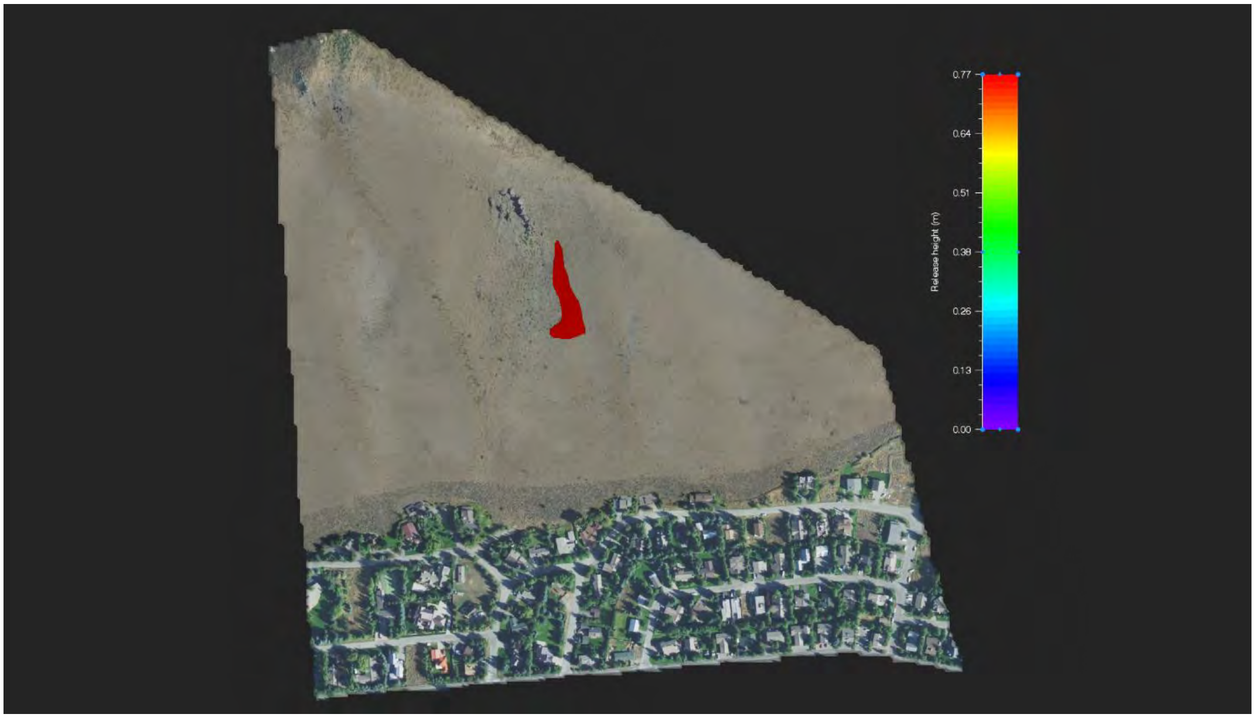

Figure 7 - Release Area, R5, 2D

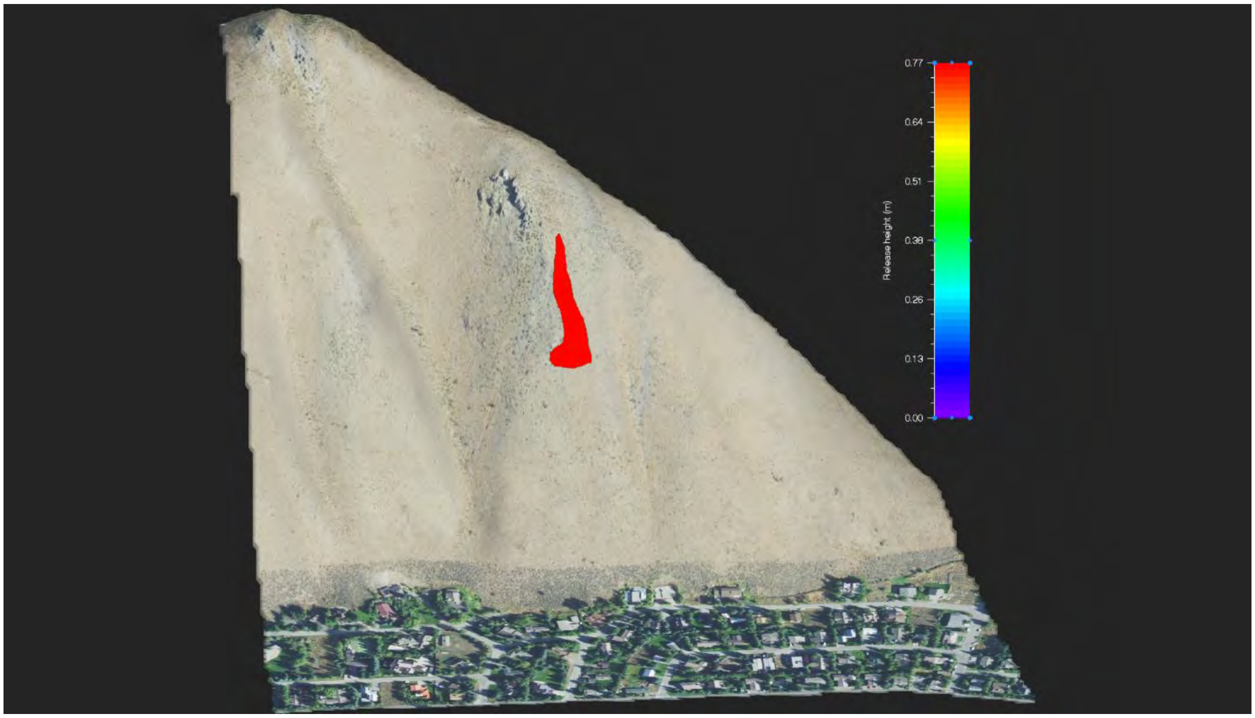

Figure 8 - Release Area, R5, 3D

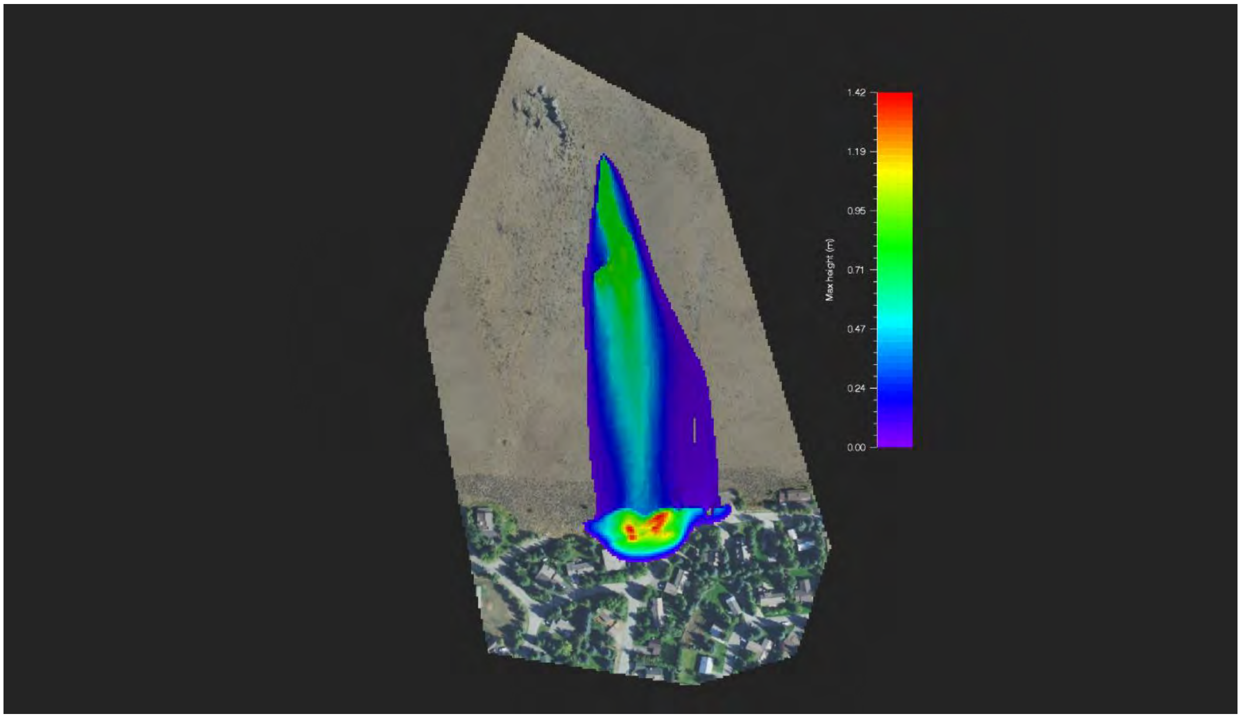

Figure 9 - Path_R5_S300 - Maximum Flow Height, 2D

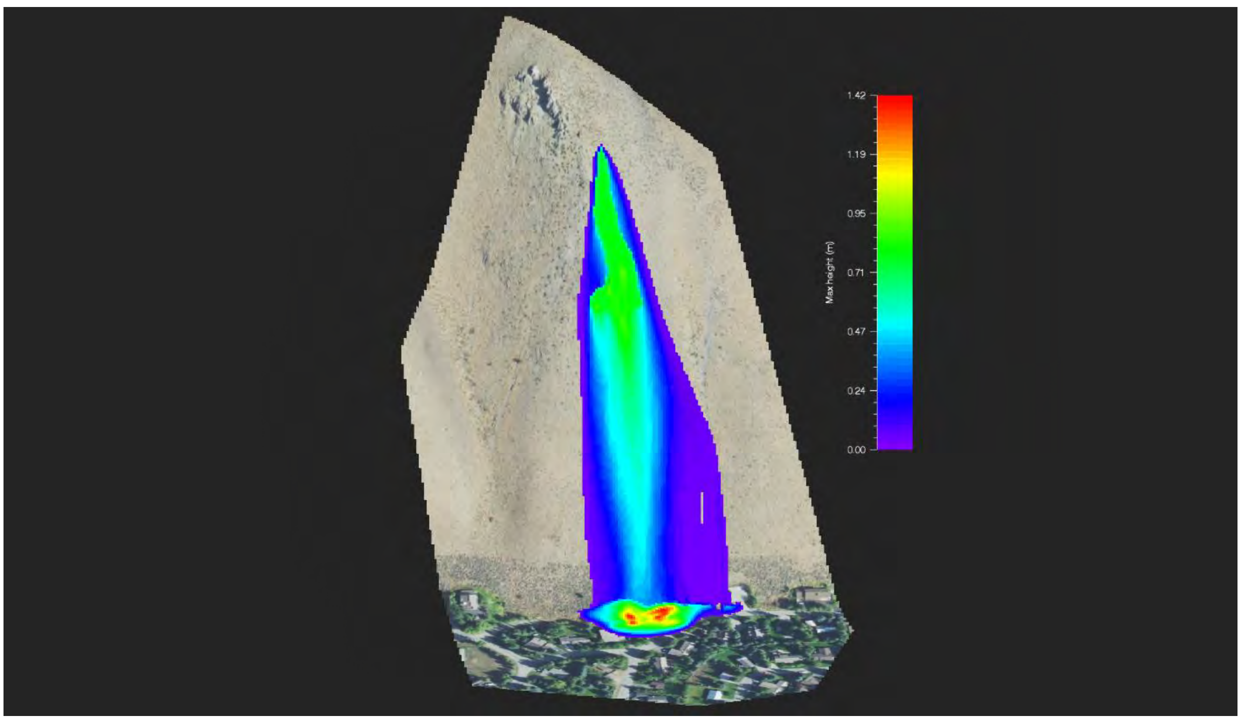

Figure 10 - Path_R5_S300 - Maximum Flow Height, 3D

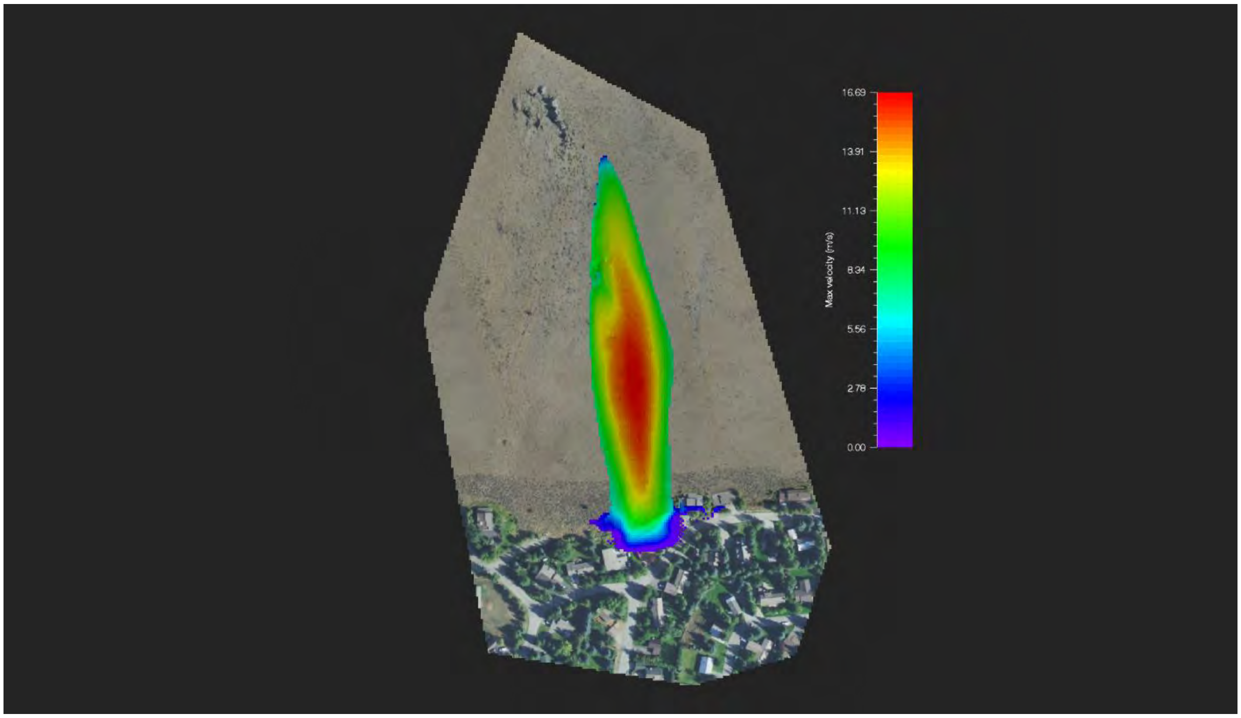

Figure 11 - Path_R5_S300 - Maximum Velocity, 2D

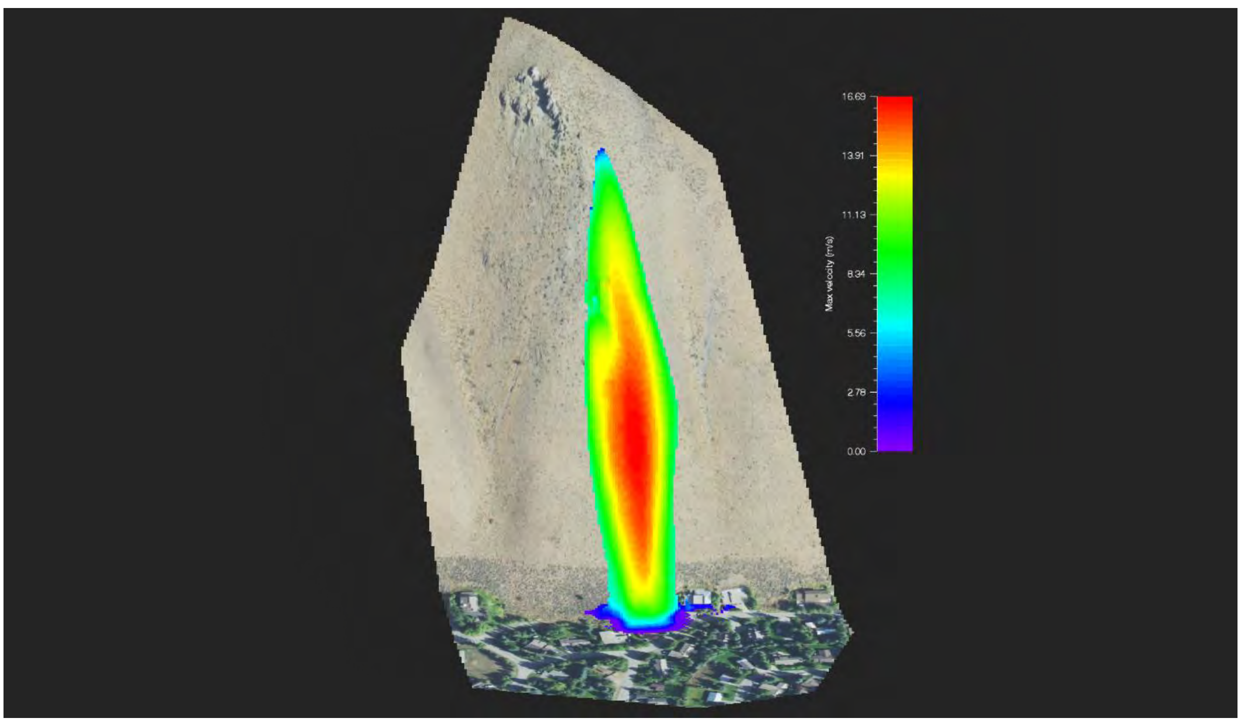

Figure 12 - Path_R5_S300 - Maximum Velocity, 3D

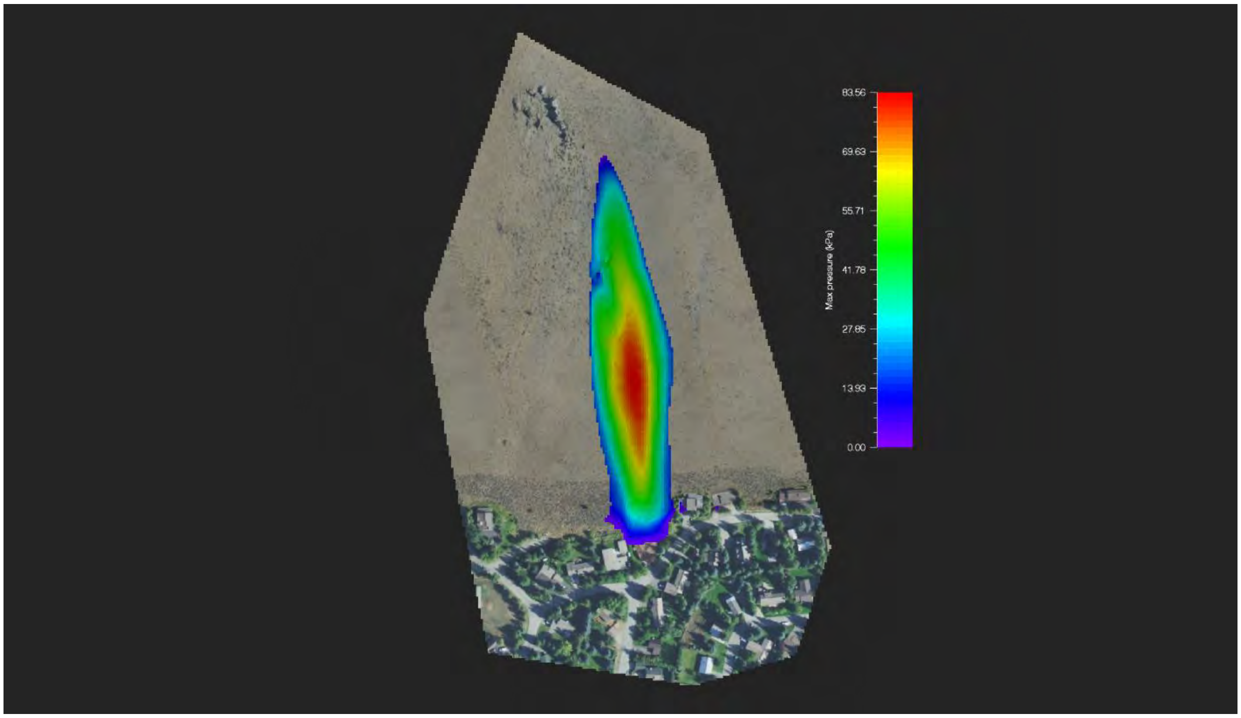

Figure 13 - Path_R5_S300 - Maximum Pressure, 2D

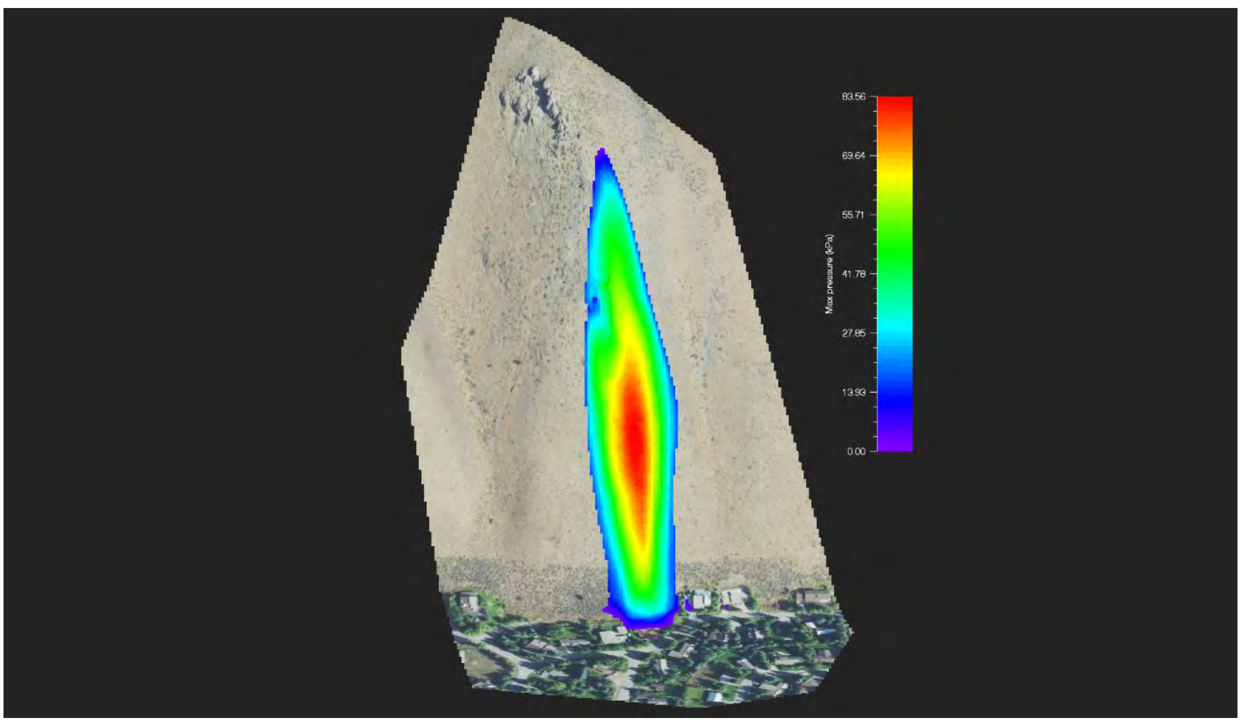

Figure 14 - Path_R5_S300 - Maximum Pressure, 3D

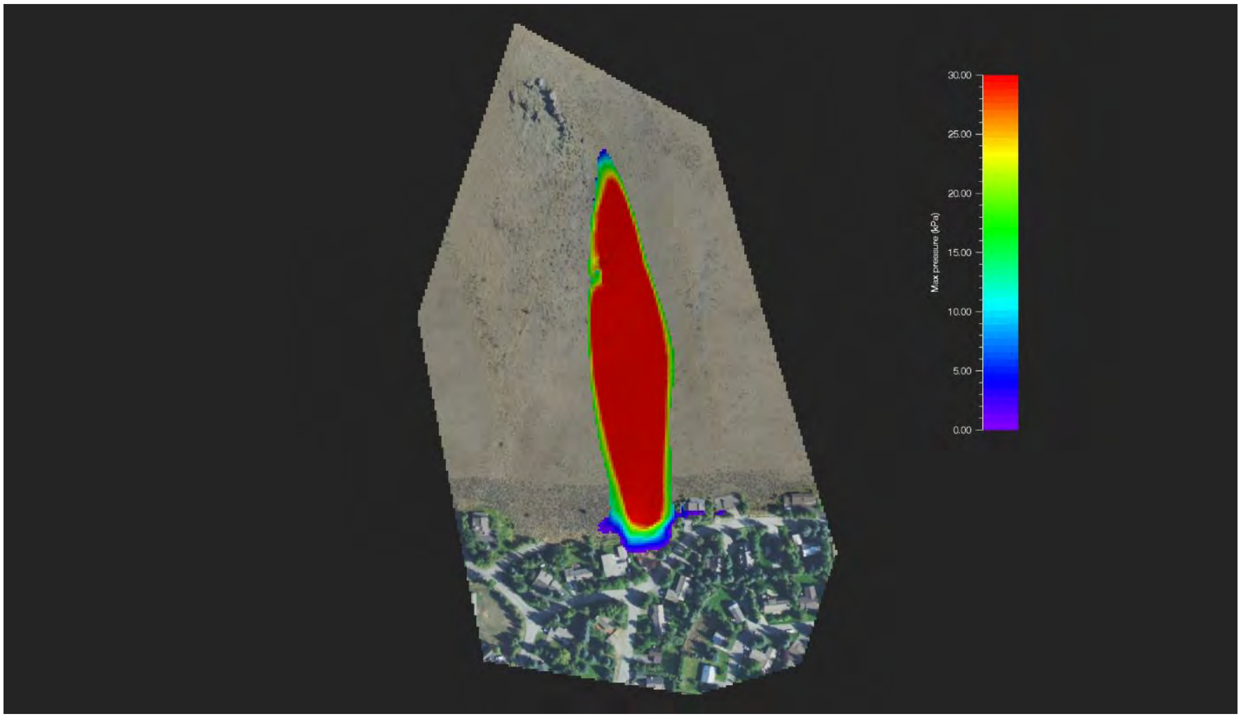

Figure 15 - Path_R5_S300 - Maximum Pressure – Red Zone, 2D

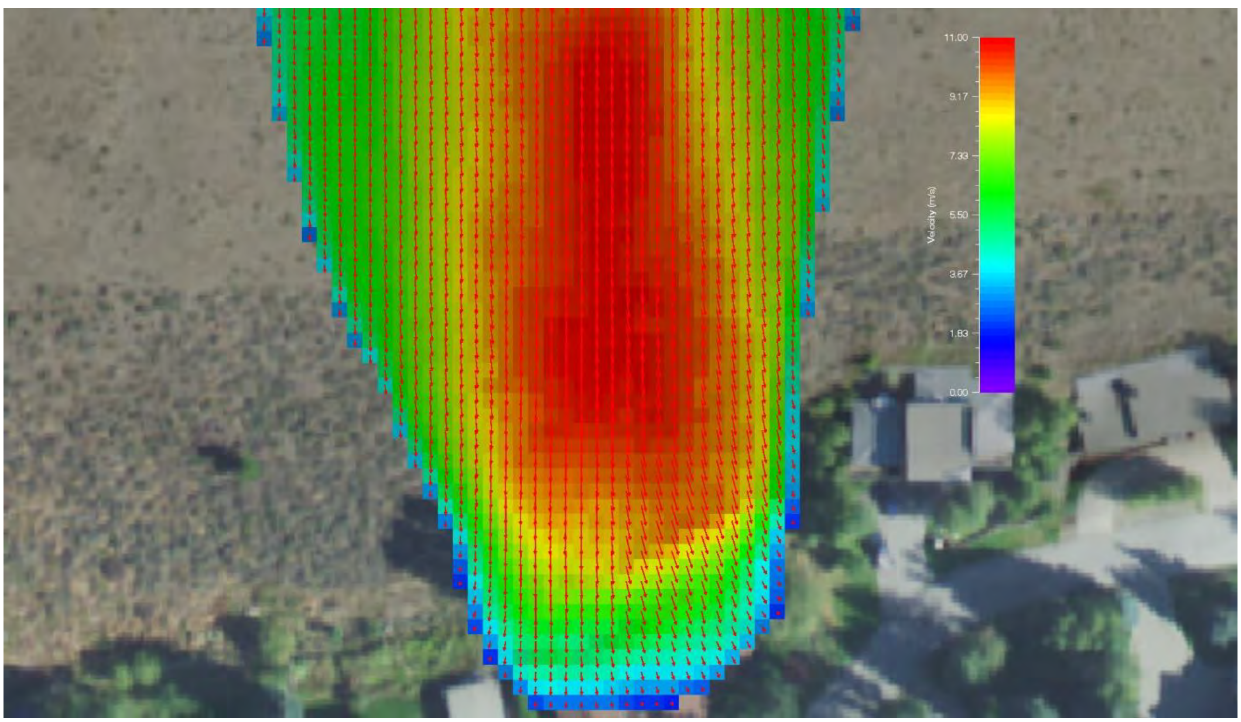

Figure 16 - Path_R5_S300 – Velocity Vectors – Time Step 22 Sec.

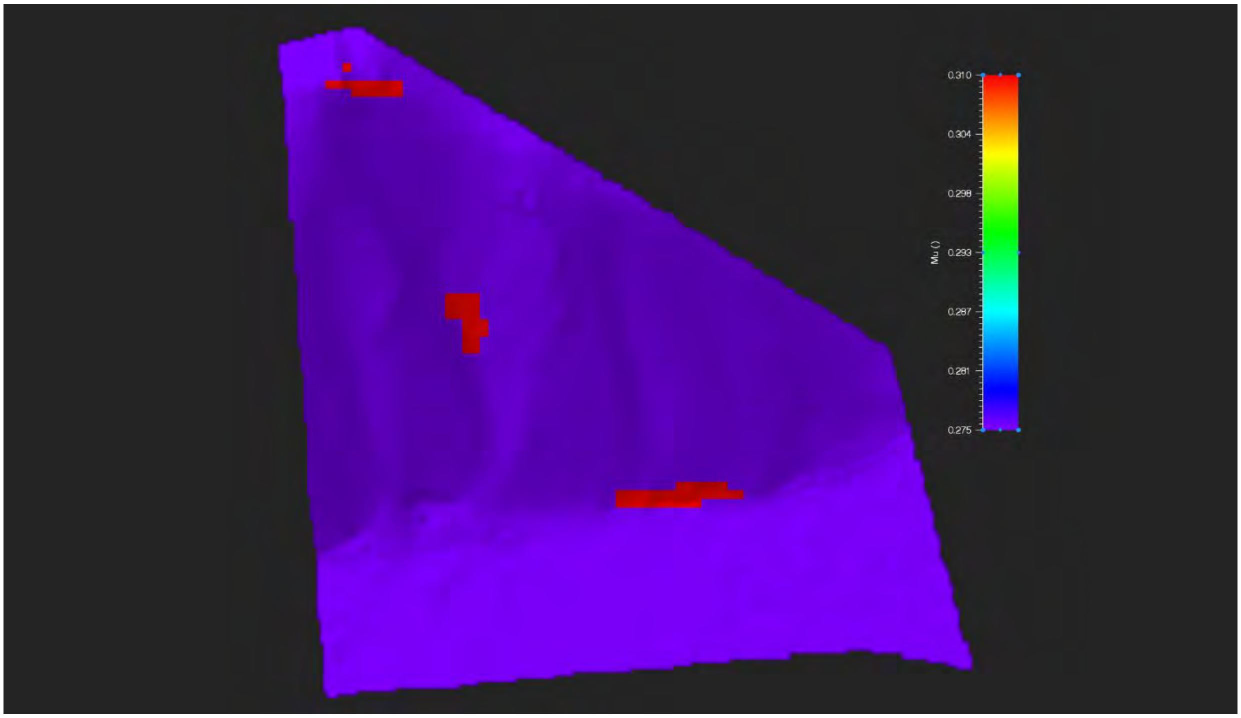

Figure 17 - Path_R5_S300 – Mu - Friction

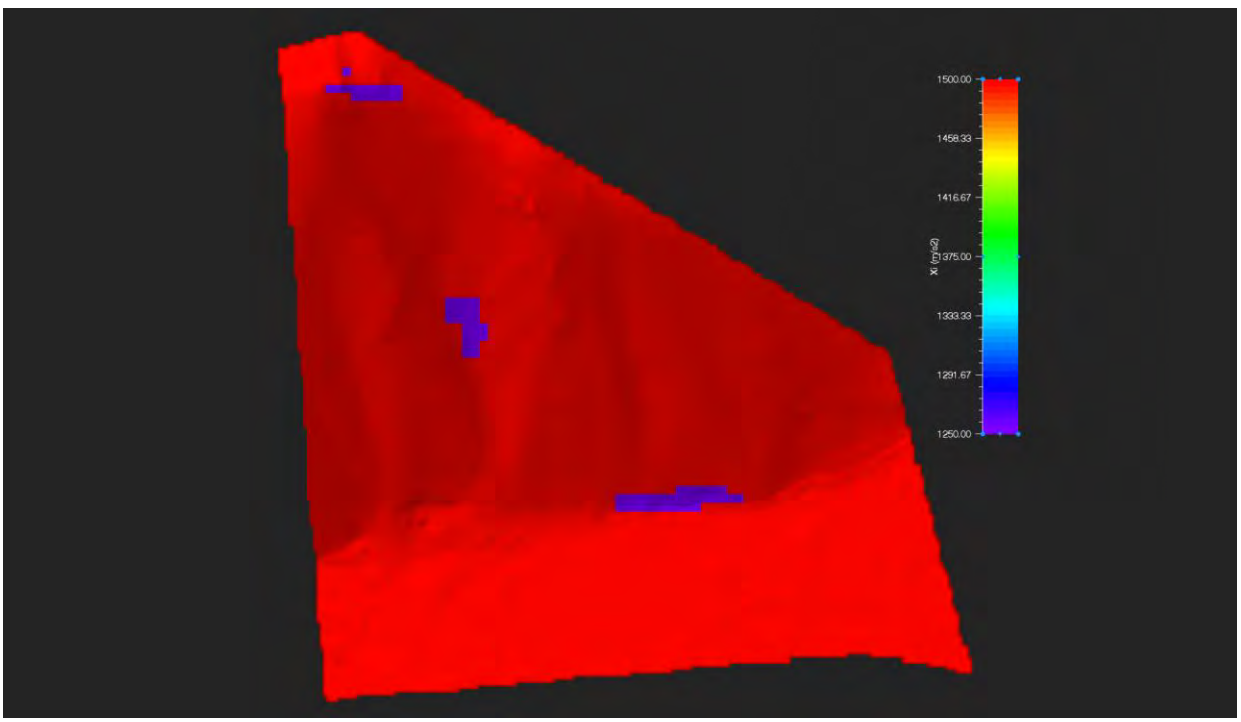

Figure 18 - Path_R5_S300 – XI – Turbulence

PATH : R5-S300 LOG FILE

****
RAMMS::AVALANCHE RAMMS OUTPUT LOGFILE

Output filename: U:\LandProjects2004\725_HURD\RAMMS_2022\725M_WSV_BLK5_LT9_2M\R5_T300.out.gz

Simulation stopped due to LOW FLUX!

Simulation stopped after 85.2500s
Calculation time (min.): 1.13

Simulation resolution (m): 2.00

SIMULATION RESULTS

Number of cells: 35824
Number of nodes: 36293

Calculated Release Volume (m3): 2107.66

Overall MAX velocity (m/s): 16.6895
Overall MAX flowheight (m): 1.42390
Overall MAX pressure (kPa): 83.5622

****
RAMMS::AVALANCHE 1.7.20 INPUT LOGFILE

Date: Fri Apr 22 12:08:13 2022
Input filename: U:\LandProjects2004\725_HURD\RAMMS_2022\725M_WSV_BLK5_LT9_2M\R5_T300.av2

Project: 725M_WSV_BLK5_LT9_2M
Details:
725M Warm Springs Valley Subdivision, Block 5, Lot 9
Avalanche Study 2022
2 Meter Grid
Kyle Miller

DEM / REGION INFORMATION:
DEM file:
U:\LandProjects2004\725_HURD\RAMMS_2022\725M_WSV_BLK5_LT9_2M\725M_WSV_BLK5_LT9_2M.xyz
DEM resolution (m): 2.00
(imported from: U:\LandProjects2004\725_HURD\RAMMS_2022\725M_WSV_BLK5_LT9_GRID_2M_ASCII.asc)

Nr of nodes: 172550
Nr of cells: 171720

Project region extent:
E - W: 468930.95 / 468082.94
S - N: 224891.81 / 225701.82

CALCULATION DOMAIN:
U:\LandProjects2004\725_HURD\RAMMS_2022\725M_WSV_BLK5_LT9_2M\D2.dom

GENERAL SIMULATION PARAMETERS:
Simulation time (s): 300.000

Dump interval (s): 0.25
Stopping criteria (momentum threshold) (%): 5
Constant density (kg/m3): 300

NUMERICS:
Numerical scheme: SecondOrder
H Cutoff (m): 0.000001
Curvature effects are ON!

RELEASE:
Depth: 0.77 m Vol: 2103.9 m3 Delay: 0.00 s Name: R5.shp
Estimated release volume: 2103.92 m3

FRICTION MUXI:
Altitude_limit_1: 1500 m a.s.l
Altitude_limit_2: 1000 m a.s.l
Format of following parameters: [< 1000] - [1000 - 1500] - [> 1500]

Open slope parameters:
Mu: 0.300 - 0.290 - 0.275
Xi: 1250 - 1400 - 1500
Channelled parameters:
Mu: 0.340 - 0.330 - 0.310
Xi: 1050 - 1180 - 1250
Gully parameters:
Mu: 0.440 - 0.430 - 0.420
Xi: 900 - 1000 - 1050
Flat parameters:
Mu: 0.280 - 0.270 - 0.260
Xi: 1500 - 1600 - 1750
Forest parameters:
Mu (delta): 0.020 - 0.020 - 0.020
Xi: 400 - 400 - 400

RETURN PERIOD (y): 300
VOLUME category: Tiny

COHESION:
No COHESION specified.

MAP / ORTHOPHOTO INFO:
Map file: U:\LandProjects2004\725_HURD\RAMMS_2022\Orthophoto\NAIP_2013_FULL.tif
OrthoPhoto file: U:\LandProjects2004\725_HURD\RAMMS_2022\Orthophoto\NAIP_2013_FULL.tif