

## AVALANCHE HAZARD INVESTIGATIONS, ORDINANCES, AND ZONING, SALT LAKE COUNTY, UTAH

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**ABSTRACT:** This presentation will discuss the development of an Avalanche Hazard Ordinance for Salt Lake County, Utah. The ordinance was enacted after recognition that urban development of high-end, hillside residential homes was encroaching into range-front avalanche hazard zones. The new ordinance was drafted by the County Geologist and an avalanche consultant by researching current requirements of other jurisdictions, identifying the standard of practice for avalanche investigations and design, and developing an Avalanche Special Study Area Map. The ordinance was adopted in 2002 as part of a major revision to the Geologic Hazards Ordinance (Chapter 19.75 of the Code of Ordinances) and avalanche hazard analysis is now considered during land use permitting in hillside development zones. The avalanche ordinance provides requirements for avalanche analysis, mitigation, and design.

**Keywords:** Zoning, Ordinance, Slope Analysis, Hillside Development, Hazards, Government Approvals.

### 1. INTRODUCTION

*"I've lived here all my life, that is for over 25 years and I have never once seen any 'snow avalanche' come down into this subdivision."*

In the early 1960's, on the eastern bench along Salt Lake City, Utah, probably in late March, a large winter storm with tropical moisture and high winds moved into the already snow-covered Wasatch Front. In the middle of the night, under the rock slabs and face of Mt. Olympus, two large avalanches roared into two alluvial fan drainage basins, running all the way to the ancient Lake Bonneville shoreline bench. With no development in the area other than industrial removal of water, timber, rock and gravel material, the 100-year avalanche event probably went largely unnoticed, except that kids in the neighborhood enjoyed an extended season toboggan slope well into the month of June.

It wouldn't be long before the rock and tree-laden avalanche debris melted and was forgotten. Avalanches remained something of

an unconsidered concept as developers began carving subdivisions into the lower reaches of the steep alluvial fan. In 2002, the last "highest street" became the proposed "second to highest street" as a new subdivision was proposed a level higher onto the alluvial fan.

Throughout the County, subdivisions approved in the 1960's and 70's remained undeveloped into the new millennium, while property values rocketed to \$500,000 or more per lot. Many buyers and real estate agents are unaware that new developments on these "lots of record" (previously platted lots, approved prior to current hillside development ordinances) must meet current development standards, including stringent slope and grading standards. Salt Lake County's "Foothills and Canyons Overlay Zone" (FCOZ) - Chapter 19.73 of the Zoning Ordinance Code) restricts or prohibits development on slopes exceeding 30% slope. The Geologic Hazard Ordinance (Chapter 19.75) requires site-specific hazard analysis in areas subject to recent faulting, liquefaction, landslides, debris flow, rock fall, and avalanches.

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## 2. DISCUSSION

Although Big and Little Cottonwood Canyons, near Salt Lake City, Utah have been leading centers of avalanche control and research for decades (USFS, UDOT, Alta, Snowbird, Brighton, Solitude), the concept of a range-front, urban avalanche hazard affecting hillside subdivisions was only recognized recently. Driven by high-end real estate offering spectacular views, residential development in Salt Lake County is rapidly encroaching into the foothills and canyons of the Wasatch Mountains. These building sites involve a myriad of geologic hazards including the Wasatch fault zone, landslides, debris flows, rock fall, and unstable slopes; in some areas, home sites were also inadvertently developed in areas prone to snow avalanches. This was largely due to a lack of hazard recognition from land use planners, engineering consultants, and landowners, probably due to their location remote from the ski areas.

Salt Lake County began requiring avalanche studies for residential home sites outside of the major canyons in 1998, when the County Geologist recognized a potential avalanche hazard on a 64-acre, 5-lot subdivision proposed in the Mt. Olympus Cove area (Figure 1). That first avalanche study confirmed two large north-facing avalanche paths, with over 3,000 feet of vertical drop, a 60-year return cycle, and classic avalanche path characteristics including channeled track and alluvial fan runout. It was estimated that the hazard could not only impact the proposed subdivision but could potentially run into the existing subdivision below. Interviews with local residents yielded an apparent witness to the 100-year event, who delineated debris from the 1960's encircling the area where several existing homes now sit.

Based on the avalanche analysis, the proposed 5-lot subdivision was re-designed and approved with 2 lots, utilizing terrain protection and avoidance to mitigate the hazard to the home sites. The home sites were moved out of the alluvial fan drainages, but developable slopes (under 30%) could only be located for two lots, although the parcel was 64 acres in size.

Residents in the area expressed mixed concern over the avalanche hazard; many were more concerned about property values. Several made

statements like 'I have lived here all my life and have never even once seen an avalanche'.



Fig. 1 Mt. Olympus, Salt Lake County, showing eyewitness account of avalanche that occurred prior to development.

## 3. THE REGULATORY REVIEW PROCESS

### 3.1 No Guidelines, No Precedent

At the time of the Mt. Olympus study, there was no precedent for avalanche-related design or regulatory review. The County had an Avalanche Path Special Study Areas map that dated from 1989, but it only covered the major canyons and was largely based on UDOT and backcountry ski-touring mapping. It did not cover the Wasatch range front, and there was no corresponding mention of avalanches in the Salt Lake County's Natural Hazards Ordinance.

Like many geological hazards, avalanche starting zones often lie outside the proposed developable parcel. At the local planning agency, subdivision review typically focuses on grading plans, street grades, curb and gutters, sewer systems, water supply designs, and storm drains. Often, the only offsite studies for subdivision development are 10 or 100 year hydrological analyses to determine runoff requirements for storm drain design. Coincidentally, the delineated hydrological basins are almost always the same as the avalanche hazard basin, and much of the work assessed slope steepness, soil, and vegetation types- but not specific to avalanche analysis.

Fortunately, the Mt. Olympus developer was forthright in conducting the avalanche analysis, and also paid the consultant to research other jurisdictions (Alta, Aspen, Vail, Ketchum, Cordova, etc.) to evaluate how this development might be viewed in jurisdictions familiar with avalanche hazard zoning.

### 3.2 The Review Process, Pre-Ordinance

The revised Mt. Olympus subdivision design focused mainly on using terrain protection and avoidance of flow paths, and did not consider mitigation for direct impact to structures. As this was a new type of hazard analysis, the County Geologist referred the study for a third-party peer review at the Utah Geological Survey. Based on the consultant's detailed analysis and the suitability of the recommendations, the 2-lot, 64-acre subdivision was approved.

### 3.3 A Need for Better Hazard Mapping

As the Mt. Olympus project progressed, it became evident that other avalanche-prone areas were being developed along the Wasatch range-front, and the County Geologist needed a method to identify areas when a special avalanche study should be performed, and needed review guidelines. As the County's Geologic Hazards Ordinance was under revision, it was an opportune time to develop a hazard map specific to avalanches, and develop avalanche hazard analysis and reporting guidelines and design standards for mitigation.

In 2002, the County retained Dave Scroggin, an avalanche consultant from Jack Johnson Company, Park City, Utah to assist in the development of the text ordinance and to develop an *Avalanche Special Study Area Map* which could be used by County planners. If the map indicated a proposed development might be in a hazard area, the County Geologist could require the developer to conduct a specific avalanche hazard study for the project.

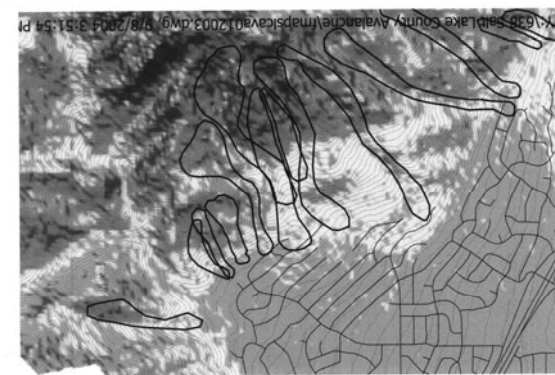


Fig. 2, Avalanche delineations from the special study map.

## 4. AVALANCHE HAZARD DELINEATION METHOD

The Wasatch Front runs north and south for about 25 miles along the entire length of Salt Lake County. There are seven major canyons, with a multitude of sub-canyons. On a limited budget (the County authorized a \$7,500 sole-source contract), identification of hundreds of 100-year avalanche paths, with basically little historic information, would be difficult.

Because of limited funds, extended field review was not an option. Thus, the map was created and is based on a digital computer terrain analysis, known avalanche records, Utah Department of Transportation (UDOT) and Utah Powderbird Guide delineations, site analysis, and inherent knowledge of the author and UDOT avalanche forecaster Greg Dollhausen.

### 4.1 Slope Analysis

The primary basis of the 1:50,000-scale map is a simple slope analysis created in Autocad Land Development software. A digital elevation model (DEM) was created using 3 meter elevation contours. The Slope analysis was run through the DEM, breaking down avalanche slopes into color codes:

- Magenta: Cliff, areas exceeding 50°
- Red: Starting Zone, 30°-50°
- Yellow: Track, 15°-30°
- Green: Runout, 0°-15°

## 4.2 Avalanche Delineations

Known avalanche delineations were then collected from available sources and previous projects and overlaid into the slope analysis. Field reviews and computer identification of obvious areas with classic avalanche characteristics were then added.

The map delineates many, but not all, of the potential avalanche paths in the County. The colored slope analysis also permits identification of potential hazard areas should encroachment into new areas be proposed. The map is dynamic and is can be updated whenever new information is acquired.

In just two years since the creation of the map, about 16 projects in the county have had some level of avalanche assessment completed prior to permitting.

## 5.0 THE NEW APPROVAL PROCESS

### 5.1 Identification of Site Specific Avalanche Study

To help recognize potential development in avalanche hazard areas, three steps were identified to help the County Geologist and Planners determine when and how to consider avalanche hazards and when to require an Avalanche Hazard Report: .

1. The Geologic Hazards Ordinance was modified to include specific definitions for avalanche reviews. 'Red Zone' (non-buildable) and 'Blue Zone' areas were specified.
2. The Avalanche Hazard Special Study and Avalanche Slope Map was posted at the County Planning and Development Services Office to help the planners and developers recognize known and potential hazard areas.
3. The County Geologist was trained in understanding general guidelines for avalanche path characteristics.

### 5.2 Site Specific Avalanche Study

The contents of a special avalanche study are described in the ordinance, and must address specific site analysis, conclusions, and recommendations. Structural mitigation of any kind must be designed and stamped by a Utah Professional Engineer.

## Chapter 19.75.083 Avalanche considerations

### 19.75.083 Avalanche considerations.

A. Development of structures for human occupancy is not permitted within an avalanche special study area, or in other areas where avalanche hazards may exist, unless a detailed avalanche hazard analysis is performed, as described in Section 19.75.060, by a qualified avalanche expert.

B. If the avalanche analysis indicates that the site may be impacted by avalanches, the report shall delineate the following areas:

1. A "red zone" of high avalanche potential [return period of twenty-five years or less, and/or impact pressures over six hundred pounds per square foot (psf)] within which critical facilities or structures for human occupancy are not permitted;
2. A "blue zone" (return period between twenty-five and three hundred years, and impact pressures less than six hundred psf) within which critical facilities or structures for human occupancy shall only be permitted when at least one of the following requirements has been met:
  - a. The structure is designed to incorporate direct protection measures that address the estimated impact forces (flowing snow/debris and powder blast loading). The estimated impact forces shall be calculated by the avalanche expert. The structure shall be designed by, and the plans stamped by, a qualified structural engineer licensed in the State of Utah; or
  - b. Appropriate engineering controls (i.e. deflection structures, snow retention nets, dams, etc.) are designed and installed to mitigate the avalanche hazard. Design or performance criteria for engineered mitigation measures (including estimated impact forces, flow heights, location and dimensions of the mitigation structures) and all supporting modeling or other analyses, calculations, and assumptions, shall be calculated by the avalanche expert and included in the report. Final design plans and specifications for engineered mitigation must be signed and stamped by a qualified professional geotechnical or structural engineer, as appropriate, licensed in the State of Utah. (Ord. 1500 (part), 2002)

Figure 2: Salt Lake County Avalanche Ordinance

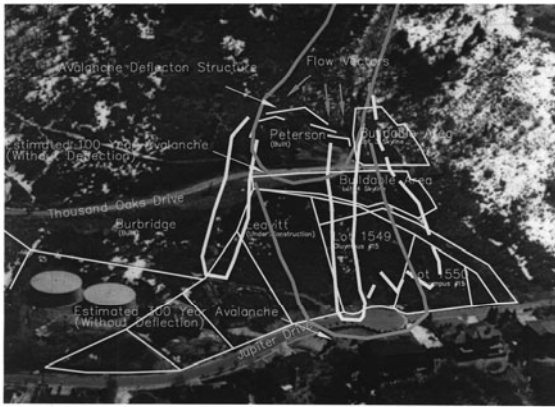


Fig. 3 An avalanche deflection wall created potential problems for neighboring landowners.



Fig. 5, Author Dave Scroggin at proposed site that experienced a 10-year event, simple point release, in the same week that the avalanche study was being conducted. This site was said by neighbors to be void of avalanche potential.



Fig 4 A typical area requiring a site-specific avalanche study - bottom of Little Cottonwood Canyon.



Fig. 6 This subdivision in was built below 40° slopes without consideration to avalanche hazard (prior to ordinance).

## 6. CONCLUSION

Salt Lake County's revised Geologic Hazards Ordinance, Chapter 19.75, was approved in July, 2002, the first time that avalanche provisions were written into their zoning code, alongside other geologic hazards including earthquakes, landslides, rock fall and debris flows. Salt Lake County, under the County Geologist's review, now considers avalanche hazards in the zoning process for hillside development in the range front as well as canyons areas. The Avalanche Hazard Special Study Area Map allows developers to identify potential avalanche hazard areas in the due diligence stage, and allows developers and County officials to recognize and initiate these studies well in advance of preliminary subdivision design and permitting, saving time and resources. Guidelines now define when a special avalanche study should be performed, who should perform it, and how it is processed. Avalanche mitigation is allowed within given parameters.

About 16 avalanche studies- many in the Mt. Olympus area- have since been completed, with mitigation methods that include terrain protection, grading enhancement, deflection walls, and structural reinforcement.

In 2002 the first avalanche protection wedge (deflection wall) in Salt Lake County was constructed to protect a residential home. In 2003 avalanche protection nets were installed near Alta; and in 2004, the first home with structural modifications for direct avalanche impact was approved and is currently under construction. As of this writing, about 4 more avalanche-related applications are currently in the works.

## 7. RECOMMENDATIONS

Salt Lake County's experience with implementing avalanche hazard analysis in the development of hillside real estate developments has been positive. There were some fortunate coincidences in that the County Geologist was already considering revising the Geologic Hazards Ordinance at the time that the Mt. Olympus subdivision was proposed, that the developer hired a consultant experienced in avalanche zoning, and that the County was willing to authorize funding to complete the Avalanche Hazard Special Study Area mapping.

After peer review by various State geologists, civil engineering and geological consultants, and developers, the County government unanimously approved the new ordinance. After 3 years, the avalanche provisions in the ordinance are being tested, and modifications may be made as appropriate.

Given recent refinements in aerial surveying, the DEM-type slope analysis model is a relatively accessible method to delineate avalanche paths, even for agencies on limited funds. These systems are available in standard package engineering or G.I.S. software. The actual path delineations should be done and/or reviewed by an avalanche professional experienced in using terrain analysis.

## 8. REFERENCES

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