EVALUATION OF SLOPE STABILITY NEAR LOTS #3-6, LOWER ICEHOUSE CANYON ROAD, MT. BALDY, CALIFORNIA

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June 2, 2004
Introduction

This report summarizes my May 30, 2004 field investigation of potential slope stability hazards that might affect four lots situated northeast of the intersection of Icehouse Canyon Road with Mt. Baldy Road. Lots #3-#6 are located precisely on a detailed topographic base map (Figure 1) surveyed and drafted by Jack Luepke and associates. My geologic map (Figure 2) and cross section (Figure 3) show a broader view of the landscape along with three-dimensional distribution of the soil and rock units. The main area of concern is a small portion of Icehouse Ridge (Photo 1) that abuts these properties on the north. Lots #3 and #5 include the lowermost slopes of Icehouse Ridge.

This investigation assesses stability of the aforementioned properties with respect to two types of slope hazards: (1) Failure of the boulder talus slope contained in northern parts of Lots #3 and #5, and (2) Potential for rock fall; i.e., rolling or possibly airborne boulders derived from steep exposures of bedrock located much higher on Icehouse Ridge to the north. Possible solutions for mitigating these hazards are also discussed.

**Figure 1.** Survey map showing locations of the four property lots described in the text. Icehouse Ridge forms the high ground directly north of Lots #3 and #5. Topographic contours are based on 300 stations surveyed by Jack Luepke and associates.
Figure 2. Geologic map of the region surrounding the study area. Note location of cross section X-X’ (shown below in Figure 3).

Figure 3. True-scale north-south geologic cross section through the study area. View is to the west, with Icehouse Ridge on the right.
Existing Geologic Conditions Bearing on Slope Stability

The properties of interests are situated mainly on a gently east-sloping alluvial flood plain located 160 ft to 400 ft north of Icehouse Creek and approximately 40 ft higher than the active stream channel (Figures 2-3). The predominant soil type underlying the properties is unconsolidated sand and gravel alluvium, mapped as Qal on Figure 2. I have mapped several rounded stream boulders (Photo 2) on the enlarged lot map of Figure 4. The size of these boulders ranges from 50 cm to 2 m in diameter. They were probably deposited during prehistoric floods on Icehouse Creek. Flood waters did not reach the level of Icehouse Canyon Road during the two largest historical storm events recorded by local residents in 1969 and 1938. The stream boulders shown adjacent to Icehouse Canyon Road may be displaced from their original resting sites due to grading that accompanied construction of this road.

Icehouse Ridge (Photo 1) forms a prominent topographic feature north of the properties. The crest of this northeast-trending ridge is underlain by a distinctive metamorphic rock mapped as my (short for mylonitic gneiss) on Figure 2. This bedrock unit is extensively fractured (Photo 3), with most of the fractures dipping moderately to steeply back into the slope. Unconsolidated deposits of talus breccia (shown as Qt on Figures 2-3) mantle the south-facing slope of Icehouse Ridge that lies directly north of the four lots. Breccia fragments range in size from coarse sand to boulders exceeding 50 cm diameter. Most of these angular pieces of loose rock are restricted to diameters between 8 cm and 25 cm. The northeast corner of Lot #5 and the northern third of Lot #3 overlap the lowermost part of this talus slope. The upper part of the slope (starting ~100 ft above the properties) is intermittently vegetated with grass and brush, plus several large fir and oak trees.

Stability of the Talus Slope

The unconsolidated talus slope directly north of Lots #3 and #5 currently rests in a meta-stable condition with respect to down-slope movement. In other words the existing slope has achieved a natural angle of repose in which a state of equilibrium exists between gravity-induced driving stresses and resisting stresses caused by friction between the breccia fragments. In more simple terms, frictional resistance should balance the tendency for down-slope movement even under conditions of maximum water-saturation.

The talus slope directly north of the north boundary of Lot #3 rests at a natural angle of 32° to 34° (Figure 3; Photo 4). The portion of this slope higher than 200 ft above the property forms a slightly steeper angle of ~38°. The 32° angle should be regarded as the maximum angle that the lower slope can form and still be meta-stable. A narrow strip of boulder talus forming the base of the slope occupies the northern third of Lot #3 and the northeastern corner of Lot #5. This slope rests at an angle between 15° and 21°. The lower angle is probably due to long-term accumulation of small boulders that have rolled down from steeper slopes to the north.

Conceivably, the slopes in the northern parts of Lots #3 and #5 could be cut back to a steeper angle, yielding a larger area of level ground. This scenario is discussed later, but the main constraints are: (1) the slope should not be cut at an angle steeper than 32°, and (2)
construction of a substantial retaining wall would be necessary. Directly north of Lot #5 near the 4804 ft contour (Figure 4), one can directly observe the short-term effects of cutting back the talus slope. Here the base of the talus slope has been excavated by earth-moving equipment (presumably to acquire gravel for some unknown construction project?). The result is the over-steepened slope shown in Photos 5-6. Part of this cut is as steep as 47°, exceeding the natural slope angle of 32° to 34°. One can see how recent rains are causing this slope to erode back to the northeast as it attempts to re-establish its natural angle of repose.

The above discussion is limited to stability of the talus deposit with respect to rapid down-slope movement. Property owners should be aware that down-slope soil “creep” occurs under natural conditions. Creep is the very slow movement of the outer layers of a soil slope induced by freezing and thawing of water in the pores between the soil particles. Over the course of decades, talus slopes can be expected to creep downhill distances of 10’s of centimeters to >1 meter. Good examples of soil creep may be observed on the north side of Icehouse Canyon trail, where many trees are attempting to maintain vertical orientations as their lower trunks are disrupted by soil creep. Retaining walls provide traditional means of inhibiting this natural down-slope soil creep.

**Rock-Fall Hazard**

In the course of walking the four lots, I observed several boulders that very likely originated from distinctive bedrock exposures located on Icehouse Ridge to the north. These boulders (Photo 7), mapped as “gneiss blocks” on Figure 4, are easily distinguished from flood-derived stream boulders on the basis of their jaggedness and a prominent mylonitic foliation (a texture resulting from metamorphism and shearing at a much earlier time when the bedrock was deeply buried). The same rock type occurs in outcrop directly north of the Lot #5-#3 boundary on the crest of Icehouse Ridge at ~5160 ft elevation (Photo 3). From these observations, I infer that the gneiss blocks broke loose from Icehouse Ridge and very rapidly reached their present-day locations.

The gneiss blocks mapped on Figure 4 range in diameter from 50 cm to 1.5 m. Although these boulders appear to be restricted to Lot #3 and Lot #5, I noticed several blocks in Lot #4 that have been uncovered by recent excavation on that property. These were not mapped because their actual resting place could not be determined. However, one would expect more gneiss blocks to occur closer to the slope from which they originated.

The time of these rock-fall events cannot be easily ascertained or even inferred. Many of the blocks appear to rest upon older flood-derived alluvium, but last time that Icehouse Creek flowed at the elevation of the four lots is not known. I suspect that most of the blocks came down before the Mt. Baldy area was settled. However, it might be prudent to query the older residents of the area to find out if anyone noticed evidence for rock-fall at the site during the past 60 years or so. Probable triggering mechanisms might include previous great earthquakes on the San Andreas Fault (located ~ 8 miles to the north) or disruptions of the upper slopes by heavy precipitation.
An important question to ponder is whether the gneiss blocks rolled to their present position after reaching the base of the slope, or whether they were airborne during their final movements. One can imagine a boulder tumbling down from Icehouse Ridge in leaps and bounds. Without direct historical observation, both scenarios should be considered as possibilities. This type of hazard is certainly not unique to the properties in question. Many other residents of the Mt. Baldy area are subject to rock-fall. In my opinion, it is simply a matter of deciding how much risk one is willing to take while living in the mountains.

Figure 4. Detailed site map showing locations of fallen boulders and calculated slope angles
Conclusions and Recommendations

Given the above stated constraints and analysis of limited data, I believe that the properties in question are reasonably safe with respect to rapid down-slope movement of the talus slope, provided that nothing is done to disturb its natural angle of repose of 32° to 34°. A certain degree of rock-fall hazard does exist, however, particularly for those areas of Lots #3 and #5 situated close to the base of the talus slope. I also recommend careful monitoring of the over-steepened cut slope north of Lot #5 near the 4804 ft contour. Without reinforcement, this cut will probably degrade back in future years, potentially affecting the presently stable slope to the east.

Many years of natural weather conditions have graded the talus slope north of Lot #3 to a meta-stable angle of repose. Other than minor amounts of soil creep (discussed above), this slope is not expected to move substantially. Vegetation on the higher parts of the talus slope has enhanced the stability somewhat. Several large trees provide evidence that this part of the slope has not failed catastrophically in recent years. Opportunity may exist for cutting back the base of the talus slope in the northern portion of Lot #3, where the boulder talus deposits rest at an angle less than the natural angle of repose. Should this endeavor be undertaken, I recommend excavating the slope no steeper than 32°, and installing a small (3-4-ft high) rock or concrete wall at the base of the slope to catch minor debris that sloughs off. Cutting back into the slope at an angle steeper than 32° would be feasible, but this would require a much more sophisticated retaining wall. Design of such retaining walls is beyond the scope of this report.

Assessment of the rock-fall hazard is uncertain because of the inherent infrequency and randomness of these events. The only thing one can say for sure is that at least 10 blocks ranging between 50 cm and 1.5 m diameter have come down onto the property sometime in the past (probably before the Mt. Baldy area was settled). How to mitigate this type of hazard depends on whether one believes the boulders rolled to their present positions or whether they arrived there from an airborne state. In terms of first order prevention, I recommend erecting a sturdy wall or fence on the north side of all structures intended for human occupation. This wall should theoretically be strong enough to impede a 1.5 m-diameter rolling boulder. As for the threat of airborne boulders, I believe that assessment of risk or security is simply a matter of serendipity that many mountain dwellers need to rationalize for themselves. Yes, there is a hazard, but will you or your structure be located precisely at the place the boulder falls, at the time that it falls? The most obvious preventive measures are: (1) Be prepared to evacuate quickly during any substantial earthquake, preferably as far as Icehouse Canyon Road, and (2) Keep a vigilant eye (and ear) directed toward Icehouse Ridge during and following heavy precipitation events.
Photo 1. View northeast towards Icehouse Ridge taken from Mt. Baldy Road below Icehouse bridge. The properties in question abut a talus slope along the southeast end of Icehouse Ridge.

Photo 2. Large stream boulder probably deposited by a prehistoric flood on Icehouse Creek. Hammer is ~15 inches long. Rounded shape indicates transport by flowing water.
Photo 3. Fractured mylonitic gneiss exposed ~240 ft above Lot #3. Note hammer for scale.

Photo 4. View to the west across talus breccia deposit forming slope north of Lot #3. The lower part of slope rests at ~21°; the upper part at ~32°. Pink flag marks the NE corner of Lot #3.
Photo 5. Over-steepened cut into talus slope adjacent to the Mt. Baldy road just north of Lot #5. The talus slope in the background rests at angle of repose of $\sim 32^\circ$.

Photo 6. Another view of the over-steepened slope
Photo 7. Boulder of mylonitic gneiss that occurs near the Lot #3-Lot#5 boundary. Hammer is ~15 inches long. Notice angular (jagged) nature of this rock, indicating transport by down-slope gravity mechanism