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National Park Service
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L3023 (2360)

April 18, 1997

Memorandum

To: Superintendent
Whiskeytown National Recreation Area

From: David L. Steensen, Geologist
Science and Technical Services Branch
Geologic Resources Division

Subject: Trip Report - Reconnaissance of Landslides and Channel Changes Associated with the 1997
New Year's Storm Event; February 3-5, 1997

PURPOSE

Whiskeytown National Recreation Area (WHIS), requested the assistance of Geologic Resources Division staff to participate in ongoing assessments of park watersheds that sustained significant changes resulting from the "New Year's Storm" event. In particular, park staff sought geologic and geomorphic information related to three landslides and an evaluation of: (1) the likely causes of the failures, and (2) whether further failure is imminent.

FINDINGS

The New Year's Storm delivered 19 inches of rain in a 48-hour period to already saturated watersheds within WHIS. Above about 4500 feet in elevation, rapid snowmelt may have exacerbated the effects of the rain event. At least two debris flows originated in backcountry headwater regions that significantly heightened the effects of flooding downstream, causing extensive damage to park facilities. Another observed landslide, immediately below Clair A. Hill Dam, which could catastrophically fail and temporarily block Clear Creek with subsequent rapid breakout and downstream flooding, was also of concern.

The landslides are each located in three separate watershed areas: a debris flow that originated in the upper Paige-Boulder watershed, another debris flow that originated in the upper Brandy Creek watershed, and a debris avalanche that is located near the outlet and immediately downstream of Clair A. Hill Dam on the right bank of Clear Creek. Debris flows and debris avalanches are specific types of landslides that are named based on their morphology and material characteristics.

Paige-Boulder and Brandy Debris Flows

The Paige-Boulder Creek and the Brandy Creek debris flows are very similar in origin, development, and effects on downstream resources. Therefore, the following description applies to both debris flows. They began as small-scale (pickup truck sized) failures originating in headwater swales - precisely at the intersection of abandoned timber skid-roads. The crown (top) areas are in weathered granitic rocks of the Shasta Bally batholith (diorite-granodiorite in composition). Development of the debris flows appear to progress from these relatively small sidecast fill failures to much larger debris flows by scouring colluvial materials in the downslope "zero-order" (headwater) and first-order basins. These now substantial debris flows then delivered sediment and organic debris to higher-order streams. In the case of the Paige-Boulder debris flow, it entered the main-stem of Paige-Boulder Creek and the Brandy Creek debris flow entered Rich Gulch, approximately 1-mile above the main-stem of Brandy Creek.

When the debris flows combined with flood flows in the larger channels, the debris flows converted to what is often referred to in the Pacific Northwest as a "debris torrent." The debris torrent, which may be pictured as a flood wave containing a significant load of organic debris, scoured the main stem channels all the way to their confluence with either Clear Creek in the case of Paige-Boulder Creek, or, in the case of Brandy Creek, Whiskeytown Lake. Along both streams, virtually all riparian vegetation was removed, up to 10 feet of the pre-flood channel was incised (the average is unknown, possibly 1-2 feet), and an estimated 200,000 to 500,000 cubic yards of coarse sediment was delivered to both the creek and lake, respectively.

In addition, the Paige-Boulder debris torrent removed one bridge and cut access to another bridge near the N.E.E.D. Camp. The Brandy Creek debris torrent removed the Sheep Camp Bridge and, by sediment deposition and subsequent rerouting of the channel (at the lakeshore), significantly altered the beach at the park's Brandy Creek facilities.

Observations show that naturally caused debris flows, much larger than the 1997 event, have occurred in both the Paige-Boulder and Brandy Creek drainages. Field evidence for such events include: (1) the abundant large boulders strewn about the Brandy Creek picnic area; (2) the road cut at the Sheep Camp Bridge (Brandy Creek) exposes debris flow deposits; and (3) the large boulders scattered on the surface adjacent to Paige-Boulder Creek near its confluence with Clear Creek. The boulders and underlying sediments are composed of granitic rocks of the Shasta Bally batholith and, at all three sites mentioned above, the surrounding bedrock is metamorphosed andesite. Thus, the material originated much higher in the watersheds. Because the boulders are supported by an unsorted matrix of finer-grained granitic material, the boulders represent the coarse fraction of a debris flow deposit; water laid deposits would show grains sorted by size. These debris flow deposits have mature forest vegetation growing on them and pre-date modern human habitation of the area.

As a final note, the Crystal Creek drainage did not experience any large-scale debris flows or torrents

during the New Year's event and observed flood effects were minimal near its confluence with Clear Creek. Crystal Creek has a slightly larger drainage area than either Brandy Creek or Paige-Boulder Creek, but has a similar geomorphic setting nonetheless (headwaters originate on the Shasta Bally batholith, meta-andesites lower in the watershed).

Clair Hill Debris Avalanche

The third site, a debris avalanche immediately below Clair A. Hill Dam, did not experience any significant instability during the 1997 New Year's Storm event. Field evidence indicates that this landslide pre-dates the New Year's Storm. Such evidence includes vertically growing 10-15 year old conifers on the landslide surface, relatively advanced lichen growth on rock surfaces, well established vegetation (e.g., mosses, grasses) growing directly on scarps and earlier-disrupted soils, and a lack of fresh cracks, scarps, or soil exposures. Isolated small areas of loose material near the base of the slide may have slipped, probably due to stream bank scour at or near the peak discharge, but were quite minor in scope. Based on anecdotal information from the U.S. Bureau of Reclamation and the same field evidence cited above, the landslide may have initiated during construction of the dam in 1963, or shortly thereafter.

CONCLUSIONS

Paige-Boulder and Brandy Debris Flows

Continued or persistent failure of the Paige-Boulder and Brandy debris flows is unlikely at the scale of watershed modifications produced by the New Year's event. However, hazards do presently exist within and directly below the debris flow scars due to unstable soils, rocks, and perched large organic debris. Some ravelling and minor landslide activity will sporadically occur during "average" rainfall/runoff events until vegetation becomes well established on the debris flow scars.

Nevertheless, if a storm occurs that is similar in magnitude to the 1997 New Year's event, renewed activity may develop at the existing debris flow crown areas or initiate landslide activity in new areas. Considering the widespread roading and other disturbances associated with former timber harvesting and mining, now abandoned and unmaintained, future nonnatural adjustments in the landscape, and subsequent downstream effects, are likely.

Along the affected channels of Paige-Boulder and Brandy Creeks, the numerous large piles of organic debris also present potential hazards. Park staff or visitors scrambling around on these piles could easily slip or logs could shift suddenly. The larger piles of organic debris may increase fire hazards. In addition, exposed soils in the landslide scars and along the streambanks may facilitate exotic plant invasion.

Also, the larger watersheds on the south side of Whiskeytown Lake are capable of producing large-scale debris flows. It is unknown what range of conditions favor the development of such debris flows; one possibility is widespread stand-replacing fire.

Clair Hill Debris Avalanche

In relation to the debris avalanche below Clair A. Hill Dam, the initial concern that a massive failure could temporarily block Clear Creek, with subsequent rapid breakout and downstream flooding, was unwarranted. An estimated 10-15 or more years has passed since any significant mass movement at this site and the landslide has apparently reached quasi-equilibrium, at least in relation to storms of the character and magnitude of the New Year's event.

In spite of the apparent ability to withstand large magnitude rain events, the Clair Hill debris avalanche does present potential hazards. Certainly, any foot travel on the landslide face is dangerous: it is very steep, most rocks are unstable, and the numerous patches of finer-grained soil material is also unstable; any fall could involve sliding all the way to the base and landing on large jagged boulders. In addition, it is probable that "pickup- to bus-sized" blocks of unsupported ground, particularly above the crown scarp, will intermittently fail (not necessarily during rain events). However, a catastrophic failure of the entire slope is much less likely. Even if a volume that is equal to that already evacuated from the landslide were to enter Clear Creek, it would not block the stream entirely (based on visual estimates). The rocky character of the debris would also inhibit a rapid catastrophic breakout during a flood.

DISCUSSION

Debris flows are a dominant landforming process in mountainous regions throughout the world. As with all landforming events, debris flows occur on a frequency dependent on numerous internal and external factors. Generally speaking, landforms are in dynamic equilibrium with the processes acting upon them. When human activities change the form, the equilibrium conditions likewise change; sometimes with catastrophic results. The fact that both of the damaging debris flows within WHIS originated at abandoned skid-roads underscores the clear connections between form and process. Based on this reconnaissance-level site visit however, I cannot conclusively say whether these debris flows would have occurred without the disturbances associated with timber harvesting. Yet, no landslides occurred in undisturbed ground. It is likely that the disruption of the natural form (i.e., constructing a road) has changed the way this form interacts with processes (e.g., rain events); the 1997 debris flows are probably caused by management activities and are not natural events. Such phenomena are well-documented throughout the Pacific Northwest and are a key concern in programs addressing anadromous fish decline.

In addition to potential acceleration of mass failure processes, roads often divert stormwater or stream flow away from natural channels. Where the diverted flow exits the road prism, gullies may form and/or landsliding may be initiated downslope; downstream sedimentation can directly affect the quality of aquatic habitat. While not a specific focus of this site visit, observations indicate that stream diversion, and subsequent erosion and sedimentation, is a significant concern throughout the disturbed watersheds in WHIS.

The most effective treatment of physical land disturbances is to reestablish the balance between form and process. For roads, treatments typically include retrieving sidecast fill and placing it back into the cut void, or storing the fill in a stable location, to reduce the potential for landsliding. Complete excavation of fill from stream crossings eliminates the potential for diverting stream flow and the pre-disturbance channel is often uncovered, reducing the potential for post-excavation erosion. In addition, reshaping the road prism to its pre-road contour allows some salvage of native topsoils, which is valuable in reestablishing native vegetation.

RECOMMENDATIONS

I recommend that the follow actions be considered as part of the storm repair and monitoring work currently underway at WHIS:

- establish a monitoring program to evaluate recovery of the landslide features and affected stream corridors. The park may wish to consider incorporating the monitoring of physical features in combination with monitoring or surveying aquatic biologic conditions;
- conduct a thorough inventory of abandoned timber- and mining-related roads. This inventory should include information related to geomorphic position and an assessment of the potential for failure. Such an inventory will allow the park to appropriately rank watershed areas needing treatment;
- identify treatment options for actively eroding sites and those sites with a high potential for future erosion. Treatment options may be modelled using examples from watershed rehabilitation work completed in the adjacent Grass Valley Creek watershed and/or the large-scale restoration program at Redwood National Park;
- investigate the geologic history of the debris flow deposits found within WHIS. Understanding how and when these deposits were emplaced can allow an estimation of conditions that lead to such events. This study would allow park staff to better understand and prepare for potential landslide risks; and
- ensure visitors are kept away from the base of the Clair Hill debris avalanche (restrictions are already in effect for this area?).

If you have questions or would like further assistance, please call me at (303) 969-2014, or you can reach me by name on cc:Mail.

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