Angora Burn Area Emergency Response

Geology Report

Lake Tahoe Basin Management Unit

Thomas E. Koler, PhD, RG
Eldorado National Forest Geologist
CA RG #7041 Expires 11-30-08

July 7, 2007

PURPOSE AND SCOPE 3
METHODS 3
SOIL, BEDROCK AND GLACIAL DEPOSIT UNITS 4
SPRINGS AND SEEPS 4
GEOLOGIC SETTING 4
LANDSLIDES 5
RESOURCES AT RISK AND TREATMENT 5
GEOLOGIC HAZARDS AND RISKS 5
TREATMENTS 9
CONCLUSIONS 9
LIMITATIONS 9
REFERENCES 10

TABLE 1: QUALITATIVE TERMINOLOGY FOR USE IN ASSESSING RISK TO PROPERTY (MODIFIED BY KOLER FROM FELL ET AL., 2005) 7
TABLE 2: DEBRIS FLOW RISK VALUES FOR 0%-30% SLOPE CLASS OF THE ANGORA FIRE AREA. 8
TABLE 3: DEBRIS FLOW RISK VALUES FOR 30%-60% SLOPE CLASS OF THE ANGORA FIRE AREA. 8
TABLE 4: DEBRIS FLOW RISK VALUES FOR GREATER THAN 60% SLOPE CLASS OF THE ANGORA FIRE AREA. 9

Purpose and Scope

This report serves as documentation of the initial fieldwork, aerial reconnaissance and preliminary modeling of the existing and potential geologic hazards and risks that may occur or become reactivated due to the loss of vegetation in the Angora Fire within and near South Lake Tahoe, California. This work was requested by Stephenie Heller, Lake Tahoe Basin Management Unit BAER Team Leader, as well as cooperators within the interagency fire and emergency services teams. Information from this work has been synthesized into the formal BAER report submitted to the Lake Tahoe Basin Management Unit Supervisor and the Regional Forester. The size of the wildfire was just over 3,000 acres and therefore the scope falls within a watershed scale or Level I slope stability analysis as described in Hall et al. (1994).

Methods

Methods utilized for this work are described in detail in Hall et al. (1994) and in summary include the following:

1. Review of all reports, maps and other sources of data pertaining to the geologic hazards within the Angora Fire area.
2. Complete time-series stereo-pair aerial photogrammetry analyses using flight line photographs to identify potential or existing geologic hazards.
3. Map potential geologic hazards during helicopter flights and record the mapped features on a 1:24000 scale topographic map.
4. Identify and classify soil units within the area using the visual method of the Unified Soil Classification (Howard, 1986).
5. Identify location of and spatial relationships between springs and seeps within the fire area.
6. Characterize slope stability hazards including rockfall, debris flows, debris landslides and rotational/translational landslides.
7. Deterministically assign values to physical parameters for evaluating slope movements in bedrock and soil units following methods described in Hammond et al. (1992), Hall et al. (1994) and Koler (1998). Forecast probabilities of slope movement in response to vegetation loss in the Angora Fire through stochastic iterations of the data evaluated in the deterministic step.
8. Using empirical field data model rockfall potential including zones of possible runout applying the Colorado Rockfall Simulation Program (Jones et al., 2000).
9. Zone hazard areas using available information and tools that are available and assign risk ratings to the resources at risk.
10. Document findings for the Angora BAER Report.

Soil, Bedrock and Glacial Deposit Units

The soil within the fire area has been identified within the Natural Resources Conservation Service's (NRCS) soil inventory for the Lake Tahoe Basin Area as being primarily coarse-grained non-plastic or low plasticity soils (SM, SP, GM and GP Unified Soil Classification). A few minor soil units in the NRCS soil inventory for this area are comprised of plastic soils but in the field work completed none were observed or classified. Based on this information as well as work by Prellwitz and Koler (2003) the following physical index property values were assigned and later tested deterministically: phi angle range of 24° to 35° (some GP units the phi angles are as high as 45° but in the statistical analyses these values were constrained to within the statistical tail), dry unit weight ranging between 70 pcf to 100 pcf, moisture content range of 0.02 to 0.08 (due to the coarse texture of the soils), and an assumption that the soil is non-cohesive based on field dilatancy, dry strength and toughness tests.

Bedrock in the area is several tens if not hundreds of feet below the overlying Quaternary glacial till (Saucedo, 2005) and is composed of Jurassic and Cretaceous age intrusive and metamorphic rocks. Overlying the bedrock are glacial tills that were deposited as lateral moraines. Age for these tills is 10,000 to 150,000 years. Till materials are composed of sands and gravels with large boulders that have diameters in excess of 10 feet.

Springs and Seeps

Local conventional wisdom indicates the glacial till materials "act like a sponge" holding a great deal of ground water. During field reconnaissance no positive indicators such as hydrophilic vegetation and geomorphic landforms typically found in areas of springs and seeps were observed. However, a major break in slope occurs along the lower valley wall where numerous swales and ephemeral channel initiate near a common contour. This elevation and drainage features may or may not be a topographical expression of the local ground water phreatic surface. In the far southern portion of the fire area are several lakes, ponds and springs. These wet areas are most likely related to faulting and bedrock discontinuities (i.e., fractures and joints) where ground water is routed to the topographic surface.

Geologic Setting

The Angora Fire area lies within glacial deposits comprised of glacial tills. These materials were deposited along the lateral margins of a Pliocene age alpine glacier that was moving in a northerly direction with a terminus now located under the southern portion of Lake Tahoe. The till materials have been interpreted as being deposited as a lateral moraine (Birkeland1964, 1966 and 1968; Wahrhaftig and Curtis, 1965) and range in age from 10,000 to 150,000 BCE. A northwesterly trending Holocene fault trace has been mapped by Saucedo (2005) crossing the fire area. This fault trace may explain the presence of the lakes, ponds, and springs in the far southern portion of the fire area.

Landslides

Landslides within the Angora Fire area are debris flows and rockfall. Debris flow deposits are found along the western lower valley wall and across the valley floor of the Angora Creek basin. In many areas of the valley floor the debris flow deposits have influenced the drainage pattern of the streams. Angora Creek in particular has been forced to change its drainage pattern in response to these deposits. For example, the upper part of this creek has been displaced by a large debris flow deposit that is several hundred feet wide and long. The stream channel has re-established itself by down-cutting through the debris flow deposits. Rockfall has occurred in the fire area in the past as indicated by the boulders (some with diameters greater than 10 feet) strewn down the hill slope and across the valley floor. No debris landslides or rotational/translational landslides were identified in this project. Avalanche source areas and chutes are not present in the area but are located to the south and southwest of the area.

Resources at Risk and Treatment

Resources at risk from geologic hazards include the following: (1) private lots along the lower valley wall and valley floor of Angora Creek; (2) water tank and the Elk Lookout Circle neighborhood; (3) South Lake Tahoe High School and homes within the vicinity of the high school; and, (4) the aquatic habitat and water quality of Angora Creek. With the exception of the water tank and the Elk Lookout Circle neighborhood, these areas have long runout distances between geologic hazard initiation sites (i.e., rockfall and debris flows) and the resources at risk. The runout distances are defined as the slope lengths where the slope gradients are gentle (usually less than 10°) and are several hundred feet long before reaching the resources at risk. The longer the runout distance the lower the consequences will be adverse.

Geologic Hazards and Risks

Geologic hazards related to the Angora Fire include debris flows and rockfall. These hazards were evaluated using empirical field data applied in deterministic and stochastic modeling with the Deterministic Level I Stability Analysis (DLISA), stochastic Level I Stability Analysis (LISA) and the Colorado Rockfall Simulation Program (CRSP) (Hammond et al., 1992; Jones et al., 2000). Hazard and risk determinations were completed using the concept that risk is a combination of the likelihood that a hazard will occurred with the predicted consequences that may result (e.g., Koler, 1998; and Fell et al., 2005). The characterization of the geologic hazards and predicted consequences applied in a risk matrix are summarized in Table 1 below.

A field transect was measured from the Angora Lookout Station down slope to Angora Creek along a bearing of 130°. Data included slope distances, slope angle (to be used later for plotting a cross-section) soil properties (using the Unified Soil Classification), hydrophobic soil conditions, and changes in hill slope shape and form. From these data several thousand iterations of CRSP were completed to assess the rockfall hazard. Additional transects were measured from the topographic map to evaluate rockfall hazards above other housing areas as well as the South Lake Tahoe

High School. All of these rockfall simulations resulted in an extremely low number of rockfall reaching more than a few tens of feet from potential initiation sites. Therefore it is extremely unlikely that rockfall will result in any resource damage directly related to the vegetation mortality from the Angora Fire. However, in the event of a large seismic event (probably M 5 or greater) there is a likelihood that rockfall may occur. Therefore rockfall is assigned a very low to low risk value (i.e., rare likelihood and medium consequence equal a very low to low risk in Table 1).

For determining the debris flow risk a deterministic analysis was first completed applying DLISA using field data and the NRCS soil inventory. From these computer iterations the data were input to the stochastic LISA for calculating the hazard rating for the debris flows that may result from the vegetation mortality associated with the wildfire. Prior to any field work the BAER team specialists agreed as a group that data would be gathered according to three slope classes: 0% to 30%, 30% to 60%, and 60% and greater. Therefore the hazard/risk assessment for debris flows was discriminated into these slope classes. Results from these analyses are provided in Tables 2 through 4 below. Although no debris flow areas were within the 60% and greater slope class an analysis was completed to assure a complete analysis.

The most significant difference between the four resources at risk is the runout distance. As discussed above, the runout distance is defined as the slope length at which the slope gradient becomes more gentle (usually 10° or less) and the distance is several hundred feet long. Of the four resources at risk only the second (i.e., water tank and Elk Lookout Circle neighborhood) has the shortest runout distance. The photo in Figure 1 shows the water tank within the black zone of the fire. However, even this potential runout distance is several hundred feet and therefore the predicted consequence was characterized as “medium.” The other three predicted consequences were characterized as “minor.” Fortunately there are no areas above this resource and the other three that have a 60% and greater slope class. Consequently Table 4 is solely for information and to complete the analyses as originally agreed to by the BAER team. Therefore, the only resource at risk with a risk rating of low to moderate was the water tank and the Elk Lookout Circle neighborhood. The other resources at risk were assigned lower risk ratings.

Figure 1: Looking down slope above the water tank within the Elk Lookout Circle neighborhood.

Table 1: Qualitative terminology for use in assessing risk to property (modified by Koler from Fell et al., 2005)

Qualitative measures of likelihood of landsliding		
Level	**Descriptor**	**Description**
A	Almost certain	The event is expected to occur
B	Likely	The event will probably occur under adverse conditions
C	Possible	The event could occur under adverse conditions
D	Unlikely	The event could occur under very adverse circumstances
E	Rare	The event is conceivable but only under exceptional circumstances
F	Not credible	The event is inconceivable or fanciful
Qualitative measures of consequences to the resource		
1	Catastrophic	Resource is completely destroyed or large scale damage occurs requiring major engineering works for stabilization
2	Major	Extensive damage to most of the resource, or extending beyond site boundaries requiring significant stabilization
3	Medium	Moderate damage to some of the resource, or significant part of the site requires large stabilization works
4	Minor	Limited damage to part of the resource, or part of the site requires some reinstatement/stabilization works
5	Insignificant	Little damage

Qualitative risk analysis matrix – classes of risk to resource					
	Consequences to the resource				
Likelihood	Catastrophic	Major	Medium	Minor	Insignificant
Almost certain	VH	VH	H	H	H
Likely	VH	H	H	M	L-M
Possible	H	H	M	L-M	VL-L
Unlikely	M-H	M	L-M	VL-L	VL
Rare	M-L	L-M	VL-L	VL	VL
Not credible	VL	VL	VL	VL	VL

Legend – VH: very high risk; H: high risk; M: moderate risk; L: low risk; VL: very low risk

Table 2: Debris flow risk values for 0%-30% Slope Class of the Angora Fire area.

Resources at Risk	LISA Probability	Table 1 Likelihood Descriptor	Table 1 Consequence Descriptor	Risk Rating
Houses below the Angora Ridge excluding the Elk Lookout Circle and Water Tower	0%	Not Credible	Insignificant	Very Low
Elk Lookout Circle and Water Tower	0%	Not Credible	Insignificant	Very Low
South Lake Tahoe High School	0%	Not Credible	Insignificant	Very Low
Angora Creek aquatic and water quality	0%	Not Credible	Insignificant	Very Low

Table 3: Debris flow risk values for 30%-60% Slope Class of the Angora Fire area.

Resources at Risk	LISA Probability	Table 1 Likelihood Descriptor	Table 1 Consequence Descriptor	Risk Rating
Houses below the Angora Ridge excluding the Elk Lookout Circle and Water Tower	11% to 14%	Unlikely	Minor	Very Low to Low
Elk Lookout Circle and Water Tower	11% to 14%	Unlikely	Medium	Low to Moderate
South Lake Tahoe High School	11% to 14%	Unlikely	Minor	Very Low to Low
Angora Creek aquatic habitat water quality	11% to 14%	Unlikely	Minor	Very Low to Low

Table 4: Debris flow risk values for greater than 60% Slope Class of the Angora Fire area.

Resources at Risk	LISA Probability	Table 1 Likelihood Descriptor	Table 1 Consequence Descriptor	Risk Rating
Houses below the Angora Ridge excluding the Elk Lookout Circle and Water Tower	19% to 23%	Possible	Minor	Low to Moderate
Elk Lookout Circle and Water Tower	19% to 23%	Possible	Medium	Moderate
South Lake Tahoe High School	19% to 23%	Possible	Minor	Low to Moderate
Angora Creek aquatic habitat water quality	19% to 23%	Possible	Minor	Low to Moderate

NOTE: No slopes evaluated for potential debris flow activity were within this slope class.

Treatments

No treatments will be necessary to mitigate the geologic risks. However, if possible, in order to reduce the moderate risk to the water tower and Elk Lookout Circle neighborhood, it may be prudent to request a priority in having the upslope areas re-seeded above this resource. In addition, for the first year after the fire, it will also be prudent to advise residents in this area to be advised to the remote change that slope failure may occur after a torrential rainfall or rain-on-snow event.

Conclusions

All resources at risk from geologic hazards were evaluated and classified as very low to low to moderate. No high risk ratings were assigned to resources at risk.

Limitations

This study is preliminary in nature to give the Lake Tahoe Basin Management Unit Supervisor and the Regional Forester an immediate report on the possible resources at risk from the loss of vegetation in the Angora Fire. The information and commentary are therefore a “first iteration” to be used for mitigating short-term effects that may occur within the first year after the fire. Although these data can be used for evaluating long-term effects they will probably be incomplete for a thorough study of the geological hazards in this part of the Lake Tahoe Basin. The report is for an emergency response following BAER guidelines and therefore should be solely treated as such.

References

Birkeland, P.W., 1964, Pleistocene glaciation of the northern Sierra Nevada north of Lake Tahoe, California: Journal of Geology, v. 72, pp. 810-825.

Birkeland, P.W., 1966, Tertiary and Quaternary geology along the Truckee River with emphasis on the correlation of Sierra Nevada glaciations with fluctuations of Lake Lahontan. In: Lintz, J., and Abdullah, S.K.M., (eds.), Geological Society of America Guidebook to Field Trip Excursions in Northern Nevada: University of Nevada, Reno, pp. D1-D24.

Birkeland, P.W., 1968, Correlation of Quaternary stratigraphy of the Sierra Nevada with that of Lake Lahotan area, in Morrison, R.B., and Wright, H.E., Jr., (eds.), INQUA Congress, 7th, Boulder, CO, 1965: Salt Lake City, University of Utah Press, 631 p.

Fell, R., Ho, K.K.S., Lacasse, S., and Leroi, E., 2005, A framework for landslide risk assessment and management. In: Hungr, O., Fell, R., Couture, R., and Eberhardt, E., (eds.), Landslide Risk Management: Balkema Publishers, New York, pp. 3-25.

Hall, D.E., Long, M.T., and Remboldt, M.D., (Eds.), 1994, Slope Stability Reference Guide for National Forests in the United States: Publication EM 7170-13, USDA Forest Service Washington Office, 1091 p.

Hammond, C.J., Hall, D.E., Miller, S., and Swetik, P., 1992, Level I Stability Analysis (LISA) documentation for version 2.0: General Technical Report INT-295, USDA Forest Service Intermountain Research Station, Moscow, Idaho, 190 p.

Howard, A.K., 1986, Visual classification of soils, Unified Soil Classification System: US Bureau of Reclamation Engineering and Research Center, Geotechnical Branch Training Manual No. 5, Denver, CO, 106 p.

Jones, C.L., Higgins, J.D., and Andrew, R.D., 2000, Colorado Rockfall Simulation Program Version 4.0: Colorado Department of Transportation, Colorado Geological Survey, and Colorado School of Mines, 127 p.

Koler, T.E., 1998, Evaluating slope stability in forest uplands with deterministic and probabilistic models: Environmental and Engineering Geosciences Vol. IV, No. 2, pp. 185-194.

Prellwitz, R.W., and Koler, T.E., 2003, Soil Unit Shear Strengths Pilot Study for the Eldorado National Forest: USDA Forest Service Eldorado National Forest internal doc.

Saucedo, G.J., 2005, Geologic Map of the Lake Tahoe Basin California and Nevada: California Department of Conservation Geological Survey Regional Geological Map Series 1:100,000 scale Map 4.

Wahrhaftig, C., and Curtis, G.H., 1965, Tahoe City to Hope Valley. In: Morrison, R.B., and Wahrhaftig, C., (eds.), Guidebook for field conference I, Northern Great Basin and California, INQUA, pp. 59-71.