August 31, 2006 Embankment Failure – Debris Flow at the Cascades Development
Haywood County, North Carolina

Introduction

North Carolina Geological Survey (NCGS) staff members visited the site of the August 31, 2006 embankment failure – debris flow at the tentatively named "Cascades" development in Haywood County on September 8, 2006. The purpose of the visit was to document the debris flow and collect data for inclusion in the NCGS slope movement database, and for the future preparation of landslide hazard maps for Haywood County as authorized in the Hurricane Recovery Act of 2005.

Findings

The debris flow appears to have initiated as an embankment failure at the southwest termination of a development road at elevation ~4580 ft. (latitude 35.49239 degrees; longitude -83.07519 degrees) on the northwest-facing slopes of Eaglenest Ridge (Figures 1 and 2). This location is about 2 miles southeast of Maggie Valley. The track is about 90 feet wide at the widest point and is about 1,300 feet long (Figures 2 and 3). The upper portion of the track is scoured down to bedrock, and most of the mud, boulders and large woody debris of the deposit came to rest in the lower 500 feet of the track. The lower 200 feet of the track is in Pine Tree Cove Creek. A large volume of material transported by the debris flow was deposited in lot 107 (Figure 4). Had there been a home on this lot it would have been significantly damaged, if not destroyed, by a direct hit from a debris flow of this magnitude.

Heavy rains associated with the remnants of Tropical Storm Ernesto probably triggered the debris flow. Development contractors at the site reported 6.5 inches of rain during a 12-hour period prior to the debris flow. Likely contributing factors in the embankment failure include: woody debris and graphitic-sulfidic bedrock fragments in the embankment; a steep embankment slope placed on a steep natural slope overlying a steeply inclined, weathered bedrock surface; and, a possible seepage zone beneath the embankment.

The remaining ~300-ft long extent of road embankment northeast of the head scarp of the August 31, 2006 failure is a primary concern for future embankment failures of similar magnitude. Future slope failures that pose a threat to public safety will likely originate in this embankment unless it is stabilized. Additional tension cracks observed in the embankment northeast from the scarp of the August 31, 2006 failure are evidence of other existing unstable areas (Figure 5). The embankment appears to be constructed with significant amounts of graphitic-sulfidic bedrock excavated by blasting to construct the road prism. This type of bedrock contains carbon in the form of graphite, and naturally occurring sulfur-bearing minerals such as pyrite and pyrrhotite.

The metamorphosed sedimentary bedrock exposed in the road cut is along strike and likely contiguous with a graphitic-sulfidic rock unit and thrust fault mapped by Montes (1996) approximately 500 ft to the northeast. Fabric in the bedrock exposed in the road cut above the slope failure indicates that ancient (inactive) ductile and brittle faulting has produced closely-spaced fractures in the bedrock, and numerous planes of weakness in the sequence of interlayered graphitic and sulfidic schist and metagraywacke.

The graphitic-sulfidic bedrock is a well-documented problematic rock type prone to acid runoff and instability in embankments (Bryant and others, 2003; Schaeffer and Clawson, 1996; Wooten and Latham, 2004). Road construction can have a destabilizing affect on steep mountain slopes underlain by graphitic-sulfidic rock types and can increase the potential for damaging slope failures. In addition to the potential for acid runoff that can adversely affect aquatic life, acid-producing rocks can be prone to slope failure in natural settings. The potential for slope movements increases when these rocks are exposed in cut slopes and used in embankments.

The August 18, 2006 rockslide that closed the Blue Ridge Parkway occurred in a similar graphitic-sulfidic rock type that is generally along strike with the graphitic-sulfidic outcrop in Cascades development area. Five of six damaging debris flows that occurred during the heavy rains of May 2003 in Swain County originated in embankments that contained sulfidic rock. In December 1990, a debris flow that originated in a road embankment underlain by graphitic-sulfidic rock destroyed the chlorinator building for the Bryson City municipal water system. Acidic runoff can decrease the natural pH of stream waters and kill aquatic life, as happened in 1963 during reconstruction of U.S. Highway 441 near Newfound Gap in the Great Smoky Mountains National Park. Acidic runoff is usually greatest shortly after road construction; however, it can continue at a decreased level for years after road construction.

NCGS staff also observed debris fan deposits exposed downslope in Pine Tree Cove (Figure 1). These unconsolidated surficial deposits mapped in the area by Hadley and Goldsmith (1963) indicate that naturally occurring debris flows have originated on the northwest-facing slopes of Eaglenest Ridge in the past, likely going back to prehistoric times.

Recommendations

Geologic and geotechnical expertise should be retained to determine the extent of graphitic-sulfidic rock, and the potential for future slope failures and acid runoff in the development area. The known ~300-ft length of embankment constructed with the graphitic-sulfidic bedrock should be stabilized or removed. Possible stabilization methods include: reconstructing the embankment in compacted lifts treated with lime and limestone as shown in Byerly (1996); or encapsulating the acidic material in lime and limestone as shown in Schaeffer (1996). Both of these methods neutralize the acidic runoff and improve the stability of the embankment. Establishing vegetation on an

embankment constructed with graphitic-sulfidic rock material may prove to be difficult, and it is unlikely that vegetation alone will prevent future slope failures.

Frequent inspections during construction of this and other projects by soil scientists, geologists, and geotechnical engineers can help minimize the potential for future damaging slope failures. These specialists should be qualified in slope stability and in recognizing problematic soil and rock types. Identification of potentially unstable slopes and problematic soil and rock types during project development and prior to construction can also reduce the likelihood of damaging slope failures.

References

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Montes, C., 1996, The Greenbrier and Hayesville faults in central-western North Carolina [M.S. Thesis]; Knoxville, Univ. of Tennessee, 145p, maps scale 1:24,000.

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Figures

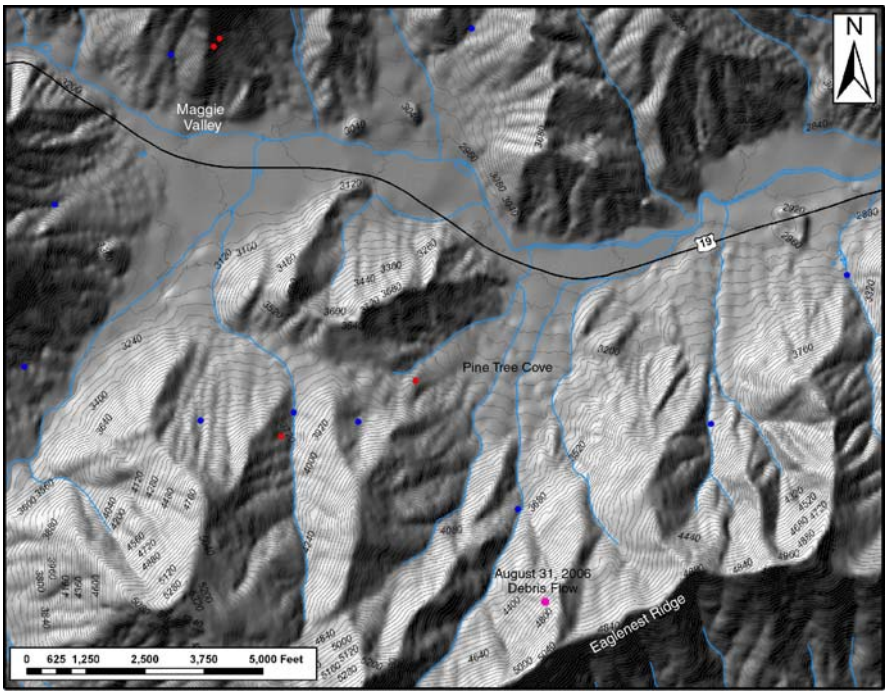

Figure 1. Location map showing initiation point of the August 31, 2006 embankment failure-debris flow (pink circle). Blue circles show apex locations of slope movement deposits; red circles show initiation points of slope movements currently in the NCGS slope movement-slope movement deposit database. Perennial streams are shown in light blue. Map base is U.S. Geological Survey 10-meter digital elevation model.

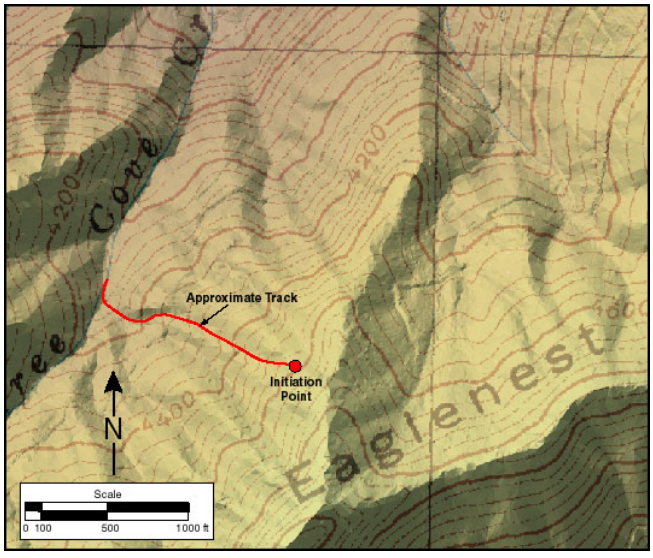

Figure 2. Excerpt of topographic map showing the initiation point and approximate track of the August 31, 2006 embankment failure-debris flow. The base map is a hillshade derived from a LiDAR (Light Detecting And Ranging) digital elevation model. Contour lines are from the Hazelwood 7.5-minute topographic map.

Figure 3. View looking up the track of the August 31, 2006 embankment failure-debris flow from the development road near lot 107. September 8, 2006 photograph.

Figure 4. View looking downslope at the debris deposit and damage to lot 107. September 8, 2006 photograph.

Figure 5. View of cracks in embankment extending northeast from the head scarp of the August 31, 2006 embankment failure-debris flow. September 8, 2006 photograph.