COMMONWEALTH OF VIRGINIA
DEPARTMENT OF ENERGY
GEOLOGY AND MINERAL RESOURCES PROGRAM

MAP OF KNOWN AND POTENTIAL DEBRIS FLOW PATHWAYS IN ALBEMARLE AND NELSON COUNTIES, VIRGINIA

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GEOLOGIC HAZARDS MAP SERIES 3
SLOPE MOVEMENT HAZARD MAPS OF
ALBEMARLE AND NELSON COUNTIES, VIRGINIA
SHEET 3 of 3, VERSION: September 20, 2024

EXPLANATION

Table 1. Definitions and explanation of map unit designations.

Relative Hazard	Map Symbol	Map Unit Designation	Description
Increasing		Known debris flow pathways	Areas of documented historical debris flows (circa 1969 to present).
		Potential debris flow pathways	Areas in the possible flow paths of debris flows and other shallow, translational slope movements that could initiate within high and moderate hazard susceptibility zones predicted on the Landslide Susceptibility Map (Sheet 2). Slope movements that initiate on unstable modified slopes within these high hazard zones may also follow similar paths.
		Areas of past debris flow activity	Locations where slope movement deposits have been mapped outside of potential flow paths. Debris flows and other slope movements have previously deposited material at these locations. As slope movements often reoccur and deposit material in the same general area, future slope movements could also affect these areas. Additionally, a potential hazard exists for slope movement deposits because they typically consist of deep, unconsolidated accumulations of clay- to boulder-sized material that can be unstable in high, steep-sided excavations, and in areas over-steepened by stream erosion.
Decreasing		Areas of no known or potential debris flow activity	Areas that are outside of known and potential debris flow pathways and the mapped extent of past debris flow activity. While these areas are unlikely to be damaged by debris flows or other shallow, translational slope movements, the modification or alteration of slopes in these areas could result in slope movement activity.

MAP FEATURES

Initiation Zones

Initiation zones of shallow, translational slope movments on unmodified slopes

Roads

Primary roads

Secondary roads

Blue Ridge Parkway & Skyline Drive

Rivers

Rivers and Streams

Lakes

Political Boundaries

County boundary

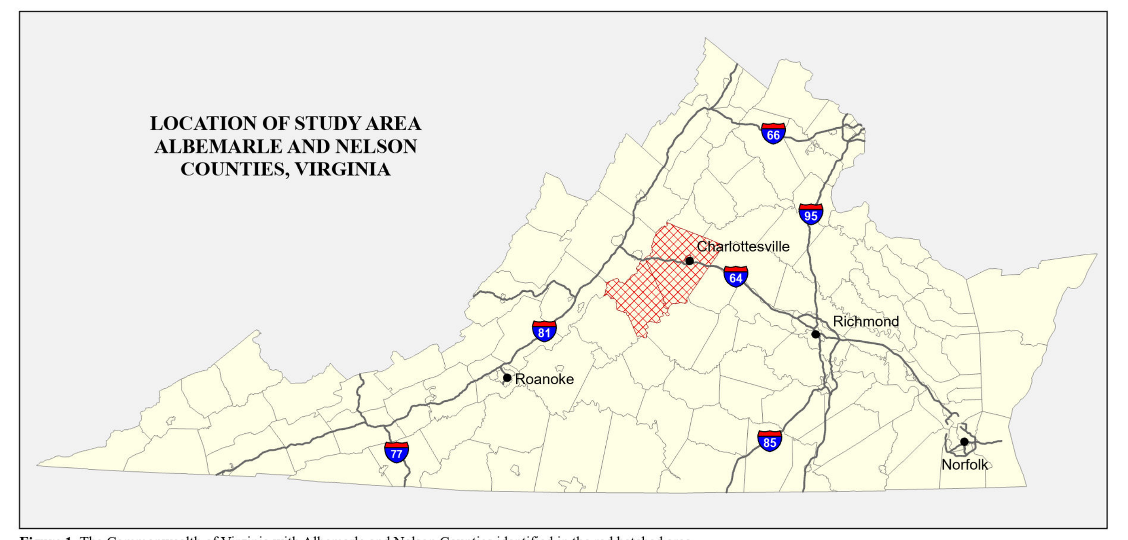
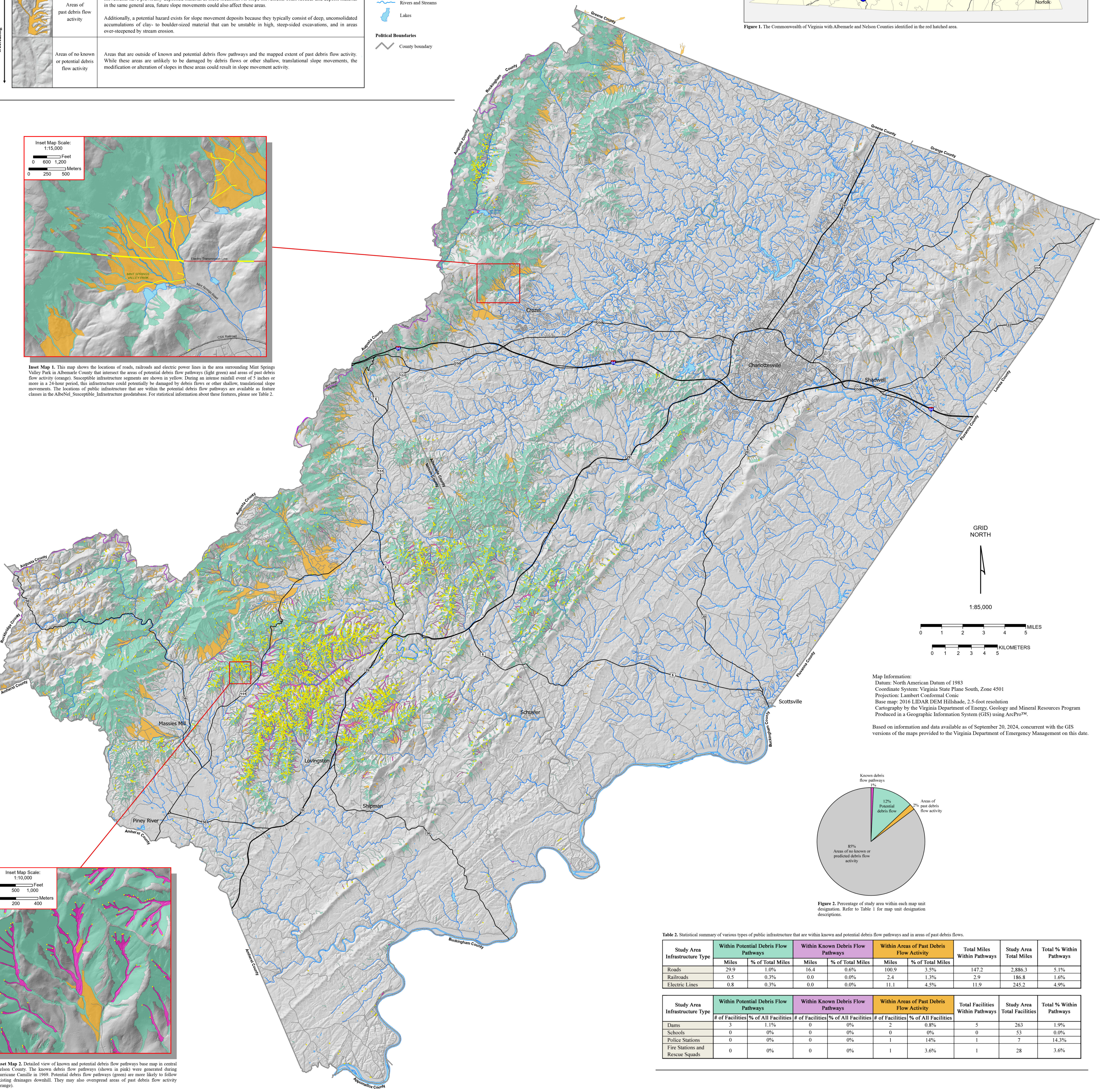


Figure 1. The Commonwealth of Virginia with Albemarle and Nelson Counties identified in the red hatched area.



Inset Map 1. This map shows the locations of roads, railroads and electric power lines in the area surrounding Mint Springs Valley Park in Albemarle County that intersect the areas of potential debris flow pathways (light green) and areas of past debris flow activity (orange). Susceptible infrastructure segments are shown in yellow. During an intense rainfall event of 5 inches or more in a 24-hour period, this infrastructure could potentially be damaged by debris flows or other shallow, translational slope movements. The locations of public infrastructure that are within the potential debris flow pathways are available as feature classes in the AlbeNel_Susceptible_Infrastructure geodatabase. For statistical information about these features, please see Table 2.

Map Information:
Datum: North American Datum of 1983
Coordinate System: Virginia State Plane South, Zone 4501
Projection: Lambert Conformal Conic
Base map: 2016 LIDAR DEM Hillshade, 2.5-foot resolution
Cartography by the Virginia Department of Energy, Geology and Mineral Resources Program
Produced in a Geographic Information System (GIS) using ArcPro™.

Based on information and data available as of September 20, 2024, concurrent with the GIS versions of the maps provided to the Virginia Department of Emergency Management on this date.

Known debris flow pathways
1%
12%
Potential debris flow
2%
Areas of past debris flow activity
85%
Areas of no known or predicted debris flow activity

Figure 2. Percentage of study area within each map unit designation. Refer to Table 1 for map unit designation descriptions.

Inset Map 2. Detailed view of known and potential debris flow pathways base map in central Nelson County. The known debris flow pathways (shown in pink) were generated during Hurricane Camille in 1969. Potential debris flow pathways (green) are more likely to follow existing drainages downhill. They may also overspread areas of past debris flow activity (orange).

Table 2. Statistical summary of various types of public infrastructure that are within known and potential debris flow pathways and in areas of past debris flows.

Study Area Infrastructure Type	Within Potential Debris Flow Pathways		Within Known Debris Flow Pathways		Within Areas of Past Debris Flow Activity		Total Miles Within Pathways	Study Area Total Miles	Total % Within Pathways
	Miles	% of Total Miles	Miles	% of Total Miles	Miles	% of Total Miles			
Roads	29.9	1.0%	16.4	0.6%	100.9	3.5%	147.2	2,886.3	5.1%
Railroads	0.5	0.3%	0.0	0.0%	2.4	1.3%	2.9	186.8	1.6%
Electric Lines	0.8	0.3%	0.0	0.0%	11.1	4.5%	11.9	245.2	4.9%

Study Area Infrastructure Type	Within Potential Debris Flow Pathways		Within Known Debris Flow Pathways		Within Areas of Past Debris Flow Activity		Total Facilities Within Pathways	Study Area Total Facilities	Total % Within Pathways
	# of Facilities	% of All Facilities	# of Facilities	% of All Facilities	# of Facilities	% of All Facilities			
Dams	3	1.1%	0	0%	2	0.8%	5	263	1.9%
Schools	0	0%	0	0%	0	0%	0	53	0.0%
Police Stations	0	0%	0	0%	1	14%	1	7	14.3%
Fire Stations and Rescue Squads	0	0%	0	0%	1	3.6%	1	28	3.6%

OVERVIEW OF THE MAP OF KNOWN AND POTENTIAL DEBRIS FLOW PATHWAYS

Background and Purpose

The Geology and Mineral Resources Program of the Virginia Department of Energy has produced slope movement hazard maps for Albemarle and Nelson Counties (Figure 1) to provide the public and local and state government agencies with descriptions and locations where slope movements have occurred, or are likely to occur, and the general areas at risk from these slope movements. The locations of previous slope movements and their deposits are important because slope movements often reoccur in the same general areas, and typically deposit material in areas where there are pre-existing slope movement deposits.

The slope movement hazard map series for Albemarle and Nelson Counties, Virginia, consists of three maps: Geologic Hazards Map Series 3 (GHMS-3), Sheets 1, 2, and 3, that are designed to be used in conjunction with each other. Brief descriptions of this map (Sheet 3) and accompanying maps follow.

1. Sheet 1, Slope Movement and Slope Movement Deposits Map, shows the extent and distribution of known historical slope movements (all types) and pre-existing slope movement deposits.

2. Sheet 2, Slope Stability Map, shows where naturally occurring, shallow, translational slope movements (e.g., debris flows) may begin on otherwise undisturbed slopes in response to a major rainfall event.

3. Sheet 3 (this map), Map of Known and Potential Debris Flow Pathways, shows where debris flows may travel if they were to occur.

These printed maps are smaller scale representations of digital spatial data that have been created for use in a Geographic Information System (GIS). The Geology and Mineral Resources Program slope movement hazard map products are not intended to be a substitute for a detailed, site-specific analysis by a qualified geologist or engineer.

Map of Known and Potential Debris Flow Pathways (Geologic Hazards Map Series 2, Sheet 3).

This color-coded map portrays areas that could be affected by debris flows or other shallow, translational slope movements that may originate during a high-rainfall event as described on Sheet 2. The map shows areas potentially in the path of these slope movements if they occur and includes areas significantly farther down slope from where the slope movements may initiate (Figure 2). Designated units on this map are: known debris flow pathways, potential debris flow pathways, areas of past debris flow activity, and areas of no known or potential debris flow activity. Table 1 shows the color codes used on the map with explanations that correspond to the map unit designations.

This map identifies areas that could be affected by debris flows or other shallow, translational slope movements given the conditions on the ground at the time the map was made. Changes in the landscape as a result of human activity and future slope movements can alter the pathways of subsequent debris flows; therefore, the map represents the general areas that could be affected by debris flows and other shallow translational slope movements. In areas of known, potential, and past debris flow activity, further slope stability analysis, including onsite field investigation, may be appropriate prior to siting facilities or undertaking ground-disturbing activities.

Map Production

The Map of Known and Potential Debris Flow Pathways is derived from two sources:

1. Outlines of debris flow tracks and slope movement deposits from the Slope Movements and Slope Movement Deposits Map (Sheet 1)

2. Areas designated as high or moderate hazard on the Landslide Susceptibility Map (Sheet 2)

The following sequential steps outline the method used to produce the areas of potential debris flow pathways using a 5-foot LIDAR digital elevation model (DEM).

1. High and moderate hazard zones from the Landslide Susceptibility Map with areas greater than 0.25 acres (approximately 10,900 $feet^2$ or 1,000 $meters^2$) were assumed to be the probable source areas for slope movements that could affect areas down slope (i.e., high-to-moderate hazard areas less than 0.25 acres were eliminated as source areas).

2. Hydrologic flow paths, based on topographic gradients derived from the 5-foot LIDAR DEM, were created in ArcPro 3.1 from the center of each high-to-moderate hazard cell that met the above criteria.

3. Flow paths were automatically terminated in ArcPro 3.1:

   a. At slope gradients less than six degrees for contiguous areas $\geq$ 0.25 acres (approximately 10,900 $feet^2$ or 1,000 $meters^2$). A nominal slope of six degrees was selected because it is consistent with the lowermost down slope extent of most debris flow tracks delineated in the study area. Note: Flow paths were extended to the downstream extent of debris deposits where these deposits are mapped downstream of slope gradients < 6 degrees.

   b. At the 500-year floodplain boundary as mapped by the FEMA - Flood Hazard Mapping Program.

   c. At water bodies $\geq$ 0.25 acres, such as ponds or lakes, as mapped by the U.S. Geologic Survey: National Hydrography Dataset (NHD) or provided as breaklines for maintaining the definition of water features in the 2016 LIDAR DEM.

4. Flow paths were buffered to 27.5 feet on all sides to delineate the potential debris flow pathways. This buffer approximates the average track width of mapped debris flows in the study area. Note: In some cases, the automated 27.5-foot buffering routine may extend the predicted debris flow pathways slightly upslope and over ridge tops above debris flow source areas.

Manual editing of the digital map was required to adjust the downstream extents of the potential debris flow pathways to terminate flow paths deemed to be unrealistic. Adjustments included:

1. Ending flow paths that originated on man-made cut slopes near the base of the cut.

2. Removing flow paths that originated on dams or aggregate stockpiles.

3. Removing flow paths that erroneously follow roads along topographic ridges.

4. Removing flow paths from areas of high hazard natural slopes that are < 0.25 acres after disregarding high hazard areas associated with road cuts within the same high hazard polygon. If the remaining high hazard area associated with the road cut is also < 0.25 acres, flow paths were removed from that area as well.

Potential Hazards to Public Infrastructure

Shallow, translational landslides, (e.g. debris flows) are gravity-driven, swift-moving, viscous mixtures of sediment and water that appear to move like churning, wet concrete (Cruden and Varnes, 1996; Iverson, 1997). The destructive force of a debris flow can cause significant damage to life, property, and existing infrastructure. Due to their high-water content, debris flows can travel long distances from their initiation zone before they reach a low-gradient area and dissipate (Iverson, 1997). As they move down slope, debris flows can entrain and transport additional soil and water, boulders, vegetation, and manmade objects such as cars and building debris that are in their path.

The feature classes within the AlbeNel_Susceptible_Infrastructure geodatabase (a portion of which is shown in Inset Map 1) indicate where public infrastructure, such as roads, railroads, electrical transmission lines, and dams intersect potential debris flow pathways and areas of past debris flow activity. Public infrastructure that is in a known debris flow pathway (pink) or potential debris flow pathway (green) has a higher relative hazard as debris flows or other shallow, translational slope movements may travel along a similar, channelized path. Infrastructure that is in an area of past debris flow activity (orange) has a low-to-moderate relative hazard. These data are intended to guide emergency management personnel in identifying areas for further investigation in the event of a hurricane or other high-intensity rainfall event ($\geq$ 5-inches of rain in a 24-hour period).

References Cited

Cruden, D.M. and Varnes, D.J., 1996, Landslide types and processes, in Turner, A.K., and Schuster, R.L., eds., Landslides - Investigation and mitigation: Transportation Research Board Special Report No. 247, National Research Council, National Academy Press, Washington, D.C., p. 36-75.

Iverson, R.M., 1997, The physics of debris flows. Reviews of Geophysics, v. 35, no. 3, p. 245-296.

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