

Field Report

Allen Street Slope Failures Sylva, North Carolina

November 2, 2020

North Carolina Geological Survey



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Introduction

At the request of the Town of Sylva, North Carolina Geological Survey geologists investigated slope failures affecting a section of Allen Street in Sylva, North Carolina. The purpose of this investigation is to document and provide information on the slope failures in this area, and to aid the Town of Sylva in their deliberations on landslide mitigation options along this section of Allen Street (Figs. 1 and 2).

We made field visits on October 1 and October 8, 2020. Michael Morgan, Interim Town Manager, and Jake Scott, Town of Sylva Director of Public Works, met us at the site on October 1. Jake Scott met with us at Bryson Park for a short time during our October 8 site visit. The areas affected by slope failures occur on the southeast-facing slopes generally between Allen Street and Chipper Curve Road. For the purpose of this report these areas are designated as Slope Failure Area 1 (SFA-1) and Slope Failure Area 2 (SFA-2) respectively as shown in Figures 1 and 2. SFA-1 is the slide area investigated and reported on by the Kessel Engineering Group (Kessel and Johnson, 2020). SFA-2 is the general area of ground ruptures and slope movements southwest of SFA-1.

Allen Street, maintained by the Town of Sylva, is affected by SFA-1 and SFA-2. Chipper Curve Road, under the jurisdiction of the North Carolina Department of Transportation (NCDOT), is affected by SFA-2, and potentially by SFA-1. Public utility water supply and sewer lines operated by the Tuckaseegee Water and Sewer Authority (TWSA) are within both slope failure areas. Bryson Park, owned by the Town of Sylva and accessed via Chipper Cove Road, is affected by slide movement in SFA-1. Private property parcels at 527 Allen Street are affected by SFA-1. A tract owned by Jackson Paper Manufacturing Company is affected by SFA-1 and SFA-2.

Kessel and Johnson (2020) cite anecdotal evidence that slope failures have occurred along sections of Allen Street for several decades. Landslide hazard maps for Jackson County by Appalachian Landslide Consultants, PLLC show an active slide area they documented in 2016 affecting a 175-foot long segment of Allen Street located approximately 330 feet northeast of SFA-1 (Appalachian Landslide Consultants, 2019). Investigation of these slope failures are beyond the scope of our study.

Methods

We collected field data on GPS-enabled field computers equipped with 2019 orthophotography and sub-meter resolution (QL1) topographic data derived from a 2017 QL1 LiDAR digital elevation model. On October 8, 2020 we conducted Unmanned Aerial Systems (UAS) flights over the affected areas to obtain digital imagery for mapping surface features related to the slope failures (Figs. 3 and 4). Structural features observed in bedrock outcrops were measured with Brunton compasses.

Geology

The locations of bedrock outcrops we examined in the area are shown in Figure 2. We interpret the areas of bedrock outcrop to be stable and not involved in slope movements. The metamorphic bedrock consists of interlayered migmatitic biotite gneiss and amphibolite. The residual soil observed in the area is derived from the weathering of these rock types. Planar

discontinuities observed as fracture planes and foliation planes (zones of aligned minerals) in the bedrock exposures are potential planes of weakness. There are ENE-striking fractures oriented perpendicular to the SE-directed slope movement that could act as back-release surfaces if the slide involved detachment of the bedrock. Relict planes of weakness of similar origin and orientations are likely present at depth in the residual soil and weathered rock in the area, including those areas affected by the slope movements.

Slope Failure Area 1

Slope Failure Area 1 (SFA-1) is an active slide that encompasses approximately 0.46 acres (19,849 ft²) and affects a roughly 120-ft long section of Allen Street as estimated from our mapping. The Kessel Engineering Group (KEG) investigated the slide and prepared a report with recommendations for stabilizing the area for the Town of Sylva (Kessel and Johnson, 2020). The KEG recommended the installation of soil nails or ground anchors along with a system of horizontal drains to stabilize the slope. We understand that the Town of Sylva has secured bids from contractors to stabilize the slope.

A generalized timeline of the movement in SFA-1 compiled from information from Jake Scott, Director of Public Works, and from the KEG report follows:

- Mid-March 2020: minor cracking observed in the Allen Street pavement.
- April 6, 2020: the cracking had worsened.
- April 2020: the road shifted by approximately 4 inches, breaking the TWSA water line located within Allen Street. (Note: this movement occurred after heavy rainfall during April 12-13, 2020).
- May 5-6, 2020: KEG reported a scarp height of approximately 2 ft in the Allen Street asphalt, and a tension crack (scarp) extended upslope into private property at 527 Allen Street; and bulging of the pavement at the Bryson Park entrance.

Our observations of the slide extent and characteristics, and geologic materials exposed at the surface are generally consistent with those presented in the KEG report (Kessel and Johnson, 2020). Figure 5 illustrates slide conditions as observed during our investigation. Figure 5A shows the down-dropped section of Allen Street, now barricaded. The upper portion of the main slide scarp extends into private property at 527 Allen Street (Fig. 5B) and threatens the driveway. Bulging, buckling, and deterioration of the pavement at the Bryson Park entrance (Fig. 5C) appears to have progressed somewhat from that shown in the KEG report. In summary, the areal extent of slide activity and the relative amounts of displacement we observed do not appear to be greatly different than those described in the KEG report.

Slope Failure Area 2

Slope Failure Area 2 (SFA-2) is a general area southwest of SFA-1 that includes a series of discontinuous ground ruptures affecting Allen Street and the vegetated slopes immediately to the southeast (Figs. 1 and 2). Also included in SFA-2 is an active slide area that encompasses approximately 0.2 acres (~9,085 ft²) at the toe of the slope where it impinges on Chipper Curve Road.

The cracks in Allen Street in SFA-2 appeared in the late August-early September 2020 time frame as reported by Jake Scott. The two areas of cracked pavement are approximately 260 ft

apart, and indicate initial stages of slope movement along this segment of Allen Street (Figs. 6A, C). We observed a ground rupture approximately 30-ft long, oriented SW-NE, in a vegetated slope approximately 15ft southeast of Allen Street (Fig. 6B) between the two areas of cracked pavement. The direction of slope movement indicated by these ground ruptures is generally toward the southeast. The TWSA has taken precautionary measures in anticipation of water and sewer line breaks in this section of the Allen Street corridor.

The active slide area along Chipper Curve Road is mitigated by concrete median barriers placed at the toe of the slope by NCDOT (Figs. 7A-C). Loose, wet soil has impinged on the barriers and resulted in some tipping of the barriers (Fig. 7C). A recent slide scarp is exposed midway up the kudzu-covered slope with as much as 10ft of vertical displacement (Fig. 7B,C). Completely decomposed bedrock (saprolite) is exposed in the scarp, consistent with other observations of residual soil derived from weathered bedrock in the area. Evidence indicates that this active slide area may have enlarged since 2017 with the main scarp migrating toward the northwest. Ground ruptures (scarps) and displaced soil are visible in the 2017 lidar digital elevation model for this area (Fig. 2). These coalescing slide areas predate the larger scarp observed in our ground investigations (Figs. 2 and 7B, C) and UAS imagery (Figs. 3 and 4), which is not visible in the 2017 lidar.

It is not clear if the ground ruptures in SFA-2 along Allen Street represent: A) localized movement confined to Allen Street and the associated fill slopes; B) a larger slope response to continued movement of the active slide area below along Chipper Cove Road; or, C) some combination of the above scenarios. Further investigations and monitoring would be required to make these determinations which would involve additional costs. In any case, continued movement of the Allen Street corridor in this area will likely have a negative impact on public and emergency vehicle access, and TWSA water and sewer lines, and potentially private property upslope.

Over the long term, continued movement and enlargement of the active slide area along Chipper Cove Road could have a destabilizing effect on the Allen Street corridor. Consequently, any plans by the NCDOT to mitigate the slide area along Chipper Curve Road may have a bearing on the Town of Sylva's decisions regarding this section of Allen Street. Any action the NCDOT may take outside of their right-of-way typically requires the consent of the property owner, which in this case is the Jackson Paper Manufacturing Company.

Summary

Table 1 presents observations and findings from this study the Town of Sylva may wish to consider regarding mitigation options for Allen Street in Slope Failure Areas 1 and 2. Although these areas are presented separately, they are interrelated with respect to the overall economic and public safety consequences involved. These observations and findings are from a geologic perspective and do not substitute for an engineering assessment and cost-benefit analysis.

References

Appalachian Landslide Consultants, 2019, Landslide susceptibility maps for Jackson County, North Carolina available online June 2019. Accessed 2020/10/29.

Kessel, B.E., Johnson, I., 2020, Report of geotechnical exploration and slope stability analyses, Allen Street – slope failure, Sylva, North Carolina, KEG Project No. JA20-4021-01, Kessel Engineering Group, July 14, 2020.

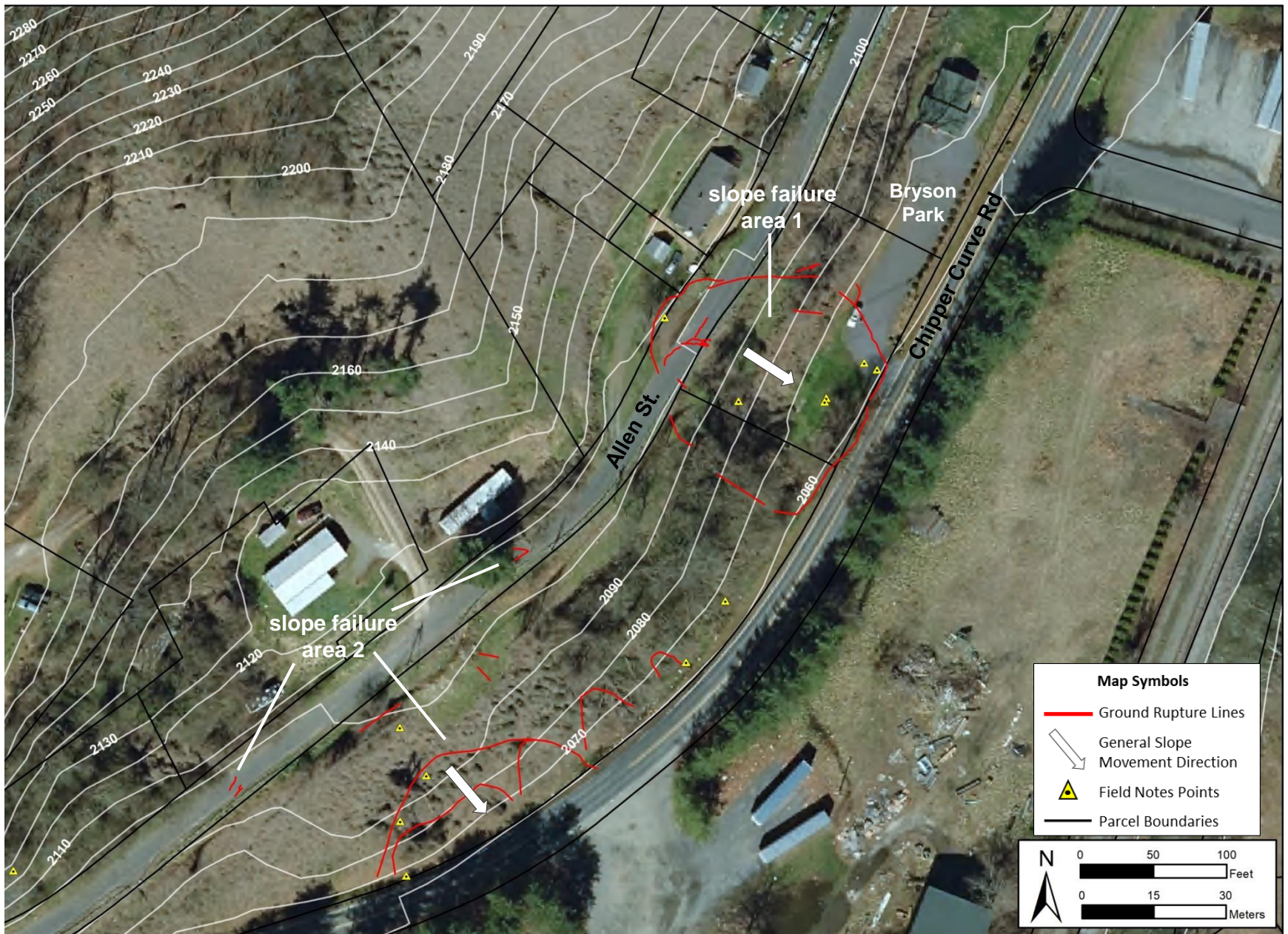


Figure 1. Map showing ground rupture lines (scarps) in slope failure areas 1 and 2. Field notes points are specific locations where data were collected on October 1 and 8, 2020. All locations are approximate. Map base is 2019 orthophotography and elevation contours are in feet.

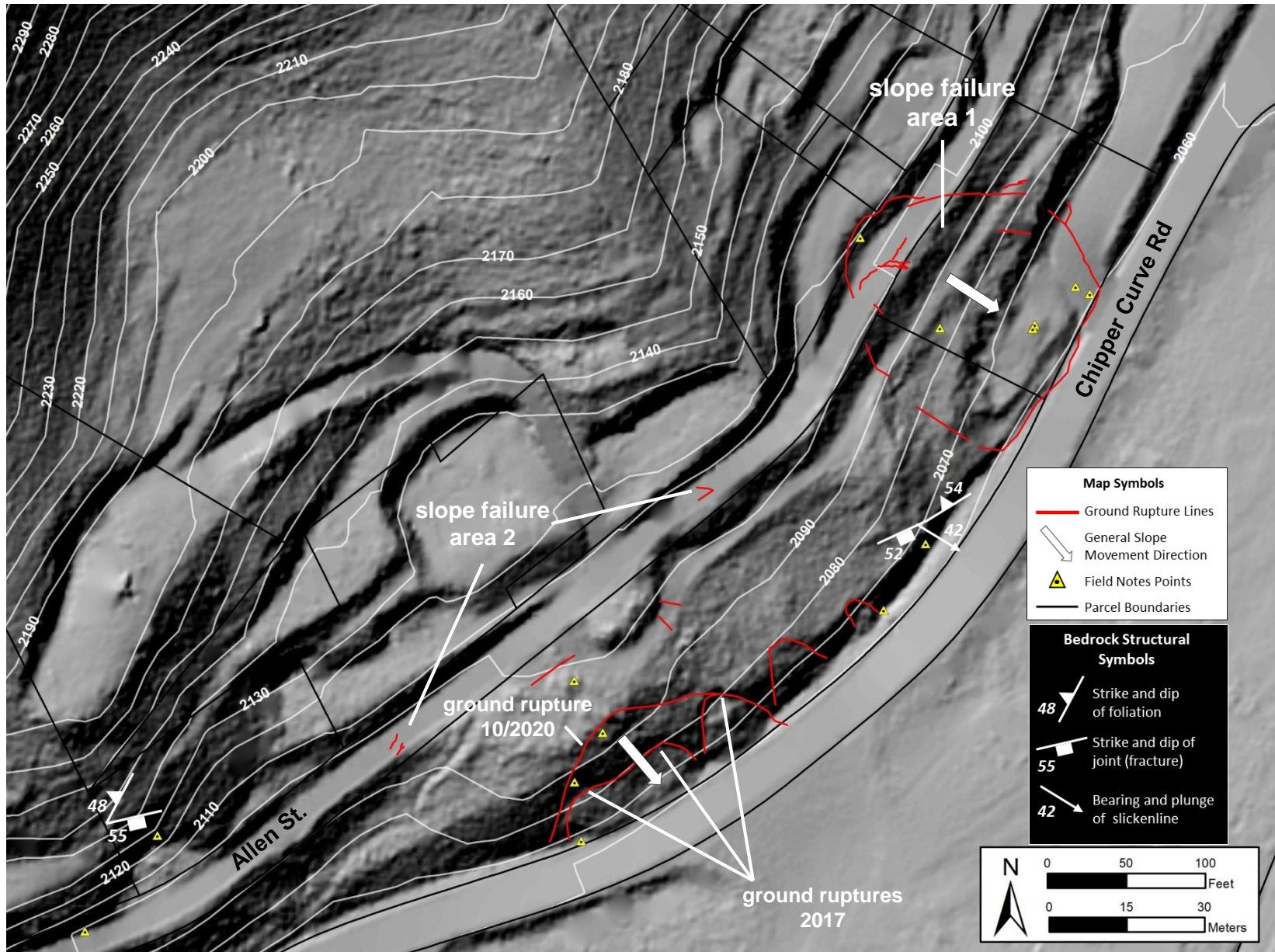


Figure 2. Map showing ground rupture lines (scarps) in slope failure areas 1 and 2. Note the upslope progression of the ground ruptures (scarps) from 2017 to 2020 above Chipper Curve Road. Field notes points are specific locations where data were collected on October 1 and 8, 2020. Bedrock structural symbols are adjacent to the outcrop location at the field note point. All locations are approximate. Map base is a shaded relief map derived from a sub-meter resolution 2017 lidar digital elevation model. Elevation contours are in feet.



Figure 3. Map showing ground rupture lines (scarps) in slope failure areas 1 and 2. Field notes points are specific locations where data were collected on October 1 and 8, 2020. All locations are approximate. Map base is a 10/08/2020 UAS orthomosaic image.

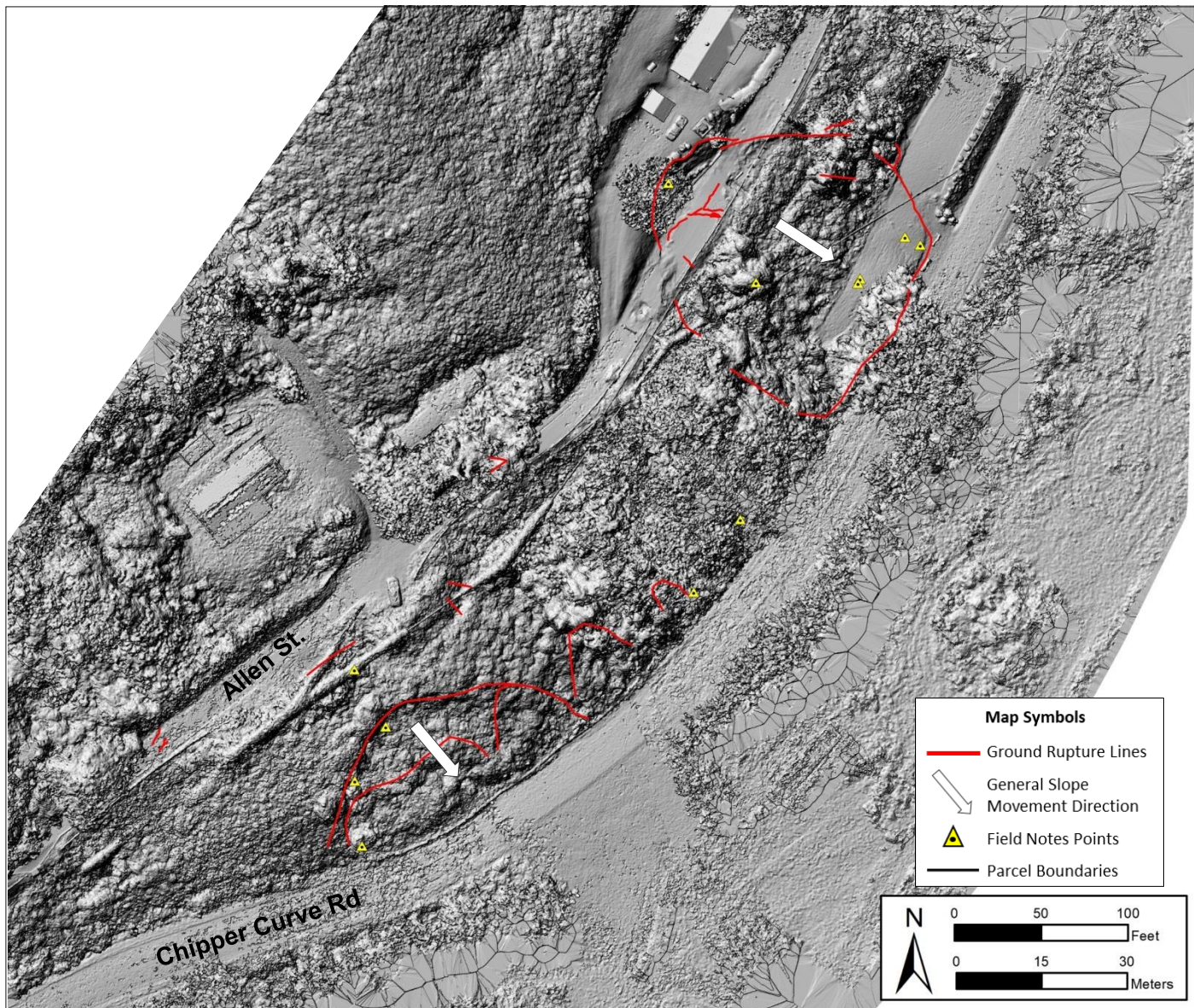


Figure 4. Map showing ground rupture lines (scarps) in slope failure areas 1 and 2. Field notes points are specific locations where data were collected on October 1 and 8, 2020. All locations are approximate. Map base is a digital surface model derived from 10/08/2020 UAS imagery. The vegetation surface is depicted in the image.

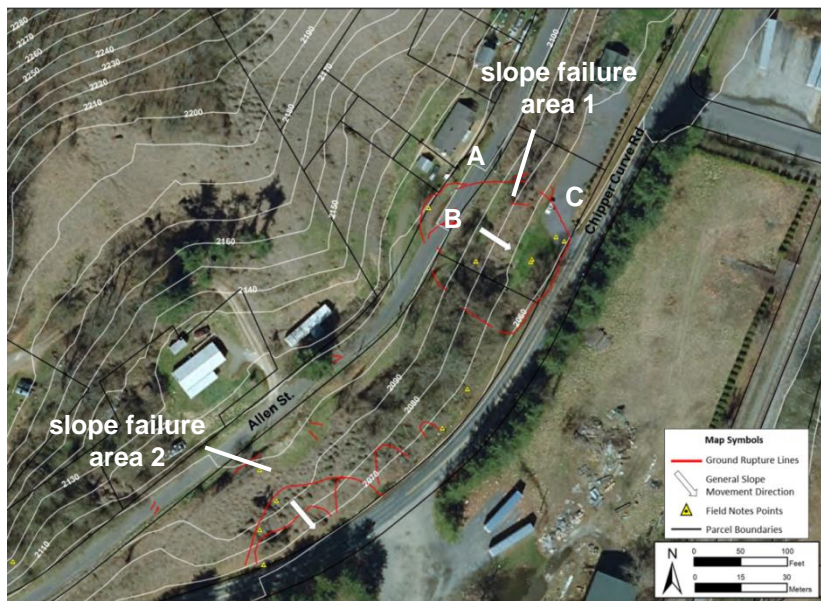


Figure 5. Map showing ground rupture lines in slope failure areas 1 and 2 (see also Fig. 1). Map base is 2019 orthophotography. Locations A-C refer to photos.



Figure 5A. Location A on map. Photograph showing down-dropped section of Allen Street. View looking southwest. 10/08/2020 NCGS photo.



Figure 5C. Location C on map. Bulge in pavement from slide movement, Bryson Park entrance road. Ground bulging and wet ground was observed in the grassed area of the Park in the background. View looking southwest 10/08/2020 NCGS photo.

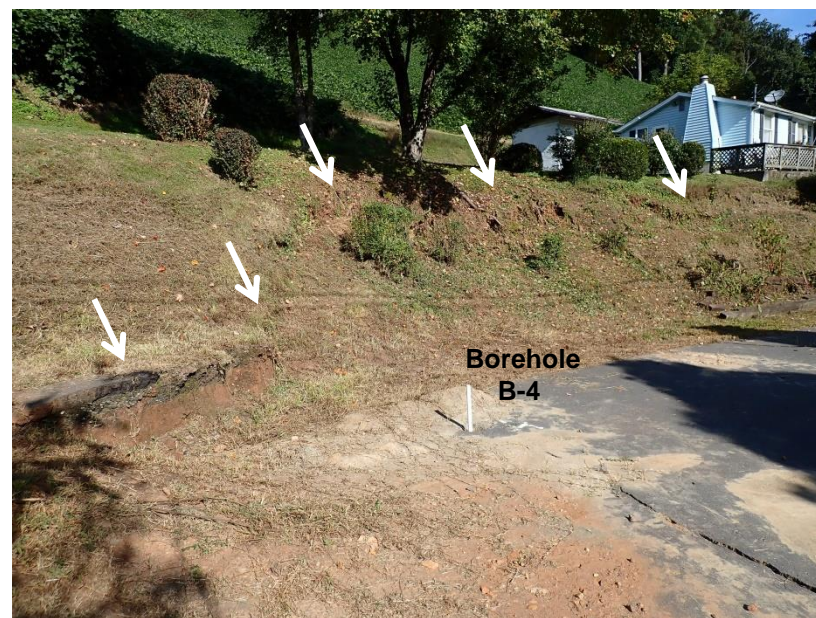


Figure 5B. Location B map. Arrows point to ground rupture (scarp) affecting Allen Street and private property upslope, and KEG borehole B-4. View looking northeast 10/08/2020 NCGS photo.

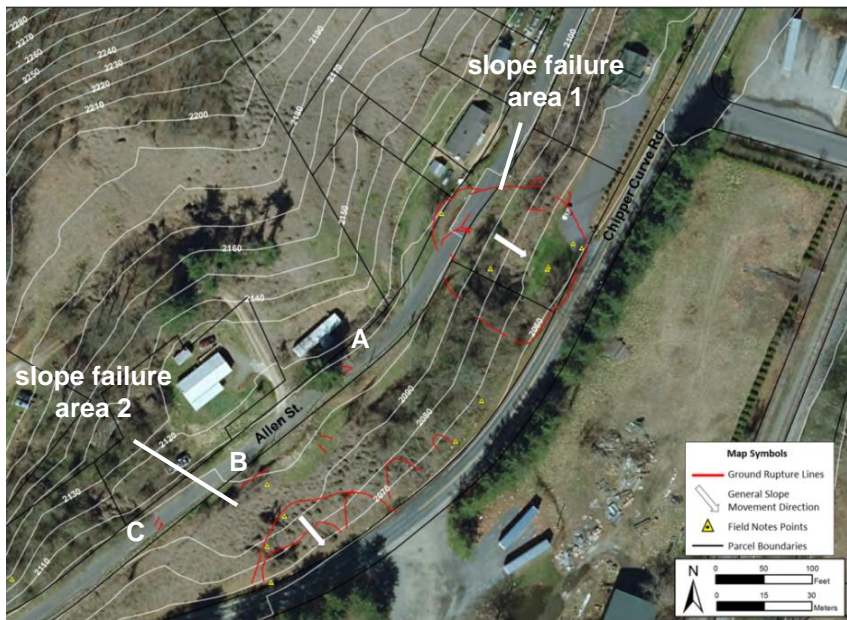


Figure 6. Map showing ground rupture lines in slope failure areas 1 and 2 (see also Fig. 1). Map base is 2019 orthophotography. Locations A-C refer to photos.



Figure 6A. Location A on map. Ground ruptures in Allen Street pavement. View looking SW. Inferred movement direction toward the SSW. 10/08/2020 NCGS photo.



Figure 6C. Location C on map. Arrows point to ground ruptures in Allen Street pavement. Inferred movement direction toward the SE. View looking NE. 10/01/2020 NCGS photo.



Figure 6B. Location B on map. Segment of ~30-ft long ground rupture in soil approximately 15 ft. SE of, and parallel to Allen Street. Arrow shows slope movement toward the SE. Hammer handle is ~14in long. View looking NE. 10/08/2020 NCGS photo.

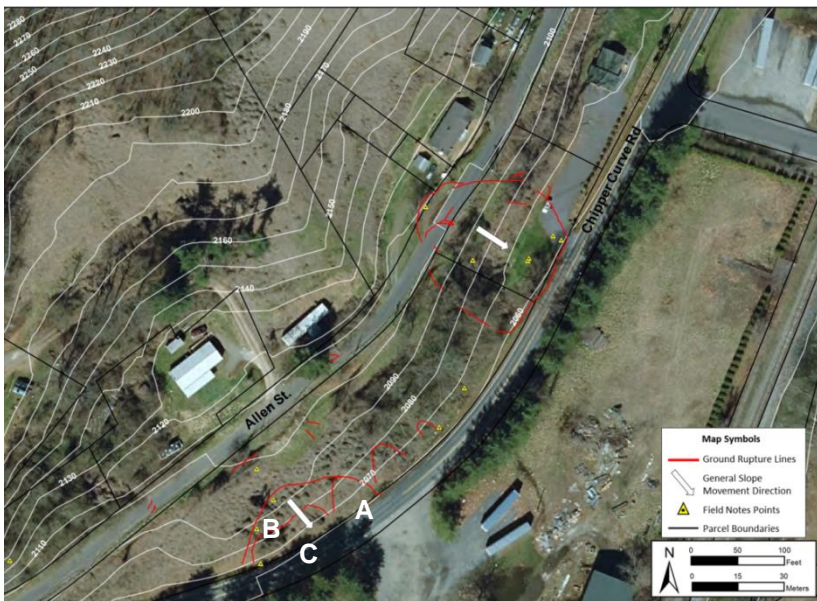


Figure 7. Map showing ground rupture lines in slope failure areas 1 and 2 (see also Fig. 1). Map base is 2019 orthophotography. Locations A-C refer to photos.



Figure 7A. Location A on map. Concrete median barriers at the toe of slope failure impinging on Chipper Curve Road. View looking NW. 10/08/2020 NCGS photo.



Figure 7C. Location C on map. Concrete median barriers at the toe of slope failure impinging on Chipper Curve Road in foreground. Leader line shows location of slide scarp in Fig. 7B right. View looking NW. 10/08/2020 NCGS photo.



Figure 7B. Location B on map. Segment of the upper slide scarp (ground rupture) above Chipper Curve Road at location indicated in Fig. 7C. Arrow shows orientation of aligned grooves on scarp face from slide movement. Scraped section at hammer shows relict bedrock layering in completely decomposed biotite gneiss. Hammer handle is ~14in long. View looking NW. 10/08/2020 NCGS photo.

Slope Failure Area 1	Allen Street	Cost Considerations	Private Properties	TWSA Water and Sewer Lines	Bryson Park	Other Considerations
Repair as recommended by Kessel Engineering Group	Provides safe roadway access through this section of Allen St. for the design life of the repair.	Estimated repair cost approx. \$640K; additional maintenance and monitoring costs related to horizontal drains may apply.	Improves likelihood that failure will not advance further into private property.	Reconfiguration and/or rerouting likely required in repair area. Improved long-term reliability and reduced maintenance frequency in slide repair area.	Stabilization of slide mass upslope will improve public safety; Should reduce ongoing repair and maintenance costs related to the bulge in entrance road.	Improves likelihood that the slide would not have further impacts on Chipper Curve Rd.
Do Not Repair	No through access via Allen St. for local traffic and emergency response vehicles.	Slope grading for improved drainage and stability advisable under guidance of a qualified engineer. Costs to construct turn-arounds at the terminations on Allen St.	Will involve property buy-outs due to lost access via Allen St and increased potential for failure to progress into private property.	Will require reconfiguration or termination of lines through the slide area. Leaking water or sewer lines will interrupt customer service and exacerbate slide movement.	Unstable slide mass upslope could threaten public safety; Will not reduce repair and maintenance costs for bulge in entrance road.	Possibly relocate vehicle access to Bryson Park and close-off area threatened by slide to limit public exposure to slide hazard. Closing park is an option. Increases likelihood that the slide would have further impacts on Chipper Curve Rd.
Temporary Repair	Taper road grade at scarps and maintain as a gravel road through the slide area. Will likely adversely affect emergency vehicle access over the long term.	Slope grading for improved drainage and stability advisable under guidance of a qualified engineer.	Increased potential for failure to progress into private property.	Will require reconfiguration or termination of lines through the slide area. Leaking water or sewer lines will interrupt customer service and exacerbate slide movement.	Unstable slide mass upslope could threaten public safety; Will not reduce repair and maintenance costs for bulge in entrance road.	Possibly relocate vehicle access to Bryson Park and close-off area threatened by slide to limit public exposure to slide hazard. Closing park is an option. Increases likelihood that the slide would have further impacts on Chipper Curve Rd.
Slope Failure Area 2	Allen Street	Cost Considerations	Private Properties	TWSA water and sewer lines	Bryson Park	Other Considerations
Long Term Repair	Long term stability of this section of Allen St. possibly related to NCDOT actions along Chipper Curve Rd. NCDOT plans unknown at this time.	Cost of geotechnical investigation and/or repairs if needed are unknown, but could be significantly greater than those for Slope Failure Area 1 and may depend on NCDOT actions along Chipper Curve Rd.	Improve likelihood that failures will not advance into private property upslope of Allen Street. Private property (Jackson Paper Company) between Allen St. and Chipper Curve Rd. already affected.	Reconfiguration and/or rerouting likely required in repair area. Improved long-term reliability and reduced maintenance frequency in repair area;	No direct impacts	Involves multiple stakeholders: Town of Sylva, NCDOT; private property owners.
Short Term Repair / No Repair (wait and see approach)	Patch pavement or replace pavement with gravel; or no action. Long term stability of this section of Allen Street possibly related to NCDOT actions along Chipper Curve Rd. NCDOT plans unknown at this time. May adversely affect emergency vehicle access over the long term.	Relatively inexpensive in the short term; may not provide long term stability	Probably will not improve likelihood that failures will not advance into private property upslope of Allen Street. May involve multiple private property buy-outs if Allen Street becomes unsafe.	May require reconfiguration or termination of lines through the slide area over the long term. Leaking water or sewer lines will interrupt customer service and exacerbate slide movement	No direct impacts	

Table 1. Considerations for mitigation alternatives for Slope Failure Areas 1 and 2.