Utah Geological Survey Technical Report

Project: Preliminary assessment of two landslides in 2005 between a sewer line and Gordon Creek, Mountain Green, Morgan County, Utah			
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USGS Quadrangles: Snow Basin (1344)	Section/Township/Range: Secs. 22 and 27, T. 5 N., R. 1 E.		
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INTRODUCTION

Beginning on June 8, 2005, Utah Geological Survey (UGS) geologists conducted an investigation of two landslides between a sewer line northeast of Creekside Drive and Gordon Creek in the Highlands West subdivision in Mountain Green (figures 1 and 2). The purpose of the investigation was to assess the potential hazard to the sewer line and creek and to determine the state of activity of the two landslides. This report presents the conclusions of this investigation. Our preliminary concerns and recommendations related to the potential threat posed by the two landslides to the sewer line were sent to Morgan County in a letter dated June 17, 2005. During this investigation, I provided periodic updates on movement monitoring results and field observations to Morgan County Engineer Austin Rowser. A representative of the Mountain Green Sewer Improvement District was informed of the landslides at a public meeting on June 30, 2005.

CONCLUSIONS AND RECOMMENDATIONS

The two small landslides pose a direct threat to the sewer line if upslope enlargement of the landslides occurs or if the main scarps of the landslides grow to sufficient height to initiate local failure. Damage to the sewer line poses an environmental hazard if sewage is discharged into Gordon Creek, a tributary of the Weber River. Upslope expansion of the southernmost landslide may also threaten Creekside Drive and part of a residential lot. Future downslope movement of debris, particularly in the southern of the two landslides, may divert Gordon Creek or create a small temporary blockage. Minor erosion and/or sedimentation may accompany diversion or blockage of the creek.

The UGS recommends that the sewer company regularly monitor the condition of the buried sewer line for potential leakage and develop a contingency plan if sewage is discharged from a break upslope of the creek. We also recommend that the sewer company hire a professional geotechnical engineering firm to assess potential landslide stabilization options. Ideally, stabilization efforts should be conducted in the dry summer months of June through August, in the absence of an emergency situation that requires more immediate action.

GEOLOGY

The sewer line is underlain by a complex of late Holocene and older landslides in the underlying Tertiary Norwood Tuff (Kaliser, 1972; Coogan and King, 2001). The Norwood Tuff consists of tuffaceous sedimentary rocks and crops out along the northwest-trending ridge crest southwest of Creekside Drive. The ridge is flanked on three sides (north, east, and south) by landslides that formed in the tuff and Quaternary surficial deposits that formed on the tuff. To the west, the Norwood Tuff is in contact with the underlying (older) Tertiary Wasatch Formation that consists mostly of conglomerate and sandstone. The bedding in these formations dips moderately to the east in the Creekside Drive area. Soils developed in residual, colluvial, and landslide deposits derived from the Norwood Tuff are commonly expansive.

LANDSLIDE DESCRIPTIONS

The two small landslides occur at separate locations on the northeast-facing slope between the buried sewer line and Gordon Creek, north of Creekside Drive in the Highlands West subdivision in Mountain Green (figure 2). In this report we refer to the landslides as the Southern and Northern Sewer-Line landslides. Table 1 summarizes the approximate dimensions and average slope of the two landslides.

Table 1. *Summary of approximate dimensions and average slope of sewer-line landslides.*

Location of slide	Length (feet)	Width (feet)	Slope (percent)
Southern	250	47 head; 60 toe	25
Northern	150	139 head; 177 (lower slide)	32-39

The Southern Sewer-Line landslide (figure 3) is on a relatively flat slope (about 25 percent) between the sewer line and Gordon Creek. The head of the landslide included embankment fill from the sewer-line corridor, but most of the landslide occurred on a natural slope that had been partly disturbed by emplacement of a drainpipe between the sewer line and the creek. Broken pieces of the drainpipe were exposed on the upper north flank of the landslide and had been thrust to the surface in the lower part of the slide. However, most of the lower part of the landslide is in undisturbed native soils. On June 8, the main scarp exceeded seven feet (2 m) in height (figure 3A), but continued offset throughout the remainder of 2005 increased the scarp height slightly. The main scarp cut across the eastern half of the sewer-line corridor. Landsliding displaced the downslope side of the sewer-line embankment, but the sewer line had not been exposed in the main scarp face as of November 1. A house at 6110 N. Creekside Drive is to the west-northwest of the head of the landslide, but not directly upslope.

The toe of the landslide overrode the active flood plain of Gordon Creek. The downslope tip of the slide was as close as 3.4 feet (1 m) from the southwest edge of the incised creek on October 12, 2005 (figure 3B). A wooden bridge across the creek, used for a trail crossing, is directly downslope of the landslide. Internal deformation features include an east-trending graben in the lower part of the landslide (figure 3D). A broken and displaced drainpipe in the lower part of the landslide (figure 3E) indicated about 3.9 feet (1.2 m) of shortening as shown by the downslope distance the upper pipe was displaced at the break.

The Northern Sewer-Line landslide (figure 4) occurred in a location where Gordon Creek cuts into the base of a relatively steep slope below the sewer line. The landslide is crescent shaped, widening in a downslope (eastern) direction. On June 8, the main scarp zone of the landslide was within a few feet of the downslope edge of the sewer-line corridor. The main scarp zone (figure 4A) consisted of two parallel scarps separated by about 3 to 4 feet (1-1.2 m) with roughly equal amounts of offset. The maximum offset on the upper (main) scarp on June 8 was about 4 feet (1.2 m). The toe of the landslide was being directly eroded by Gordon Creek on June 8 (figure 4B). In the lower part of the landslide, shallow sliding into the creek had removed all surficial soils and vegetation. As in the Southern Sewer-Line landslide, a drainpipe was exposed in both the upper and lower parts of the slide. The pipe was broken in the lower part of the landslide.

LANDSLIDE MOVEMENT HISTORY AND POTENTIAL FOR FUTURE MOVEMENT

Most of the landslide movement in 2005 preceded our initial site visit on June 8. Local residents indicated that movement of the two slides initiated earlier in the year, roughly coincident with the end of the snowmelt in the area. In early June, the UGS installed survey stakes to measure landslide movement across the main scarp zone of each landslide (figure 5). At the Southern Sewer-Line landslide, movement continued throughout the latter part of the year (June 10, 2005, through January 13, 2006). The plot shows a gradual decrease in the rate of movement in the latter part of June and movement at a relatively steady rate subsequently. Total movement (stretching) during the measurement interval exceeded 4 inches (10 cm) and was accompanied by additional offset on the main scarp (figure 2F). At the Northern Sewer-Line landslide, the rate of movement slowed in the latter part of June in a similar manner as at the Southern Sewer-Line landslide, but movement suspended by the end of the month.

Given the excess precipitation in the area in 2005 (6.4 inches of excess precipitation between September 2004 and August 2005 at the National Weather Service Huntsville station), ground-water levels in landslide deposits in the slope below the sewer line likely remained high (shallow) at the end of 2005. Continued movement of the Southern Sewer-Line landslide throughout the latter part of 2005 also suggests sustained high ground-water levels. Thus, the necessary ground-water-level rise to reactivate the two landslides, or to cause a rapid increase in the rate of movement of continuously moving slides, may be possible even with a below-normal snowpack.

FIELD METHODS

Landslide boundaries and ground deformation features were mapped using handheld global positioning system devices with an approximate accuracy range of between 10 and 30 feet at the time of the fieldwork. Maps of the two landslides and dimensions listed in this report were derived using this method. Short-term variation in location was tested using duplicate measurements from the same device and was typically less than 2 feet.

ACKNOWLEDGMENTS

Michael Kirschbaum (formerly UGS), Greg McDonald, and Richard Giraud (both UGS) assisted with the fieldwork. Lucas Shaw (UGS) provided assistance in creating several of the figures in this report.

LIMITATIONS

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REFERENCES

Coogan, J.C., and King, J.K., 2001, Geologic map of the Ogden 30’ x 60’ quadrangle: Utah Geological Survey Open-File Report 380, scale 1:100,000.

Kaliser, B.N., 1972, Geological hazards in Morgan County with applications to planning: Utah Geological and Mineralogical Survey Bulletin 93, 56 p.

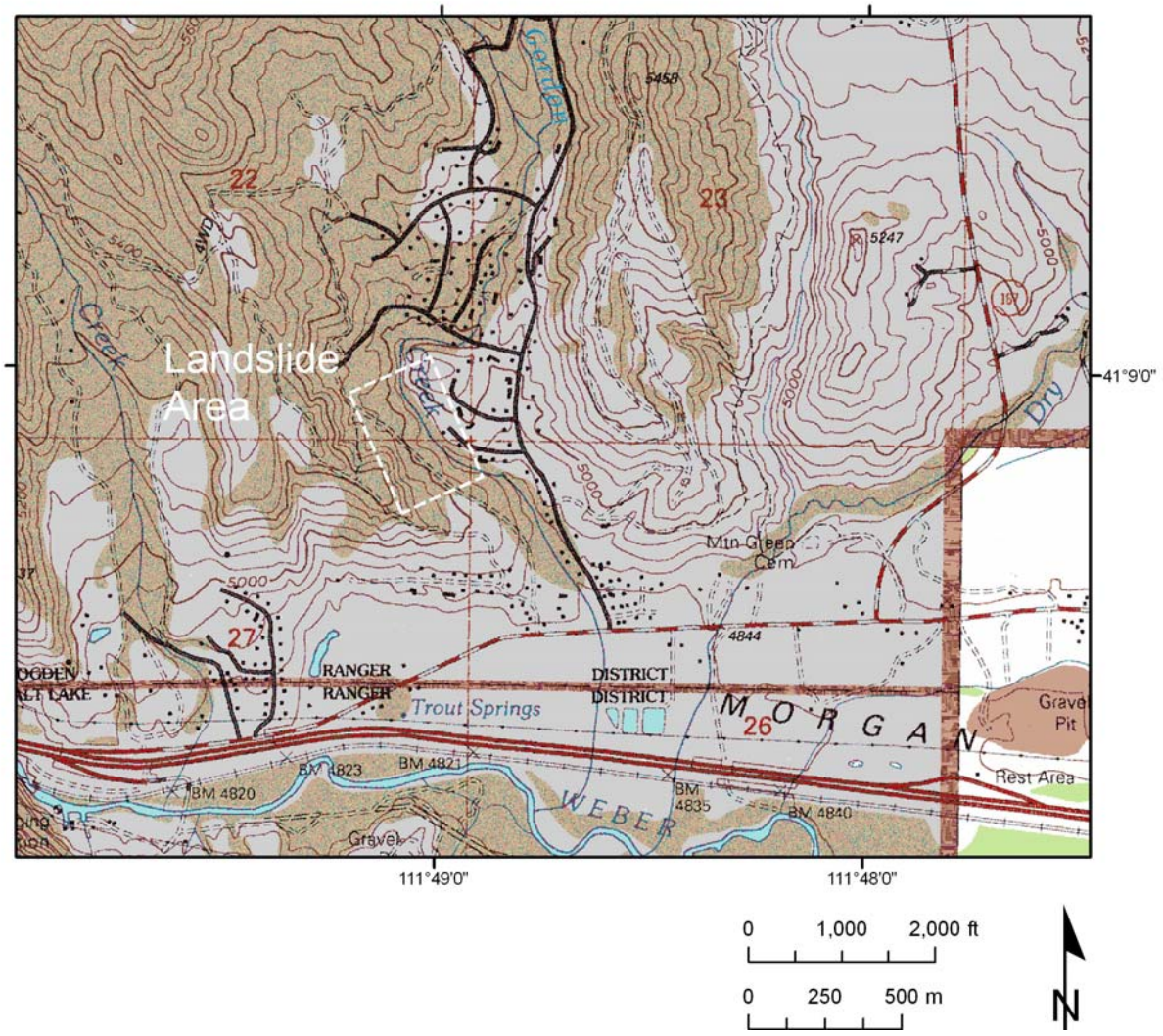

Figure 1. *Location map of landslide area abutting sewer line in the Highlands West subdivision northeast of Creekside Drive in Mountain Green. Base from U.S. Geological Survey Snow Basin 7-1/2' quadrangle map.*

Figure 2. *Aerial photograph showing approximate locations of two small landslides between Gordon Creek and buried sewer line northeast of Creekside Drive in Mountain Green. Northern Sewer-Line (NSL) and Southern Sewer-Line (SSL) landslides shown. Locations and boundaries of landslides approximate.*

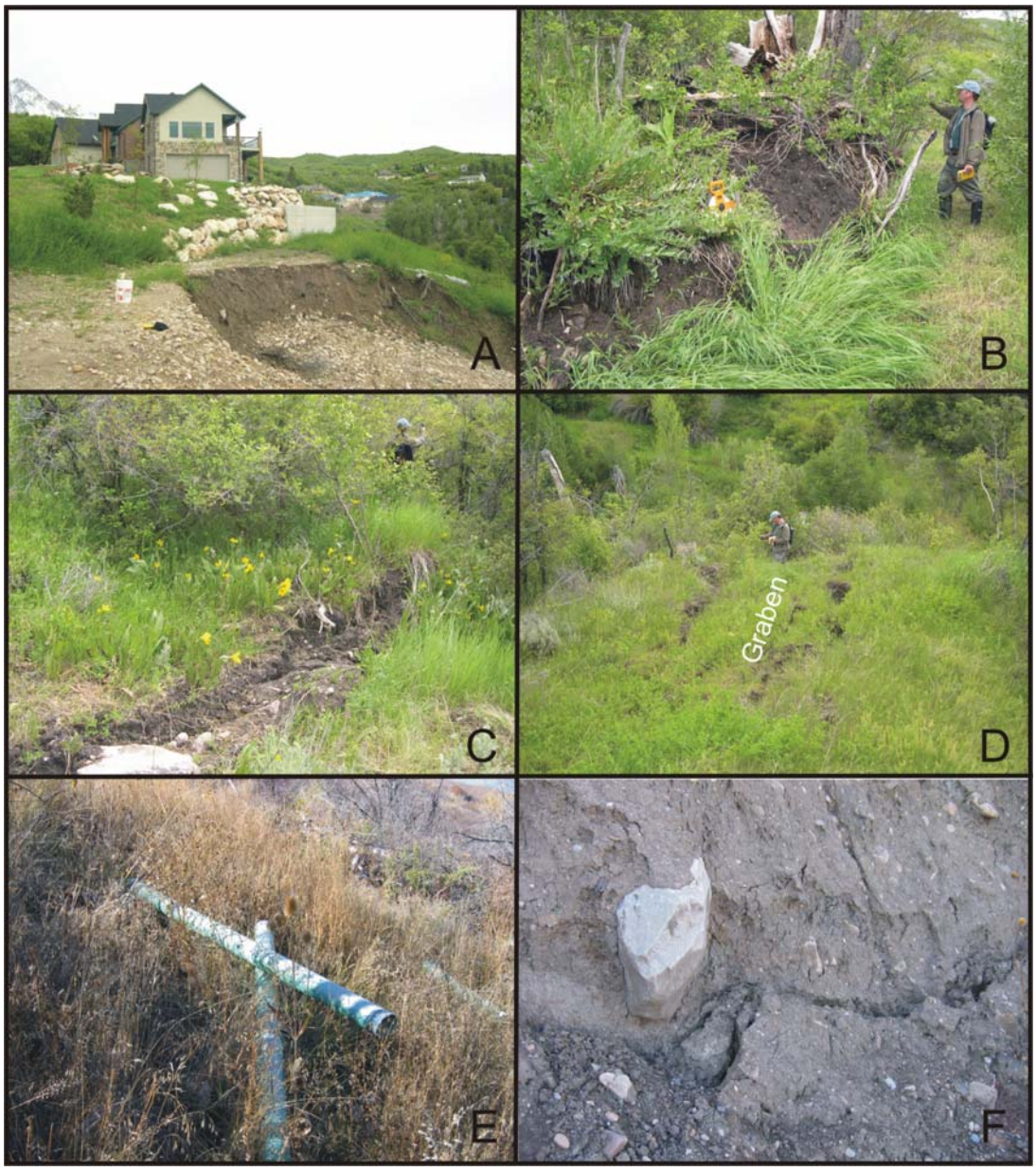

Figure 3. *Southern Sewer-Line landslide. (A) View to the northwest of main scarp of the Southern Sewer Line landslide. Landsliding destroyed the eastern part of the sewer corridor embankment, but had not exposed the sewer pipe as of January 13, 2006. House at 6110 N. Creekside Drive visible in background. (B) View to the northwest of toe of the landslide. Lower toe thrust/fold is approximately 5 feet high. West edge of Gordon Creek (not visible just to the right of the edge of the photograph) was only 3.4 feet from toe on October 12, 2005. (C) View downslope of right-flank shear cutting across natural slope. (D) View downslope of east-trending graben in lower part of slide. (E) Broken drainpipe in lower part of slide. Upslope pipe displaced about 3.9 feet downslope. (F) Recent offset of main scarp on November 1, 2005, due to continued movement of slide in latter part of 2005.*

Figure 4. *Northern Sewer-Line landslide. (A) View to the south-southwest of main scarp zone of the landslide. Top of main scarp was only a few feet from the east edge of the sewer-line corridor. (B) View to the south of toe of the landslide along Gordon Creek. Note drainpipe exposed along south flank of landslide.*

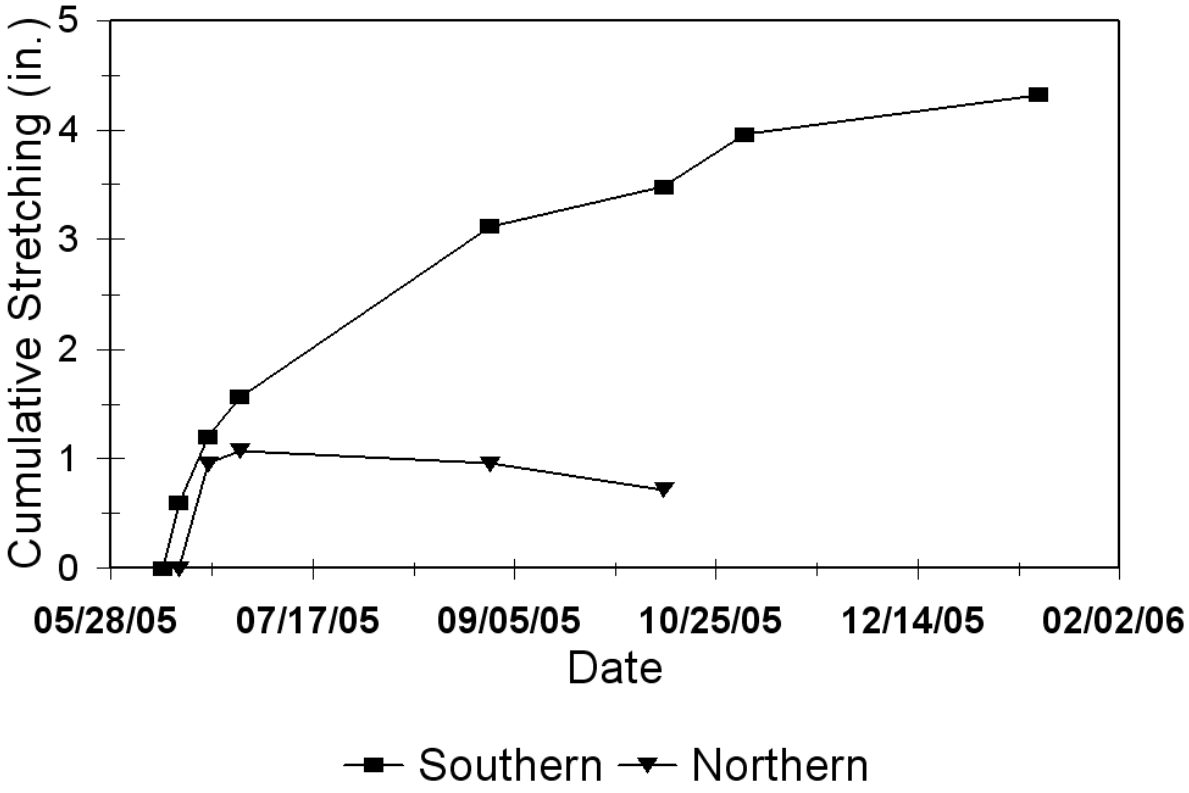

Figure 5. *Landslide movement and ground deformation between June 10, 2005 and January 13, 2006. Plot shows continuous movement (stretching) at survey stake station across main scarp of the Southern Sewer-Line landslide (squares). The rate of movement slowed in late June, but movement continued at a relatively steady rate through January 13, 2006. At the Northern Sewer-Line landslide (triangles), movement continued through most of June, but likely suspended by the end of the month. Subsequent minor shortening across main scarp zone is likely due to collapse of extensional fissures separating soil blocks in zone.*