Utah Geological Survey

Project: Reconnaissance of the 425 East South Weber Drive landslide, South Weber, Utah			
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USGS Quadrangles: Ogden (1345)	Section/Township/Range: SE¼NE¼ and NE¼SE¼ section 29, T. 5 N., R. 1 W., SLBLM		
Requested by: Boyd Davis, South Weber City Engineering			Job number: 05-03

INTRODUCTION

Upon notification by a member of the State Hazard Mitigation Team, Gary Christenson (Utah Geological Survey [UGS]) and I conducted a reconnaissance of the 425 East South Weber Drive landslide in South Weber, Davis County, Utah (figure 1) on February 21, 2005. Rick Chesnut (Terracon) and Lee Cammack (JUB Engineers) were also conducting a field study of the landslide at the time of our visit as a follow-up to ongoing studies (Terracon, 2005) for the Davis-Weber Canal Company. I again visited the landslide on March 4, 2005 with Francis Ashland (UGS).

The landslide occurred shortly after 6 p.m. on the evening of February 20, 2005, just below the Davis-Weber Canal, demolishing a barn and blocking State Route 60 (South Weber Drive). The purpose of my investigation was to determine the physical characteristics of the landslide and evaluate its hazard potential to aid South Weber City in assessing the risk to development at the base of the bluff from landslides and potential canal breaches.

CONCLUSIONS AND RECOMMENDATIONS

Based on this geologic investigation and hazard assessment of the 425 East South Weber Drive landslide, the UGS concludes the following:

- Landsliding will likely continue both above and below the Davis-Weber Canal in this area unless measures are taken to stabilize these slopes.

- The 425 East South Weber Drive landslide was a rapid earth-flow-type landslide involving the canal embankment and underlying slope materials that traveled 150 feet beyond the slope toe out onto flat ground.

- The steep slope, above-normal precipitation, shallow ground water, weight of the embankment fill, and weak geologic materials probably all contributed to landslide movement.

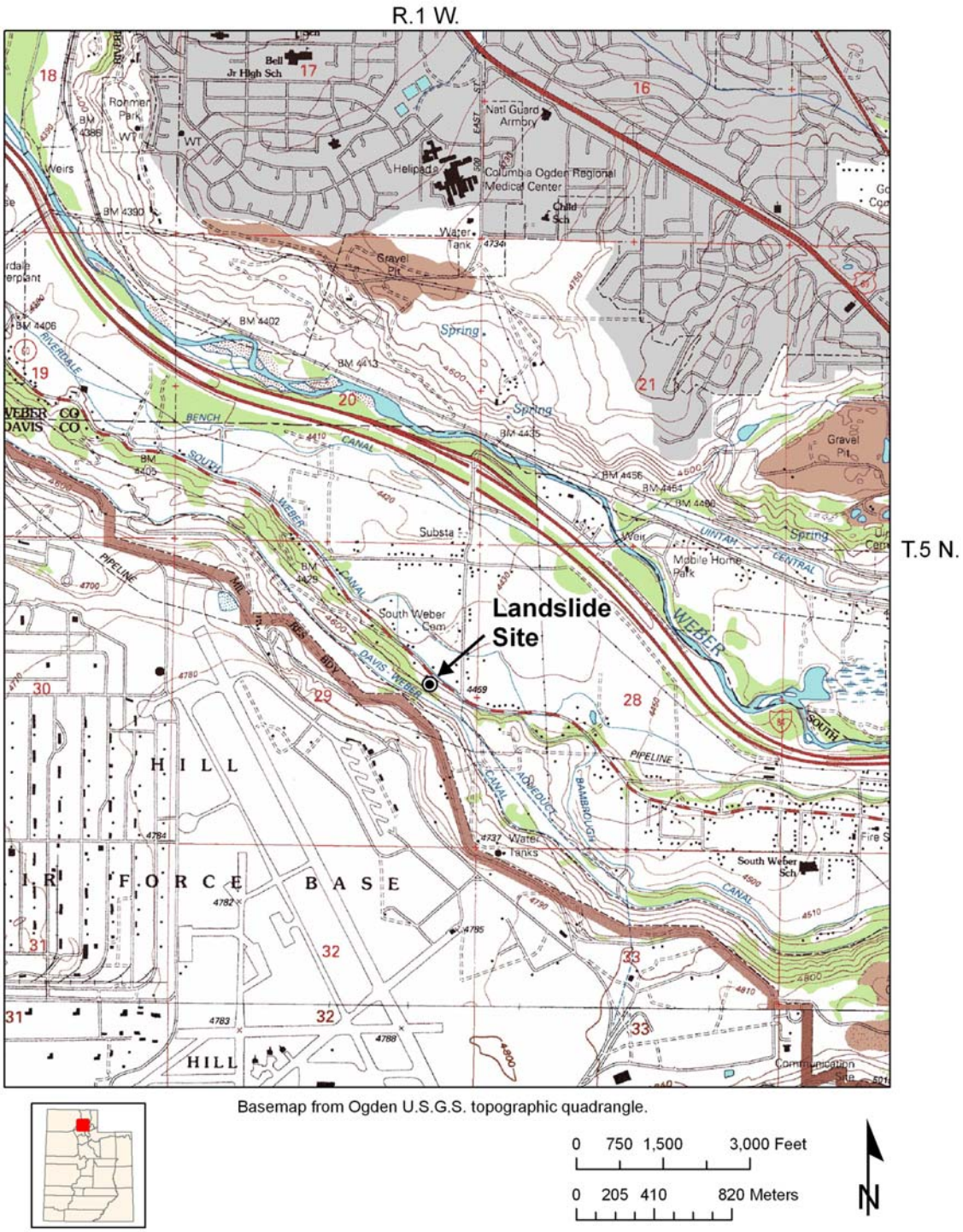

Figure 1. Location for the 425 East South Weber Drive landslide.

- Retreat of the landslide main scarp and possible expansion of the landslide to the east or west directly threatens the Davis-Weber Canal.

- If the canal were conveying water and a landslide caused a canal breach, widespread flooding and sedimentation could occur at the base of the slope.

To reduce the potential impacts of landslide movement and manage future movement of landslides in this area, the UGS recommends the following:

- This slope should be reconstructed and stabilized prior to delivering water into this canal section, or the canal or water should be rerouted in the area.

- Risk-reduction measures may also be needed to stabilize landslides above and below the canal pending results of additional study and emergency reconstruction measures.

- Monitoring of inclinometers for landslide movement and ground-water levels in piezometers should be continued to assess changes in conditions following the landslide and to aid in stability assessment before, during, and after reconstruction.

- South Weber City should consider the landslide potential and hazards related to a possible canal breach when evaluating existing or future development near the base of the slope along the city's entire south side.

GEOLOGIC SETTING

The 425 East South Weber Drive landslide occurred in the lower part of a northeast-facing slope on the edge of a bluff forming the south side of the Weber River valley (figure 2). The slope formed as the Weber River cut down into its former delta as Lake Bonneville receded after 16,000 years ago and the shoreline retreated to the present level of Great Salt Lake. The slope is approximately 200 feet high. The Davis-Weber Canal is about mid-slope and is a concrete canal with an impervious rubber liner. The demolished barn and State Route 60 (South Weber Drive) are at the base of the slope. The slope above the canal is about 80 feet high and has a gradient of 34%. Active shallow landslides in the slope above the canal locally override the southern canal bank. The slope below the canal is about 120 feet high and has an average gradient of 45%, but locally the gradient is up to 65%. Snow 1 to 3 inches deep covered approximately 40% of the slope above the canal and 20% of the slope below the canal on February 21, 2005.

Yonkee and Lowe (2004) mapped the northeast-facing slope as younger Holocene landslide deposits that display relatively recent movement and fresh scarps, local ground cracks, and distinct hummocky surfaces. These younger Holocene landslide deposits lie within older Holocene landslide deposits. Lowe (1988) shows the younger Holocene landslide deposits as a historically active landslide (LSa 316) and the entire northeast-facing bluff as an older landslide

Figure 2. View to the south showing the landslide main scarp in the Davis-Weber Canal embankment, the demolished barn (right foreground), and runout onto the field.

complex (LS 335). The younger and older landslide deposits are derived from Lake Bonneville fine-grained lacustrine and delta deposits. Shallow ground water and weak soil materials are present within the northeast-facing slope. All of these landslide deposits are within the large South Weber landslide complex mapped by Pashley and Wiggins (1972). The South Weber landslide complex has many landslides that have moved in historical time. Historical records and geologic evidence indicate relatively frequent landsliding on these slopes. Yonkee and Lowe (2004) mapped older Holocene stream alluvium from the base of the northeast-facing slope northward across an abandoned stream terrace of the Weber River. The stream alluvium consists of pebble and cobble gravel, gravelly sand, and silty sand.

LANDSLIDE DESCRIPTION

The 425 East South Weber Drive landslide is mostly a failure of non-engineered embankment fill of the Davis-Weber Canal but also involved underlying and downslope natural materials. Water was not flowing in the canal at the time of failure, and the canal was undamaged. The landslide occurred within the youngest Holocene landslide unit mapped by Yonkee and Lowe (2004) and a historically active landslide mapped by Lowe (1988).

The landslide occurred shortly after 6 p.m., and demolished a barn, took out telephone poles, and blocked State Route 60 (South Weber Drive) (figures 2, 3, 4). The landslide is approximately 480 feet long and 80 feet wide at its widest point (figure 3) and between stations 305 and 310 on the Davis-Weber Canal. According to Nolan Birt (verbal communication, March 4, 2005), the barn owner who witnessed the event, the total landslide travel time was about a

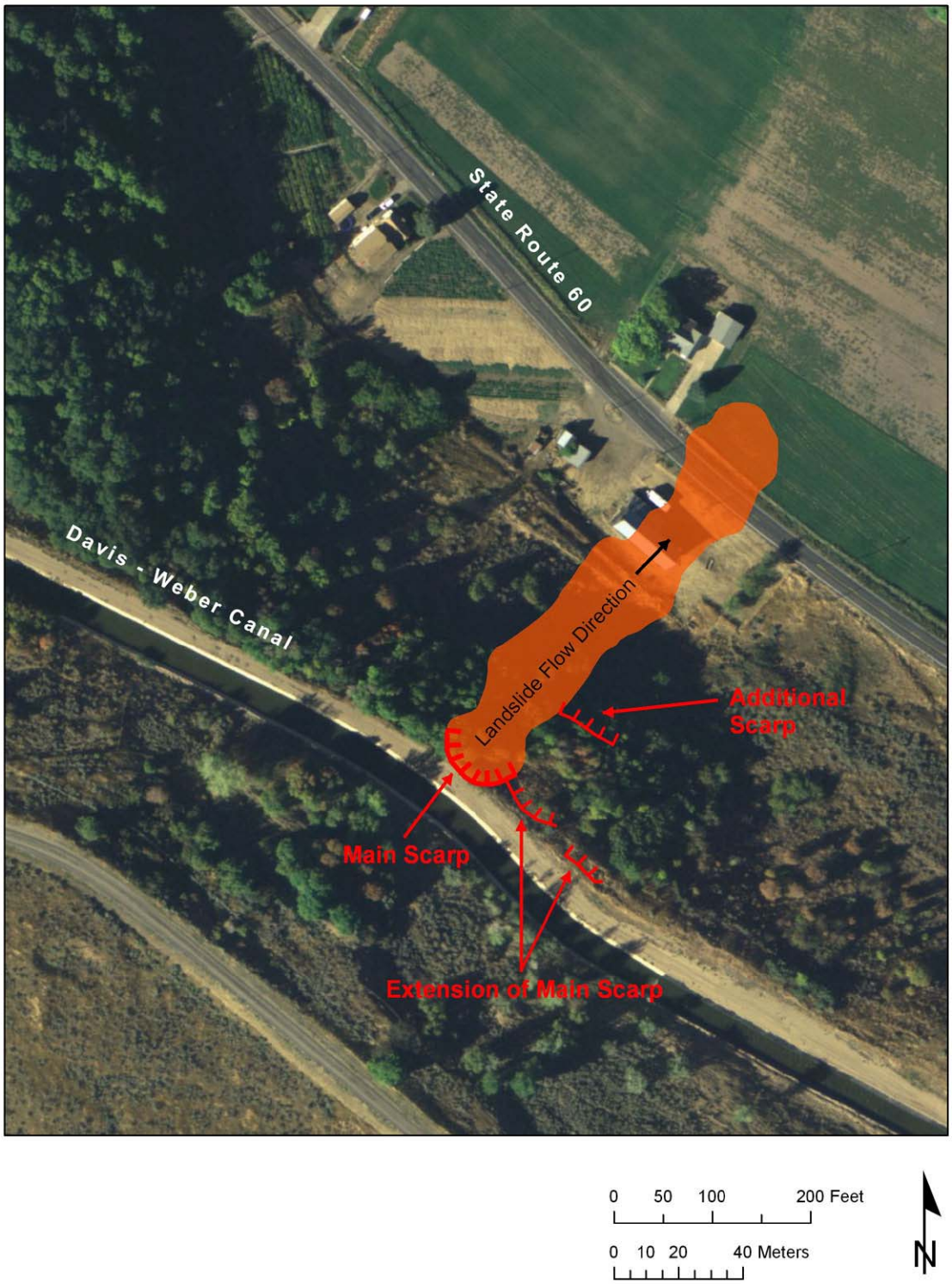

Figure 3. Image showing landslide flow direction, the Davis-Weber Canal, main scarp, other scarps, and runout beyond State Route 60 (South Weber Drive).

Figure 4. Looking across the lower part of the landslide at the demolished barn. The clump of trees in the foreground was rafted downslope on top of the landslide debris.

minute and the barn provided no resistance to landslide movement. Based on this approximate travel time, the estimated landslide velocity is about 8 feet per second, which classifies as very rapid landslide movement (Cruden and Varnes, 1996). The landslide is just below the Davis-Weber Canal and likely started moving as a rotational slide, but likely transformed into a rapid earth flow about midway downslope and ran out 150 feet beyond the toe of the slope across State Route 60 and onto a flat field. Grass, shrubs, and trees cover this northeast-facing slope. Some trees were rafted on top of the landslide debris (figure 4).

The steep landslide main scarp is in the canal and roadway embankment. Only 20-25 feet now separate the canal from the main scarp (figures 3, 5) and the canal is threatened by eventual retreat of the main scarp. The landslide main scarp has extended to the east (figures 3, 5) as adjacent pre-existing landslide deposits reactivated. Based on my observations, the landslide below the main scarp extension dropped approximately 10 to 12 inches between February 21 and March 4, 2005, indicating the slope east of the 425 East South Weber Drive landslide was still moving. Based on observations of the evacuated landslide main scarp area, the embankment fill was placed onto native slope materials and was not keyed into the underlying slope.

The landslide removed an inclinometer installed on June 11, 2004, in the canal embankment to monitor slope movement (Terracon, 2005). Terracon (2005) logged the following lithologies in the inclinometer borehole: fill from 0 to 7.5 feet, clay from 7.5 to 18 feet, silty sand from 18 to 40 feet, clay from 45 to 60 feet, silty sand from 60 to 90 feet, and clay from 90 to the bottom of the hole at 102 feet. The fill, clay, and silty sand in the upper part of the borehole are exposed in the landslide main scarp.

Figure 5. View west of the landslide crown, the Davis-Weber Canal, and the landslide main scarp. Eastward extension of the main scarp in the foreground indicates movement in the slope east of the landslide.

Ground water is relatively shallow in slopes both above and below the canal. Water was observed flowing from the sand unit exposed in the main scarp following the landslide and was ponding locally on the landslide deposits below. Terracon (2005) reported a ground-water depth of 30 feet in the inclinometer borehole, which coincides with the level of water observed flowing from the sand unit exposed in the main scarp. Water flowing from the main scarp later had to be channeled to flow into a small ditch to stop ponding and flow across State Route 60 (Nolan Birt, verbal communication, March 4, 2005). All of the landslide material was very wet the day after the landslide and too soft to support the weight of a 170 pound person.

PREVIOUS SLOPE-STABILITY INVESTIGATION

Terracon (2005) completed a slope-stability investigation in January 2005 on the slopes above and below the canal in this area for the Davis-Weber Canal Company. The investigation included installation of piezometers and inclinometers. Terracon (2005) estimated a static factor of safety of 1.0 to 1.2 for the overall slope above and below the canal. For the slope below the canal at the landslide, Terracon (2005) estimated a factor of safety of about 1.0. The occurrence of the landslide confirmed that this estimate was accurate. For earthquake ground shaking conditions, Terracon (2005) estimated the factor of safety to be well below 1.0, meaning the slope would fail during an earthquake. Terracon (2005) provided recommendations to reduce the potential for slope failure and potential impacts to the canal.

PROBABLE CAUSES OF MOVEMENT

Several factors likely contributed to landslide movement. The landslide included part of the canal and roadway fill embankment and the weight of the fill increased the load and shear stress in the underlying weak slope materials, promoting slope failure. Above-normal precipitation also contributed to the landslide as excess precipitation infiltrated into the ground and raised ground-water levels and pore pressures in the slope. Records from nearby National Weather Service stations indicate that prior to the landslide, the Layton-South Weber-Ogden area received 148% of normal precipitation for an informal landslide water year (LWY) that began in September 2004. The informal LWY tracks cumulative precipitation from September through May to monitor excess precipitation that infiltrates into the ground and raises ground-water levels in landslides (Ashland, 2003). In addition, the area received greater than normal precipitation during the previous LWY. About 0.72 inches of rain fell in Layton on the day of the landslide (National Weather Service, 2005), likely wetting and increasing the weight of the fill. The steep slope, above-normal precipitation, shallow ground-water conditions, weight of embankment fill, and weak underlying geologic materials probably all contributed to the landslide.

FUTURE HAZARD POTENTIAL

The February 20, 2005, landslide clearly demonstrates the potential for rapidly moving earth-flow-type landslides with significant runout distances on similar slopes in South Weber. Flow-type landslides are destructive due to their velocity and impact. Where flow-type landslides occur above subdivisions within the landslide runout zone, the potential exists for loss of life in addition to property damage. Also, this landslide demonstrates the distance a small earth flow can travel beyond the toe of a slope. Future earth flows in this area could block State Route 60 again.

Several landslide hazards threaten the Davis-Weber Canal as a result of the 425 East South Weber Drive landslide. The most direct threat is from upslope retreat of the landslide main scarp, which could impact the remaining embankment and canal. Numerous shallow landslides are also present in the area, and movement of slopes directly east and west of the landslide also threaten the canal. Terracon (2005) estimated a factor of safety of about 1.0 for the slope below the canal at the landslide. Shallow active landslides in the slope above the canal are also a threat. Although all of the observed landslides are relatively shallow, deep rotational landslides must also be considered in hazard analysis. Earthquakes could trigger both shallow and deep landslides. If landslides impact the Davis-Weber Canal when the canal is conveying water, the potential exists for the canal to breach and cause widespread flooding and sediment deposition similar to the July 11, 1999, Davis-Weber Canal breach in Riverdale (Black and others, 1999).

SUMMARY

The 425 East South Weber Drive landslide was a rapid earth flow that demolished a barn and telephone poles and blocked State Route 60. The steep slope, above-normal precipitation, shallow ground-water conditions, weight of embankment fill, and weak underlying geologic materials probably all contributed to the landslide. The retreat of the landslide's main scarp directly threatens the Davis-Weber Canal. The landslide removed lateral support of the canal embankment and this slope should be reconstructed prior to putting water in this section of the canal, or the canal or water should be rerouted in the landslide area. Other shallow landslides above and below the canal also threaten the canal. Landsliding in this area will continue in the future as it has in the past unless measures are taken to stabilize these slopes.

LIMITATIONS

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