LANDSLIDES IN THE NORWOOD TUFF AND THEIR IMPACT ON HIGHWAYS IN WEBER AND MORGAN COUNTIES, NORTHERN UTAH

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Tertiary Norwood Tuff

- Late Eocene to Early Oligocene
- Altered tuff, tuffaceous siltstone, sandstone, and conglomerate
- Locally overlain by Late Pleistocene glacial and lacustrine deposits
- Dip slopes particularly susceptible to failure
- Numerous pre-existing landslides
Rural Highways

- Connect Wasatch Back communities in Weber and Morgan Counties
- Provide access to Snowbasin and Powder Mountain ski resorts
- State Routes 167, 226, and 158
  - SR-167 opened in September 1989
  - SR-226 opened in early 2001
Landslide Hazards

• Reactivation or acceleration of pre-existing landslides crossed by highways

• Modification-induced landslides
  – Landslides in cut slopes
  – Loading-induced landslides (embankment and other fills)
Highway Crossings of Large Landslides

• Persistent movement has resulted in local pavement damage
• Mitigation efforts focused on stabilizing highway corridor (shear key and drainage)
• Alignment chosen to cross narrow parts of landslides

• SR-226 crosses two large landslides: Bear Wallow and Green Pond landslides
Bear Wallow and Green Pond landslides

Modified from King and others (2008)
Results of Utah Geological Survey (UGS) movement monitoring of SR-226 landslides:

Oct 2005 – June 2009
Green Pond landslide
Movement

- Persistent movement
- Highest average velocities occurred following the wet 2005 water year
Green Pond landslide
SR-226 damage

- Damage where active shear zones cross highway
- En echelon road cracks
- Minor displacement and pavement heave

June 2006
Modification-Induced Landslides

- Landslides in cut slopes
  - Some formed during construction
  - New landslides continue to form
  - State of activity varies (dormant to continuously moving)
  - Recurrence interval for reactivation or new landsliding
  - Landslide enlargement
  - Little impacts to highway

- Loading-induced landslides
  - Waste Dump landslides formed only a few years after fill placement
  - Relatively rapid landslide enlargement (mostly progressive)
Landslides in Cut Slopes
SR-167 (Trappers Loop Rd.)

- TLR landslide no. 1 and companion slide in south-facing cut slope
- Benched cut slope constructed in weathered Norwood Tuff; east slope of ridge is pre-existing landslide
- Upper slope failures (above bench); bench overridden by main slide and material is displaced onto lower slope
- Initial failure of main slide occurred prior to September 1993; companion slide occurred ~2003

October 2002
Summary

TLR landslide no. 1 cut slope

Initial failure of upper slope above bench occurred less than ~4 years after construction Reactivates in 2006

Companion landslide in upper slope forms in ~2003; also reactivates in 2006
Landslides in Cut Slopes
SR-167 (Trappers Loop Rd.)

LR landslide no. 2

Benched cut in dip slope

Bedding-parallel failure in 2001

Reactivates and enlarges in 2009 following prolonged period of shortening deformation across the main scarp zone

April 2001
Longitudinal Deformation
TLR landslide no. 2, SR-167, Morgan Co

Cumulative Deformation (cm)

Date

02/17/05  02/17/06  02/17/07  02/17/08  02/16/09  02/16/10

-50  -40  -30  -20  -10   0   10   20   30   40   50

2001 Main Scarp
2001 Upper Slide
2001 Main Scarp (Pre-reactivation)
Summary

TLR landslide no. 2 cut slope

Initial failure of upper slope above bench occurred in 2001; ~12 years after cut slope constructed

Reactivates and enlarges in 2009; 8-year recurrence interval

Companion landslides (one resulting in a small debris flow) occurred in upper slope in 2006
State of Activity
Landslides in Cut Slopes

- Recurrent movement
- Continuous movement
Impacts from Landslides in Cut Slopes

Deformation and blockage of drainage ditches at toe and crest of slopes and rock inlays on slopes
Damage to cut-slope landscaping
Encroachment of debris onto highway pavement (rare)

Retrogressive enlargement of landslides onto upslope private property

UDOT mitigation: rock buttresses at toe (2 slides)
age of age ditch
Waste material from SR-226 construction placed on upper part of pre-existing landslides directly downslope of SR-167

Initial failure in 2004; easternmost landslide displaced a buried Questar gas line, which was subsequently relocated upslope of highway

Persistent movement and enlargement of the landslide occurs between 2004 and 2010

By 2010, the landslide has encroached onto most of the SR-167 embankment (due to retrogressive enlargement) damaging a land drain in the lower slope
Waste Dump landslides
SR-167
October 1997
Waste Dump landslides
SR-167
November 2004
Upslope enlargement of landslide; ground deformation within ~20 feet of highway
Questions?

May 2001