THURBER ENGINEERING LTD.
GEOTECHNICAL ▪ ENVIRONMENTAL ▪ MATERIALS

ALBERTA TRANSPORTATION
LANDSLIDE RISK ASSESSMENT

SECTION A: GEOTECHNICAL FILE REVIEW

NORTH CENTRAL REGION

Site NC50: North of Cadomin

LEGAL LOCATION:	NW33-47-24-W5M
HIGHWAY CONTROL SECTION	HWY 40:28 km 11.73
NEAREST LANDMARK:	11.7 km North of Cadomin Access
DATE OF INITIAL OBSERVATION:	2005
DATE OF LAST INSPECTION:	June 2008
LAST INSPECTED BY:	Thurber Engineering Ltd.
INSTRUMENTS INSTALLED:	3 Standpipe Piezometers (2006) 2 Slope Inclinometers (2006)
INSTRUMENTS OPERATIONAL:	3 Standpipe Piezometers
RISK ASSESSMENT:	PF(14) CF(4) = **56** (2008)
LAST UPDATED:	Thurber Engineering Ltd.,
PREVIOUS UPDATE:	April 2009 – Thurber Engineering Ltd.

1. LOCATION

The site is located on Highway 40:28 about 11.7 km north of the Cadomin access at km 11.73.

2. GENERAL DESCRIPTION OF DISTRESS

The distress affects the north lane (west-bound) of the highway in an area constructed on a sidehill cut/fill with terrain sloping steeply to the north toward the Gregg River. The general area has been subject to several slides since the 1980's including a significant slide and resulting realignment about 300 m to the west (km 12 to km 12.4). The current slide first affected the highway in 2005 when Thurber performed a call-out in August. At that time, the arch-shaped cracking affected about 45 m of the highway (measured along the shoulder) with crack widths up to 100 mm and differential height up to 90 mm. The crack extended to the west into the north sideslope.

The Gregg River is located about 70 m north of the highway at the slide location and approximately 25 m lower in elevation. The overall slope, as measured from the toe of the highway fill, is approximately 2.5H:1V. Exposed bedrock was observed about 4 m above river level on the north valley slope. The backslope south of the highway is inclined at about 3H:1V and is about 13 m high. A catchwater ditch is located at the top of the backslope and discharges into a riprap-lined channel leading to a 1020 mm diameter culvert just east of the slide. There is also a 150 mm diameter corrugated steel pipe outlet at the base of the highway fill located at the west edge of the main scarp.

A geotechnical investigation was conducted in 2006 by Jacques Whitford including a topographic survey and installation of two slope inclinometers and three standpipe piezometers. The slope inclinometers had sheared off by spring of 2007. At the time of the 2007 annual GeoHazard inspection, the differential height was up to 400 mm and several signs had been placed to warn motorists of the drop. A large patch was placed in August and within two weeks, the crack pattern had re-established. Additional patching continued in 2007 and 2008. During the 2008 GeoHazard inspection, the differential in the lane was measured at 200 mm. Measured from the shoulder, the total settlement of the roadway surface appears that have been about 1 m. The crack extends 40 m to the west and 10 m to the east beyond the pavement edge.

A second scarp is located about 15 m north of the current active slide. The west end of this older scarp appeared to have reactivated between the 2007 and 2008 site visits. An extended reconnaissance undertaken during the 2008 site visit identified a second inactive scarp located 18 m north of the highway at km 11.9

west of the NC50 slide. Three additional active slides with widths between 4 m and 10 m were observed in the forested portion closer to the river and extended to the toe of the valley. Several skin slides were noted on valley sides in the vicinity of the twin culverts and half-culverts at km 12.0.

The main slide appears to be translation with the slip surface located in clay overtop of clay till. Lower down on the slope, the slide is likely slipping on bedrock. From the standpipes installed in 2006, groundwater is not a factor in the upper portion of the slide but may be lower down as seepage was observed at ground surface in the lower 1/3 of the valley. The other slides observed are likely similar in nature. The skin slides in the backslope and valley slope are probably groundwater driven.

A conceptual design study undertaken in 2009 considered two alternatives to remediate the distress in this area. A pile wall could be constructed along the north edge of the highway that would be anchored in the bedrock and tie-backed into the intact clay till. The second alternative would be to realign the highway approximately 10 m to 20 m south which would also reduce the risk presented by the other slides observed in the area. The study recommended the pile wall option.

3. GEOLOGICAL/GEOTECHNICAL CONDITIONS

Physiographic Region: Rocky Mountain Foothills (1969, Atlas of Alberta, University and Government of Alberta).

Bedrock Geology: The bedrock at the site is marine and non-marine conglomerate and sandstone, with some shale and coal, of the Blairmore Formation (Journeay 2000). No published bedrock topographic information is available for this site. However, test holes drilled for instrumentation installation encountered clay shale bedrock at 14 m depth below ground surface (elevation 1542 m) at the north toe of the highway embankment fill (Jacques Whitford 2006).

Surficial Geology: Larger-scale (1:250,000) surficial geology mapping indicates that high ground to the south is located on terrain composed of sandy clay till. The Gregg River valley, including the NC50 site is located within an area of alluvial sediments deposited on the sides and base of the valley (Bayrock 1980). From conversations with mine geologists during work undertaken by Thurber for AT on a previous, nearby project (NC34), it is understood that the valley was dammed during the last glaciation resulting in the deposition of a layer of lacustrine clay over much of the valley.

Hydrogeology: The sandstones of the Blairmore Formation bedrock have an estimated yield of 2 L/s to 8 L/s groundwater flow. Regional groundwater table contouring was not been completed for this area given the complexity of flow in the

folded bedrock of the foothills. The regional groundwater flow pattern is downward to deeper bedrock aquifers and northeast toward lower ground at the edge of the foothills about 100 km distant (Vogwill 1981, NTS 83F 1982). Local flow, in near-surface sediments above the bedrock, at the site is from high ground to low ground trending north toward the Gregg River valley. Springs were noted in the lower third of the river valley (below the highway) and seepage has been observed from the highway backslope.

Stratigraphy: Three test holes were drilled during the 2005 geotechnical investigation (Jacques Whitford, 2006, previously included in Section G). The test holes were drilled along a north-south cross-section with one standpipe installed south of the highway and the remaining instruments to the north. The stratigraphy generally consisted of clay overlying clay till and clay shale bedrock. Test holes drilled through the highway embankment encountered fill at the surface which was a mixture of clay, sand, and gravel. Bedrock was encountered in only one test hole but is presumed to slope northward.

4. CHRONOLOGY

It should be noted that the chronology for this site was difficult to determine given the high number of slides that have occurred in the vicinity and that the highway chainage has changed over the years with ongoing realignment for both geometric improvements and geotechnical hazards. Most of the slides were referenced to "Gregg River" which in fact affects this highway for several kilometres. In many cases, the files were unclear as to whether proposed work was actually completed and how it may have deviated from the proposal. This chronological sequence has been supplemented with historical airphoto information from the Thurber conceptual design review.

1969 – 1970

Initial construction of highway through this area with an oiled surface (as Hwy 50:10).

1975

Highway 40 designated primary highway.

1981

First reference in Alberta Transportation (AT) files to the proposal to realign the portion of Hwy 40:28 from km 12.0 to km 12.4 (about 300 m west of NC50). Recommendations included installation of subsurface trench drain in the south

ditch west of the current twin culverts (km 11.98) and backslope flattening to 3H:1V.

1982

Evidence in aerial photography of slides at the twin culvert area as well as in the backslope along portion to be realigned. Backslope in vicinity of NC50 appears to have been also repaired at that time.

1983

Hill located to south of the NC50 site within the coal mine boundaries was cleared of vegetation.

1984

The coal mine began using the hill for waste rock storage. According to mine personnel, this stockpile consists of blast rock end-dumped from large rock trucks. The material is sandstone, siltstone, and clay shale bedrock.

1988

The slide at km 12.0 affected the highway and an investigation was requested in early October. Three test holes and seven test pits were done in October in Section 33-47-24-W5M.

Oblique photograph in AT files showed the presence of the older scarp located about 15 m north of the highway at NC50.

1989

Ten test pits were excavated in June for slide in NE32-47-24-W5M. The failure plane was at the interface of stripping layer and original ground surface. The problem was with groundwater seepage in this old stripping material. The plan was to intercept the groundwater with drainage trenches – 100 m in east ditch and 50 m perpendicular (T-pattern).

1993

Test pits were undertaken along much of Hwy 40:28 as part of the proposed realignment of the highway. Plan/Profile drawings show the realignment between km 12 to km 12.4.

1994

Planning report for upgrades to Hwy 40:28 noted existing geotechnical problems at km 12.9 (likely refers to slide at the twin culverts) and km 14.4 (probably NC34). It was also noted that the proposed realignment at twin culverts will improved highway stability and as well as geometrics.

1997

Aerial photographs show beginning of realignment construction including work on the backslope through this area. Backslope slide area to east of NC50 between km 11.0 and km 11.2 was also being benched. It is understood from AT personnel that this area was used as a borrow source during construction and backfilled with poor quality material not suitable for embankment fill. The older scarp at NC50 is visible in these photographs.

2000

The mine waste stockpile was reclaimed with topsoil and seeding.

2000/2001

Realignment of portion of highway to west. Included installation of French drains in south ditch. (This was reported from conversations with the MCI at the time of the 2005 call-out and likely refers to the section between km 12.0 and km 12.4).

2005

Cracking at NC50 was first noted by the MCI on August 3 and had noticeably worsened by the August 8 call-out inspection undertaken by Thurber.

2006

Instrumentation was installed as part of a geotechnical investigation undertaken by Jacques Whitford. Three conceptual designs were developed: 150 m long pile wall with tie-backs, highway realignment about 10 m south with installation of subdrain, or install horizontal wells to lower the groundwater table.

2007

The site becomes part of the annual GeoHazard inspection and instrumentation monitoring program. The first routine assessment was conducted in July.

Significant patch placed in early August to repair road surface for safety reasons. At the time of a second visit undertaken by Thurber on August 23, the cracking and height differential had reappeared through the recent patch.

2008

Annual GeoHazard site inspection identified three skin slides in the valley slope west of the twin culverts and north of the highway. The slope angles for these slides are steep (40° to 45°). The slides are located beyond the tree line and outside of AT right-of-way, and extend down to the river.

2009

A conceptual design study to consider slide remediation alternatives was undertaken by Thurber. The study recommended a pile wall solution rather than the alternative of roadway realignment with a 10 m or 20 m offset. The pile wall option was chosen by AT and detailed design has commenced including additional drilling and instrumentation to confirm the depth of the shear plane.

5. REFERENCES

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3. Bayrock, L.A. and Reimchen, T.H.F. 1980. Surficial Geology, Alberta Foothills and Rocky Mountains. Alberta Research Council, Map 150.
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5. Survey and Mapping Branch, Department of Energy, Mines, and Resources, 1982. NTS 1:50,000 Topographic Map, 83 F/3: Cadomin, Alberta.
6. Survey and Mapping Branch, Department of Energy, Mines, and Resources, 1988. 1:250,000 Topographic Map, 83F: Edson, Alberta.
7. Alberta Transportation, Geotechnical Files.
8. Jacques Whitford, December 19, 2006 report to Alberta Infrastructure and Transportation: Geotechnical Investigation and Conceptual Design, NC-50: Highway 40:28 13 km north of Cadomin Hamlet, Alberta, South of Gregg River Gorge. Job No. 1012822.15. Contract No. CE401/2005.