November 2012

CG25399

Alberta Transportation
2nd Floor, 803 Manning Road NE
Calgary, AB T2E 7M8

Attention: Mr. Ross Dickson

Dear Ross:

Re: Southern Region Geohazard Assessment
2012 Annual Inspection Report
Site S4: Highway 2:08, Willow Creek

This report documents the 2012 annual site inspection of Site S4 – Willow Creek, along Highway 2:08, south of Claresholm, Alberta and approximately 4.7 km north of the Highway 2 bridge over the Oldman River. This site is located on a segment of the west slope of the Willow Creek valley where the slope crest has been retrogressing westwards towards the highway in recent years.

AMEC Environment and Infrastructure (AMEC), a division of AMEC Americas Limited, performed this inspection in partial fulfillment of the scope of work for the supply of geotechnical services for Alberta Transportation's (AT's) Southern Region (AT contract CON0013506).

The site inspection was performed on June 21, 2012 by Georgina Griffin, P.Eng., Bryan Bale, P.Eng., and Tyler Clay, E.I.T., of AMEC; and Roger Skirrow, P.Eng., Ross Dickson, and Nathan Madigan, E.I.T. of AT during the 2012 Annual Tour.

1.0 BACKGROUND

A general description of the geohazard conditions at this site along with the site geological setting and chronology of previous events, investigations, monitoring and repair work were provided in the Geotechnical File Review (Section A of the site binder) and summarized in the annual inspection reports up to 2007[1].

The landsliding at this site has been monitored by AT and their consultants since 1993. This site has been under greater scrutiny since the summer of 2005 when a relatively large increment of slope crest retrogression towards the highway occurred.

[1] AMEC Earth & Environmental, 2007. *Southern Region Geohazard Assessment, Annual Assessment Report, 2007*, Project Number CG25263, Report submitted to AT on November 6, 2007.

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A repair was performed in late 2008 and consisted of:

- Construction of longitudinal peak stone toe protection (LPSTP) and vanes along the right creek bank along with bioengineering treatments to reduce creek erosion along the toe of the slope in the landslide area.

- Slope re-grading and the installation of launched soil nails to stabilize the segment of the slope crest that had retrogressed towards the highway and westwards of the fenceline.

- Trial applications of numerous bioengineering and erosion control treatments on the exposed soils on the slope in the landslide area as part of a field workshop hosted by AT.

Please refer to Figures S4-1 and S4-2, attached, which are adapted from the as-constructed drawings for the 2008 repair and show the type and locations of the various repair measures at this site.

2.0 SITE OBSERVATIONS

Key observations from the June 2012 inspection were as follows:

- The slide mass was wet at the time of the inspection, with groundwater observed seeping from the scarps to within 2 m below the upland ground surface elevation. Similar groundwater seepage was observed during the June 2011 inspection.

- The main gully (at the south end of the site) was in approximately the same condition as the June 2011 inspection and was well vegetated, except on the steep upper side-slopes within the gully.

- The repair work performed on the upper slide mass and headscarp in 2008 has continued to be damaged by ongoing slide movement. The repairs in this area included slope re-grading, installation of launched soil nails to stabilize the uppermost portion of the headscarp, and bioengineering and erosion control treatments. Please refer to Photos S4-1 and S4-2 for a comparison of the site at the time of the June 2012 inspection to the June 2011 inspection. Staked reference points showed continued retrogression at the slope crest and the vegetation was disturbed in several areas from soil flows; however, the overall slope appears more vegetated and stable than previous years.

- The steep, upper scarps to the south of the soil nail repair area have collapsed onto the slide mass as large blocks have detached and slide down. No new large slide blocks were observed during the June 2012 inspection and previous blocks had less settlement relative to the movement seen between June 2010 and 2011.The headscarp is prone to incremental retrogression as these large blocks form and slide downwards. Please refer to Photos S4-3 and S4-4. Reference stakes were placed along the slope crest for

comparison during future inspections. Two reference stakes at the main soil nailed area have fallen indicating only minor retrogression of up to 1 m. Retrogression is ongoing, but at a slower rate as compared to the 2011 inspection.

- At the area of closest encroachment to the highway, the slide scarp was offset from the paved surface by 13.5 m. The scarp height at this area was 2.0 m. The overall slide mass below the scarp was sloping at 15 degrees. This offset is relatively unchanged from the 2011 inspection.

- Only a few soil nails remained visible at the crest of the slope, as most have been eroded and are buried in colluvium.

- The lower slopes of the slide mass were in good condition. The bioengineering and erosion control treatments applied on the lower half of the slide mass across the site have been effective, and no significant post-repair landslide damage or bank erosion was noted. Vegetation has become well established. Numerous containerized plantings have become established. Photos S4-5 and S4-6 show the lower slopes at the time of the June 2011 inspection as well as the June 2009 inspection.

- The LPSTP along the creek bank was in good condition, but the willow plantings have not survived. The vanes are performing well and extensive sediment deposition has occurred between the vanes. The thalweg (deepest part of the channel) is now located adjacent to the tip of the vanes and is no longer undermining the toe of the slope. The large gravel point bar that was previously located adjacent to the opposite (left) bank is no longer there due to this shift in the thalweg. No additional erosion has occurred on the opposite (left) bank. Some individual rocks have eroded from the vanes and are now located adjacent to the vanes. However, there has been no significant damage to the vanes. The change in channel configuration adjacent to the vanes is due to the deposition that is occurring and is not evidence of extensive damage to the vanes.

3.0 ASSESSMENT

Groundwater seepage observed during inspections since 2010 seems to be a key factor in the slope instability causing shallow earth flows and block toppling along the crest. The steep upper slopes, including the soil nail repair area, have been the most affected and re-vegetation in this area has begun but is not yet well established. The soil nails are no longer effective, as shallow earth flows have eroded the slope around the nails.

The trial bioengineering techniques applied at the site have had variable amounts of effectiveness. The flexible growth medium has generally worked well, as long as earth flows do not displace the vegetation. Benching of the slope has also worked well; it serves to catch any earth flows and disrupt the formation of gullies. Drainage by rock channels along the slope, where present, has reduced gully formation. The LPSTP and vanes have been very effective; resulting in extensive sediment deposition adjacent to the bank. There has been some loss of

individual rocks from the vanes but no significant damage. Please refer to the 2010 inspection report for details on the performance of each remediation technique[2].

Remediation is recommended at the site to establish vegetative cover in some areas, and to re-vegetate/stabilize the slope crest in the soil nailed area.

Without additional remediation techniques, ongoing slope crest retrogression is expected at the steep scarps across the upper slopes until the slope achieves a long-term stable configuration. As the scarps continue to slump, the overall slope angle will become reduced, as will the free-standing height of the scarps. It is expected that the amount of retrogression occurring with each increment of crest retrogression will become reduced. The observations in 2012 support this concept of increasing long-term stability, with only minor retrogression in the last year and improved vegetation. The lower slope is stable due to the 2008 repairs, and will provide support to the upper slide mass as scarp retrogression continues.

Based upon a simple extrapolation of the slope angle in the landslide mass in the mid to upper valley slope, the slope crest in the area of the closest encroachment to the highway (where the soil nails had been installed) may eventually retrogress to approximately 5 m offset from the highway surface. This may not provide sufficient clear zone width according to the highway standards.

4.0 RISK LEVEL

The recommended Risk Level for this site, based on AT's general geohazard risk matrix, is as follows:

- Probability Factor of 6. This is equal to the value from 2010, and an increase from the value of 5 assigned in 2009 after the repairs were completed to reflect that the soil nailed area has become less stable in recent years. The current Probability Factor is less than the pre-repair level of 9 since the creek bank erosion protection and other reclamation measures remain functional.

- Consequence Factor of 2 for the present location of the landslide relative to the northbound lanes of the highway. This is unchanged from the previous assessments.

Therefore, the current recommended Risk Level for this site is 12, which is unchanged from 2010.

[2] AMEC Environment & Infrastructure, 2010.*Southern Region Geohazard Assessment, Annual Assessment Report, 2010*, Project Number CG25332.200, report submitted to AT October 14, 2010.

5.0 RECOMMENDATIONS

The recommendations for this site are unchanged from 2010, and are summarized below.

5.1 Maintenance and Short Term Measures

- Vegetation should be established in areas where it has not grown properly or has been disturbed by earth flows. The flexible growth medium with broadcast seed and fertilizer, in combination with fibre rolls is recommended. It will be preferable to apply the flexible growth medium without restoring truck access to the lower slope areas (e.g. using longer hoses from a truck parked near the crest of the slope, if practical). Fibre rolls should be installed with longer stakes than were used in 2008. Plantings on the lower slope could be improved by adding more willows in poorly vegetated areas.

- Areas subject to earth flows will likely not be stabilized by vegetation alone, and will require grading and drainage accommodation. This is not recommended at this time, but can be implemented in the future based on conditions observed during the next annual inspection and the offset of the slope crest from the highway at that time.

- The vanes are currently functioning as intended and no repair of vanes is required at this time. The vanes should be monitored in the future to assess their performance and any damage that may occur.

5.2 Long Term Measures

- The risk of the upper scarp retrogressing further towards the highway remains. Groundwater seepage from the upper slopes seems to be the driver for continued movement in this area. The persistence and severity of groundwater seepage likely varies year-to-year, based upon the amount and intensity of precipitation. It may be possible to mitigate the effects of groundwater seepage from the upper slopes by installing a drainage trench along the ditch-line parallel to the slope crest to intercept high groundwater levels and lower the groundwater level at the slope face. Such a drainage trench should include an outlet pipe to an area midway down the slope. Alternatively, perforated soil nails could be installed at the head scarp to attempt to provide drainage outlets from within the slope. The slope face would need to be protected against erosion with either vegetative cover or erosion resistant matting (attached to the nails). AMEC could provide design details for either of these options if requested.

- The annual site inspections by AT and AMEC personnel should be continued.

5.3 Investigation

Based on the 2012 inspection and to aid design of any future mitigation, further monitoring and investigation of this site was determined to be warranted. AT has requested AMEC to provide a cost estimate and proposal for the following scope of work:

- A site survey of the LPSTP, crest, ditch invert and several sections through the site area, to allow for comparison of the current conditions with the as-built conditions for assessing the performance of the repair.

- Installation of four vibrating wire piezometers to measure groundwater pressures in the highway shoulder and median across from the main encroachment area. The instruments will be nested within a single borehole in each of these areas and monitored with a data-logger. Additional piezometers will be useful to guide any future drainage improvement work.

It would also be of interest to perform a bathymetric survey of the creek channel (including the thalweg position and profile) after a few years in order to compare to the 2007 channel survey and assess changes in the channel cross-section and profile as a result of the installation of the bank armouring and rock vanes in late 2008. This would be of interest in further assessing and documenting this case history of the use of rock vanes and their effect on channel conditions, and could be cross.

6.0 CLOSURE

This report has been prepared for the exclusive use of Alberta Transportation for the specific project described herein. Any use which a third party makes of this report, or any reliance on or decisions to be made based on it are the responsibility of such third parties. AMEC Environment & Infrastructure, a division of AMEC Americas Limited, cannot accept responsibility for such damages, if any, suffered by any third party as a result of decisions made or actions based on this report. This report has been prepared in accordance with accepted geotechnical engineering practices. No other warranty, expressed or implied, is made.

We trust that this meets your needs at this time. Please contact the undersigned if you have any questions or require any further information.

Respectfully Submitted,

AMEC Environment & Infrastructure,
a division of AMEC Americas Limited

ORIGINAL SIGNED AND STAMPED NOVEMBER 19, 2012

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