December 2013

CG25399

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

Attention: Mr. Ross Dickson

Dear Ross:

Re: Southern Region Geohazard Assessment
2013 Annual Inspection Report
Site S26: Highway 41:03, Elkwater

This report documents the 2013 annual site inspection at Site S26 – Elkwater, along Highway 41:03 and approximately 3 to 4 km south of the turnoff from Highway 41 to the town of Elkwater, AB.

AMEC Environment & Infrastructure (AMEC), a division of AMEC Americas Limited, performed this inspection in partial fulfilment 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 by Bryan Bale, P.Eng., Hui Wang, P.Eng, and Tyler Clay, E.I.T., of AMEC; and Roger Skirrow, P.Eng., and Ross Dickson, of AT during the 2013 Annual Tour.

1.0 SUMMARY

The overall site conditions at Area A are relatively unchanged since the 2012 inspection. The previously observed cracking did not appear to be coming through the 2012 overlay but ongoing apparent shallow movement upslope and downslope of the road was evident. The remaining SI instrument has not shown movement as of the Fall 2013 readings. A retrogression of the lower slide activity at Area A could take out part of the road if it failed suddenly. It is recommended that a repair design be prepared in the event an emergency repair is needed. The risk level at Area A is 52, which is unchanged from the 2012 assessment.

The site conditions of Area B have changed significantly following the 2012 repair work and relative to the 2010 site assessment. The shear pile repair work was completed in Fall 2012 and appeared to be performing well. Future monitoring will be required to assess its effectiveness. The risk level at Area B has been decreased to 8, a significant reduction from the 2010 level of 80, due to the successful completion of the repair work.

The spring/fall instrument readings and annual site inspections by AT and AMEC personnel should be continued in 2014.

2.0 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 a 2007 call-out site inspection report by AMEC[1] and are summarized as follows:

- The highway is constructed across the lower portion of the east valley slope of a north-draining, unnamed creek valley incised into the north slope bordering the Cypress Hills Plateau to the south.

- There are two segments of the highway that are being damaged by landslide movement at this site and they are referred to as Area A and Area B. Area A is near the crest of the hill and is approximately 500 m southbound from Area B. Site plans for the two areas are presented on Figures S26-1 and S26-2.

Area A

- There is visible landslide terrain upslope and downslope of the highway around Area A and widespread signs of landslide damage along this segment of the road. The landsliding consists of slumping (possibly with a translational component of movement) seated in the bedrock underlying the slope. The primary driver for the landsliding appears to be the erosion and down-cutting of the creek valley over time and possibly also relatively high groundwater levels in the valley slope.

- Numerous patches and overlays have been placed over the years to maintain the road grade through Area A.

- The landsliding in Area A was investigated and assessed by AT between the early 1970's and the late 1980's. There is some reference in AT's files to shallow drainage trenches having been installed, but no documentation of the construction of these trenches or any assessment of their effectiveness.

- AMEC performed a geotechnical site investigation at Area A in 2008. The investigation included the installation of five standpipe piezometers, three slope inclinometers (SI's) and a trial installation of a Measurand ShapeAccelArray (SAA) cable adjacent to one of the SI's. These instruments have been monitored since installation, with the most recent readings from October 2013. The SAA cable is connected to datalogging and communications equipment to enable remote access to continuous data from the instrument. A rainfall gauge, also with remote data access, was also installed at the site. The instrument and weather station locations are illustrated on Figure S26-1.

[1] AMEC Earth & Environmental, 2007. *Report on March 17, 2007 Call-Out Request, Highway 41:03, near Elkwater, AB*, Project Number CG25239.D. submitted to AT October 30, 2007.

- Numerous slumps affecting the roadway occurred at Area A in May and June 2010. In general, the slumps were relatively shallow (perhaps 1 to 5 m deep), and were judged to be translational or retrogressive failures of saturated surface soils. Some of the slides were linked to well-developed rotational slides on the lower slope along the creek, and likely indicate upslope retrogression of these existing slides. Figure S26-1 illustrates the locations of some of the more significant slides that were noted. The slide damage was repaired by placing asphalt overlays. Shallow slumps also formed along the backslope across the site, with tilted trees and torn vegetation mats. The slumps were estimated to be up to about 5 m deep.

- The shallow landsliding noted to have affected the road surface to date has not affected the area around the SI's or SAA cable. No movement had been detected by the remaining working SI as of October 2013.

Area B

- Area B is a curved segment of the highway that is constructed on a cut and fill embankment. No past geotechnical assessments or reporting for this area were found in the file review for this site. This area was first inspected in 2007, when it was noted that the road surface had been experiencing significant settlement in recent years due to instability of the road fill and possibly underlying landslide movement, and that multiple, thick overlays had resulted in a reduction in the net height of the guardrail along the downslope side of the road.

- Several geotechnical boreholes and instrument installations were completed at Area B in 2008. Instrument monitoring confirmed the slide mechanism causing the slow, ongoing damage to the road in 2009, but repair work was deferred with the intent at that time of combining repair work at Area A and Area B.

- A rapid slope failure occurred at Area B in late May 2010 with a headscarp matching the pattern and extent of the persistent cracking and settlement that was noted in the 2008 and 2009 inspections. The failure took the southbound (downslope) lane of the road out of service, and the road surface within the failure area settled by 3 to 4 m shortly after the initial failure. The trigger for the May 2010 failure was thought to be high groundwater levels following a period of high precipitation and spring snowmelt.

- As a temporary repair, AT's maintenance contractor excavated a portion of the failed slide mass, contracted a company to install launched soil nails, and constructed a detour lane in the upslope road ditch. AMEC provided geotechnical input to the planning and execution of the temporary repair, along with a design for the detour lane construction and alignment.

- AMEC provided a shear pile repair design, which was constructed in 2011/2012.

3.0 SITE OBSERVATIONS

Key observations from the May 27, 2013 inspection are summarized as follows:

Area A

- The weather station was observed to be in good working condition. The slope between the weather station and the road did not show signs of recent slide activity.

- The ditch upslope of the culvert at the south end of the site was wet and flowing. This area was consistently wet during past inspections. As noted in previous inspections, the ditch gradient is relatively flat, which causes water to pond. There were no significant changes to the previously noted erosion at the culvert outlet.

- The downslope road shoulder north of the culvert had a steep drop off due to accumulated overlays. A recent overlay was placed at the site in the summer or fall of 2012. Refer to Photo S26-1.

- Several rotational type landslides were noted along the lower slope below the highway during previous inspections. The slides had well-developed scarps and flanks, and appeared to have formed over a period of years. In 2010, the headscarps of several of these landslides retrogressed upslope and undermined portions of the road surface, as illustrated on Figure S28-1. These slides did not intersect any of the existing SI's. The main slide areas within the lower slope had minor cracking at the road edge where overlays were placed in Fall 2012. The cracking was not observed to reform through the overlay further upslope from the west road shoulder. (Refer to Photo S26-2).

- The creep movement on the backslope above the road way appeared unchanged since June 2012.

- No seepage was noted from the back slope at the north end of Area A but the soil was saturated. The ditch was blocked as result of additional movement in the back-slope slide.

- The Measurand SAA instrument was non-operational, possibly due to damaged wiring in the instrument.

Area B

- The shear pile repair work was completed in Fall 2012. The shear piles were installed and the backfill was placed; along with the installation of a SI in Area B, as illustrated on Figure S28-2. Refer to Photo S26-3 and S26-4.

- Vegetation had begun to grow downslope of the road surface, with approximately half of the site covered in grass.

- No cracking was observed on the road surface but there was slight settlement north of Area B, past the site extent.

4.0 ASSESSMENT

Area A

The landslide damage to the road surface at Area A worsened in early 2010, with extensive damage to the road surface from shallow, localized slides and flows. Slide movement continued in 2013, but at lower rates than in 2010. Two of the SI's were damaged by the shallow landslide movement in 2010 and 2011 and are now out of service. The trial Measurand SAA instrument stopped reporting data in January 2012 and is assumed to be out of service due to a wiring failure within the datalogger enclosure. No confirmed deep-seated landslide movement was recorded as of the October 2013 readings. Only one SI and several standpipe piezometers remain operational, which limits the monitoring capability at the site.

The slide activity on the slope below the road appears to be retrogressive, and was noted to extend up the backslope and into the treed area further upslope. These slides continued to cause damage to the road surface and additional overlays (likely annually, at a minimum) will be required to maintain a smooth road surface.

The instrument data from the summer of 2008 onwards has not shown any deep-seated landslide movement consistent with the widespread landslide terrain on the valley slope and slickensided zones in the drill core from this area. It is possible that deep seated movement at this site may be responsive to longer-term trends in precipitation (e.g. a series of relatively wet years may lead to one or several years of deeper landslide movement). It is also possible that the site is no longer experiencing deep-seated movement, and that the damage to the road in Area A in recent years may be solely due to shallow and localized slide movements that are accelerated during peak precipitation events, such as those that occurred in April and May 2010.

The shallow slides and flows that have damaged the road surface in recent years have required extensive paving repairs to maintain a smooth road surface. Although the presence of deep-seated landsliding has not been confirmed, a repair to strengthen the road against the shallow slides would be beneficial. Such a repair would likely include replacing the road subgrade with

granular fill, providing improved ditch and subsurface drainage, and shifting the road upslope away from the creek.

The numerous asphalt overlays have created a steep drop at the road edge, and a guardrail is required according to AT's Highway Design Guidelines.

Area B

The effectiveness of the Summer/Fall 2012 repairs for the site will be monitored during future annual inspections and via post-construction instrumentation. The repair appeared to be performing well as of the June 2013 inspection.

5.0 RISK LEVEL

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

Area A

- Probability Factor of 13 based on active movement that is steady or increasing.
- Consequence Factor of 4 to reflect the ongoing damage to the road surface that requires maintenance work to maintain a relatively smooth running surface and the potential for a relatively large increment of landslide movement to require a partial closure of the road and/or immediate work to establish a temporary running surface through the landslide area.
- Therefore the recommended Risk Level for Area A is 52, which is unchanged from 2012.

Area B

- Probability Factor of 2 to reflect the recent repair that appears to have stabilized the previous landslide hazard. This is a reduction from the 2012 factor based on the observed performance since construction.
- Consequence Factor of 4 to reflect the history of large landslide movement at this site and the potential lane closure of the road and a required detour if a similar landslide were to occur.
- Therefore, the recommended Risk Level is 8, which is significant reduction from the 2010 level of 80, due to the successful completion of the repair work. The risk level can be adjusted in 2014 based on observations of the repair area.

6.0 RECOMMENDATIONS

6.1 Maintenance and Short Term Measures

- AT's maintenance contractor should continue to apply patches and overlays to Area A to maintain a suitable traffic surface in response to ongoing damage by shallow, localized slide activity.

- The erosion channel forming at the culvert outlet at Area A should be protected. This could be done with armouring, erosion resistant matting, or a full culvert or flume extended to creek level.

- The ditch in Area A should be cleaned out at the upslope seepage area to allow for proper drainage.

- A guardrail should be constructed on the southwest road shoulder through Area A as per AT's highway design guidelines. Overlays and slope movement have created hazardous drop-offs in several locations.

6.2 Long Term Measures

Area A:

- The persistent damage to the road surface due to shallow, localized movements is the most likely hazard at this site. This hazard could be reduced with a combination of improved drainage, stronger road sub-grade, and shifting the road alignment. This type of repair may be required in the future, as the continued overlay type repairs will likely not be sufficient as the slides continue to develop on the lower slope. The cost of such a repair may be less than ongoing paving repairs in the long-term. AMEC submitted a proposal for this work to AT in 2012.

- The shallow landslide activity below the road retrogressed into the road in recent years. A sudden increment of slide movement that causes loss of a portion of the road should be expected. The most probable area for such retrogression is near the north end of Area A (refer to Figure 1). Repair strategies should be developed in case urgent mitigation is required.

- Deep-seated landsliding has not been confirmed at the site since the SI's were installed in 2008, but may occur in the future. Repairs to target the damage to the road surface, as described above, would not be sufficient to mitigate against deep-seated movement. Additional repairs could be required if deeper seated landsliding becomes active in the future.

Area B:

- No repairs or maintenance recommendations are required at this time, but this will be confirmed after monitoring the repair for several years and observing the site conditions.

6.3 Monitoring

The spring/fall instrument readings and annual site inspections by AT and AMEC personnel should be continued. AMEC has also installed an SI at Area B for post-construction monitoring, and will monitor this instrument as part of the semi-annual monitoring program.

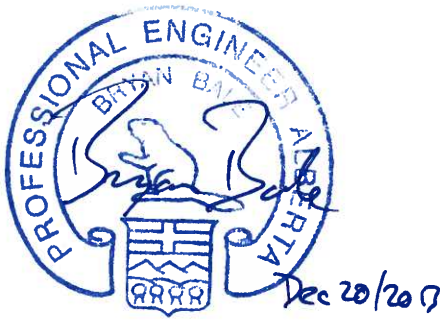
7.0 CLOSURE

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



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