October 28, 2010

CG25332.200

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

Attn: Mr. Ross Dickson

Re: Southern Region Geohazard Assessment Program
Site S26 – Elkwater, Highway 41:03
2010 Annual Inspection Report

This letter documents the 2010 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 Earth & Environmental (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 CE061/08).

The site inspection was performed on June 23, 2010 by Mr. Bryan Bale, P.Eng., of AMEC in the company of Mr. Neil Kjelland, P.Eng., Mr. Roger Skirrow, P.Eng., and Mr. Ross Dickson of AT.

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 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 illustrated on Figure S26-1, and Figure S26-2 presents Area B. Area A is near the crest of the hill and is approximately 500 m southbound from Area B.

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- 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 downcutting 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 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 their effectiveness.

- AMEC performed a geotechnical site investigation at Area A in late May and early June 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 May and June 2010. 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.

- Area B is a curved segment of the highway that appears to be constructed on a cut and fill embankment. No past documentation for this area was found in the file review for this site. This segment of the highway has been experiencing significant settlement in recent years which has necessitated multiple, thick overlays and reduced the net height of the guardrail along the downslope side of the road. Geotechnical investigation and instrument installations were performed at the site in 2008.

SPRING 2010 CONDITIONS

The condition of both Area A and Area B changed during the spring of 2010. Details of the changes are listed in the following bullets:

- AT and their maintenance contractor noted that the cracking at Area B had worsened in late April 2010. Photos of the site taken by the maintenance contractor showed an arc shape crack in the southbound lane extending to the road centreline along a 25 m long segment of the road. The crack followed the same pattern as observations of lesser cracking during the 2008 and 2009 inspections, but had worsened considerably. The

April 2010 cracking was not as laterally extensive as the cracking noted during 2008 and 2009 before the site was most recently repaved. The vertical displacement was estimated at 100 mm.

- AMEC inspected Area B on May 3, 2010 and found that the area of cracking reported on April 28, 2010 had failed, with a 2 to 3 m high headscarp. A single lane of traffic had been closed by the maintenance contractor, and traffic control was provided day and night by flag persons. The inspection determined that the failure mode was landsliding of the fill embankment along the movement planes previously measured by the slope inclinometers (SI's) at Area B. The trigger was thought to be due to high groundwater following a period of high precipitation and snowmelt.

- As a temporary repair, AT's maintenance contractor excavated a portion of the failed slide mass and contracted a company to install launched soil nails. AMEC provided general instructions on how to perform the repair, and design drawings for a detour lane construction and alignment.

- The site was inspected again on May 13, 2010 by AMEC in conjunction with the planned instrument readings at Areas A and B. The slide mass had continued to move and the headscarp was 3 to 4 m high. Cracks had also formed to the south of the failed area, following the pattern of previously observed damage to the road surface. An initiation meeting was held between the various contractors at this time, and the repair work commenced.

- Shortly after the completion of the soil nail installations, the slide expanded towards the south along the pattern of previously observed cracking, affecting a 40 m long segment of the road. The same type of repair was implemented in this area, which reportedly included excavation of a portion of the slide mass, establishment of positive drainage within the slide mass, and the installation of 3 to 4 rows of launched soil nails on a 1 m grid with embedment lengths of up to 6 m depth.

- Another site inspection was performed on June 4, 2010 at Area A following the formation during May 2010 of numerous slumps in the roadway, lower embankment slope, and backslope. Readings of the SI's in Area A were obtained during the inspection; however no movement zones were detected at the SI locations. The roadway had several recent asphalt patches at the time of the inspection.

SITE OBSERVATIONS

Key observations from the June 23, 2010 inspection are summarized as follows:

Area A

- The upslope highway ditch in the area southbound (uphill) from the Area A instruments was noted again to be wet with standing water and it appears that the 900 mm diameter culvert a short distance south from SI 08-1 (see Figure S26-1) carries a lot of drainage from the wet area. A fill ditch block had recently been constructed at this location to direct water to the culvert rather than continuing downhill into Area A (Photo S26-1). An erosion channel is forming at the culvert outlet and should be protected against erosion (Photo S26-2).

- The creek to the southwest of the site was flowing at a high volume at the time of the inspection, and some recent slumps along the bank were noted.

- There was extensive damage to the road surface across the Area A site, which had worsened considerably since the June 2, 2010 inspection. The damage generally followed the pattern of previously noted cracks, but was more pronounced. The damaged areas had been recently patched, and cracking had developed again through the asphalt patches. Each of the damaged areas is described in the following points, from the south end of the site to the north end:

    - The first damaged area had cracks following a long arc across the southbound lane, extending slightly beyond the road centerline (refer to Photo S26-3). The cracks followed the general pattern of past cracking, with a possible expansion towards the south. The cracks had an aperture of up to 20 mm, and vertical displacement of up to 100 mm. The slide appears to be within the upper road fill, and is likely only a few metres deep. The toe of the slide was not discernable.

    - The second damaged area from the south (Photo S26-4) followed the same pattern as past cracking, had 10 to 20 mm aperture, 50 mm vertical displacement, and appeared quite shallow.

    - The third damaged area from the south (Photo S26-5) was in an area without previously observed cracks. The cracking formed an arc shape across the southbound lane to near the centreline, and had flanks visible on the lower slope below the road. This slide is directly upslope of a previously noted slump on the lower slope near the creek, and is likely a retrogression of the older slide below. It is difficult to estimate the depth of this slide, but it may be 5 to 10 m deep.

- The fourth damaged area (Photo S26-6) had irregular shaped cracking across the entire road surface, with up to 100 mm aperture and vertical displacement. The toe of the slide was not observed, but is expected to be at the base of the main road fill at about 3 m depth.

- The fifth damaged area (Photo S26-7) had cracks following the same pattern as noted in the past, but more extensive with aperture of 20 mm and vertical displacement of 30 to 40 mm. These cracks may indicate a link to the circular failure on the lower slope.

- There were numerous slumps along the backslope across the site, typically shallow earth flows (Photos S26-8 and S26-9). The area around the previously noted groundwater spring located near the fourth damaged area (Figure S26-1) was especially active, with slides extending approximately 50 m upslope of the road into the trees (30 m into the trees). Fresh scarps were noted in the treed area upslope from the highway, with tilted trees and torn vegetation mats. The slumps were estimated to be about 5 m deep.

- No slope movement has been measured at the SI's at Area A or the SAA cable relative to the June 7, 2008 baseline readings. The weather station that was installed in early June 2008 has been recording precipitation data since that time.

Area B

- The repairs at Area B appeared to be holding up well and the slide mass was draining freely with no ponding water observed. The slide mass at the southern portion of the repaired area was not completely excavated as was done at the north end. No new cracking had formed in the road surface since the May 2010 inspection. Some portions of the scarp had retrogressed slightly, however these appeared unstable after the May 2010 repairs and were expected to fall in the future. The road detour was in good condition. Refer to Photos S26-10 and S26-11.

- The SI's at Area B have sheared off at shallow depth. SI 08-6 in the northbound lane remains functional and has not detected any slope movement. This data is consistent with the locations of the SI's within the landslide area. Please refer to the Spring 2010 monitoring report for details[1].

[1] AMEC report, "Southern Region Geohazard Assessment Program, Spring 2010 Instrumentation Monitoring Results, Site S26: Highway 41:03: Elkwater 'Area A' and 'Area B'", submitted to AT July 19, 2010, CG25332.300.

ASSESSMENT

Area A

The landslide damage at Area A has increased far more than in past years. The weather station installed at the site indicates that Spring 2010 was far wetter than 2008 and 2009. Intense rainfall events are thought to be the trigger for the shallow slope movements noted across the site. It is also noted that the road fill at Area A is of poor quality, which likely has contributed to the recent damage.

Since the slope inclinometers and SAA did not detect any slope movement, it is interpreted that the April/May 2010 slumps in Area A are shallow and localized to steep areas or slopes with higher groundwater pressures, such as at the groundwater spring near the north end of Area A. These slumps appear to be retrogressive, and were noted to extend up the backslope and into the treed areas further upslope.

The instrument readings since the summer of 2008 have not shown that the past deep-seated landslide movement at this site (evidenced by the widespread landslide terrain on the valley slope and slickensided zones in the drill core from this area) has been active in recent years. It is possible that deep movement 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 active 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 due only to shallow and localized slumps such as those that occurred in April and May 2010. As noted in previous reports, until the depths of active movement zones are confirmed by the SI's, there is no basis to confirm and design the most appropriate repair measures with respect to deep-seated landslide movement.

Area B

The slide at Area B failed in April 2010, likely due to high groundwater pressure and/or accumulated movement reducing the soil strength. The movement had been ongoing for years, and the site had been treated as a maintenance issue up to the spring of 2010. The design of a pile wall repair is underway for the Area B site at the time of writing, and a design and draft tender package will be submitted to AT as soon as possible.

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 an increase from the rating of 36 in 2009.

Area B

- Probability Factor of 20 to reflect the significant failure that occurred.

- Consequence Factor of 4 to reflect the partial closure of the road and required detour.

Therefore, the recommended Risk Level is 80, which is an increase from the rating of 52 in 2009.

RECOMMENDATIONS

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 slumping.
- 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.

- Add a culvert to intercept the ditch flow from the groundwater spring noted in the slope above the highway and roughly 50 to 70 m south of southernmost end of the Area B guardrail. This new culvert would intercept this water before it flows into Area B and possibly contributes to the ongoing damage to the road surface. AMEC understands that

the trench drain that was installed along the upslope ditch in this area in 2008 was capped with clay therefore the surface flow from this spring likely does not percolate into the slope to a great extent. Constructing a culvert would reduce the risk of water infiltrating into Area B from this spring and would be beneficial for the slope stability at the site.

Long Term Measures

Area A:

- Continue monitoring the instruments in order to confirm the depth and rate of the deeper-seated landslide movement that has formed the widespread landslide terrain on the valley slope. Confirmation of the active landslide movement surfaces is required in order to determine suitable repair options (e.g. shallow drainage or horizontal drains).

- AMEC will continue the remote monitoring of the SAA cable.

Area B:

- A repair design for a pile wall is underway, and a design and draft tender package will be submitted to AT as soon as possible.

Monitoring

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

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 Earth & Environmental, 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 Earth & Environmental,
a division of AMEC Americas Limited

ORIGINAL SIGNED
OCTOBER 28, 2010

Bryan Bale, M.Sc., P.Eng.
Geotechnical Engineer

APEGGA Permit to Practice No. P-04546

Reviewed by:

Andrew Bidwell, M.Eng., P.Eng.
Associate Geological Engineer

Attachments: Figure S26-1 – Area A site plan
Figure S26-2 – Area B site plan
Figure S26-3 – Daily Precipitation Plot
Figure S26-4 – Monthly Precipitation Plot
Photos