August 20, 2009

CG25309.B

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
2009 Annual Inspection Report

This letter documents the 2009 annual site inspection and instrument readings 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 8, 2009 by Mr. Andrew Bidwell, P.Eng. and Mr. Bryan Bale of AMEC in the company of Mr. Ross Dickson and Mr. Neil Kjelland 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.

- 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)

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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 details on the construction of these trenches or their effectiveness.

- AMEC performed a geotechnical site investigation 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 during the June 2009 site inspection. 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.

- The damage to the road surface in Area B looks like it is being caused by landslide movement with a headscarp around the centerline of the highway, but possibly extending further upslope.

SITE OBSERVATIONS

Key observations from the June 2009 inspection are summarized as follows:

- The extent and magnitude of the damage to the road surface in Area A had not changed significantly since the 2008 inspection or since observations during the late May 2009 instrument readings. Photos S26-1 and S26-2 show views of the damage to the road in this area. Figure S26-1 shows the approximate locations of cracking in the road surface interpreted to be due to landslide movement, as noted during the June 2008 and June 2009 inspections.

- The upslope highway ditch in the area southbound 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 groundwater spring was noted in a shallow, localized slumping area in the cut slope immediately above the upslope highway ditch and approximately 50 to 70 m south of the south end of the Area B guardrail. The water from this spring flows northwards along the upslope highway ditch and appeared to percolate into the highway subgrade around or slightly upslope of the segment of damaged road in Area B (Photo S26-3). This groundwater spring has been noted on occasion during previous site inspections, but does not appear to flow year-round.

- There was additional settlement and a possible additional retrogression of the arc shaped tension crack along an approximately 45 m long segment of the southbound lane (on the downslope side of the highway) in Area B. Photos S26-4 to S26-5 show the damaged area as it appeared at the time of the June 2009 inspection. A small crack was noted in the northbound lane near SI 08-1 just upslope of the centreline. This crack was not noted in previous inspections during 2007 and 2008 and may indicate a possible retrogression of the instability into the upslope lane. Figure S26-2 shows a schematic site plan of the site features and damage to the road surface at Area B.

Other notes:

- The instrumentation was read during the June 2009 inspection.
    - As of the June 8, 2009 readings, 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.
    - The SI's at Area B have detected shallow movement within the fill, as described in the Spring 2009 monitoring report[1]. SI 08-4 is located very close to the inferred head scarp at Area B and may not detect horizontal movement.
    - Refer to Tables S26-1 and S26-2 for a summary of the instrument readings, as well as to Figures 3 to 23.

[1] AMEC report "Southern Region Geohazard Assessment, Spring 2009 Instrumentation, Monitoring Results, Site S26: Highway 41:03, Elkwater", submitted to AT June19, 2009.

ASSESSMENT

Area A

There does not appear to be significantly more landslide damage to the road surface in Area A since the 2008 inspection. The SI's and SAA cable have not yet shown any landslide movement since the June 7, 2008 baseline readings. This suggests that relatively deep-seated movement could be occurring in the valley slope and may not be active each year, perhaps due to variations in annual precipitation or longer-term trends in precipitation (e.g. one or a series of relatively wet years may lead to one or several years of active landslide movement). The available data from the rainfall gauge (June 2008 onwards) is not sufficient to make any conclusions about rainfall trends vs. the apparent lack of landslide movement from June 2008 onwards, however as the rainfall gauge and SI/SAA data accumulate in the coming years it may be possible to more definitely determine the link between rainfall and ground movement at this site.

There is also the possibility that the damage the highway in Area A is due to landslide movement seated in the slope below the highway (i.e. between the highway and the creek channel, and therefore would not be detected in the instruments installed along the upslope side of the highway). This is considered less likely based on the overall assessment of the landslide conditions at this site. The lack of significant additional damage to the highway from June 2008 onwards does not necessarily support this, but the possibility should be borne in mind in the event that additional/ongoing damage to the highway is observed in the future but the instruments installed along the upslope edge of the road continue to show no movement.

Overall, it is still considered most likely that over the long term it will be more cost-effective to try to reduce the landslide damage to the road in Area A than to continue to treat it as a maintenance item. When the instruments are able to confirm the depth of active landslide movement it will be possible to determine the most appropriate repair method (e.g. shallow drainage trenches vs. horizontal drains, or other options).

Area B

Sufficient information has been obtained from the Area B instruments to proceed to a repair design. Damage to the road surface appears to be due to shallow landslide movement and/or settlement within the poor quality road fill. Movement has been confirmed by the SI's, and the magnet extensometer is indicating probable settlement that may be due to slide movement. Deeper seated landslide movement has not yet been confirmed. Refer to the recommendations section for more details.

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 9 based on the inferred active movement (not yet confirmed by the SI's installed in late May/early June 2008) but with the uncertainty regarding the rate (or frequency) of movement at this time. This is the same value as recommended after the 2008 inspection, and a reduction from the value of 13 recommended after the 2007 inspection when it was assumed the there was ongoing movement at a high rate, based on the visual observations to that time.

- 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 (however low) 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 36, which is the same as the risk level recommended after the 2008 inspection.

Area B

- Probability Factor of 13 to reflect the active movement damaging the road, with an inferred high and at least steady rate of movement measured by the SI's and inferred from the rapid cracking of the road surface.

- Consequence Factor of 4 to reflect the ongoing damage to the road surface that requires significant maintenance work and the potential (albeit possibly low) for a relatively large increment of movement to require a partial closure of the road and/or immediate work to establish a temporary running surface extending into the upslope ditch.

Therefore, the recommended Risk Level is 52 and remains unchanged from the August 2008 call-out site inspection of Area B.

RECOMMENDATIONS

Maintenance and Short Term Measures

- AT's maintenance contractor should continue to apply patches and overlays to both Areas A and B as required to maintain a suitable traffic surface. This should be treated as an ongoing maintenance issue, pending confirmation of the most appropriate repair measure for Area A and then repairing Area A and Area B at the same time.

- 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 at Area B 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 landslide movement and from that determine suitable repair methods.

- Repair options for Area A will likely consist of subsurface drainage – either horizontal drains with entry points on the slope below the highway or deep trench trains excavated and backfilled with single-pass deep trenching equipment.

- AMEC will continue the remote monitoring of the SAA cable during the fall summer of 2009, and the next set of SI readings is planned for the fall of 2009 unless the SAA cable shows movement beforehand.

Area B:

- Repair work to mitigate the ongoing damage to the road surface. A suitable repair option could be selected now however AMEC understands that AT would prefer to perform repairs at both Area A and Area B simultaneously. Therefore, it is recommended that a repair at Area B be delayed until movement is detected at Area A.

- Repair options for Area B may include the following:
    - Realignment – shifting the road upslope.
    - Excavation and reconstruction of the fill embankment using engineered backfill (an improvement over the current poor quality fill), with geogrid or other reinforcement measures if required.
    - A combination of excavation/replacement and realignment.

- AMEC would be pleased to submit a repair design and draft tender package for the Area B repair method if AT chooses to proceed with a repair in advance of the Area A work.

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,

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Attachments: Figure S26-1 – Area A site plan
Figure S26-2 – Area B site plan
Table S26-1 and S26-2 – Instrumentation Summary
Figure S26-3 to S26-23 – Instrumentation Plots
Photos S26-1 to S26-5

TABLE S26-1
ANNUAL INSPECTION 2009 – Elkwater
Slope Inclinometer Instrumentation
Reading Summary

Date Monitored: June 8, 2009

INSTRUMENT NAME AND COORDINATES (LATITUDE AND LONGITUDE)	DATE INITIALIZED	TOTAL CUMULATIVE RESULTANT MOVEMENT AT DEPTH SINCE INITIAL READING	MAXIMUM RATE OF MOVEMENT	CURRENT STATUS	DATE OF PREVIOUS READING	SINCE PREVIOUS READING		
						INCREMENTAL MOVEMENT	RATE OF MOVEMENT	CHANGE IN RATE OF MOVEMENT
"Area A"								
SI 08-1 (49°38.391 'N, 110°15.377' W)	June 7, 2008	No confirmed movement to date.	n/a	Operational	May 7, 2009	n/a	n/a	n/a
SI 08-2 (49°38.419' N, 110°15.389' W)	June 7, 2008	No confirmed movement to date.	n/a	Operational	May 7, 2009	n/a	n/a	n/a
SI 08-3 (49°38.425 N, 110°15.420 W)	June 7, 2008	No confirmed movement to date.	n/a	Operational	May 7, 2009	n/a	n/a	n/a
"Area B"								
SI 08-4 (49°38.647' N, 110°15.636' W)	September 26, 2008	9 mm	29 mm/yr	Operational	May 7, 2009	3 mm	29 mm/yr	+25 mm/yr
SI 08-5 (49°38.645' N, 110°15.638' W)	September 26, 2008	9 mm	21 mm/yr	Operational	May 7, 2009	1 mm	11 mm/yr	+3 mm/yr

INSTRUMENT NAME AND COORDINATES (LATITUDE AND LONGITUDE)	DATE INITIALIZED	TOTAL CUMULATIVE RESULTANT MOVEMENT AT DEPTH SINCE INITIAL READING	MAXIMUM RATE OF MOVEMENT	CURRENT STATUS	DATE OF PREVIOUS READING	SINCE PREVIOUS READING		
						INCREMENTAL MOVEMENT	RATE OF MOVEMENT	CHANGE IN RATE OF MOVEMENT
SI 08-6 (49°38.648' N, 110°15.635' W)	September 26, 2008	No confirmed movement to date.	n/a	Operational	May 7, 2009	n/a	n/a	n/a

TABLE S26-2
ANNUAL INSPECTION 2009 – Elkwater
Piezometer Instrumentation, Reading Summary

Date Monitored: June 8, 2009

INSTRUMENT TIP SERIAL NUMBER AND COORDINATES (LATITUDE AND LONGITUDE)	DATE INITIALIZED	SENSING ZONE ELEVATION RANGE *or* TIP ELEVATION* (m)	GROUND ELEVATION* (m)	CURRENT STATUS	MAXIMUM PIEZOMETRIC ELEVATION (m)	CURRENT PIEZOMETRIC ELEVATION (m)	PREVIOUS PIEZOMETRIC ELEVATION (m)	CHANGE IN CALCULATED EQUIVALENT GROUNDWATER ELEVATION SINCE PREVIOUS READING (m)	PORE WATER PRESSURE RATIO (r_u)
"Area A"									
SP 08-1A (49°38.391' N, 110°15.377' W)	June 7, 2008	441.6-445	466.3	Operational	451.8 (June 2008)	450.2	450.4 (May 2009)	-0.1	n/a
SP 08-1B (49°38.391 'N, 110°15.377' W)	June 7, 2008	457.2-461.1	466.3	Operational	461.6 (Sept. 2008)	460.8	460.7 (May 2009)	-0.1	n/a
SP 08-2A (49°38.419' N, 110°15.389' W)	June 7, 2008	439.6-442.8	464.3	Operational	445.5 (June 2008)	444.9	444.9 (May 2009)	0	n/a
SP 08-2B (49°38.419' N, 110°15.389' W)	June 7, 2008	455.5-458.8	464.3	Operational	460.2 (June 2008)	459.6	460.0 (May 2009)	-0.4	n/a
SP 08-3A (49°38.425 N, 110°15.420 W)	June 7, 2008	437.2-440.7	461.9	Not operational	444..4 (June 2008)	n/a	443.7 (Sept. 2008)	n/a	n/a
SP 08-3B (49°38.425 N, 110°15.420 W)	June 7, 2008	454.1-457.4	461.9	Not operational	454.6 (June 2008)	n/a	454.2 (Sept. 2008)	n/a	n/a
SP 08-4A (49°38.416' N, 110°15.400' W)	June 7, 2008	445-448.3	463.3	Operational	450.7 (June 2008)	450.1	450.1 (May 2009)	0	n/a

INSTRUMENT TIP SERIAL NUMBER AND COORDINATES (LATITUDE AND LONGITUDE)	DATE INITIALIZED	SENSING ZONE ELEVATION RANGE *or* TIP ELEVATION* (m)	GROUND ELEVATION* (m)	CURRENT STATUS	MAXIMUM PIEZOMETRIC ELEVATION (m)	CURRENT PIEZOMETRIC ELEVATION (m)	PREVIOUS PIEZOMETRIC ELEVATION (m)	CHANGE IN CALCULATED EQUIVALENT GROUNDWATER ELEVATION SINCE PREVIOUS READING (m)	PORE WATER PRESSURE RATIO (r_u)
SP 08-4B (49°38.416' N, 110°15.400' W)	June 7, 2008	458.7-461.9	463.3	Operational	460.9 (June 2008)	459.4	459.2 (May 2009)	-0.2	n/a
SP 08-5A (49°38.404' N, 110°15.384' W)	June 7, 2008	450.4-453.7	465.6	Operational	455.7 (June 2008)	454.9	454.8 (May 2009)	+0.1	n/a
SP 08-5B (49°38.404' N, 110°15.384' W)	June 7, 2008	461-464.4	465.6	Operational	463.3 (June 2008)	463.1	462.2 (May 2009)	+0.9	n/a
"Area B"									
PP08-1 upper tip (serial no. 61209) (49°38.648' N, 110°15.635' W)	September 26, 2008	422.2	429.7	Operational	423.3 (Sept. 2008)	n/a (zero pressure)	n/a (zero pressure, January 2009)	n/a	n/a
PP08-1 lower tip (serial no. 61314) (49°38.648' N, 110°15.635' W)	September 26, 2008	416.4	429.7	Operational	416.5 (May 2009)	416.4	416.5 (May 2009)	-0.1	0

*Relative to assumed site benchmark.