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Karl Engineering Consultants Ltd.

File: 2008-1002a (Site Summary) (GP#28) Date: April 2009

BRIEF SITE SUMMARY AND RISK ASSESSMENT

(Updated from a previous July 20, 2004 Summary)

1. Site (GP#28) Hwy 43:14 Two Creeks
2. Reference Location along Highway Hwy 43:14 Two Creeks
3. Legal Description Section 27, Twp 61, Rge 16, W5M
4. UTM Coordinate N 6,017,009 E 544,358
5. AT File
6. Alberta Transportation Plan and Profile
7. General Description of Instability

The sliding movement of roadway occurred (at the top of the Two Creek valley slope) along the new eastbound lane which was the new grade construction for 2000 twinning of highway. The pavement construction was completed around 2001. Cracking of pavement was first observed around 2001 to indicate the sliding of fill which movement manifested around 2003 to require remediation.

Around 2004, the investigation results indicated that high groundwater pore pressure and seepage flow were assessed the main cause of sliding, as well as that the twinning alignment was located at a relic slide area of the Two Creek valley slope. From instrumentation monitoring results (3 SIs), slide movement was observed and assessed at about 12 to 14m depths (around Elevation 836m) (possibly at creek elevation) along the highway sideslope R/W area. With reference to highway elevation, the slide movement depth zone was estimated at about 19m depth below highway EBL (about Elevation 855m). The toe area of slide remains to be investigated to determine whether the slide may be daylighting at creek level along toe of valley slope (i.e. at about 170m offset from highway EBL centerline) where a scouring meandering bend of creek channel is located.

In Fall 2003, the remedial measures of subsurface drain was constructed (2.5m to 3.5m depths) to top of bedrock (weak sandstone/clayshale) along the median ditch to depress and intercept the adverse groundwater flow. Manholes were installed along median ditch at intermediate points of the subdrain. Apparent, the subsurface drain measure was installed as a temporary measure to relieve the adverse effect of seepage and observe its effectiveness as a 1st stage remediation approach.

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From 2004-2008, the site was observed to have not deteriorated since the 2003 installation of subdrain. However, due to strong adverse presence of groundwater seepage flow and deep movement zones monitored, a level of reactivation of distress is anticipated. A recent summary of 2008 site conditions was noted in 2008 Slide Tour.

Recent observation in 2008 Slide Tour:

Along the eastbound lane

- Slope indicator data indicate a creep type rate of movement (5mm per year) over last 5 years (2003-2008). However, future acceleration of movement can be expected as adverse seepage groundwater conditions prevail at this site.
- Pavement cracking and undulation of pavement from previous slide headscarp has apparently started to reappear. The cracking has subsided during the previous 2 years (2004/2006) of inspection, apparently due to a relief of pore pressure and drying of subgrade, resulted from the installation of subdrain along the median ditch.
- Some tension cracks have started to reflect through the pavement.
- Some of the cracks may be apparent relic cracking from installation of lateral drains below the pavement.

Along the median ditch
(Same as in previous year (2006) observation):

- About 80m length of median ditch erosion was observed along the subgrade soils of weak fractured sandstone which is located at shallow depth and close to surface. Very wet ground and seepage exit can be assessed along this median ditch area showing signs of internal erosion of subgrade soil due to strong groundwater seepage exit gradient. At selective locations, AT maintenance forces has started to lay riprap stone lining to minimize further erosion.
- Active water flow was observed at bottom of manholes indicative of effective functioning of subdrain along the median to intercept and depress the shallow groundwater and to relieve the high pore pressures. A steady flow of groundwater was collected by subdrain and outfalled through a centreline culvert towards the south riparian areas.

8. Date of Initial Observation

   - 2001. At about 1 year after completion of twinning and pavement construction of the eastbound lane

9. Date of Recent Observation

   - 2008 July (2008 Slide Tour)

10. Instrumentation Installed

    Refer to previous Thurber Report (November 10, 2003 Ref: 15-16-158) for quantities.
    3 to 4 Slope indicator
    5 to 8 standpipe piezometers

11. Instrumentation Operational

Hwy	Site		Instrument			Remarks
GP-28	43:1 2	Two Creeks	SI#02-1, 02—2* Piezometer # 02-5, 02-7, 02-8	2	3	*not operational

11.1 Instrumentation Monitoring Result Update

Current (2008) monitoring of the only remainder operational slope indicator (SI02-01) at the road shoulder sideslope edge indicated slow (creep type) movement rate of around 5mm per year. (5 year duration after the installation of sub-surface drains in late 2003).

From the 2008 Fall Cycle Instrumentation Monitoring Report, it can be noted that:

SLOPE INDICATOR:
The slope indicator (SI02-01); still operational, the recent increase in rate of movement can be noted as:

Movement Rate	Period	Remarks
• 24mm per year	2002 to late 2003	before installation of sub-drain
• 5mm per year	late 2003 to fall 2008	after installation of subdrain a 25mm cumulative movement over a 5 year duration

STANDPIPE/PIEZOMETERS

- For the standpipe reading, it is apparent that the water level has risen 1-2m to re-establish at the same level as pre- 2002 prior to installation of subsurface drains.
- The installation of subsurface drain has resulted, at best, a 1-2m drop of water level which is (i) normally monitored at 2-4m depth below ground surface (median ditch) at most monitored locations; (ii) and can rise to as high as 1m depth below grade at one location (SP02-07).

As can be observed on site, it should be realistic to recognize the intercepted groundwater flow is so vast that the outflow is actually a substantial spring outflow. Thus, a re-surge of water level to a previous level can be randomly occurring.

GROUNDWATER REGIME ASSESSMENT AND RELATED MOVEMENT

- It is realistic to recognize that the shallow depths of subdrains (2003 installation) can only function for a while on lowering pore pressure condition for the distressed slide area thus functions to enhance drying of the wet subgrade conditions to a shallow depth. It pragmatically allowed a tightening of the immediate subbase soils so that previous crack will not be readily reflected back. Thus, a slowing down of slide movement (which actually was monitored to occur at 12m to 14m depths, and possibly daylighted at creek level) remains to be undertaken in a 2nd stage remediation investigation.

- It is realistic to accept that the subdrain has served its temporary purpose of relieving pore pressure at shallow depth and the groundwater surge. It will be cautious to observe when a rise of water level will start to reactivate slide movement again.

12. Risk Assessment

PF (9) * CF (5) = 45

PF = 9

- Movement is still active with a slow creep rate (5mm per year)
- Groundwater level is apparently re-surging up in a cyclic manner to similar levels prior to subdrain installation
- Headscarp and tension cracking is slowly reflecting back through the pavement with some pavement subsidence, and contortion is slowly becoming evident. As of summer 2008, the level of obvious distress seemed to not be adversely affecting pavement serviceability level.

CF = 5

- Partial closure of roadway in event of site deterioration
- Pavement patching as required

Note:
The risk assessment is provided based on a categorization of Hazard Probability Factor (PF) and Consequence Factor (CF) as provided by AIT's RFP 2000.

PF 1 to 20 scale
CF 1 to 10 scale

13. Geotechnical Conditions

The site is a sidehill cut/fill embankment situated on the lower portion of the east valley slope of the Two Creeks Valley. Bedrock was exposed and intercepted by this highway twinning construction across the Two Creeks Valley, especially along the median ditch.

From published information of the area:

- The bedrock stratigraphy is the Paskapoo Formation: grey to greenish grey, thick-bedded, calcareous, cherty sandstone; grey to green siltstone and mudstone; minor conglomerate, thin limestone, coal, and tuff beds; non-marine.
- The bedrock elevations in the vicinity of the site vary between Elevation 820 and 860 m, and the surficial elevations range between Elevation 835 and 915 m, suggesting that the site may intercept the bedrock stratigraphy.

14. Chronology

2000	Twinning construction of highway eastbound lane (along south side of old 2 lane roadway). The twinning has dispositioned the twinning area onto a relic slide zone of the valley slope. Strong groundwater seepage exit was prevailing at the valley slope area. The grading work entailed placement of sidehill fill up the creek valley slope incurring a blockage of groundwater exit into the valley riparian zones.
2001	Cracking of pavement noted at about one year after completion of pavement and traffic operations.
2003	Investigation of this site by Consultant Engineer

Thurber Consultants carried out the investigation and instrumentation monitoring of site. Provided recommendation on subdrainage measures and improvement drainage to subbase.

2004 Installation of subsurface drain (to shallow depths of 2.5m 3.5m) along median ditch.

2005-08 Improvement from subdrain is apparent but stabilization of slide still remains to be carried out

- Site deterioration not apparent. Level pavement cracking has been observed as slow. Drastic deterioration of this site not apparent.
- The existing 1st stage remediation subdrain is considered only partially effective and it is appropriate that a 2nd stage remediation of the slide should be investigated when site deterioration occurs.
- It will be appropriate that a 2nd stage investigation should entail a detailed site reconnaissance, aerial photo review, survey, and additional instrumentation for understanding of the slide movements.
- In the interim, visual inspection and monitoring existing instrumentation should be continued.

END

LANDSLIDE RISK ASSESSMENT **date: September 2006**
SITE SUMMARY

1) **SITE:** **GP-28**
Hwy 43:12 Two Creeks

2) **REFERENCE LOCATION** along Highway:
Hwy 43:12 @ Km 34.9 at Eastbound Lane at approxi. 0.5km east of Two Creek Box Culvert
Site Location is presented in Figure 1.

3) **LEGAL DESCRIPTION:** SW27-61-16-W5M

4) **UTM COORDINATE:** N54.301201 E-116.319013

5) **AI FILE:** None

6) **AI PLAN AND PROFILE:**

N/A

7) **GENERAL DESCRIPTION OF INSTABILITY**

Instability of the fill embankment developed (2000/2001) along the eastbound lane at the top of the Two Creek valley slope. Cracking of pavement was observed around 2001 approximately 1 year after twinning completion (i.e. the new eastbound lanes). The road instability was caused by fill surcharge over a dormant slide area along the Two Creeks valley slope. The valley slope area of this crossing was infested with shallow groundwater and high seepage conditions. In Fall 2003, the remediation measure comprising subsurface drains was constructed along the median ditch to intercept groundwater flow and to dissipate pore water pressure along the slip plane areas. Bedrock can be located at shallow depths (1-4m) below median ditch. According to AIT records, approximately 300m of subsurface drains were installed to a 4m depth zone along the median ditch. The intercepted groundwater was piped (through a culvert) below the eastbound lane to outflow to the Two Creeks riparian area to the south.

Instrumentation, including slope indicators and standpipe piezometers, were installed for investigation and monitored. The site location is presented in Figure 1.

8) **DATE OF INITIAL OBSERVATION:**

2001

9) **DATE OF LAST INSPECTION:**

June 2006 (2006 Annual Slide Tour)

- No apparent recurrence of past cracking and settlement of pavement
- Substantial flow of shallow groundwater intercepted and depressed in the subsurface drains
- Highway eastbound lane (previously affected by slide) performing well

10) **INSTRUMENT INSTALLED:**

Instrument	Installed*	Operational**	Remarks
Slope Indicators (SI)	3	2	*SI02-01, 02-02, 02-03 (SI02-03 sheared-off)
Standpipe Piezometers (SP)	8	5	*SP02-01, 02-03, 02-05, 02-07, 02-08 (SP02-02, 02-04, 02-06 damaged)

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11) INSTRUMENT OPERATIONAL:

SI: 2
SP: 3

12) RISK ASSESSMENT:

PF (9) * CF (4) = 36

- **PF = 7**
  - Inactive and decreasing rate of settlement and lateral movement of roadway embankment for past 2-3 years.
  - As groundwater seepage flow has been intercepted by subsurface drains and high pore pressure conditions alleviated, the anticipated rate of movement in the future should be slow. The failure was mainly caused by adverse groundwater conditions. As slip planes were of gentle inclinations along bedrock (sandstone/clayshale) interfaces, the probability of catastrophic failure will be unlikely.
  - To minimize possibility of future reactivation of movements, the maintenance requirement on flushing of subdrain should be undertaken to ensure non-blockage and free-flowing of the subdrain. Thus, the possibility of slide reactivation will be low when the subdrains are well maintained.
- **CF = 4**
  - In future event of abrupt reactivation of sliding to affect the eastbound lanes, partial closure of road may be possible. The traffic can be detoured to the westbound lanes when necessary to allow emergency repairs.
  - The presence of shallow bedrock will confine this slide to shallow-seated movement if drainage of groundwater is to be maintained by ensuring functioning of the subsurface drains.

Note: This Risk Assessment rating is based on Scheme proposed by AI in the Request for Proposal. (2000)

Probability Factor (PF) :	1 to 20 scale
Consequence Factor (CF)	1 to 10 scale

13) GEOTECHNICAL CONDITIONS

- The site is close to crest of the Two Creeks valley slope and probably triggered by highway fill surcharge along a dormant slide area.
- The site was infested with shallow groundwater table and strong seepage along the soil interfaces of overburden/bedrock (soft shale/sandstone strata) which can be located at shallow to intermediate depths of 1-4m depths below the median ditch.

14) CHRONOLOGY

- 1999-2000 construction of fill embankment for highway twinning across the Two Creeks Valley
- 2001 (1 year after twinning completion), instability of embankment fill for the new twinning observed.
- 2002 Installation of subsurface drainage along median ditch as slide remedial measures.

- END -

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ALBERTA TRANSPORTATION LANDSLIDE RISK ASSESSMENT

SECTION A: GEOTECHNICAL FILE REVIEW

NORTH CENTRAL REGION

SITE NC26: TWO CREEKS

LEGAL LOCATION:	**SW27-61-16-W5M**
NEAREST LANDMARK:	**47 KM WEST OF WHITECOURT**
Highway Control Section:	**HWY 43:12 km 34.82**
Date of Initial Observation:	**2001**
Date of Last Inspection:	**2004**
Last Inspected By:	**Thurber Engineering Ltd. (Thurber)**
Instruments Installed:	**3 Slope Inclinometers (2002), 8 Standpipe Piezometers (2002)**
Instruments Operational:	**2 Slope Inclinometers (2004), 6 Standpipe Piezometers (2004)**
Risk Assessment:	PF(9) · CF(6) = **54**
Last Updated:	July 2004 – Thurber Engineering Ltd.