THURBER ENGINEERING LTD.

ALBERTA TRANSPORTATION GEOHAZARD ASSESSMENT

SECTION A: GEOTECHNICAL FILE REVIEW

PEACE RIVER/HIGH LEVEL REGION

SITE: PH2 EAST HILL (2+280 SLIDE)

LEGAL LOCATION:	SE28-083-21 W5M
AT CONTROL SECTION:	HWY 2:60
NEAREST LANDMARK:	Peace River; 2.3 km southeast of Grouard Trail overpass.
DATE OF INITIAL OBSERVATION:	May 30, 2007
DATE OF LAST INSPECTION:	May 27, 2008
LAST INSPECTED BY:	Thurber Engineering Ltd.
INSTRUMENTS INSTALLED:	None
INSTRUMENTS OPERATIONAL:	N/A
RISK ASSESSMENT:	PF(9) * CF(4) = 36
LAST UPDATED:	Thurber Engineering Ltd. October 2008

1. INTRODUCTION

This section is a review of files made available by Alberta Transportation specifically pertaining to conditions at the referenced geohazard site. This review is based on a compilation of previous Part 'A' Reviews and Part 'B' Site Inspections from 2001 to 2008, as well as relevant information from Part 'F' Plans and Part 'G' Site Documentation. Published geological and geotechnical information was also used to supplement the report.

Highway 2 descends into the Town of Peace River by traversing the northeast valley slope of the Heart and North Heart River Valleys which meet the Peace River in the townsite. The Peace River Valley at this location is approximately 220 m deep. Landsliding is widespread in this area and the highway has been affected by numerous large instabilities since construction in 1965-67. The largest of these slides have been identified as Sites 1 to 4, inclusive. Numerous other slope inabilities and erosional hazards also exist.

2. DESCRIPTION OF GEOHAZARD

At Station 2+280, a shallow instability exists within the fill on the downslope side of the highway (Figure 1). The slide is approximately 20 m across and has a rupture surface estimated to be less than 2 m deep. The headscarp of the slide is approximately 2 m from the guardrail and several communication cables have been severed by this slope movement.

3. GEOLOGICAL AND GEOTECHNICAL CONDITIONS

3.1 Physiographic Setting

The study area is located within the Peace River Lowland physiographic region.

3.2 Bedrock Geology

According to Hamilton et al. (1999), the Heart and Peace River Valleys cut through several bedrock sequences and the following bedrock groups underlie portions of the general study area from the upland level to river level:

- Dunvegan Formation (Kd): grey, fine-grained, feldspathic sandstone with hard calcareous beds; laminated siltstone and grey silty shale; deltaic to marine.

- Shaftesbury Formation (Ksh): dark grey fish-scale bearing shale, silty in upper part; numerous nodules and thin beds of concretionary ironstone; bentonite partings; lower part with thin silty and sandy intervals; marine.
- Peace River Formation (Kp): dark grey silty shale; fine-grained glauconitic sandstone, silty interbeds in lower part (Harmon Member); fine-grained quartzose sandstone (Cadotte Member); shoreline complex.

Bedrock is exposed on the lower portion of the valley slope along much the Heart and North Heart Rivers below Highway 2 (Figure 1).

3.3 Surficial Geology

The east valley wall of the Peace River Valley and the north valley walls of the Heart and North Heart Rivers are covered with colluvium (i.e. landslide terrain) that is derived from the upland glaciolacustrine materials and the underlying soils and bedrock. The lacustrine deposits are complex and consist of layers of clay, silt and sand, and overlie clay till and, locally, sand and gravel.

These lacustrine deposits are believed to be pre-glacial in origin and have been only partially eroded by the present day Peace, Heart and North Heart Rivers, leaving much of this material exposed in the valley walls.

3.4 Stratigraphy

The slide at Station 2+280 is contained completely within road fill. It is believed this road embankment is likely comprised predominately of fine grained local material either of glaciolacustrine or clay till origin. Soil exposed within the rupture surface was a medium to high plastic clay.

4. CHRONOLOGY

General

1965	Construction of present day roadway.
1967	Development of four large landslides within areas of large road fills.
1996/97	Began off loading backslope of Sites 1, 3 and 4.

Site Specific

2004 First observation of minor soil creep about 20 m from the 2+280 Slide.

2007 Shallow instability occurred at 2+280. Rupture surface estimated less than 2 m deep and headscarp about 2 m from guardrail.

2008 No further retrogression of scarp or lateral extent of slide, although ongoing movement of the slide mass has occurred since 2007.

REFERENCES

Alberta Transportation, Miscellaneous In-House Files, Various Dates

AMEC Earth & Environmental Limited, Part A: File Review – Site PH2 Peace River East Hill, 2000.

AMEC Earth & Environmental Limited, Part B: Site Visit – Site PH2 Peace River East Hill, 2001.

AMEC Earth & Environmental Limited, Part B: Site Visit – Site PH2 Peace River East Hill, 2002.

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Fox, J.C.; Richardson, R.J.H.; Gowan, R.; Sham, P.C., Surficial Geology of the Peace River - High Level Area, Alberta, Alberta Geological Survey, Map 2005 1987.

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Thurber Engineering Ltd., Peace Region (Peace River/High Level) Geohazard Assessments – Peace River East Hill Sites (PH2) – 2004 Annual Inspection Report, 2005.

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ALBERTA TRANSPORTATION GEOHAZARD ASSESSMENT

SECTION A: GEOTECHNICAL FILE REVIEW

PEACE RIVER/HIGH LEVEL REGION

SITE: PH2 EAST HILL (0+670) ELEPHANT TRUNK DRAIN

LEGAL LOCATION:	NE29-083-21 W5M
AT CONTROL SECTION:	HWY 2:60
NEAREST LANDMARK:	Peace River; 0.67 km southeast of Grouard Trail overpass.
DATE OF INITIAL OBSERVATION:	1996
DATE OF LAST INSPECTION:	May 27, 2008
LAST INSPECTED BY:	Thurber Engineering Ltd.
INSTRUMENTS INSTALLED:	None
INSTRUMENTS OPERATIONAL:	N/A
RISK ASSESSMENT:	N/A (Classified as an Erosional Hazard)
LAST UPDATED:	Thurber Engineering Ltd. October 2008

1. INTRODUCTION

This section is a review of files made available by Alberta Transportation specifically pertaining to conditions at the referenced geohazard site. This review is based on a review of the last Part 'A' Review by AMEC dated November 2000, Part 'B' Site Inspections from 2001 to 2008, as well as relevant information from Part 'F' Plans and Part 'G' Site Documentation. Published geological and geotechnical information was also used to supplement the report.

Highway 2 descends into the Town of Peace River by traversing the northeast valley slope of the Heart and North Heart River Valleys which meet the Peace River in the townsite. The Peace River Valley at this location is approximately 220 m deep. Landsliding is widespread in this area and the highway has been affected by numerous large instabilities since construction in 1965-67. The largest of these slides have been identified as Sites 1 to 4, inclusive. Numerous other slope instabilities and erosional hazards also exist.

2. DESCRIPTION OF GEOHAZARD

The geohazard at 0+670 is an erosional hazard which originally developed from large runoff volumes from a road culvert under Highway 2 being directed onto the slope below the highway and allowed to discharge directly over a rock cliff to the Heart River below (Figure 1). This runoff erosion was originally mitigated by the installation of a large corrugated Big 'O' drain pipe referred to as an Elephant Trunk Drain. The drain was successful in directing flow away from the eroding ravine; however, because of defects in the design/materials/installation the drain leaked significantly resulting in new erosional problems and local slumping.

As with many of the erosional hazards along the East Hill of Highway 2, by themselves they do not pose an immediate threat to the highway. However, as overall slope stability is generally quite low, large erosion can often trigger future landslide events. Consequently, these hazards do not lend themselves well to the slope geohazard classification system outlined by AT, but their monitoring is an integral part of the overall hazard inspection/assessment process.

3. GEOLOGICAL AND GEOTECHNICAL CONDITIONS

3.1 Physiographic Setting

The study area is located within the Peace River Lowland physiographic region.

3.2 Bedrock Geology

According to Hamilton et al. (1999), the Heart and Peace River Valleys cut through several bedrock sequences and the following bedrock groups underlie portions of the general study area from the upland level to river level:

- Dunvegan Formation (Kd): grey, fine-grained, feldspathic sandstone with hard calcareous beds; laminated siltstone and grey silty shale; deltaic to marine.
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Bedrock is exposed on the lower portion of the valley slope along much the Heart and North Heart Rivers below Highway 2 (Figure 1).

3.3 Surficial Geology

The east valley wall of the Peace River Valley and the north valley walls of the Heart and North Heart Rivers are covered with colluvium (i.e. landslide terrain) that is derived from the upland glaciolacustrine materials and the underlying soils and bedrock. The lacustrine deposits are complex and consist of layers of clay, silt and sand, and overlie clay till and, locally, sand and gravel.

These lacustrine deposits are believed to be pre-glacial in origin and have been only partially eroded by the present day Peace, Heart and North Heart Rivers, leaving much of this material exposed in the valley walls.

3.4 Stratigraphy

The general soil/bedrock stratigraphy at the Elephant Trunk Drain site consists of predominantly clayey soils from the elevation of the Highway 2 roadway overlying bedrock which is exposed in the valley wall and corresponds to the steep break in slope gradient on the lower portion of the valley wall.

4. CHRONOLOGY

General

1965 Construction of present day roadway.

1967 Development of four large landslides within areas of large road fills.

1996/97 Began off loading backslope of Sites 1, 3 and 4.

Site Specific

1996/97 Installation of original 920 mm diameter Big 'O' corrugated Elephant Trunk Drain. The drain alignment bypassed a steeply eroding ravine that had been cut into the rock face. Local runoff into this feature was blocked and diverted down the current Elephant Trunk Drain alignment.

1996 – 2003 Degradation of original Elephant Trunk Drain continued, including failed couplings and leaky joints.

2003 Major repairs undertaken to Elephant Trunk from the rock slope down to the river level including the installation of a concrete anchor block, a segment of welded HDPE pipe and an outlet structure. Repair works identified in Part 'B' inspection reports were noted as being deficient and concerns existed regarding the integrity of the pipe and slope.

2003 – 2007 Degradation of original Elephant Trunk Drain section and repaired areas continued through this time period.

2007 Entire Elephant Trunk Drain replaced by a new welded HDPE drain placed on surface along approximately the same alignment as

original drain. Construction of new outlet structure (facing downstream) and restoration of eroding slope segments.

2008 Remediation measures installed in 2007 were generally in satisfactory condition. Local erosion and breach of erosion control products on lower steep rock slope were noted and recommendations for maintenance and repair provided to AT.

REFERENCES

Alberta Transportation, Miscellaneous In-House Files, Various Dates

AMEC Earth & Environmental Limited, Part A: File Review – Site PH2 Peace River East Hill, 2000.

AMEC Earth & Environmental Limited, Part B: Site Visit – Site PH2 Peace River East Hill, 2001.

AMEC Earth & Environmental Limited, Part B: Site Visit – Site PH2 Peace River East Hill, 2002.

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Fox, J.C.; Richardson, R.J.H.; Gowan, R.; Sham, P.C., Surficial Geology of the Peace River - High Level Area, Alberta, Alberta Geological Survey, Map 2005 1987.

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PART A: FILE REVIEW
LANDSLIDE RISK ASSESSMENT
PEACE REGION (PEACE RIVER VALLEY/HIGH LEVEL)

SITE PH2 PEACE RIVER EAST HILL

LEGAL LOCATION:	28-83-21-W5M
Location along Highway:	Station 1+800, Grouard Trail crossing is 0+000
AI FILE:	H2:60
Date of Initial Observation:	1984 failure at Site 2
Date of Last Inspection:	1999
Instruments Installed:	numerous slope inclinometers
Instruments Operational:	slope inclinometers: Site 1: 3, Site 2: 18; Site 3: 8, Site 4: 3
Risk Assessment:	PF(9) * CF(4) = **36**
Last Updated:	AMEC Earth & Environmental Limited November, 2000

INTRODUCTION

This section is a review of files for the site made available by Alberta Infrastructure. The file review was prepared prior to the site visit. The description of the sites is based on the information that was present in the file, topographical and geological information was added if it was not present in the file and if the site was familiar, previous observations were also included.

A risk assessment, solely based on the file review is provided. The risk assessment may change once the observations made during the site visit are incorporated.

Highway 2 approaches the Town of Peace River from the southeast. As the road descends from prairie level to the Peace River, it follows the valleys of a tributary of the Heart River and then the Heart River itself. The valley is 220 m deep. Landslides have been common along this stretch of highway since its construction in 1965-67. It is reported that there were four areas where large fills (up to 20 m fill thickness) were constructed. The fills were constructed with slopes between 2H:1V and 3H:1V.

In the past few years, there has been slide activity in five areas (see Figure 1). Four of these slides are large, they are typically two hundred metres wide or more and extend from near the crest of the valley to the bottom of the valley. The fifth area was a relatively small slide, apparently where the road was in fill.

Remedial measures have already been implemented over the past four years at Sites 1 (Station 2+600), 3 (Station 1+000) and 4 (Station 0+000), where soil was removed from the backslope (uphill of the highway) to unload the slide mass. Since removal of material from the backslope, slide movement appears to have slowed down considerably. Thus, Sites 1, 3 and 4 are considered inactive. A pile wall was constructed at the fifth slide area, located to the south of Site 1 (at Station 3+400), this site is also considered inactive. At Site 2 (Station 1+800), no remedial measures have been implemented beyond removal of material uphill of the road, this site is considered active.

GEOTECHNICAL CONDITIONS

Highway 2 is constructed on the edge of an infilled pre-glacial valley, which is located to the west of the site. The valley is infilled with lacustrine clay, underlain by till and locally sand and gravel layers.

Along the highway, the soil conditions consist of clay fill (derived from lacustrine clay and clay till) overlying lacustrine clay, clay till, sand and gravel, followed by clay shale and sandstone of the Shaftsbury formation. The clay fill is medium to high plastic. It was derived from cuts along the highway. According to documents in the file, its moisture content at the time of placement was probably wet of optimum, and it was compacted to 100 % of SPMDD. The lacustrine clay is medium to high plastic; it may contain silt and sand layers. The clay till is medium plastic, silty, sandy clay with pebbles. Sand and gravel beds were encountered at the base of the till in some of the boreholes. The clay shale and sandstone are of the Shaftesbury formation. The clay shale is high plastic and its strength tends to reduce to low residual values.

Boreholes drilled at Site 1 indicate clay shale at 5 to 17 m, boreholes drilled at Site 3 indicate clay shale at 8 to 14 m and a borehole drilled at Site 4 indicates clay shale at 5 m.

The water table in the area of the slides appears to have been high. At the time of construction of the road, granular drainage blankets were incorporated at the base of the fills.

Borehole information collected during installation of the numerous slope inclinometers after 1994 is not available. The borehole logs that are available do not differentiate fill from native material.

Slope instabilities were encountered at four main sites along the alignment. At Sites 1 and 3 the surface of rupture appears to have been in clay shale. At Site 4 clay shale was not encountered in the borehole, and the slope inclinometer records do not indicate a clear shear zone.

CHRONOLOGY

Table A1 provides the chronological background of the various sites.

Station 1+800 Site 2

Description of Instability

At Site 2, the highway is located approximately halfway up the valley slope. It was constructed in cut and fill. Based on the air photos, prior to construction of the highway, at Site 2 there was a large slide that extended from the valley crest to the Heart River. The overall valley slope at Site 2 is inclined at approximately 14 degrees.

In 1984, a failure uphill of the highway occurred, which spilled onto the highway at Site 2 and appears to have displaced the highway downhill several metres. The current slope instability is deep-seated uphill of the highway (based on slope inclinometer data), getting thinner at the highway elevation. A cross section at Site 2 is presented in Figure 2. Downhill of the road, the failure appears to be parallel with the surface. Slope inclinometers installed in the vicinity of the highway do not clearly indicate shear movement.

After the 1984 failure, a large volume of material was removed uphill of the highway. It is not clear whether the lower slide and the upper slide are still connected.

Observations regarding the presence of cracks, scarps and a toe are not present in the file.

Past Investigations

Prior to construction of the road, in 1964, a number of boreholes were drilled along the alignment. Only two logs are in the file.

A photograph of the 1984 failure is in the file. No other information regarding this failure is in the file.

It is our understanding that 18 slope inclinometers were installed in 1996 at Site 2. Only brief descriptions of the soil conditions are available, detailed borehole logs are not in the file.

Remedial Measures

After the 1984 failure, a large volume of material was removed uphill of the road. It appears that the road would have been reconstructed at the time, but there are no records of the repairs in the file.

In 1999, GAEA proposed removal of approximately 100,000 m^3 of additional material from the area uphill of the road at an estimated cost of $ 908,000. This work was not undertaken.

Monitoring Results

Slope inclinometers installed uphill of the road, near the top of the valley, registered shear movement at depth; slope inclinometer 65 registered movement at 24.5 m and slope inclinometer 71 registered movement at 30.5 m (at a rate of 56 mm per year in 1996) and slope inclinometer 77 registered movement at 20 m.

Slope inclinometers installed uphill of the road, halfway up the uphill slope, registered shear movement at shallower depth than those that were near the top of the valley. Slope inclinometer 66 registered movement at 11.5 m and slope inclinometer 72 at 10 m (at a rate of 34 mm per year in 1996) and slope inclinometer 76 registered movement at 14 m.

Slope inclinometers installed in the direct vicinity of the road registered shallow movement or only surficial creep. Slope inclinometer 67, 73 (at a rate of 30 mm per year in 1996-97), 74, 79 and 80 registered surficial creep only, slope inclinometer 75 did not register any movement and slope inclinometer 68 registered shear movement at 2.5 m.

Slope inclinometers installed well downhill of the road registered shear movement. Slope inclinometer 76 registered shear movement at 14 m (at a rate of 14 mm per year) and 82 at 12 m.

Generally, the rates of slope movement were high during 1996 and 1997, but they have slowed down considerably since then.

Ten of the eighteen slope inclinometers have been destroyed or have sheared off.

Assessment

Since the slope inclinometers uphill of the road have indicated deep-seated movement, there is a risk that a backslope failure as occurred in 1984 could happen again. However, there is now a buffer zone where material was excavated so that the landslide debris may not immediately block the road.

One of the causes of the 1984 failure may have been heavy precipitation. In May 1984, precipitation was 98 mm, compared with a 30-year average of 30 mm; and in June 1984, precipitation was 121 mm, compared with a 30 year average of 60 mm.

Risk Assessment:

The probability factor is 9, a failure of the backslope, as has occurred in the past, could occur again. The consequence factor is 4, the slope is high and the previous slide required a diversion around the slide mass. The risk level is estimated at 36.