THURBER ENGINEERING LTD.

ALBERTA TRANSPORTATION GEOHAZARD ASSESSMENT PROGRAM
PART A: FILE REVIEW

PEACE REGION – PEACE-HIGH LEVEL

PH33 JUDAH HILL – TRUNK AND CNR SLIDES

Legal Location:	SE & NE¼29-083-21 W5M
Nearest Landmark:	CNR Slide is at the CN Rail crossing on Hwy 744. Judah Trunk is 700 m south of the CN Rail crossing on Hwy 744.
Highway Control Section:	Hwy 744:04
Date of Initial Observation:	1984
Date of Last Inspection:	2008
Last Inspected By:	Thurber Engineering Ltd.
Instrumentation Installed:	At least 6 Inclinometers and 4 piezometers at the CNR Slide. 2 Inclinometers and 4 Pneumatic Piezometers at Judah Trunk.
Instrumentation Operational:	No operational instruments at CNR Slide. 2 Inclinometers and 4 Pneumatic Piezometers at Judah Trunk.

Risk Assessment:

	Judah Trunk	CNR Slide
PF	5	13
CF	2	4
Risk	10	52

1. INTRODUCTION

The CNR Slide is located on the east side of Hwy 744 at the CN Rail crossing as you enter the town of Peace River from the south. The road turns westwards to cross the rail line, at the end of a spur formed where the upland has been eroded on both sides by the Peace and Heart Rivers. The slide is on the NE side of the rail crossing, moving eastwards towards the Heart River, with a roughly 50 m wide lower scarp and active zone near the river, and an upper 80 m wide scarp in gravel fill within 45 m of the ATrans pile wall.

The Judah Trunk is approximately 700 m south of the railway crossing, where drainage from the upslope ditch is taken across the road and directed down the slope in a band-coupled corrugated plastic pipe. The pipe discharges on a flatter area immediately above the rail line.

Highway 744 runs south from Peace River through Marie-Reine to Highway 683 and on to Highway 49 near Girouxville. For the first 2 km south of the town of Peace River, it climbs roughly 200 m up the valley wall of the Peace River to prairie level at elevation 545 m.

The locations of the sites are shown on Figure 1, while site details are shown on Figures 2 and 4, based on the last inspection. An illustrative cross-section through the CNR slide is given in Figure 3.

This section is a review of files made available by Alberta Transportation regarding this site, and has been conducted to update the previous Part A review, which covered all the Judah Hill sites.

2. BACKGROUND

2.1 Bedrock Geology

Based on the AGS 1:1,000,000 bedrock geology map of Alberta, the following bedrock units occur in the valley slope down to the Peace River:

- Dunvegan Formation – fine sandstone with hard calcareous beds, laminated siltstone, silty shale.

- Shaftsbury Formation – silty shale and shale, ironstone beds, bentonite partings, thin silty and sandy intervals.

- Peace River Formation – silty shale, fine sandstone, silty interbeds.

Rock is exposed locally along the Heart River upstream of the toe of the CNR slide, but none is noted at the Judah Trunk. Rock exposed in cliffs on the Heart River consists of bands of massive coarse sandstone, 5 m to 7 m thick, separated by interbedded sandstone, shale and lignite (coal) of the Peace River Formation. These rocks are overlain by dark grey, high plastic, fissured, slickensided 'clay shale' of the Shaftsbury Formation above elevation 338 m.

2.2 Surficial Geology

AGS Map 291 (Surficial geology of the Grimshaw area) indicates a local veneer of eolian sand and silt overlying glaciolacustrine fine sand, silt and clay on the upland, with mixed colluvial materials on the slopes. Coarser sand and gravel deposits have been noted in road cuts locally along Hwy 744. Preglacial sand and gravel has been mapped overlying bedrock locally, with postglacial sand and gravel terrace deposits also found at the site.

There have been a number of geotechnical investigations conducted by Alberta Transportation and CN rail at the CNR Slide. A cross-section prepared by Thurber Engineering for a report in 1988 summarising test hole information through the slide is presented on Figure 3.

2.3 Hydrogeology

The ARC 1:250,000 Hydrogeological map of Peace River does not show springs or flowing wells (mainly completed within glacial deposits) on the valley slopes in this area, though there are local springs and wells with variable yields in the valley floor. Perched aquifers are expected locally, associated with local pockets of sand and gravel. Such pockets can become confined where covered by colluvium or fill on slopes. Previous investigations have identified lower than hydrostatic or negligible pore pressures within the clay till, and an indication that the Peace River Formation sandstone acts as a drain. Both the till and the till-derived colluvium are

fissured, and contain discontinuous lenses of sand and gravel. The fissuring is expected to allow rapid infiltration.

2.4 Geomorphology

The site is below the crest of the east valley slope of the Peace River, on a ridge formed between the Peace River and Heart River valleys. Highway 744 runs down the west side of the ridge as it decreases in height and narrows northwards, towards the town of Peace River. The sides of the Peace River and Heart River valleys are characterised by extensive landslide activity. Common landslide mechanisms in this region include:

- Earthflows caused by sudden saturation of surficial material.
- Landslides with a base in the weak Shaftsbury Formation shales.
- Landslides within weak glaciolacustrine silts and clays.

At the Judah Trunk, the road is constructed in cut and fill, with a relatively steep fill slope below the downslope road shoulder. There are several older slide scarps in the uphill cutslope, with some recent near-surface slide activity. There is also cracking and surface water erosion along the downslope road shoulder. The catchment for the drain includes the upslope ditch southwards through the Makeout and Michelin slides and as far as the Lookout site. The drain is a similar band-coupled corrugated plastic pipe used at the East Hill drain (PH2) and the Dunvegan Elephant Trunk (PH36), both of which have experienced problems with coupling failure and leakage. Immediately south of the trunk down-drain is a deeply eroded gully where drainage was presumably previously directed.

The CNR Slide is located on a spur created between the Heart River and Peace River valleys. The spur is rock-cored, but overlain by till, colluvium and other pre-glacial and post-glacial deposits. On the east side of this spur, the Heart River takes a sharp turn northwards at a rock cliff on the west side of the valley. The river appears to carry large amounts of sediment, and over the past four years of inspections has undergone noticeable changes in bed elevation and channel character. Since 2006, presumably due to increased upstream bed depth, the

main channel has shifted towards the base of the CNR Slide, having inundated a rip rap berm at the base of the slope.

3. HISTORIC INFORMATION

3.1 Summary

The CNR Slide has been the focus of much work by both Alberta Transportation and CN Rail, with CN's involvement being earlier as evident from test hole investigations and remedial works from the 1970's. ATrans became involved shortly after the gravel road was re-graded and first paved, and shortly after a period of heavy rain. A number of attempts by CNR to stabilise their grade in 1984 were unsuccessful, and a 25 m high stabilising berm was constructed at the toe of the slope in early 1986. Failure of the SE flank of this berm in early 1987 propted further investigation by CNR and ATrans and installation of horizontal drains within the slide mass. These drains were subsequently sheared off by continued slide movement. Movement of the slide mass continued through 1988.

In August 1988, ATrans installed a concrete pile retaining wall along the centreline of the road at that time, consisting of 36 un-supported 0.76 m diameter augered piles. Records indicate that the pile wall terminates above rock, and above the level of the proposed shear plane. Design calculations and installation records for the original pile wall are on file. Pump tests were conducted in four wells at the east end of the wall where seepage and sloughing were noted during pile installation. In May 1989, a series of 14 gravel-filled piles were constructed in front of the concrete pile wall, with two pumping wells in order to de-water the ground. Further significant movement of the slide occurred in the summer of 1989, resulting in exposure of the front of the concrete pile wall, prompting emergency repair work consisting of tie-back anchors and additional piles. There are no design calculations or installation records for the tie-back anchors or additional piles on file. CNR relocated their rail line again.

From 1990 through 1992, additional subsidence was noted in front of the ATrans and CNR walls, culminating in rotation of the CNR solider pile wall. Both ATrans pumping wells had dried up by this point. Some of the tie-back anchors for the ATrans wall had sheared by this point, and additional anchors were proposed. In December 1992, CNR constructed two levels of shear key in the slope below the

rail line. However, movements at the slide continued to be observed until at least September 1994.

From late 1994 until early 2003, changes in the slide appear to have been minor, or not as well documented. In April 2003, erosion of the toe berm by the Heart River was noted. Further erosion and reactivation of slide movement occurred in early 2007 and continued in 2008 at the time of the last inspection.

The only records related to the Judah Trunk are a note of its installation in May 1999.

3.2 Chronology

June 1979	CNR installs 6 water wells to allow pumping, and 3 test holes for slope and groundwater monitoring.
May 1984	Hwy 744 first paved. CN reported track subsidence and tension cracks appearing within 1 week of the road being paved. Record rainfall reported in May – July 1984.
June 1984	Up to 0.3 m of track subsidence reported. CN attempts to drive piles to support the grade – abandoned due to excessive movements.
July 1984	Rail grade and road crossing realigned. Cracks visible in the pavement shortly after realignment, and timber piles on east side of track deforming.
Autumn 1984	Completion of a further realignment of rail grade and road crossing.
1985	Progressive movement of slide monitored during 1985. CN Rail initiates work on stabilising berm at the toe of the slope.
Spring 1986	CNR stabilising 25 m high berm completed.
1986	ATrans drilled test holes AT86-1 through AT86-7. CNR drilled test holes 20 through 27. No records on file.
April 1987	Portion of SE flank of stabilising berm failed. Subsequent investigations indicate movement is still occurring below the stabilising berm. Five horizontal drains installed in slide mass.
September 1987 to	Geological assessment of landslide by K.W. Savigny.

May 1988	Compilation of previous test hole data, examination of air photos and exposures, discussion with CNR, ATrans, Town of Peace River and Groundwater Division of AEnv.
June 1988	Continued movement of slide, beginning to constrict Heart River. Flow observed from horizontal drains and seepage from gravel berm below. Liner being installed along 600 m of the road ditch. North-bound lane of road dropped 75 mm in one week.
August 1988	Drilled pile wall constructed to 20 m depth – 36 piles installed. Note in 1990 letter that piles were terminated above the rupture surface. Four pump wells installed at east end of concrete pile wall and pump test conducted.
September 1988	Pump tests re-done successfully.
April 1989	Proposal for pumped wells at pile wall, to be installed in 2 of the 14 gravel piles (0.76 m dia. at 1.5 m centre to centre to between 13 m and 15 m depth) constructed downslope of the concrete pile wall in an area of gravel and seepage noted during concrete pile installation . Wells were to extend below the base of the gravel piles to EL. 388.2. Horizontal drains noted to have sheared off.
May 1989	Installation of belled gravel piles for seepage collection and installation of pumping wells. Soft clay encountered locally below wet sand and gravel, preventing belling tool from working properly.
June 1989	2 m high scarp developed at CNR crossing extending to east end of wall, adjacent to down drain – had already been shifted in the spring of 1989. Wells pumped under manual control roughly every other day.
August 1989	Continued movement of CNR Slide – new cracks developing tangent to the concrete pile wall extending towards track signals, with 4 cm drop in pavement. Proposal to install additional concrete piles, horizontal tie-backs and a new down-drain. Dewatering pumps installed – first well installation initially expected to produce 4,000 L/day. Permanent power to pumps approved. Horizontal tie-backs

	and 17 additional piles to 20 m to 29 m depth installed at concrete pile wall as an emergency measure in response to further widespread slide movement. CNR relocates rail line again.
February 1990	Installation/initialisation of inclinometers 1 – 4 at CNR Slide.
March 1990	Reinstallation of water pumps after emergency repair work. North well found to be dry. South well continuing to produce water.
August 1990	Cracks observed roughly 30 m away from concrete pile wall. Settlement of lightweight sawdust fill in front of pile wall.
September 1990	Lightweight sawdust fill covered by soil at caisson wall. Ditches along road cleaned out.
1990	Tie-backs installed at CNR slide – some grouted, some connected to concrete deadman anchors.
April 1991	Additional subsidence of road at CNR Slide.
September 1991	Cracks forming downhill of CNR pile wall. Concerns over corrosion of tie-backs on ATrans concrete pile wall.
October 1991	Enlargement of cracks around concrete pile wall. Both pumping wells now appear dry.
May 1992	Further sagging of lightweight fill in front of ATrans concrete pile wall. Rotation of CN soldier pile wall.
October 1992	Some existing tie-back rods sheared (settlement of fill behind wall). Additional anchors proposed at 2 m and 6 m below the top of the wall. Trial of chicken wire mesh and concrete to protect exposed soil between piles.
November 1992	Additional subsidence of road at CNR Slide – signs of movement on SI plots and cracking around piles. Proposal to install additional tie-backs. CNR proposing shear key and granular drains – concern that these works might impair stability of ATrans pile wall as movements have been observed below the level of the proposed shear key.
December 1992	CNR conducts earthworks below soldier pile wall including two levels of shear key.
August 1993	Loss of soil from behind CNR Slide pile wall – proposal to install mesh and cement to protect the front of the wall.

August 1994	CNR Slide experienced 125 mm settlement behind concrete pile wall – concern that this might have been caused by CNR downslope remedial works.
September 1994	Installed additional tie-backs at CNR Slide wall. Two test holes (BH1 and BH2 – 18 inch diameter) drilled using Texoma auger rig within cracking behind ATrans concrete pile wall. Deflections in SI-1 installed behind the wall noted to 10 m depth, with lesser deflections to 13 m depth.
May 1999	Judah Trunk downdrain constructed.
October 1999	Hwy 744 re-paved.
May 2001	Catch basin for drain at CNR pile wall silted. Wall appears to be performing well. Inclinometers covered during re-paving. Pumps not working.
May 2002	Catch basin for drain at CNR pile wall silted. Wall appears to be performing well. Inclinometers covered during re-paving. Pumps not working.
April 2003	Catch basin for drain at CNR pile wall silted. Wall appears to be performing well. Inclinometers covered during re-paving. Pumps not working. Erosion of the toe berm by the Heart River, removing support from the slope.
June 2004	Some possible additional movement at toe berm.
June 2005	Downdrain at CNR Slide pile wall is showing signs of leakage, with failure of the last 5 joints. Trowelled cement between piles is spalling. Void noted at the back of the wall near the crossing stop line. Pumps not working. Minor cracking noted along downslope road shoulder at Judah Trunk. Numerous pipe joints have failed.
June 2006	Active erosion of the cliff below the CNR Trunk outlet. Pipe inlet is clogged. No significant erosion occurring along pipe, despite separation at a number of joints. No significant changes at CNR Slide wall. No changes at the Judah Trunk.
May 2007	Toe of the CNR Slide has been reactivated – significant slide movement. River flow now occurring along toe of slide, through/over the rip rap berm. Slight additional spalling of

	cement between piles. Debris in downdrain inlet.
	Debris at inlet of Judah Trunk. Minor spalling in old gully adjacent to downdrain. More band couplings have failed, and erosion has occurred under the pipe. Fresh surface soil failure above upslope ditch.
June 2008	Significant settlement of rail grade just prior to site visit – being repaired during visit. Additional erosion by the Heart River and movement at the toe – backscarp is 45 m from toe of pile wall. Majority of Heart River flow is now occurring in the channel along the toe of the slide. Additional failure of band couplings on CNR Slide downdrain.
	Minor erosion in ditch upstream of Judah Trunk inlet. Debris at inlet. All band couplings on downdrain have failed, and erosion is occurring under first joint. Cracking and surface water erosion on downslope road shoulder has worsened.

NOTES:

1 LOCATION DATA RECORDED USING HAND HELD GPS RECEIVER. ALL LOCATIONS ARE APPROXIMATE AND ARE FOR ILLUSTRATIVE PURPOSES ONLY.

0 100 200 300 400 500 m

DRAWN BY ICB	DESIGNED BY	APPROVED BY
SCALE 1:10 000	DATE OCTOBER 29, 2008	FILE No. 15-16-213A-C1A

Alberta Transportation

PEACE REGION (PEACE RIVER/HIGH LEVEL)
JUDAH HILL

KEY PLAN

FIGURE 1

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ONLY MINOR FLOWS

RIP RAP IS PARTLY SUBMERGED BY RIVER BED

CLIFFS

HEART RIVER

FRAC. NE29 83-21-5

ACTIVE EROSION AT TOE OF SLOPE

EROSION OF PIPE BASE

MAIN RIVER FLOW NOW ALONG BASE OF SLOPE

BAND COUPLINGS BEGINNING TO FAIL

GAS PIPELINE R/W

LEAKAGE FROM JOINT AT BASE OF SLOPE

CNR TRUNK DOWN PIPE INLET

A

AT-3

AT-2

CONTINUED SLIDE MOVEMENT

SI50.51

59.5 km

SI4

SI2

SI3

SI5

AT-5

AT-1

AT-4

AT-7

CEMENT BETWEEN PILES IS SPALLING FRESH SPALLING OF CEMENT BETWEEN PILES

45m TO BACKSCARP

PUMPS (INOPERATIVE)

SI1

APPROXIMATE LIMIT OF PILES EXPOSED AT DOWNSLOPE FACE

R.L.11

86-22

86-25

86-27

86-24

86-21

86-26

86-23

86-20

DRIVEN STEEL PILES WITH CREOSOTE-TREATED TIMBER LAGGING

AT-3

WOODEN PILES

TH84-1

TH84-6B/C

TH84-6/A

TH84-7A/B

TH84-8A/B

TH84-9A/B

TH84-3

TH84-2

TH84-5

A'

59.6 km

RAILWAY TRACKS

CNR TRACK SETTLEMENT

TH84-4

59.7 km

LEGEND:

- CN RAIL TEST HOLE LOCATION
- ALBERTA TRANSPORTATION TEST HOLE LOCATION
- SLOPE INCLINOMETERS LOCATION
- INITIAL SLIDE
- SECONDARY SLIDE
- SECTION LINE

NOTES:

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2 2008 OBSERVATIONS SHOWN IN RED

0 10 20 30 40 50 m

DRAWN BY	DESIGNED BY	APPROVED BY
ICB		
SCALE 1:1 000	DATE OCTOBER 31, 2008	FILE No. 15-16-213A-C0A

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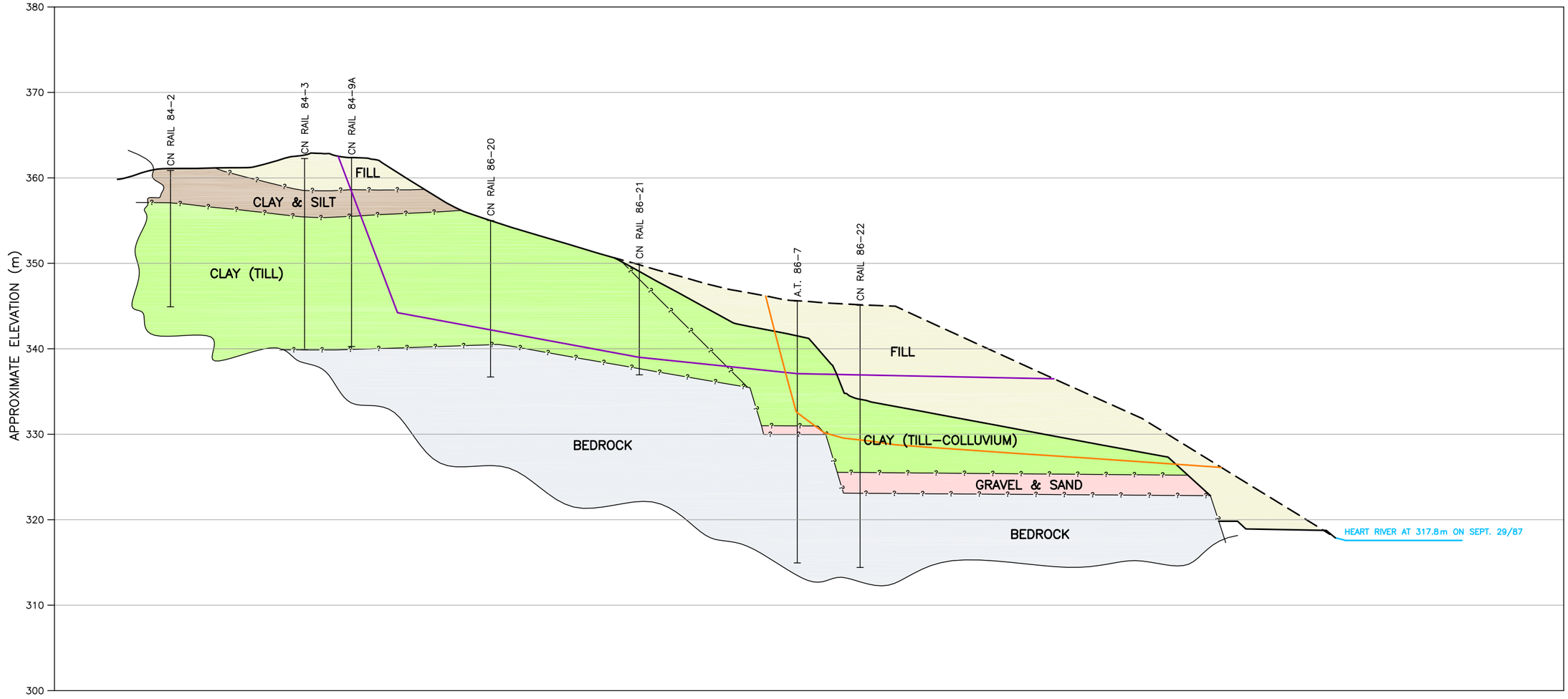
PEACE REGION (PEACE RIVER/HIGH LEVEL)
PH33 JUDAH HILL - CNR SLIDE

SITE PLAN

FIGURE 2

THURBER ENGINEERING LTD.
GEOTECHNICAL ▪ ENVIRONMENTAL ▪ MATERIALS



LEGEND:

- ORIGINAL GROUND SURFACE
- GROUND SURFACE AFTER COMPLETION OF BERM
- INITIAL FAUILURE SURFACE
- SECONDARY FAILURE SURFACE

NOTES:

1 BASE FROM DWG NO. 15-16-34-3 FROM THURBER REPORT DATED MAY 1988.

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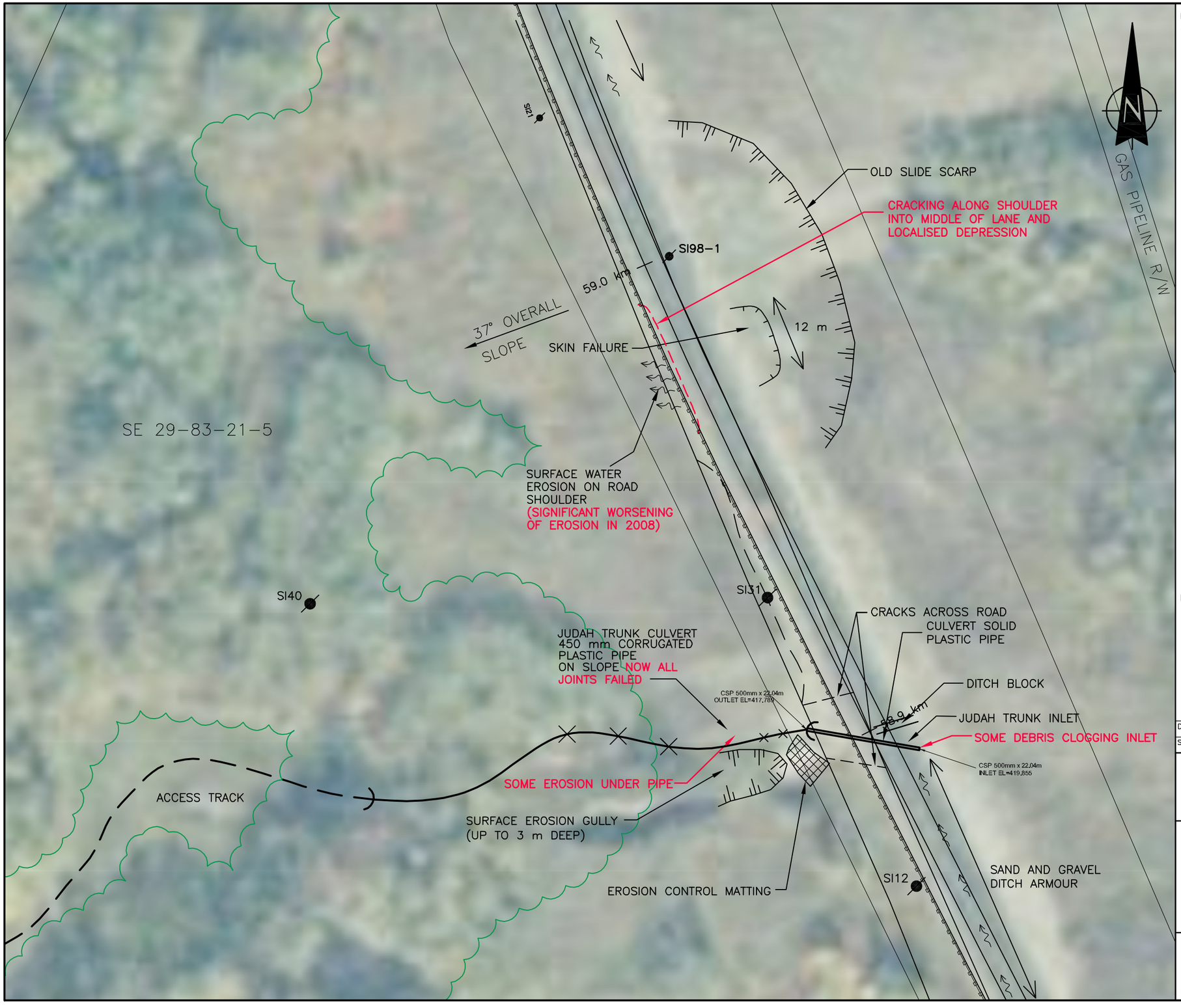
PEACE REGION (PEACE RIVER/HIGH LEVEL)
PH33 JUDAH HILL - CNR SLIDE

CROSS SECTION

FIGURE 3

DRAWN BY	ICB	DESIGNED BY	APPROVED BY
SCALE	1:500	DATE OCTOBER 31, 2008	FILE No. 15-16-213A-C6A

THURBER ENGINEERING LTD.
GEOTECHNICAL ▪ ENVIRONMENTAL ▪ MATERIALS



LEGEND:

SLOPE INDICATOR

NOTES:

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2 2008 OBSERVATIONS SHOWN IN RED

0 10 20 30 40 50 m

DRAWN BY ICB	DESIGNED BY	APPROVED BY
SCALE 1:750	DATE JULY 10, 2008	FILE No. 15-16-213A-C0A

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PEACE REGION (PEACE RIVER/HIGH LEVEL)
PH33 JUDAH HILL - JUDAH TRUNK

SITE PLAN

FIGURE 4

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