ALBERTA TRANSPORTATION
GEOHAZARD ASSESSMENT PROGRAM
PEACE REGION –
GRANDE PRAIRIE DISTRICT – NORTH
2022 INSPECTION

THURBER ENGINEERING LTD.

Site Number	Location	Name	Hwy	km
PH037	Dunvegan	Dunvegan South 1+250 to 2+000	2:68	15.674
Legal Description		**UTM Co-ordinates**		
NW¼ 06-080-04 W6M		11U E 398514	N 6197340	

	Date	PF	CF	Total
Previous Inspection:	July 15, 2021	10	7	70
Current Inspection:	May 20, 2022	10	7	70
Road WAADT:	2,360		**Year:**	2021
Inspected By:	Kristen Tappenden, TRANS Ed Szmata, TRANS Max Shannon, TRANS Jason Parr, TRANS		Don Proudfoot, Thurber José Pineda, Thurber	
Report Attachments:	☑ Photographs	☑ Plans		☑ Maintenance Items

Primary Site Issues:	Flow slides and shallow slumps occur along gullies eroded below the highway where ditch drainage is directed downslope towards Dunvegan Creek at Sta. 2+000. There is a large deep-seated landslide which crosses the highway between Sta. 1+650 and Sta.1+850 (Photos 5, 6, and 7). There are several slides downslope of the SBL shoulder between Sta. 1+350 and 1+650, the largest of these being at Sta. 1+400, with a backscarp that has retrogressed into the highway shoulder (Photos 9, 10, 11, and 12). There are old rotational features further downslope at Sta. 1+860 and at Sta. 1+600 to 1+700, with a sag pond. There are several shallow slumps upslope of the NBL at Sta. 1+455, 1+610, 1+860, 1+900 and 1+985.
Dimensions:	The 1+800 slide is 160 m to 200 m wide at the downslope road shoulder, and the backscarp appears to be along the upslope ditch. The 1+400 slide is 40 wide at the SBL shoulder, with the backscarp crack on the highway shoulder between the guardrail and the white line about 0.3 m from the white line.
Maintenance:	An ACP patch was placed over the dip and ruts in the ACP at the south end of the 1+800 slide in October of 2017 and at the north end of the 1+800 slide in 2019. ACP patch was also placed in the summer of 2020 on the northbound lane at the south flank of the 1+800 landslide.

Observations:	Description	Worsened?
☑ Pavement Distress	Dips across road at 1+690 and 1+820 associated with both ends of slide. Cracks and loss of the edge of the paved road in the shoulder of the pavement at 1+400 landslide	☑

☑ Slope Movement	Additional slope movement downslope of Sta. 2+000 to 1+900 indicated by cracking at crests of gullies further downslope. Backscarp cracks were noted in the upslope ditch at the Sta. 1+800 landslide. Slight movement in the slide feature below the highway in the sideslopes. The slide at 1+860 has a backscarp that is at 0.8 m from the guardrail (Photo 4). On-going movement in the sliding zone below the highway between Sta. 1+400 to 1+490. The backscarps at this location range between 5 to 7 m high and the slide are impacting the southbound shoulder with cracks at 0.3 m from the white line and four guardrail posts impacted (two posts are hanging and two posts are partially exposed).	☑
☑ Erosion	Up to 3.3 m wide by 0.8 m deep erosion gullies in the upslope ditch between 1+350 and 2+000.	☑
☑ Seepage	Some seepage and tension cracks have been observed below the highway between Sta. 1+540 and 1+600	☑
☐ Bridge/Culvert Distress		☐
☐ Other		☐

Instrumentation:

Fifteen slope inclinometers, 24 piezometers (22 pneumatic and 2 standpipe) were read on June 19 and 21, 2022.

Overall, the slope inclinometers showed an increasing rate of movement compared to the fall of 2021 readings ranging from -7.2 mm/yr in SI-54 in the south backslope at Station 1+600 to 10.7 mm/yr in SI-59 near the 1+800 slide. SI18-10 at the north of the site near Station 1+600 also showed an incremental rate of movement of 9.6 mm/yr. No new zones of movements have been observed since the fall of 2022.

Standpipe piezometer SP09-6 showed a water level at 26.2 m below ground surface. SP09-8 continued to be dry. The change in water levels on the pneumatic piezometers from the Fall of 2021 readings ranged from an increase of 2.23 m in PN18-9A to a decrease of 0.2 m in PN18-1.

Assessment:

Ongoing slide activity was observed at the Sta. 1+400 slide in 2016 right through 2022. Soil below the matting and around the soil nails, installed in 2010, has failed superficially, with more substantial failure extents below the surface treated area. It is anticipated that the rate of retrogression will likely accelerate above the areas where the soil nails have been bent downward due to a combination of confining soil loss and slope movement. The backscarp located at the shoulder of the SBL ranges between 5 to 7 m high. The SI's installed within the footprint of the 1+400 slide had rapid rates of movement in the spring and summer of 2018 (50 to 700 mm/yr.) and sheared off at a depth of 2 m as a result of mud flow after the fall of 2018.

The 1+800 slide is a deep-seated slide that is currently affecting all three lanes of the highway over a 200 m length with the backscarp likely within the NBL ditch bottom. Based on the ongoing slope

inclinometer monitoring, the 1+800 slide plane depth varies within the embankment of the highway from about 18 m near the SBL shoulder to a depth of 28 m below the NBL shoulder with the toe of the landslide likely situated some 300 m further downslope towards Dunvegan Creek. Rates of movement in the 1+800 slide SI's typically vary from small creep movements to 11 mm/yr. and have accelerated to about 20 mm/yr. in recent years. The 1+800 slide continues to exhibit moderate rates of movement up to 11 mm/yr; however, its footprint currently affects the entire highway embankment whereby a complete closure of the highway could result from a sudden increase in slide activity.

The 1+400 slide is retrogressing rapidly and is impacting the SBL shoulder. When considering the existing smaller slide features to the south, this suggests that the expansion of this slide further to the south should be anticipated.

Thurber provided a preliminary engineering assessment report with three remedial options with ballpark "A" cost estimates to address the features affecting the highway through the site in July of 2018.

Shallow surface movement elsewhere is expected to continue, with the possibility of further shallow surface failures developing. This is likely a function of the soil type at this location and is triggered by rainfall or snowmelt and gradual loss of cohesion in the surface due to weathering.

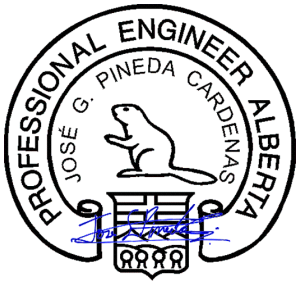
Erosion and slope movement downslope of the highway near Sta. 2+000 are a function of water flows in the ditch and are expected to worsen.

Recommendations:	**Cost**
<u>Short Term</u> Consider closing the climbing lane with Jersey barriers starting at the boat launch turn off to approximately Sta. 1+500. Reduce the posted speed to 80 km/hr. Widen the shoulder of the northbound lane and adjust the jersey barriers further into the southbound climbing lane when required to maintain at least 2 lanes of safe traffic. Continue to monitor visually for sign of activity at both slides and close the outer SBL at the 1+400 slide should tension cracks or dips appear in the roadway surface. Apply small asphalt patches at each end of the 1+800 slide to smooth out the dip when required for traffic safety.	Maintenance
<u>Intermediate Term</u> Install driven steel pile walls at the Sta. 1+400 landslide location to temporarily maintain the climbing lane until a more permanent repair is implemented.	$500,000
<u>Long Term</u> Thurber's preliminary engineering assessment provided three remedial options ranging from a realignment further to the east to completely circumvent the landslide features to maintaining the existing alignment with pile walls built at the 1+400 to 1+800 slides.	$45 million to $110 million

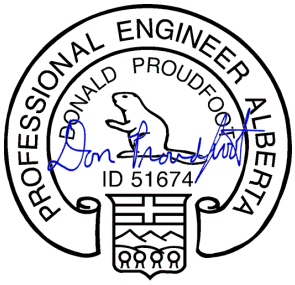
CLOSURE

It is a condition of this letter report that Thurber's performance of its professional services will be subject to the attached Statement of Limitations and Conditions.

Don Proudfoot, P.Eng.
Principal | Senior Geotechnical Engineer



October 16, 2022
ID 93452



October 17, 2022

PERMIT TO PRACTICE
THURBER ENGINEERING LTD.
RM SIGNATURE: Don Proudfoot
RM APEGA ID #: 51674
DATE: October 17, 2022
PERMIT NUMBER: P005186
The Association of Professional Engineers and Geoscientists of Alberta (APEGA)

José Pineda, P.Eng.
Associate | Geotechnical Engineer

THURBER

STATEMENT OF LIMITATIONS AND CONDITIONS

1. STANDARD OF CARE

This Report has been prepared in accordance with generally accepted engineering or environmental consulting practices in the applicable jurisdiction. No other warranty, expressed or implied, is intended or made.

2. COMPLETE REPORT

All documents, records, data and files, whether electronic or otherwise, generated as part of this assignment are a part of the Report, which is of a summary nature and is not intended to stand alone without reference to the instructions given to Thurber by the Client, communications between Thurber and the Client, and any other reports, proposals or documents prepared by Thurber for the Client relative to the specific site described herein, all of which together constitute the Report.

IN ORDER TO PROPERLY UNDERSTAND THE SUGGESTIONS, RECOMMENDATIONS AND OPINIONS EXPRESSED HEREIN, REFERENCE MUST BE MADE TO THE WHOLE OF THE REPORT. THURBER IS NOT RESPONSIBLE FOR USE BY ANY PARTY OF PORTIONS OF THE REPORT WITHOUT REFERENCE TO THE WHOLE REPORT.

3. BASIS OF REPORT

The Report has been prepared for the specific site, development, design objectives and purposes that were described to Thurber by the Client. The applicability and reliability of any of the findings, recommendations, suggestions, or opinions expressed in the Report, subject to the limitations provided herein, are only valid to the extent that the Report expressly addresses proposed development, design objectives and purposes, and then only to the extent that there has been no material alteration to or variation from any of the said descriptions provided to Thurber, unless Thurber is specifically requested by the Client to review and revise the Report in light of such alteration or variation.

4. USE OF THE REPORT

The information and opinions expressed in the Report, or any document forming part of the Report, are for the sole benefit of the Client. NO OTHER PARTY MAY USE OR RELY UPON THE REPORT OR ANY PORTION THEREOF WITHOUT THURBER'S WRITTEN CONSENT AND SUCH USE SHALL BE ON SUCH TERMS AND CONDITIONS AS THURBER MAY EXPRESSLY APPROVE. Ownership in and copyright for the contents of the Report belong to Thurber. Any use which a third party makes of the Report, is the sole responsibility of such third party. Thurber accepts no responsibility whatsoever for damages suffered by any third party resulting from use of the Report without Thurber's express written permission.

5. INTERPRETATION OF THE REPORT

a) Nature and Exactness of Soil and Contaminant Description: Classification and identification of soils, rocks, geological units, contaminant materials and quantities have been based on investigations performed in accordance with the standards set out in Paragraph 1. Classification and identification of these factors are judgmental in nature. Comprehensive sampling and testing programs implemented with the appropriate equipment by experienced personnel may fail to locate some conditions. All investigations utilizing the standards of Paragraph 1 will involve an inherent risk that some conditions will not be detected and all documents or records summarizing such investigations will be based on assumptions of what exists between the actual points sampled. Actual conditions may vary significantly between the points investigated and the Client and all other persons making use of such documents or records with our express written consent should be aware of this risk and the Report is delivered subject to the express condition that such risk is accepted by the Client and such other persons. Some conditions are subject to change over time and those making use of the Report should be aware of this possibility and understand that the Report only presents the conditions at the sampled points at the time of sampling. If special concerns exist, or the Client has special considerations or requirements, the Client should disclose them so that additional or special investigations may be undertaken which would not otherwise be within the scope of investigations made for the purposes of the Report.

b) Reliance on Provided Information: The evaluation and conclusions contained in the Report have been prepared on the basis of conditions in evidence at the time of site inspections and on the basis of information provided to Thurber. Thurber has relied in good faith upon representations, information and instructions provided by the Client and others concerning the site. Accordingly, Thurber does not accept responsibility for any deficiency, misstatement or inaccuracy contained in the Report as a result of misstatements, omissions, misrepresentations, or fraudulent acts of the Client or other persons providing information relied on by Thurber. Thurber is entitled to rely on such representations, information and instructions and is not required to carry out investigations to determine the truth or accuracy of such representations, information and instructions.

c) Design Services: The Report may form part of design and construction documents for information purposes even though it may have been issued prior to final design being completed. Thurber should be retained to review final design, project plans and related documents prior to construction to confirm that they are consistent with the intent of the Report. Any differences that may exist between the Report's recommendations and the final design detailed in the contract documents should be reported to Thurber immediately so that Thurber can address potential conflicts.

d) Construction Services: During construction Thurber should be retained to provide field reviews. Field reviews consist of performing sufficient and timely observations of encountered conditions in order to confirm and document that the site conditions do not materially differ from those interpreted conditions considered in the preparation of the report. Adequate field reviews are necessary for Thurber to provide letters of assurance, in accordance with the requirements of many regulatory authorities.

6. RELEASE OF POLLUTANTS OR HAZARDOUS SUBSTANCES

Geotechnical engineering and environmental consulting projects often have the potential to encounter pollutants or hazardous substances and the potential to cause the escape, release or dispersal of those substances. Thurber shall have no liability to the Client under any circumstances, for the escape, release or dispersal of pollutants or hazardous substances, unless such pollutants or hazardous substances have been specifically and accurately identified to Thurber by the Client prior to the commencement of Thurber's professional services.

7. INDEPENDENT JUDGEMENTS OF CLIENT

The information, interpretations and conclusions in the Report are based on Thurber's interpretation of conditions revealed through limited investigation conducted within a defined scope of services. Thurber does not accept responsibility for independent conclusions, interpretations, interpolations and/or decisions of the Client, or others who may come into possession of the Report, or any part thereof, which may be based on information contained in the Report. This restriction of liability includes but is not limited to decisions made to develop, purchase or sell land.

H:\32000\32123 AT GRMP Grande Prairie District North 2021-2025\CAD\2022\JGP\32123-PH037.dwg - PH37 - Oct. 15, 2022

SLIDE CRACK 0.3m FROM WHITE LINE, 200mm WIDE PLUS 2 MORE CRACKS CLOSER TO GUARDRAIL, 70mm AND 90mm WIDE (2022)

SCARP RETROGRESSION BENDING OVER SOIL NAILS

EROSION GULLY 22m LONG, UP TO 3.2m WIDE AND 0.8m DEEP (2022)

NEW CRACK ALONG CENTRE OF CLIMBING LANE

MORE MOVEMENT

WORSE

CULVERT 31A 900mm CMP (NOT IN USE)

DITCH BLOCK REMOVED

SEEPAGE

GREEN

LOSS OF SOIL BETWEEN SOIL NAILS

MORE RILLS (2020)

ONGOING SLIDE MOVEMENT

END OF CULVERT EXPOSED

SEEDETAIL 1

WORSENED RETROGRESSION BIT MORE

SLUMP IN SIDEWALL

SLIDES REGRESSING SLIGHT CHANGE

VERY ACTIVE FAILURE FRONT

FLOW SLIDE TO RIVER

POSSIBLE SURFACE CREEP/SCARP

GROUND ROUGH FROM REGRADING FOR DRILL BENCH, SLIGHTLY WET (2020)

MORE FRESH MOVEMENT

FRESH MOVEMENT

16 m

30 m

HIGHWAY 2

18° OVERALL SLOPE

VERY GREEN SLOPE SOME SCARPS, WET

SLIGHT MOVEMENT (2019) MORE MOVEMENT (2022)

NEW ACP PATCH PLACED IN 2019

NO PASSING SIGN

SPRAY PATCHING IN WHEEL RUTS

GUARD RAIL SALT LEACHING

MORE MOVEMENT

CRACKING AT ACCESS TRACK

MORE MOVEMENT

ADDITIONAL SURFACE SLIDE MOVEMENT

WATER IN SAG POND

SEEPAGE NOTED IN 2022

TH18-3

SI-58

SI-54

SI-57

SI-31

TH18-14

TH18-13

TH18-12

SI-56

TH18-10

TH18-8

SI-63

SI-55

TH18-9

SI-64

TH18-6

TH09-06

TH09-07

TH09-04

POSSIBLE SMALL SLUMP AROUND TELUS BASE

MINOR CRACK

MINOR CRACKING

DITCH EROSION 3.3m WIDE, 0.8m DEEP

SCARP CRACK

SI-60

SI-59

TH18-11

TH09-09

DIP

EROSION GULLY 0.5m DEEP, 1.2-0.5m WIDE (WET)

CRACKS IN SHOULDER ALONG WHITE LINE

SMALL ACP PATCH PLACED PRIOR TO 2018

PATCH

CRACKS (WORSE)

SI-66 (SHEARED AT 4.3m)

ACP PATCH PLACED IN 2020

TH18-4

TH18-2

NEW SCARP 0.8m FROM GUARD RAIL, 1.1m DEEP WITH TENSION CRACKS 0.2m FROM GUARD RAIL

TILTING SIGN IN SLIDE MASS

SLIGHT MOVEMENT (SAME)

TOE ROLL PARTLY BLOCKING DITCH

WATER PONDED AT BLOCKED OFF CULVERT DITCH BLOCK

SHALLOW SKIN FAILURE

SLIGHT RAVELLING SKIN FAILURES (1m TO 2m DEEP); NO CHANGE. GOOD GROWTH COVER

OLDER SURFICIAL SLIDE FEATURE

DITCH EROSION

CULVERT INLET SILTED UP

SLUMP; MORE MOVEMENT

DEBRIS

MORE REGRESSION FROM GUARD RAIL

SOIL NAIL TRIAL ABANDONED

RECP TRIAL HAS GREENED-UP WELL AND PERFORMING WELL

MORE MOVEMENT WITHIN SLUMP; SAME (2022)

MORE SIDE WALL SLUMPING

TENSION CRACKS AROUND GULLIES

SIGNIFICANT ADDITIONAL EROSION AND MOVEMENT

SOME TENSION CRACKS

EROSION GULLY, 1.6m WIDE, 0.6m DEEP (2021); 2.1m WIDE, 1.2m DEEP (2022)

BENCH

SMALL RETROGRESSION IN 2020

BACKSCARP UP TO 4-5m HIGH

SCARP RETROGRESSION

DITCH BLOCK

12.4m, 12.0m (2022)

ENLARGED

SAME

SMALL CRACK WORSE

TH18-7

TH09-08

SHOULDER CRACK

DIP

CRACKING WITH 0.5m VERTICAL OFFSET

BOW IN GUARDRAIL, DIP AND ARCH SHAPED TENSION CRACKS BETWEEN WHITE LINE AND GUARDRAIL, SAME (2021, 2022)

CRACKS ARE 60mm WIDE, SAME (2021, 2022)

SI-65

MORE ACTIVE

SLUMP: MORE RETROGRESSION

ERODING GULLY

SI01-1

GRASS COVER SINCE CSP BLOCKED

ERODED EDGES

FLOWSLIDE

MORE ACTIVE ZONE

MUD AND SILT FLOW

DEBRIS

RAVELING WITH MUDFLOW DOWNSLOPE

SI01-2

NW 6-80-4-6

619800

619700

619600

619500

619400

398400

LEGEND:

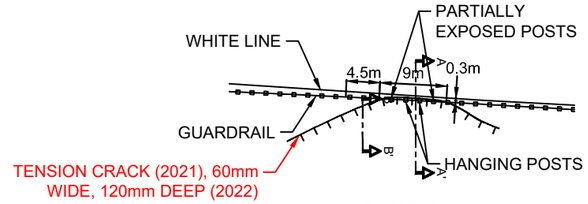
- SLOPE INDICATOR
- SLOPE INDICATOR (INACTIVE/DESTROYED)
- TEST HOLE LOCATION
- DIRECTION AND NUMBER OF PHOTO
- SCARP CRACK

NOTES:

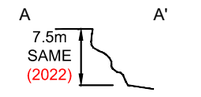
1. LOCATION DATA RECORDED USING HAND HELD GPS RECEIVER. ALL LOCATIONS ARE APPROXIMATE AND ARE FOR ILLUSTRATIVE PURPOSES ONLY.
2. MAY 20, 2022 OBSERVATIONS SHOWN IN RED

0 20 40 60 80 100 120m

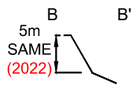
SCALE 1:2000



DETAIL 1
SCALE:1:800



CROSS - SECTION A - A'
SCALE:1:800



CROSS - SECTION B - B'
SCALE:1:800

Alberta

PEACE REGION (GRANDE PRAIRIE DISTRICT - NORTH)
PH037 DUNVEGAN SOUTH - 1+250 TO 2+000

2022 PH037 INSPECTION PLAN

FIGURE 1

DRAWN BY	ML
DESIGNED BY	JGP
APPROVED BY	DWP
SCALE	1:2000
DATE	OCTOBER 2022
FILE No.	32123

THURBER ENGINEERING LTD.

THURBER

	**Photo 1.** Looking northwest from Sta. 2+000 at erosion gully in SBL ditch south of ditch block
	**Photo 2.** Looking west from Sta. 1+980 below the SBL highway. More movement noted in 2022

	**Photo 3.** Looking east at backslope skin failure at Sta. 1+900 (More movement since 2021).
	**Photo 4.** Looking north from Sta. 1+890 at the slump in the sideslope of the SBL. The scarp is 1.1 m high and 0.8 m from the guardrail.

	**Photo 5.** Looking north from Sta. 1+800 at the erosion gully developed on the ditch up to 3.3 m wide and 0.8 m deep. Erosion gully wider and deeper than noted at the 2021 inspection
	**Photo 6.** Looking northeast across the dip in the highway at the south end of the 1+800 slide.

	**Photo 7.** Looking from the shoulder of the SBL at Sta. 1+660 across the dip in the highway at the north end of the 1+800 slide.
	**Photo 8.** Looking north near Sta. 1+550 at rough area (drill access bench) with some seepage and tension cracks

	**Photo 9.** Looking west across soil matting and nails which were installed in August 2010 at Sta. 1+450 slide. Backscarp (5 m to 7.5 m high) continues to retrogress and is now impacting the highway. Two guardrail posts are hanging and other two posts are partially exposed.
	**Photo 10.** Looking north from Sta. 1+450 backscarp. The slide scarp cracks up to 200 mm wide just west of the white line.

	**Photo 11.** Looking south from Sta. 1+390 at the backscarp of the 1+400 slide which is impacting the highway shoulder. Slide cracks are wider and closer to the white line
	**Photo 12.** Looking southeast towards the 1+400 slide. The slide has further retrogressed towards the highway, is wider than in 2021 and there is a 5 m to 7.5 m drop below the guardrail.

	**Photo 13.** Looking south at the fresh slump slide that is impacting the highway at Sta. 1+400.
	**Photo 14.** Looking northwest from the north side of the erosion gully at Sta. 1+360

Photo 15.
Drone photo of the backscarp of the 1+400 slide impacting the highway shoulder.