ALBERTA TRANSPORTATION AND ECONOMIC CORRIDORS
GEOHAZARD ASSESSMENT PROGRAM
NORTH CENTRAL REGION – ATHABASCA & FORT MCMURRAY DISTRICTS
2023 SITE INSPECTION

THURBER ENGINEERING LTD.

Site Number	Location	Name	Hwy	km
NC096	13 Km north of Wandering River	Wandering River Bridge (75731N)	63:04	2.85

Legal Description	UTM Co-ordinates (NAD 83)		
NW 12-73-17 W4	12	N6130357.92	E405776.13

	Date	PF	CF	Total
Previous Inspection:	June 7, 2022	15	5	75
Current Inspection	May 17, 2023	15	5	75
Road WAADT:	3,920		**Year:**	2022
Inspected By:	José Pineda, Tarek Abdelaziz (Thurber) Arthur Kavulok, Kristen Tappenden (TEC)			
Report Attachments:	☑ Photographs ☑ Plans ☑ Maintenance Items			

Primary Site Issue	Two slumps developed beside the NBL bridge south headslope. The west slump exposed NW wing wall and extended below bridge headslope.
Dimensions:	The slump on the east side of the bridge (Slump 1) is approximately 25 m wide (perpendicular to bridge alignment) and 13 m long (parallel to bridge alignment); the erosion gully to the east of Slump 1 is about 10 m wide, 20 m long, and up to 2.5 m deep. The slump on the west side of the bridge (Slump 2) is approximately 27 m wide (perpendicular to bridge alignment) and 19 m long (parallel to bridge alignment).
Site History / Available Information:	The existing bridge structure was first in service since 2014 as part of the twining of Highway 63 to Fort McMurray. As part of the bridge construction, the Wandering River was re-aligned by creating a bend that would allow a more perpendicular river flow under the new bridge. The new highway embankment was constructed by placing approximately 4 to 8 m of fill over the native ground on the south and north of the river alignment, respectively. The approach fill head slopes are inclined at 2H:1V and the north head slope also has a 2 m wide bench halfway up the slope. The side slopes of the approach fill are inclined at approximately 3H:1V on both sides of the highway. As part of the bridge construction, the wandering river channel was also realigned to the south. The three-span concrete girder bridge structure has a total length of 51 m. The abutment/wing walls are supported on driven steel H piles (310x125) and the piers are supported on 610 mm diameter x 12.5 mm thick closed end pipe piles filled with concrete. A geotechnical investigation was conducted by EBA in 2011 for the design of the existing bridge. During the 2011 geotechnical investigation, two boreholes were drilled as shown on Figures 1 and 2. Borehole BF3-2, drilled on the north highway embankment, showed that at least 0.6 m of peat were buried under approximately 8 m of fill. Borehole BF3-1, drilled on the south highway embankment,

	did not encounter any peat. Both boreholes encountered clay till below either the peat or fill. The clay till extended to depths ranging between 15 to 17 m below the ground surface at the time of the investigation. BF3-1 and BF3-2 were terminated in sandstone at elevations of 541 m and 542 m, respectively. Groundwater was measured at an elevation of 561 m and 563 m on the north and south embankments, respectively. The bridge headslope was designed with a factor or safety of 1.3, which is less than typically recommended for bridge headslopes (i.e., a FOS of 1.5). Review of satellite images indicate that the highway NBL east ditch conveys surface drainage from a low-lying area about 135 m to the south of the bridge to the re-aligned river channel; the images also show that a riprap lined channel was constructed at the mouth of the east ditch within the riverbank slope. Slumping of the riverbank by the bridge head slope was first noted by TEC on August 28, 2020. A geotechnical investigation, consisting of drilling four test holes along with the installation of slope inclinometers and piezometers, was completed by Thurber in 2020. The test holes showed the soil conditions mainly consist of medium to high plastic clay fill over high plastic clay over clay till.	
Maintenance /Repairs	Beaver dam that used to block muskeg terrain drainage path located east of the highway southbound lanes was removed and did not reappear since 2022	
Observations:	**Description**	**Worse?**
☑ Pavement Distress	10 to 20 mm dip within the south approach slab; worse area within the western lanes	☐
☑ Slope Movement	A slump developing on each side of the bridge headslope. Slump 1 on the east side of the highway: head scarp cracks up to 1.5 deep and 1.5 m wide. Slump 2 on the west side of the highway: head scarp cracks up to 4 m deep and 1 m wide; multiple tension cracks within the Slump 2 slide area. The eastern flank of Slump 2 extends under the bridge by at least 2 m, and exposed the underside of the wingwall. Slump 2 sheared off existing 150 mm diameter subdrain pipe and developed a 200 mm gap under the southwest wing wall. Both slumps 1 and 2 are toeing out into the river channel and are narrowing the river channel by approximately 1.2 m; new open and wide cracks noted within the bridge headslope downslope of the abutment seat location.	☑
☑ Erosion	Erosion developed east of Slump 1 at the mouth of the north facing riprap lined channel. Erosion became worse in 2023 and it is at least 3.5 m deep and has distorted the existing riprap within the channel. Scattered and subdued riprap areas along the outside bend of the river channel	☑
☑ Seepage	Ground within the west landslide area was soft and wet; a steady flow in the highway east ditch originating from the low-lying area located to the south of the bridge location.	☐

☑ Bridge/Culvert Distress	Slumps 1 and 2 are getting larger; Slump 2 continues to impact the bridge northbound lanes headslope; bridge headslope fill showed signs of distress in 2023.	☑
☐ Other	Both slumps restricted the river channel width; sediment accumulation within the stream at the mouth of the erosion gully	☐

Instrumentation Readings (Two SP and Four VW Piezometers; Spring 2023):

SI20-1, installed within Slump 1 to the east of the bridge, sheared off at showed at a depth 1.5 m below ground surface. Prior to shearing off, SI20-1 showed a maximum rate of movement of 292 mm/yr. SI20-3, installed within Slump 2 to the west of the bridge, sheared off at 2.1 m below ground surface. Prior to shearing off, SI20-3 showed a maximum rate of movement of 103.1 mm/yr.

Standpipe piezometers SP20-2 and SP20-4 showed groundwater depths of 2.3 m and 4.1 m, respectively, corresponding to decreases in groundwater level of 0.7 m and 0.1 m since the piezometers were last read in Fall 2022.

Vibrating wire piezometers VW20-1A, VW20-1B and VW20-3A show current groundwater depths of 1.5 m, 1.2 m, and 1.0 m, respectively. VW20-3B currently shows an above-ground (artesian) groundwater level of -2.8 m. The vibrating wire piezometers showed increases in groundwater level of 0. 5m in VW20-3A and 0.1 m in VW20-3B and decreases in groundwater levels of 0.3 m in VW20-1A and 0.6 in VW20-1B since the instruments were last read in Fall 2022.

Assessment (Refer to attached Figures and Photos)**:**

The site condition appears to have deteriorated since the 2022 site inspection.

The placement of relatively steeply inclined deep high plastic clay fill (i.e., 2H:1V), elevated groundwater levels within the slope, potential winter construction of embankment fills, and ongoing toe erosion by the river are likely the triggering factors for the observed slumps. In addition, the existing riprap (mainly Class 1M) along the riverbank is relatively smaller in size than what is typically used to armour riverbanks in similar bridge projects.

The placement of geogrid layers within the south headslope was recommended in EBA's geotechnical report to achieve the target factor of safety. It is suspected that the geogrid layers were not placed within the bridge headslope or approach fills, and this may have been another contributing factor to observed instabilities. However, there are no detailed construction notes/records to confirm this hypothesis.

The existing erosion gully has become wider and deeper than observed in 2022. It appears that the east ditch was not properly designed to carry the current flow . It is anticipated that the gully will continue get deeper and wider with time, resulting in more sediment accumulation in the stream and loss of land/trees to the east of the gully.

The slumps within the south approach fills, on each side of the bridge, did not appear to have yet impacted the integrity of the bridge and the highway. However, Slump 2 has exposed the base of the NW wing wall and its flank extended below the headslope of the bridge downslope of the abutment location. Slump 2 is considered more critical than Slump 1 in terms of its potential impact on the highway and the bridge conditions.

The approach fill slumps, to the east and the west of the bridge headslope, are very active, moving at very high rates and will continue to grow bigger in size. Future erosion of the toe of the landslides at the river location and/or rise in groundwater levels within the landslides may result in (a) failure of the majority of the headslope under the bridge deck, and (b) distress of the wing walls and exposure of abutment seat and a few of the pile supports (particularity at Slump 2 location). In addition, the complete failure of these closely spaced slumps, if occurs with time, could significantly restrict the width of the river channel and (a) cause flooding of areas located upstream of the site and/or (b) result in the development of additional slumps above the restricted channel width on the north side of the bridge.

The bridge headslope, between the two slumps, is likely in a meta-stable condition and the complete failure of the headslope may take place abruptly similar to the currently active slumps. The observed cracks within the headslope may reflect a slope movement and/or shrinkage of fill in response to poor compaction.

The recent structural assessment indicates that the bridge structure may not be impacted in response to future movements of the slopes. However, the roadway condition will be significantly impacted. If the roadway fails at this location in response to future landslide movements, a major detour will be required. However, the SBLs may be used to accommodate traffic through this area.

Recommendations:

This site should be visited again in the spring of 2024.

Short-Term Repair Measures

In the short term, consideration should be given for the following:

- Monitor the highway periodically for signs of distress and watch closely for the development of new cracks or widening of existing cracks.
- Monitor existing cracks under the bridge headslope and check for signs of movement of the headslope.
- Place heavy rock riprap (Min. Class 1) at the base of the slumps (near the river location) to provide additional buttress and erosion protection.
- Reshape the failed riprap-lined channel within the east ditch and add heavy rock riprap (Min Class 2) to armor the re-graded channel. This should prevent future accumulation of sediment in the river channel and reduce the probably of further loss of land/trees to the east of the gully location.
- Undertake slight grading to seal open cracks within landslide masses.
- Insert a flexible HDPE pipe into the void below the NW wing wall to convey as much flow as possible from the location of the sheared off subdrain pipe to the river channel.

Long-Term Repair Measures

Various long-term repair options were presented in the preliminary engineering report prepared by Thurber in 2022 to deal with the ongoing stabilities of the active slumps and potential future instability of the meta-stable bridge headslope. The repair options included: a) dig and replace with granular material, b) installation of soil nails, c) installation of sheet pile walls, or d) a combination of options a) to c).

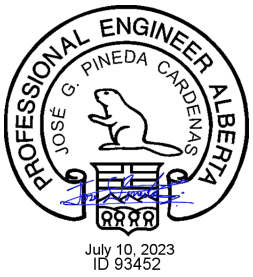
Any of the repair options will include re-shaping and armoring the eroded gully and the failed banks with heavy rock riprap. A detailed hydrotechnical study was recommended to confirm the size of the riprap and properly design the highway east ditch.

The ballpark cost to complete the repairs was estimated to be in the order of $2 million (including engineering and contingencies).

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.

Tarek Abdelaziz, Ph.D., P.Eng.
Principal | Geotechnical Review Engineer



PERMIT TO PRACTICE
THURBER ENGINEERING LTD.
RM SIGNATURE: _____
RM APEGA ID #: 91085
DATE: July 10, 2023
PERMIT NUMBER: P005186
The Association of Professional Engineers and Geoscientists of Alberta (APEGA)

José Pineda, M.Eng., P.Eng.
Associate | Senior Geotechnical Engineer

H:\32000\32122 AT GRMP Athabasca and Fort McMurray Districts 2021-2025\CAD\2023 GEO HAZARD\JGP\32122 NC096 Drawings.dwg - 1 - Jun. 09, 2023

150mm-300mm DIAMETER ROCKS IN THE BANK;
~70% SMALLER SIZE ROCK

SEVERE EROSION ALONG RIPRAP ARMORED CHANNEL (MIX OF CLASS 1M AND CLASS 2 RIPRAP) DOWNSTREAM OF BEAVER DAM (SAME 2021)

CLASS 1M RIPRAP

NW 12–73–17–4

REALIGNED CHANNEL
2.5m DEEP (2022)
3.5m DEEP (2023)

1~2m DROP x 0.8m WIDE

45.00 NEW R/W

58+370.00

500mm DEEP (2022)

BOULDERS >700mm DIAMETER WITHIN GULLY

NEW GULLY, 900mm DEEP, 2.7m WIDE (2022)

WATER FLOWING IN DITCH (2021)
SLOWLY FLOWING IN 2022
STEADY FLOW (2023)

DRAINAGE FROM LOW-LYING AREA

PONDING WATER (2022)

13+350

2:1 (MIN)

15.7

13+500

NEW CHANNEL

OLD CHANNEL

SUBDUED ZONE

STRAW BALES

A5

2:1 (MIN)

R=50

13+

3+300

WANDERING RIVER

DRAIN

SEDIMENT IN STREAM CHANNEL (2023)

BEAVER DAM, REMOVED BY AT IN THE FALL OF 2020 (SOME DEBRIS LEFT IN PLACE AFTER REMOVAL OF BEAVER DAM)

DISTURBED / SCATTERED RIPRAP (WATER FLOWING UNDER RIPRAP) (SAME 2022)

NEW CRACK 300mm DROP (2023)

SI20-1/
VW20-1A/
WV20-1B
15m

0.8m DROP x 1m WIDE (2020),1.5m DROP x 1.5m WIDE (2021, 2022,2023)

15m SP20-2

SUBDRAIN PIPE (DRY IN 2021) (SAME 2022)

DRAIN

CRACK (50mm WIDE X 10mm DEEP) (SAME 2021, 2022, 2023)

CRACK (40-70mm WIDE X 40mm DEEP X NO DROP)
(SAME 2022, 2023)

DRAIN TROUGHS

APPROACH SLAB: 10 TO 20mm DROP, THE DROP IS MORE DISTINCT ON THE WESTERN HALF BETWEEN YELLOW LINE AND EDGE OF PAVEMENT (SAME 2022, 2023)

45.30 R/W

DISTINCT TOE ROLL
(SAME 2022)

SLUMP 1

CRACKS:
30mm WIDE X 10mm DEEP

100mm DEEP

3+250

3:1

3+040

58+

STA 58+

A

A'

7.5 TYP

TH BF3-1

TYP

58+350

A2

1m WIDE x 0.7-2.2m DROP (2020), 1m WIDE x 0.8-3.8m DROP (2021)
1.1m DROP (2021); 1.5m DROP (2023)

GRABEN FEATURE
(NOT VISIBLE IN 2021)

GABION MATTRES (10m WIDE):
4m BOTTOM AND 3m SIDESLOPES INCLINED AT 5H:1V ON BOTH SIDES OF THE CHANNEL

HWY 63 NBL

58+450

58+500

NEW CRACK - 100mm WIDE, 300mm DROP (2023)

3:1

BF3-2

3+200

1m DROP

2m DROP

15m SP20-4

4.0m DROP (SAME 2022, 2023)

0.7m WIDE X 1m DROP

SHEARED AT 3.0m

SI20-3/
VW20-3A/
WV20-3B

150mm DIAMETER SUBDRAIN PIPE (FLOWING IN 2020)

PP

DRAIN

DISTINCT TOE ROLL
(SAME 2021, 2022)

SLUMP 2

GROUND SOFT AND WET (2023)

0.9m WIDE x 0.5m DROP (2020)
0.9m WIDE X 0.9m DROP (2021)

55.00

CRACK: 40mm WIDE X 30mm DEEP
CRACK: 100mm WIDE X 30mm DROP

600mm DROP

CP690

EXISTING BRIDGE

APPROACH SLAB SETTLED AND CAUSED A HUMP AT END OF BRIDGE

HWY 63 SBL

EXISTING BRIDGE FILLS

3+150

158+490

ASCM 55112-7

WANDERING RIVER

APPROACH SLAB SETTLED AND CAUSED A HUMP AT END OF BRIDGE

GAP: 500mm WIDE X 500mm DEEP X 2m LONG
(GAP EXPOSED THE 300mm THICK APPROACH SLAB)

SLUMP 3

SEVERE PAVEMENT DISTRESS WITH MULTIPLE POTHOLES CRACK, 200 - 250mm WIDE X 40 - 50mm DROP

CRACK: 60mm WIDE X 25mm DEEP

158+300

EXISTING BRIDGE FILLS

LEGEND

- APPROXIMATE INSTRUMENT LOCATION (DEPTH (m))
- APPROXIMATE TEST HOLE LOCATION (BY EBA)
- ACTIVE HEADSCARP (APPROXIMATE)
- EXISTING RIPRAP (150 - 300mm)
- TREE LINE (APPROXIMATE)
- PHOTOGRAPH NUMBER, AND APPROXIMATE DIRECTION AND LOCATION
- SI SLOPE INCLINOMETER
- VW VIBRATING WIRE PIEZOMETER
- SP STANDPIPE PIEZOMETER

NOTE:
1. MAY 17, 2023 OBSERVATIONS ARE SHOWN IN RED.

0 10 20 30 40 50m
SCALE 1:800

BASE PLAN PROVIDED BY ALBERTA TRANSPORTATION DRAWING 35349-P

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NC096: HWY 63:04 WANDERING RIVER BRIDGE (km 2.85) SITE PLAN SHOWING APPROXIMATE SITE FEATURES

FIGURE 1

DRAWN BY	ML
DESIGNED BY	JGP
APPROVED BY	TSA
SCALE	1:800
DATE	JUNE 2023
FILE No.	32122

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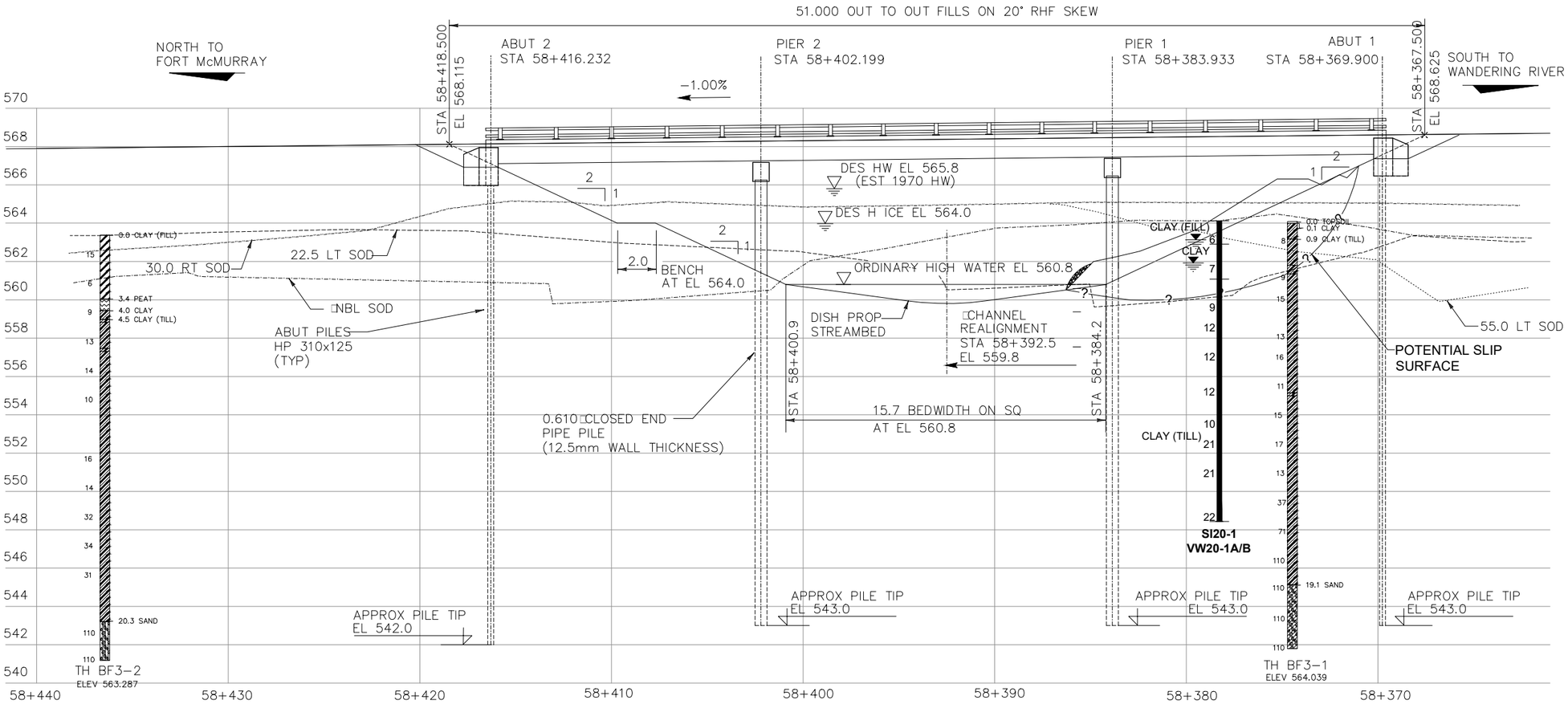

NOTES:

1. MAY 17, 2023 OBSERVATIONS ARE SHOWN IN RED.
2. SLUMP 1 IS WITHIN THE RIVERBANK SLOPE TO THE EAST OF THE BRIDGE HEADSLOPE.

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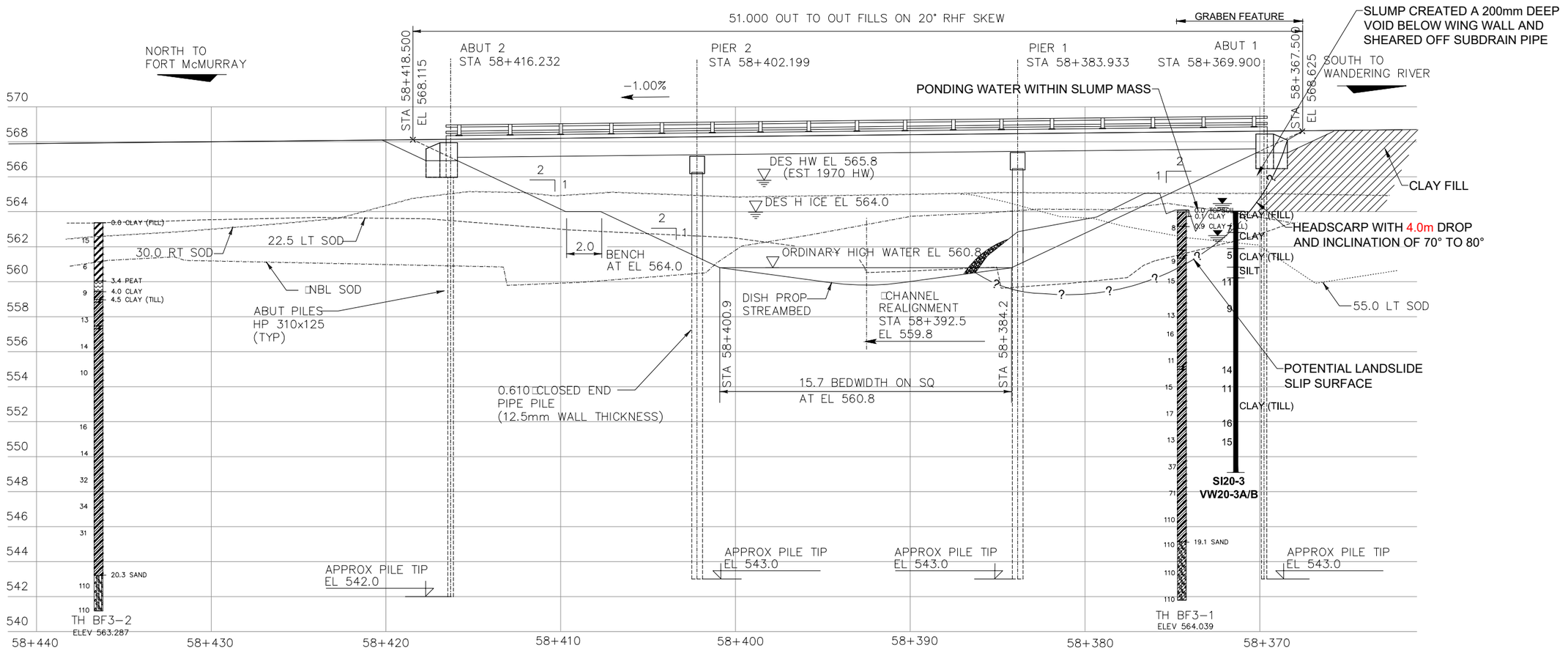
CROSS - SECTION A - A'
SHOWING SLUMP 1 - EAST OF BRIDGE HEADSLOPE

FIGURE 2

DRAWN BY	ML
DESIGNED BY	JGP
APPROVED BY	TSA
SCALE	1:250
DATE	JUNE 2023
FILE No.	32122

THURBER ENGINEERING LTD.



NOTES:

1. MAY 17, 2023 OBSERVATIONS ARE SHOWN IN RED.
2. SLUMP 2 IS WITHIN NORTHWEST APPROACH FILL TO THE WEST OF BRIDGE HEADSLOPE. THE EASTERN FLANK OF THE SLUMP EXTENDS INTO BRIDGE HEADSLOPE.
3. SLUMP 2 IS TOEING OUT NEAR THE MOST WESTERN BRIDGE PIER SUPPORT.

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(ATHABASCA AND FORT MCMURRAY DISTRICTS)
2023 GEOHAZARD ASSESSMENT

CROSS - SECTION A - A'
SHOWING SLUMP 2 - WEST OF BRIDGE HEADSLOPE

FIGURE 3

DRAWN BY	ML
DESIGNED BY	JGP
APPROVED BY	TSA
SCALE	1:250
DATE	JUNE 2023
FILE No.	32122

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Photo No. 1 – Looking northeast from the south side of the bridge at the low-lying area within the bush.

Photo No. A2 – Aerial view showing existing active slumps to the east and the west of the bridge south headslope and a severe erosion gully along the highway east ditch; both landslides reduced the stream width; note sediment accumulations within the stream at the mouth of the erosion gully.

Photo No. 3 – Looking north at north facing riprap channel to the east of the bridge location. Note the deep erosion along the channel.

Photo No. 4 – Looking southeast at the same area in Photo No. 3

Photo No. 5 (Aerial photo) – Slumping within the riverbanks to the east of the Hwy (slump 1) and to the west of the Hwy (slump 2). Note distinct toe rolls in the river channel.

Photo No. 6 – Looking southwest at Slump No. 2

Photo No. A7 (Aerial photo) – Looking at the head scarp crack of Slump No. 2

Photo No. 8 – Looking southeast at Slump No. 2 flank. Note: (a) void developed under wingwall, (b) change in soil type between the area under the bridge and the area beyond (west of) the wing wall, and (c) eastern flank of slump extending below the bridge headslope

Photo No. 9 – Looking northeast at the bridge south approach slab; there is a slight dip in the highway surface, and it is more noticeable within the western half between the yellow line and the edge of pavement above Slump 2