

**ALBERTA TRANSPORTATION
GEOHAZARD ASSESSMENT PROGRAM
NORTH CENTRAL REGION – ATHABASCA
2021 SITE INSPECTION**



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:	September 9, 2020	13	5	65
Current Inspection	June 24, 2021	15	5	75
Road AADT:	3,730	Year:	2020	
Inspected By:	José Pineda, Tarek Abdelaziz (Thurber) Arthur Kavulok, Kristen Tappenden, Bernard Ching (Alberta Transportation)			
Report Attachments:	<input checked="" type="checkbox"/> Photographs <input checked="" type="checkbox"/> Plans <input checked="" type="checkbox"/> Maintenance Items			

Primary Site Issue	Two slumps developed beside the NBL bridge south headslope. The east slump exposed NW wing wall and extended below bridge headslope.
Dimensions:	<p>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 m deep.</p> <p>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).</p>
Site History / Available Information:	<p>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 realigned 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.</p> <p>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.</p> <p>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</p>

	<p>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 of safety of 1.3, which is less than typically recommended for bridge structures (i.e., a FOS of 1.5).</p> <p>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 creek channel; the images also show that a riprap lined channel was constructed at the mouth of the east ditch within the riverbank slope.</p> <p>Slumping on the highway embankment was first noted by Alberta Transportation on August 28, 2020.</p> <p>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.</p>
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Maintenance /Repairs	None	
Observations:	Description	Worse?
<input checked="" type="checkbox"/> Pavement Distress	10 to 20 mm dip within the south approach slab; worse area within the western lanes	<input type="checkbox"/>
<input checked="" type="checkbox"/> 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; western flank extended a bit further west. Slump 2 on the west side of the highway: head scarp cracks up to 4 m deep and 1 m wide; 2 m long graben feature noted during the previous visit was not visible during the 2021 inspection; multiple tension cracks within the Slump 2 slide area. The eastern flank of Slump 2 extends under the bridge by at least 2 m, but it is not exposing the abutment or pile supports. 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.	<input checked="" type="checkbox"/>
<input checked="" type="checkbox"/> Erosion	Erosion developed east of Slump 1 at the mouth of the north facing riprap lined channel. Erosion is approximately 1 to 2 m deep and has distorted the existing riprap within the channel. Scattered and subdued riprap areas along the outside bend of the river channel	<input type="checkbox"/>
<input checked="" type="checkbox"/> Seepage	Seepage along exposed scarp crack surfaces not observed during the 2021 inspection (very dry spring	<input type="checkbox"/>

	season this year); ground within the landslide areas was drier than noted during the 2020 inspection. Beaver dam that used to block muskeg terrain drainage path located east of the highway southbound lanes was removed	
<input checked="" type="checkbox"/> Bridge/Culvert Distress	Slumps 1 and 2 are getting larger and continue to impact the bridge northbound lanes headslope	<input checked="" type="checkbox"/>
<input type="checkbox"/> Other		<input type="checkbox"/>

Instrumentation Readings (Spring 2021):

SI20-1, installed within Slump 1 to the east of the bridge, showed a rate of movement of 292.0 mm/yr over 0.1 m to 1.9 m depth since the previous reading in March 2021, corresponding to a total cumulative movement of 100.9 mm since initialization. SI20-3, installed within Slump 2 to the west of the bridge, sheared off at 3 m below ground surface (likely below the creek bed level). Prior to shearing off, SI20-3 showed a maximum rate of movement of 103.1 mm/yr in February 2021.

Standpipe piezometers SP20-2 and SP20-4 showed groundwater depths of 1.66 m and 3.28 m, respectively, corresponding to increases in groundwater level of 0.04 m and 2.91 m since the piezometers were last read in March 2021.

Vibrating wire piezometers VW20-1A, VW20-1B and VW20-3A show current groundwater depths of 1.08 m, 0.53 m, and 1.38 m, respectively. VW20-3B currently shows an above-ground (artesian) groundwater level of 0.95 m. The vibrating wire piezometers showed increases in groundwater level ranging from 0.05 m in VW20-3A to 1.08 m in VW20-1A since the instruments were last read in March 2021.

Assessment (Refer to attached Figures and Photos):

In general, it appears that the placement of relatively steeply inclined deep 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 considered to be the triggering factors for the observed landslides. In addition, the existing riprap (Class 1M) is relatively smaller in size than typically used for other river bridges and does not appear to extend all the way up to the HWL elevation shown on the as-built drawings of the bridge.

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 outside the footprint of the bridge, and this may have been another contributing factor to observed instabilities. However, there are no detailed construction notes/records to confirm this hypothesis.

The presence of a beaver dam and ponding water to the east of the highway may have resulted in saturation of the highway embankment and riverbank slopes to the east of the bridge. Field observations from the 2020 inspection indicated that ponded water may have overtopped/breached the dam during a prolonged heavy rainfall event and high flow velocities may have caused the severe erosion to the east of the bridge and saturated the east slump (Slump1). Removal of the beaver pond should help reducing groundwater levels within the mass of Slump1.

The slumps 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 landslides are very active, moving at very high rates and growing 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, (b) distress of the wing walls and exposure of abutment seat and a few pile supports (particularly at Slump 2 location), and

(c) possibly intolerable lateral movement of the bridge abutment, wing walls and piles. In addition, the complete failure of these closely spaced slumps, if occurs with time, may also restrict the width of the river channel and results in flooding of areas located upstream of project area.

If the roadway/bridge fail at this location in response to the ongoing 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 2021.

A structural engineer should be consulted to assess the impact of headslope failure on the integrity of the bridge structure.

The conditions of the landslides present a serious hazard (in particular Slump 2) that may impact the bridge structure if repairs are not addressed in the near future.

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 any additional voids or cracks on the highway.
- 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.
- Remove the debris left in place at the location of the old beaver dam to improve surface draining and allow lowering groundwater levels within the highway embankment and direct the water away from Slump 1 location.
- Reshape the failed riprap-lined channel and add heavy rock riprap (Min Class 1) to armor the re-graded channel.
- 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 creek channel.

Long-Term Repair Measures

The long-term repair may include be one of the following options:

Option 1:

Dig and replace the landslide mass of slumps 1 and 2 using granular fill.

It should be noted however that the repair of Slump 2 could be tricky due it its proximity to the headslope and the feasibility of this option should be assessed during the detailed design. The other challenge associated with this option is excavating failed mass below the creek level, which may require the installation of a light sheet pile wall at the at the toe of the slope to provide a cut-off wall.

The ballpark cost of this option would be in the range of \$800,000 to \$1.0 Million (excluding engineering). If light sheet piles are used to provide a cut off for construction purposes, the estimated cost will increase by an additional \$200,00 to \$300,000.

Option 2:

- Install continuous pile walls (30 m long x 15 m deep each) approximately halfway down the failed slope, perpendicular to and on both sides of the highway embankment to stabilize the landslide movements.
- Regrade the slopes above and below the concrete pile wall.
- Undertake minor regarding of the impacted area under the bridge.

The ballpark cost for this option would be in the range of \$1.2 to 1.5 Million (excluding engineering).

Any of the above measures will include re-shaping and armoring the eroded gully and failed banks with heavy rock riprap (at least Class 1), subject to the completion of a hydrotechnical study.

Environmental approvals will be required to undertake the in-stream work, and Restricted Work Activity Period (RAP) in the stream will impact the schedule of the repair project.

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 | Senior Geotechnical Engineer

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



STATEMENT OF LIMITATIONS AND CONDITIONS

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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.

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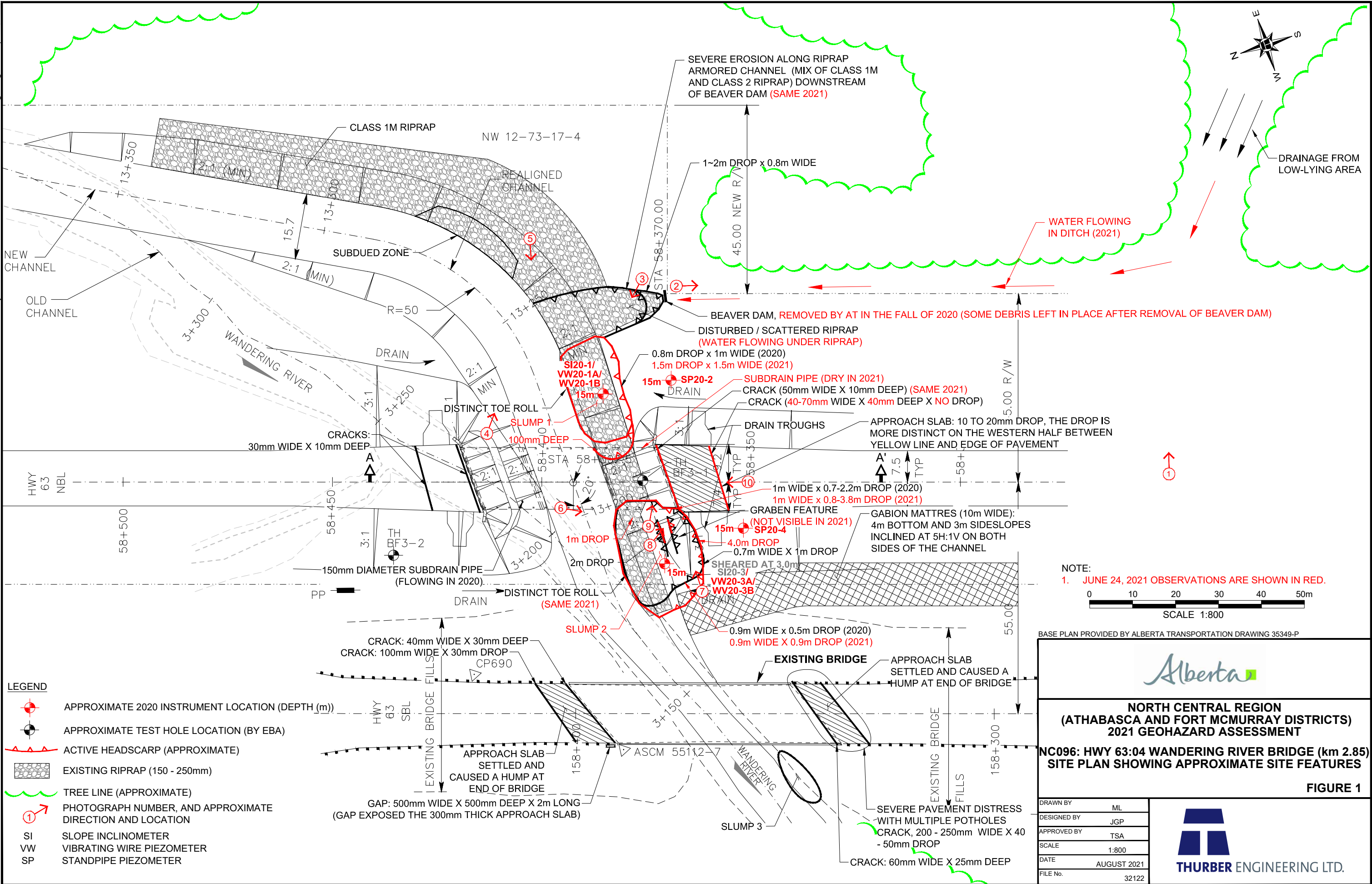
- a) Nature and Exactness of Soil and Contaminant Description: Classification and identification of soils, rocks, geological units, contaminant materials and quantities have been based on investigations performed in accordance with the standards set out in Paragraph 1. Classification and identification 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.

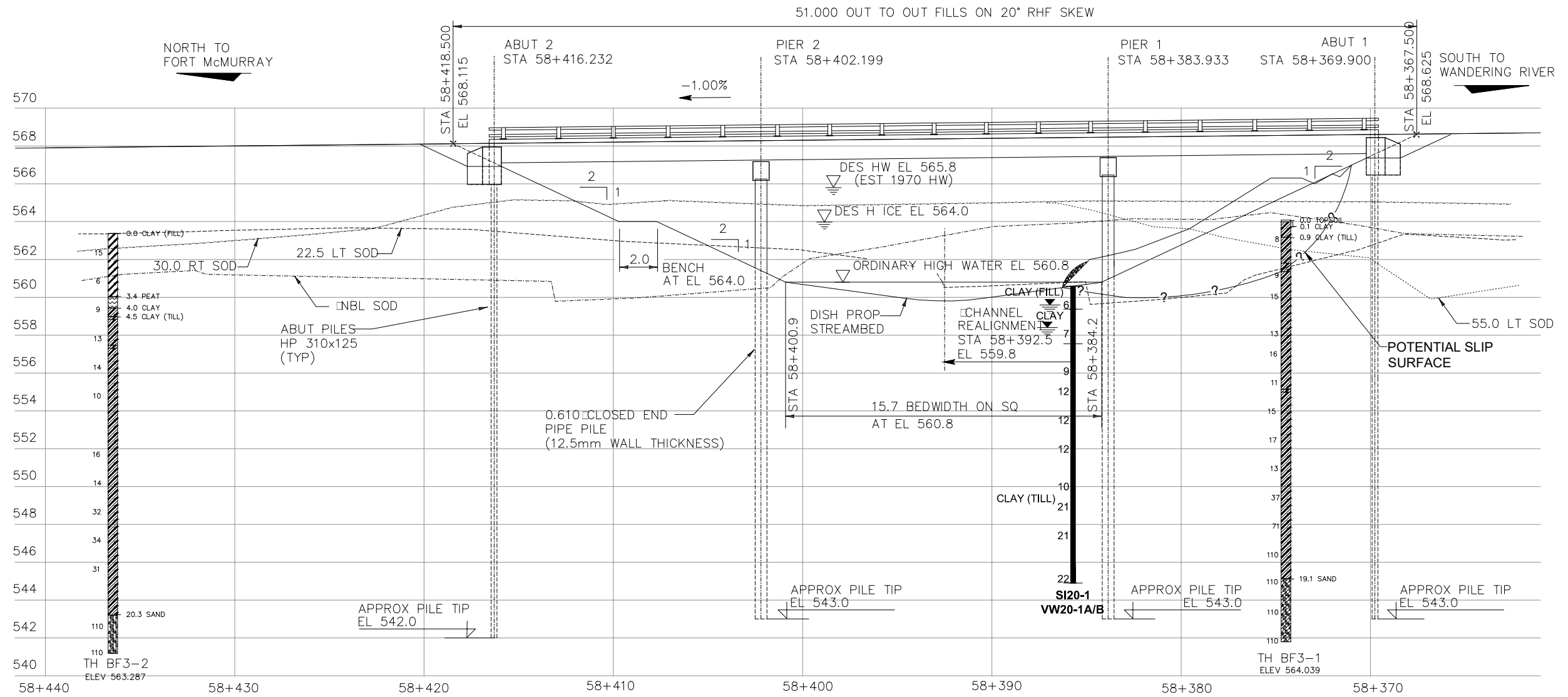
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NOTES:

1. JUNE 24, 2021 OBSERVATIONS ARE SHOWN IN RED.
2. SLUMP 1 IS WITHIN THE RIVERBANK SLOPE TO THE EAST OF THE BRIDGE HEADSLOPE.



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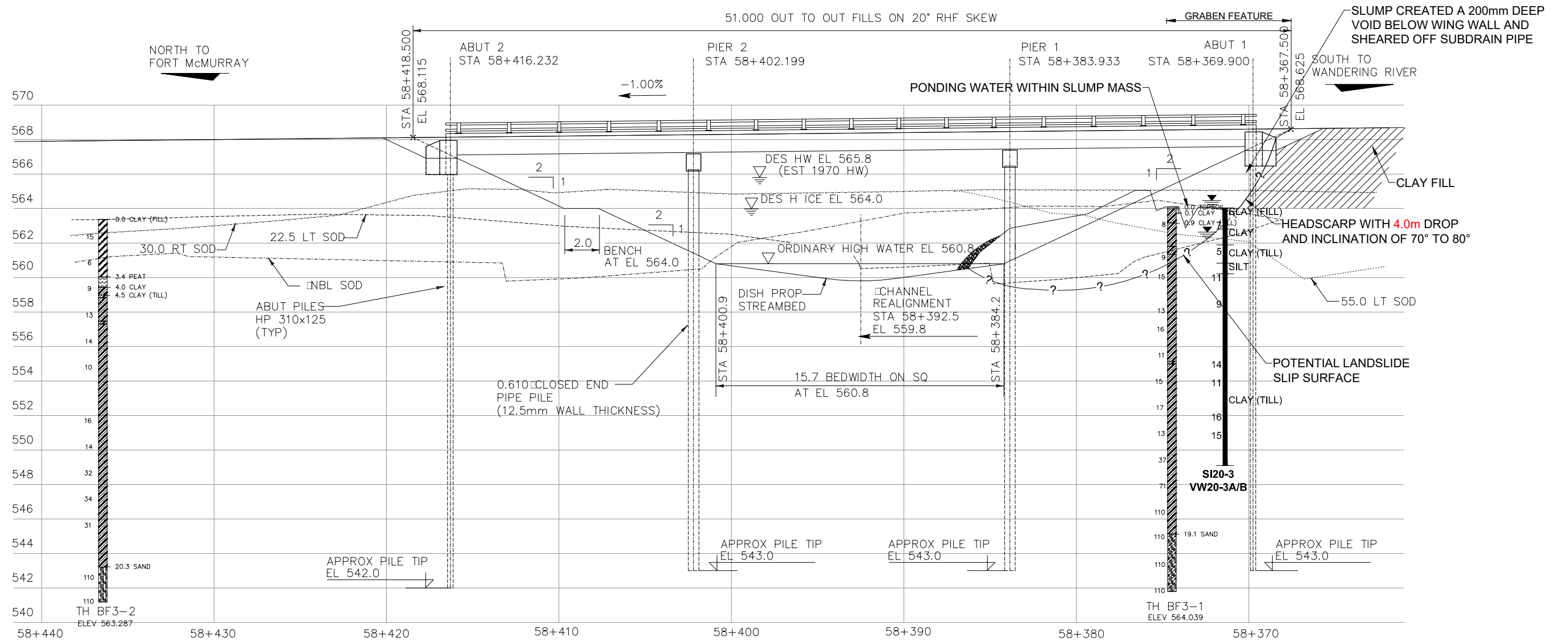
CROSS - SECTION A - A'
SHOWING SLUMP 1 - EAST OF BRIDGE HEADSLOPE

FIGURE 2

DRAWN BY	ML
DESIGNED BY	JGP
APPROVED BY	TSA
SCALE	1:250
DATE	AUGUST 2021
FILE No.	32122




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NOTES:

1. JUNE 24, 2021 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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**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	AUGUST 2021
FILE No.	32122



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Photo No. 1 – Looking southeast from the south side of the bridge at the low lying area within the bush. This area was noted to be flooded in 2020, but it is currently drained due to beaver dam removal by AT in the fall of 2020



Photo No. 2 – Looking south at the highway west ditch; water is draining towards the eroded riprap channel to the east of the bridge



Photo No. 3 – Looking north at north facing riprap channel to the east of the bridge location. Note erosion along the channel. Beaver dam noted in this area in 2020 was removed.



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

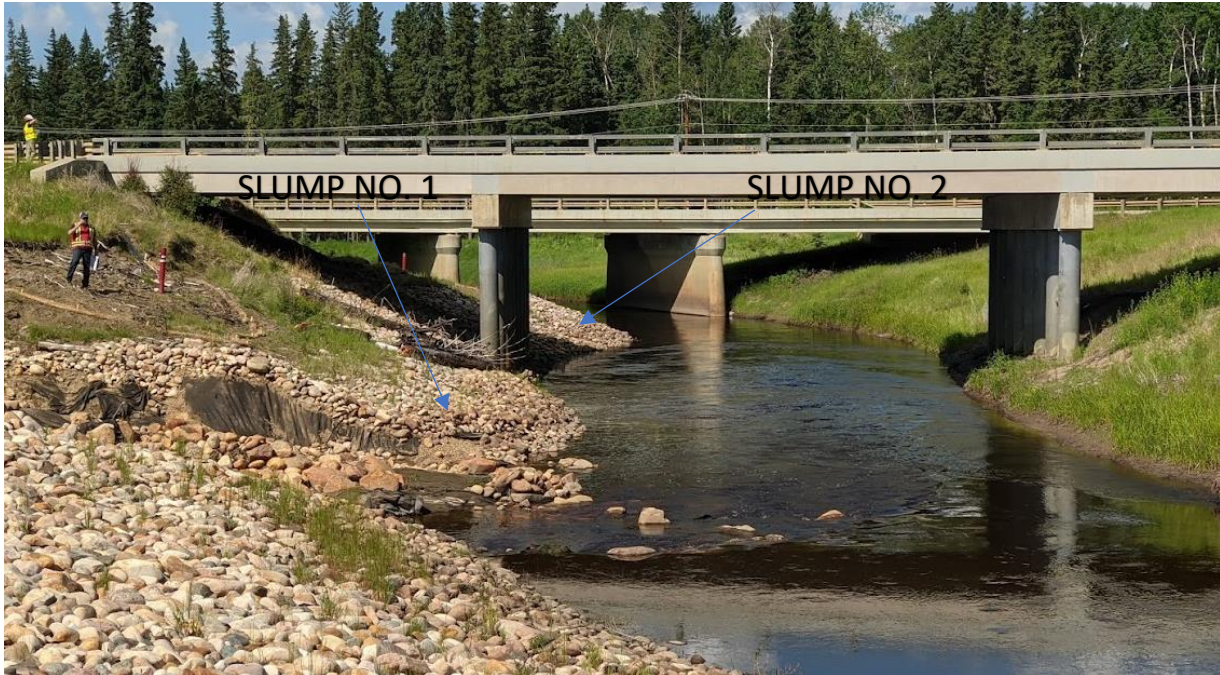


Photo No. 5 – Looking west at river channel; Note slumping within the riverbanks to the east (slump 1) and the west (slump 2) of the south headslope location and the distinct toe rolls in the river channel.



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



Photo No. 7 – Looking east at the head scarp of Slump No. 2



Photo No. 8 – Looking southeast at Slump No. 2 head scarp. Note (a) void developed under wing wall, (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 east at the portion of the head slope impacted by Slump No. 2

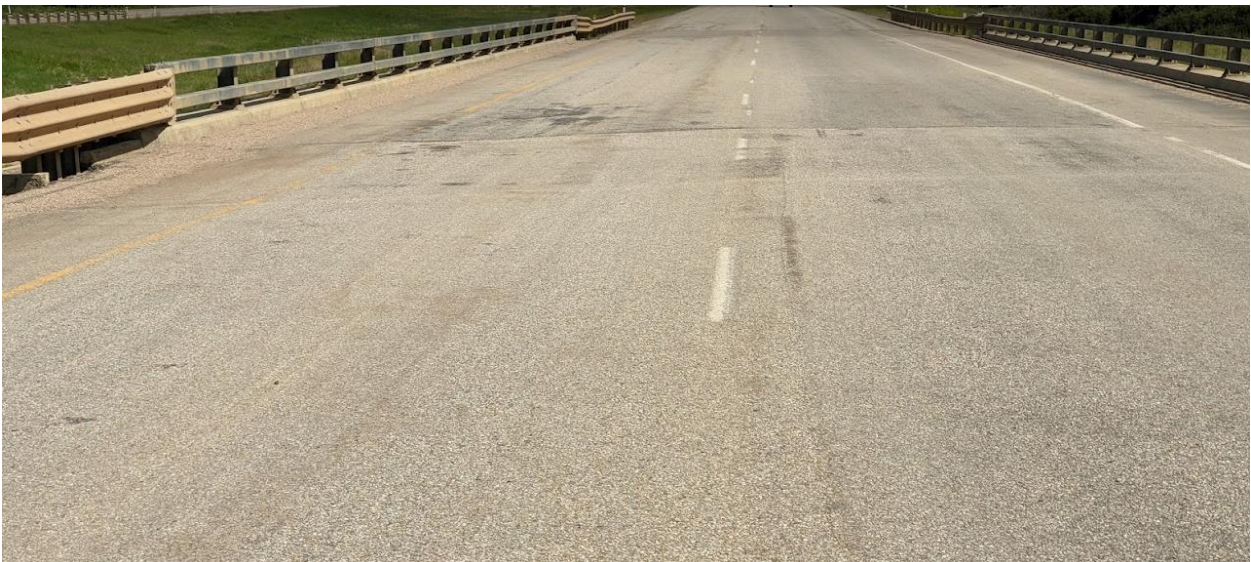


Photo No. 10 – Looking north at the northbound lane bridge south approach slab; there is a slight dip in the highway surface, and it is more noticeable within the western half between the yellow line and the edge of pavement above Slump 2