ALBERTA TRANSPORTATION
GEOHAZARD ASSESSMENT
PEACE REGION (PEACE RIVER DISTRICT)
2022 INSPECTION

THURBER ENGINEERING LTD.

Site Number	Location	Name	Hwy	km
PH048-1 (S) PH048-2 (N)	Northwest of Fort Vermillion, Alberta	Fort Vermillion Bridge (BF74227-1) Abutments	88:18	29.47 (South) 29.96 (North)
Legal Description		**UTM Co-ordinates**		
South Abutment: SE29-108-13-W5M North Abutment: NE29-108-13-W5M		11U E 550,889 N 6,473,826 11U E 550,950 N 6,474,310		

	Date	PF	CF	Total
Previous Inspection:	5-Jun-2020	South: 5 North: 9	4 4	20 36
Current Inspection:	2-Jun-2022	South: 5 North: 9	4 4	20 36
Road AADT:	1540		**Year:**	2022
Inspected By:	Rishi Adhikari, TRANS Max Shannon, TRANS		Ken Froese, Thurber Mark Gallego, Thurber	
Report Attachments:	☑ Photographs	☑ Plans	☐ Maintenance Items	

Primary Site Issue:	Abutment headslope movement (north) and river erosion (south).	
Dimensions:	See Drawings	
Date of Remediation:	2015: Toe berm and riprap constructed at the south abutment with driven steel shear piles. 2016/17: North-most pier foundation underpinned with concrete piles, drainage blanket and gravel toe berm installed against north headslope	
Maintenance:	2011: Repairs to the concrete drainage troughs at the north abutment and concrete added to the base of the south abutment wall. 2021/2022: Grouting of the voids adjacent to the west wing walls at the north abutment.	
Observations (North Abutment):	**Description**	**Worsened?**
☐ Pavement Distress		☐
☑ Slope Movement	Continuing distortion of concrete drainage elements from headslope settlement/movement as well as further deterioration of scarps and cracks adjacent to the abutment.	☑
☑ Erosion	Gully forming below and beside concrete drainage trough and along east wingwall. Damage (2020) to riprap armour of toe berm.	☑
☑ Seepage	One seep in upper slope bench area; lower headslope seepage now handled by toe berm drainage layer and subdrain flows steadily when not buried by silt. Additional seepage from headslope noted previously immediately above top of toe berm.	☐
☑ Bridge/Culvert Distress	Gap between abutment wall and bridge beams changes likely due to thermal contraction and expansion of bridge deck.	☑

	Ongoing spalling of the concrete and rusting of the underlying rebar observed at several locations. Cracking of the concrete facing observed beneath the approach slab.	
☐ Other		☐
Observations (South Abutment):	**Description**	**Worsened?**
☑ Pavement Distress	Slight dip in pavement surface just south of the approach slab. Recent patch at edge of approach slab and transverse crack further south – pothole has been patched.	☐
☐ Slope Movement		☐
☑ Erosion	River erosion repaired with toe berm and riprap construction in 2015 but minor flood-damage occurred on top of toe berm in 2018 and 2020. Minor erosion occurring at base of abutment wingwalls and slightly worse in 2022.	☑
☐ Seepage		☐
☑ Bridge/Culvert Distress	Gap between bridge beam and abutment wall changes likely due to thermal contraction and expansion of bridge deck. There is also ongoing spalling of the abutment concrete.	☑
☐ Other		☐

Instrumentation (Spring 2022):

South Abutment	SI3: no discernable movement pattern has developed. SI13-6: Destroyed by a vehicle in 2018. SP13-5: Water level dropped between Fall 2016 and Fall 2019 and now appears to have an increasing trend since Fall 2020 and is near the historical high level sent in Spring 2021.
North Abutment	SI13-2: relatively significant, albeit shallow, cumulative movement of 167 mm at an average depth of 2.5 m. Movement appears cyclical (slower or reversed in Fall), and jumped 21 mm since Fall 2019, but has a continuous movement trend that might be a result of the shallow earth rotation along the outside of the concrete gutter. SI15-4: Downhole camera images determined the pipe is broken at 1.5 m and obstructed at 6.7 m. It should be replaced. PN13-2A has varied less than 0.6 m since 2015 stabilizing at an average of 3.8 m BGL The water level at PN13-2B dropped about 3 m from the average of the previous 3 years in Fall 2020 but has since increased to a historical high of 15.3 m BGL.

Assessment:

RECENT HIGH WATER EVENTS:
Spring 2018: Estimated at 255 m El which is 2 m below the north abutment toe berm and 3 m above the south abutment toe berm
Spring 2020: Peak water level recorded at the town of Fort Vermilion downstream of the bridge was 257.8 m El (April 28). At the bridge, the north abutment toe berm does not appear to have been overtopped but debris was located just below the crest putting the peak at 257.0 m El which is 2 m higher than in Spring 2018 and 5 m above the south abutment toe berm.

NORTH ABUTMENT:
The toe berm was constructed, and Pier 4 foundation underpinned in 2016 and 2017. The presence of the toe berm should result in a decrease in the amount of displacement observed on the headslope due to the rotational movement previously documented at this site. Seepage was observed at several locations on the headslope, particularly below the drain trough. Significant silt has accumulated at the toe of the slope and in the riprap facing of the toe berm from the 2018 and 2020 floods. Although the subdrain from the toe berm was not visible in 2018 and 2019, there was seepage and erosion through the silt at the toe where the subdrain is likely located. The subdrain was buried again in 2020 and seepage was not evident at the ground surface. In 2022, the river level was halfway up the toe berm and the subdrain was not visible. There was also seepage and erosion happening to the east of the toe berm in the accumulated silt sediments. The geogrid at the top of the toe berm was exposed in a few small locations. There was some ponded water on the surface of the toe berm. There has been displacement of riprap over much of the bottom of the toe berm, although this was not visible in 2022 due to the higher river level. The underlying geotextile was exposed at the upstream corner (southwest) and rock has been displaced up to 6 m away from the toe of the protected slope.

The slope below the north abutment continues to show signs of movement as indicated by the tilted concrete mats adjacent to the abutment walls, depressed ground around the abutment, and increasing crack widths on the headslope. The scarps at the east and west sides of the slope also appear to be intermittently active with fresh movement observed in 2019 east of the abutment. The inclination of the headslope, which ranges from 2.0H:1V to 2.35H:1V, is steeper than typical for slopes in the area. It is likely that the local factor of safety against slope failure is lower than normal design standards and has led to the observed rotational creep movement. A high-water table in the abutment fill area, as evidenced by seepage that has been observed , is likely a contributing factor to the observed slope movements. The depressed area around the abutment also might trap water and add to the problem.

The displacements of the slope are likely adding vertical and lateral loads on the bridge abutment piles. The drainage gutters along the wing walls continue to settle and rotate as the headslope fill settles and rotates. Ongoing slope movement has resulted in cracking and separation of a portion of the gutter, which will contribute additional water into the slope causing further undermining of the gutter and gabion baskets. The concrete trough below the bridge has noticeably deteriorated since 2020 and the formation of erosion gullies beside and below will lead to an increased rate of movement.

Thurber has assisted GeoMetrix with geotechnical improvements to the north headslope that will be included with structural repairs scheduled for later in 2022. This will include flattening the headslope below and adjacent to the abutment, which should reduce the continual deterioration of the slope. The cracked concrete drain trough will be removed and replaced with riprap-lined channels set away from the structure. Inclinometer SI15-4 will also be replaced as part of this work.

SOUTH ABUTMENT:
The riverbank on the south abutment had shown continued retrogressive erosion towards the abutment slope caused by river water and ice. It may have been exacerbated by localized eddying from the abandoned test piles located adjacent to the toe of the slope. This was mitigated by constructing a toe berm and riprap facing which was complete by 2016. There were no signs of river erosion along the toe of the riverbank in the vicinity of the bridge in 2017. However, high flood waters in Spring 2018 and 2020 rose to about 3 m and 5 m, respectively, above the toe berm. The flood removed significant quantities of vegetation and eroded the banks beyond the riprap protection. Some displacement of rocks in the riprap facing was observed and gravel was lost from behind the riprap exposing and damaging the geocell containment. Silt was embedded into the riprap and piles of dead trees were observed on both sides of the abutment fill. The much higher water level in 2020 deposited a significant amount of driftwood on the west side of the approach fill.

In 2022, there was little change from the conditions observed in 2020. The erosion gullies on each side of the abutment wingwalls were slightly deeper. It was noted that there was an accumulation of fine gravel at the west corner of the abutment seat, which appears to be from degrading concrete. In discussions with GeoMetrix regarding the bridge repairs planned, they pointed out that there is a distinct horizontal shear crack through the abutment seat, which is likely at the contact between

unreinforced concrete below (in which the steel piles are embedded) and the reinforced concrete above. They are planning to have the contractor excavate below this seat to expose the void, install some dowels to reinforce the seat, and fill the void with grout or concrete.

Recommendations:

Thurber undertook a geotechnical investigation at this site in 2012 to 2013 for CH2M Hill and was involved with the construction which commenced in 2014 and was completed in late 2017. The repairs at the north abutment consisted of a toe berm to stabilize the headslope against shallow failures and placement of 16 concrete piles to underpin Pier 4 as well as to provide lateral resistance to a potential failure surface along a bentonite seam in the bedrock. The repairs on the south abutment consisted of removing slump soil and reconstituting the bank with granular fill installing driven steel shear piles and a riprap facing and was complete at the time of the 2016 annual site inspection.

Recommendations were made in 2015 for changes to the north abutment toe berm design to accommodate the additional seepage observed in 2015 which were incorporated. The over steepened slope immediately above the top of the toe berm was repaired by placing gravel material at a 3H:1V to buttress the slope.

As discussed above, Thurber also provided input to Geometrix in 2022 for geotechnical improvements that should be incorporated into a planned bridge rehabilitation project.

Short-Term:

- North Abutment: Riprap on toe berm needs to be fixed and/or augmented due to the amount of rock displaced during the flood of Spring 2020 which could lead to greater damage in the next flood.
- North Abutment: Erosion gullies should be backfilled with compacted clay and erosion control measures (such as Filtrexx socks) placed across the slope to reduce surface water flow velocities.
- North Abutment: Voids under the concrete slabs adjacent to the wingwalls should be filled with fillcrete or urethane foam to reduce water infiltration. This will be regraded as part of the planned rehabilitation.
- South Abutment: Repair the erosion gullies on either side of the abutment wing walls. Grouting the voids might be the most-economical method.

Medium-Term:

- It is recommended that the concrete gutters at the north abutment be removed and rebuilt ensuring a controlled drainage path down to and across the toe berm. A combination of concrete, half-round culverts, and erosion control products could be used. This will be done as part of the planned rehabilitation.
- The upper part of the north headslope should be regraded on both sides of the abutment to a flatter inclination to improve drainage along the slope and reduce driving forces on the shallower slip surfaces that may be present. Subdrains should also be installed to dewater the upper slope. This will be done as part of the planned rehabilitation.
- There is no functioning slope inclinometer at the toe of the north abutment that will measure whether or not the remedial measures have been effective. It is recommended that at least one inclinometer be installed through the toe berm for this purpose. Consideration could be given to also installing one or two additional inclinometers and piezometers in the upper portion of the slope while a drill rig is on site. This will be done as part of the planned rehabilitation.
- The concrete in the wing walls is in poor condition and should be assessed by a bridge engineer to determine when structural repairs are warranted.

Ongoing Investigation:

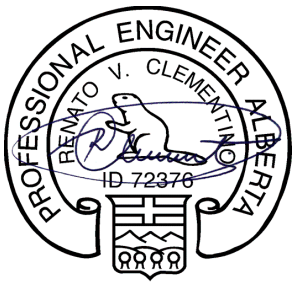
- It is recommended that the annual Geohazard inspection should continue as scheduled.
- The Geohazard instrumentation readings should continue as scheduled.

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.

Renato Clementino, Ph.D., P.Eng.
Principal | Senior Geotechnical Engineer

October 16, 2022



October 17, 2022

PERMIT TO PRACTICE
THURBER ENGINEERING LTD.
RM SIGNATURE: _____
RM APEGA ID #: 72376
DATE: October 17, 2022
PERMIT NUMBER: P005186
The Association of Professional Engineers and Geoscientists of Alberta (APEGA)

Ken Froese, P.Eng.
Associate | Senior Geotechnical Engineer

THURBER

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.

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.

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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.

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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.

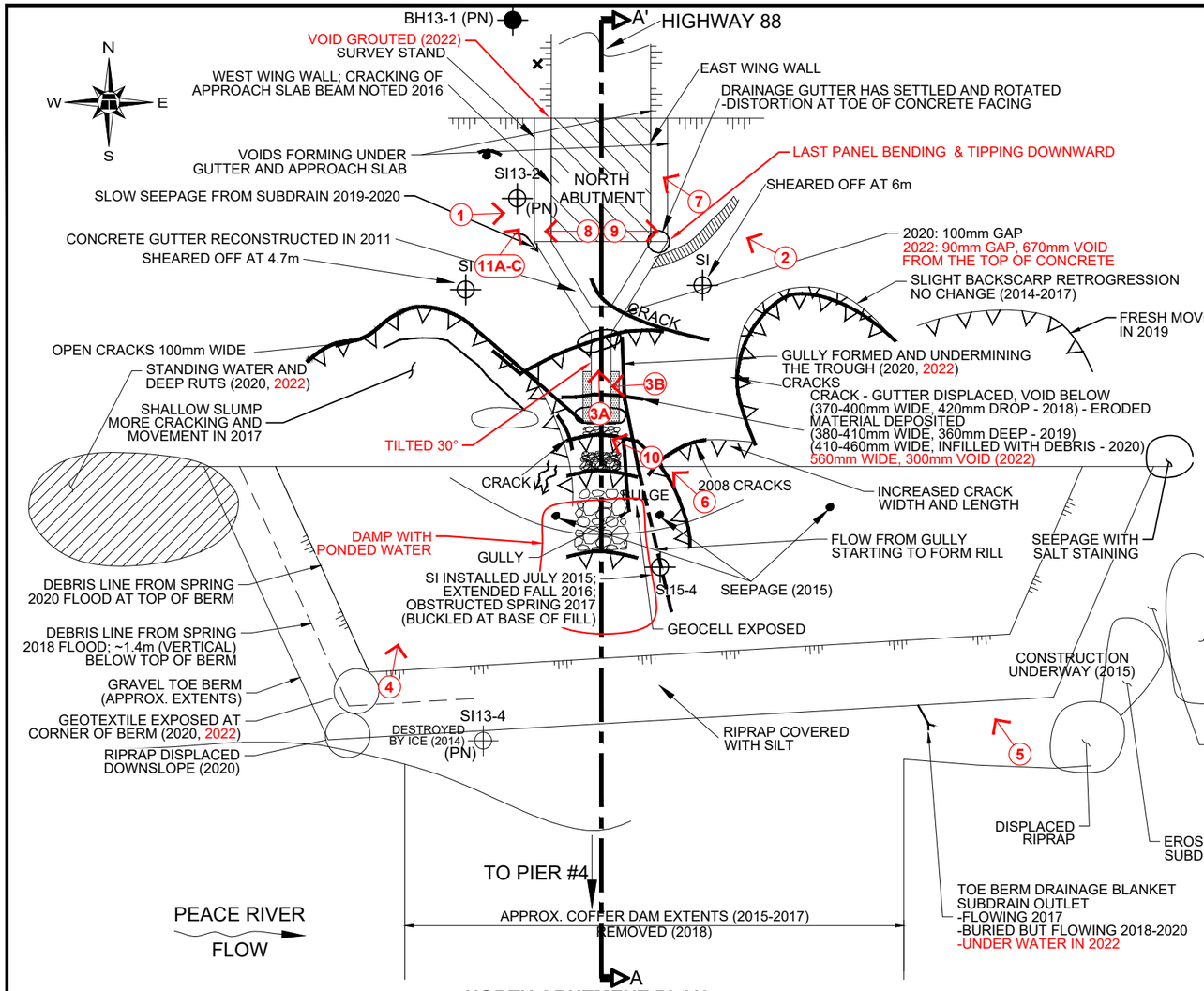
d) Construction Services: During construction Thurber should be retained to provide field reviews. Field reviews consist of performing sufficient and timely observations of encountered conditions in order to confirm and document that the site conditions do not materially differ from those interpreted 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.

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.

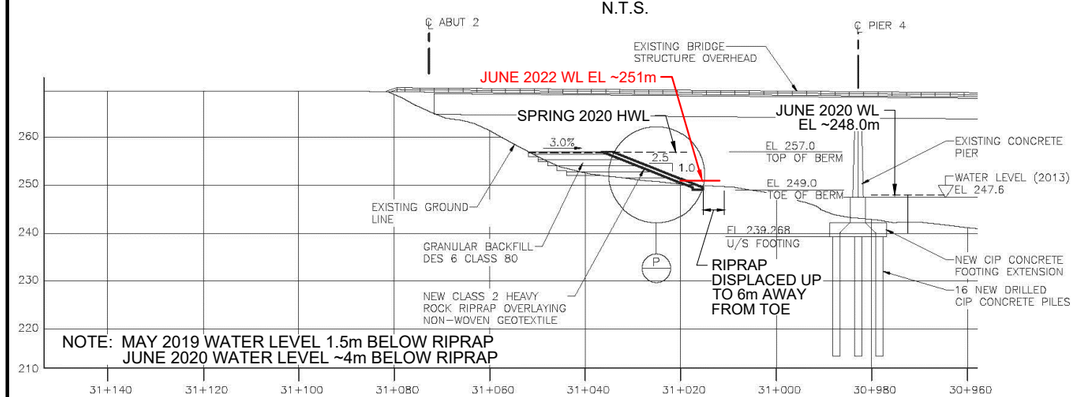
7. INDEPENDENT JUDGEMENTS OF CLIENT

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.



NORTH ABUTMENT PLAN

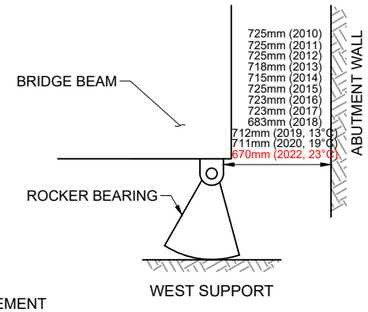
N.T.S.



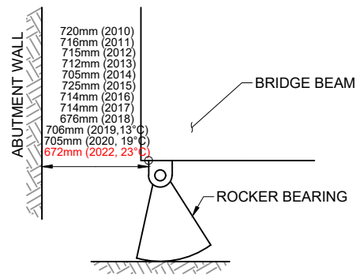
NOTE: MAY 2019 WATER LEVEL 1.5m BELOW RIPRAP
JUNE 2020 WATER LEVEL ~4m BELOW RIPRAP

CROSS-SECTION A-A'

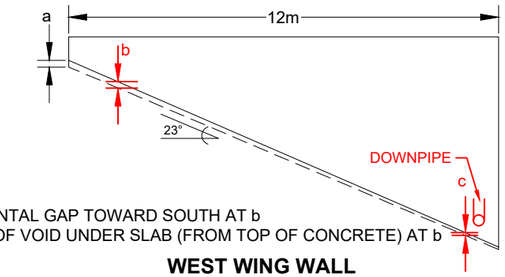
1:1250



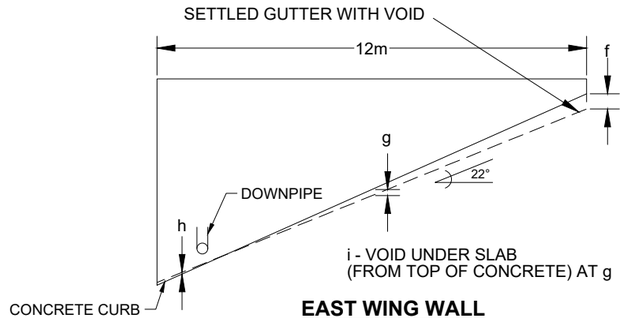
WEST SUPPORT



EAST SUPPORT



WEST WING WALL



EAST WING WALL

WEST WING WALL MEASUREMENT (mm)					
DATE	a	b	c	d	e
MAY 2006	190	150	65	-	-
MAY 2007	200	160	75	120	-
MAY 2008	210	200	50	110	280
MAY 2009	215	210	60	110	290
JUNE 2010	200	180	45	120	-
JUNE 2011	220	215	60	123	-
JUNE 2012	240	220	70	130	290
MAY 2013	240	220	80	130	290
JUNE 2014	230	220	70	145	330
JUNE 2015	280	240	70	150	330
JUNE 2016	280	-	-	160	300
JUNE 2017	260	240	85	150	310
JUNE 2018	230	240	90	150	230
MAY 2019	220	240	-	160	240
JUNE 2020	230	230	90	160	255
JUNE 2022	230	235	90	180	-

EAST WING WALL MEASUREMENT (mm)				
DATE	f	g	h*	i
MAY 2006	420	230	75	-
MAY 2007	285	100	90	-
MAY 2008	315	100	70	750
MAY 2009	250	100	70	750
JUNE 2010	475	235	75	-
JUNE 2011	490	260	75	-
JUNE 2012	520	270	60	770
MAY 2013	520	290	60	840
JUNE 2014	510	270	55	605
JUNE 2015	560	220	35	750
JUNE 2016	560	-	35	600
JUNE 2017	540	300	40	630
JUNE 2018	560	360	20	610
MAY 2019	600	360	-20	650
JUNE 2020	640	375	-20	730
JUNE 2022	630	390	60	600-870

* HEAVE

VERTICAL DISPLACEMENTS AT NORTH ABUTMENT

N.T.S.

CROSS-SECTION TAKEN FROM ISSUED FOR CONSTRUCTION DRAWINGS (CH2M HILL, SEPTEMBER 19, 2014)

LEGEND

- TEST HOLE WITH PIEZOMETER
- SLOPE INCLINOMETER (SI) *(currently using)*
- SLOPE INCLINOMETER (SI) *(not in use)*
- (PN) PNEUMATIC PIEZOMETER(S)
- SCARP
- SEEPAGE
- (1) PHOTO AND DIRECTION

NOTE: JUNE 2022 OBSERVATIONS SHOWN IN RED

Alberta

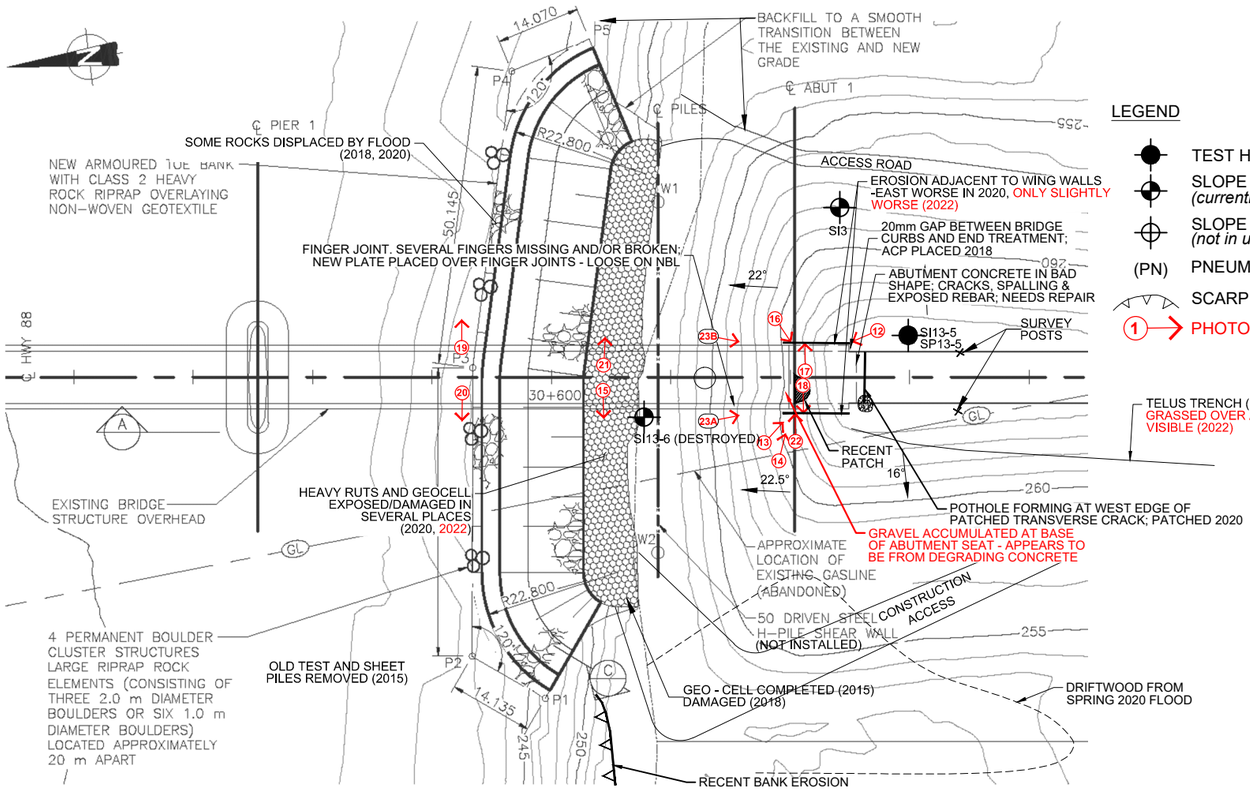
PEACE REGION (PEACE RIVER / HIGH LEVEL)

PH048-1: HWY 88, FT. VERMILION BRIDGE (NORTH ABUTMENT) - km 29.96
2022 GEOHAZARD ASSESSMENT

DWG No. 32121-PH048-1-1

DRAWN BY	ML
DESIGNED BY	KEF
APPROVED BY	RVC
SCALE	AS SHOWN
DATE	OCTOBER 2022
FILE No.	32121

THURBER ENGINEERING LTD.

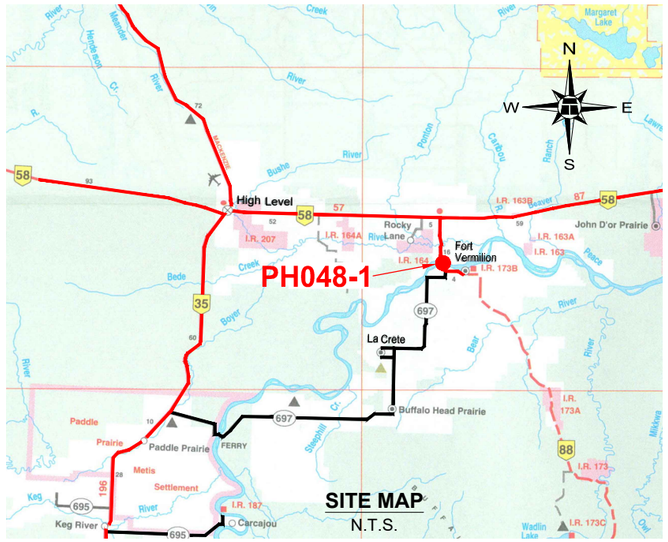


SOUTH ARMOURED TOE BANK PLAN

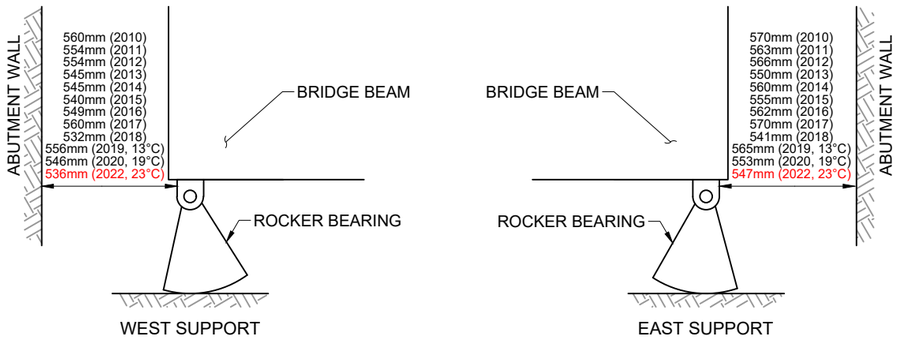
SCALE: 1:1000

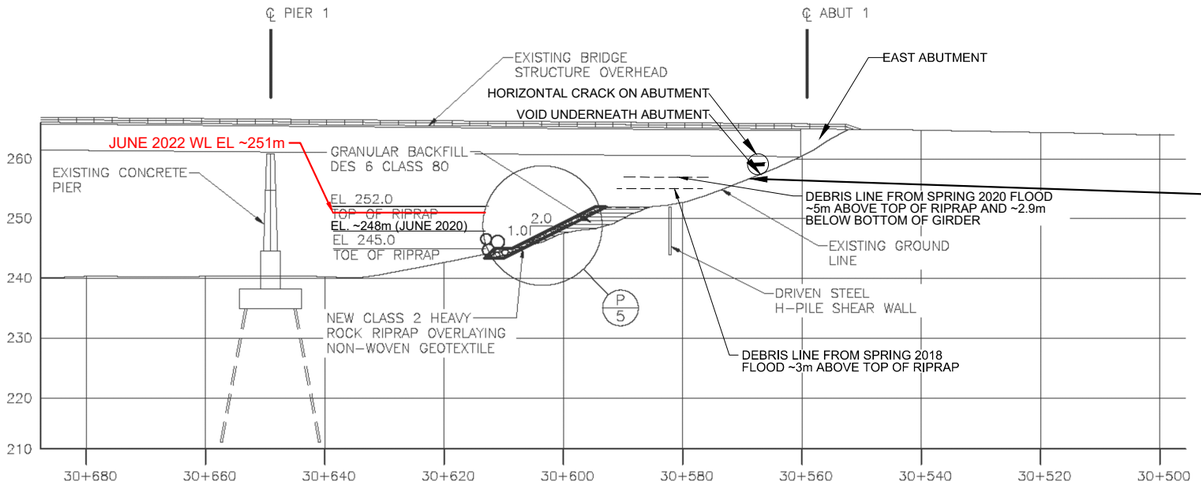
LEGEND

- TEST HOLE WITH PIEZOMETER
- SLOPE INCLINOMETER (SI) *(currently using)*
- SLOPE INCLINOMETER (SI) *(not in use)*
- (PN) PNEUMATIC PIEZOMETER(S)
- SCARP
- 1 → PHOTO AND DIRECTION



SITE MAP
N.T.S.





A SOUTH ARMOURED TOE BANK ELEVATION

SCALE: 1:1000

ABUTMENT SETTLEMENTS (MEASURED BELOW ABUTMENT PILE CAP)			
LOCATION	SETTLEMENT (mm)		
	IN 2010	IN 2011	IN 2012
1m FROM THE EAST WING WALL	120	140	STUB WALL ADDED IN FRONT OF VOID IN 2011
AT THE PIPE	140	175	
2m FROM THE WEST WING WALL	80	90	

NOTE: JUNE 2022 OBSERVATIONS SHOWN IN RED

PLAN AND CROSS - SECTION TAKEN FROM ISSUED FOR CONSTRUCTION DRAWINGS (CH2M HILL, SEPTEMBER 19, 2014)

Alberta

PEACE REGION (PEACE RIVER / HIGH LEVEL)

PH048-1: HWY88, FT. VERMILION BRIDGE (SOUTH ABUTMENT) - km 29.47
2022 GEOHAZARD ASSESSMENT

DWG No. 32121-PH048-1-2

DRAWN BY	ML
DESIGNED BY	KEF
APPROVED BY	RVC
SCALE	AS SHOWN
DATE	OCTOBER 2022
FILE No.	32121

THURBER ENGINEERING LTD.

Photo 1, North – Looking east at north abutment finger joints.

Photo 2, North – Looking north at east wing wall.

Photo 3A, North – Looking north at north abutment concrete gutter. Void below the gutter is up to 670 mm deep.

Photo 3B, North – Looking west at cracked and shifting north abutment concrete gutter. Void below the lower portion of the slab up to 300 mm (measured from top of concrete).

Photo 4, North – Looking north at west side of north abutment.

Photo 5, North – Looking north at east side of north abutment.

Photo 6, North – Seepage along toe of headslope face just above the top of the toe berm which is ponding on the surface of the berm.

Photo 7, North – Looking northwest at gap between the concrete gutter and north abutment wing wall resulting from settlement of abutment fill.

Photo 8, North – Looking west at north abutment west rocker bearing.

Photo 9, North – Looking east at north abutment east rocker bearing.

Photo 10, North – Looking northwest at tension cracks on the east side of the north abutment.

Photo 11A, North – Looking northeast at north abutment west side wing wall. Blue arrow shows recent grouting of voids. Cracking of beam denoted by red arrow shown in Photo 11B.

Photo 11B, North – cracking of approach slab beam above west side wingwall.

Photo 11C, North – Hump of material creeping into concrete drainage trough adjacent to west wingwall.

Photo 12, South – Looking northwest at top of east side wing wall.

Photo 13, South – Looking southeast at south abutment west side wing wall. Erosion occurring at the base of the wall.

Photo 14, South – Looking east at south abutment concrete wall.


Photo 15, South – Looking west at new toe berm at south riverbank. Erosion of gravel at the top of toe berm occurred with high flood levels in Spring 2018 and 2022 exposing the GeoCell at several locations.

Photo 16A, South – Looking southwest at south abutment concrete wall.

Photo 16B, South – Looking southwest at spalling on south abutment wall.

Photo 17, South – Looking east at south abutment east rocker bearing.

Photo 18, South – Looking west at south abutment west rocker bearing.

Photo 19, South – Looking at east side of south abutment with completed construction of toe berm.

Photo 20, South – Looking at west side of south abutment.

Photo 21, South – Looking east at new toe berm under south abutment.

Photo 22, South – Looking east at south abutment finger joints which was covered with a plate between the 2017 and 2018 visits and repaired prior to the 2022 visit.

Photo 23A, South – Riprap placed in 2015 on south headslope below west deck drains.

Photo 23B, South – Riprap placed in 2015 on south headslope below east deck drain.