

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



THURBER ENGINEERING LTD.

Site Number	Location	Name	Hwy	km
SH016-1	Little Smoky River	West Bridge Abutment	49:12	1.90
Legal Description		UTM Co-ordinates		
NE33-74-21-W5M		11U E 489,573	N 6,145,499	

	Date	PF	CF	Total
Previous Inspection:	28-Jun-2021	14	6	84
Current Inspection:	31-May-2022	14	6	84
Road AADT:	1450		Year:	2022
Inspected By:	Rishi Adhikari, TRANS Ed Szmata, TRANS Max Shannon, TRANS		Ken Froese, Thurber Mark Gallego, Thurber	
Report Attachments:	<input checked="" type="checkbox"/> Photographs <input checked="" type="checkbox"/> Plans <input type="checkbox"/> Maintenance Items			

Primary Site Issue:	West abutment of bridge is located on toe of deep-seated landslide as well as affected by local bank slumping from river erosion.
Dimensions:	The west abutment and west-most pier (Pier 1) are affected by landslide movement as well as some minor pavement distortion extending about 100 m further west. The width of the scarp of the local slump at the river edge adjacent to Pier 2, estimated from LiDAR, is 60 m.
Date of Remediation:	1999: Geotechnical investigation by Thurber including SI99-1 through SI99-5 installation. 2000: Pier 1 wing walls installed. 2017: Slump and erosion above Pier 2 repaired with stone columns, granular fill, and riprap. 2021: Geotechnical investigation by Thurber to support Most Engineer's design and implementation of structural repairs.
Maintenance:	2015: Bridge superstructure painted 2019: Pier 1 adjusted with new shims and slider plates Fall 2020: Pavement overlay and guardrail replacement

Observations:	Description	Worsened?
<input checked="" type="checkbox"/> Pavement Distress	Sag in pavement profile just west of the bridge abutment.	<input type="checkbox"/>
<input checked="" type="checkbox"/> Slope Movement	There is overall slope movement although the localized failure at Pier 2 has been repaired.	<input checked="" type="checkbox"/>
<input checked="" type="checkbox"/> Erosion	Ongoing erosion of valley toe at river's edge (repaired 2017) – south end of riprap over-steepened and north end displaced. Erosion gullies forming on south side of West Abutment, Abutment #1, and Pier #1	<input checked="" type="checkbox"/>
<input type="checkbox"/> Seepage		<input type="checkbox"/>
<input checked="" type="checkbox"/> Bridge/Culvert Distress	The West Abutment, Abutment #1, and Pier 1 are routinely adjusted to compensate for ongoing slope movement.	<input checked="" type="checkbox"/>
<input type="checkbox"/> Other		<input type="checkbox"/>

Instrumentation (Fall 2021):2022
Instruments

The new instrumentation was last read in Fall 2021 about 120 days after installation:

On the south side of Pier 1, SI21-07 has distinct zone at 479.5 m elevation with an overall movement rate of 22 mm per year. On the north side of Pier 1, SI21-08 has a distinct zone at 483.4 m elevation with an overall movement rate of 22.7 mm per year. These two are moving nearly due east.

Near Abutment 1, SI21-09 has a distinct zone at 484.4 m elevation with an overall movement rate of 28.8 mm per year. This SI is moving a bit north of east.

Water levels in the VW piezometers have been relatively stable since installation.

The flow pattern at TH21-07 is nearly hydrostatic with only a small downward gradient; TH21-08 is strongly downward; and TH21-09 is downward as well.

Assessment:

The overall valley slope is moving as several separate slide blocks resulting in numerous scarps, sag ponds, and differential movement zones all coalescing on a common base failure plane in the base of a disturbed clay shale unit immediately above an underlying gravel layer. This gravel layer daylights in the river immediately upslope of Pier #2.

Based on GPS survey of the inSAR points conducted by Alberta Geological Survey (AGS Open Report 2013-14), the west abutment of the bridge is situated on a faster-moving block (greater than 90 mm per year) compared to the rest of the west slope which is moving at 5 mm to 40 mm per year. Figure 1 shows a high-level view of the LiDAR (flown in 2008 and provided by Alberta Transportation) for the overall west slope where slide scarps and sag pond features can be readily identified.

Information on the relative deformations between Abutment #1 and Pier #1 indicate that Pier #1 is likely situated on or near the intersection of two different blocks. The deformation at Pier #1 is further complicated by the presence of additional, near-surface movements (likely creep) zones in the upper 4 m. The dominant driving mechanism appears to be toe erosion due to lateral migration of the Little Smoky River; correlation with precipitation levels and stability analyses indicate that a high ground water table may also be contributing.

The West Abutment, Abutment 1, and Pier 1 were designed to compensate for movement of the landslide and foundation below the bridge. The West Abutment compensation is done by adjusting the location of the west half of the finger joints along with adjustment of the length of the approach slab by removing steel I-beams (see photos). Since 2000, three of the five beams have been removed with the fourth likely to be taking out in the next couple of years. As each beam is approximately 368 mm in width, there has been 1104 mm of horizontal displacement in 20 years for an annualized rate of 55 mm/year. Based on measurements between the bridge deck and wingwall, there has been 220 mm of displacement in the last three years which is 73 mm/year.

The girders between the West Abutment and Abutment 1 had been partially supported mid-way by a block of the older foundation. This was jack-hammered out during bridge structural repairs in 2021/2022 so the girders can move freely now.

Abutment 1 teflon bearing pads move laterally over stainless-steel slide plates and are adjusted vertically using shim plates above the bearing pads, and like Pier 1, require frequent adjustment. When additional shim plates are added, the contractor also jacks the bridge transversely to correct the alignment. Measurements taken at the south-most bearing pad indicate 110 mm of movement between October 28, 2020, and May 29, 2021, for an annualized rate of 264 mm per year.

Pier 1 has a similar bearing pad and slide plate arrangements and, in June 2019, new shims and slider plates (to extend the distance the bearing pads can travel) were installed by Ardy Rigging. There is currently 0.84 m of shim between the foundation and the pier. The height of shims was 0.62 m in 2018 and 0.75 m in 2019 giving approximate annual settlements of 130 mm between 2018 and 2019 and 80 mm between 2019 and 2020. Since 1958, there has been 2.97 m of vertical settlement at this pier (approximately 48 mm/year average). Comparing current bolt holes in use on the wingwall with the ones that appear to have been used in the past, there has also been 1.18 m of

horizontal movement since the wingwalls were installed in 2000 (74 mm per year). Previous measurements of marks on the slider plates estimated movement annual movement rates of 96 mm in 2016 and 89 mm in 2018. New slider plates were installed during the inspection in 2019. As of October 28, 2020, there had been 220 mm of displacement since June 16, 2019 (160 mm/year), 185 mm since May 29, 2020 (444 mm per year), and 110 mm since June 2, 2020 (271 mm per year). The Pier 1 foundation had a maximum cross-slope angle of 5°. The previous marks were partially obscured by mud and debris during the 2022 visit. It is anticipated that future repairs may replace the steel plates so new measurement references will be established.

Previous measurements made by Dave Morrison, Bridge Technologist, AT, were summarized in the 2021 Geohazard report and have not been repeated herein. Furthermore, Mr. Morrison has retired, and his routine measurements have not been carried on by others in the Branch.

The cracking and accelerating movements and tilting observed in the concrete foundation at Pier 1 might be related to a change in foundation support conditions. The older downstream part of the foundation was supported on deep reaching steel piles; however, the landslide has moved the foundation to the transition point with the south part of the concrete slab which has no piles. The change in loading condition might be causing the slab to tilt and the side walls to crack.

Ongoing river erosion had caused a localized slump between Piers 1 and 2. The slumped material was impacting against the west side of Pier 2 where ongoing river erosion kept the slide active. A repair of this slump was undertaken by AMEC in 2017 which involved the installation of stone columns, a subdrainage system, and riprap slope protection. The potted willows shown at the toe of the slope on the drawings have died. Future observations will be required to determine if the repair is effective; however, this will likely have only a limited effect on the overall valley movements. River erosion has over steepened the south section of the riprap apron resulting in the loss of some material which worsened in 2020. This was also observed in 2021. At the lower water levels in October 2020, it was also noted that there is some erosion and slumping cutting into the apron north (downstream) of the bridge. The slumping at the river toe, both in and adjacent to the riprap did not appear significantly worse in 2022.

Recommendations:

Short-Term:

- Routine assessment of the bridge should be undertaken such that adjustments can be made when required (it is understood that AT's Bridge Branch is routinely inspecting this structure). Should cracking form on the highway to the west of the abutment, crack sealing should be undertaken to minimize water infiltration.
- Milling and patching of the pavement surface at the west end of the bridge should be carried out on a periodic basis as required to maintain a safe riding surface.
- Annual Geohazard Inspection should observe the south end of the riprap apron as there is the potential for loss of further material.

Medium Term:

Carry out repairs to Pier 1 to deal with the accelerated movements and tilting that have been observed there in recent years. It is understood that this work is currently being designed and scheduled for 2023 or 2024.

Long-Term:

It is understood that the potential realignment options that have been considered for this valley crossing have maintained the same river crossing as there is no better location for several kilometers either side. Thus, a new bridge at a more-stable location is not currently being considered. It is understood that AMEC's High Water Related Mitigation Works reports for SH003 and SH004 recommended erosion control at the toe of the slope to limit river erosion which would also benefit this site.

Outgoing Investigation:

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

- A geotechnical investigation was carried out at Pier 1 in 2021 (after the annual geohazard site visit) by Thurber on behalf of Most Engineering, who are assessing why the Pier 1 foundation is cracking and designing improved foundation support conditions for the pier. As part of the investigation, new instruments were installed at Abutment 1 and Pier 1 to investigate the foundation conditions below the Pier 1 foundation slab and to monitor subsurface movements and groundwater levels in the vicinity of the west end of the bridge. The instruments included slope inclinometers wrapped with fibre optic cable, and vibrating wire piezometers.
- A routine robust and detailed terrestrial survey of points on the bridge and the ground surface would also help track movement rates at a relatively low cost.

Consideration should be given to re-surveying the InSAR (interferometric synthetic aperture radar) targets, perhaps annually, to supplement the work done by the AGS as this will provide an overall view of ground movements.

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

Ken Froese, P.Eng.
Senior Geotechnical Engineer



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.

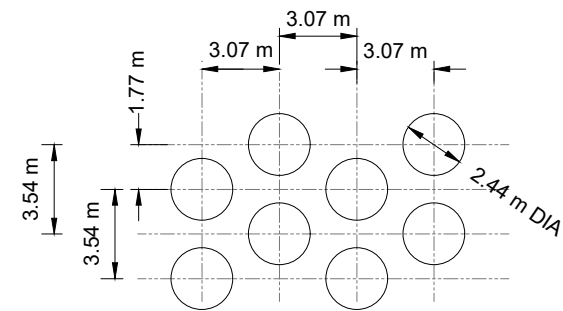
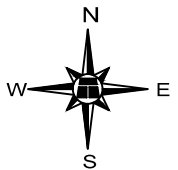
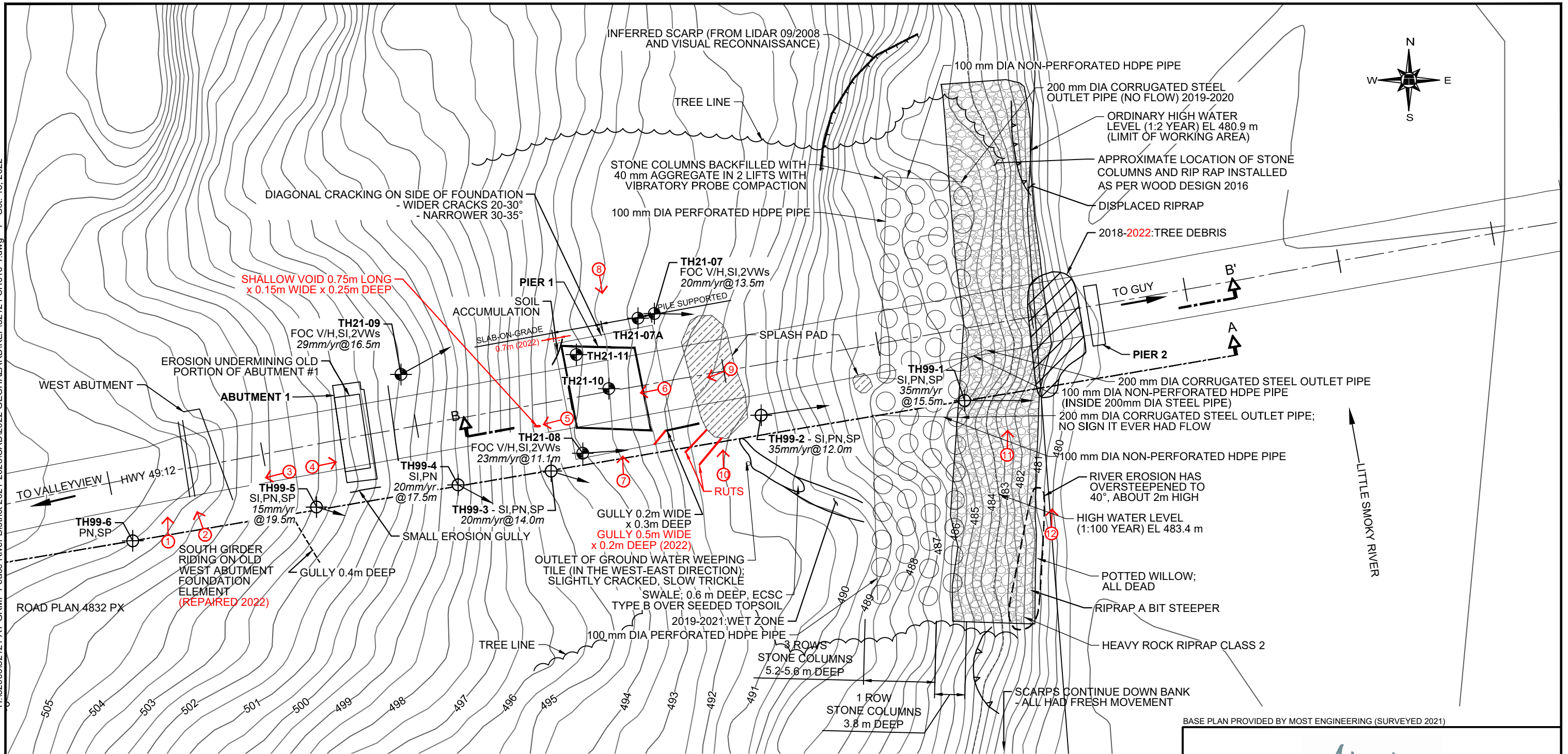
6. RELEASE OF POLLUTANTS OR HAZARDOUS SUBSTANCES

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\32121 AT GRMP Peace River District 2021-2025\CAD\2022 GEOHAZARD\KEF\32121 SH016-1.dwg - 1 - Oct. 15, 2022



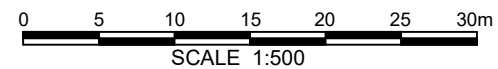
TYPICAL DETAIL OF STONE COLUMN SPACING
SCALE 1:300

LEGEND

- APPROXIMATE TEST HOLE LOCATION (THURBER, 2021)
- APPROXIMATE TEST HOLE LOCATION (THURBER, 1999)
- SI SLOPE INCLINOMETER
- FOC V/H FIBRE OPTIC CABLE: VERTICAL / HELICAL ORIENTATION
- PN PNEUMATIC PIEZOMETER
- SP STANDPIPE PIEZOMETER
- VW VIBRATING WIRE PIEZOMETER
- GROUND SURFACE CONTOUR (CONTOUR INTERVAL = 0.5m)
- 13mm/yr @ 15m MOVEMENT VECTOR AND DEPTH (SCALED BY OVERALL MOVEMENT RATE)
- PHOTO LOCATION AND DIRECTION

NOTES

1. MAY 2022 OBSERVATIONS SHOWN IN RED.
2. DETAILS OF REPAIR BELOW PIER 1 PROVIDED BY AMEC FOSTER WHEELER.
3. HIGHWAY RIGHT OF WAY BOUNDARY IS 91 m FROM THE HIGHWAY CENTERLINE (OUTSIDE OF DRAWING LIMITS)



BASE PLAN PROVIDED BY MOST ENGINEERING (SURVEYED 2021)



PEACE REGION (PEACE RIVER DISTRICT)

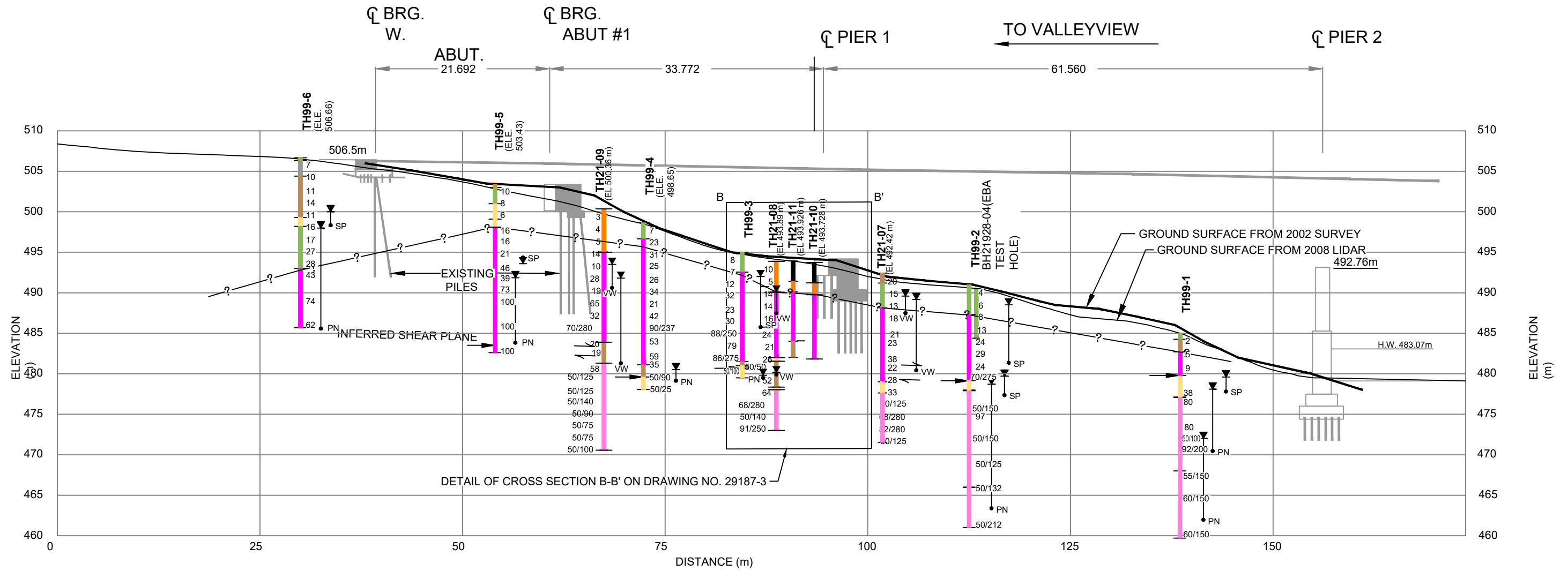
SH016: HWY 49:12 LITTLE SMOKY RIVER
2022 SITE INSPECTION PLAN

DWG No. 32121-SH016-1-1

DRAWN BY	ML
DESIGNED BY	KEF
APPROVED BY	RVC
SCALE	1:500
DATE	OCTOBER 2022
FILE No.	32121



H:\32000\32121 AT GRMP Peace River District 2021-2025\CAD\2022 GEOHAZARD\KEF\32121 SH016-1.dwg - 2 - Oct. 15, 2022



LEGEND:

- | | | | |
|----|--|--|------------------------------------|
| | ZONE OF MOVEMENT IN SLOPE INCLINOMETER | | CONCRETE |
| | OBSERVED SHEAR | | FILL |
| | INFERRED SHEAR PLANE | | CLAY |
| | WATER LEVEL (OCTOBER 12, 2021) | | CLAY TILL |
| | TIP ELEVATION | | SAND, GRAVEL |
| SI | SLOPE INCLINOMETER | | SILT |
| PN | PNEUMATIC PIEZOMETER | | CLAY SHALE (DISTURBED) |
| SP | STANDPIPE PIEZOMETER | | CLAY SHALE / BEDROCK (UNDISTURBED) |
| VW | VIBRATING WIRE PIEZOMETER | | |
| | SPT N VALUE (BLOWS PER 300mm) | | |
| | SPT N VALUE (BLOWS PER 70mm) | | |

NOTES:

- PIER DIMENSIONS AND PILE CONFIGURATIONS FROM 2002 THURBER REPORT AND DRAWING NUMBER 1577-P (2000) PROVIDED BY MOST ENGINEERING
- DATA CONCERNING THE VARIOUS STRATA HAVE BEEN OBTAINED AT THE TEST HOLE LOCATIONS ONLY. THE SOIL STRATIGRAPHY BETWEEN TEST HOLES HAS BEEN INFERRED FROM GEOLOGICAL EVIDENCE AND SO MAY VARY FROM THAT SHOWN.



PEACE REGION (PEACE RIVER DISTRICT)

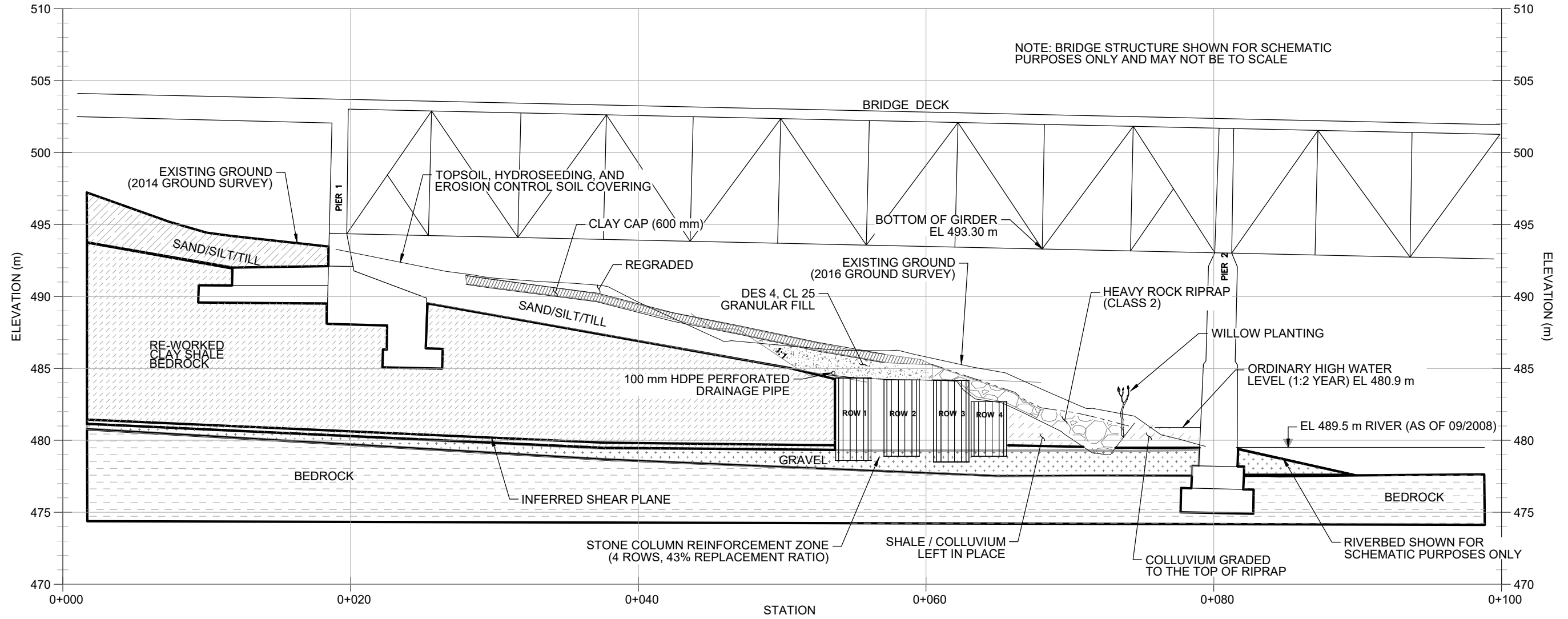
SH016: HWY 49:12 LITTLE SMOKY RIVER
STRATIGRAPHIC CROSS-SECTION A-A'

DWG No. 32121-SH016-1-2

DRAWN BY	ML
DESIGNED BY	KEF
APPROVED BY	RVC
SCALE	1:300
LAST UPDATED	OCTOBER 2022
FILE No.	32121



H:\32000\32121 AT GRMP Peace River District 2021-2025\CAD\2022 GEOHAZARD\KEF\32121 SH016-1.dwg - 3 - Oct. 15, 2022



NOTE: BRIDGE STRUCTURE SHOWN FOR SCHEMATIC PURPOSES ONLY AND MAY NOT BE TO SCALE

BASE PLAN PROVIDED BY AMEC FOSTER WHEELER



PEACE REGION (PEACE RIVER DISTRICT)

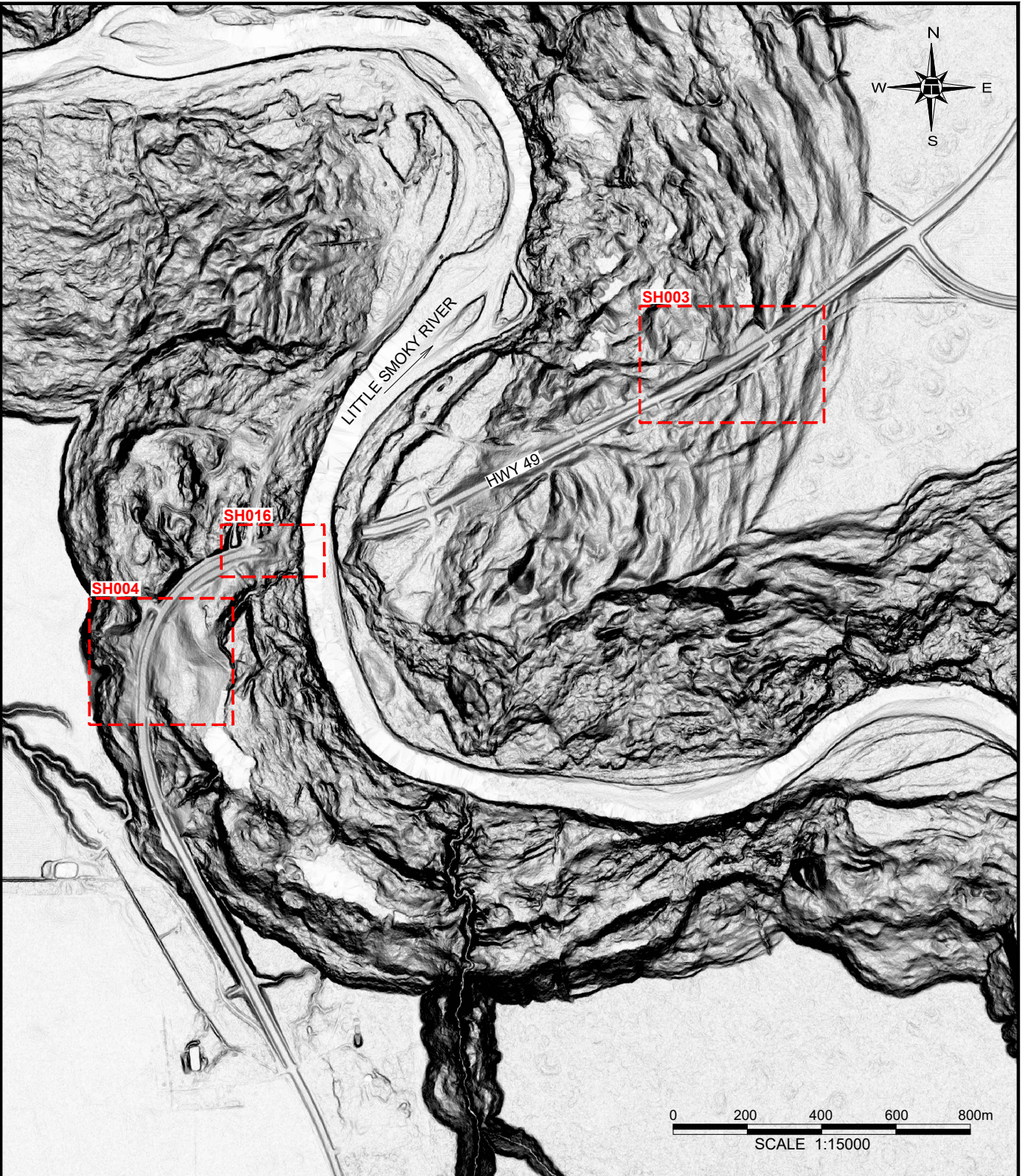
SH016: HWY 49:12 LITTLE SMOKY RIVER
DESIGN CROSS-SECTION B-B'

DWG No. 32121-SH016-1-3

DRAWN BY	ML
DESIGNED BY	KEF
APPROVED BY	RVC
SCALE	1:300
LAST UPDATED	OCTOBER 2022
FILE No.	32121



H:\32000\32121 AT GRMP Peace River District 2021-2025\CAD\2021\MG\32121 Figure 1 - SH003, SH004, SH016 Key Map.dwg - Layout1 - Oct. 05, 2021



2008 LIDAR PROVIDED BY ALBERTA TRANSPORTATION.

PEACE REGION (PEACE RIVER DISTRICT)

SH003-1, SH004-1, SH016-1 KEY MAP

FIGURE 1



DRAWN BY	KLW
DESIGNED BY	MG
APPROVED BY	DWP
SCALE	1:15000
DATE	OCTOBER 2021
FILE No.	32121



THURBER ENGINEERING LTD.



Photo 1 – Looking southeast at crack pattern forming at the west abutment expansion joint. This was overlaid or patched since 2020.



Photo 2 – Looking north at west bridge abutment. Distance between angle iron and concrete of bridge deck was 2.42 m (2.60 m in 2020, 2.69 m in 2019, 2.72 m in 2018, 2.82 m in 2017). The two I-beams at the edge of the wingwall are the remainder of the 5 installed in 2000.



Photo 3 – Looking towards the West Abutment where portions of the old foundation concrete was removed to allow movement of the girders between the West Abutment and Abutment 1.



Photo 4: Sliding configuration at Abutment 1. Movement at right-most (south) bearing plate in June 2020 was 35 mm since May 14, 2020, and 121 mm since June 10, 2019.



Photo 5: Shallow voids on headslope below Abutment 1. The voids, now combined, showed up in 2021 and the cause is unknown.



Photo 6 – Shims (increased to 0.84 m from 0.755 m) under rocker bearings at Pier 1: remained 0.84 m at the south bearing plate (left-most) and 0.76 m at the north bearing plate (right-most).



Photo 7 – Looking north at Pier 1 wingwall where bolts have been moved over 1.18 m since construction in 2000.



Photo 8 – Looking south at Pier 1 wingwall at arc-shaped compression crack pattern in foundation. Left-hand portion of foundation is pile supported; right-hand is on-grade. Crack at the base is 40 mm in width.



Photo 9 – Looking west at Pier 1 foundation which is tilted downward to the south. The angle from horizontal was 4° at the top and 7° at the bottom stage. Concrete is starting to crack and spall in circled area.



Photo 10 – Looking north at previous scarp of local slump below Pier 1.



Photo 11 – Looking north at accumulated tree debris against Pier 2.



Photo 12 – Looking south at erosion along toe of riprap and riverbank.