ALBERTA TRANSPORTATION AND ECONOMIC CORRIDORS
GEOHAZARD ASSESSMENT PROGRAM
PEACE REGION (PEACE RIVER DISTRICT)
2024 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		11 E 489,573	N 6,145,499	

	Date	PF	CF	Total
Previous Inspection:	7-Jun-2023	14	6	84
Current Inspection:	3-Jun-2024	14	4	56
Road AADT:	1530		**Year:**	2024
Inspected By:	Rishi Adhikari, TEC Robert Senior, TEC		Ken Froese, Thurber Roger Skirrow, Thurber	
Report Attachments:	☒ Photographs	☒ Plans	☒ Maintenance items	

Primary Site Issue:	West foundations of the bridge are located near the toe of a deep-seated landslide.
Dimensions:	The west abutment, Abutment 1, and Pier 1 are affected by landslide movement which is about 125 m from the river measured along the bridge axis. Refer to the GRMP Inspection Report for SH004 for a description of the overall valley slope instability.
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. Riprap placed along the riverbank to the upstream and downstream of the bridge. 2021: Geotechnical investigation by Thurber to support MOST Engineer's design and implementation of structural repairs. 2022-2024: Bridge rehabilitation work including new I-beam at West Abutment, removal of concrete between West Abutment and Abutment 1, and new slider plates at Pier 1 (2024)
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?
☒ Pavement Distress	Previously observed sag in pavement profile just west of the bridge abutment has not been noticeable in last few years.	☒
☒ Slope Movement	There is ongoing slope movement along a slip plane the extends underneath the foundations; the localized failure upslope of Pier 2 has been repaired and appears to be stable.	☒
☒ 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 repaired in 2024. Rutting left from vehicle traffic (Photo 10) may result in preferential erosion conditions.	☒
☒ Seepage		☐

☒ Bridge/Culvert	The West Abutment, Abutment #1, and Pier 1 are routinely adjusted to compensate for ongoing slope movement.	☒
☐ Other		☐

Instrumentation (Spring 2024):	
2021 Instruments	In 2022, the inclinometers were found to have sheared off – the final readings were taken in October 2021. On the south side of Pier 1, SI21-07 had a distinct zone at 479.5 m elevation with a cumulative movement of 7.2 mm (average 21.8 mm/year) and sheared off at 479.0 m. On the north side of Pier 1, SI21-08 had a distinct zone at 483.4 m elevation with a cumulative movement of 7.5 mm (average 22.7 mm/year) and sheared off at 482.9 m. These two were moving nearly due east. For comparison, the riverbed elevation near Pier 2 is estimated to be at 478 m elevation. Near Abutment 1, SI21-09 had a distinct zone at 484.4 m elevation with a cumulative movement of 9.3 mm (average 28.8 mm/year) and sheared off at 483.9 m. This SI was moving slightly north of east. Fibre optic cables were installed with the 2021 inclinometers and, as of Fall 2023, still had continuity so further readings could be taken if deformation measurements were of importance despite the loss of the inclinometers. In March 2023, dataloggers were added to the six vibrating wire piezometers installed in 2021. Water levels in the VW piezometers had been relatively stable since installation; the increased data collection frequency shows only slight seasonal variations though more pronounced at VW21-8A. The pattern at VW21-8B is an exception and has steadily increased since installation and has risen about 2 m. 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 near 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 and Economic Corridors) for the overall west slope where slide scarps and sag pond features can be readily identified.

Pier #1 is likely situated on, or near, the intersection of two different slide 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 by the Little Smoky River; an assessment of precipitation levels and antecedent stability analyses indicates that a high ground water table may also be a contributing factor.

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. 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. In late 2022 or early 2023, the West Abutment was reset with 5 new beams added (366 mm wide for a total width of 1.83 m). A sixth beam (371 mm wide) was placed below the finger joints. The gap measured between the bridge deck and abutment changed by 4 cm between June 7, 2023, and June 3, 2024, giving an annualized rate of approximately 40 mm/year.

The Teflon bearing pads at Abutment 1 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.

The bearing pad and sliding plate arrangement at Pier 1 was replaced in 2024. Previous measurements were summarized in the 2021 and 2023 Geohazard reports: 2.97 m of vertical settlement (approximately 48 mm/year) since 1957 and 1.18 m horizontal since 2000 (74 mm/year). The new configuration consists of four sets of galvanized steel I-beam pairs bolted to the concrete pier foundation and supporting a stainless-steel plate thus elevating the sliding surface to the bottom of the bent eliminating the tipping risk of the previous configuration. As noted on the Drawings, the outside corners of the slider plates were measured to the outside corners of the stainless-steel plates for future comparison. The lateral restraint has been shifted to vertical steel piles bolted to the exterior of the concrete foundations as the existing bolt holes in the wingwalls were too low. Considering these bridge support improvements, the consequence factor in the risk equation has been reduced to a 4.

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 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 as noted on the north side of Pier 1.

The 2017 repair of the slope below Pier 1 is still effective. This repair has only a limited effect on the overall valley movements. River erosion had over-steepened a portion of 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 and seems to have stabilized as of 2023 and 2024.

Recommendations:

Short-Term:

- Routine assessment of the bridge should be undertaken such that adjustments can be made when required. 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 (if needed).

Long-Term:

- There are potential realignment options that have been considered for this valley crossing maintaining the same bridge which could be implemented to reduce maintenance for the highway approaches on either side. A long-term plan for this crossing includes a new bridge about 8 km away but there is no plan to implement this large realignment as the bridge is currently being rehabilitated.
- 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.

Ongoing Investigation:

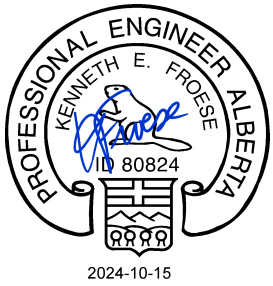
- It is recommended that the annual Geohazard inspection and twice-annual instrumentation readings should continue as scheduled.

- A routine robust and detailed terrestrial survey of points on the bridge and the ground surface would also help track ground movement rates at a relatively low cost. It is understood that is being considered. The InSAR (interferometric synthetic aperture radar) targets could also be included in this terrestrial survey to build on the work done by AGS to provide an overall interpretation of the valley-scale 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.

Roger Skirrow, M.Sc., P.Eng.
Senior Geotechnical Engineer



PERMIT TO PRACTICE
THURBER ENGINEERING LTD.
RM SIGNATURE: _____
RM APEGA ID #: 51674
DATE: October 15, 2024
PERMIT NUMBER: P005186
The Association of Professional Engineers and Geoscientists of Alberta (APEGA)

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

THURBER

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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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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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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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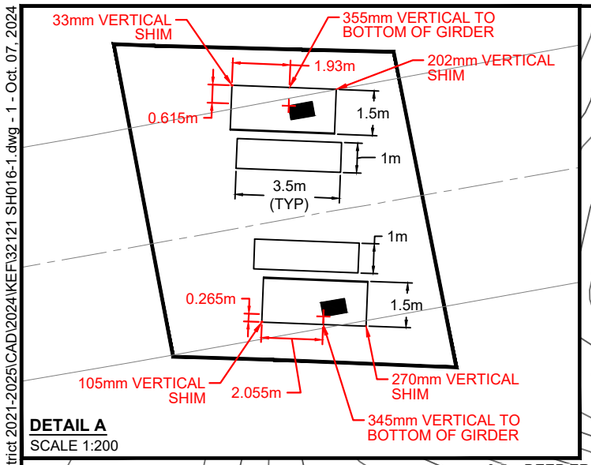
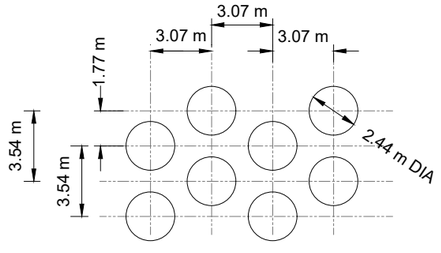


DETAIL A
SCALE 1:200

INFERRED SCARP (FROM LIDAR 09/2008 AND VISUAL RECONNAISSANCE)
TREE LINE
PIER 1 NE BENT: 2.350m TO EAST AND 0.335m TO SOUTH
DIAGONAL CRACKING ON SIDE OF FOUNDATION - WIDER CRACKS 20-30°; NARROWER 30-35°; 2023: SPALLING PIECE AT THE TOP OF THE WINGWALL: 780mm WIDE , 105mm DEEP
WATER LEVEL 1.75m BELOW CONCRETE IN OPEN TEST HOLE
WATER LEVEL 0.08m BELOW CONCRETE IN OPEN TEST HOLE
POSSIBLE TOE ROLL
SHALLOW VOID 0.75m LONG x 0.15m WIDE x 0.25m DEEP; 2023: GRADED OUT
0.5m DEEP EROSION HOLE
VOID BACK 4.9m HORIZONTALLY UNDER CONCRETE
EROSION UNDERMINING OLD PORTION OF ABUTMENT #1
ABUTMENT 1 NE BENT: 2.015m TO EAST AND OVERHANGING ON NORTH BY 0.012m
BEARING AND SLIDE PLATE OFFSET 2024: 1.71m ALONG BRIDGE AXIS, 0.54m CROSS-AXIS
BEARING AND SLIDE PLATE OFFSET 2024: 0.35m ALONG BRIDGE AXIS, 18.5m CROSS-AXIS
WEST ABUTMENT
2023: 5 NEW I-BEAMS ADDED BEHIND ABUTMENT, FINGER JOINTS RESET
ABUTMENT 1
TO VALLEYVIEW HWY 49:12
ROAD PLAN 4832 PX
PATCH AT CENTERLINE JUST SOUTH OF THE WEST FINGER JOINTS
SOUTH GIRDER RIDING ON OLD WEST ABUTMENT FOUNDATION ELEMENT (REPAIRED 2022)
BRIDGE DECK FROM ANGLE IRON 2023: 3.61m (RESET) 2024: 3.57m
LATERAL BRACES REMOVED?
ABUTMENT 1 SE BENT: 0.165m TO EAST AND 0.0435m TO SOUTH
SMALL EROSION GULLY
GULLY 0.4m DEEP
2024: SIDE SLOPE REGRADED AND STRAW WATTLES PLACED
TH99-6 PN,SP
TH99-5 SI,PN,SP 15mm/yr @19.5m
TH99-4 SI,PN 20mm/yr @17.5m
2023: STRAW WATTLES; 2024: SILT FENCES ADDED
TH21-09 FOC V/H,SI,2VWs 29mm/yr@16.5m
SOIL ACCUMULATION
SLAB-ON-GRADE 0.7m (2022)
PILE SUPPORTED
PIER 1
TH21-07 FOC V/H,SI,2VWs 20mm/yr@13.5m
TH21-07A
TH21-11
TH21-10
SILT FENCE
TH21-08 FOC V/H,SI,2VWs 23mm/yr@11.1m
TH99-3 - SI,PN,SP 20mm/yr@14.0m
2024: AREA AROUND PIER 1 REGRADED AND TOPSOILED
PIER 1 SE BENT: 2.060m TO RIVER EDGE AND 0.190m TO SOUTH
GULLY 0.2m WIDE x 0.3m DEEP (2020); 0.5m WIDE x 0.2m DEEP (2022)
OUTLET OF GROUND WATER WEEPING TILE (IN THE WEST-EAST DIRECTION); SLIGHTLY CRACKED, SLOW TRICKLE
RUT BLOCKING FLOW AND WATER PONDING
SWALE; 0.6 m DEEP, ECSC TYPE B OVER SEEDED TOPSOIL
TREE LINE
2019-2021:WET ZONE
100 mm DIA PERFORATED HDPE PIPE
STONE COLUMNS BACKFILLED WITH 40 mm AGGREGATE IN 2 LIFTS WITH VIBRATORY PROBE COMPACTION
100 mm DIA PERFORATED HDPE PIPE
2024: NEW I-BEAM SUPPORTS WITH STEEL SLIDE PLATES ADDED BELOW BENTS AT PIER 1 (SEE DETAIL A)
SPLASH PAD; 2024: SHIFTING / EROSION OF RIPRAP IN SPLASH PADS
TH99-2 - SI,PN,SP 35mm/yr@12.0m
RUTS
RUTS: 0.5m WIDE, 0.3m DEEP
3 ROWS STONE COLUMNS 5.2-5.6 m DEEP
100 mm DIA NON-PERFORATED HDPE PIPE
200 mm DIA CORRUGATED STEEL OUTLET PIPE (NO FLOW) 2019-2020
ORDINARY HIGH WATER LEVEL (1:2 YEAR) EL 480.9 m (LIMIT OF WORKING AREA)
APPROXIMATE LOCATION OF STONE COLUMNS AND RIP RAP INSTALLED AS PER WOOD DESIGN 2016
DISPLACED RIPRAP
2018-2024:TREE DEBRIS
TO GUY
B'
A
PIER 2
TH99-1 SI,PN,SP 35mm/yr @15.5m
200 mm DIA CORRUGATED STEEL OUTLET PIPE
100 mm DIA NON-PERFORATED HDPE PIPE (INSIDE 200mm DIA STEEL PIPE)
200 mm DIA CORRUGATED STEEL OUTLET PIPE; NO SIGN IT EVER HAD FLOW
100 mm DIA NON-PERFORATED HDPE PIPE
RIVER EROSION HAS OVERSTEEPENED TO 40°, ABOUT 2m HIGH
HIGH WATER LEVEL (1:100 YEAR) EL 483.4 m
POTTED WILLOW; ALL DEAD
RIPRAP A BIT STEEPER
HEAVY ROCK RIPRAP CLASS 2
1 ROW STONE COLUMNS 3.8 m DEEP
SCARPS CONTINUE DOWN BANK - ALL HAD FRESH MOVEMENT
LITTLE SMOKY RIVER
BASE PLAN PROVIDED BY MOST ENGINEERING (SURVEYED 2021)



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. JUNE 2024 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)
4. ABUTMENT 1 AND PIER 1 BENT DISPLACEMENTS REFERENCED TO EDGES OF STAINLESS STEEL SLIDER PLATES

0 5 10 15 20 25 30m
SCALE 1:500

Alberta

PEACE REGION (PEACE RIVER DISTRICT)

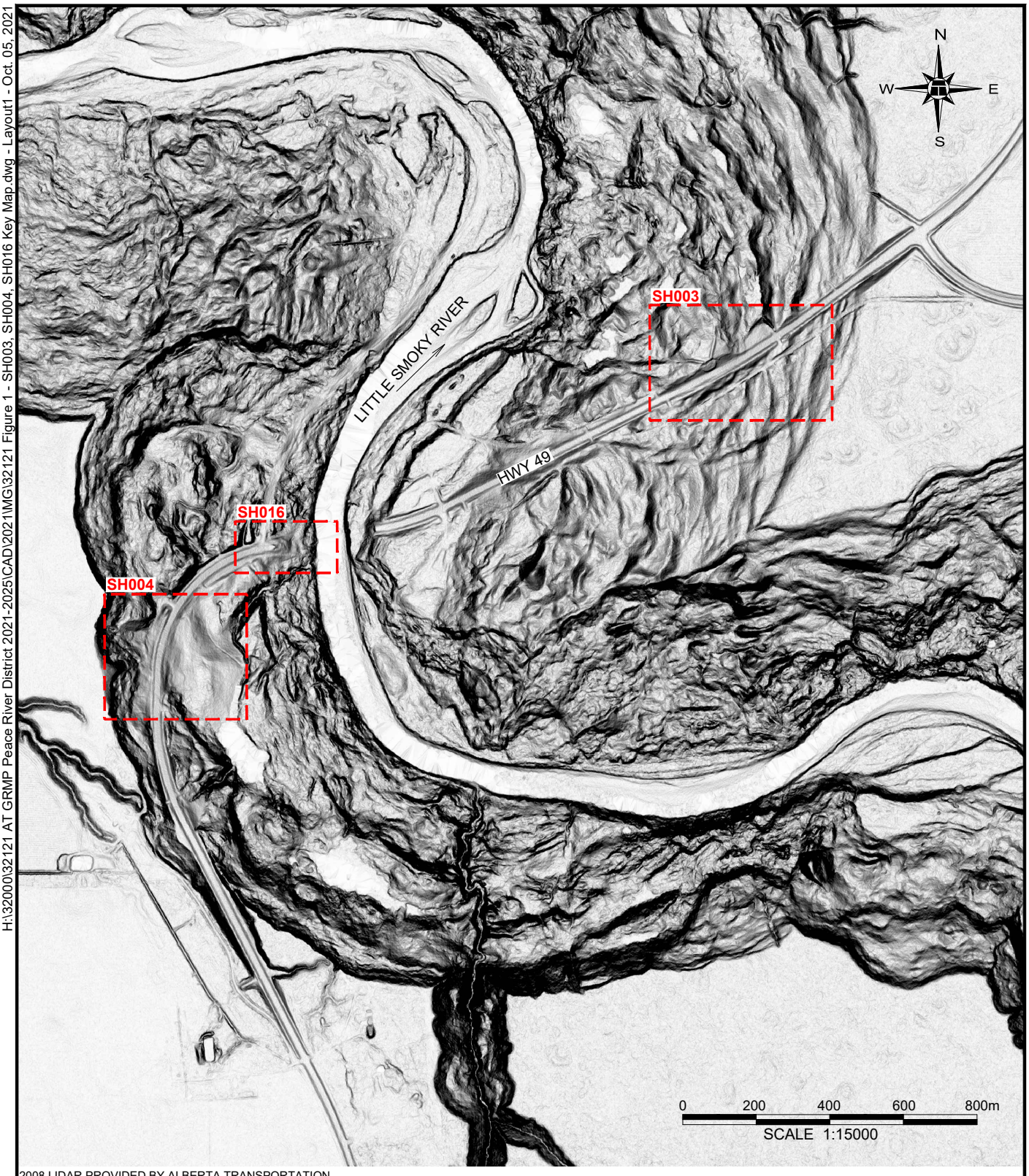
SH016: HWY 49:12 LITTLE SMOKY RIVER
2024 SITE INSPECTION PLAN

DWG No. 32121-SH016-1-1

DRAWN BY	KLP
DESIGNED BY	KEF
APPROVED BY	DWP
SCALE	1:500
DATE	SEPTEMBER 2024
FILE No.	32121

THURBER ENGINEERING LTD.

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

Alberta

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Photo 1 – Looking northeast at new finger joints and repaved approach (done since 2023 inspection).

Photo 2 – Looking north at west bridge abutment. New I-beams added in 2023 (5 total) plus one below the finger joints. The tarps were added in 2024. Distance between angle iron and concrete of bridge deck was reset to 3.61 m prior to 2023 inspection and was 3.57 m in 2024 (previous gap shrunk to 2.42 m in 2022 from 2.82 m in 2017).

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: Void forming underneath the northeast corner of the old Abutment 1.

Photo 5: Looking west at headslope below Abutment 1. New erosion control measures installed since 2023.

Photo 6 – New slide plates installed at Pier 1.

Photo 7 – Looking north at Pier 1 where new sliding plates and lateral restraints were installed since 2023 as well as regrading and topsoil around the pier.

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.

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 west toward Pier 1 at rutting and recently-installed erosion control measures.

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

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