ALBERTA TRANSPORTATION
GEOHAZARD ASSESSMENT PROGRAM
PEACE REGION – SWAN HILLS
2022 INSPECTION

THURBER ENGINEERING LTD.

Site Number	Location	Name	Hwy	km
SH001-1 SH001A-1	North of Swan Hills	Swan Hills Retaining Wall	33:12	9.33-9.75 10.00-10.05
Legal Description		**UTM Co-ordinates**		
SE/NE05-67-09-W5M		11U E 607,545	N	6,070,516

	Date	PF	CF	Total
Previous Inspection:	10-Jun-2020	SH001-1: 9 SH001A: 7	4 3	36 21
Current Inspection:	30-May-2022	SH001-1: 9 SH001A: 7	4 3	36 21
Road AADT:	1110		**Year:**	2022
Inspected By:	Rishi Adhikari, TRANS Ed Szmata, TRANS Max Shannon, TRANS Rodney Johnston, TRANS		Ken Froese, Thurber Mark Gallego, Thurber Trevor Sterling, Thurber (Safety) Rob Cottreau, Thurber (GIS)	
Report Attachments:	☑ Photographs ☑ Plans		☐ Maintenance Items	

Primary Site Issue:	SH001-1: Highway embankment placed over creek/gully obstructing seepage and mobilizing slide with creep movements at about 18 m to 20 m depth below the roadway. Pavement distress occurring behind and to the south of the floating pile wall. SH001A: Rotational landslide causing vertical displacement of highway surface.
Dimensions:	SH001-1: The pile wall is ~81 m in length. Pavement distress encompasses approximately 270 m of highway. SH001A-1: 50 m of highway affected by soft subgrade and slope movements.
Date of Remediation:	**Site SH001-1:** 1970: Highway reconstructed about 30 m from original alignment which was buried by backslope failure. 1979: 9 – 50mm dia. slotted steel horizontal subdrains installed 3 m to 7.5 m below the roadway. Subdrain at 3 m depth installed in backslope ditch draining to four culverts. 1982: Backslope drains no longer functioning; 5 horizontal PVC drains installed from toe of north-facing embankment slope with lengths between 61 m and 73 m. 1989: Floating concrete pile wall 81 m long installed to depths of 6 m to 12 m below roadway surface. The 82 piles were 760 mm diameter installed at 1 m centre-to-centre spacing. 1991: Two rows of tie-back anchors install 1 m and 3 m below top of piles at 30° into clay shale at a length of 7.5 m. 1995, 1996: Backslope offloading undertaken. 2010: ACP curb installed directing surface water into two “T” drains; sideslopes regraded and tops of piles covered with gravel; guardrail installed. **Site SH001A-1:** No remediation was done other than patching.
Maintenance:	ACP patching as required to maintain surface (most recent in 2015). 2014 and 2016: T-Drains cleaned out.

	2016: Washed rock placed in erosion gullies on sideslope at east end of guardrail; patch placed to the west of the guardrail. 2018: Installation of three inclinometer/piezometers sets at SH001-1 and one set at SH001A-1. 2020: Patching 2022: Patching	
Observations:	**Description**	**Worsened?**
☑ Pavement Distress	SH001-1: Cracking present over much of the length; dip south of the wall appeared Spring 2016 and second in 2019. Slight hump near west end of guardrail appeared in 2018 and second in 2019. Tension cracking continues to increase. Lack of maintenance leading to surficial deterioration (potholes). SH001A-1: dips have formed at both ends of patch and hump appeared in 2019; crack pattern is widening and becoming braided.	☑
☑ Slope Movement	SH001-1: Ongoing creep movement causing cracking and settling of highway surface at south end of pile wall. Slope may be pulling away from pile wall. SI south of wall sheared off in 2 years. SH001A-1: pavements cracks have developed into scarp pattern and are widening with vertical deformation.	☑
☑ Erosion	SH001-1: Some erosion noted on sideslope between and below piles. Deeper channels at west end of wall were infilled but are reforming Erosion in east ditch south of wall starting to revegetate; new gully forming in west ditch.	☑
☑ Seepage	SH001-1: Seepage observed in backslope area and wet zones noted below the pile wall. SH001A-1: Steady flow observed in east tree line and ditch.	☐
☑ Bridge/Culvert Distress	SH001-1: T-Drains outlets have been plugged with debris (partially accumulated since last cleaning) and one inlet is slightly damaged. Two sinkholes near the inlet of the culvert north of the pile wall have joined to form a single and larger sinkhole and there are slumps near the outlet. SH001A-1: No apparent distress at culvert 130 m north of site.	☑
☐ Other		☐

Instrumentation (as of Spring 2022) – SH001-1:	
SI-16, -18, -20	Have not shown a discernable movement pattern. Likely located outside of the main movement area.
SH18-4	Located southwest of pile wall. Sheared off at 16.8 m depth after less than two years at a cumulative displacement of 37 mm.
SI18-5	Located on the upslope of the southwest half of the pile wall. There is movement at about 8.6 m depth with current rate of 1.8 mm/year and a cumulative displacement of 10.5 mm.
SI18-6	Located on the upslope of the northeast half of the pile wall. No discernable movement pattern.

PN-1, PN-2, PN-3, PN-4, PN01-2	Measured water levels have been relatively stable for about the last 10 years with minor seasonal variation (typically less than 1 m) noted at the piezometers.
PN18-4A, 4B, 5A, 5B, 6A, 6B	Slight increasing trend at PN18-4B, -6A, and -6B since installation in March 2018 and the remainder have been relatively stable.
PN01-1	Not operational.
Instrumentation (as of Spring 2022) – SH001A-1:	
SI18-7	Sheared off at 8.5 m after Spring 2019 reading. Cumulative displacement was 50 mm from installation in March 2018.
PN18-7A & 7B	PN18-7A has a slow upward trend and is currently at a historical high of 2.2 m above-ground level; PN18-7B had been trending downward slightly since all 2018 but has now stabilized at 11.3 m BGL.

Assessment:

At SH001-1, the highway embankment crosses two natural gullies which may have had prior instability. The additional weight of the embankment fill combined with blocking springs and natural drainage paths led to movements at this site. The floating pile wall appears to be adequately stabilizing the highway over its length; however, there is some ongoing creep movement and increasing amount cracking and distortion (dips and humps) of the highway at and beyond the southwest end of the wall. New inclinometers installed in March 2018 show movement of the slope south of the wall (SI18-4 has sheared off) and minor movement behind the south half of the wall (SI18-5) but no discernable displacement behind the north half (SI18-6). The drainage control measures implemented in 2010 (asphalt curb and T-down drains) had been functioning though the continued deterioration of the curb and plugging of the drains is currently limiting their functionality (although the drains are occasionally flushed). It was observed that the drains are partially plugged and showing signs of undermining. The piezometers installed in 2018 have identified that the water level behind the wall is approximately 4 m lower than in the unstable ground to the south of the wall.

The highway surface south of the wall was patched over, which covered the previous cracks and potholes observed from the 2020 inspection. However, the cracks have started to reflect through the patched area and potholes are forming, especially in the southbound lane. There continues to be minor increases in the crack length, width, and frequency beyond both ends of the wall. The two sinkholes at the culvert inlet north of the wall have joined together to form a larger sinkhole that likely extends right down the culvert. The scarp previously observed at the outlet was still present with some indication that it might be located over an abandoned culvert outlet. Apparent movement of the soil downslope of the pile wall has further opened up tension cracks between and below some of the piles. The absence of movement at SI18-6 would indicate that this movement is occurring downslope of the wall rather than through it. Although the scarp features located northwest of SI16 through SI21 are not new (they are apparent on 2007 LiDAR), it was noted this year that there appeared to be more movement since 2020, which will need to be monitored in future visits. The SI's between the 2007 scarps and the highway do not yet indicate movement.

Site SH001A-1 was first observed in 2013 after an FWD (falling weight deflectometer) program. The distress consists of cracking with associated dips in the pavement surface and has required patching in 2014 and 2015. It was initially suspected that the underlying issue was a soft/wet subgrade possibly associated with shallow groundwater flow. This is plausible as this location is on the flank of a small channel passing through a culvert (600mm diameter smooth-wall steel-lined at km 10.156) approximately 120 m to the northeast and the terrain to the northwest appeared to be wetter than surrounding areas. In 2017, the site inspection was conducted shortly after heavy rainfall and it was observed that there was significant flow (northeast toward a centreline culvert) in the east ditch but within the treeline, which has continued to be the case in all subsequent visits. By 2018, the crack pattern across the highway had developed into a landslide scarp and the movement zone in the inclinometer (which sheared off after the Spring 2019 readings) confirmed there is slope movement at this location at a depth of 8 m. The crack pattern lines up with the 0.5 m scarp feature observed to the west of the highway. Thus, the soft/wet subgrade may be a result of slope displacement and resultant

modified groundwater flow regime. Like at SH001-1, the highway was patched in 2022 but the cracks and potholes are starting to surface through the patch. The soil stratigraphy observed in SH18-7 consists of gravel and clay fill overlying native clay over a thin zone of clay till. The site is underlain by clay shale with sandstone layers. The movement zone appears to be at the contact between the clay till and clay shale. The high groundwater level measured in the clay till layer, which became artesian in Spring 2019, might be a trigger for the slide movements. The Spring 2022 readings still indicate flowing artesian groundwater conditions. The mechanism for the landslide occurring at this site has not yet been identified. There is about 20 m of relief from the highway surface to the downslope creek but over a distance of about 190 m which is relatively flat (6°); however, remolded shale is expected to have a low friction angle.

Recommendations:

Short-Term:

- Road maintenance should continue as necessary to maintain the roadway surface and may consist of milling, patching, and crack sealing of the ACP.
- Re-establish the asphalt curb and clean the T-drains (this should be a periodic maintenance item).
- Re-grade, and augment with additional granular material, if necessary, the sideslope below the pile wall as was partially undertaken since the 2016 inspection.

Medium Term

SH001A: An inexpensive option would be to install a subdrain in the upslope ditch to see if intercepting some of the groundwater might reduce the rate of movement. Although this is unlikely to remediate the site, it might extend the time before a full intervention is necessary.

Long-Term:

SH001-1: Consideration should be given to placing additional horizontal drainage measures to further reduce groundwater levels in the highway embankment particularly to the southwest of the wall. This might also be accomplished with a subdrain or relief wells to the south of the highway. Consideration could also be given to extending the pile wall further southwest should ongoing maintenance become difficult and/or expensive.

SH001A-1: With confirmed movement at this site, it is recommended that a preliminary engineering assessment be undertaken to determine potential mechanisms and develop alternates for stabilizing this location. A LiDAR review should be included to try to better define the possible limits of the landslide.

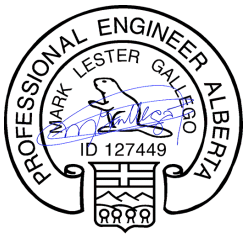
Ongoing Investigation:

It is recommended that the annual Geohazard inspection should continue as scheduled.

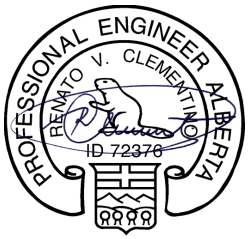
Closure:

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, P.Eng.
Principal | Senior Geotechnical Engineer



October 17, 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)

Mark Gallego, P.Eng.
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.

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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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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.

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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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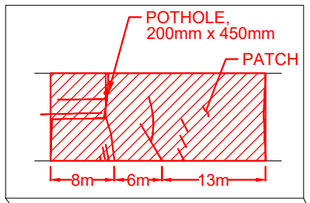

DETAIL
SCALE: 1:750

50mm Ø HORIZONTAL DRAINS
OLD SCARP (2011)
RIPRAP APRON
OUTLET HANGING ABOUT 300mm (2022)
PONDED WATER (2017)
SLOPE UNEVEN AND SOFT
COBBLE ACCUMULATING
SEEPAGE
PN3/PN4
GULLY:
0.2m WIDE, 0.3m DEEP (2017)
0.3m WIDE, 0.5m DEEP (2019)
0.2m WIDE, 0.2m DEEP (2020)
6m LONG x <10mm WIDE
7.2m LONG (2017)
920 CSP
SMALL PATCH - POPPED OUT (2020)
SINKHOLE 2.4m x 1.9m
(PREVIOUSLY TWO
SMALLER SINKHOLES)
0.3m WIDE, 0.2m DEEP
SEEPAGE BENEATH T-PIPE DOWN DRAIN (2014-2018)
TREES LEANING ON MOST OF SLOPE
50mm Ø HORIZONTAL DRAIN
TOE ROLL
SEEPAGE
(2019-2020,
2022)
9+700
20-50mm
WIDE
60mm WIDE
POT HOLE
10-50mm WIDE (2019-2020)
SLUMP AT
END OF CSP
INLET APPEARS STEEP
T-PIPE DOWN DRAINS (TYP)
PARTIALLY PLUGGED AND ERODED BELOW (2022)
PN1/PN2
SLIGHT SCARP (LESS DISTINCT 2022)
0.4m WIDE, 0.7m DEEP GULLY (2016)
ROUNDED ROCK PLACED IN 2017
SI2
2 PILES (2021)
10 PILES (2022)
1m WIDE
2 PILES
8 PILES
SI18-6/PN18-6A/PN18-6B
SOFT AND WET (2021)
ESTIMATED OUTSIDE LIMITS OF
SLIDE MOVEMENTS (LIDAR)
GUARDRAIL DETACHED
FROM POST (2019-2020)
ACP CURB DAMAGE (16.5m LENGTH OF CURB
COMPLETELY DESTROYED IN 2014-2020)
2 PILES
SI18-5/PN18-5A/PN18-5B
9+800
SI/PN01-2
SI12
DIP OVER PATCH (2019-2020)
GULLY FORMING (2020)
10-40mm WIDE (2017); 20-50mm WIDE (2018)
20-90mm WIDE (2019); UP TO 150mm WIDE (2020)
TWO POT HOLES
(2021, 2022)
HUMP
SI/PN01-1
SLIGHT
HUMP(2021, 2022)
UP TO 0.7m OF PILE TOPS EXPOSED WHERE NOTED;
TENSION CRACKS OPENING ON DOWNSLOPE SIDE UP
TO 70mm WIDE AND 200mm DEEP
SI10-3
TENSION CRACKS
20-30mm WIDE (2017)
30mm WIDE, 40mm DEEP (2018)
SI18-4/PN18-4A/PN18-4B
50-100mm WIDE
DIP (2016-2017)
COBBLE DITCH CHECK (TYP)
CRACK FORMING <10mm WIDE
30mm WIDE, 30mm DEEP (2018)
30-60mm WIDE, 10mm DEEP (2019)
100mm WIDE (2020)
8m LONG, 20mm WIDE, 10m LONG, 20-30mm WIDE (2022)
10-50mm WIDE
CRACK PATCH (2019);
POUNDED OUT 2020
SHEARED AT 16.8m DEPTH (2020)
SI16
70mm WIDE, 10mm DEEP
≤ 200mm WIDE, ≤ 80mm
DEEP (2022)
PATCH (2016)
SI18
17m LONG (2018); 18m LONG (2019);
31m LONG (2020)
POTHOLE;
PATCHED (2019)
POUNDED OUT, ≤ 270mm
WIDE,≤ 60mm WIDE (2022)
13m LONG (2018); 14m LONG (2019)
24m LONG (2022)
SI20
9+400
RUTTING IN DITCH
AND PONDED WATER
1.1m HIGH
1.3m HIGH
0.3m HIGH
SI21
TOE ROLLS
MORE MOVEMENT, POSSIBLY
FROST-DRIVEN (2022)
DITCH EROSION CHANNEL
APPROX. 28m LONG x 0.6m DEEP.
VEGETATED IN 2015.
0.8m WIDE x 0.4m DEEP (2016-2018)
GRASS REGROWING (2019)
PREVIOUSLY OFFLOADED
BACKSLOPE AREA

N
W
E
S

LEGEND

- SCARP (INTERPRETED FROM LIDAR)
- SLOPE INCLINOMETER (APPROXIMATE)
- DESTROYED SLOPE INCLINOMETER
- APPROXIMATE INSTRUMENT LOCATION (2018)
- PN — PNEUMATIC PIEZOMETER
- SI — SLOPE INCLINOMETER
- GULLY
- DRAINAGE PATHS (INTERPRETED FROM LIDAR)
- GUARDRAIL
- TREE LINE
- RED TEMPORARY HAZARD SIGN
- DIRECTION AND NUMBER OF PHOTO

NOTES

1. FEATURE LOCATIONS ARE APPROXIMATE.
2. LIDAR SHADED ACCORDING TO SLOPE FROM WHITE AT 0° TO BLACK AT 35° AND STEEPER.
3. PREVIOUS OBSERVATIONS SHOWN IN BLACK.
4. MAY 2022 OBSERVATIONS SHOWN IN RED.
5. DRAWING UPDATED IN 2017 USING LIDAR, SATELLITE IMAGERY, AND A MEASURING WHEEL.

0 20 40 60 80 m
SCALE 1:1500

LIDAR PROVIDED BY ALBERTA TRANSPORTATION (FLOWN 2007)

Alberta

PEACE REGION (SWAN HILLS)

SH001-1: HWY 33:12
2022 SITE INSPECTION PLAN

DWG No. 32121-SH001-1

DRAWN BY	ML
DESIGNED BY	KEF
APPROVED BY	RVC
SCALE	1:1500
DATE	SEPTEMBER 2022
FILE No.	32121

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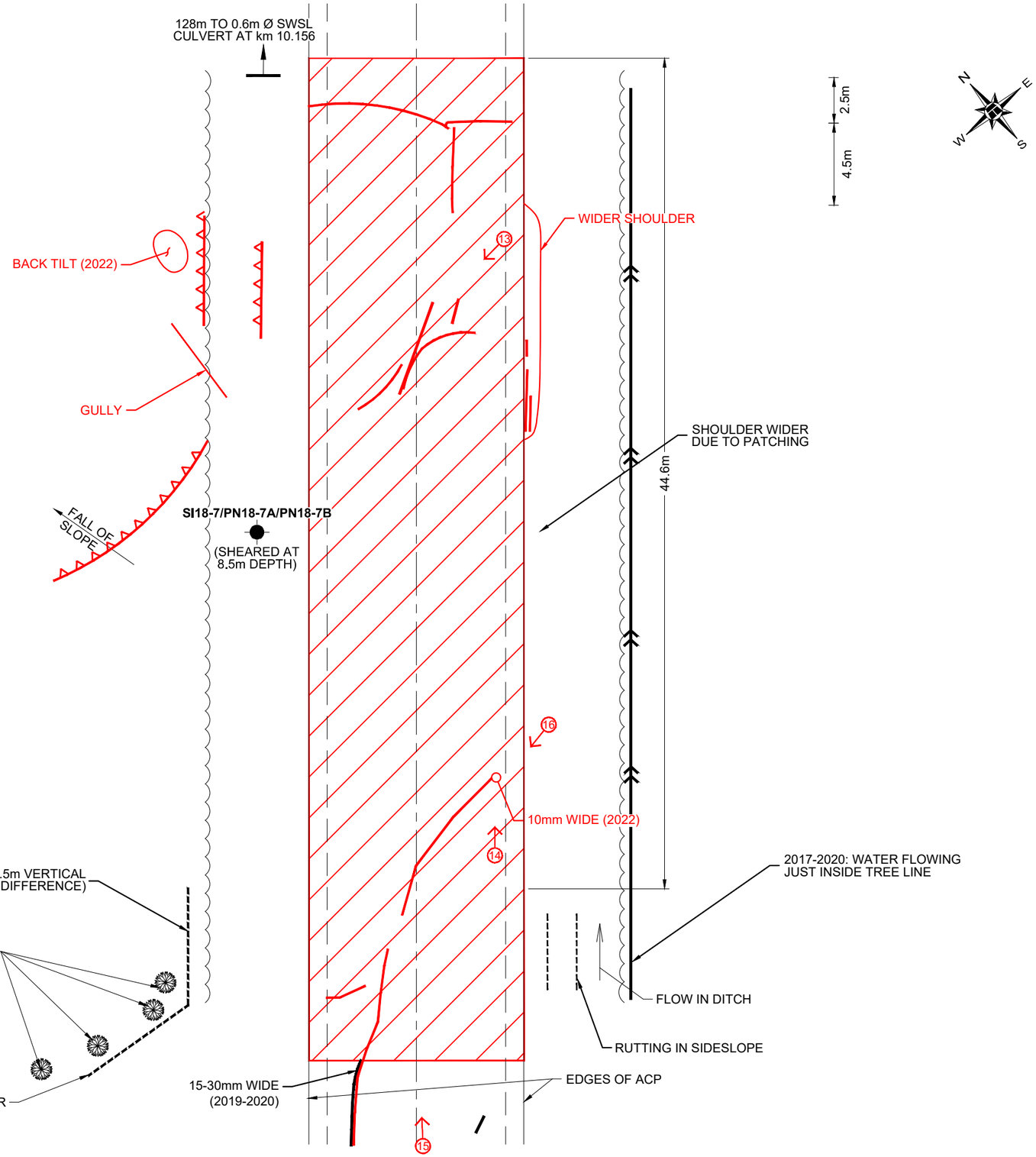

LEGEND

- CRACK
- WATER COURSE
- APPROXIMATE INSTRUMENT LOCATION (2018)
- PN PNEUMATIC PIEZOMETER
- SI SLOPE INCLINOMETER
- (1) DIRECTION AND NUMBER OF PHOTO

NOTES

1. FEATURE LOCATIONS ARE APPROXIMATE.
2. PREVIOUS OBSERVATIONS SHOWN IN BLACK (2013-2015 FROM AMEC FIGURE 1, PROJECT EG10030, PROVIDED BY ALBERTA TRANSPORTATION).
3. CRACK PATTERN REDRAWN AFTER PATCHES PLACED IN 2020 AND 2022.
4. MAY 2022 OBSERVATIONS SHOWN IN RED

0 2.5 5 7.5 10 12.5 15 m

SCALE 1:250

Alberta

PEACE REGION (SWAN HILLS)

SH001A-1: HWY 33:12
2022 SITE INSPECTION PLAN

DWG No. 32121-SH001A-1

DRAWN BY	ML
DESIGNED BY	KEF
APPROVED BY	RVC
SCALE	1:250
DATE	SEPTEMBER 2022
FILE No.	32121

THURBER ENGINEERING LTD.

Photo 1, SH001-1 – Looking southwest at patch over cracks forming at the southwest end of the wall .

Photo 2, SH001-1 – Looking north at cracking in highway surface immediately south of the pile wall.

Photo 3, SH001-1 – Looking southwest at scarp on slope below highway between SI20 and SI21.

Photo 4, SH001-1 – Looking southwest at scarp below highway near SI18.

Photo 5, SH001-1 – Looking south at erosion in east ditch.

Photo 6, SH001-1 – Looking south at cobbles placed in gully at north end of guardrail.

Photo 7, SH001-1 – Looking southwest at cracked curb at south end of guardrail.

Photo 8, SH001-1 – Seepage out of slope below north-most T-drain.

Photo 9, SH001-1 – Erosion and/or movement away from the piles around the southwest down drain.

Photo 10, SH001-1 – Soil pulling away from the downslope side of piles near the northwest downdrain.

Photo 11, SH001-1 – 920 mm dia. centreline culvert outlet.

Photo 12, SH001-1 – Two sinkholes at culvert inlet have combined to form a larger sinkhole.

Photo 13, SH001A-1 – Crack pattern at the north end of the Site.

Photo 14, SH001A-1 - Looking northeast from the south end of the patch.

Photo 15, SH001A-1 – Looking northeast at roadway crack and scarp (red line) at tree line.

Photo 16, SH001A-1 - Looking west at cracks at south end of patch.