

**ALBERTA TRANSPORTATION
GEOHAZARD ASSESSMENT PROGRAM
NORTH CENTRAL REGION – ATHABASCA
2019 INSPECTION**



Site Number	Location	Name	Hwy	km
NC024-4 (NC24C)	Approximately 7.7 km north of Hwy 29 (North of Elk Point)	KEHIWIN LAKE	41:23 (previously 28:16)	7.7
Legal Description		UTM Co-ordinates (NAD 83)		
NE-25-58-7-W4M		12 N 5988325	E	506652

	Date	PF	CF	Total
Previous Inspection:	May 9, 2018	8	4	32
Current Inspection:	June 12, 2019	8	4	32
Road AADT:	1540	Year:	2019	
Inspected By:	Tarek Abdelaziz, José Pineda (Thurber) Rishi Adhikari, Arthur Kavulok, Calvin Kissel (TRANS)			
Report Attachments:	<input checked="" type="checkbox"/> Photographs <input checked="" type="checkbox"/> Plans <input type="checkbox"/> Maintenance Items			

Primary Former Site Issue:	Landslide developed abruptly to the south of the km 7.8 pile wall after occurrence of heavy rainfall events in 2011, causing pavement distress in the highway surface.	
Dimensions:	Cracked section of highway: About 180 m long (parallel to the highway alignment) and 80 m wide (parallel to the slope direction). Area susceptible to future local landslides to the south of the cracked section of the highway: About 160 m long	
Date of any remediation:	Remedial measures were implemented between the fall of 2016 and the fall of 2017 and consisted of the following: (a) the construction of a 230 m long cast-in-place tied-back pile wall to the south of NC24A to retain the cracked section of the highway (NC24C tied-back wall), (b) the construction of a 125 m cast-in-place cantilever pile wall (NC24 pile wall extension) to the south of the NC24C tied-back wall as a precautionary measure against future landslides. The NC24C pile wall extension (NC24C interim pile wall) was designed to accommodate the installation of additional piles, anchors and waler (if needed) in the future subject to instrumentation monitoring results, (c) installation of twin culverts and lining of C2 culvert by others, (d) grouting of culvert C1, ditch regarding and lining with TRM. Slope inclinometers load cells were installed in the NC24C tied-back pile wall to monitor the wall movement and anchor loads. Slope inclinometers, a Shape Accelerometer Array (SAA) and strain gauges were installed in selected piles of the NC24C pile wall extension to assess wall movements and the bending moment in one of the piles.	
Maintenance:	After the first site visit was completed on May 12, 2011, the most pronounced distressed area of the highway surface was patched in the fall of 2011; patched again in fall 2012; cracks opened again and sealed in the early spring of 2013; cracks were sealed in June 2014. ACP patch was completed after construction in the fall of 2017.	
Observations:	Description	Worse?
<input type="checkbox"/> Pavement Distress	N/A	<input type="checkbox"/>
<input type="checkbox"/> Slope Movement	N/A	<input type="checkbox"/>
<input type="checkbox"/> Erosion		<input type="checkbox"/>

<input checked="" type="checkbox"/> Seepage	Seepage from the face of the backslope is draining across the highway through C2 Culvert	<input type="checkbox"/>
<input type="checkbox"/> Bridge/Culvert Distress		<input type="checkbox"/>
<input checked="" type="checkbox"/> Other	Sharp drop off on the west side of highway due to previous ACP patches	<input type="checkbox"/>

Instrumentation: (1SAA, 18SIs, 7PNs, 5SPs, 16VCs, 18SGs)

The following provides the slope inclinometers' rate of movements in the Spring of 2019:

- SI15-15 (located in the east ditch within the southern limit of the landslide) = 4.0 mm/yr.
- SI15-16, SI15-19, and SI15-21 (located near the west edge of the highway downslope of the pile walls) ranged between 1.3 and 4.0 mm/yr.
- SI12-11, SI15-7, SI15-20 (located at the bottom of the highway west side slope) ranged between 0.9 and 2.6 mm/yr.

Total pile head movement (between fall 2018 and spring 2019):

- N24C tied-back pile wall: SI16-1= 1.3 mm, SI16-2 = 0.4 mm, SI16-3 = 0.8 mm, SI16-4 = 0.1 mm, SI16-5 = 0 mm.
- N24C Interim pile wall: SI17-1= 1.3 mm, SI17-2 = 2.3 mm, SI17-3 = 2.3 mm, SI17-4 = 2.8 mm, SAA17-1 = 0.1 mm.

Vibrating wire load cell readings ranged from 170 kN to 245 kN; The readings of the strain gauge, installed in Pile 146 of the NC24C Interim pile wall, are still below warning threshold values.

Groundwater levels fluctuated in the piezometers and ranged from an increase of 1.17 m in SP12-9 to a decrease of 0.17 m in PN15-20.

Assessment (Refer to attached Figure):

The site observations and instrumentation readings indicate that implemented remedial measure has been effective in stabilizing the landslide mass. Reflective highway surface cracks may however appear over time until the pile wall mobilizes the full magnitude of the stabilizing force.

The instrumentation readings of the NC24C pile wall extension (slope inclinometers, SAA, and strain gauges) are still below the warning thresholds established during the design stage. Hence, the installation of the full retaining wall system (i.e. additional piles, anchors and waler) is not needed at the mean time.

The existing sharp drop off near the edge of pavement constitutes a safety hazard to runaway vehicles.

Recommendations:

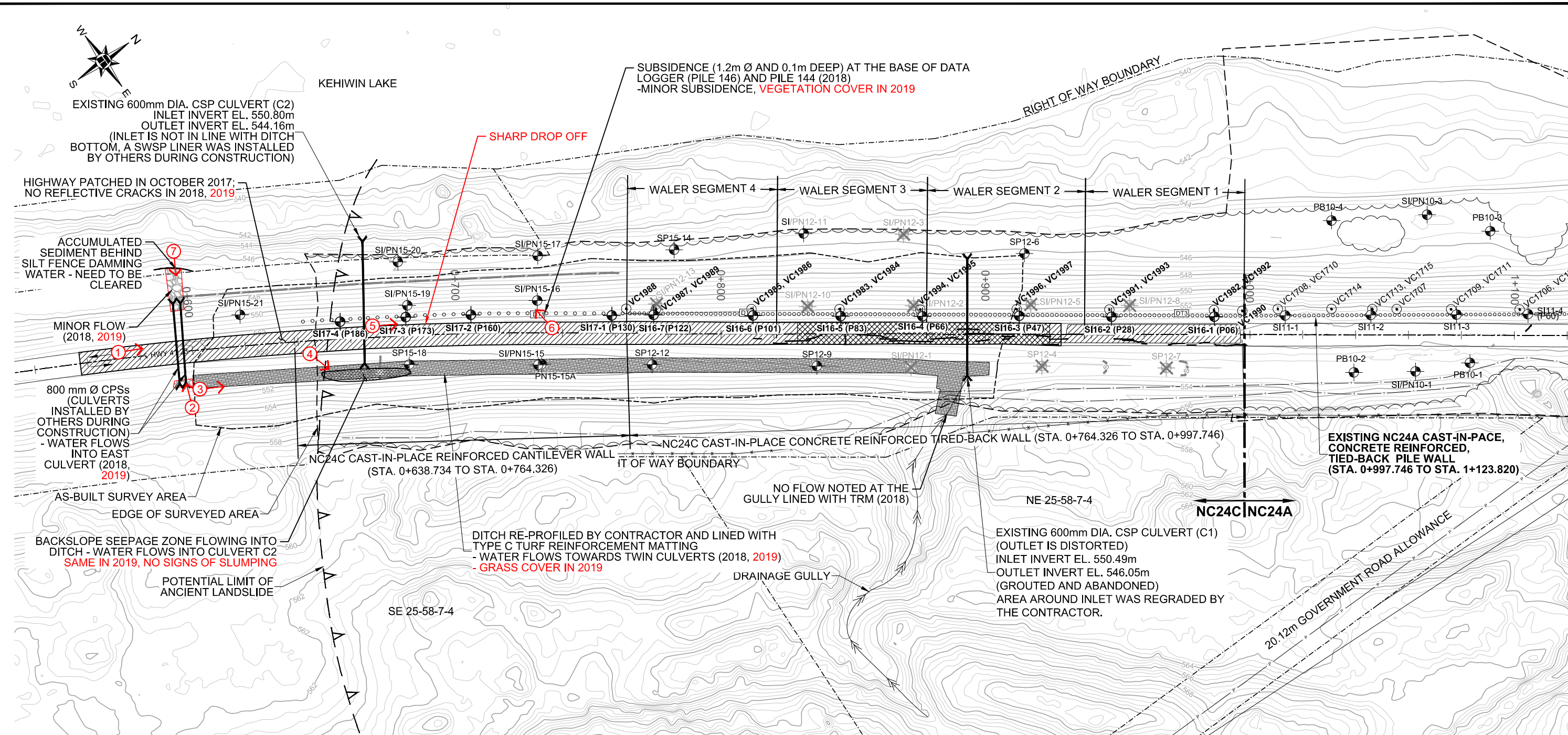
The site visit could be skipped next year; however, instrumentation monitoring should be continued at this site.

The local MCI should watch closely for the development of any cracks in the highway section above the NC24C pile wall extension and notify us immediately. Cracks should generally be sealed to reduce ground water infiltration into the landslide mass.

Accumulated sediment behind the silt fence, located between the outlet of the twin pipes and the bush, should be cleared to avoid damming of culvert flow. The silt fence will need to be maintained for a few years and then be removed after vegetation is established in this area.

Consideration should be given for placing the least amount of fill off the highway surface to smoothen the existing sharp drop off and eliminate the existing hazard. Otherwise, sharp shoulders warning signs should be erected to warn the motorists of the existing hazard.

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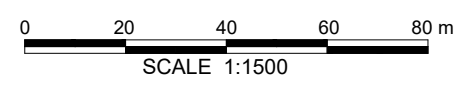
LEGEND


- | | | | |
|------------|--------------------------------|-------|---|
| ○○○○○○○○○○ | PILE WALL | —550— | GROUND SURFACE CONTOUR |
| —x—x—x— | FENCE LINE | —P— | OVERHEAD POWER LINE (APPROXIMATE) |
| —w—w—w— | BUSH LINE | —T— | TELUS LINE (APPROXIMATE) |
| — — — — | ACTIVE SLIDE CRACKS ON HIGHWAY | —S— | SILT FENCE |
| ⊙ | TEST HOLE LOCATION | ⊙ | VIBRATING WIRE LOAD CELL LOCATION |
| ⊗ | DAMAGED INSTRUMENT | ▨ | PAVEMENT DISTRESS AREA |
| SI | SLOPE INCLINOMETER | ▧ | ACP PATCH (OLD) |
| PN | PNEUMATIC PIEZOMETER | ▩ | RIP RAP |
| SP | STANDPIPE PIEZOMETER | ① | PHOTOGRAPH NUMBER, AND APPROXIMATE DIRECTION AND LOCATION |
| PB | POORBOY | | |
| VC | VIBRATING WIRE LOAD CELL | | |
| SAA | SHAPE ACCELEROMETER ARRAY | | |
| □ | DATALOGGER | | |

Load Cell Serial #	Anchor
VC1990	G0001S
VC1982	G007U
VC1992	G007L
VC1993	G029U
VC1991	G029L
VC1997	G049U
VC1996	G049L
VC1995	G070U
VC1994	G070L
VC1984	G087U
VC1983	G087L
VC1985	G106U
VC1986	G106L
VC1987	G126U
VC1989	G126L
VC1988	G132S

NOTES:

1. FEATURE LOCATIONS ARE APPROXIMATE.
2. PREVIOUS OBSERVATIONS ARE SHOWN IN BLACK.
3. **JUNE 12, 2019 OBSERVATIONS ARE SHOWN IN RED.**
4. CONTOUR INTERVAL IS 0.5m.
5. CONTOURS INSIDE SURVEYED AREA WERE SURVEYED BY WSP. ELEVATION CONTOURS OUTSIDE SURVEYED AREA WERE DERIVED FROM LIDAR DATA.
6. INSTRUMENTS AND DATALOGGERS INSTALLED DURING CONSTRUCTION ARE SHOWN IN BOLD.
7. SHAPE ACCELEROMETER ARRAY AND STRAIN GAUGES ARE CONNECTED TO DT1 (CAMPBELL SCIENTIFIC CR6 DATALOGGER, SERIAL No. 5839); LOAD CELLS VC1983 - VC1989, VC1994, VC1995 ARE CONNECTED TO DT2 (RST DT2040 DATALOGGER, SERIAL No. 2202); AND LOAD CELLS VC1982, VC1990 - VC1993, VC1996, VC1997 ARE CONNECTED TO DT3 (RST DT2040 DATALOGGER, SERIAL No. 2203).
8. SHAPE ACCELEROMETER ARRAY AND STRAIN GAUGES ARE INSTALLED IN PILE P146.






**NORTH CENTRAL REGION - ATHABASCA AREA
2019 GEOHAZARD ASSESSMENT**

**NC024-4 (NC24C): HWY 41:23 LANDSLIDE (km 7.7)
SITE PLAN SHOWING SITE FEATURES AND
INSTRUMENT LOCATIONS**

DWG NO. 13357-NC024-4

DRAWN BY	ML
DESIGNED BY	JGP
APPROVED BY	TSA
SCALE	1:1500
DATE	AUGUST 2019
FILE No.	13357



THURBER ENGINEERING LTD.



Photo No. 1 - Looking north at highway surface; no reflective cracks or dips noted in 2019



Photo No.2 - Looking at twin culverts (northwest); water flows into most eastern pipe



Photo No.3 - Looking north at the TRM lined ditch; water flows south towards the twin culverts and vegetation grew in the ditch and backslope



Photo No.4 - Looking east at backslope seepage zone; vegetation grew between 2018 and 2019



Photo No.5 - Looking north at a sharp drop off along the western edge of the road; vegetation grew on the highway side slope



Photo No.6 - Looking at data logger DT1 installed at pile 146 location; vegetation grew at previously noted subsidence at the base of the data logger



Photo No.7 - Looking at the outlets of the twin culverts; water flows downstream of the pipes toward the bush