July 15, 2024

Alberta Transportation and Economic Corridors
Main Floor, Provincial Building
9621 96 Avenue
Peace River, Alberta
T8S 1T4

Robert Senior
Construction Technologist

Dear Mr. Senior:

CON0022166 Peace Region (Grande Prairie District – South) GRMP Instrumentation Monitoring Site GP038-I and II; H40:38, km 25.831 and km 25.426 Slides 1.6 km and 2.0 km North of Kakwa River Bridge (North Little Prairie Creek)
Section C – 2024 Spring Readings

1 GENERAL

One slope inclinometer (SI) (SI17-1) and four pneumatic piezometers (PNs) (PN17-1A, PN17-2A/B, and PN17-3B)) were read at the GP038-I site in the Peace Region (Grande Prairie District – South) (GP South Region) on May 23, 2024, by Tim Hillman, E.I.T. of Klohn Crippen Berger Ltd. (KCB). These instruments were read as part of the GP South Region Geohazard Risk Management Program (GRMP). The GP038-I and GP038-II sites are located on Hwy 40:38, km 25.831 and 25.426, respectively. The approximate site coordinates of GP038-I and GP038-II are 6033163 N, 398377 E and 6032912 N, 398677 E, respectively (UTM Zone 11, NAD 83). A site plan is presented on Figure 1.

The geohazard at the GP038-I and GP038-II sites consists of two repaired landslides in the highway embankment fill, approximately 2.0 km and 1.6 km north of the Kakwa River bridge, respectively. Construction to remediate the landslides (described below) was completed in 2018. Minor post-construction pavement cracking and settlement have been observed at both sites.

Previous remedial actions completed at the sites between 2017 and 2018 include a culvert extension and construction of a toe berm at the GP038-I site, and reconstruction of the GP038-II site with compacted granular fill along with a sheet pile wall installed to isolate work from the creek. An overlay was completed between 2017 and 2020, and pavement cracks were sealed in 2022.

In February 2017, a geotechnical site investigation, which included instrument installation, was conducted by a previous consultant. The encountered stratigraphy was as follows: fill, overlying clay till, and overlying clay.

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1.1 Instrumentation

KCB has been reading the instruments at this site since the spring of 2021. Instrumentation installation details are tabulated in Table 1.1. Instrument locations are shown on Figure 1. Any instruments not included in Table 1.1 or shown on Figure 1 are assumed to be inoperable and are not presented or discussed herein.

In 2017, three SIs and eight piezometers were installed at the sites by a previous consultant to monitor movement and groundwater conditions, respectively. Some of these instruments have since become inoperable (e.g., destroyed, sheared, or lost), as detailed in Table 1.1 (see table notes).

The instruments are protected with above-ground casing protectors.

Between the spring 2023 and spring 2024 readings, SP17-1 at the GP038-II site was destroyed (appeared to have been struck by a vehicle).

SI17-1 was read using the same metric RST Digital MEMS Inclinometer System that has been used to read the SI since KCB took over the readings in June 2021. The operable PNs were read using an RST C109 pneumatic piezometer readout box.

Table 1.1 Instrumentation Installation Details[1]

Site	Instrument ID	Instrument Type	Date Installed	UTM Coordinates(m)		Ground Surface Elevation (m)	Stick Up(m)	Depth (mbgs[2])	Condition
				Northing	Easting				
GP038-1	SI17-1	SI	Feb. 8, 2017	6033126	398415	844.7	0.8	18.0	Operable
	~~SI17-2~~	~~SI~~	~~Feb. 8, 2017~~	~~Unknown~~	~~Unknown~~	~~Unknown~~	~~Unknown~~	~~Unknown~~	~~Inoperable[3]~~
	~~SI17-3~~	~~SI~~	~~Feb. 8, 2017~~	~~Unknown~~	~~Unknown~~	~~Unknown~~	~~Unknown~~	~~Unknown~~	~~Inoperable[3]~~
	PN17-1A	PN	Feb. 4, 2017	6033126	398415	844.7	N/A	7.2	Operable
	~~PN17-1B~~	~~PN~~	~~Feb. 4, 2017~~	~~6033126~~	~~398415~~	~~844.7~~	~~N/A~~	~~15.9~~	~~Inoperable~~
	PN17-2A	PN	Feb. 4, 2017	6033103	398444	842.3	N/A	7.6	Operable
	PN17-2B	PN	Feb. 4, 2017	6033103	398444	842.3	N/A	12.6	Operable
	~~PN17-3A~~	~~PN~~	~~Feb. 3, 2017~~	~~6033083~~	~~398433~~	~~839.3~~	~~N/A~~	~~8.9~~	~~Inoperable[4]~~
	PN17-3B	PN	Feb. 3, 2017	6033083	398433	839.3	N/A	13.9	Operable
	~~SP17-2~~	~~SP~~	~~Feb. 2, 2017~~	~~6032873~~	~~398710~~	~~821.8~~	~~1.0~~	~~14.9~~	~~Inoperable[5]~~
~~GP038-II~~	~~SP17-1~~	~~SP~~	~~Feb. 3, 2017~~	~~6032882~~	~~398720~~	~~822.3~~	~~1.0~~	~~10.4~~	~~Inoperable[5]~~

Notes:

[1] Instrument installation details were taken from reports and data files prepared or provided by the previous consultant(s) or TEC. Ground surface elevations were not provided for the SIs, so the ground surface elevation from the adjacent instruments/piezometer tips were used if available. Instrument coordinates and stick ups (where applicable) were confirmed by KCB using a handheld GPS (accuracy of ± 5 m) and tape measure, respectively.

[2] Meters below ground surface (mbgs). Bottom reading depth for SIs, and tip or screen depth for piezometers.

[3] SI17-2 and SI17-3 have sheared at an approximate depth of 12.2 m and 11.0 m below ground surface, respectively.

[4] PN17-3A has not stabilized since the fall 2017 reading and is no longer being read.

[5] SP17-1 and SI17-2 were destroyed in 2024 and 2017, respectively.

2 INTERPRETATION

2.1 General

For SI17-I, the cumulative displacement, incremental displacement, and displacement-time data was plotted in the A-direction (i.e., the direction of the A0-groove) and the X-direction (i.e., the direction of maximum movement obtained at a skew angle from the A0-grooves). SI17-1 has a skew angle of 348°, measured clockwise from the direction of the A0-grooves.

For the operable PNs, the recorded porewater pressures were converted to an equivalent water/piezometric elevation and plotted relative to ground surface elevation and the tip elevation for each instrument.

The SI and piezometer plots are included in Appendix I, and a summary of the SI and piezometer data is provided in Table 2.1 and Table 2.2, respectively. The SI data plots presented herein include data for readings taken with both the previous consultants' and KCB's SI reading equipment.

2.2 Zones of Movement

Discrete movement (i.e., occurring on a defined failure plane) is being recorded in SI17-1 from an approximate depth of 10.0 m to 12.5 m below ground surface (approximately elevation 832.2 m to 834.7 m) and possibly from 15.0 m to 17.0 m (approximately elevation 827.7 m to 829.7 m). The upper and lower zones of movement are occurring in the clay till and the underlying clay foundation units, respectively. Shallow distributed movement is also being recorded in the fill from an approximate depth of 2.5 m below ground surface to ground surface (approximately elevation 842.2 m to 844.7 m).

2.3 Interpretation of Monitoring Results

2.3.1 GP038-I Site

Between June 2017 and June 2018, an increased rate of movement (approximately 29 mm/year) was recorded in the upper monitoring zone of SI17-1, likely in response to toe berm construction in 2017 and 2018. Since June 2018, the rate of movement has decreased and is currently less than 1 mm/year indicating the toe berm is stabilizing the highway embankment. The rate of movement recorded in the lower monitoring zone of SI17-1 has been slow (less than 1 mm/year) since installation and is within the reading accuracy of the SI equipment.

Table 2.1 Slope Inclinometer Reading Summary

Site	Instrument ID	Date				Ground Surface Elevation (m)	Depth of Movement (mbgs[1])	Direction of Movement, Skew Angle[2]	Movement (mm)		Rate of Movement (mm/year)		
		Initialized	Previous Maximum Cumulative Movement Recorded	Previous Reading	Most Recent Reading				Maximum Cumulative	Incremental Since Previous Maximum Cumulative	Previous Maximum	Most Recent Reading	Change from Previous Reading
GP038-I	SI17-1	Feb. 8, 2017	Oct. 10, 2019	Jun. 06, 2023	May 23, 2024	844.7	10.0 – 12.5	X-Direction, 348°	28.6	-1.2	29.3	-0.7	-2.2
			Jun. 25, 2020				15.0 – 17.0	X-Direction, 348°	2.3	-1.1	5.8	-0.5	-1.4

Notes:
[1] Meters below ground surface (mbgs).
[2] Skew angle of the X-direction measured clockwise from the A-direction. The azimuth of the A0-grooves in the SI was measured by KCB with a magnetic compass in spring 2022.

Table 2.2 Pneumatic Piezometer Reading Summary

Site	Instrument ID	Date			Ground Surface Elevation (m)	Tip Depth (mbgs[1])	Water Level		
		Installed	Previous Reading	Most Recent Reading			Previous Reading (mbgs[1])	Most Recent Reading (mbgs[1])	Change from Previous Reading (m)
GP038-I	PN17-1A	Feb. 04, 2017	Jun. 06, 2023	May 23, 2024	844.7	7.2	0.7	1.1	-0.4
	PN17-2A	Feb. 04, 2017	Jun. 06, 2023	May 23, 2024	842.3	7.6	0.0	-0.2 (above ground surface elevation)	0.2
	PN17-2B	Feb. 04, 2017	Jun. 06, 2023	May 23, 2024	842.3	12.6	0.2	0.2	0.0
	PN17-3B	Feb. 03, 2017	Jun. 06, 2023	May 23, 2024	839.3	13.9	1.9	2.3	-0.4

Notes:
[1] Meters below ground surface (mbgs).

Overall, the water levels/porewater pressures recorded in the piezometers are relatively high and have been near to above ground surface since mid-2017, indicating the presence of a high groundwater table. The relatively high-water level recorded in the piezometers could result in embankment instability and explain the pavement cracking observed at this site. However, the cracking, in combination with the observed pavement dip and settlement, could also be due to settlement of the recently placed fill. Reactivation of the slide could occur due to continued erosion (less likely) or increases in water level. However, the large toe berm should reduce the potential for reactivation of the slide.

Since mid-2018, an approximate 2.3 m decrease has been recorded in PN-3B, which is installed below the toe berm in a clay foundation unit. The recorded decrease is most likely due to porewater pressures dissipating following toe berm construction between 2017/2018.

2.3.2 GP038-II Site

Before SP17-1 became inactive (last reading spring 2023), the water levels recorded in the instrument were relatively high and had been near ground surface since mid-2018, indicating the presence of a high groundwater table. The pavement cracking and small dip observed at this site may be unrelated to the relatively high-water level recorded in SP17-1, being more likely due to minor settlement of recently placed fill.

3 RECOMMENDATIONS

3.1 Future Work

All operable instruments should continue to be read once per year (spring). Spring readings should be completed after late-May or early-June, due to the risk of water inside the instrument casings being frozen earlier in the year.

The site should continue to be inspected by the Maintenance Contract Inspector (MCI) but be excluded from the GP South GRMP Section B inspections.

3.2 Instrument Repairs and Maintenance

Above-ground-steel-casing protectors for some instruments are close to pavement edge. These are potential roadside hazards to motorists who go off the highway. These should be removed if the instrument(s) are inoperable or replaced with flush-mounted casing protectors if instruments are operable.

Since SP17-1 was the last active instrument at the GP038-II site, it could be replaced. However, since mid-2018, relatively steady water levels had been recorded in this instrument, approximately 1.0 m to 2.4 m below ground surfaces and replacement of this instrument is likely not needed unless site conditions visually change from previous observations (e.g., the slide or area of known high groundwater table appears to be expanding and impacting the highway).

4 CLOSING

This report is an instrument of service of Klohn Crippen Berger (KCB). The report has been prepared for the exclusive use of Alberta Transportation and Economic Corridors (Client) for the specific application to the GP South Geohazard Risk Management Program (Contract No. CON0022166), and it may not be relied upon by any other party without KCB's written consent.

KCB has prepared this report in a manner consistent with the level of care, skill and diligence ordinarily provided by members of the same profession for projects of a similar nature at the time and place the services were rendered. KCB makes no warranty, express or implied.

Use of or reliance upon this instrument of service by the Client is subject to the following conditions:

1. The report is to be read in full, with sections or parts of the report relied upon in the context of the whole report.
2. The observations, findings and conclusions in this report are based on observed factual data and conditions that existed at the time of the work and should not be relied upon to precisely represent conditions at any other time.
3. The report is based on information provided to KCB by the Client or by other parties on behalf of the client (Client-supplied information). KCB has not verified the correctness or accuracy of such information and makes no representations regarding its correctness or accuracy. KCB shall not be responsible to the Client for the consequences of any error or omission contained in Client-supplied information.
4. KCB should be consulted regarding the interpretation or application of the findings and recommendations in the report.
5. This report is electronically signed and sealed and its electronic form is considered the original. A printed version of the original can be relied upon as a true copy when supplied by the author or when printed from its original electronic file.

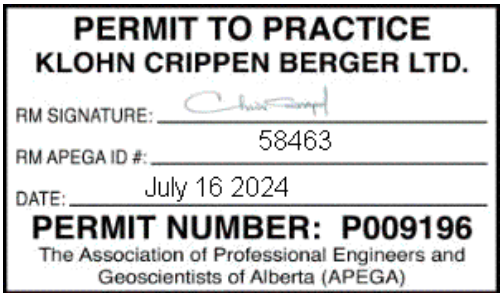
Yours truly,

KLOHN CRIPPEN BERGER LTD.

Courtney Mulhall, M.Sc., P.Eng.
Geotechnical Engineer

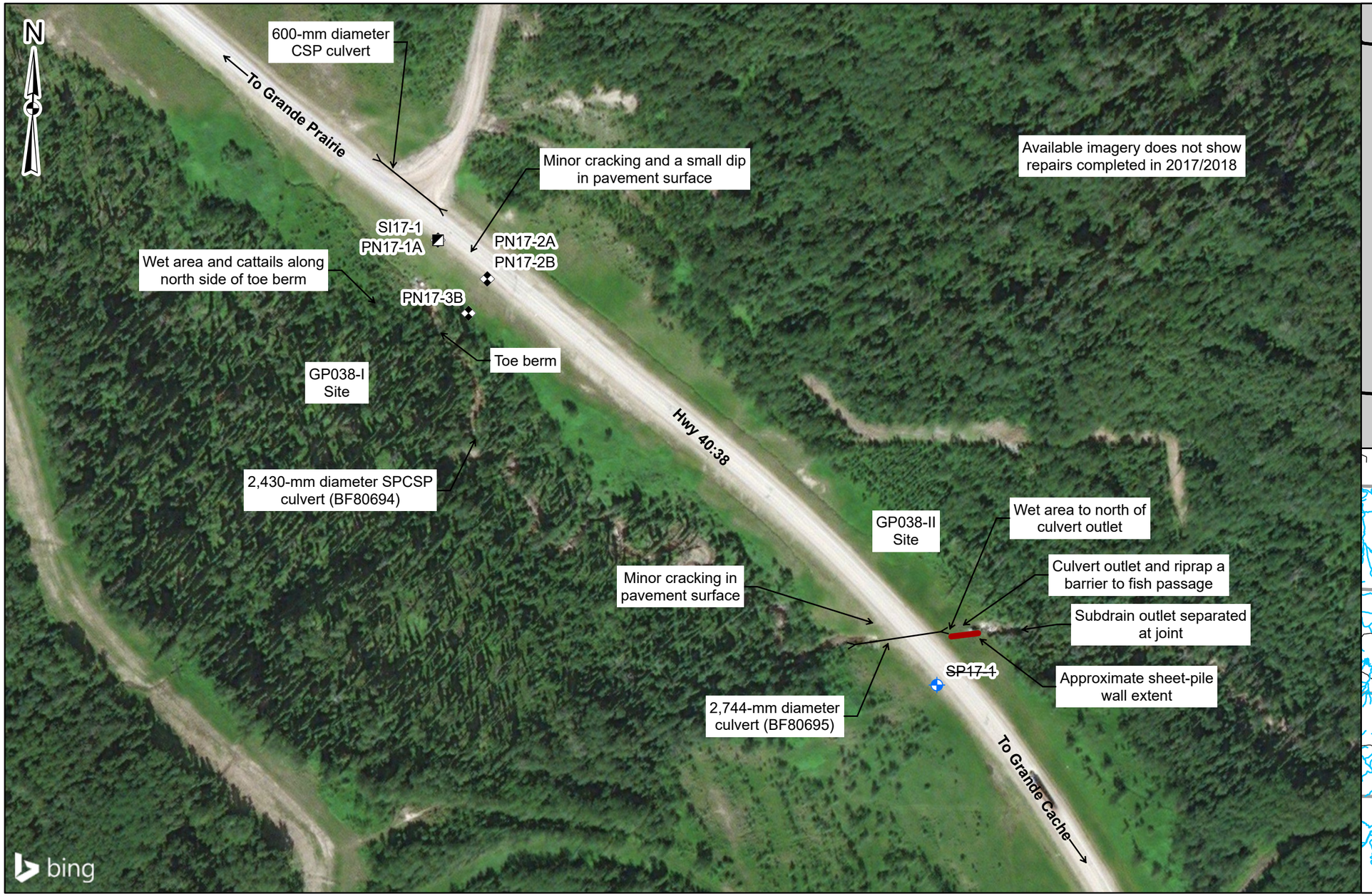
Tim Hillman, E.I.T.
Geotechnical Engineer-in-Training

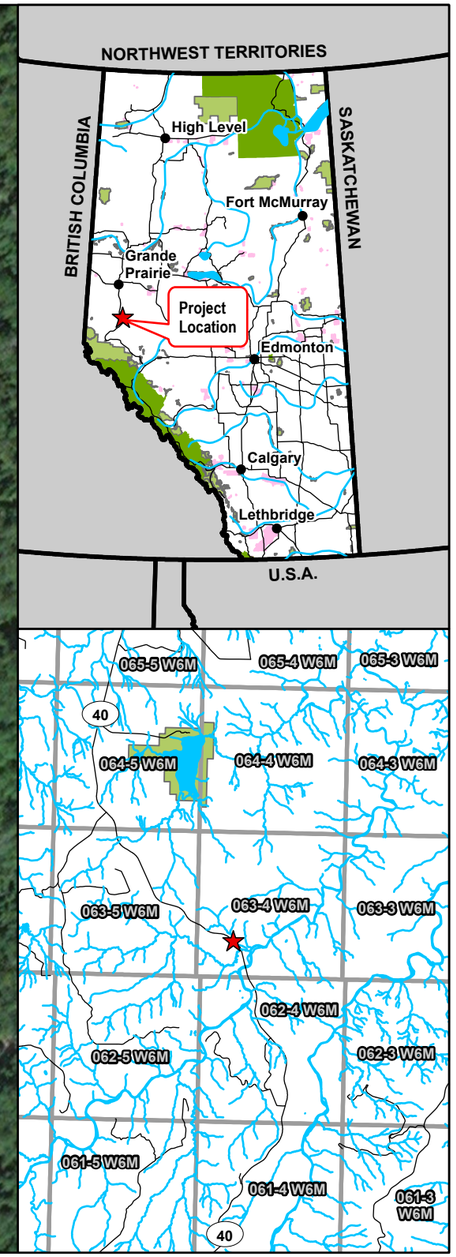
CM/TH/GB:bb



ATTACHMENTS
Figure
Appendix I Instrumentation Plots

FIGURE





Legend

- Approximate Pneumatic Piezometer (PN) Location
- Approximate Slope Inclinometer (SI) Location
- Approximate Standpipe Piezometer (SP) Location
- Culvert
- Sheet Pile

0 100 Metres

NOTES:
1. HORIZONTAL DATUM: NAD83
2. GRID ZONE: UTM ZONE 11N
3. IMAGE SOURCE: 2022 MICROSOFT CORPORATION, 2022 MAXAR CNES, DISTRIBUTION AIRBUS DS
4. STRIKETHROUGH INDICATES INSTRUMENT IS INOPERABLE

CLIENT: Alberta

Klohn Crippen Berger

PROJECT: PEACE REGION (GRANDE PRAIRIE DISTRICT-SOUTH) GEOHAZARD RISK MANAGEMENT PROGRAM

TITLE: Site Plan
GP038-I and -II - Slides 1.6 km and 2.0 km
North of Kakwa River Bridge
Hwy 40:38, km 25.831

SCALE	PROJECT No.	FIG No.
1:2,500	A05116A01	1

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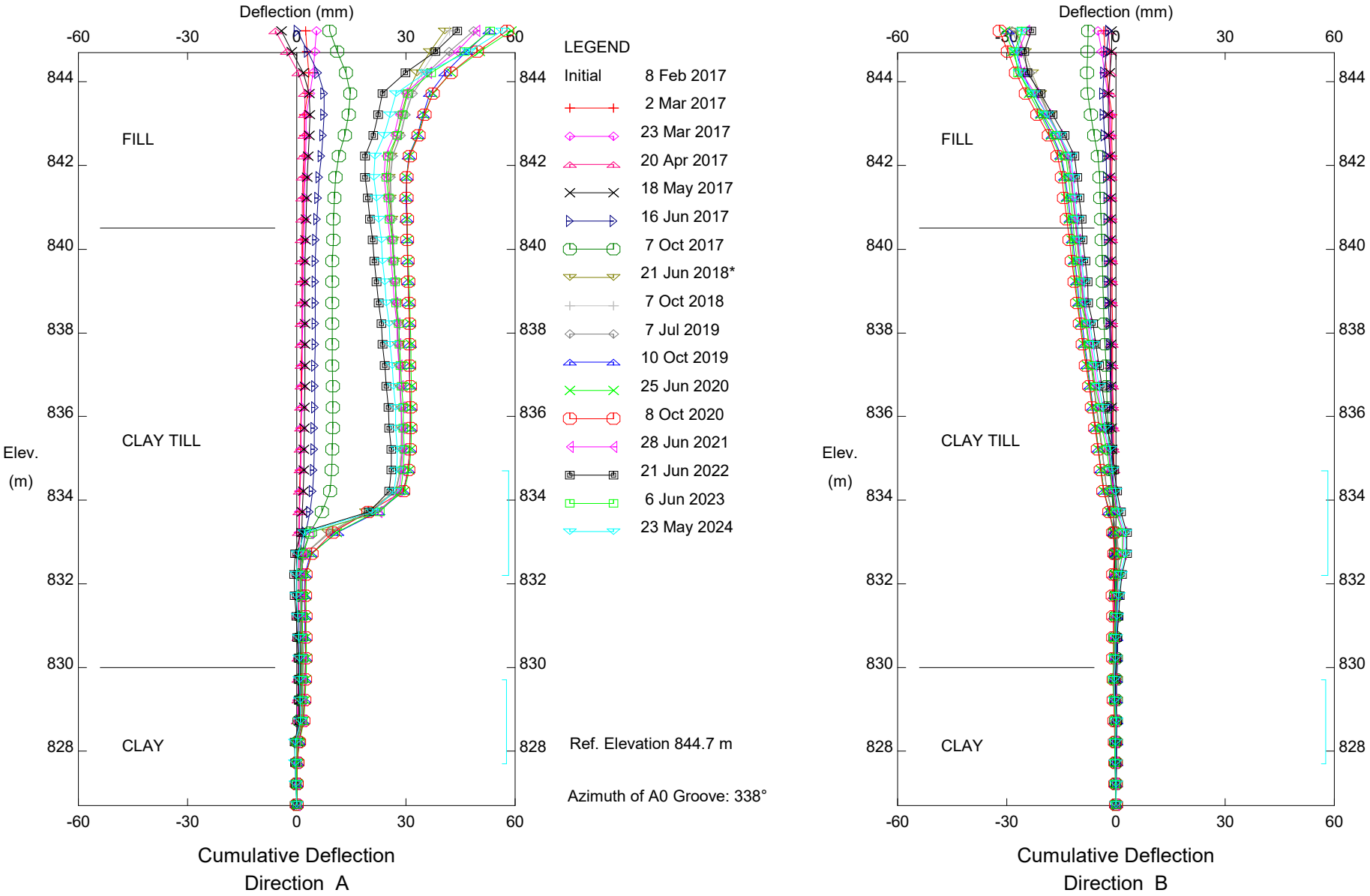
APPENDIX I

Instrumentation Plots

Klohn Crippen Berger - Edmonton



GP038-I; H40:38, Kakwa River Bridge, Inclinometer SI17-1

Alberta Transportation

GP038-I; H40:38, Kakwa River Bridge

Sets marked * include zero shift and/or rotation corrections.

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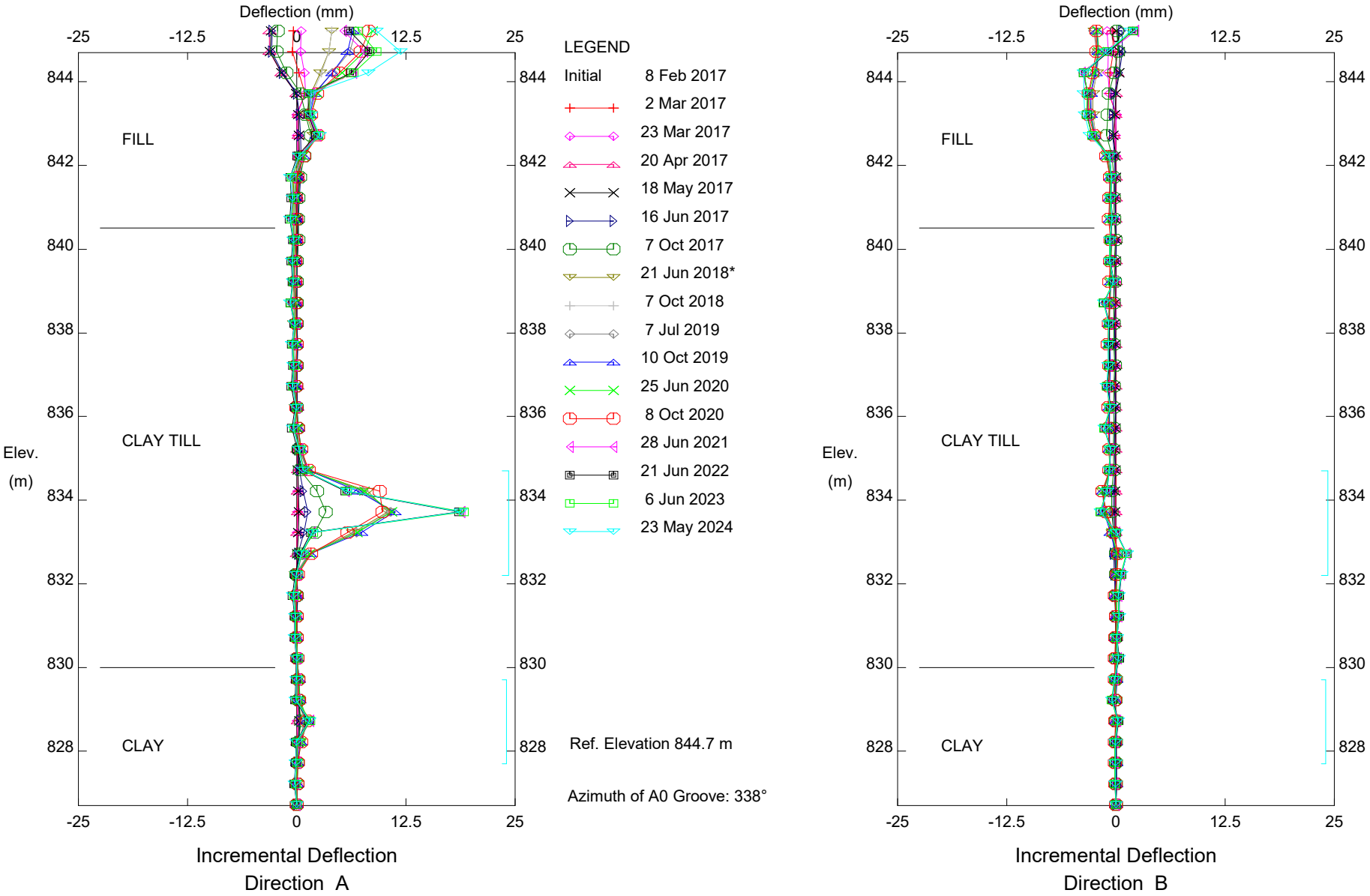

GP038-I; H40:38, Kakwa River Bridge, Inclinometer SI17-1

Alberta Transportation

GP038-I; H40:38, Kakwa River Bridge

Sets marked * include zero shift and/or rotation corrections.

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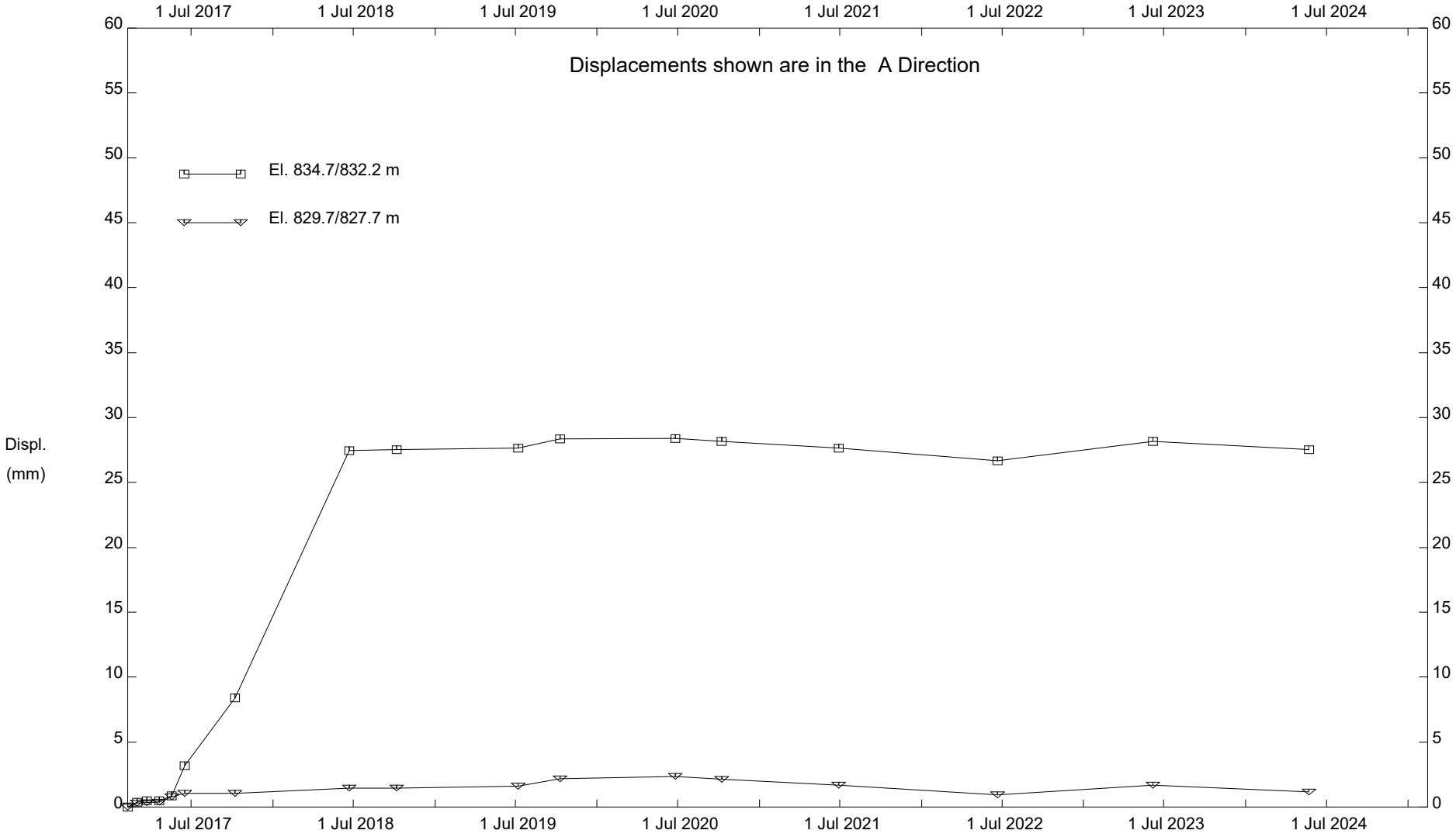

GP038-I; H40:38, Kakwa River Bridge, Inclinometer SI17-1

Alberta Transportation

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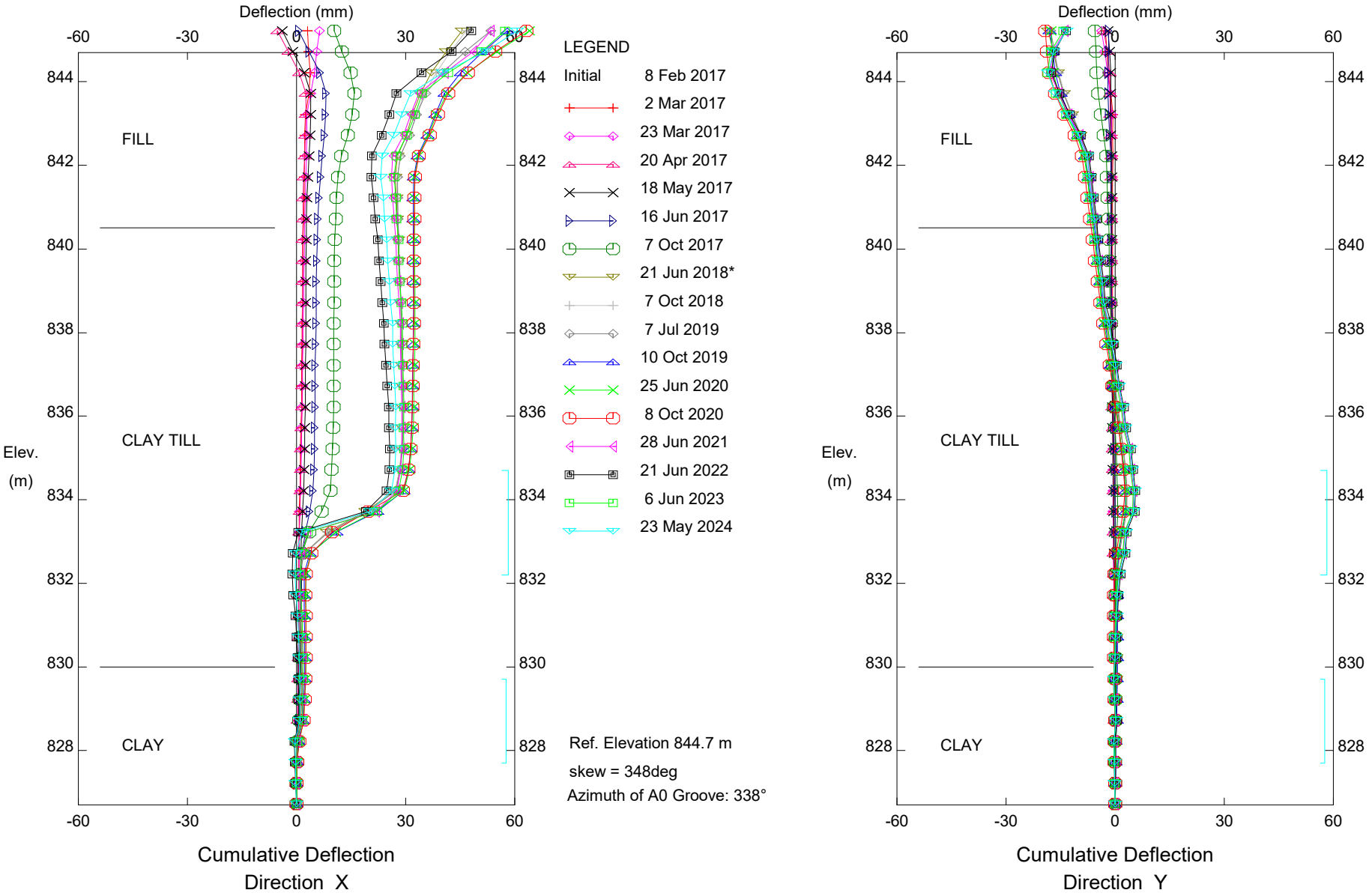


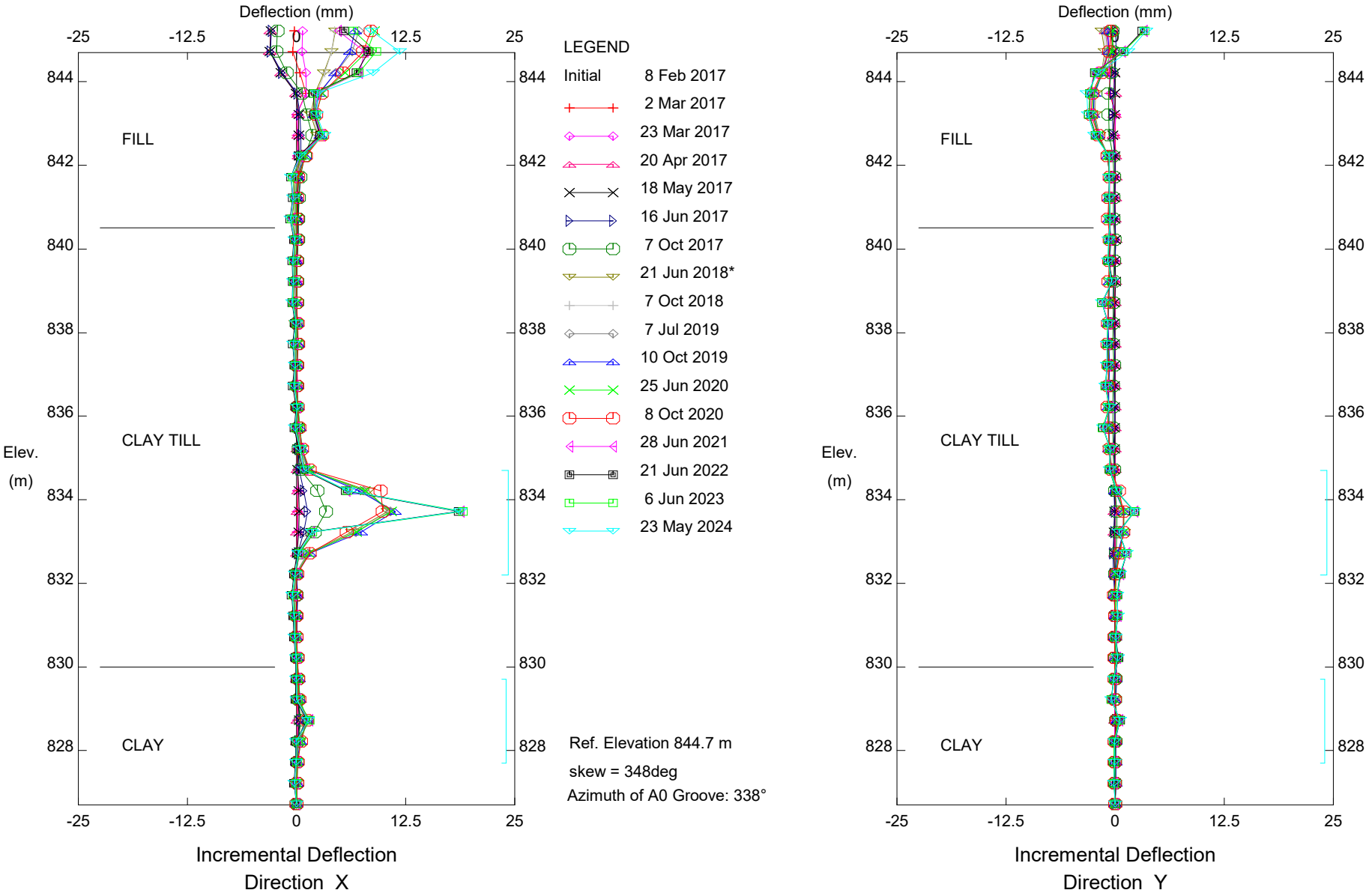
GP038-I; H40:38, Kakwa River Bridge, Inclinometer SI17-1

Alberta Transportation

GP038-I; H40:38, Kakwa River Bridge

Sets marked * include zero shift and/or rotation corrections.

Klohn Crippen Berger - Edmonton



GP038-I; H40:38, Kakwa River Bridge, Inclinometer SI17-1

Alberta Transportation

GP038-I; H40:38, Kakwa River Bridge

Sets marked * include zero shift and/or rotation corrections.

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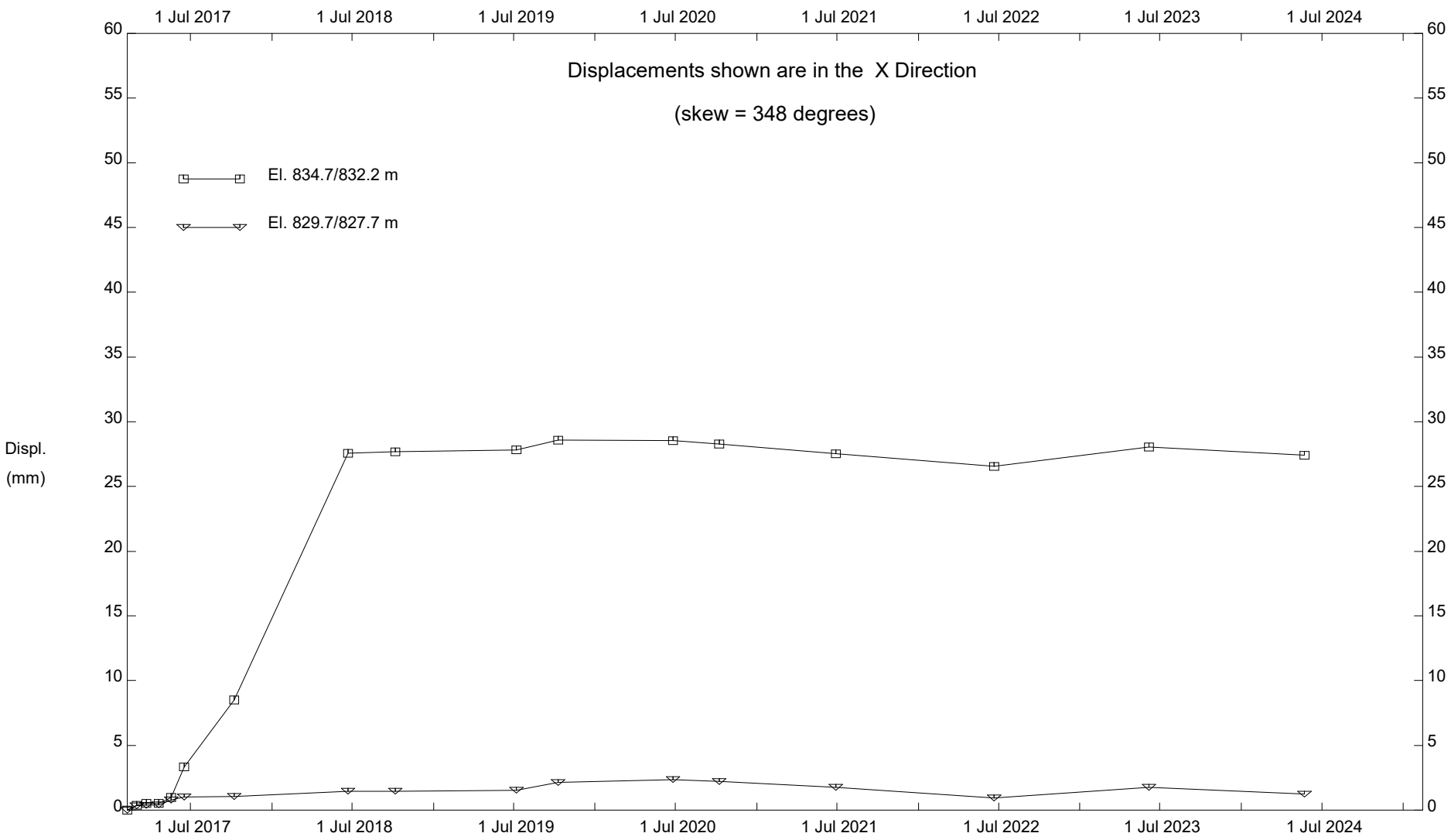
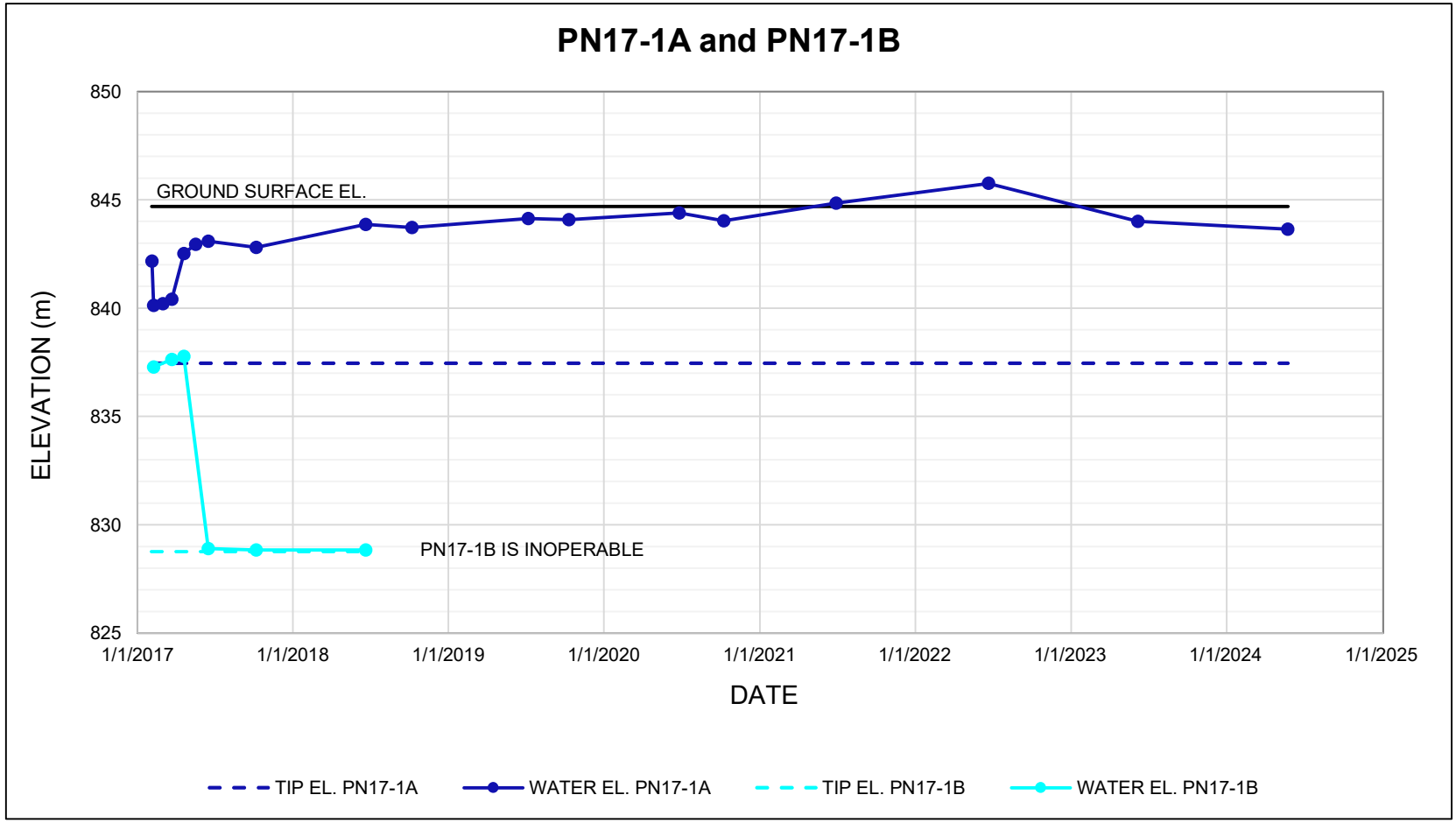


GP038-I; H40:38, Kakwa River Bridge, Inclinometer SI17-1

Alberta Transportation



NOTES:
1. PIEZOMETER DATA OBTAINED BEFORE JUNE 28, 2021, PROVIDED TO KLOHN CRIPPEN BERGER LTD. BY ALBERTA TRANSPORTATION AND ECONOMIC CORRIDORS ON JUNE 25, 2021.

CLIENT
Alberta
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PROJECT
PEACE REGION (GRANDE PRAIRIE DISTRICT - SOUTH)
GEOHAZARD RISK MANAGEMENT PROGRAM

TITLE
Piezometer Data
GP038-I - Slide 2.0 km N. of Kakwa River Bridge
Hwy 40:38, km 25.831

SCALE	PROJECT No.	FIG No.
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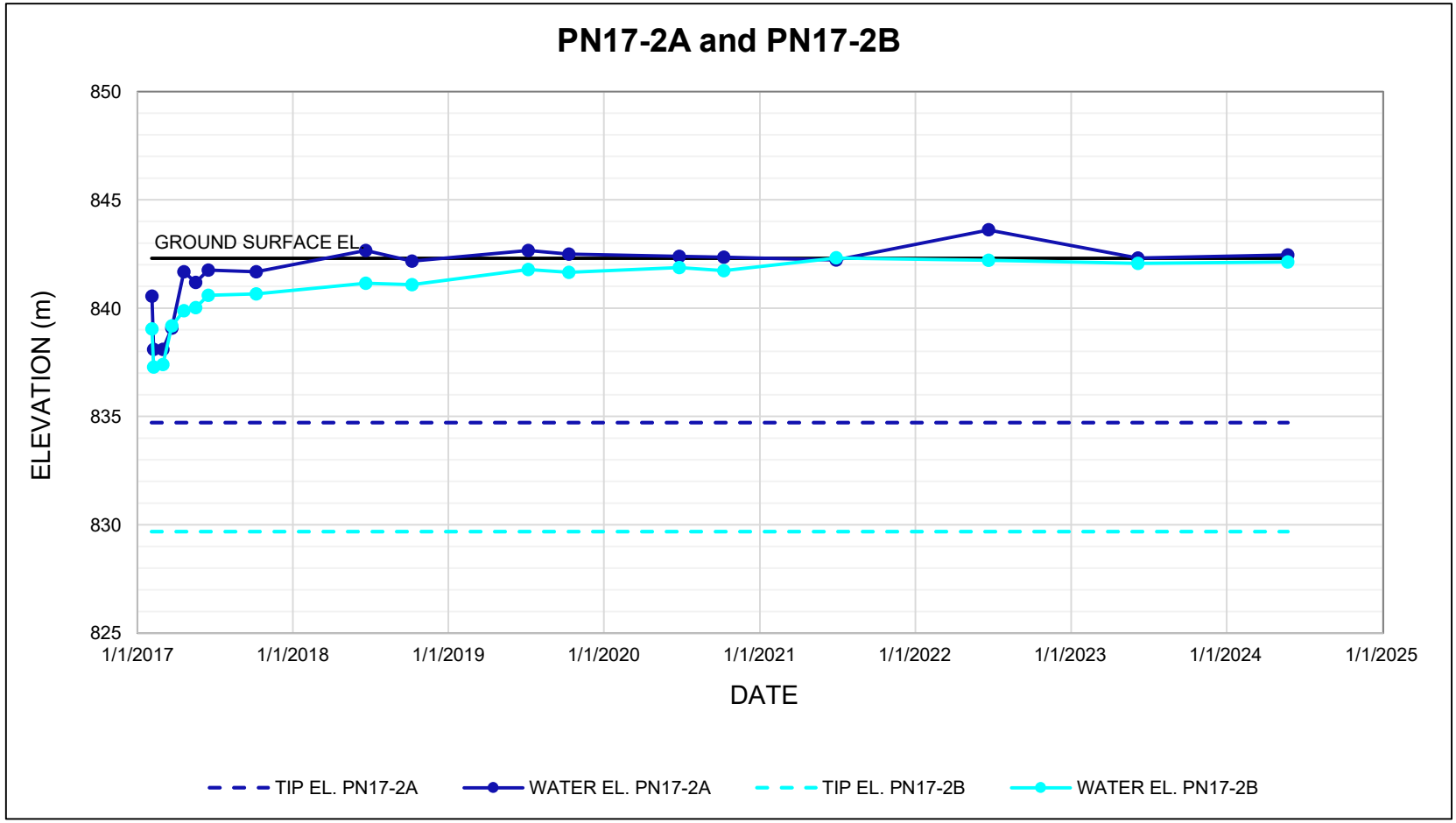

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PEACE REGION (GRANDE PRAIRIE DISTRICT - SOUTH)
GEOHAZARD RISK MANAGEMENT PROGRAM

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Piezometer Data
GP038-I - Slide 2.0 km N. of Kakwa River Bridge
Hwy 40:38, km 25.831

SCALE	PROJECT No.	FIG No.
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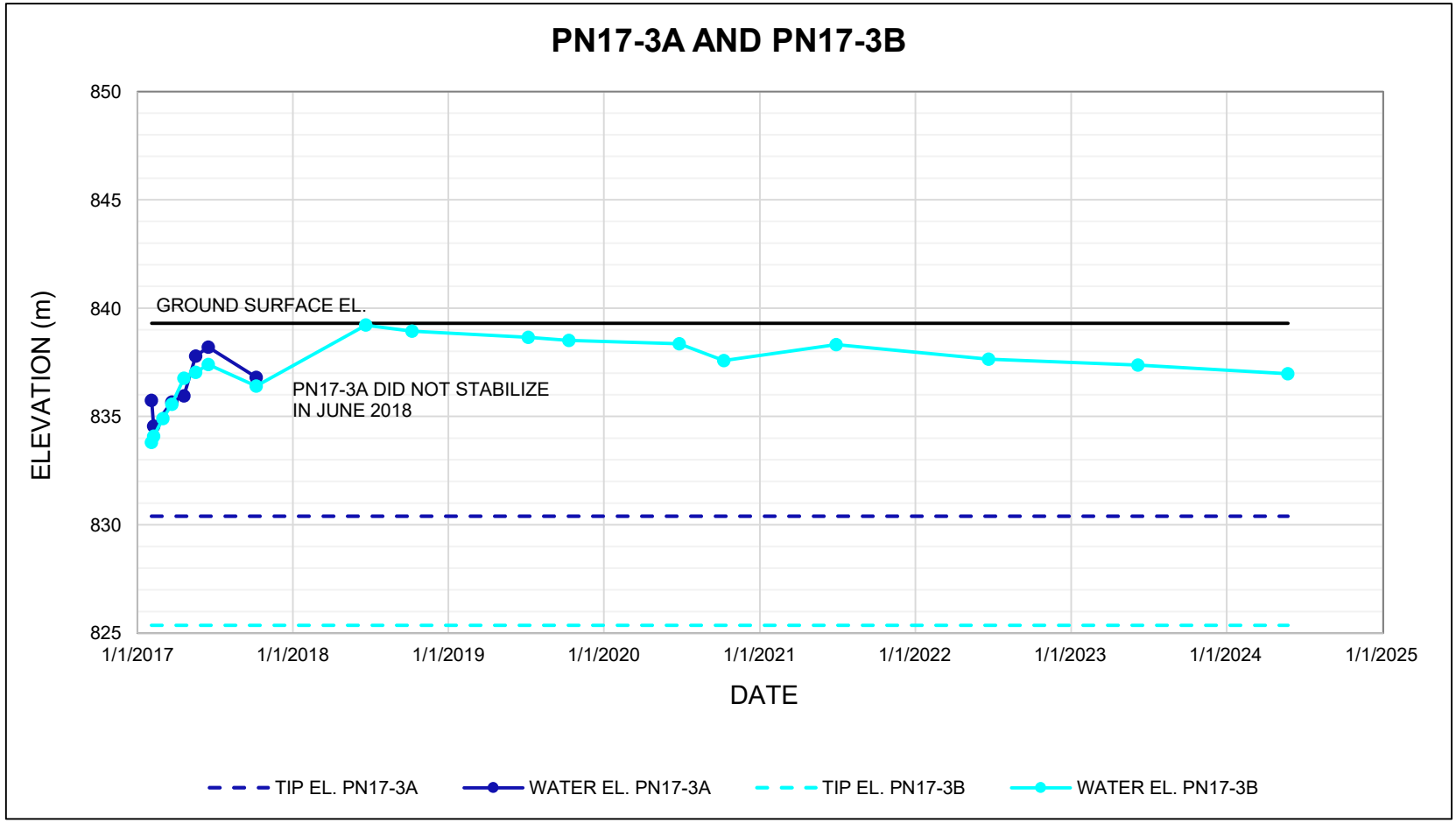

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SCALE	PROJECT No.	FIG No.
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