July 14, 2023

Alberta Transportation and Economic Corridors
2nd Floor, 803 Manning Road N.E.
Calgary, Alberta
T2E 7M8

Alex Frotten, P.Eng.
Construction Engineer – Delivery Services Division (Southern Region)

Dear Mr. Frotten:

CON0022161 Southern Region GRMP Instrumentation Monitoring
Site S075; H540:02, km 5.720 Pekisko Creek Slides
Section C – 2023 Spring Readings

1 GENERAL

Three slope inclinometers (SIs) (SI17-01 through SI17-03) and three vibrating wire piezometers (VWPs) (VW17-01, VW17-02, and VW17-04B) were read at the S075 site in Southern Region on June 13, 2023, by Mr. Bradley Lawson, E.I.T., of Klohn Crippen Berger Ltd. (KCB). These instruments were read as part of the Southern Region Geohazard Risk Management Program (GRMP). The site is located approximately 5.7 km east of the Hwy 22:10 intersection and approximately 26.8 km west of the intersection with Hwy 2:10. The approximate site coordinates are 5590915 N, 701866 E (UTM Zone 11, NAD 83), and the legal land description for the site is NW 12-17-02-W5. A site plan is presented in Figure 1.

The geohazard at the S075 site consists of two adjacent landslides located approximately 30 m apart, denoted as Site A and B, along the west (southbound) lane of Hwy 540:02. Previously, this site was included with a riverbank erosion site located approximately 1.1 km southwest along Hwy 520:02. In early-2022, KCB and AT separated the riverbank erosion and landslide sites, with the landslide site (Site A and B) becoming the S075 site and riverbank erosion site retaining the original S051 site number.

In July 2017, KCB conducted a geotechnical site investigation, which included installing instruments, at the S075 site to support design and construction work. Drilling was completed by Mayfield Drilling and Environmental Service Ltd. The encountered stratigraphy was as follows: silt, overlying clay till, and overlying bedrock (siltstone).

1.1 Instrumentation

Instrumentation installation details are tabulated in Table 1.1. Instrument locations are shown in Figure 1.

Klohn Crippen Berger Ltd.
500 - 2618 Hopewell Place NE ▪ Calgary AB T1Y 7J7 ▪ Canada
t 403.274.3424 ▪ f 403.274.5349 ▪ www.klohn.com

In July 2017, KCB installed three SIs (SI17-01 through -03) and four VWPs (VW17-01, VW17-02, and VW17-04A/B) to monitor the depth of movement and groundwater conditions, respectively. Instrumentation installed in BH17-01 (SI17-01 and VW17-01) and BH17-02 (SI17-02 and VW17-02) are located at the crest and toe of the slide at Site B, respectively. Instrumentation installed in BH17-03 (SI17-03) and BH17-04 (SI17-04 and VW17-04A/B) are installed at the crest and within the slide mass at Site A, respectively. SI17-04 and VW17-04A are not inoperable. The instruments are protected by above-ground casing protectors.

In the spring of 2019, KCB was unable to lower the SI probe past an approximate depth of 4 m below ground surface in SI17-04. In July 2019, KCB inspected the inside of the SI casing with a GeoVISION downhole camera. During the camera inspection, a portion of the SI casing near ground surface was observed to be loose and separated from the lower SI casing. The stick-up of the SI was also measured, and it had increased approximately 0.25 m since installation in July 2017, indicating the ground around the instrument may have heaved and then settled, separating the SI casing and rendering the instrument inoperable. There is also water inside the SI casing, approximately 0.5 m above ground surface. It is assumed that VW17-04A is inoperable due to the cable being impacted by the SI casing separation.

KCB changed the SI reading equipment in May 2022 after the previous equipment became inoperable. Currently, KCB is reading the SIs with a metric RST Digital MEMS Inclinometer System.

The VWPs were read using an RST VWP readout box.

Table 1.1 Instrumentation Installation Details

Instrument ID	Instrument Type	UTM Coordinates[1]		Date Installed	Ground Surface Elevation (m)	Stick Up (m)	Depth (mbgs[2])	Condition[3,4]
		Northing	Easting					
SI17-01	SI	5590967	701872	Jul. 13, 2017	1221.9	0.6	19.2	Operable
SI17-02	SI	5590934	701820	Jul. 17, 2017	1199.0	0.6	17.9	Operable
SI17-03	SI	5590801	701834	Jul. 24, 2017	1216.0	0.8	24.7	Operable
~~SI17-04~~	~~SI~~	~~5590861~~	~~701884~~	~~Jul. 24, 2017~~	1208.3	~~1.0~~	~~26.0~~	~~Inoperable~~
VW17-01	VWP	5590967	701872	Jul. 13, 2017	1221.9	N/A	14.4	Operable
VW17-02	VWP	5590934	701820	Jul. 17, 2017	1199.0	N/A	14.0	Operable
~~VW17-04A~~	~~VWP~~	~~5590861~~	~~701844~~	~~Jul. 19, 2017~~	~~1208.3~~	~~N/A~~	~~25.0~~	~~Inoperable~~
VW17-04B	VWP	5590861	701844	Jul. 19, 2017	1208.3	N/A	7.5	Operable

Notes:
[1] Instrument locations were taken with a handheld GPS during installation and have a horizontal accuracy of +/- 5 m.
[2] Meters below ground surface (mbgs). Bottom casing depth for SIs and tip depth for piezometers.
[3] VW17-02 cable leads were cut and re-stripped during the May 2022 readings and is now operable.
[4] VW17-04A is inoperable due to a joint becoming separated at approximately 4 m below ground surface.

2 INTERPRETATION

2.1 General

For the SIs, the cumulative displacement, incrementation displacement, and displacement-time data was plotted in the A-direction (i.e., in the direction of the A0-grooves) and, where applicable, the X-direction (i.e., the direction of maximum movement obtained at a skew angle from the A0-grooves). SI17-03 has a skew angle of 300°, measured clockwise from the A0-grooves.

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

Monthly precipitation data is also plotted with the piezometer data. The data was obtained from the Alberta Climate Information Service (ACIS) database, referencing legal subdivision TWP017-02-W5.

The SI and piezometer data 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.

2.2 Zones of Movement

2.2.1 Site A

Movement has been recorded in SI17-03 from an approximate depth of 15 m to 20 m below ground surface (approximately El. 1201 m to El. 1196 m). SI17-03 is located at the crest of the slope outside of the identified slide mass.

Before becoming inoperable in 2019, distributed movement had been recorded in SI17-04 from ground surface to an approximate depth of 8 m below ground surface (approximately El. 1200 m) and discrete movement at an approximate depth of 14 m to 22 m below ground surface. SI17-04 is located midslope within the slide mass.

Some of the movement recorded in SI17-03 and SI17-04 could be related to casing buckling or settlement due to poor grouting, as discussed below.

2.2.2 Site B

Movement has been recorded in SI17-01 from an approximate depth of 6 m to 12 m below ground surface (approximately El. 1211 m to El. 1216 m). SI17-01 is located near the crest of the slide.

Movement has been recorded in SI17-02 from an approximate depth of 4 m to 5 m and 8 m to 11 m below ground surface (approximately El. 1194 m to El. 1195 m and El. 1188 m to 1191 m). SI17-02 is located near the toe of the slide.

Table 2.1 Slope Inclinometer Reading Summary

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 (Re-initialized)[3]	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
								Before Re-Initialization	After Re-Initialization	Total				
SI17-01	Aug. 29, 2017 (Sep. 27, 2017)	Jun. 17, 2021	May 02, 2022	June 12, 2023	1221.9	6.0 – 13.0	A-Direction	1.0	4.7	5.7	0.9	9.7	0.8	-0.7
SI17-02	Aug. 29, 2017	Jun. 17, 2021	May 02, 2022	June 12, 2023	1199.0	4.0 – 5.0	A-Direction	NA	2.9	2.9	0	1.3	0.8	0.8
						8.0 – 11.0		N/A	2.5	2.5	0	3.4	0.1	0.2
SI17-03	Aug. 29, 2017 (Apr. 24, 2018)	Jun. 17, 2021	May 02, 2022	June 12, 2023	1216.0	14.0 – 22.0	X-Direction, 300°	49.7	2.7	52.4	-0.2	86.9	-0.2	-1.7

Notes:
[1] Meters below ground surface (mbgs).
[2] Skew angle of X-direction measured clockwise from the A-direction.
[3] SI17-01 was re-initialized on September 27, 2017, due to poor data quality during the first reading. SI17-03 was re-initialized on April 24, 2018, due to post-installation casing settlement/grouting issues.

Table 2.2 Vibrating Wire Piezometer Reading Summary

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)
VW17-01	Jul. 13, 2017	May 02, 2022	June 12, 2023	1221.9	14.4	13.3	12.8	0.5
VW17-02	Jul. 17, 2017	May 02, 2022	June 12, 2023	1199.0	14.0	3.6	3.3	0.3
VW17-04B	Jul. 19, 2017	May 02, 2022	June 12, 2023	1208.3	7.5	-1.4	-1.5	-0.1

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

2.3 Interpretation of Monitoring Results

2.3.1 Site A

Prior to SI17-03 being re-initialized in April 2018 and SI17-04 becoming inoperable in 2018, settlement or buckling was observed in both instruments, which could indicate the instruments were poorly grouted with possible grout voids. The interpretation of the SI data is complicated by the potential for settlement or buckling of the SI casing in the poorly grouted casing segment. The instrument was re-initialized to remove possible noise associated with this zone. Overall data quality has improved since the instrument was re-initialized, but settlement or buckling of the casing may still be occurring at this depth. The rate of settlement or buckling has slowed since the first few months following installation and has been generally negligible since the instrument was re-initialized. If the settlement or buckling begins to impact the interpretation of the SI data again, the instrument may need to be re-initialized.

Since the SI17-03 was re-initialized to April 2018 reading, an overall slow rate of movement (less than 2 mm/year) has been recorded in SI17-03. The negative rate of movement recorded in this instrument during some readings indicates the rate of movement is within the accuracy of the reading equipment.

VW17-04B was installed 7.5 m below ground surface (approximately El. 1201 m) in the clay till. Relatively small and steady water level increases were recorded in VW17-04B since installation to September 23, 2020 (total increase of 2.5 m). The water level has since steadily decreased by 0.9 m between September 2020 and June 2023. The water level recorded in VW17-04B is above-ground, indicating artesian groundwater conditions at this instrument.

2.3.2 Site B

Since installation in 2017, a slow rate of movement (less than 2 mm/year) has been recorded in SI17-01 in the clay till (an approximate depth of 6 m to 12 m below ground surface). Between the fall 2021 and spring 2022 readings, some movement was recorded between 6 m and 16 m below ground surface. This movement could be due to a small data shift caused by KCB changing the SI reading equipment when the old equipment became inoperable. The small rate of movement being recorded in the SIs makes the data sensitive to changes in equipment. More data is needed to assess.

Slow, steady movement (less than 1 mm/year) has been recorded in SI17-02 since it was installed in 2017. The movement is occurring from an approximate depth of 4 m to 5 m and 8 m to 11 m below ground surface in the clay till. The instrument is located at the toe of the slide at Site B, and the depth of movement is consistent with site observations.

Since installation, water levels recorded in VW17-01 (installed in the clay till) have fluctuated between 10.0 m and 13.3 m below ground surface. Before the reading frequency of the instrument was decreased from twice to once per year in 2020, water levels recorded in this instrument appeared to fluctuate seasonally, with the spring readings being lower than fall readings.

Water levels recorded in VW17-02 (installed in the bedrock) have been relatively steady since installation between an approximate depth of 2.2 m and 3.6 m below ground surface.

Overall, the June 2023 reading of VW17-01 and VW17-02 were consistent with rainfall and historical trends observed in these instruments.

3 RECOMMENDATIONS

3.1 Future Work

All instruments should continue to be read twice per year (spring and fall).

Preliminary engineering, final design, and tendering should be carried out before the slides retrogress further towards the highway and begin impacting the highway surface.

The site should continue to be inspected by the Maintenance Contract Inspector (MCI) and as part of the Southern Region GRMP Section B inspections.

3.2 Instrument Repairs and Maintenance

No instrument repairs or maintenance is required.

4 CLOSURE

This report is an instrument of service of Klohn Crippen Berger (KCB). The report has been prepared for the exclusive use of Alberta Transportation (Client) for the specific application to the Southern Region Geohazard Risk Management Program (Contract No. CON0022161), 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

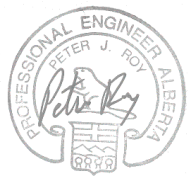
shall not be responsible to the Client for the consequences of any error or omission contained in Client-supplied information.

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.

Please contact the undersigned if you have any questions or comments regarding this report.

Yours truly,

KLOHN CRIPPEN BERGER LTD.



14 Jul. 2023
ID 141695

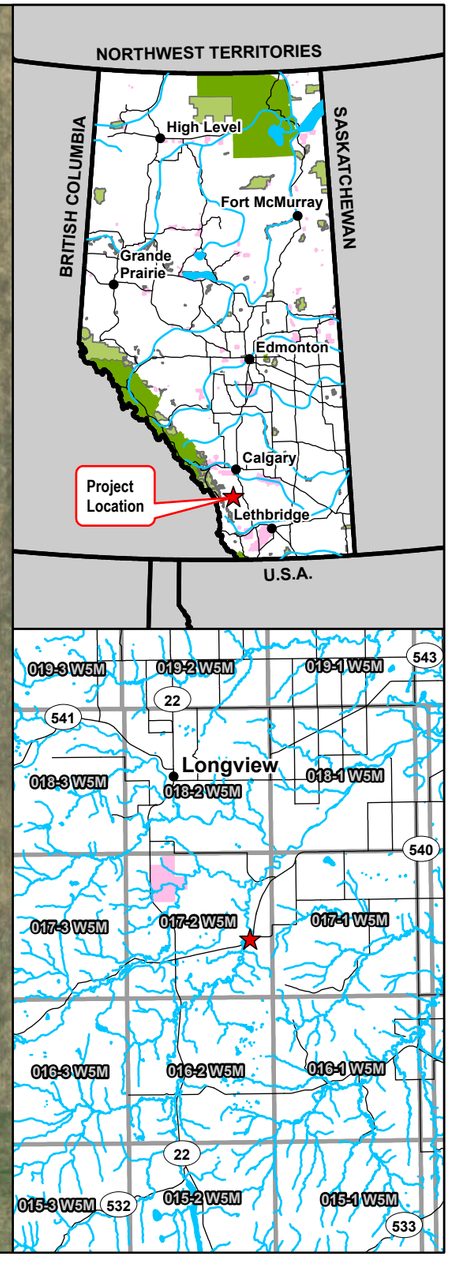
PERMIT TO PRACTICE
KLOHN CRIPPEN BERGER LTD.
RM SIGNATURE: _____
RM APEGA ID #: 187607
DATE: 14 Jul. 2023
PERMIT NUMBER: P009196
The Association of Professional Engineers and Geoscientists of Alberta (APEGA)

Peter Roy, P.Eng.
Civil Engineer

PR:kb

ATTACHMENTS
Figure
Appendix I Instrumentation Plots

FIGURE



Legend

- Slope Inclinometer (SI)
- Vibrating Wire Piezometer (VW)
- Powerpole
- Flow Direction
- Scarp
- Fence

0 50 Meters

NOTES:
1. HORIZONTAL DATUM: NAD83
2. GRID ZONE: UTM ZONE 11N
3. IMAGE SOURCE: CHALLENGER GEOMATICS LTD.
4. STRIKETHROUGH INDICATES INSTRUMENT IS INACTIVE

CLIENT: Alberta

Klohn Crippen Berger

PROJECT: SOUTHERN REGION GEOHAZARD RISK MANAGEMENT PROGRAM

TITLE: Site Plan
S075 - Pekisko Creek Slides
Hwy 540:02, km 5.72

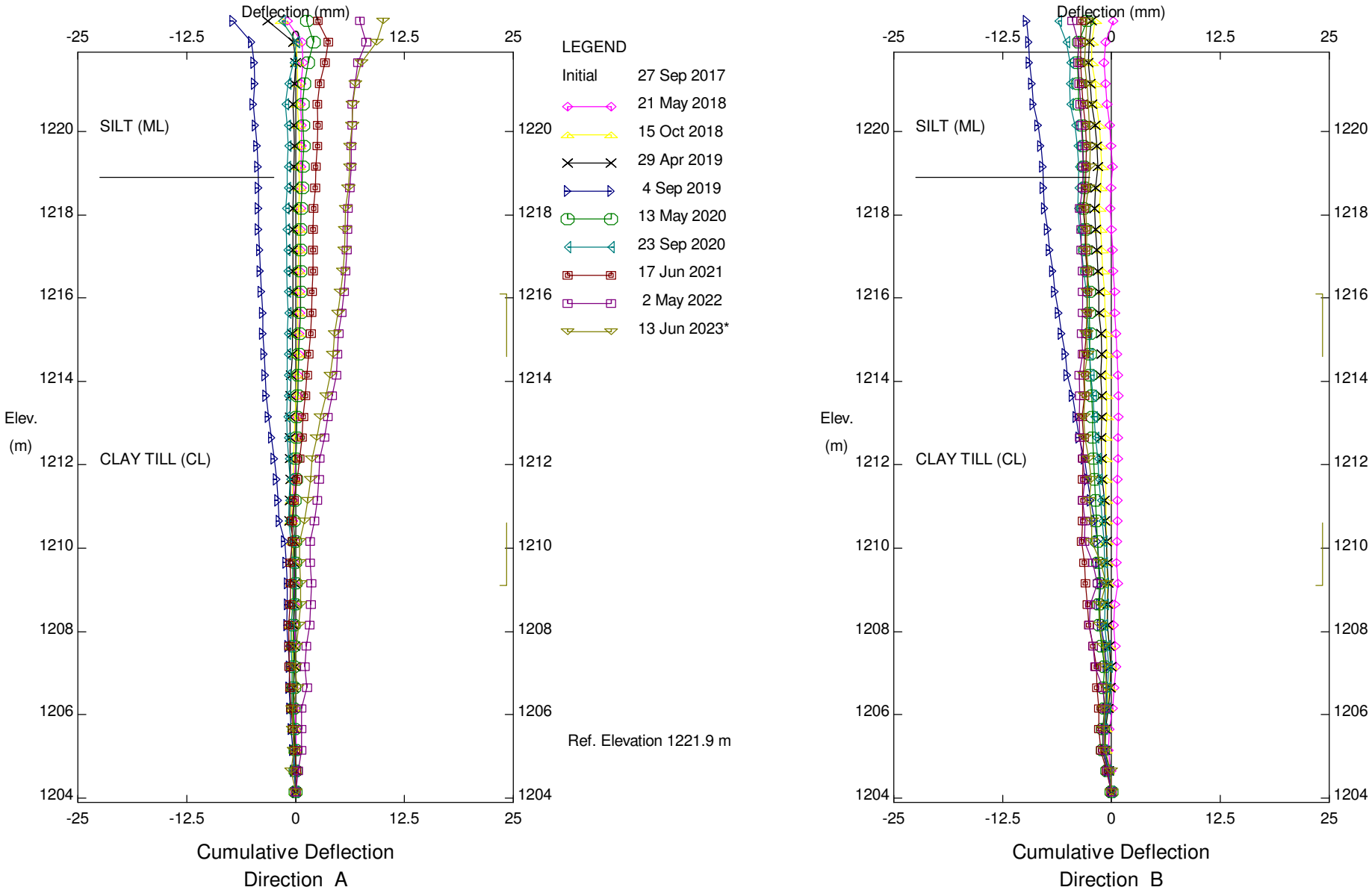
SCALE	PROJECT No.	FIG No.
1:1,500	A05116A03	1

File: Z:\AC\GY\Alberta\A05116A03 ABT Southern Region GRMP\400 Drawings\2022\Section C\Section C - Spring 2022\Section C - Spring 2022.aprx Date: Time: Creator: aharrison

APPENDIX I

Instrumentation Plots

Klohn Crippen Berger Ltd. - Calgary, AB



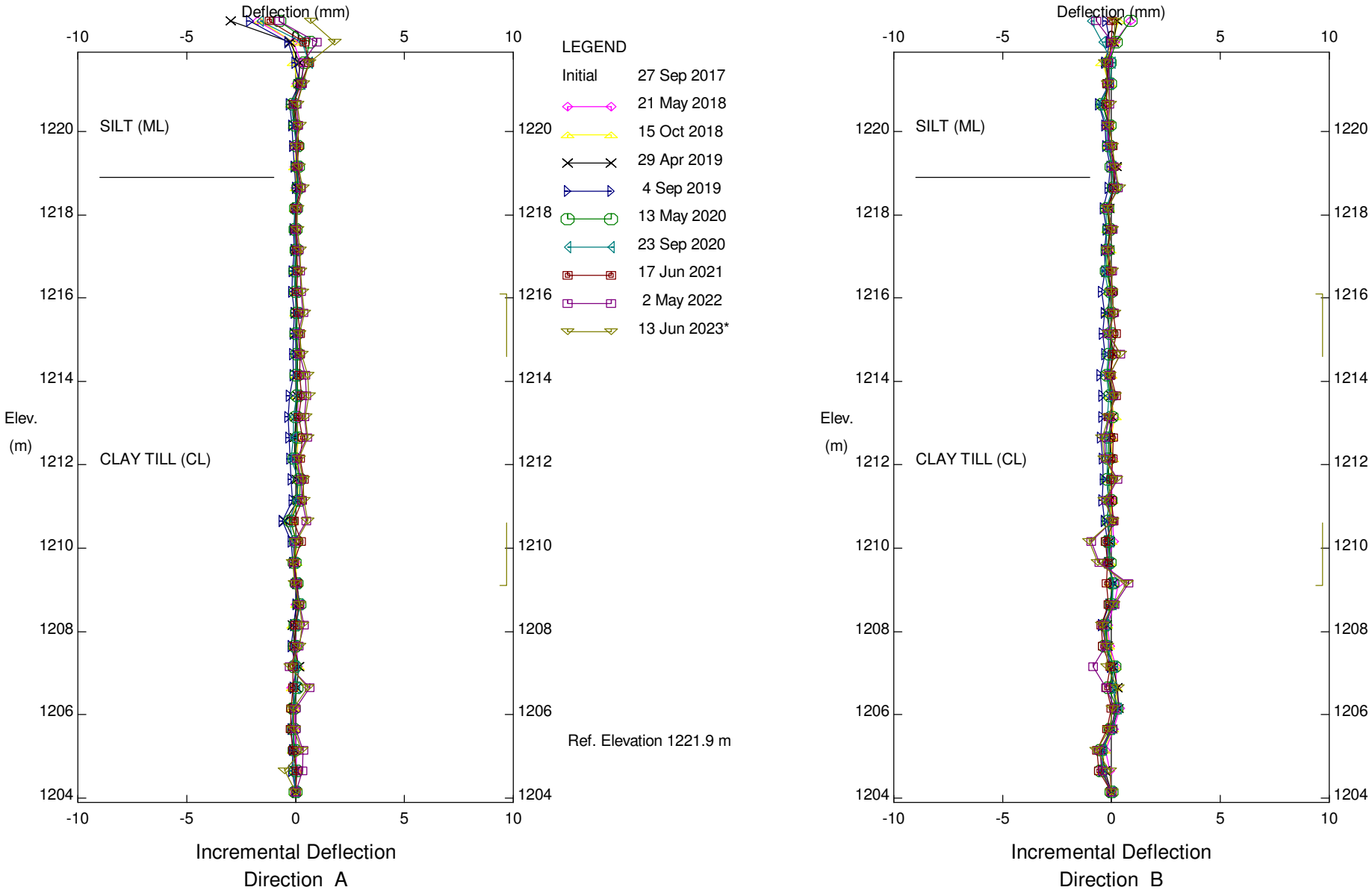
S075; H540:02 - Pekisko Creek, Inclinometer SI17-01

Alberta Transportation

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

Z:\A\CGY\ALBERTA\A05116A03 ABT SOUTHERN REGION GRMP\300 DESIGN\2023\SECTION C\04 INSTRUMENTATION\S075 - PEKISKO\SIS\ABT S075 SI17-01.GTL

Klohn Crippen Berger Ltd. - Calgary, AB



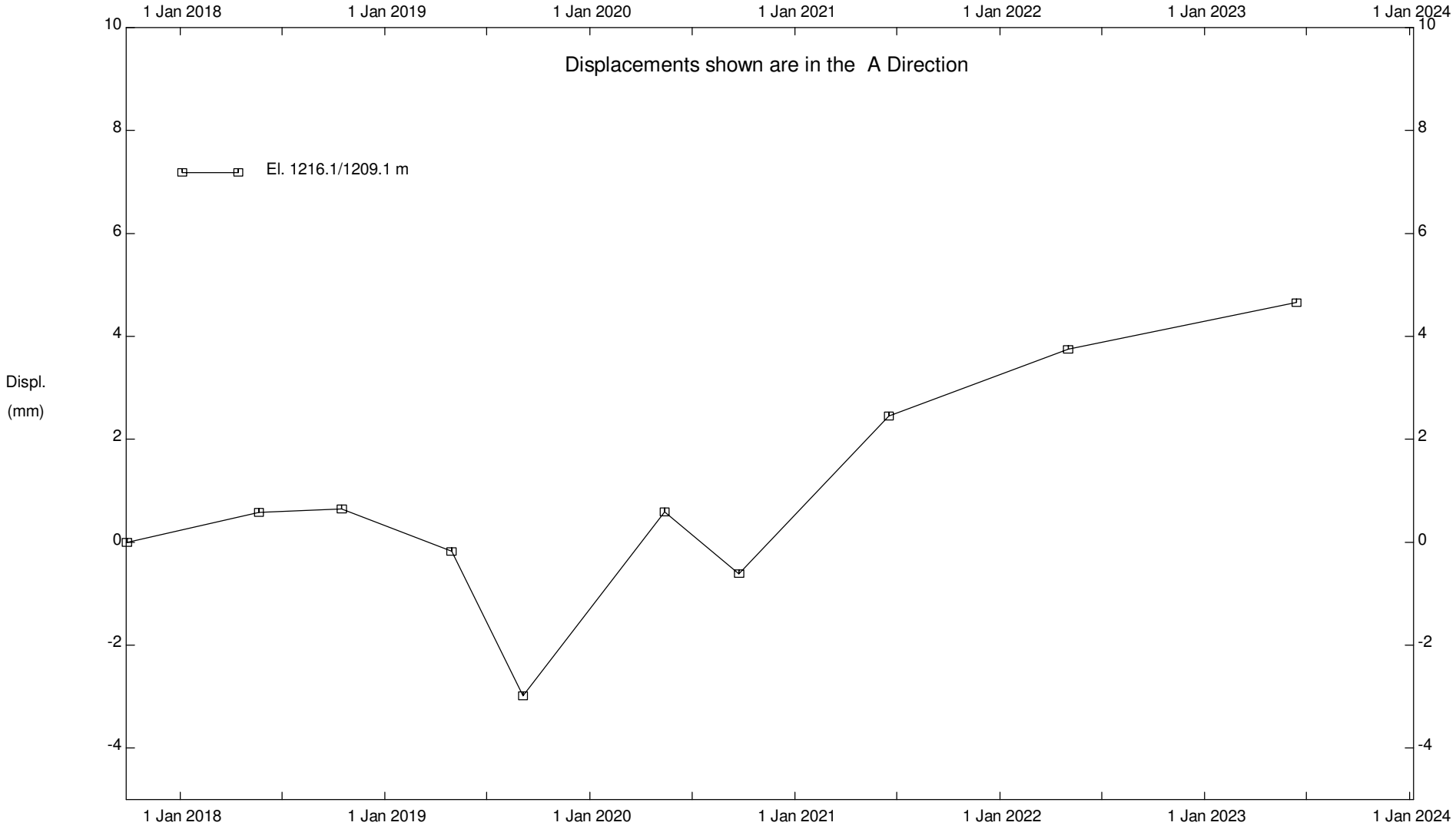
S075; H540:02 - Pekisko Creek, Inclinometer SI17-01

Alberta Transportation

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

Z:\A\CGY\ALBERTA\A05116A03 ABT SOUTHERN REGION GRMP\300 DESIGN\2023\SECTION C\04 INSTRUMENTATION\S075 - PEKISKO\SIS\ABT S075 SI17-01.GTL

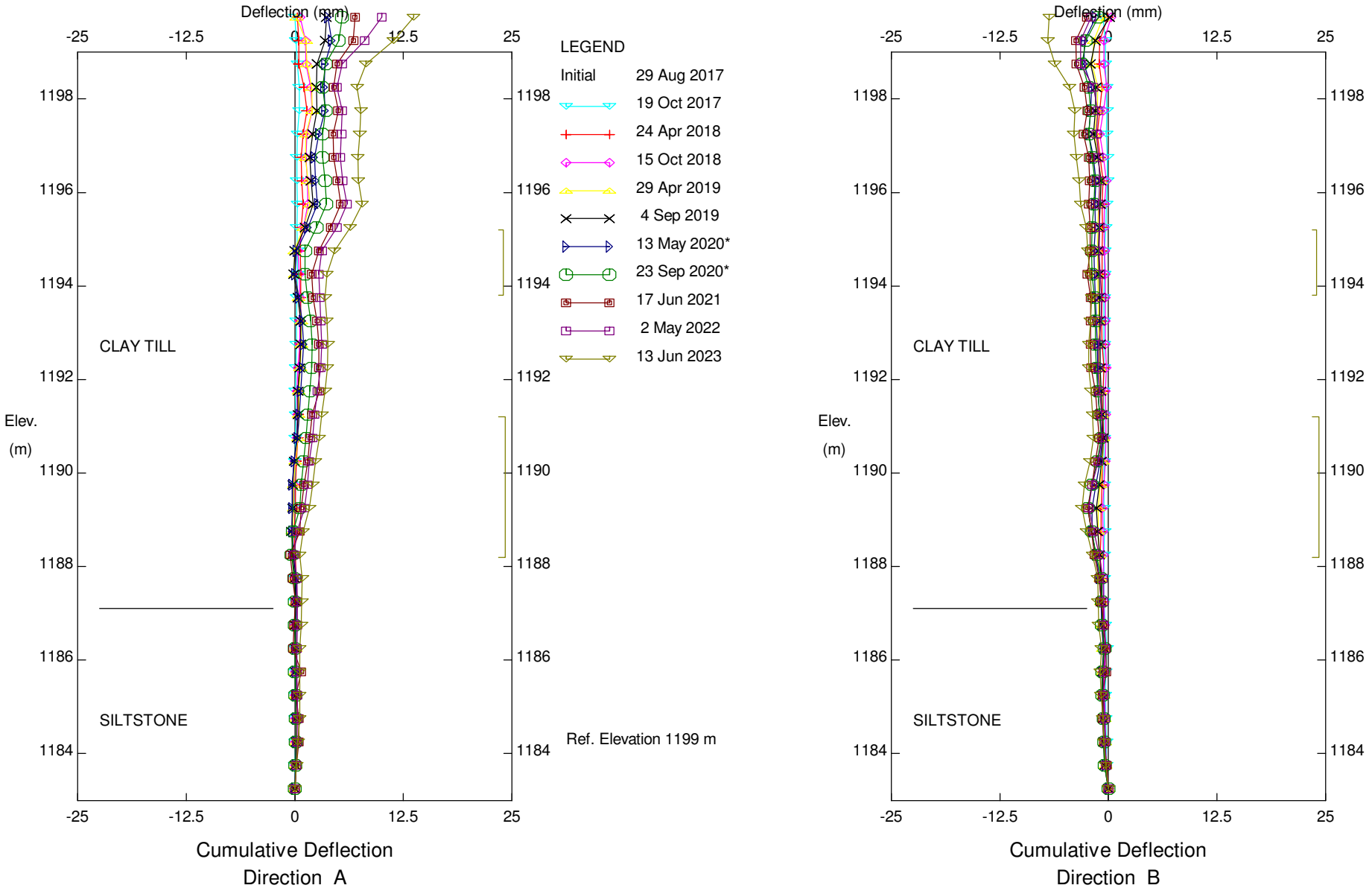
Klohn Crippen Berger Ltd. - Calgary, AB



S075; H540:02 - Pekisko Creek, Inclinometer SI17-01

Alberta Transportation

Klohn Crippen Berger Ltd. - Calgary, AB



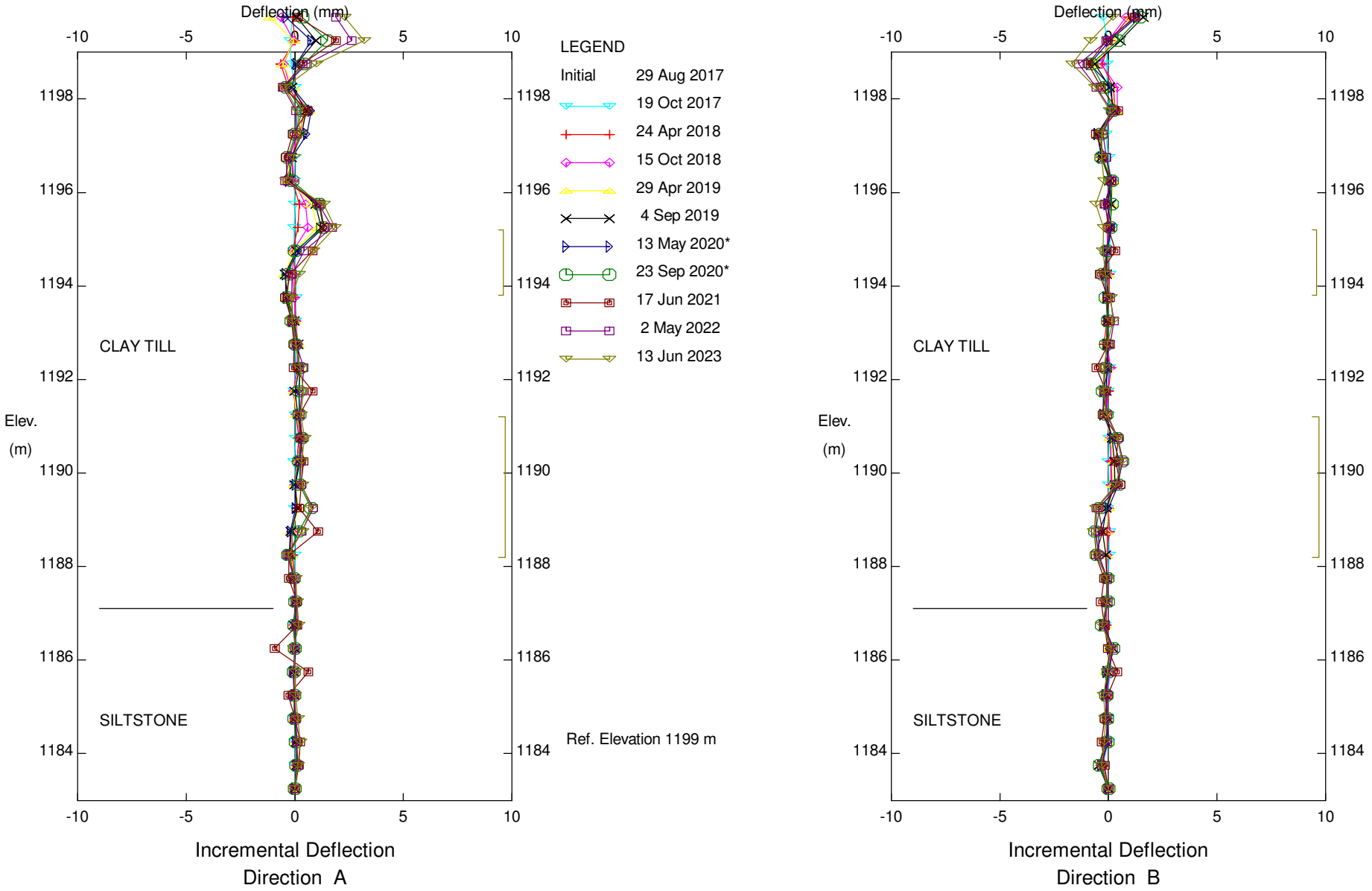
S075; H540:02 - Pekisko Creek, Inclinometer SI17-02

Alberta Transporation

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

Z:\A\CGY\ALBERTA\A05116A03 ABT SOUTHERN REGION GRMP\300 DESIGN\2023\SECTION C\04 INSTRUMENTATION\S075 - PEKISKO\SIS\ABT S075 SI17-02.GTL

Klohn Crippen Berger Ltd. - Calgary, AB



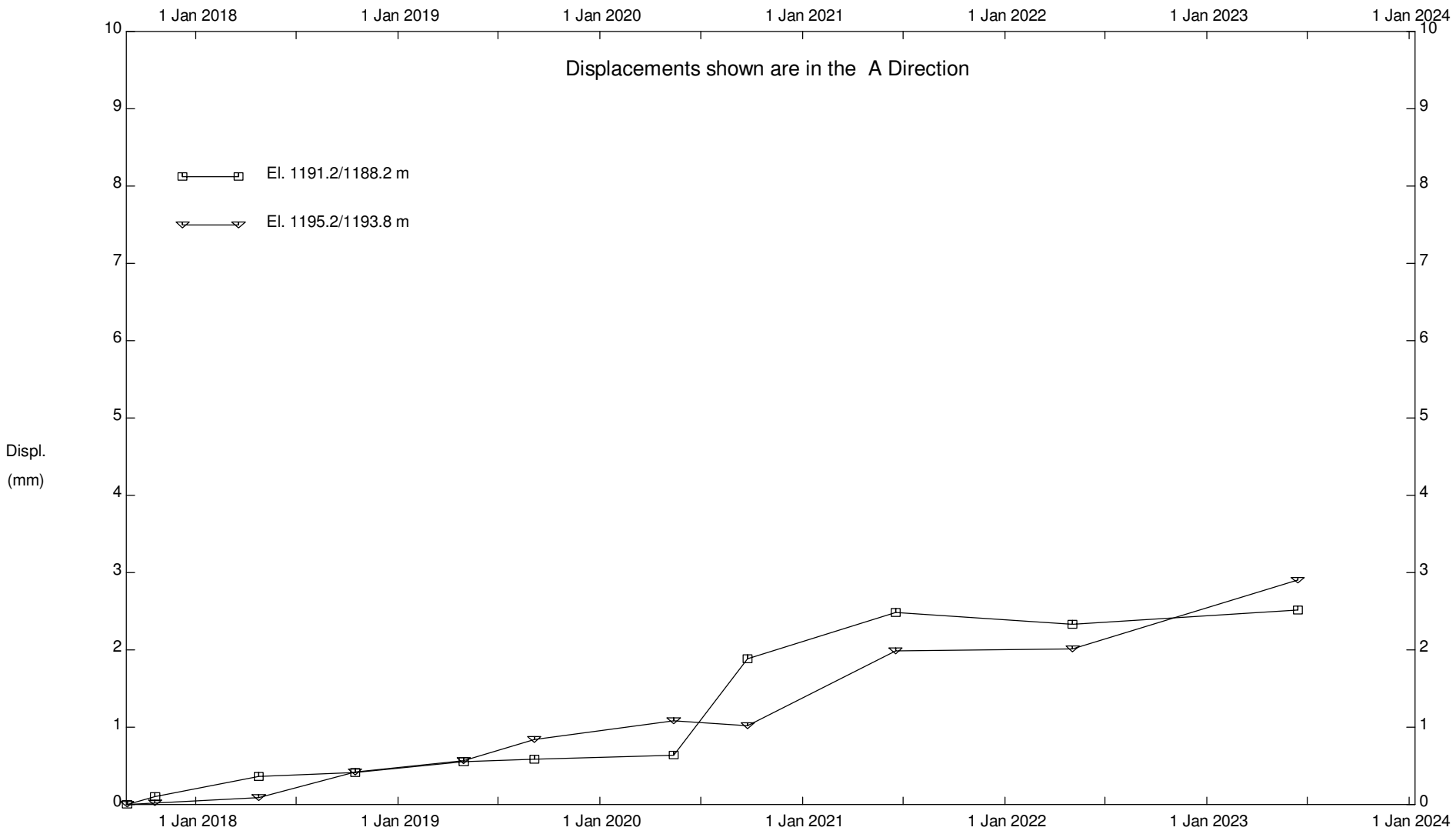
S075; H540:02 - Pekisko Creek, Inclinometer SI17-02

Alberta Transporation

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

Z:\A\CGY\ALBERTA\A05116A03 ABT SOUTHERN REGION GRMP\300 DESIGN\2023\SECTION C\04 INSTRUMENTATION\S075 - PEKISKO\SIS\ABT S075 SI17-02.GTL

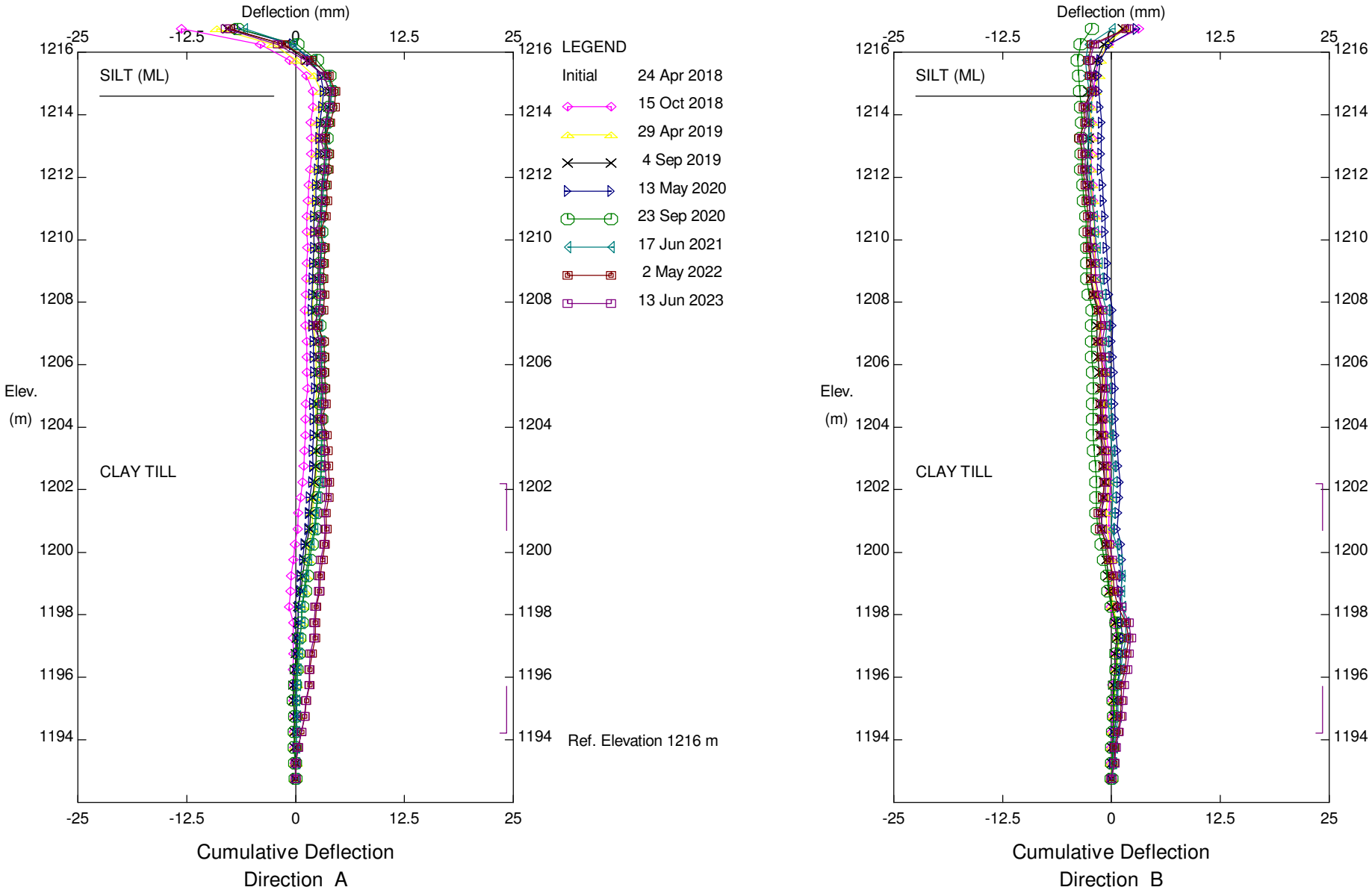
Klohn Crippen Berger Ltd. - Calgary, AB



S075; H540:02 - Pekisko Creek, Inclinometer SI17-02

Alberta Transporation

Klohn Crippen Berger Ltd. - Calgary, AB

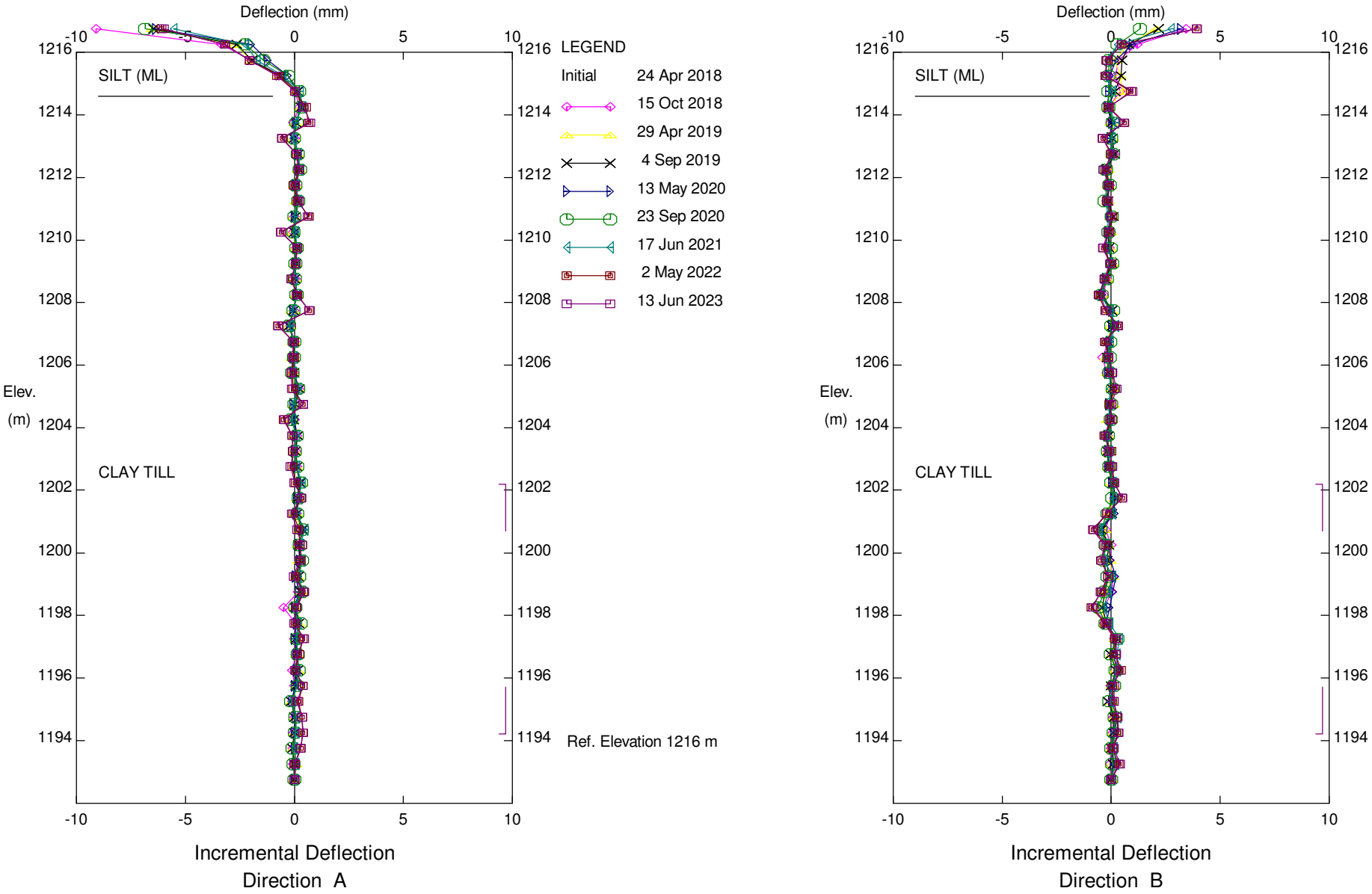


S075; H540:02 - Pekisko Creek, Inclinometer SI17-03

Alberta Transportation

Z:\A\CGY\ALBERTA\A05116A03 ABT SOUTHERN REGION GRMP\300 DESIGN\2023\SECTION C\04 INSTRUMENTATION\S075 - PEKISKO\SIS\ABT S075 SI17-03.GTL

Klohn Crippen Berger Ltd. - Calgary, AB

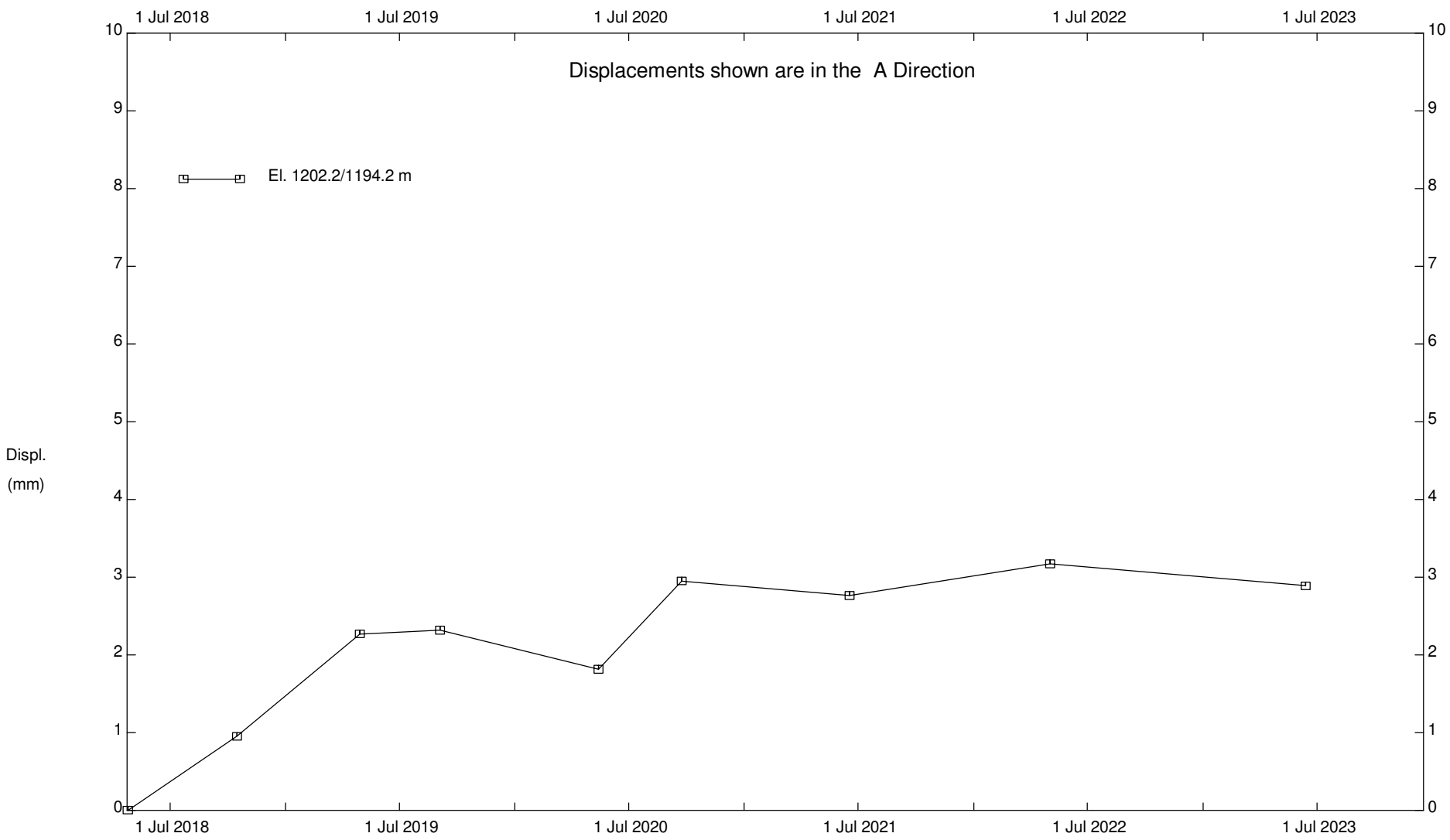


S075; H540:02 - Pekisko Creek, Inclinometer SI17-03

Alberta Transportation

Z:\A\CGY\ALBERTA\A05116A03 ABT SOUTHERN REGION GRMP\300 DESIGN\2023\SECTION C\04 INSTRUMENTATION\S075 - PEKISKO\SIS\ABT S075 SI17-03.GTL

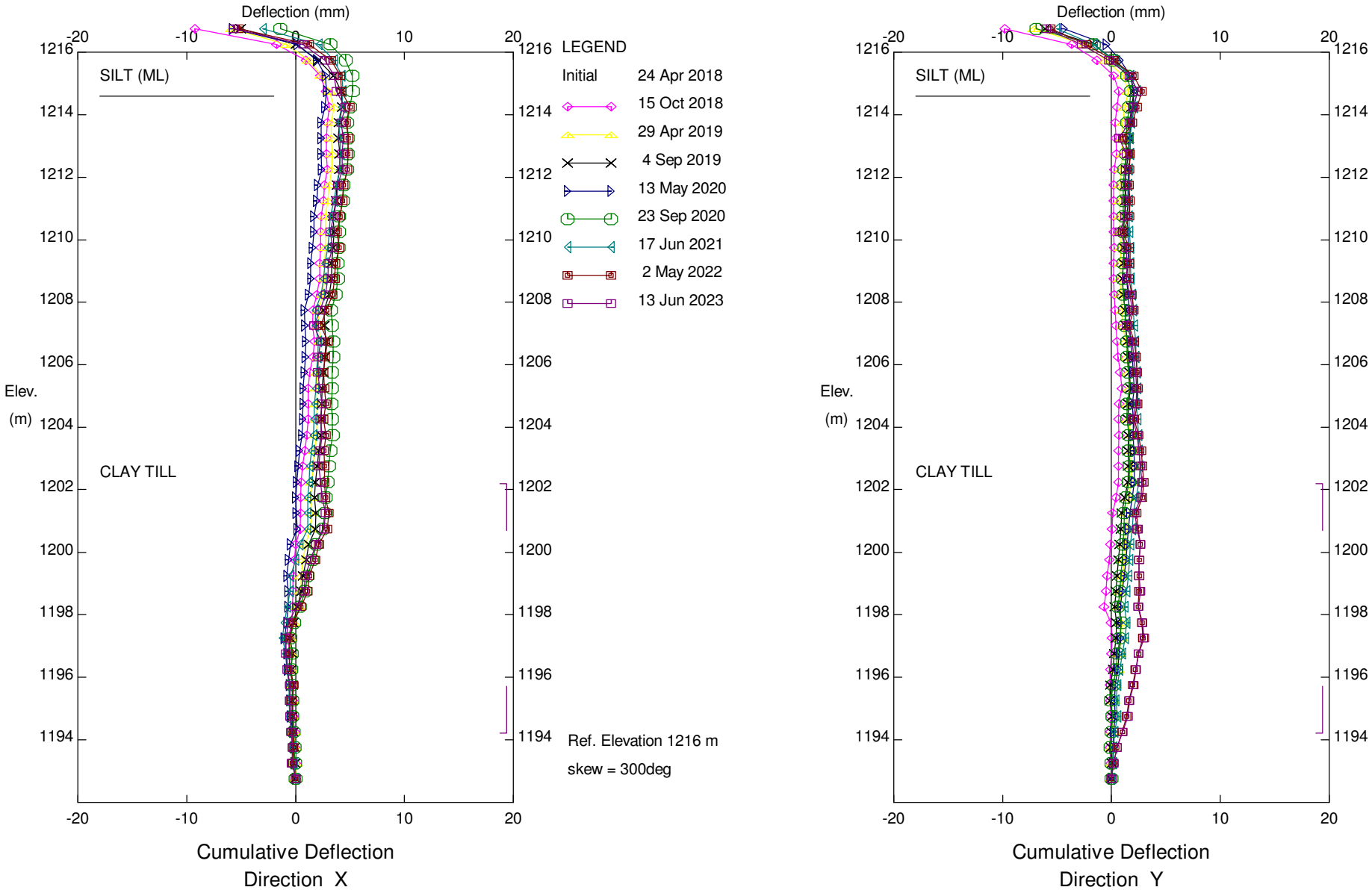
Klohn Crippen Berger Ltd. - Calgary, AB



S075; H540:02 - Pekisko Creek, Inclinometer SI17-03

Alberta Transportation

Klohn Crippen Berger Ltd. - Calgary, AB

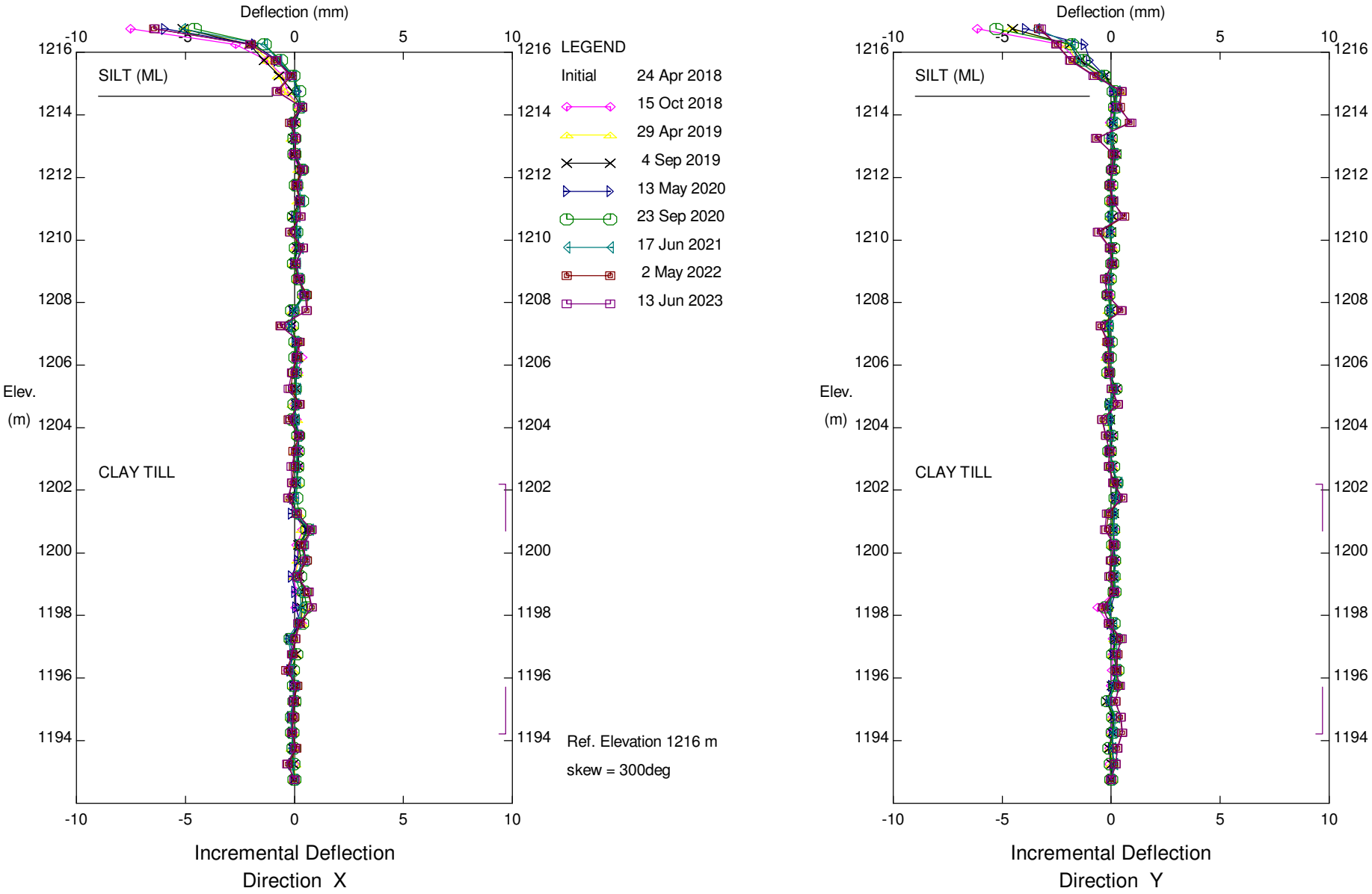


S075; H540:02 - Pekisko Creek, Inclinometer SI17-03

Alberta Transportation

Z:\A\CGY\ALBERTA\A05116A03 ABT SOUTHERN REGION GRMP\300 DESIGN\2023\SECTION C\04 INSTRUMENTATION\S075 - PEKISKO\SIS\ABT S075 SI17-03.GTL

Klohn Crippen Berger Ltd. - Calgary, AB

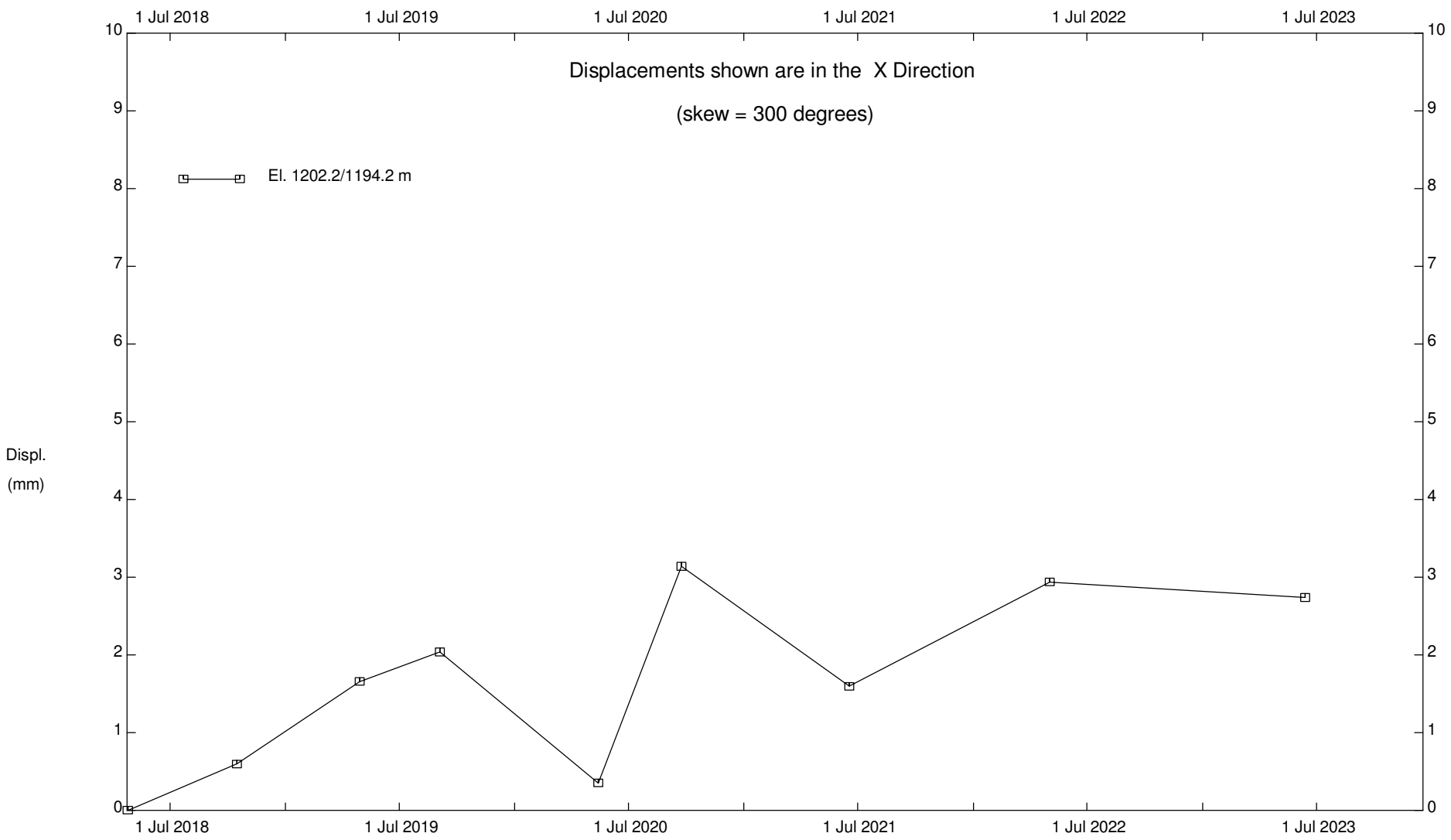


S075; H540:02 - Pekisko Creek, Inclinometer SI17-03

Alberta Transportation

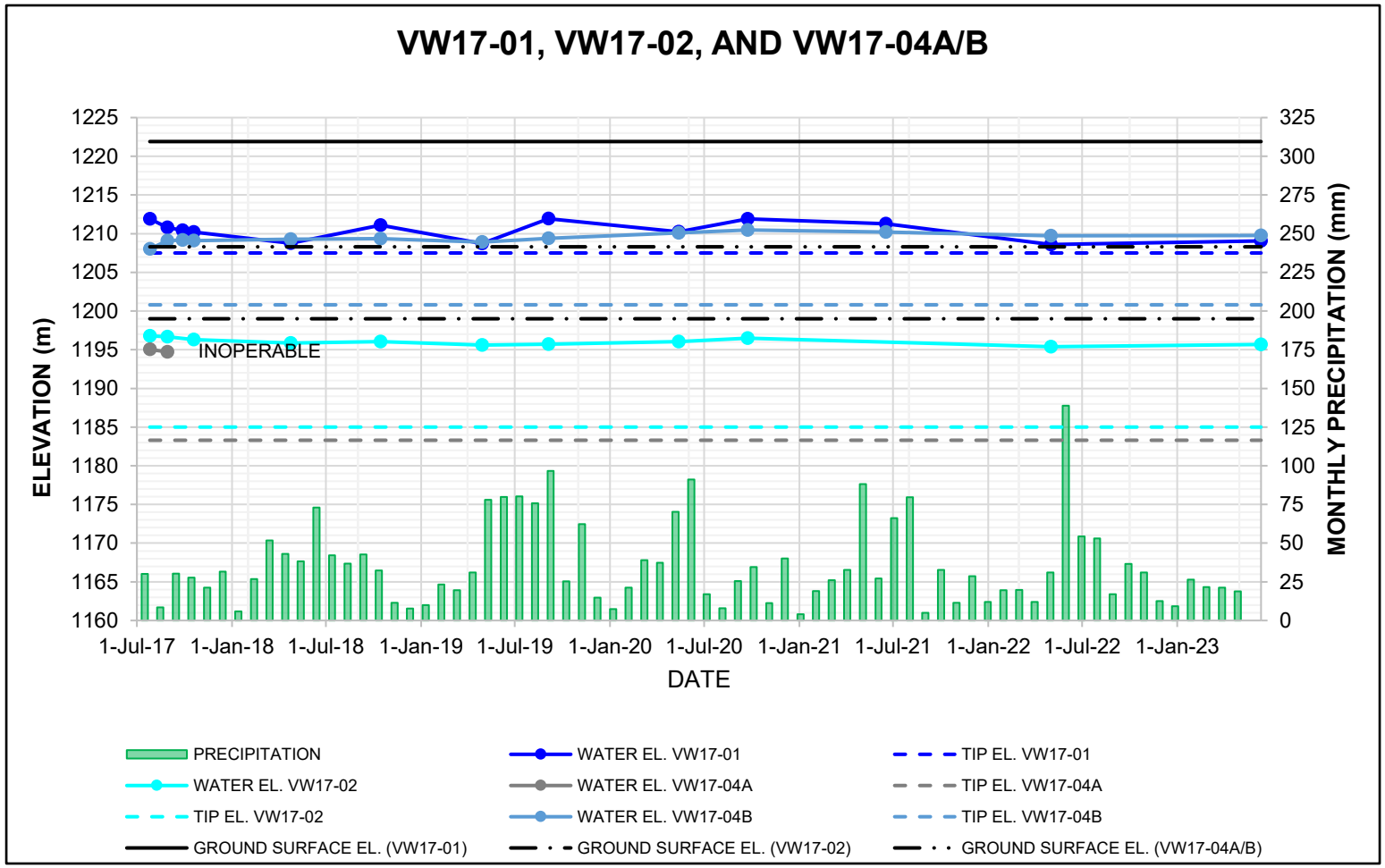
Z:\A\CGY\ALBERTA\A05116A03 ABT SOUTHERN REGION GRMP\300 DESIGN\2023\SECTION C\04 INSTRUMENTATION\S075 - PEKISKO\SIS\ABT S075 SI17-03.GTL

Klohn Crippen Berger Ltd. - Calgary, AB



S075; H540:02 - Pekisko Creek, Inclinometer SI17-03

Alberta Transportation



NOTES:
1. MONTHLY PRECIPITATION DATA OBTAINED FROM THE ALBERTA CLIMATE INFORMATION SERVICE (ACIS) DATABASE, REFERENCING LEGAL SUBDIVISION T017R02W5.

CLIENT
Alberta
Klohn Crippen Berger

PROJECT
SOUTHERN REGION GEOHAZARD RISK MANAGEMENT PROGRAM

TITLE
Piezometer Data
S075 - Pekisko Creek Slides
Hwy 540:02, km 5.72

SCALE	PROJECT No.	FIG No.
	A05116A03	