

September 21, 2022

Alberta Transportation
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 S026; H41:03, km 35.169 Elkwater Slides
Section C – 2022 Spring Readings**

1 GENERAL

Three slope inclinometers (SIs) (SI08-1, SI08-3, and SI12-1) and two standpipe piezometers (SPs) (SP08-01A and SP08-01B) were read at the S026 site in the Southern Region on July 7, 2022 by Mr. Guerin White, E.I.T. of Klohn Crippen Berger Ltd. (KCB). These instruments were read as part of the Southern Region Geohazard Risk Management Plan (GRMP). The site is located at Hwy 41:03 km 35.2, approximately 4 km south of the turnoff from Hwy 41:03 to the Town of Elkwater, Alberta. The approximate site coordinates are 5499046 N, 553536 E (UTM Zone 12, NAD 83). A site plan is presented in Figure 1.

The highway is constructed across the lower portion of the east valley slope of a north-draining, unnamed creek valley that is incised into the north slope bordering the Cypress Hills Plateau to the south.

There are two segments of the highway that are being impacted by landslide movement at this site:

- Area A – located at the north extent of the site where there is a failure in a cut and fill section of the highway embankment. Previous remedial actions in Area A include shallow drainage installed near the south end in the 1970s or 1980s (records unavailable). In the fall of 2016, both lanes of the highway in Area A were resurfaced and the east slope was regraded. A new overlay was placed in the fall of 2017.
- Area B – located at the south extent of the site near the crest of a hill, where a landslide was repaired with a driven-steel H-pile wall in 2012. The H-pile wall was installed after an earlier temporary repair (date unknown) using air-launched soil nails was unsuccessful and deformations of the highway surface continued. Design and construction details for the soil nail and H-pile wall repairs have not been provided to KCB for review.

1.1 Instrumentation

KCB has been reading the instruments at this site since 2016. Instrumentation installation details are tabulated in Table 1.1. Instrument locations are shown in Figure 1. Any instruments not included in Table 1.1 or shown in Figure 1 are assumed to be inoperable and are not presented or discussed herein.

Several instruments have been installed at the site by previous consultants during various geotechnical site investigations. Some of these instruments are now inoperable, including:

- Numerous slope inclinometers and piezometers which have either been destroyed, sheared, or lost (e.g., buried due to ongoing roadway maintenance and construction activities);
- A rainfall gauge with remote access installed in 2008, which became inoperable and was removed in 2019 and relocated to the Central Region C018 site; and
- A SAA readout and remote connectivity system, which was removed from the casing before June 2016. At the request of AT, KCB dismantled and removed the SAA datalogger box, battery pack, and solar panel in May 2019. The equipment is in temporary storage at KCB's Calgary Office.

The operable instruments in Area A (SI08-1, SI08-3, SP08-01A, and SP08-01B) are located on or beyond the shoulder of the east (northbound) lane of Hwy 41:03 and are protected by either a flush-mounted or above-ground casing protector. The operable instrument in Area B (SI12-01) is located along the west (southbound) lane of Hwy 41:03 between the highway and the pile wall and does not have a casing protector.

KCB changed the SI reading equipment in 2016 when KCB took over the readings from the previous consultant, and again in October 2021 after the previous equipment became inoperable. Currently, KCB is reading the SIs with a metric RST Digital MEMS Inclinometer System.

The operable standpipe was read using an RST Water Level Meter.

Table 1.1 Instrument Installation Details

Instrument ID	Instrument Type	UTM Coordinates ^{1,2} (m)		Date Installed ¹	Ground Surface Elevation ¹ (m)	Stick Up (m)	Depth ¹ (mbgs ³)	Condition
		Northing	Easting					
SAA	SI	Unknown	Unknown	2008	Unknown	Unknown	Unknown	Inoperable
SI08-1	SI	5498854	553697	Jun. 2008	466.4	0.0	25.0	Operable
SI08-2	SI	Unknown	Unknown	Jun. 2008	464.3	Unknown	Unknown	Inoperable ⁴
SI08-3	SI	5498915	553651	Jun. 2008	462.1	-0.1	26.0	Operable
SP08-2	SP	Unknown	Unknown	2008	464.3	Unknown	Unknown	Inoperable
SP08-3	SP	Unknown	Unknown	2008	461.9	Unknown	Unknown	Inoperable
SP08-4	SP	Unknown	Unknown	2008	463.3	Unknown	Unknown	Inoperable
SP08-4A	SP	5498962	553624	Jun. 2008	463.3	0.0	18.3	Inoperable ⁵
SP08-5	SP	Unknown	Unknown	2008	465.6	Unknown	Unknown	Inoperable
SP08-1A	SP	5498854	553697	Jun. 2008	466.3	0.0	24.7	Operable
SP08-1B	SP	5498854	553697	Jun. 2008	466.3	0.0	9.1	Operable
SI08-4	SI	Unknown	Unknown	2008	463.3	Unknown	Unknown	Inoperable
SI08-5	SI	Unknown	Unknown	2008	465.6	Unknown	Unknown	Inoperable
SI08-6	SI	Unknown	Unknown	2008	Unknown	Unknown	Unknown	Inoperable
SI12-01	SI	5499335	553370	2012	Unknown	1.0	21.0	Operable

Notes:

- ¹ Instrument installation details taken from reports and data files prepared or provided by the previous consultant(s) or Alberta Transportation.
- ² Coordinates reported by the previous consultants were confirmed by KCB with a handheld GPS. The handheld GPS had an accuracy of ±5 m.
- ³ Meters below ground surface (mbgs).
- ⁴ SI08-2 has sheared at an approximate depth of 2.0 m below ground surface.
- ⁵ SP08-04A is blocked at an approximate depth of 4.6 m below ground surface.

2 INTERPRETATION

2.1 General

For the operable SIs, the cumulative displacement, incremental displacement, displacement-time data was plotted in the A-direction (i.e., 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). SI12-01 has a skew angle of 15° measured clockwise from the direction of the A0-grooves.

For the operable SPs, the recorded water levels were converted to an equivalent water/piezometric elevation and plotted relative to ground surface 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 TWP008-03-W4.

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. The SI data plots only includes data obtained by KCB.

Table 2.1 Slope Inclinometer Reading Summary

Instrument ID	Area	Date				Ground Surface Elevation ² (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	Current	Change from Previous Reading
									Before Re-Initialization ³	After Re-Initialization	Total				
SI08-1	A	Jun. 2008 (May 28, 2016) ³	N/A – no discernible movement recorded since re-initialized	Oct. 6, 2021	Jul. 7, 2022	466.4	N/A – no discernible movement recorded since re-initialized ³			2.0	N/A – no discernible movement recorded since re-initialized ³	2.0	N/A – no discernible movement recorded since re-initialized		
SI08-3	A	Jun. 2008 (May 28, 2016) ³		Oct. 6, 2021	Jul. 7, 2022	462.1				2.0			2.0	N/A – no discernible movement recorded since re-initialized	
SI12-01	B	2012 (May 28, 2016) ³	Oct. 6, 2021	Oct. 6, 2021	Jul. 7, 2022	Unknown	4.8 – 6.3	X-Direction, 15°	12.0	35.6	47.6	4.9	16.1	5.4	-10.7

Notes:

¹ Meters below ground surface (mbgs).

² Skew angle of X-direction measured clockwise from the A-direction.

³ All SIs were re-initialized in May 2016 when KCB took over the readings from the previous consultant and changed the SI reading equipment. Movement recorded before 2016 was taken from reports prepared by the previous consultant.

Table 2.2 Standpipe Piezometer Reading Summary

Instrument ID	Area	Date			Ground Surface Elevation (m)	Screen 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)
SP08-1A	A	Jun. 2008	Oct. 6, 2021	Jul. 7, 2022	Unknown	21.3 – 24.7	17.1	15.4	1.7
SP08-1B	A	Jun. 2008	Oct. 6, 2021	Jul. 7, 2022	Unknown	6.0 – 9.1	6.1	4.8	1.2

Notes:

¹ Meters below ground surface (mbgs).

2.2 Zones of Movement

2.2.1 Area A

No discernible movement has been recorded in SI08-01 or SI08-03.

2.2.2 Area B

Discrete movement has been recorded in SI12-01 between an approximate depth of 4.5 m and 6.5 m below ground surface.

2.3 Interpretation of Monitoring Results

2.3.1 Area A

Water levels recorded in SP08-01A and SP08-01B appear to fluctuate seasonally (with the spring readings being higher than fall readings) from an approximate depth of 14.4 m to 17.5 m below ground surface and 4.5 m to 6.1 m below ground surface, respectively. The July 2022 readings were consistent with historical trends observed in these instruments, with increases of 1.7 m and 1.2 m recorded in SP08-01A and SP-01B, respectively.

2.3.2 Area B

The zone of movement recorded in SI12-01 is occurring at a similar depth to the original slide plane reported by the previous consultant prior to construction of the H-pile wall.

Since KCB took over the instrument readings in 2016, the rate of movement recorded in SI12-01 has been relatively steady (approximately 5 mm/year), except for an increased rate of movement recorded in the fall of 2017 and fall of 2021 (approximately 13.7 mm/year and 16.1 mm/year, respectively). The increased rate of movement recorded in the fall of 2021 could be due to a small data shift caused by KCB changing the SI reading equipment when the old equipment became inoperable. However, the increased rate of movement recorded in 2017 was reflective of site observations made by KCB and Alberta Transportation (AT) during the 2017 Section B inspection.

Soil sliding observed downslope of the H-pile wall, has exposed the H-piles and reduced the passive support of the H-pile wall on the downslope side. The movement recorded in SI12-01 reflects the movement of the H-pile occurring as this passive support is reduced.

In May 2020, KCB began measuring the exposed lengths (i.e., steel above ground surface) of the H-piles as a baseline for subsequent measurements. As of June 2021, the exposed height of the H-pile (Piles 1 through 23) varied from approximately 0.42 m to 2.07 m. The height of the exposed H-pile wall was not measured during the spring 2022 readings and will be measured again during the fall 2022 readings.

3 RECOMMENDATIONS

3.1 Future Work

All operable instruments should continue to be read twice per year (spring and fall). 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) and as part of the Southern Region GRMP Section B inspections.

Instrument readings should include measurements and photographs of the length of H-pile exposed on the downslope side of the H-pile wall to monitor ongoing slope movements and erosion downslope of the H-pile wall.

Recommendations for additional future work include:

- A data logger could be installed in one or more of the SPs to assess for short-term fluctuations (e.g., increases and decreases) in groundwater level that could be occurring in response to periods of heavy or prolonged rainfall or freshet infiltration between readings.
- A geotechnical site investigation (drilling and instrument installations) to assess depth of movement in recently active slides areas to support repair design. Two additional SIs should be installed in Area B, one upslope of the H-pile wall near its south end and one adjacent to the highway north of the H-pile wall, to monitor for movement.

3.2 Instrument Repairs and Maintenance

No instrument repairs are required. However, an above-ground casing protector should be installed to protect SI12-01.

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.

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

Yours truly,

KLOHN CRIPPEN BERGER LTD.



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

James Lyons, P.Eng.
Civil Engineer

JL:bb

ATTACHMENTS

Figure
Appendix I Instrumentation Plots

FIGURE



Legend

- Slope Inclinator (SI)
- ⊕ Standpipe Piezometer (SP)
- Flow Direction
- Watercourse
- - - Slope Failure



NOTES:
 1. HORIZONTAL DATUM: NAD83
 2. GRID ZONE: UTM ZONE 12N
 3. IMAGE SOURCE: CYPRESS COUNTY, MAXAR
 4. STRIKETHROUGH INDICATES INSTRUMENT IS INACTIVE

CLIENT

Alberta

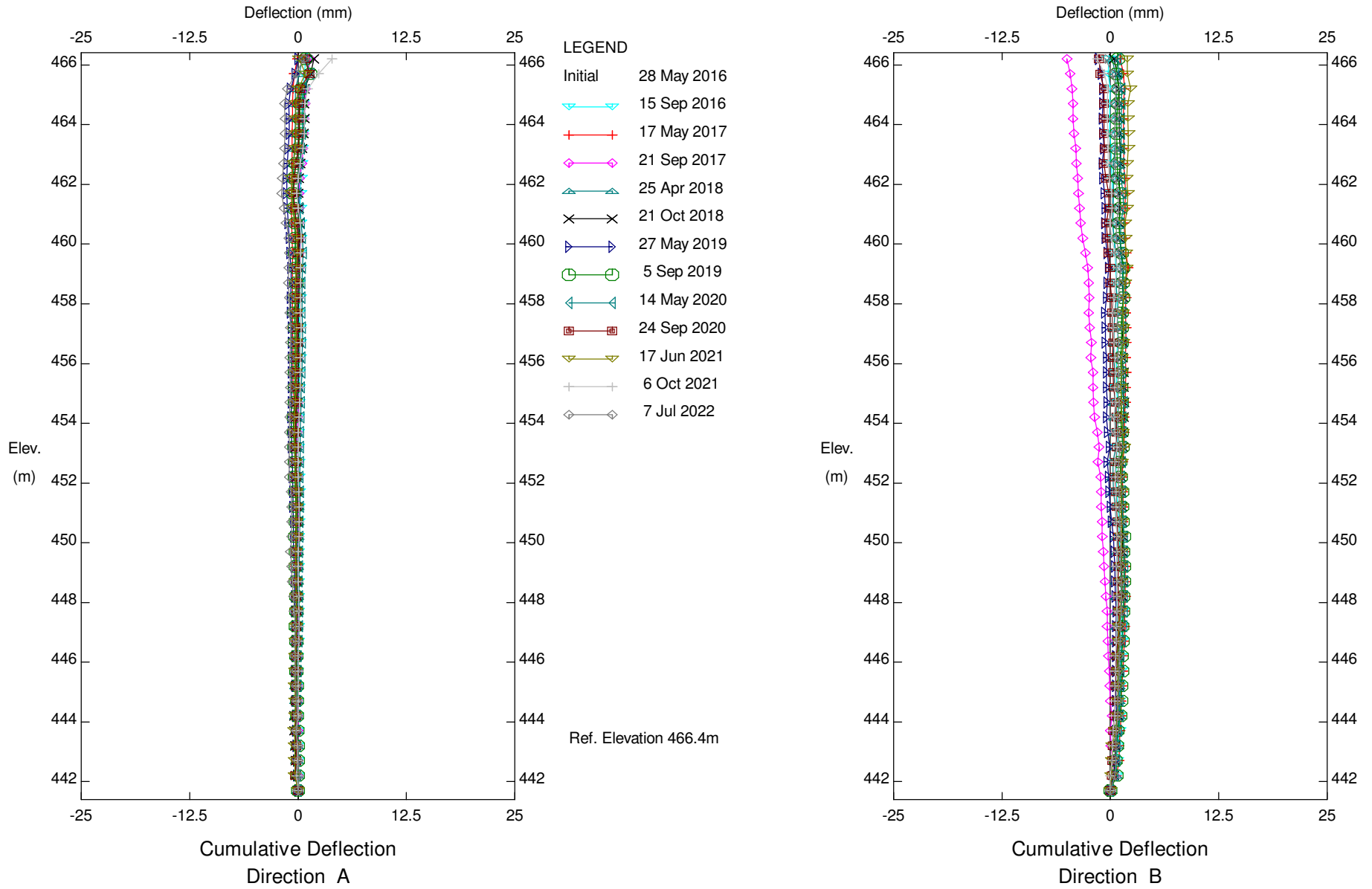
Klohn Crippen Berger

PROJECT SOUTHERN REGION GEOHAZARD RISK MANAGEMENT PROGRAM		
TITLE Site Plan S026 - Elkwater Slides Hwy 41:03, km 35.169		
SCALE 1:4,000	PROJECT No. A05116A03	FIG No. 1

APPENDIX I

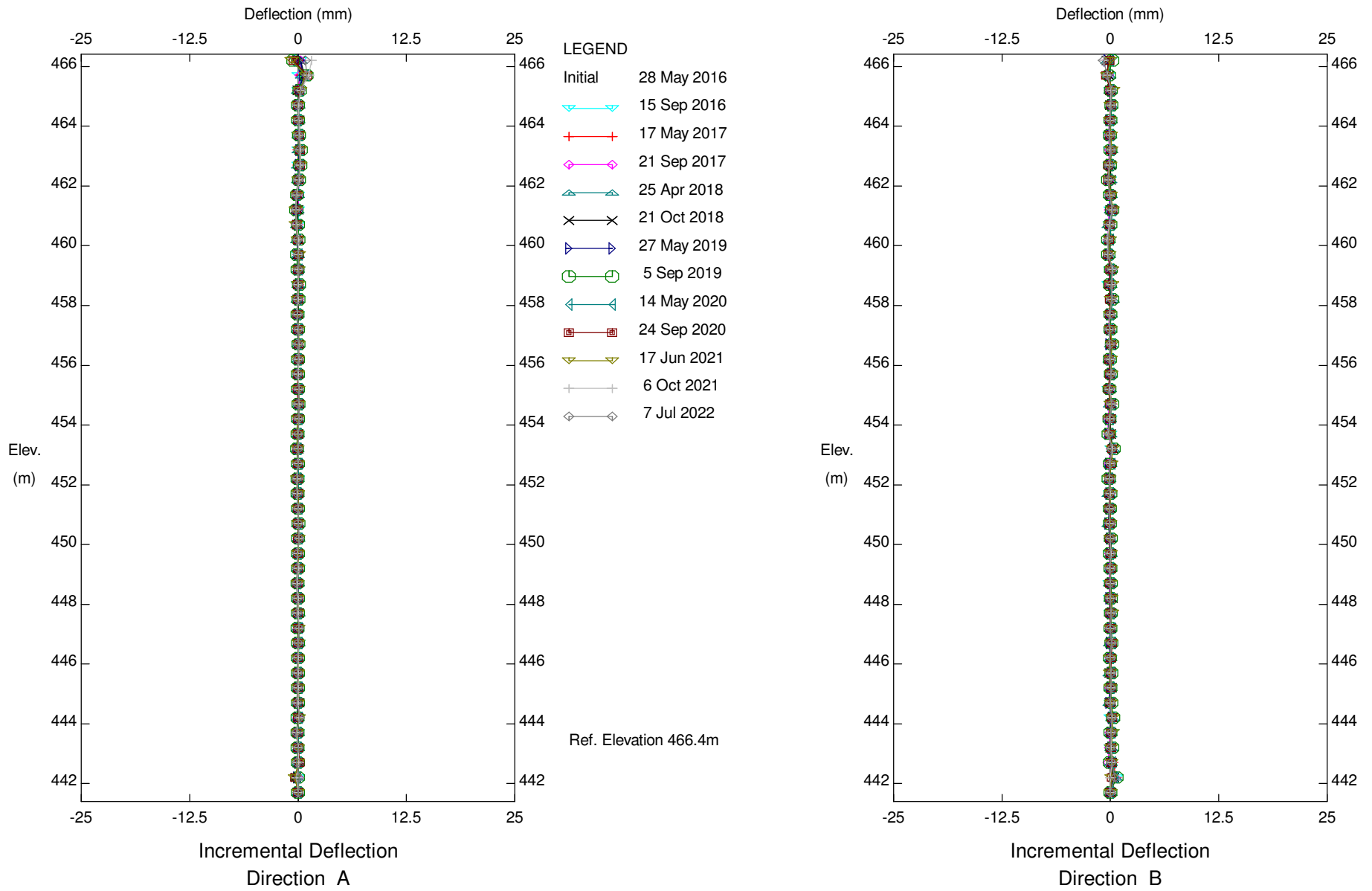
Instrumentation Plots

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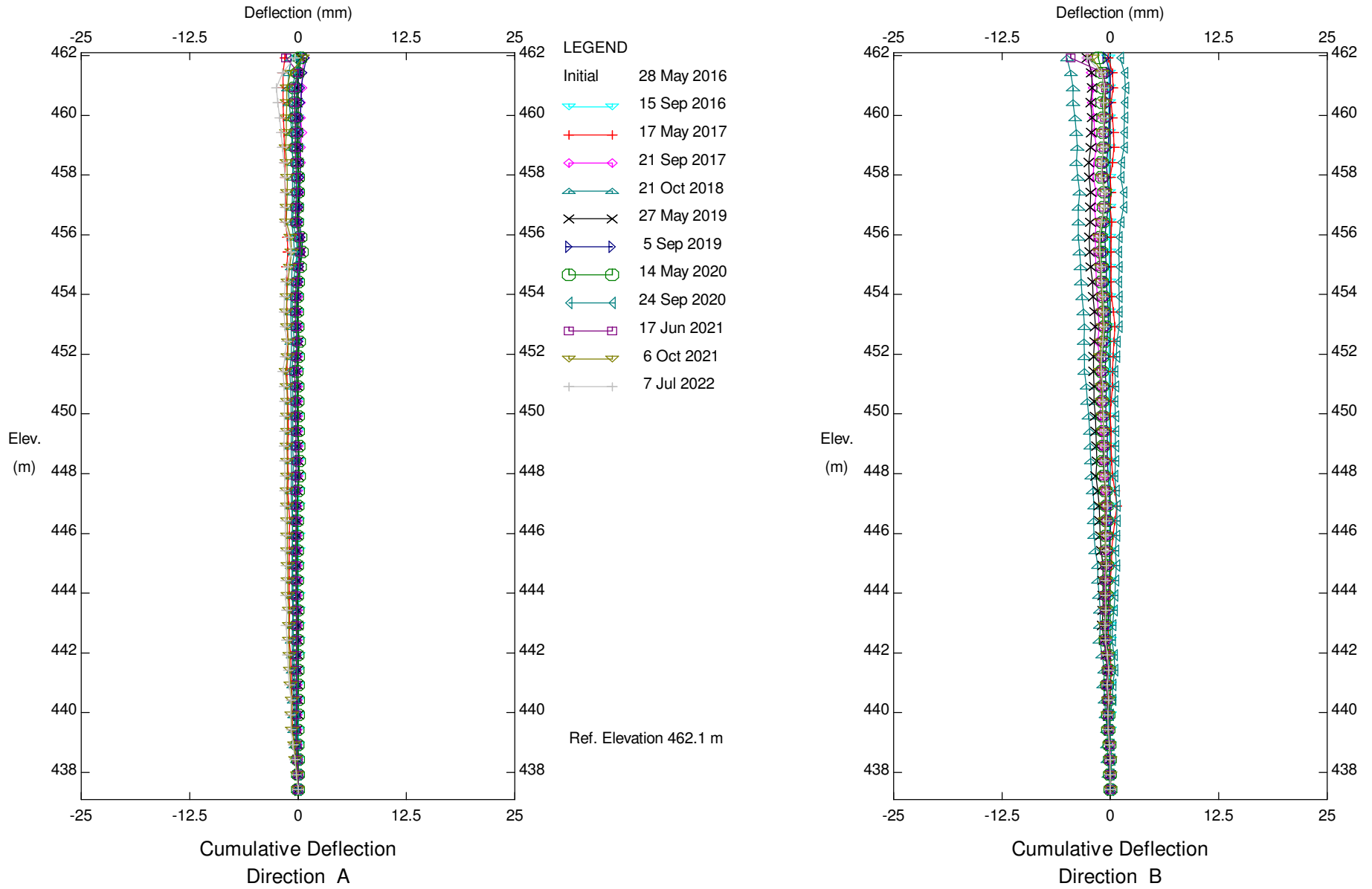
S026; H41:03, Elkwater Slides, Area A, Inclinometer SI08-1
Alberta Transportation

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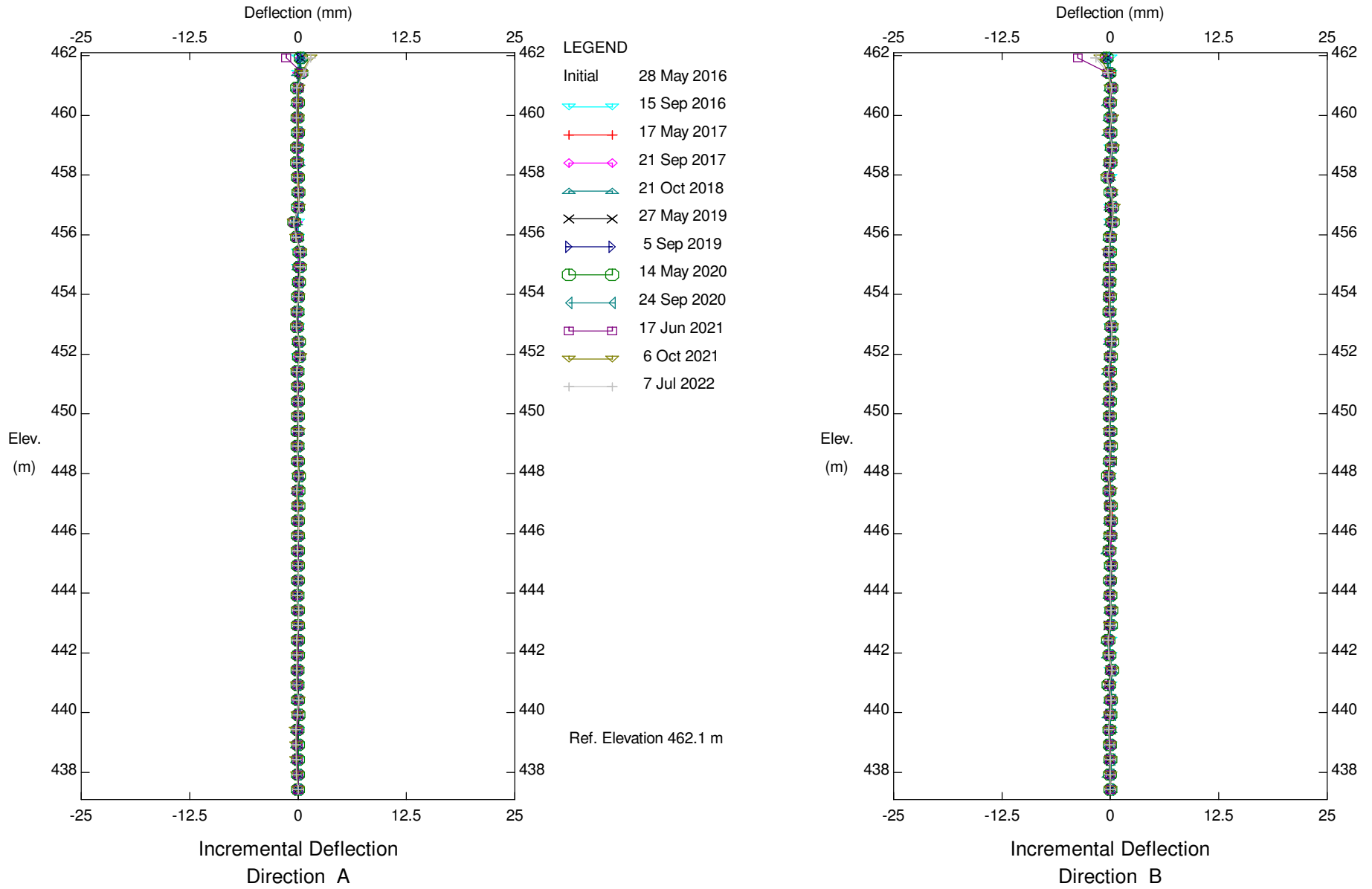


S026; H41:03, Elkwater Slides, Area A, Inclinometer SI08-1
Alberta Transportation

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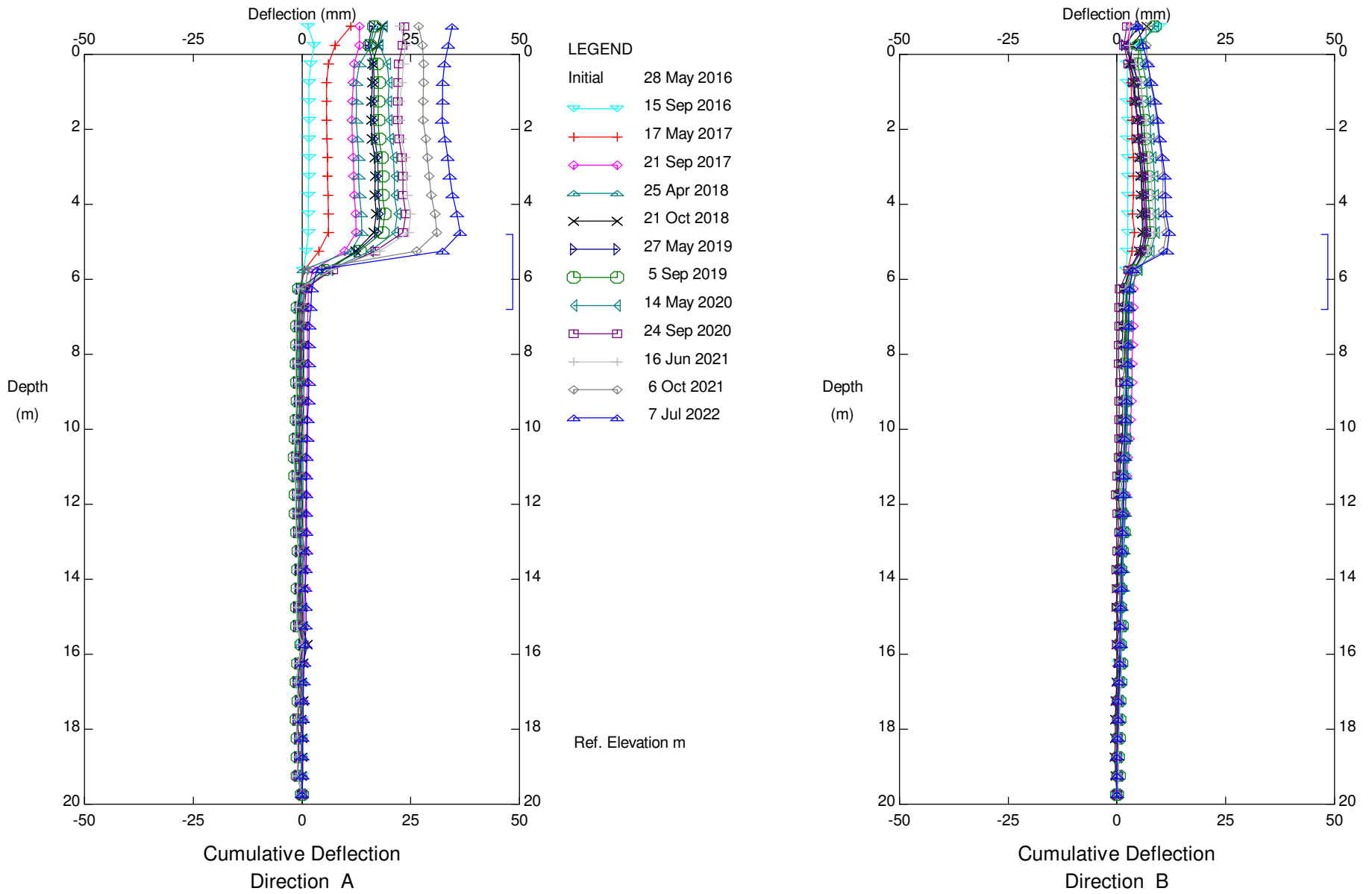


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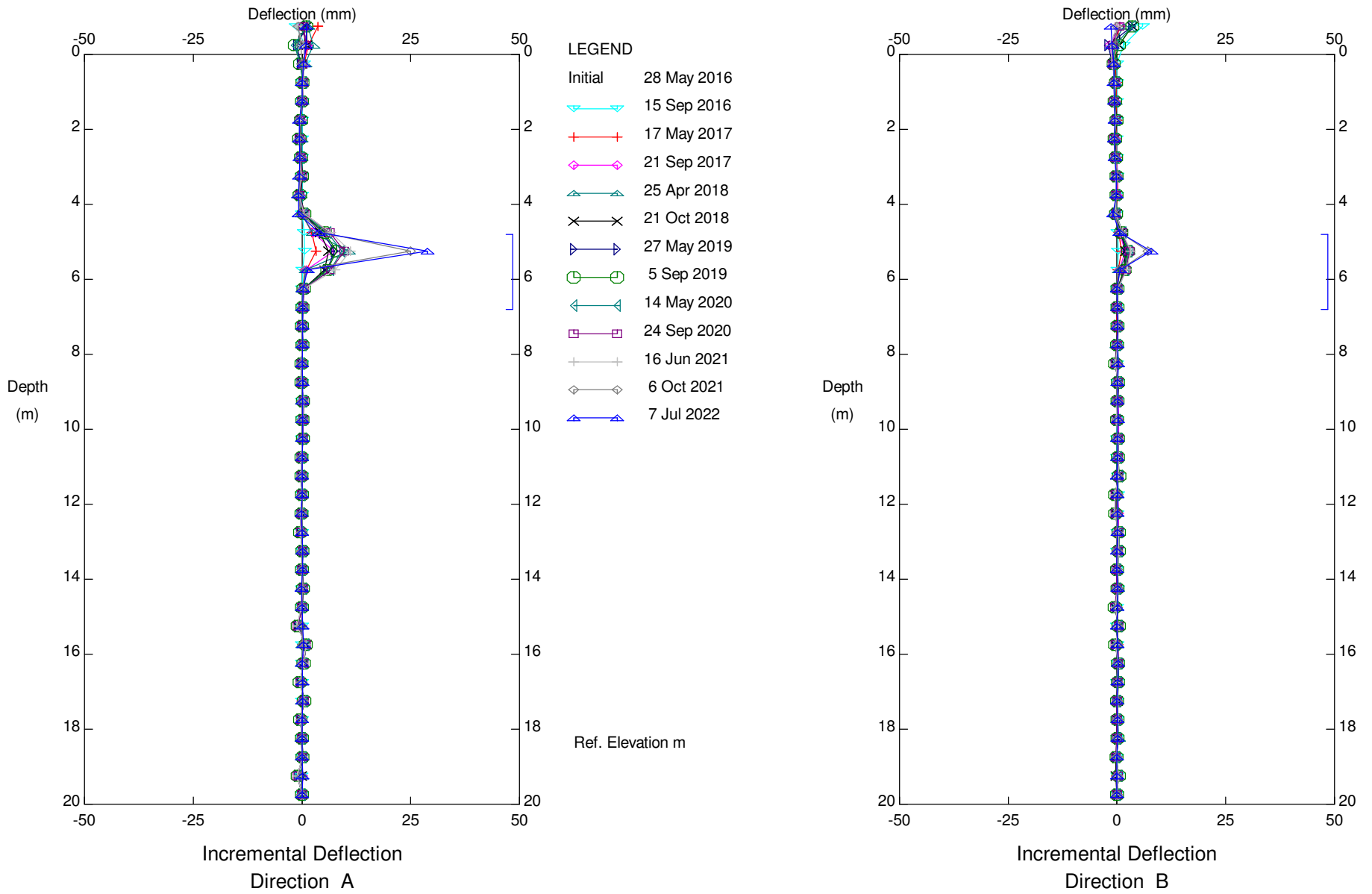
S026; H41:03, Elkwater Slides, Area A, Inclinometer SI08-3
 Alberta Transportation

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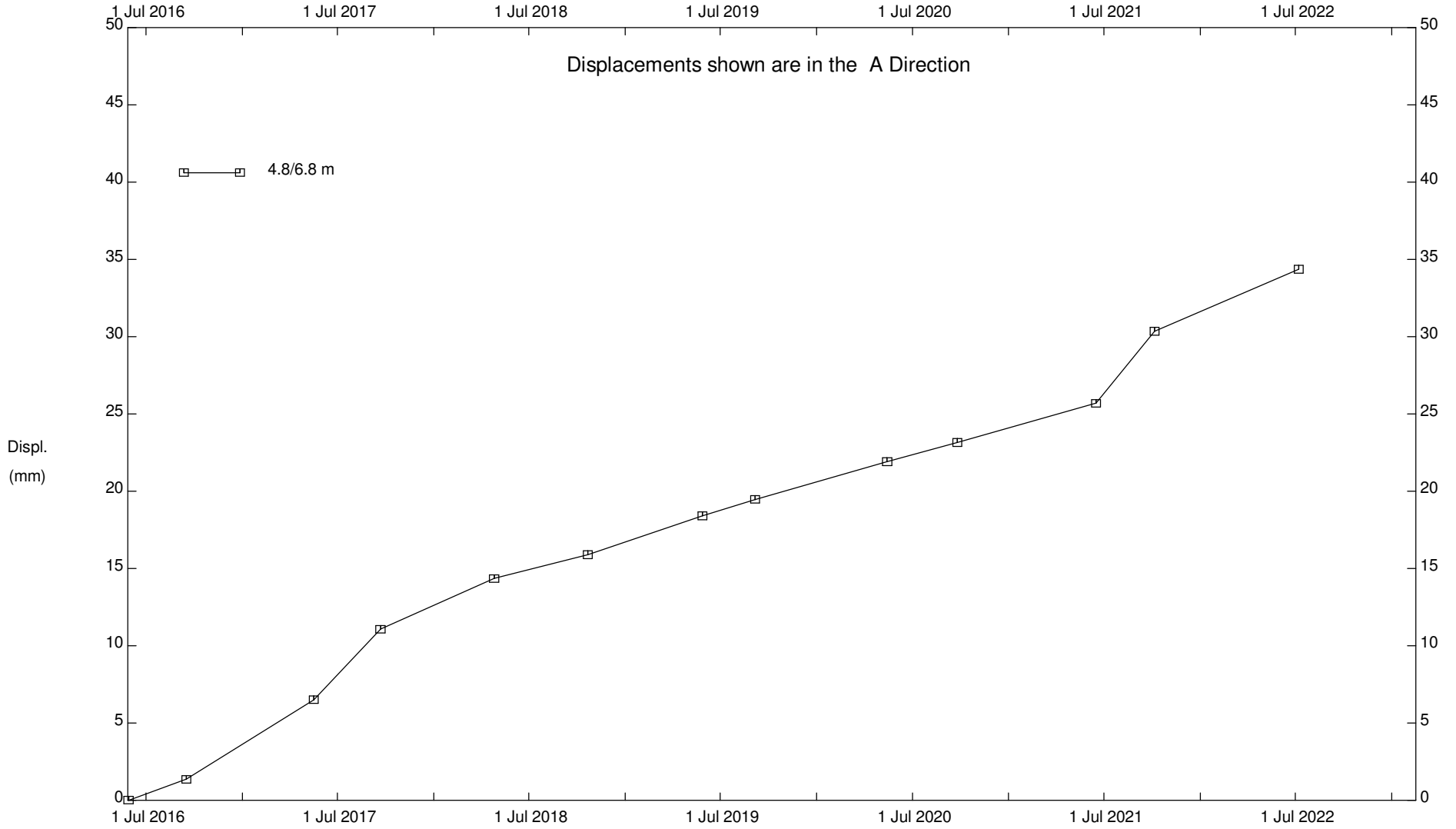
S026; H41:03, Elkwater Slides, Area B, Inclinator SI12-01
 Alberta Transportation

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S026; H41:03, Elkwater Slides, Area B, Inclinometer SI12-01
 Alberta Transportation

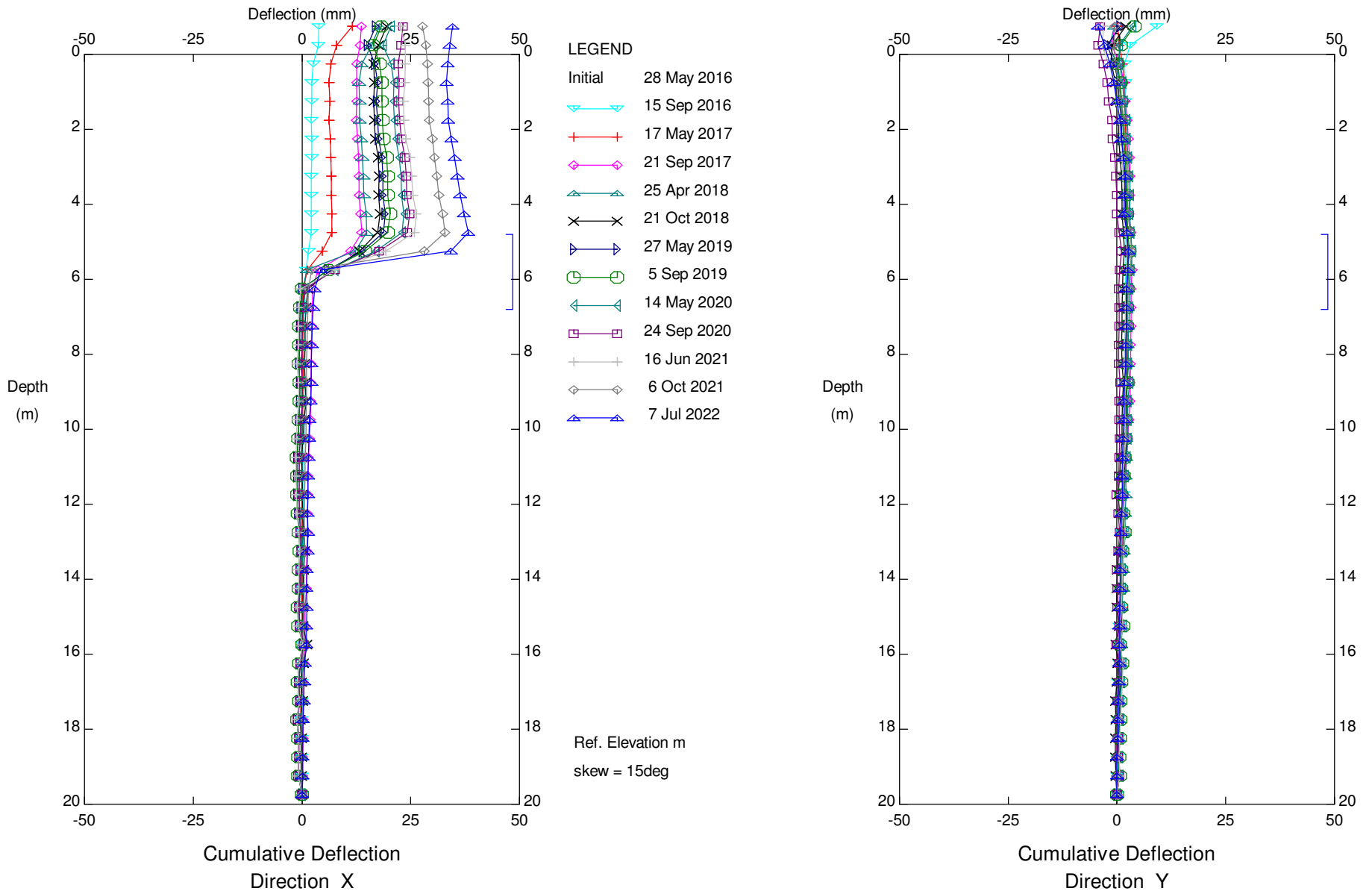
Klohn Crippen Berger - Calgary



S026; H41:03, Elkwater Slides, Area B, Inclinator SI12-01

Alberta Transportation

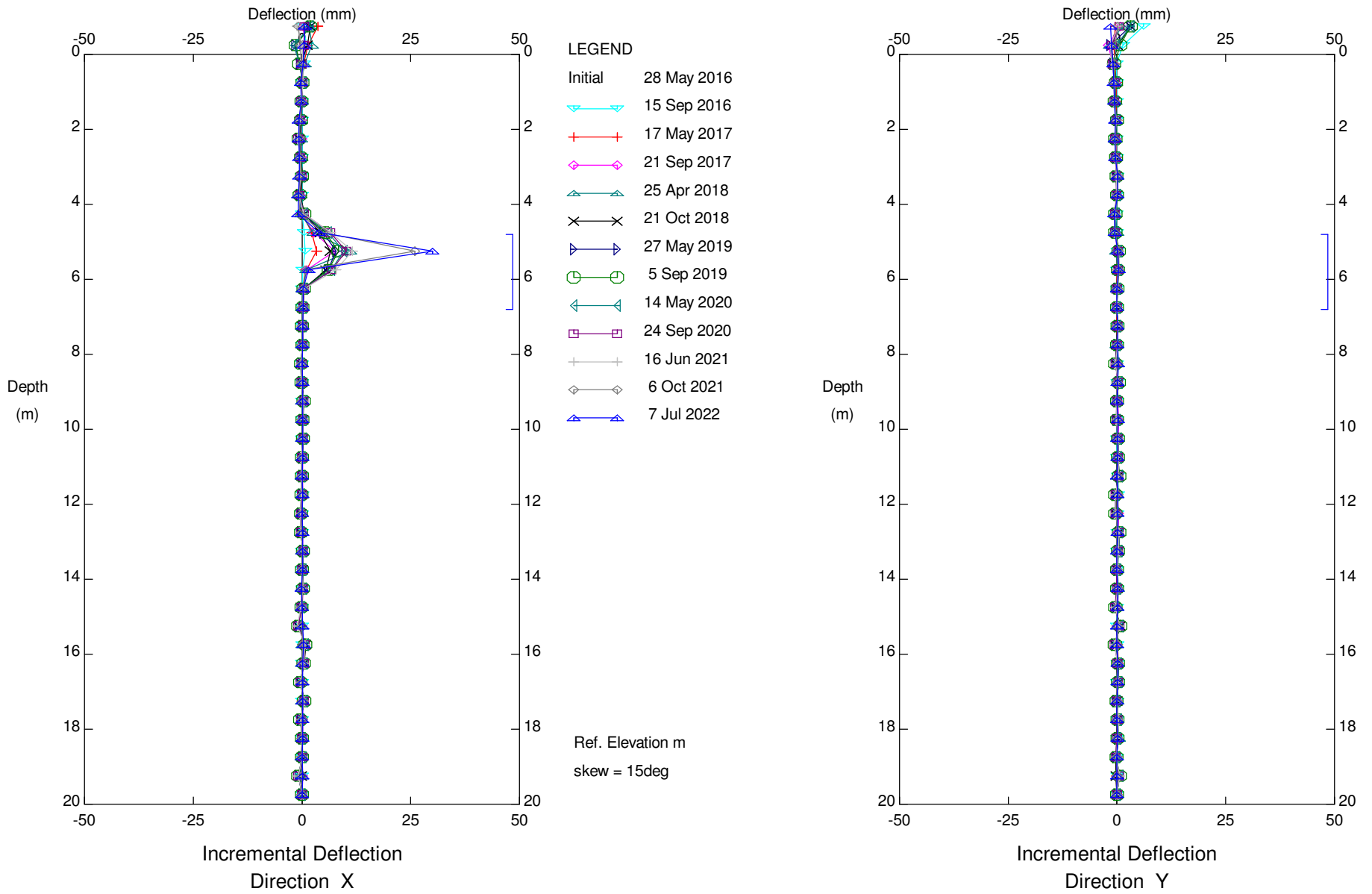
Klohn Crippen Berger - Calgary



S026; H41:03, Elkwater Slides, Area B, Inclinator SI12-01

Alberta Transportation

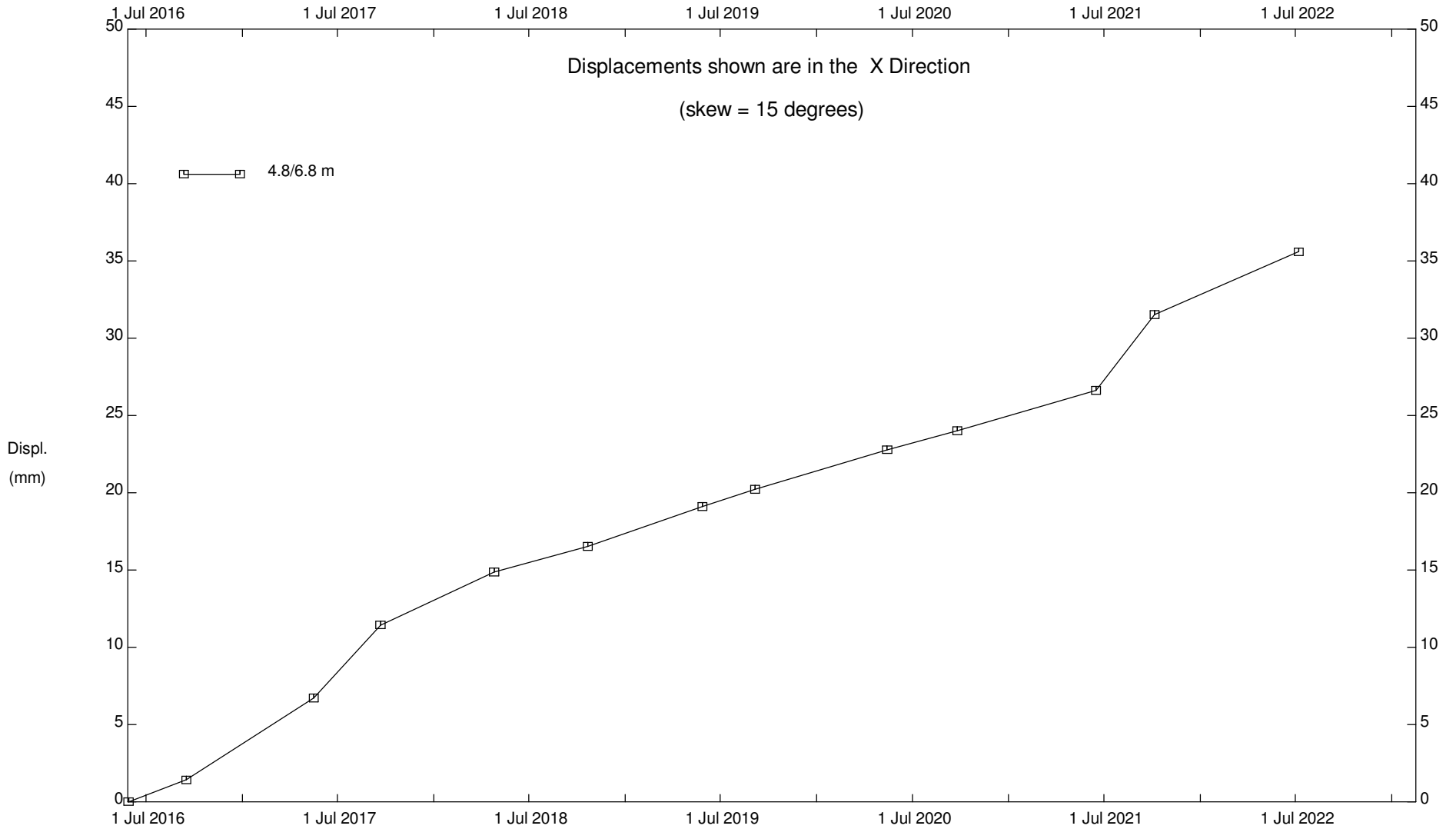
Klohn Crippen Berger - Calgary



S026; H41:03, Elkwater Slides, Area B, Inclinometer SI12-01

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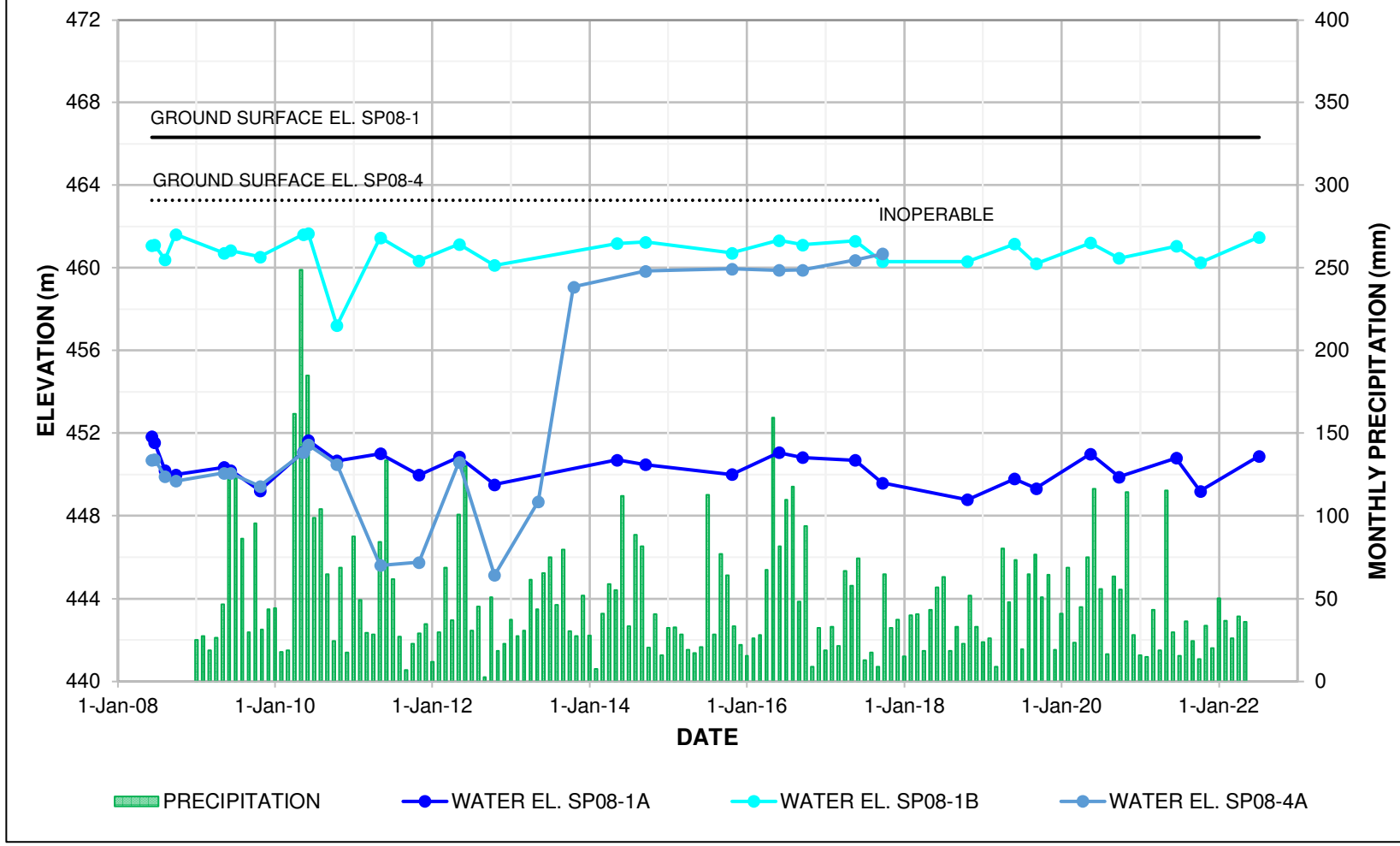
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S026; H41:03, Elkwater Slides, Area B, Inclinator SI12-01

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SP08-1A, SP08-1B, AND SP08-4A



NOTES:
 1. MONTHLY PRECIPITATION DATA OBTAINED FROM THE ALBERTA CLIMATE INFORMATION SERVICE (ACIS) DATABASE, REFERENCING LEGAL SUBDIVISION TWP008-03-W4.

CLIENT		PROJECT	
 		SOUTHERN REGION GEOHAZARD RISK MANAGEMENT PROGRAM	
		TITLE	
		Piezometer Data S026 - Elkwater Slide Area A Hwy 41:03, km 35.169	
SCALE	PROJECT No.	A05116A03	FIG No.