November 26, 2025

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 S039-I; H03:06, km 12.952 West Brocket Slide
Section C – 2025 Fall Readings

1 GENERAL

Four slope inclinometers (SIs) (SI16-01, SI23-01, SI23-02, and SI23-03) and two vibrating wire piezometers (VWPs) (BH16-02A/B) were read at the S039 site in the Southern Region on October 9, 2025 by Mr. Shawn Keegan, 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 on Hwy 03:06, km 12.95, approximately 1.9 km west of the junction with Hwy 786:02 and approximately 500 m west of Brocket, Alberta. The S039 site is located on the southern slope of the Oldman River Valley, and Hwy 03:06 is routed along the crest of the slope. The approximate site coordinates are 5491976 N, 298990 E (UTM Zone 12, NAD 83). A site plan is presented in Figure 1.

The geohazard at the S039 site consists of a range of instabilities over a total length of approximately 600 m along Hwy 03:06. Two subsites have been identified: S039-I at the west end of the site and S039-II at the east end of the site. Instrumentation is only installed at the S039-I site.

Previous remedial actions at the S039-I site include:

- In 2015, pavement patching, crack filling, and installation of an asphalt curb to limit pavement runoff from flowing onto the slide area was completed. Previously, the Maintenance Contract Inspector (MCI) has dumped loose gravel over the guardrail onto the head of the slide to reduce the height of the head scarp.
- In 2017, pavement patching and repairs to the asphalt curb were completed.
- In 2023, 215 grouted soil nails, 16 m in length each, were installed into the slide backscarp with a metal mesh surface treatment and hydroseeding. The back scarp slope was regraded from approximately 2H:1V to 1.5H:1V during soil nail installation and drainage diversion

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measures were installed at the crest of the slope to keep water from flowing off the highway onto the slope. As part of this work two additional SIs were installed on the mid-slope bench of the landslide area. During construction the contractor damaged the existing SI16-01 at the crest of the slope. This SI was replaced with SI23-03 as part of the construction.

Since completion of the repair, a wet zone on the east limit of the anchored backscarp slope at the upper ¾ mark was first observed during the May 2023 Section B inspection. This wet zone was not observed or encountered during the 2017 drilling investigation, during any Section B inspections prior to 2023, or during construction. A small, shallow zone of movement developed in 2023 approximately 30 m by 6 m at the east extent of the repair. During the spring 2024 Section B inspection additional slope movement and sloughing was observed across the repair slope. Additionally, erosion from runoff from the highway surface has created rills on the slope face, some of which have undermined the soil nail anchor plates. Instrumentation is not in place to monitor the performance of the anchored back slope or the zone of movement associated with an isolated wet area on the upper east part of the anchored slope.

1.1 Instrumentation

Instrumentation installation details are tabulated in The SI equipment was changed in 2020 when KCB began reading the instruments, and again in October 2021 after the previous equipment became inoperable. Currently, the operable SIs were read using a metric RST Digital MEMS Inclinometer System. The VWPs were read using an RST VWP readout box.

Table 1.1. Instrument locations are shown in Figure 1. Any instruments not included in The SI equipment was changed in 2020 when KCB began reading the instruments, and again in October 2021 after the previous equipment became inoperable. Currently, the operable SIs were read using a metric RST Digital MEMS Inclinometer System. The VWPs were read using an RST VWP readout box.

Table 1.1 or shown in Figure 1 are assumed to be inoperable and are not presented or discussed herein.

In 2016, five boreholes were drilled at the S039-I site:

- BH16-04A and BH16-04B were drilled through the mid-slope bench so one SI (SI16-04B) and two VWPs (BH16-04A/B) could be installed to monitor depth of movement and groundwater conditions, respectively, within the slide mass. By September 2020, SI16-04B was sheared and the two VWPs were inoperable, likely due to ongoing slide movements.
- BH16-01 and BH16-03 were drilled on either side of the active slide mass so two SIs (SI16-01 and SI16-03) could be installed to monitor if the slide is expanding laterally.
- BH16-02 was drilled on the south side of the highway so two VWPs (BH16-02A/B) could be installed to monitoring groundwater conditions upslope of the highway and slide.

In 2023, three boreholes were drilled at the S039-I site:

- BH23-01 and BH23-02 were drilled at the bench at the base of the repair slope. Two SIs (SI23-01 and SI23-02) were installed to monitor slope movement at the mid-slope bench of the landslide area.
- BH23-3 was drilled at the crest of the slope on the west side. SI23-03 was installed to replace SI16-01, which was damaged during construction.

The SI equipment was changed in 2020 when KCB began reading the instruments, and again in October 2021 after the previous equipment became inoperable. Currently, the operable SIs were read using a metric RST Digital MEMS Inclinometer System. The VWPs were read using an RST VWP readout box.

Table 1.1 Instrument Installation Details

Instrument ID	Instrument Type	Installation Date	UTM Coordinates[1] (m)		Ground Surface Elevation (m)	Stick Up (m)	Depth (mbgs[2])	Condition
			Northing	Easting				
BH16-02A	VWP	Oct. 20, 2016	5491940	298971	1078	N/A	17.4	Operable
BH16-02B	VWP	Oct. 20, 2016	5491940	298971	1078	N/A	22.6	Operable
SI16-03	SI	Oct. 19, 2016	5492020	299047	1065	0.9	19.0	Operable
SI23-01	SI	Feb. 27, 2023	5492004	298993	1061	0.80	14.0	Operable
SI23-02	SI	Feb. 27, 2023	5492003	298962	1061	0.80	15.0	Operable
SI23-03	SI	Feb. 28, 2023	5491993	298930	1070	0.84	21.0	Operable

Notes:
[1] Coordinates were obtained by KCB during installation with a handheld GPS with NAD83/UTM 11N Datum. The handheld GPS had a horizontal accuracy of +/- 5 m
[2] Meters below ground surface (mbgs). Bottom reading depth for SIs and tip depth for VWPs.
[3] SI16-04B has sheared at an approximate depth of 5.5 m below ground surface.
[4] SI16-01 was destroyed during construction and replaced with SI23-03.

2 INTERPRETATION

2.1 General

The SI plots presented in the report include cumulative displacement, incremental displacement, and displacement-time data (Appendix I). The displacement-time data is plotted in the A-direction (i.e., the direction of the A0-groove). Since October 2021, KCB has been using a new inclinometer probe and reel, which might lead to slight differences in data compared to earlier readings. However, during the review of the SI data for this report, all prior data corrections were removed to facilitate better interpretation of displacement trends.

For the operable VWPs, the recorded porewater pressures were converted to an equivalent water/piezometric elevation and plotted relative to ground surface elevation 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 the Brocket AGDM Station.

The SI and piezometer data plots are included in Appendix I

2.2 Zones of Movement

The last movement readings of SI16-04B prior to shearing in 2020 (see Figure 1) which was situated near the center of the sliding mass, a shear zone was estimated to be approximately 6.5 m to 8.0 m below ground level (roughly El. 1053.5 m to El. 1052.0 m) within the clay till. Similarly, SI16-03, which is located on the east flank of the slide near the mid-slope, has shown distributed movement of about 12 mm at an approximate depth of 8 m below ground surface (approximately El. 1057 m) in the clay till.

The movement data obtained from the SI23-01 located on the east side of the bench at the toe of the repaired zone have been relatively noisy (despite good data quality) and challenging to interpret, compared with the existing SI (SI16-03). It is unclear whether the noise is caused by installation problems (such as a kinked or tilted casing), since the casing is tilted approximately 0.8 m over its 14 m depth. Still, the readings show a deflection in the upper 3 m of SI23-01 that could be related to true movement or post-installation settlement of the casing. The instrument might need to be reset in the future if the next data set continues to show noise.

The SI23-02, located on the west side of the bench at the toe of the repaired section, has shown zones of distributed movement starting at the transition zone of bedrock, approximately at depths of 9 m to 11 m below ground surface (approximately El. 1052.1 m to El. 1050.1 m).

SI23-03, located on the west flank of the slide near the crest of the slope, was tilted approximately 1 m over its 21 m depth from installation. The SI23-03 shows a possible zone of distributed movement approximately at 10 m to 12 m below ground surface (approximately El. 1062 m to El. 1057 m) in the clay till and possibly some casing settlement above this depth.

2.3 Interpretation of Monitoring Results

2.3.1 Slope Inclinometers

Most of the movement recorded in SI16-03 (located east of the slide mass) occurred immediately after installation and could be due to post-installation SI casing flexure. Since late 2018, the rate of movement recorded in SI16-03 has been slow (less than 5 mm/year). Readings since spring 2024 have recorded approximately 9 mm of movement in the top 1.5 m of the SI, suggesting the slide is expanding laterally to the east. Although the data collected spring and fall 2025 readings have shown little decrease in movement, the total movement remains above 12 mm. Additional readings could help confirm the current interpretation of the data and determine whether this is a long-term trend.

SI23-02 shows that movement has progressively increased since installation, with a total movement reaching 18 mm in the fall of 2025. The magnitude of the movement rates appears to be seasonally correlated with higher rates during the spring and summer. Future readings would confirm the seasonal increase in movement rates for SI23-02.

Distributed movement has been recorded in SI23-03 (located west of slide mass) between depths of approximately 10 m to 12 m below ground level at a skew angle of 45 degrees (northeast) from the down slope direction (perpendicular to the highway). Movement at similar depths was previously recorded in SI16-01 (replaced by SI23-03) before it was damaged. This elevation is approximately the same as the bench at the base of the slope. Movement has continued to slow, with only 0.7 mm noted since May 2024.

Future readings would help to corroborate the interpretation of the data and movement zones. Currently, there is no instrumentation in place to monitor movement on the repair slope.

2.3.2 Water Levels and Precipitation

Since fall 2017, the water levels recorded in the two VWPs installed in BH16-02A (clay till) and BH16-02B (bedrock) have been relatively steady (up to ±1.0 m), except for an approximate 1.9 m to 1.7 m decrease recorded in these instruments, respectively, since the spring 2024 readings. The last three readings of these instruments are the lowest recorded since installation (up to 0.7 m and 0.8 m lower, respectively).

In May 2023, during the Section B inspection, a wet area was noted at the eastern extent of the repair slope, which did not relate to the water levels recorded in the VWPs read in June 2023. During the 2024 fall readings in September, no wet areas were observed on the slope. During the 2025 spring readings, some wet areas were observed at the toe of the slope, but they were minor and may have been due to rainfall earlier that day. No wet spots noted during the 2025 fall readings in October. Still, wet areas on the slope may be associated with perched water tables in more permeable seams, as previously reported by KCB and Thurber. Data loggers should be installed on the VWPs to obtain more information on how groundwater levels fluctuate in relation to snowmelt and precipitation events.

2.4 Summary

The summary of the SI and piezometer data is provided in Table 2.1 and Table 2.2, respectively. SI16-03 was re-initialized to the September 2022 readings when the SI reading equipment was changed. No data obtained before September 2022 is shown on the SI plots for this instrument.

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]	Cumulative Movement (mm)				Rate of Movement (mm/year)		
	Initialized (Re-initialized)	Previous Maximum Cumulative Movement	Previous Reading	Most Recent Reading				Before Re-Initialization	Most Recent Reading	Incremental Since Previous Maximum Cumulative	Total	Previous Maximum	Most Recent Reading	Change from Previous Reading
SI16-03	Nov. 24, 2016 (Jan. 30, 2017)[3] (Sep. 22, 2022)[4]	Oct. 15, 2018	May 23, 2025	October 9, 2025	1065	0.4 – 7.9	X-Direction, 340°	8.3	11.9	-1.4	20.2	23.3	-3.7	-0.7
SI23-01	Mar. 10, 2023	N/A	May 23, 2025	October 9, 2025	1061	N/A	N/A	N/A – no discernible movement recorded						
SI23-02	Jun. 7, 2023	May 23, 2025	May 23, 2025	October 9, 2025	1061	9.0 – 11.0	X-Direction, 345°	N/A	18.7	4.1	18.7	14.9	10.8	9.3
SI23-03	Mar. 10, 2023	May 23, 2025	May 23, 2025	October 9, 2025	1070	10.0 - 12.0	X-Direction, 45°	N/A	7.3	-0.1	7.3	13.4	-0.1	-0.5

Notes:
[1] Meters below ground surface (mbgs).
[2] Skew angle of X-direction measured clockwise from the A-direction.
[3] Bad data was obtained during the first two readings of this instrument, so it was re-initialized to the January 2017 reading.
[4] Re-initialized to September 2022 reading when the SI reading equipment was changed.

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)
BH16-02A	Oct. 20, 2016	May 23, 2025	October 9, 2025	1078	17.4	10.6	10.8	-0.2
BH16-02B	Oct. 20, 2016	May 23, 2025	October 9, 2025	1078	22.6	7.78	7.78	0

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

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 mid-May, due to the risk of water inside the instrument casings being frozen earlier in the year.

If the designed slope repairs continue to be delayed, surveys (e.g., ground-based Light Detection and Ranging, LiDAR, or Unmanned Aerial Vehicle, UAV, photogrammetry) should be conducted to complete change detection analysis to monitor movement on the repair slope because there is no instrumentation currently installed that can monitor movement of the soil-nail repaired slope.

A data logger should be installed on the functioning VWPs upslope of the repair section to monitor groundwater fluctuations throughout 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.

3.2 Instrument Repairs and Maintenance

No instrument repairs or maintenance is required.

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 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

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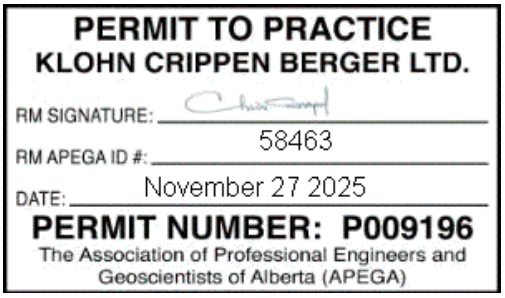
5. This report is electronically signed and sealed and its electronic form is considered the original. A printed version of the original can be relied upon as a true copy when supplied by the author or when printed from its original electronic file.

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

Yours truly,

KLOHN CRIPPEN BERGER LTD.

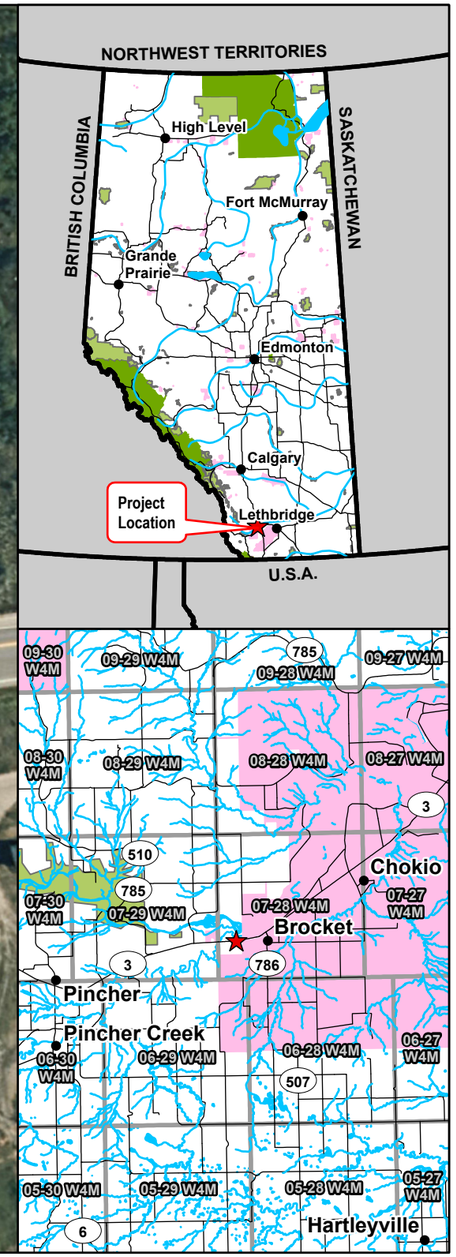


Jorge Rodriguez, Ph.D., M.Sc., P.Eng.
Geotechnical Engineer

JR:bb

ATTACHMENTS
Figure
Appendix I Instrumentation Plots

FIGURE



Legend

- Slope Inclinometer (SI)
- Vibrating Wire Piezometer (VW)
- Flow Direction
- Scarp
- Soil Nail Repair Area

0 50 Metres

NOTES:
1. HORIZONTAL DATUM: NAD83
2. GRID ZONE: UTM ZONE 12N
3. IMAGE SOURCE: MD OF WILLOW CREEK NO. 26, TOWN OF CARDSTON, TOWN OF PINCHER CREEK, MAXAR
4. STRIKETHROUGH INDICATES INSTRUMENT IS INACTIVE
5. AVAILABLE IMAGERY DOES NOT SHOW EXTENT OF REPAIRS.

CLIENT: Alberta

Klohn Crippen Berger

PROJECT: SOUTHERN REGION GEOHAZARD RISK MANAGEMENT PROGRAM

TITLE: Site Plan
S039 - Brocket Slides
Hwy 3.06, km 12.952

SCALE	PROJECT No.	FIG No.
1:1,250	A05116A03	1

File: Z:\AC\CGY\Alberta\A05116A03 ABT Southern Region GRMP\400 Drawings\2023\01_ProFile\Section C\AT_Southern_SectionC_231124\AT_Southern_SectionC_231124.aprx Date: Time: Creator: aharrison

APPENDIX I

Instrumentation Plots

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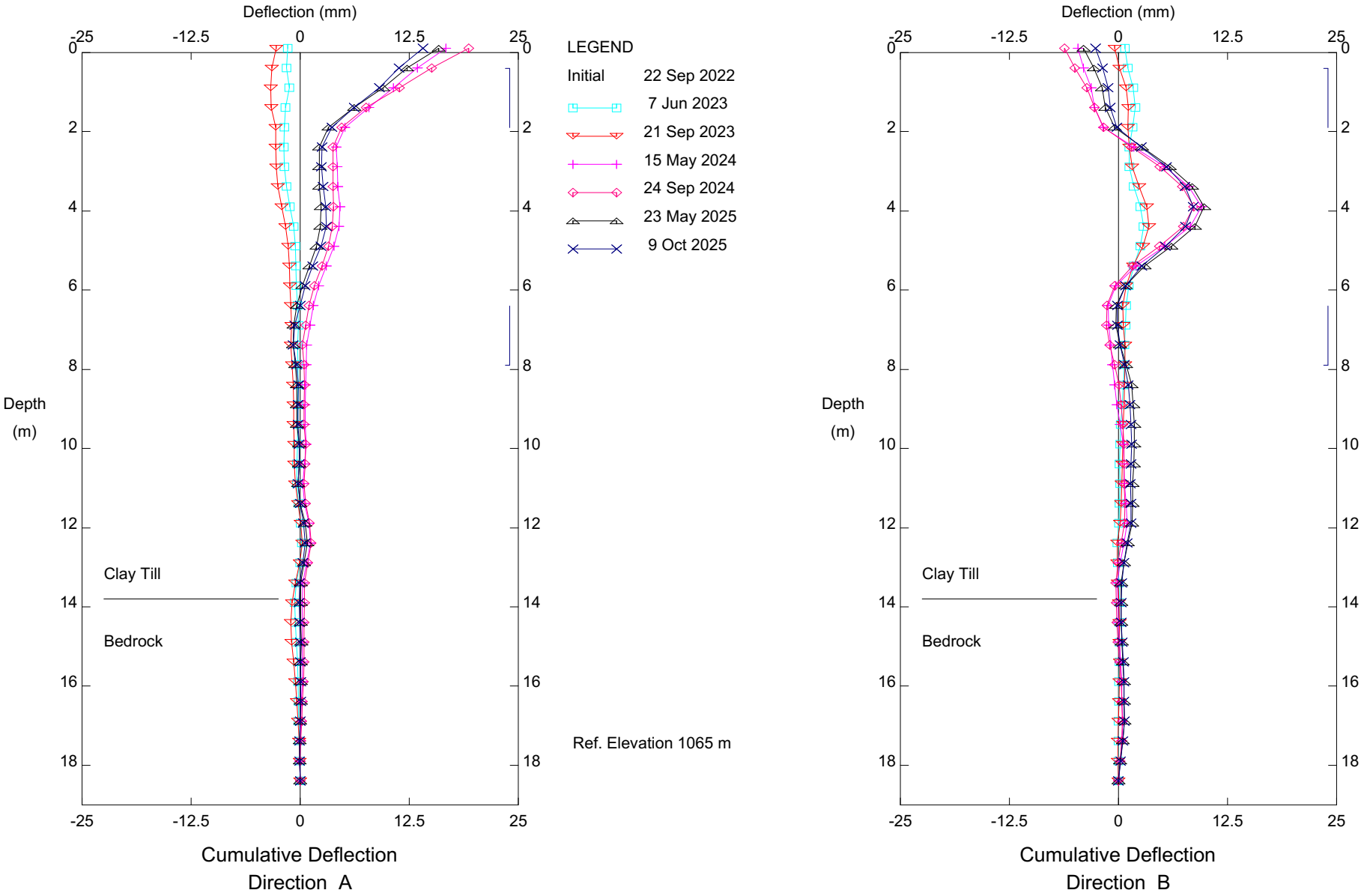

S039; H03:06, West Brocket Slide, Inclinometer SI16-03

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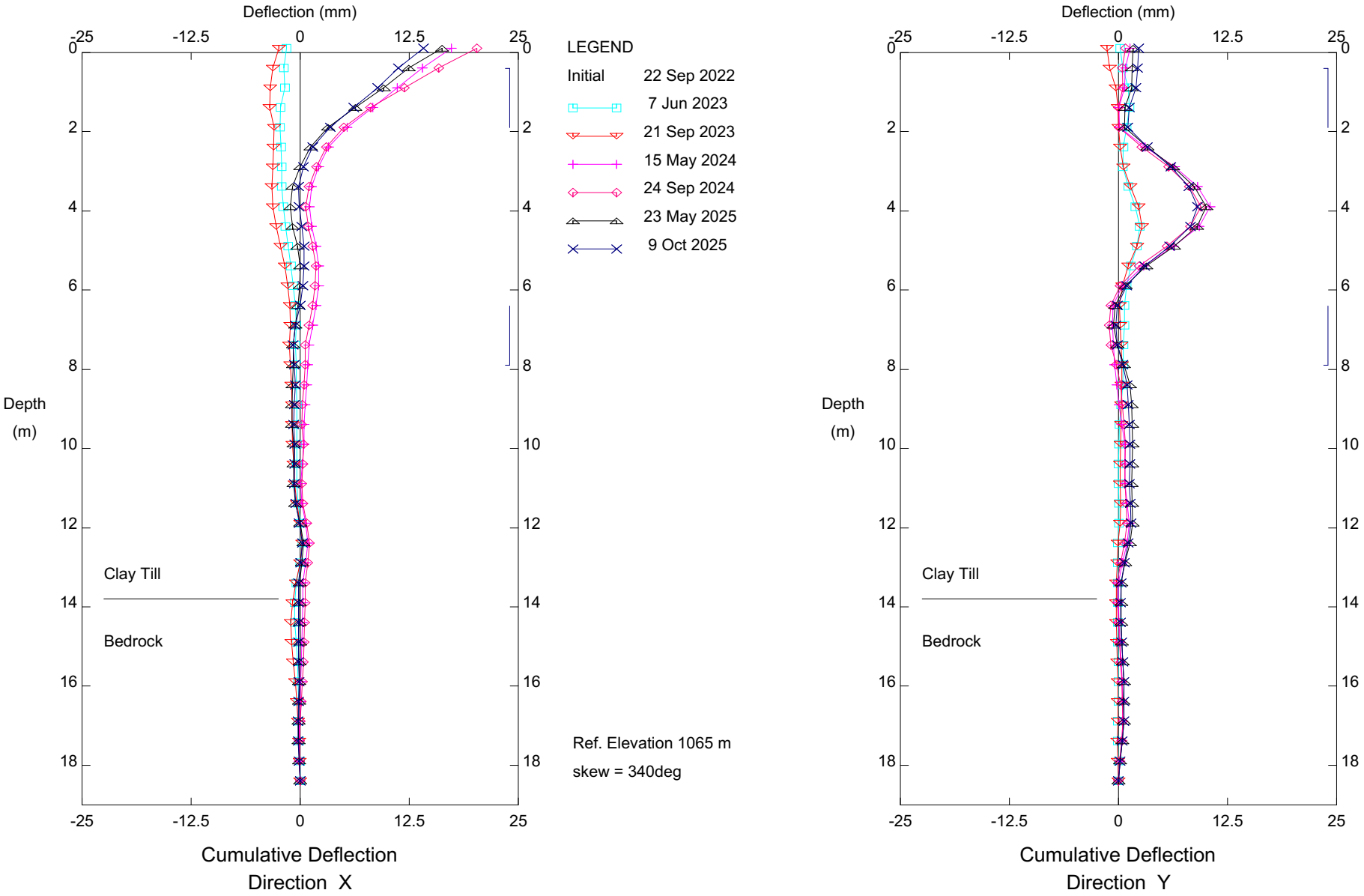

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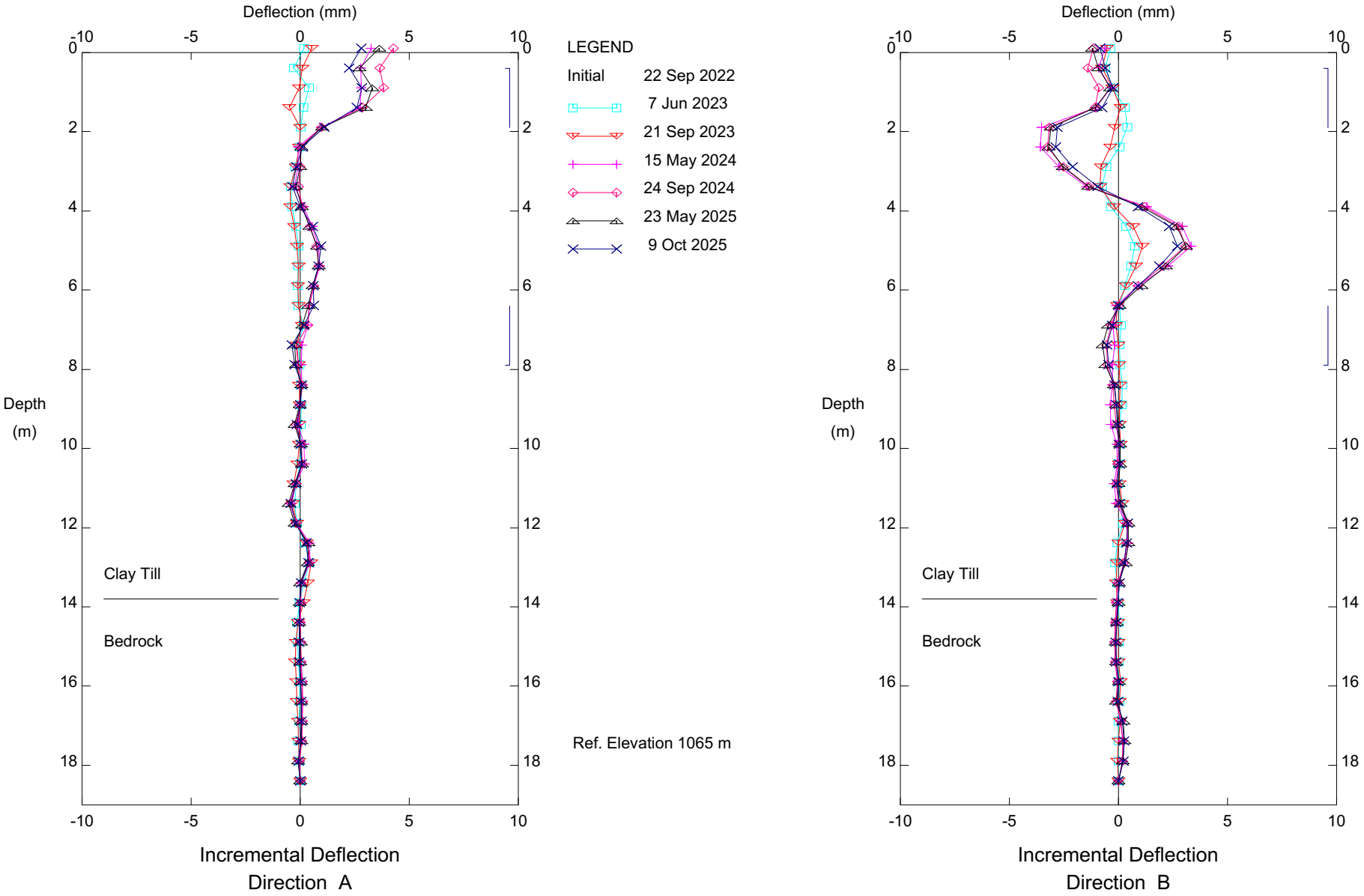

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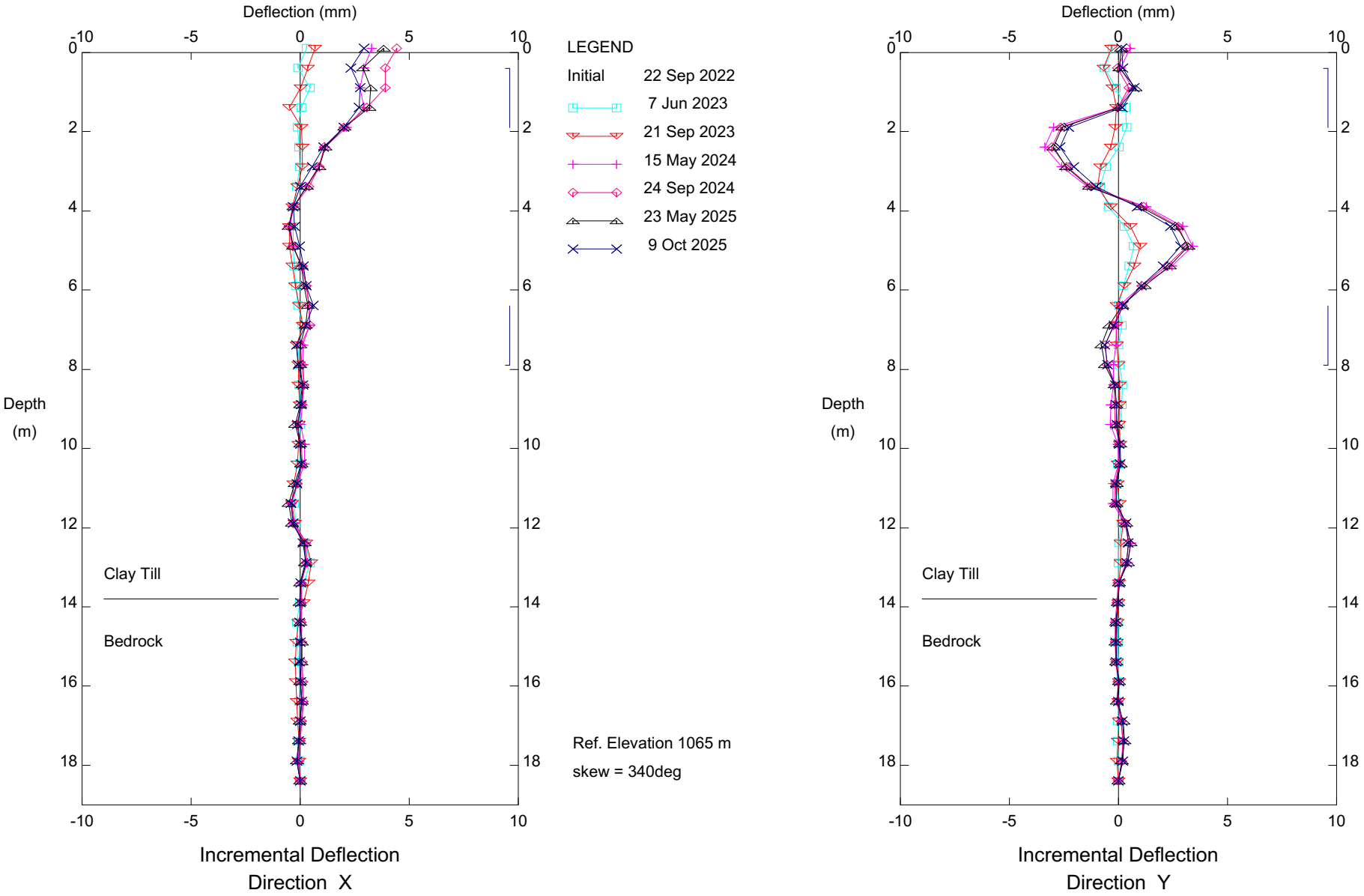

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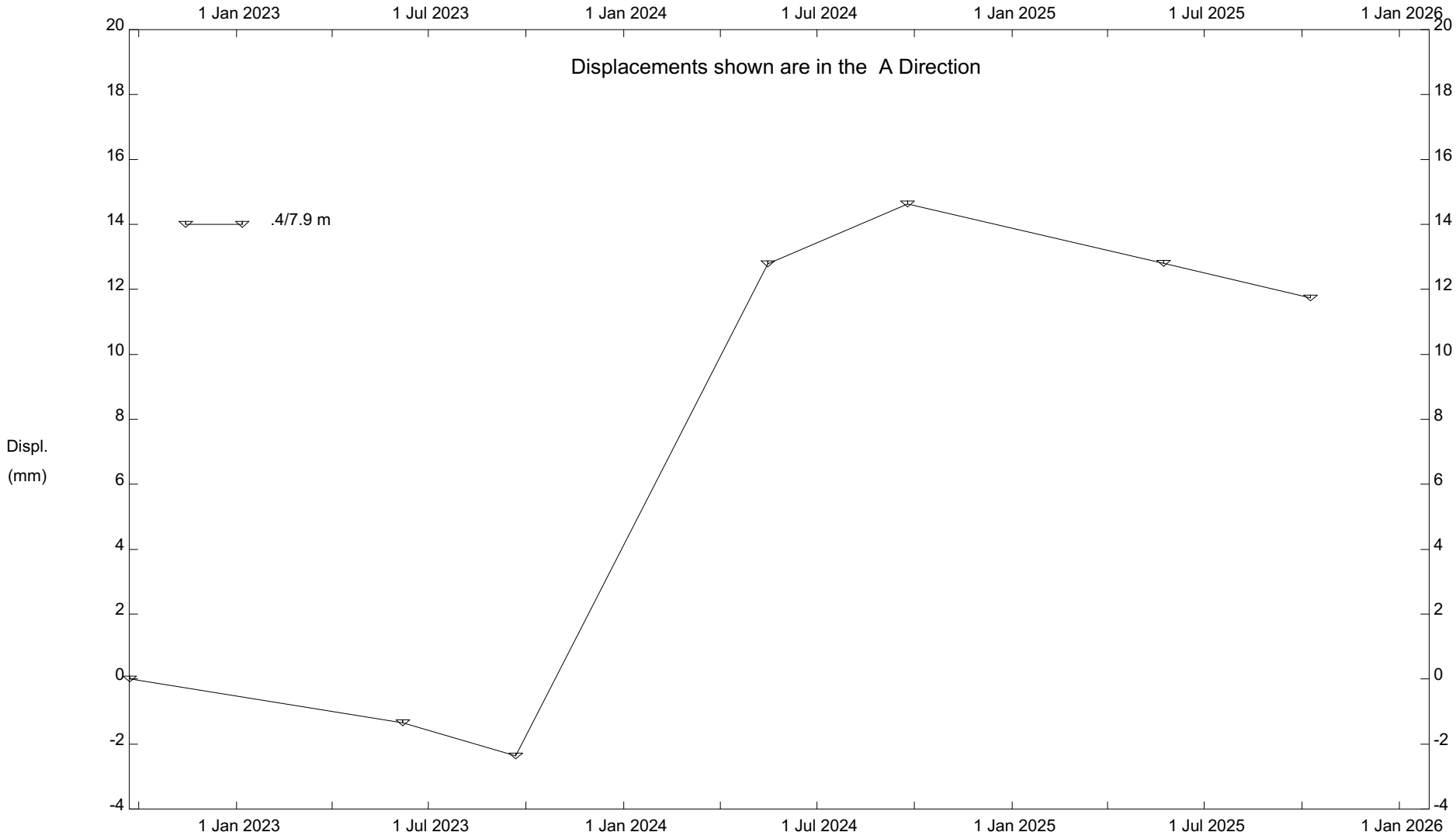

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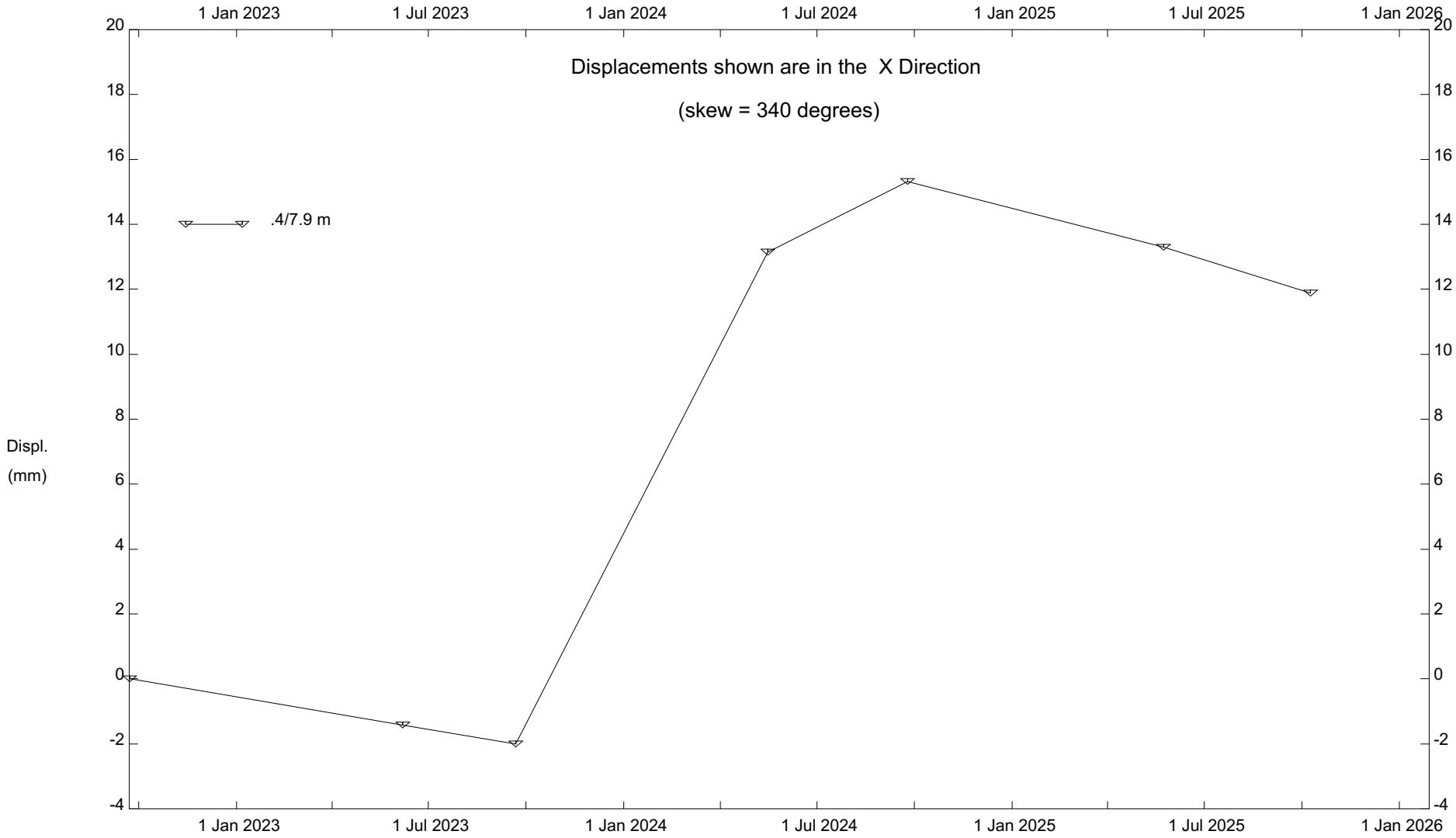

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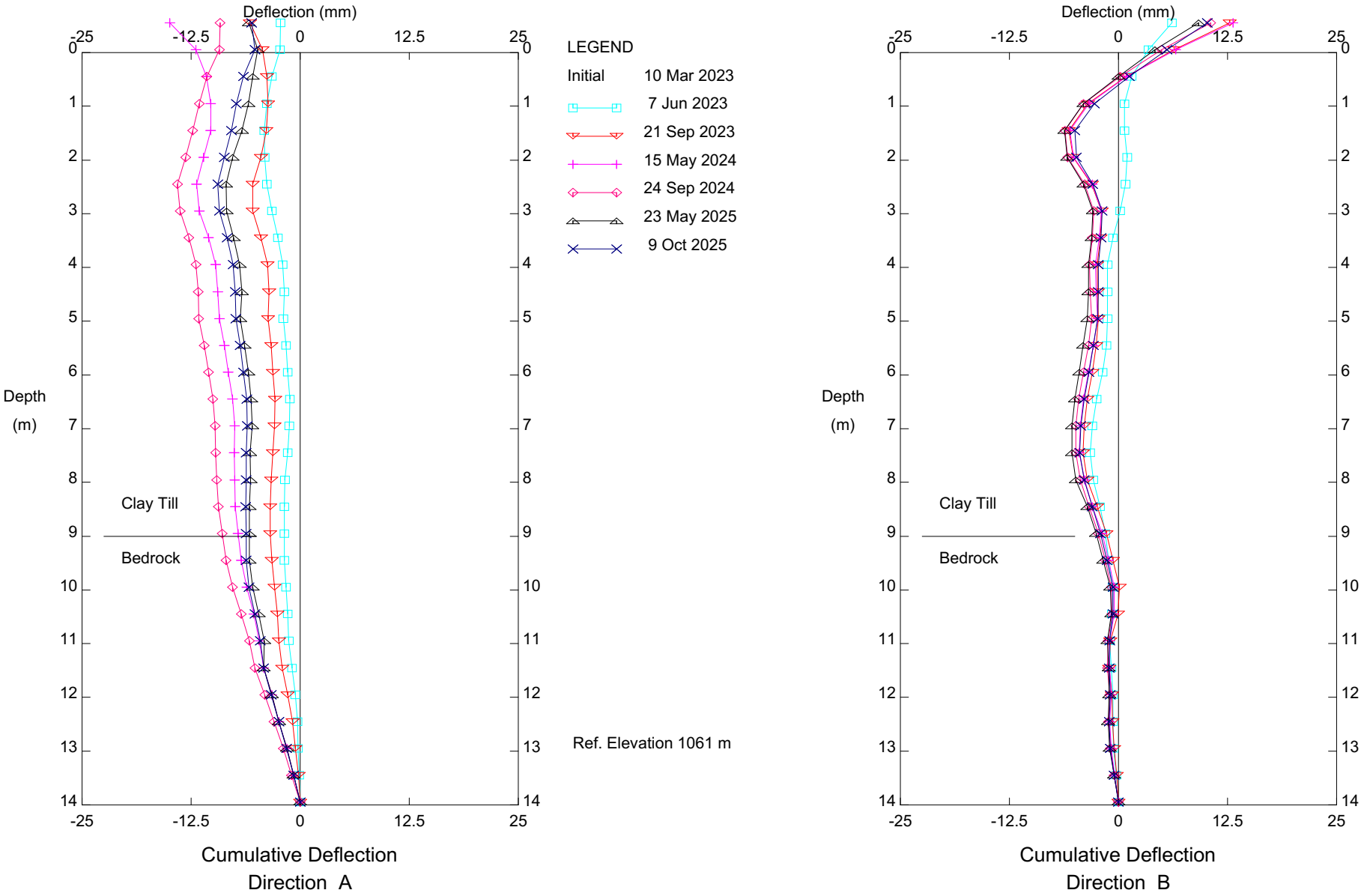

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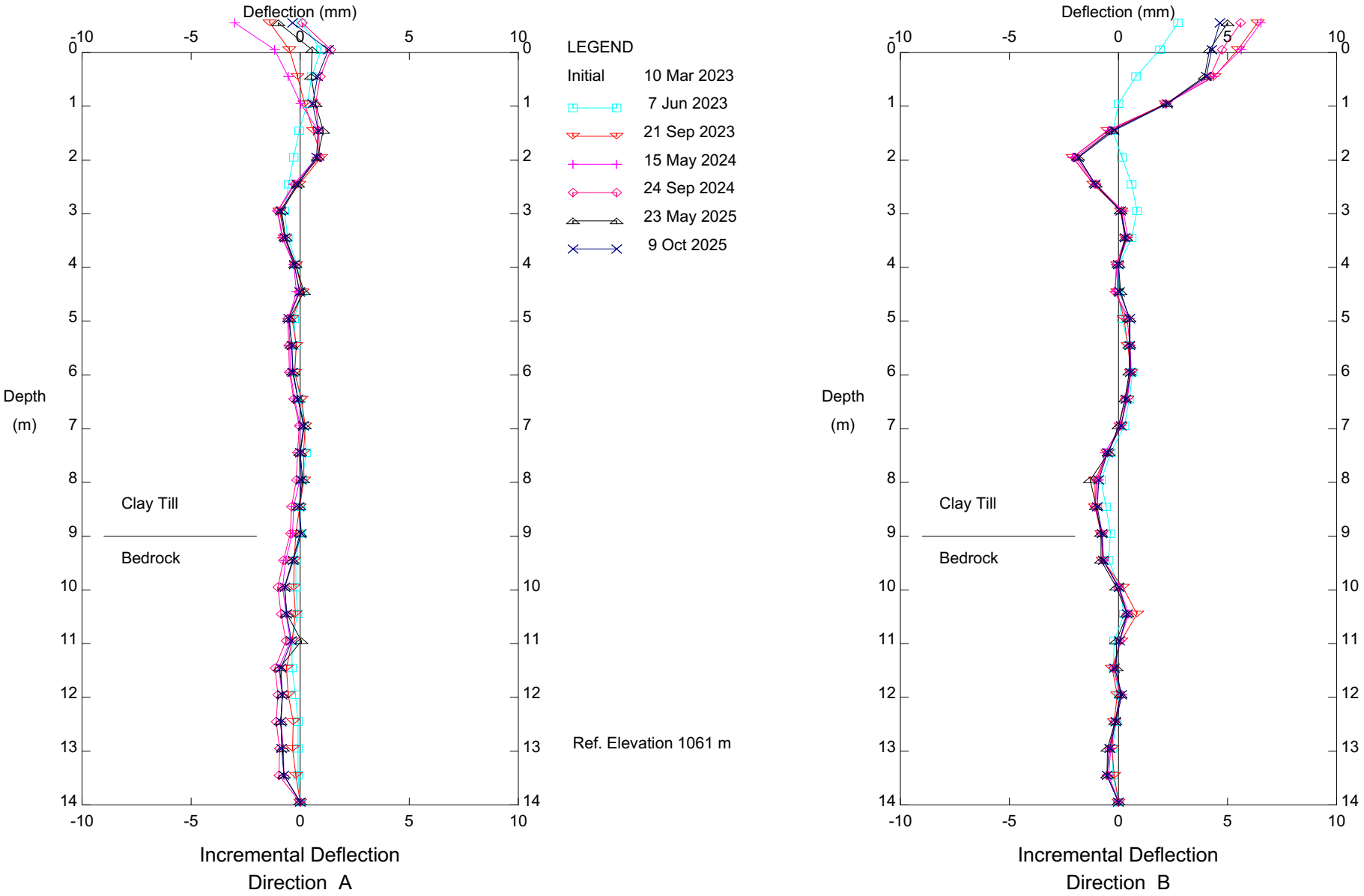

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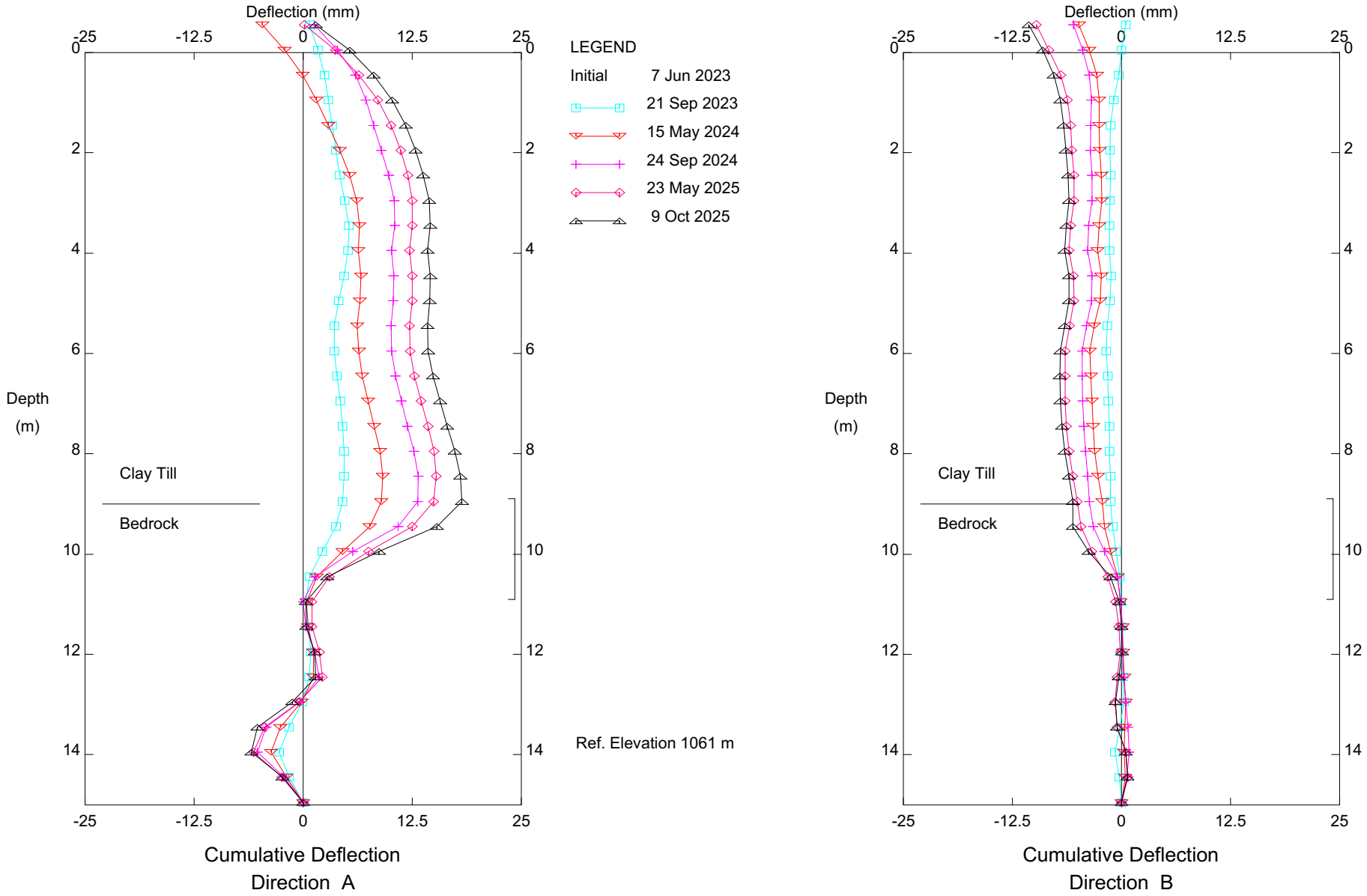

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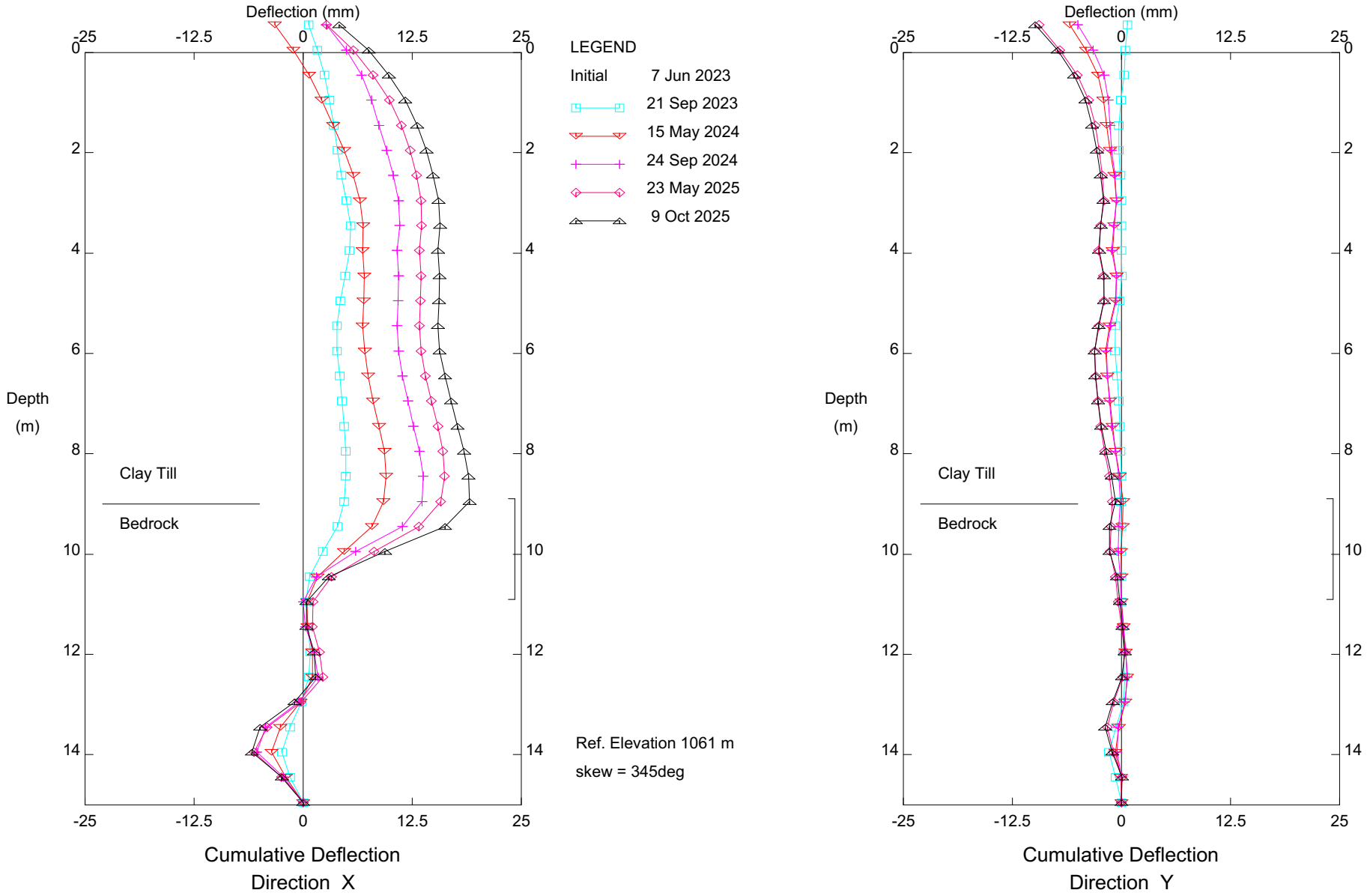

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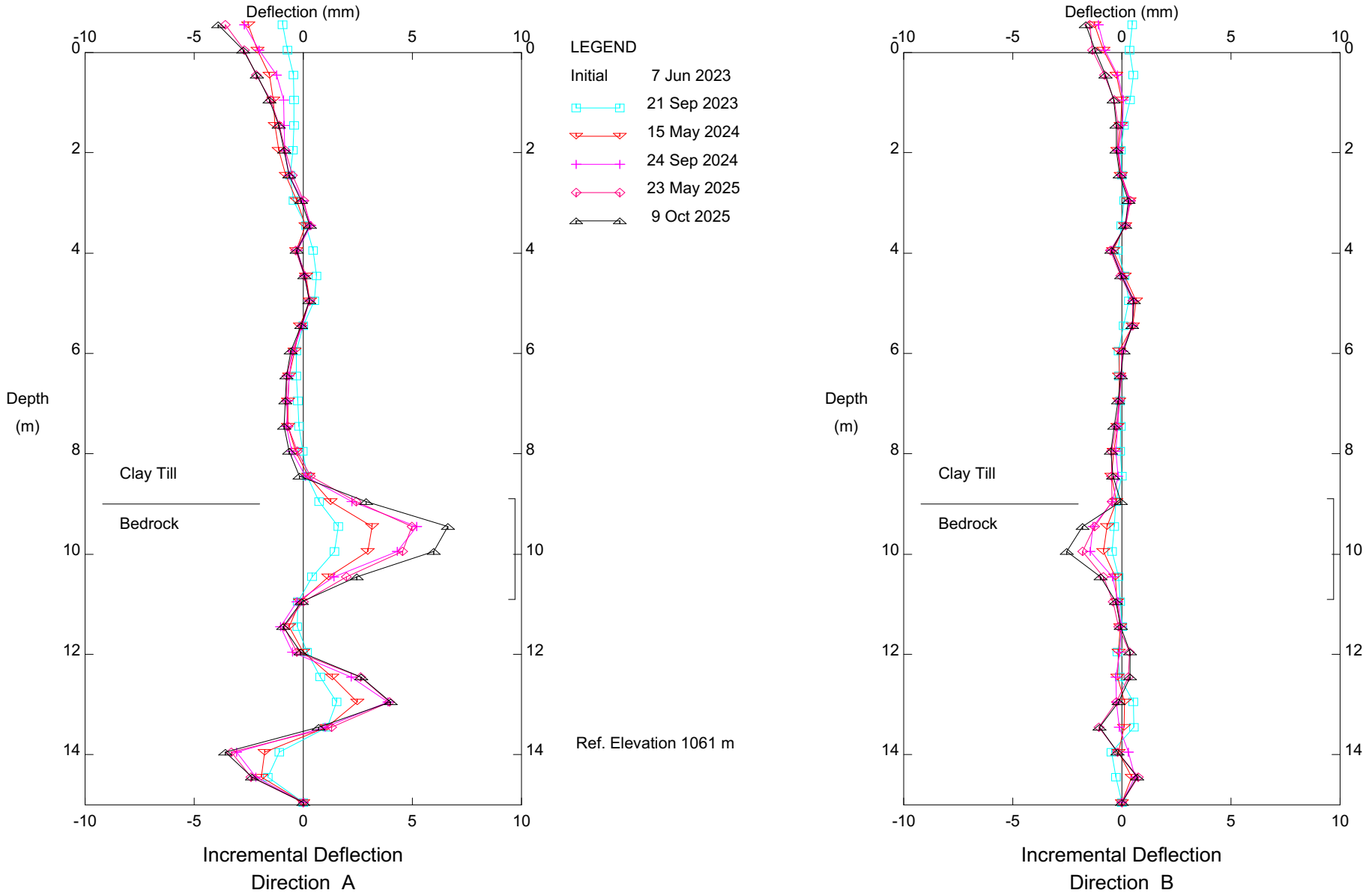

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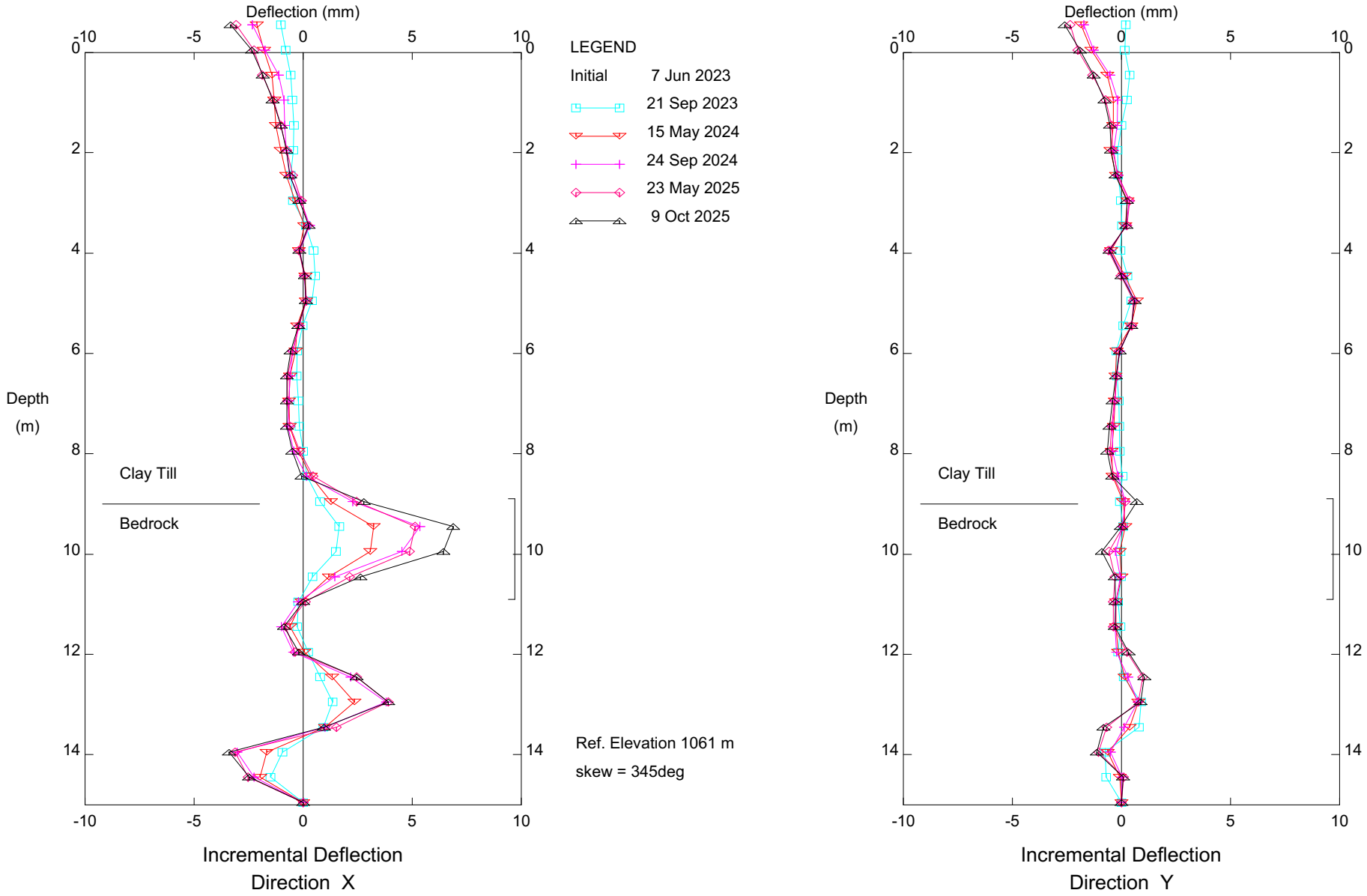

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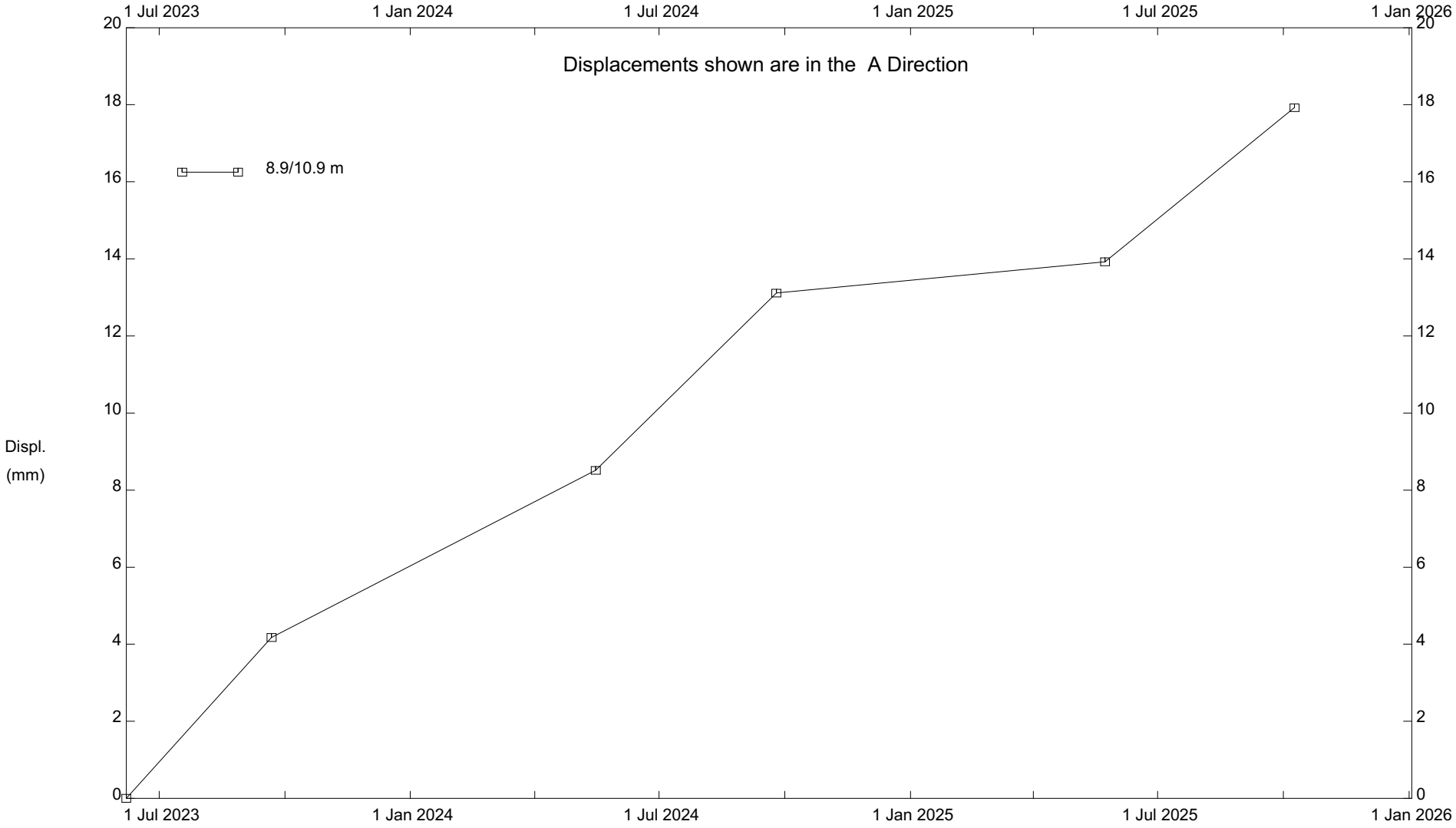

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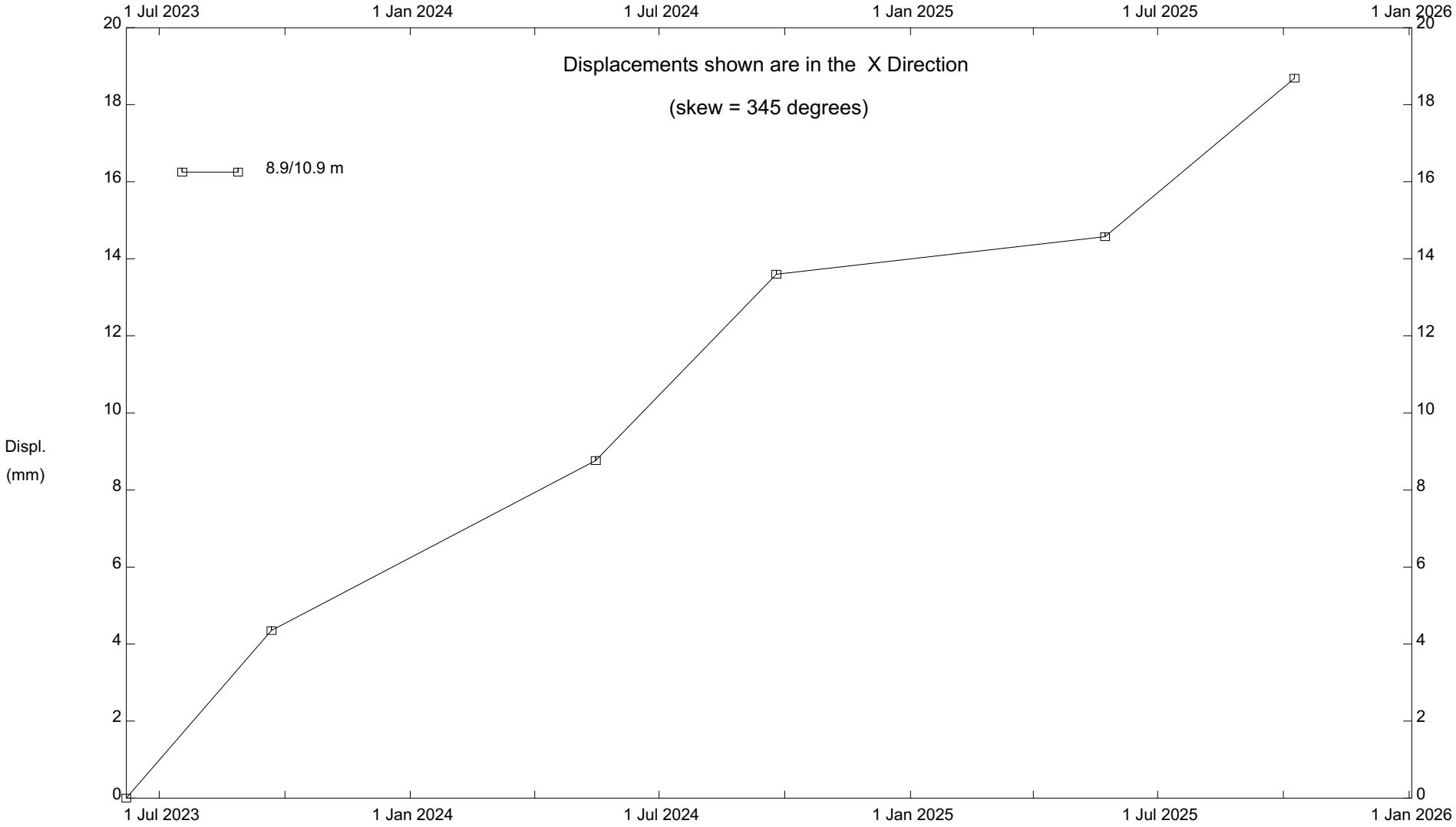

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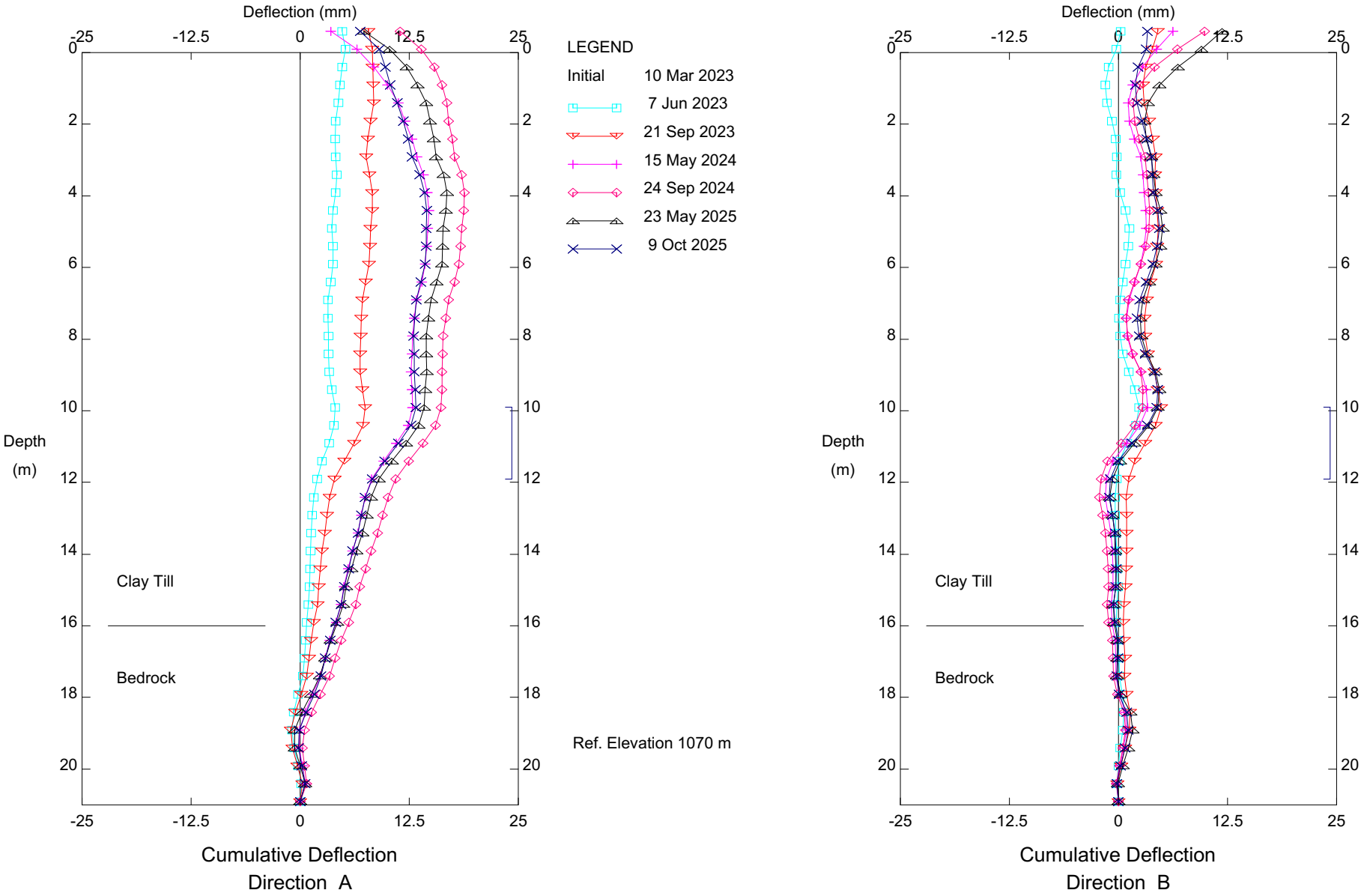

S039 West Brocket Slide, Inclinometer SI 23-03

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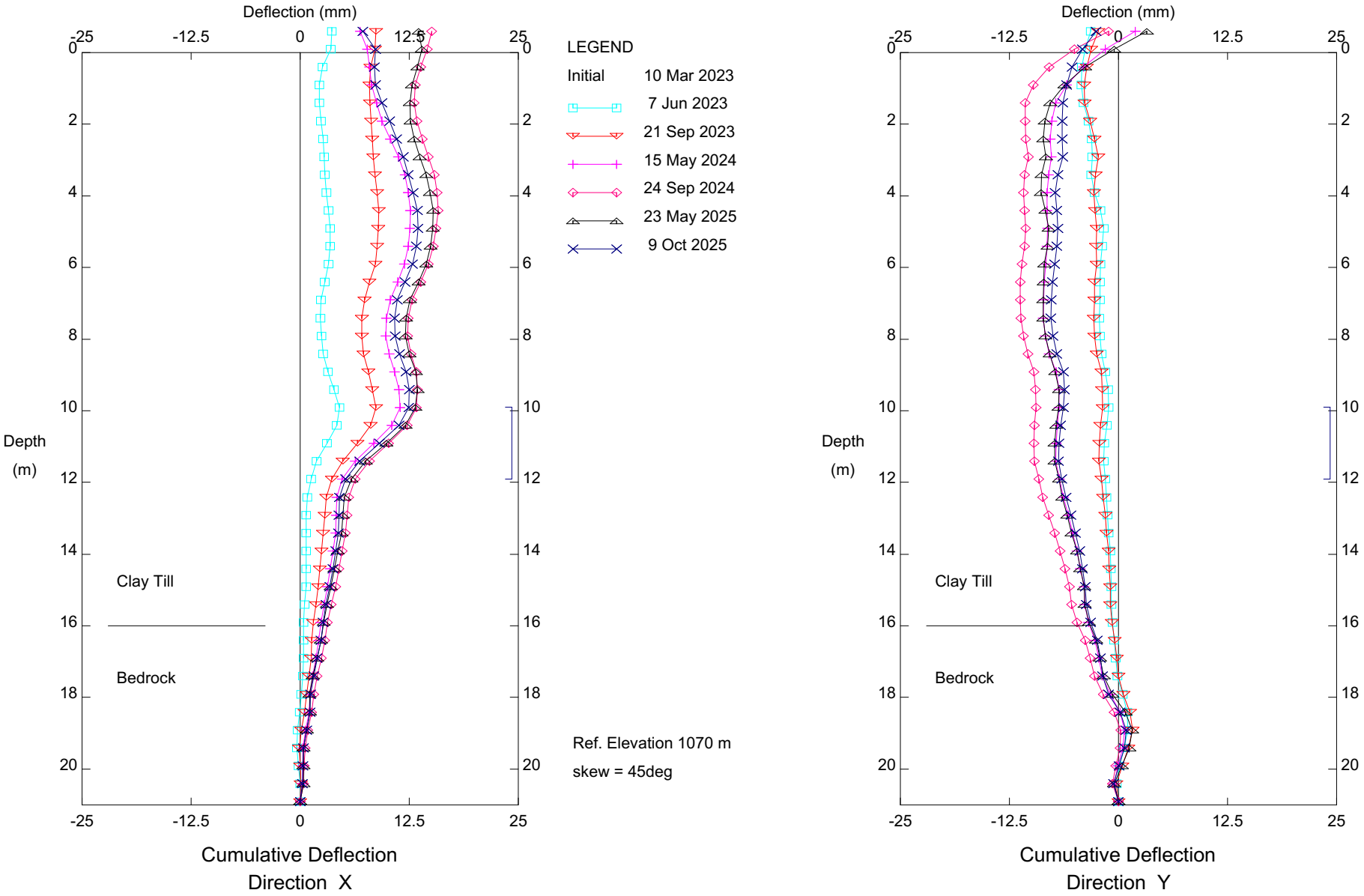

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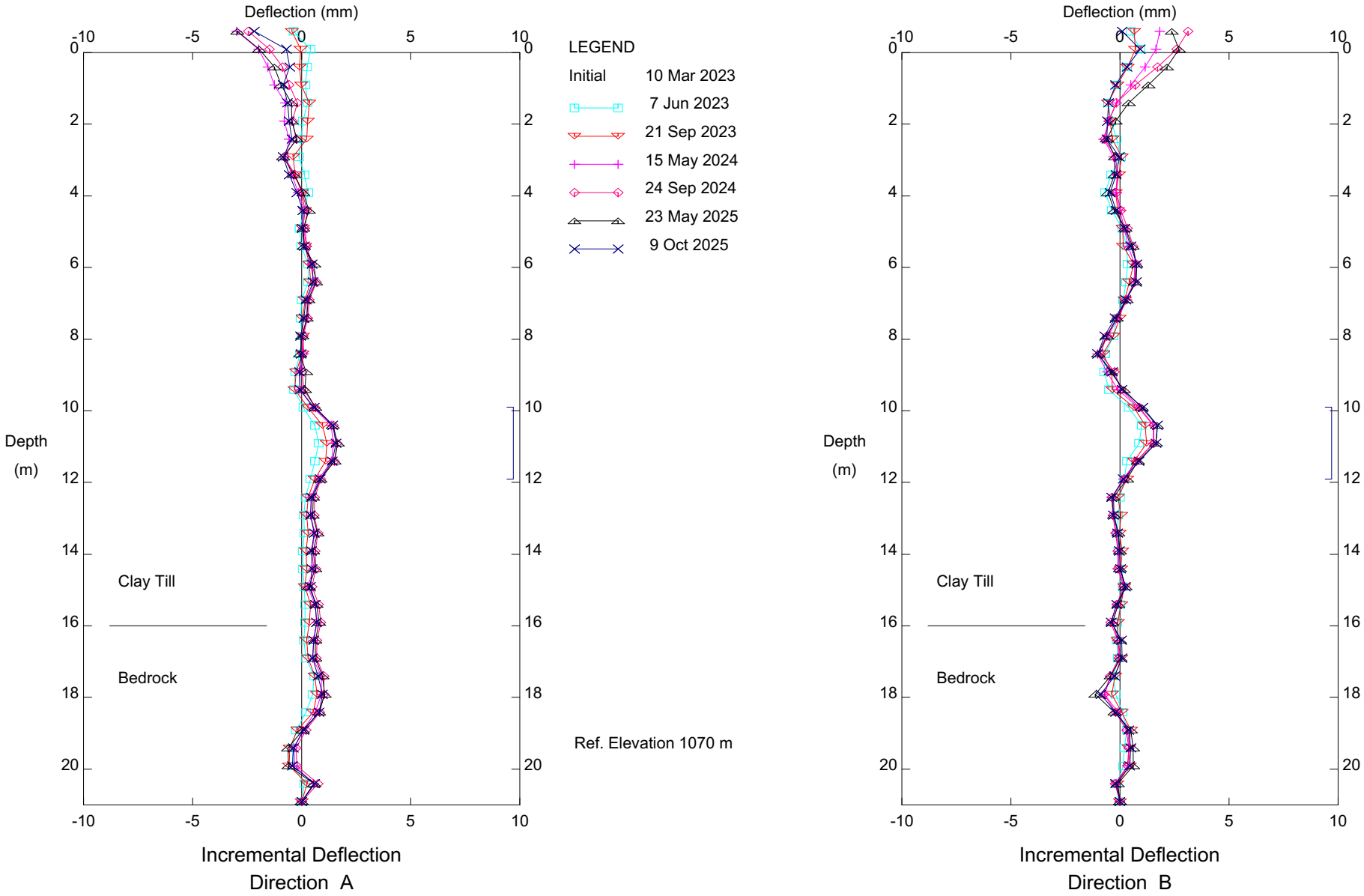

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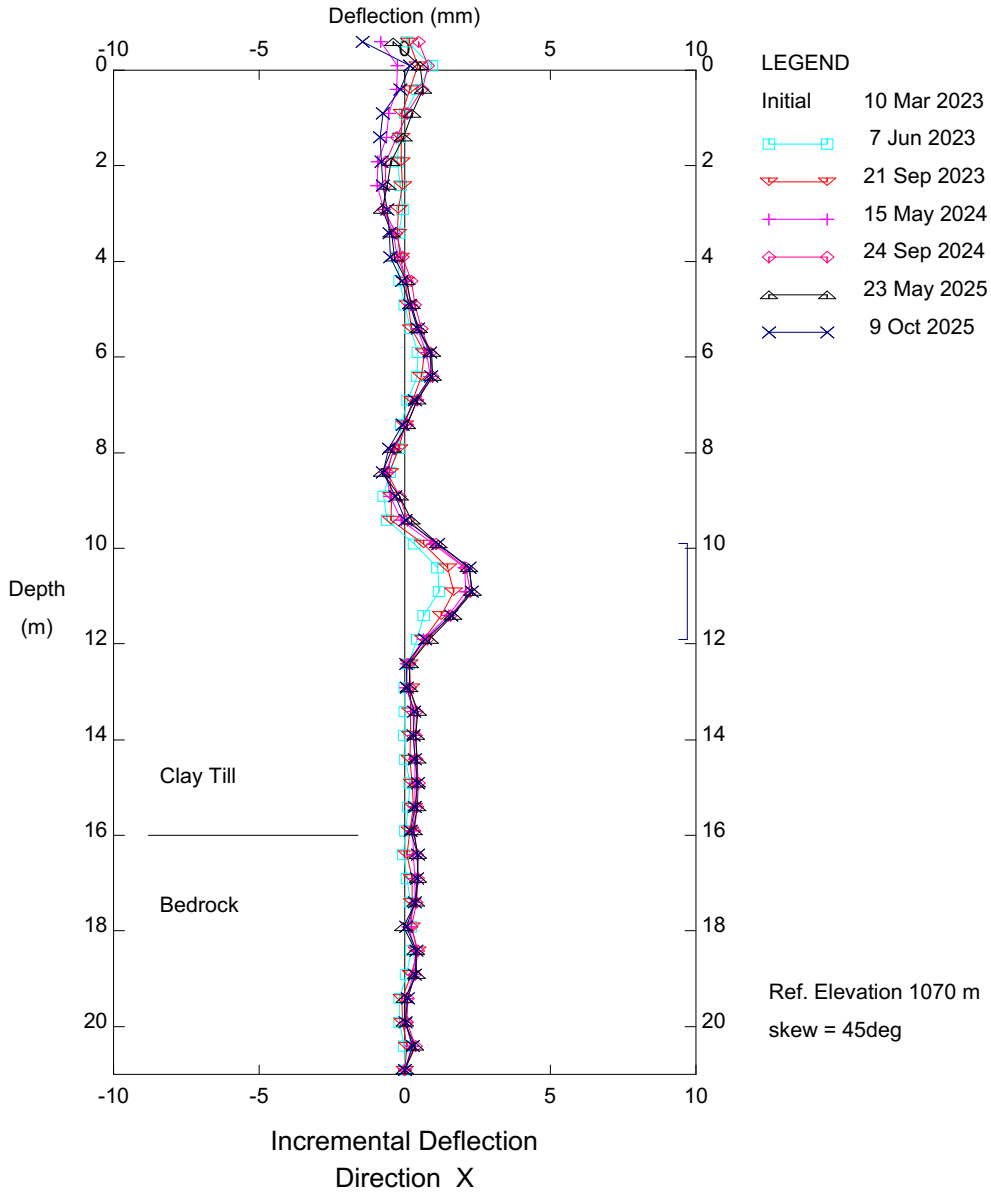

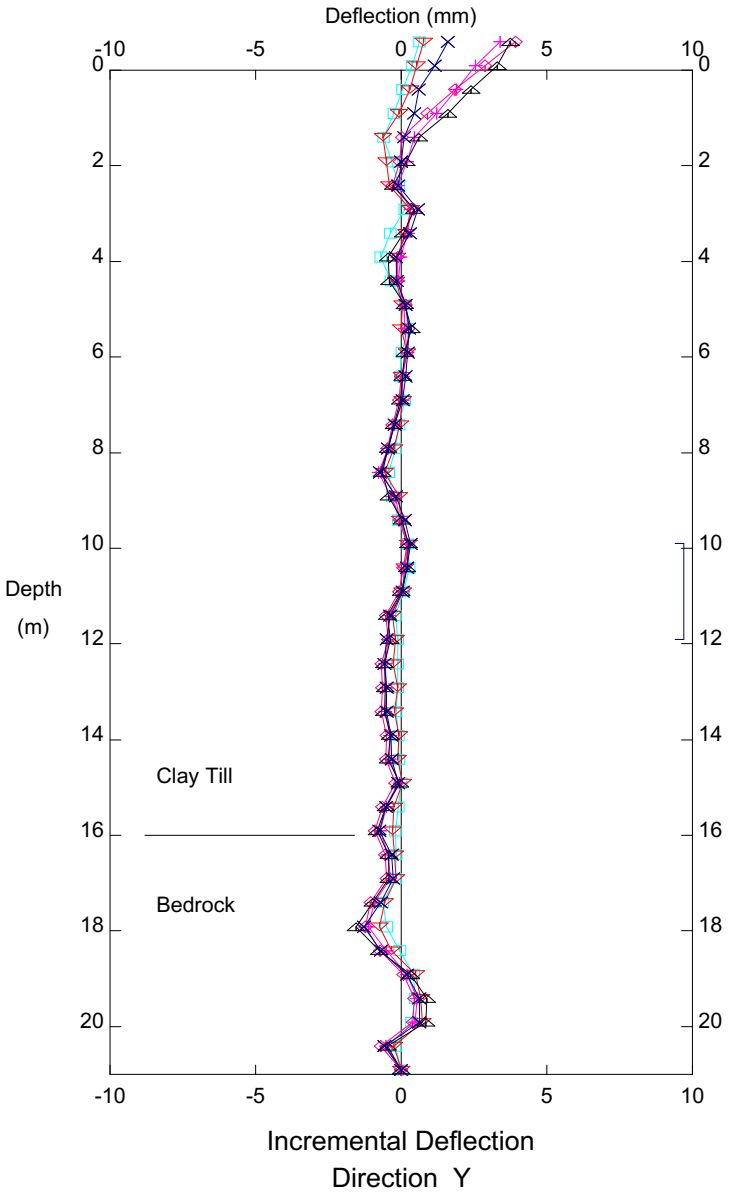

S039 West Brocket Slide, Inclinometer SI 23-03

Alberta Transportation

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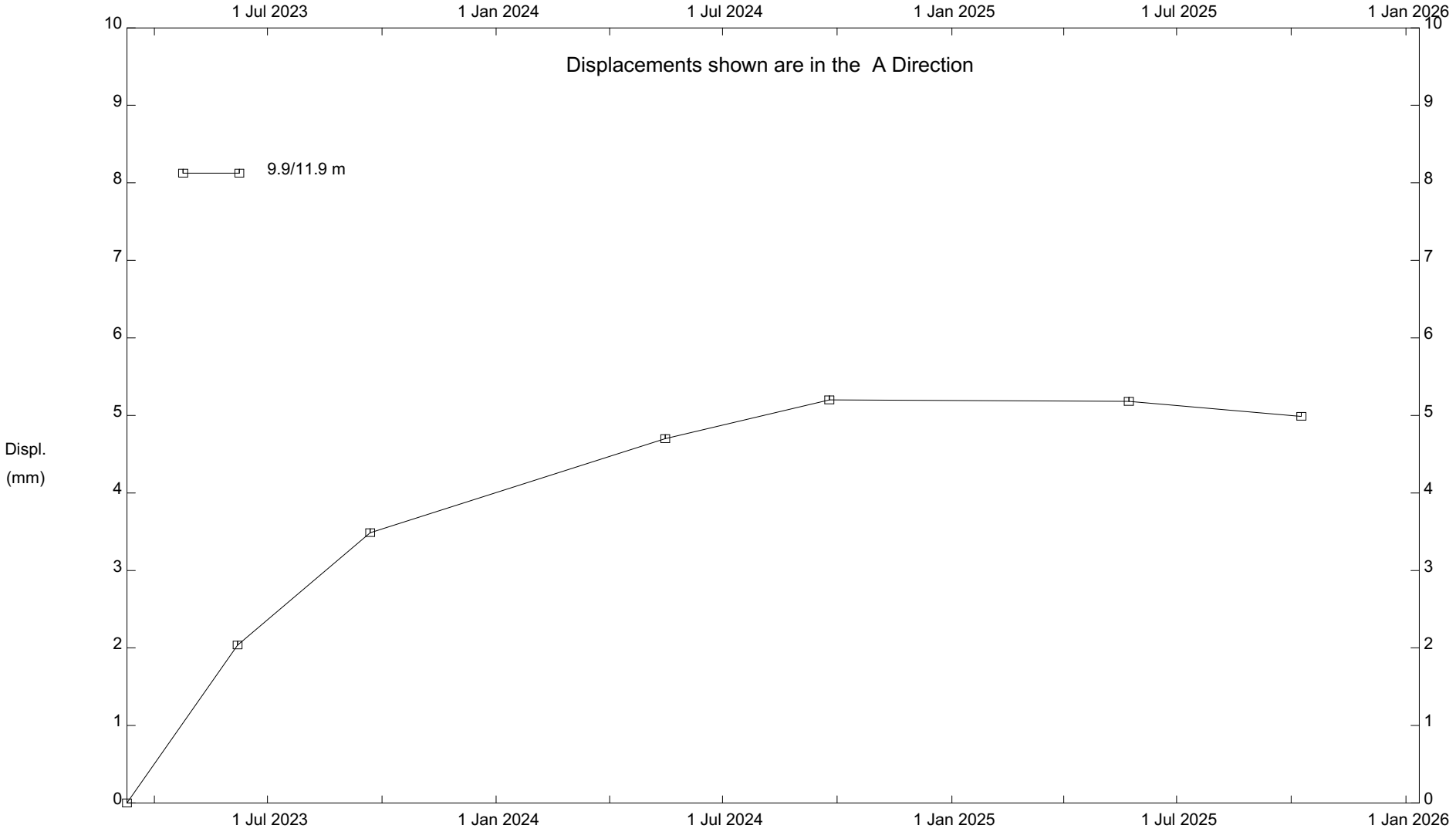

S039 West Brocket Slide, Inclinometer SI 23-03

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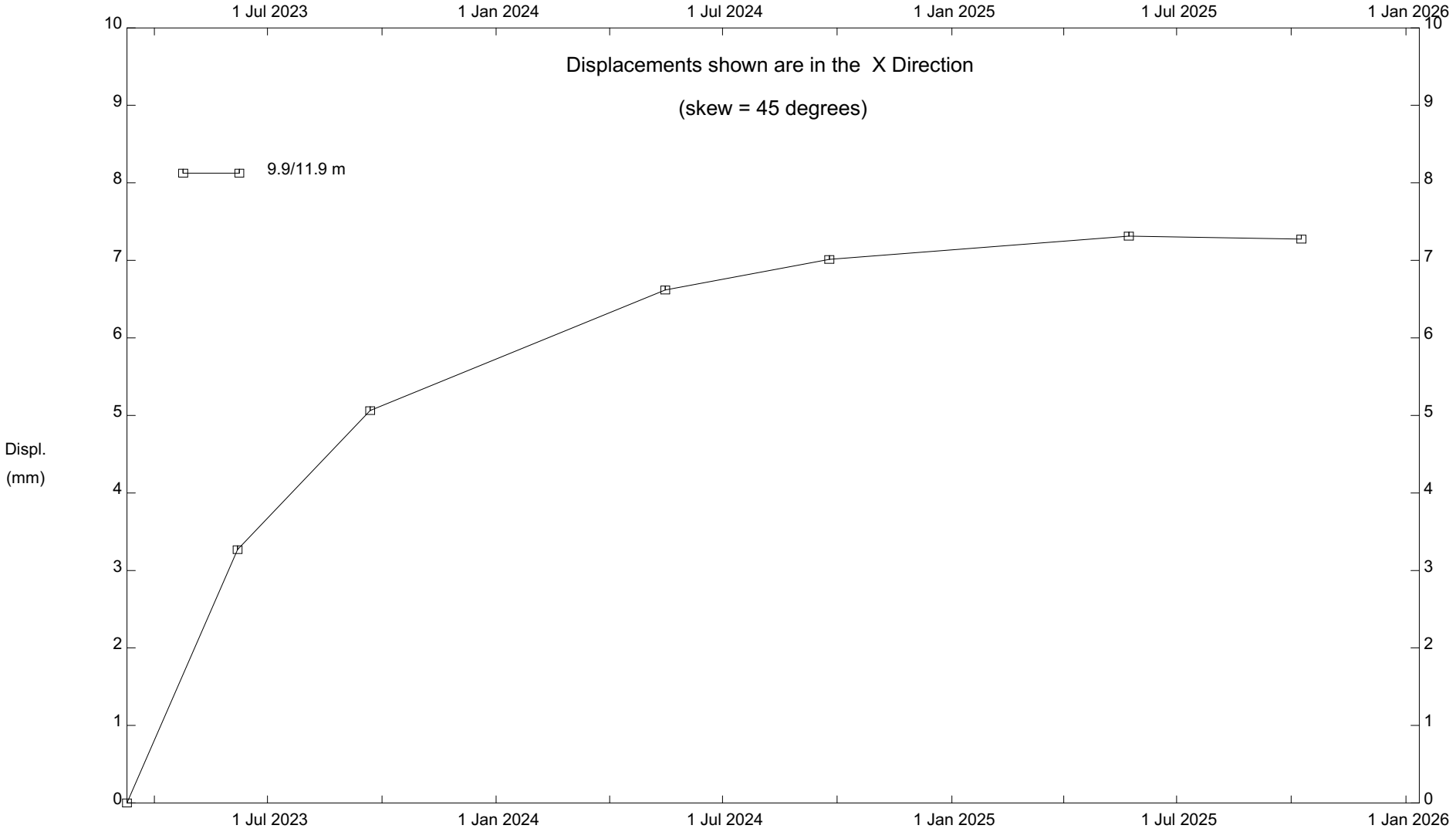

S039 West Brocket Slide, Inclinometer SI 23-03

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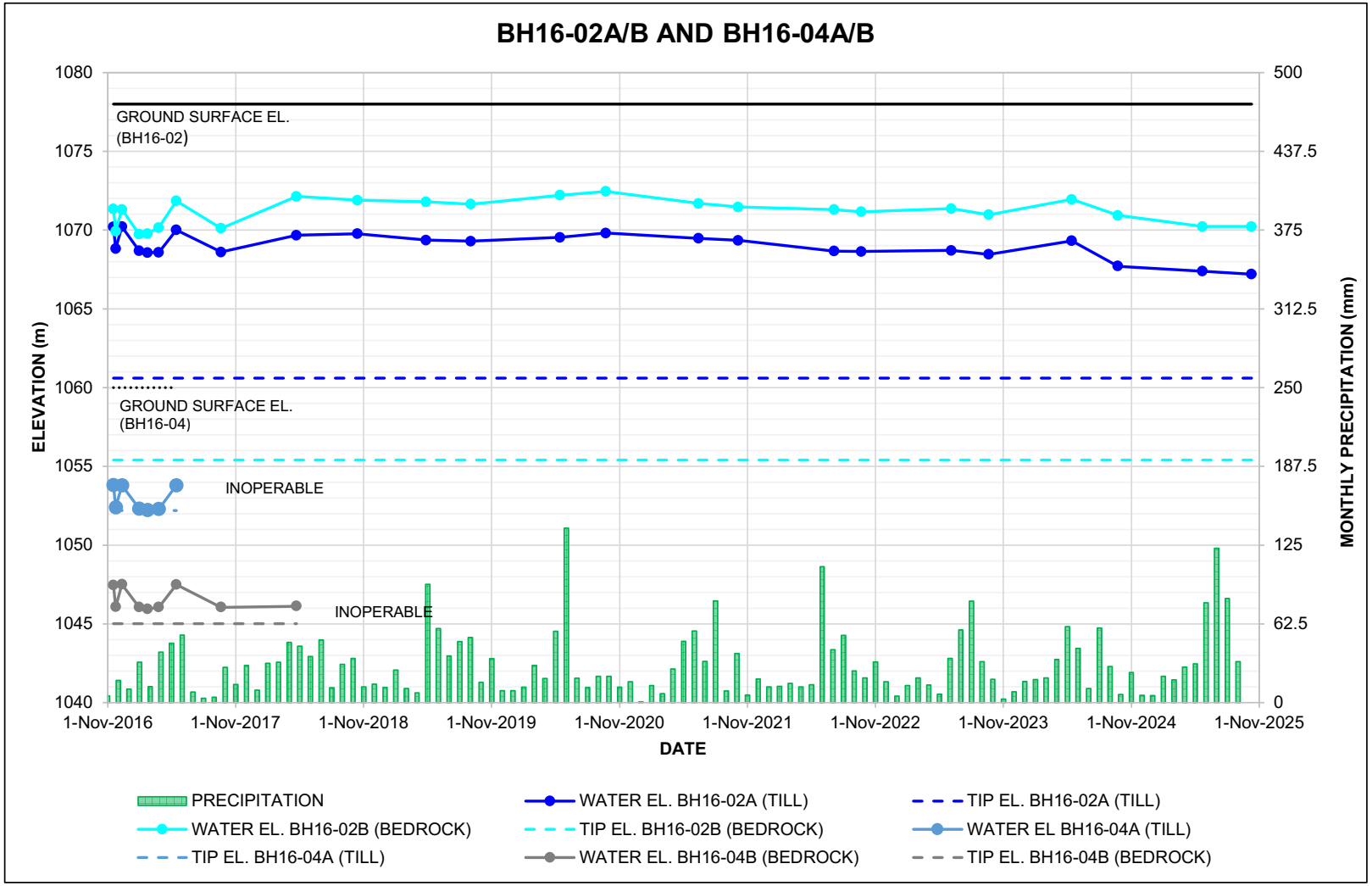

NOTES:
1. MONTHLY PRECIPITATION DATA OBTAINED FROM THE ALBERTA CLIMATE INFORMATION SERVICE (ACIS) DATABASE, REFERENCING BROCKET AGDM STATION.
2. BAROMETRIC PRESSURE DATA OBTAINED FROM THE ALBERTA CLIMATE INFORMATION SERVICE (ACIS) DATABASE, REFERENCING PINCHER CREEK STATION.

CLIENT: Alberta

Klohn Crippen Berger

PROJECT: SOUTHERN REGION GEOHAZARD RISK MANAGEMENT PROGRAM

TITLE: Piezometer Data
S039 - West Brocket Slide
Hwy 03:06 km 12.952

SCALE

PROJECT No. A05116A03

FIG No.