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 GP016; H666:02, km 34.837 Slide 2 km West of Hwy 40 and Hwy 666 Junction
Section C – 2024 Spring Readings

1 GENERAL

Three slope inclinometers (SIs) (SI-1, SI-2, and SI-41), one vibrating wire piezometer (VWP) (VW14-55A), five pneumatic piezometers (PNs) (PN-13A/B, PN-51A/B, PN-52B), and two standpipe piezometers (SPs) (SP14-51 and SP14-54) were read at the GP016 site in the Peace Region (Grande Prairie District – South) (GP South Region) on May 24, 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 site is located on Hwy 666:02, km 34.837, 2 km west of Hwy 40 and Hwy 666 junction. The approximate site coordinates are 6103361 N, 383748 E (UTM Zone 11, NAD 83). A site plan is presented on Figure 1.

The geohazard at the GP016 site consists of three landslides (Sites 1 through 3) along the south slope of the Wapiti River Valley. Site 1 is the middle landslide, while Sites 2 and 3 are on the east and west sides of the site, respectively. It is noted that the entire south slope of the Wapiti River Valley is a sliding zone.

Previous remedial actions completed at the GP016 site include regular milling and paving, with milling and paving being completed in both 2020 and 2021. This site is currently being returned to gravel.

Between 1989 and 2014, several geotechnical site investigations, which included installing instruments, were conducted by the previous consultants. The encountered stratigraphy has not been provided to KCB.

Klohn Crippen Berger Ltd.
109, 4208 87 St NW ▪ Edmonton AB T6E 5Z9 ▪ Canada
t 780.444.0706 ▪ www.klohn.com

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.

Between 1989 and 2014, several SIs and piezometers were installed by the previous consultants to monitor the depth of movement and groundwater conditions, respectively. Many of these instruments are now inoperable (e.g., sheared, destroyed, or lost), as detailed in Table 1.1 (see table notes).

A reading could not be obtained from PN-52A in spring 2024. Prior to spring 2021, this instrument was dry, but the three readings obtained between spring 2021 and spring 2023 were several meters above tip elevation and up to 2 m about ground surface elevation. The readings above tip elevation were likely an indication the instrument was malfunctioning or failing due to age (installed in 2003). Attempts to repair this instrument have been unsuccessful and this instrument will no longer be read.

PN-51A appears to be damaged. A 6.4 m was increase recorded in this instrument between fall 2020 and spring 2022 followed by an 8.4 m decrease between spring 2022 and spring 2024. During the spring 2022 and spring 2024 readings, the porewater pressures recorded in PN-51A were above ground surface and near the tip elevation of the instrument, respectively. The readings above ground surface and near tip elevation were likely an indication the instrument was malfunctioning or failing due to age (installed in 2003). KCB will attempt to repair this instrument once more during the fall 2024 reading.

The instruments are protected by above-ground casing protectors.

The operable SIs were read using the same metric RST Digital MEMS Inclinometer System that has been used to read the SIs since KCB took over the readings in June 2021. The operable VWPs, PNs, and SPs were read using an RST VW2106 vibrating wire readout, RST C109 pneumatic piezometer readout box, and Heron Water Level Meter, respectively.

Table 1.1 Instrumentation Installation Details [1]

Instrument ID	Instrument Type	Date Installed	UTM Coordinates (m)		Ground Surface Elevation (m)	Stick Up (m)	Depth (mbgs[2])	Condition
			Northing	Easting				
SI-1	SI	Feb. 19, 1997	6102779	383229	668.6	0.8	59.5	Operable
SI-2	SI	Feb. 19, 1997	6102788	383279	668.5	0.8	59.5	Operable
~~SI-3~~	~~SI~~	~~Unknown~~	~~Unknown~~	~~Unknown~~	~~Unknown~~	~~Unknown~~	~~Unknown~~	~~Inoperable~~
~~SI-13~~	~~SI~~	~~Jun. 19, 1989~~	~~6103089~~	~~383338~~	~~Unknown~~	~~0.8~~	~~22.9~~	~~Inoperable[3]~~
SI-41	SI	May 09, 1995	6103289	383731	570.1	1.1	19.6	Operable
~~SI-51~~	~~SI~~	~~Unknown~~	~~Unknown~~	~~Unknown~~	~~Unknown~~	~~Unknown~~	~~Unknown~~	~~Inoperable~~
~~SI-52~~	~~SI~~	~~Dec. 06, 2003~~	~~Unknown~~	~~Unknown~~	~~Unknown~~	~~Unknown~~	~~Unknown~~	~~Inoperable[3]~~
~~SI-53~~	~~SI~~	~~Dec. 06, 2003~~	~~Unknown~~	~~Unknown~~	~~Unknown~~	~~Unknown~~	~~Unknown~~	~~Inoperable[3]~~
PN-13A	PN	Jun. 06, 2001	6103088	383338	594.6	N/A	4.6	Operable
PN-13B	PN	Jun. 06, 2001	6103088	383338	594.6	N/A	18.3	Operable
~~PN-51A~~	~~PN~~	~~Dec. 06, 2003~~	~~6103441~~	~~383704~~	~~554.2~~	~~N/A~~	~~7.6~~	~~Inoperable[4]~~
PN-51B	PN	Dec. 06, 2003	6103441	383704	554.2	N/A	10.7	Operable
~~PN-51C~~	~~PN~~	~~Dec. 06, 2003~~	~~6103441~~	~~383704~~	~~554.2~~	~~N/A~~	~~18.0~~	~~Inoperable~~
~~PN-52A~~	~~PN~~	~~Dec. 06, 2003~~	~~6103499~~	~~383723~~	~~548.8~~	~~N/A~~	~~4.9~~	~~Inoperable[4]~~
PN-52B	PN	Dec. 06, 2003	6103499	383723	548.8	N/A	17.4	Operable
~~PN14-51~~	~~PN~~	~~Oct. 08, 2014~~	~~6102924~~	~~382899~~	~~630.2~~	~~N/A~~	~~15.2~~	~~Inoperable~~
~~PN14-52~~	~~PN~~	~~Oct. 11, 2014~~	~~6102955~~	~~382905~~	~~623.4~~	~~N/A~~	~~14.0~~	~~Inoperable~~
~~VW14-51~~	~~VWP~~	~~Oct. 08, 2014~~	~~Unknown~~	~~Unknown~~	~~631.2~~	~~N/A~~	~~30.5~~	~~Inoperable~~
~~VW14-53~~	~~VWP~~	~~Oct. 16, 2014~~	~~Unknown~~	~~Unknown~~	~~616.9~~	~~N/A~~	~~15.2~~	~~Inoperable~~
VW14-55A	VWP	Oct. 18, 2014	6102966	382935	621.7	N/A	12.2	Operable
SP14-51	SP	Oct. 21, 2014	6102924	382899	631.2	0.9	6.5	Operable
SP14-54	SP	Oct. 23, 2014	6102932	382934	627.0	0.8	6.4	Operable

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] SI-13, SI-52, and SI-53 have sheared at an approximate depth of 16.0 m, 18.9 m, and 4.9 m below ground surface, respectively.

[4] During the spring 2024 reading, PN-51A was near tip elevation and PN-52A did not provide a reading. Previous readings indicate these instruments were possibly malfunctioning or failing due to age.

INTERPRETATION

1.2 General

For the operable SIs, the cumulative displacement, incremental displacement, and displacement-time data was plotted in the A-direction (i.e., the direction of the A0-groove) and, where applicable, the X-direction (i.e., the direction of maximum movement obtained at a skew angle from the A0-grooves). SI-41 has a skew angle of 351°, measured clockwise from the direction of the A0-grooves.

For the operable PNs and VWPs, 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.

For the operable SPs, the water level data was plotted relative to ground surface elevation and the screen 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 through Table 2.4, respectively.

Table 2.1 Slope Inclinometer Reading Summary

Instrument ID	Date				Ground Surface Elevation[1] (m)	Depth of Movement (mbgs[1])	Direction of Movement, Skew Angle[2]	Movement (mm)				Rate of Movement (mm/year)		
	Initialized (Re-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
								Before Re-Initialization	After Re-Initialization	Total				
SI-1	Feb. 19, 1997 (Jun. 27, 2021)	N/A	Jun. 06, 2023	May 24, 2024	668.6	N/A – no discernible movement recorded								
SI-2	Feb. 19, 1997 (Jun. 27, 2021)	N/A	Jun. 23, 2023	May 24, 2024	668.5	N/A – no discernible movement recorded								
SI-41	May 09, 1995	Jun. 20, 2022	Jun. 23, 2023	May 24, 2024	570.1	0.1 - 3.1	X-direction, 351°	58.4			1.2	5.7	1.8	2.4

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

Table 2.2 Pneumatic 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)
PN-13A	Jun. 06, 2001	Jun. 06, 2023	May 24, 2024	594.6	4.6	N/A –instrument was dry	4.5	0.1 above tip
PN-13B	Jun. 06, 2001	Jun. 06, 2023	May 24, 2024	594.6	18.3	6.6	6.4	0.2
PN-51B	Dec. 06, 2003	Jun. 06, 2023	May 24, 2024	554.2	10.7	6.9	7.4	-0.5
PN-52B	Dec. 06, 2003	Jun. 06, 2023	May 24, 2024	548.8	17.4	15.4	15.5	-0.1

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

Table 2.3 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)
VW14-55A	Oct. 18, 2014	Jun. 06, 2023	May 24, 2024	621.7	12.2	5.6	5.9	-0.3

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

Table 2.4 Standpipe Piezometer Reading Summary

Instrument ID	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)
SP14-51	Oct. 21, 2014	Jun. 06, 2023	May 24, 2024	631.2	6.5	2.2	2.0	0.2
SP14-54	Oct. 23, 2014	Jun. 06, 2023	May 24, 2024	627.0	6.4	4.7	5.7	-1.0

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

In 2021, KCB reviewed the instrumentation data provided by the previous consultant and removed corrections applied to the historical SI data based on our experience. The instrumentation data obtained by KCB is generally consistent with the data obtained by the previous consultant, except for the following:

- For SI-1, the data is relatively noisy and the readings after 2021 do not line up well with the previous consultants' readings. To improve our ability to interpret the data, we have re-initialized this instrument to the June 2021 readings. Only the re-initialized plots are included in Appendix I.
- For SI-2, the previous consultant was copying the bottom eight readings (4 m) for each subsequent reading instead of using the data obtained in the field. Without this correction, there is a "kick-out" at the base of the instrument when compared to the previous readings. With the replacement readings, KCB's readings are relatively consistent with the previous readings. However, to improve our ability to interpret the data, we have re-initialized this instrument to the June 2021 readings. Only the re-initialized plots are included in Appendix I.

In general, the data for SI-1 and SI-2 is noisy and difficult to interpret. Based on the absolute plots for these instruments, they have several kinks and tilts up to 1.0 m.

The SI data plots presented herein include data for readings taken with both the previous consultants' and KCB's SI reading equipment.

1.3 Zones of Movement

No defined zones of discernible movement have been recorded in SI-1 and SI-2 since installation. These instruments are installed at the valley crest of Site 1, upslope (south) of the highway.

Before shearing between the spring 2021 and spring 2022 readings, distributed movement was recorded in SI-13 from an approximate depth of 1.5 m to 5.0 m below ground surface (elevation 588.5 m to 593.0 m). Another less pronounced zone of movement was also recorded from approximately 15.0 m to 16.0 m below ground surface (elevation 579.0 m and 578.0 m). This instrument is installed on the valley slope of Site 1, downslope (north) of the highway. Between 2017 and late-2021/early-2022, when the instrument sheared, movement rates up to approximately 25 mm/year and 28 mm/year were recorded.

In SI-41, which is installed upslope (south) of the highway at Site 2, distributed movement is being recorded from ground surface to an approximate depth of 2.1 m below ground surface (elevation 570 m to 568 m).

1.4 Interpretation of Monitoring Results

Since June 2009, the rate of movement recorded in SI-41has been slow (less than 4 mm/year). The pavement distress observed at Site 2 does not appear to be reflected in the data obtained from SI-41, which is installed upslope (south) of the highway.

The spring 2024 readings for most of the piezometers (SP14-51, SP14-54, PN-13A, PN-13B, PN-51B, PN52-B, and VW14-55A) are relatively consistent with previous readings for these instruments. Water levels/porewater pressures recorded in these instruments have historically fluctuated, likely in response to seasonal variations in precipitation and freshet infiltration.

2 RECOMMENDATIONS

2.1 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) and as part of the GP South GRMP Section B inspections.

Since SI-13 was the last active SI at Site 1, it could be replaced. TEC should consider a change detection annual assessment for this slope using LiDAR or InSAR. Such an assessment would help provide a wider perspective assessment on where movements are occurring across the slope and may offer some opportunities to assess the influence of toe-of-slope movements and associated time-lag effects to when the slope movements affect the highway surface. Alternatively, TEC could use the GP016 site as a trial site for low-cost differential GPS monitoring if the risk of equipment loss or damage is acceptable.

2.2 Instrument Repairs and Maintenance

No instrument repairs or maintenance is required.

3 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.

PROFESSIONAL ENGINEER ALBERTA
COURTNEY E. MULHALL
2024 Jul. 15
APEGA ID#: 153449

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

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

CM/TH/GB:bb

PERMIT TO PRACTICE
KLOHN CRIPPEN BERGER LTD.
RM SIGNATURE:
RM APEGA ID #: 58463
DATE: July 16 2024
PERMIT NUMBER: P009196
The Association of Professional Engineers and Geoscientists of Alberta (APEGA)

ATTACHMENTS
Figure
Appendix I Instrumentation Plots

FIGURE

Legend

- Approximate Pneumatic Piezometer (PN) Location
- Approximate Slope Inclinometer (SI) Location
- Approximate Standpipe Piezometer (SP) Location
- Approximate Vibrating Wire Piezometer (VW) Location
- Flow Direction
- Scarp
- Culvert
- Site Extent

0 150 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. INSTRUMENT LABELS THAT ARE INDICATED WITH STRIKE THROUGH TEXT ARE INOPERABLE. INSTRUMENTS INOPERABLE PRIOR TO 2021 NOT SHOWN.

CLIENT: Alberta

Klohn Crippen Berger

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

TITLE: Site Plan
GP016 - Slide 2km W. of Hwy 40 and Hwy 666 Junction
Hwy 666:02, km 34.837

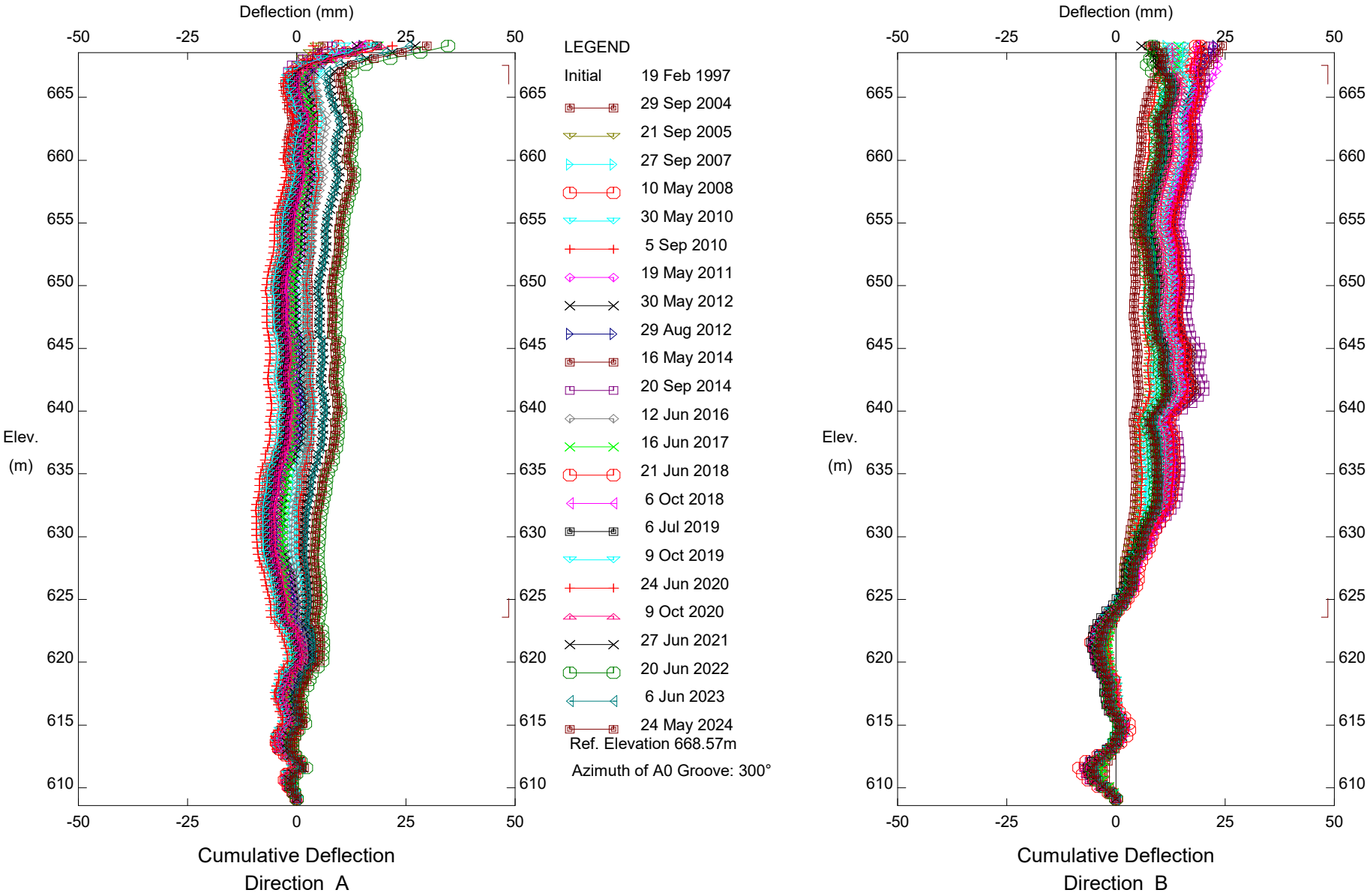
SCALE	PROJECT No.	FIG No.
1:5,000	A05116A01	1

File: Z:\AE\EDM\A05116A01 ABT Grande Prairie South GRMP\400 Drawings\GIS\MXD\2023\Section B\ABT_GPSouth_SectionB_230619\ABT_GPSouth_SectionB_230619.aprx Date: Time: Creator: AShipton

APPENDIX I

Instrumentation Plots

Klohn Crippen Berger - Edmonton

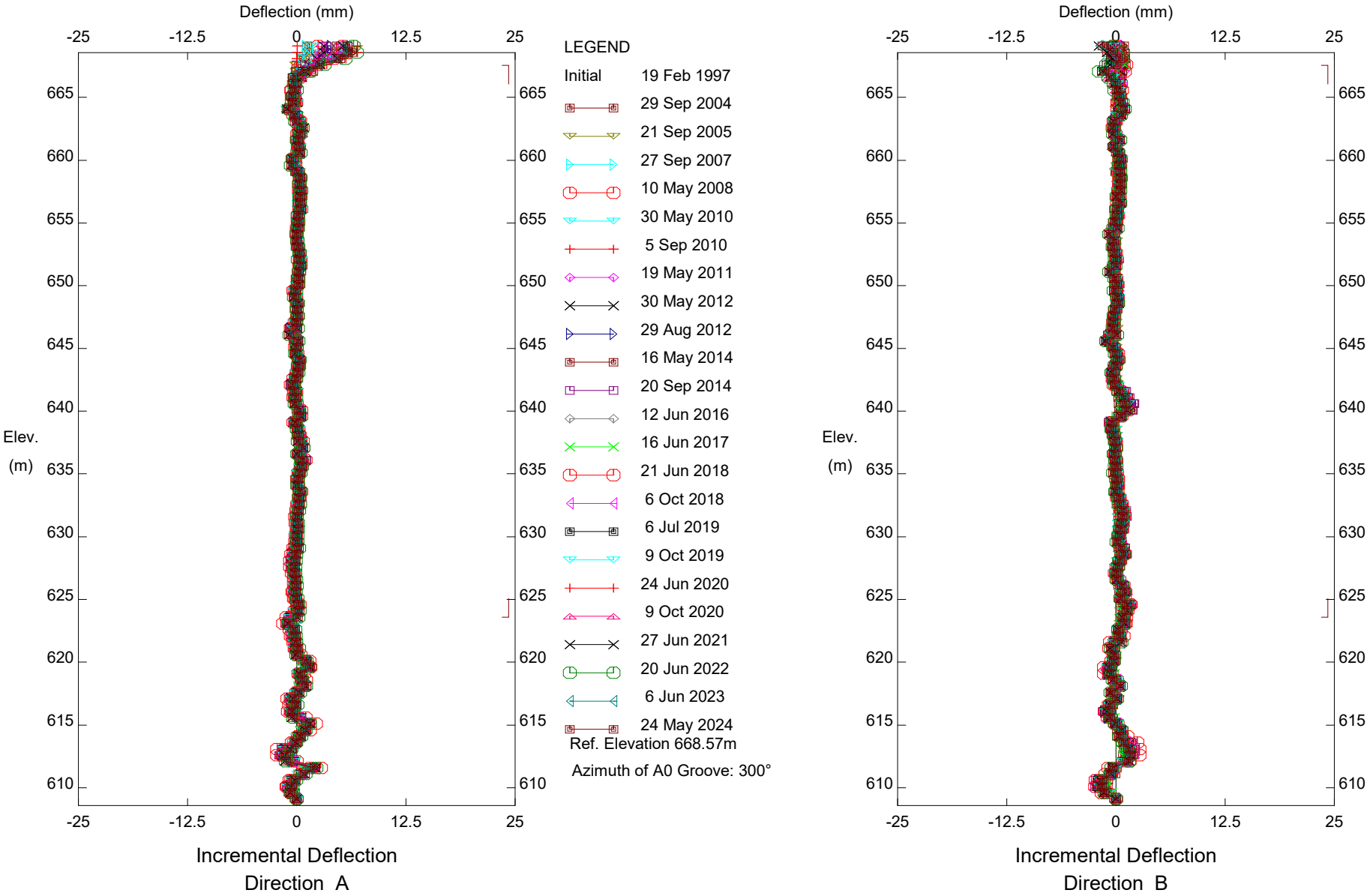


GP016; H666:02 Slide 2 km West of Hwy 40, Inclinometer SI-1

Alberta Transportation

GP016; H666:02, 2 km West of Hwy 40 and Hwy 666 Junction

Klohn Crippen Berger - Edmonton

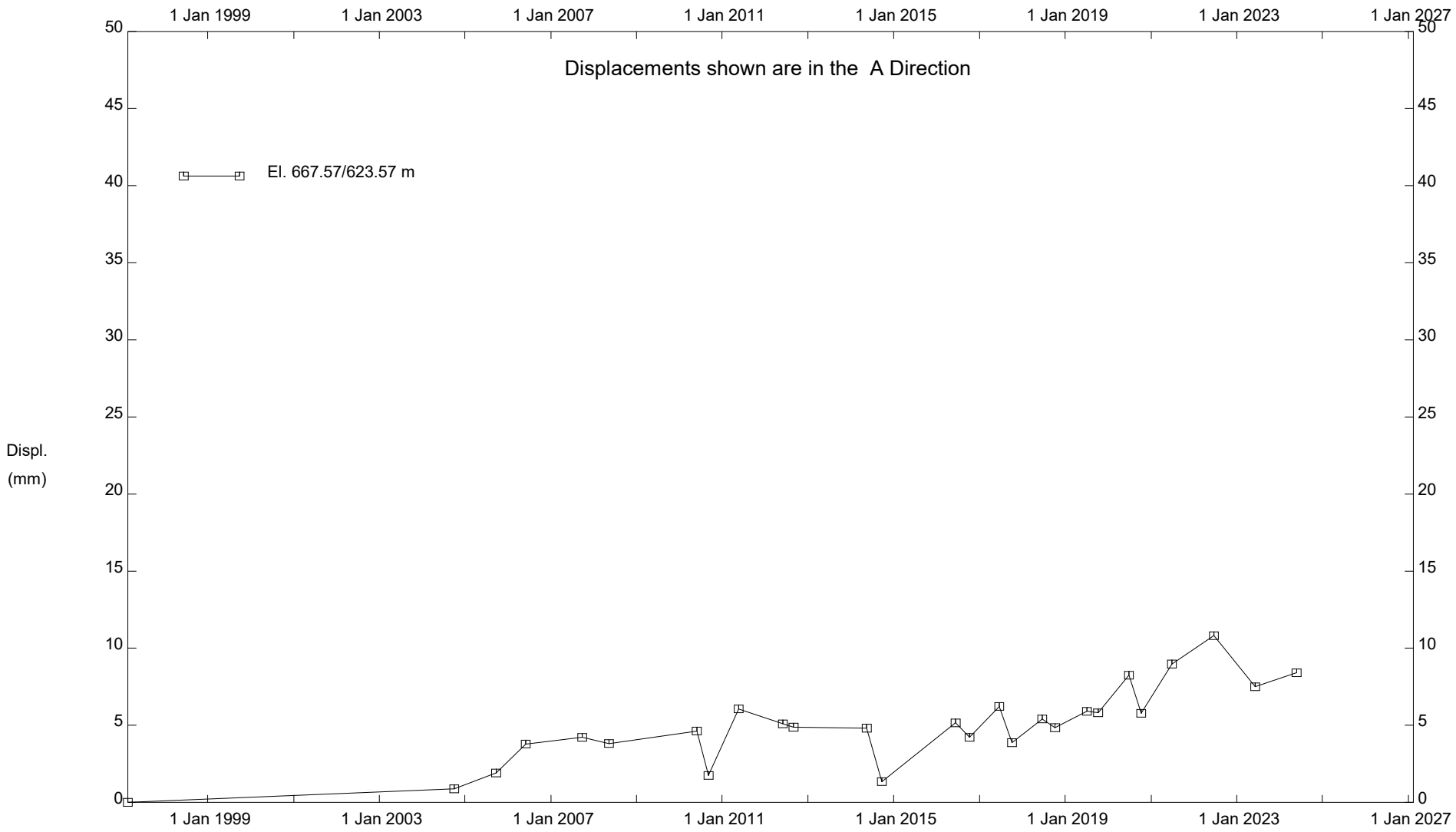


GP016; H666:02 Slide 2 km West of Hwy 40, Inclinometer SI-1

Alberta Transportation

GP016; H666:02, 2 km West of Hwy 40 and Hwy 666 Junction

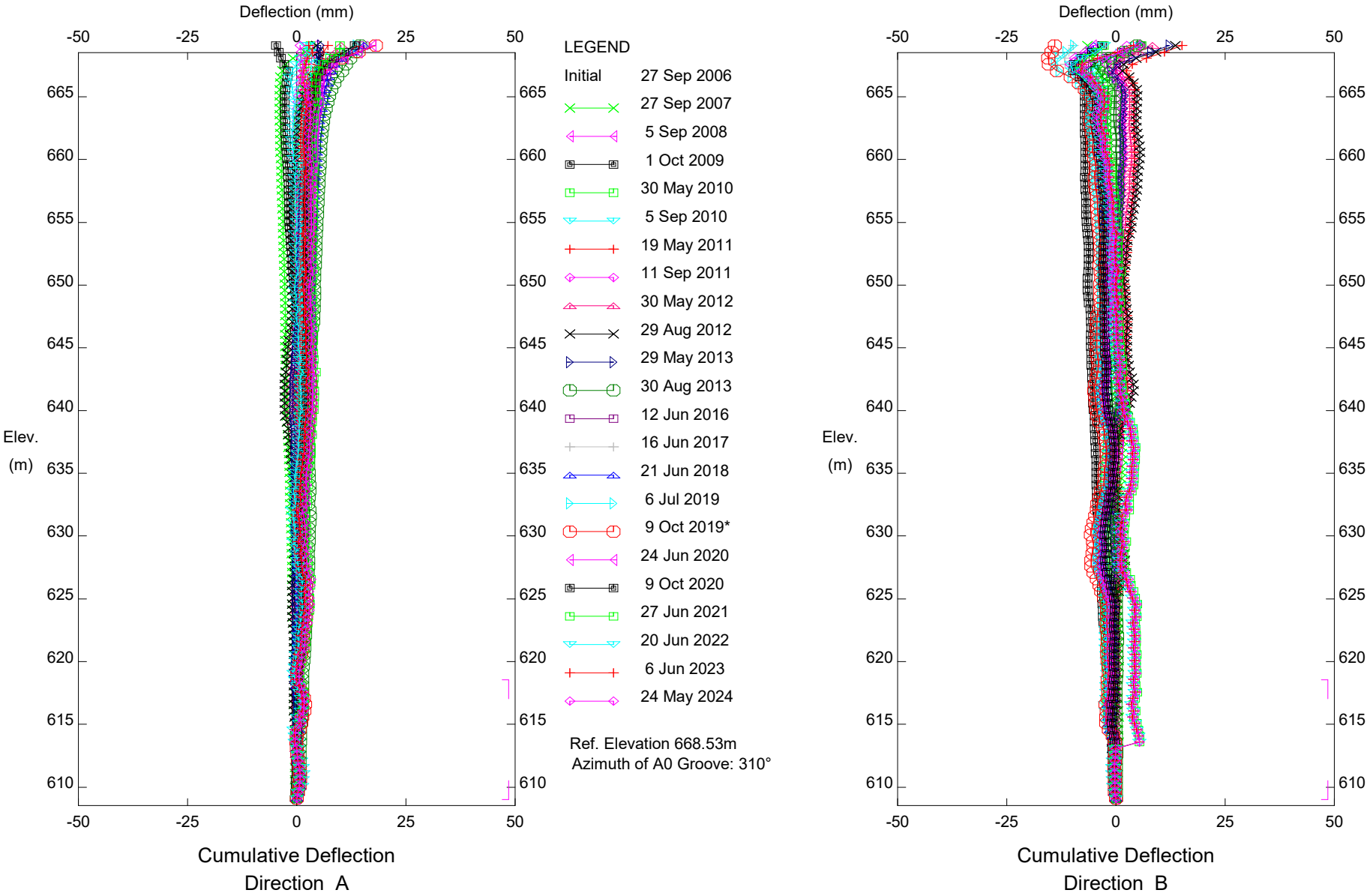
Klohn Crippen Berger - Edmonton



GP016; H666:02 Slide 2 km West of Hwy 40, Inclinometer SI-1

Alberta Transportation

Klohn Crippen Berger - Edmonton



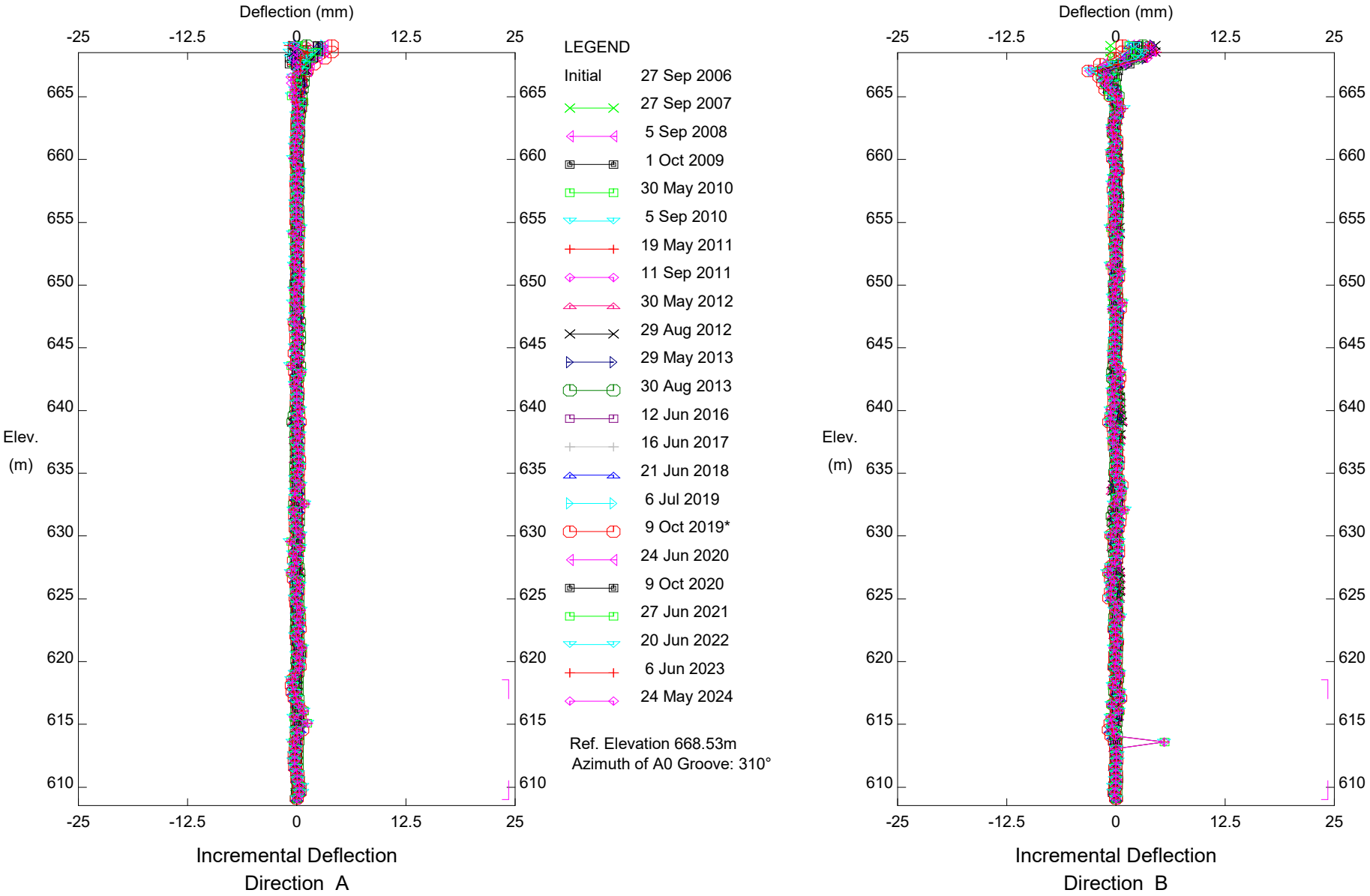
GP016; H666:02 Slide 2 km West of Hwy 40, Inclinometer SI-2

Alberta Transportation

GP016; H666:02, 2 km West of Hwy 40 and Hwy 666 Junction

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

Klohn Crippen Berger - Edmonton



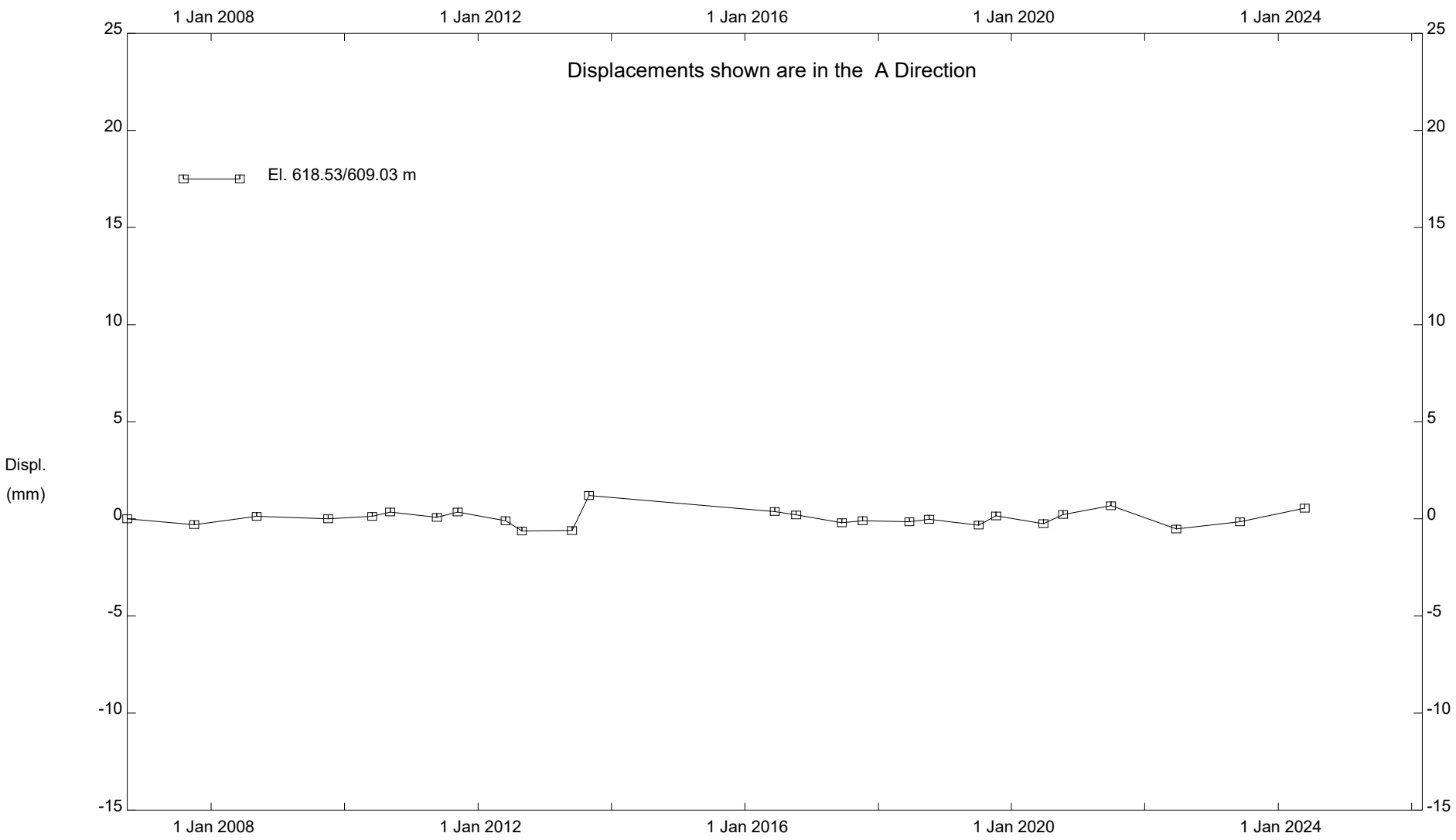
GP016; H666:02 Slide 2 km West of Hwy 40, Inclinometer SI-2

Alberta Transportation

GP016; H666:02, 2 km West of Hwy 40 and Hwy 666 Junction

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

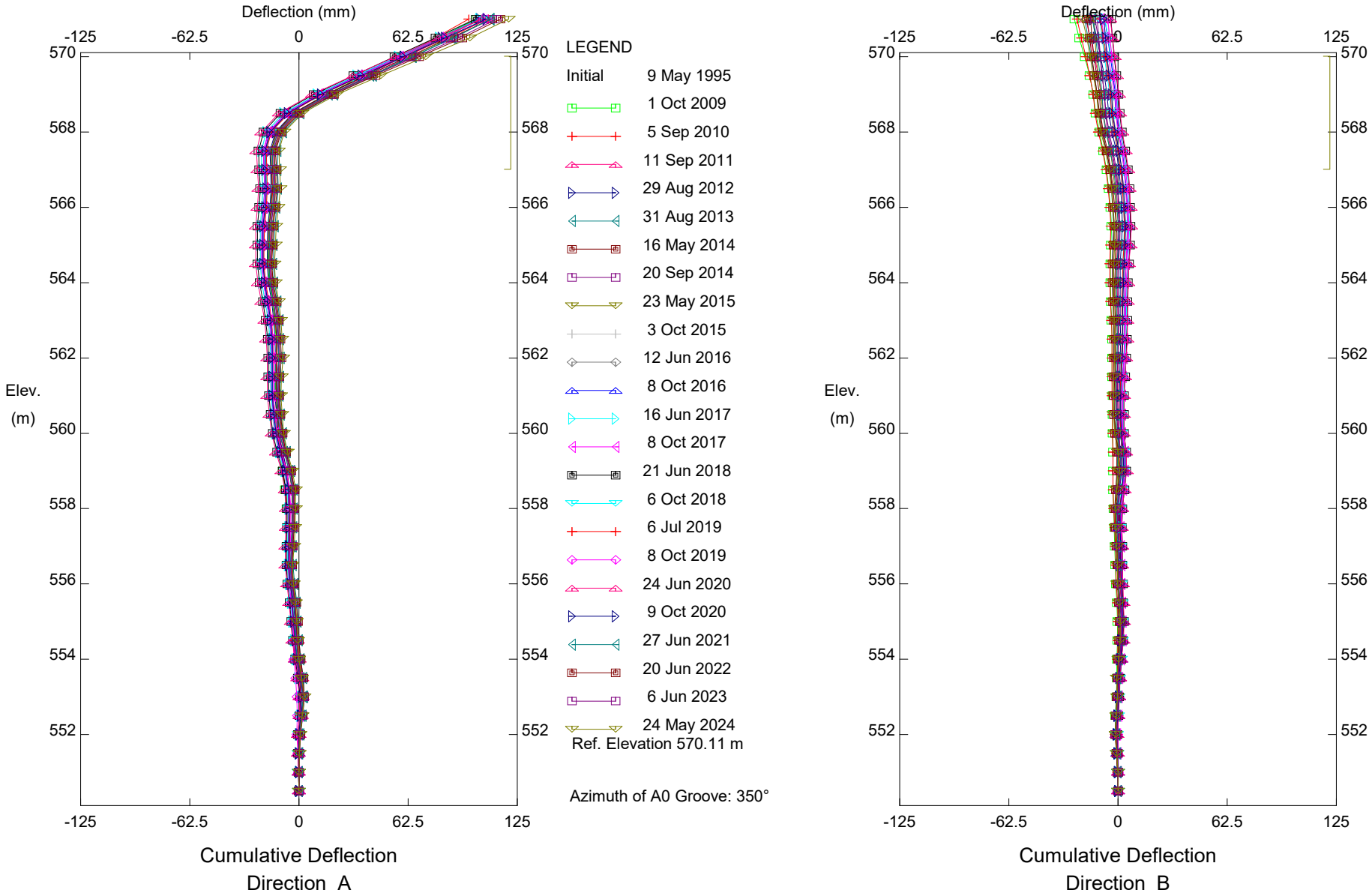
Klohn Crippen Berger - Edmonton



GP016; H666:02 Slide 2 km West of Hwy 40, Inclinometer SI-2

Alberta Transportation

Klohn Crippen Berger - Edmonton

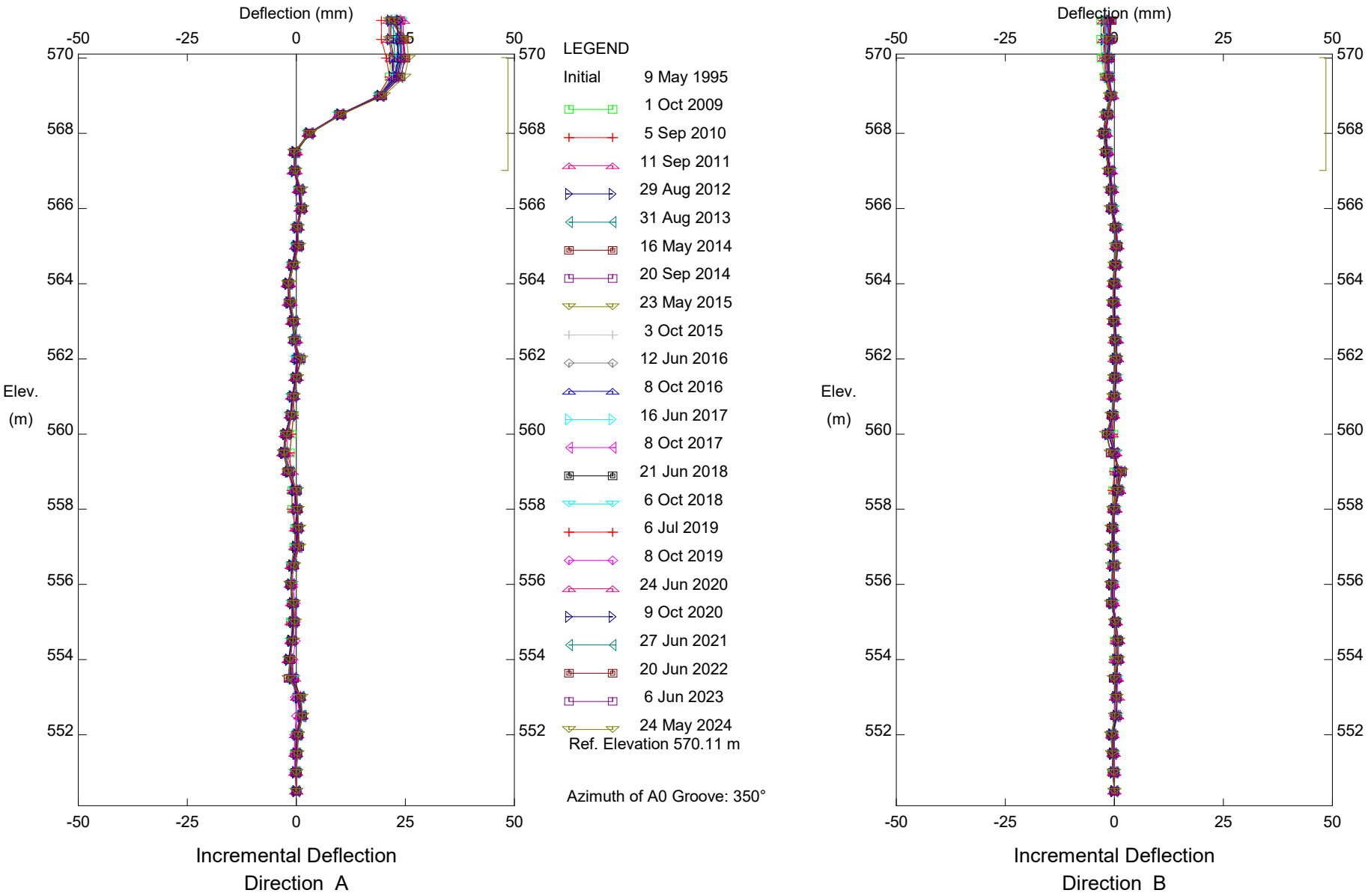


GP016; H666:02 Slide 2 km West of Hwy 40, Inclinometer SI-41

Alberta Transportation

GP016; H666:02, 2 km West of Hwy 40 and Hwy 666 Junction

Klohn Crippen Berger - Edmonton

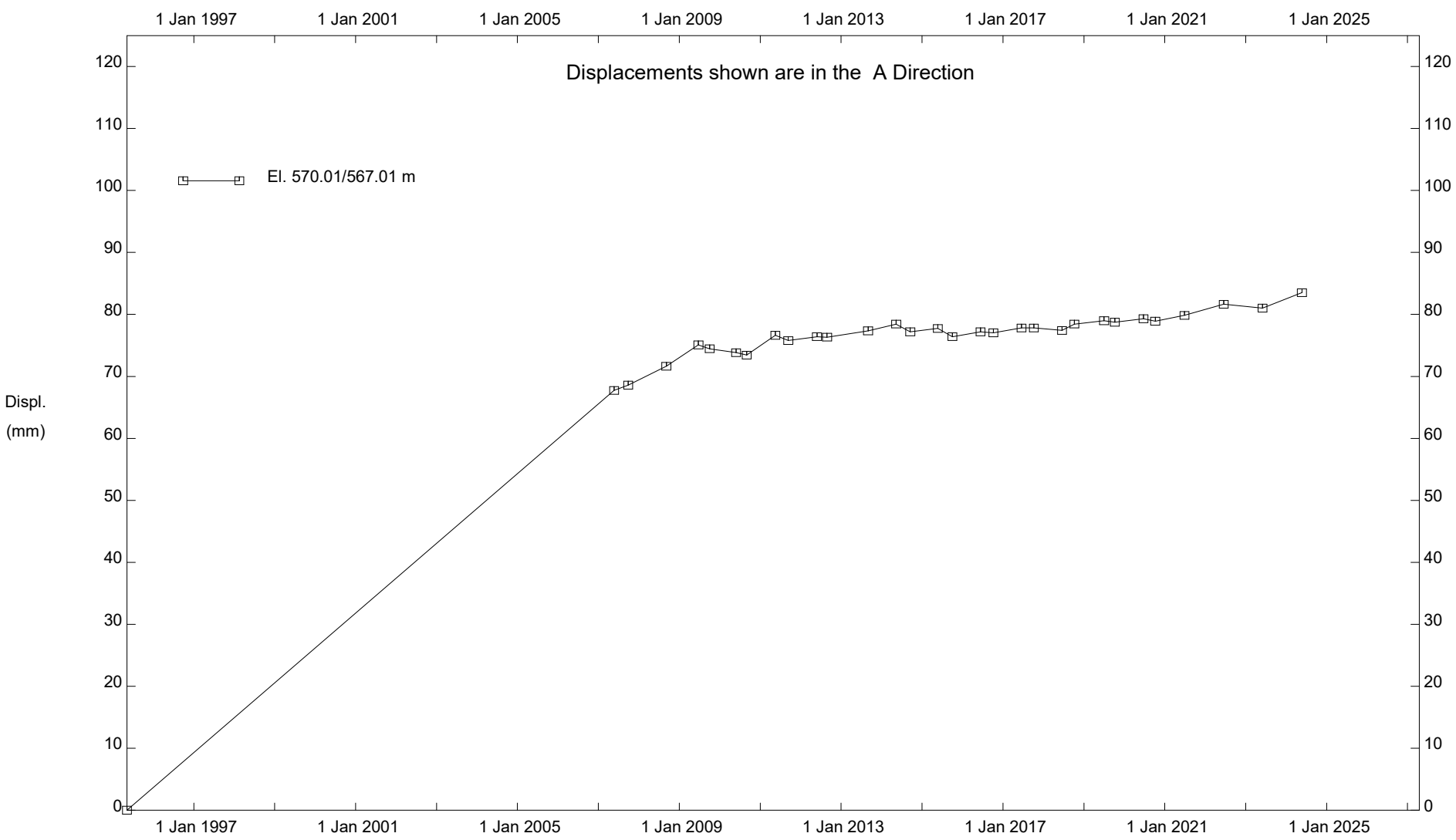


GP016; H666:02 Slide 2 km West of Hwy 40, Inclinometer SI-41

Alberta Transportation

GP016; H666:02, 2 km West of Hwy 40 and Hwy 666 Junction

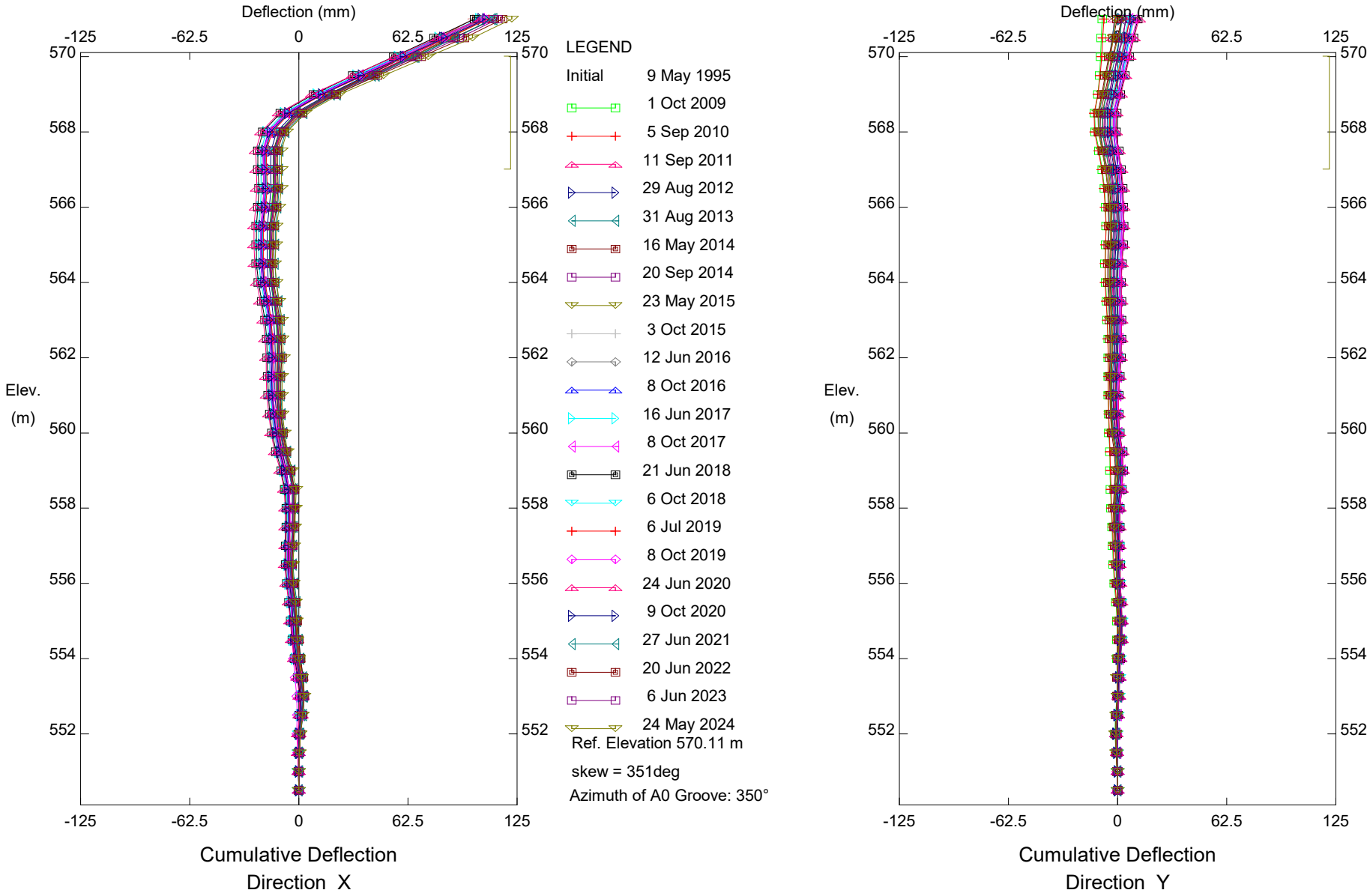
Klohn Crippen Berger - Edmonton



GP016; H666:02 Slide 2 km West of Hwy 40, Inclinometer SI-41

Alberta Transportation

Klohn Crippen Berger - Edmonton

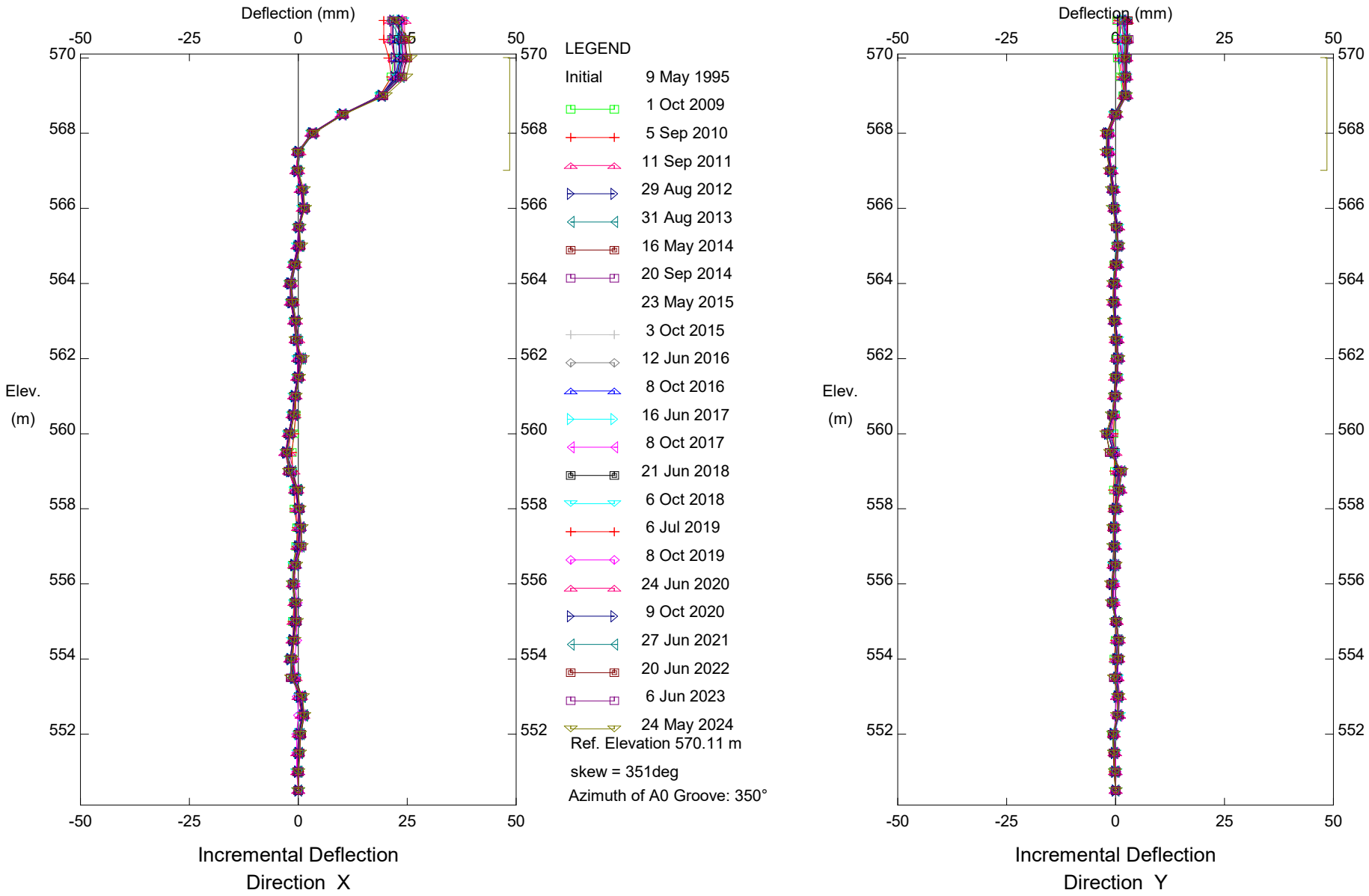


GP016; H666:02 Slide 2 km West of Hwy 40, Inclinometer SI-41

Alberta Transportation

GP016; H666:02, 2 km West of Hwy 40 and Hwy 666 Junction

Klohn Crippen Berger - Edmonton

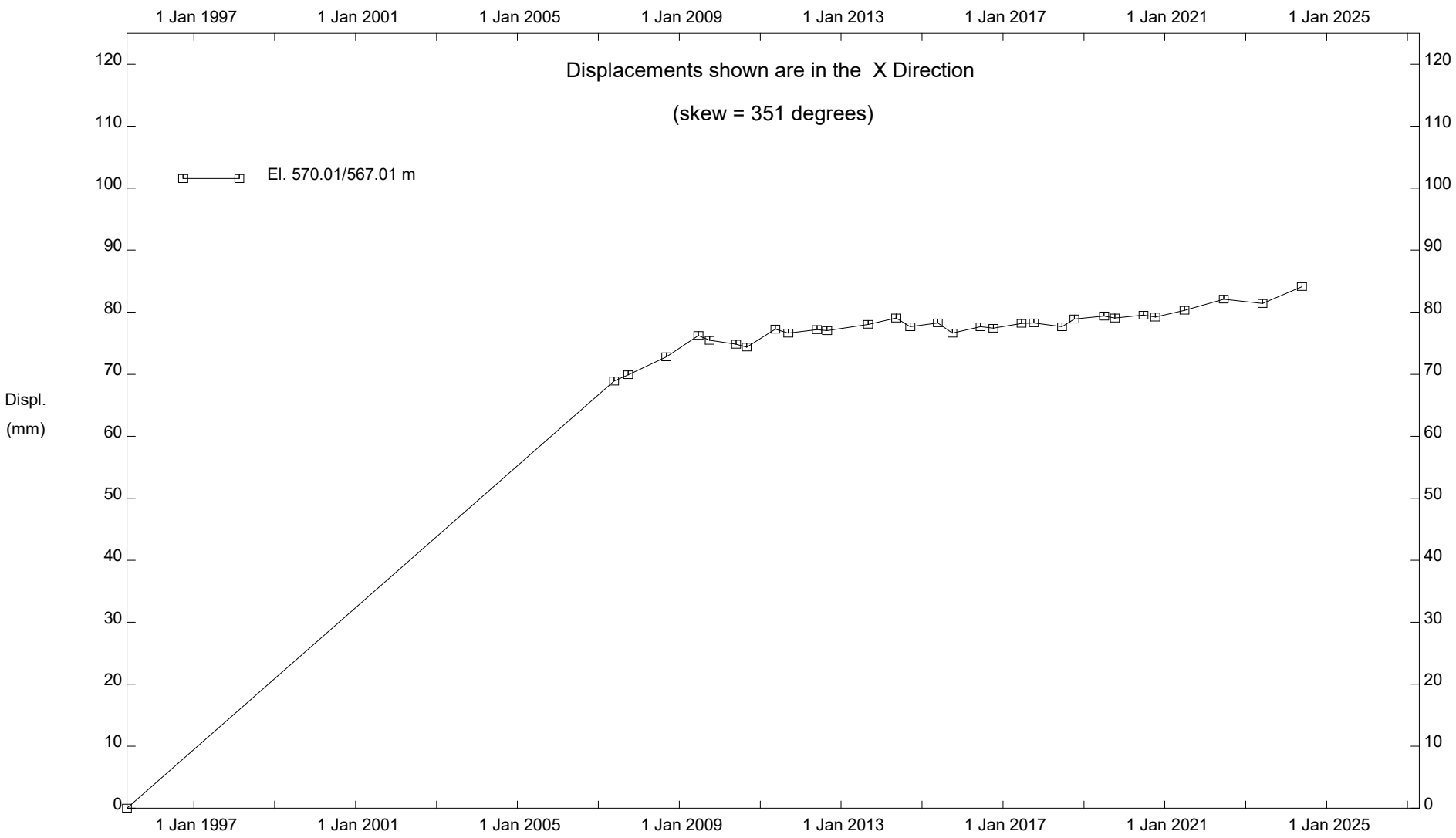


GP016; H666:02 Slide 2 km West of Hwy 40, Inclinometer SI-41

Alberta Transportation

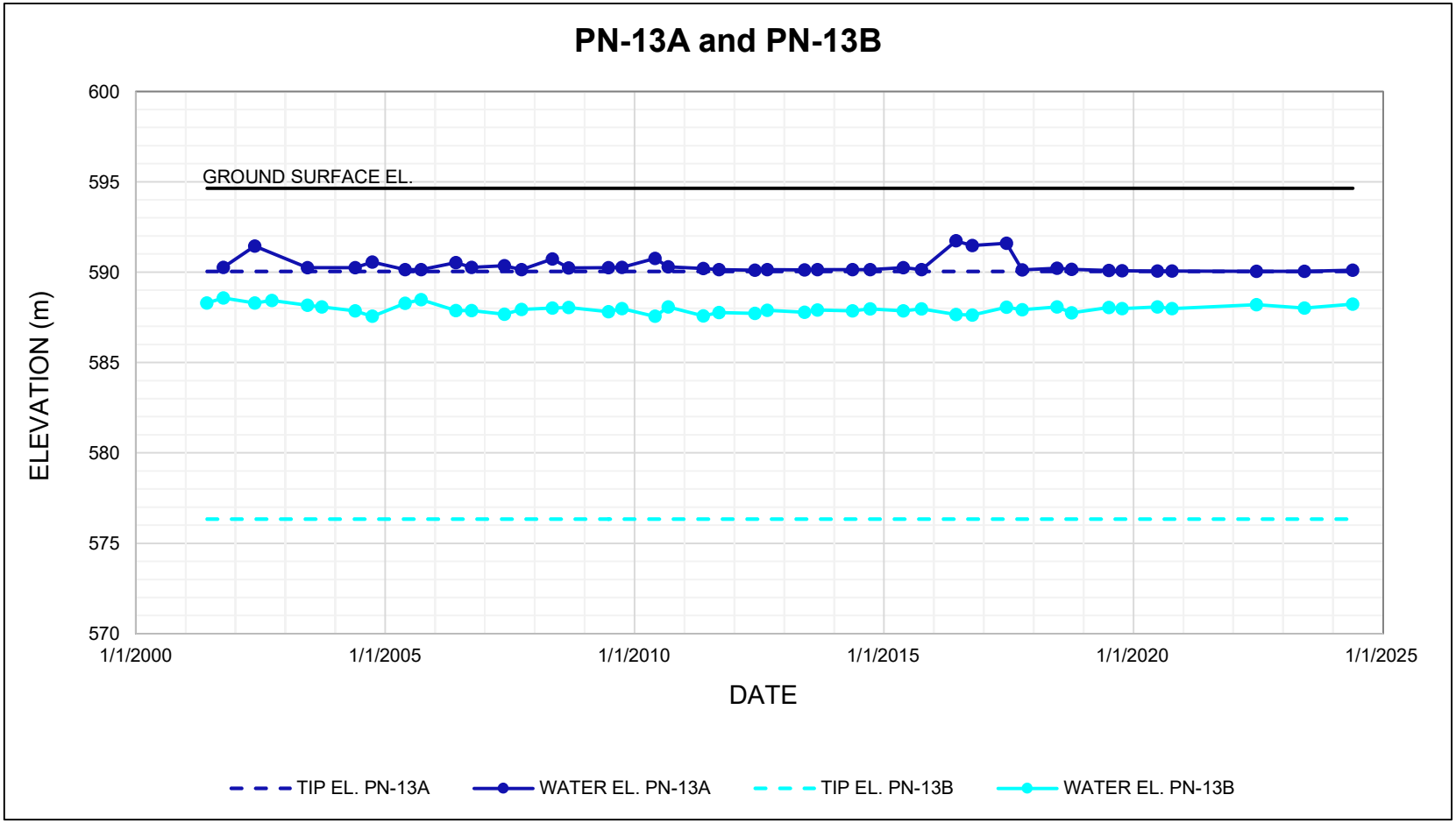
GP016; H666:02, 2 km West of Hwy 40 and Hwy 666 Junction

Klohn Crippen Berger - Edmonton



GP016; H666:02 Slide 2 km West of Hwy 40, Inclinometer SI-41

Alberta Transportation



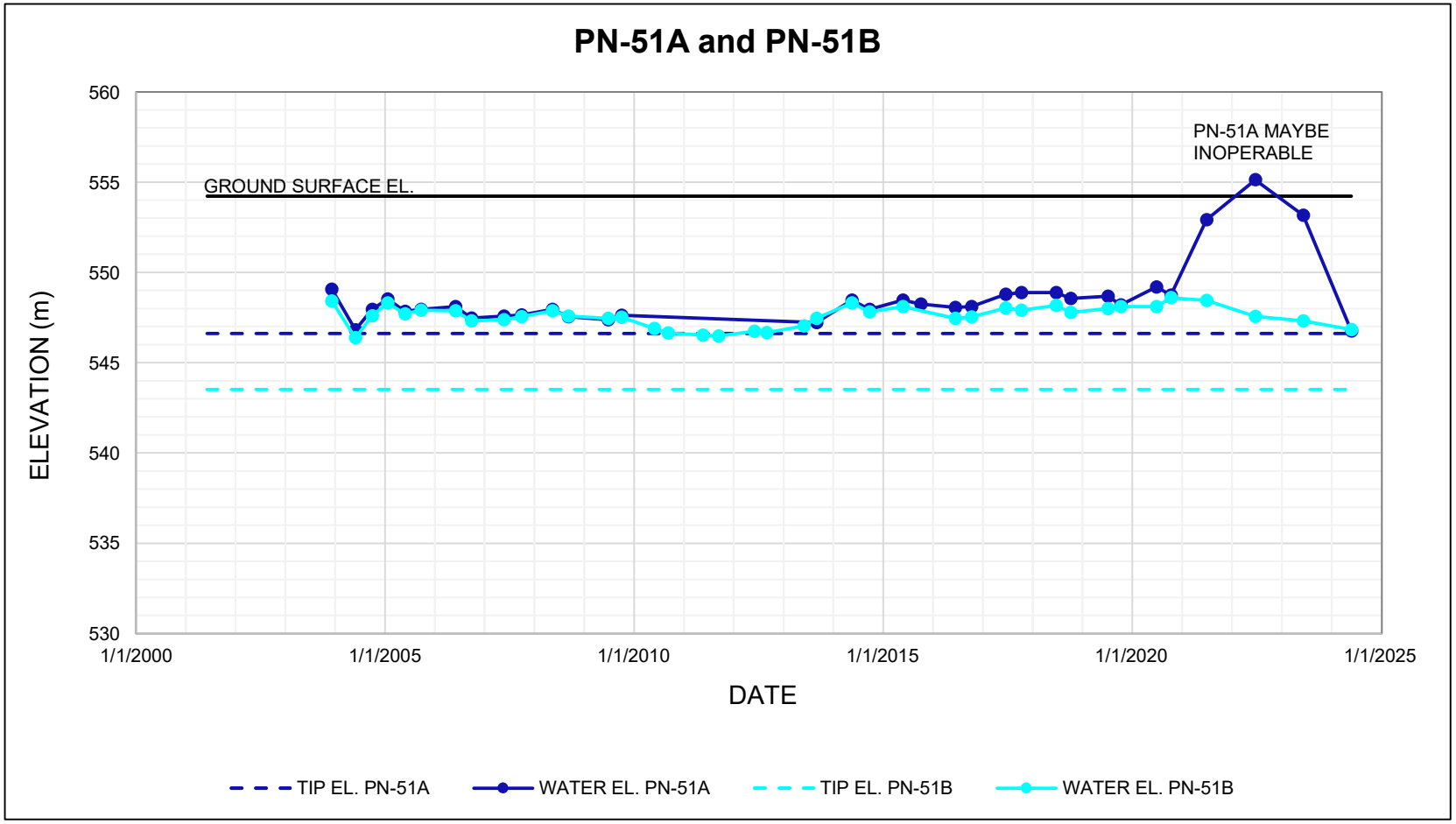
NOTES:
1. PIEZOMETER DATA OBTAINED BEFORE JUNE 28, 2021, PROVIDED TO KLOHN CRIPPEN BERGER LTD. BY ALBERTA TRANSPORTATION AND ECONOMIC CORRIDORS ON JUNE 25, 2021.

CLIENT
Alberta
Klohn Crippen Berger

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

TITLE
Piezometer Data
GP016 - Slide 2 km West of Hwy 40
Hwy 666:02, km 34.837

SCALE	PROJECT No.	FIG No.
--	A05116A01	



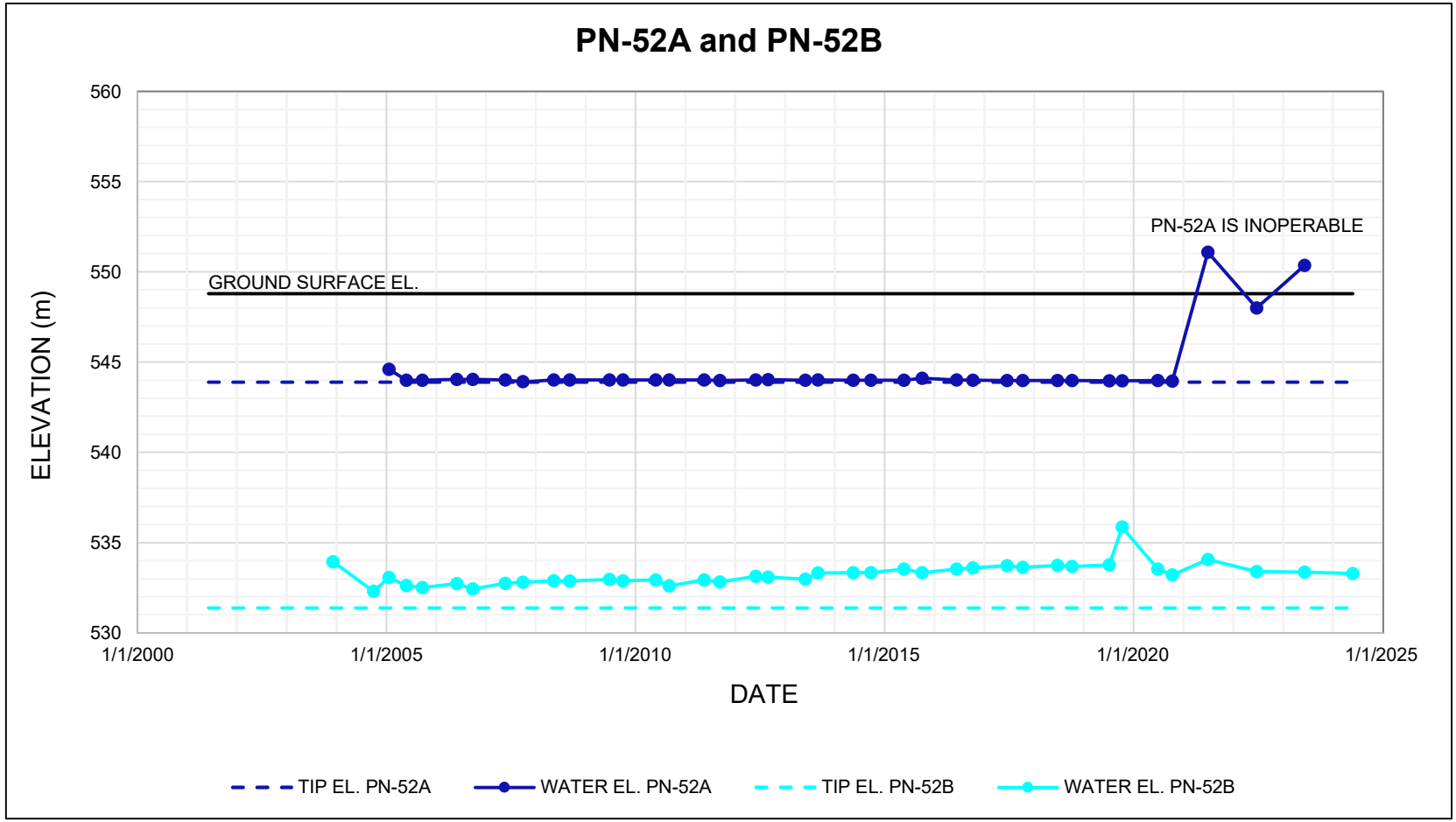
NOTES:
1. PIEZOMETER DATA OBTAINED BEFORE JUNE 28, 2021, PROVIDED TO KLOHN CRIPPEN BERGER LTD. BY ALBERTA TRANSPORTATION AND ECONOMIC CORRIDORS ON JUNE 25, 2021.

CLIENT
Alberta
Klohn Crippen Berger

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

TITLE
Piezometer Data
GP016 - Slide 2 km West of Hwy 40
Hwy 666:02, km 34.837

SCALE	PROJECT No.	FIG No.
--	A05116A01	



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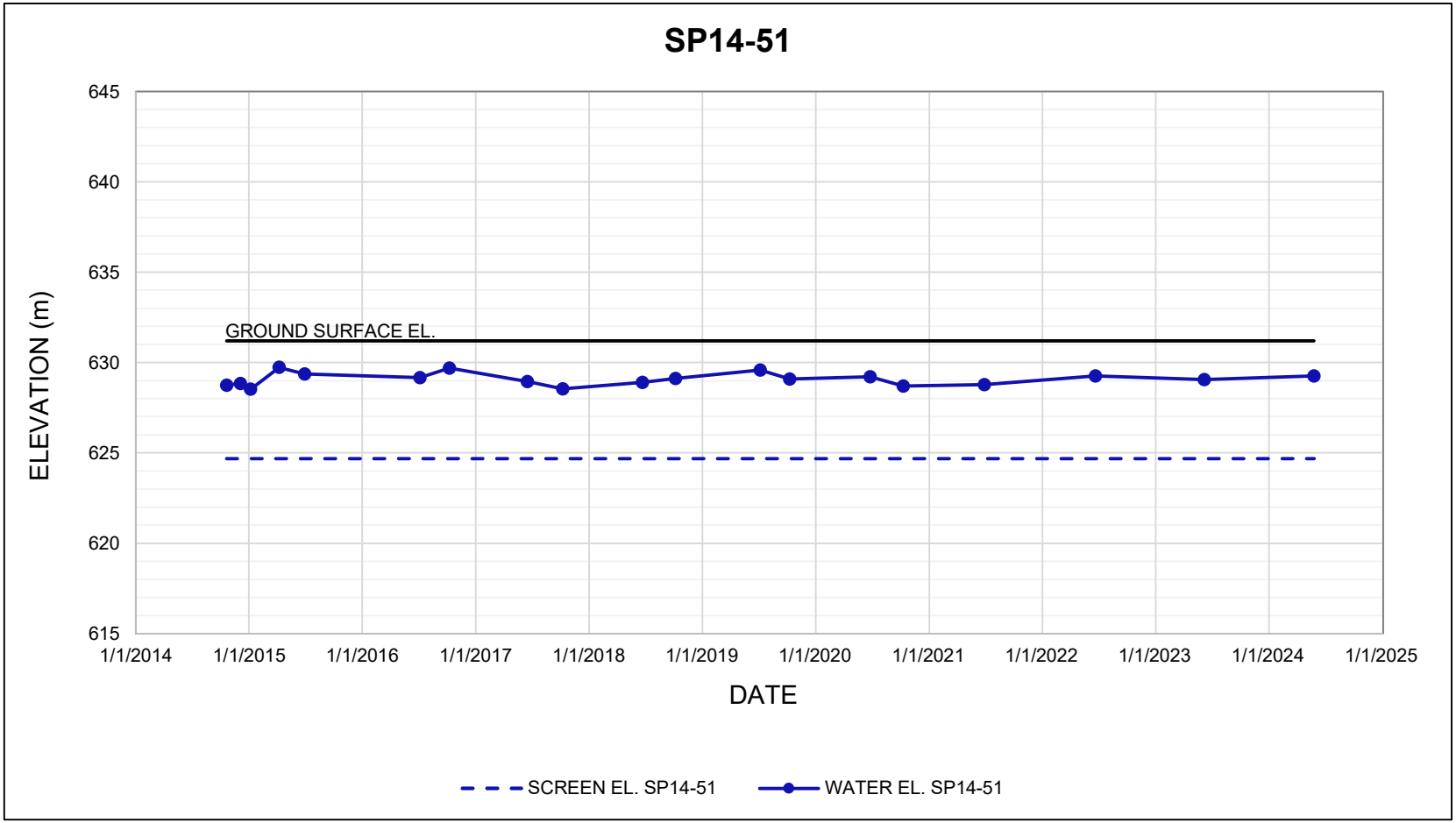
SCALE	PROJECT No.	FIG No.
--	A05116A01	



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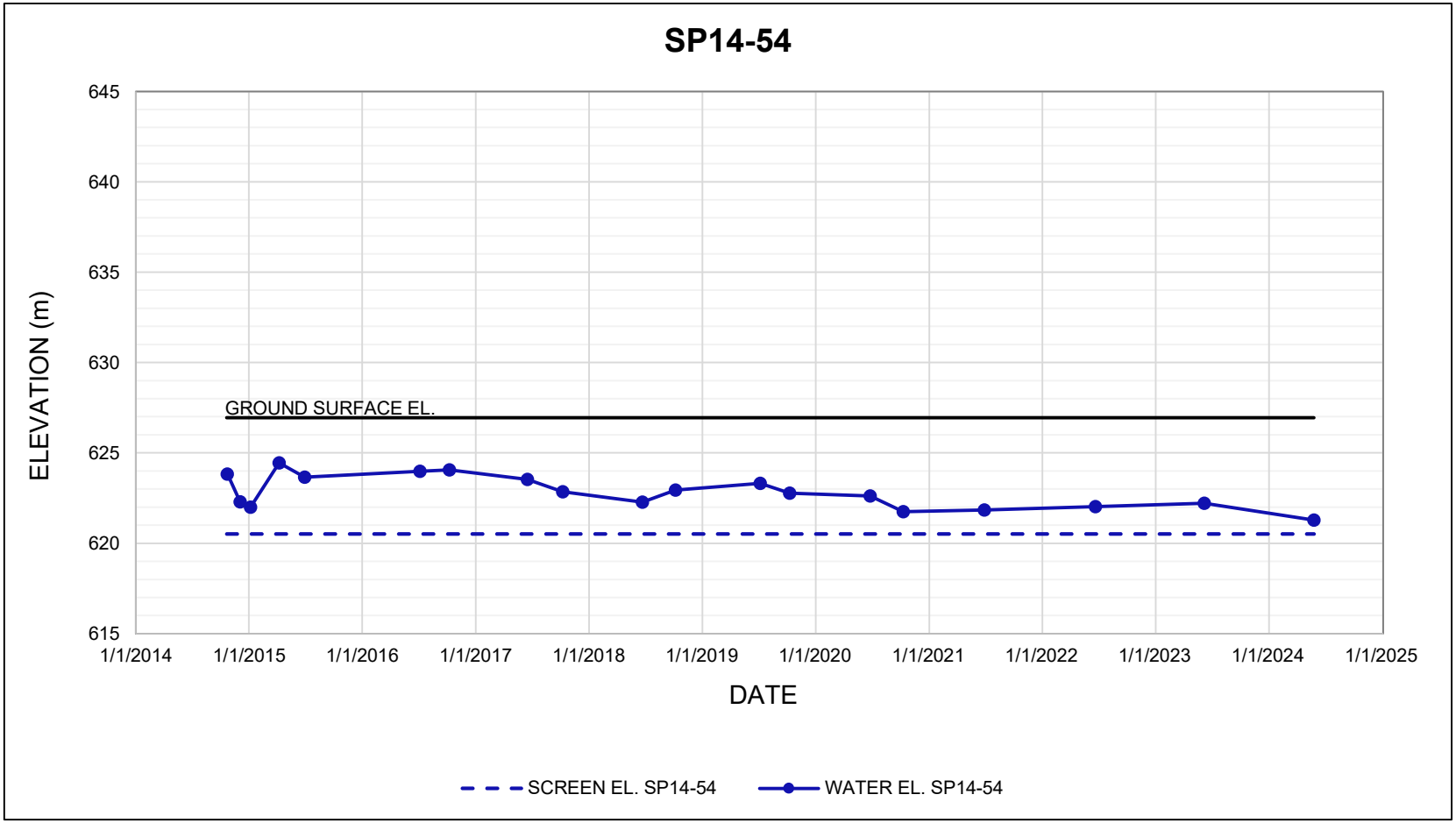
SCALE	PROJECT No.	FIG No.
--	A05116A01	



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SCALE	PROJECT No.	FIG No.
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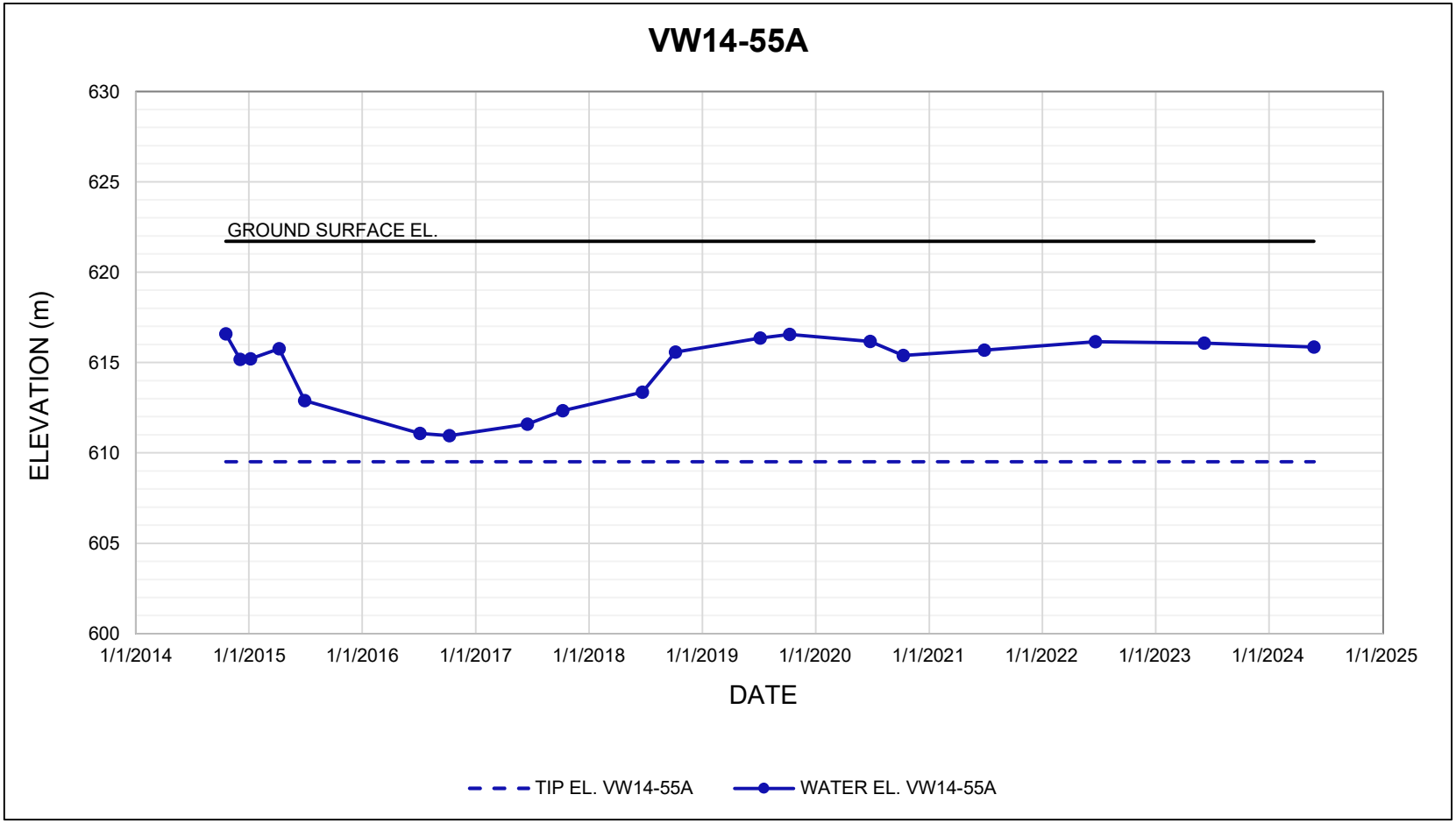

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