November 30, 2022

Alberta Transportation
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Ed Szmata
Construction Technologist

Dear Mr. Szmata:

CON0022166 Peace Region (Grande Prairie District – South) GRMP Instrumentation Monitoring Site GP007; H40:36, km 29.339 Wanyandie Road Slide
Section C – 2022 Fall Readings

1 GENERAL

Eleven slope inclinometers (SIs) (SI98-4, SI98-6, SI98-7, SI03-11, SI03-12, SI20-2, SI20-3, SI22-1, SI22-2A, SI22-3 and SI22-4), ten pneumatic piezometers (PNs) (PN-11A/B, PH-12A/B/C, PN-13A, and PN-4 through PN-7), nineteen vibrating wire piezometers (VWPs) (VW20-2A/B, VW20-3A/B, VW20-6A/B, VW22-1A/B/C, VW22-2A/B/C/D, VW22-3A/B/C/D, VW22-4A/B), and three standpipe piezometers (SPs) (SP20-1, SP20-4, and SP20-8) were read at the GP007 site in the Peace Region (Grande Prairie District – South, GP South Region) on September 27, 2022 by Messrs. Gabriel Bonot, E.I.T. and Guerin White, 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 40:36, km 29.339, near the intersection with Wanyandie Road. The approximate site coordinates are 5993890 N, 372875 E (UTM Zone 11, NAD 83). A site plan is presented in Figure 1.

The geohazard at the GP007 site consists of a deep-seated landslide along the north valley slope of the Smoky River.

Previous remedial actions completed at the GP007 site includes asphalt overlays in 2018 and 2019, and ongoing pavement patching and sub-excavation and backfilling of surface voids with granular fill. In 2020 and 2021, the highway surface was returned to gravel in the summer/fall then paved for winter.

Geotechnical site investigations were conducted at the GP007 site in 1998, 2002, 2003, and 2020 by the previous consultants. During these investigation, 14 SIs and 21 piezometers were installed.

In March and May 2022, KCB conducted a site reconnaissance and geotechnical site investigation, respectively, to support design work for a potential highway re-alignment. During the site reconnaissance, data loggers were installed on the existing VWPs installed in 2020 to assess if short-

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term fluctuations (i.e., increases and decreases) in water level are occurring in response to periods of heavy or prolonged rainfall or freshet infiltration between readings. During the 2022 geotechnical site investigation, 4 deep SIs and 13 VWPs (with data loggers) were installed to improve our understanding of movement and groundwater conditions at the site, respectively.

The stratigraphy encountered during the 2022 investigation varied, but generally consisted of silt, colluvium, till, or some combination thereof, overlying bedrock (clay shale, siltstone, and sandstone). At the western site limit, the encountered stratigraphy was not consistent with stratigraphy encountered during the 1998 investigations.

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 in Figure 1.

As discussed above, 18 SIs and 34 piezometers have been installed at the site between 1998 and 2022 by the previous consultants and KCB. Some of these instruments are now inoperable (e.g., sheared, or damaged) as detailed in Table 1.1 (see table notes). For the instruments installed by previous consultants (14 SIs and 21 piezometers) it is noted that:

- Several of these piezometers have been dry or near dry (i.e., recording water levels below or near their tip elevations) since installation with a water level above tip elevation only being recorded in the spring of 2020 and/or 2021. A sustained water level has only been recorded in PN98-1 and PN98-3 (both now inoperable), and the piezometers (VW20-02A/B, VW20-03A/B, and VW20-06A/B, and SP20-4) at the eastern site limit.
- Several of these SIs may not have been installed deep enough (e.g., SI98-4 and SI98-6, SI03-11 and SI03-12) were not anchored in bedrock (TH20-2, TH20-3, and TH20-6) or did not record clear movement patterns before they became inoperable (e.g., SI98-1).

Most instruments are protected by above-ground casing protectors, excluding SI98-4, PN-4, PN-5, SI98-6, PN-6, SI98-7, and PN-7.

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 PNs and SPs were read using an RST C109 pneumatic piezometer readout and RST Water Level Meter, respectively.

Between March and May 2022, the VWPs were connected to RST DT2055B Multichannel Data loggers. The data loggers are programed to take a reading every 12-hours to assess if short-term fluctuations (i.e., increases and decreases) in water level are occurring in response to periods of heavy or prolonged rainfall or freshet infiltration between spring and fall readings. Data from the data loggers was downloaded using an RST USB-serial cable and DT Logger Host software.

Table 1.1 Instrumentation Installation Details

Instrument ID	Instrument Type	Date Installed[1]	UTM Coordinates[1] (m)		Ground Surface Elevation[1] (m)	Stick Up[1] (m)	Depth[1] (mbgs[2])	Condition
			Northing	Easting				
~~SI98-1~~	~~SI~~	~~Mar. 10, 1998~~	~~5993897~~	~~372794~~	~~965.4~~	~~Unknown~~	~~Unknown~~	~~Inoperable[3]~~
~~SI98-2~~	~~SI~~	~~Mar. 05, 1998~~	~~5993849~~	~~372785~~	~~961.0~~	~~Unknown~~	~~Unknown~~	~~Inoperable[4]~~
~~SI98-3~~	~~SI~~	~~Mar. 05, 1998~~	~~5993519~~	~~372798~~	~~903.7~~	~~Unknown~~	~~Unknown~~	~~Inoperable[3]~~
SI98-4	SI	Oct. 24, 1998	5993906	372878	965.5	0.6	20.5	Operable
~~SI98-5~~	~~SI~~	~~Oct. 20, 1998~~	~~5993850~~	~~372882~~	~~954.5~~	~~Unknown~~	~~Unknown~~	~~Inoperable[5]~~
SI98-6	SI	Oct. 22, 1998	5993869	373077	968.3	0.8	28.5	Operable
SI98-7	SI	Oct. 21, 1998	5993764	373093	944.3	0.6	29.5	Operable
~~SI98-8~~	~~SI~~	~~Oct. 26, 1998~~	~~5993585~~	~~373184~~	~~926.7~~	~~Unknown~~	~~Unknown~~	~~Inoperable[6]~~
SI03-11	SI	Dec. 2003	5993953	372954	992.1	0.6	45.0	Operable
SI03-12	SI	Dec. 2003	5993953	373054	992.1	1.1	45.5	Operable[7]
~~SI03-13~~	~~SI~~	~~Dec. 2003~~	~~5993972~~	~~373167~~	~~996.1~~	~~Unknown~~	~~Unknown~~	~~Inoperable[7]~~
SI20-2	SI	Jul. 28, 2020	5993885	373240	985.0	1.0	35.0	Operable
SI20-3	SI	Jul. 23, 2020	5993915	373252	981.0	0.9	34.5	Operable[8]
~~SI20-6~~	~~SI~~	~~Jul. 27, 2020~~	~~5993874~~	~~373298~~	~~967.0~~	~~0.8~~	~~30.0~~	~~Inoperable[8]~~
SI22-1	SI	May 19, 2022	5993925	372803	965	0.4	40.5	Operable
SI22-2A	SI	May 06, 2022	5993906	372920	966	0.6	41.0	Operable
SI22-3	SI	May 11, 2022	5993907	373089	971	0.6	49.5	Operable
SI22-4	SI	May 17, 2022	5993936	373239	980	0.2	54.5	Operable
~~PN98-1~~	~~PN~~	~~Mar. 10, 1998~~	~~5993897~~	~~372794~~	~~965.4~~	~~N/A~~	~~16.8~~	~~Inoperable~~
~~PN98-3~~	~~PN~~	~~Mar. 05, 1998~~	~~5993519~~	~~372798~~	~~903.7~~	~~N/A~~	~~10.7~~	~~Inoperable~~
PN98-4	PN	Oct. 24, 1998	5993906	372878	964.9	N/A	7.3	Operable, but dry
PN98-5	PN	Oct. 20, 1998	5993850	372882	954.5	N/A	11.3	Operable, but dry
PN98-6	PN	Oct. 22, 1998	5993869	373077	967.4	N/A	10.1	Operable, but dry
PN98-7	PN	Oct. 21, 1998	5993764	373093	943.5	N/A	4.6	Operable, but dry
PN03-11A	PN	Dec. 2003	5993953	372954	992.1	N/A	6.1	Operable, but dry
PN03-11B	PN	Dec. 2003	5993953	372954	992.1	N/A	15.2	Operable, but dry
PN03-12A	PN	Dec. 2003	5993953	373054	992.5	N/A	6.6	Operable, but dry
PN03-12B	PN	Dec. 2003	5993953	373054	992.5	N/A	14.9	Operable, but dry
PN03-12C	PN	Dec. 2003	5993953	373054	992.5	N/A	22.7	Operable, but dry
PN03-13A	PN	Dec. 2003	5993991	373395	996.1	N/A	6.4	Operable, but dry
VW20-2A	VWP	Jul. 28, 2020	5993885	373240	985.0	N/A	11.3	Operable
VW20-2B	VWP	Jul. 28, 2020	5993885	373240	985.0	N/A	22.9	Operable
VW20-3A	VWP	Jul. 23, 2020	5993915	373252	981.0	N/A	17.4	Operable, but dry
VW20-3B	VWP	Jul. 23, 2020	5993915	373252	981.0	N/A	28.2	Operable
VW20-6A	VWP	Jul. 27, 2020	5993874	373298	967.0	N/A	16.2	Operable
VW20-6B	VWP	Jul. 27, 2020	5993874	373298	967.0	N/A	24.1	Operable
VW22-1A	VWP	May 19, 2022	5993925	372803	965	N/A	29.2	Operable
VW22-1B	VWP	May 19, 2022	5993925	372803	965	N/A	32.9	Operable, but dry
VW22-1C	VWP	May 19, 2022	5993925	372803	965	N/A	40.0	Operable, but dry
VW22-2B	VWP	May 06, 2022	5993906	372920	966	N/A	33.1	Operable
VW22-2C	VWP	May 06, 2022	5993906	372920	966	N/A	36.3	Operable
VW22-2D	VWP	May 06, 2022	5993906	372920	966	N/A	40.0	Operable, but dry
VW22-2A	VWP	May 19, 2022	5993901	372923	966	N/A	21.3	Operable
VW22-3A	VWP	May 11, 2022	5993907	373089	971	N/A	19.9	Operable
VW22-3B	VWP	May 11, 2022	5993907	373089	971	N/A	37.9	Operable
VW22-3C	VWP	May 11, 2022	5993907	373089	971	N/A	42.5	Operable
VW22-3D	VWP	May 11, 2022	5993907	373089	971	N/A	49.4	Operable, but dry
VW22-4A	VWP	May 17, 2022	5993936	373239	980	N/A	33.9	Operable
VW22-4B	VWP	May 17, 2022	5993936	373239	980	N/A	45.2	Operable, but dry
SP20-1	SP	Jul. 30, 2020	5993954	373591	964.0	0.93	7.5	Operable, but dry

Instrument ID	Instrument Type	Date Installed[1]	UTM Coordinates[1] (m)		Ground Surface Elevation[1] (m)	Stick Up[1] (m)	Depth[1] (mbgs[2])	Condition
			Northing	Easting				
SP20-4	SP	Jul. 26, 2020	5993964	373312	988.0	0.9	19.5	Operable
SP20-8	SP	Jul. 30, 2020	5994000	373791	1008.0	0.9	10.0	Operable

Notes:
[1] Installation details taken from reports and data files prepared or provided by the previous consultant(s) or AT. Ground surface elevations for SI98-4, SI98-6, and SI03-12 vary from the adjacent piezometers (PN98-4, PN98-6, PN03-12A/B/C). Also, ground surface elevations were not provided for SI20-2, SI20-3, or SI20-6, so ground surface elevations from adjacent/nested piezometers were used (VW20-2A/B, VW20-3A/B, and VW20-6A/B). Instrument coordinates and stick ups (where applicable) were confirmed by KCB using a handheld GPS (accuracy of ± 5 m) and a tape measure, respectively.
[2] Meters below ground surface (mbgs). Bottom reading depth for SIs, and tip or screen depth for piezometers.
[3] SI98-1 and SI98-3 were damaged near the top of casing in 2006.
[4] SI98-2 has sheared at an approximate depth of 21.5 m below ground surface (approximate elevation of 939.5 m).
[5] SI98-5 has sheared at an approximate depth of 22.0 m below ground surface (approximate elevation of 932.0 m).
[6] SI98-8 and SI03-13 are blocked at an approximate depth of 15.0 m (approximate elevation of 912.0 m) and 33.5 m below ground surface, respectively. It is unclear if these instruments have sheared as no previous movement had been recorded in them.
[7] SI03-12 has been re-sleeved twice (i.e., had a small diameter casing installed in it) (dates unknown).
[8] SI20-6 has sheared at an approximate depth of 27 m below ground surface (elevation 940 m).

2 INTERPRETATION

2.1 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-grooves) and, where applicable, the X-direction (i.e., the direction of maximum movement obtained at a skew angle from the A0-grooves). SI98-6, SI98-7, SI03-12, SI20-2, SI20-3, and SI20-6 have skew angles between 10° and 100°, 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 each instruments tip elevation.

For the operable SPs, the water level data was plotted relative to ground surface elevation and each instruments screen elevation.

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 through Table 2.3, respectively.

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 consistent with the data obtained by the previous consultant and no re-initialization of the SIs is recommended. The SI data plots presented herein include data for readings taken with both the previous consultants' and KCB's SI reading equipment.

It is noted that the data for SI98-6 and SI98-12 is noisy and difficult to interpret. Based on the absolute plots for these instruments, SI98-6 has kinks in the casing at an approximate depth of 11.9 m and 13.9 m below ground surface, and SI98-12 is tilted approximately 1.5 m in the A-direction. SI98-12 has also been re-sleeved twice (i.e., had a small diameter casing installed in it) (dates unknown). KCB will continue to assess if re-initialization is needed to reduce reading noise in these instruments.

Table 2.1 Slope Inclinometer Reading Summary

Instrument ID	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)	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				
SI98-4	Oct. 25, 1998	N/A – no discernible movement recorded	Jun. 22, 2022	Sep. 27, 2022	965.5	N/A – no discernible movement recorded								
SI98-6[3]	Oct. 23, 1998 (Jun. 22, 2018)	N/A	Jun. 22, 2022	Sep. 27, 2022	968.3	N/A – no discernible discrete movement recorded, but the data is noisy as discussed in Section 2.2								
SI98-7	Oct. 23, 1998	Oct. 03, 2015	Jun. 22, 2022	Sep. 27, 2022	944.3	1.4 - 29.8	X-Direction, 100°	N/A		29.8	-24.6	18.8	6.1	12.7
SI03-11	Dec. 7, 2003 (Jun. 12, 2016)[4]	N/A	Jun. 22, 2022	Sep. 27, 2022	992.1	N/A – no discernible movement recorded								
SI03-12[3]	May 12, 2008 (Jun. 12, 2016)	N/A	Jun. 22, 2022	Sep. 27, 2022	992.1	N/A – no discernible discrete movement recorded, but the data is noisy as discussed in Section 2.2								
SI20-2	Aug. 01, 2020	Jun. 29, 2021	Jun. 22, 2022	Sep. 27, 2022	985.0	27.2 – 29.2	X-Direction, 45°	N/A		86.3	9.0	86.9	34.3	9.1
SI20-3	Aug. 01, 2020	Jun. 29, 2021	Jun. 22, 2022	Sep. 27, 2022	981.0	17.9 – 19.4	X-Direction, 27°	N/A		29.2	3.2	32.0	11.9	3.9
		Jun. 29, 2021				24.9 – 25.9	X-Direction, 27°	N/A		21.1	0.9	15.6	3.4	-4.3
SI22-1	Jun. 22, 2022	N/A – initialized on Jun. 21 and 22, 2022	Jun. 22, 2022	Sep. 27, 2022	965	N/A – no discernible movement recorded, discussed in Section 2.2								
SI22-2A	Jun. 22, 2022		Jun. 22, 2022	Sep. 27, 2022	966	5.0 – 11.5	A-direction	N/A		3.8	3.8	N/A	13.6	N/A
SI22-3	Jun. 21, 2022		Jun. 21, 2022	Sep. 27, 2022	971	N/A – no discernible movement recorded, discussed in Section 2.2								
SI22-4	Jun. 22, 2022		Jun. 22, 2022	Sep. 27, 2022	980	N/A – no discernible movement recorded								

Notes:
[1] Meters below ground surface (mbgs).
[2] Skew angle of X-direction measured clockwise from the A-direction. The azimuth of the A0-grooves for the SIs were measured by a magnetic compass in spring 2022.
[3] As discussed in Section 2.1, data for SI98-6 and SI03-12 is noisy and difficult to interpret.
[4] A large data shift was previously recorded in SI03-11 between the May 2015 and June 2016 readings when the SI equipment was changed by the previous consultant. The data obtained by KCB is consistent with the data obtained after June 2016, so the instrument was re-initialized to the June-2016 reading.

Table 2.2 Pneumatic Piezometer Reading Summary

Instrument ID	Serial No.	Date Installed	Date of Previous Reading	Date of Most Recent Reading	Ground Surface Elevation (m)	Tip Depth (mbgs[1])	Previous Water Level (mbgs[1])	Most Recent Reading (mbgs[1])	Change from Previous Reading (m)
PN98-4	51191	Oct. 1998	Jun. 22, 2022	Sep. 27, 2022	964.9	7.3	7.0	6.9	0.1
PN98-5	51190	Oct. 1998	Jun. 22, 2022	Sep. 27, 2022	954.5	11.3	11.3	11.3	0.0
PN98-6	51194	Oct. 1998	Jun. 22, 2022	Sep. 27, 2022	967.4	10.1	9.8	9.8	0.0
PN98-7	51193	Oct. 1998	Jun. 22, 2022	Sep. 27, 2022	943.5	4.6	4.6	4.5	0.1
PN03-11A	28835	Dec. 2003	Jun. 22, 2022	Sep. 27, 2022	992.1	6.1	6.0	6.0	0.0
PN03-11B	28828	Dec. 2003	Jun. 22, 2022	Sep. 27, 2022	992.1	15.2	15.2	15.2	0.0
PN03-12A	28902	Dec. 2003	Jun. 22, 2022	Sep. 27, 2022	992.5	6.6	6.3	6.3	0.0
PN03-12B	28899	Dec. 2003	Jun. 22, 2022	Sep. 27, 2022	992.5	14.9	14.8	14.8	0.0
PN03-12C	28827	Dec. 2003	Jun. 22, 2022	Sep. 27, 2022	992.5	22.7	22.7	22.7	0.0
PN03-13A	28834	Dec. 2003	Jun. 22, 2022	Sep. 27, 2022	996.1	6.4	6.3	6.3	0.0

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

Table 2.3 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)
SP20-1	Jul. 30, 2020	Jun. 22, 2022	Sep. 27, 2022	964.0	7.5	N/A – instrument is dry		
SP20-4	Jul. 26, 2020	Jun. 22, 2022	Sep. 27, 2022	988.0	19.5	18.2	17.9	0.3
SP20-8	Jul. 30, 2020	Jun. 22, 2022	Sep. 27, 2022	1008.0	10.0	5.1	5.2	-0.1

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

Table 2.4 Vibrating Wire Piezometer Reading Summary[1]

Instrument ID	Serial No.	Date			Ground Surface Elevation (m)	Tip Depth (mbgs[2])		Water Level		
		Installed	Previous Reading	Most Recent Reading[1]				Previous Reading (mbgs[2])	Most Recent Reading (mbgs[2])	Change from Previous Reading (m)
VW20-2A	67078	Jul. 28, 2020	Jun. 22, 2022	Sep. 27, 2022	985.0	11.3	10.3	10.3	0.0	
VW20-2B	67099	Jul. 28, 2020	Jun. 22, 2022	Sep. 27, 2022	985.0	22.9	12.5	12.5	0.0	
VW20-3A	67093	Jul. 23, 2020	Jun. 21, 2022	Sep. 27, 2022	981.0	17.4	N/A – instrument is dry			
VW20-3B	67095	Jul. 23, 2020	Jun. 21, 2022	Sep. 27, 2022	981.0	28.2	26.6	26.6	0.0	
VW20-6A	67088	Jul. 27, 2020	Jun. 22, 2022	Sep. 27, 2022	967.0	16.2	15.1	14.9	0.2	
VW20-6B	67096	Jul. 27, 2020	Jun. 22, 2022	Sep. 27, 2022	967.0	24.1	14.6	14.8	-0.2	
VW22-1A	VW145733	May 19, 2022	Jun. 21, 2022	Sep. 27, 2022	965.0	29.2	12.3	12.2	0.1	
VW22-1B	VW143171	May 19, 2022	Jun. 21, 2022	Sep. 27, 2022	965.0	32.9	N/A – instrument is dry			
VW22-1C	VW140853	May 19, 2022	Jun. 21, 2022	Sep. 27, 2022	965.0	40.0	N/A – instrument is dry			
VW22-2B	VW145722	May 06, 2022	Jun. 21, 2022	Sep. 27, 2022	966.0	33.1	13.0	13.0	0.0	
VW22-2C	VW145742	May 06, 2022	Jun. 21, 2022	Sep. 27, 2022	966.0	36.3	12.9	12.8	0.1	
VW22-2D	VW140069	May 06, 2022	Jun. 21, 2022	Sep. 27, 2022	966.0	40.0	N/A – instrument is dry			
VW22-2A	SN1910356	May 19, 2022	Jun. 21, 2022	Sep. 27, 2022	966.0	21.3	19.2	19.2	0.0	
VW22-3A	VW145498	May 11, 2022	Jun. 21, 2022	Sep. 27, 2022	971.0	19.9	16.0	16.1	-0.1	
VW22-3B	VW145717	May 11, 2022	Jun. 21, 2022	Sep. 27, 2022	971.0	37.9	16.4	16.4	0.0	
VW22-3C	VW145708	May 11, 2022	Jun. 21, 2022	Sep. 27, 2022	971.0	42.5	16.8	16.9	-0.1	
VW22-3D	VW143066	May 11, 2022	Jun. 21, 2022	Sep. 27, 2022	971.0	49.4	N/A – instrument is dry			
VW22-4A	VW145746	May 17, 2022	Jun. 21, 2022	Sep. 27, 2022	980.0	33.9	25.2	25.2	0.0	
VW22-4B	VW139732	May 17, 2022	Jun. 21, 2022	Sep. 27, 2022	980.0	45.2	N/A – instrument is dry			

Notes:
[1] All vibrating wire piezometers are connected to multi-channel data loggers, which are scheduled to take a reading every 12-hours.
[2] Meters below ground surface (mbgs).

2.2 Zones of Movement

At the western site limit, discrete movement was being recorded in SI98-2 and SI98-5 before they sheared at an approximate depth of 21.5 m and 22.0 m, respectively. SI98-2 was located along the south (northbound) shoulder of the highway and SI98-5 was located below the highway along Wanyandie Road. No discernible movement has been recorded in SI98-4, which is still operable and located upstream of SI98-5 in the north (southbound) highway ditch. However, as discussed in Section 1.1, SI98-4 may not have been installed deep enough. An adjacent deeper SI was installed in May 2022 (SI22-01) and a small "kink" has been recorded at an approximate depth of 8 m to 9 m below ground surface (elevation 966 m to 967 m, in a zone of softer material observed during drilling) which may indicate post-installation casing settlement/flexure. However, this instrument has only been read twice and more data is needed to assess the movement trend for this instrument.

Near the middle of the site, no discernible movement has been recorded in SI98-6, SI98-7, SI03-11 or SI03-12 since installation, except for some possible movement in SI98-7 at an approximate depth of 8.5 m (elevation 935 m). As discussed in Section 1.1, SI98-6, SI03-11, and SI03-12 also may not have been installed deep enough. SI98-6 is located along the south (northbound) shoulder of the highway, SI03-11 and SI03-12 are located above the highway along the backslope, and SI98-7 is located below the highway along Wanyandie Road. In May 2022, two deeper SIs (SI22-02A and SI22-03) were installed to assess if there were deeper failure planes in the middle of the site. SI22-02A has recorded distributed movement from an approximate depth of 5.0 m to 11.5 m below ground surface (elevation 961.0 m to 954.5 m) and is confined to the colluvium/till unit. SI22-03 appears to have recorded post-installation casing settlement/flexure at approximately 6 m below ground surface, which may be caused by grout loss in a more granular zone in the colluvium unit. However, these two instruments have only been read once since installation. More data is needed to assess the movement trends for these instruments.

At the eastern site limit, discrete movement is/was being recorded in:

- SI20-2 (operable) between an approximate depth of 27.2 m and 29.2 m (elevation 957.8 m and 955.8 m) below ground surface; and
- SI20-3 (operable) between an approximate depth of 17.9 m and 19.4 m (elevation 963.1 m and 961.6 m), and 24.9 m and 25.9 m (elevation 956.1 m and 955.1 m) below ground surface.
- SI20-6 (inoperable) at an approximate depth of 25.9 m and 27.1 m below ground surface (elevation 939.9 m) before it sheared at an approximate depth of 27 m between the fall 2021 and spring 2022 readings.

In May 2022, a deeper SI (SI22-04) was installed to assess if a deeper failure plane was present at the eastern extent of the site. SI22-04 has recorded no discernible movement since installation. However, this instrument has only been read once since initialization. More data is needed to assess the movement trend for this instrument.

2.3 Interpretation of Monitoring Results

Based on site observations and the SI data, portions of the landslide that appear most active coincide with areas of high fill at the western site limit below and adjacent to the intersection with Wanyandie Road and at the eastern site limit near the deep gully. The landslide currently appears relatively inactive near the middle of the site and above the highway.

Based on the surface expression of the 2005 bare-earth LiDAR data and historic air photos, the most active slide terrain is located downslope of Hwy 40:36 and Wanyandie Road at the western site limit as shown in Figure 1. KCB hiked to this area during our March 2022 site reconnaissance and the 2022 Section B inspection with AT. A series of ridges and troughs were observed, which could be the result of blocks sliding and eroding overtime with vegetation growth, becoming more rounded. The direction of movement recorded in SI98-2 and SI98-5 was towards the area of ridges and troughs before they sheared.

As discussed above, no discernible movement has been recorded in SI98-4 installed upslope of SI98-5 or SI98-6 near the middle of the landslide but these instruments may not have been installed deep enough. Three deeper SIs (SI22-01, SI22-02A, and SI22-03) were installed by KCB in 2022 into bedrock near the western site limit and middle of the site to assess if deeper movements are occurring at these locations. No discernible movement has been recorded in SI22-01 and SI22-03 (excluding potential post-installation casing settlement/flexure). Distributed movement was recorded in SI22-02A from an approximate depth of 5.0 m to 11.5 m below ground surface (elevation 961.0 m to 954.5 m) at a rate of approximately 13.6 mm/year. These instruments have only been read one since installation and more data is needed to assess movement trends.

Movement is/was being recorded in both the A- and B-directions of SI20-2, SI20-3, and SI20-6 (now inoperable) with an overall resultant towards the south to southeast. The movement appears to be in response to high fill placement at this location in the ravine on the east side of the site. Alternatively, the size of the area of valley-wall instability could be such that natural slope movements have A- and B-direction components due to the shape of the basal failure plane, potentially more stable zones, or other unknown factors. Since these instruments were terminated in clay till (not bedrock) a deeper SI (SI22-04) was installed by KCB in 2022 into bedrock to assess if deeper movements are occurring at this location. No discernible movement has been recorded in SI22-04. This instrument has only been read once since installation and more data is needed to assess movement trends. Given the rate of discrete movement being recorded in SI20-2 and SI20-3, KCB anticipates that these instruments could shear soon and become inoperable.

Less active portions of the landslide above the highway may not be as influenced by fill placement or water infiltration into the backscarp at highway level. However, without any changes to the slide or highway geometry, continued movement of the lower portions of the slide or prolonged periods of wet weather causing groundwater levels to rise could eventually result in movements further upslope.

The porewater pressures/water levels recorded in the SPs, VWPs and PNs were steady (± 0.3 m) or decreasing, and consistent with previous readings for these instruments. It is noted that the porewater pressure recorded in VW20-2B increased 6.7 m between July 2020 (installation) and June 2021. The instrument was likely reaching equilibrium from the grout backfill after installation in July 2020. Pore pressure monitored by VW20-2B has been steady since July 2021. Porewater pressures monitored by VW22-1A/B/C, VW22-2A/B/C/D, VW22-3A/B/C/D, and VW22-04A/B remain steady since the data loggers first started recoding data in mid May 2022. The grout may be muting the instruments response to changing water levels, or the water level variations are too rapid to be recorded by the data loggers. KCB can increase the reading frequency of the data logger (currently set to record data every 12-hours). Leveloggers could be installed in the SPs on site (e.g., TH20-04) in an attempt to capture short-term water level fluctuations (i.e., seasonal variations or in response to heavy or prolonged precipitation or infiltration due to freshet).

VWP22-1B/C have been dry since installation and are installed in bedrock (siltstone and sandstone, respectively). VW22-1B was installed near a possible shear zone observed near the top of the siltstone unit. VW22-2D and -3D have been dry since installation and are both installed in clay shale.

Between October 2020 and June 2021, an increase in porewater pressures between 0.4 m and 1.0 m was recorded in all ten PNs. Historically, the porewater pressures recorded in the PNs have been near the tip elevation of each instrument (i.e., the instruments have been dry), except in PN-4. A porewater pressure approximately 1.0 m above the tip elevation of PN-4 was recorded between the spring of 2018 and spring of 2020. As of the July 2022 reading, the recorded porewater pressures have decreased and returned to just above the tip elevation of each instrument.

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 instruments casing 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 region GRMP Section B inspections.

Leveloggers could be installed in the SPs on site in an attempt to capture short-term water level fluctuations (i.e., seasonal variations or in response to heavy or prolonged precipitation or infiltration due to freshet).

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 (Client) for the specific application to 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.

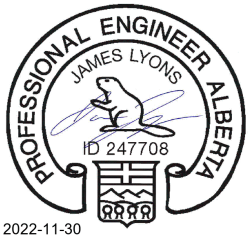
Use of or reliance upon this instrument of service by the Client is subject to the following conditions:

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.

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

Yours truly,

KLOHN CRIPPEN BERGER LTD.



2022-11-30

James Lyons, P.Eng
Civil Engineer

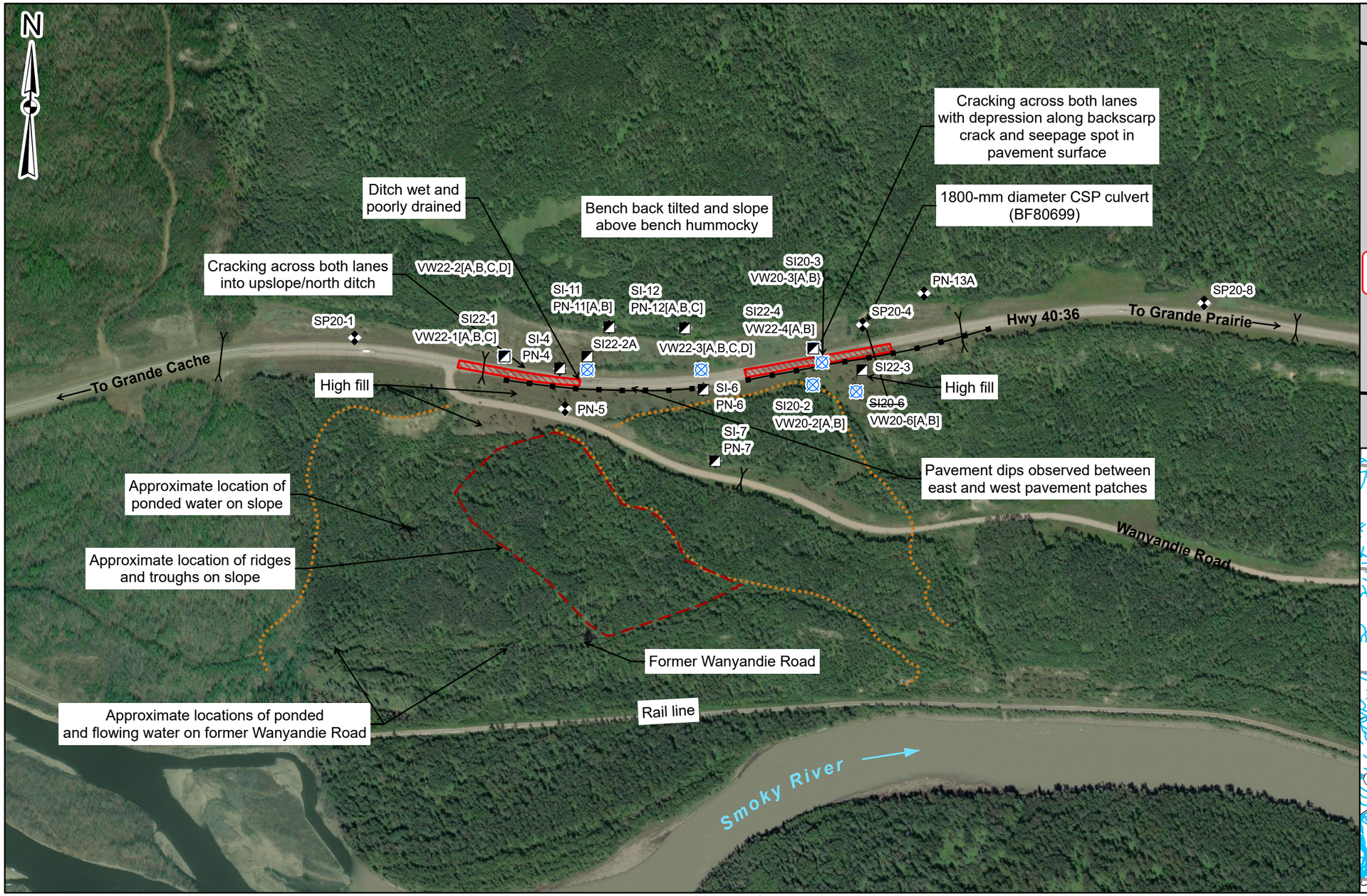
Chris Gräpel, M.Eng., P.Eng.
Senior Civil Engineer, Associate

JL:bb

PERMIT TO PRACTICE
KLOHN CRIPPEN BERGER LTD.
RM SIGNATURE: _____
RM APEGA ID #: 187607
DATE: 30 Nov. 2022
PERMIT NUMBER: P009196
The Association of Professional Engineers and Geoscientists of Alberta (APEGA)

ATTACHMENTS
Figure
Appendix I Instrumentation Plots

FIGURE



Legend

- Approximate Pneumatic Piezometer Location
- Approximate Slope Inclinometer Location
- Approximate Vibrating Wire Piezometer Location
- Flow Direction
- Culvert
- Guardrail
- Active Slide Zone
- Ridges and Troughs
- Pavement Patch

0 200 Metres

NOTES:
1. HORIZONTAL DATUM: NAD83
2. GRID ZONE: UTM ZONE 11N
3. IMAGE SOURCE: ESRI, MAXAR, EARTHSTAR GEOGRAPHICS, AND THE GIS USER COMMUNITY
4. STRIKETHROUGH INDICATES INSTRUMENT IS INOPERABLE.

CLIENT: Alberta

Klohn Crippen Berger

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

TITLE: Site Plan
GP007 - Wanyandie Road Slide
Hwy 40:36, km 29.339

SCALE	PROJECT No.	FIG No.
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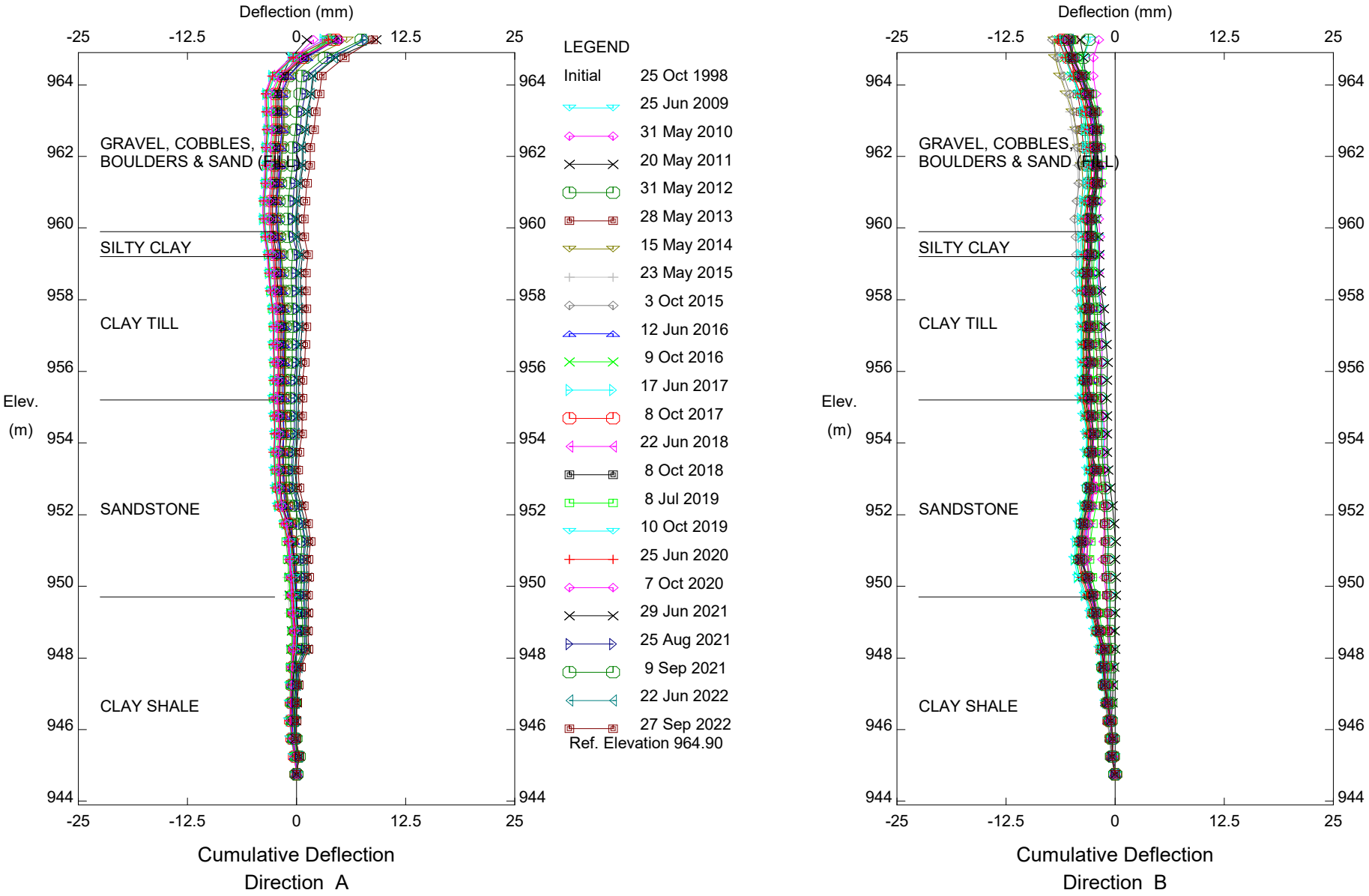
APPENDIX I

Instrumentation Plots

Klohn Crippen Berger - Edmonton



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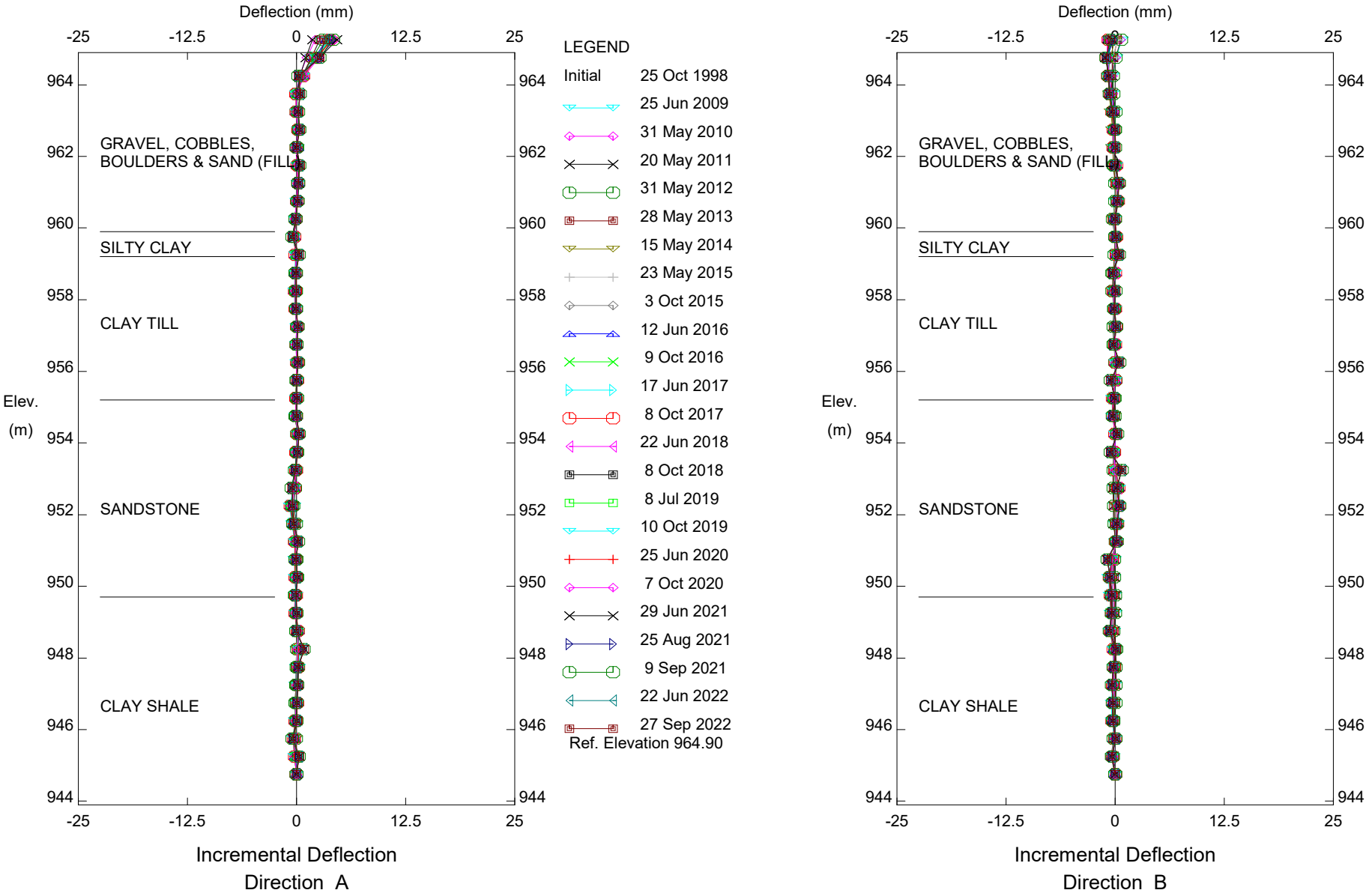
Klohn Crippen Berger - Edmonton



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Alberta Transportation

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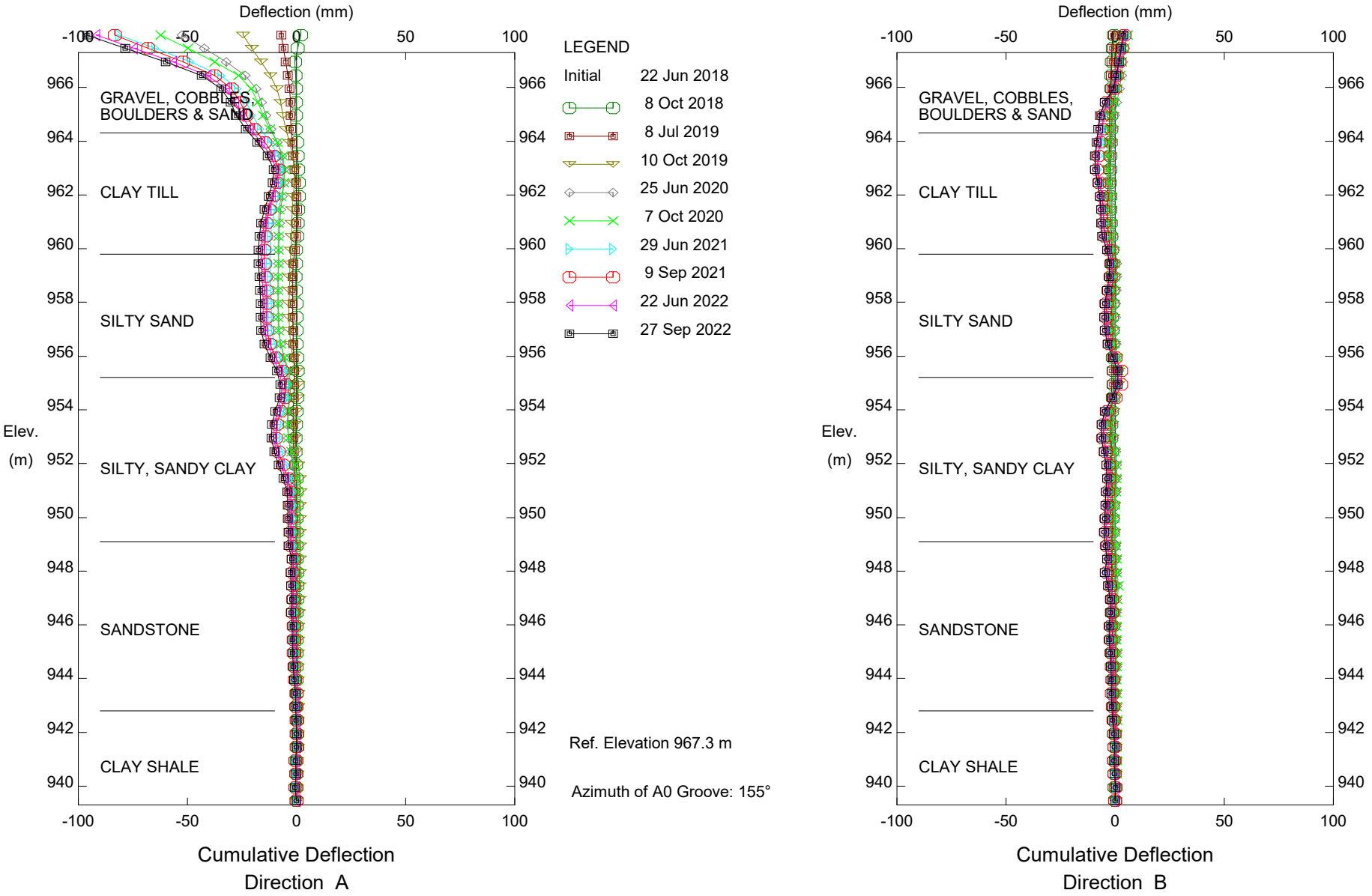

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Alberta Transportation

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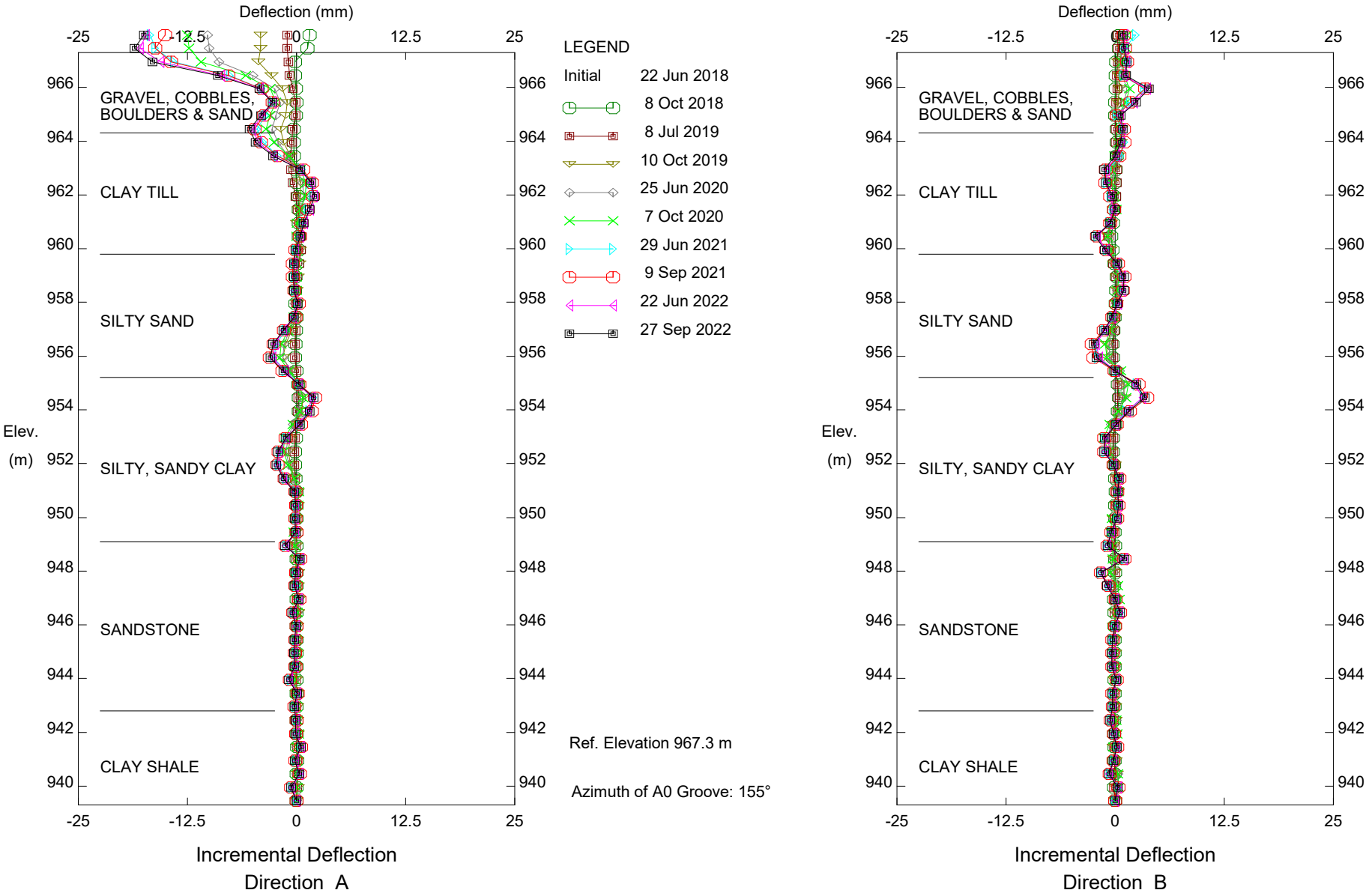

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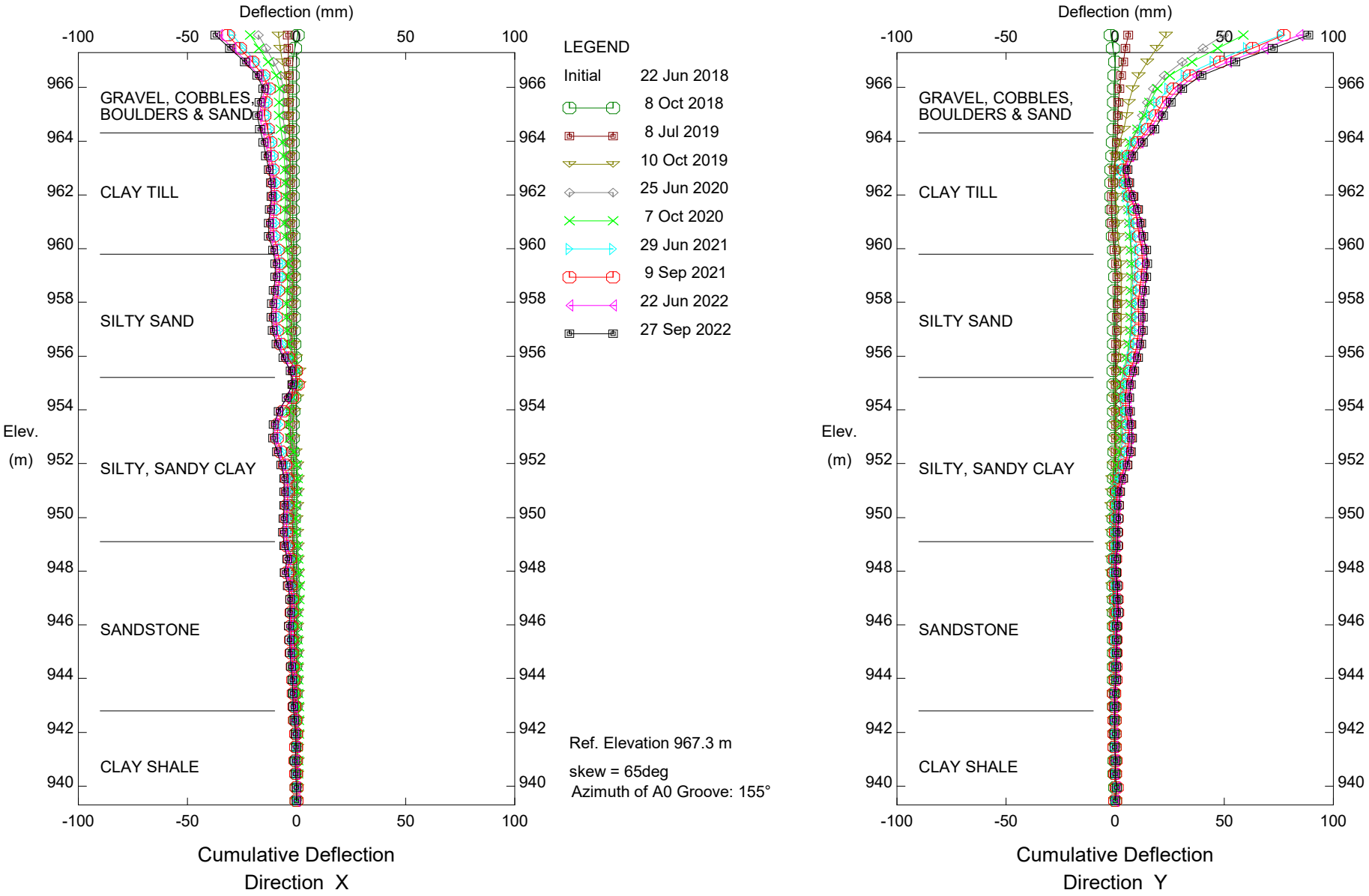

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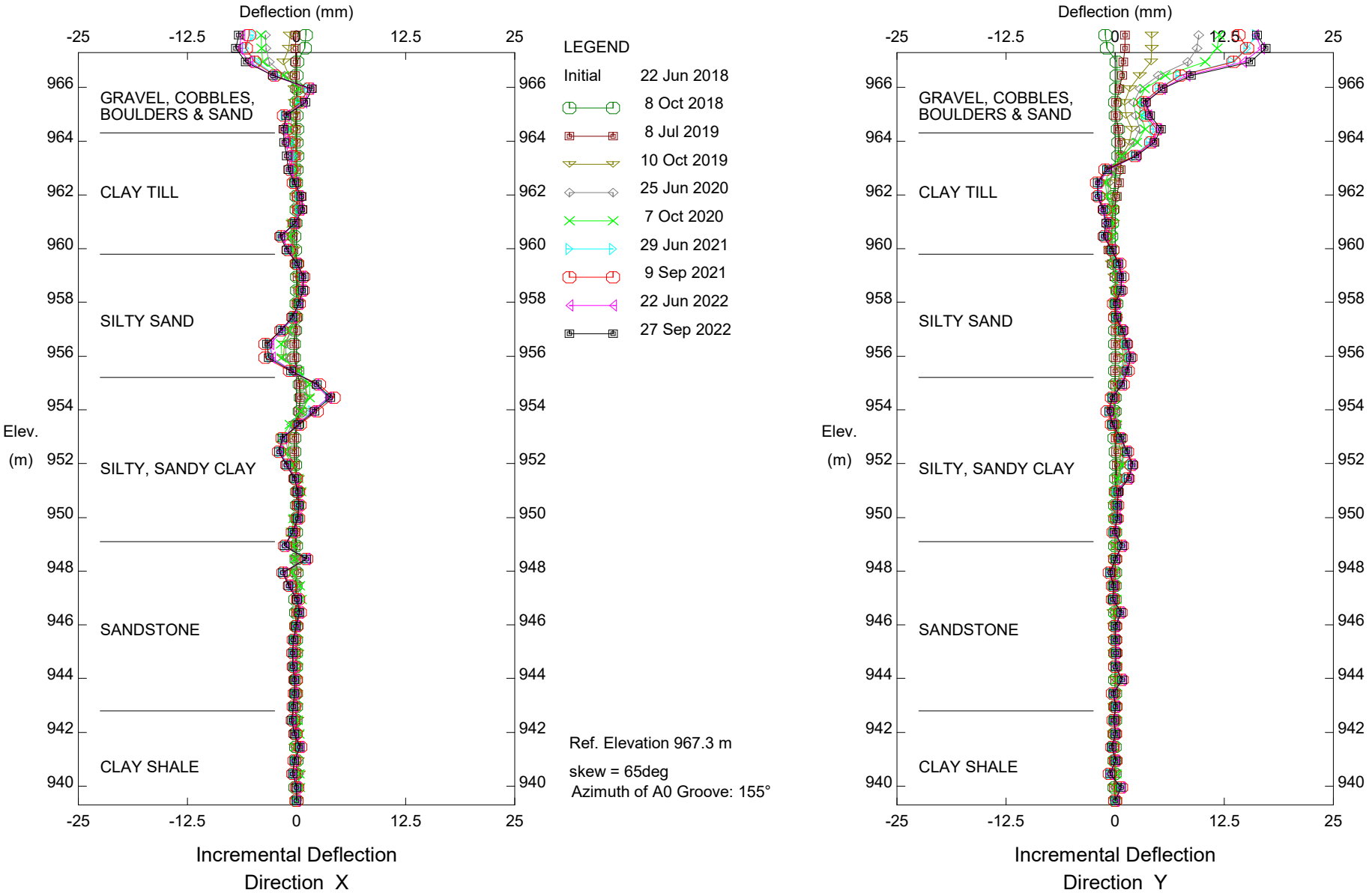
Alberta Transportation

Klohn Crippen Berger - Edmonton



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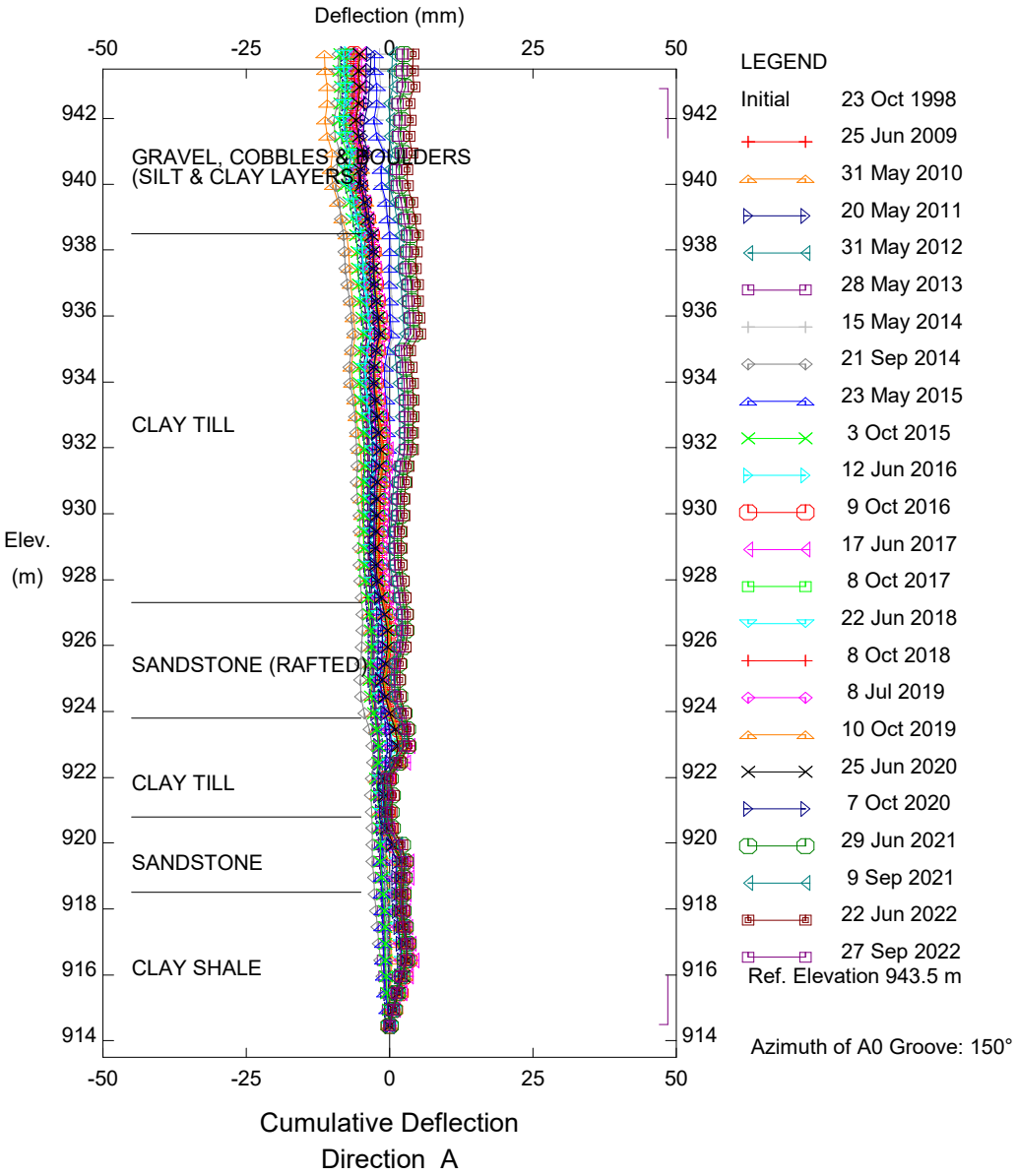

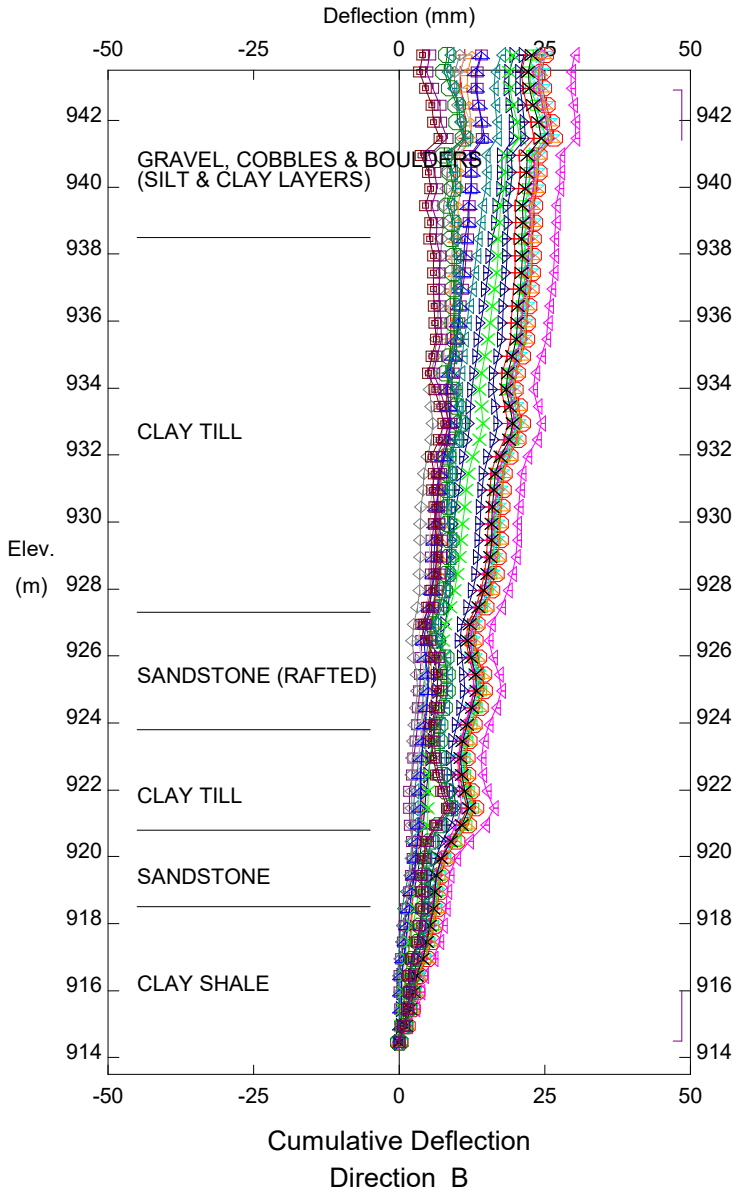

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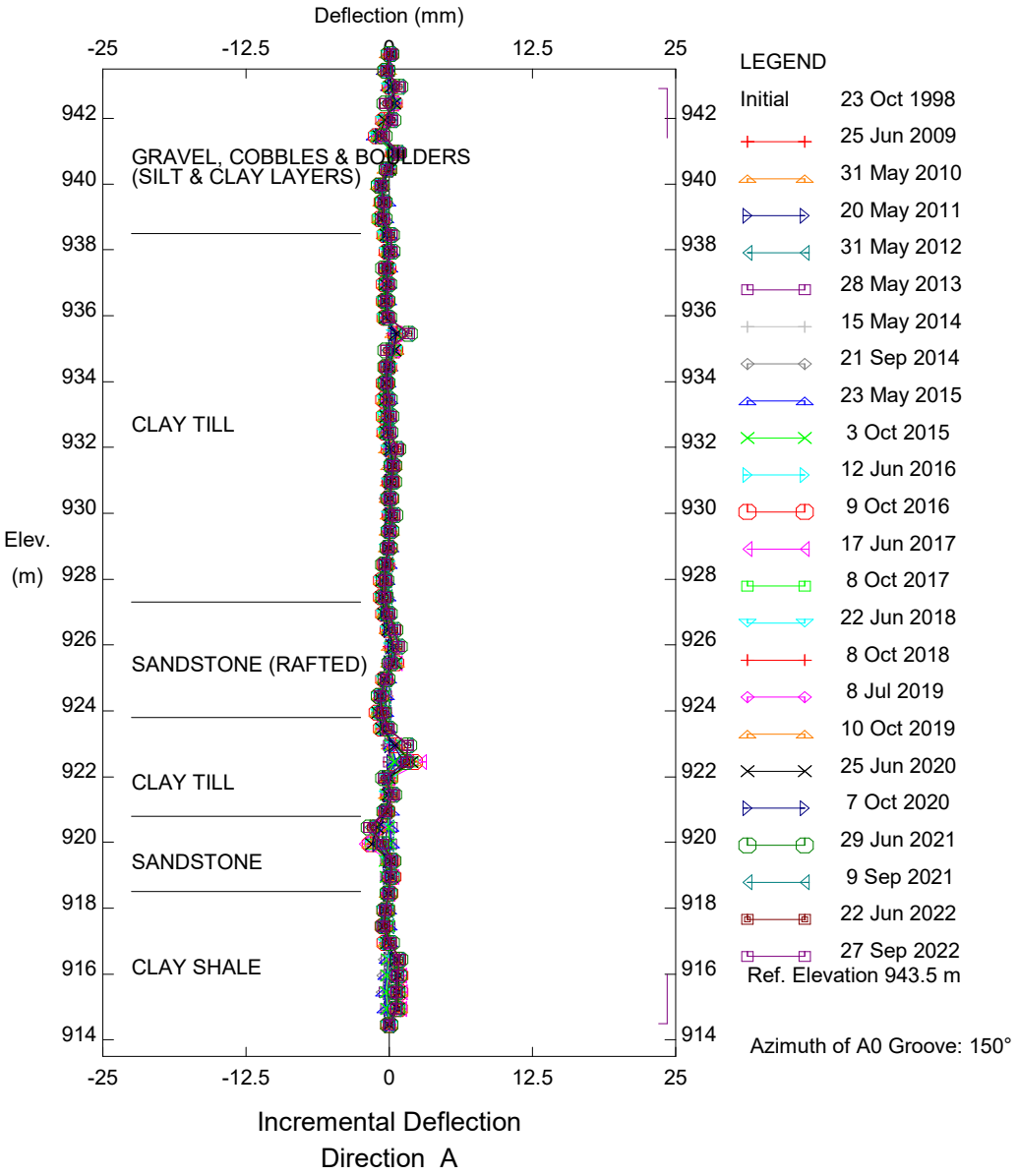

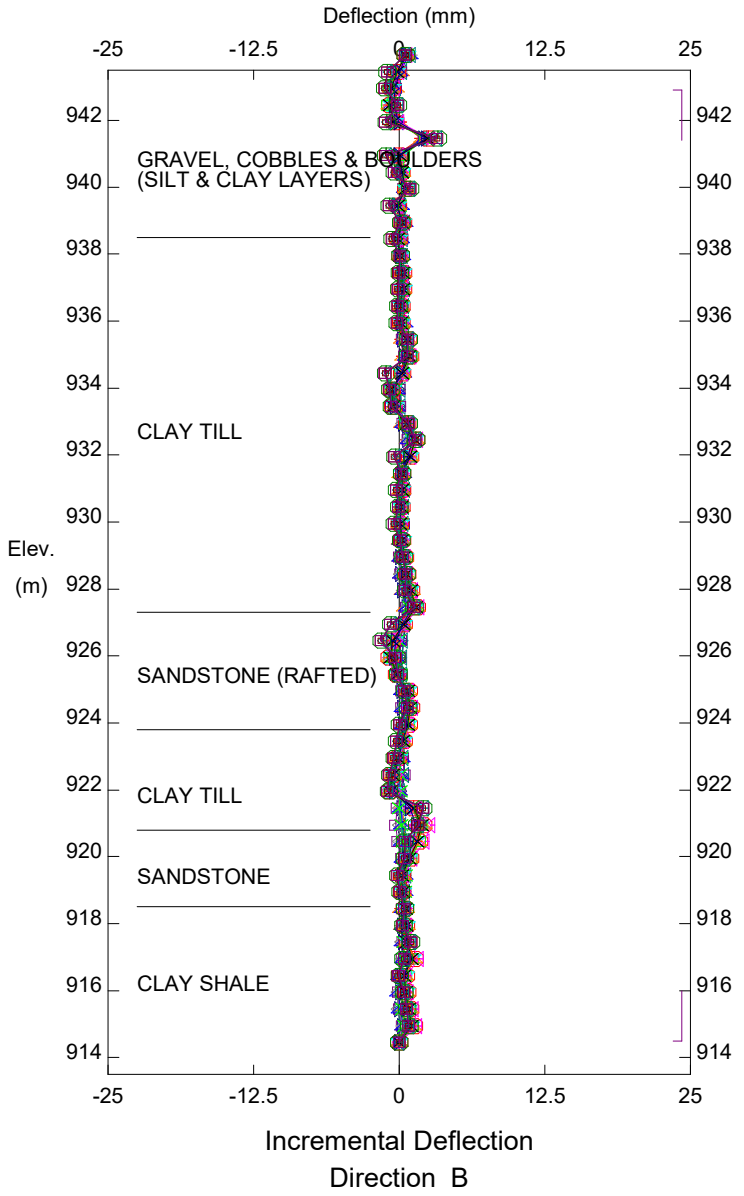

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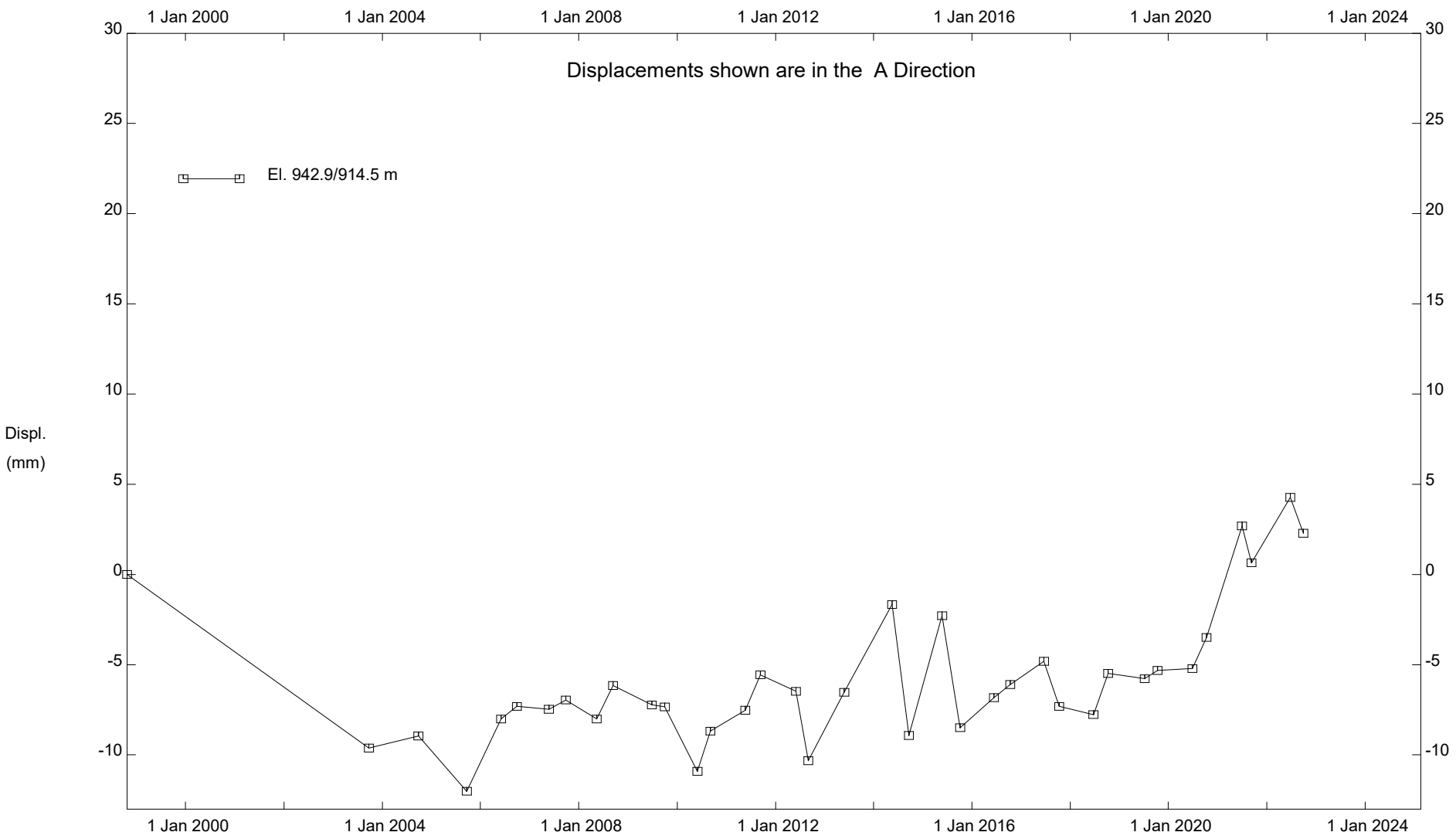

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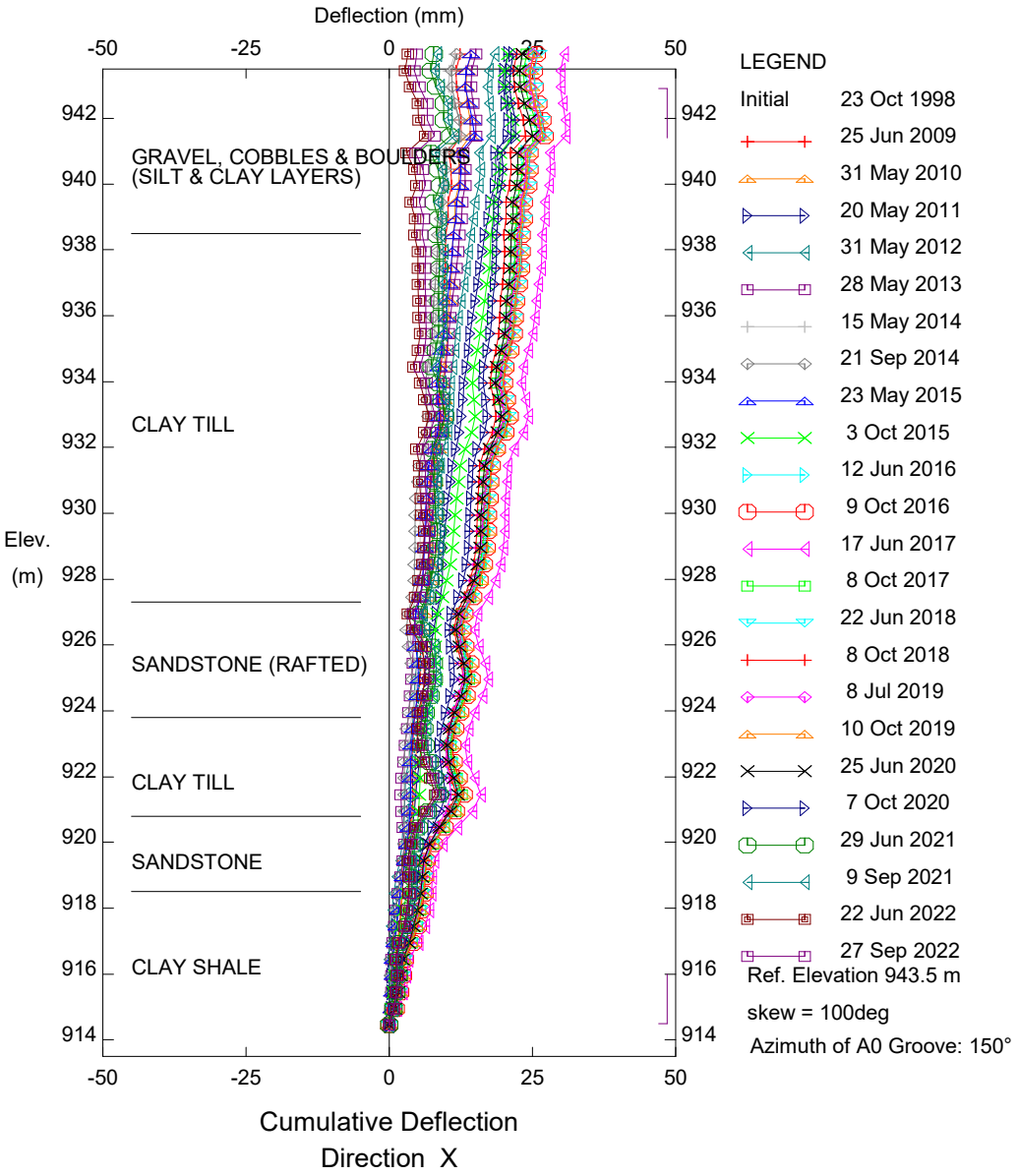

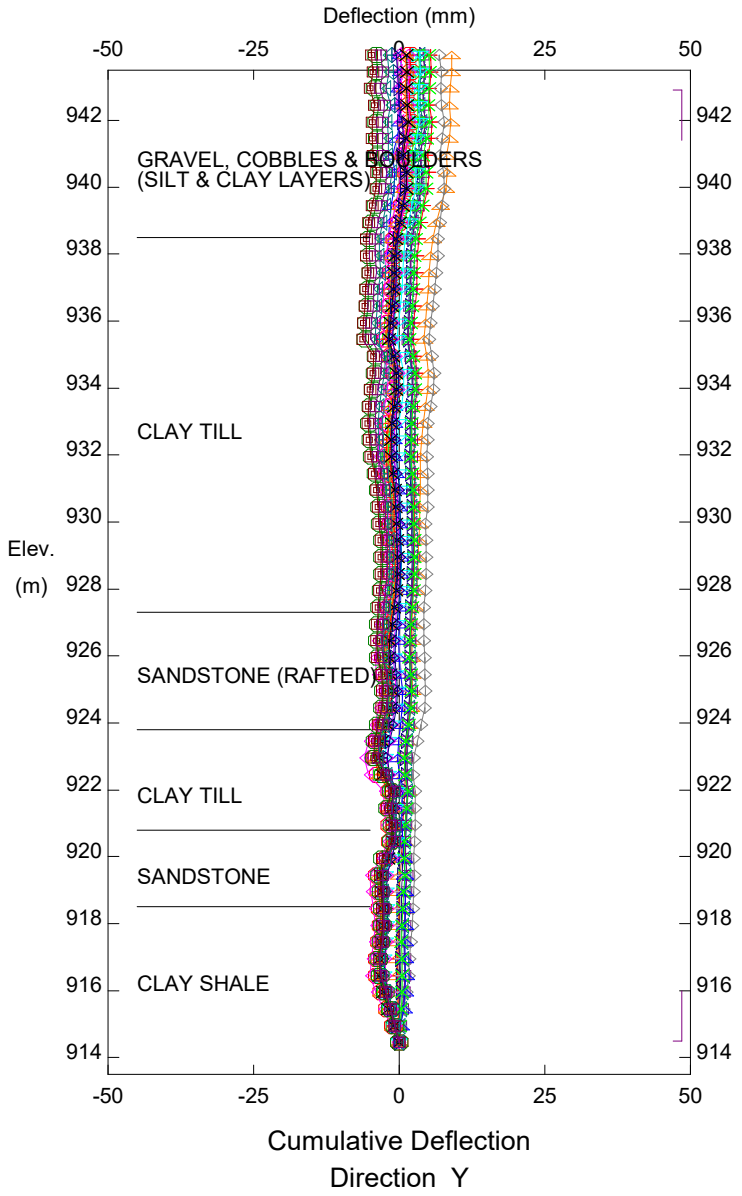

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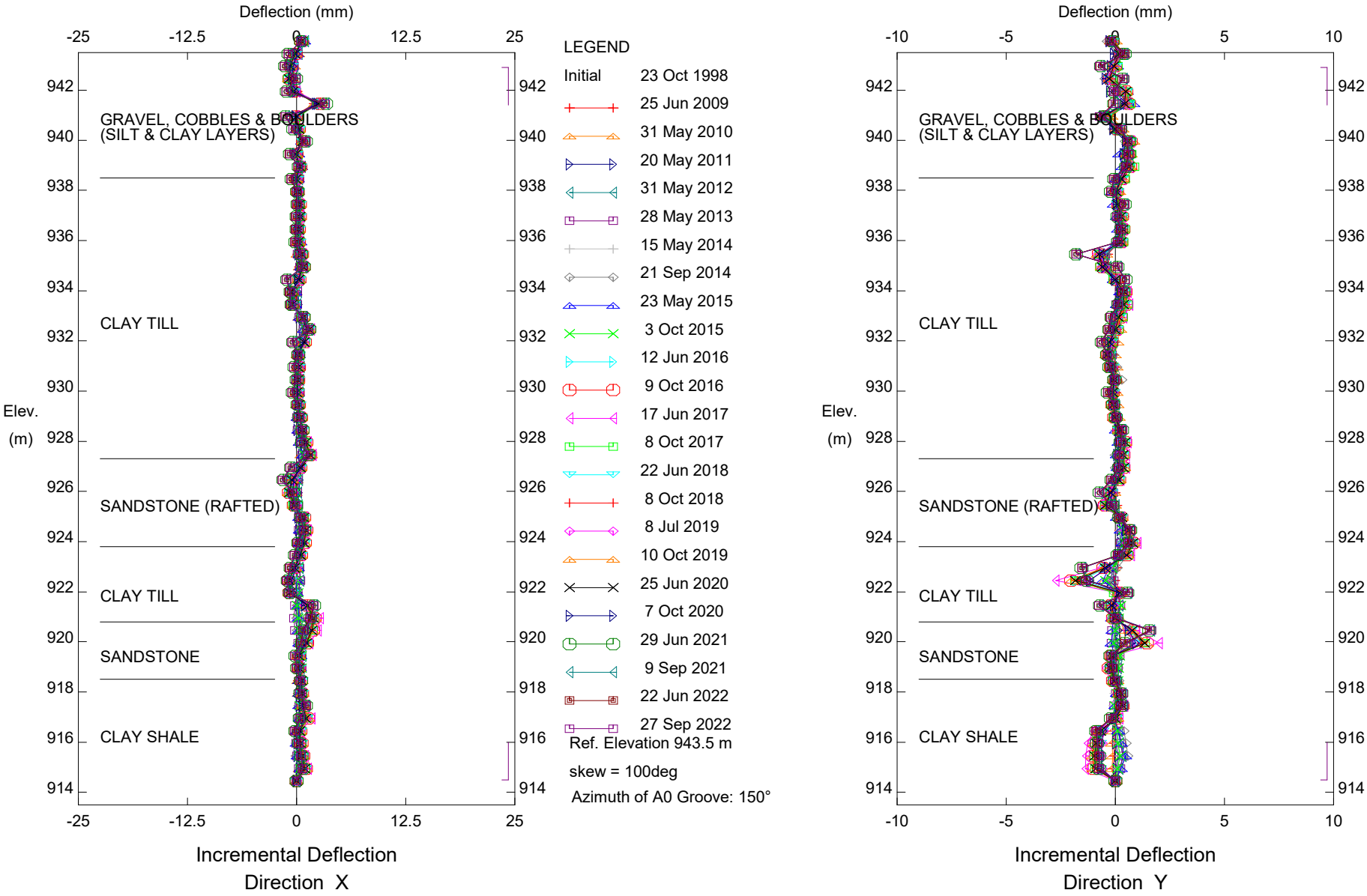

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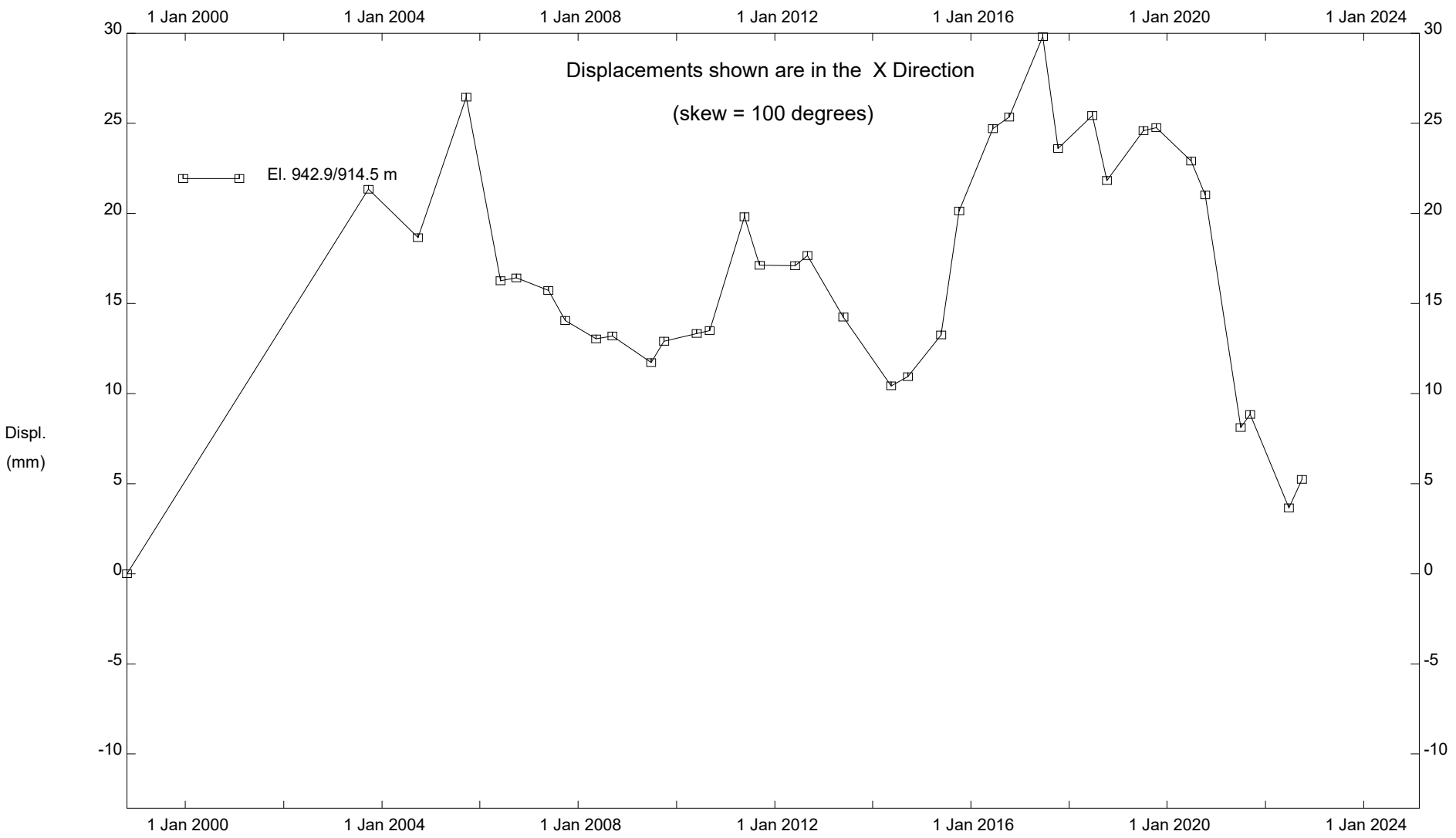

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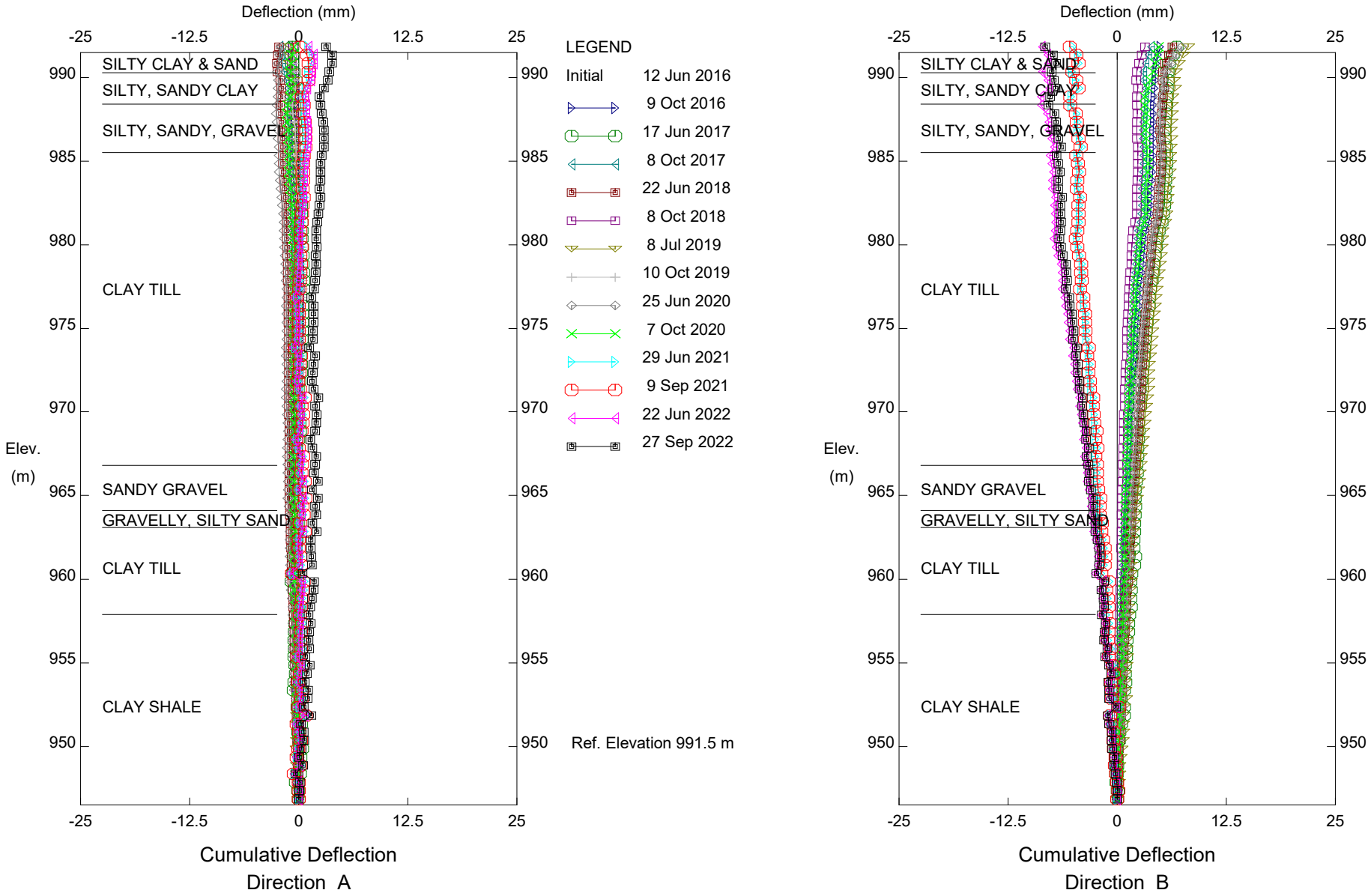

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Alberta Transportation

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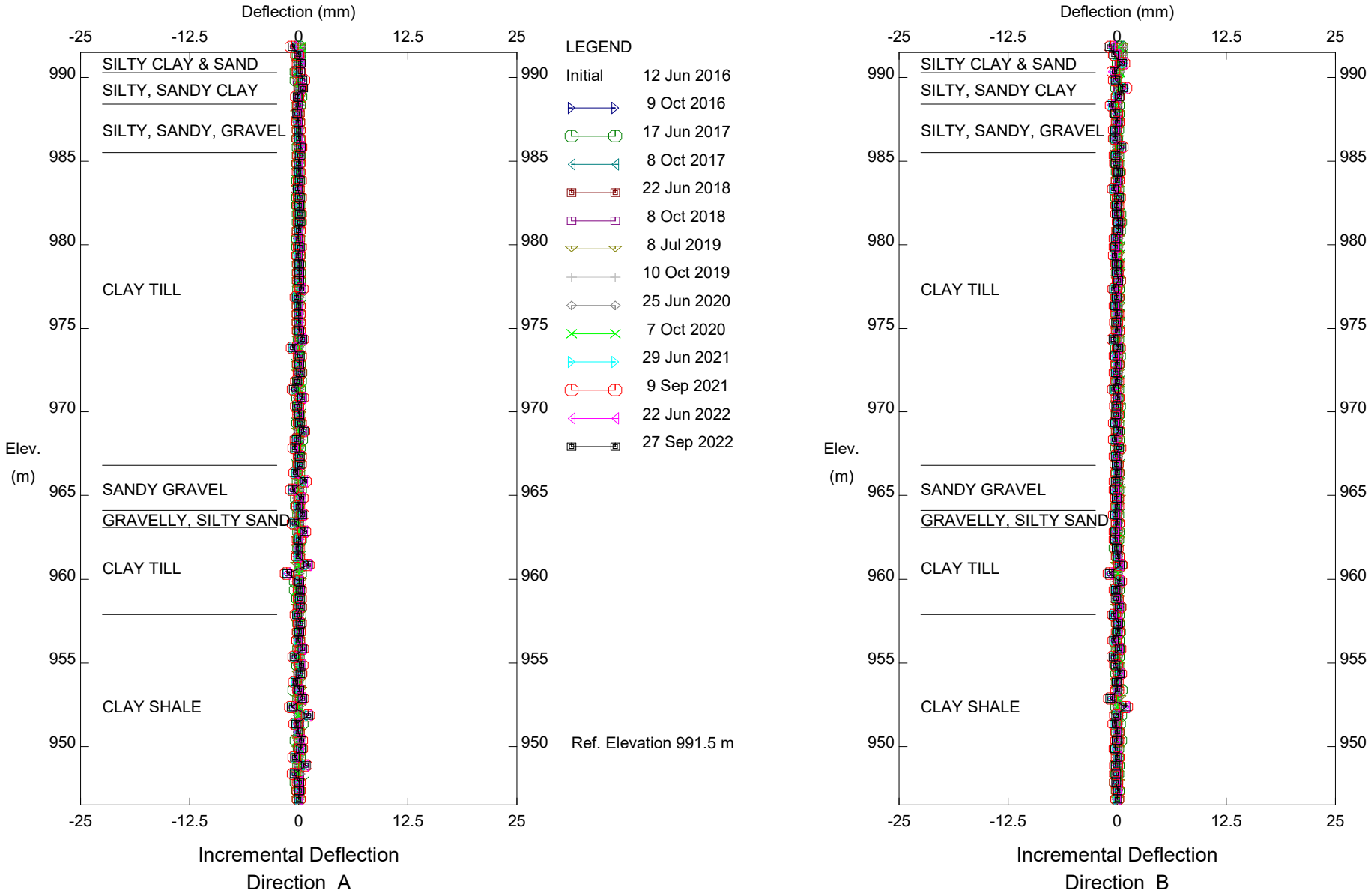

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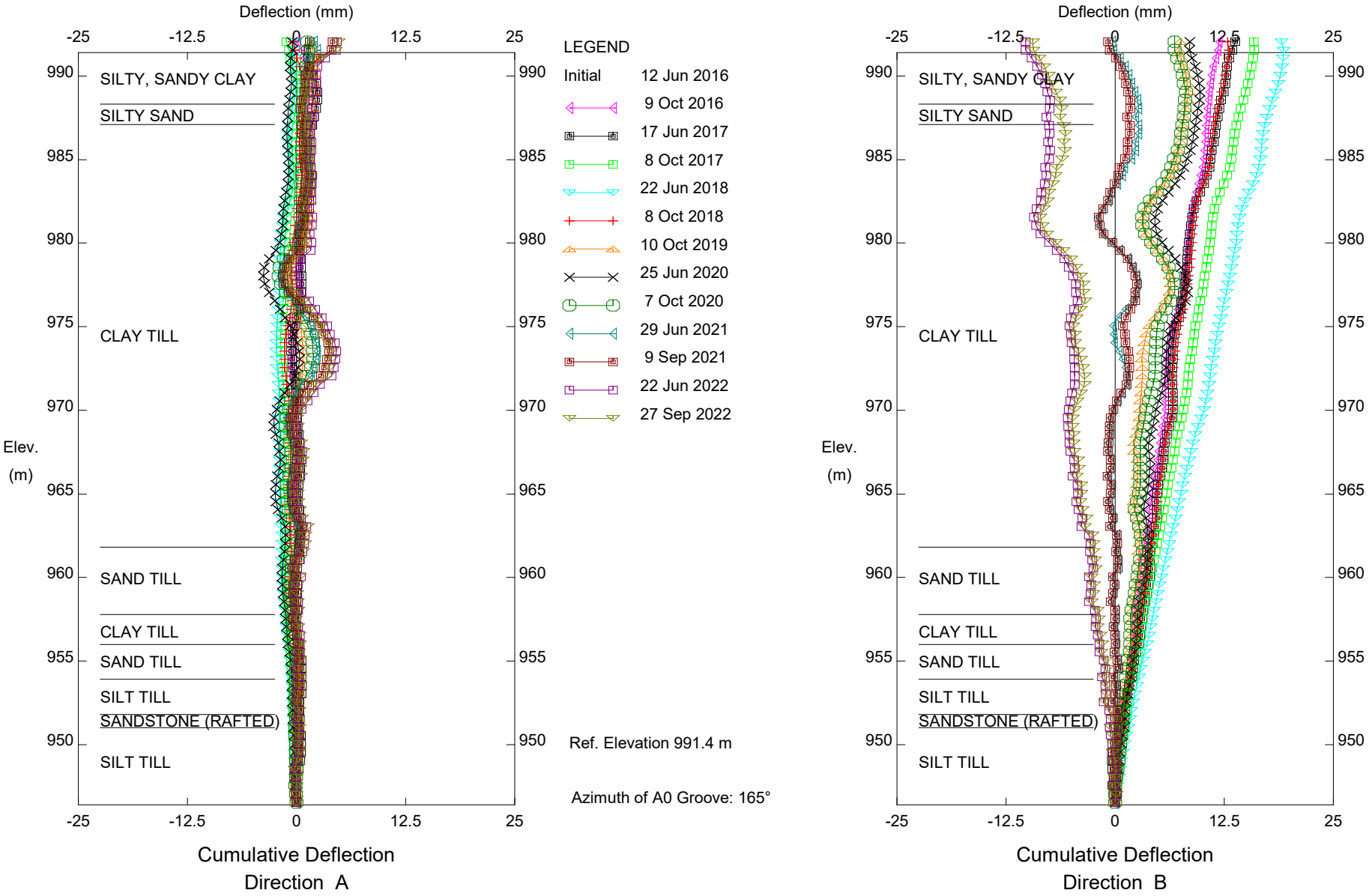

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Alberta Transportation

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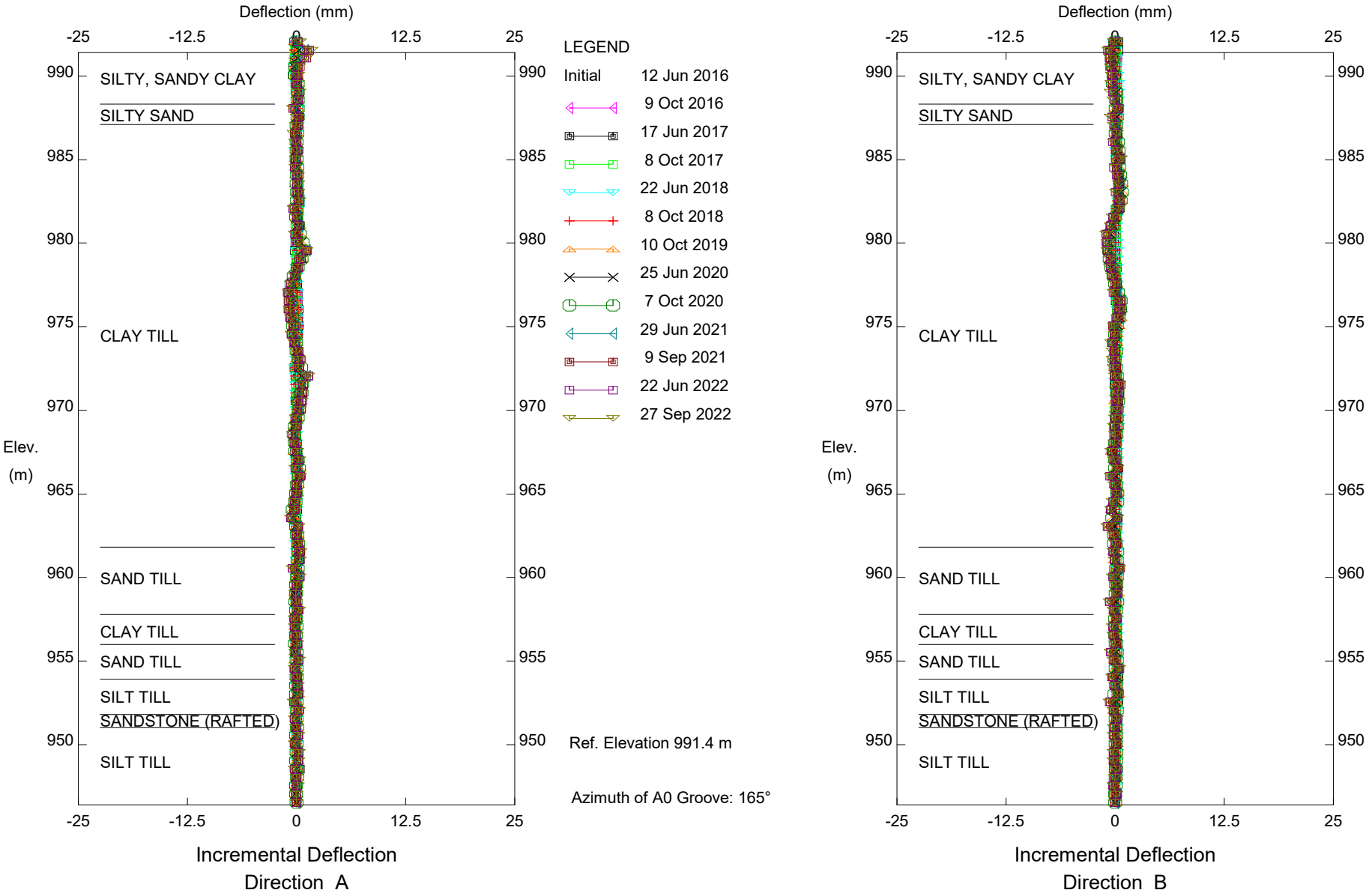

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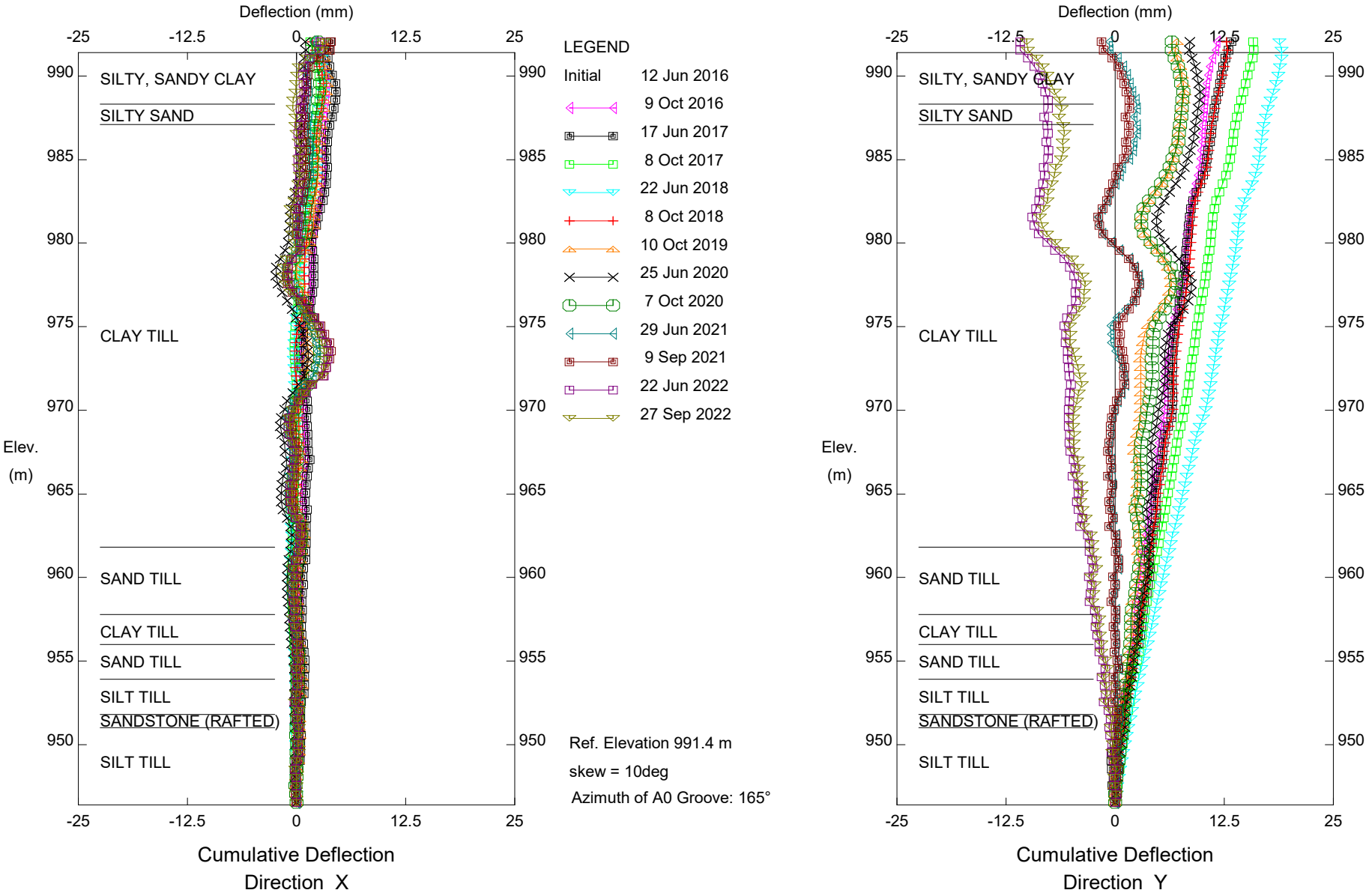

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Alberta Transportation

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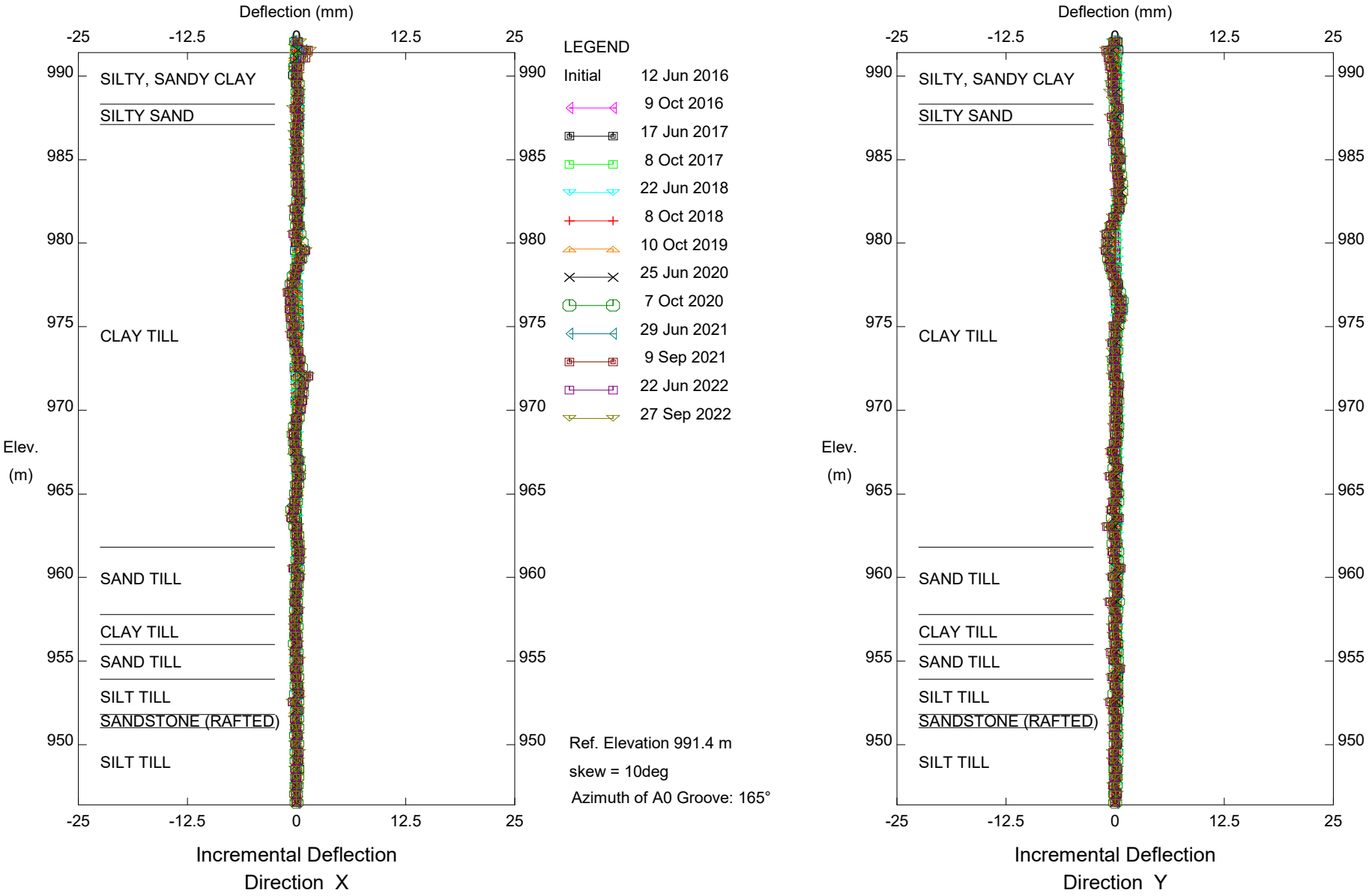

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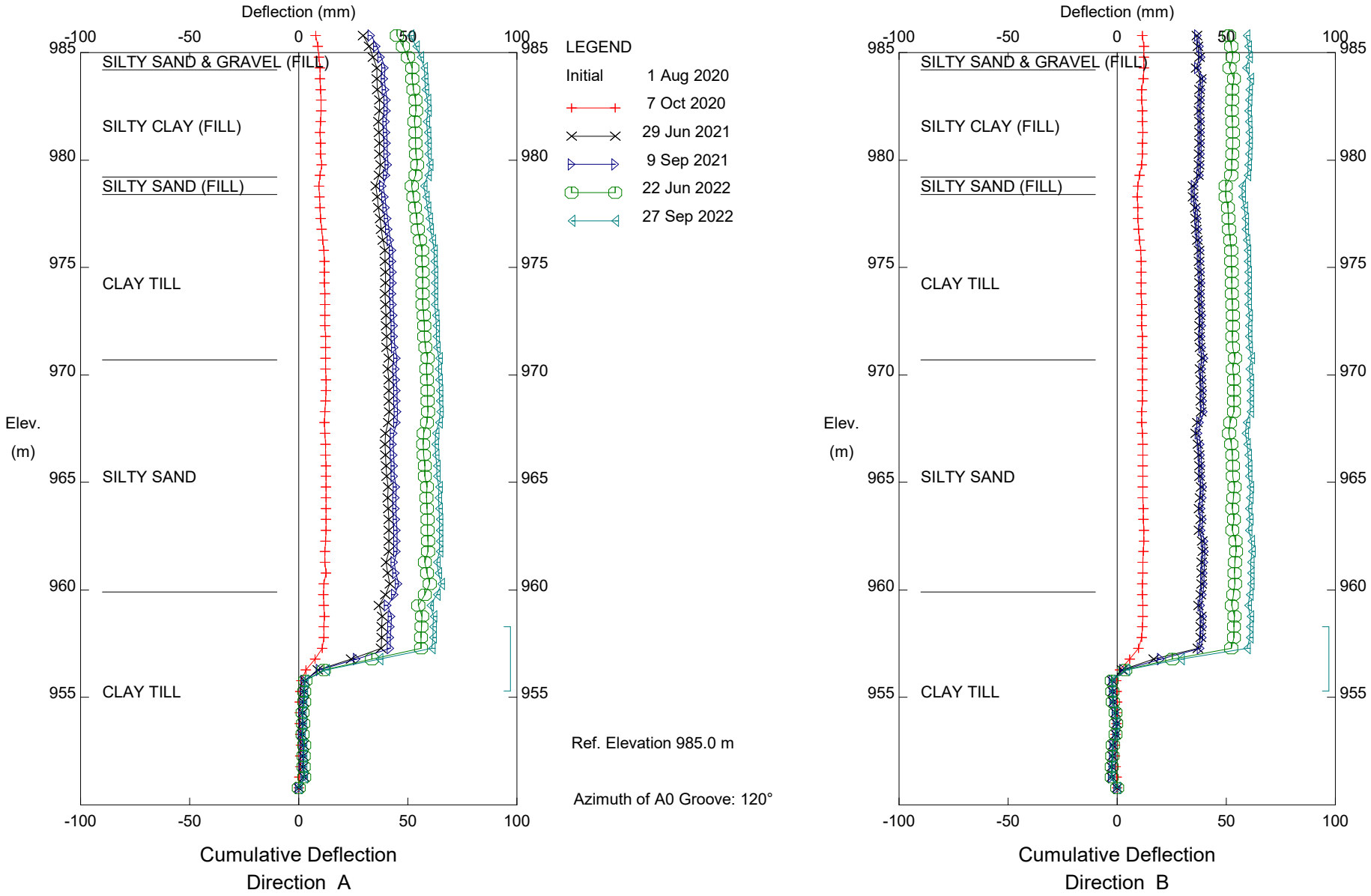

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Alberta Transportation

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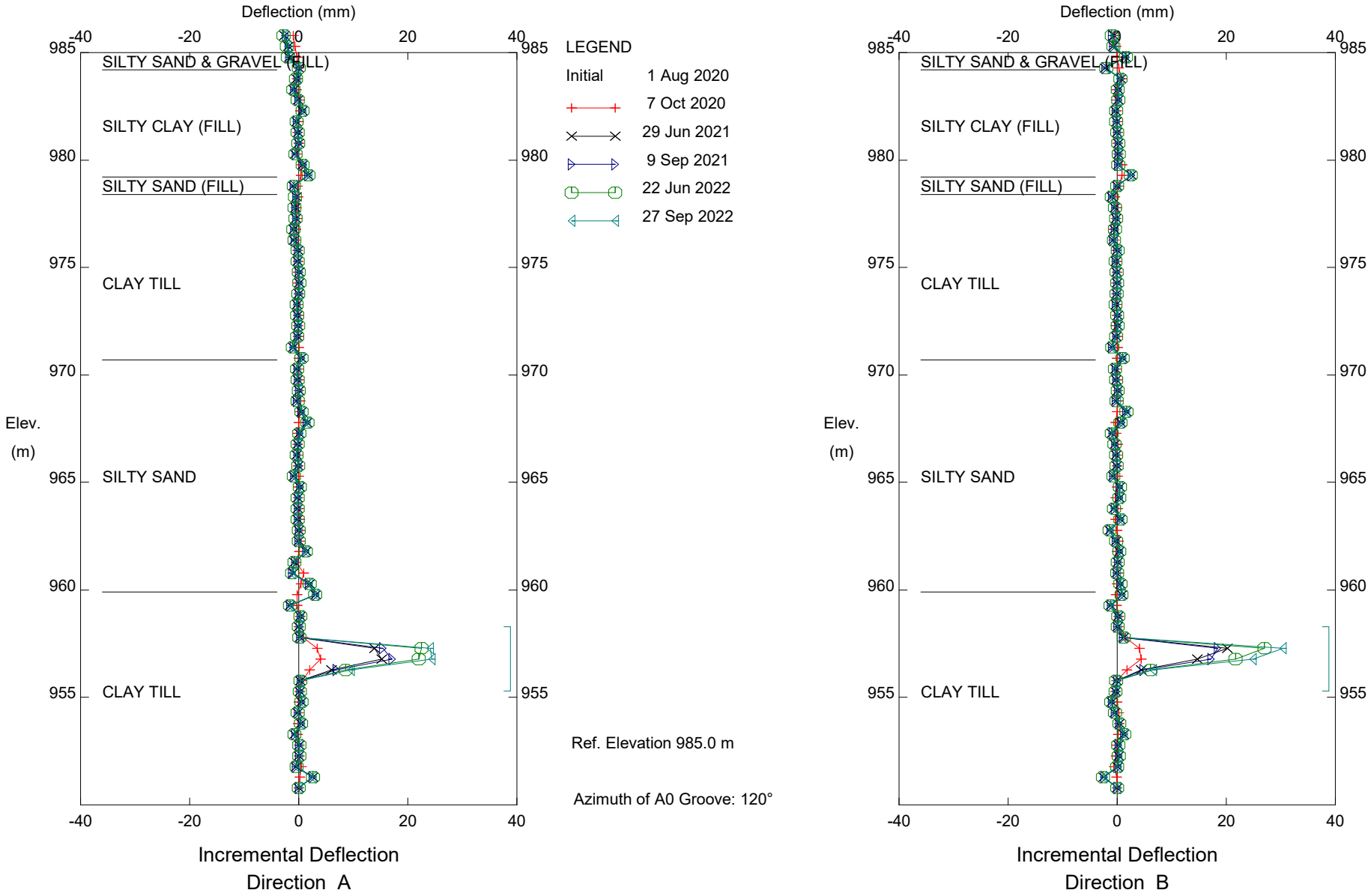

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Alberta Transportation

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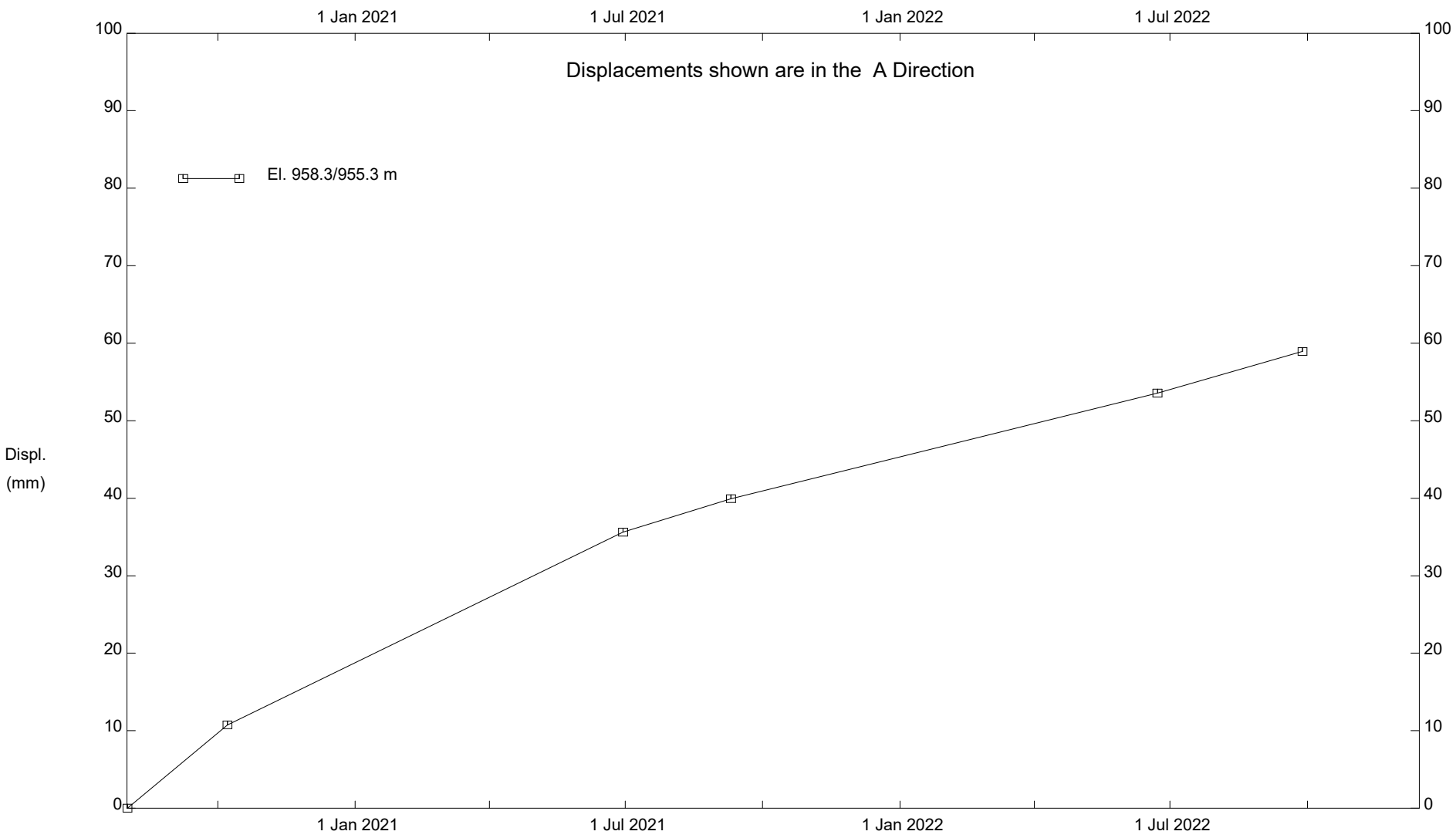

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Alberta Transportation

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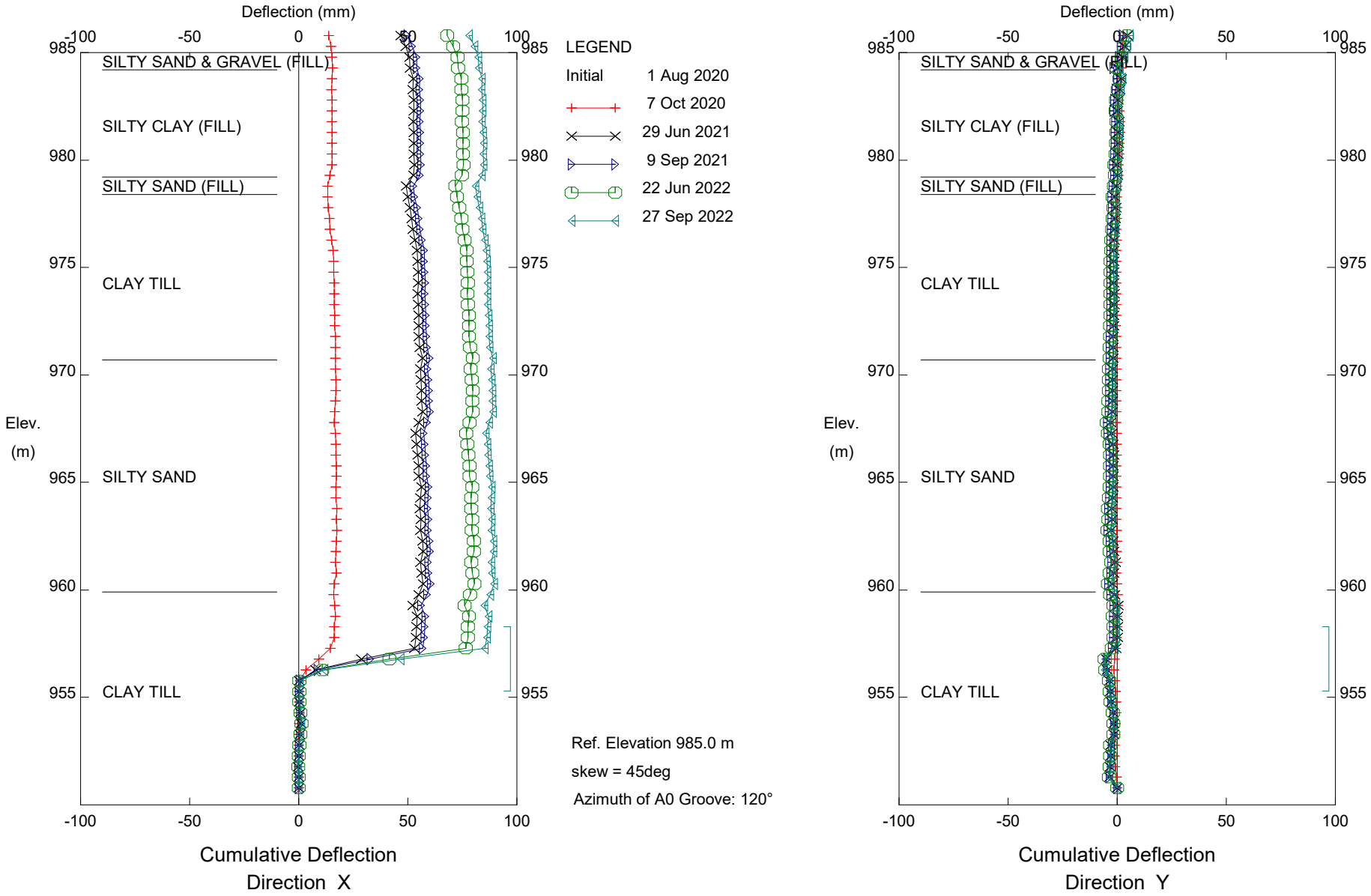

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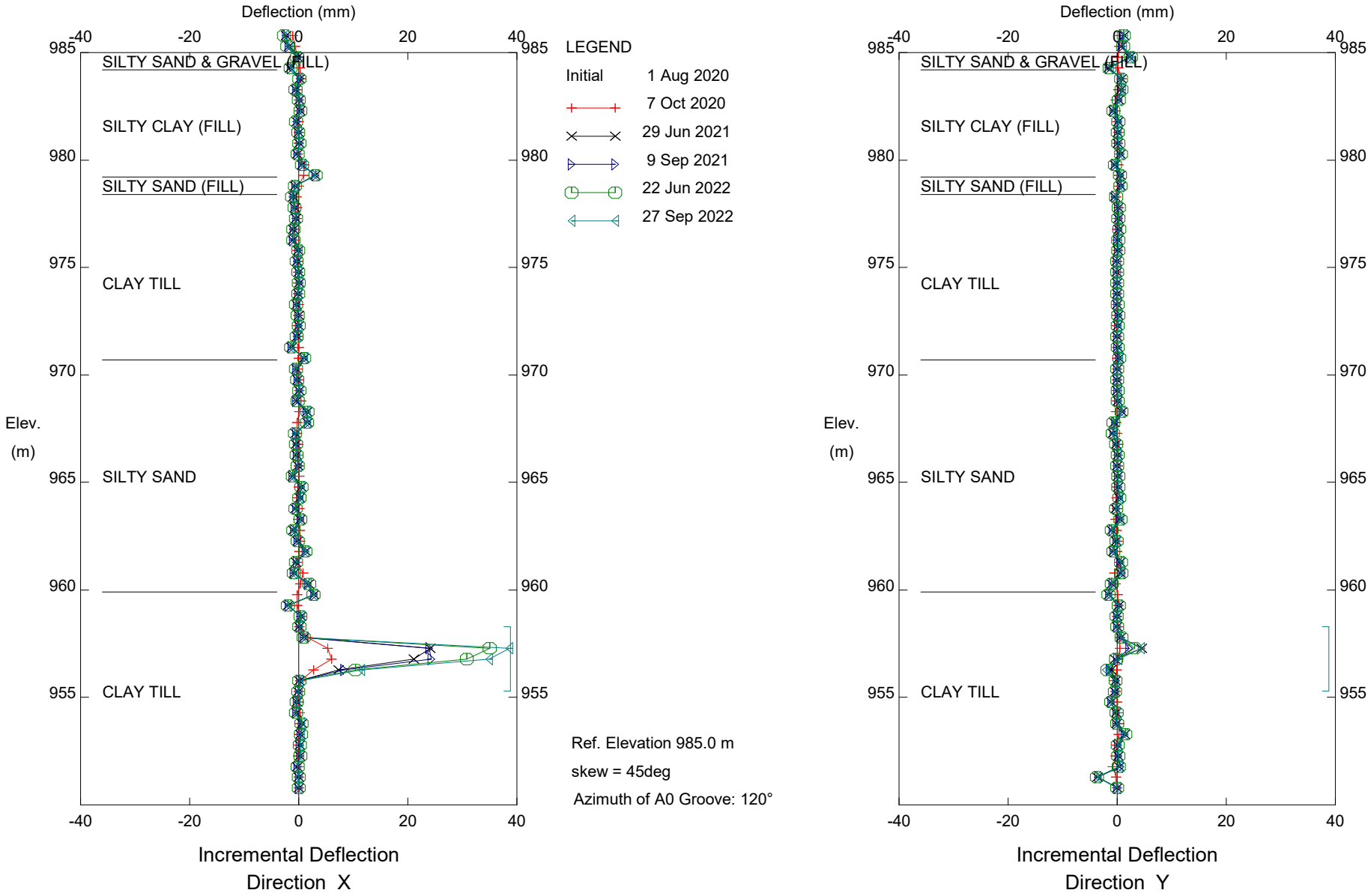
Alberta Transportation

Klohn Crippen Berger - Edmonton



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Alberta Transportation

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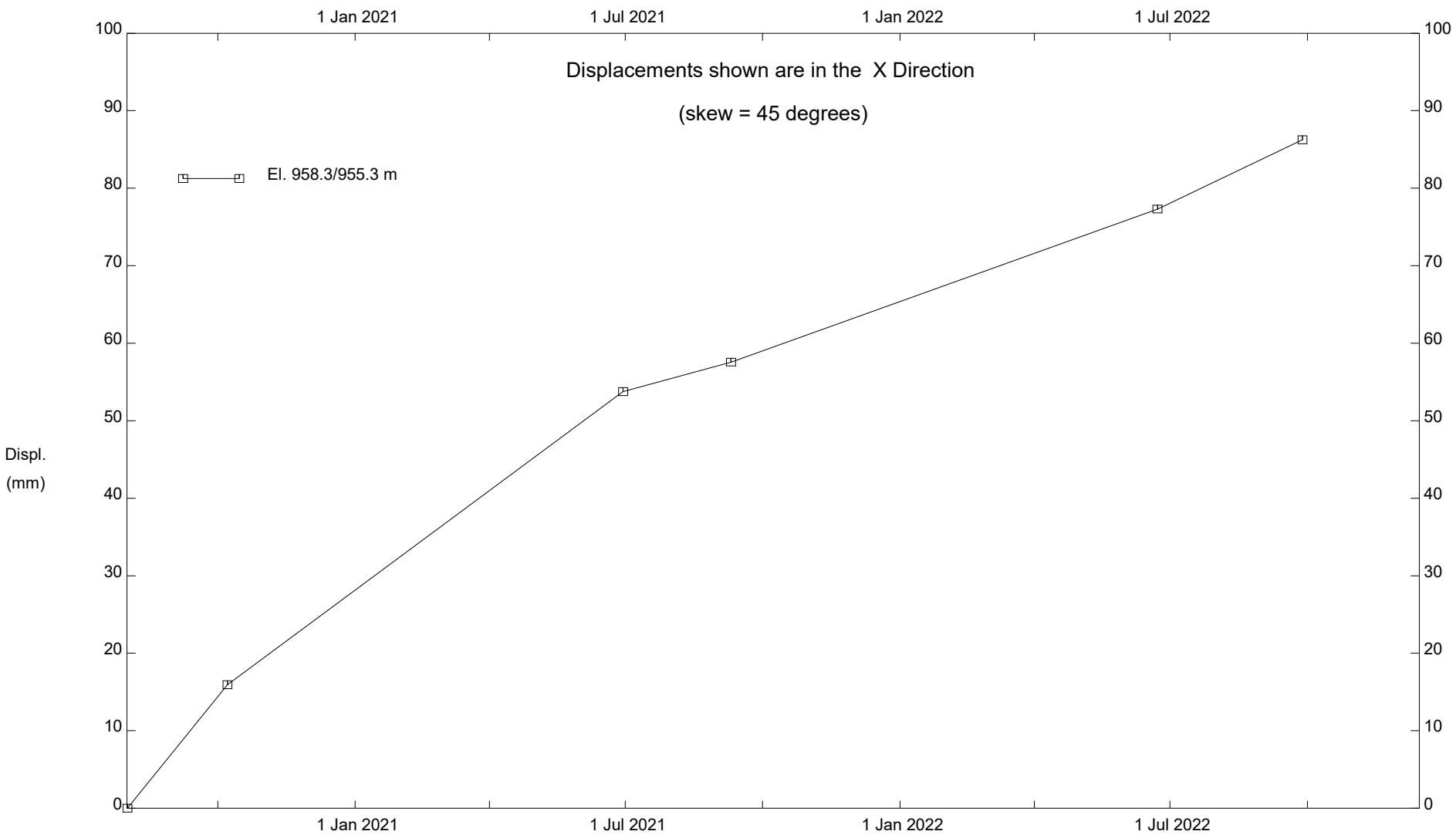

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Alberta Transportation

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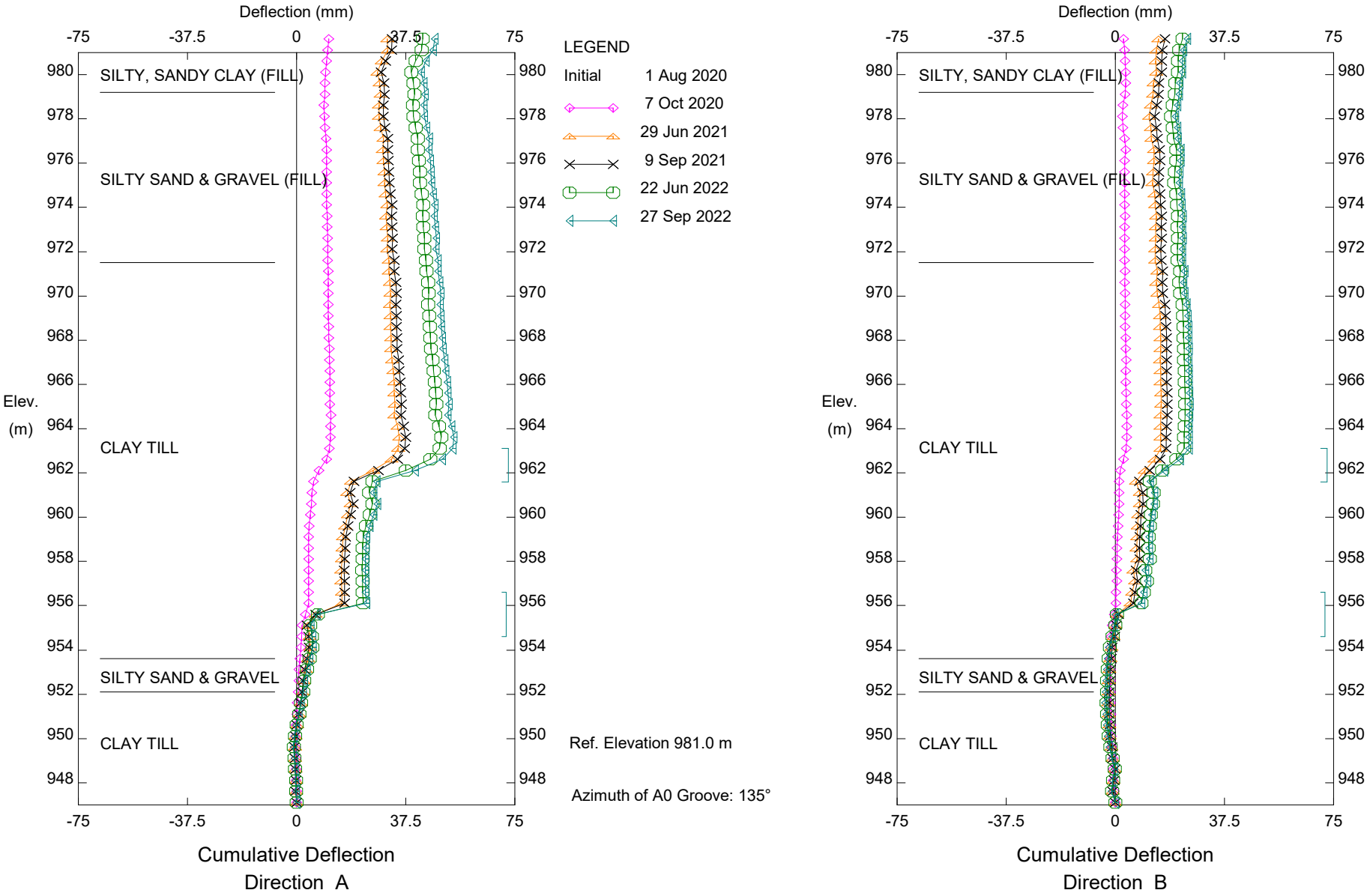

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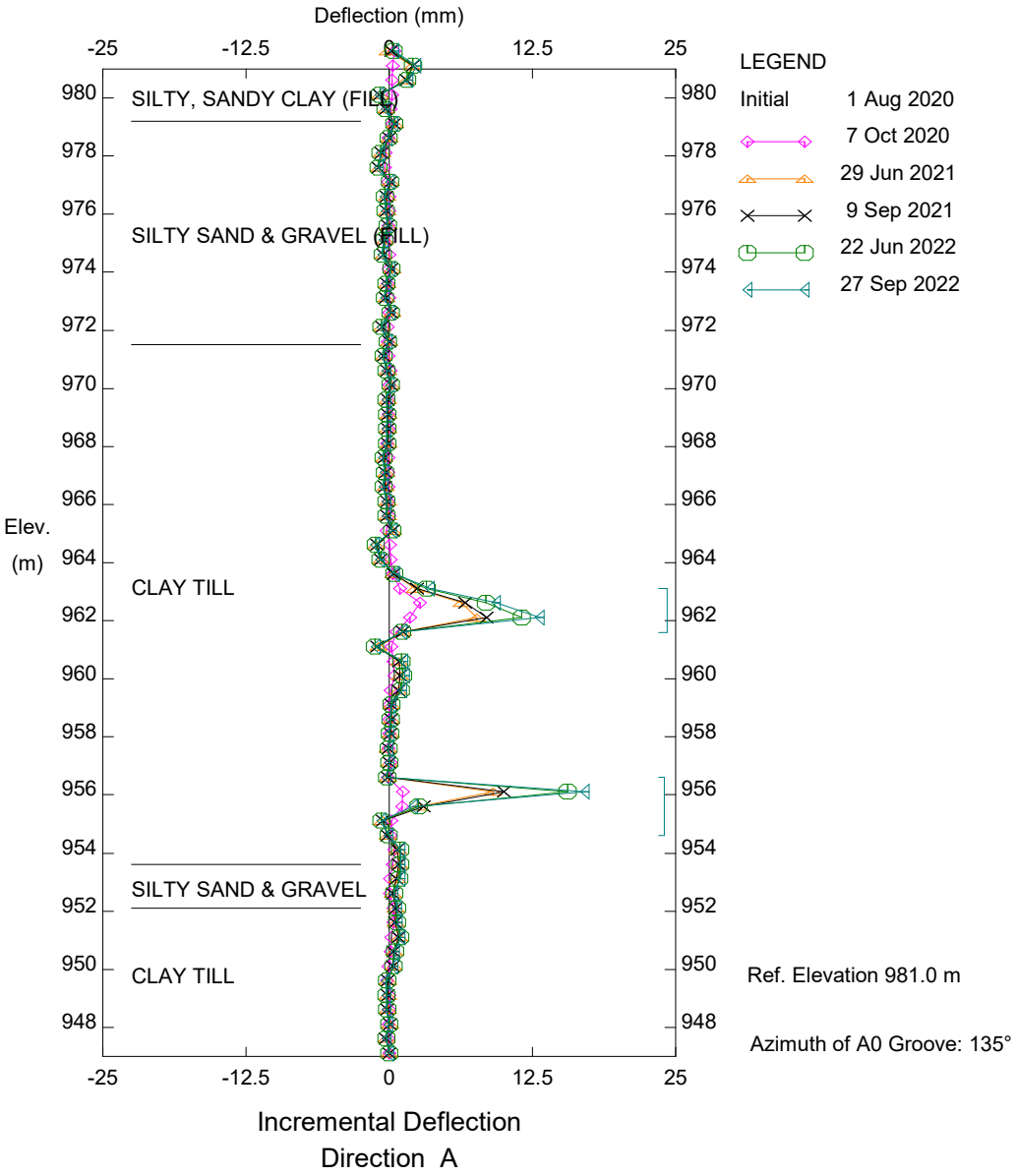
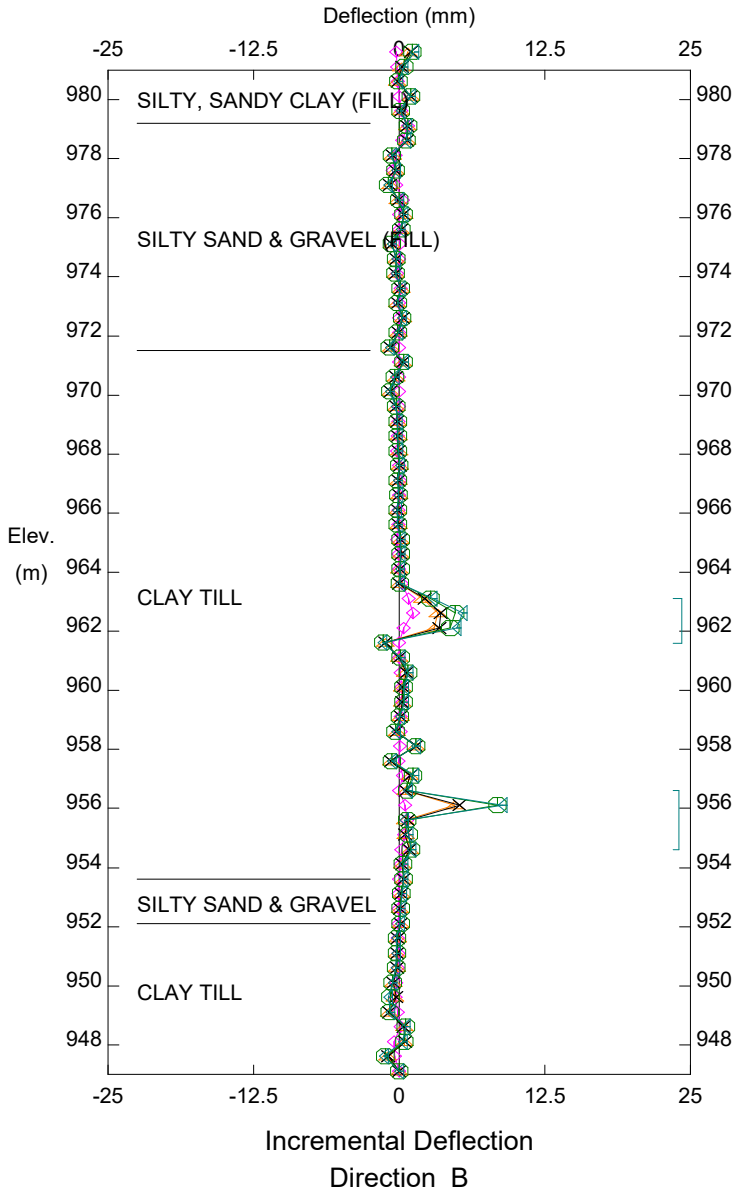
Alberta Transportation

Klohn Crippen Berger - Edmonton

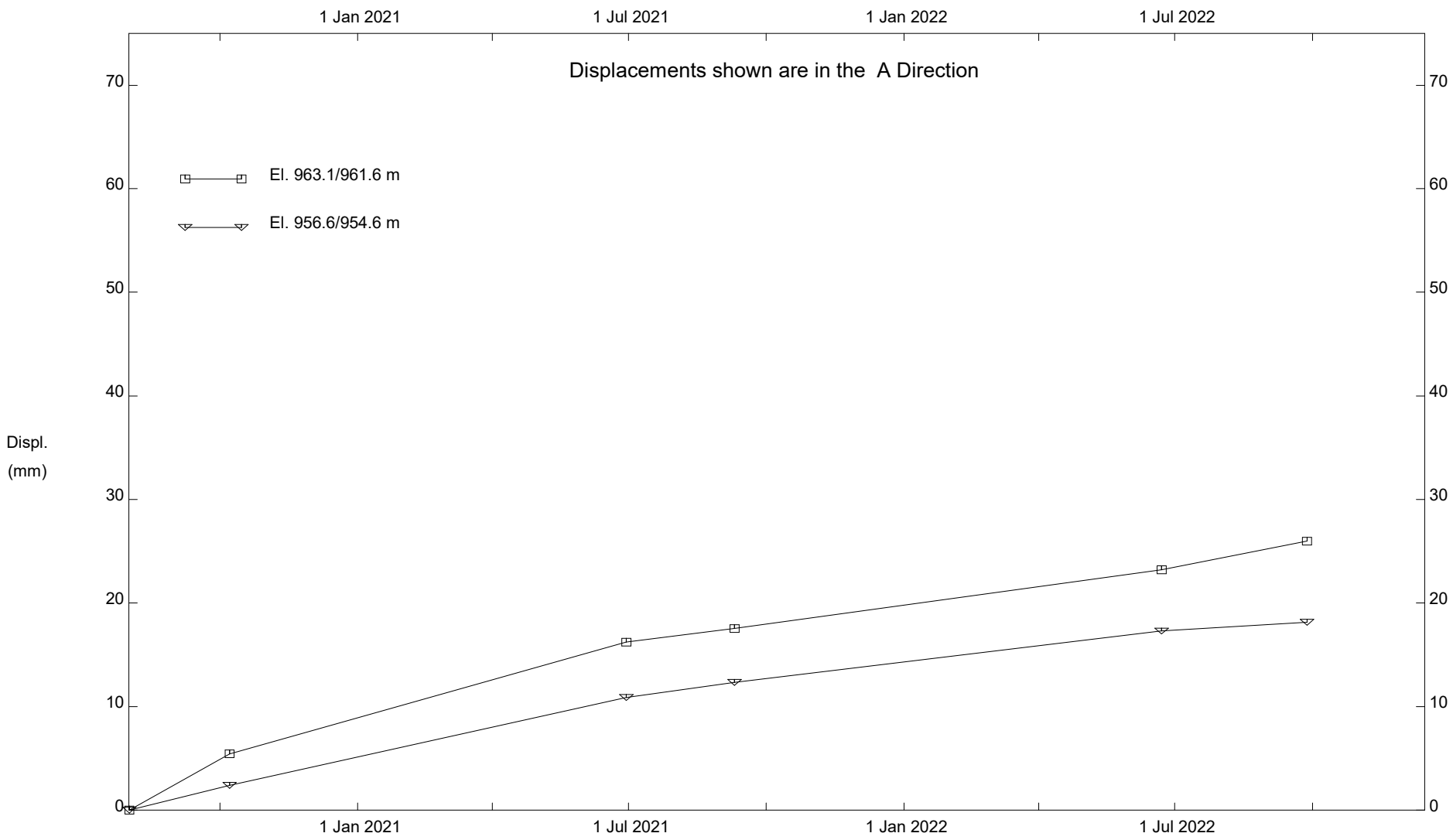




GP007; H40:36, Wanyandie Road Slide, Inclinometer SI20-03

Alberta Transportation

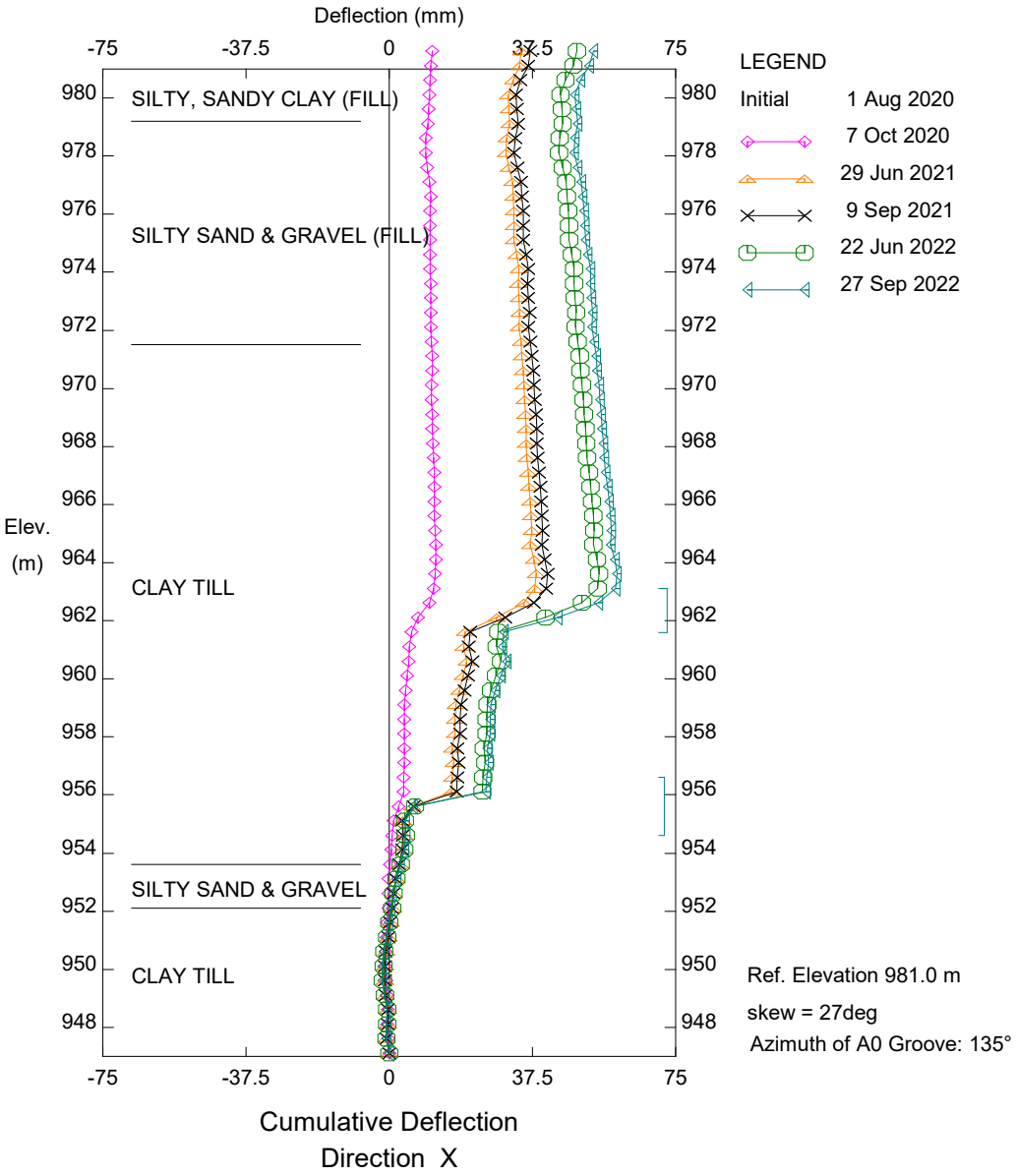
Klohn Crippen Berger - Edmonton

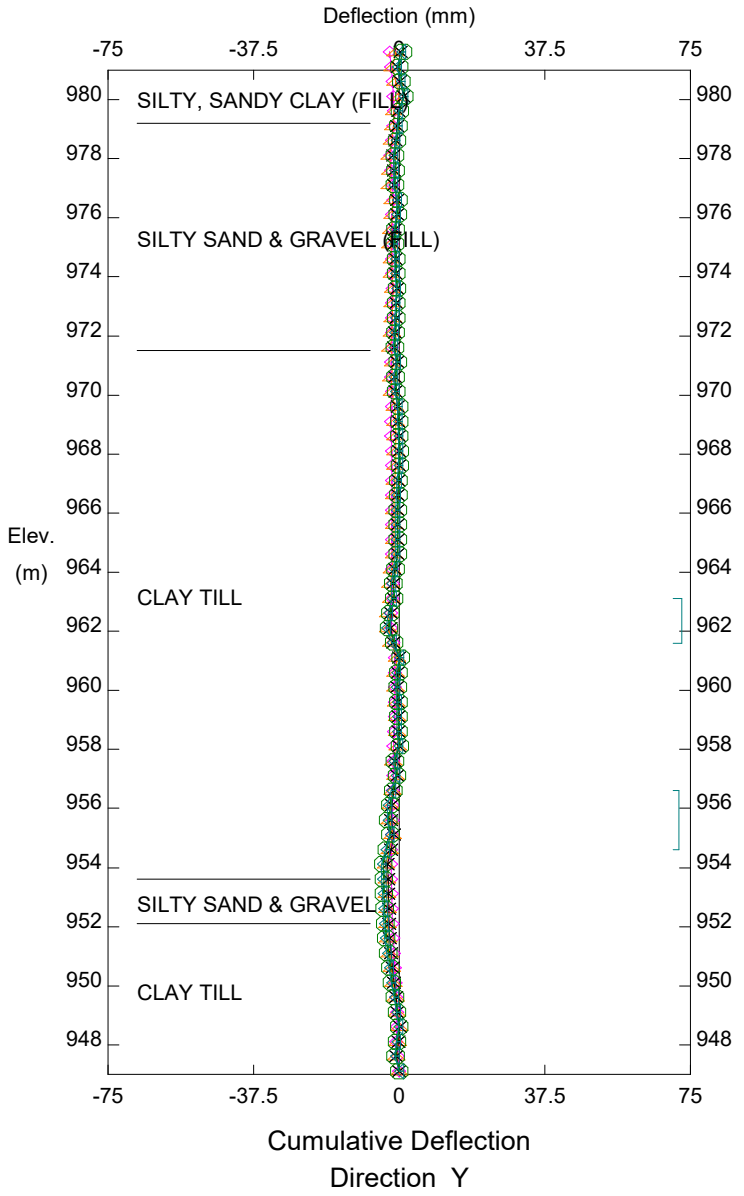


GP007; H40:36, Wanyandie Road Slide, Inclinometer SI20-03

Alberta Transportation

Klohn Crippen Berger - Edmonton

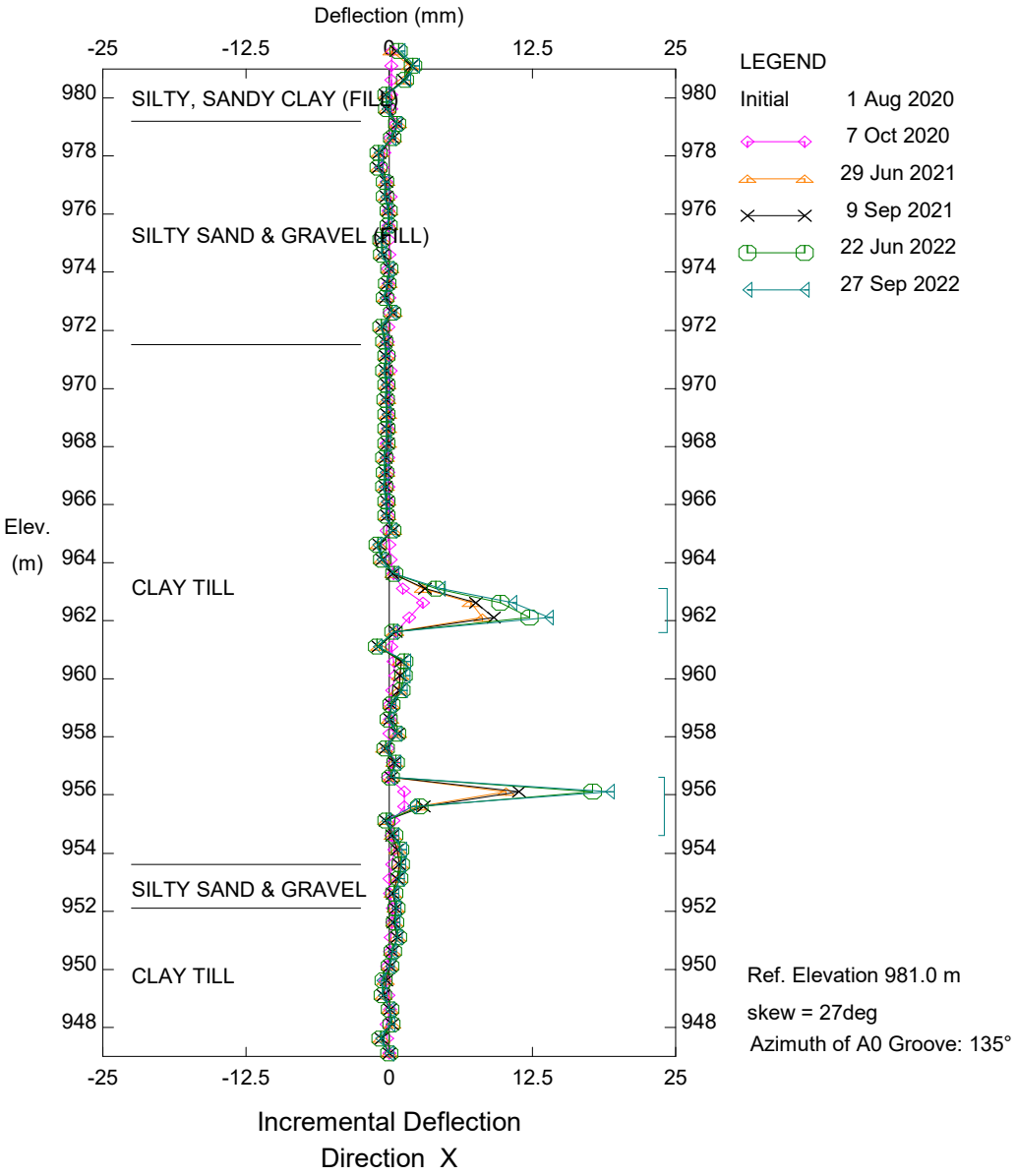


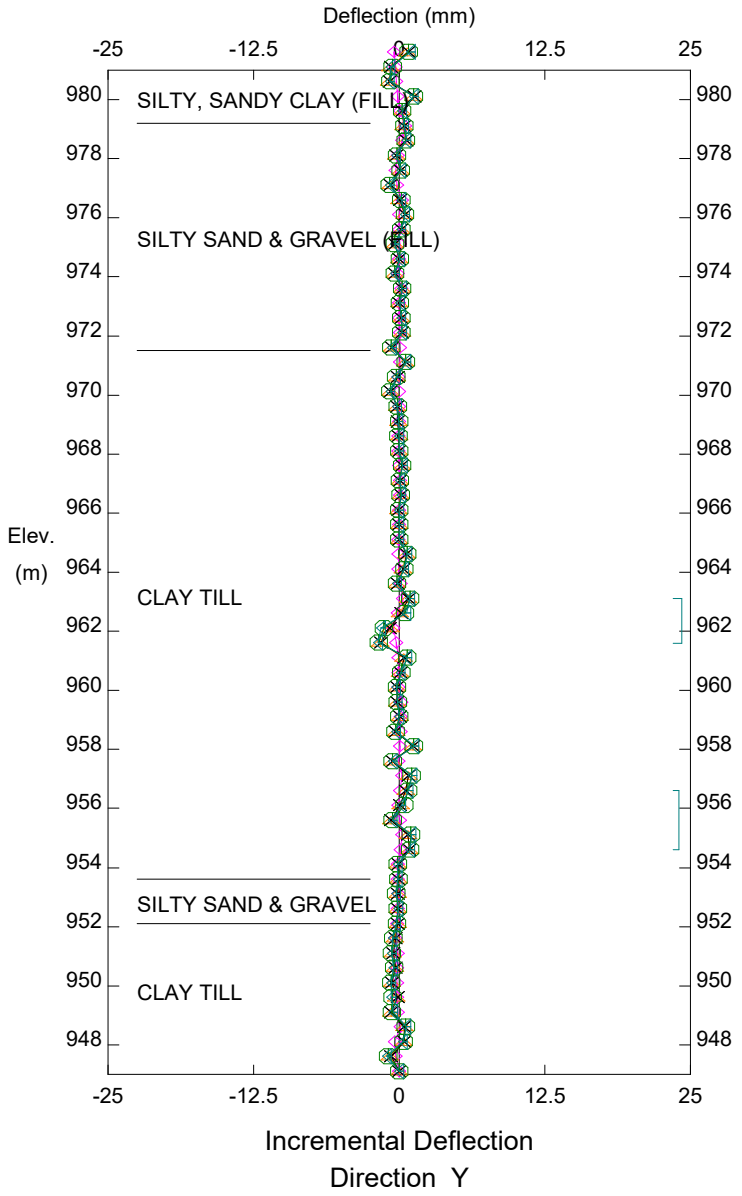


GP007; H40:36, Wanyandie Road Slide, Inclinometer SI20-03

Alberta Transportation

Klohn Crippen Berger - Edmonton

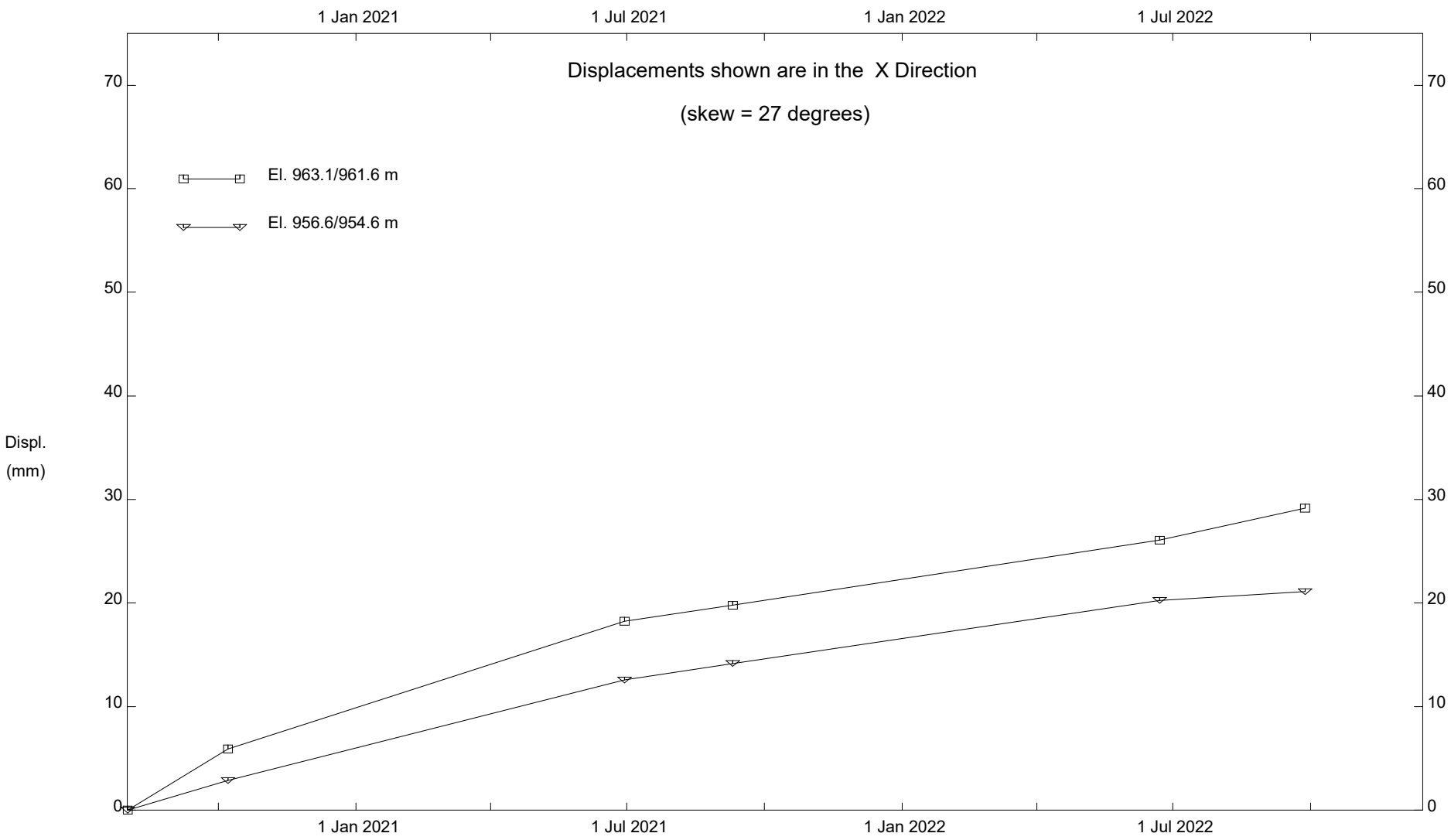




GP007; H40:36, Wanyandie Road Slide, Inclinometer SI20-03

Alberta Transportation

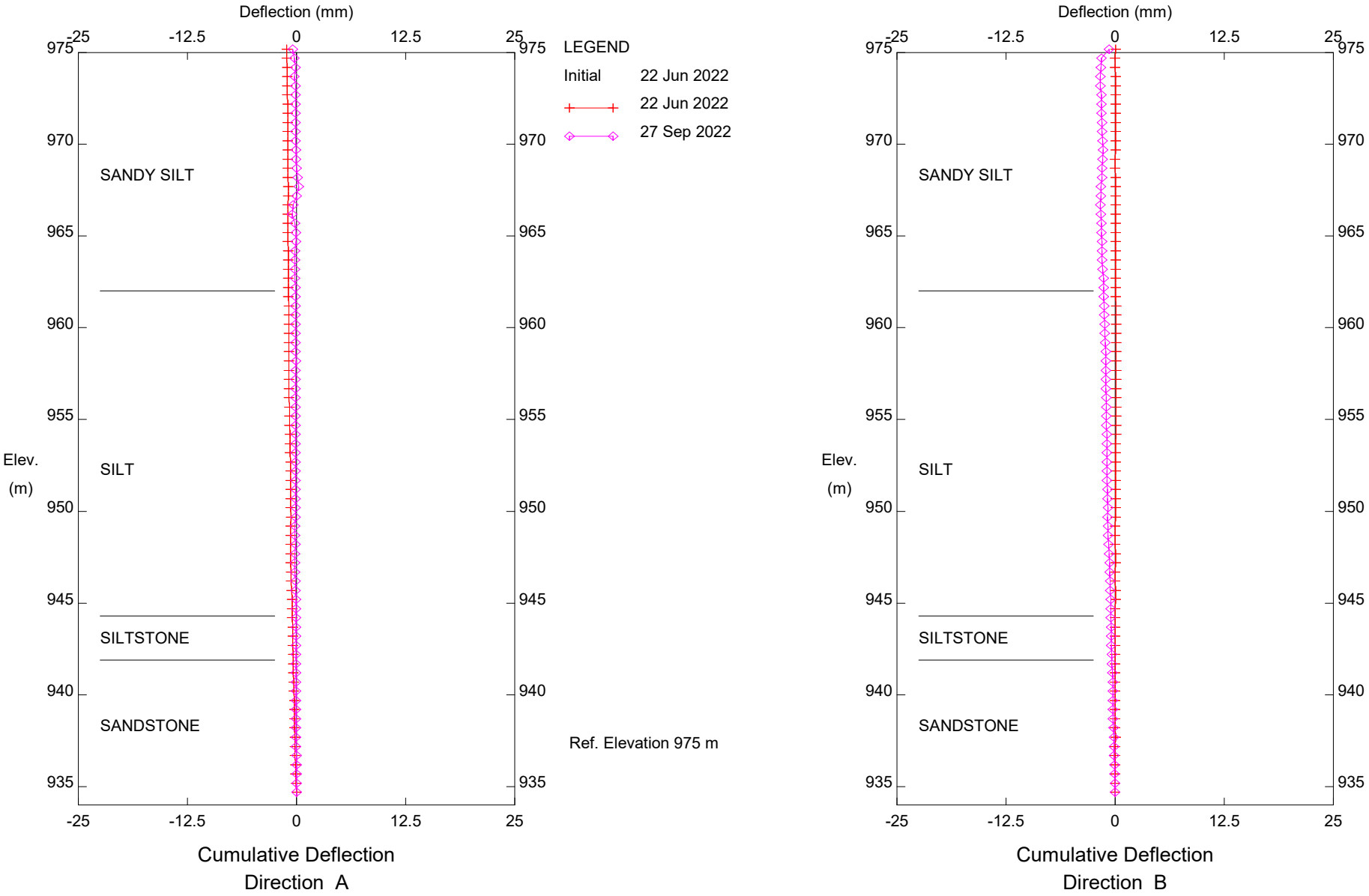
Klohn Crippen Berger - Edmonton



GP007; H40:36, Wanyandie Road Slide, Inclinometer SI20-03

Alberta Transportation

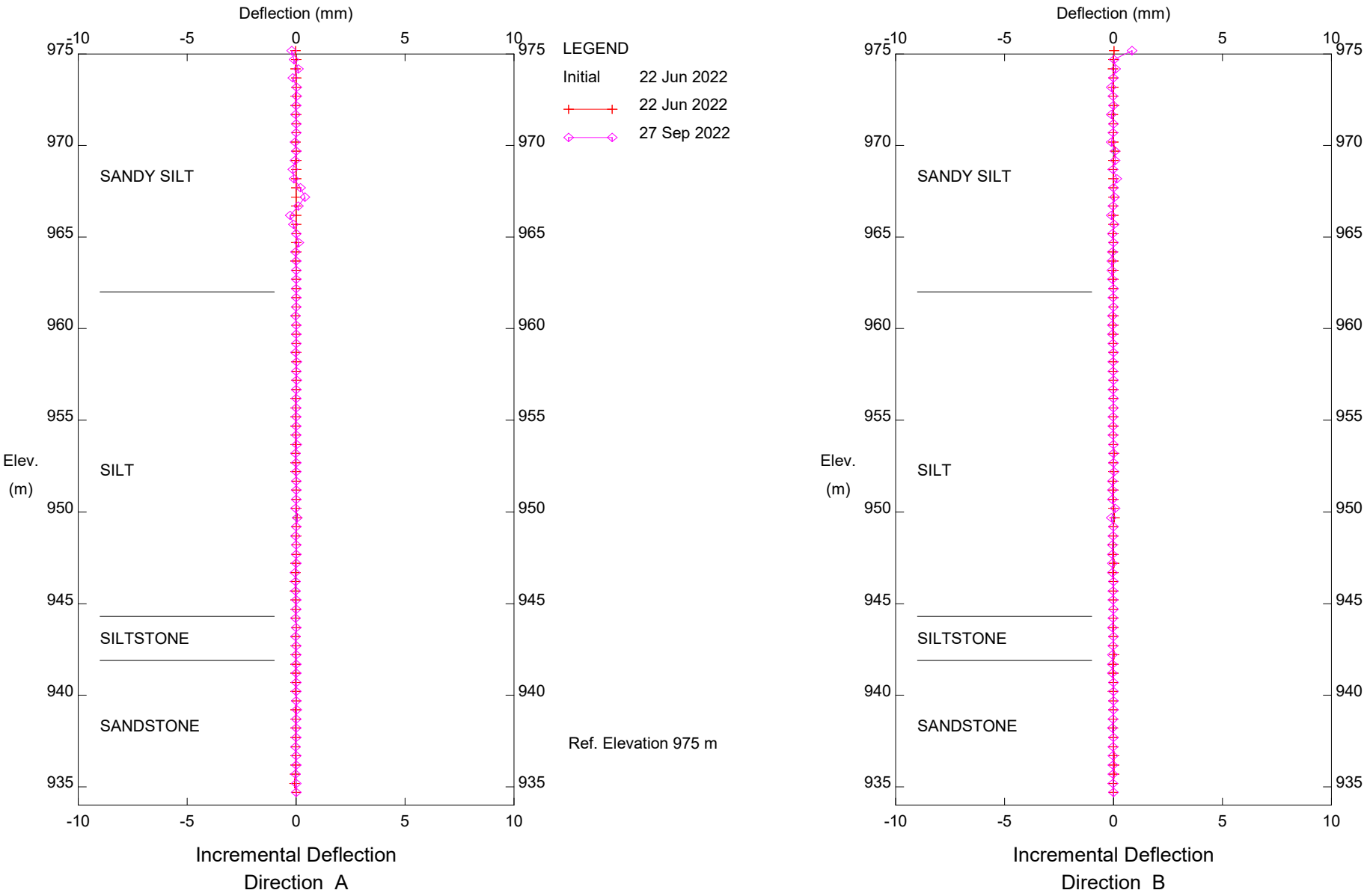
Klohn Crippen Berger - Edmonton



Peace Region - Grande Prairie South, Inclinometer SI22-01

Alberta Transportation

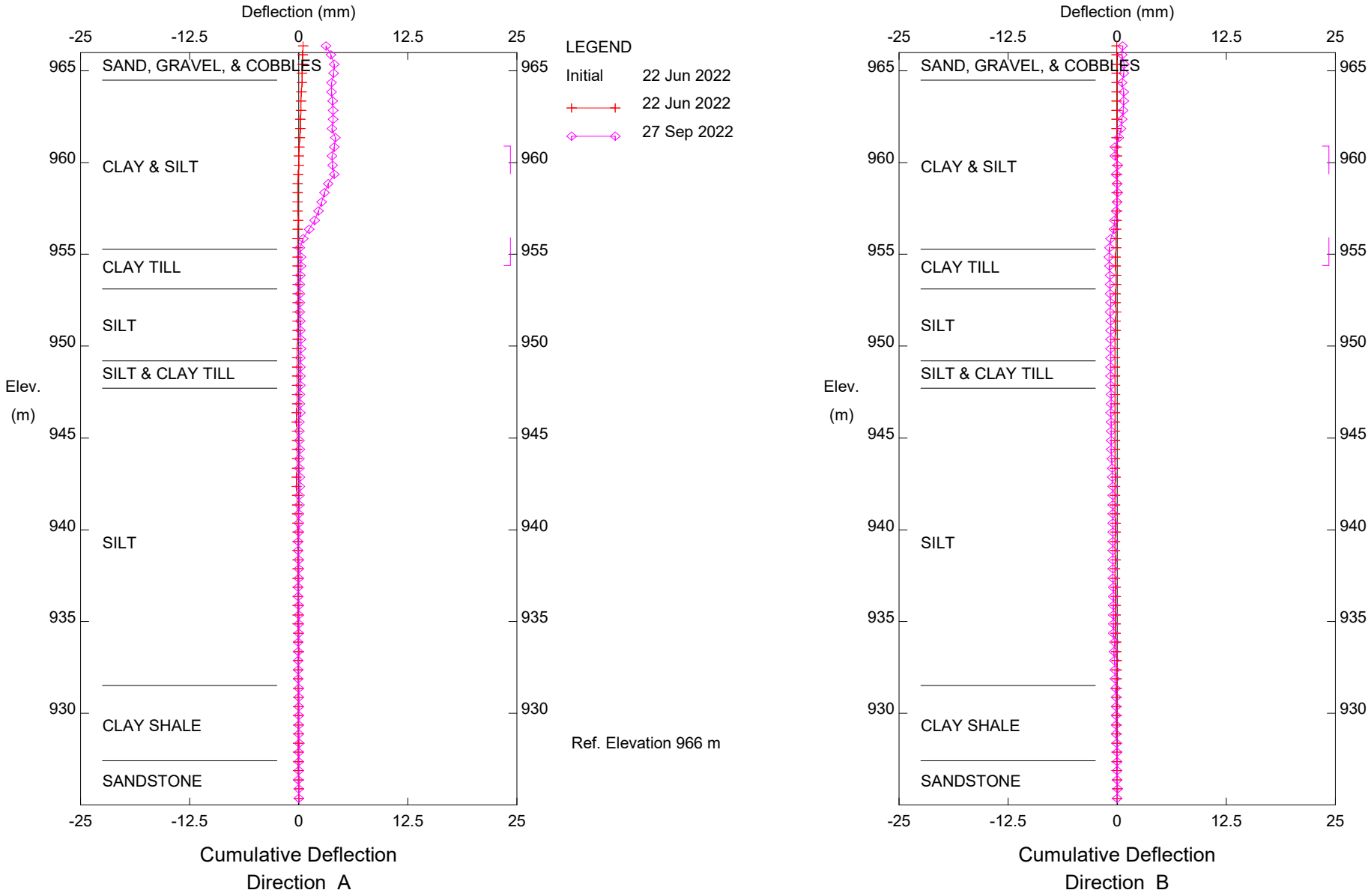
Klohn Crippen Berger - Edmonton



Peace Region - Grande Prairie South, Inclinometer SI22-01

Alberta Transportation

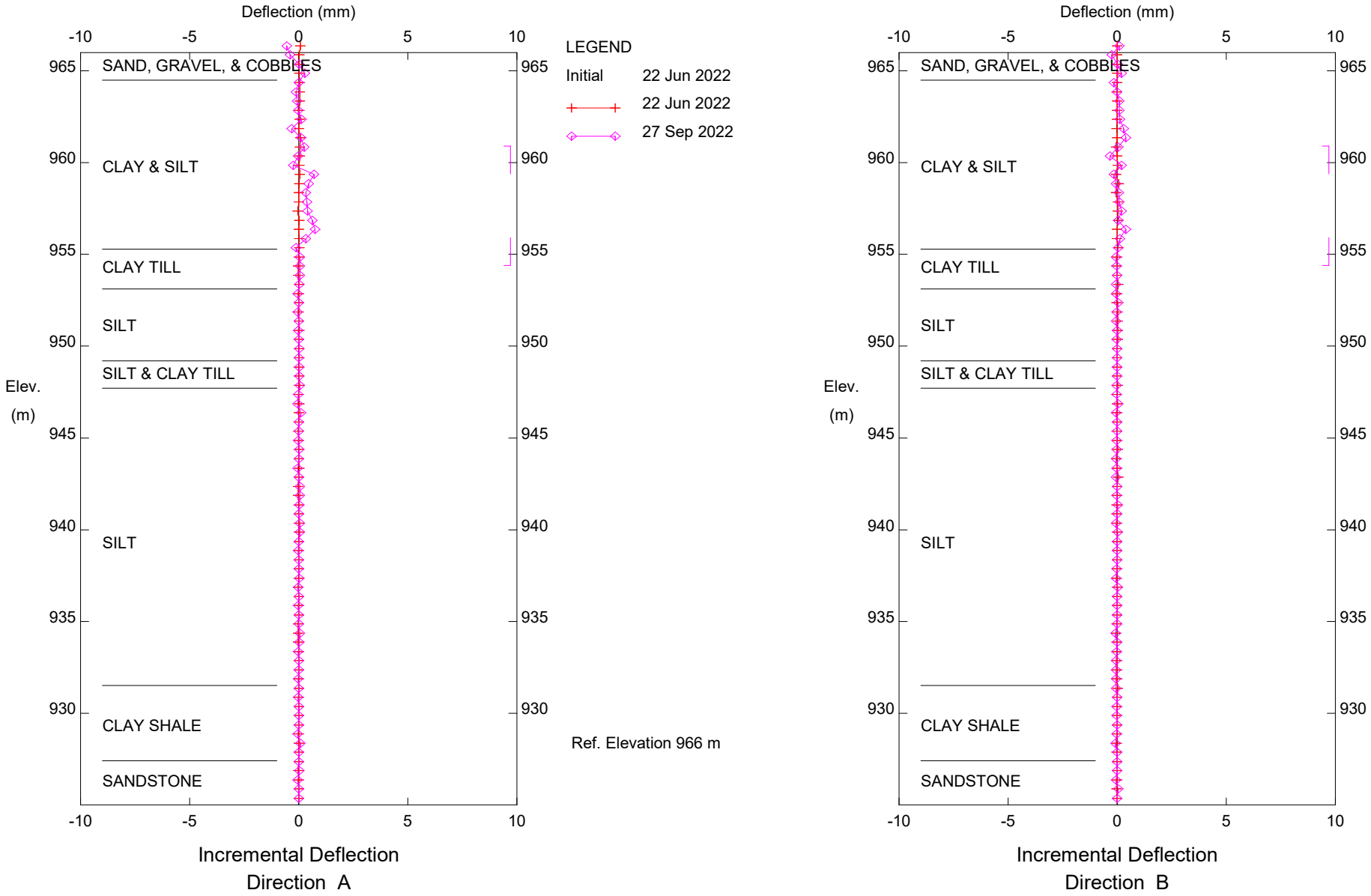
Klohn Crippen Berger - Edmonton



Peace Region - Grande Prairie South, Inclinometer SI22-02

Alberta Transportation

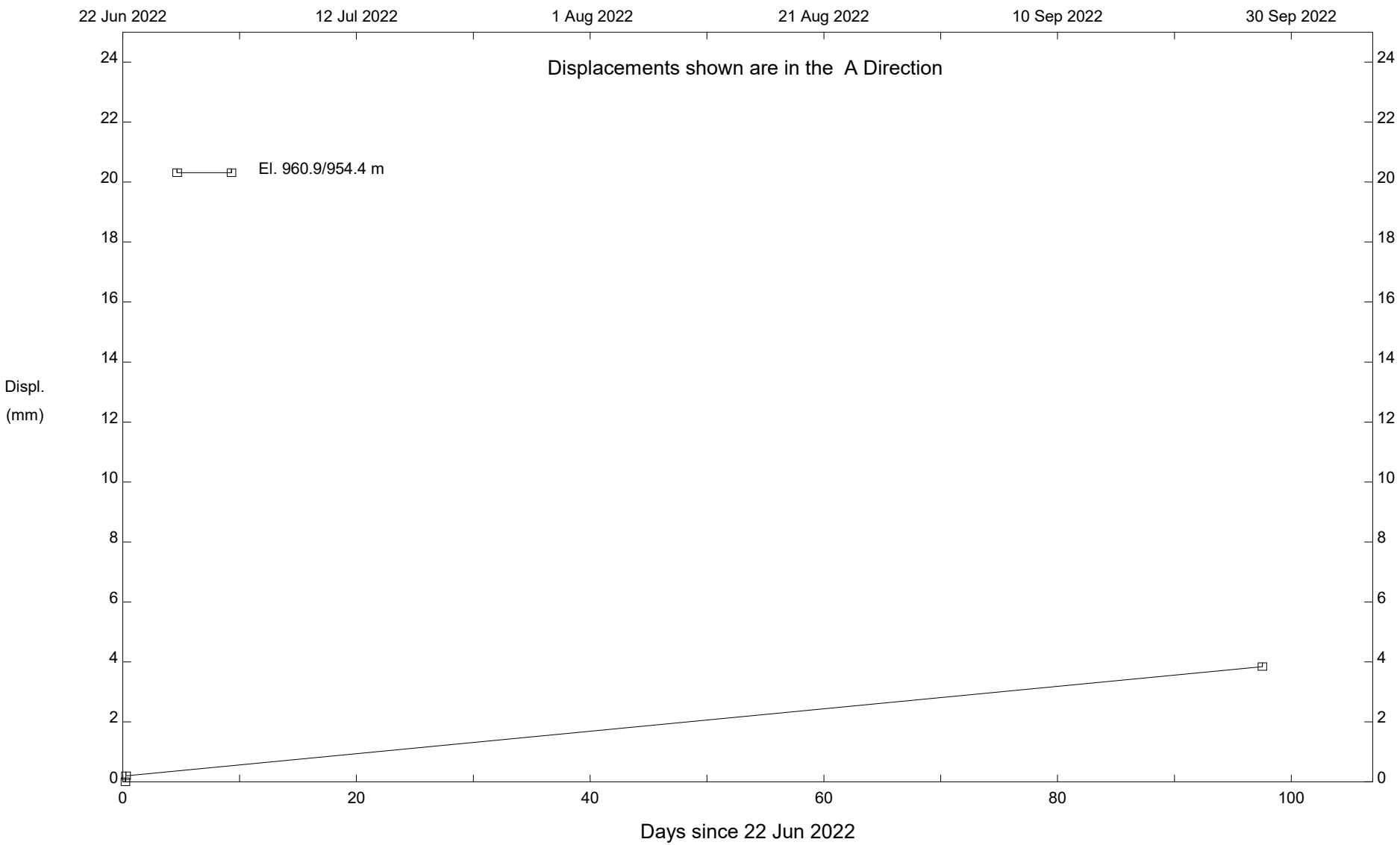
Klohn Crippen Berger - Edmonton



Peace Region - Grande Prairie South, Inclinometer SI22-02

Alberta Transportation

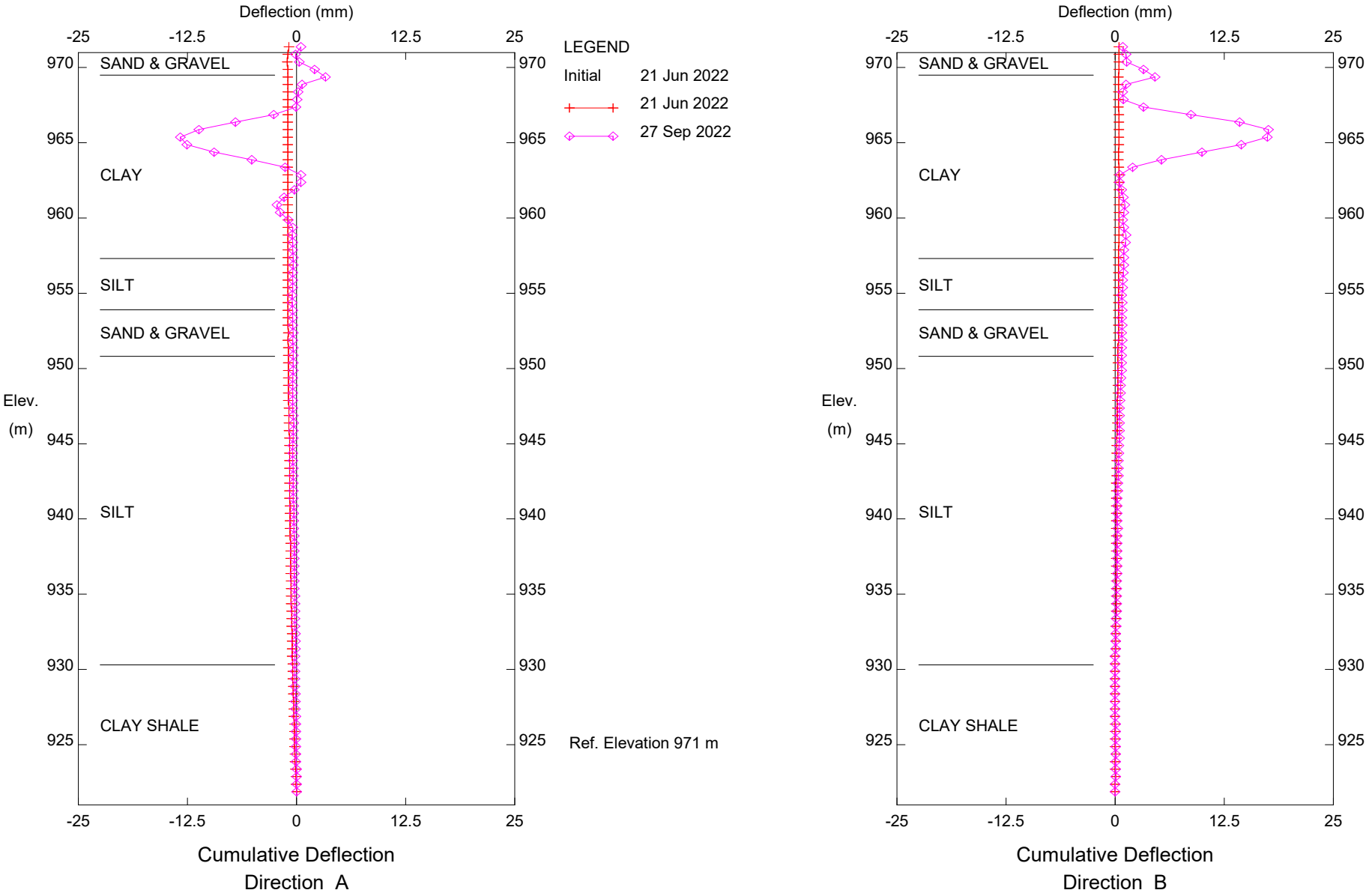
Klohn Crippen Berger - Edmonton



Peace Region - Grande Prairie South, Inclinometer SI22-02

Alberta Transportation

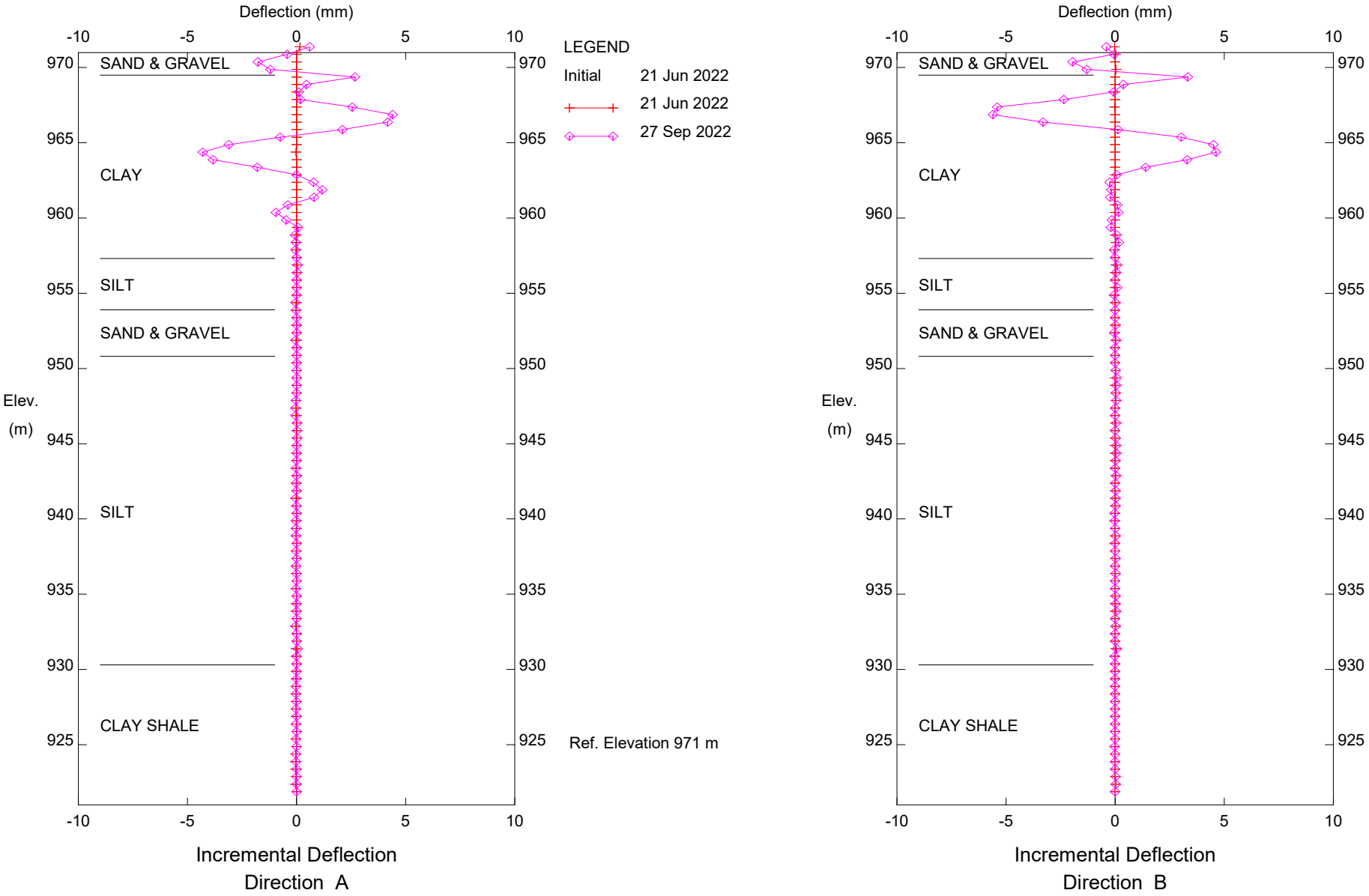
Klohn Crippen Berger - Edmonton



GP007; H40:36, Wanyandie Road Slide, Inclinometer SI22-03

Alberta Transportation

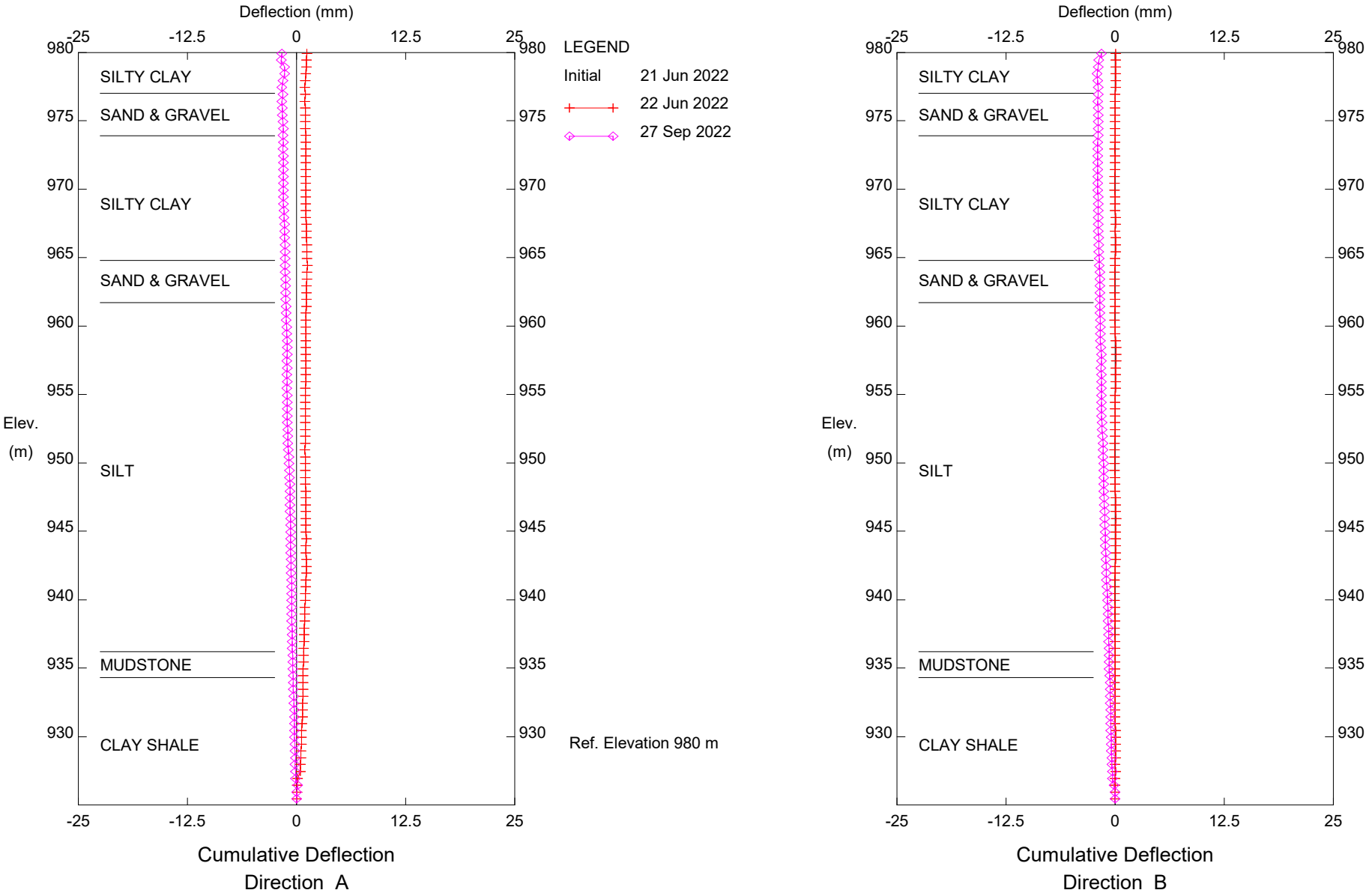
Klohn Crippen Berger - Edmonton



GP007; H40:36, Wanyandie Road Slide, Inclinometer SI22-03

Alberta Transportation

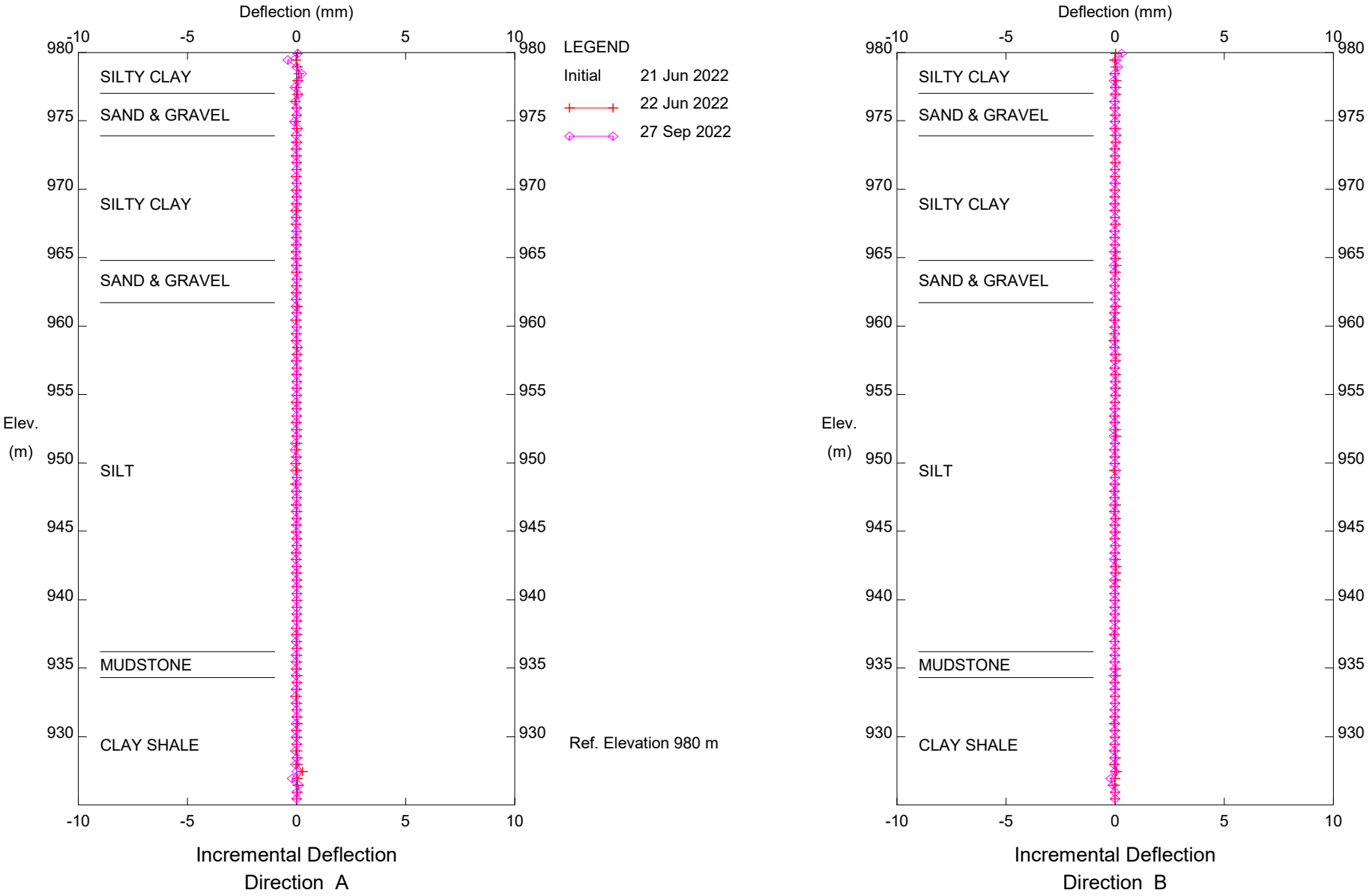
Klohn Crippen Berger - Edmonton



GP007; H40:36, Wanyandie Road Slide, Inclinometer SI22-04

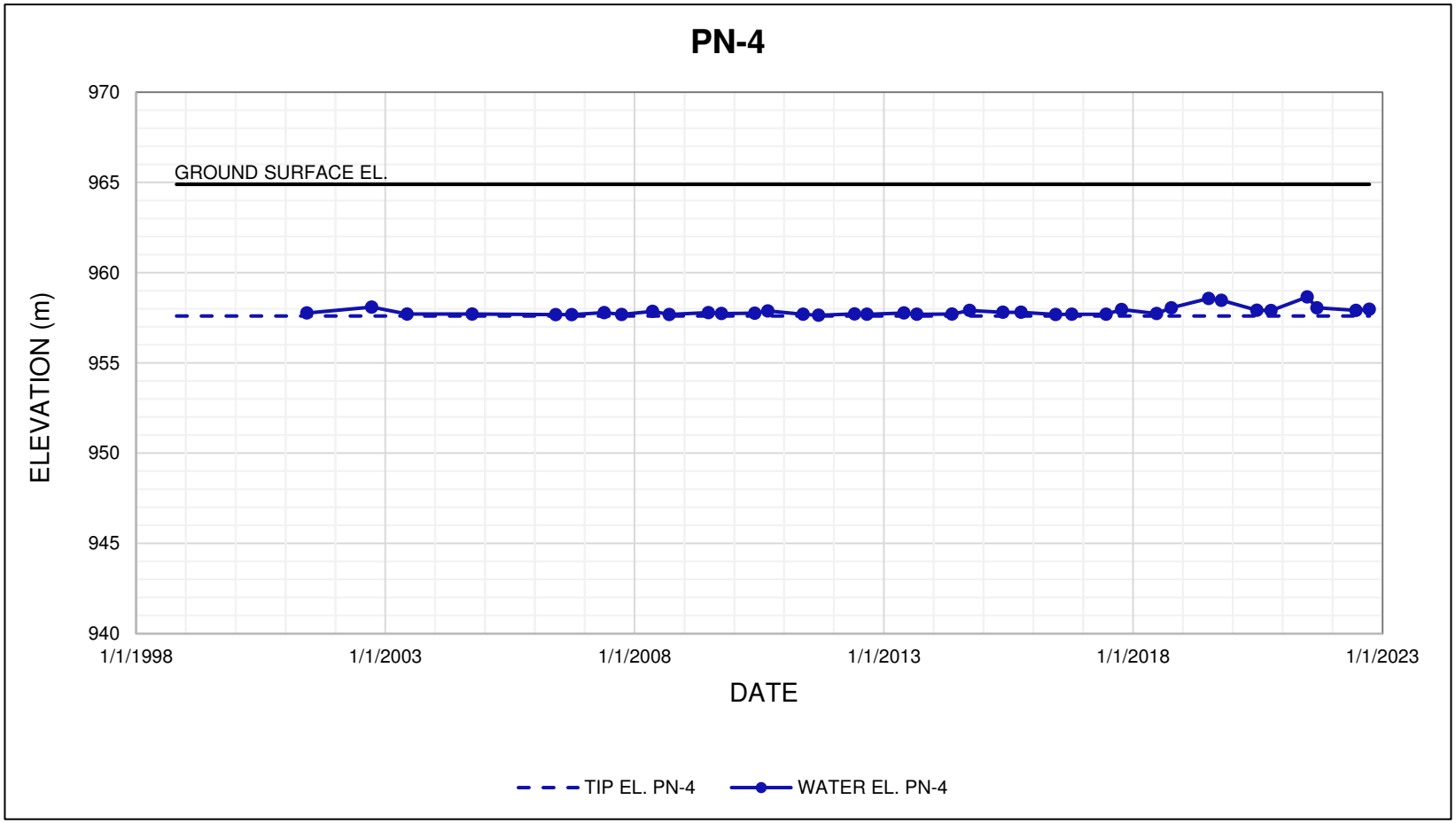
Alberta Transportation

Klohn Crippen Berger - Edmonton



GP007; H40:36, Wanyandie Road Slide, Inclinometer SI22-04

Alberta Transportation



NOTES:
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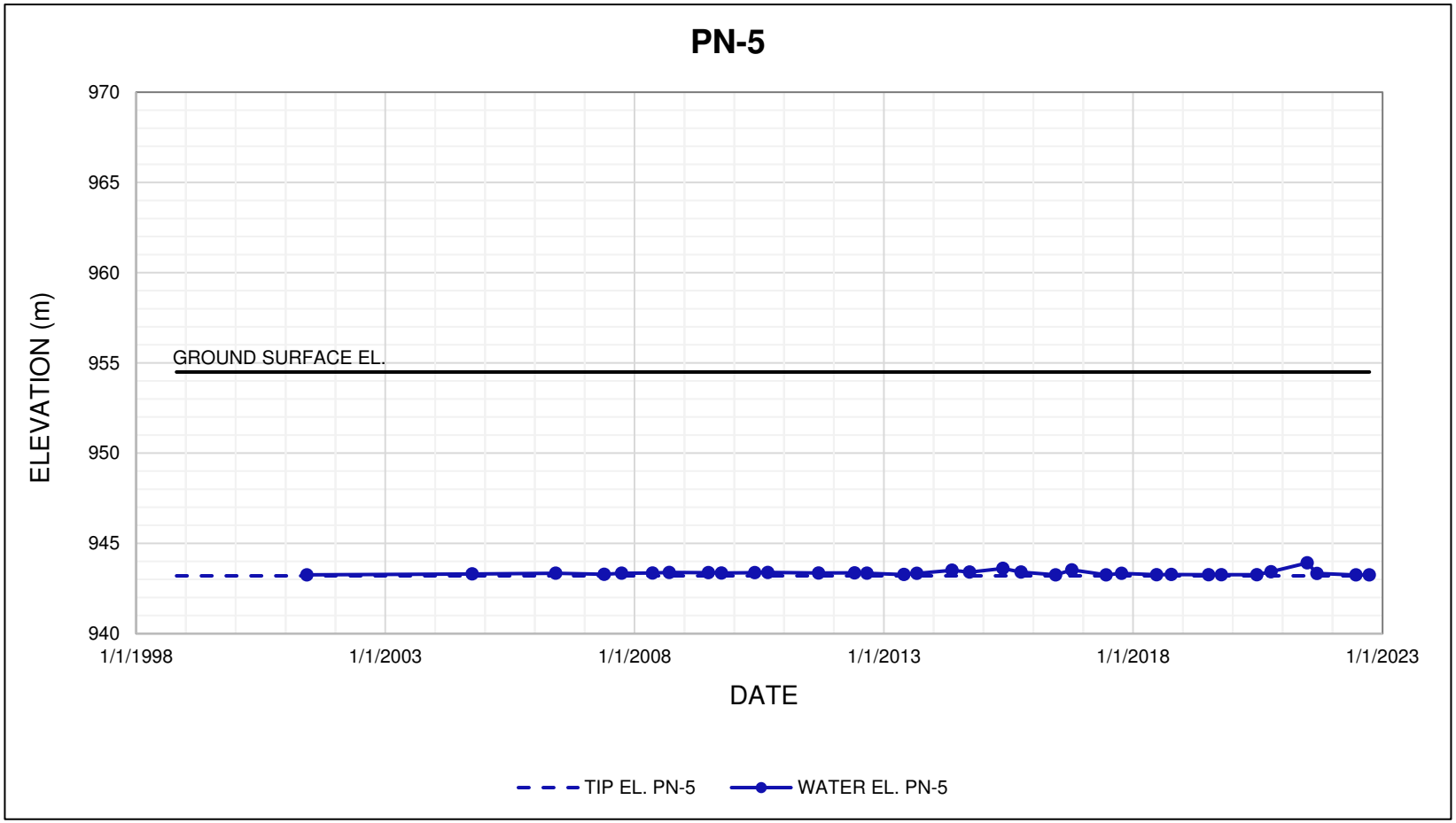
CLIENT
Alberta
Klohn Crippen Berger

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

TITLE
Piezometer Data
GP007 - Wanyandie Road Slide
Hwy 40:36, km 29.339

SCALE	PROJECT No.	FIG No.
AS SHOWN	A05116A01	



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GEOHAZARD RISK MANAGEMENT PROGRAM

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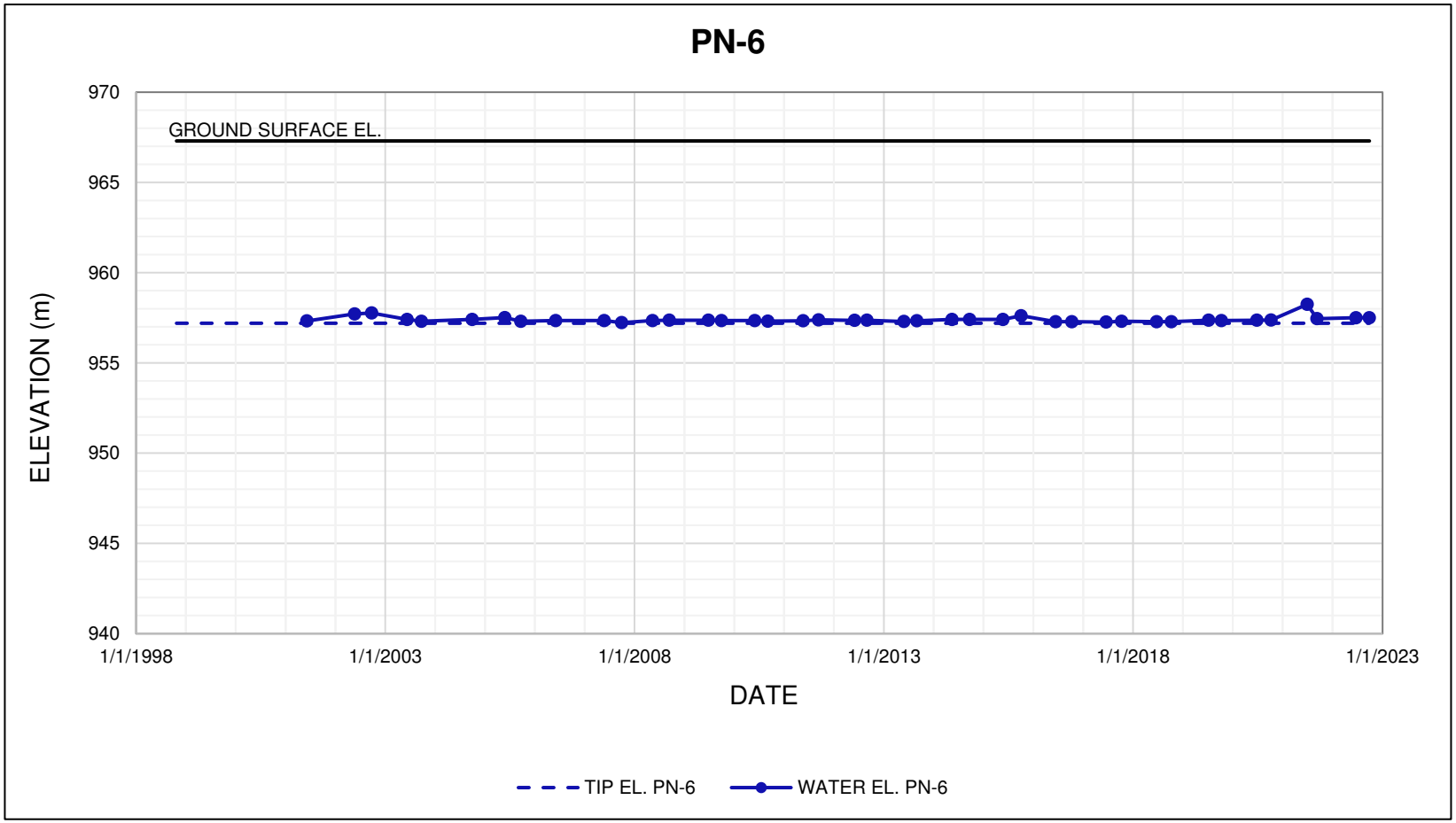
GP007 - Wanyandie Road Slide
Hwy 40:36, km 29.339

SCALE	PROJECT No.	FIG No.
AS SHOWN	A05116A01	



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SCALE	PROJECT No.	FIG No.
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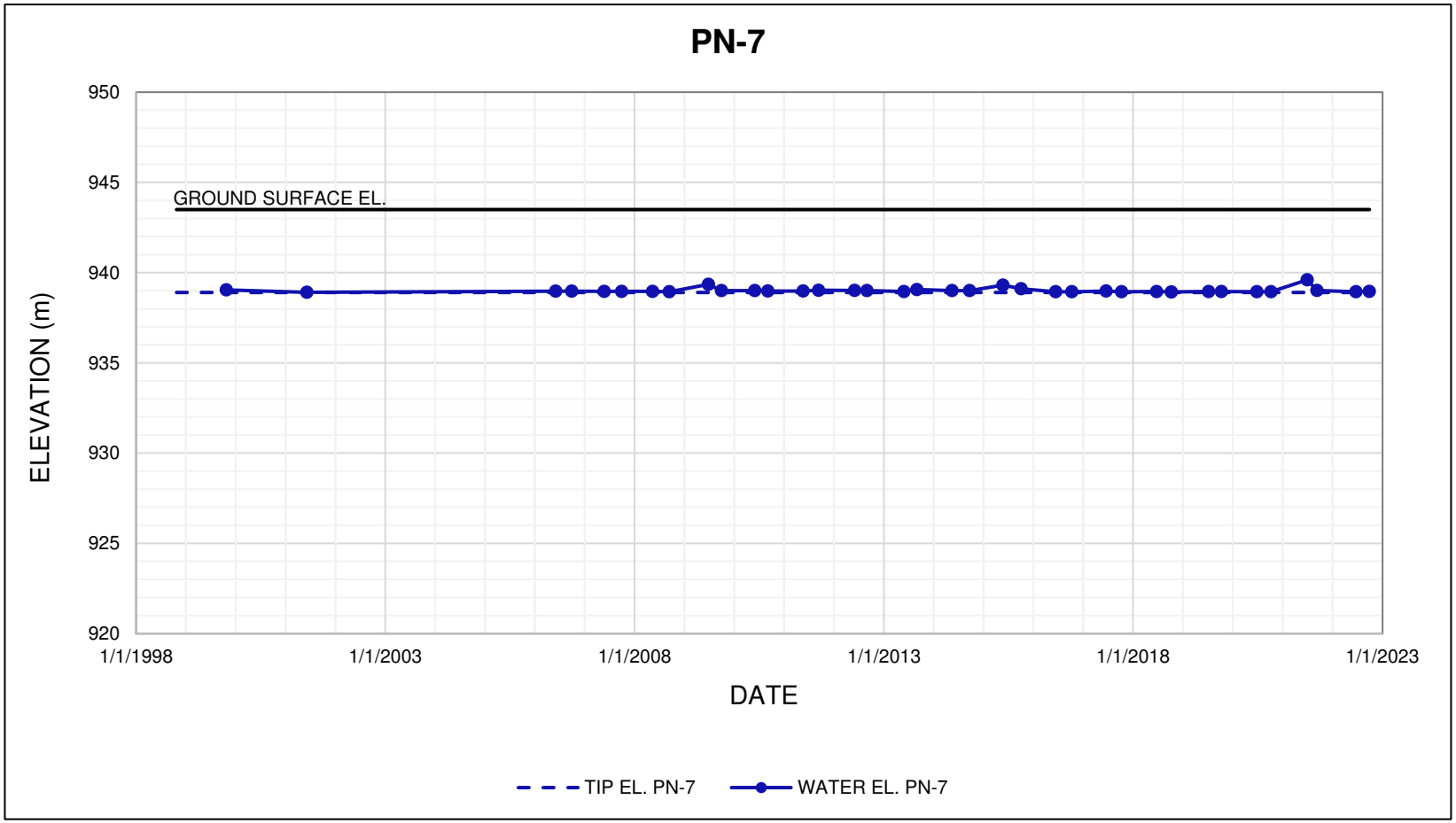

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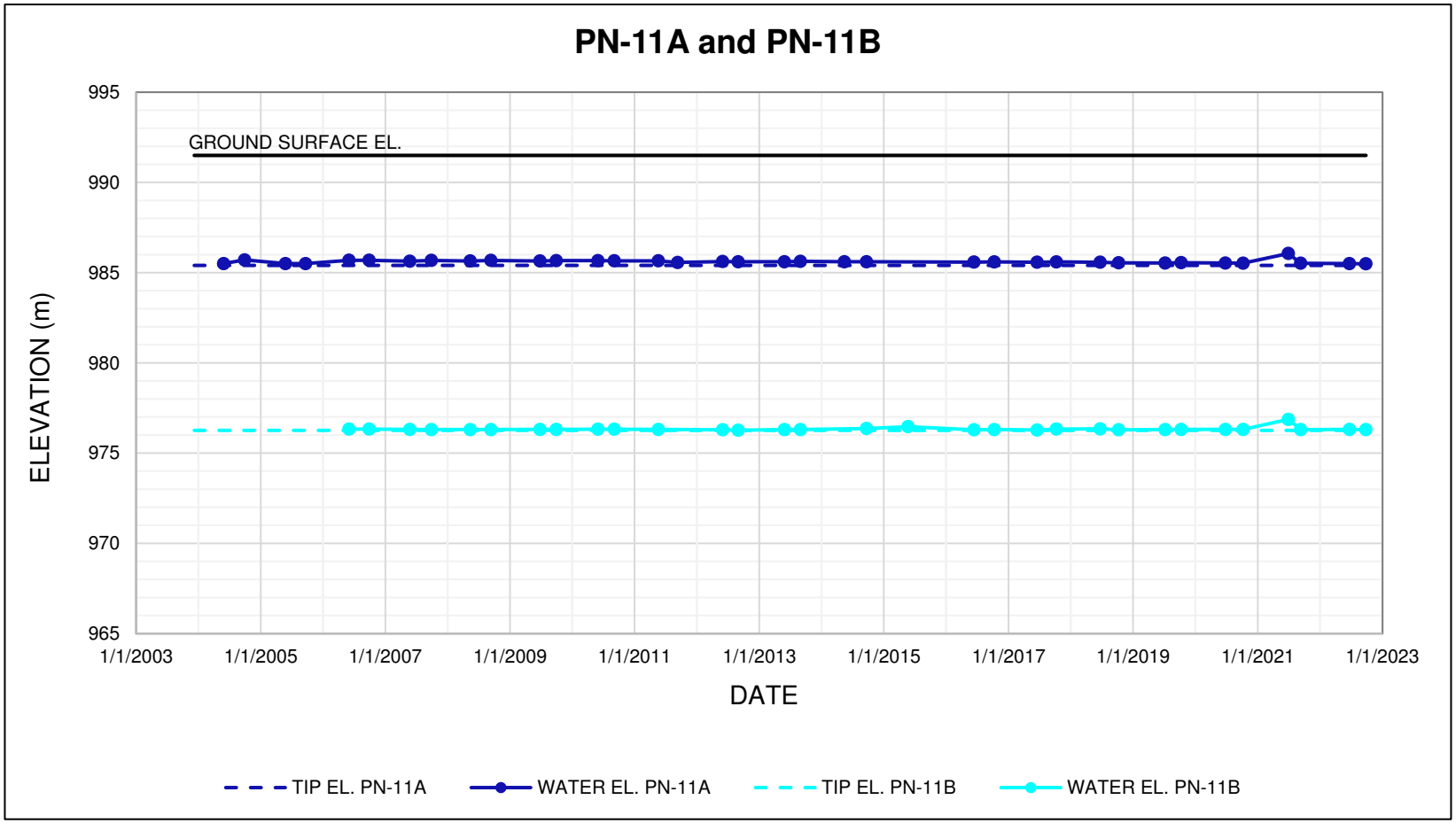
GP007 - Wanyandie Road Slide
Hwy 40:36, km 29.339

SCALE	PROJECT No.	FIG No.
AS SHOWN	A05116A01	



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Hwy 40:36, km 29.339

SCALE	PROJECT No.	FIG No.
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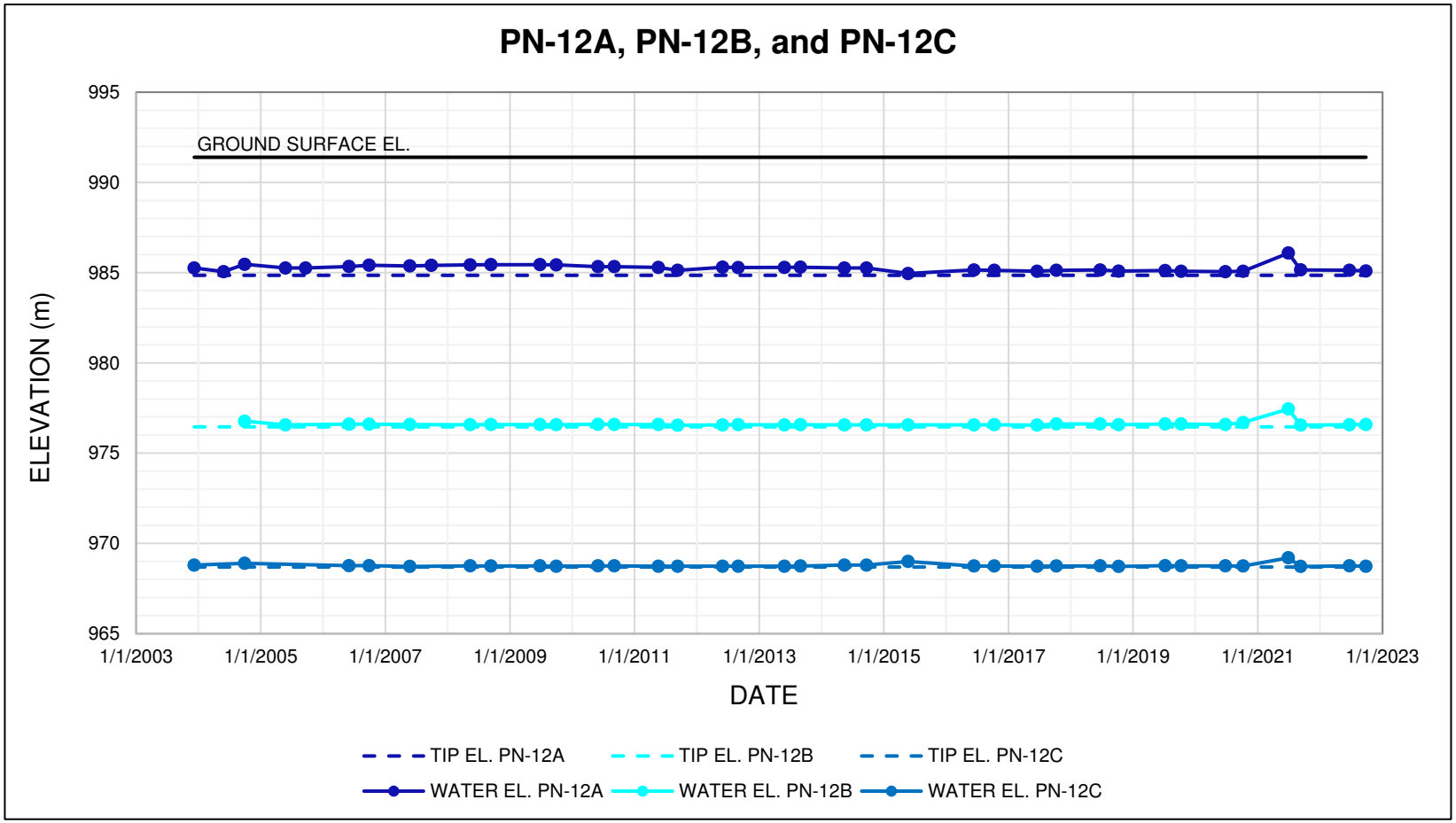

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Piezometer Data
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SCALE	PROJECT No.	FIG No.
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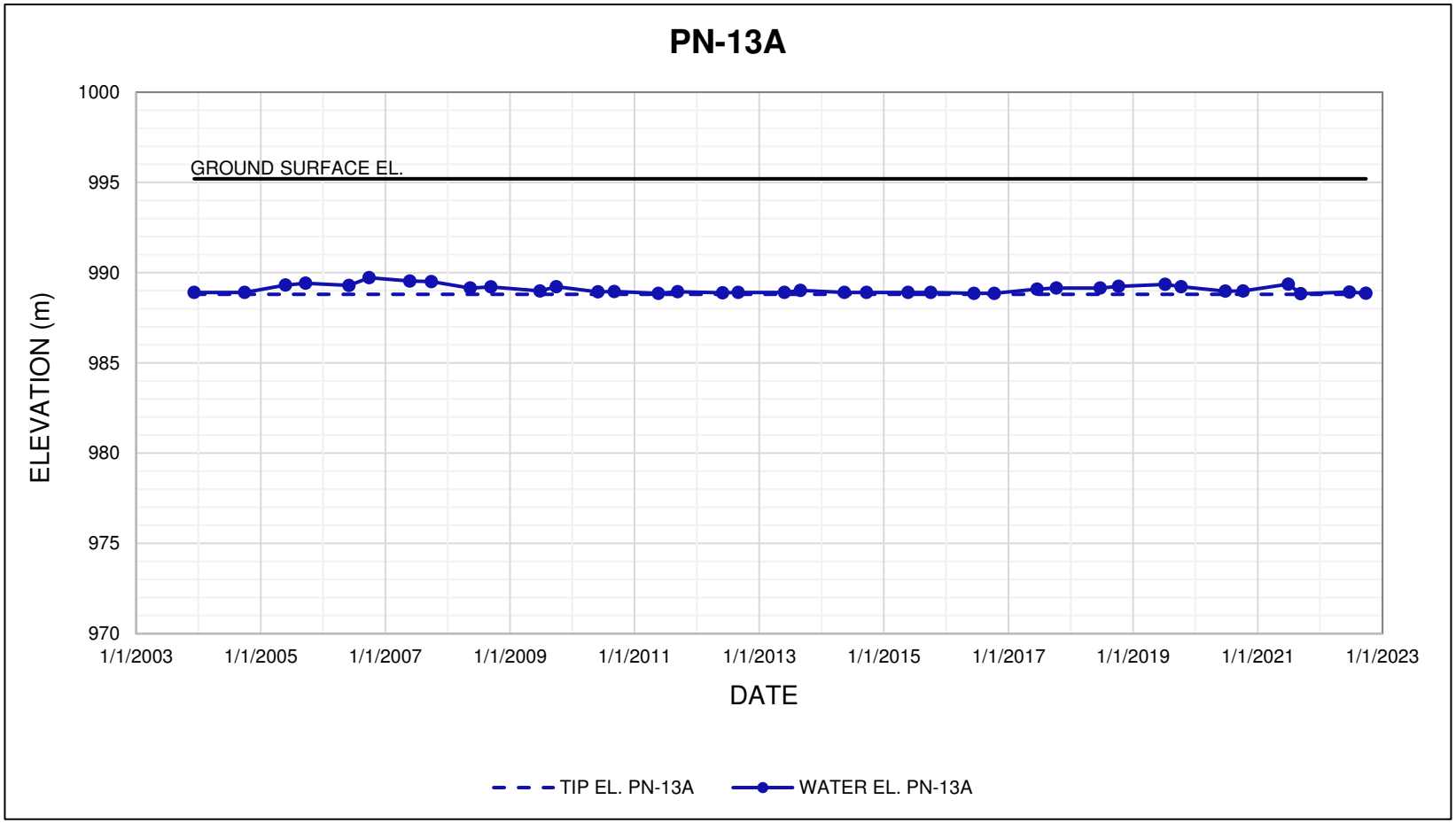

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PROJECT
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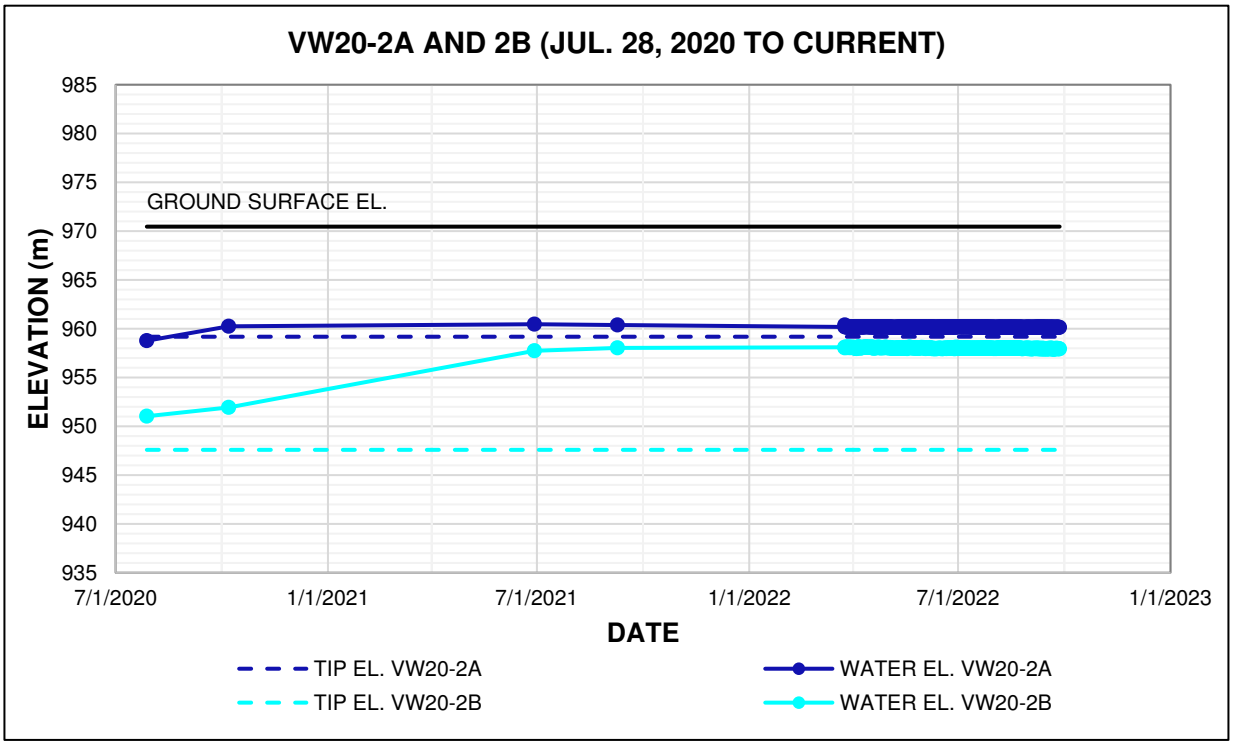
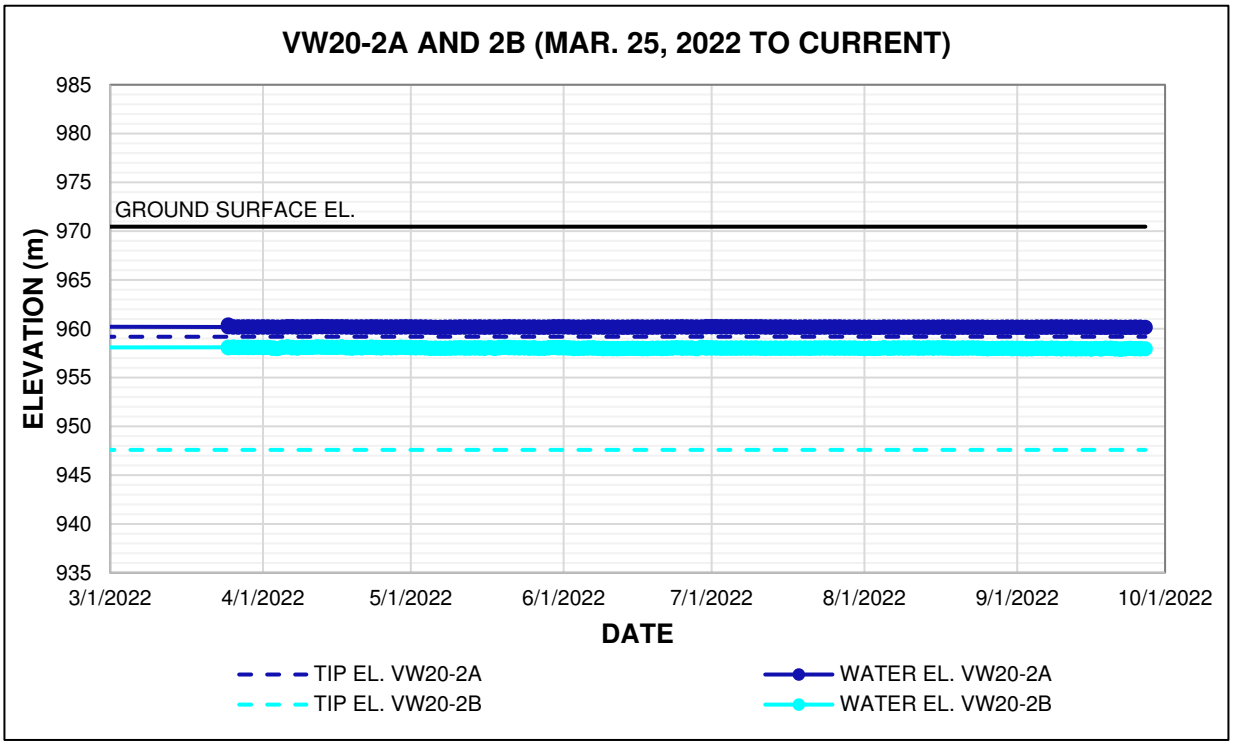
GEOHAZARD RISK MANAGEMENT PROGRAM

TITLE
Piezometer Data
GP007 - Wanyandie Road Slide
Hwy 40:36, km 29.339

SCALE	PROJECT No.	FIG No.
AS SHOWN	A05116A01	





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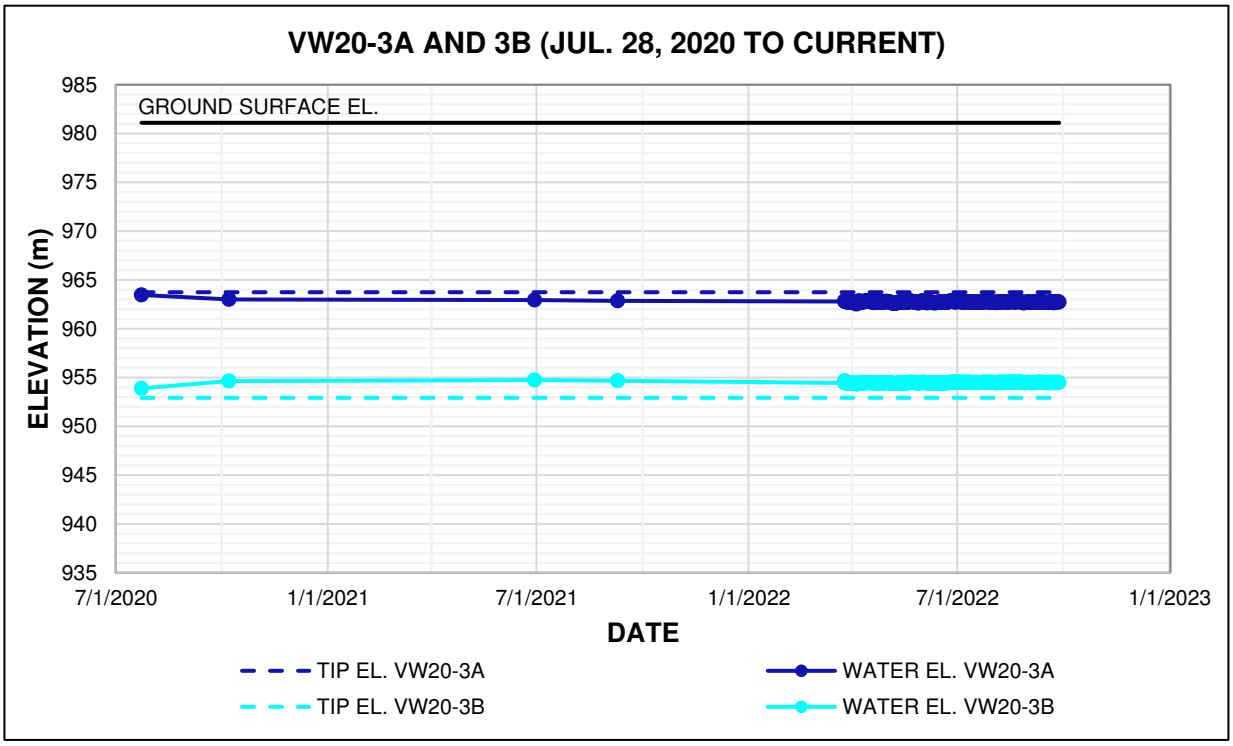
2. RST INSTRUMENTS MULTI-CHANNEL DATA LOGGER WAS INSTALLED ON THESE INSTRUMENTS ON MARCH 25, 2022.

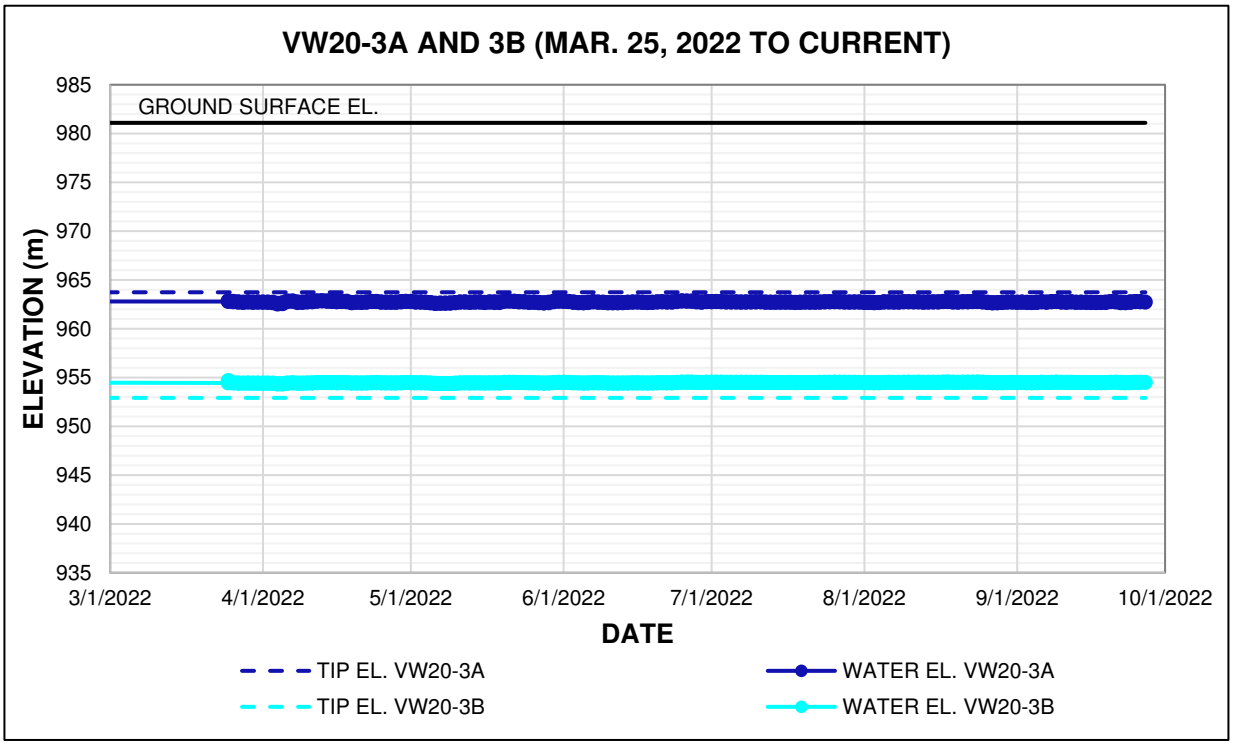
CLIENT
Alberta
Klohn Crippen Berger

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

TITLE
Piezometer Data
GP007 - Wanyandie Road Slide
Hwy 40:36, km 29.339

SCALE	PROJECT No.	FIG No.
AS SHOWN	A05116A01	





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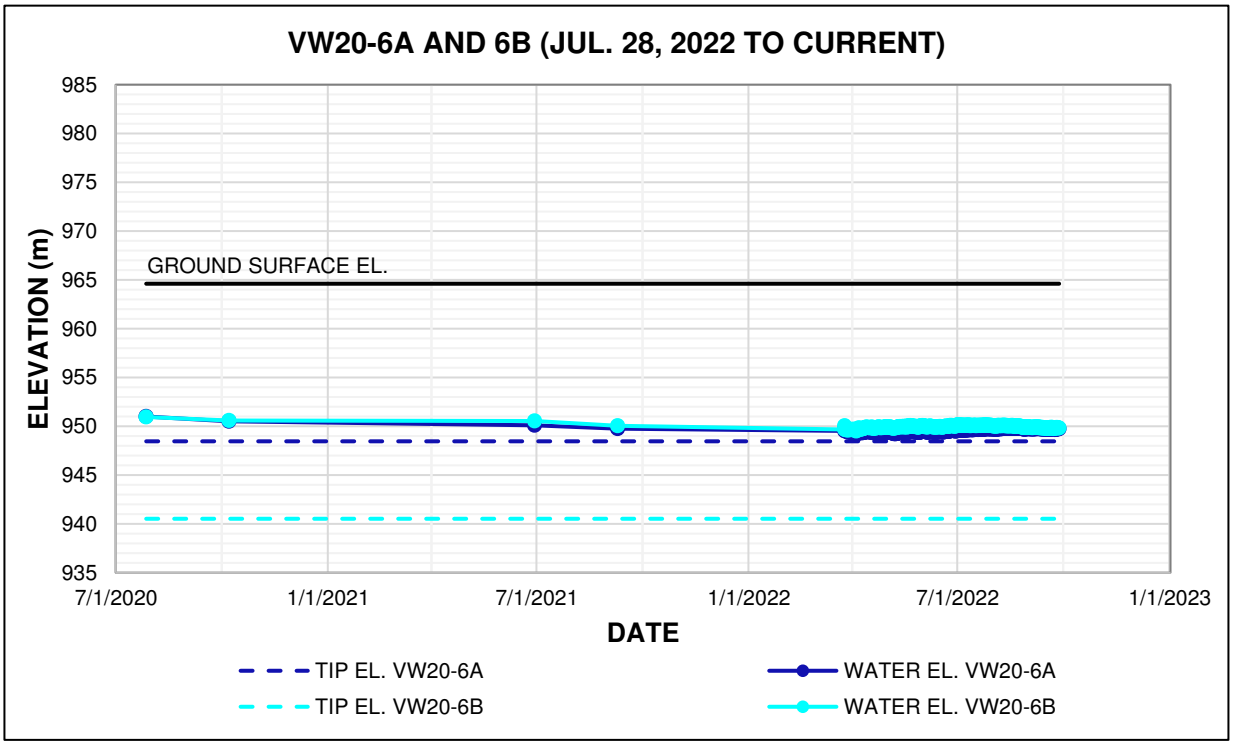
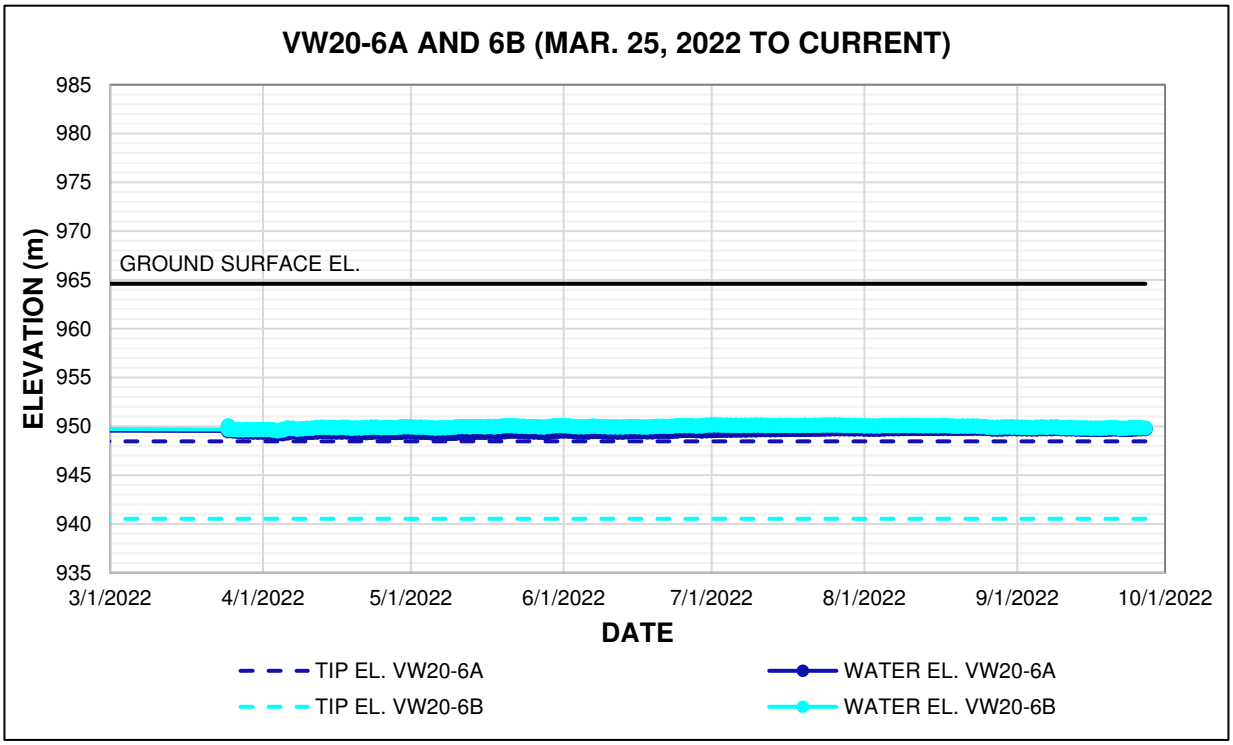
CLIENT
Alberta
Klohn Crippen Berger

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

TITLE
Piezometer Data
GP007 - Wanyandie Road Slide
Hwy 40:36, km 29.339

SCALE	PROJECT No.	FIG No.
AS SHOWN	A05116A01	





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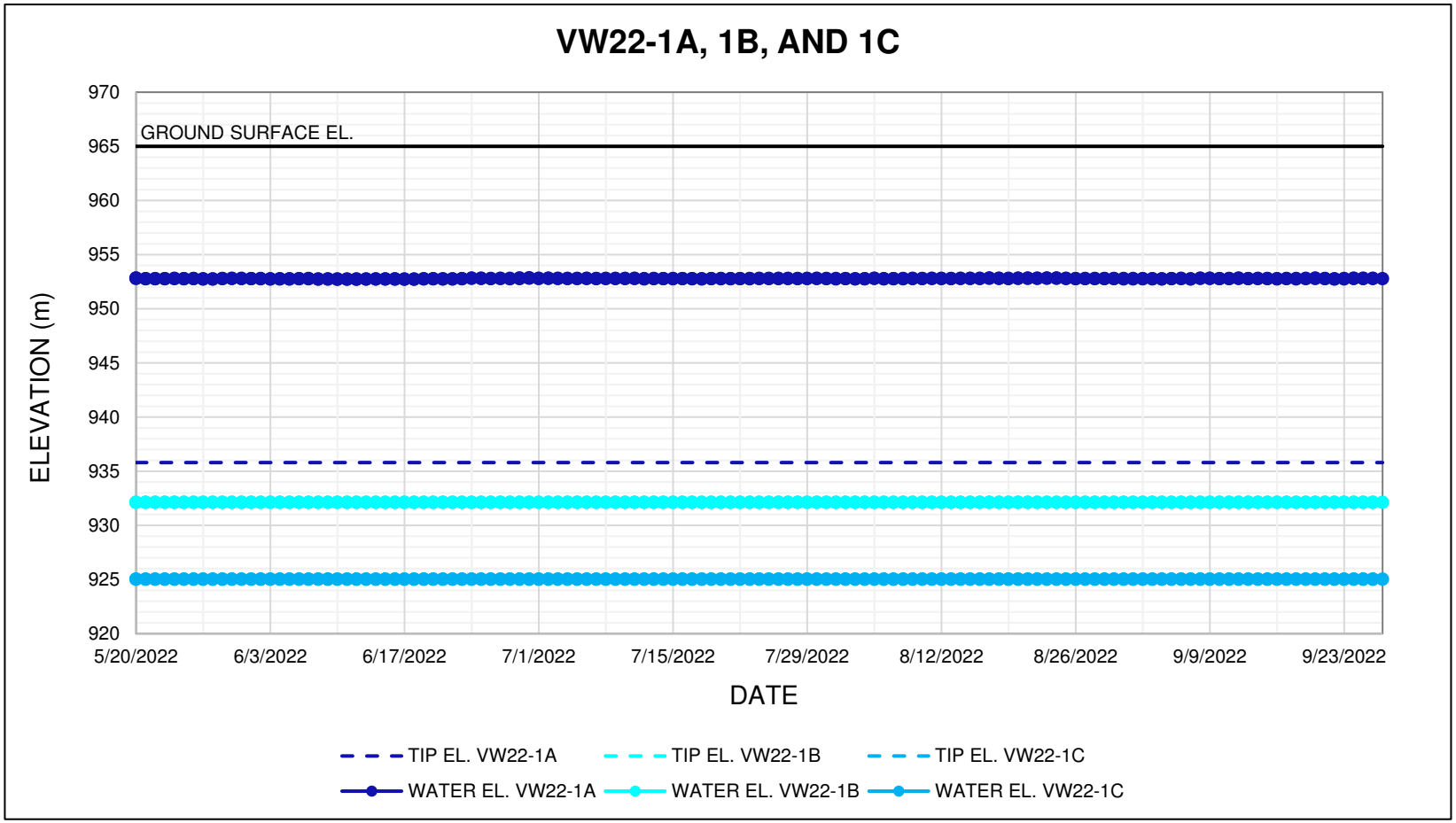
PROJECT
PEACE REGION (GRANDE PRAIRIE DISTRICT - SOUTH)
GEOHAZARD RISK MANAGEMENT PROGRAM

TITLE
Piezometer Data
GP007 - Wanyandie Road Slide
Hwy 40:36, km 29.339

SCALE	PROJECT No.	FIG No.
AS SHOWN	A05116A01	



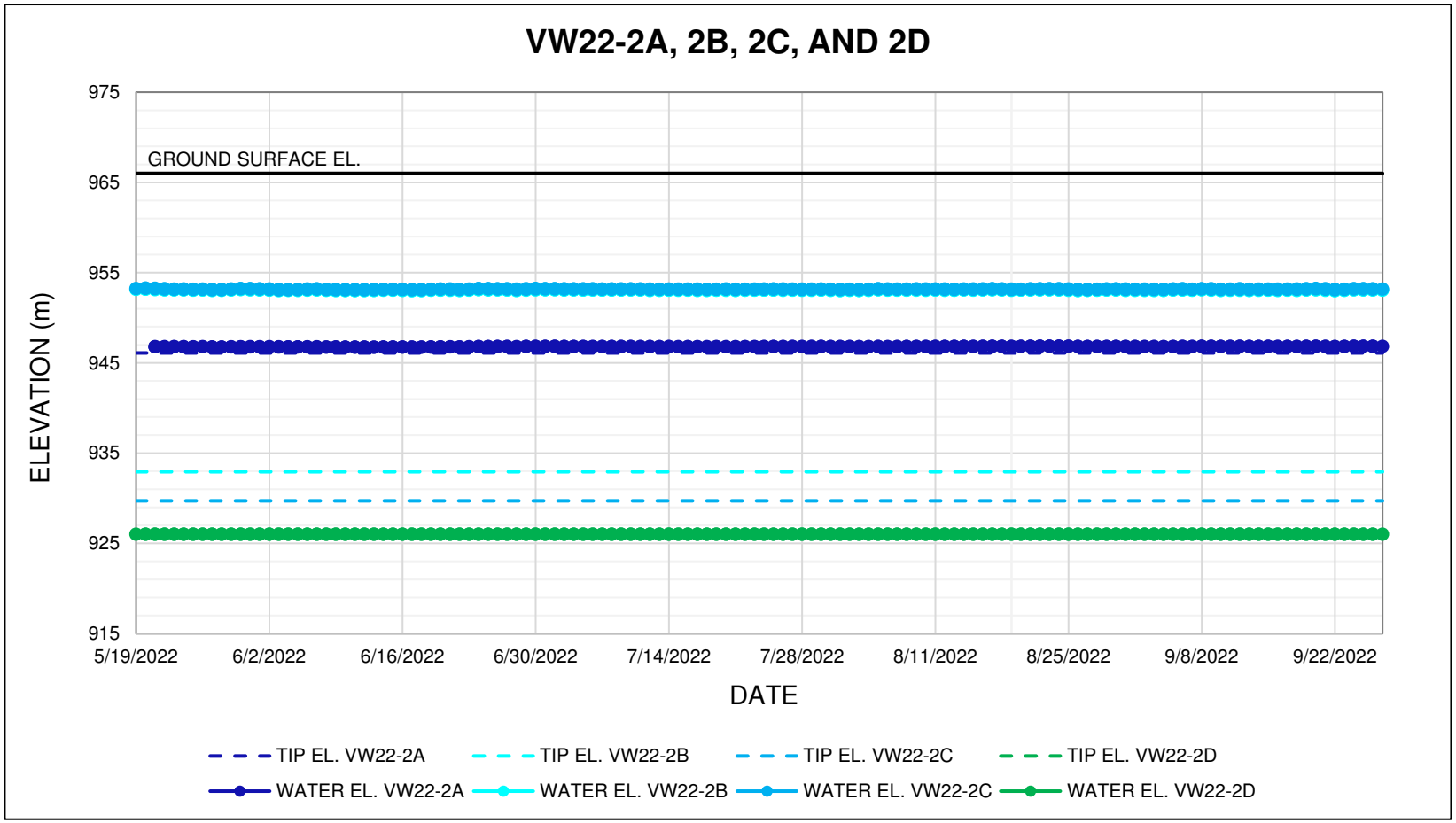
NOTES:
1. RST INSTRUMENTS MULTI-CHANNEL DATA LOGGER WAS INSTALLED ON THESE INSTRUMENTS IN MAY 2022.
2. GROUND SURFACE ELEVATION ESTIMATED FROM LiDAR DATA.

CLIENT
Alberta
Klohn Crippen Berger

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

TITLE
Piezometer Data
GP007 - Wanyandie Road Slide
Hwy 40:36, km 29.339

SCALE	PROJECT No.	FIG No.
AS SHOWN	A05116A01	



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CLIENT
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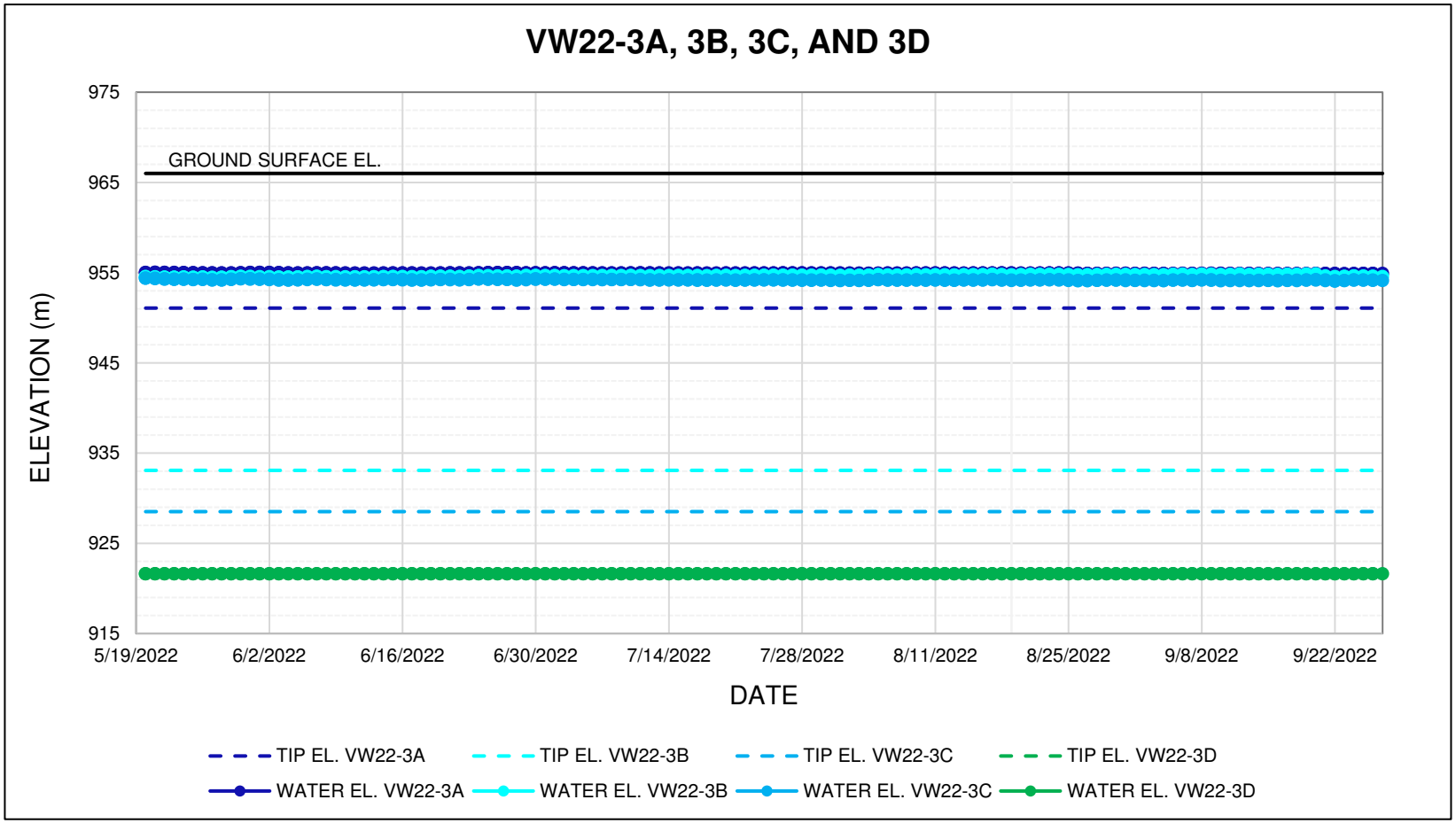
Klohn Crippen Berger

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

TITLE
Piezometer Data
GP007 - Wanyandie Road Slide
Hwy 40:36, km 29.339

SCALE	PROJECT No.	FIG No.
AS SHOWN	A05116A01	



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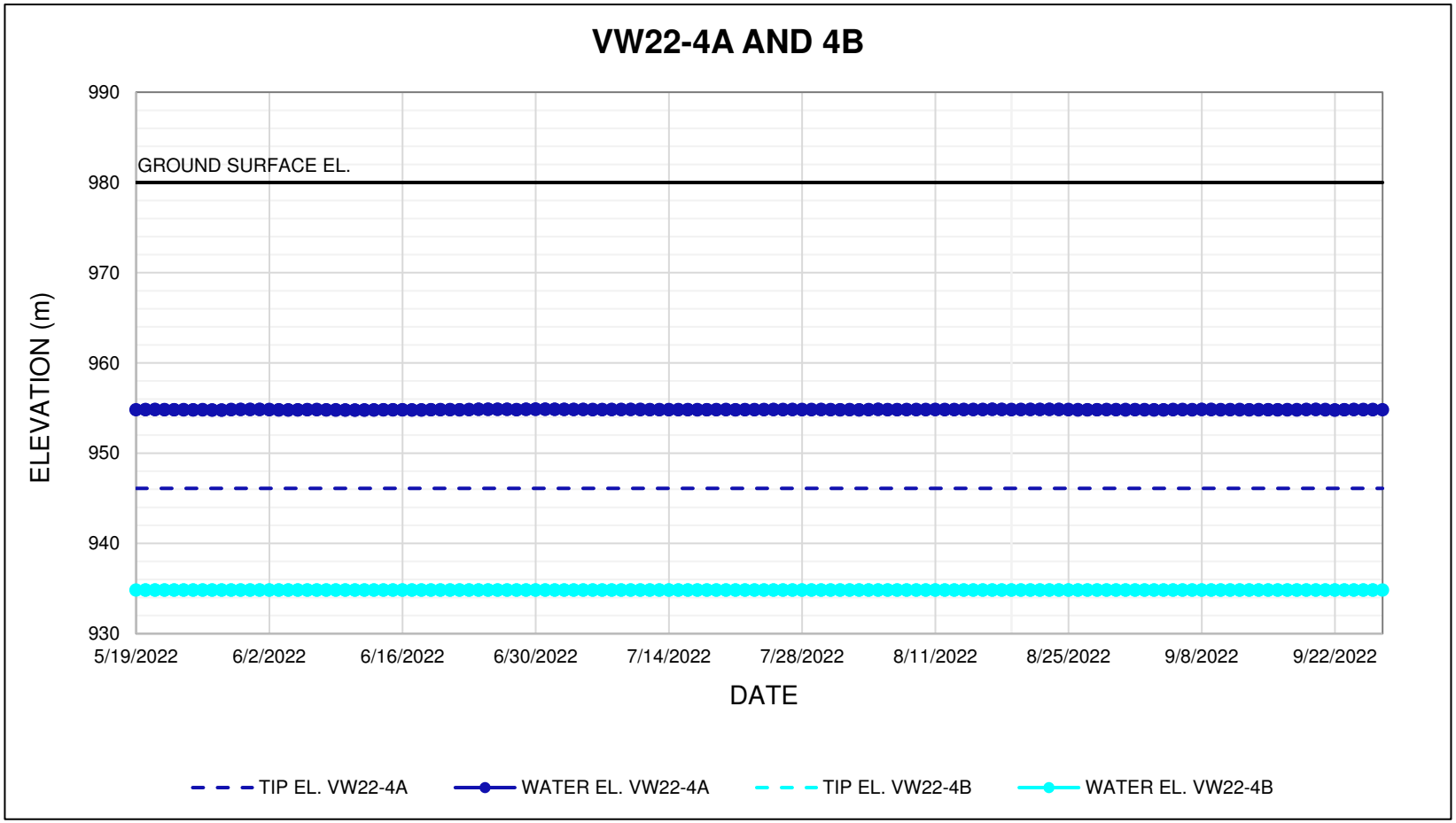
PROJECT
PEACE REGION (GRANDE PRAIRIE DISTRICT - SOUTH)
GEOHAZARD RISK MANAGEMENT PROGRAM

TITLE
Piezometer Data
GP007 - Wanyandie Road Slide
Hwy 40:36, km 29.339

SCALE	PROJECT No.	FIG No.
AS SHOWN	A05116A01	



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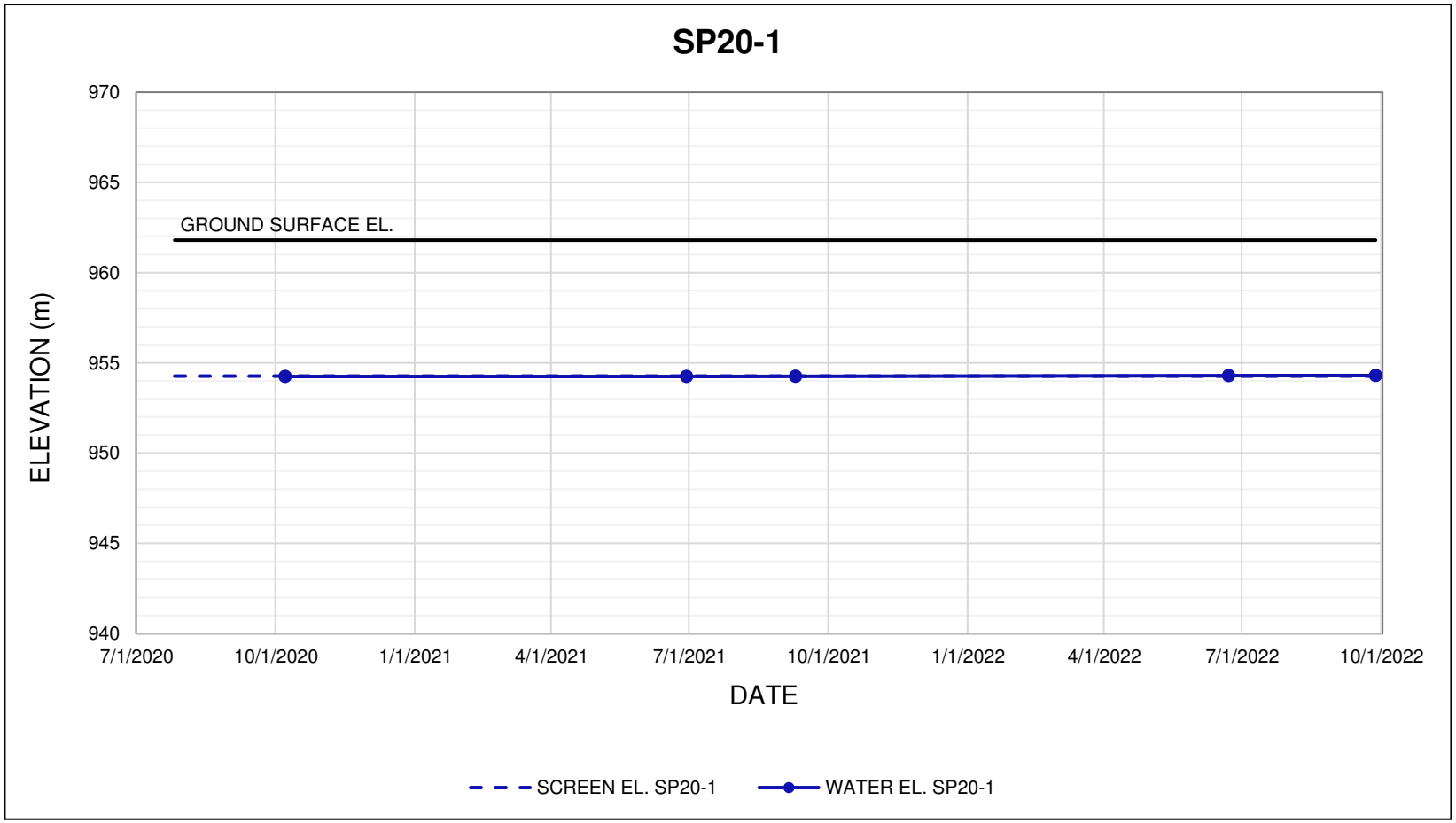
PROJECT
PEACE REGION (GRANDE PRAIRIE DISTRICT - SOUTH)
GEOHAZARD RISK MANAGEMENT PROGRAM

TITLE
Piezometer Data
GP007 - Wanyandie Road Slide
Hwy 40:36, km 29.339

SCALE	PROJECT No.	FIG No.
AS SHOWN	A05116A01	



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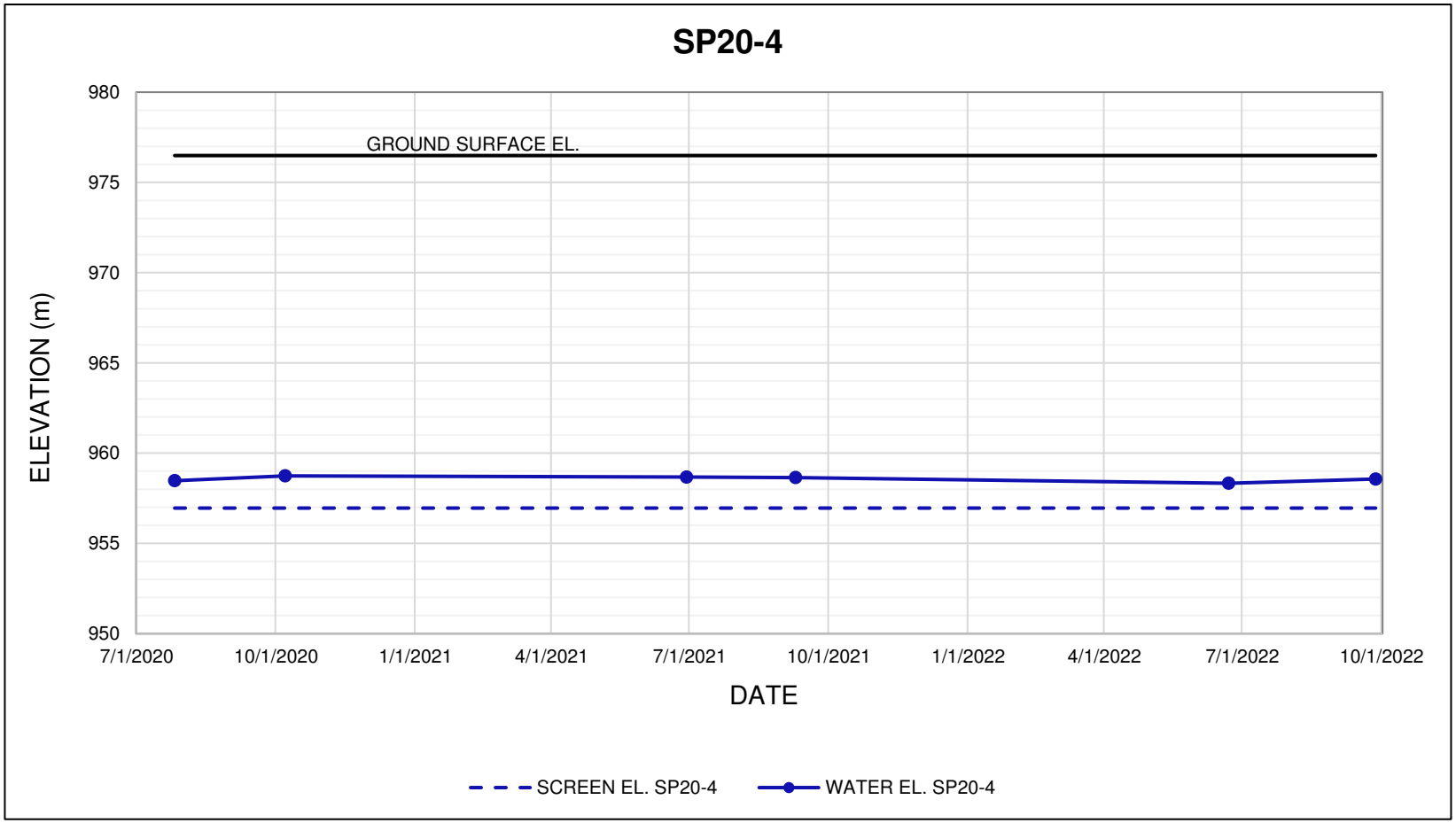
CLIENT	Alberta Klohn Crippen Berger
PROJECT	PEACE REGION (GRANDE PRAIRIE DISTRICT - SOUTH) GEOHAZARD RISK MANAGEMENT PROGRAM
TITLE	Piezometer Data GP007 - Wanyandie Road Slide Hwy 40:36, km 29.339
SCALE	AS SHOWN
PROJECT No.	A05116A01
FIG No.	



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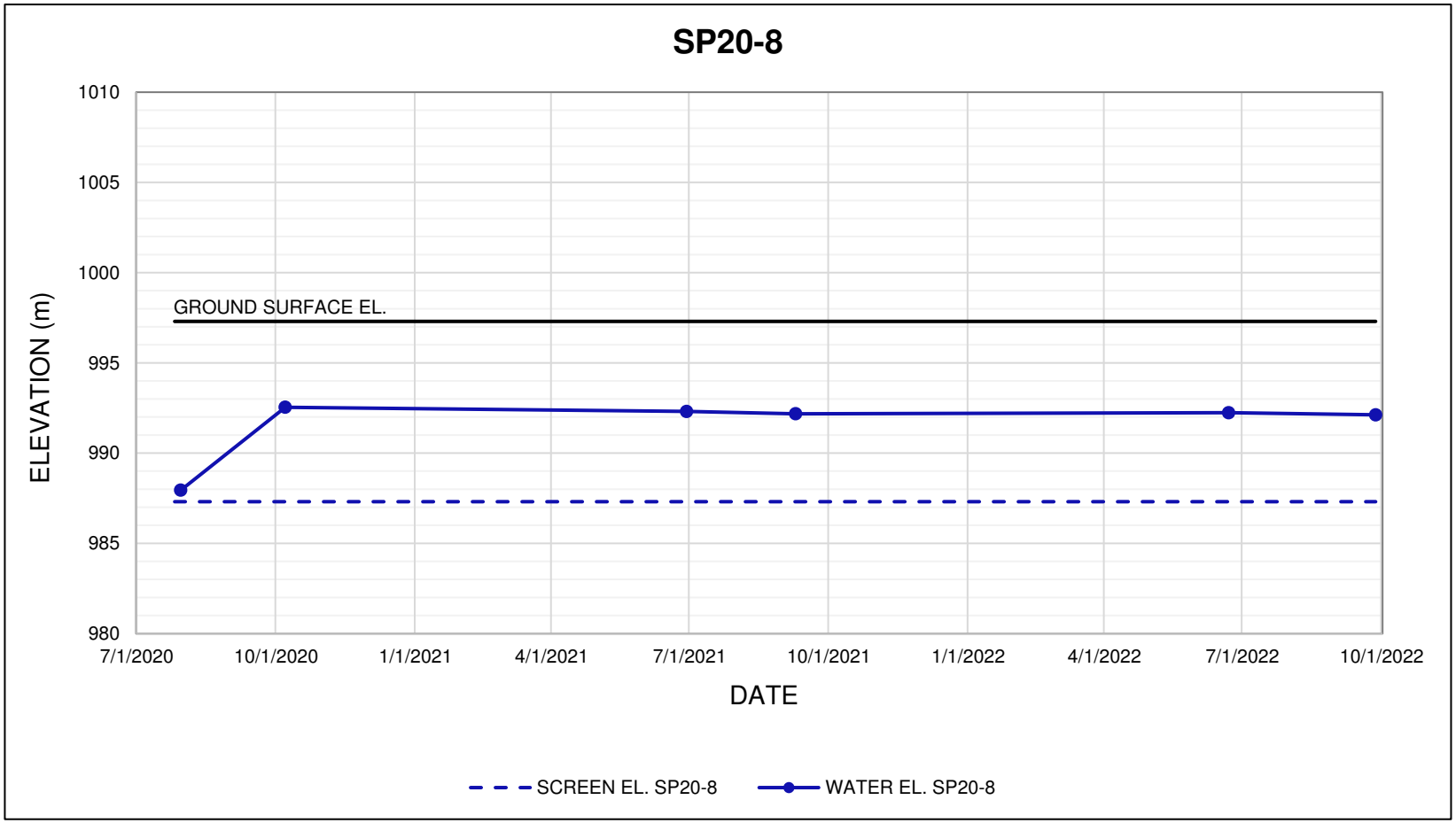
CLIENT	Alberta Klohn Crippen Berger
PROJECT	PEACE REGION (GRANDE PRAIRIE DISTRICT - SOUTH) GEOHAZARD RISK MANAGEMENT PROGRAM
TITLE	Piezometer Data GP007 - Wanyandie Road Slide Hwy 40:36, km 29.339
SCALE	AS SHOWN
PROJECT No.	A05116A01
FIG No.	



NOTES:
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CLIENT: Alberta / Klohn Crippen Berger	PROJECT: PEACE REGION (GRANDE PRAIRIE DISTRICT - SOUTH) GEOHAZARD RISK MANAGEMENT PROGRAM	
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	SCALE: AS SHOWN	PROJECT No.: A05116A01
		FIG No.: