



**THURBER** ENGINEERING LTD.

July 5, 2022

File No.: 32122

Alberta Transportation  
Construction and Maintenance Division  
North Central Region  
Box 4596, 4513 – 62 Avenue  
Barrhead, Alberta  
T7N 1A5

Attention: Ms. Amy Driessen, P.Eng.

**ALBERTA TRANSPORTATION GRMP (CON0022163)  
NORTH CENTRAL (ATHABASCA AND FORT McMURRAY DISTRICTS)  
INSTRUMENTATION MONITORING RESULTS – SPRING 2022**

**SECTION C**

**SITE NC104 (NC024-4): HWY 41:23 KEHIWIN LAKE (km 7.7)**

Dear Ms. Driessen:

This report provides the results of the annual geotechnical instrumentation monitoring for the above-mentioned site as part of Alberta Transportation's Geohazard Risk Management Program for North Central – Athabasca and Fort McMurray Districts (CON0022163).

It is a condition of this letter report that Thurber's performance of its professional services will be subject to the attached Statement of Limitations and Conditions.

**1. FIELD PROGRAM AND INSTRUMENTATION STATUS**

In 2016, a 207 m long reinforced concrete tied-back pile wall was constructed at the Hwy 41:23 Kehiwin Lake site NC104 (formerly known as NC24-4 from 2016 to 2020 and NC24C prior to 2016) to repair a landslide that was affecting the highway. The pile wall was built immediately to the south of the existing pile wall at NC103 (formerly NC24-3), constructed in 2011. During construction, seven new slope inclinometers (SI16-1 to SI16-7) were installed in piles P06, P28, P47, P66, P83, P101 and P122 of the new pile wall. Additionally, 16 new vibrating wire load cells (VC1982 through VC1997) were installed along the wall on selected anchors and wired to two RST DT2040 dataloggers, which were both programmed to read the load cells twice a day.

In 2017, after landslide creep movements were noted in slope inclinometers south of the new NC024-4 pile wall, an additional thirty-five piles were installed to extend the NC104 wall further to the south. Four additional SIs (SI17-1 to SI17-4) were installed in piles P130, P160, P173 and P186 of the pile wall extension. A shape accelerometer array (SAA17-1) was installed in pile P146 to provide continuous monitoring of pile deflection. Eighteen vibrating wire strain gauges were also installed in pile P146 to measure changes in strain in the pile reinforcing steel. The SAA



and strain gauges were wired to a Campbell Scientific CR6 datalogger. The datalogger was programmed to read the strain gauges once per day, and the SAA twice per day.

In addition to the instruments installed during construction, there are six SIs (SI12-11, SI15-15 to SI15-17, SI15-20, and SI15-21), six pneumatic piezometers (PN15-15A, PN15-16, PN15-17, and PN15-19 to PN15-21) and five standpipe piezometers (SP12-6, SP12-9, SP12-12, SP15-14, and SP15-18) that were installed prior to construction.

The above instruments were read on May 26, 2022 by Mr. Niraj Regmi, G.I.T. and Mr. Jayden Del Cid, both of Thurber Engineering Ltd, except for the instruments wired to the Campbell Scientific datalogger, which was accessed remotely by Mr. Bruce Nestor, P.Eng., of Thurber.

A site plan showing the approximate instrumentation locations is included in Appendix A.

The SIs were read using two RST Digital Inclinator probes with 2 ft wheelbases and RST Pocket PC readouts. Inclinator reading depths were defined as per cable markings with respect to the top of the inclinometer casings. The standpipe piezometers were read using a Heron dipmeter. The pneumatic piezometers were read using a RST C108 pneumatic piezometer readout. The load cell data was downloaded from the two dataloggers using a field laptop and RST DT Logger Host software. The SAA and strain gauge data was downloaded Campbell Scientific Loggernet software via a remote modem connection to the logger.

## **2. DATA PRESENTATION**

### **2.1 General**

SI plots for A and B directions are presented in Appendix A and are summarized below. Where movement has been recorded the resultant plot (X direction, if applicable) and rate of movement have also been provided. Strain gauge readings, the standpipe and pneumatic piezometer results, and the vibrating wire load cell readings, are also provided in Appendix A.

### **2.2 Zones of Movement**

No new zones of movement were observed in the SIs or SAA since the previous readings in the spring of 2021.

Zones of movement are summarized in Table NC104-1 below. Table NC104-1 also provides a historical account of the total movement, the depth of movement and the maximum rate of movement that has occurred in the SIs since initialization. The SAA movement is summarized in Table NC104-2.



**TABLE NC104-1  
 SPRING 2022 – HWY 41:23 KEHIWIN LAKE (km 7.7)  
 SLOPE INCLINOMETER INSTRUMENTATION READING SUMMARY**

Date Monitored: May 26, 2022

<b>INSTRUMENT #</b>	<b>DATE INITIALIZED</b>	<b>TOTAL CUMULATIVE RESULTANT MOVEMENT AND DEPTH OF MOVEMENT TO DATE (mm)</b>	<b>MAXIMUM RATE OF MOVEMENT (mm/yr)</b>	<b>CURRENT STATUS OF SI</b>	<b>DATE OF PREVIOUS READING</b>	<b>INCREMENTAL MOVEMENT SINCE PREVIOUS READING (mm)</b>	<b>CURRENT RATE OF MOVEMENT (mm/yr)</b>	<b>CHANGE IN RATE OF MOVEMENT SINCE PREVIOUS READING (mm/yr)</b>
SI12-1	December 14, 2012	1.4 over 5.0 m to 6.2 m depth in 110° direction	1.3 in May 2013	Damaged during construction	September 7, 2016	N/A	N/A	N/A
SI12-2	December 14, 2012	33.3 over 5.8 m to 7.6 m depth in 300° direction	61.4 in September 2014	Damaged during construction	September 7, 2016	N/A	N/A	N/A
SI12-3	December 14, 2012	33.1 over 7.9 m to 9.8 m depth in 295° direction	76.2 in September 2014	Damaged during construction	September 7, 2016	N/A	N/A	N/A
SI12-5	December 14, 2012	29.7 over 7.3 m to 9.1 m depth in 280° direction	51.6 in September 2014	Damaged during construction	September 7, 2016	N/A	N/A	N/A
SI12-8	December 14, 2012	21.0 over 5.0 m to 6.9 m depth in 275° direction	27.2 in September 2014	Damaged during construction	September 7, 2016	N/A	N/A	N/A
SI12-10	December 14, 2012	30.2 over 5.8 m to 8.2 m depth in 315° direction	39.4 in September 2014	Damaged during construction	September 7, 2016	N/A	N/A	N/A
SI12-11	December 14, 2012	20.5 over 9.2 m to 12.3 m depth in 286° direction	22.8 in September 2014	Operational	June 23, 2021	0.3	0.3	0.1
SI12-13	December 14, 2012	11.7 over 7.3 m to 9.1 m depth in 290° direction	17.7 in September 2014	Damaged during construction	September 7, 2016	N/A	N/A	N/A

Drawing 32122-NC104 in Appendix A provides a sketch of the approximate location of the monitoring instrumentation for this site



**TABLE NC104-1 – CONTINUED...  
 SPRING 2022 – HWY 41:23 KEHIWIN LAKE (km 7.7)  
 SLOPE INCLINOMETER INSTRUMENTATION READING SUMMARY**

Date Monitored: May 26, 2022

<b>INSTRUMENT #</b>	<b>DATE INITIALIZED</b>	<b>TOTAL CUMULATIVE RESULTANT MOVEMENT AND DEPTH OF MOVEMENT TO DATE (mm)</b>	<b>MAXIMUM RATE OF MOVEMENT (mm/yr)</b>	<b>CURRENT STATUS OF SI</b>	<b>DATE OF PREVIOUS READING</b>	<b>INCREMENTAL MOVEMENT SINCE PREVIOUS READING (mm)</b>	<b>CURRENT RATE OF MOVEMENT (mm/yr)</b>	<b>CHANGE IN RATE OF MOVEMENT SINCE PREVIOUS READING (mm/yr)</b>
SI15-15	August 20, 2015	22.6 over 5.1 m to 6.9 m depth in 297° direction	11.9 in September, 2017	Operational	June 23, 2021	0.2	0.2	-0.5
SI15-16	August 20, 2015	29.3 over 9.7 m to 11.5 m depth in 299° direction	45.9 in September, 2017	Operational	June 23, 2021	0.5	0.5	0.4
SI15-17	August 20, 2015	28.2 over 9.2 m to 11.0 m depth in 275° direction	35.0 in September, 2017	Operational	June 23, 2021	No discernible movement	N/A	-1.3
SI15-19	August 20, 2015	25.9 over 8.2 m to 9.4 m depth in 303° direction	38.0 in September, 2017	Damaged	May 25, 2019	N/A	N/A	N/A
SI15-20	August 20, 2015	30.6 over 8.6 m to 10.4 m depth in 270° direction	37.9 in September, 2017	Operational	June 23, 2021	1.1	1.2	0.6
SI15-21	August 20, 2015	18.7 over 8.5 m to 10.4 m depth in 323° direction	12.6 in September, 2017	Operational	June 23, 2021	0.6	0.7	-0.3
SI16-1 (P06)	October 19, 2016	-7.3 over 2.7 m to 17.3 m depth in 274° direction	25.8 in January, 2017	Operational	June 23, 2021	No discernible movement	N/A	-0.5
SI16-2 (P28)	October 19, 2016	-3.7 over 2.7 m to 17.4 m depth in 29° direction	30.7 in January 2017	Operational	June 23, 2021	1.0	1.0	0.8

Drawing 32122-NC104 in Appendix A provides a sketch of the approximate location of the monitoring instrumentation for this site



**TABLE NC104-1 – CONTINUED...  
 SPRING 2022 – HWY 41:23 KEHIWIN LAKE (km 7.7)  
 SLOPE INCLINOMETER INSTRUMENTATION READING SUMMARY**

Date Monitored: May 26, 2022

<b>INSTRUMENT #</b>	<b>DATE INITIALIZED</b>	<b>TOTAL CUMULATIVE RESULTANT MOVEMENT AND DEPTH OF MOVEMENT TO DATE (mm)</b>	<b>MAXIMUM RATE OF MOVEMENT (mm/yr)</b>	<b>CURRENT STATUS OF SI</b>	<b>DATE OF PREVIOUS READING</b>	<b>INCREMENTAL MOVEMENT SINCE PREVIOUS READING (mm)</b>	<b>CURRENT RATE OF MOVEMENT (mm/yr)</b>	<b>CHANGE IN RATE OF MOVEMENT SINCE PREVIOUS READING (mm/yr)</b>
SI16-3 (P47)	October 19, 2016	-3.4 over 2.9 m to 14.5 m depth in 299° direction	65.6 in November 2016	Operational	June 23, 2021	0.2	0.3	1.4
SI16-4 (P66)	October 19, 2016	-4.3 over 3.0 m to 14.6 m depth in 336° direction	44.2 in November 2016	Damaged	May 25, 2019	N/A	N/A	N/A
SI16-5 (P83)	October 19, 2016	-0.4 over 2.9 m to 14.4 m depth in 319° direction	56.2 in November 2016	Operational	June 23, 2021	0.9	0.9	0.7
SI16-6 (P101)	September 7, 2016	3.6 over 2.9 m to 17.5 depth in 298° direction	36.7 in October 2016	Operational	June 23, 2021	0.7	0.7	0.6
SI16-7 (P122)	Reinitialized September 18, 2020	No discernible movement	N/A	Operational	June 23, 2021	N/A	N/A	N/A
SI17-1 (P130)	September 13, 2017	3.2 over 2.6 m to 17.8 m depth in 276° direction	8.4 in April 2018	Operational	June 23, 2021	No discernible movement	N/A	0.6
SI17-2 (P160)	September 13, 2017	8.9 over 2.6 m to 17.8 m depth in 295° direction	20.8 in September 2017	Operational	June 23, 2021	0.1	0.1	-0.7
SI17-3 (P173)	July 9, 2017	16.1 over 2.6 m to 17.8 m depth in 323° direction	65.9 in July 2017	Operational	June 23, 2021	0.6	0.7	-1.1

Drawing 32122-NC104 in Appendix A provides a sketch of the approximate location of the monitoring instrumentation for this site



**TABLE NC104-1 – CONTINUED...  
 SPRING 2022 – HWY 41:23 KEHIWIN LAKE (km 7.7)  
 SLOPE INCLINOMETER INSTRUMENTATION READING SUMMARY**

Date Monitored: May 26, 2022

<b>INSTRUMENT #</b>	<b>DATE INITIALIZED</b>	<b>TOTAL CUMULATIVE RESULTANT MOVEMENT AND DEPTH OF MOVEMENT TO DATE (mm)</b>	<b>MAXIMUM RATE OF MOVEMENT (mm/yr)</b>	<b>CURRENT STATUS OF SI</b>	<b>DATE OF PREVIOUS READING</b>	<b>INCREMENTAL MOVEMENT SINCE PREVIOUS READING (mm)</b>	<b>CURRENT RATE OF MOVEMENT (mm/yr)</b>	<b>CHANGE IN RATE OF MOVEMENT SINCE PREVIOUS READING (mm/yr)</b>
SI17-4 (P186)	September 27, 2017	10.1 over 2.7 m to 17.3 m depth in 303° direction	8.8 in May 2018	Operational	June 23, 2021	0.7	0.8	0.6

Drawing 32122-NC104 in Appendix A provides a sketch of the approximate location of the monitoring instrumentation for this site



**TABLE NC104-2  
 SPRING 2022 – HWY 41:23 KEHIWIN LAKE (km 7.7)  
 SHAPE ACCELEROMETER ARRAY INSTRUMENTATION READING SUMMARY**

Date Monitored: May 26, 2022

<b>INSTRUMENT #</b>	<b>DATE INITIALIZED</b>	<b>TOTAL CUMULATIVE RESULTANT MOVEMENT AT NOTED DEPTH SINCE INITIAL READING (mm)</b>	<b>CURRENT STATUS</b>	<b>DATE OF PREVIOUS READING</b>	<b>INCREMENTAL MOVEMENT SINCE PREVIOUS READING (mm)</b>	<b>AVERAGE RATE OF MOVEMENT SINCE PREVIOUS READING (mm/yr)</b>	<b>CHANGE IN AVERAGE RATE OF MOVEMENT SINCE PREVIOUS READING (mm/yr)</b>
SAA17-1 (P146)	September 27, 2017	1.4 mm over 3.1 m to 18.6 m depth	Operational	September 18, 2020	No discernible movement	N/A	0.1

Drawing 32122-NC104 in Appendix A provides a sketch of the approximate location of the monitoring instrumentation for this site



**TABLE-NC104-3**  
**SPRING 2022 – HWY 41:23 KEHIWIN LAKE (km 7.7)**  
**VIBRATING WIRE STRAIN GAUGE INSTRUMENTATION READING SUMMARY**

Date Monitored: May 26, 2022

DEPTH FROM TOP OF PILE P146 (m)	GAUGE #	TOTAL MICROSTRAIN (µε)	CHANGE IN MICROSTRAIN SINCE PREVIOUS READING (µε)	THRESHOLD WARNING MICROSTRAIN (µε)	GAUGE #	TOTAL MICROSTRAIN (µε)	CHANGE IN MICROSTRAIN SINCE PREVIOUS READING (µε)	THRESHOLD WARNING MICROSTRAIN (µε)
	<b>UPSLOPE PILE FACE</b>				<b>DOWNSLOPE PILE FACE</b>			
0.8	138017001	-17.8	-0.2	1000	138017002	-15.5	-0.4	-350
2.65	138017003	-54.4	-8.8	1000	138017004	-43.7	14.0	-350
4.5	138017005	-47.2	-31.9	1200	138017006	-13.7	36.1	-430
6.35	138017007	-3.4	-23.0	1200	<i>138017008</i>	<i>No Reading</i>	<i>N/A</i>	<i>-430</i>
8.2	138017009	63.5	48.5	1200	138017010	14.6	-45.1	-430
10.05	138017011	64.8	66.3	1200	138017012	-1.5	-63.2	-430
11.9	138017013	98.6	46.6	1200	138017014	52.8	-42.9	-430
13.75	138017015	5.9	0.6	1000	138017016	7.1	3.0	-350
15.6	138017017	25.3	12.1	1000	138017018	15.2	-7.9	-350

Drawing 32122-NC104 in Appendix A provides a sketch of the approximate location of the monitoring instrumentation for this site; Negative values are compressive strains





**TABLE NC104-4  
 SPRING 2022 – HWY 41:23 KEHIWIN LAKE (km 7.7)  
 PNEUMATIC PIEZOMETER INSTRUMENTATION READING SUMMARY**

Date Monitored: May 26, 2022

<b>INSTRUMENT #</b>	<b>DATE INITIALIZED</b>	<b>TIP DEPTH (m)</b>	<b>GROUND ELEV. (m)</b>	<b>CURRENT STATUS</b>	<b>HIGHEST MEASURED GROUNDWATER LEVEL BGS (m)</b>	<b>MEASURED PORE PRESSURE (kPa)</b>	<b>CURRENT GROUNDWATER LEVEL BGS (m)</b>	<b>PREVIOUS GROUNDWATER LEVEL BGS (m)</b>	<b>CHANGE IN WATER LEVEL SINCE PREVIOUS READING (m)</b>
PN12-1	December 14, 2012	5.0	-	Damaged	0.65 m in May, 2017	N/A	N/A	0.65 (May 24, 2017)	N/A
PN12-2	December 14, 2012	7.1	-	Destroyed during construction	4.08 in September, 2014	N/A	N/A	4.99 (Sep. 7, 2016)	N/A
PN12-3	December 14, 2012	9.4	-	Destroyed during construction	1.46 in September, 2014	N/A	N/A	3.78 (Sep. 7, 2016)	N/A
PN12-5	December 14, 2012	8.9	-	Non-Operational	5.25 in December, 2012	N/A	N/A	8.9 (July 30, 2013)	N/A
PN12-8	December 14, 2012	9.0	-	Destroyed during construction	5.00 in September, 2014	N/A	N/A	5.98 (Sep. 7, 2016)	N/A
PN12-10	December 14, 2012	8.1	-	Destroyed during construction	3.75 in September, 2014	N/A	N/A	8.03 (Sep. 7, 2016)	N/A
PN12-11	December 14, 2012	12.0	-	Damaged	1.89 in September, 2014	N/A	N/A	9.49 (May 24, 2019)	N/A

Drawing 32122-NC104 in Appendix A provides a sketch of the approximate location of the monitoring instrumentation for this site



**TABLE NC104-4  
 SPRING 2022 – HWY 41:23 KEHIWIN LAKE (km 7.7)  
 PNEUMATIC PIEZOMETER INSTRUMENTATION READING SUMMARY**

Date Monitored: May 26, 2022

<b>INSTRUMENT #</b>	<b>DATE INITIALIZED</b>	<b>TIP DEPTH (m)</b>	<b>GROUND ELEV. (m)</b>	<b>CURRENT STATUS</b>	<b>HIGHEST MEASURED GROUNDWATER LEVEL BGS (m)</b>	<b>MEASURED PORE PRESSURE (kPa)</b>	<b>CURRENT GROUNDWATER LEVEL BGS (m)</b>	<b>PREVIOUS GROUNDWATER LEVEL BGS (m)</b>	<b>CHANGE IN WATER LEVEL SINCE PREVIOUS READING (m)</b>
PN12-13	December 14, 2012	12.0	-	Destroyed during construction	9.05 in May, 2017	N/A	N/A	9.05 (May 24, 2017)	N/A
PN15-15A	August 20, 2015	6.1	-	Active	4.63 in May, 2017	8.0	5.28	5.14	-0.14
PN15-16	August 20, 2015	8.4	-	Active	6.41 in September, 2018	13.1	7.04	6.95	-0.09
PN15-17	August 20, 2015	12.2	-	Active	2.30 in May, 2020	93.5	2.66	2.54	-0.12
PN15-19	August 20, 2015	9.1	-	Active	3.17 in September, 2016	39.1	5.15	5.06	-0.09
PN15-20	August 20, 2015	11.4	-	Active	1.29 in May, 2020	96.5	1.59	1.40	-0.19
PN15-21	August 20, 2015	9.1	-	Active	3.08 in May, 2019	48.1	4.24	3.94	-0.30

Drawing 32122-NC104 in Appendix A provides a sketch of the approximate location of the monitoring instrumentation for this site



**TABLE NC104-5  
 SPRING 2022 – HWY 41:23 KEHIWIN LAKE (km 7.7)  
 STANDPIPE PIEZOMETER INSTRUMENTATION READING SUMMARY**

Date Monitored: May 26, 2022

<b>INSTRUMENT #</b>	<b>DATE INITIALIZED</b>	<b>TIP DEPTH (m)</b>	<b>GROUND ELEV. (m)</b>	<b>CURRENT STATUS</b>	<b>HIGHEST MEASURED GROUNDWATER LEVEL BGS (m)</b>	<b>CURRENT GROUNDWATER DEPTH BGS (m)</b>	<b>PREVIOUS GROUNDWATER DEPTH BGS (m)</b>	<b>CHANGE IN WATER LEVEL SINCE PREVIOUS READING (m)</b>
SP12-4	December 14, 2012	13.0	-	Destroyed during construction	1.19 in September 2015	N/A	N/A	N/A
SP12-6	December 14, 2012	18.5	-	Operational	2.21 in September 2014	2.91	2.82	-0.09
SP12-7	December 14, 2012	17.6	-	Destroyed during construction	4.20 in May 2013	N/A	N/A	N/A
SP12-9	December 14, 2012	11.5	-	Operational	0.96 in May 2017	2.78	2.59	-0.19
SP12-12	December 14, 2012	14.6	-	Operational (blocked at 2.96 m BGS)	0.79 in May 2017	DRY	DRY	N/A
SP15-14	August 20, 2015	2.47	-	Operational	N/A	DRY	DRY	N/A
SP15-18	August 20, 2015	14.78	-	Operational	0.00 in May 2020	1.71	0.58	-1.13

Drawing 32122-NC104 in Appendix A provides a sketch of the approximate location of the monitoring instrumentation for this site



**TABLE NC104-6  
 SPRING 2022 – HWY 41:23 KEHIWIN LAKE (km 7.7)  
 VIBRATING WIRE LOAD CELL INSTRUMENTATION READING SUMMARY**

Date Monitored: May 26, 2022

LOAD CELL SERIAL #	ANCHOR NUMBER	DESIGN LOAD / LOCK-OFF LOAD (kN)	MAXIMUM RECORDED LOAD (kN)	RECORDED LOAD <sup>(1)</sup> (MAY 26, 2022) (kN)	PREVIOUS RECORDED LOAD <sup>(1)</sup> (JUNE 24, 2021) (kN)	CHANGE IN LOAD SINCE PREVIOUS READING (kN)
VC1990	G001S	340/272	212.21 on Mach 21, 2017	188.24	189.64	-1.40
VC1982	G007U	340/272	225.14 on March 19, 2017	210.64	215.56	-4.92
VC1992	G007L	340/272	210.61 on March 5, 2017	191.52	196.25	-4.73
VC1993	G029U	340/272	192.34 on March 20, 2017	176.06	178.99	-2.93
VC1991	G029L	340/272	200.00 on March 22, 2017	181.79	184.81	-3.02
VC1997	G049U	340/272	229.65 on February 26, 2021	224.73	226.45	-1.72
VC1996	G049L	340/272	202.47 on March 5, 2017	194.68	195.47	-0.79
VC1995	G070U	340/272	222.22 on March 22, 2017	199.29	202.70	-3.41
VC1994	G070L	340/272	237.72 on March 23, 2017	225.24	228.26	-3.02
VC1984	G087U	340/272	229.59 on March 25, 2017	203.22	203.72	-0.50
VC1983	G087L	340/272	250.46 on March 25, 2017	241.97	243.55	-1.58

Drawing 32122-NC104 in Appendix A provides a sketch of the approximate location of the monitoring instrumentation for this site

Notes:

- 1) Load cell data is recorded daily with datalogger on site. Dataloggers are uploaded annually during instrumentation readings.



**TABLE NC104-6 – CONTINUED...  
 SPRING 2022 – HWY 41:23 KEHIWIN LAKE (km 7.7)  
 VIBRATING WIRE LOAD CELL INSTRUMENTATION READING SUMMARY**

Date Monitored: May 26, 2022

LOAD CELL SERIAL #	ANCHOR NUMBER	DESIGN LOAD / LOCK-OFF LOAD (kN)	MAXIMUM RECORDED LOAD (kN)	RECORDED LOAD <sup>(1)</sup> (MAY 26, 2022) (kN)	PREVIOUS RECORDED LOAD <sup>(1)</sup> (JUNE 24, 2021) (kN)	CHANGE IN LOAD SINCE PREVIOUS READING (kN)
VC1985	G106U	340/272	231.15 on March 27, 2017	213.96	214.27	-0.31
VC1986	G106L	340/272	227.51 on March 24, 2017	211.58	212.63	-1.05
VC1987	G126U	340/272	227.34 on February 25, 2021	219.12	219.67	-0.55
VC1989	G126L	340/272	261.03 on January 18, 2022	254.83	255.68	-0.85
VC1988	G132S	340/272	248.82 on February 1, 2022	245.59	243.36	2.23

Drawing 32122-NC104 in Appendix A provides a sketch of the approximate location of the monitoring instrumentation for this site

Notes:

- 1) Load cell data is recorded daily with datalogger on site. Dataloggers are uploaded annually during instrumentation readings.



### 3. INTERPRETATION OF MONITORING RESULTS

Slope inclinometer SI15-15, installed in the highway east ditch within the southern limit of the site, showed a rate of movement of 0.2 mm/yr over 5.1 m to 6.9 m depth since the spring of 2021 readings.

Slope inclinometers SI15-16 and SI15-21, installed along the west edge of the highway, showed rates of movement of 0.5 mm/yr over 9.7 m to 11.5 m depth and 0.7 mm/yr over 8.5 m to 10.4 m depth, respectively, since the spring of 2021 readings.

Slope inclinometer SI12-11, installed at the bottom of the slope, showed a rate of movement of 0.3 mm/yr over 9.2 m to 12.3 m depth since the spring of 2021 readings. SI15-17 installed at the bottom of the slope showed no discernible movement over 9.2 m to 11.0 m depth. SI15-20, also installed at the bottom of the slope, showed a rate of movement of 1.2 mm/yr over 8.6 m to 10.4 m depth since the spring of 2021 readings.

For the tied-back pile wall, SI16-1, SI16-2, SI16-3, and SI16-5 have shown total pile head movements in the upslope direction of 7.3 mm, 3.7 mm, 3.4 mm, and 0.4 mm, respectively. SI16-6 has shown a total pile head movement of 3.6 mm in the downslope direction. SI16-7 was reinitialized on September 18, 2020, and thus far has not shown any discernible movement.

For the interim cantilever pile wall, SI17-1 showed no discernible movement since the spring of 2021 readings. SI17-2, SI17-3 and SI17-4 showed rates of movement over the length of their respective piles of 0.1 mm/yr, 0.7 mm/yr and 0.8 mm/yr, respectively, since the spring of 2021 readings. SI17-1, SI17-2, SI17-3, and SI17-4 have shown total pile head movements of 3.2 mm, 8.9 mm, 16.1 mm and 10.1, respectively, since they were initialized. The pile head deflection in SI17-3 has now surpassed the control deflection threshold value (i.e., 16 mm) specified for the interim pile wall. The design pile head deflection value of the interim wall is 21 mm at SLS.

Overall, the current rates of movement shown in the SIs were comparable to the movement shown in the SIs over the past several years since the end of pile wall construction.

SAA17-1, installed in pile P146 of the NC104-4 wall extension (i.e., interim pile wall), showed no discernible downslope movement since the spring of 2021 readings. SAA17-1 has shown a total pile head movement of 1.4 mm in the downslope direction since it was installed.

The strain gauge readings are summarized in Table NC104-3 and plotted on Figures NC104-1 and NC104-2 included in Appendix A. The strain gauges generally showed the greatest changes in micro-strain between 8.2 m and 11.9 m below the top of the pile, consistent with the potential location of maximum bending moment within the pile. Over this zone, the strain gauges installed in the upslope pile face showed increases in positive (tension) micro-strain while the strain gauges on the downslope pile face showed increases in negative (compressive) micro-strain. However, all of the strain gauges continue to show micro-strain readings well below the threshold warning strain values specified in the pile design.



The pneumatic piezometers all showed decreases in groundwater level since the spring of 2021 readings, ranging from a decrease of 0.09 m in PN15-16 and PN15-19 to a decrease of 0.30 m in PN15-21. The pneumatic piezometer readings are summarized in Table NC104-4 above.

Standpipe piezometers SP12-6, SP12-9, and SP15-18 showed decreases in groundwater level of 0.09 m, 0.19 m, and 1.13 m, respectively, since the spring of 2021 readings. SP15-12 and SP15-14 are still dry. The standpipe piezometer readings are summarized in Table NC104-5 above.

The pneumatic and standpipe piezometer results are plotted on Figures NC104-3 and NC104-4 in Appendix A.

The load cells mainly showed decreases in measured load since the spring of 2021 readings, ranging from a decrease of 0.30 kN in VC1985 (anchor G106U) to a decrease of 4.92 kN in VC1982 (anchor G007U). Load cell VC1988 (anchor G132S) showed an increase in measured load of 2.23 kN since the spring of 2021 readings. In addition, load cells VC1989 (anchor G126L) and VC1988 (anchor G132S) registered all time high measured loads during a period between January 18, 2022, and February 1, 2022. The load cells all previously showed a decrease in load after lockoff, which is typical for pile walls of similar configuration. Overall, the load cells are currently registering a trend of stable to slowly increasing measured loads, with seasonably higher loads measured during the winter months. The load cell readings are summarized in Table NC104-6 and are plotted on Figures NC104-5 through NC104-8 in Appendix A.

## **4. RECOMMENDATIONS**

### **4.1 Future Work**

All instruments should be read again in the spring of 2023. However, it is recommended that SI17-1 to SI17-4 (installed within the piles of the interim wall) and SI15-16, SI15-17, SI15-20 (installed downslope of the interim pile wall) be read bi-annually, starting in the fall of 2022, to closely monitor the performance of the interim pile wall and the landslide movement rates at this location.

### **4.2 Instrumentation Repairs**

No instrument repairs are required at this time.



## 5. CLOSURE

We trust this report meets your requirements at present. If you have any questions, please contact the undersigned at your convenience.

Yours very truly,  
Thurber Engineering Ltd.  
Tarek Abdelaziz, Ph.D., P.Eng.  
Principal | Senior Geotechnical Engineer

Bruce Nestor, P.Eng.  
Geotechnical Engineer  
/jf

### Attachments:

- Statement of Limitations and Conditions
- Appendix A
  - Field Inspector's report
  - Site Plan Showing Approximate Instrument Locations (Drawing No. 32122-NC104)
  - SI Reading Plots
  - Figures NC104-1 and NC104-2 (Strain Gauge Readings)
  - Figures NC104-3 and NC104-4 (Piezometric Depths)
  - Figures NC104-5 to NC104-8 (Load Cell Readings)





## STATEMENT OF LIMITATIONS AND CONDITIONS

### 1. STANDARD OF CARE

This Report has been prepared in accordance with generally accepted engineering or environmental consulting practices in the applicable jurisdiction. No other warranty, expressed or implied, is intended or made.

### 2. COMPLETE REPORT

All documents, records, data and files, whether electronic or otherwise, generated as part of this assignment are a part of the Report, which is of a summary nature and is not intended to stand alone without reference to the instructions given to Thurber by the Client, communications between Thurber and the Client, and any other reports, proposals or documents prepared by Thurber for the Client relative to the specific site described herein, all of which together constitute the Report.

IN ORDER TO PROPERLY UNDERSTAND THE SUGGESTIONS, RECOMMENDATIONS AND OPINIONS EXPRESSED HEREIN, REFERENCE MUST BE MADE TO THE WHOLE OF THE REPORT. THURBER IS NOT RESPONSIBLE FOR USE BY ANY PARTY OF PORTIONS OF THE REPORT WITHOUT REFERENCE TO THE WHOLE REPORT.

### 3. BASIS OF REPORT

The Report has been prepared for the specific site, development, design objectives and purposes that were described to Thurber by the Client. The applicability and reliability of any of the findings, recommendations, suggestions, or opinions expressed in the Report, subject to the limitations provided herein, are only valid to the extent that the Report expressly addresses proposed development, design objectives and purposes, and then only to the extent that there has been no material alteration to or variation from any of the said descriptions provided to Thurber, unless Thurber is specifically requested by the Client to review and revise the Report in light of such alteration or variation.

### 4. USE OF THE REPORT

The information and opinions expressed in the Report, or any document forming part of the Report, are for the sole benefit of the Client. NO OTHER PARTY MAY USE OR RELY UPON THE REPORT OR ANY PORTION THEREOF WITHOUT THURBER'S WRITTEN CONSENT AND SUCH USE SHALL BE ON SUCH TERMS AND CONDITIONS AS THURBER MAY EXPRESSLY APPROVE. Ownership in and copyright for the contents of the Report belong to Thurber. Any use which a third party makes of the Report, is the sole responsibility of such third party. Thurber accepts no responsibility whatsoever for damages suffered by any third party resulting from use of the Report without Thurber's express written permission.

### 5. INTERPRETATION OF THE REPORT

- a) Nature and Exactness of Soil and Contaminant Description: Classification and identification of soils, rocks, geological units, contaminant materials and quantities have been based on investigations performed in accordance with the standards set out in Paragraph 1. Classification and identification of these factors are judgmental in nature. Comprehensive sampling and testing programs implemented with the appropriate equipment by experienced personnel may fail to locate some conditions. All investigations utilizing the standards of Paragraph 1 will involve an inherent risk that some conditions will not be detected and all documents or records summarizing such investigations will be based on assumptions of what exists between the actual points sampled. Actual conditions may vary significantly between the points investigated and the Client and all other persons making use of such documents or records with our express written consent should be aware of this risk and the Report is delivered subject to the express condition that such risk is accepted by the Client and such other persons. Some conditions are subject to change over time and those making use of the Report should be aware of this possibility and understand that the Report only presents the conditions at the sampled points at the time of sampling. If special concerns exist, or the Client has special considerations or requirements, the Client should disclose them so that additional or special investigations may be undertaken which would not otherwise be within the scope of investigations made for the purposes of the Report.
- b) Reliance on Provided Information: The evaluation and conclusions contained in the Report have been prepared on the basis of conditions in evidence at the time of site inspections and on the basis of information provided to Thurber. Thurber has relied in good faith upon representations, information and instructions provided by the Client and others concerning the site. Accordingly, Thurber does not accept responsibility for any deficiency, misstatement or inaccuracy contained in the Report as a result of misstatements, omissions, misrepresentations, or fraudulent acts of the Client or other persons providing information relied on by Thurber. Thurber is entitled to rely on such representations, information and instructions and is not required to carry out investigations to determine the truth or accuracy of such representations, information and instructions.
- c) Design Services: The Report may form part of design and construction documents for information purposes even though it may have been issued prior to final design being completed. Thurber should be retained to review final design, project plans and related documents prior to construction to confirm that they are consistent with the intent of the Report. Any differences that may exist between the Report's recommendations and the final design detailed in the contract documents should be reported to Thurber immediately so that Thurber can address potential conflicts.
- d) Construction Services: During construction Thurber should be retained to provide field reviews. Field reviews consist of performing sufficient and timely observations of encountered conditions in order to confirm and document that the site conditions do not materially differ from those interpreted conditions considered in the preparation of the report. Adequate field reviews are necessary for Thurber to provide letters of assurance, in accordance with the requirements of many regulatory authorities.

### 6. RELEASE OF POLLUTANTS OR HAZARDOUS SUBSTANCES

Geotechnical engineering and environmental consulting projects often have the potential to encounter pollutants or hazardous substances and the potential to cause the escape, release or dispersal of those substances. Thurber shall have no liability to the Client under any circumstances, for the escape, release or dispersal of pollutants or hazardous substances, unless such pollutants or hazardous substances have been specifically and accurately identified to Thurber by the Client prior to the commencement of Thurber's professional services.

### 7. INDEPENDENT JUDGEMENTS OF CLIENT

The information, interpretations and conclusions in the Report are based on Thurber's interpretation of conditions revealed through limited investigation conducted within a defined scope of services. Thurber does not accept responsibility for independent conclusions, interpretations, interpolations and/or decisions of the Client, or others who may come into possession of the Report, or any part thereof, which may be based on information contained in the Report. This restriction of liability includes but is not limited to decisions made to develop, purchase or sell land.



**ALBERTA TRANSPORTATION GRMP (CON0022163)  
NORTH CENTRAL (ATHABASCA AND FORT McMURRAY DISTRICTS)  
INSTRUMENTATION MONITORING RESULTS**

**SPRING 2022**

**APPENDIX A  
DATA PRESENTATION AND SITE PLANS**

**SITE NC104 (NC024-4): HWY 41:23 KEHIWIN LAKE (km 7.8)**

ALBERTA TRANSPORTATION  
 NORTH CENTRAL REGION - ATHABASCA AND FORT McMURRAY DISTRICTS  
 INSTRUMENTATION MONITORING FIELD SUMMARY (NC104)  
 SPRING 2022

<b>Location:</b> Kehiwin Lake (HWY41:23 C1 7.666) <b>File Number:</b> 32122 <b>Probe:</b> RST SET 5R and 8R <b>Cable:</b> RST SET 5R and 8R	<b>Readout:</b> <b>Casing Diameter:</b> 2.75" <b>Temp (deg C):</b> 18 <b>Read by:</b> NKR/JD
--	---

**SLOPE INCLINOMETER (SI) READINGS**

SI#	GPS Location (UTM 12)		Date	Stickup (m)	Depth from top of CASING (ft)	Azimuth of A+ Groove	Current Bottom Depth Readings				Probe/ Reel #	Remarks
	Eastings (m)	Northing (m)					A+	A-	B+	B-		
SI12-11	506555.99	5988265.01	26-May-22	0.85	62 to 2	278	472	-451	-279	287	8R/8R	
SI15-15	506537.94	5988152.50	26-May-22	0.72	48 to 2	299	-441	452	163	-176	5R/5R	
SI15-16	506518.93	5988168.05	26-May-22	0.36	68 to 2	273	-296	317	730	-728	8R/8R	
SI15-17	506502.55	5988175.82	26-May-22	0.87	64 to 2	257	1660	-1650	-860	846	5R/5R	
SI15-20	506498.70	5988117.95	26-May-22	0.85	68 to 2	272	-517	530	-334	315	5R/5R	
SI15-21	506465.37	5988066.73	26-May-22	0.92	68 to 2	305	-752	762	468	-489	5R/5R	
SI16-1	506677.30	5990167.86	26-May-22	0.65	58 to 2	291	960	-942	894	-892	8R/8R	Pile Wall NC24C (Labelled as P06)
SI16-2	506653.91	5990135.91	26-May-22	0.63	58 to 2	355	759	-744	1017	-1011	8R/8R	Pile Wall NC24C (Labelled as P28)
SI16-3	506633.17	5990107.58	26-May-22	0.42	48 to 2	286	372	-354	1413	-1412	8R/8R	Pile Wall NC24C (Labelled as P47) (Repaired / Initialized)
SI16-5	506592.58	5990052.14	26-May-22	0.49	48 to 2	314	491	-469	-276	279	8R/8R	Pile Wall NC24C (Labelled as P83)
SI16-6	506573.96	5990026.72	26-May-22	0.50	58 to 2	289	408	-384	-665	670	8R/8R	Pile Wall NC24C (Labelled as P101) (Repaired / Initialized)
SI16-7	506551.63	5989996.22	26-May-22	1.32	58 to 2	265	-145	167	-480	482	8R/8R	Pile Wall NC24C (Labelled as P122) (Repaired / Initialized)
SI17-1	506540.94	5988185.77	26-May-22	0.78	60 to 2	283	9	2	-41	45	8R/8R	NC24C Extension (Labelled as P130) ((Repaired / Initialized)
SI17-2	506509.43	5988142.83	26-May-22	0.78	60 to 2	307	192	-180	664	-673	5R/5R	NC24C Extension (Labelled as P160)
SI17-3	506495.67	5988122.42	26-May-22	0.76	60 to 2	295	-250	237	-1930	1917	5R/5R	NC24C Extension (Labelled as P173)*
SI17-4	506482.48	5988101.32	26-May-22	0.67	58 to 2	305	-222	219	-25	-5	5R/5R	NC24C Extension (Labelled as P186)

**INSPECTOR REPORT**

SAA and straining gauges are connected to a modem for remote download - no need to take manual readings any more * Stiff at 10 ft.

**ALBERTA TRANSPORTATION  
NORTH CENTRAL REGION - ATHABASCA AND FORT McMURRAY DISTRICTS  
INSTRUMENTATION MONITORING FIELD SUMMARY (NC104)  
SPRING 2022**

**Location:** Kehiwin Lake (HWY41:23 C1 7.666)  
**File Number:** 32122

**Readout:** RST PN C108 Unit 4/Heron Dipper T  
**Temp (deg C):** 18  
**Read by:** NKR/JD

**PNEUMATIC PIEZOMETER (PN) READINGS**

PN #	GPS Location (UTM 12)		Date	Reading (kPa)	Identification Number
	Easting (m)	Northing (m)			
PN15-15A	506537.29	5988151.39	26-May-22	8	36686
PN15-16	Attached to SI15-16		26-May-22	13.1	36687
PN15-17	Attached to SI15-17		26-May-22	93.5	36680
PN15-19	Attached to SI15-19		26-May-22	39.1	36684
PN15-20	Attached to SI15-20		26-May-22	96.5	36681
PN15-21	Attached to SI15-21		26-May-22	48.1	36690

**STANDPIPE PIEZOMETER (SP) READINGS**

SP#	GPS Location (UTM 12)		Date	Stick-up (m)	Water level below top of pipe (m)	Total length of pipe (m)
	Easting (m)	Northing (m)				
SP12-6	506613.00	5988323.00	26-May-22	0.99	3.9	19.14
SP12-9	506601.99	5988238.04	26-May-22	0.93	3.71	12.31
SP12-12	506564.99	5988193.04	26-May-22	1.12	2.69	15.54
SP15-14	506531.96	5988218.14	26-May-22	0.98	DRY	3.45
SP15-18	506500.66	5988121.29	26-May-22	0.85	2.56	14.78

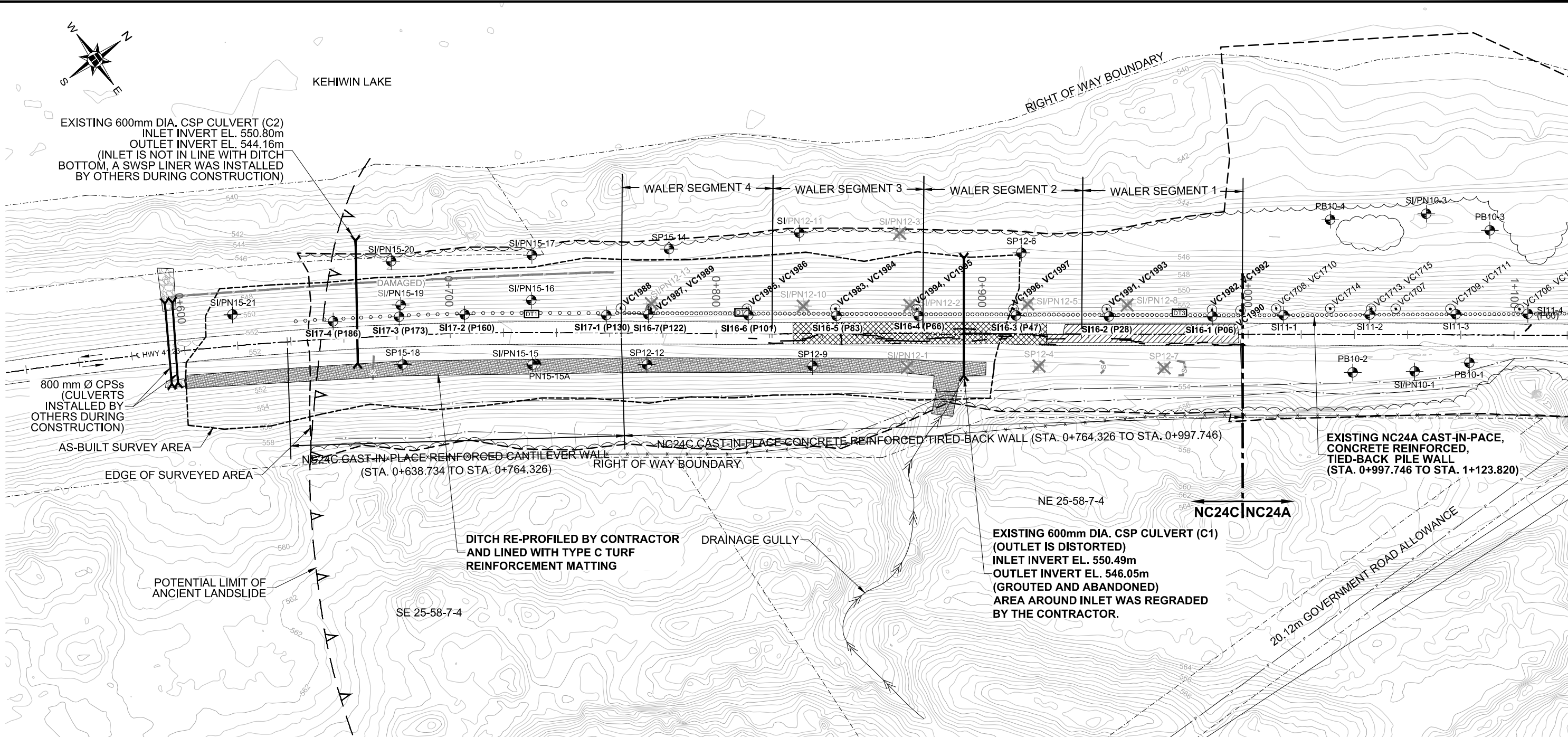
**VIBRATING WIRE LOAD CELL (VC) READINGS**

VC#	GPS Location (UTM 11)		Datalogger Serial #	Date	Remarks
	Easting (m)	Northing (m)			
VC1983-89, VC1994-95	506570.06	5988227.65	RST 2202	26-May-22	Data downloaded
VC1982, VC1990-1993, VC1996-97	506666.83	5988360.52	RST 2203	26-May-22	Data downloaded

**INSPECTOR REPORT**

\* Blocked at 4.08m

H:\32000\32122.AT GRMP Athabasca and Fort McMurray Districts 2021-2025\CAD\32122 INSTRUMENT 2021\32122-NC104.dwg - 2 11x17 - Aug. 19. 2021



EXISTING 600mm DIA. CSP CULVERT (C2)  
 INLET INVERT EL. 550.80m  
 OUTLET INVERT EL. 544.16m  
 (INLET IS NOT IN LINE WITH DITCH  
 BOTTOM, A SWSP LINER WAS INSTALLED  
 BY OTHERS DURING CONSTRUCTION)

800 mm Ø CSPs  
 (CULVERTS  
 INSTALLED BY  
 OTHERS DURING  
 CONSTRUCTION)

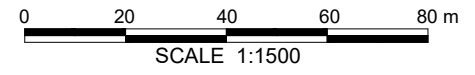
EXISTING 600mm DIA. CSP CULVERT (C1)  
 (OUTLET IS DISTORTED)  
 INLET INVERT EL. 550.49m  
 OUTLET INVERT EL. 546.05m  
 (GROUTED AND ABANDONED)  
 AREA AROUND INLET WAS REGRADED  
 BY THE CONTRACTOR.


EXISTING NC24A CAST-IN-PLACE,  
 CONCRETE REINFORCED,  
 TIED-BACK PILE WALL  
 (STA. 0+997.746 TO STA. 1+123.820)

LEGEND	
	PILE WALL
	FENCE LINE
	BUSH LINE
	ACTIVE SLIDE CRACKS ON HIGHWAY
	TEST HOLE LOCATION
	DAMAGED INSTRUMENT
	SI
	PN
	SP
	PB
	VC
	SAA
	DATALOGGER
	—550— GROUND SURFACE CONTOUR
	—P— OVERHEAD POWER LINE (APPROXIMATE)
	—T— TELUS LINE (APPROXIMATE)
	—S— SILTY FENCE
	⊙ VIBRATING WIRE LOAD CELL LOCATION
	PAVEMENT DISTRESS AREA
	ACP PATCH (OLD)
	RIP RAP

Load Cell Serial #	Anchor
VC1990	G0001S
VC1982	G007U
VC1992	G007L
VC1993	G029U
VC1991	G029L
VC1997	G049U
VC1996	G049L
VC1995	G070U
VC1994	G070L
VC1984	G087U
VC1983	G087L
VC1985	G106U
VC1986	G106L
VC1987	G126U
VC1989	G126L
VC1988	G132S

- NOTES:
- CONTOUR INTERVAL IS 0.5m.
  - CONTOURS INSIDE SURVEYED AREA WERE SURVEYED BY WSP. ELEVATION CONTOURS OUTSIDE SURVEYED AREA WERE DERIVED FROM LIDAR DATA.
  - THE LOCATION OF THE END OF THE NC24A WALL IS APPROXIMATE.
  - INSTRUMENTS AND DATALOGGERS INSTALLED DURING CONSTRUCTION ARE SHOWN IN BOLD.
  - SHAPE ACCELEROMETER ARRAY AND STRAIN GAUGES ARE CONNECTED TO DT1 (CAMPBELL SCIENTIFIC CR6 DATALOGGER, SERIAL No. 5839); LOAD CELLS VC1983 - VC1989, VC1994, VC1995 ARE CONNECTED TO DT2 (RST DT2040 DATALOGGER, SERIAL No. 2202); AND LOAD CELLS VC1982, VC1990 - VC1993, VC1996, VC1997 ARE CONNECTED TO DT3 (RST DT2040 DATALOGGER, SERIAL No. 2203).
  - SHAPE ACCELEROMETER ARRAY AND STRAIN GAUGES ARE INSTALLED IN PILE P146.






**NORTH CENTRAL  
 (ATHABASCA AND FORT MCMURRAY DISTRICTS)**

**NC104: HWY 41:23 LANDSLIDE (km 7.7)  
 SITE PLAN SHOWING APPROXIMATE  
 INSTRUMENT LOCATIONS**

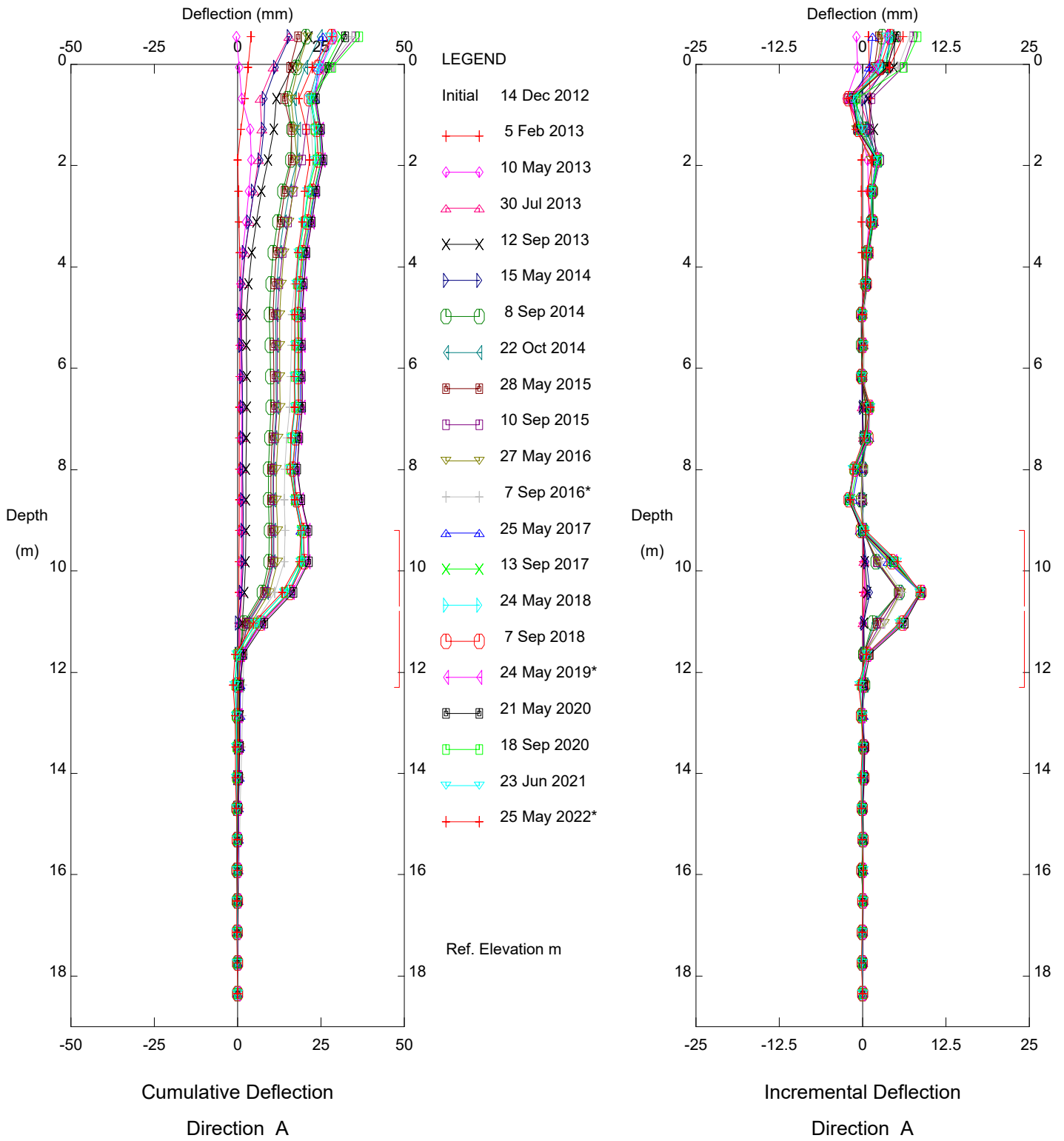
**DWG NO. 32122-NC104**

DRAWN BY	ML
DESIGNED BY	BWN
APPROVED BY	TSA
SCALE	1:1500
DATE	JULY 2021
FILE No.	32122



**THURBER ENGINEERING LTD.**

Thurber Engineering Ltd

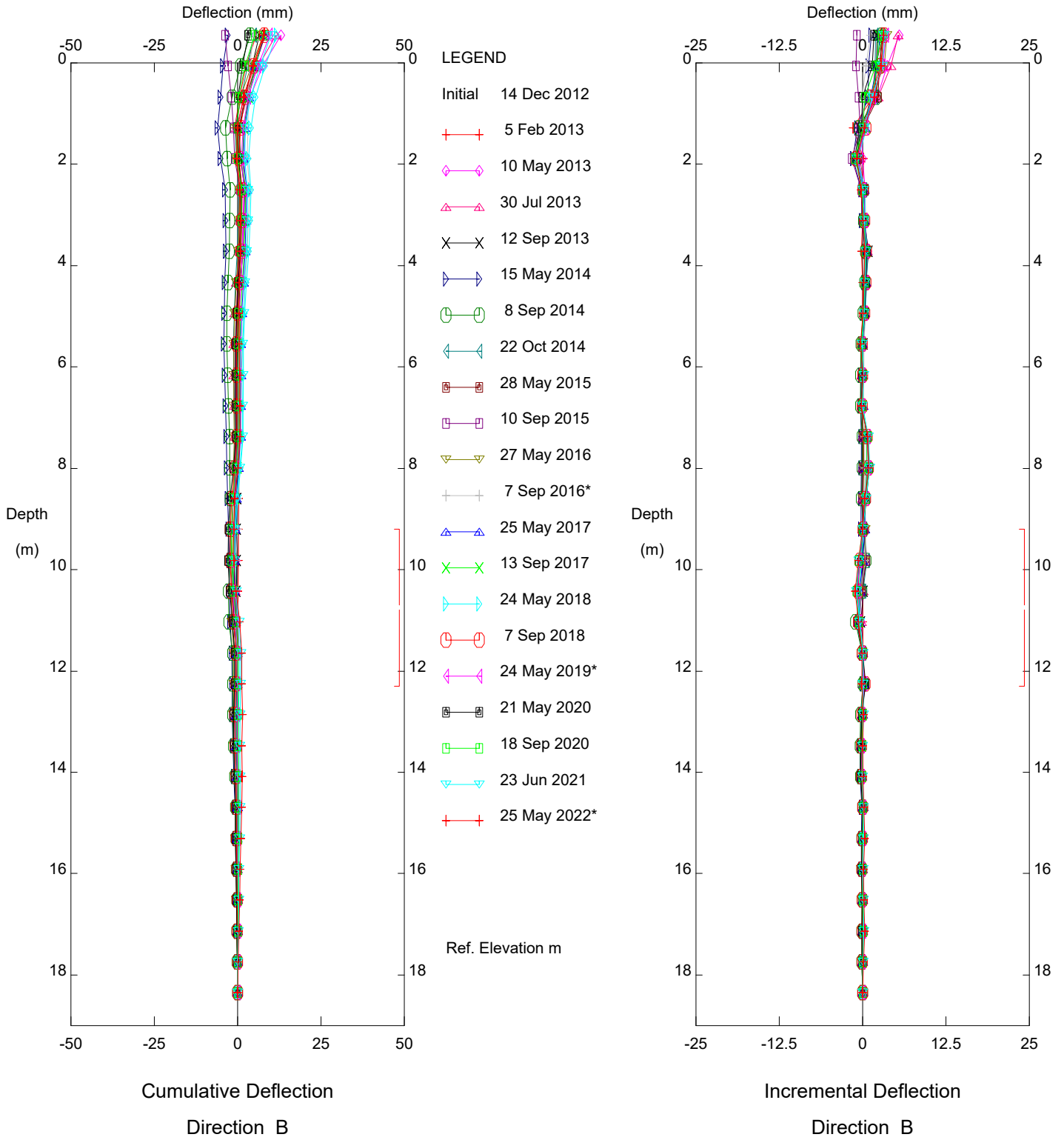


Hwy 41:23 Kehiwin Lake (NC104), Inclinometer SI12-11

Alberta Transportation

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

Thurber Engineering Ltd

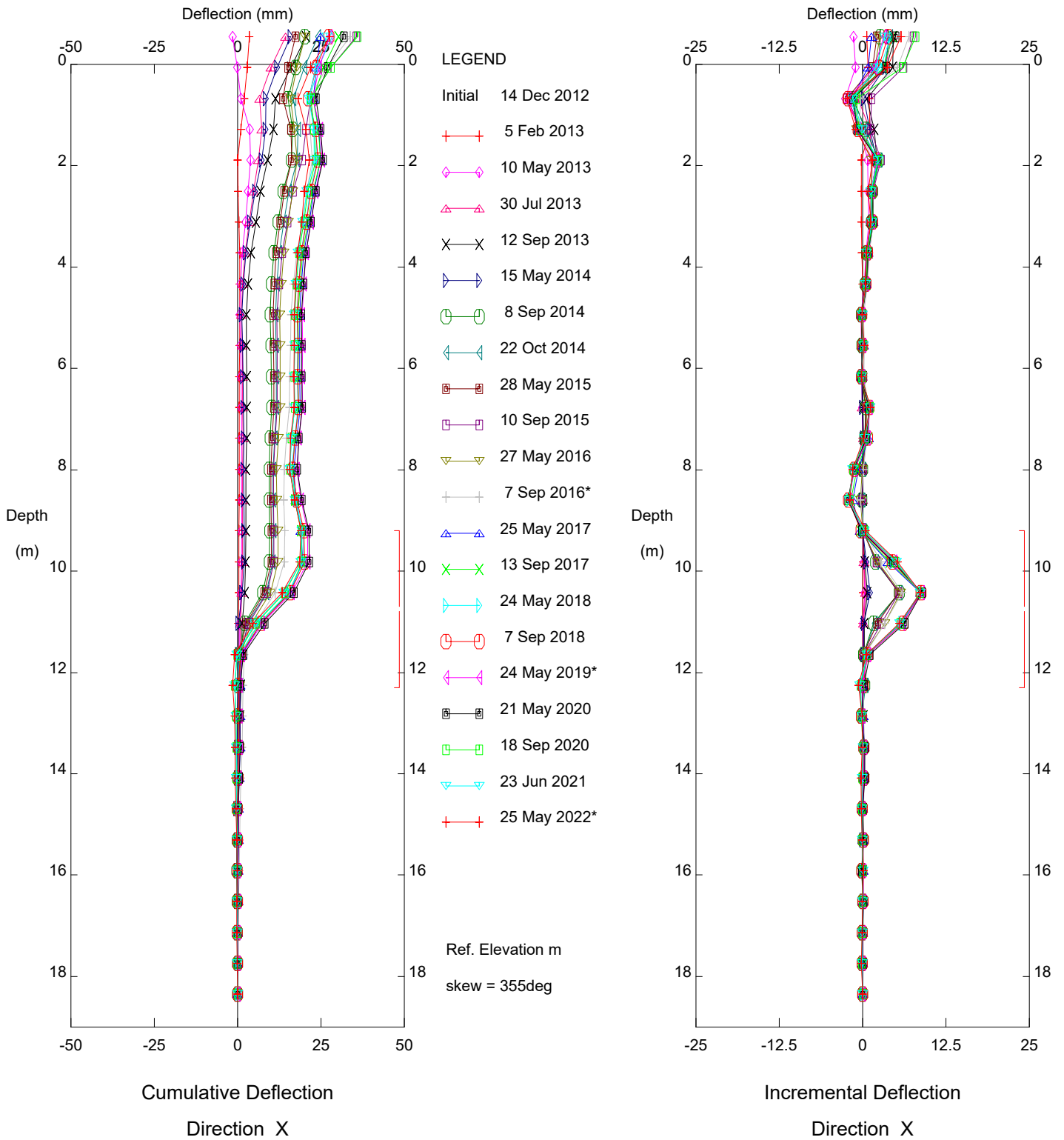


Hwy 41:23 Kehiwin Lake (NC104), Inclinometer SI12-11

Alberta Transportation

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

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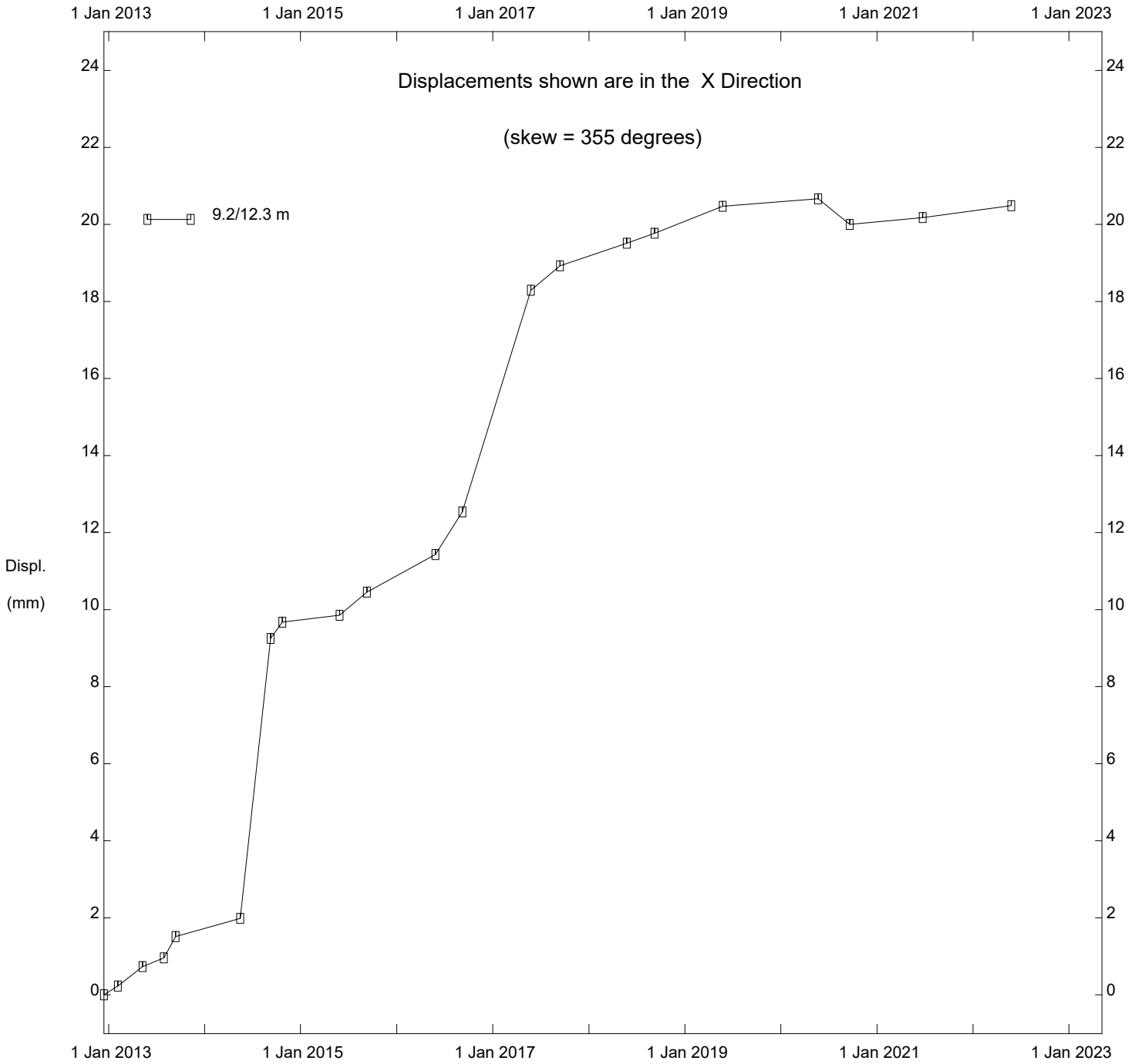
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Alberta Transportation

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



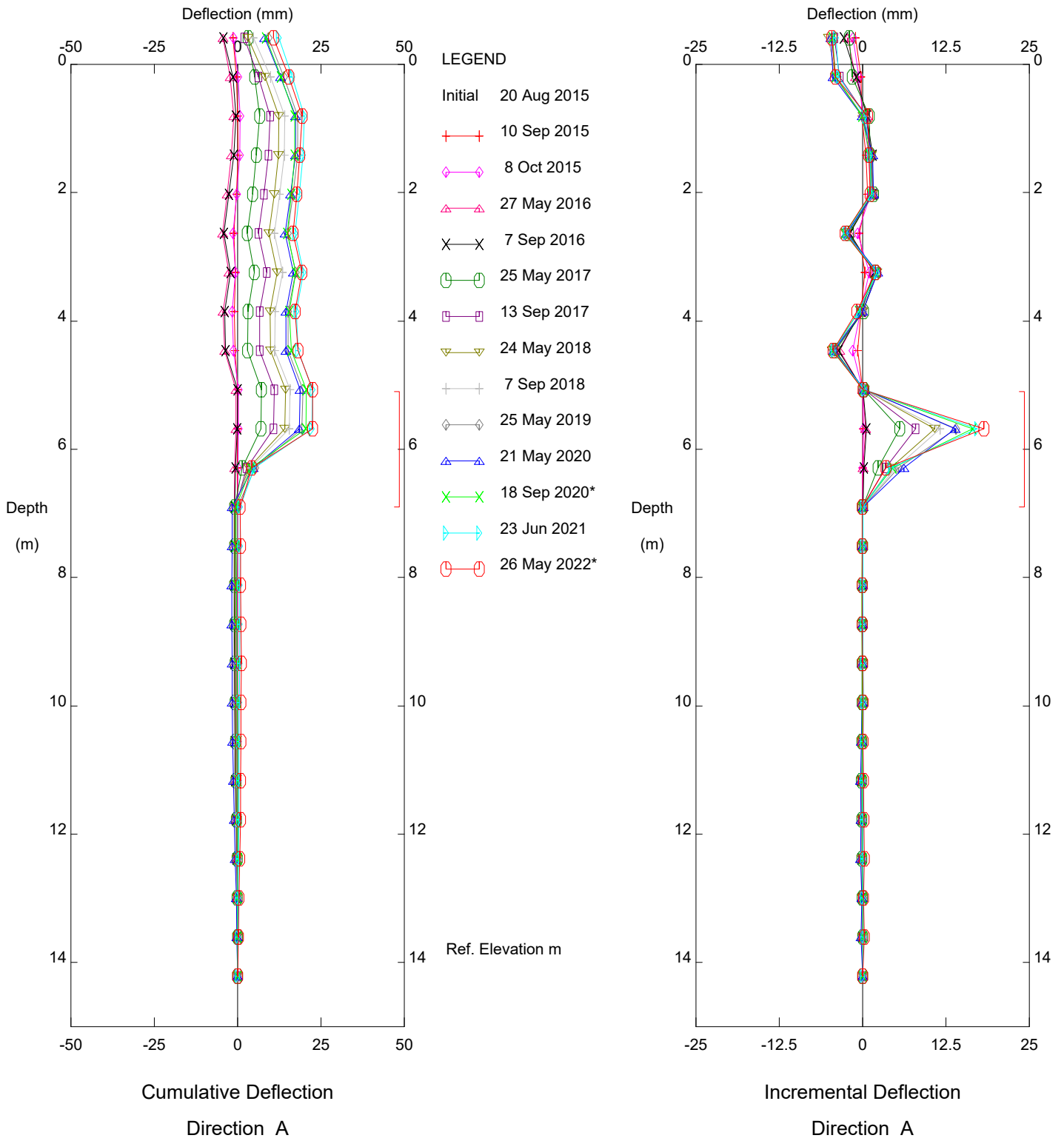
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Hwy 41:23 Kehiwin Lake (NC104), Inclinator SI12-11

Alberta Transportation

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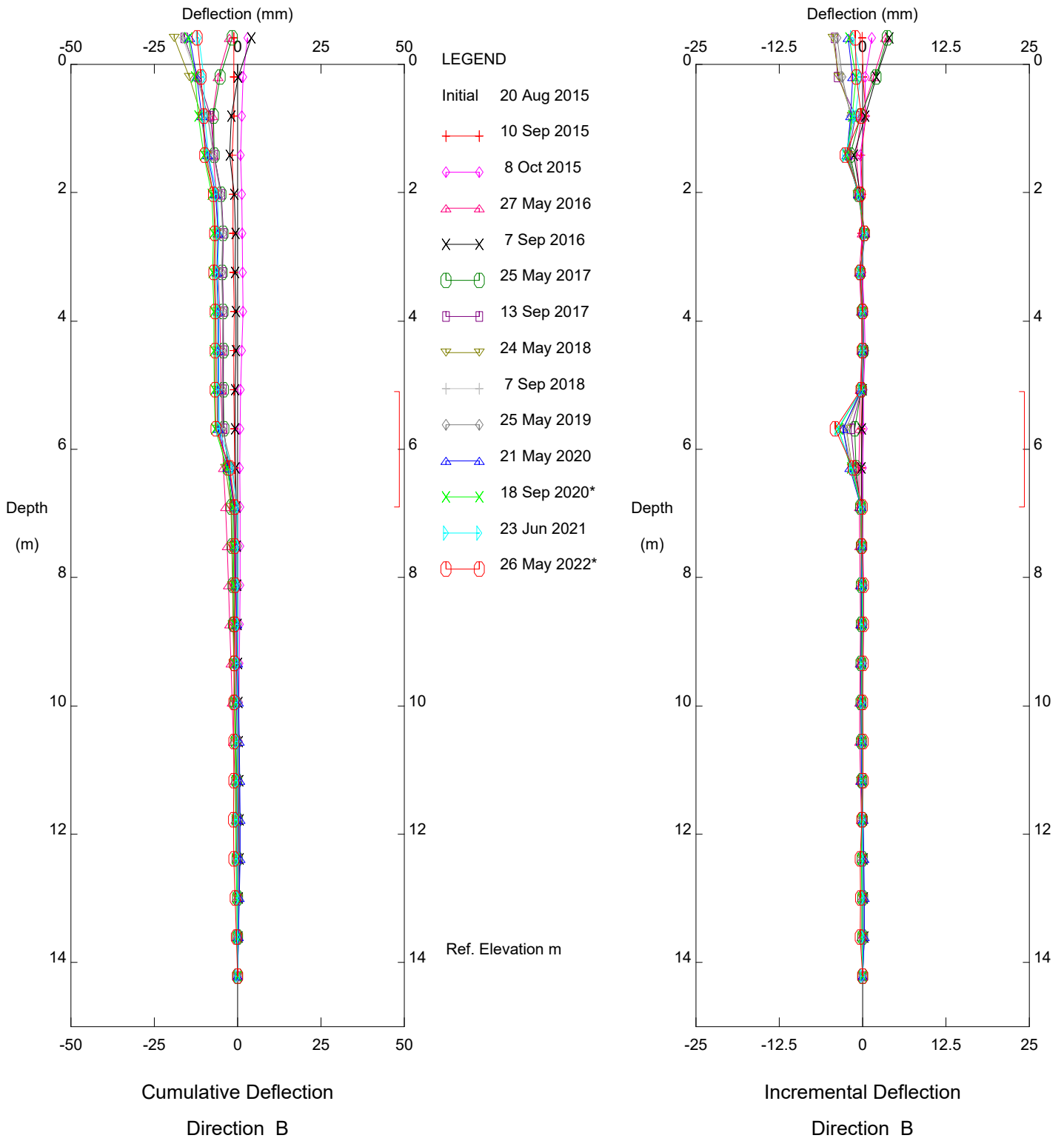


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Thurber Engineering Ltd

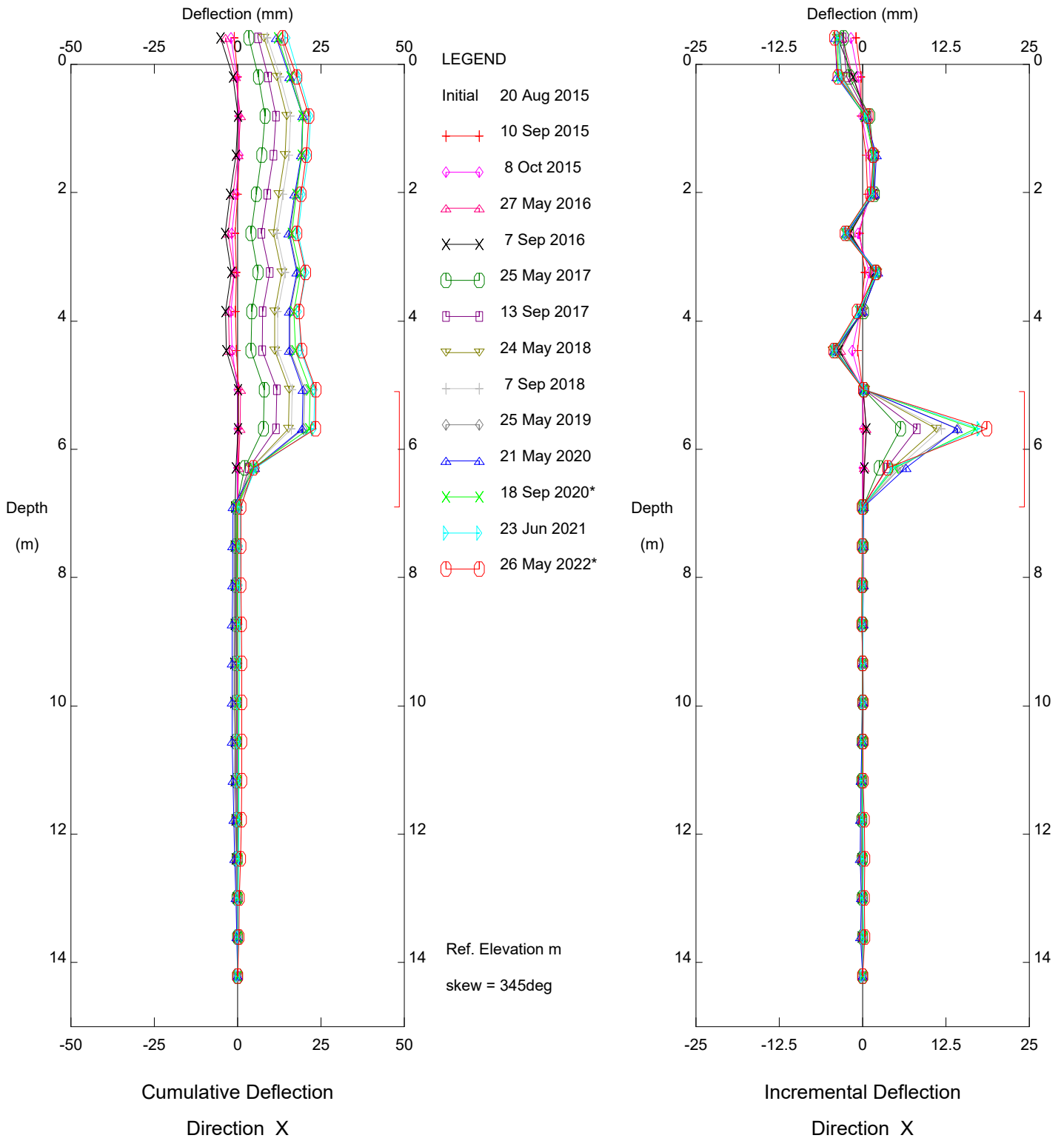


Hwy 41:23 Kehiwin Lake (NC104), Inclinometer SI15-15

Alberta Transportation

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

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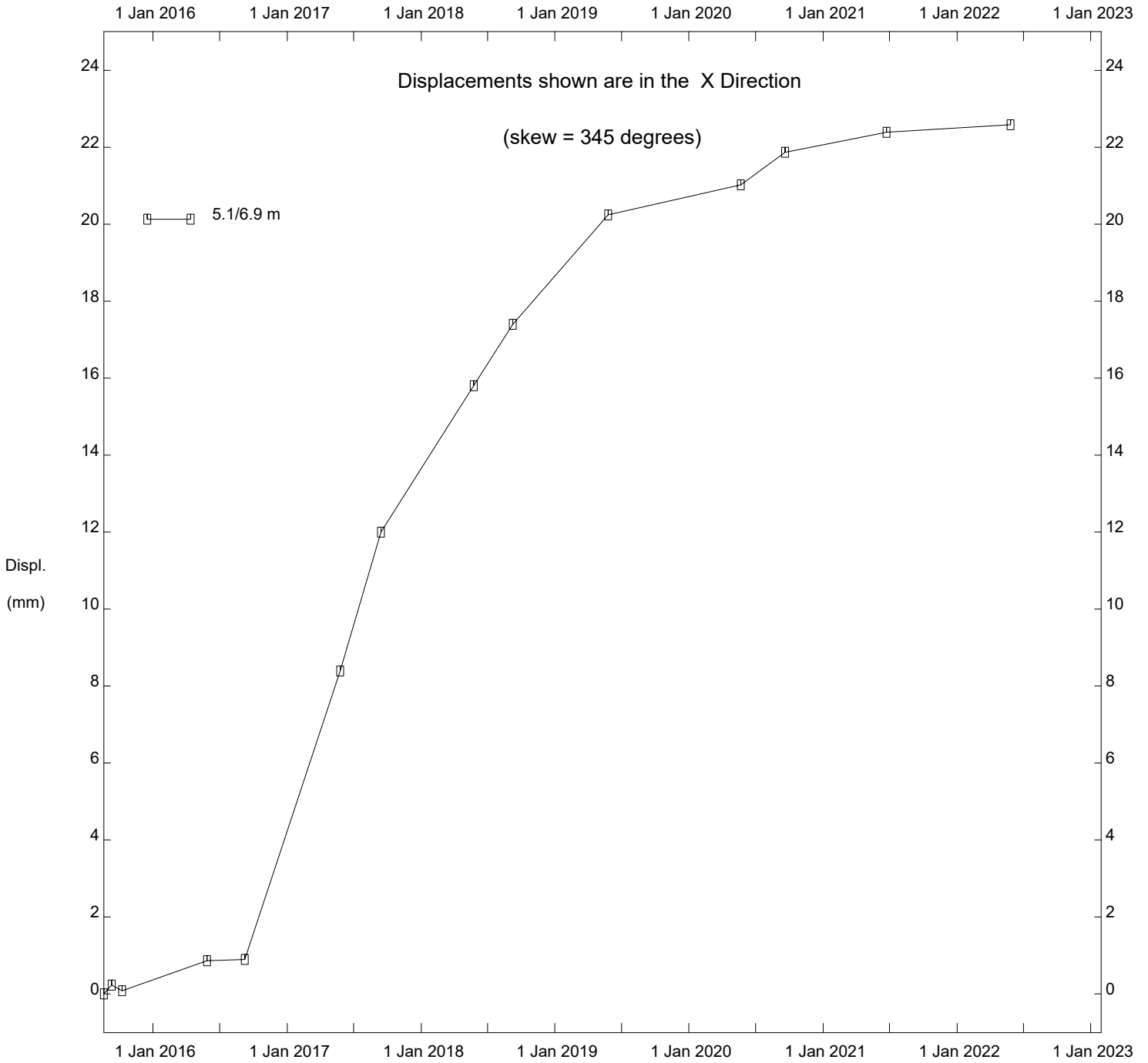


Hwy 41:23 Kehiwin Lake (NC104), Inclinometer SI15-15

Alberta Transportation

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

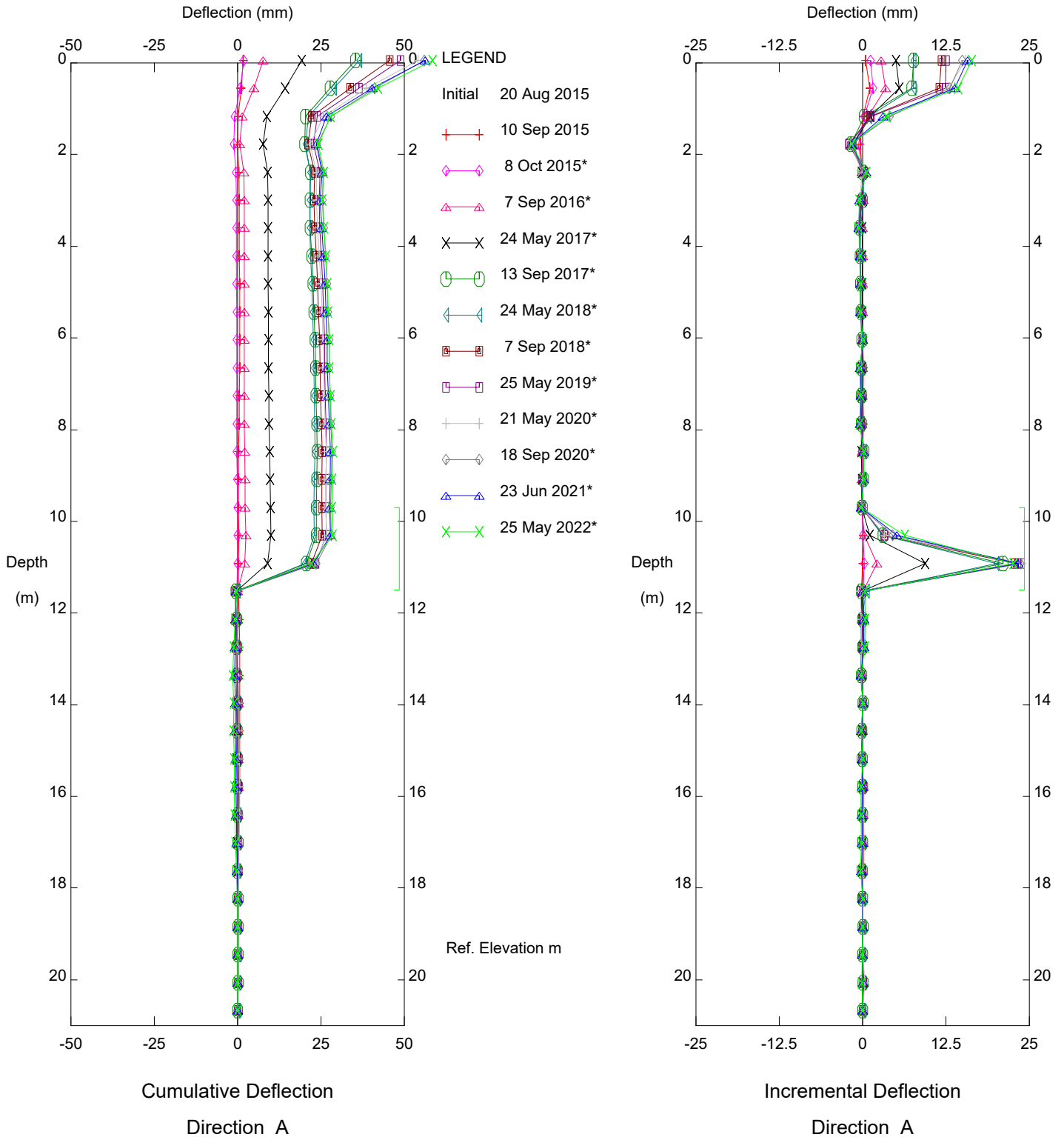
Thurber Engineering Ltd



Hwy 41:23 Kehiwin Lake (NC104), Inclinator SI15-15

Alberta Transportation

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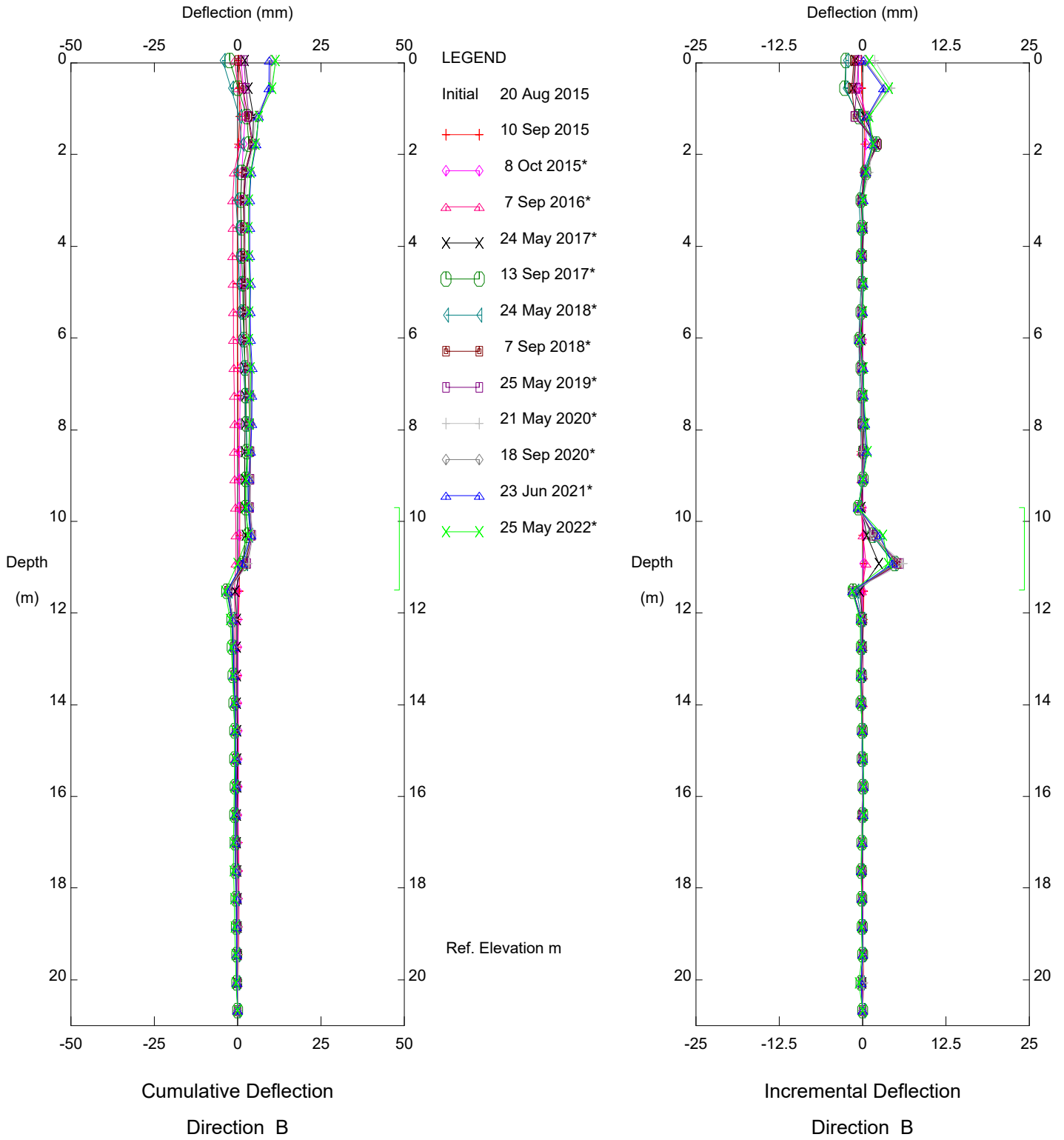


Hwy 41:23 Kehiwin Lake (NC104), Inclinometer SI15-16

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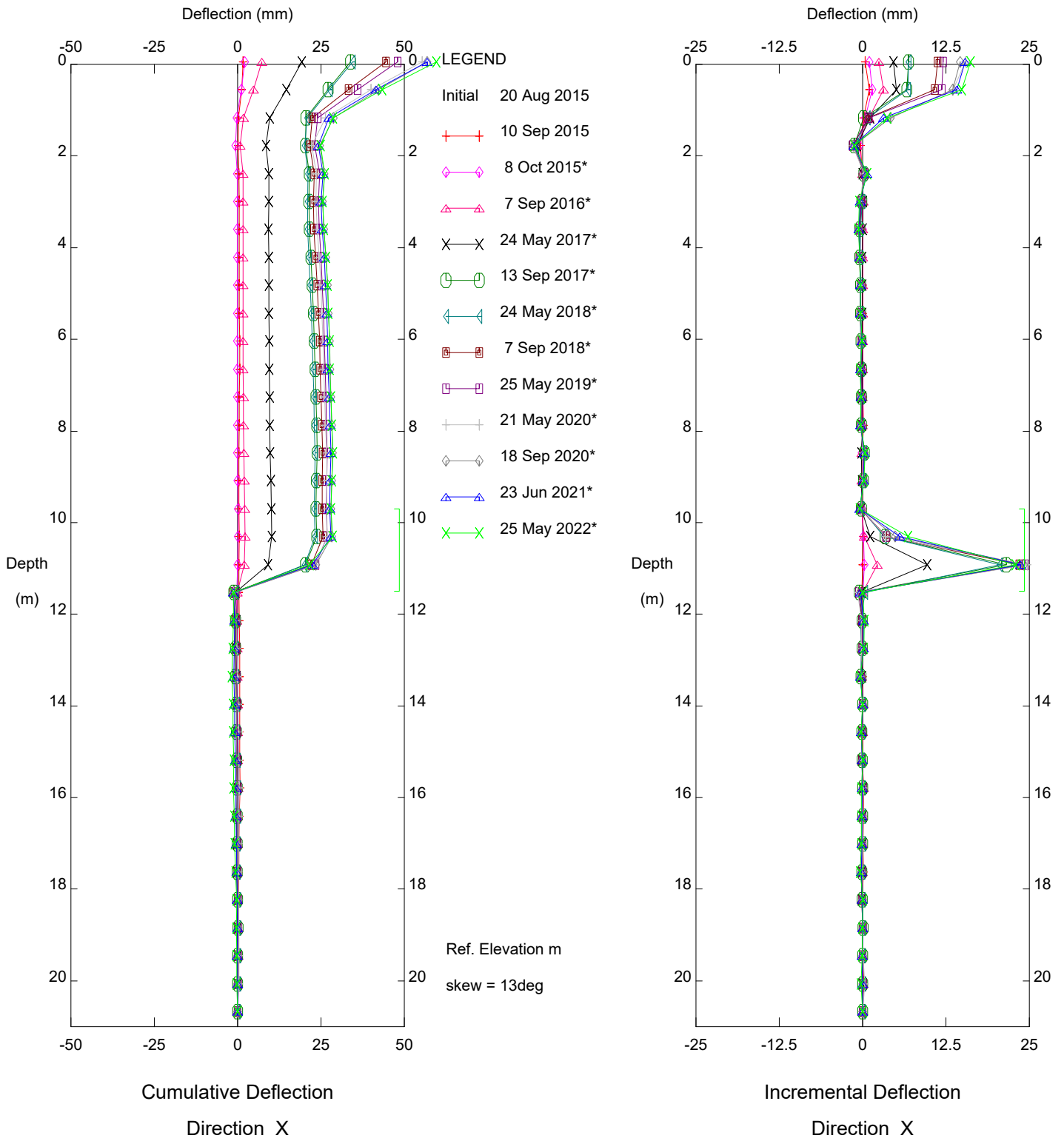


Hwy 41:23 Kehiwin Lake (NC104), Inclinometer SI15-16

Alberta Transportation

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

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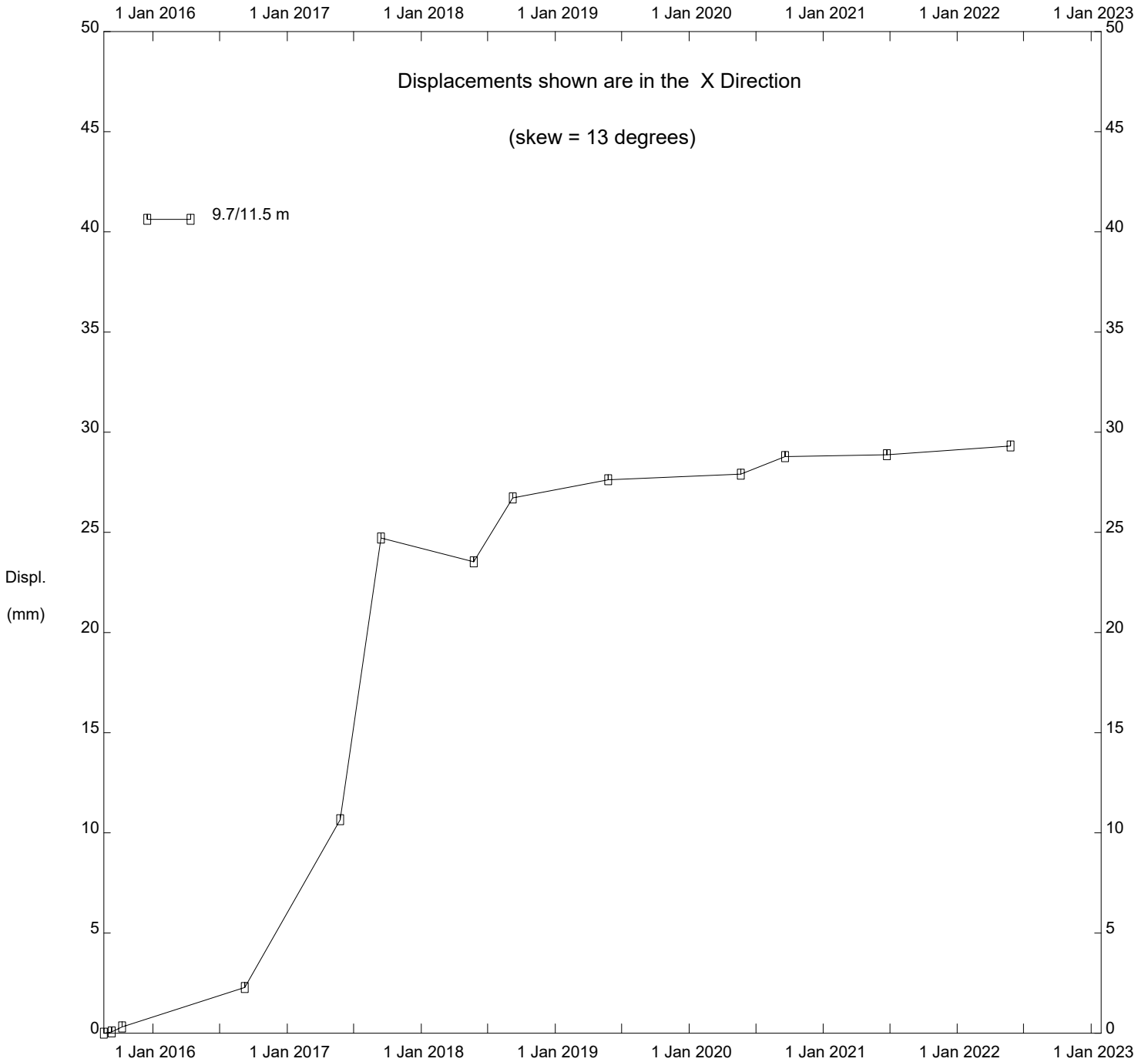
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Alberta Transportation

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



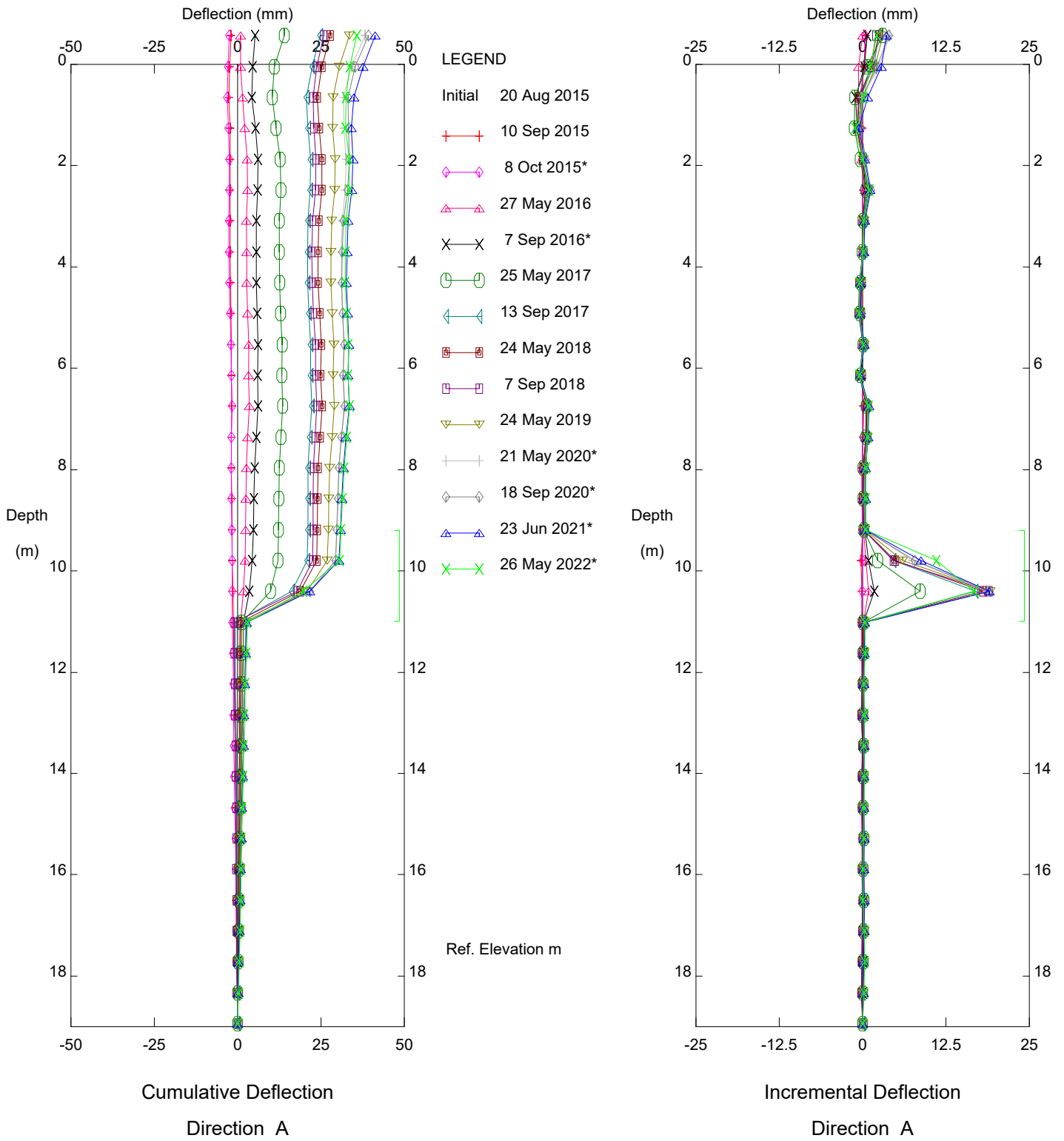
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Hwy 41:23 Kehiwin Lake (NC104), Inclinator SI15-16

Alberta Transportation

Thurber Engineering Ltd

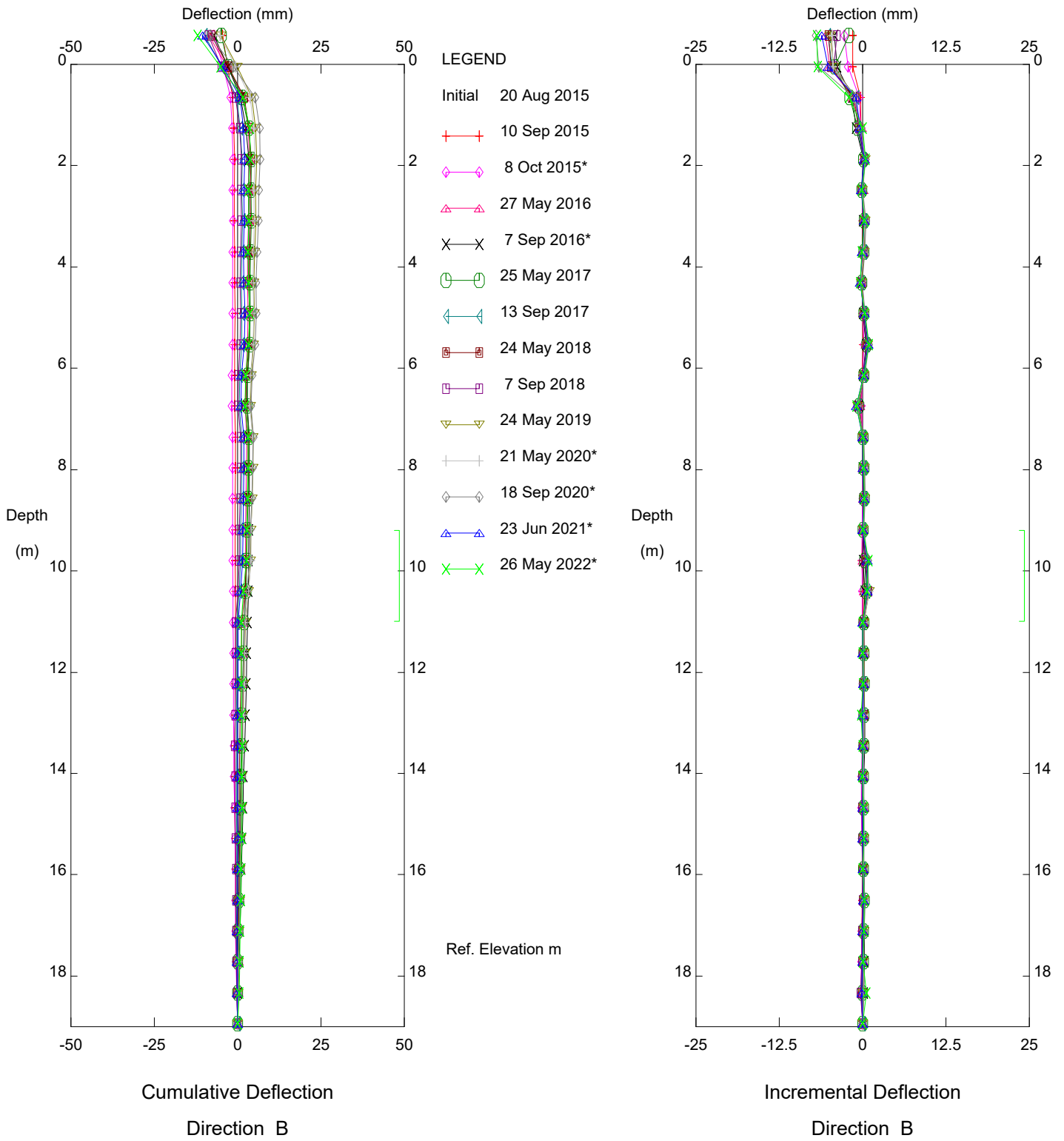


Hwy 41:23 Kehiwin Lake (NC104), Inclinometer SI15-17

Alberta Transportation

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

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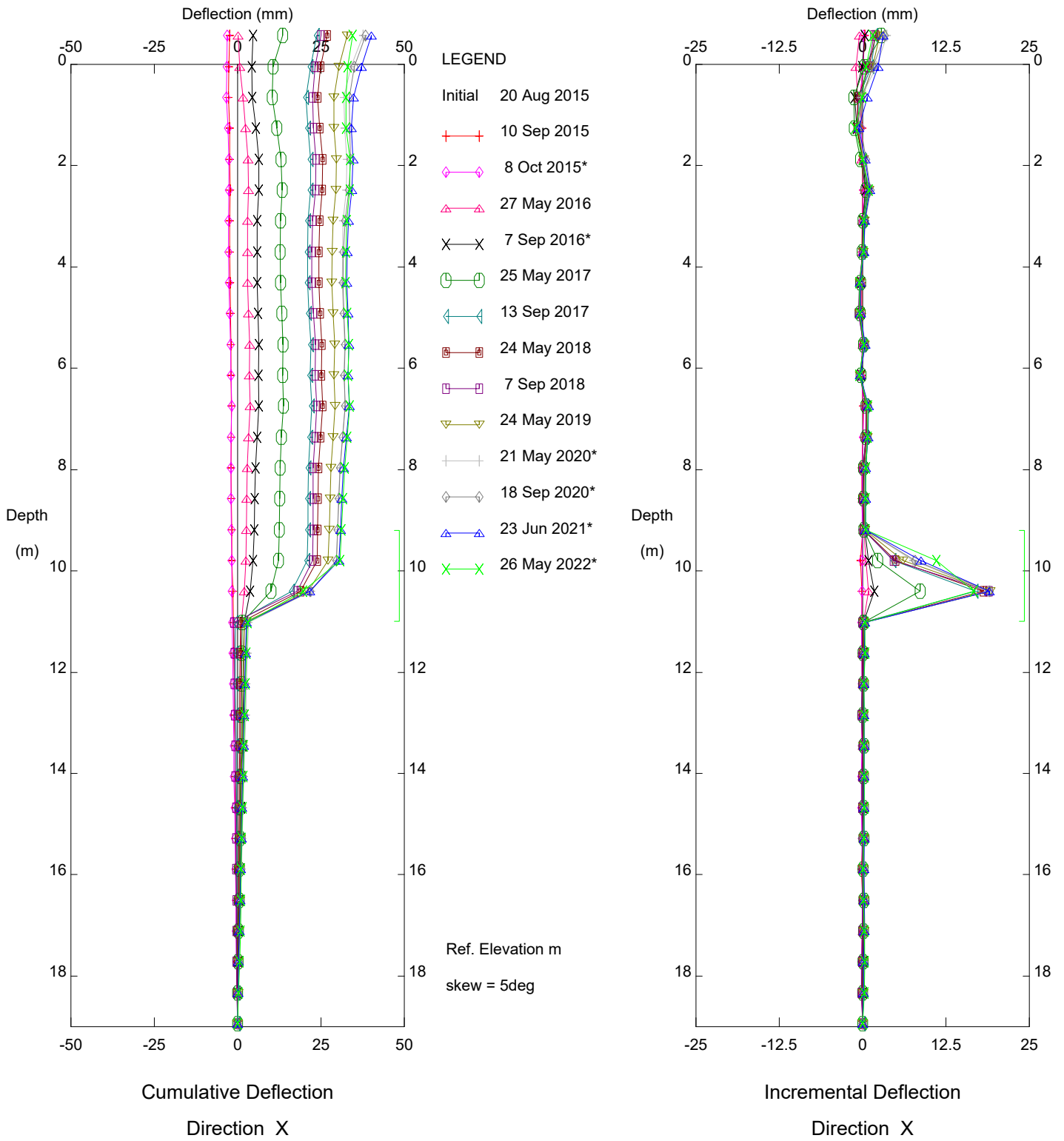


Hwy 41:23 Kehiwin Lake (NC104), Inclinometer SI15-17

Alberta Transportation

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

Thurber Engineering Ltd

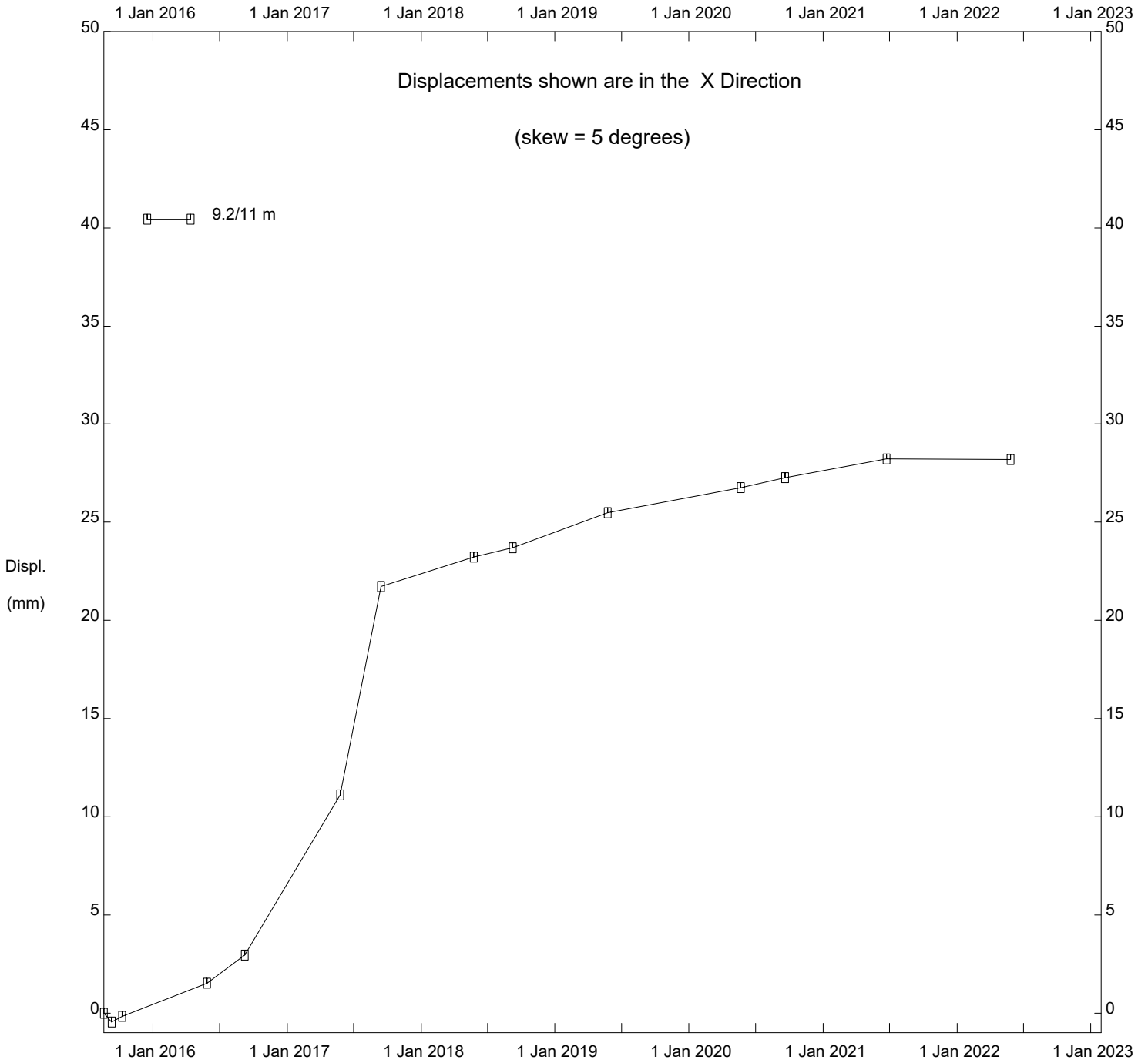


Hwy 41:23 Kehiwin Lake (NC104), Inclinometer SI15-17

Alberta Transportation

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

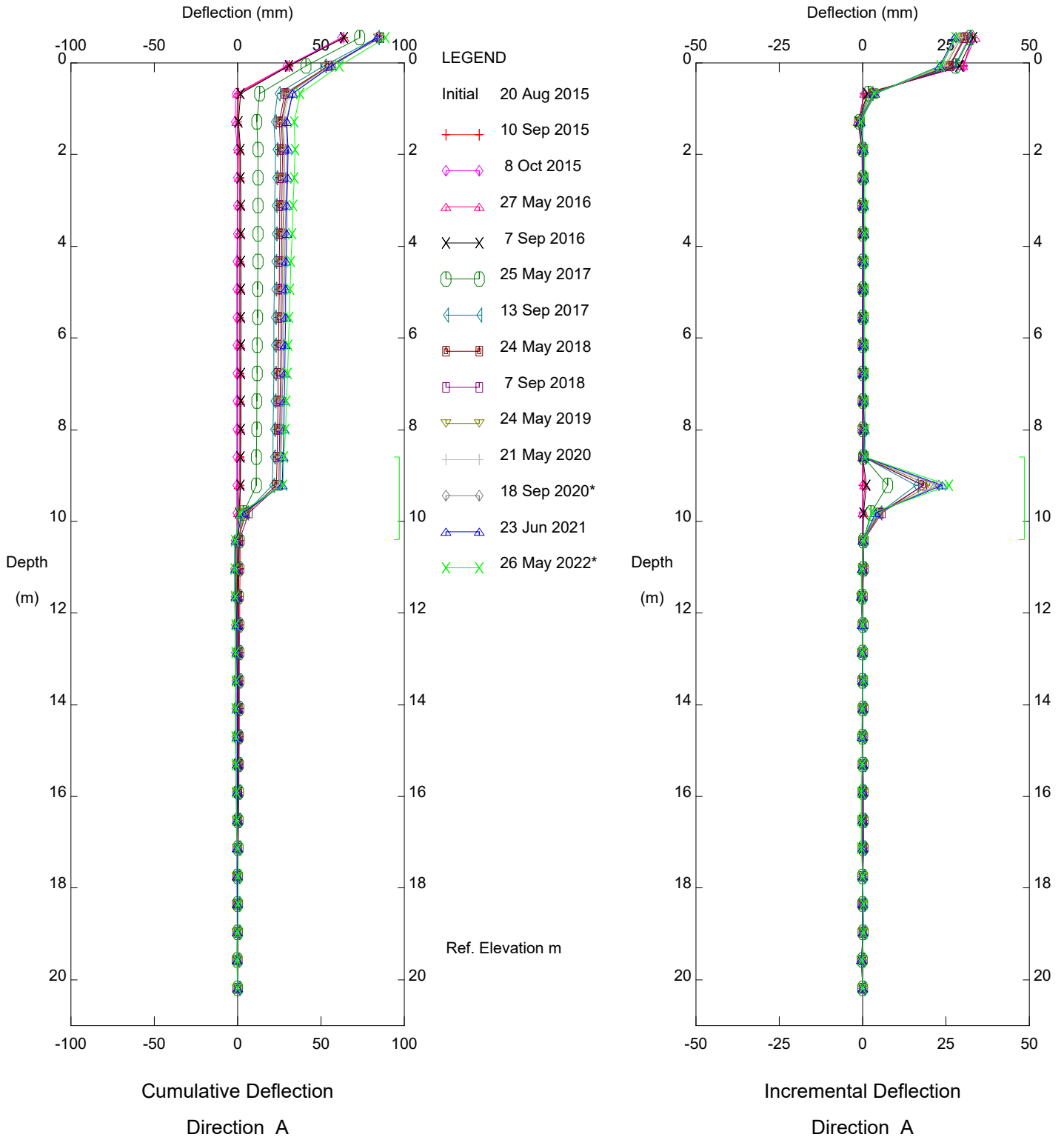
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Hwy 41:23 Kehiwin Lake (NC104), Inclinator SI15-17

Alberta Transportation

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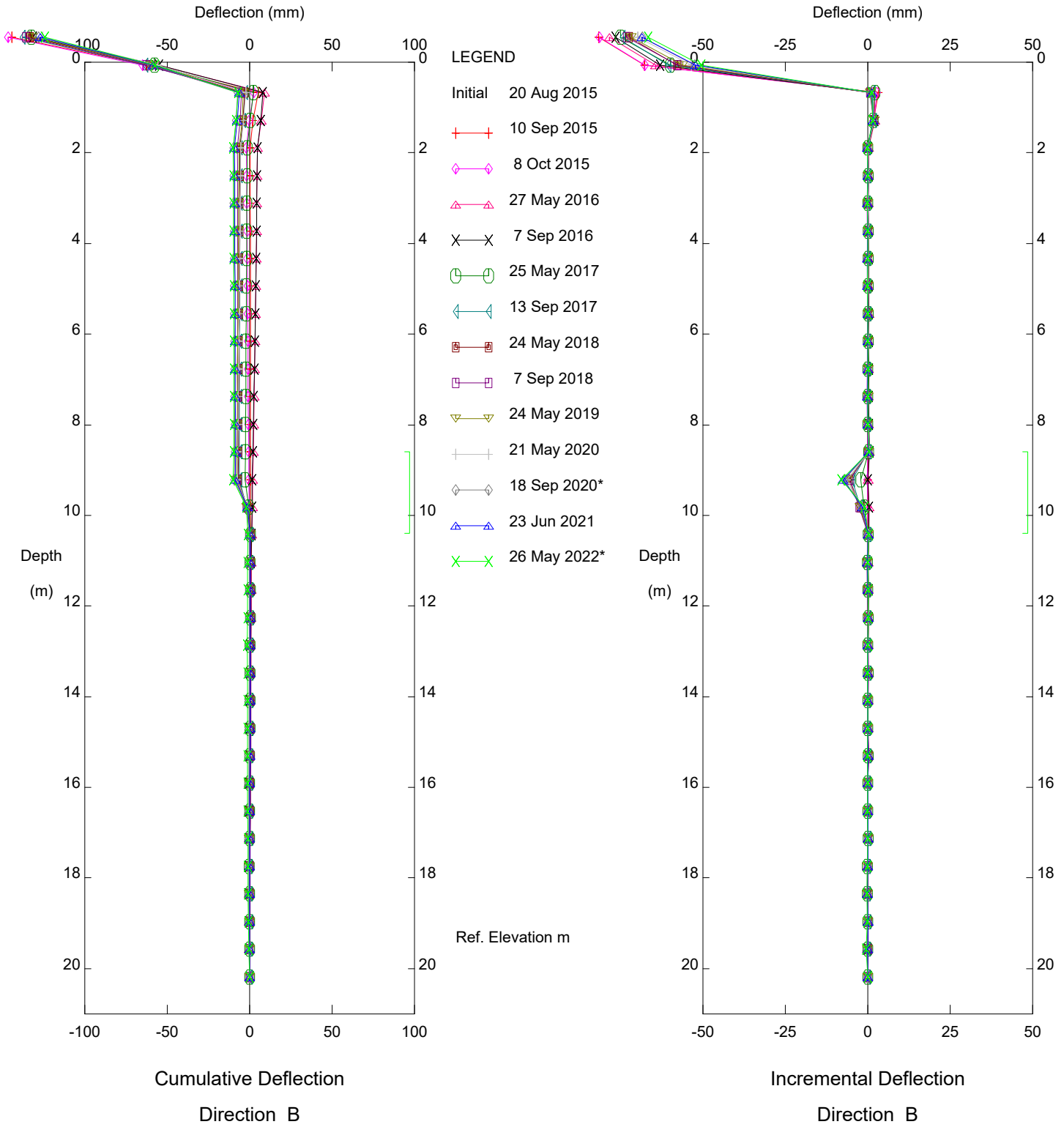


Hwy 41:23 Kehiwin Lake (NC104), Inclinometer SI15-20

Alberta Transportation

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

Thurber Engineering Ltd

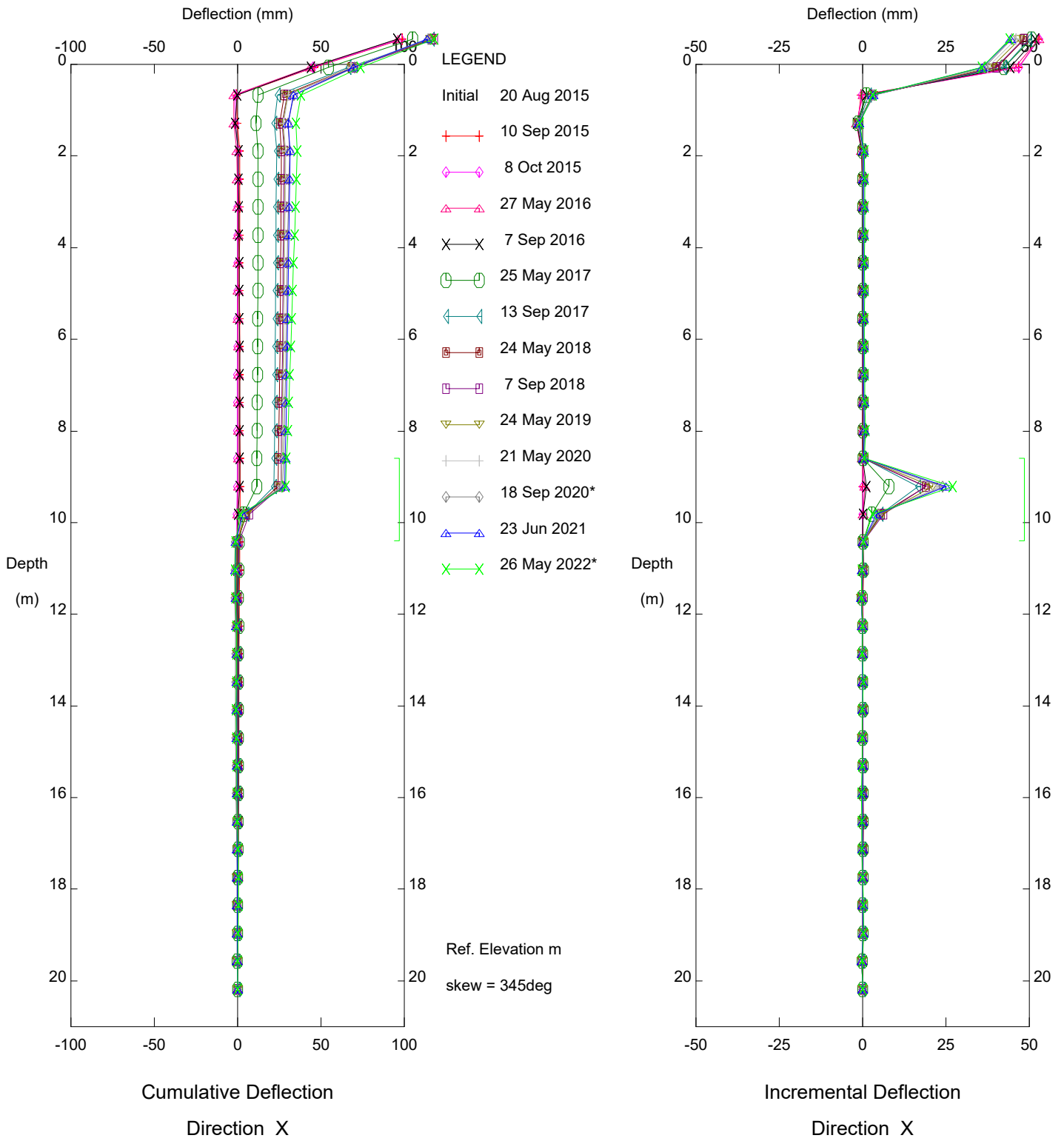


Hwy 41:23 Kehiwin Lake (NC104), Inclinometer SI15-20

Alberta Transportation

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

Thurber Engineering Ltd



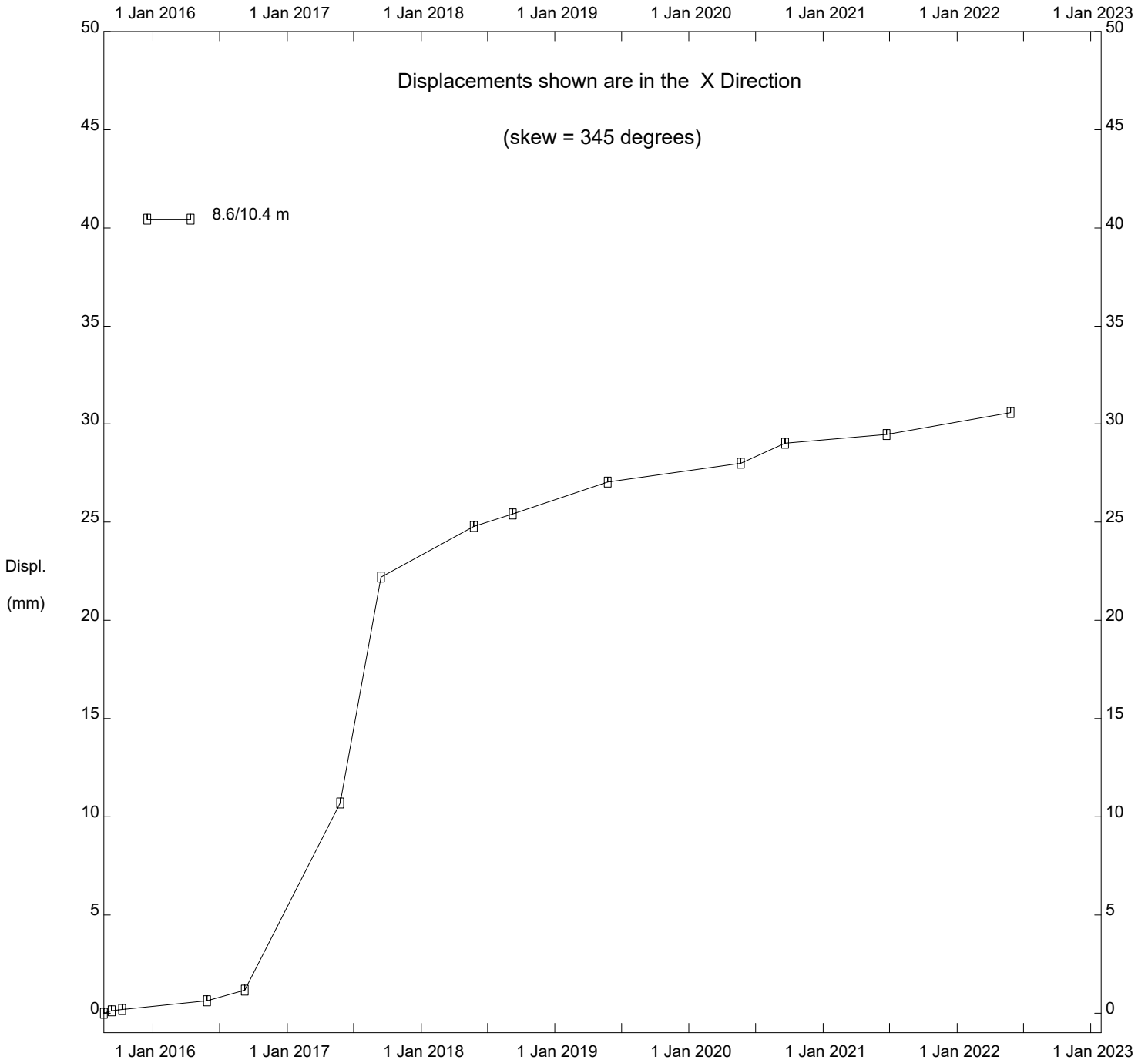
Hwy 41:23 Kehiwin Lake (NC104), Inclinometer SI15-20

Alberta Transportation

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



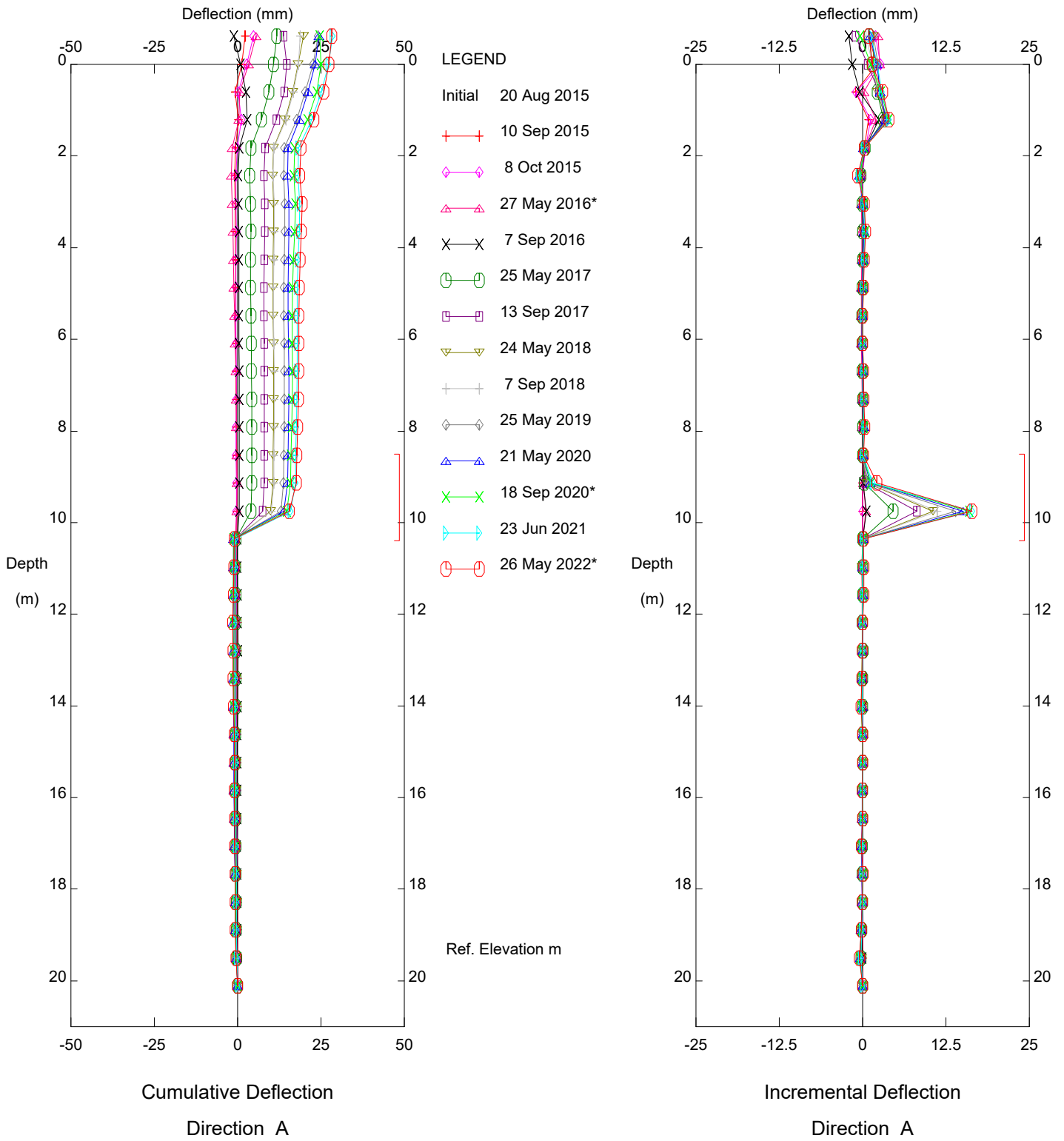
Thurber Engineering Ltd



Hwy 41:23 Kehiwin Lake (NC104), Inclinator SI15-20

Alberta Transportation

Thurber Engineering Ltd

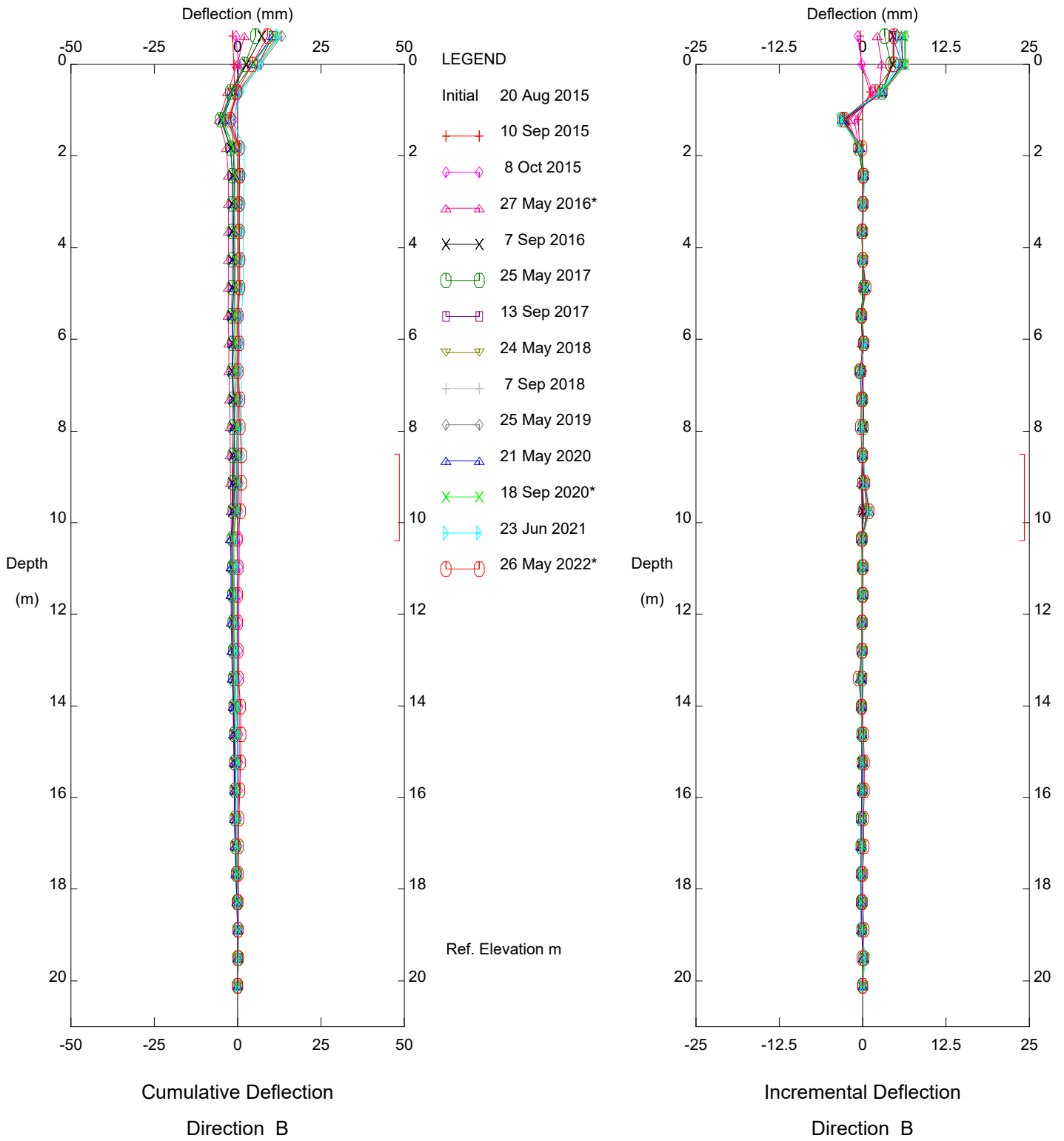


Hwy 41:23 Kehiwin Lake (NC104), Inclinometer SI15-21

Alberta Transportation

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

Thurber Engineering Ltd

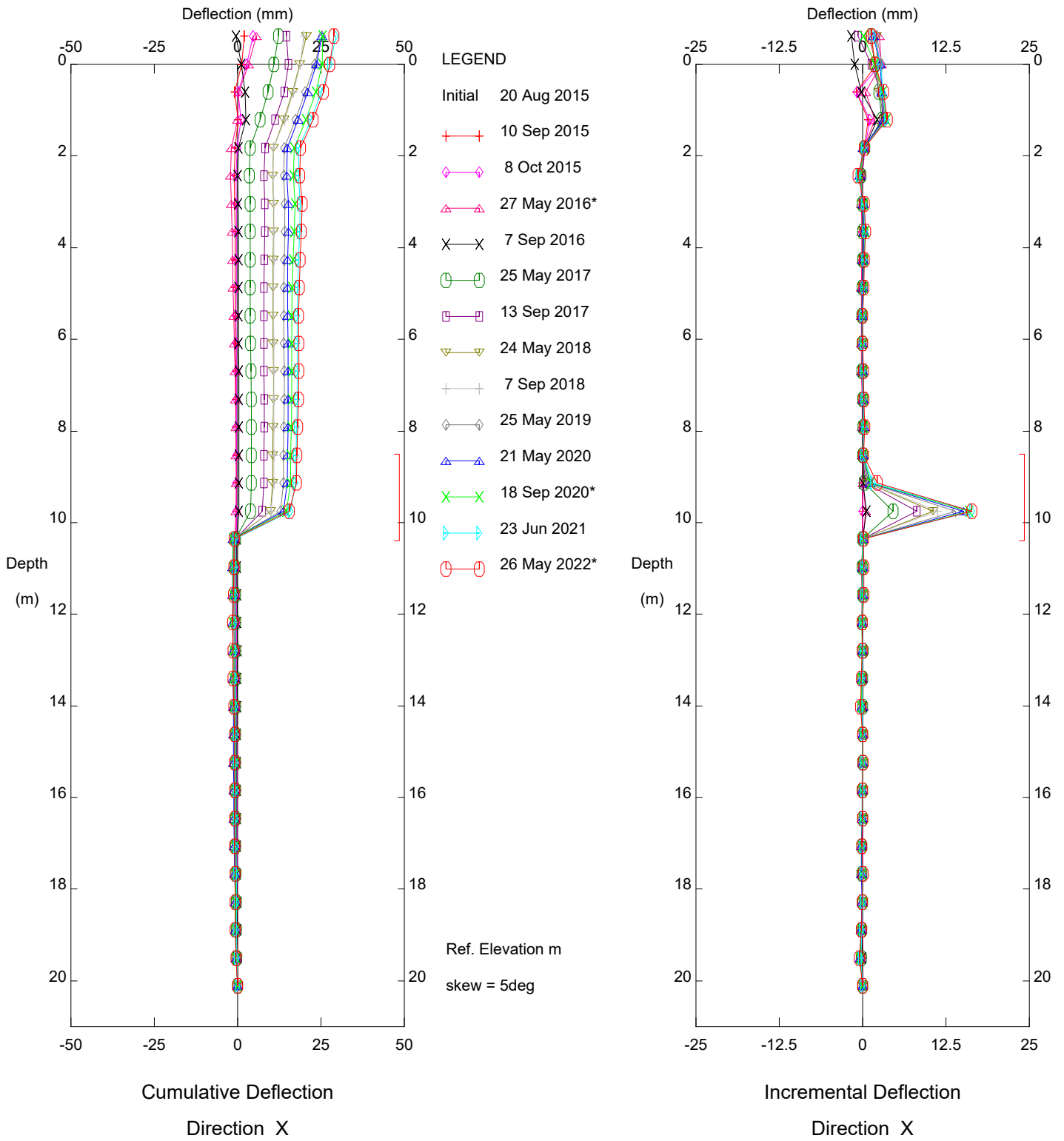


Hwy 41:23 Kehiwin Lake (NC104), Inclinometer SI15-21

Alberta Transportation

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

Thurber Engineering Ltd

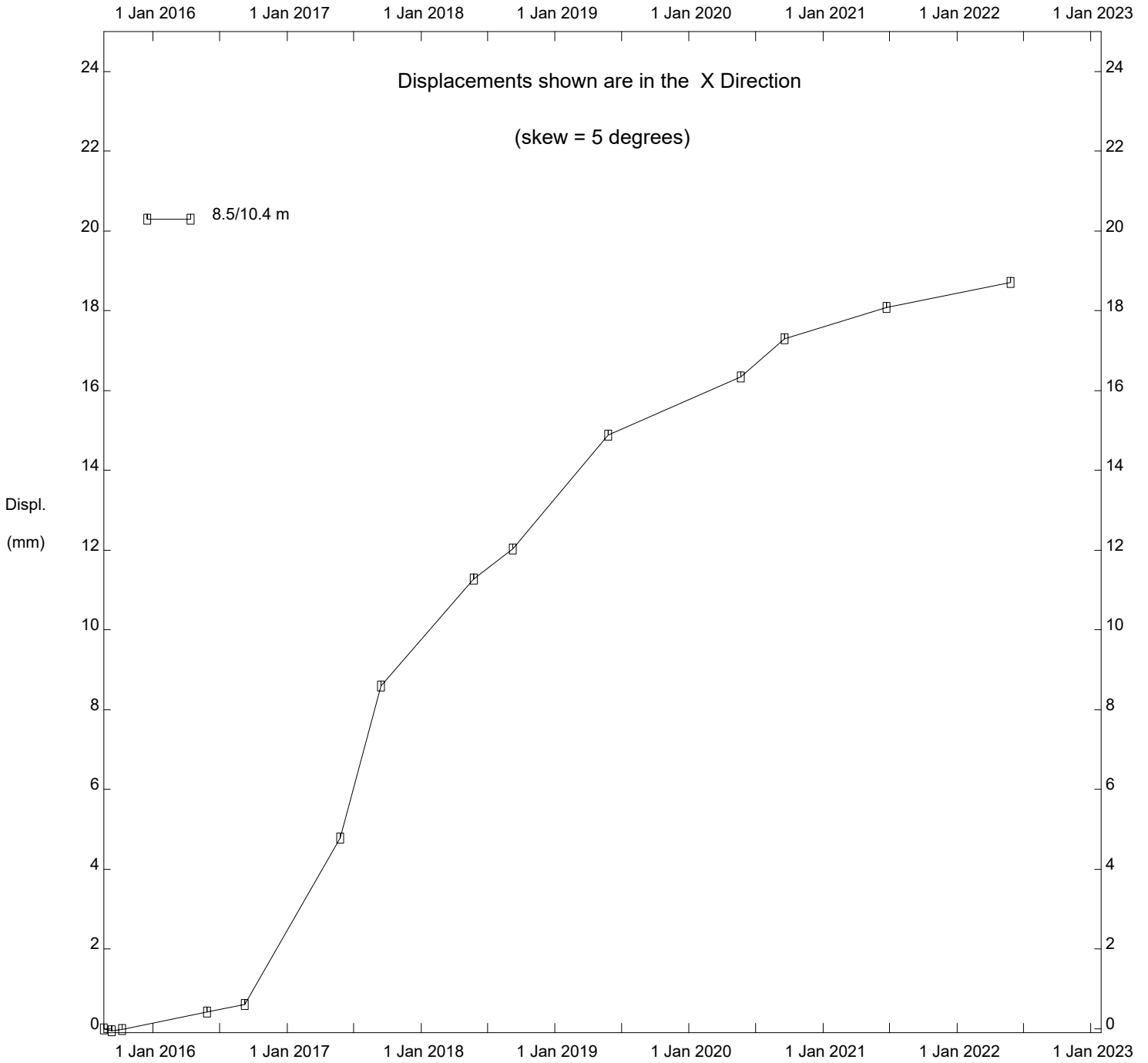


Hwy 41:23 Kehiwin Lake (NC104), Inclinometer SI15-21

Alberta Transportation

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

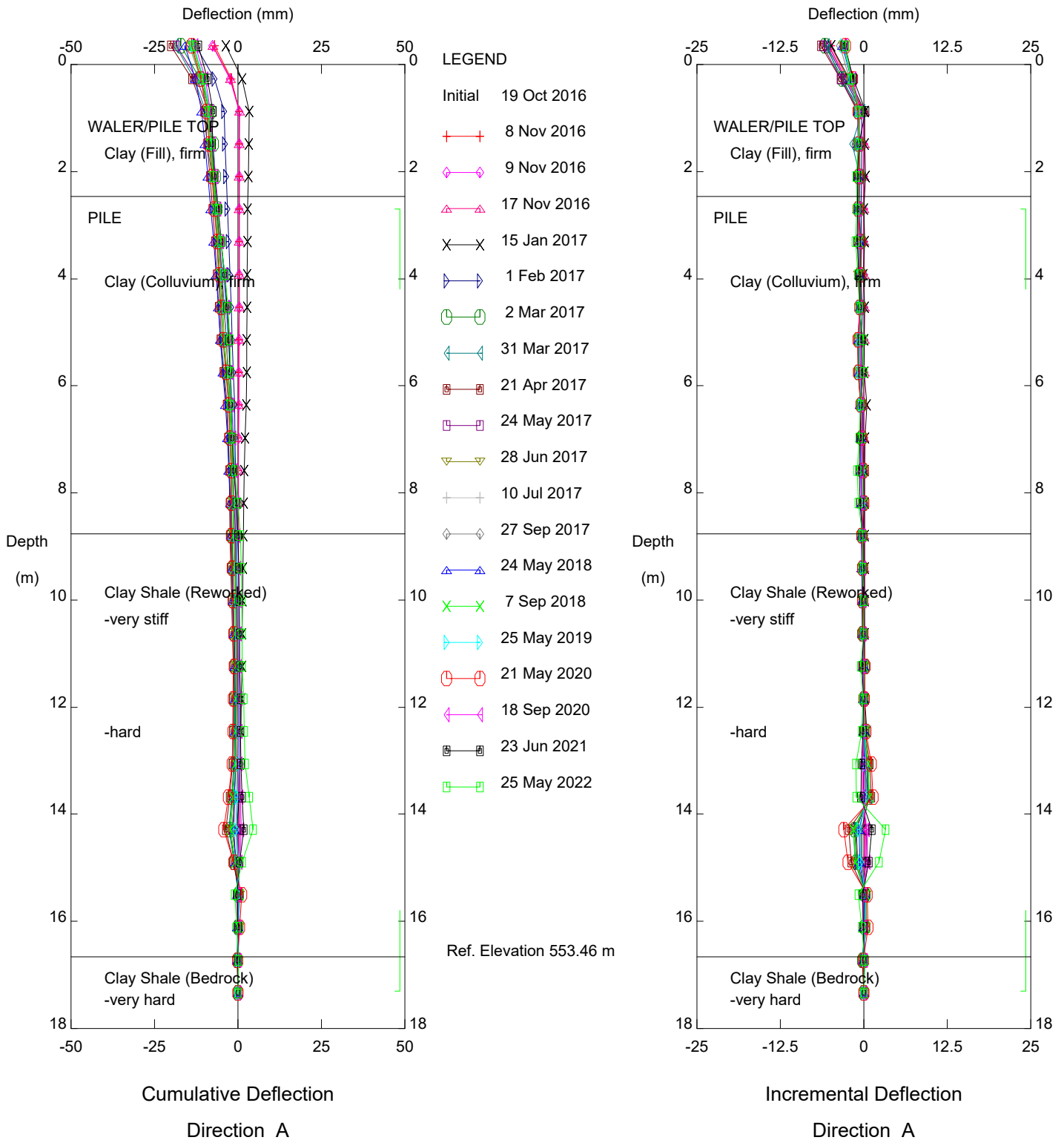
Thurber Engineering Ltd



Hwy 41:23 Kehiwin Lake (NC104), Inclinometer SI15-21

Alberta Transportation

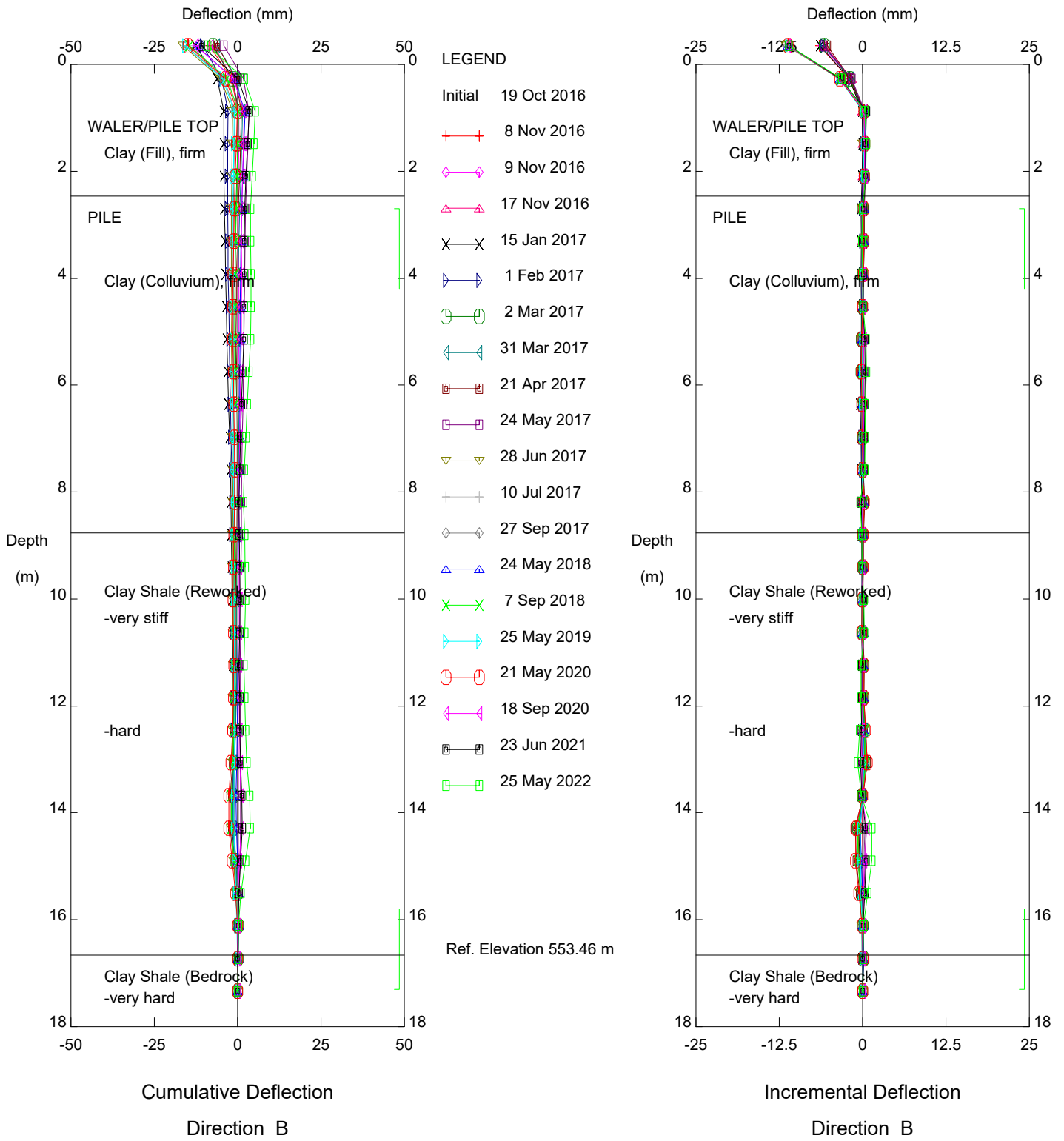
Thurber Engineering Ltd



Hwy 41:23 Kehiwin Lake (NC104), Inclinometer SI16-1 (P06)

Alberta Transportation

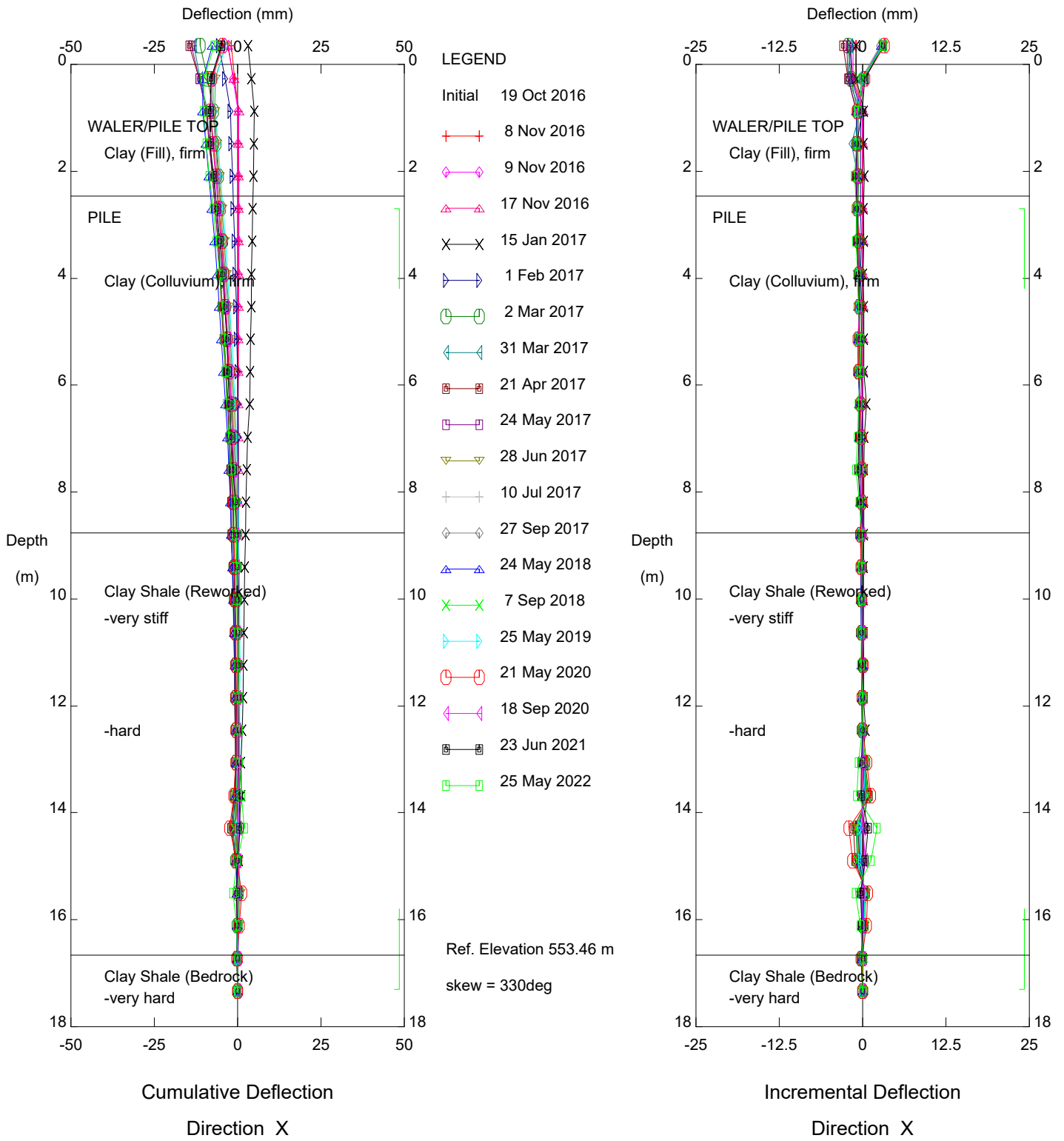
Thurber Engineering Ltd



Hwy 41:23 Kehiwin Lake (NC104), Inclinometer SI16-1 (P06)

Alberta Transportation

Thurber Engineering Ltd

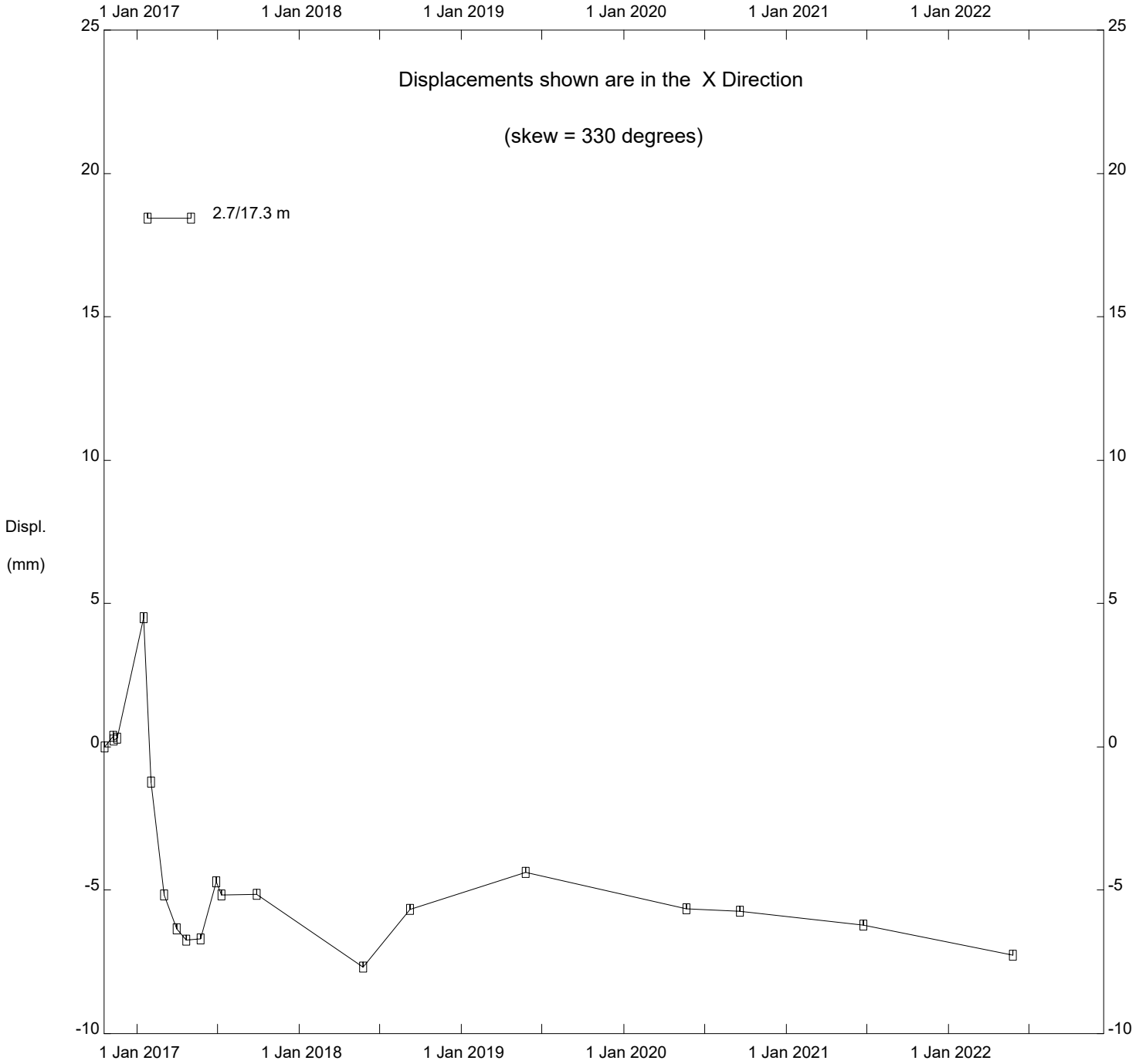


Hwy 41:23 Kehiwin Lake (NC104), Inclinometer SI16-1 (P06)

Alberta Transportation



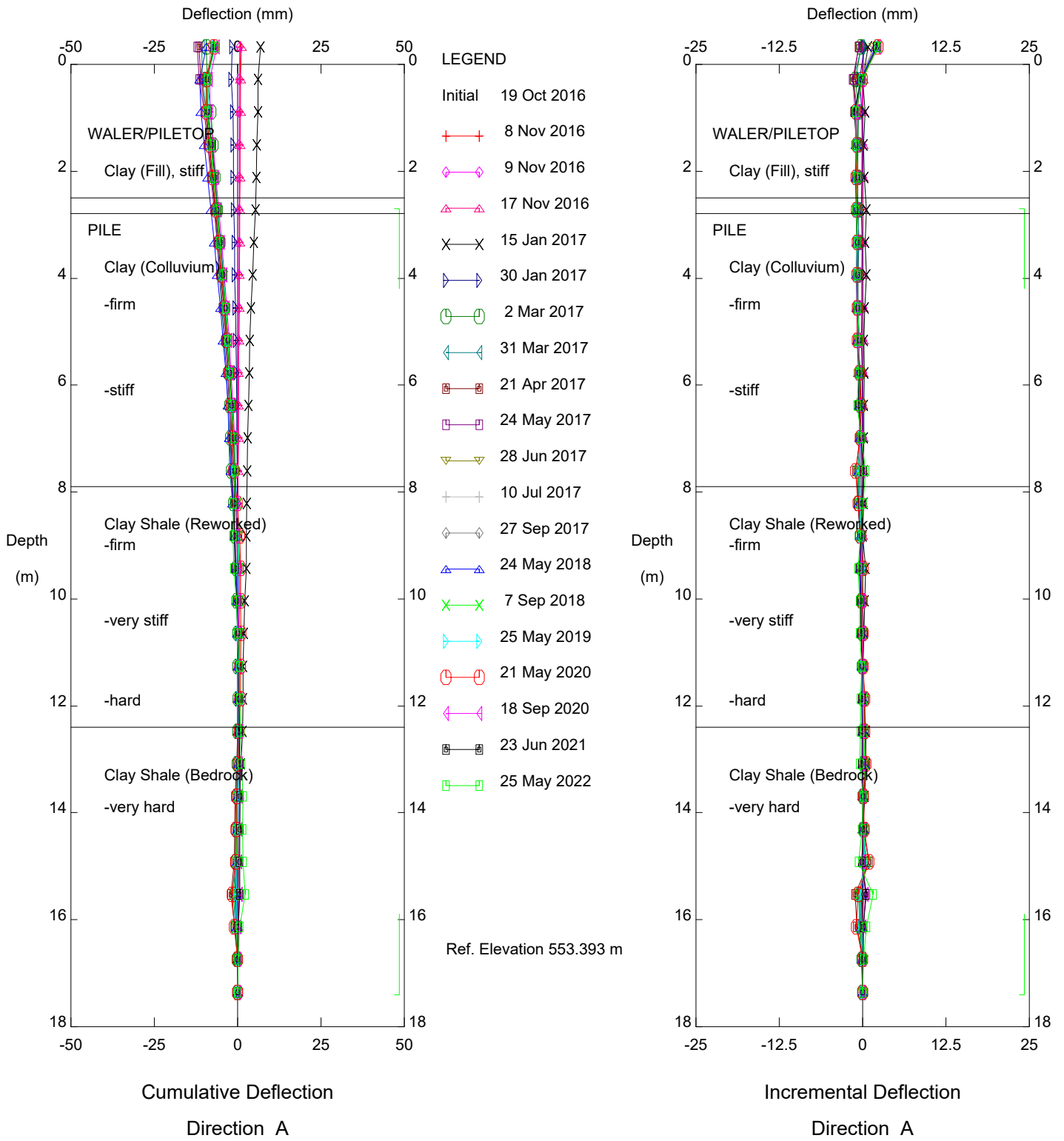
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Hwy 41:23 Kehiwin Lake (NC104), Inclinometer SI16-1 (P06)

Alberta Transportation

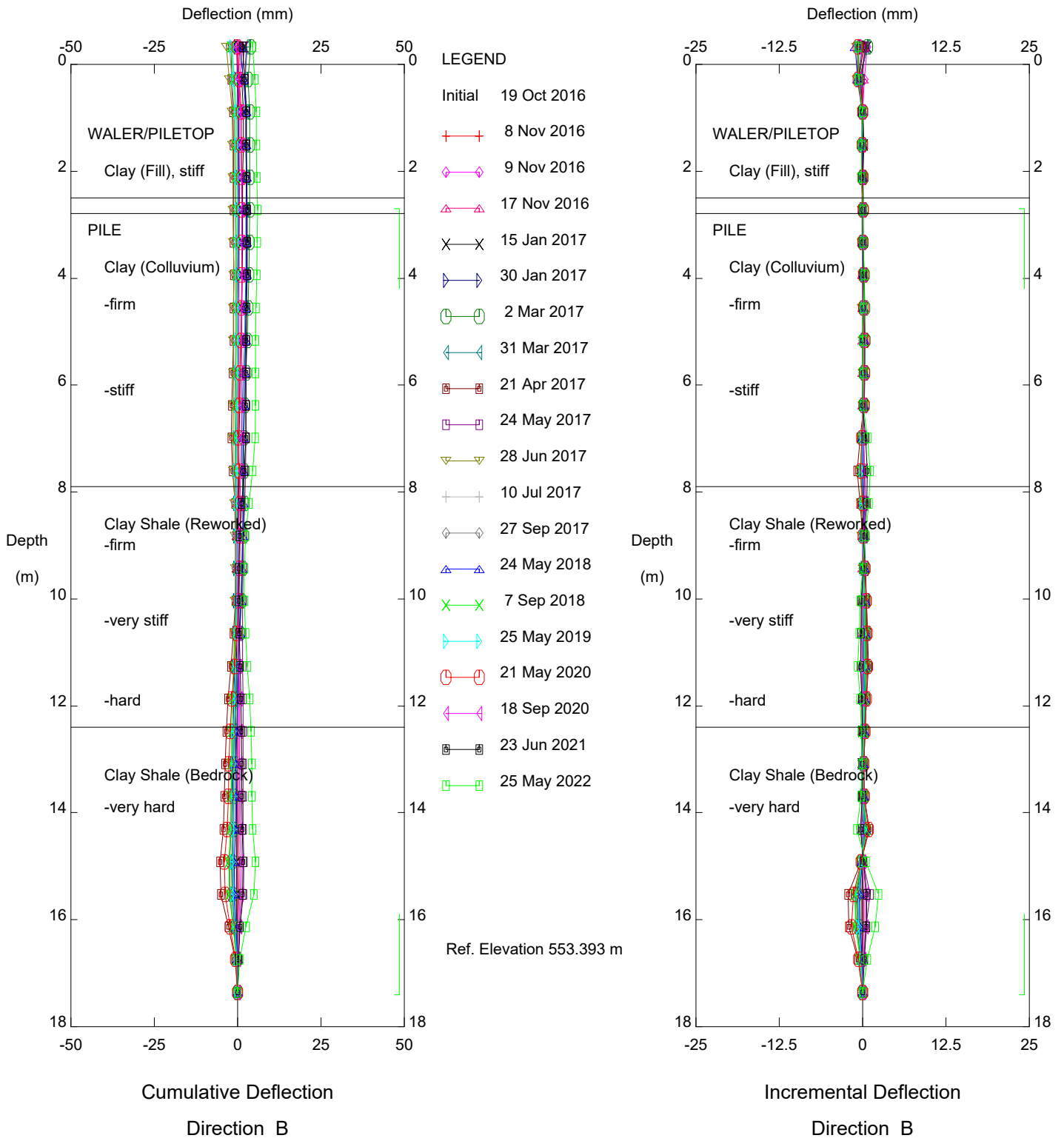
Thurber Engineering Ltd



Hwy 41:23 Kehiwin Lake (NC104), Inclinometer SI16-2 (P28)

Alberta Transportation

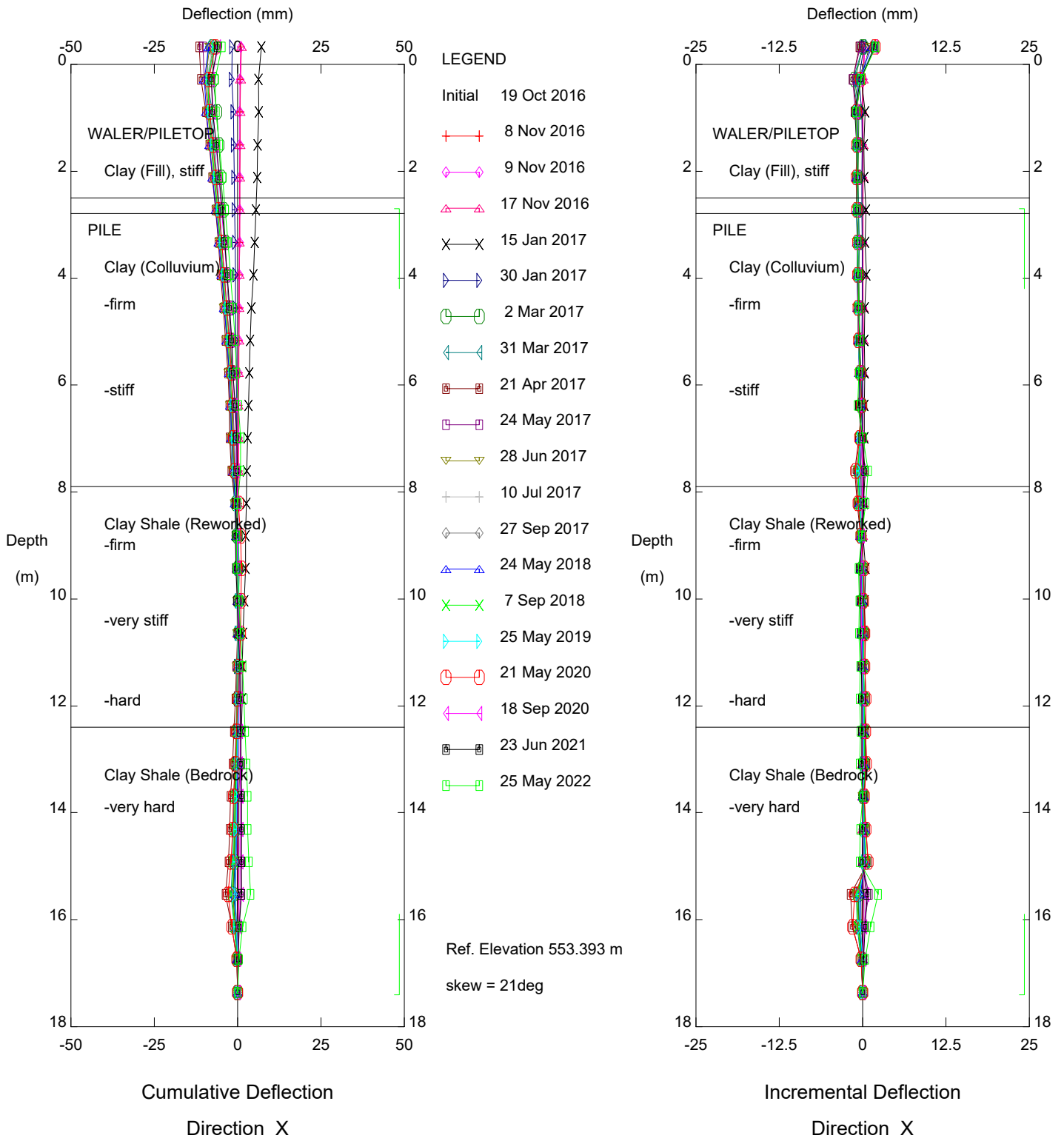
Thurber Engineering Ltd



Hwy 41:23 Kehiwin Lake (NC104), Inclinometer SI16-2 (P28)

Alberta Transportation

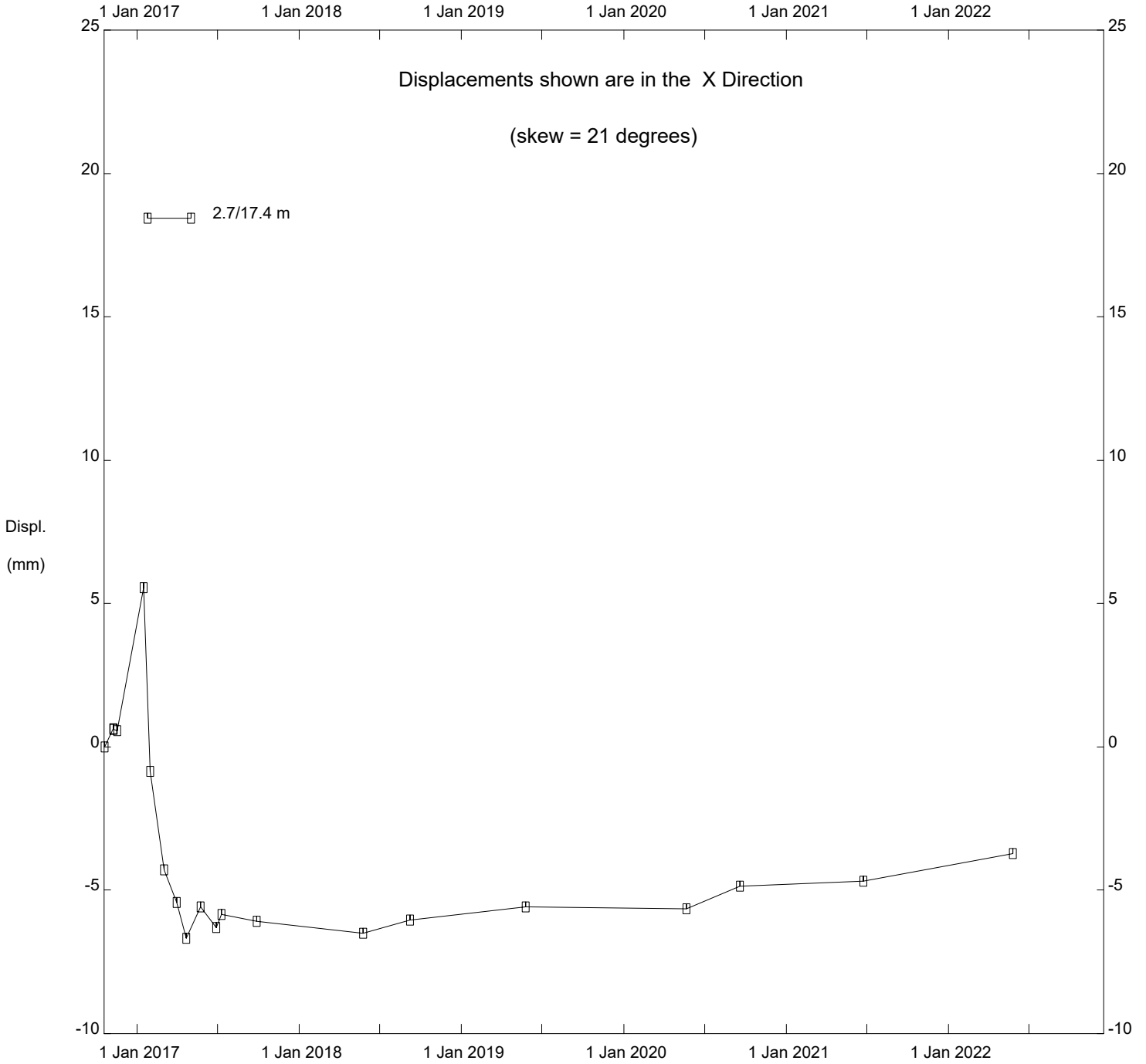
Thurber Engineering Ltd



Hwy 41:23 Kehiwin Lake (NC104), Inclinometer SI16-2 (P28)

Alberta Transportation

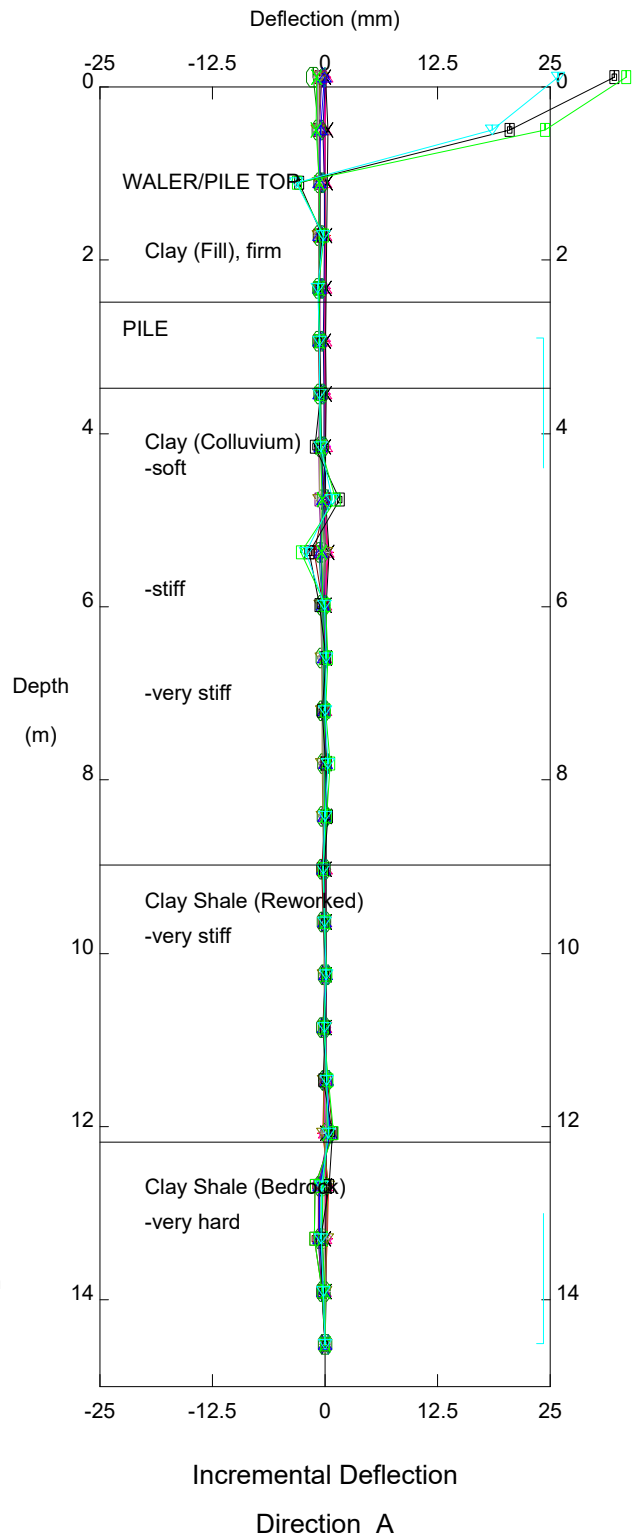
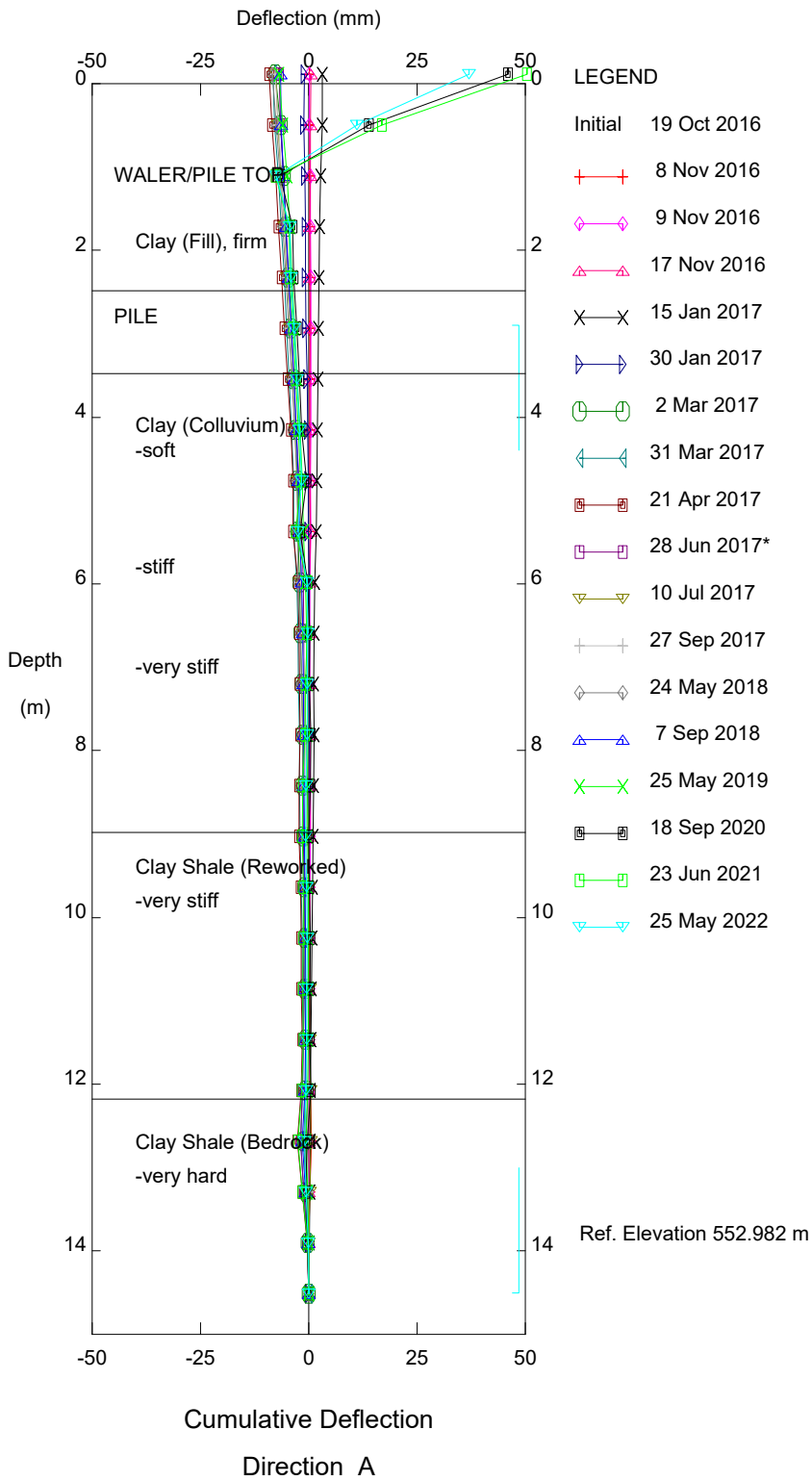
Thurber Engineering Ltd



Hwy 41:23 Kehiwin Lake (NC104), Inclinator SI16-2 (P28)

Alberta Transportation

Thurber Engineering Ltd

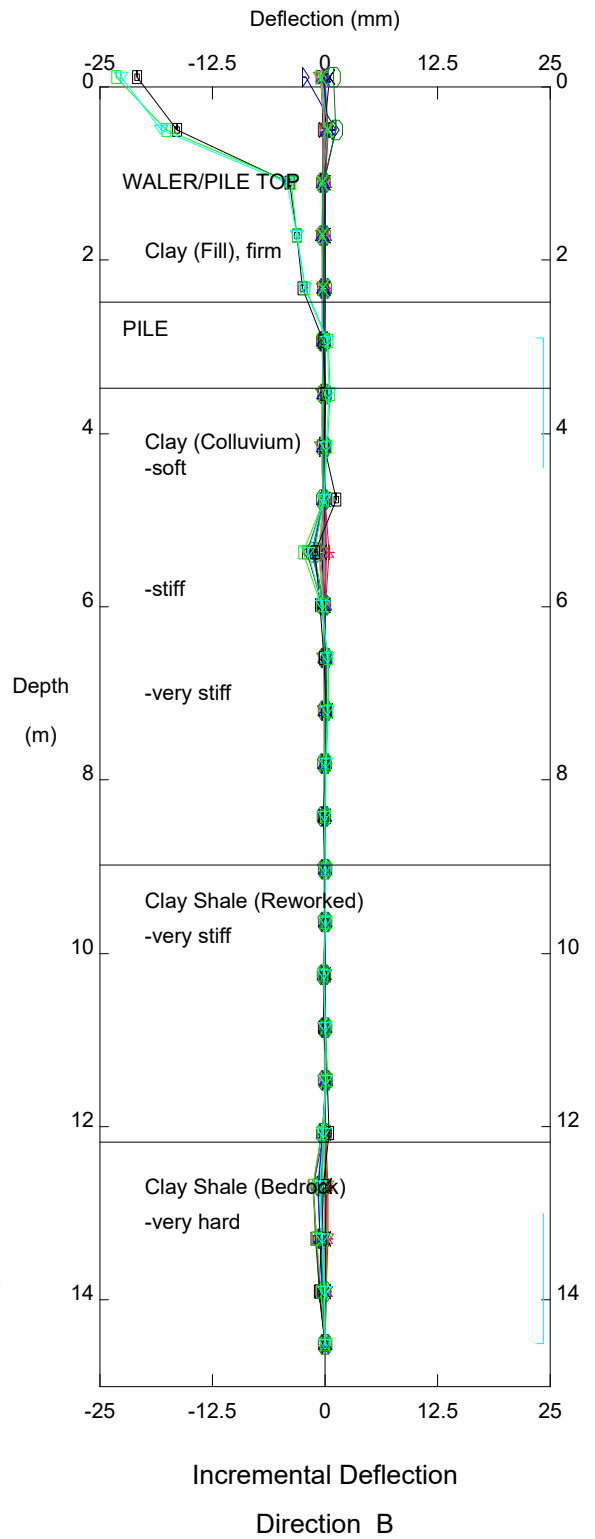
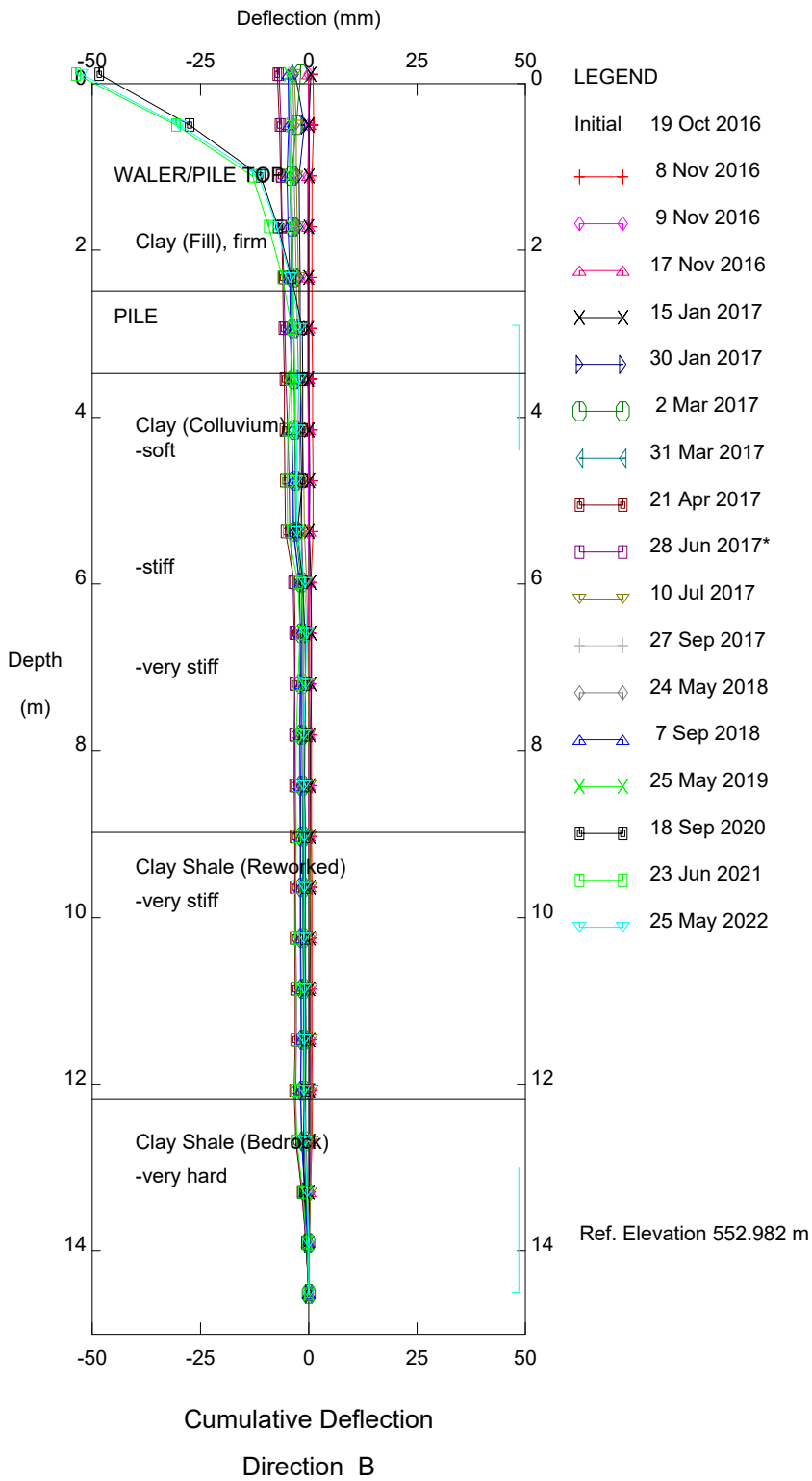


Hwy 41:23 Kehiwin Lake (NC104), Inclinometer SI16-3 (P47)

Alberta Transportation

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

Thurber Engineering Ltd

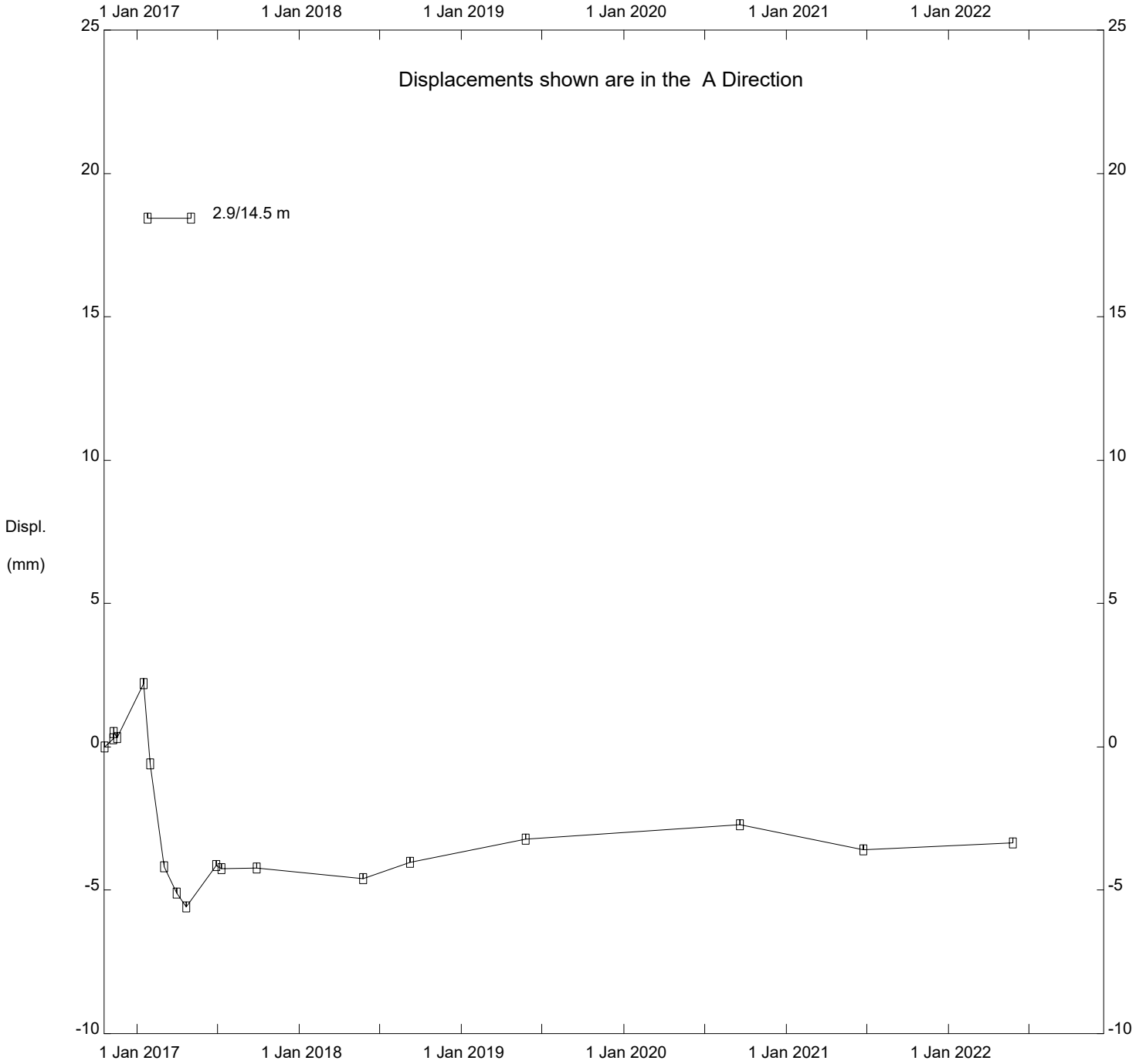


Hwy 41:23 Kehiwin Lake (NC104), Inclinator SI16-3 (P47)

Alberta Transportation

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

Thurber Engineering Ltd

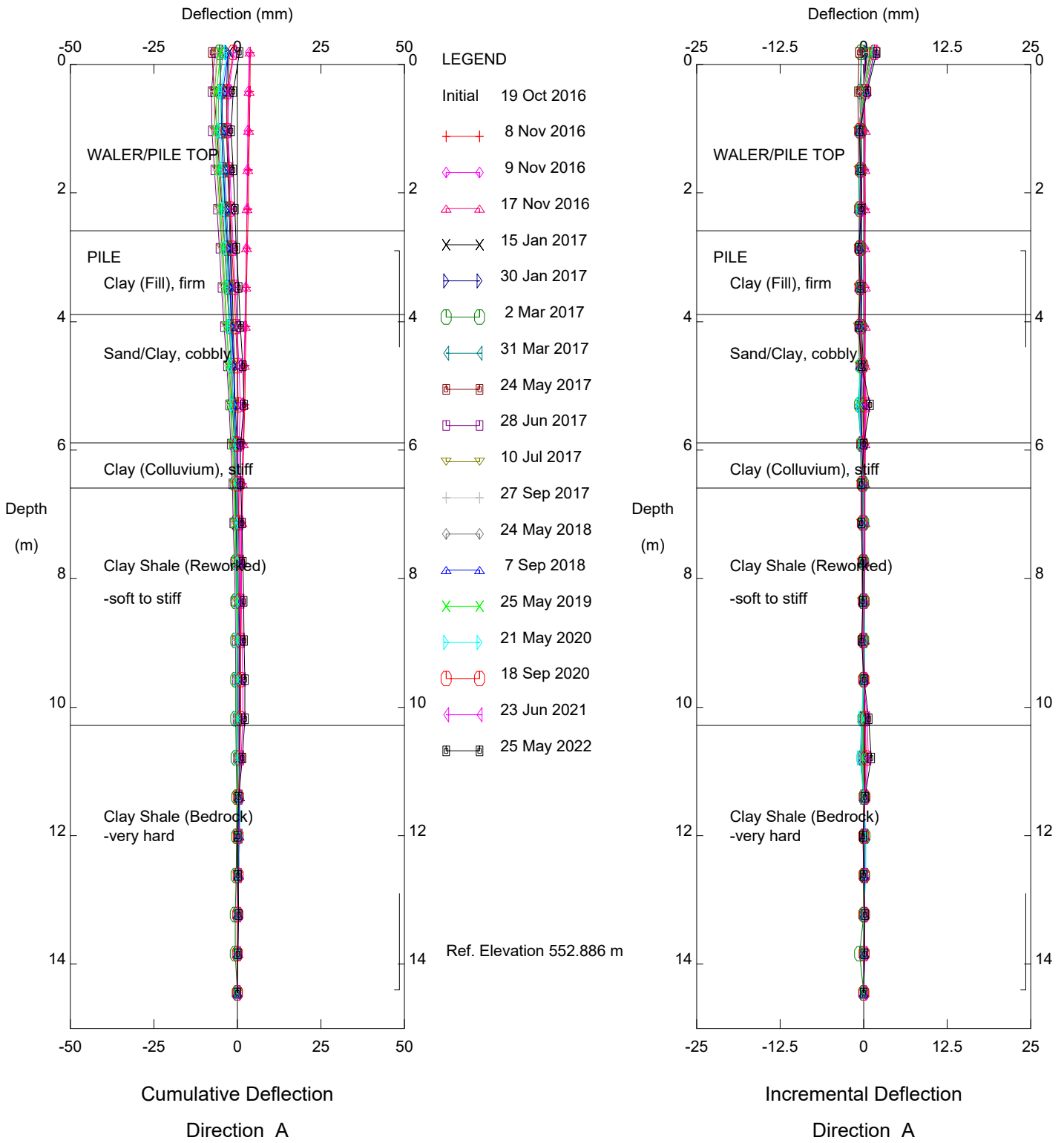


Hwy 41:23 Kehiwin Lake (NC104), Inclinator SI16-3 (P47)

Alberta Transportation



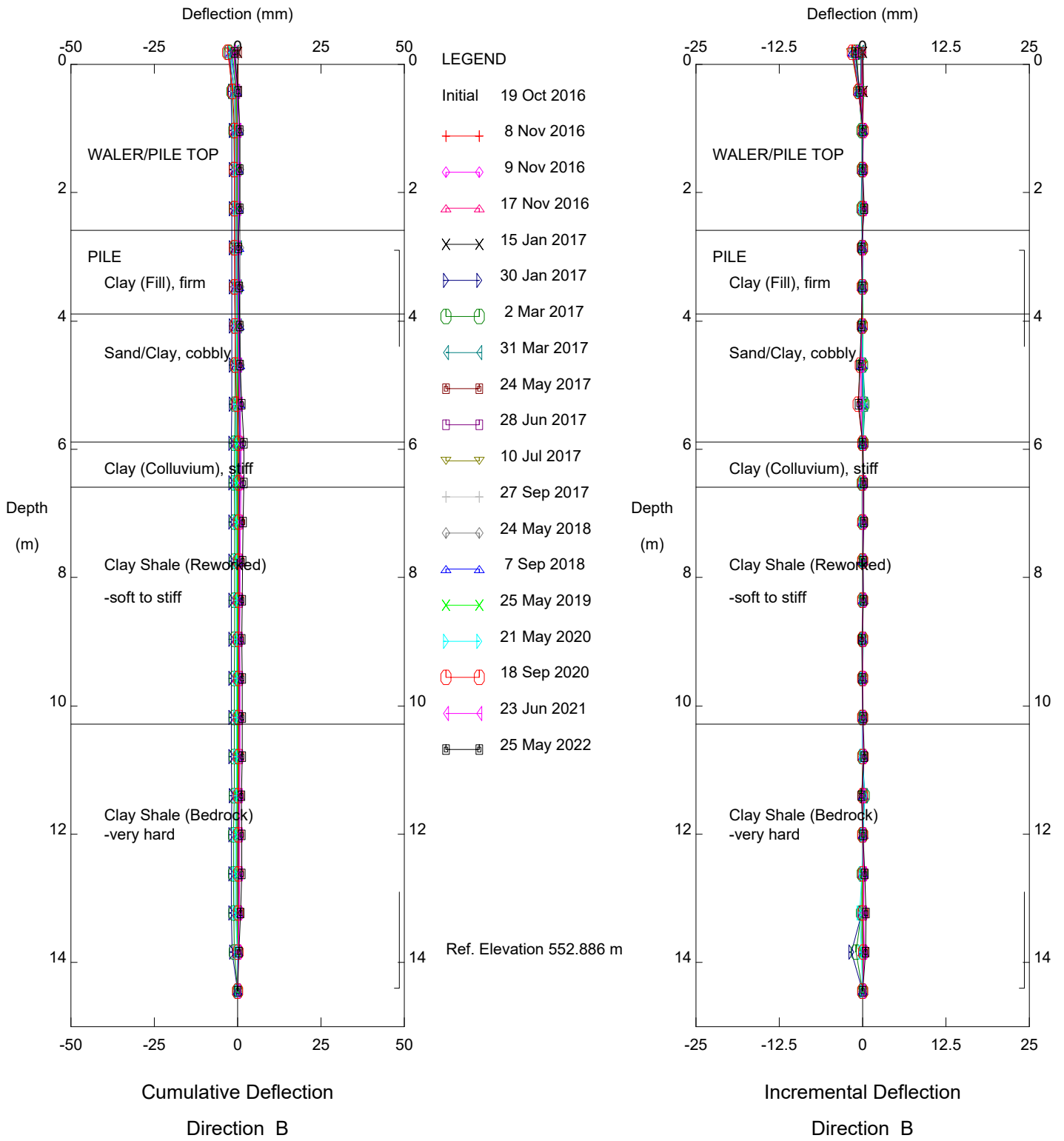
Thurber Engineering Ltd



Hwy 41:23 Kehiwin Lake (NC104), Inclinometer SI16-5 (P83)

Alberta Transportation

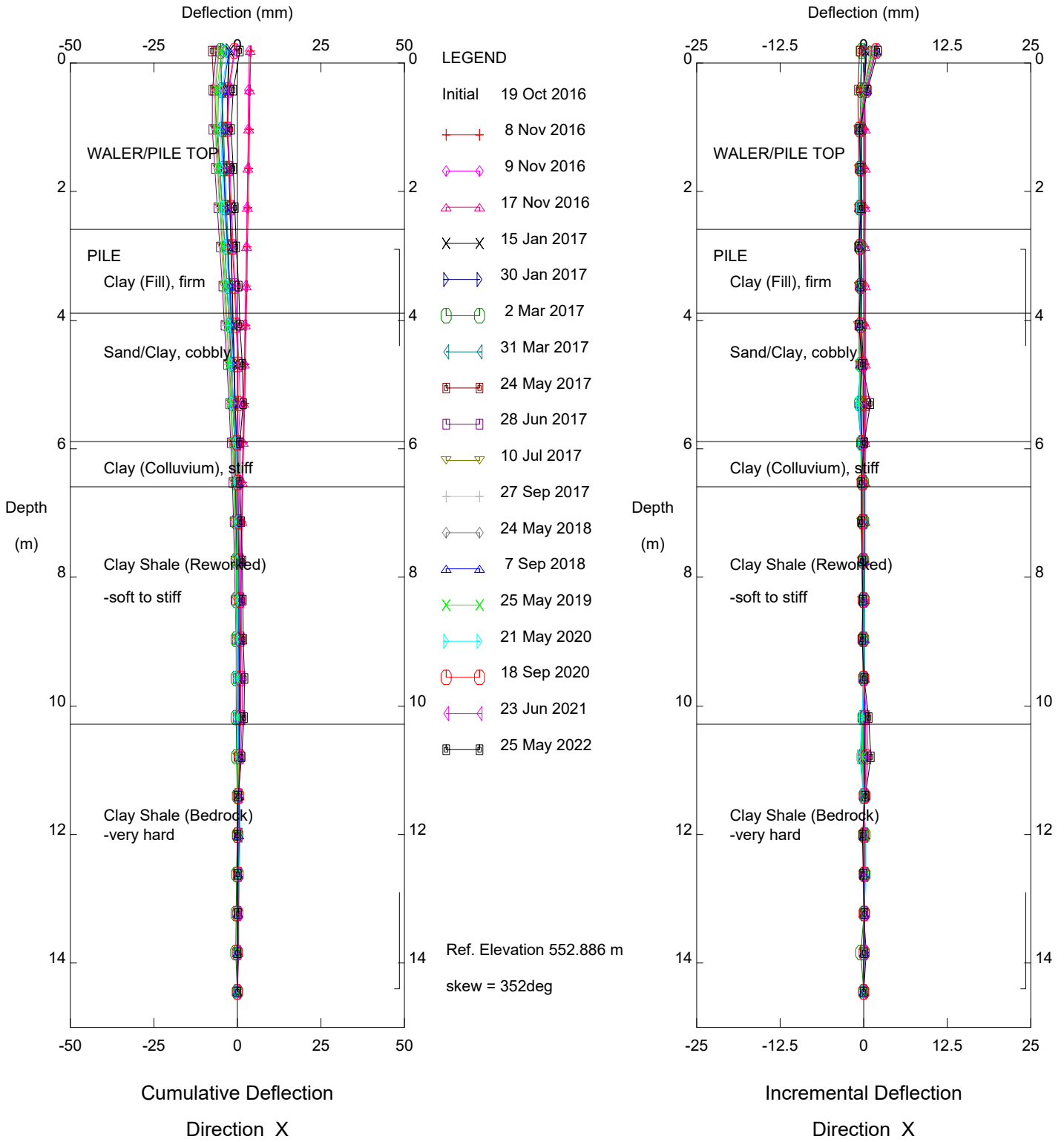
Thurber Engineering Ltd



Hwy 41:23 Kehiwin Lake (NC104), Inclinometer SI16-5 (P83)

Alberta Transportation

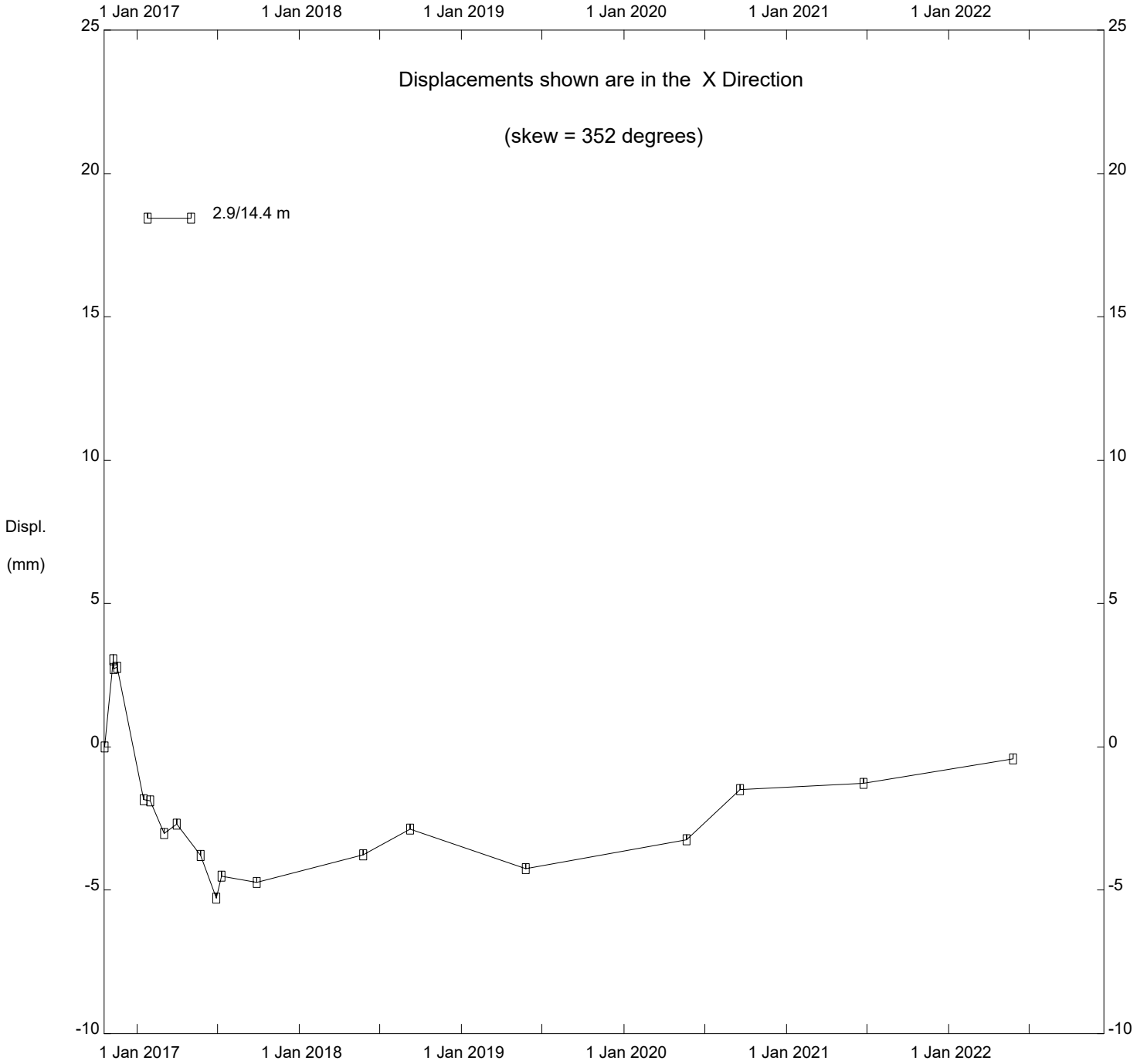
Thurber Engineering Ltd



Hwy 41:23 Kehiwin Lake (NC104), Inclinometer SI16-5 (P83)

Alberta Transportation

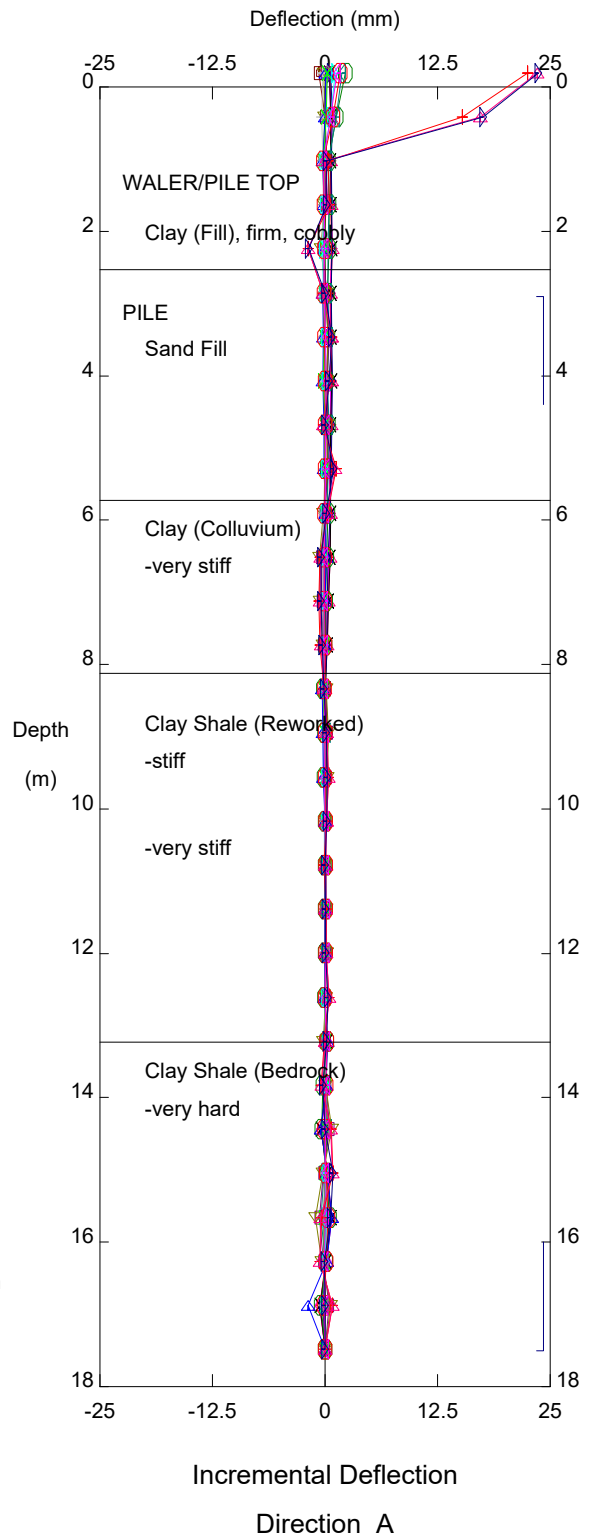
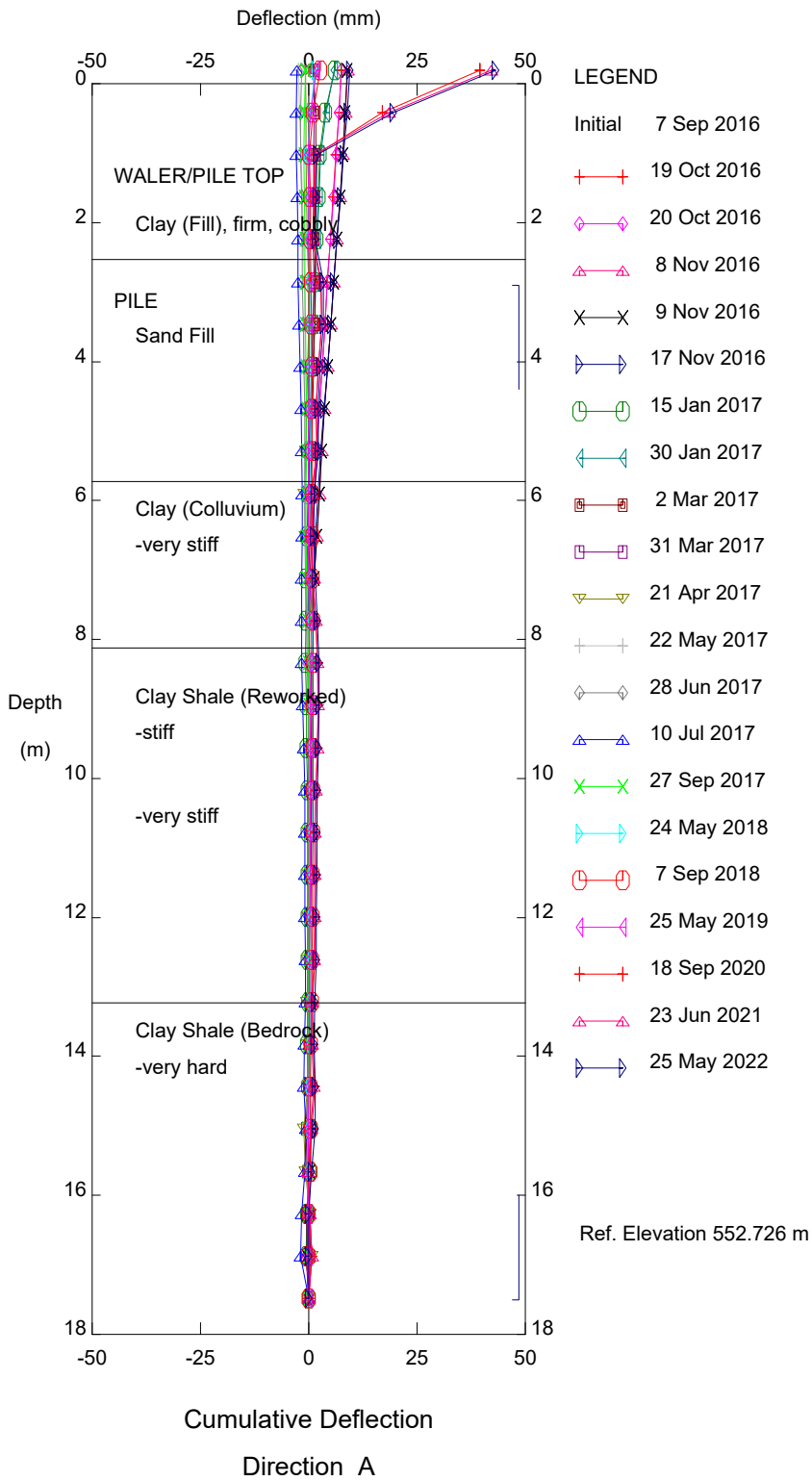
Thurber Engineering Ltd



Hwy 41:23 Kehiwin Lake (NC104), Inclinator SI16-5 (P83)

Alberta Transportation

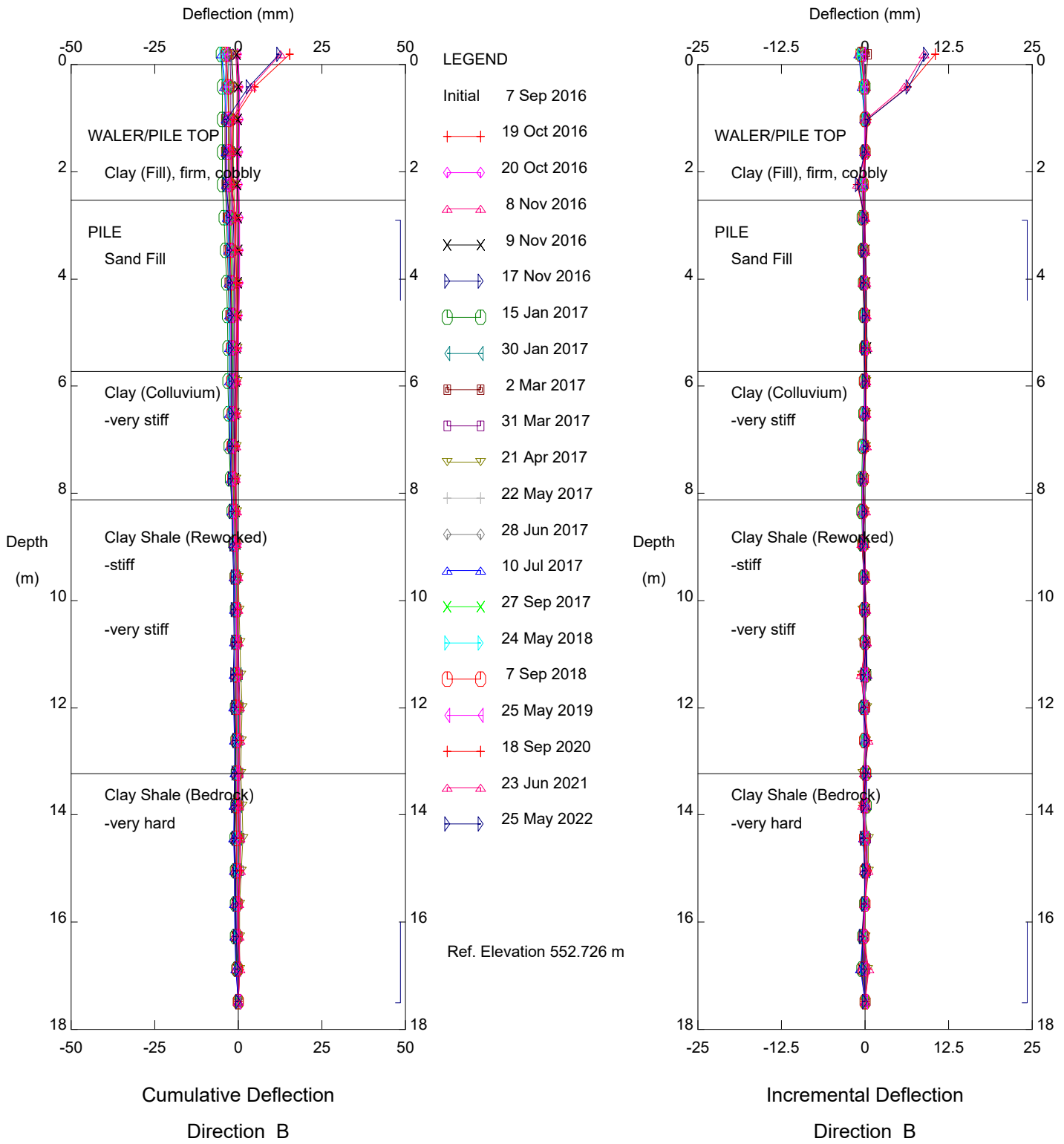
Thurber Engineering Ltd



Hwy 41:23 Kehiwin Lake (NC104), Inclinometer SI16-6(P101)

Alberta Transportation

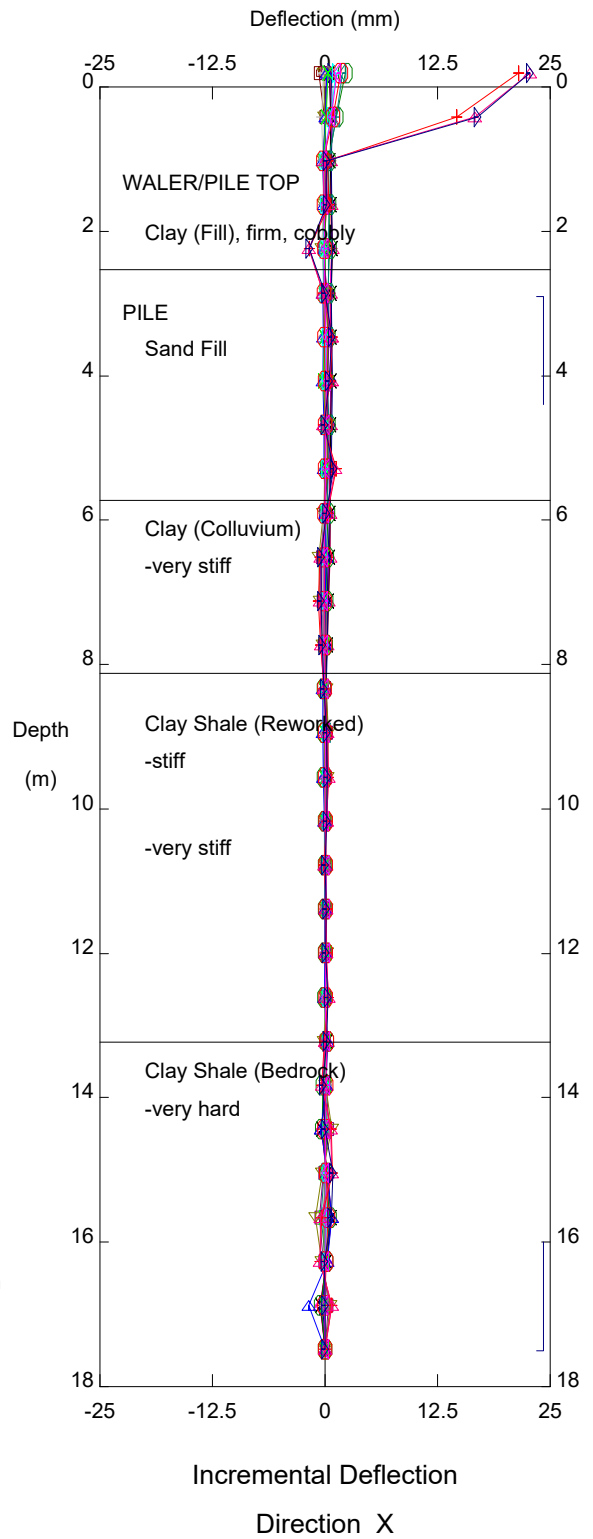
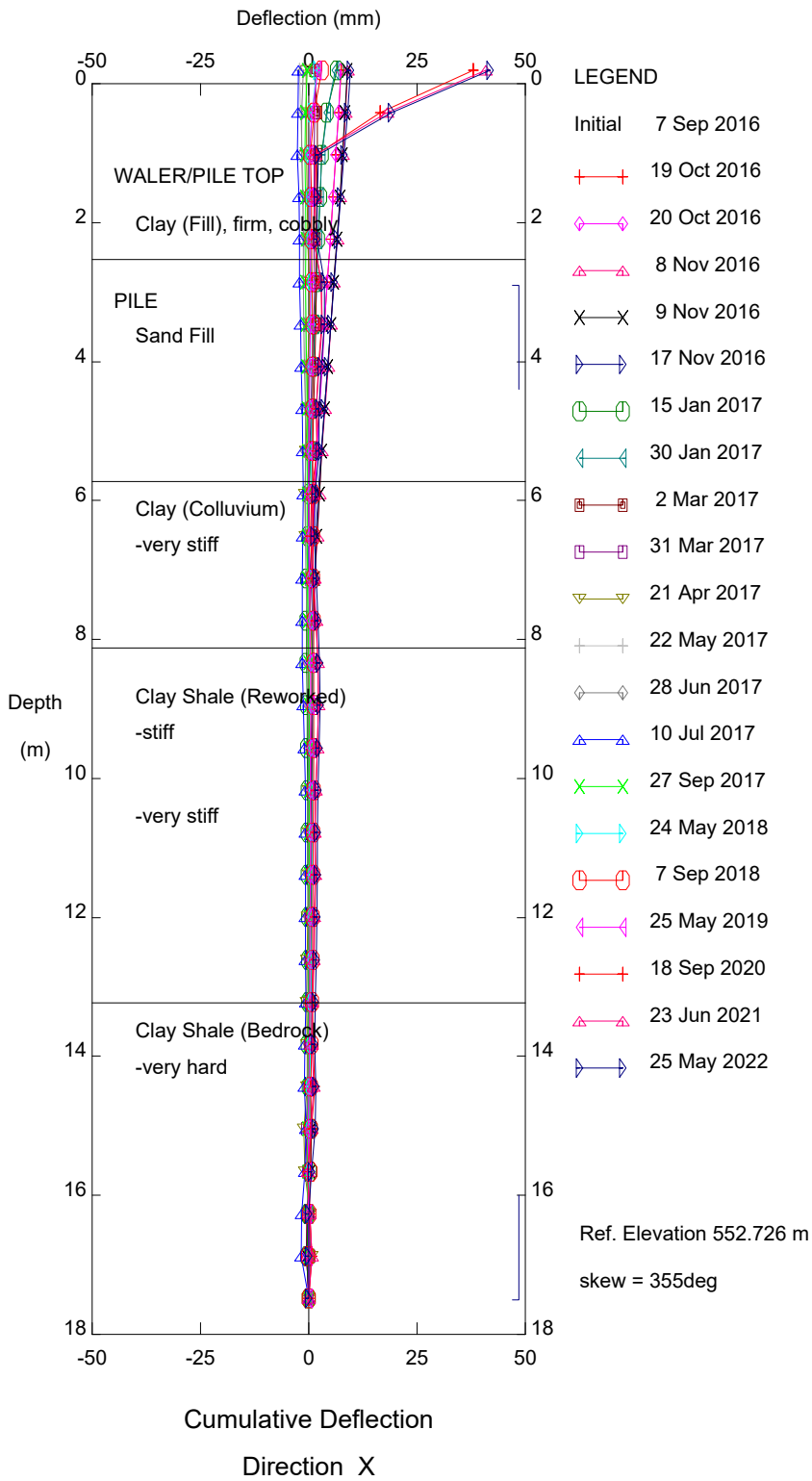
Thurber Engineering Ltd



Hwy 41:23 Kehiwin Lake (NC104), Inclinometer SI16-6(P101)

Alberta Transportation

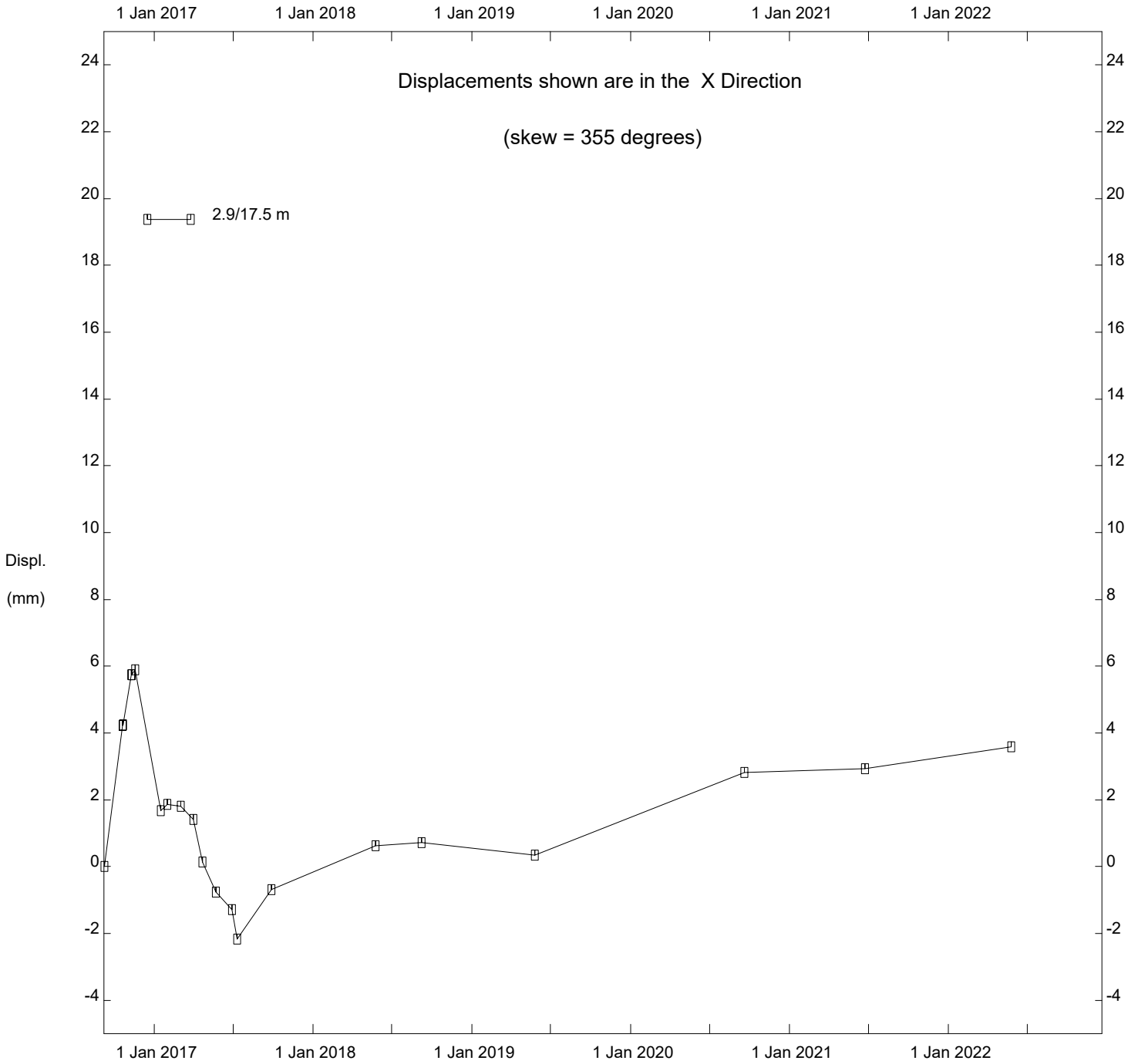
Thurber Engineering Ltd



Hwy 41:23 Kehiwin Lake (NC104), Inclinometer SI16-6(P101)

Alberta Transportation

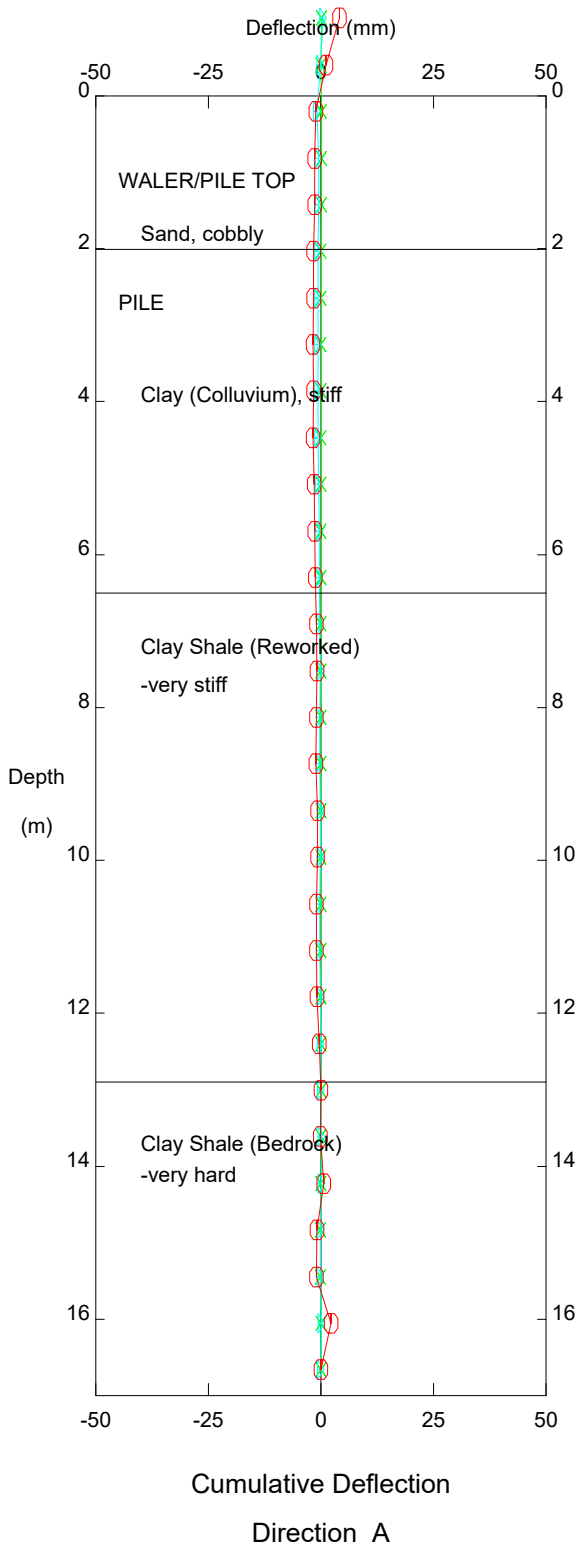
Thurber Engineering Ltd



Hwy 41:23 Kehiwin Lake (NC104), Inclinator SI16-6(P101)

Alberta Transportation





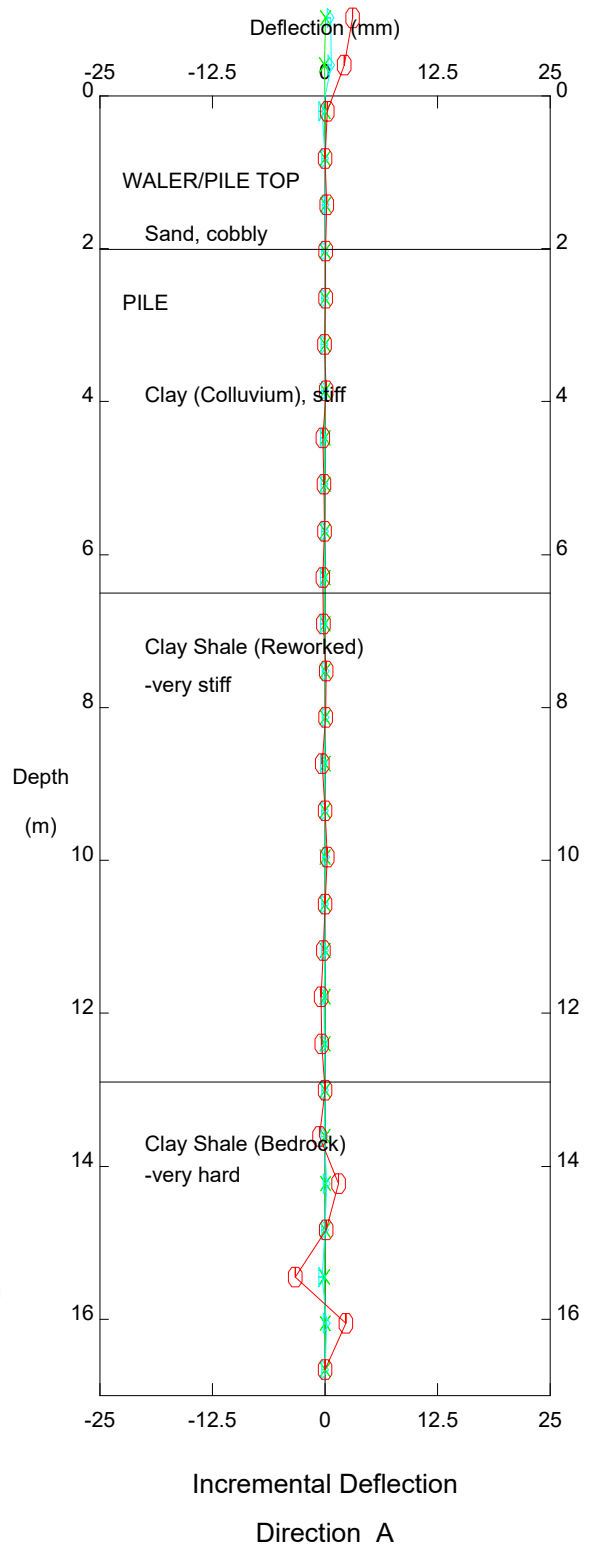
LEGEND

Initial 18 Sep 2020

18 Sep 2020

23 Jun 2021

25 May 2022

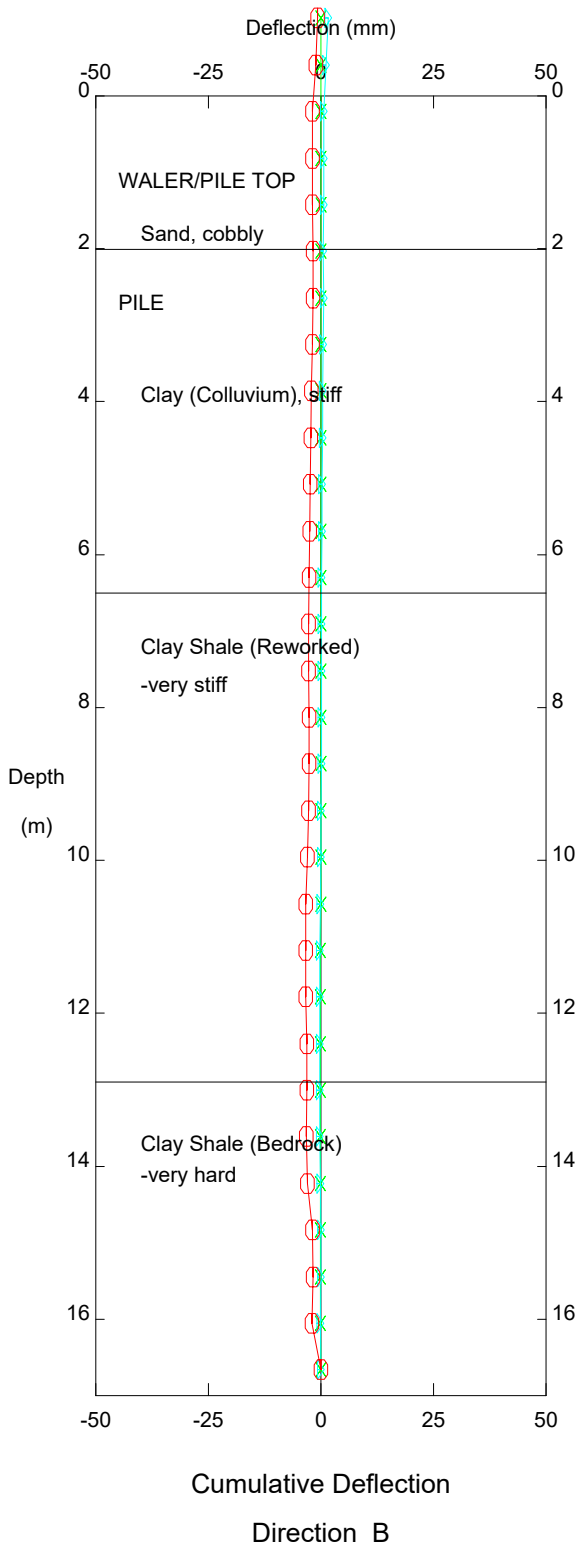


Ref. Elevation 552.303 m

Hwy 41:23 Kehiwin Lake (NC104), Inclinometer SI16-7(P122)

Alberta Transportation

Thurber Engineering Ltd



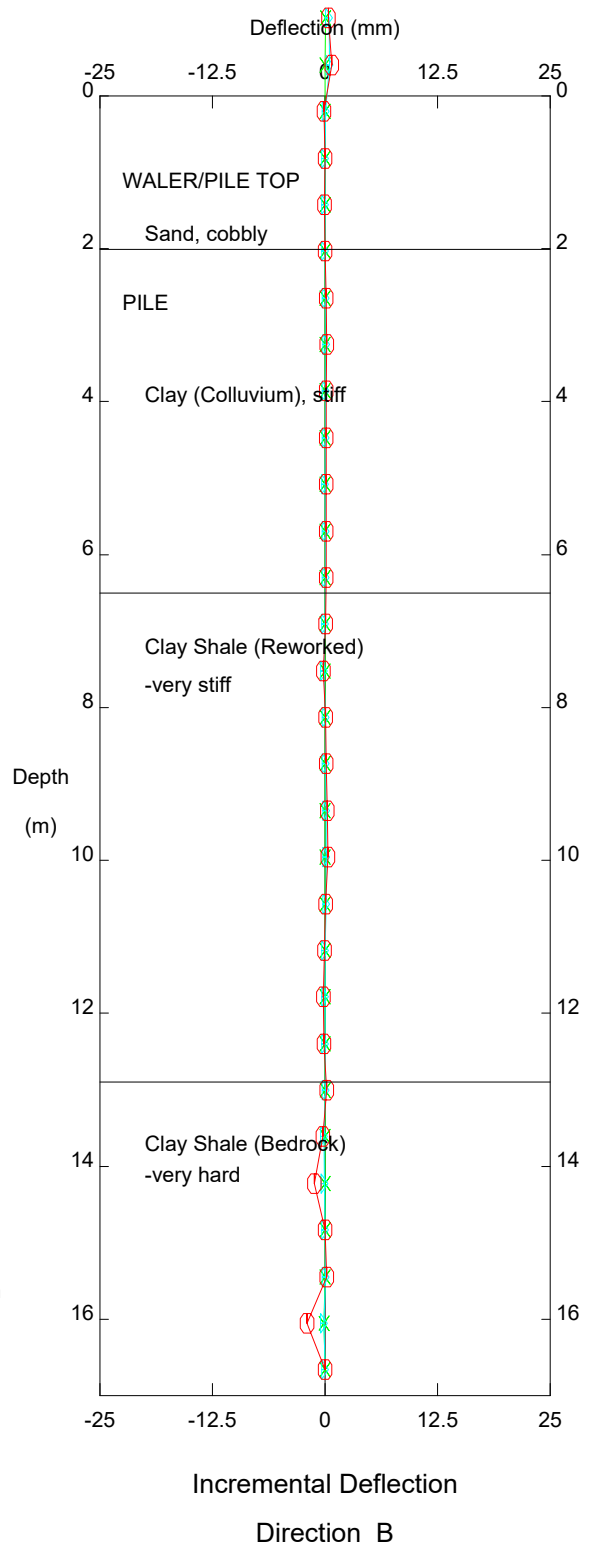
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18 Sep 2020

23 Jun 2021

25 May 2022

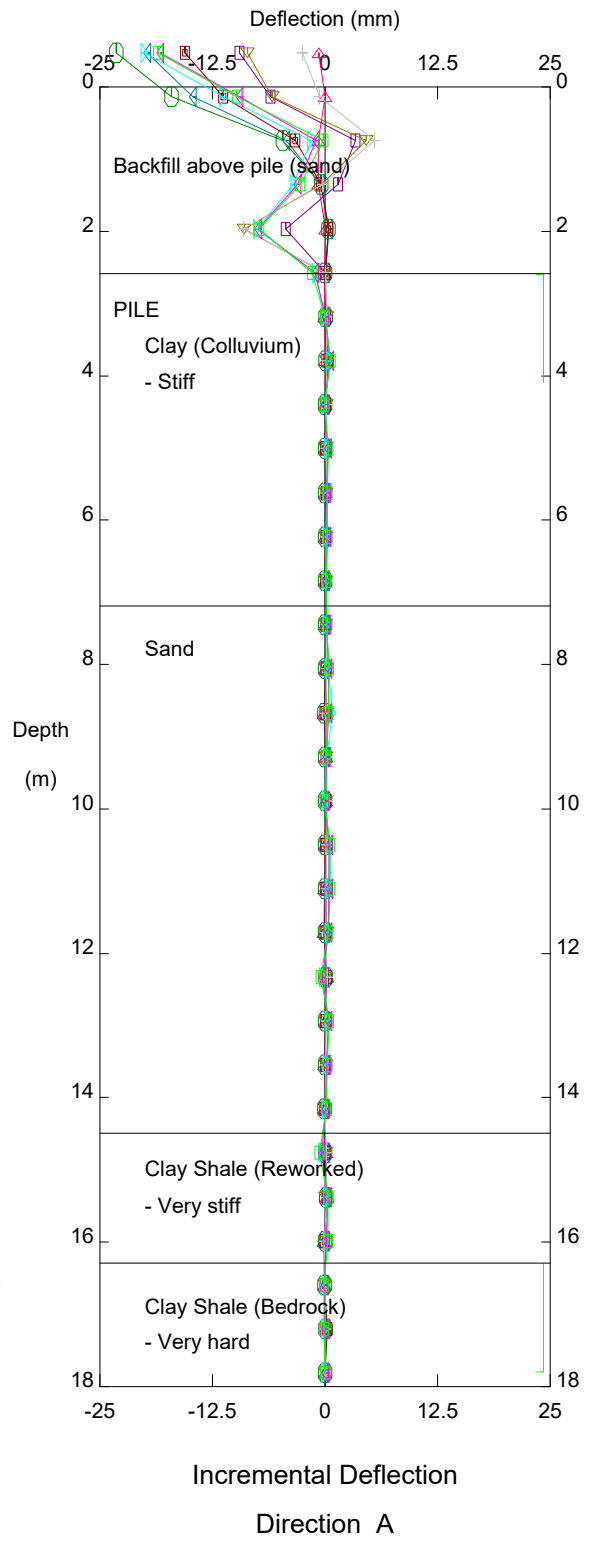
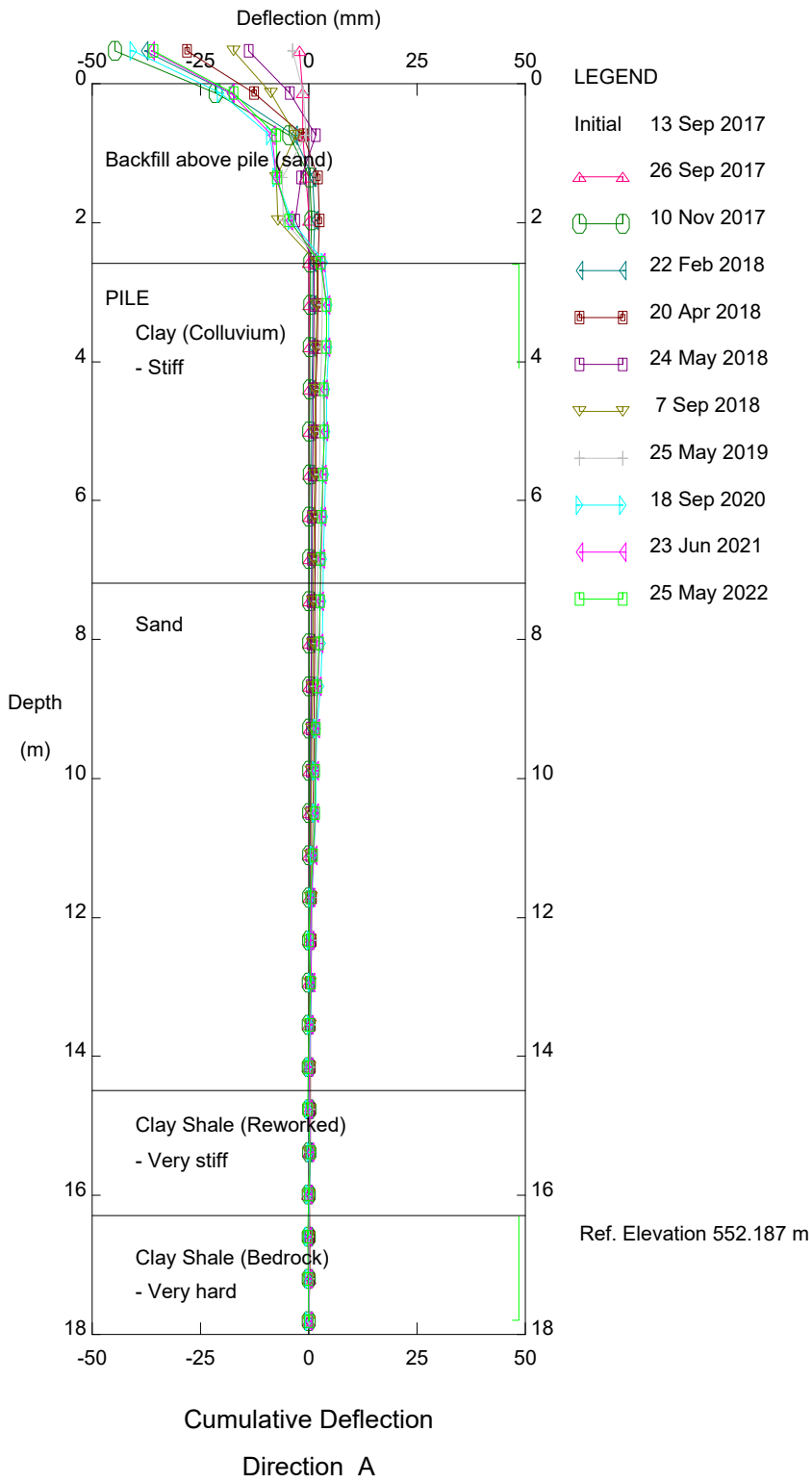


Ref. Elevation 552.303 m

Hwy 41:23 Kehiwin Lake (NC104), Inclinometer SI16-7(P122)

Alberta Transportation

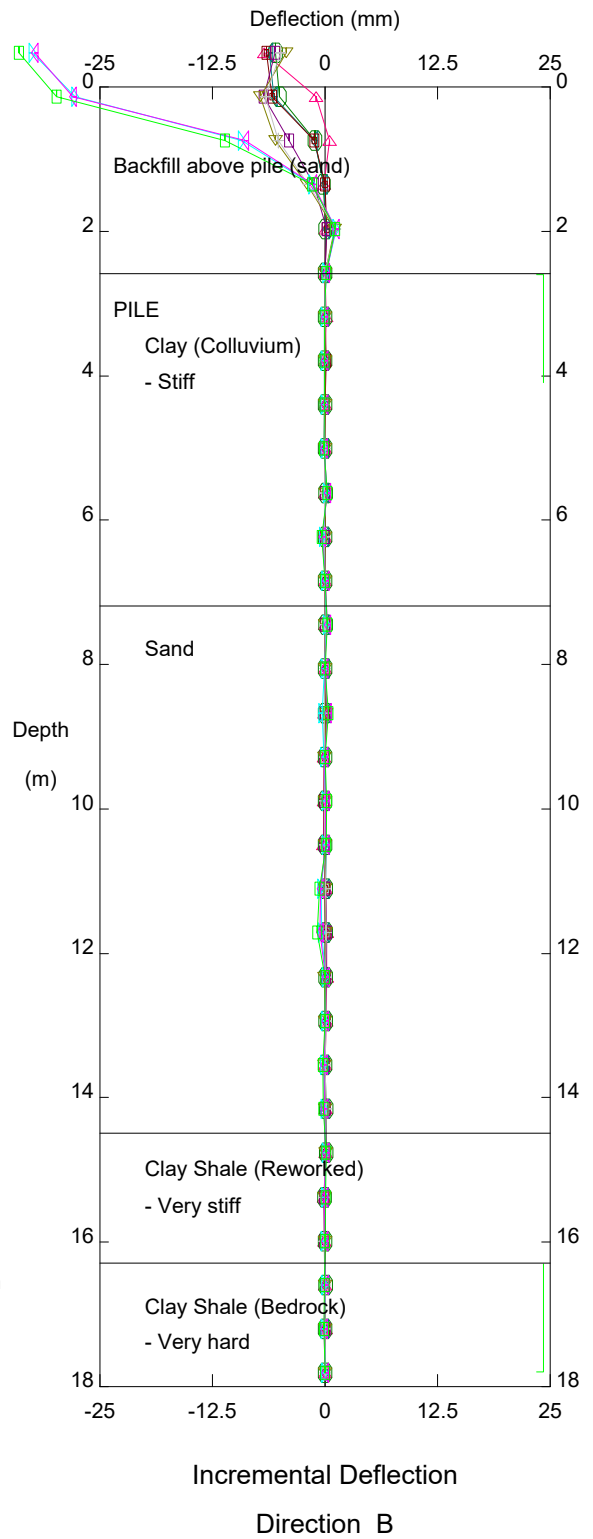
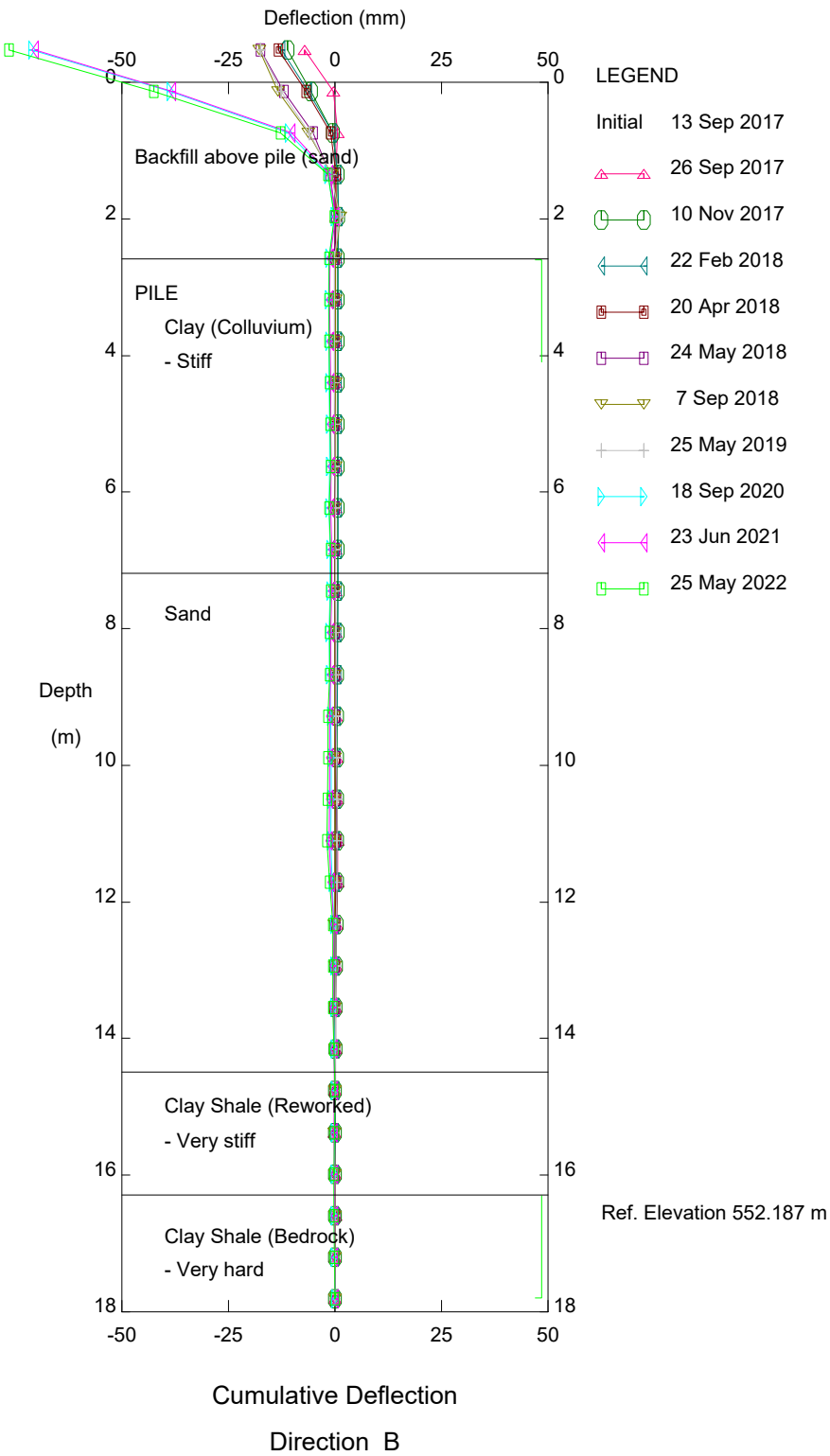
Thurber Engineering Ltd



Hwy 41:23 Kehiwin Lake (NC104), Inclinometer SI17-1(P130)

Alberta Transportation

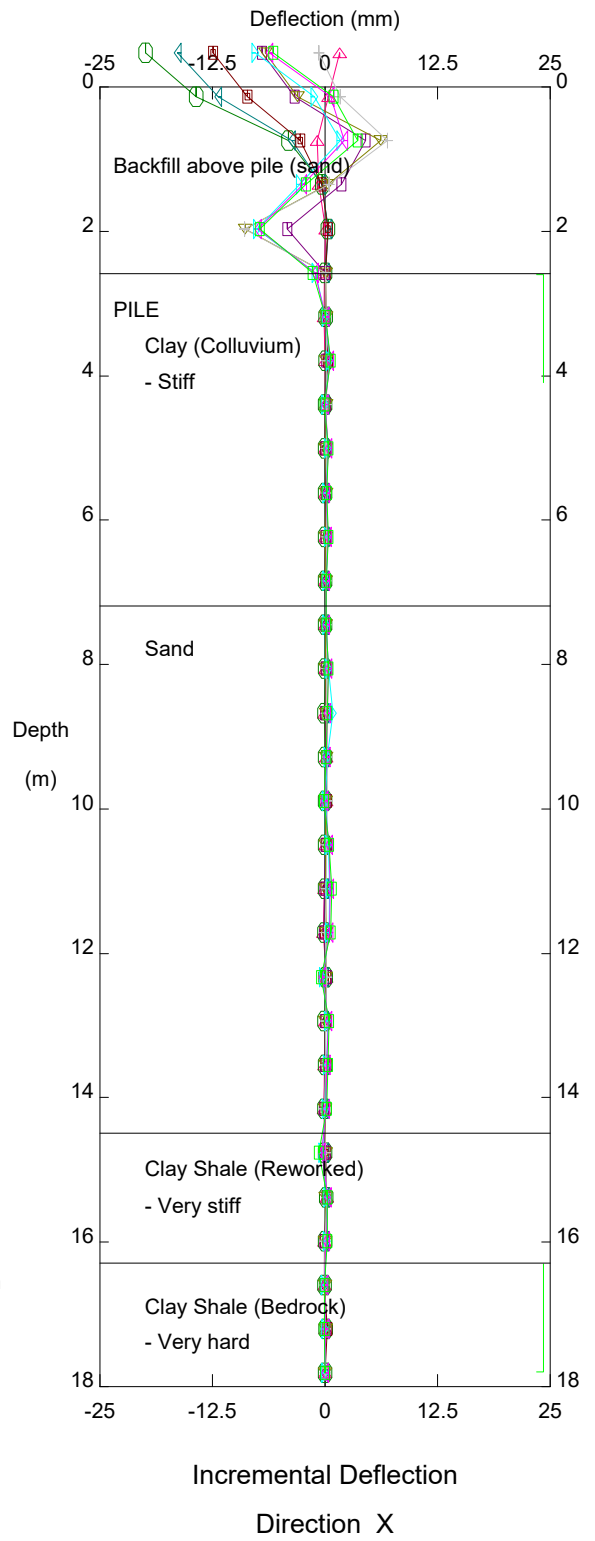
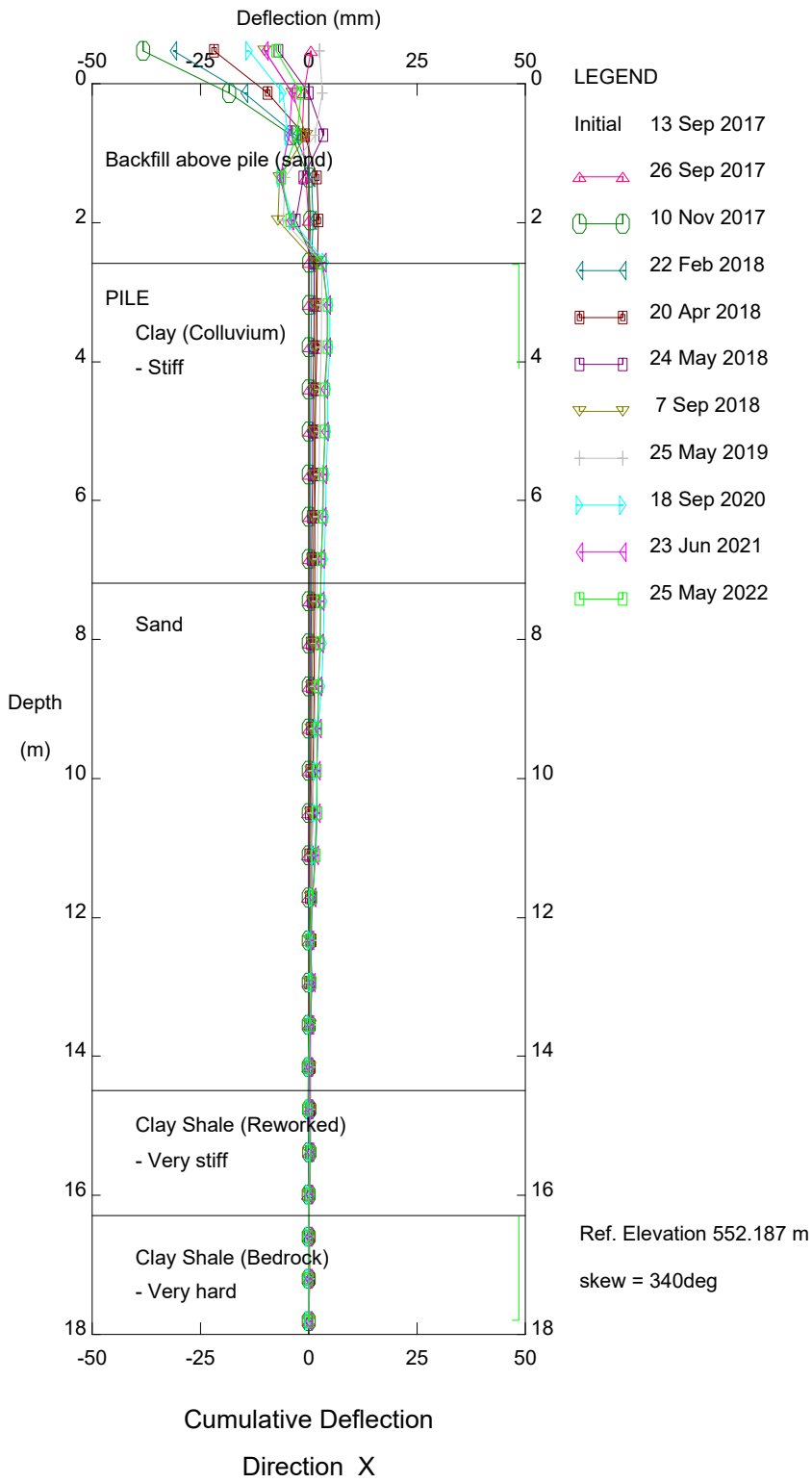
Thurber Engineering Ltd



Hwy 41:23 Kehiwin Lake (NC104), Inclinometer SI17-1(P130)

Alberta Transportation

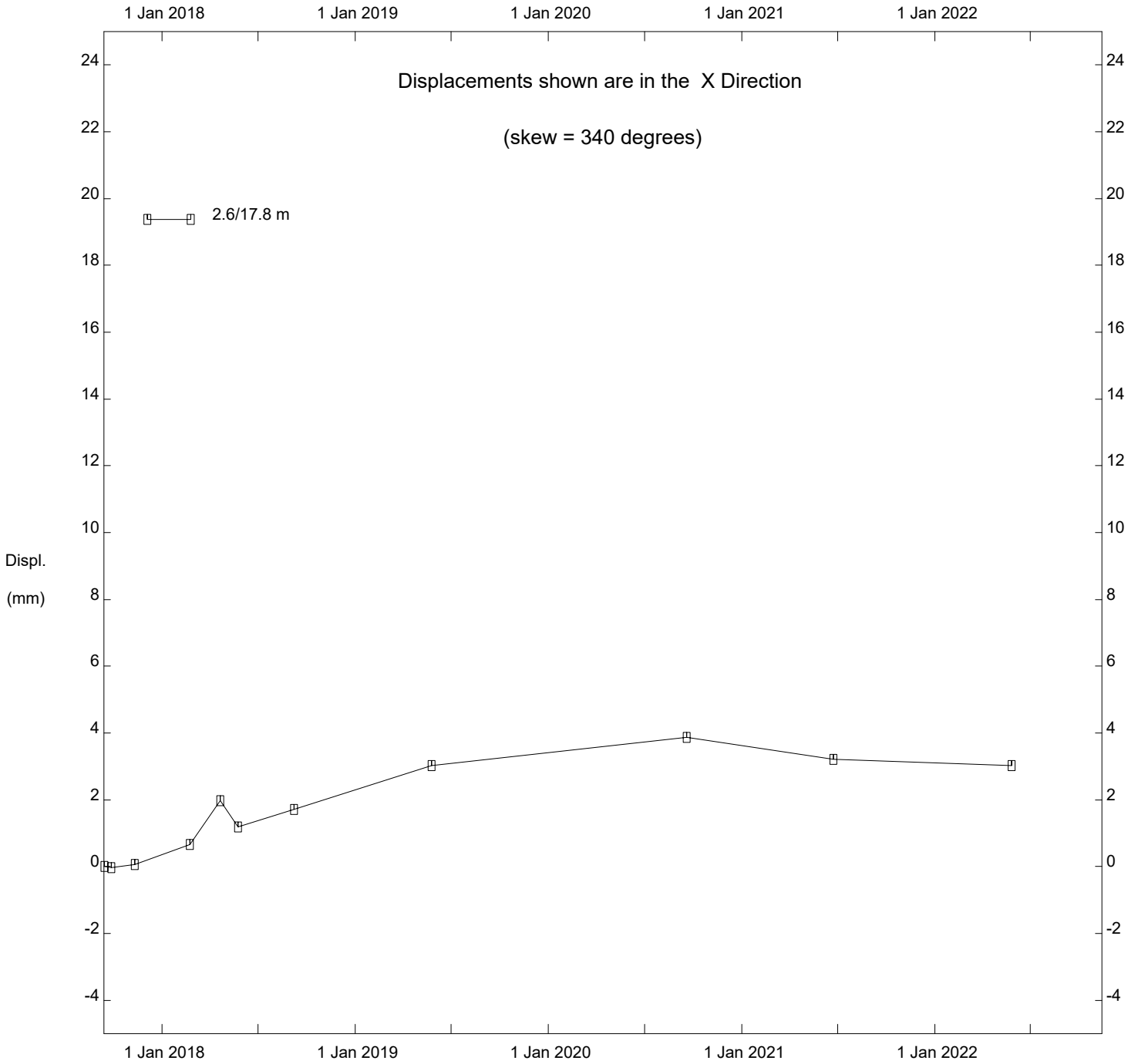
Thurber Engineering Ltd



Hwy 41:23 Kehiwin Lake (NC104), Inclinometer SI17-1(P130)

Alberta Transportation

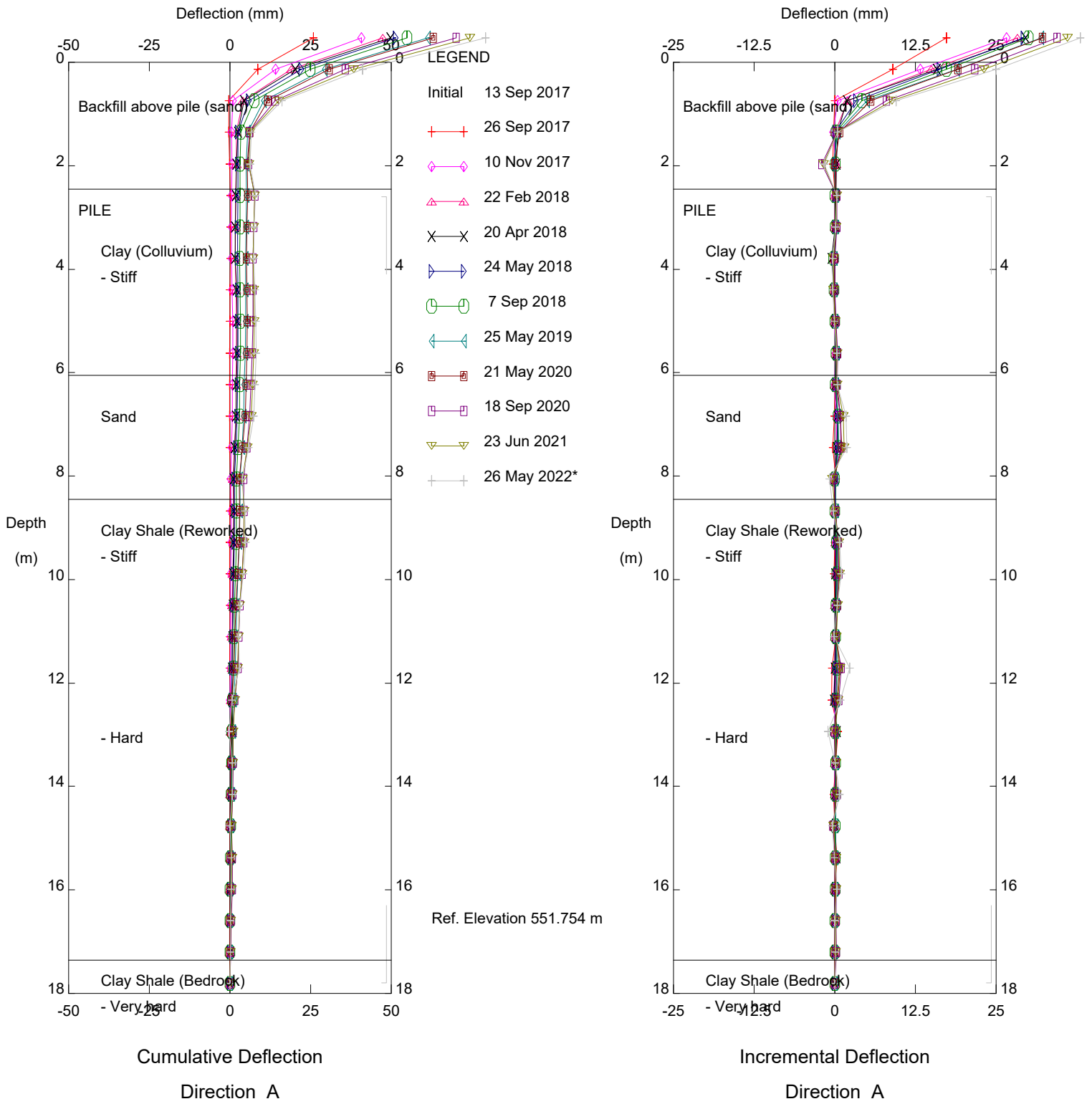
Thurber Engineering Ltd



Hwy 41:23 Kehiwin Lake (NC104), Inclinator SI17-1(P130)

Alberta Transportation

Thurber Engineering Ltd

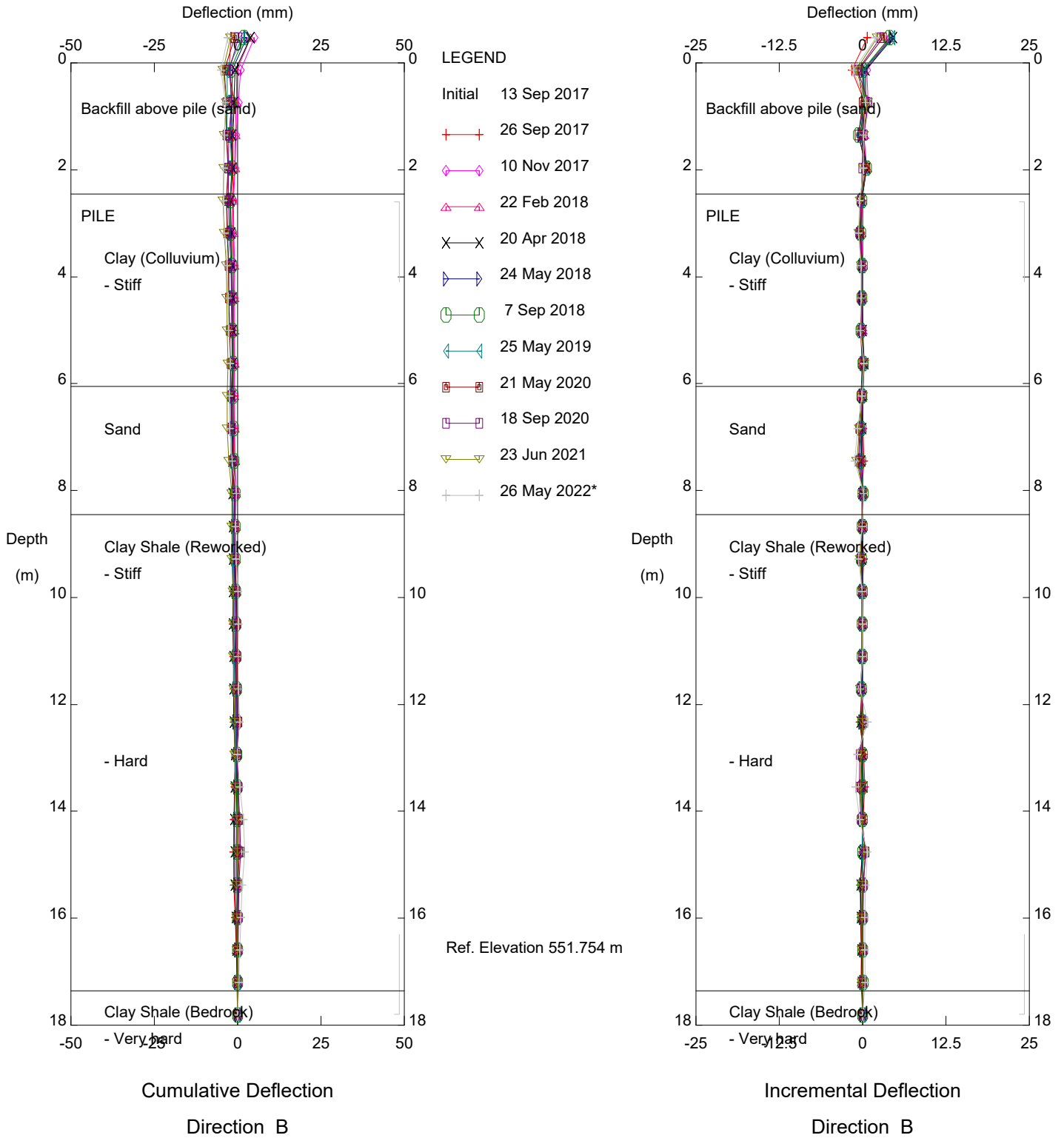


Hwy 41:23 Kehiwin Lake (NC104), Inclinometer SI17-2(P160)

Alberta Transportation

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

Thurber Engineering Ltd



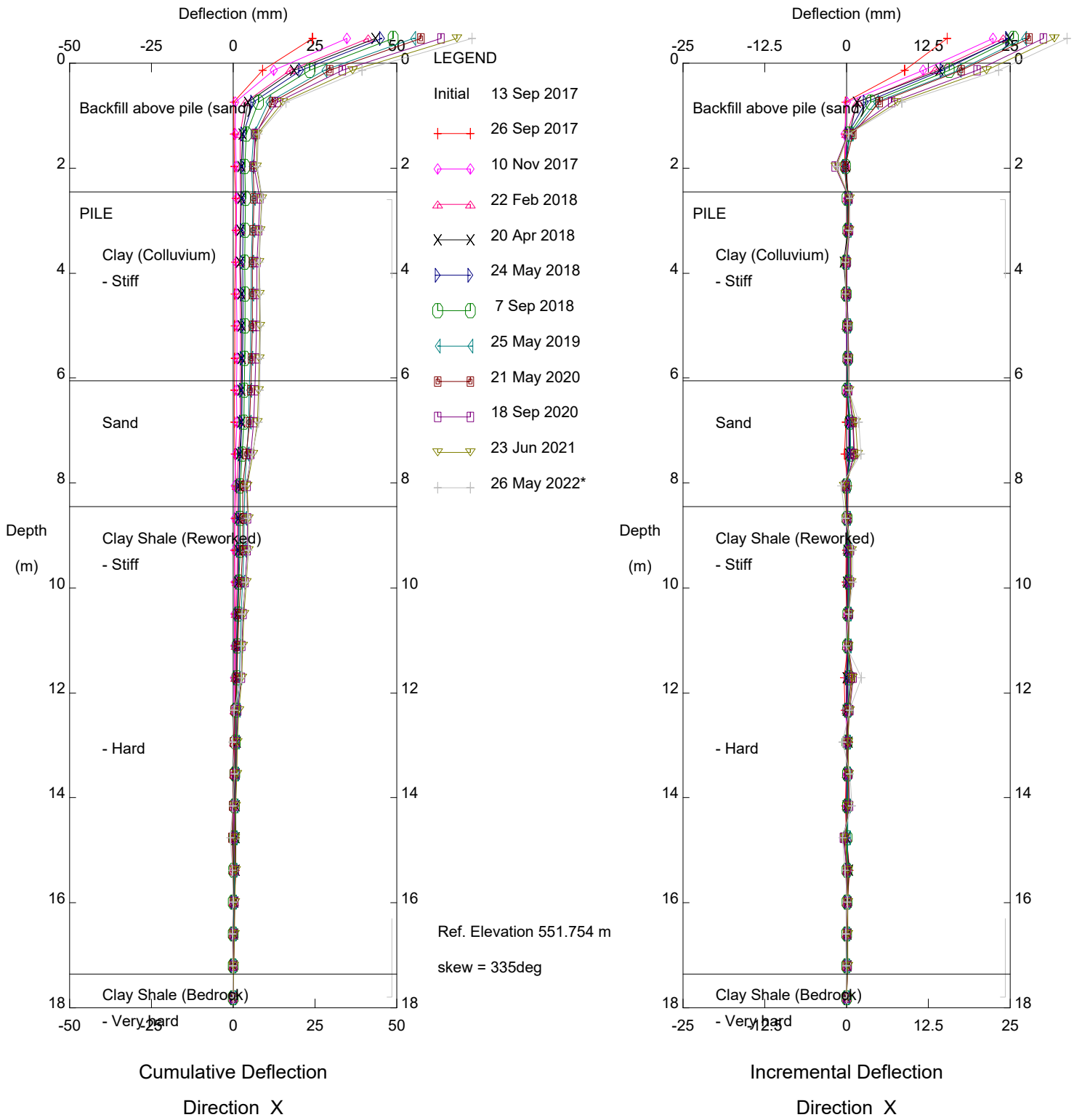
Hwy 41:23 Kehiwin Lake (NC104), Inclinometer SI17-2(P160)

Alberta Transportation

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



Thurber Engineering Ltd

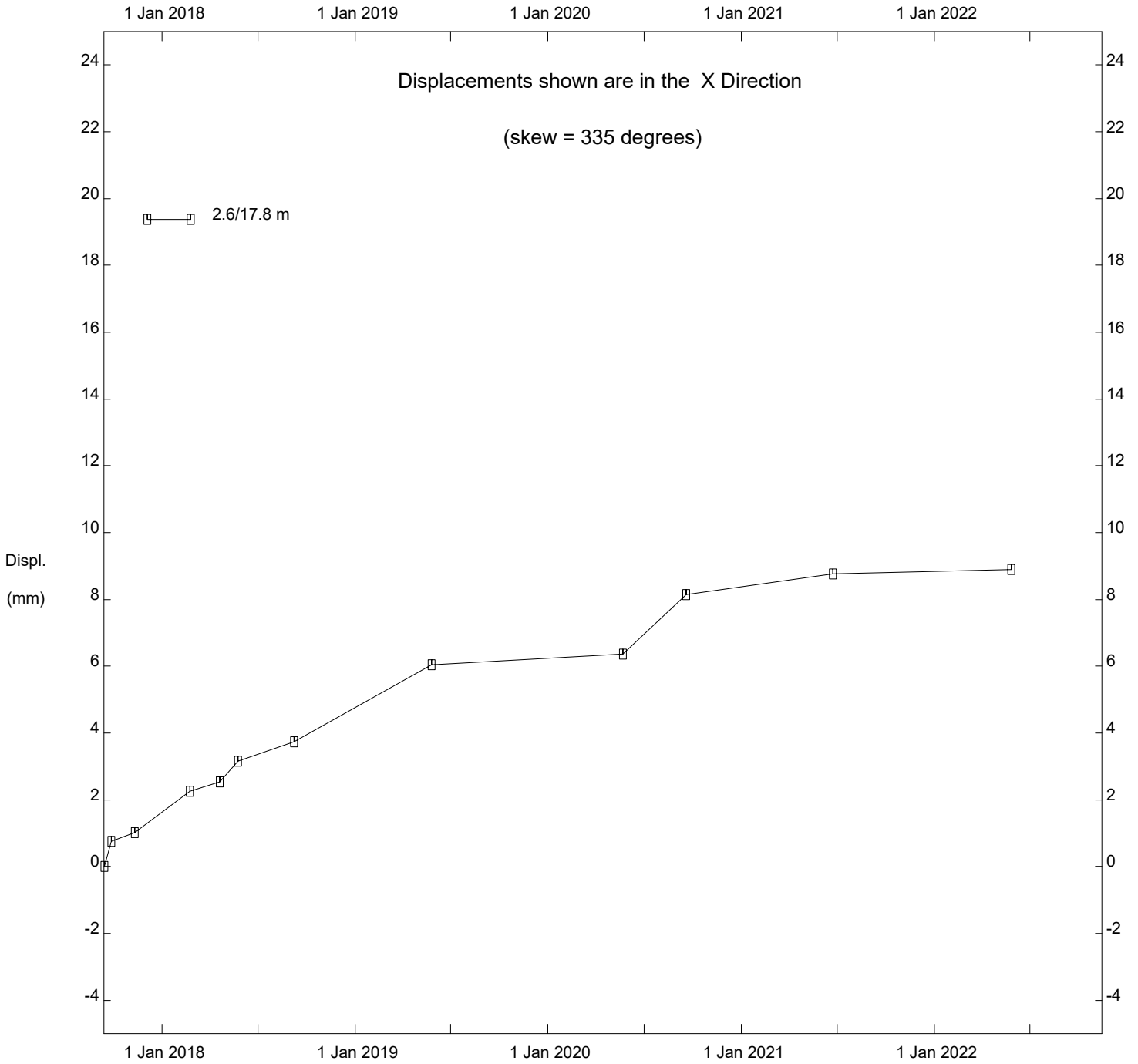


Hwy 41:23 Kehiwin Lake (NC104), Inclinometer SI17-2(P160)

Alberta Transportation

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

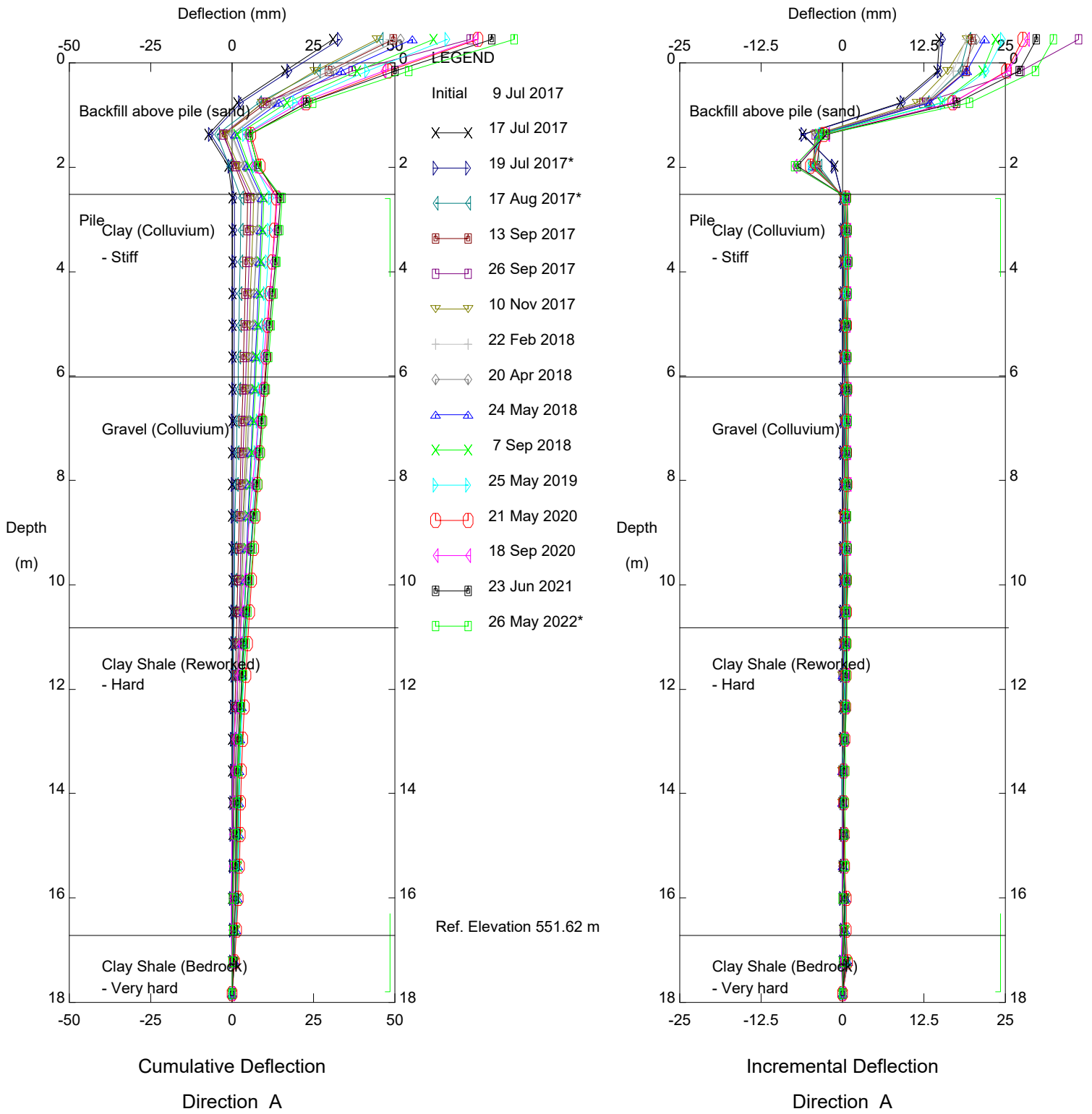
Thurber Engineering Ltd



Hwy 41:23 Kehiwin Lake (NC104), Inclinator SI17-2(P160)

Alberta Transportation

Thurber Engineering Ltd

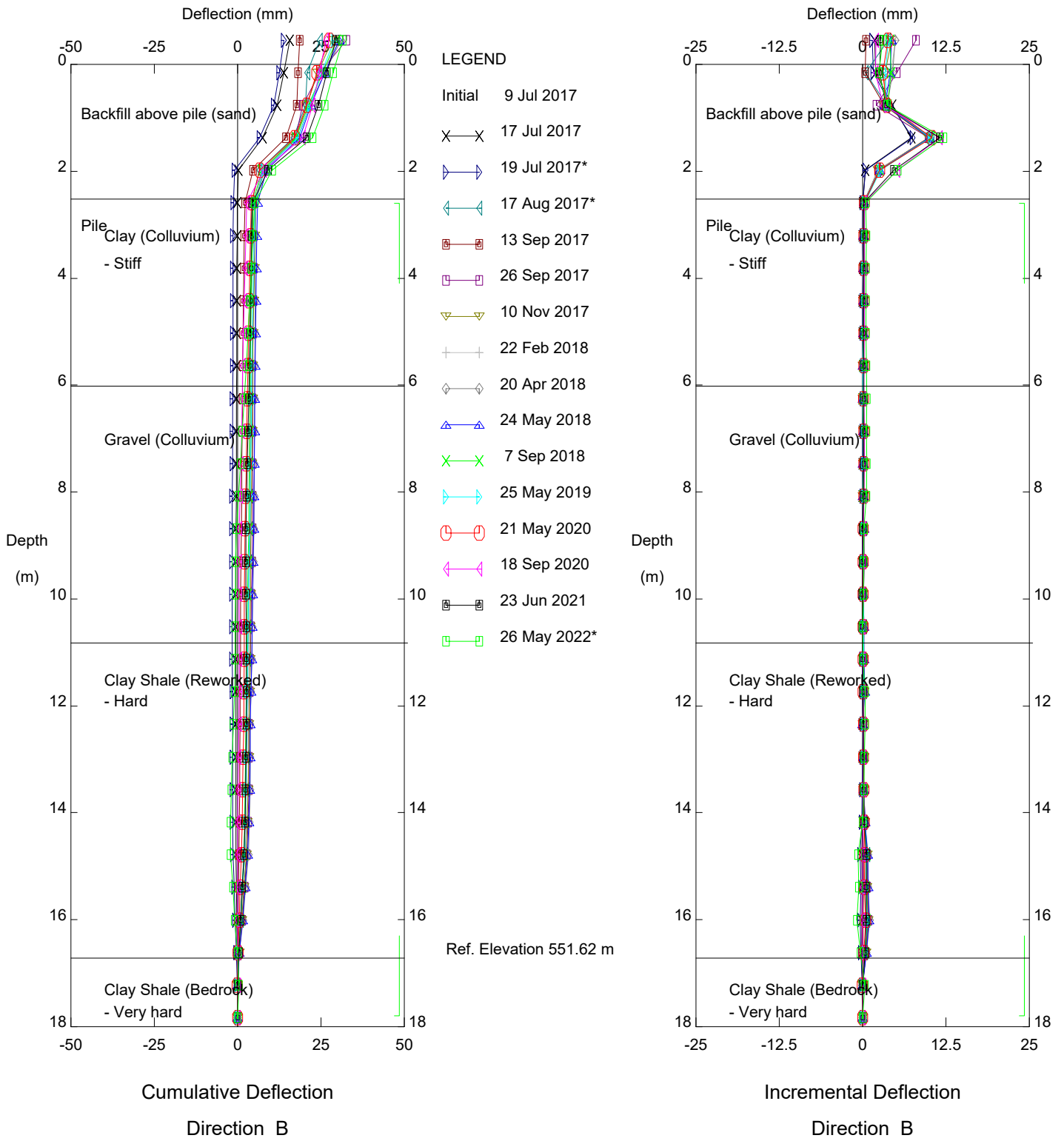


Hwy 41:23 Kehiwin Lake (NC104), Inclinometer SI17-3(P173)

Alberta Transportation

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

Thurber Engineering Ltd

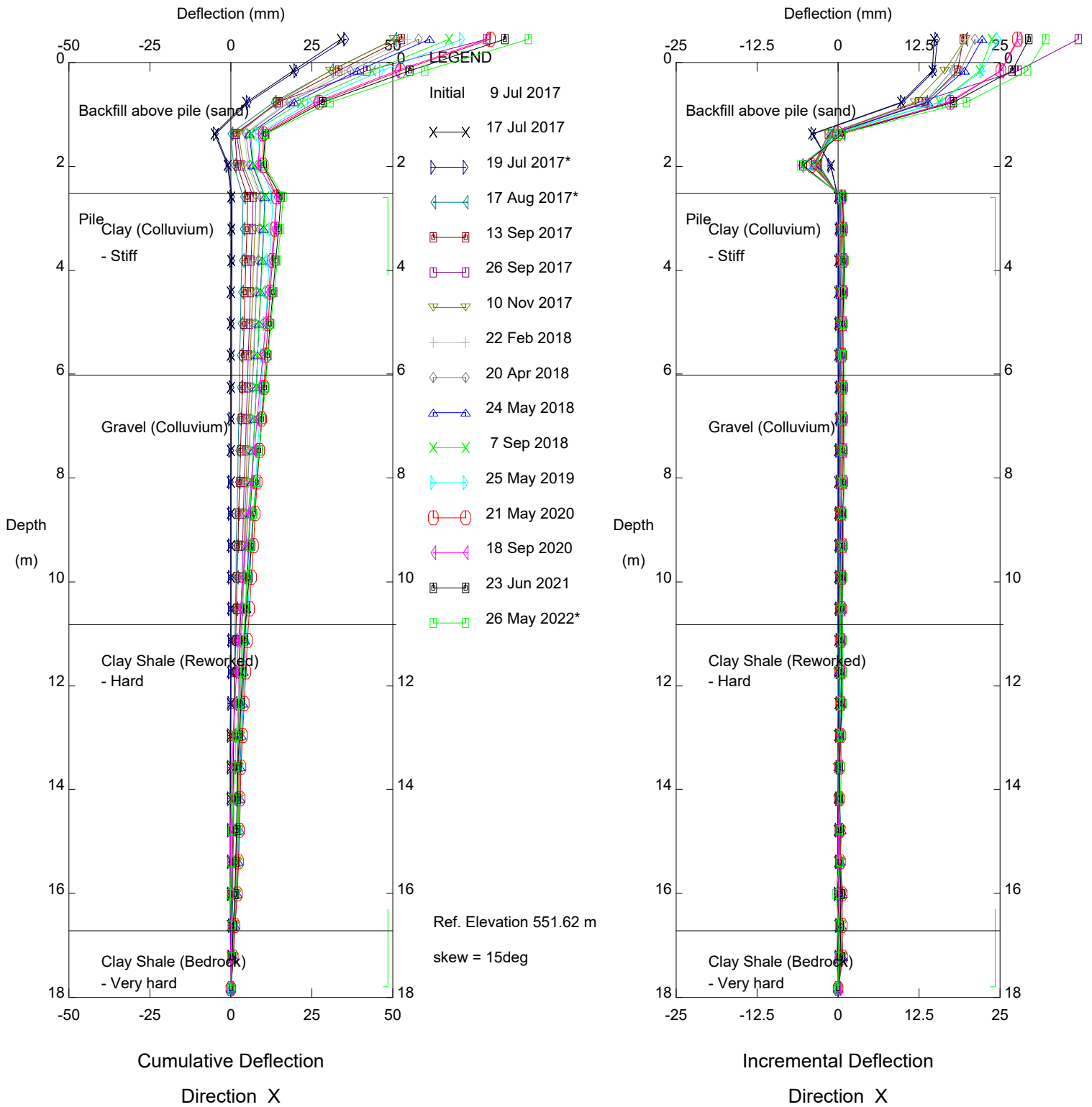


Hwy 41:23 Kehiwin Lake (NC104), Inclinometer SI17-3(P173)

Alberta Transportation

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

Thurber Engineering Ltd

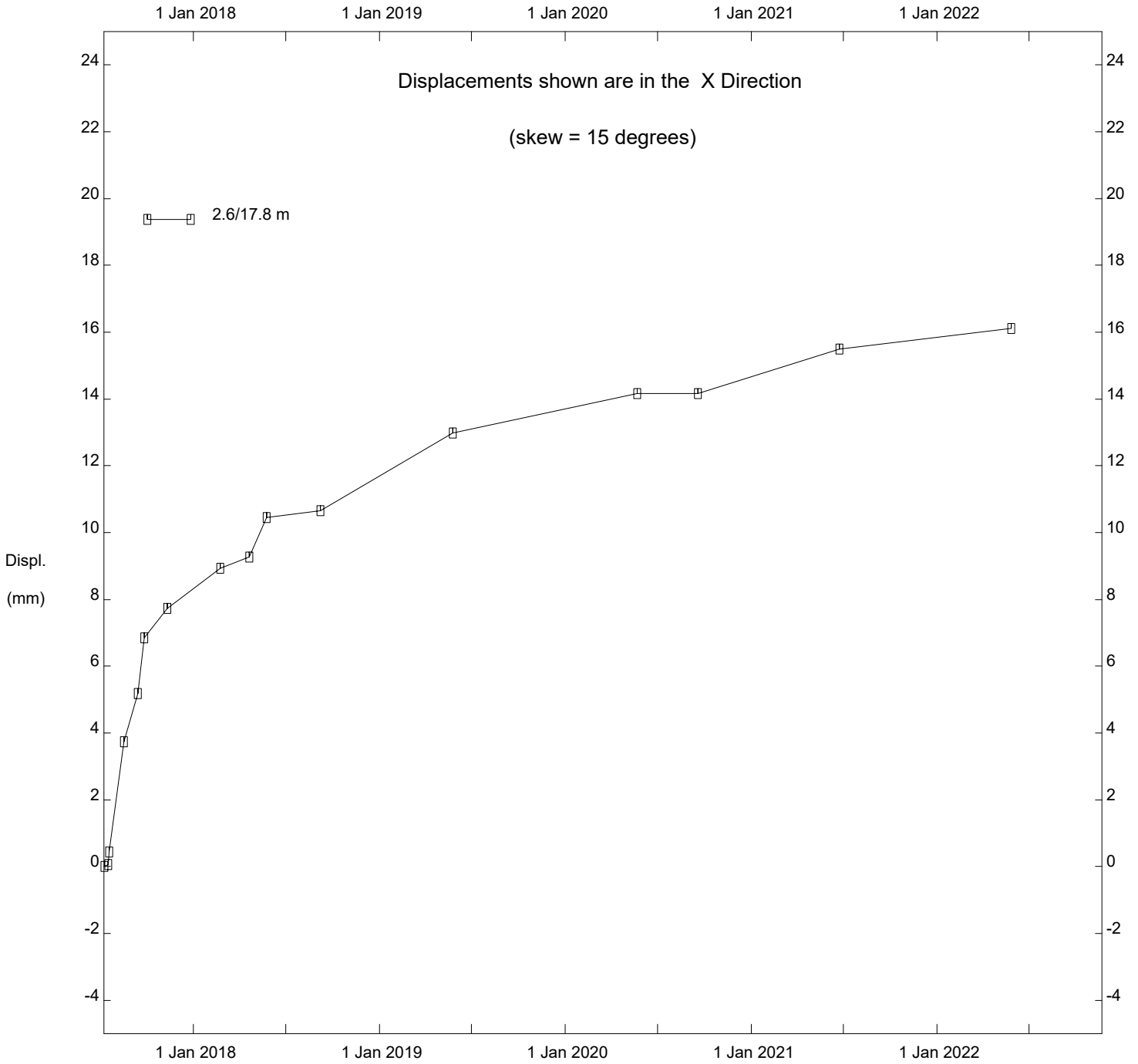


Hwy 41:23 Kehiwin Lake (NC104), Inclinometer SI17-3(P173)

Alberta Transportation

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

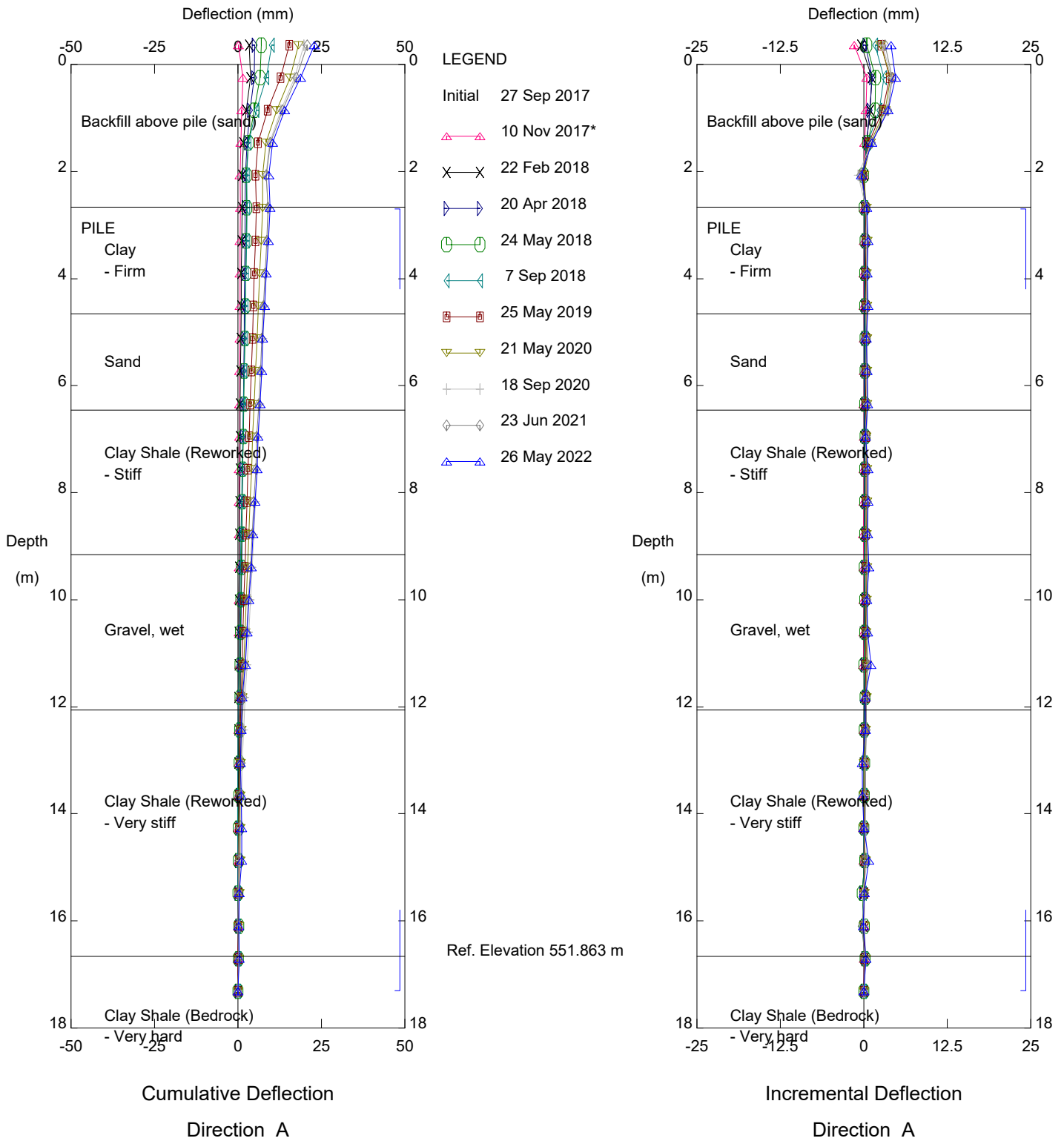
Thurber Engineering Ltd



Hwy 41:23 Kehiwin Lake (NC104), Inclinator SI17-3(P173)

Alberta Transportation

Thurber Engineering Ltd

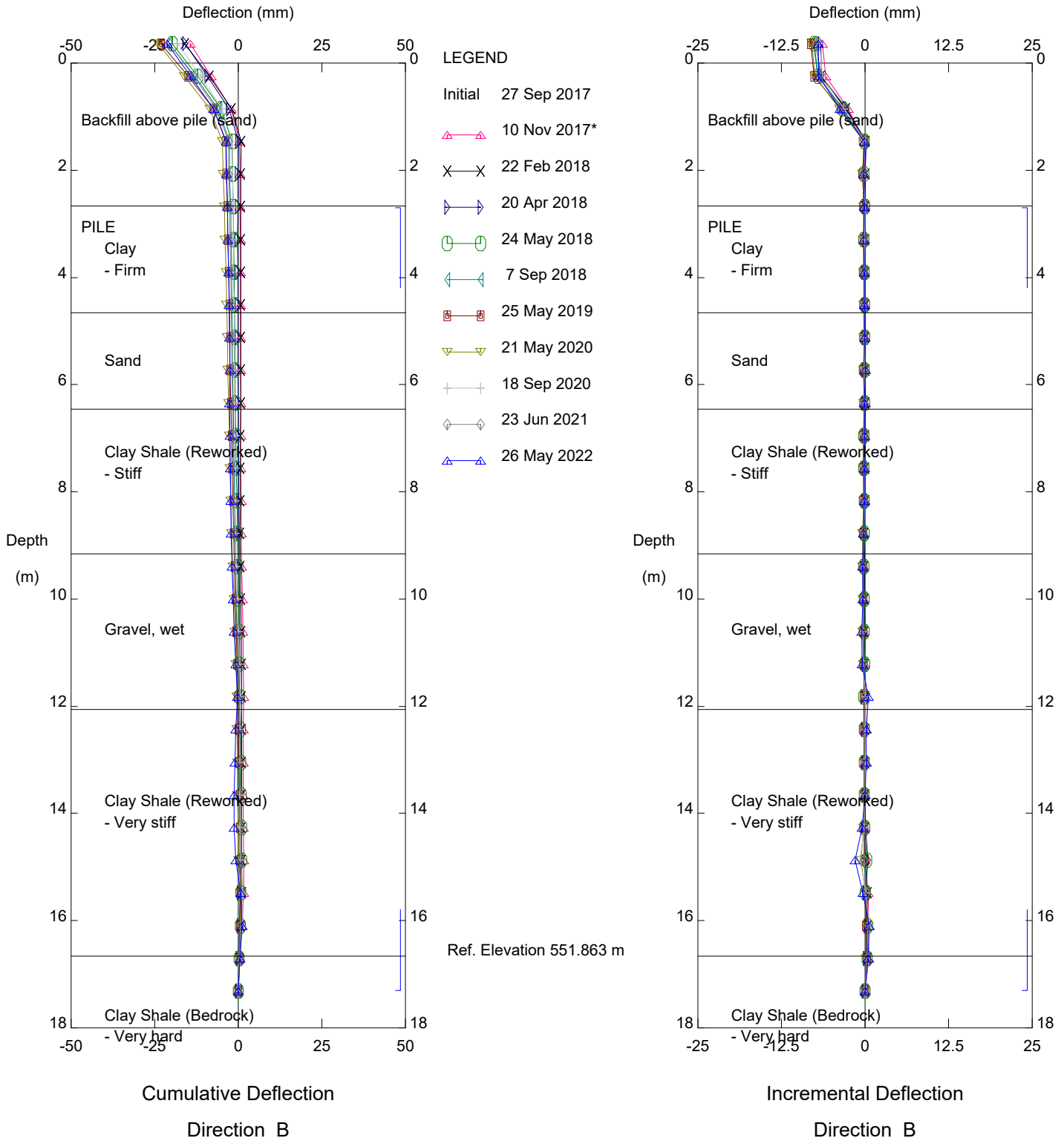


Hwy 41:23 Kehiwin Lake (NC104), Inclinator SI17-4(P186)

Alberta Transportation

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

Thurber Engineering Ltd



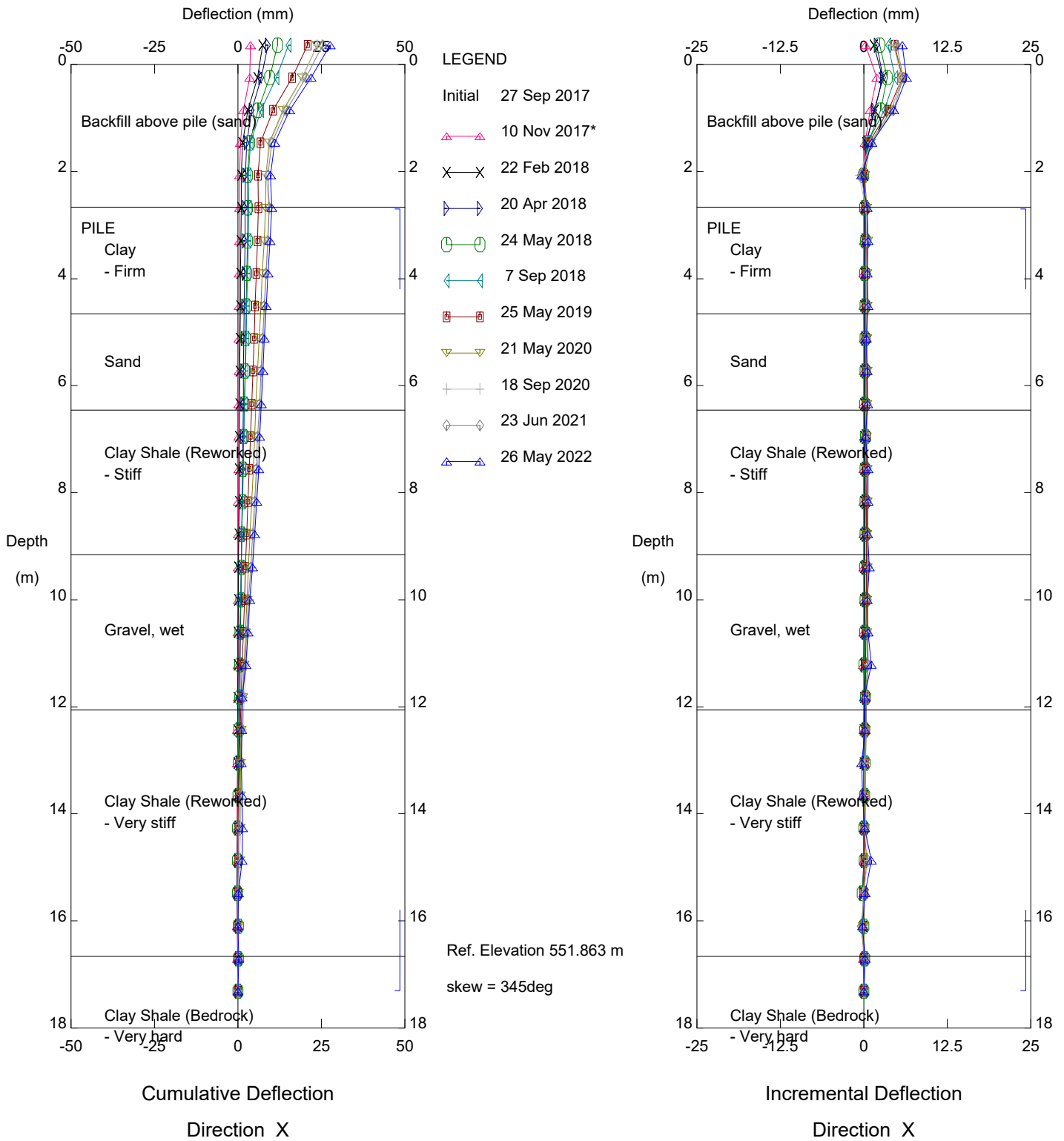
Hwy 41:23 Kehiwin Lake (NC104), Inclinometer SI17-4(P186)

Alberta Transportation

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



Thurber Engineering Ltd

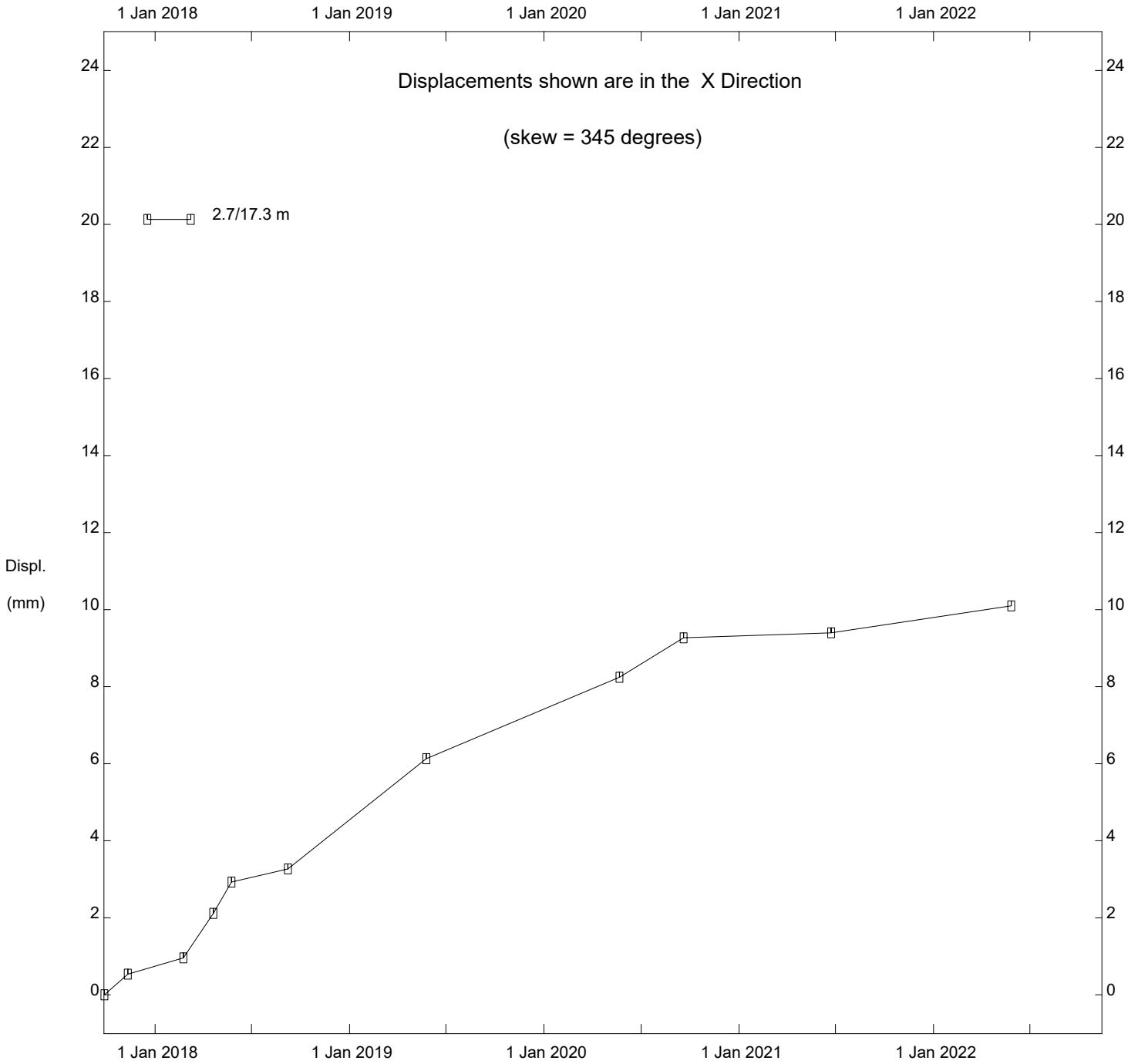


Hwy 41:23 Kehiwin Lake (NC104), Inclinometer SI17-4(P186)

Alberta Transportation

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

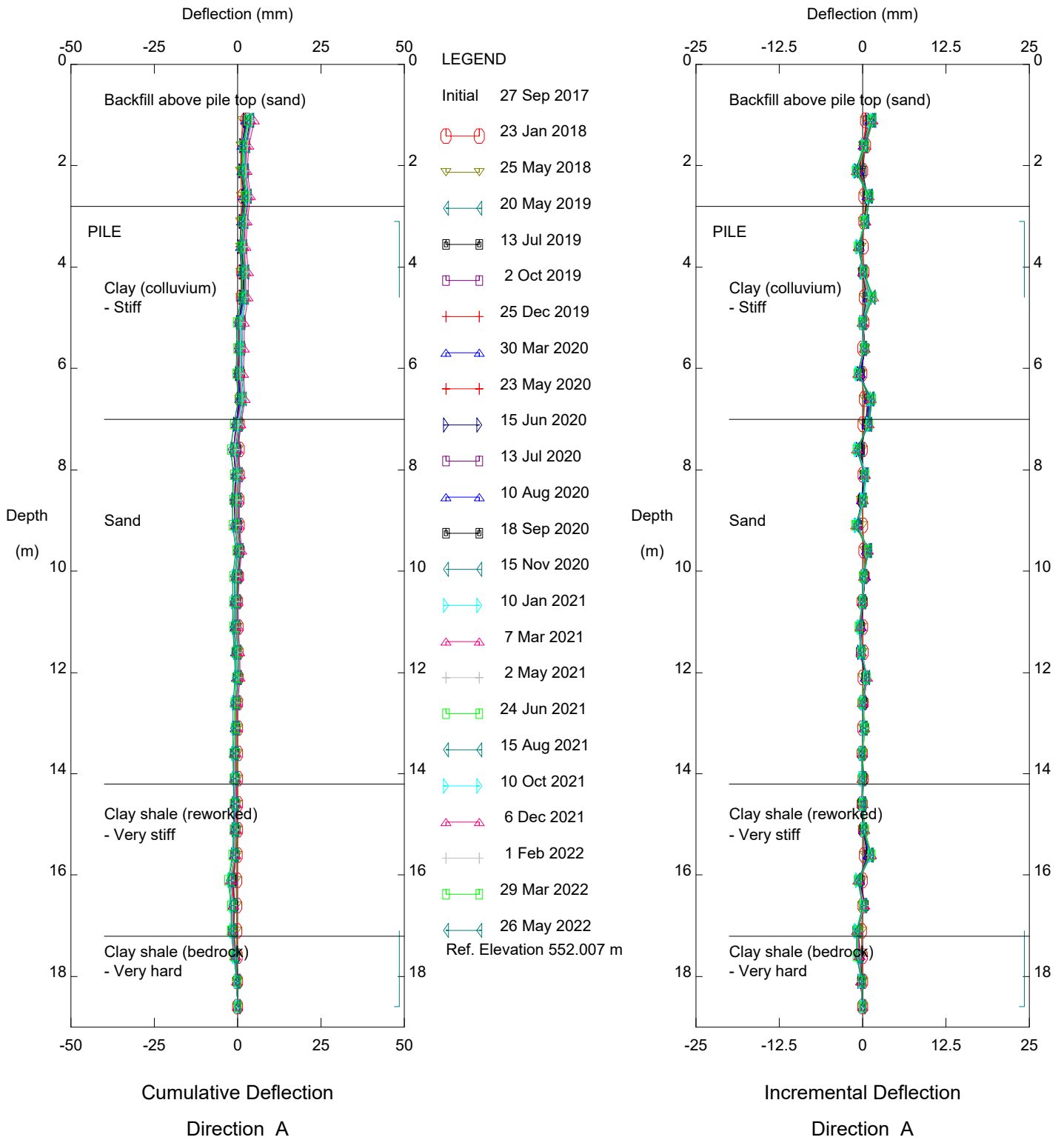
Thurber Engineering Ltd



Hwy 41:23 Kehiwin Lake (NC104), Inclinator SI17-4(P186)

Alberta Transportation

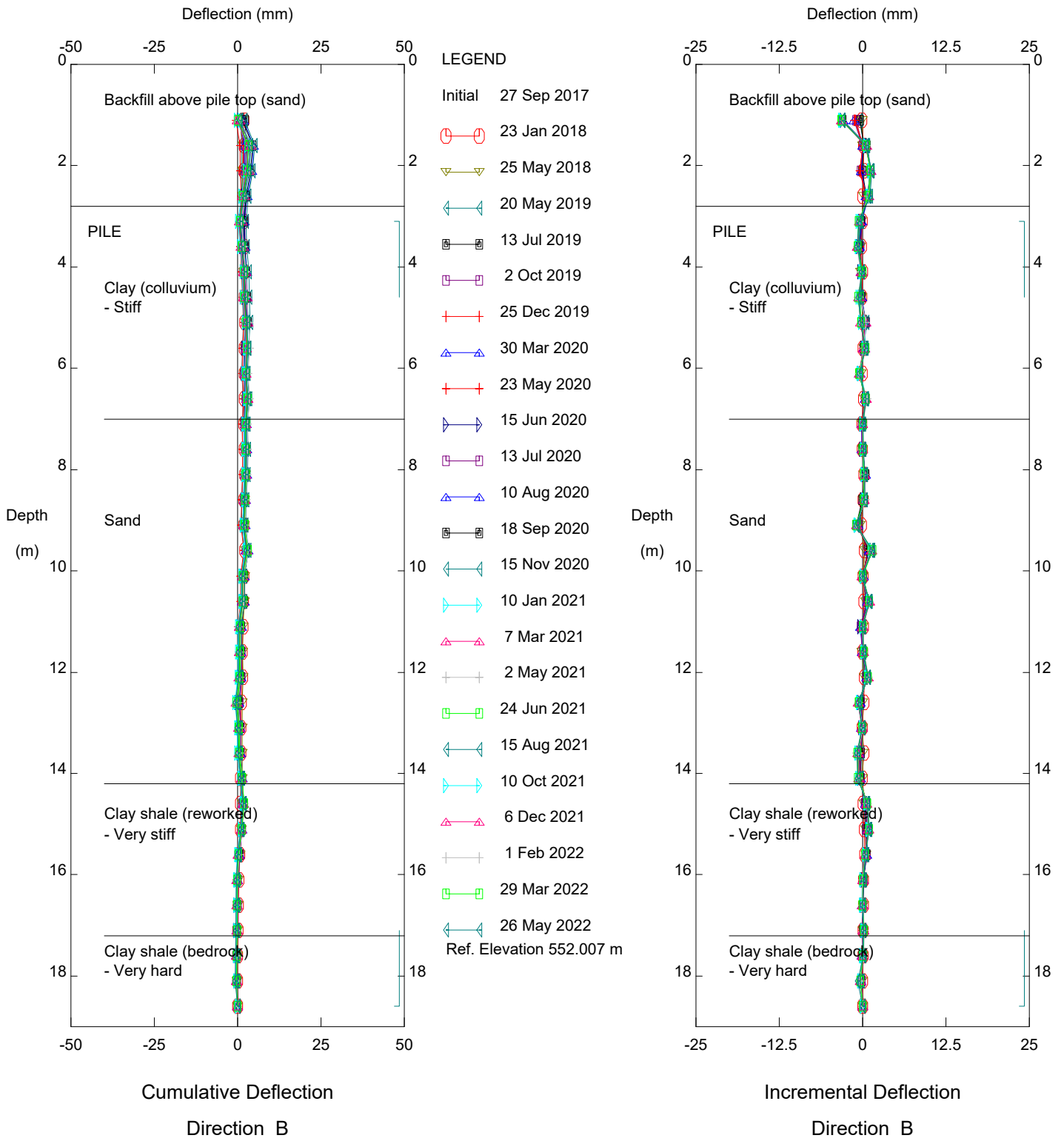
Thurber Engineering Ltd



Hwy 41:23 Kehiwin Lake (NC104), Inclinator SAA17-1(P146)

Alberta Transportation

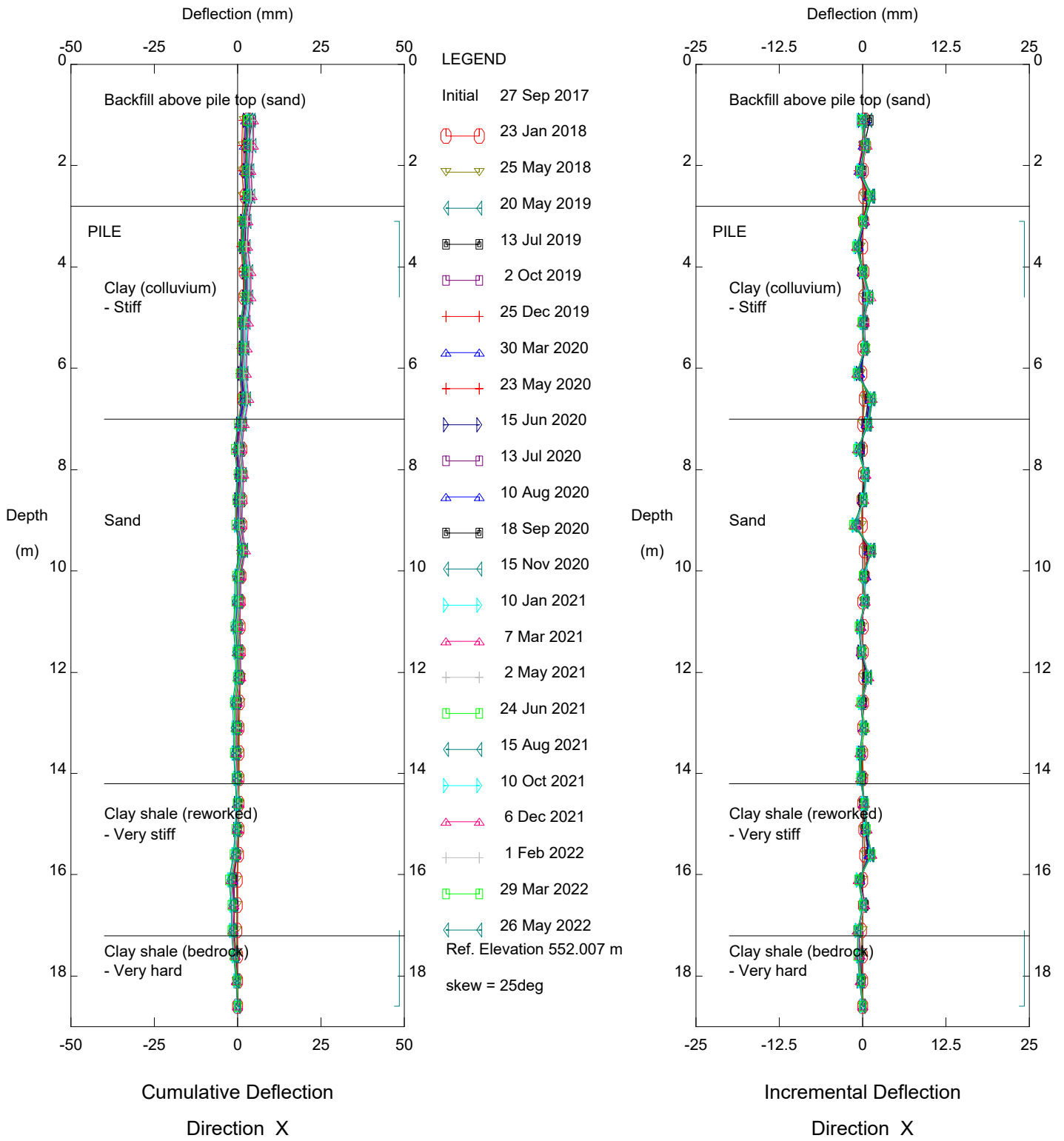
Thurber Engineering Ltd



Hwy 41:23 Kehiwin Lake (NC104), Inclinometer SAA17-1(P146)

Alberta Transportation

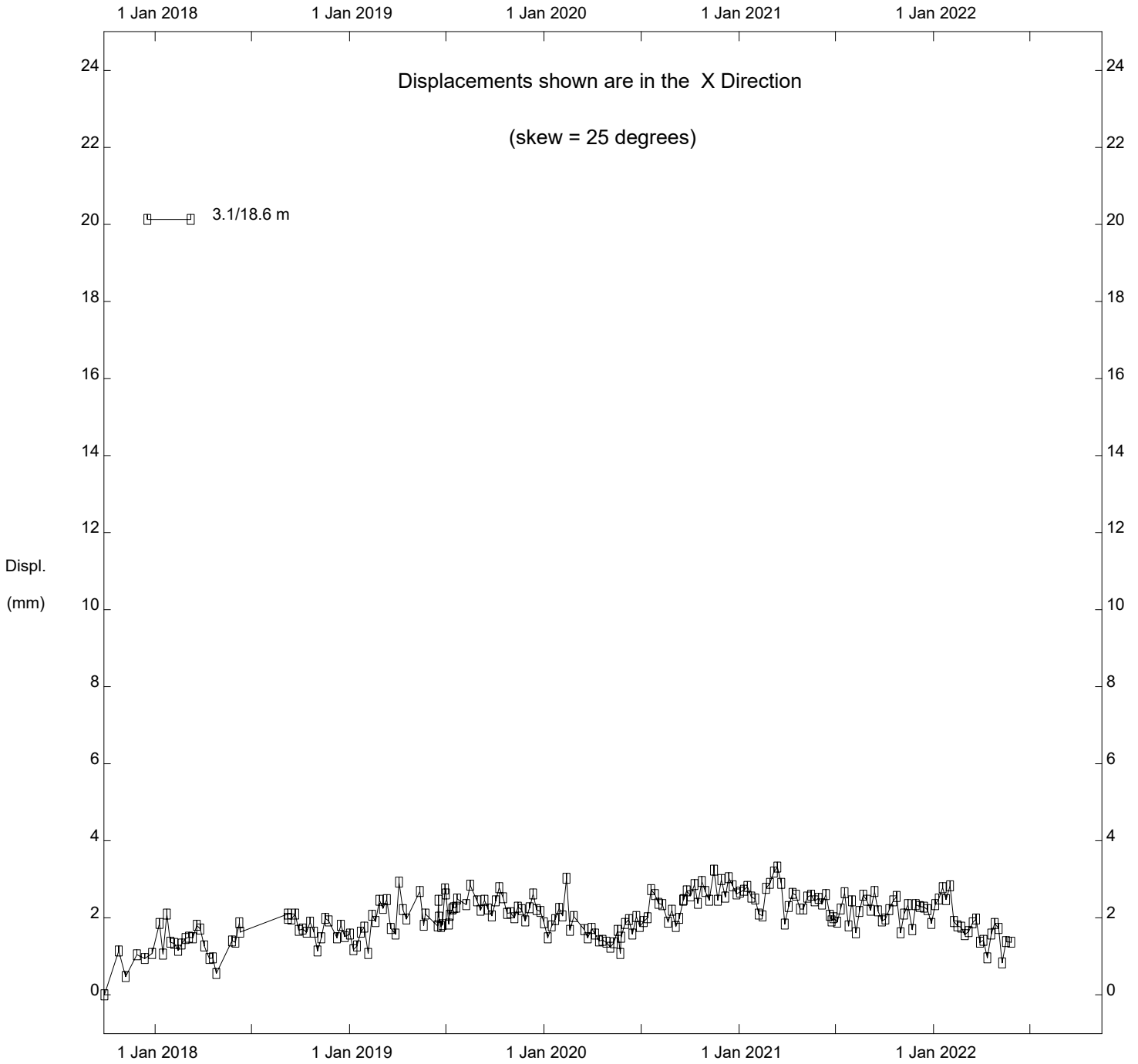
Thurber Engineering Ltd



Hwy 41:23 Kehiwin Lake (NC104), Inclinometer SAA17-1(P146)

Alberta Transportation

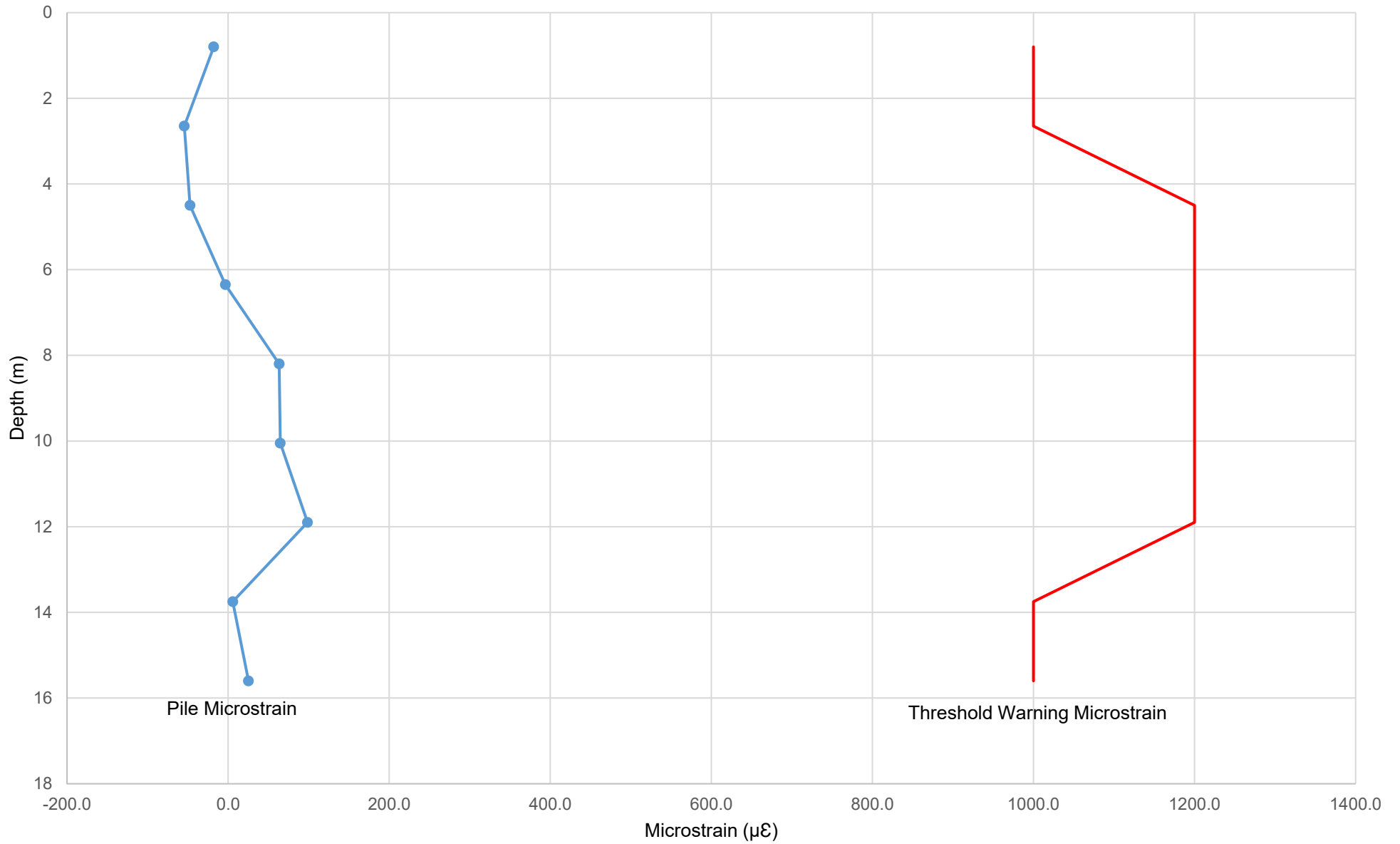
Thurber Engineering Ltd



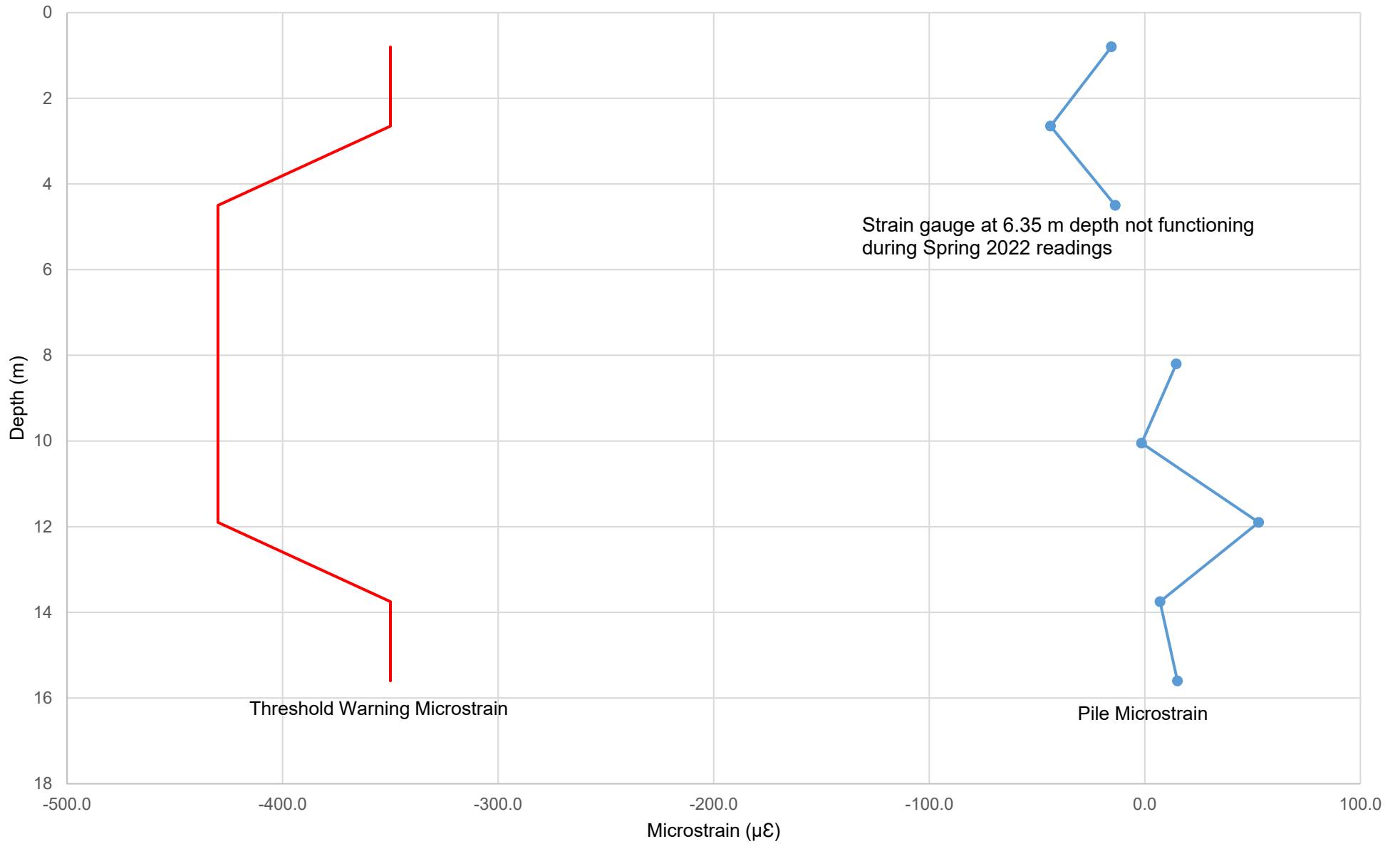
Hwy 41:23 Kehiwin Lake (NC104), Inclinator SAA17-1(P146)

Alberta Transportation

**FIGURE NC104-1  
STRAIN GAUGE DATA FOR HWY 41:23, KEHIWIN LAKE (KM 7.7) - PILE P146 UPSLOPE**

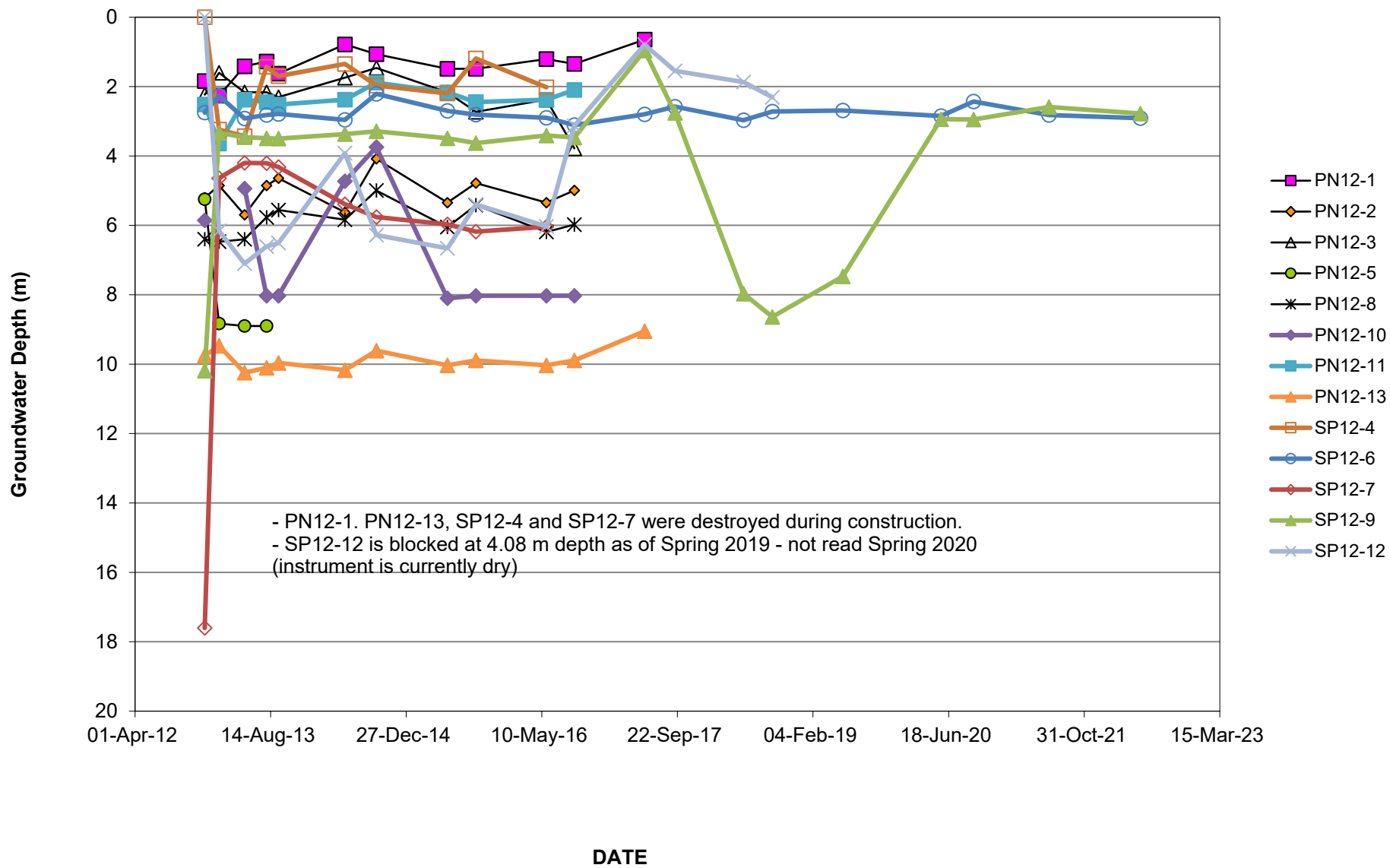


**FIGURE NC104-2**  
**STRAIN GAUGE DATA FOR HWY 41:23, KEHIWIN LAKE (KM 7.7) - PILE P146 DOWNSLOPE**

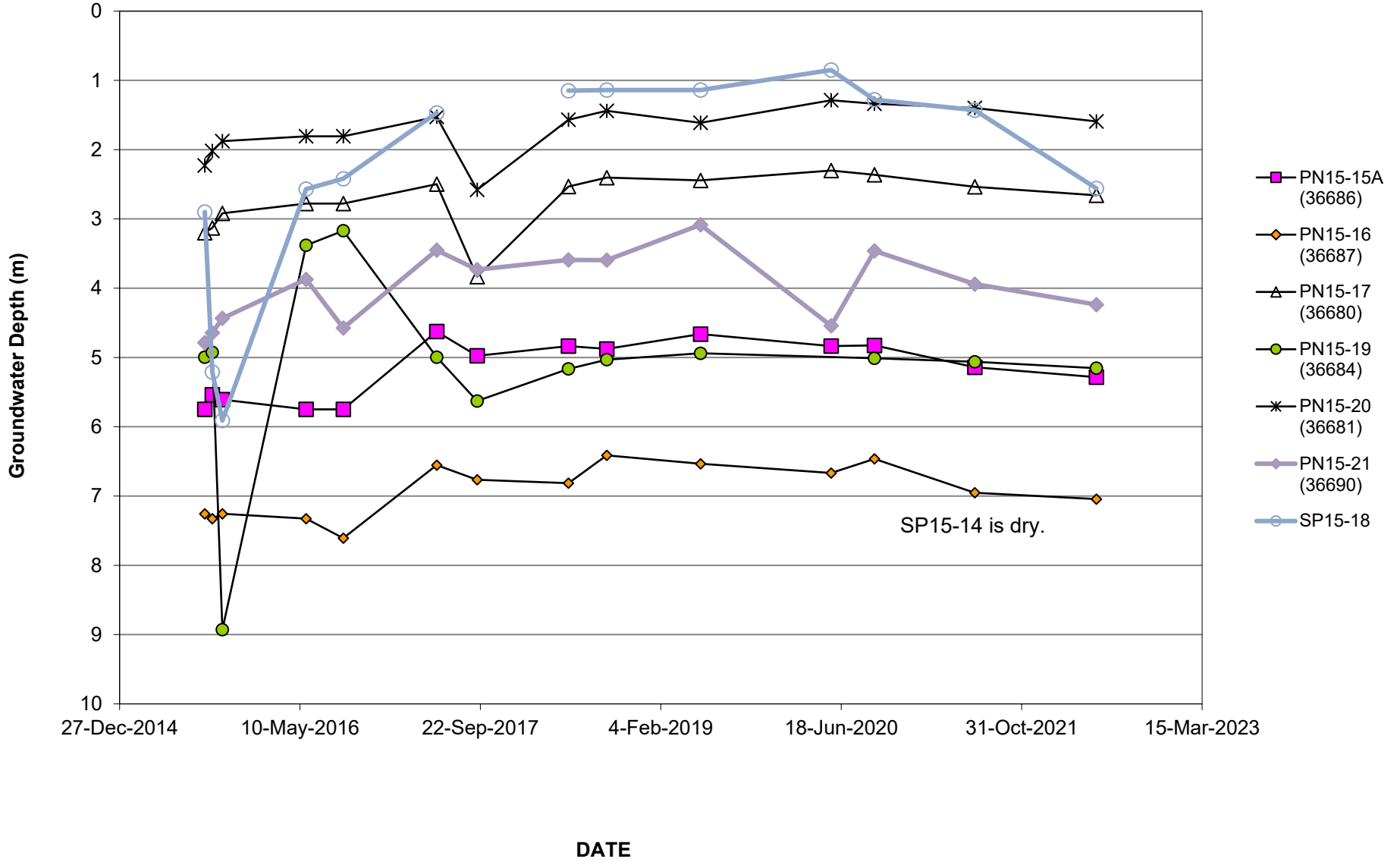




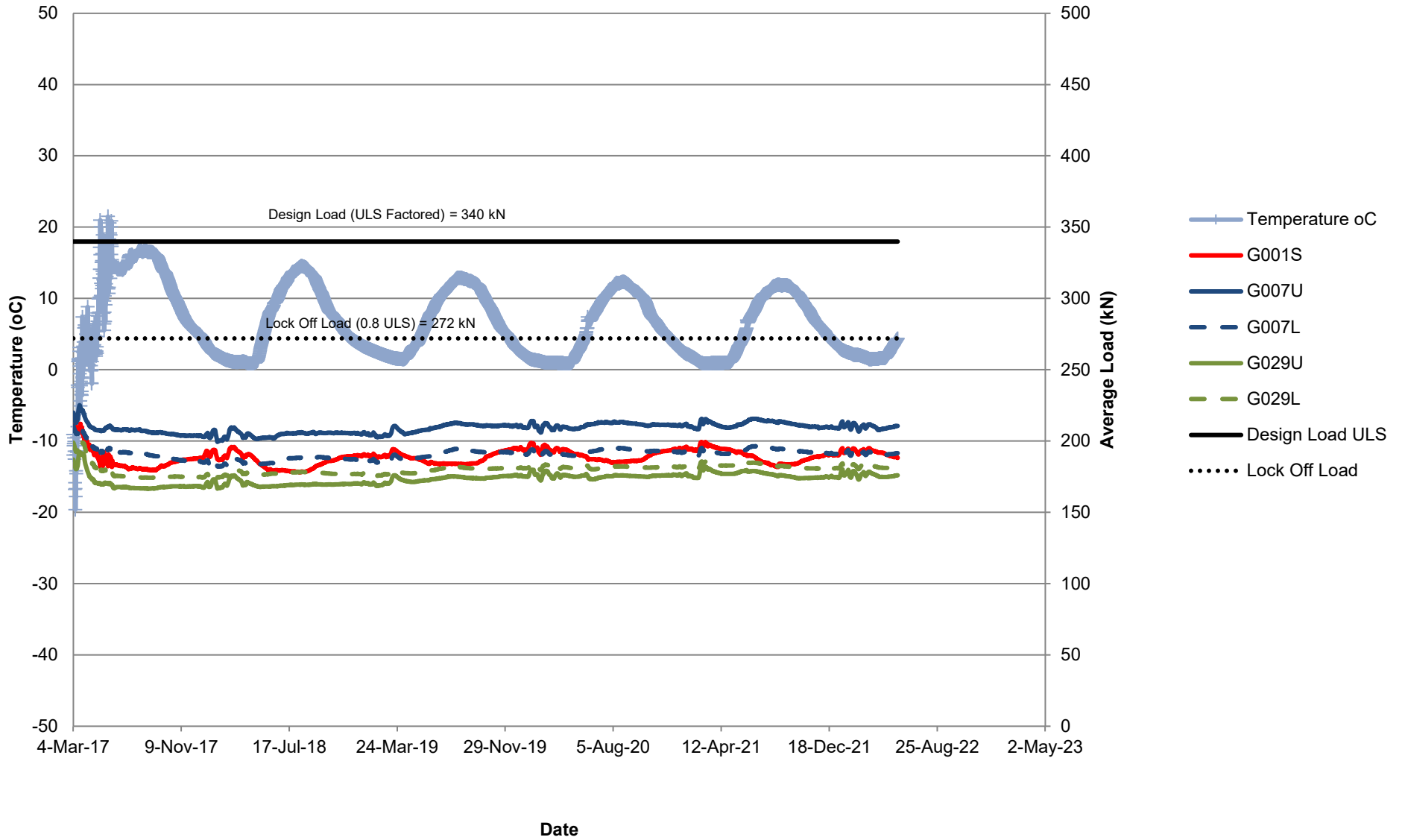
**FIGURE NC104-3  
PIEZOMETER DATA FOR HWY 41:23, KEHIWIN LAKE (KM 7.7)**



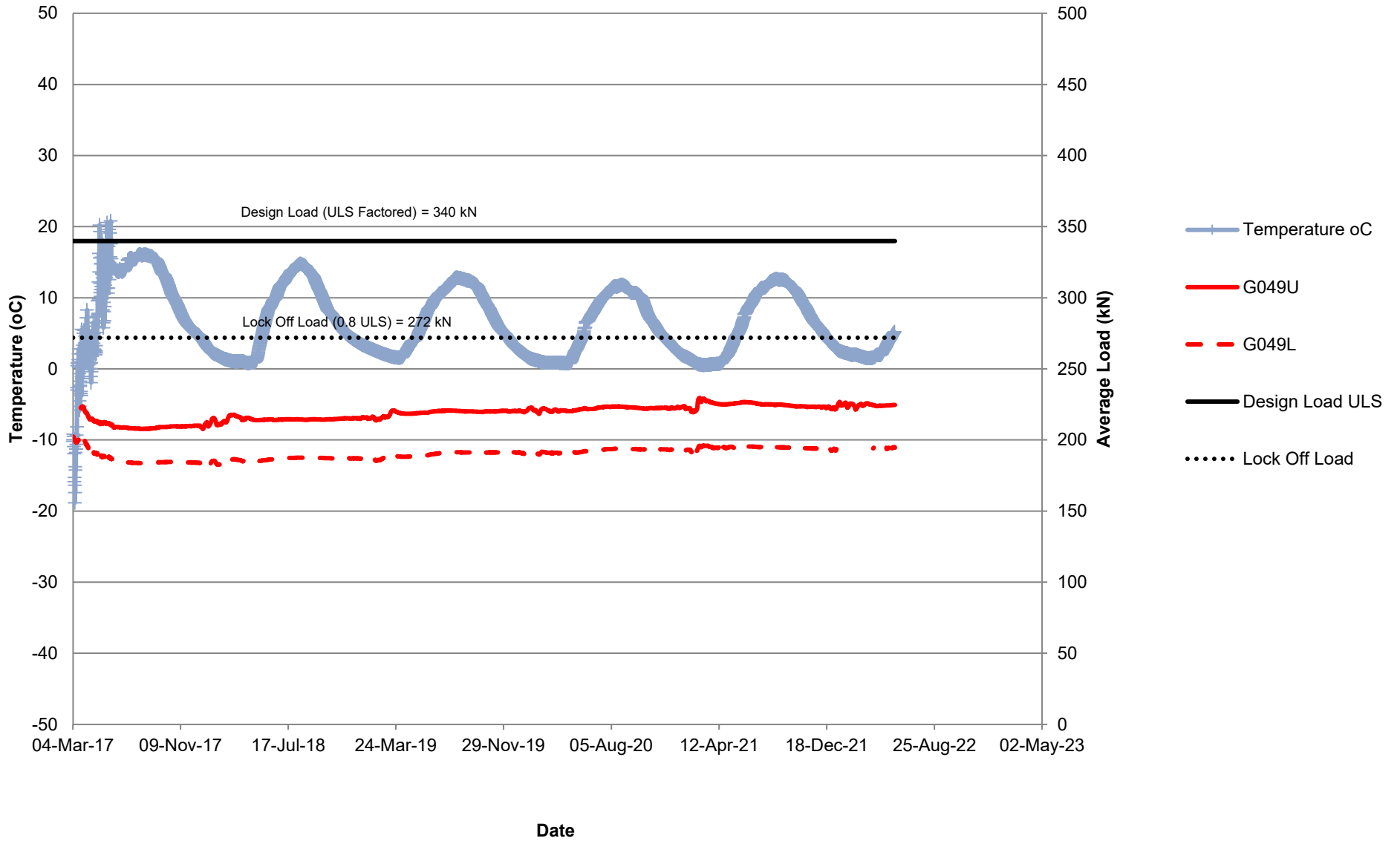
**FIGURE NC104-4  
PIEZOMETER DATA FOR HWY 41:23, KEHIWIN LAKE (KM 7.7) - 2015 INSTRUMENTS**



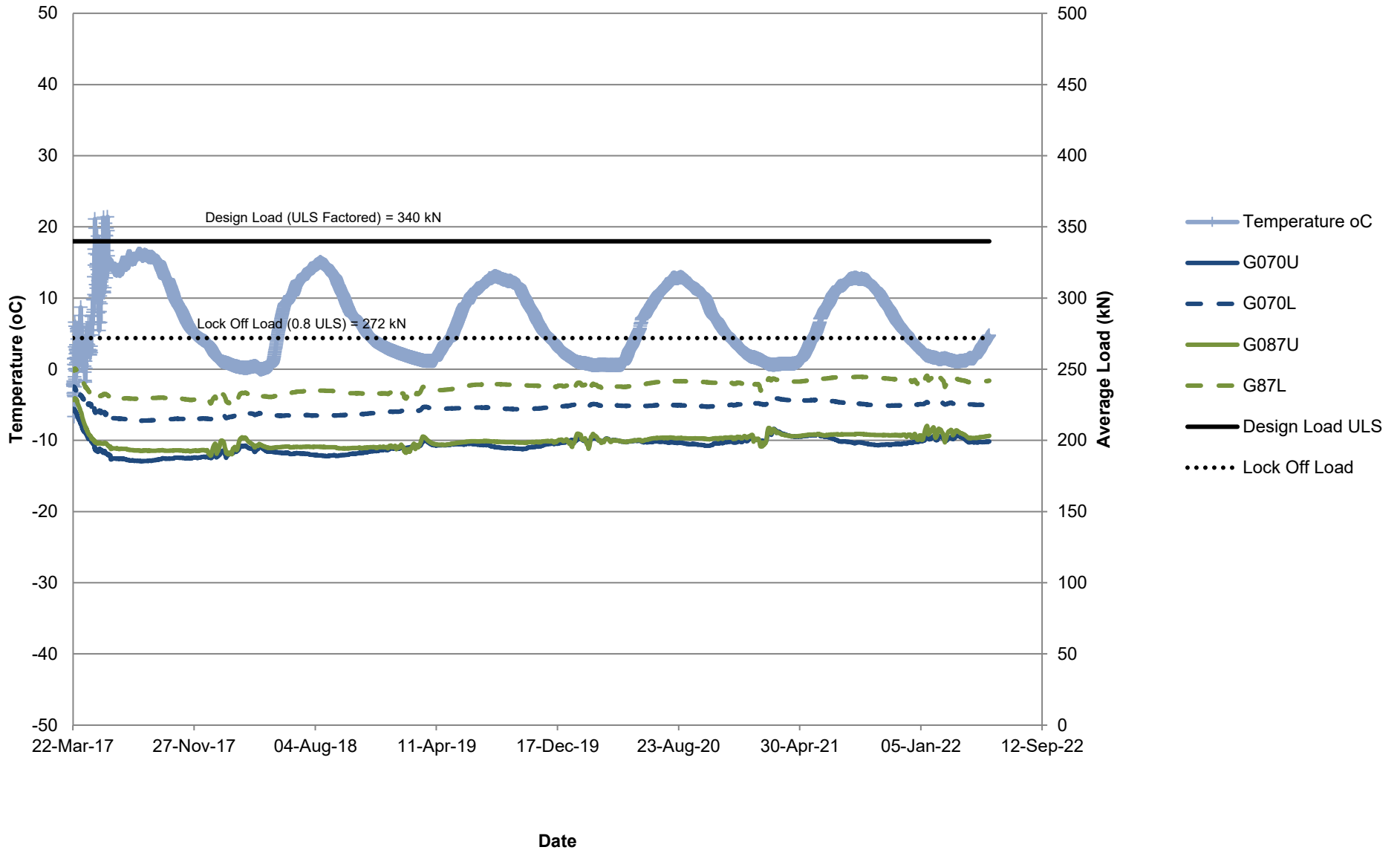
**FIGURE NC104-5**  
**LOAD CELL DATA FOR HWY 41:23, KEHIWIN LAKE (KM 7.7) - WALL SEGMENT 1**



**FIGURE NC104-6  
LOAD CELL DATA FOR HWY 41:23, KEHIWIN LAKE (KM 7.7) - WALL SEGMENT 2**



**FIGURE NC104-7**  
**LOAD CELL DATA FOR HWY 41:23, KEHIWIN LAKE (KM 7.7) - WALL SEGMENT 3**



**FIGURE NC104-8**  
**LOAD CELL DATA FOR HWY 41:23, KEHIWIN LAKE (KM 7.7) - WALL SEGMENT 4**

