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To:	Amy Driessen Alberta Transportation	From:	Leslie Cho and Xiteng Liu Stantec Consulting Ltd.
File:	123315222	Date:	October 5, 2022

Reference: North Central Region, Stony Plain, Site NC052 - Highway 621:02 Pembina River Bridge Abutment, Fall 2022 Instrumentation Monitoring Report

1.0 OBSERVATIONS

1.1 FIELD PROGRAM AND INSTRUMENTATION STATUS

The Fall 2022 reading cycle consisted of instrument readings of three slope inclinometers (SI-1, SI-2, and SI13-3), two pneumatic piezometers (PN-01 and PN-02), one vibrating wire piezometer (VW13-3), one standpipe piezometer (SP13-3A). Tiltmeter TE2 would not connect to the laptop when collection of the readings was attempted. The site plan is shown on **Figure 1** attached. The instrument readings were taken by Sonja Pharand, E.I.T. and Brian Qin, E.I.T. on September 9, 2022.

The slope inclinometers (SI) were measured using an RST MEMS digital inclinometer probe with 0.5 m increments and handheld PC. Readings were taken based on cable markings in relation to the top of SI casing. The pneumatic piezometers (PN) were read with an RST Instruments C-109 Pneumatic Readout. The vibrating wire piezometers (VW) were read with an RST VW2106 readout box. Standpipe piezometers (SP) were read with a Heron Instruments water tape.

GPS coordinates of all instruments were obtained using a Garmin GPSmap 60Cx handheld GPS unit.

2.0 INSTRUMENTATION READINGS

2.1 GENERAL

SI plots are attached and summarized in the following sections. Displacement-time plots in the resultant x-direction (i.e., slope movement direction) along with movement rates, total cumulative movement, maximum movement rates, and incremental movements since initializing each SI are provided in **Table NC052-1** and the attachments.

The groundwater levels from PN, VWP and SP readings are plotted in the attachments and summarized in **Table NC052-2.**

2.2 ZONES OF MOVEMENT

No new zones of movement were observed in the SIs. **Table NC052-1** summarizes existing zones of movement, total movement, depth of movement, and the maximum rate of movement since initializing each SI. Directions of movement are referenced to the azimuth of the A+ groove in each SI casing.

Reference: **North Central Region, Stony Plain, Site NC052 - Highway 621:02 Pembina River Bridge Abutment, Fall 2022 Instrumentation Monitoring Report**

2.3 MONITORING RESULTS

2.3.1 Slope Inclinometers

SI-1 shows negligible movement over the two zones of movement at about 3 m and 11 m depth. Total cumulative movement observed since 2006 is about 3 mm.

SI-2 shows negligible movement over the two zones of movement at about 8 m and 14 m depth.

SI13-3 has recorded about 6 mm of cumulative movement since 2014. The recorded movement is likely related to construction activities in winter 2014. Little to no movement was observed since 2015.

All slope inclinometers appear to show signs of creep movement except for SI13-3.

Table NC52-1 summarizes the slope inclinometer readings for the Fall 2022 reading cycle.

2.3.2 Piezometers

PN-01 continues to show artesian conditions with a water level about 1.8 m above ground surface, which remains within the trend in water levels since 2014.

PN-02 had artesian conditions until 2014 where the pore pressure decreased as a result of remedial work to relieve pore pressures in the east slope. The current water level is at 2.5 m below ground surface, consistent with historical trends since 2014.

VW13-3 showed a decrease in piezometric level by about 2.9 m since the previous reading cycle.

The water level in **SP13-3A** decreased by about 1.7 m after construction in winter 2014. The water level gradually increased to above pre-construction levels in May 2017. A 1.1 m drop was measured in September 2017 whereafter water levels increased again to above pre-construction levels until May 2020. Another significant drop in water levels was observed in September 2020. There appears to be a cycle developing where water levels increase for 2-3 years followed by a sharp drop in water levels. The current measured water level decreased by 1.2 m bgs from previous reading cycle.

Table NC52-2 summarizes the pneumatic, vibrating wire, and standpipe piezometer readings for the current reading cycle.

2.3.3 Tiltmeter

The tiltmeters were inactive due to battery failure during the 2021 Fall reading cycle. Stantec replaced the batteries on March 10, 2022. Only one tiltmeter (TE2) battery was replaced due to unsafe access over the ice to the other tiltmeters.

Reference: **North Central Region, Stony Plain, Site NC052 - Highway 621:02 Pembina River Bridge Abutment, Fall 2022 Instrumentation Monitoring Report**

Historically, TE2 showed seasonal oscillations within 0.05 degrees (A-axis) to 0.1 degrees (B-axis). The Spring 2022 readings for TE2 suggested a similar oscillation range since battery replacement. During the Fall 2022 readings, Stantec was unable to get the laptop to recognize the data logger.

3.0 RECOMMENDATIONS

3.1 FUTURE WORK

It is recommended that all instruments be read again for the Spring 2023 reading cycle.

3.2 INSTRUMENTATION REPAIRS

The batteries for tiltmeters TE1 and TW1 should be replaced as soon as practicable. This can be done via ice access in the winter or with the use of a snooper truck. Alternatively, precise surveys of the bridge can be completed regularly to monitor its movement.

Reference: **North Central Region, Stony Plain, Site NC052 - Highway 621:02 Pembina River Bridge Abutment, Fall 2022 Instrumentation Monitoring Report**

Table NC052-1: Fall 2022 Slope Inclinometer Reading Summary

Instrument Name	Date Initialized	Top of Casing Elevation (m aMSL)[1]	Coordinates [2] (UTM 11U, NAD1983) (m)		Total Cumulative Resultant Movement and Depth of Movement to Date* (mm)	Maximum Rate of Movement (mm/yr)	Current Status	Date of Previous Reading	Incremental Movement Since Previous Reading (mm)	Current Rate of Movement (mm/yr)	Change in Rate of Movement Since Previous Reading (mm/yr)
			Northing	Easting							
SI-1	Aug. 31 2006	828	5905058	621642	4 mm over 1.9 m to 4.4 m depth in 332º direction	2 mm/yr; Oct. 2015	Operational	6-May-22	< 1	1.0	< 1
					3 mm over 7.4 m to 11.9 m depth in 332º direction	4 mm/year; May 2016		6-May-22	-< 1	2.8	1.4
SI-2	Aug. 31, 2006	833	5905016	621726	15 mm over 6.8 m to 9.8 m depth in 176° direction	17 mm/yr; May 2014	Operational	6-May-22	-2.2	7.2	4.9
					-10 mm over 12.8 m to 14.8 m depth in 176° direction	9 mm/yr; Sept. 2022			1.3	-8.7	-7.8
SI13-3	May 23, 2013	833	5905023	621786	6 mm over 19.2 m to 21.2 m depth in 7° direction	397 mm/yr; Nov. 2013	Operational	6-May-22	Negligible movement rate since Oct. 2015 (less than 1 mm/yr)		

Note:
(1) aMSL = Above Mean Sea Level
(2) Updated September 9, 2022 with approximate accuracy of ± 3 m.

Reference: **North Central Region, Stony Plain, Site NC052 - Highway 621:02 Pembina River Bridge Abutment, Fall 2022 Instrumentation Monitoring Report**

Table NC052-2: Fall 2022 Pneumatic, Vibrating Wire, and Standpipe Piezometers Reading Summary

Instrument Name	Date Initialized	Top of Casing Elevation (m aMSL) (1)	Coordinates (2) (UTM 11U, NAD1983) (m)		Tip Elevation (m)	Current Status	Maximum Depth below Ground Surface [Elevation](3) (m)	Depth below Ground Surface(4) (m)	Piezometric Elevation (m)	Change in Piezometric Level Since Previous Reading (m)
			Northing	Easting						
PN-01 (30578)	Aug 31, 2006	828.0	5905058	621642	810.2	Operational	-6.7 [833.7 m] May 17, 2013	-1.8	828.8	-0.2
PN-02 (30579)	Aug 31, 2006	832.0	5905016	621726	809.2	Operational	-4.2 [835.9] June 5, 2012	2.5	829.2	0.1
VW13-3 (25255)	Apr 25, 2013	834.2	5905023	621786	814.4	Operational	0.2 [832.5] May 8, 2013	5.8	826.9	-2.9
SP13-3A	May 23, 2013	834.6	5905027	621792	-	Operational	0.4 [832.4] May 20, 2020	1.7	831.1	-1.2

Note:
(1) aMSL = Above Mean Sea Level
(2) Updated September 9, 2022 with approximate accuracy of ± 3 m.
(3) Negative value indicates artesian condition.

Reference: **North Central Region, Stony Plain, Site NC052 - Highway 621:02 Pembina River Bridge Abutment, Fall 2022 Instrumentation Monitoring Report**

4.0 CLOSING

We trust this instrumentation report meets your requirements. If you have any questions, please do not hesitate to contact the undersigned.

Stantec Consulting Ltd.

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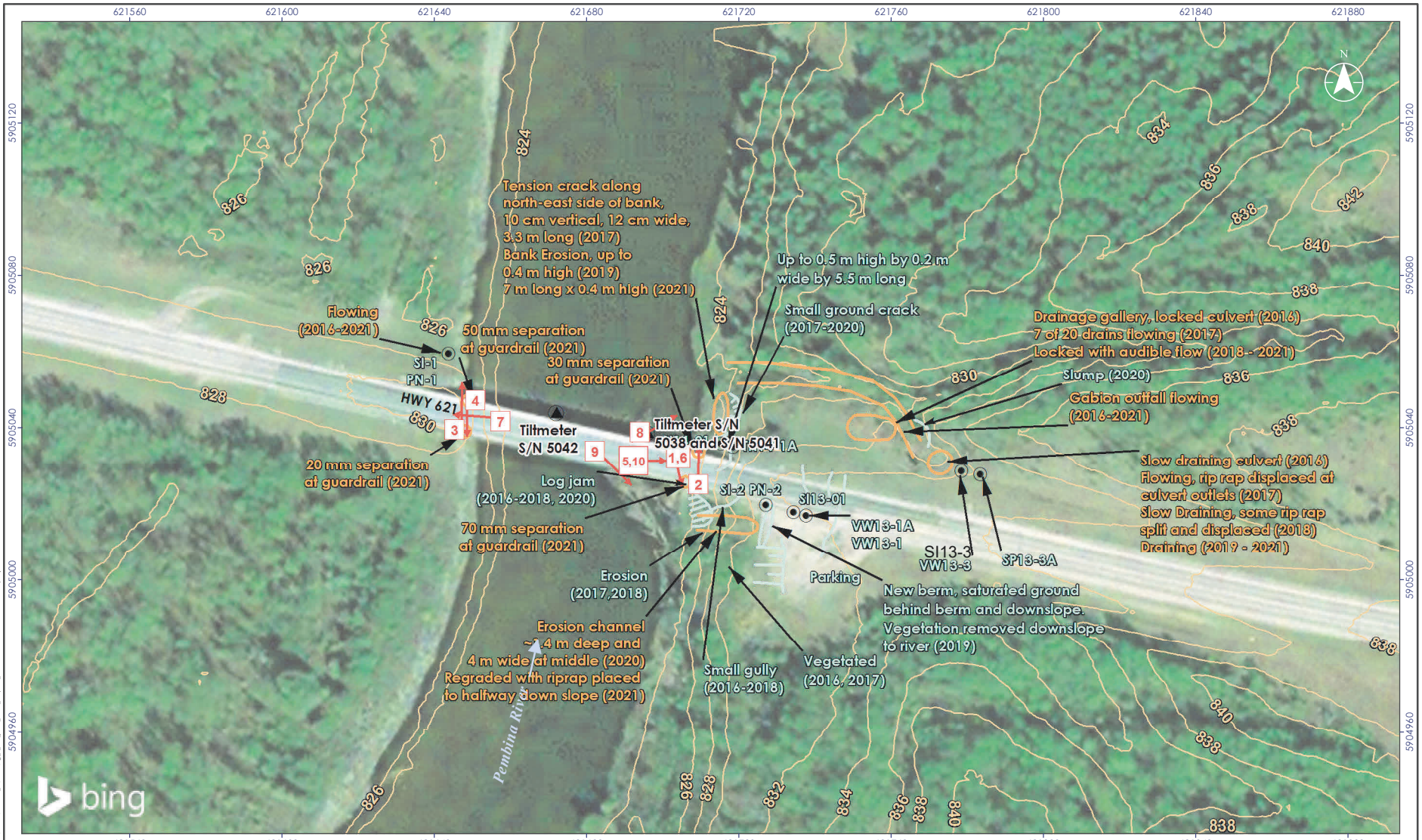
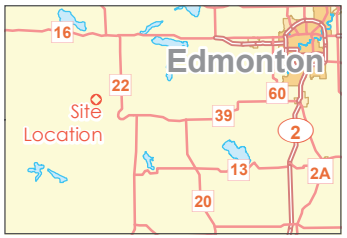
Attachment:
Figure 1 – Site Plan
SI-1 Slope Inclinometer Plots
SI-2 Slope Inclinometer Plots
SI13-3 Slope Inclinometer Plots
Pneumatic Piezometer Elevation vs. Time Plot
Vibrating Wire Piezometer Elevation vs Time Plot
Standpipe Piezometer Elevation vs Time Plot

PERMIT TO PRACTICE
STANTEC CONSULTING LTD.
Signature _____ ID 78675
Date 2022-10-07
PERMIT NUMBER: P 0258
The Association of Professional Engineers and Geoscientists of Alberta





- Instrument Location
- Tiltmeter
- Previous Observation
- 2021 Observation
- Ground Elevation Contours (m AMSL, LiDAR June-Nov. 2012)
- Photo Number and Direction

0 25 50 metres

1:1,500 (At original document size of 8.5x11)

Notes
1. Coordinate System: NAD 1983 UTM Zone 11N
2. Base features: Geogratis, ©Department of Natural Resources Canada, All rights reserved.
3. Imagery: Microsoft Bing product screen shot(s) reprinted with permission from Microsoft Corporation.

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Project Location	123315222
Hwy 621:02	Prepared by AK on 2021-09-01
Alberta	Quality Review by LC on 2021-09-14
	Independent Review by CM on 2021-09-14

Client/Project
Alberta Transportation
Geohazard Monitoring Program
NC52 Pembina River Bridge on HWY 621:02

Figure No.
1

Title
Site Plan

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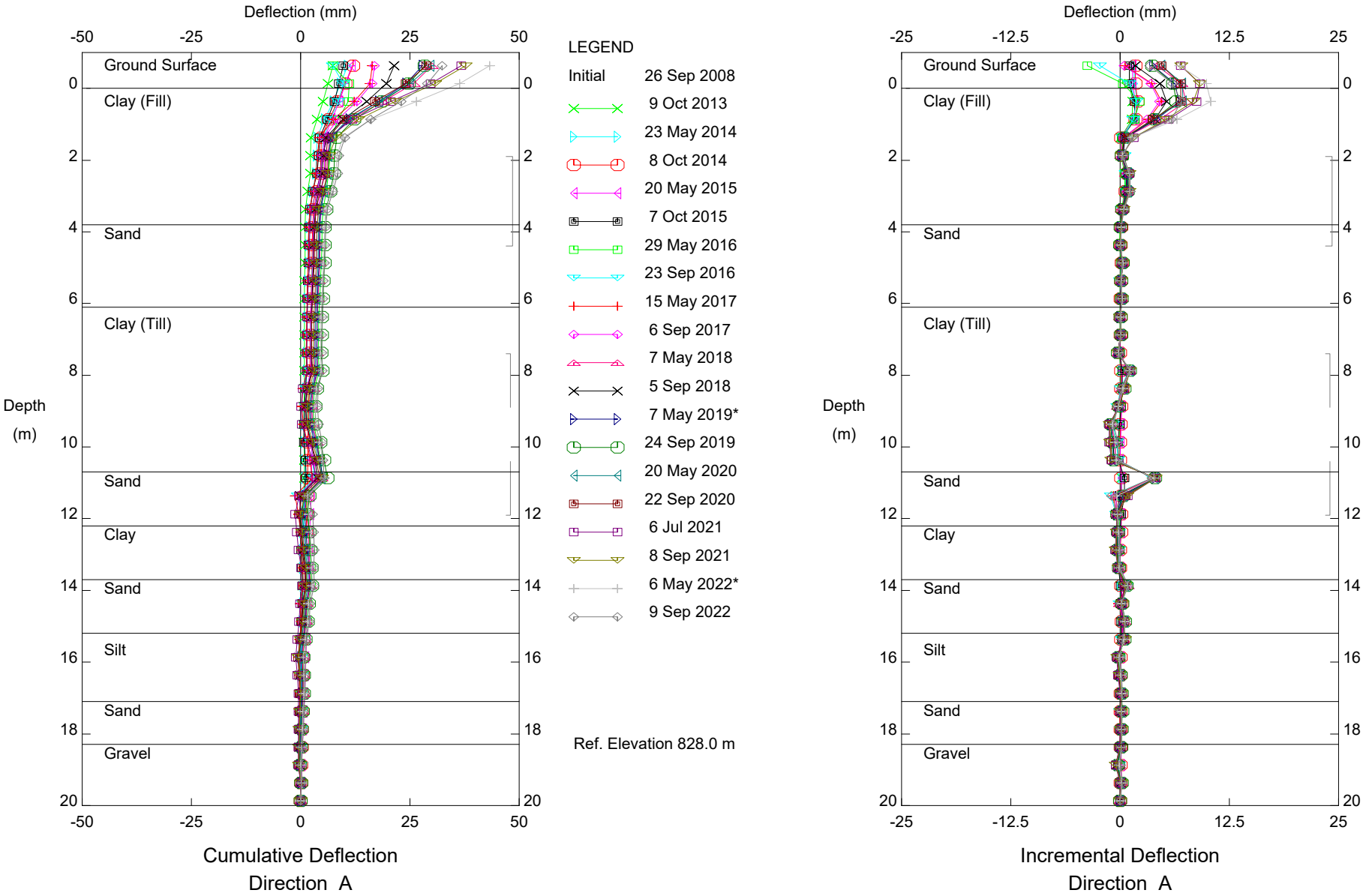

NC-52, Inclinometer SI-1

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

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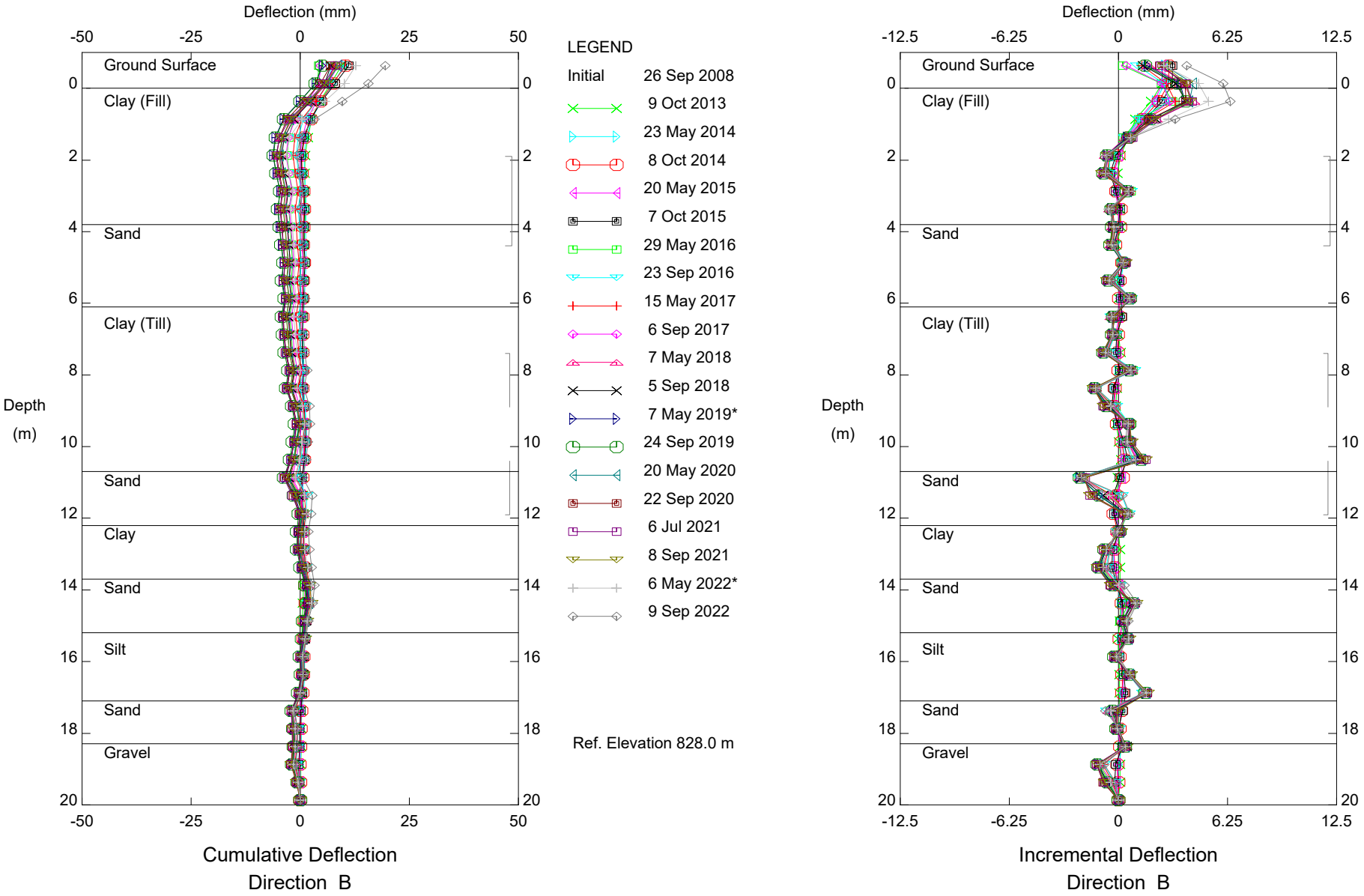

NC-52, Inclinometer SI-1

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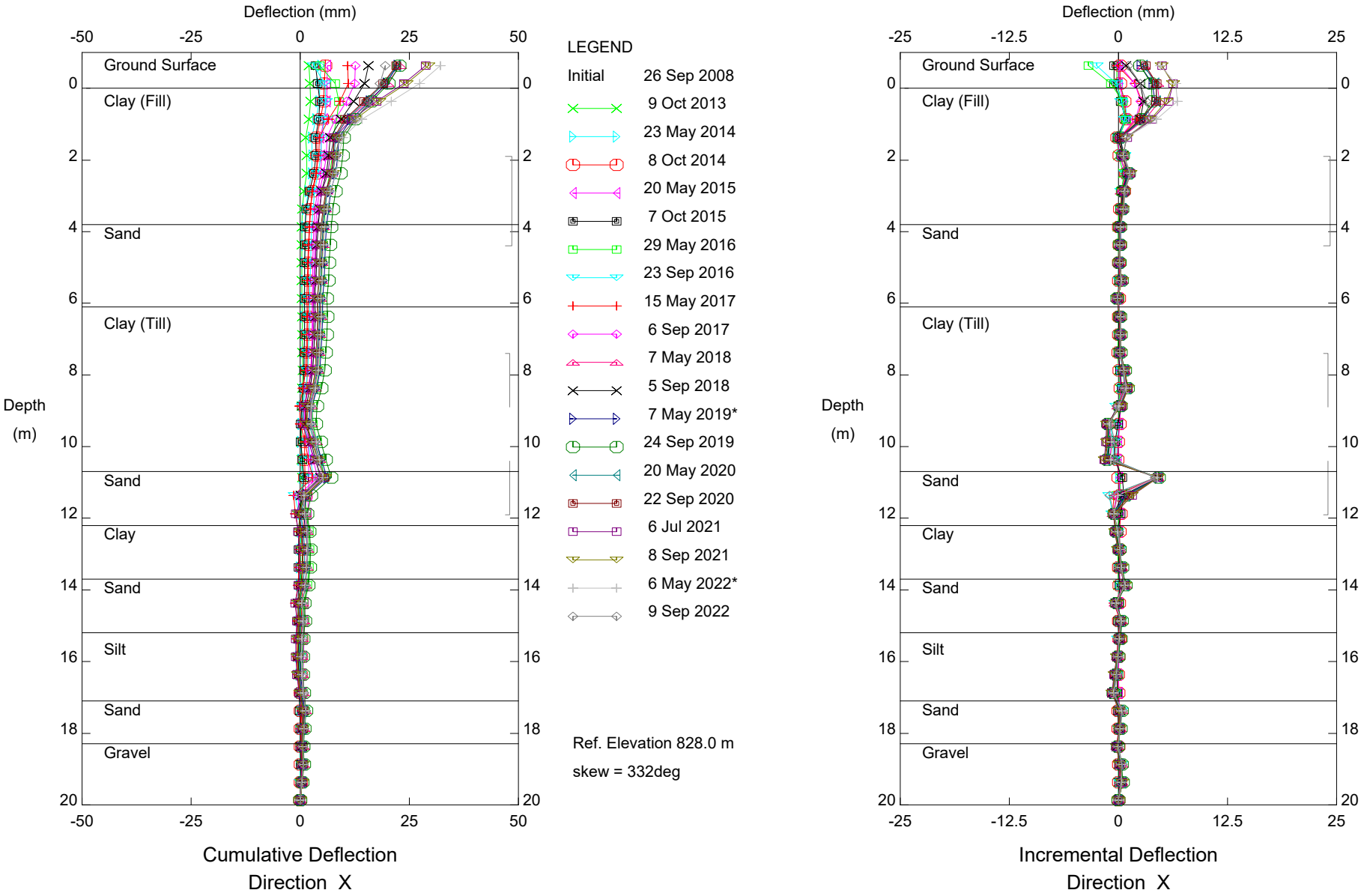

NC-52, Inclinometer SI-1

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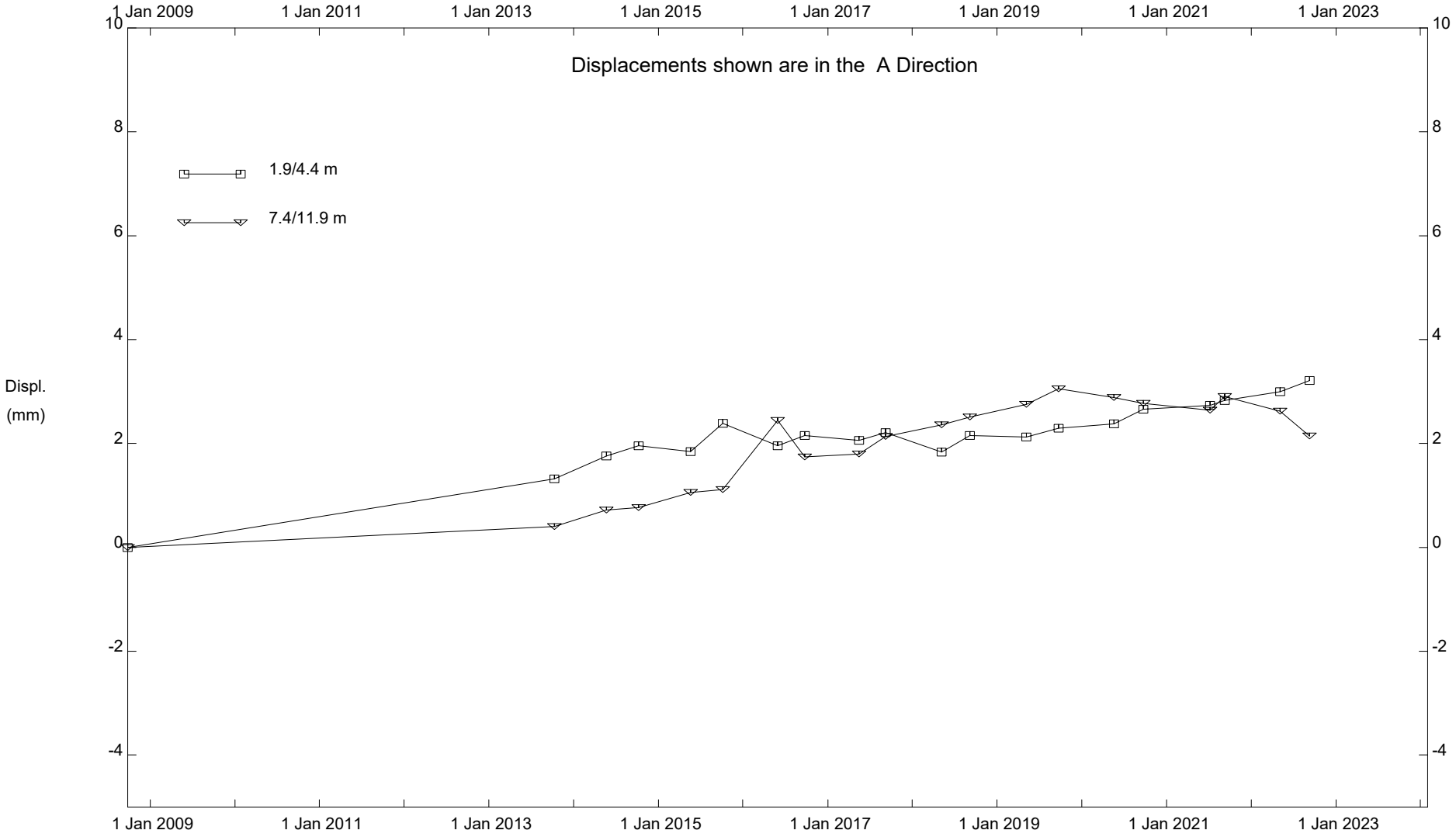

NC-52, Inclinometer SI-1

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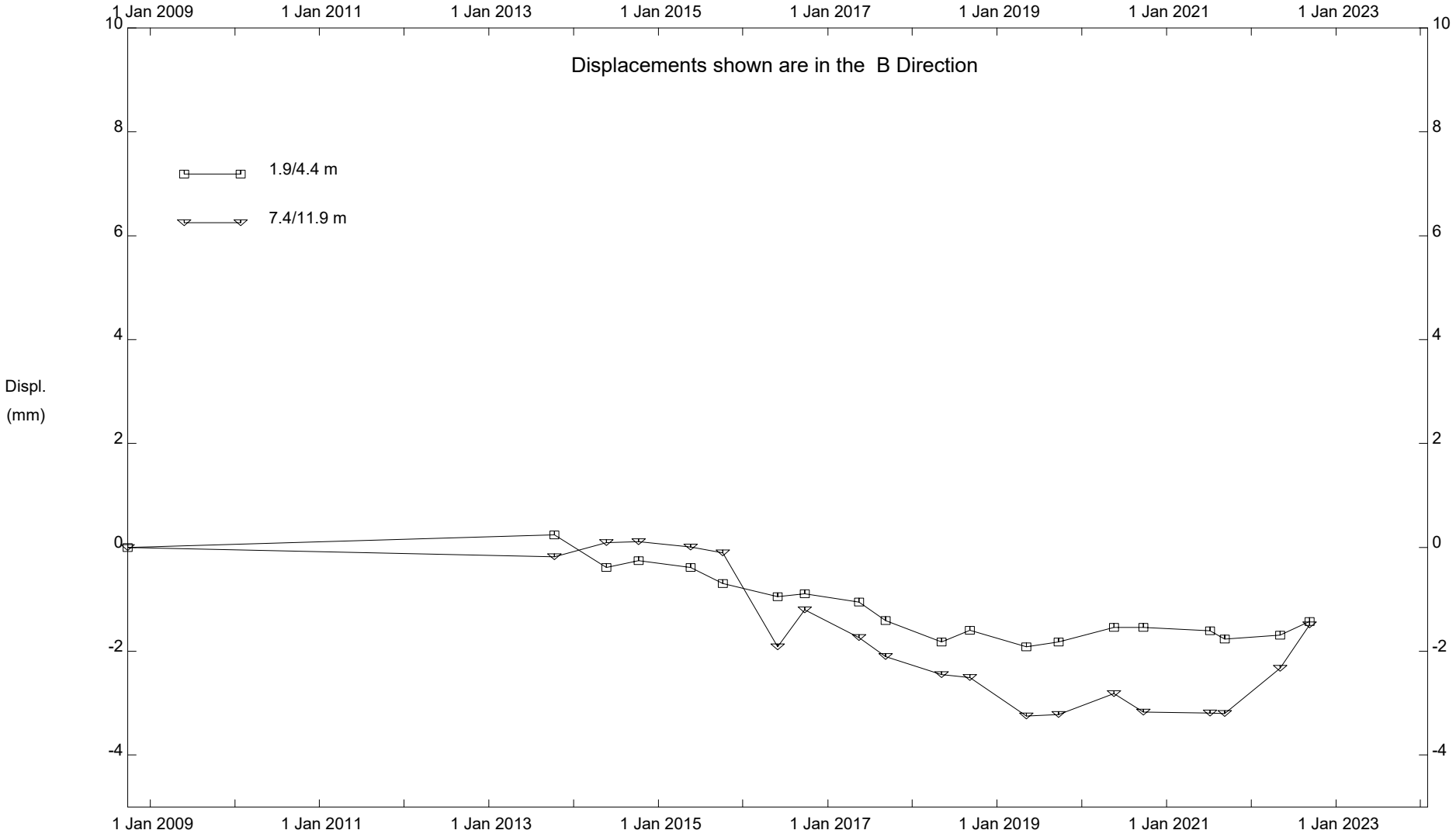

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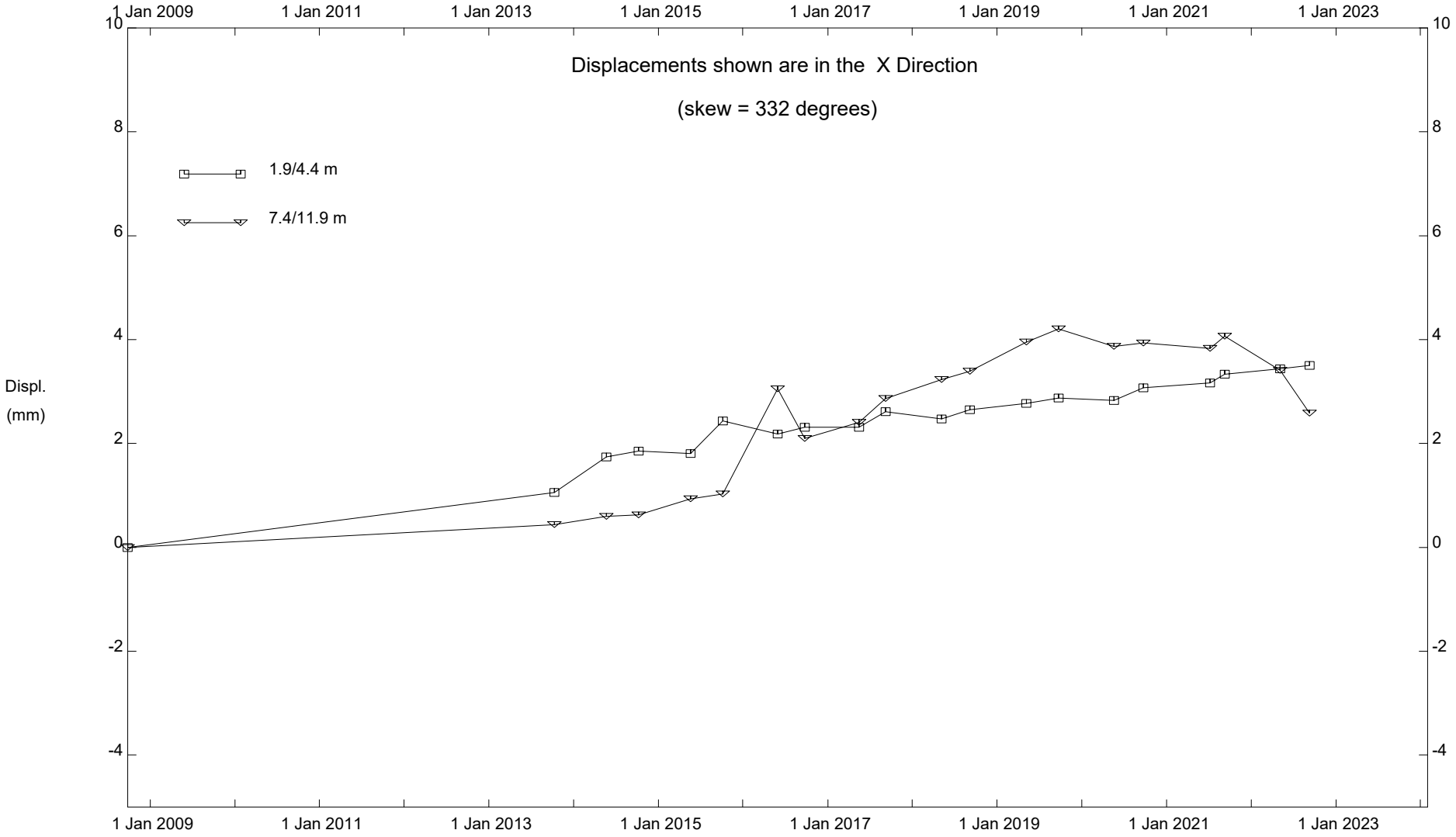

NC-52, Inclinometer SI-1

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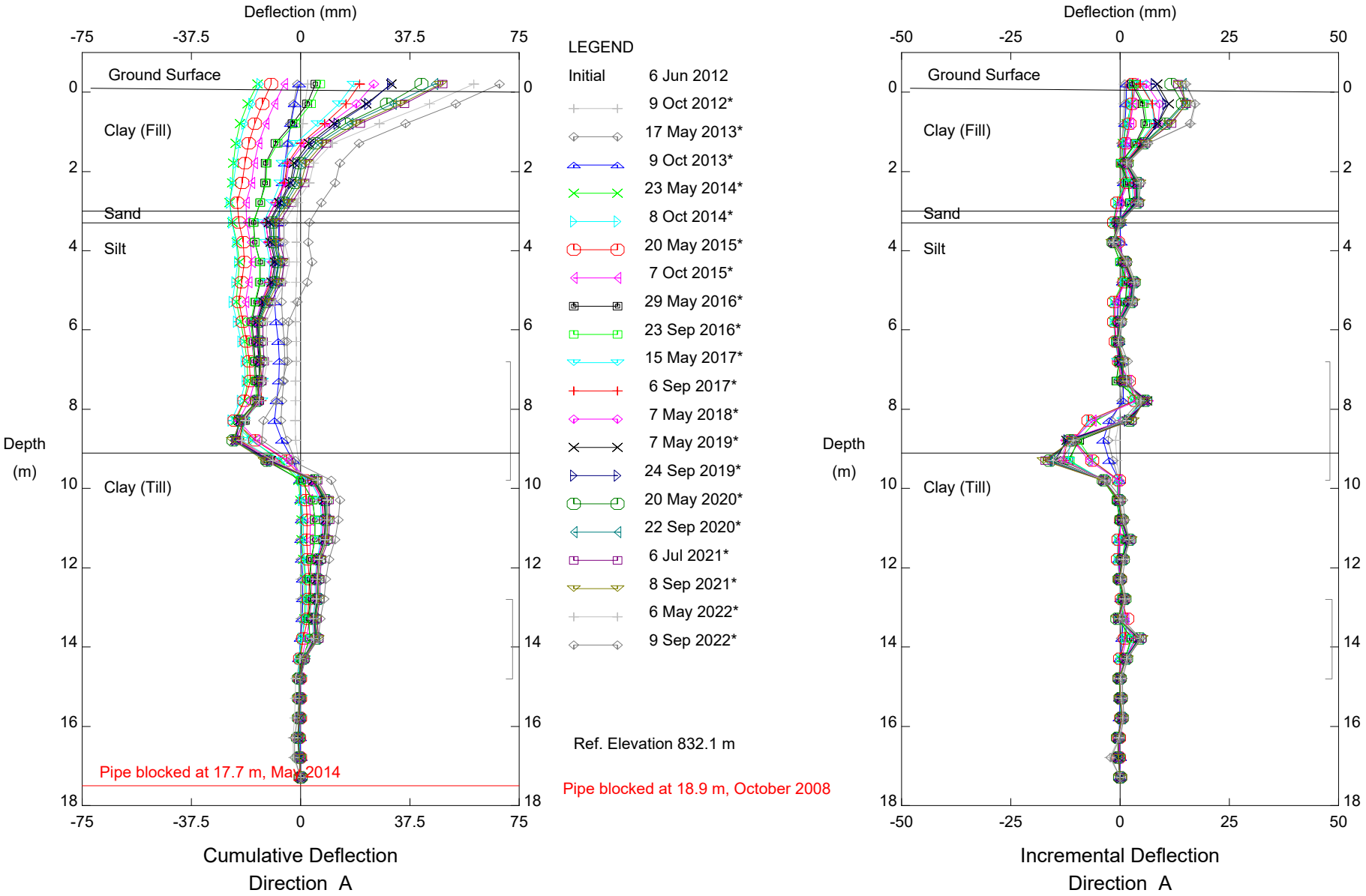

NC-52, Inclinometer SI-2

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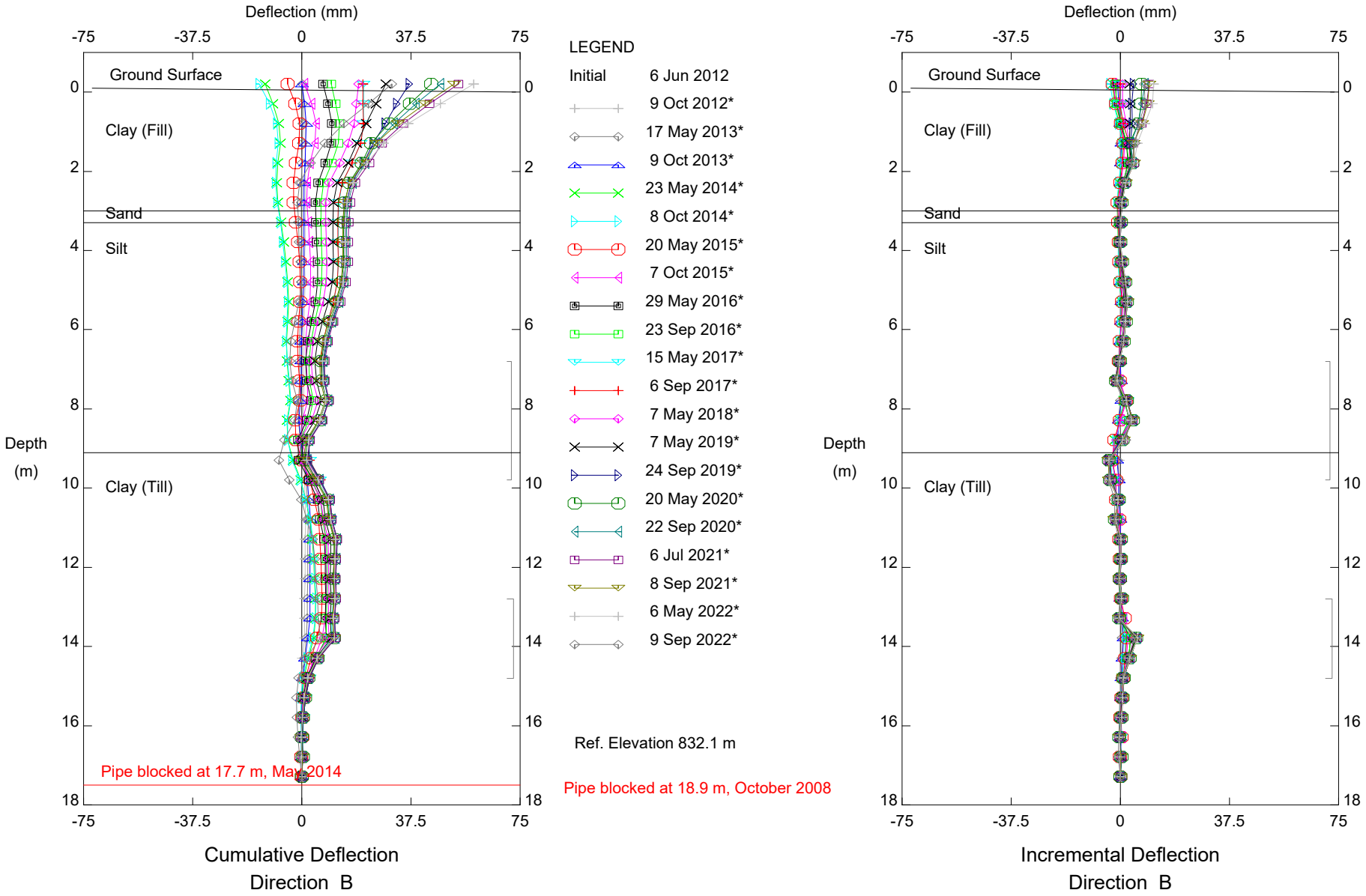

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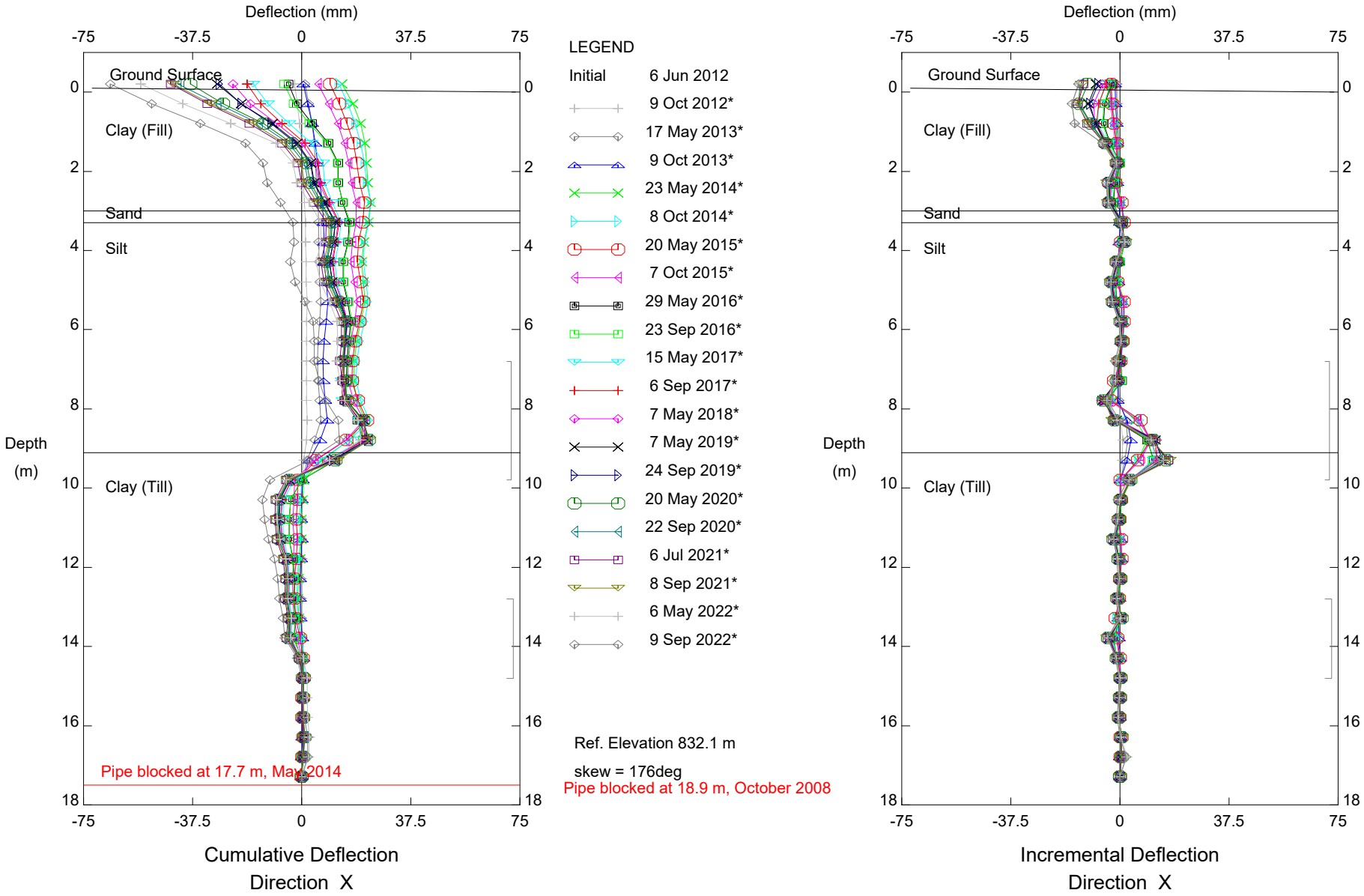

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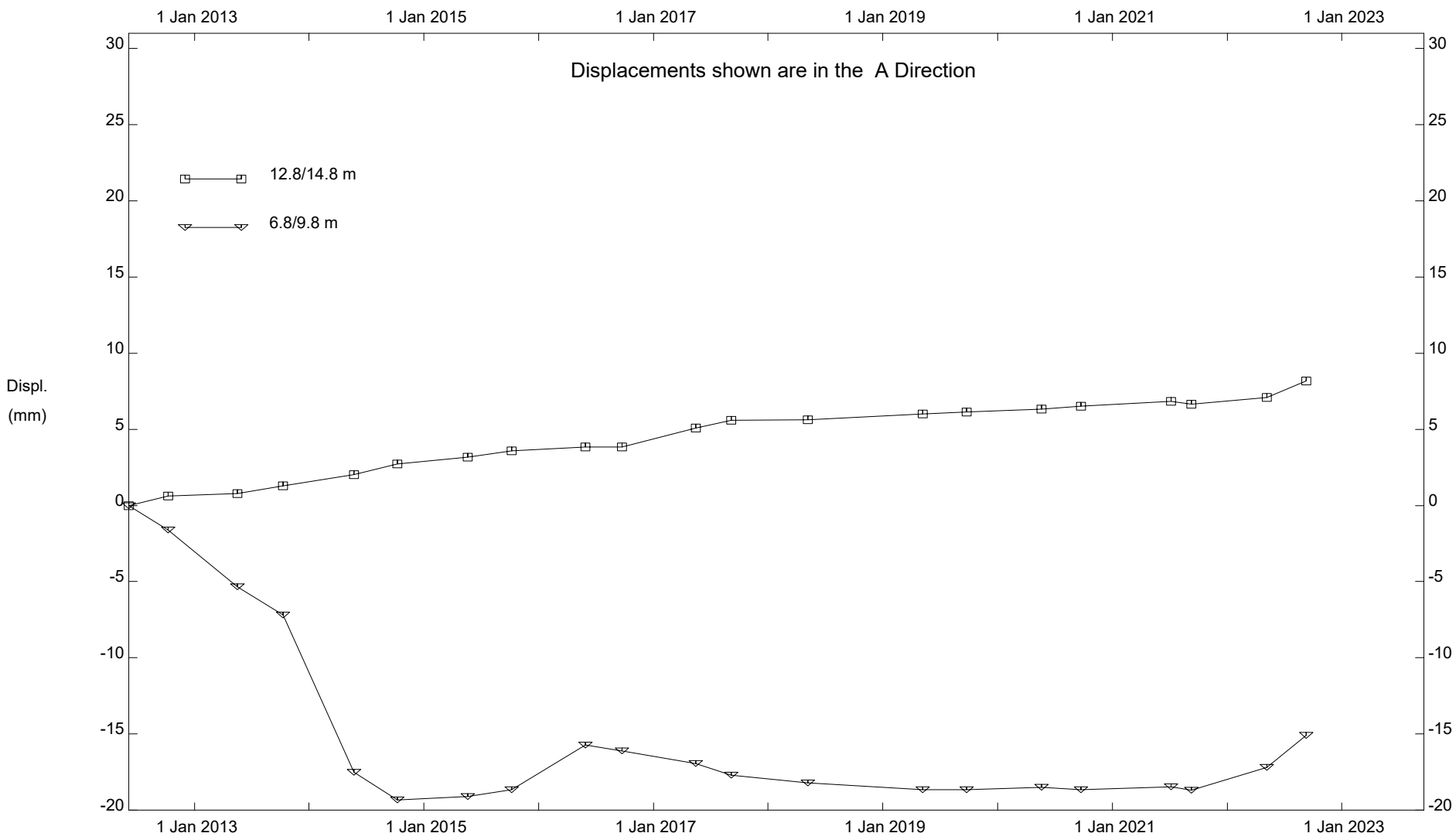

NC-52, Inclinometer SI-2

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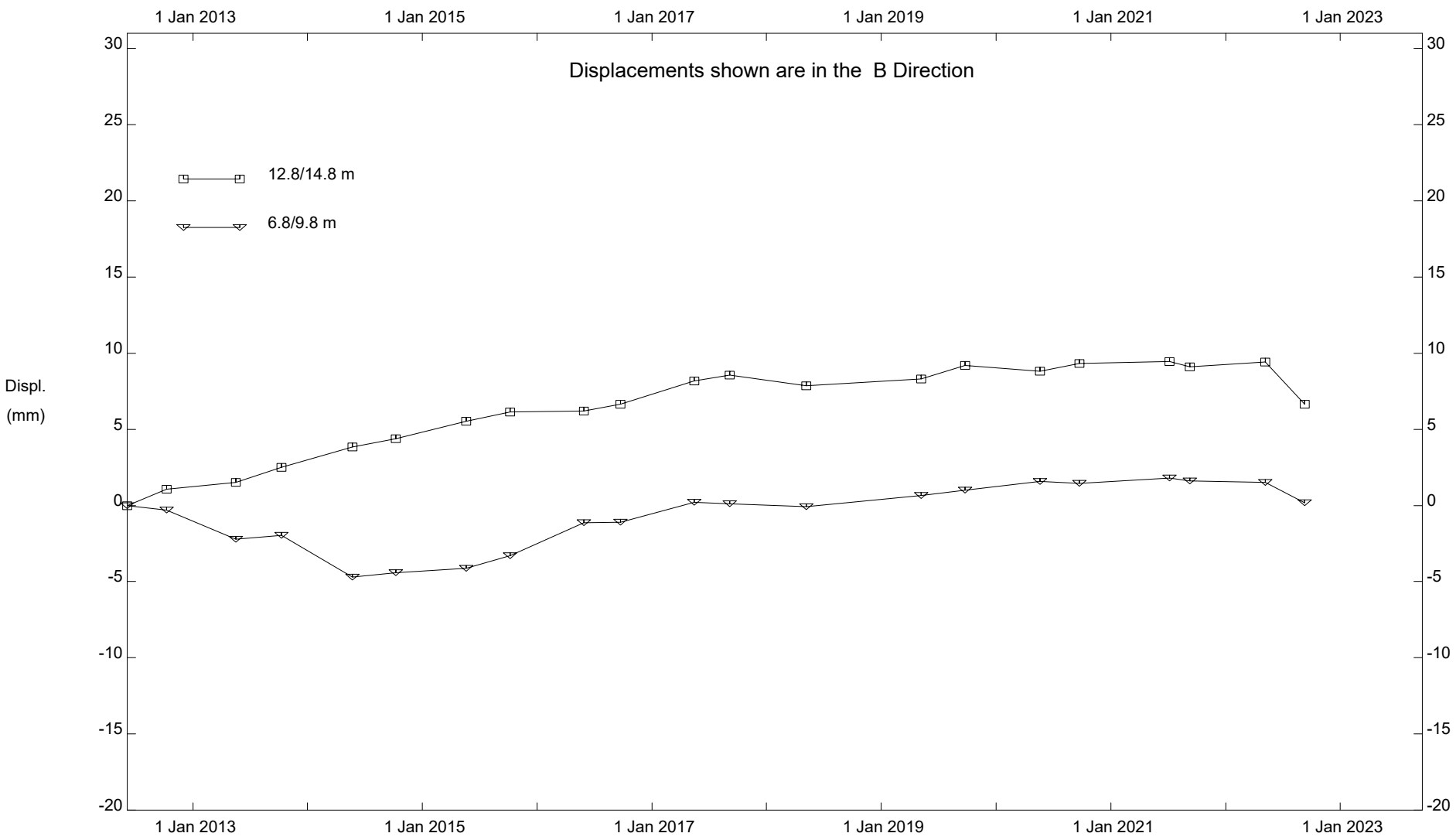

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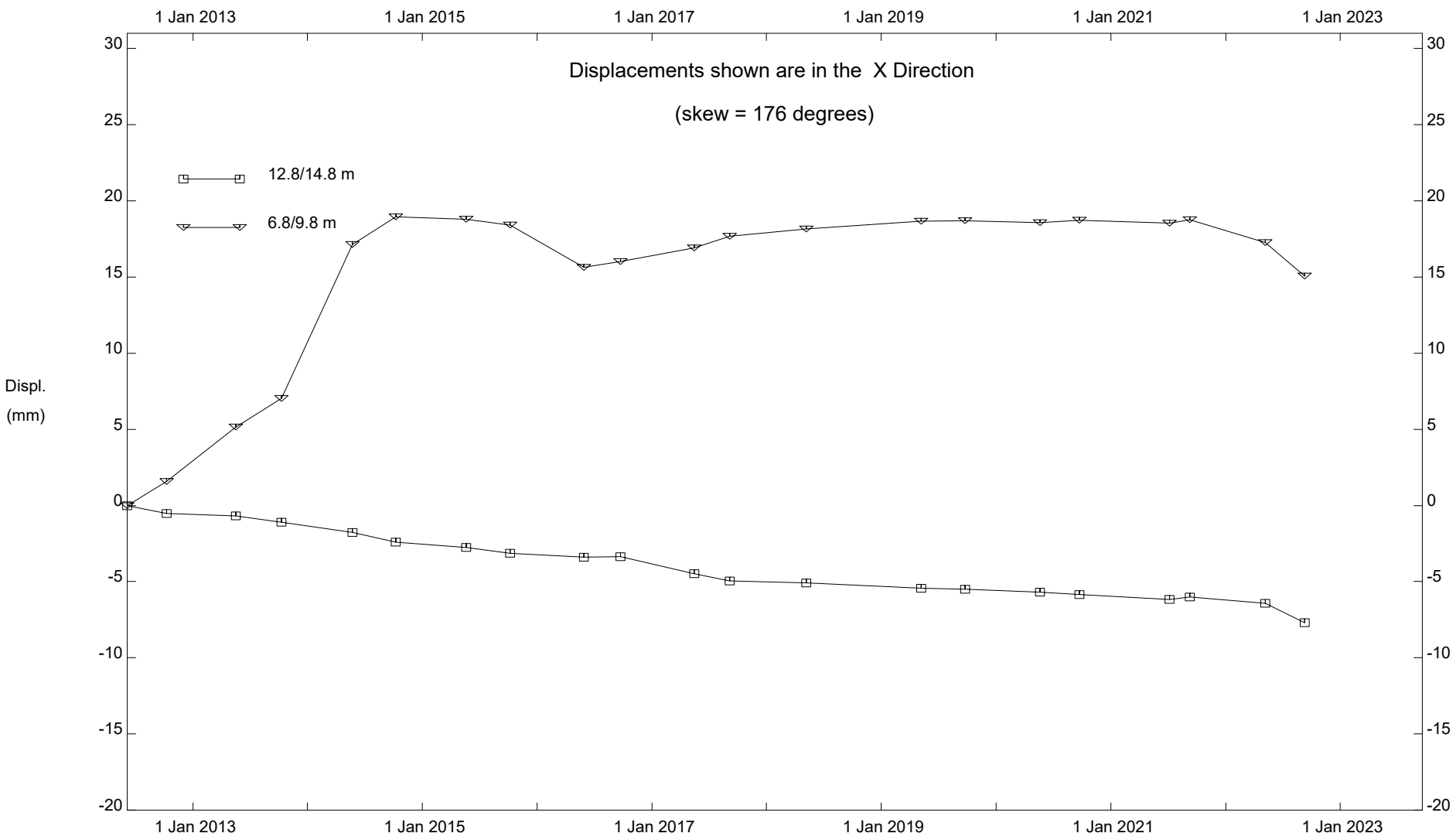

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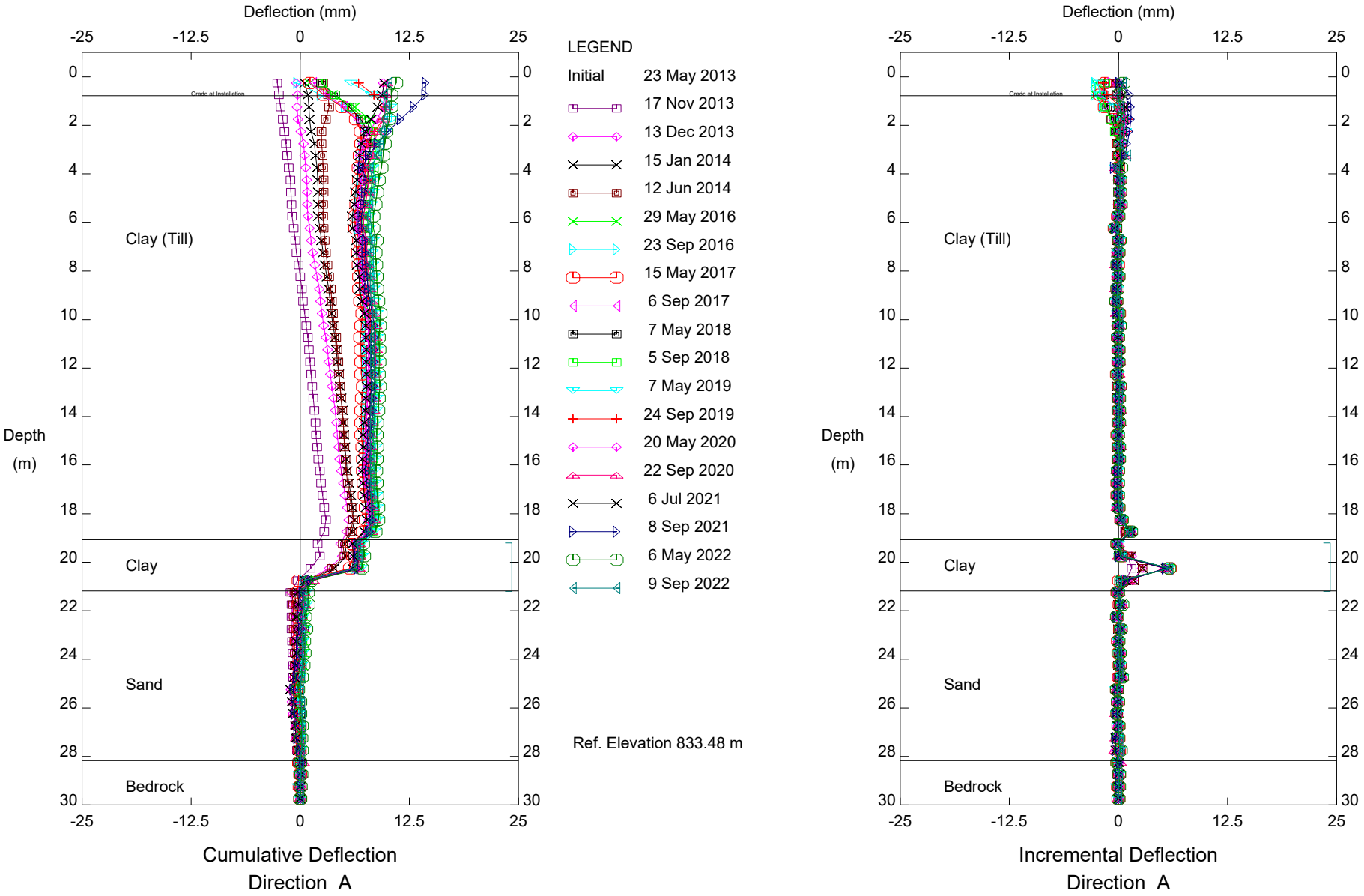

NC-52, Inclinometer SI13-3

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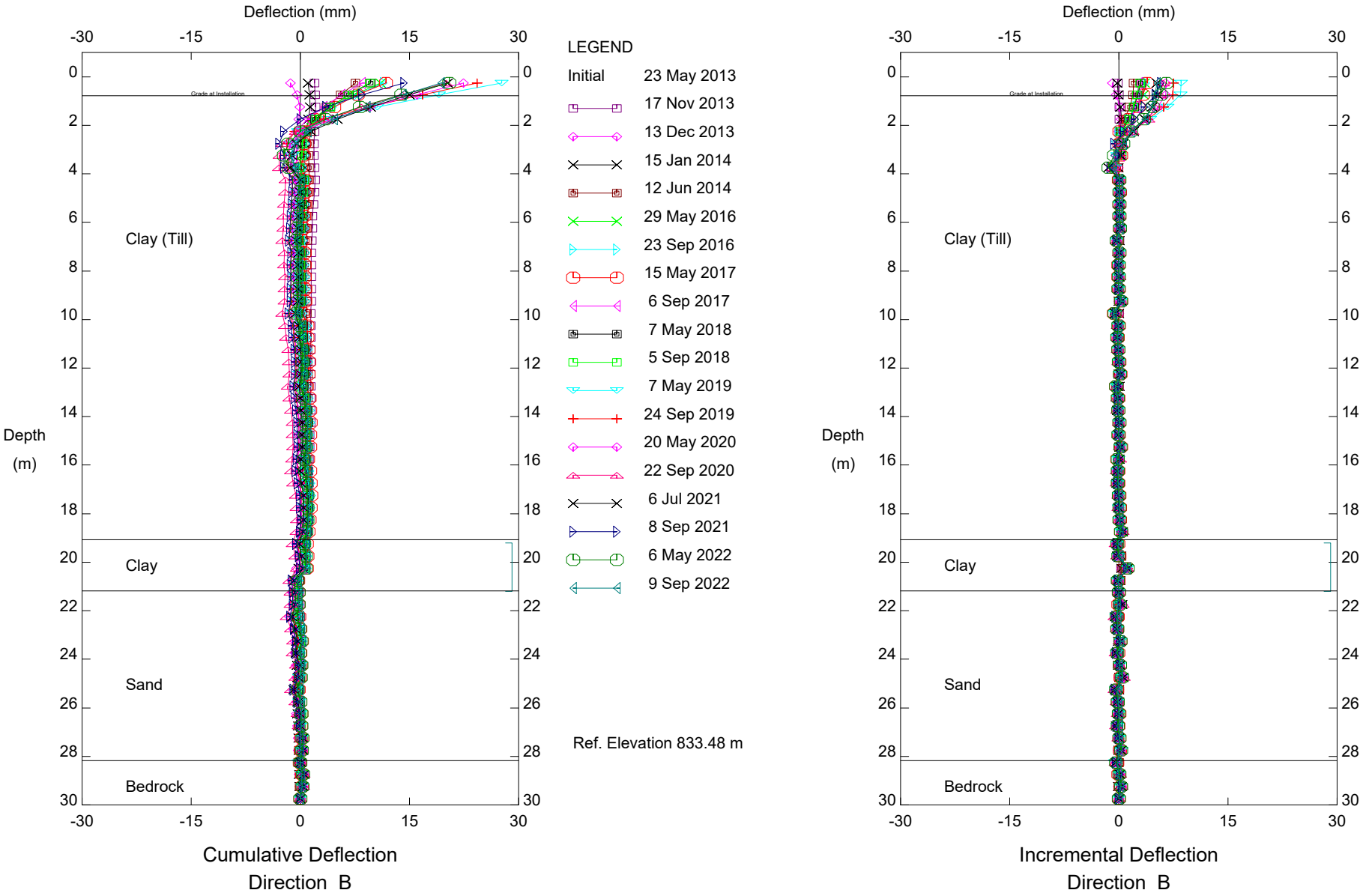

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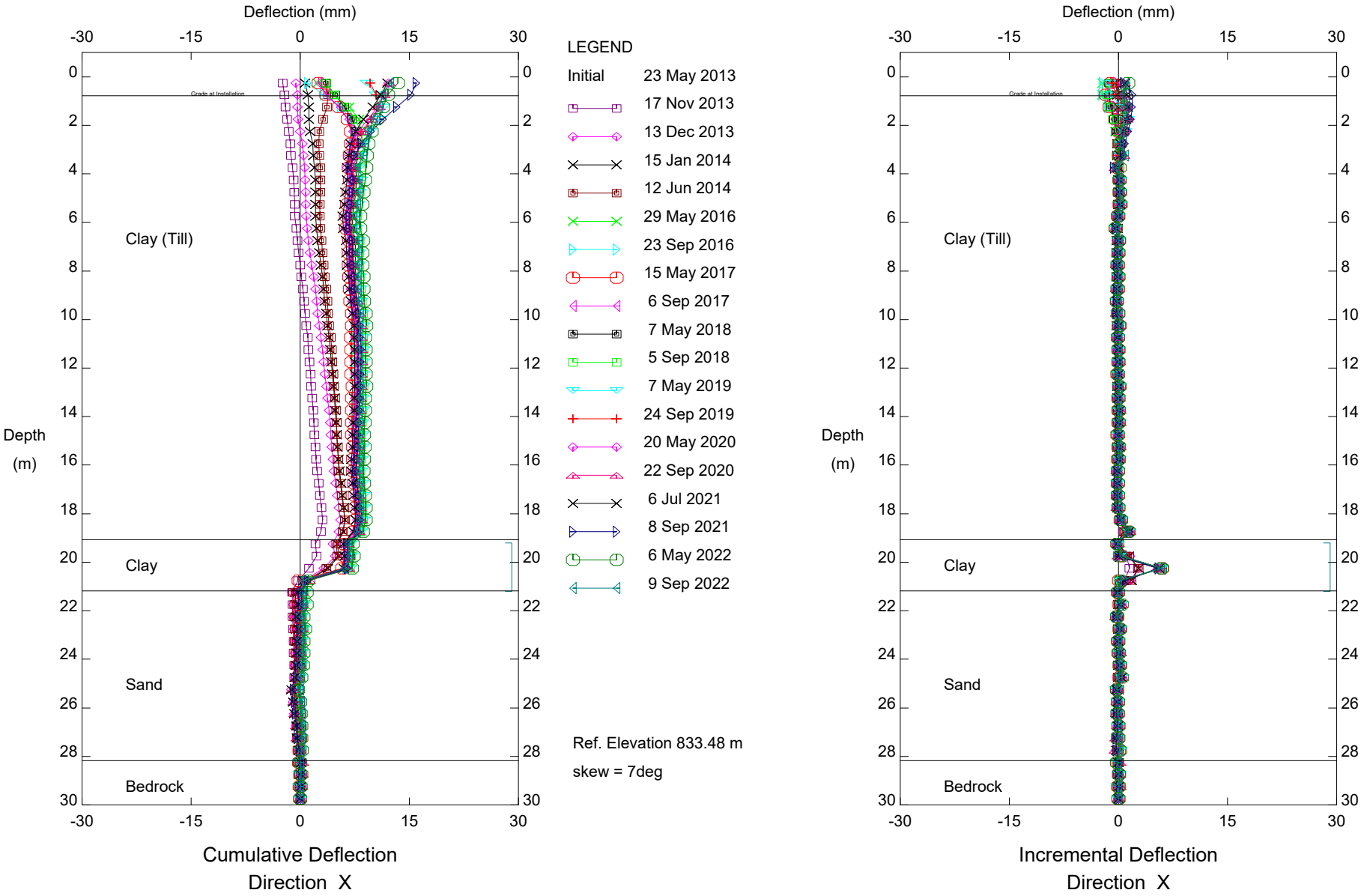

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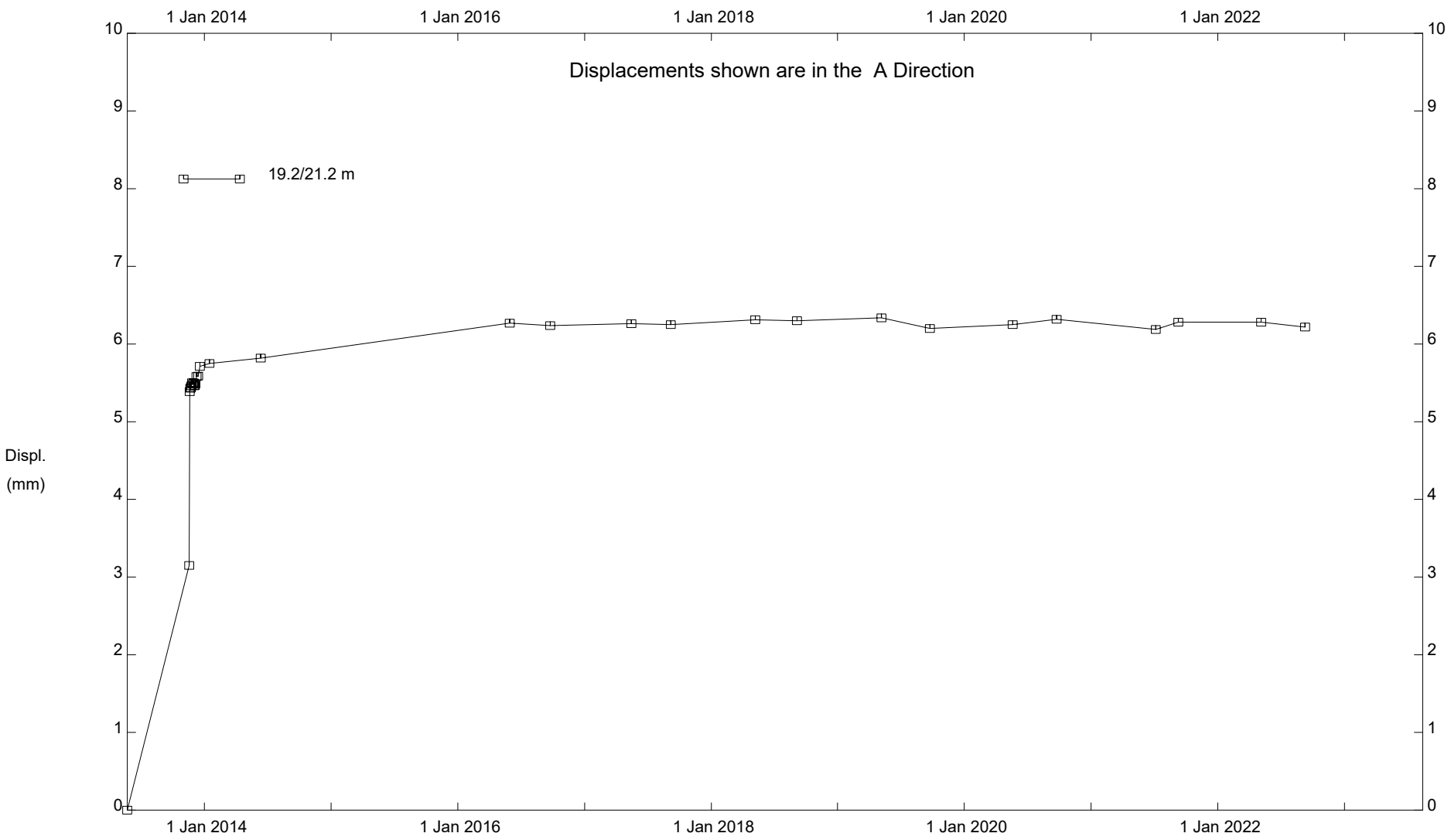

NC-52, Inclinometer SI13-3

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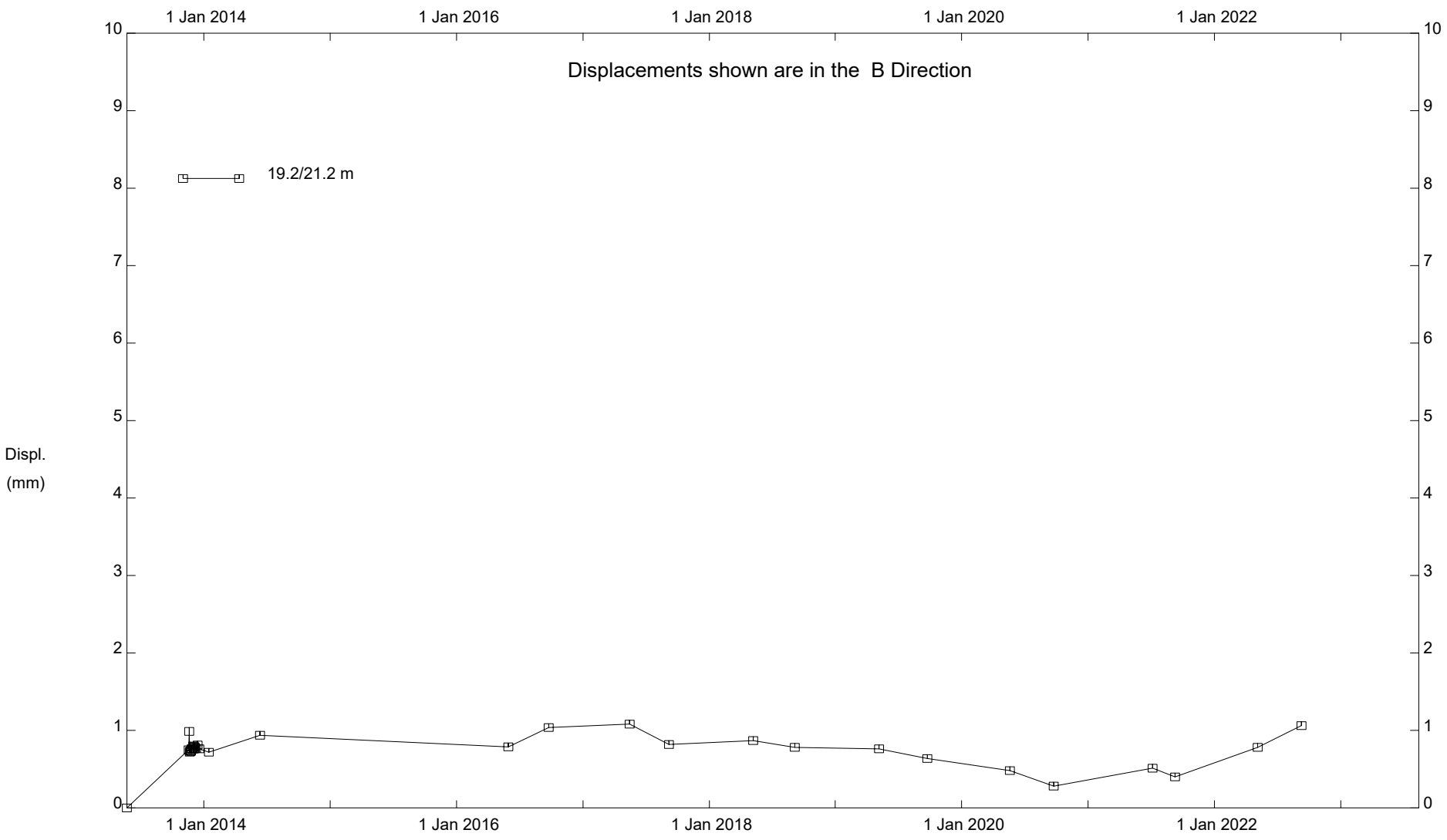

NC-52, Inclinometer SI13-3

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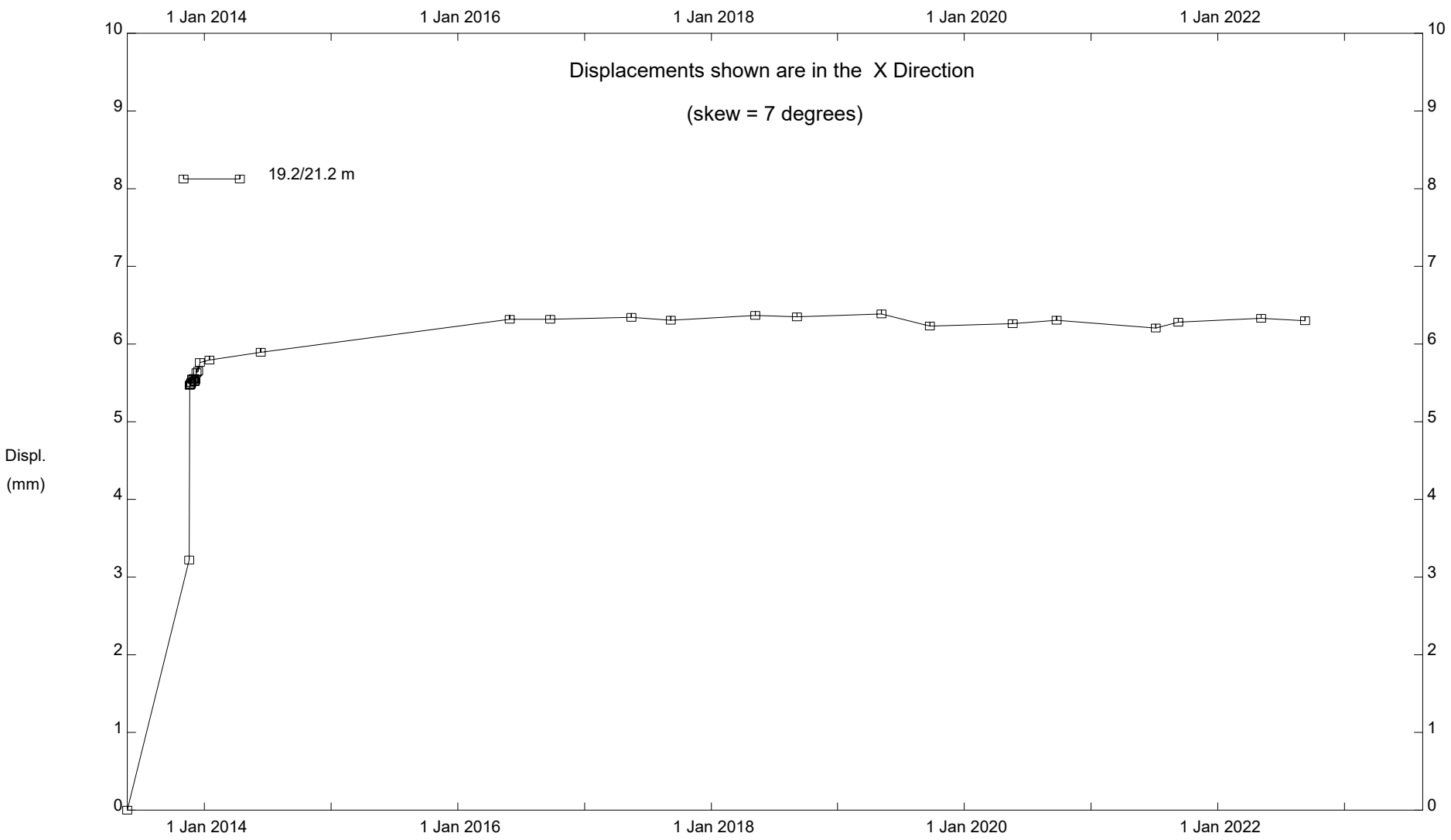

NC-52, Inclinometer SI13-3

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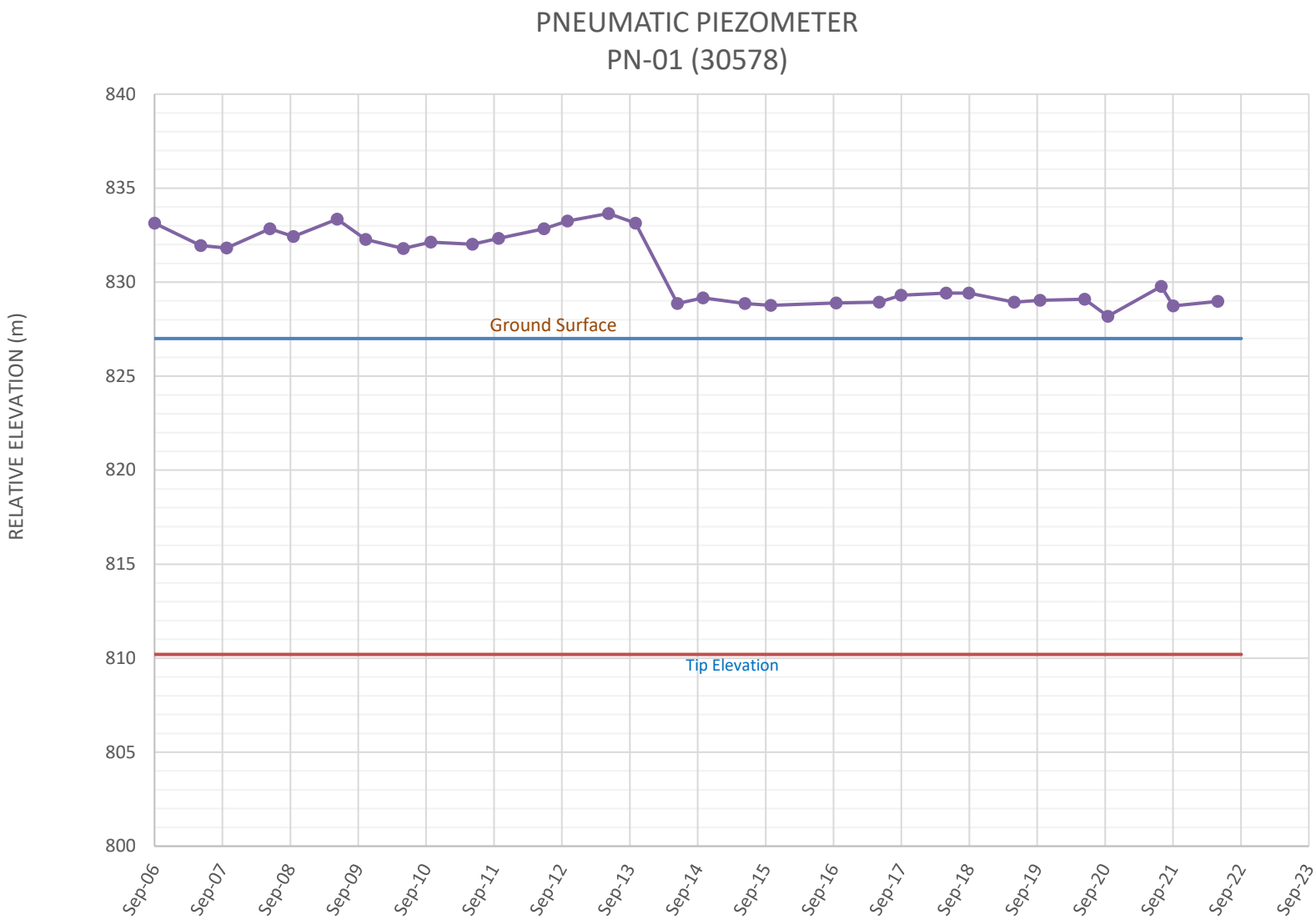
PNEUMATIC PIEZOMETER
PN-01 (30578)
RELATIVE ELEVATION (m)
840
835
830
825
820
815
810
805
800
Ground Surface
Tip Elevation
Sep-06
Sep-07
Sep-08
Sep-09
Sep-10
Sep-11
Sep-12
Sep-13
Sep-14
Sep-15
Sep-16
Sep-17
Sep-18
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Sep-22
Sep-23

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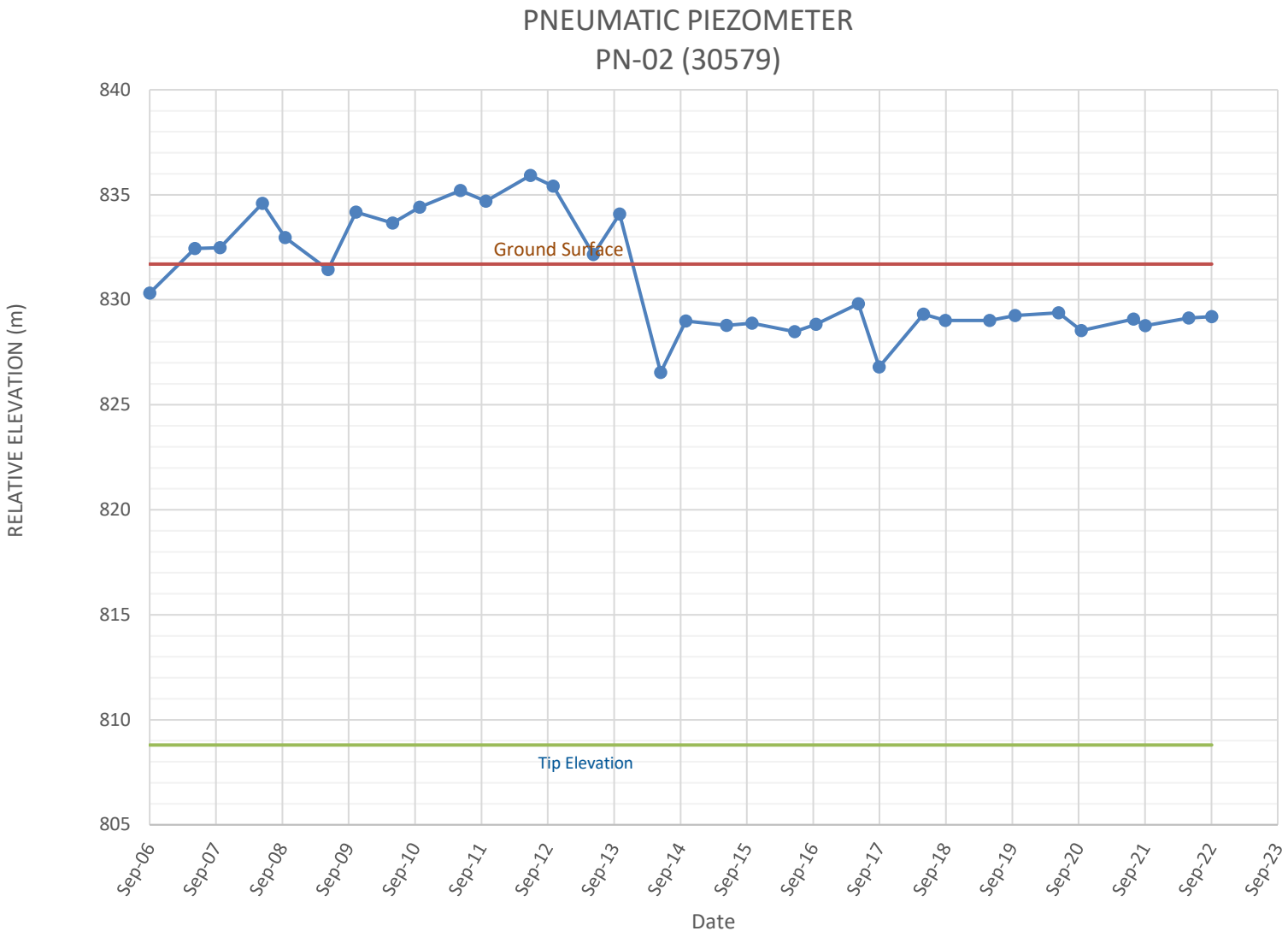
PNEUMATIC PIEZOMETER
PN-02 (30579)
RELATIVE ELEVATION (m)
840
835
830
825
820
815
810
805
Ground Surface
Tip Elevation
Sep-06
Sep-07
Sep-08
Sep-09
Sep-10
Sep-11
Sep-12
Sep-13
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Sep-23
Date

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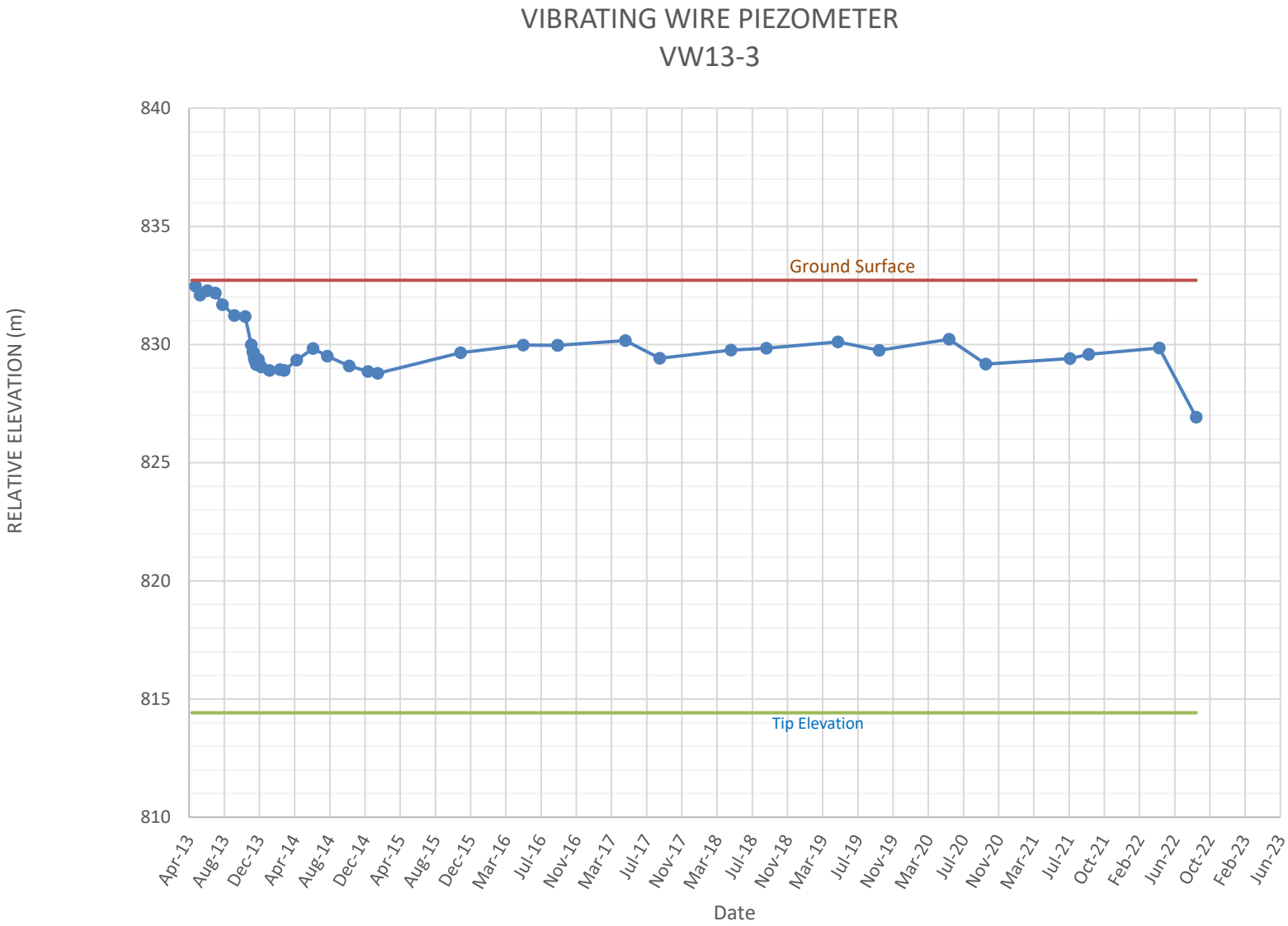
VIBRATING WIRE PIEZOMETER
VW13-3
RELATIVE ELEVATION (m)
840
835
830
825
820
815
810
Ground Surface
Tip Elevation
Apr-13
Aug-13
Dec-13
Apr-14
Aug-14
Dec-14
Apr-15
Aug-15
Dec-15
Mar-16
Jul-16
Nov-16
Mar-17
Jul-17
Nov-17
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Feb-22
Jun-22
Oct-22
Feb-23
Jun-23
Date

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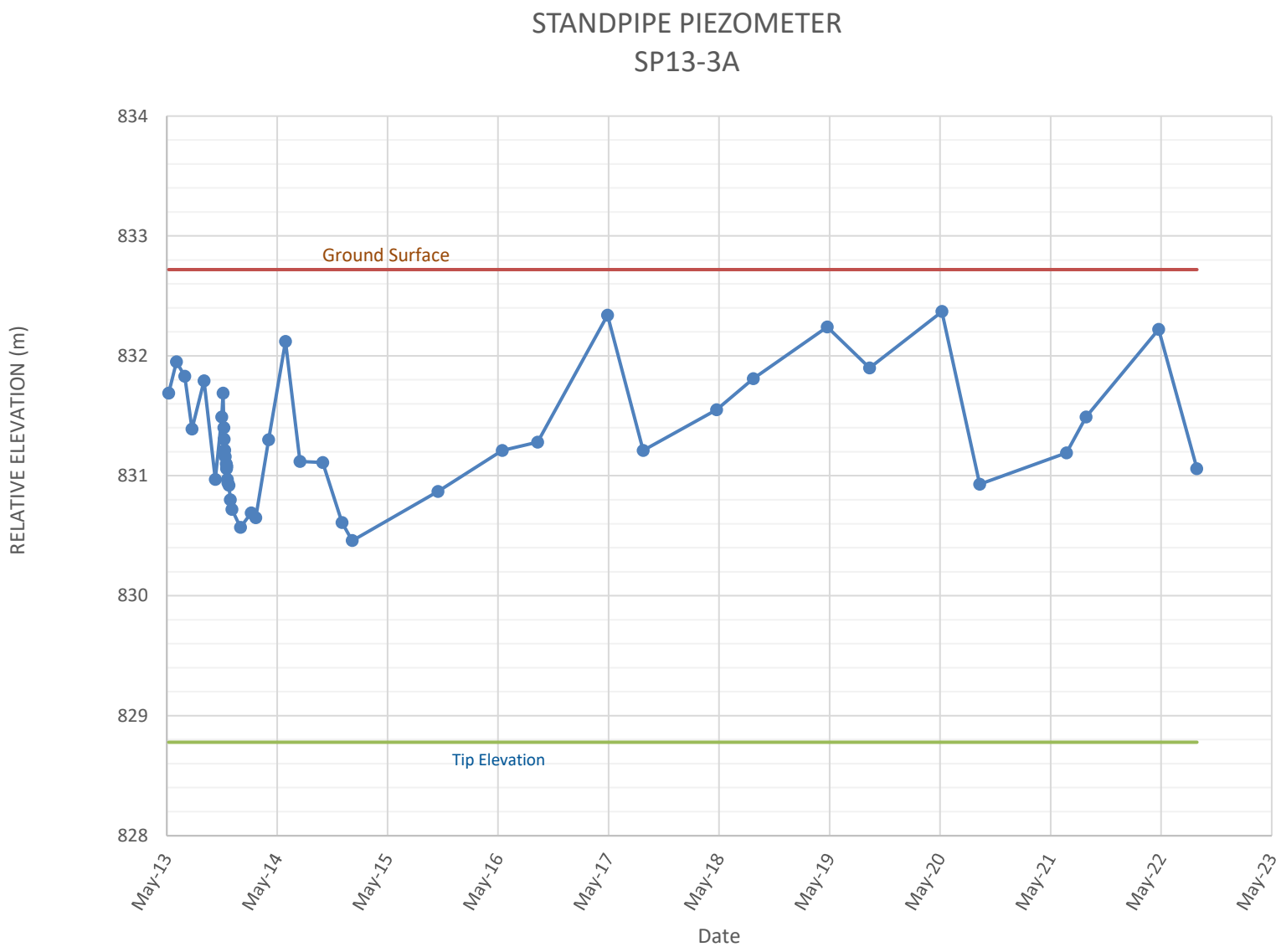
STANDPIPE PIEZOMETER
SP13-3A
RELATIVE ELEVATION (m)
834
833
832
831
830
829
828
Ground Surface
Tip Elevation
May-13
May-14
May-15
May-16
May-17
May-18
May-19
May-20
May-21
May-22
May-23
Date

Stantec