Klohn Crippen Berger

September 12, 2022

Alberta Transportation
4th Floor, Provincial Building
4920 51 Street
Red Deer, Alberta
T4N 6K8

Tony Penney, P.Eng.
Construction Engineer

Dear Mr. Penney:

CON0022160 Central Region GRMP Instrumentation Monitoring
Site C042; H579:02 km 36.540 West of Water Valley Slide
Section C – 2022 Spring Readings

1 GENERAL

Two slope inclinometers (SIs) (SI05-05 and SI05-07) were read at the C042 site in the Central Region on June 25, 2022 by Mr. Guerin White, E.I.T. of Klohn Crippen Berger Ltd. (KCB). Data was also downloaded from a data logger installed in standpipe piezometer (SP) (SP05-08). These instruments were read as part of the Central Region Geohazard Risk Management Program (GRMP). The site is located on Hwy 579:02, km 36.540, approximately 4 km west of Water Valley, Alberta and 300 m east of Little Red Deer River bridge. The approximate site coordinates are 5709031 N, 661849 E (UTM Zone 11, NAD 83). A site plan is presented in Figure 1.

The geohazard at the C042 site consists of a series of valley slope and embankment fill slides along Hwy 579:02 that predominately impact the south side (eastbound lane) of the highway. Following a slide in 1995, a portion of the slope was excavated and backfilled with granular fill. A drainage blanket was placed at the base of the excavation, and a drain was placed in a groundwater spring. In 2011, a section of Hwy 579:02 was realigned north (upslope) towards the backslope.

In 2005, AMEC conducted a geotechnical site investigation at the C042 site. The encountered stratigraphy was as follows: fill (granular, overlying silt and clay), overlying medium plastic clay till, overlying bedrock (siltstone).

1.1 Instrumentation

KCB has been reading the instruments since 2016. Instrumentation installation details are tabulated in Table 1.1. Instrument locations are shown in Figure 1.

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In 2005, AMEC installed five SPs (SP05-01 through -04, and SP05-08), one pneumatic piezometer (PN) (PN05-06), and two SIs (SI05-05 and SI05-07) in the main slide area to monitor for groundwater and slope movement, respectively. Currently, only one SP and two SIs are operable. The other instruments are inoperable either due to shearing of the instrument or because they were lost due to ongoing road maintenance (e.g., covered). The remaining operable instruments were installed in boreholes recessed below ground surface and capped with flush-mounted casing protectors. SI05-05 is in the north ditch of Hwy 579:02; and SI05-07 and SP05-08 are on the south shoulder of Hwy 579:02, aligned with the centre of the main slide area.

The SIs were read using the same metric RST Digital MEMS Inclinometer System that has been used to the read the SIs since June 2021. The SI equipment used to read these instruments was previously changed in September 2006.

A Heron Instruments (Heron) vented-dipperLog data logger was installed by KCB in SP05-08 on May 28, 2020 to a depth of 12.3 m below ground surface. The data logger is programmed to take a reading every 24 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 readings.

During the June 25, 2022 reading, KCB could not retrieve data from the data logger, despite multiple troubleshooting techniques. KCB sent the data logger to Heron for servicing, and they were able to retrieve data up to January 7, 2022 from the data logger. It is unclear of why the data logger became inoperable, as there were no visible signs of damage. KCB will re-install the replacement data logger during the next reading cycle.

Table 1.1 Instrumentation Installation Details

Instrument ID	Instrument Type	Date Installed	UTM Coordinates[1] (m)		Ground Surface Elevation (m)	Stick Up (m)	Depth (mbgs[2])	Condition
			Northing	Easting				
SI05-05	SI	Sep. 2005	661862	5709058	115.0	0	14.5	Operable
SI05-07	SI	Sep. 2005	661842	5709028	115.5	0	15.0	Operable
~~SP05-01~~	~~SP~~	~~Sep. 2005~~	~~Unknown~~	~~Unknown~~	~~Unknown~~	~~Unknown~~	~~Unknown~~	~~Inoperable~~
~~SP05-02~~	~~SP~~	~~Sep. 2005~~	~~Unknown~~	~~Unknown~~	~~Unknown~~	~~Unknown~~	~~Unknown~~	~~Inoperable~~
~~SP05-03~~	~~SP~~	~~Sep. 2005~~	~~Unknown~~	~~Unknown~~	~~Unknown~~	~~Unknown~~	~~Unknown~~	~~Inoperable~~
~~SP05-04~~	~~SP~~	~~Sep. 2005~~	~~Unknown~~	~~Unknown~~	~~Unknown~~	~~Unknown~~	~~Unknown~~	~~Inoperable~~
SP05-08	SP with logger[3]	Sep. 2005	661842	5709025	115.5	0	15.2	Operable
~~PN05-06~~	~~PN~~	~~Sep. 2005~~	~~Unknown~~	~~Unknown~~	~~Unknown~~	~~Unknown~~	~~Unknown~~	~~Inoperable~~

Notes:
[1] Coordinates and ground surface elevations have not been surveyed and were estimated based on record drawings and location plan.
[2] Meters below ground surface (mbgs).
[3] A Heron Instruments Vented-dipperLog data logger is installed in SP05-08 to a depth of 12.3 m below ground surface. The data logger became inoperable on January 7, 2022 and the replacement data logger will be installed during the next reading cycle.

2 INTERPRETATION

2.1 General

For the SIs, the cumulative displacement, incremental displacement, and displacement-time data was plotted in the A-direction (i.e., the direction of the A0-grooves). The A0-grooves in the SIs are aligned approximately with the direction of maximum movement, in the downslope direction.

For the operable SP, the recorded water levels were converted to an equivalent water/piezometric elevation and plotted relative to ground surface elevation and the instruments screen elevation on two separate plots:

- on the first data plot (Figure I in Appendix I), water level data recorded between October 2005 and May 2020 using a water level meter is plotted; and
- on the second data plot (Figure II in Appendix I), water level data recorded between May 2019 and January 2022 using a water level meter and by the data logger is plotted with precipitation data downloaded from the Alberta Climate Information Service (ACIS) website for the Water Valley Station.

The SI and piezometer plots are included in Appendix I, and a summary of the SI and piezometer data is provided in Table 2.1 and Table 2.2, respectively.

2.2 Zones of Movement

No discernible movement has been recorded in SI05-05 since installation.

Discrete movement is being recorded in SI05-07 at an approximate depth of 5.3 m below ground surface in the highway embankment fill.

2.3 Interpretation of Monitoring Results

Previous assessments of the slope failure suggest that movement is likely in response to periods of heavy or prolonged rainfall, creek erosion at the toe of the slope, and high groundwater conditions. In June 2005, after a period of heavy rainfall, movements along the south side of the highway resulted in the eastbound lane of Hwy 579:02 being closed after it settled approximately 1.5 m.

After the 2005 geotechnical site investigation, AMEC concluded that the slope failure consisted of a rotational failure in the highway embankment fill that extended into the foundation. It was believed that the movement was a result of lower slope failures, triggered by creek erosion at the toe of the slope, retrogressing up the slope, and possibly high groundwater conditions the slope.

Table 2.1 Slope Inclinometer Reading Summary

Instrument ID	Date				Ground Surface Elevation (m)	Depth of Movement (mbgs[1])	Direction of Movement	Movement (mm)		Rate of Movement (mm/year)		
	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
SI05-05	Oct. 24, 2005	N/A – no discernible movement	Jun. 12, 2021	Jun. 25, 2022	115.0	N/A – no discernible movement						
SI05-07	Oct. 24, 2005	Jun. 12, 2021	Jun. 12, 2021	Jun. 25, 2022	115.5	3.8 – 5.8	A-Direction	63.3	0.8	17.5	0.8	0.3

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

Table 2.2 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])	Range Recorded by Data Logger Between previous and Most Recent Readings (mbgs[1])	Most Recent Reading (mbgs[1])	Change from Previous Reading (m)
SP05-08	Oct. 2005	Sep. 10, 2020	Jan 7, 2022	115.5	12.2 – 15.2	-1.2	11.5 – 7.4	N/A[2]	N/A[2]

Notes:
[1] Meters below ground surface (mbgs).
[2] Data logger inoperable since Jan. 7, 2022.

Historically, movement was recorded in SI05-07 at a rate of less than 10 mm/year, except between August 2013 and June 2015, when the rate of movement increased to approximately 17.5 mm/year. Since June 2015, the rate of movement being recorded in SI05-07 is generally negligible during the winter months (i.e., between the fall and spring readings) and up to 10 mm/year (overall) during the summer months (i.e., between the spring and fall readings).

It is noted that the rate of movement recorded in the spring of 2021 and 2022 was very slow (less than 1 mm/year). This was likely due to dry weather last year and in the spring of 2022 (see the precipitation data plotted on the piezometer plots). For comparison, the rate of movement in the previous wet year (2020) was approximately 7 mm/year. Increased movement may occur in response to periods of heavy or prolonged rainfall, resulting in higher groundwater conditions.

Upon review of the data obtained from the data logger between May 2020 and January 2022, there appears to be a relatively strong relationship between precipitation and water level response recorded in SP05-08 (i.e., water level increases in response to increased rainfall in September and October 2021). There are multiple precipitation events where there is no response recorded in SP05-08. However, these events where during winter months where the ground is frozen and there was no infiltration. The increase in April 2021 was most likely in response to snow melt (i.e., freshet).

The water level fluctuations may be due to condensation in the venting of the instrument cap and modification to the vent cap will be considered to see if we get a more muted response in water level.

3 RECOMMENDATIONS

3.1 Future Work

All operable instruments should continue to be read once per year (spring).

A geotechnical site investigation is recommended. The investigation should include installing additional SIs and piezometers to assess slide movement and monitor groundwater conditions, respectively.

Remedial options are currently being assessed by KCB and Alberta Transportation and may include realignment of the highway further north (upslope), possibly with backslope flattening and drainage to lower the groundwater table (e.g., horizontal drains, or gravel columns with pumps). The impact of drainage on local wells and dugouts should be assessed, along with any issues associated with discharging drain water into a natural water body.

The site should continue to be inspected by the Maintenance Contract Inspector (MCI) and as part of the Central Region GRMP Section B inspections.

3.2 Instrument Repairs and Maintenance

The replacement Heron data logger should be reinstalled, and troubleshooting of the data logger will be completed to confirm if increases in water level are real or a function of condensation in the venting of the instrument cap.

The flush-mounted casing protectors installed in the south shoulder of Hwy 579:02 to protect SI05-07 is missing a cover (Photo 1). KCB attempted to attach a new cover during the spring of 2022 reading; however, it could not be attached to the existing flush-mounted casing protector. The old flush-mounted casing protector should be removed and a new one installed during the next reading cycle.

Photo 1 **Flush-mounted casing protector installed in the south shoulder of Hwy 579:02 to protect the SI05-07. Photo taken June 15, 2021.**

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 the Central Region Geohazard Risk Management Program (Contract No. CON0022160), 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.

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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.

PROFESSIONAL ENGINEER ALBERTA
CHRIS GRÄPEL
September 13 2022
I.D. # 58463

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DATE: 13 Sep. 2022
PERMIT NUMBER: P009196
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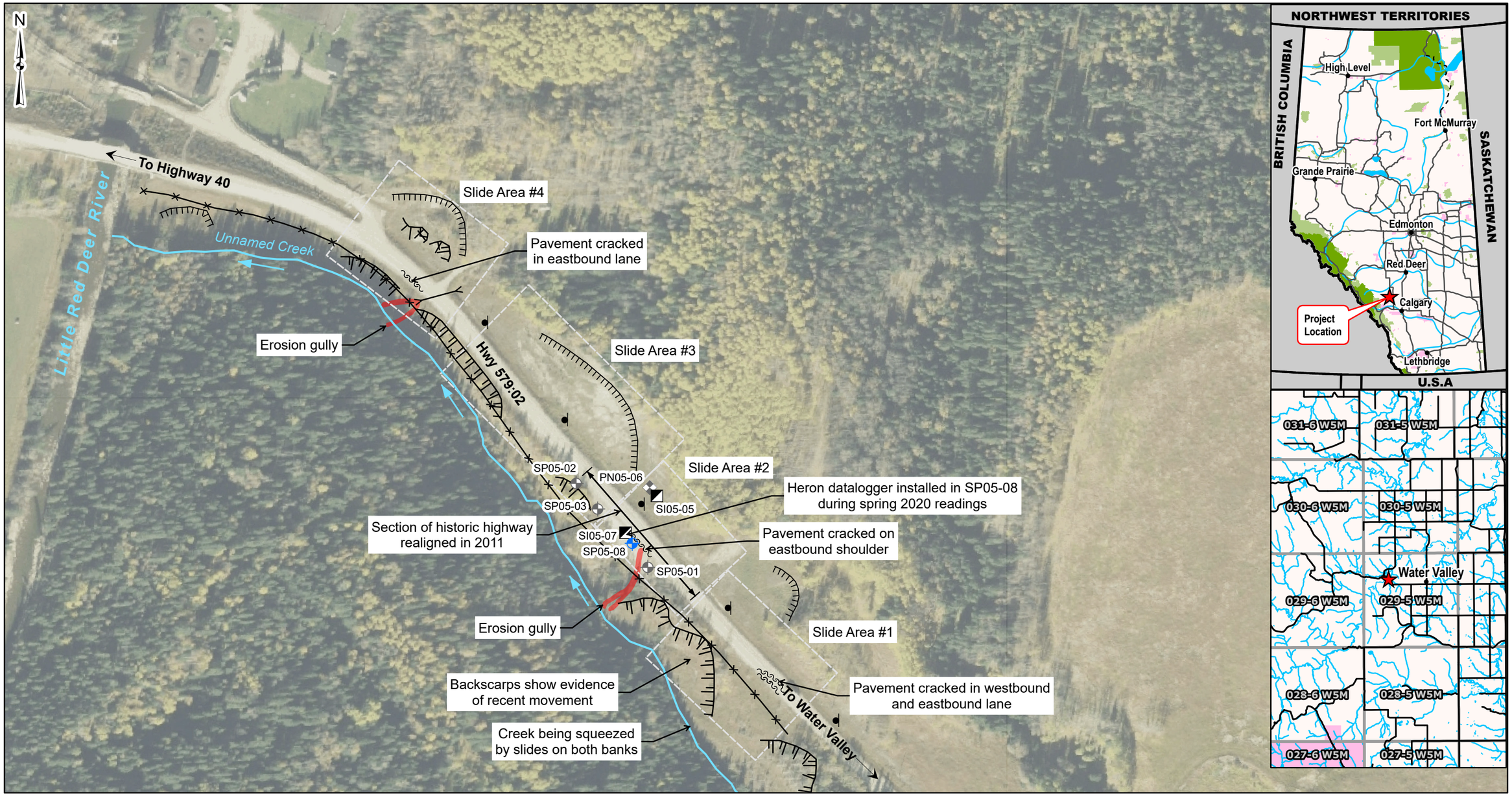
ATTACHMENTS
Figure
Appendix I Instrumentation Plots

FIGURE



Legend

- Pneumatic Piezometer (PN) (inoperable)
- Standpipe Piezometer (SP) (inoperable)
- Slope Inclinometer (SI)
- Standpipe Piezometer (SP)
- Power Pole
- Fence
- Culvert
- Crest of Slope
- Scarp
- Crack
- Creek
- Flow Direction
- Erosion

0 — 200 Meters

NOTES:
1. HORIZONTAL DATUM: NAD83
2. GRID ZONE: UTM ZONE 11N
3. IMAGE SOURCE: ABACUS DATAGRAPHICS LTD. IMAGE DATED JULY 30, 2013 to OCTOBER 14, 2013
4. LOCATION OF INSTRUMENTS IS APPROXIMATE (NOT SURVEYED)

CLIENT: Alberta

Klohn Crippen Berger

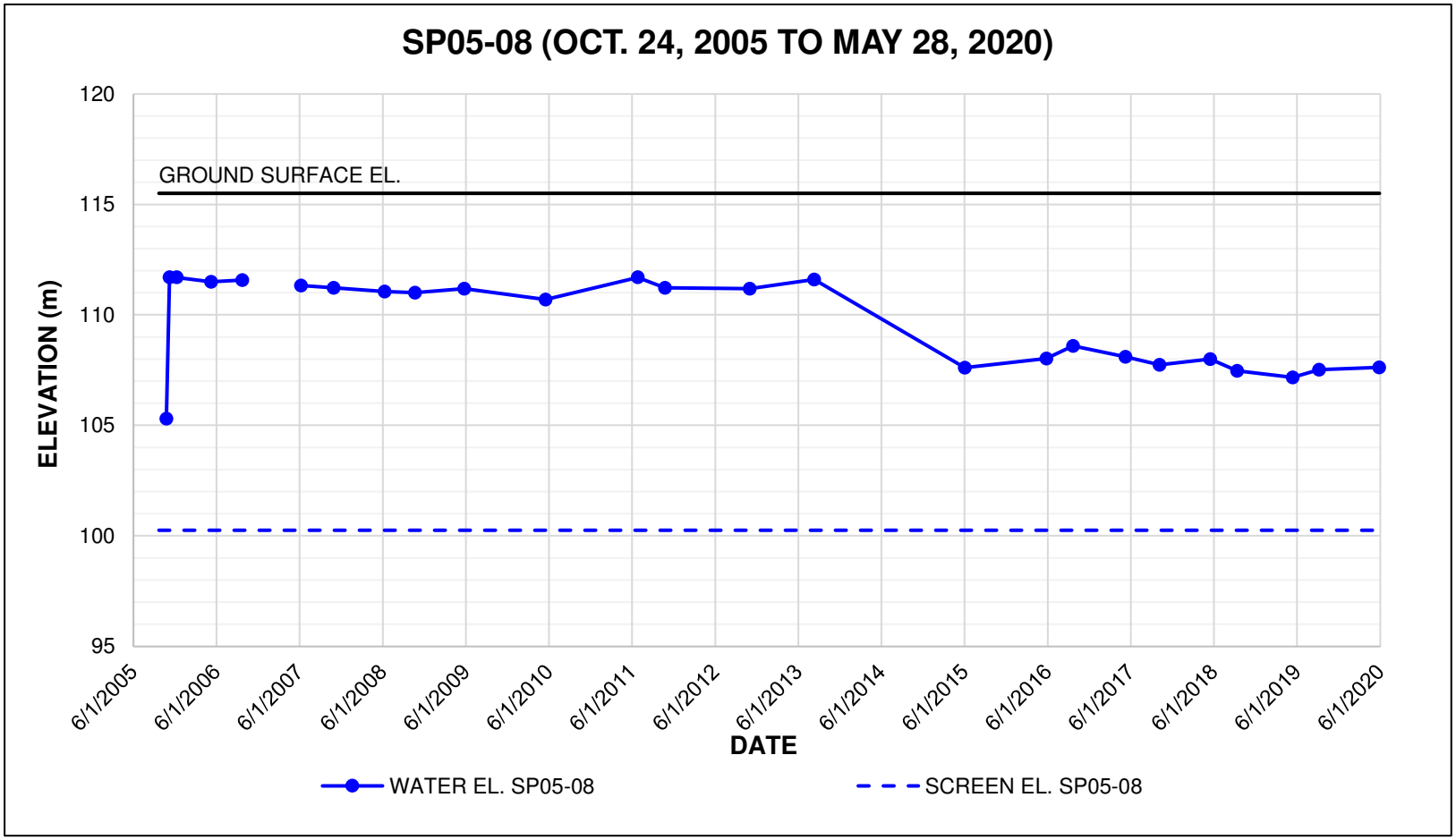
PROJECT: CENTRAL REGION GEOHAZARD RISK MANAGEMENT PROGRAM

TITLE: Site Plan
C042 - West of Water Valley Slide
H579:02, km 36.540

SCALE	PROJECT No.	FIG No.
1:2,500	A05116A02	1

APPENDIX I

Instrumentation Plots



CLIENT: Alberta / Klohn Crippen Berger	PROJECT: CENTRAL REGION GEOHAZARD RISK MANAGEMENT PROGRAM	
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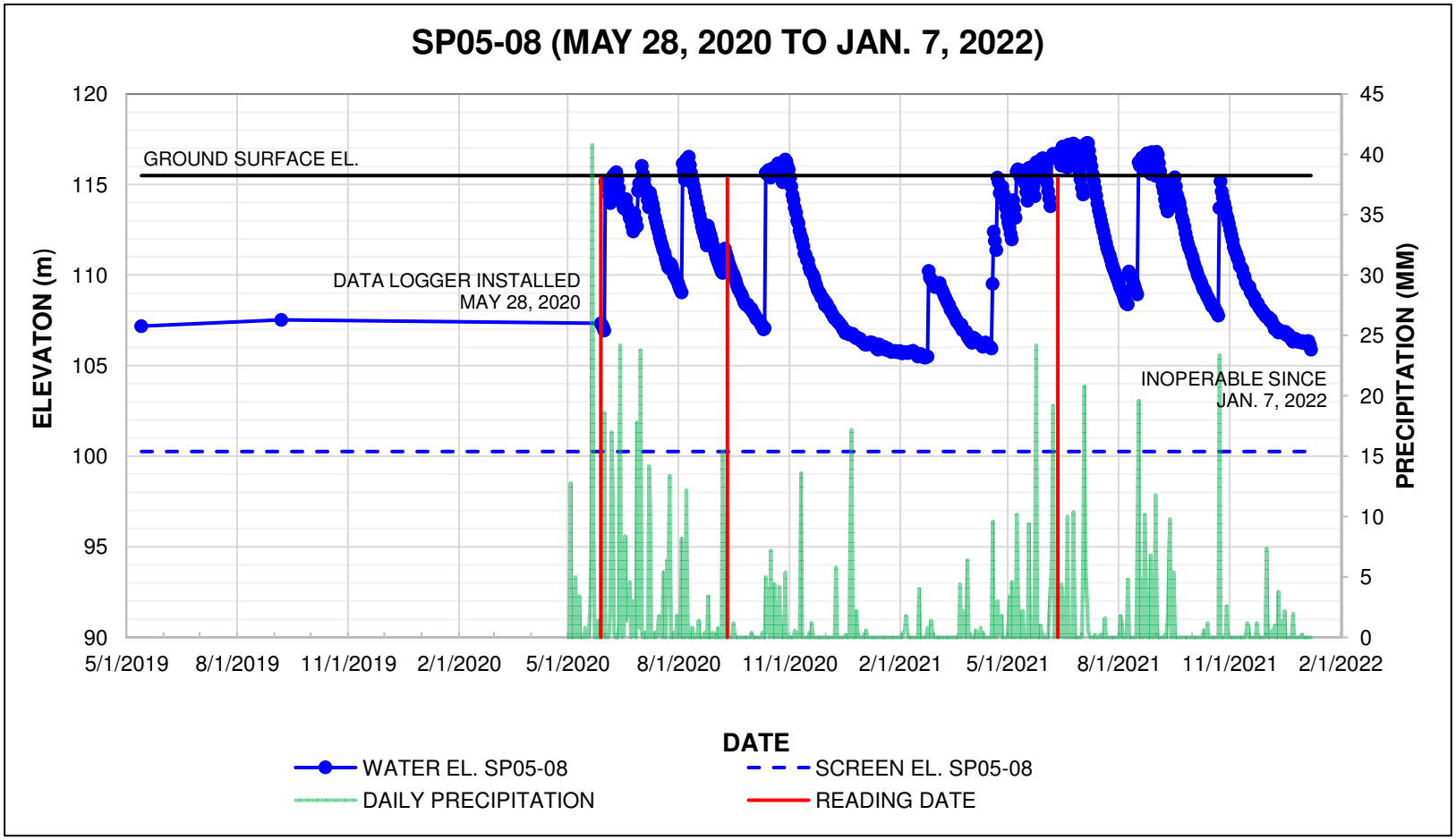
	SCALE	PROJECT No. A05116A02 / FIG No. 1



NOTES:
1. PRECIPITATION DATA OBTAINED FROM ALBERTA ENVIRONMENT AND PARKS' WATER VALLEY WEATHER STATION ON AUGUST 3, 2022.

CLIENT: Alberta / Klohn Crippen Berger	PROJECT: CENTRAL REGION GEOHAZARD RISK MANAGEMENT PROGRAM	
	TITLE: Piezometer Data C042 - West of Water Valley Slide Hwy 579:02, km 36.540	
SCALE	PROJECT No. A05116A02	FIG No. II

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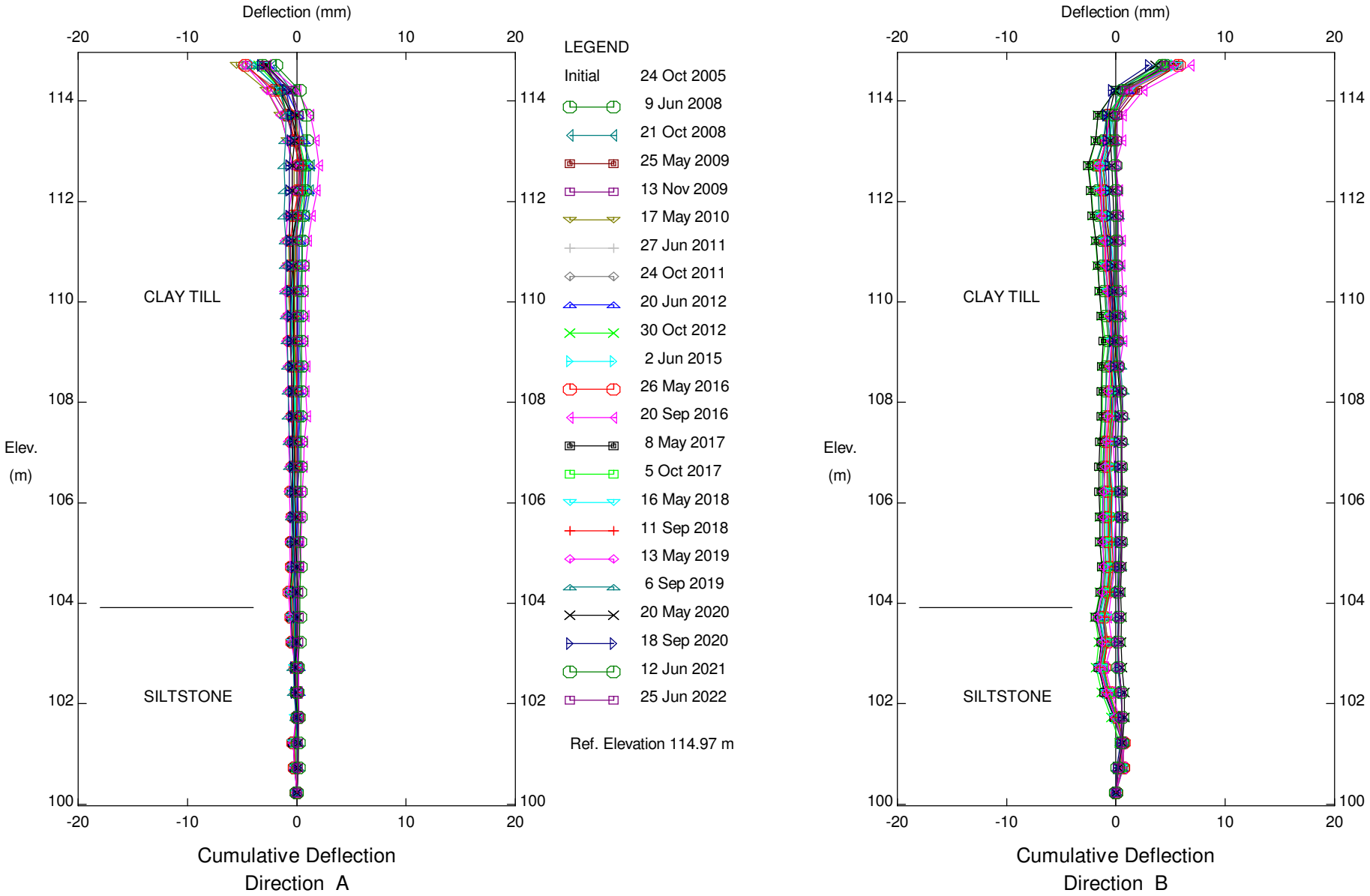

C042; H579:02,West of Water Valley Slide, Inclinometer SI05-05

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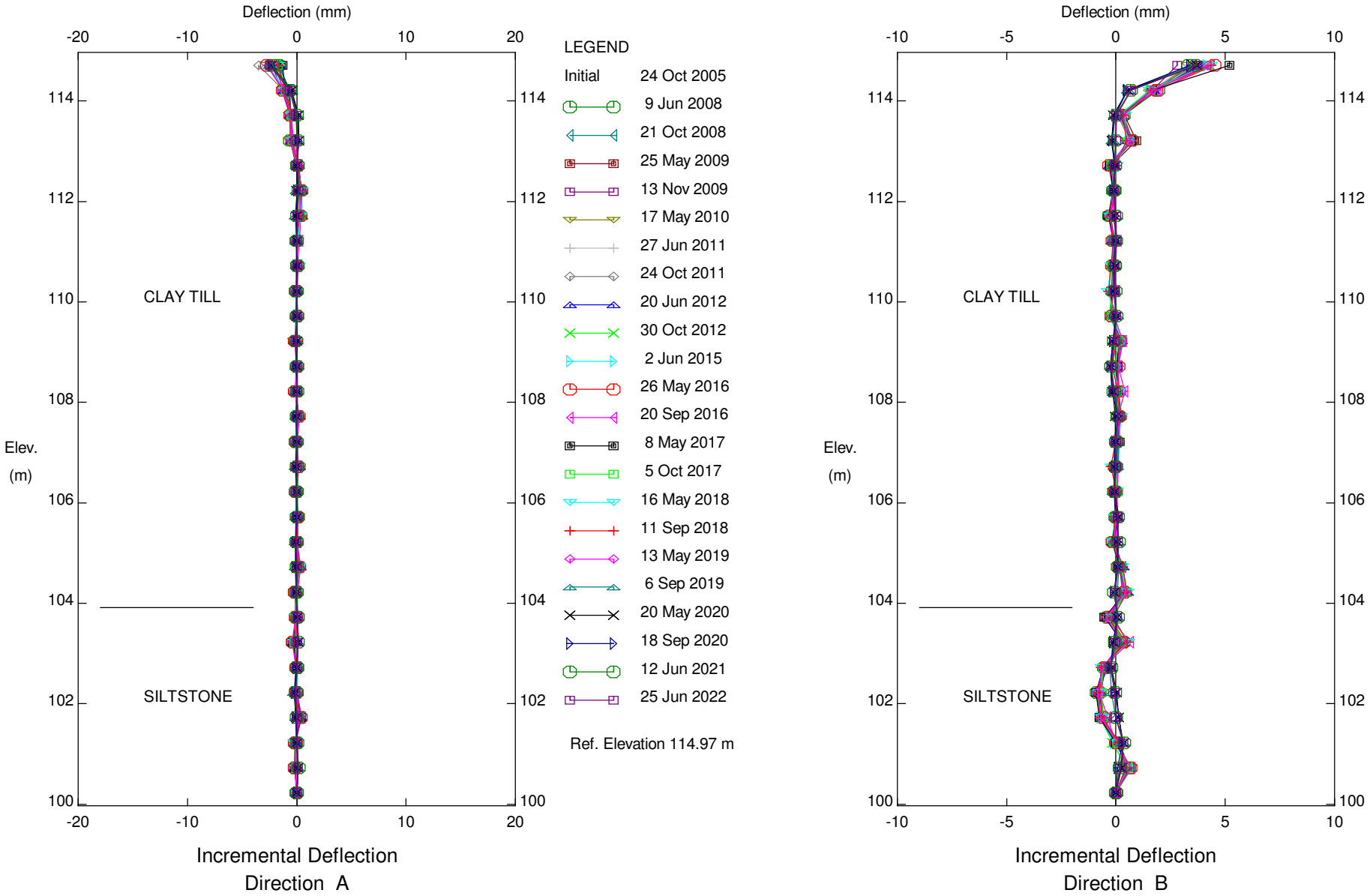

C042; H579:02,West of Water Valley Slide, Inclinometer SI05-05

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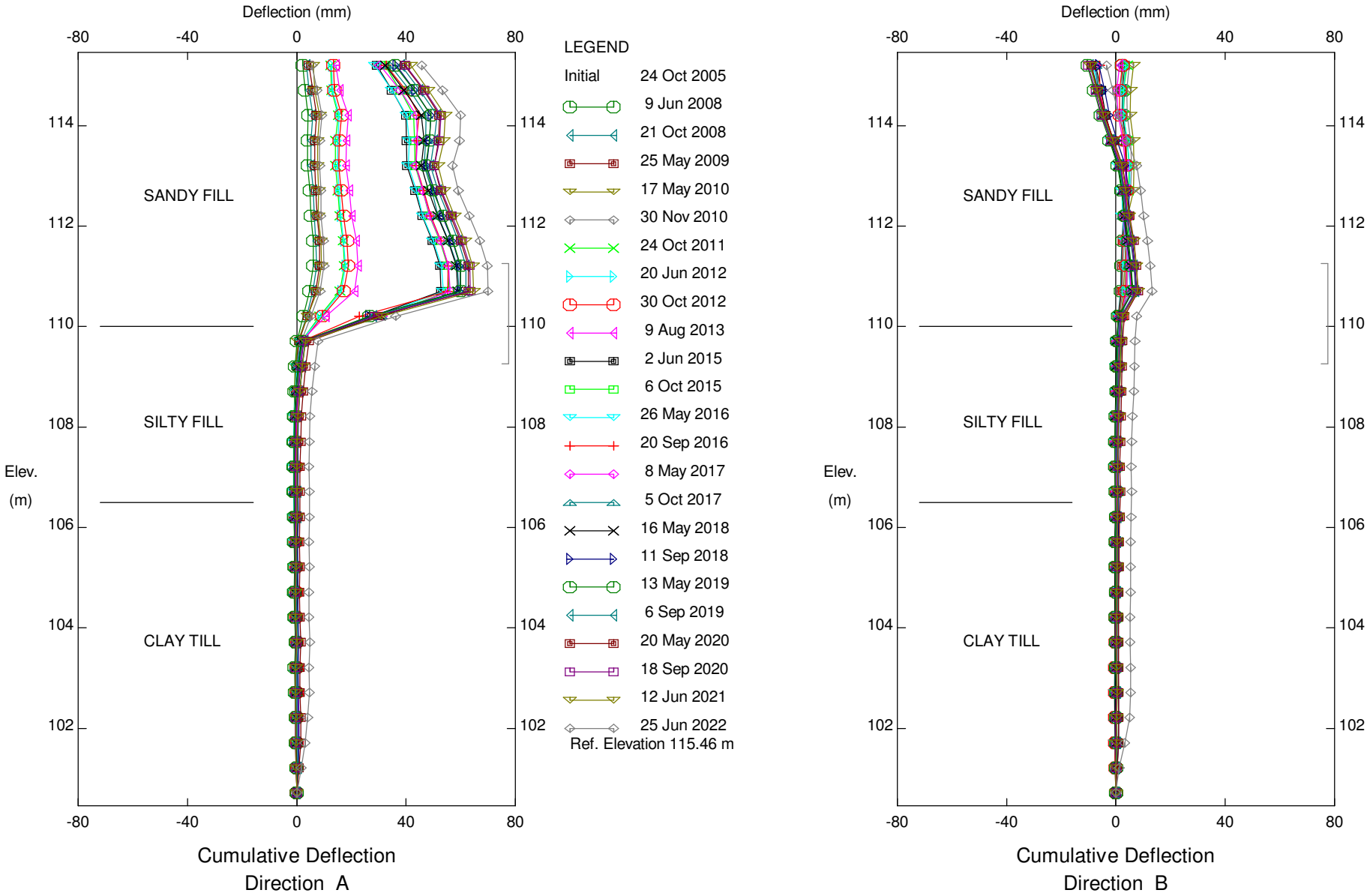

C042; H579:02,West of Water Valley Slide, Inclinometer SI05-07

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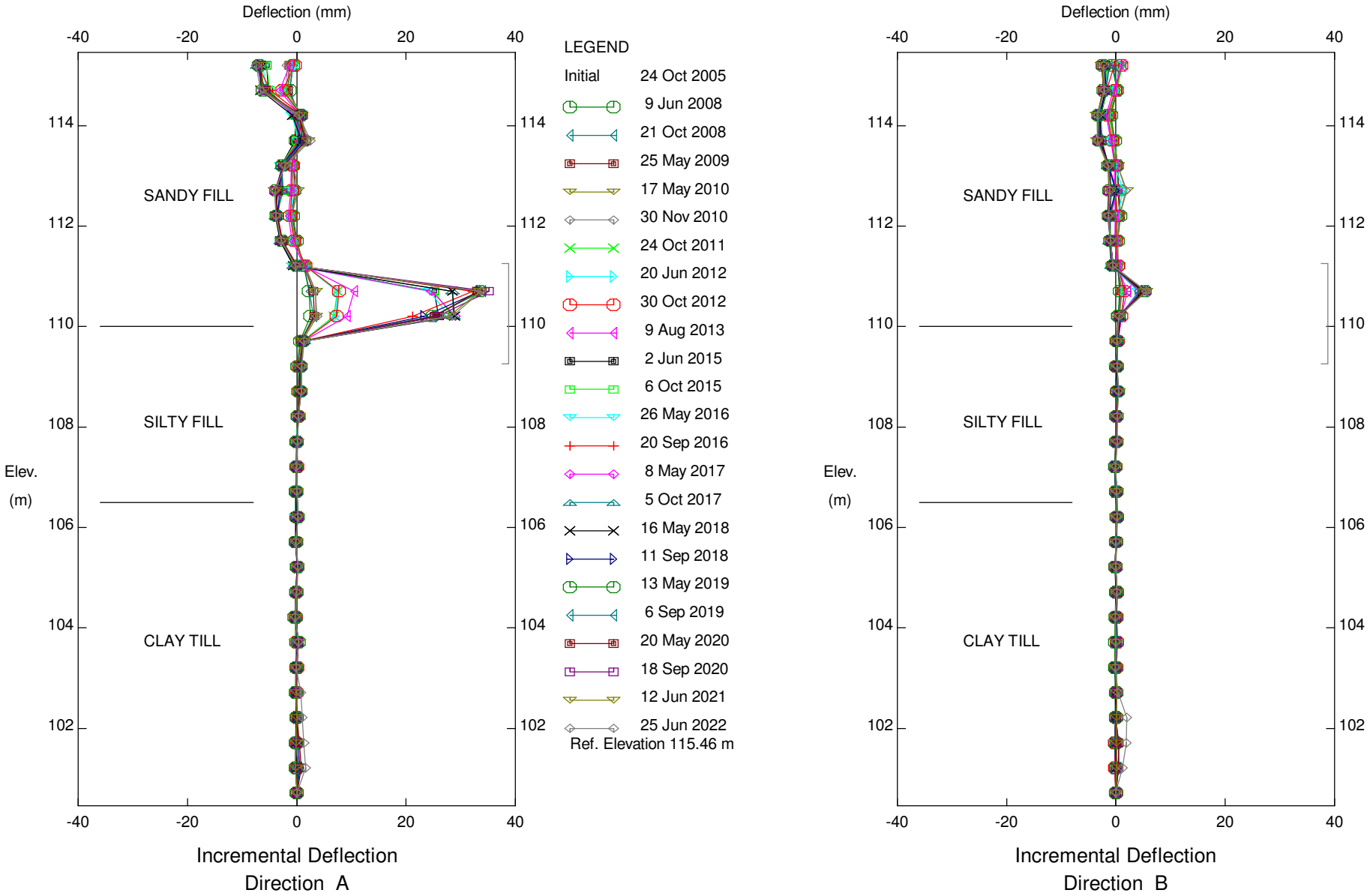

C042; H579:02,West of Water Valley Slide, Inclinometer SI05-07

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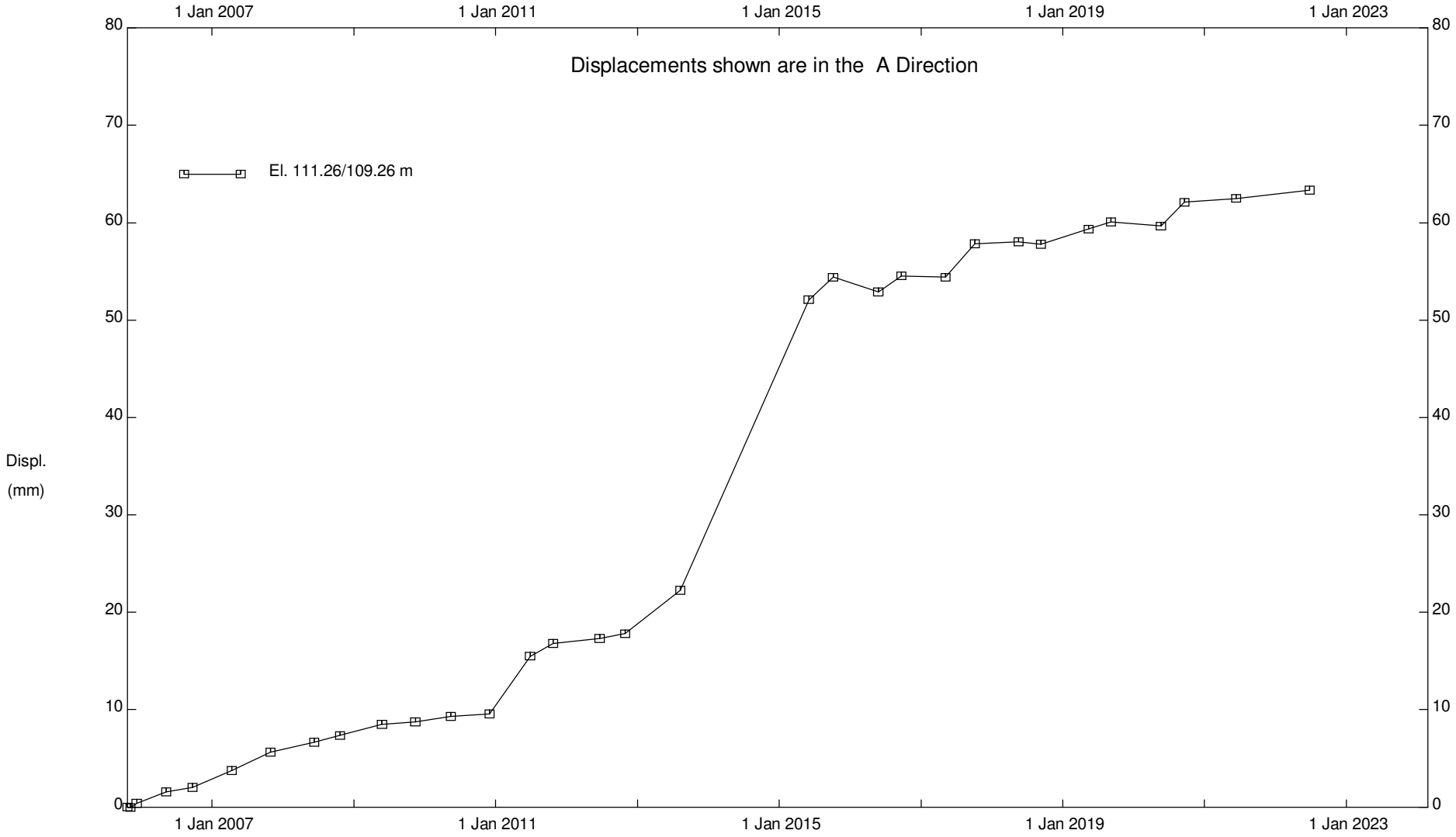

C042; H579:02,West of Water Valley Slide, Inclinometer SI05-07

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