November 29, 2022

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

Tony Penney, P.Eng.
Construction Engineer

Dear Mr. Penney:

CON0022160 Central Region GRMP Instrumentation Monitoring
Site C062; H41:02, km 2.889 Vermillion Backslope
Section C – 2022 Fall Readings

1 GENERAL

One slope inclinometer (SI) (SI18-C62-03), six vibrating wire piezometers (VWPs) (VW48782 through VW48785, VW48787, and VW48788), and one standpipe piezometer (SP) (SP18-01) were read at the C062 site in the Central Region on September 8, 2022 by Ms. Katrina Cereno of Klohn Crippen Berger Ltd. (KCB). These instruments were read as part of the Central Region Geohazard Risk Management Program (GRMP). The site is located on Hwy 41:02, km 2.889, approximately 2.9 km north of Vermillion, Alberta. The approximate site coordinates are 5912662 N, 509163 E (UTM Zone 12, NAD 83). A site plan is presented in Figure 1.

The geohazard at the C062 site consists of a large, deep-seated-translational earth slide on the east backslope (northbound lane) of Hwy 41:02.

In April 2018, KCB conducted a geotechnical site investigation at the C062 site. Drilling was completed by Mobile Augers and Research Ltd. The encountered stratigraphy was as follows: medium to high plastic silty clay till, overlying bedrock (mudstone).

1.1 Instrumentation

Instrumentation installation details are tabulated in Table 1.1. Instrument locations are shown in Figure 1.

In April 2018, KCB installed three SIs (SI18-C62-01 through SI18-C62-03), six VWPs (VW48782 through VW48785, VW48787, and VW48788), and one SP (SP18-01) to monitor depth of movement and ground water conditions, respectively. SI18-C62-01, VW48783, VW48784, and VW48788 were installed in a borehole (BH18-C62-01) located in the graben area at the crest of the slope. SI18-C62-02, VW48785, VW48787, and SP18-01 were installed in boreholes (BH18-C62-02 and -03) located

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approximately at midslope, and SI18-C62-03 and VW48782 were installed in a borehole (BH18-C62-04) located at the toe of the slope in the east (northbound) highway ditch. By September 2019, SI18-C62-01 (crest) and SI18-C62-02 (midslope) were both sheared.

The instruments are protected by above-ground casing protectors.

The operable SI was read using the same metric RST Digital MEMS Inclinometer System that has been used to read the SI since it was installed.

The VWPs were read using an RST VW2106 vibrating wire readout and the SP was read using an RST Water Level Meter.

Table 1.1 Instrumentation Installation Details

Instrument ID	Instrument Type	Date Installed	UTM Coordinates[1] (m)		Ground Surface Elevation[1] (m)	Stick Up (m)	Depth (mbgs[2])	Condition
			Northing	Easting				
~~SI18-C62-01~~	~~SI~~	~~Apr. 07, 2018~~	~~5912695~~	~~509210~~	~~608~~	~~0.9~~	~~22.2~~	~~Inoperable[3]~~
~~SI18-C62-02~~	~~SI~~	~~Apr. 06, 2018~~	~~5912669~~	~~509199~~	~~600~~	~~0.9~~	~~24.4~~	~~Inoperable[3]~~
SI18-C62-03	SI	Apr. 08, 2018	5912647	509186	593	0.8	10.5	Operable
VW48782	VWP	Apr. 08, 2018	5912647	509186	593	N/A	9.6	Operable
VW48783	VWP	Apr. 07, 2018	5912695	509210	608	N/A	6.1	Operable
VW48784	VWP	Apr. 07, 2018	5912695	509210	608	N/A	14.3	Operable
VW48785	VWP	Apr. 06, 2018	5912669	509199	600	N/A	12.8	Operable, but dry
VW48787	VWP	Apr. 06, 2018	5912669	509199	600	N/A	23.8	Operable
VW48788	VWP	Apr. 07, 2018	5912695	509210	608	N/A	21.3	Operable
SP18-01	SP	Apr. 06, 2018	5912667	509201	600	0.8	13.6	Operable, but dry

Notes:
[1] Coordinates and ground surface elevations were estimated from July 2018 survey data.
[2] Meters below ground surface (mbgs).
[3] SI18-C62-01 and SI18-C62-02 have sheared at an approximate depth of 12.0 m and 4.5 m below ground surface, respectively.

2 INTERPRETATION

2.1 General

For the operable SI, the cumulative displacement, incremental displacement, and displacement-time data was plotted in the A-direction (i.e., the direction of the A0-groove). The A0-groove in the SI is aligned approximately with the direction of anticipated maximum movement (i.e., perpendicular to the highway), in the downslope direction.

For the operable VWPs, the recorded porewater pressures were converted to an equivalent water/piezometric elevation and plotted relative to ground surface elevation and each instruments tip elevation. No data plot is provided for SP18-01 because it has been dry since installation.

The SI and piezometer data plots are included in Appendix I, and a summary of the SI and piezometer data is provided in Table 2.1 through Table 2.3, respectively.

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
~~SI18-C62-01[2]~~	~~Apr. 16, 2018~~	~~Jul. 13, 2018~~	~~May 16, 2019~~	~~N/A – inoperable[2]~~	~~608~~	~~11.4 – 12.0~~	~~A-Direction~~	~~36.5~~	~~N/A – inoperable[2]~~	~~40.2~~	~~N/A – inoperable[2]~~	
~~SI18-C62-02[2]~~	~~Apr. 16, 2018~~	~~Jul. 13, 2018~~	~~May 16, 2019~~	~~N/A – inoperable[2]~~	~~600~~	~~3.4 – 4.4~~	~~A-Direction~~	~~50.5~~	~~N/A – inoperable[2]~~	~~54.2~~	~~N/A – inoperable[2]~~	
SI18-C62-03	Apr. 16, 2018	N/A – no discernible movement has been recorded	Jun. 23, 2022	Sep. 08, 2022	593	N/A – no discernible movement recorded						

Notes:
[1] Meters below ground surface (mbgs).
[2] SI18-C62-01 and SI18-C62-02 have sheared at an approximate depth of 12.0 m and 4.5 m below ground surface, respectively.

Table 2.2 Vibrating Wire Piezometer Reading Summary

Instrument ID / Serial No.	Date			Ground Surface Elevation (m)	Tip Depth (mbgs[1])	Water Level		
	Installed	Previous Reading	Most Recent Reading			Previous Reading (mbgs[1])	Most Recent Reading (mbgs[1])	Change from Previous Reading (m)
VW48782	Apr. 08, 2018	Jun. 23, 2022	Sep. 08, 2022	593	9.6	2.7	3.5	-0.8
VW48783	Apr. 07, 2018	Jun. 23, 2022	Sep. 08, 2022	608	6.1	2.5	2.8	-0.3
VW48784	Apr. 07, 2018	Jun. 23, 2022	Sep. 08, 2022	608	14.3	12.9	12.9	0.0
VW48785	Apr. 06, 2018	Jun. 23, 2022	Sep. 08, 2022	600	12.8	N/A - instrument is dry		
VW48787	Apr. 06, 2018	Jun. 23, 2022	Sep. 08, 2022	600	23.8	14.9	14.7	0.2
VW48788	Apr. 07, 2018	Jun. 23, 2022	Sep. 08, 2022	608	21.3	20.1	20.1	0.0

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

Table 2.3 Standpipe Piezometer Reading Summary

Instrument ID	Date			Ground Surface Elevation (m)	Screen Depth (mbgs[1])	Water Level		
	Installed	Previous Reading	Most Recent Reading			Previous Reading (mbgs[1])	Most Recent Reading (mbgs[1])	Change from Previous Reading (m)
SP18-01	Apr. 06, 2018	Jun. 23, 2022	Sep. 08, 2022	600	10.6 – 13.6	N/A – instrument dry		

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

2.2 Zones of Movement

Prior to being sheared, movement was recorded in SI18-C62-01 (crest) and SI18-C62-02 (midslope) at an approximate depth of 12.0 m and 4.5 m below ground surface, respectively, in the clay till. The movement recorded in these instruments was discrete (i.e., occurring on a defined failure plane) at an approximate elevation of 596 m.

Since installation, no discernible movement has been recorded in SI18-C62-03 (toe of slope).

2.3 Interpretation of Monitoring Results

Previous geotechnical site investigations and current instrumentation data suggest the mode of failure is likely a deep-seated translational earth block slide. Discrete movement was recorded in SI18-C62-01 (crest) and SI18-C62-02 (midslope) at an approximate elevation of 596 m. No discernible movement has been recorded in SI18-C63-03 (toe of slope) since installation. Recorded movement in the midslope and crest of the backslope was at a similar elevation, and the absence of movement at the toe suggests that the depth of the basal failure planes varies from 12.0 m in the graben area (SI18-C62-01) to 4.5 m at the midslope (SI18-C62-02). During the 2018 drilling investigation, a zone of clay till with elevated moisture contents and sand/silty layers was encountered near the basal failure plane location.

The rate of movement previously recorded at the midslope in SI18-C62-02 was higher than the rate of movement recorded at the crest of the slope in SI18-C62-01. As the lower portion of the slide beneath the midslope continues to move, the upper portion of the slide beneath the crest of the slope will experience an increased rate of movement due to the loss of support associated with the lower portion of the slide moving away from the upper portion of the slide.

The piezometers have been either relatively steady (±1.35 m) or dry since installation. The September 2022 reading of the piezometers was consistent with historical trends observed in these instruments.

In the nested piezometers installed in BH18-C62-01 (VW48783, VW48784, and VW48788) at the crest of the slope two independent water levels were detected in the clay till, which could indicate the presence of two perched groundwater tables. This is likely due to the presence of sand and silt lenses found interbedded within the clay till layer.

The current porewater pressure data and previously recorded movements are consistent with the initial monitoring results presented in our 2018 geotechnical site investigation report dated October 5, 2018. The current instrumentation data also supports the analysis and recommendations presented in our 2018 report (i.e., that lowering the groundwater table or flattening the backslope could improve overall stability by approximately 50% to 60%).

3 RECOMMENDATIONS

3.1 Future Work

KCB recommends reducing the reading frequency of all operable instruments from twice per year (spring and fall) to once per year (spring) unless movements increase and began to impact the highway.

Remedial options are currently being assessed by KCB and Alberta Transportation (AT) and may include installing horizontal drains and/or flattening the slope. At this time, the highway below the slide has not been affected by slope movements, but the toe roll is starting to block the ditch. If the rate of movement is observed to be increasing, as assessed by visual observations at the toe and crest of the slide, or the ditch becomes blocked, AT will need to take action to ensure that the highway is not impacted.

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 or Maintenance

No instrument repairs or maintenance is required.

4 CLOSING

This report is an instrument of service of Klohn Crippen Berger (KCB). The report has been prepared for the exclusive use of Alberta Transportation (Client) for the specific application to 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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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.
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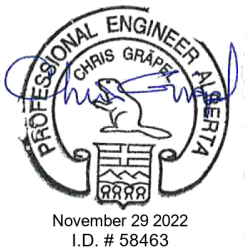
4. KCB should be consulted regarding the interpretation or application of the findings and recommendations in the report.
5. This report is electronically signed and sealed and its electronic form is considered the original. A printed version of the original can be relied upon as a true copy when supplied 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.



November 29 2022
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JL:bb

PERMIT TO PRACTICE
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RM SIGNATURE: _____

RM APEGA ID #: 187607

DATE: 29 Nov. 2022

PERMIT NUMBER: P009196
The Association of Professional Engineers and Geoscientists of Alberta (APEGA)

ATTACHMENTS
Figure
Appendix I Instrumentation Plots

FIGURE

Legend

- Instrument Location
- Power Pole
- Toe Roll
- Main Scarp
- Minor Scarp
- Crack

0 — 100 Meters

NOTES:
1. HORIZONTAL DATUM: NAD83
2. GRID ZONE: UTM Zone 12N
3. IMAGE SOURCE: World Imagery, ESRI ArcGIS Online Acquired for use October 18, 2021.
4. Instrument locations are approximate (not surveyed).
5. Strikethrough indicates the instrument is inoperable.

CLIENT: Alberta

Klohn Crippen Berger

PROJECT: CENTRAL REGION GEOHAZARD RISK MANAGEMENT PROGRAM

TITLE: Site Plan
C062 - Vermillion Backslope
Hwy 41:02, km 2.889

SCALE	PROJECT No.	FIG No.
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APPENDIX I

Instrumentation Plots

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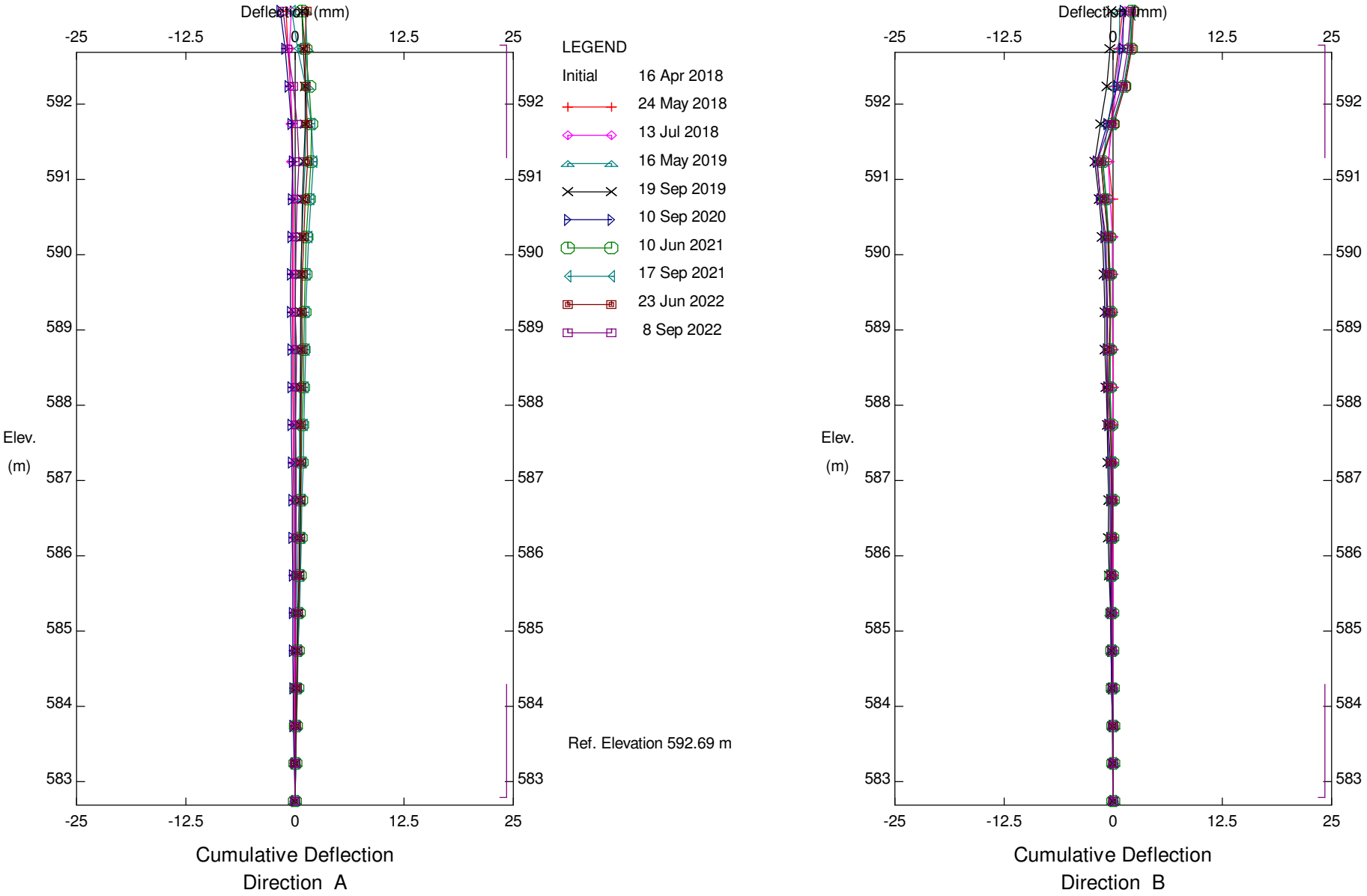

C062; H41:02, Vermilion Backslope, Inclinometer SI18-C62-03

Alberta Transportation

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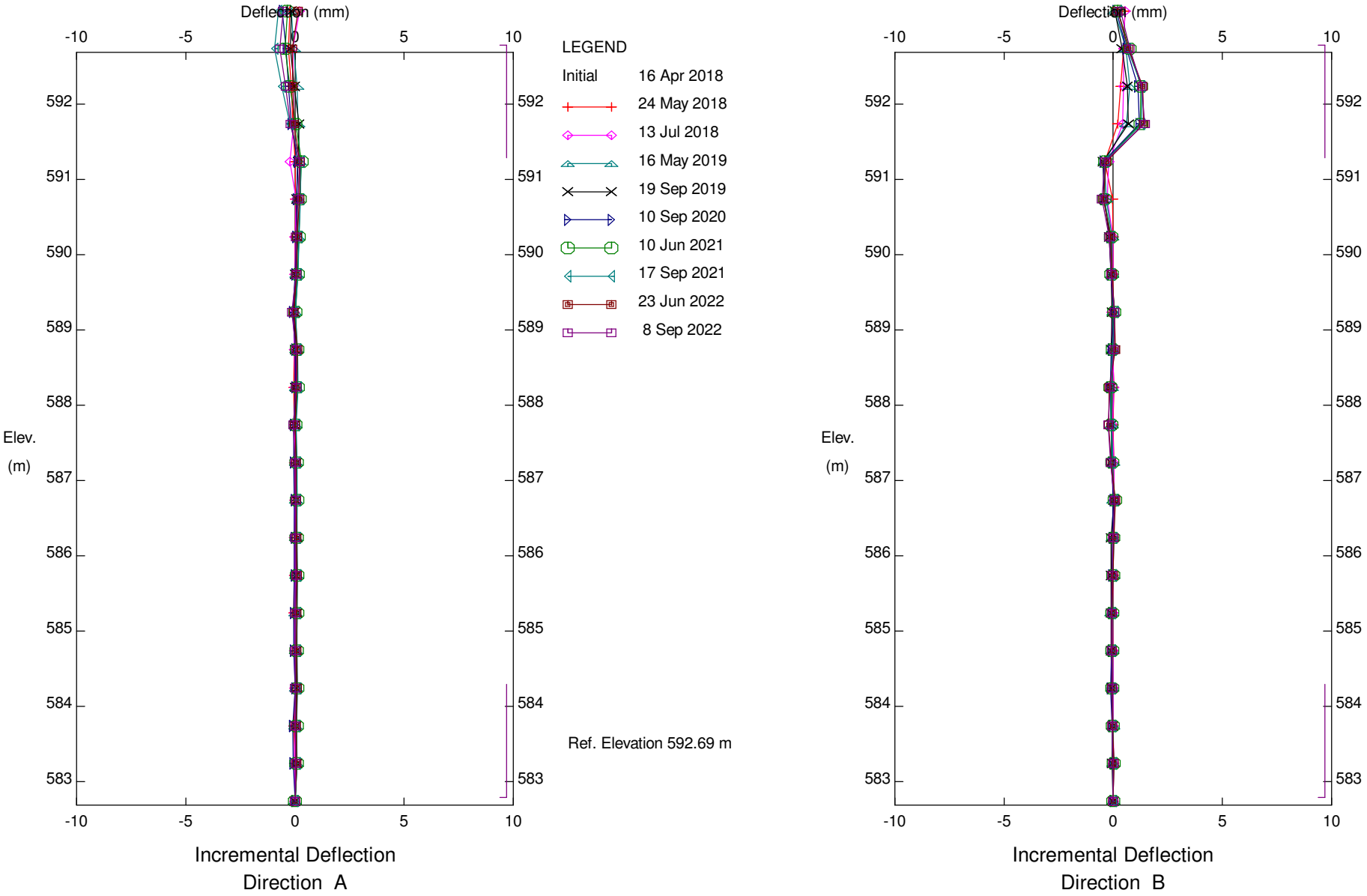

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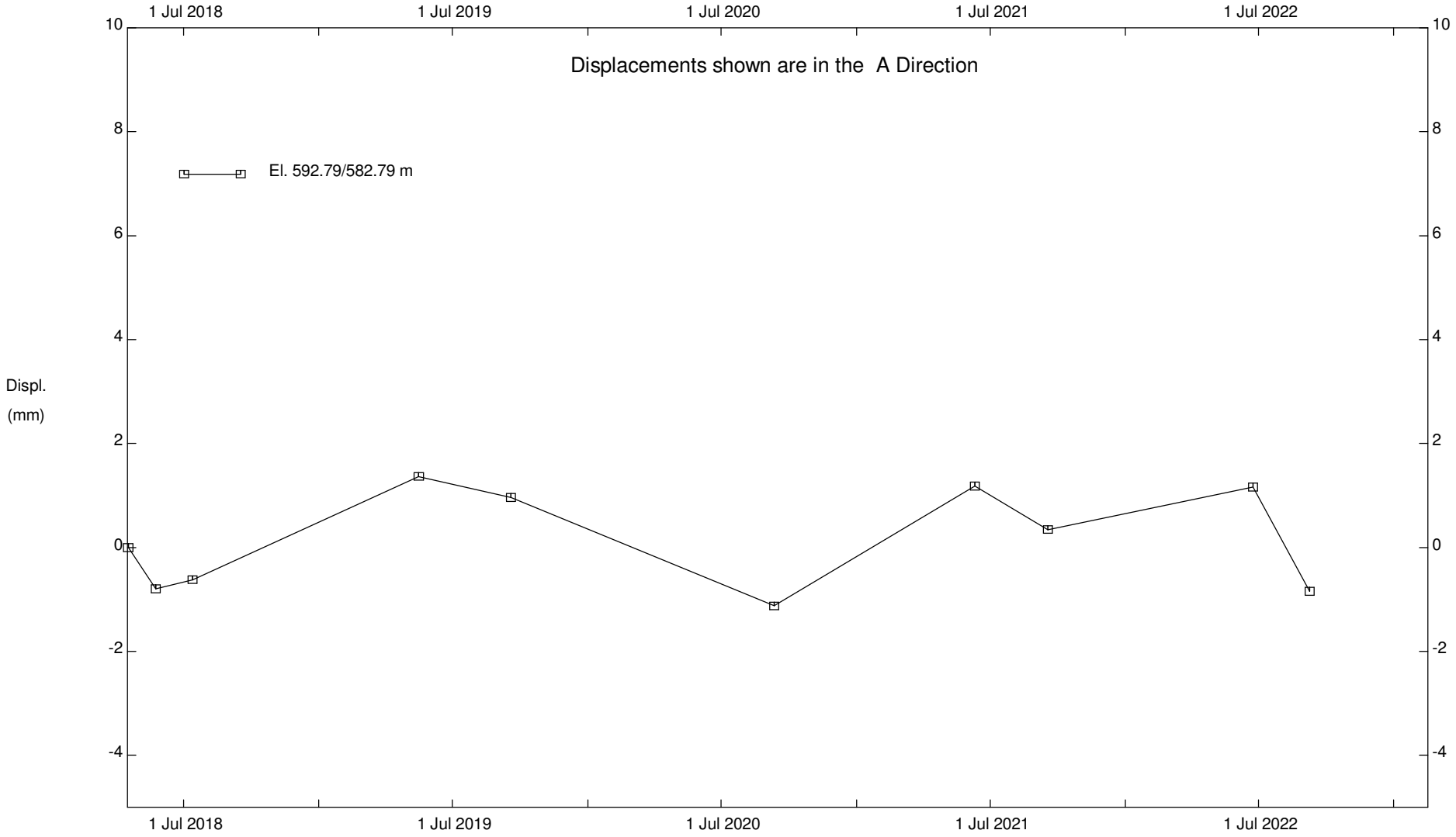

C062; H41:02, Vermilion Backslope, Inclinometer SI18-C62-03

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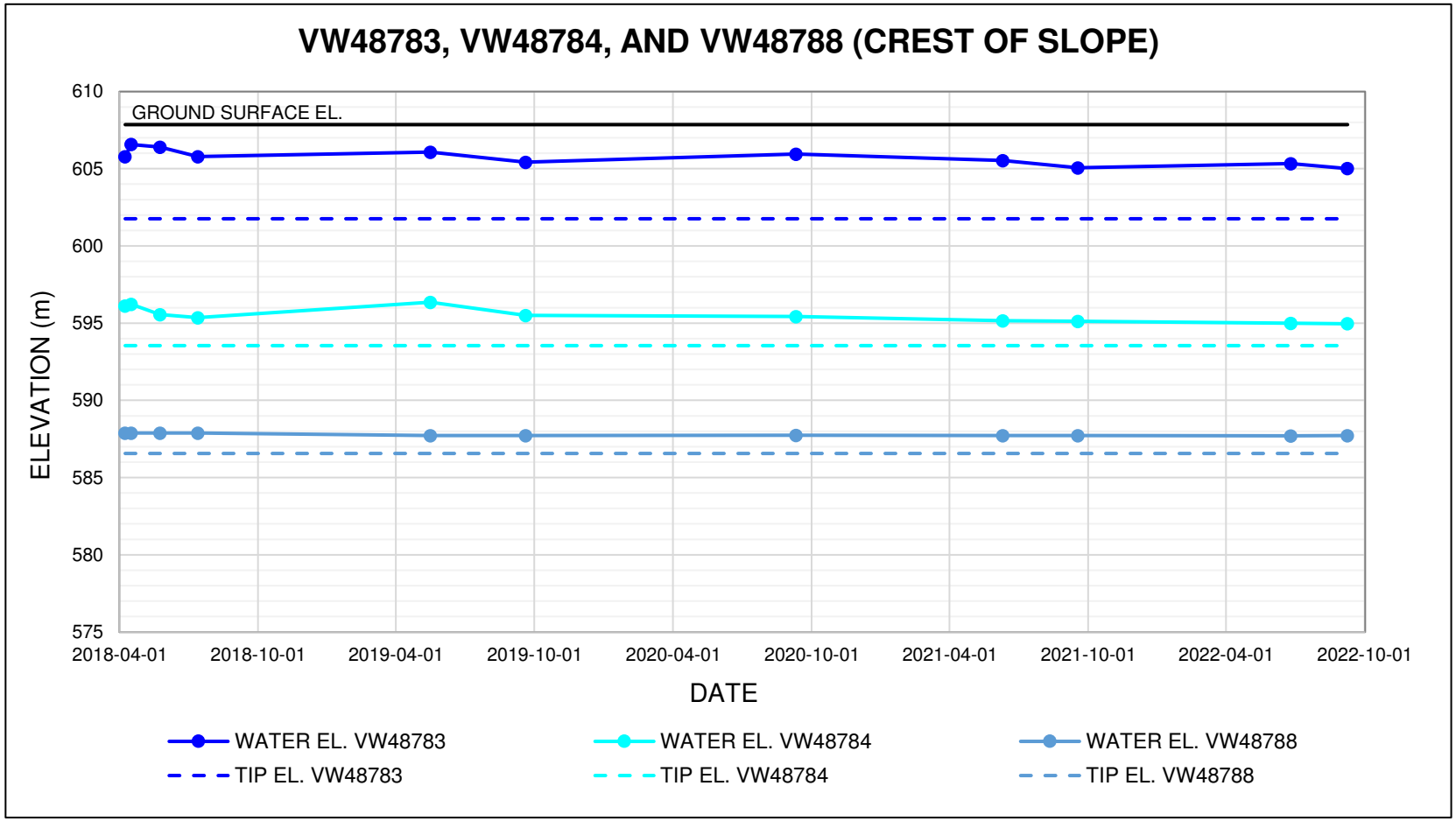


NOTES:
1. GROUND SURFACE ELEVATION OBTAINED FROM THE JULY 2018 TOPOGRAPHIC SURVEY COMPLETED BY CHALLENGER GEOMATICS LTD.

CLIENT
Alberta
Klohn Crippen Berger

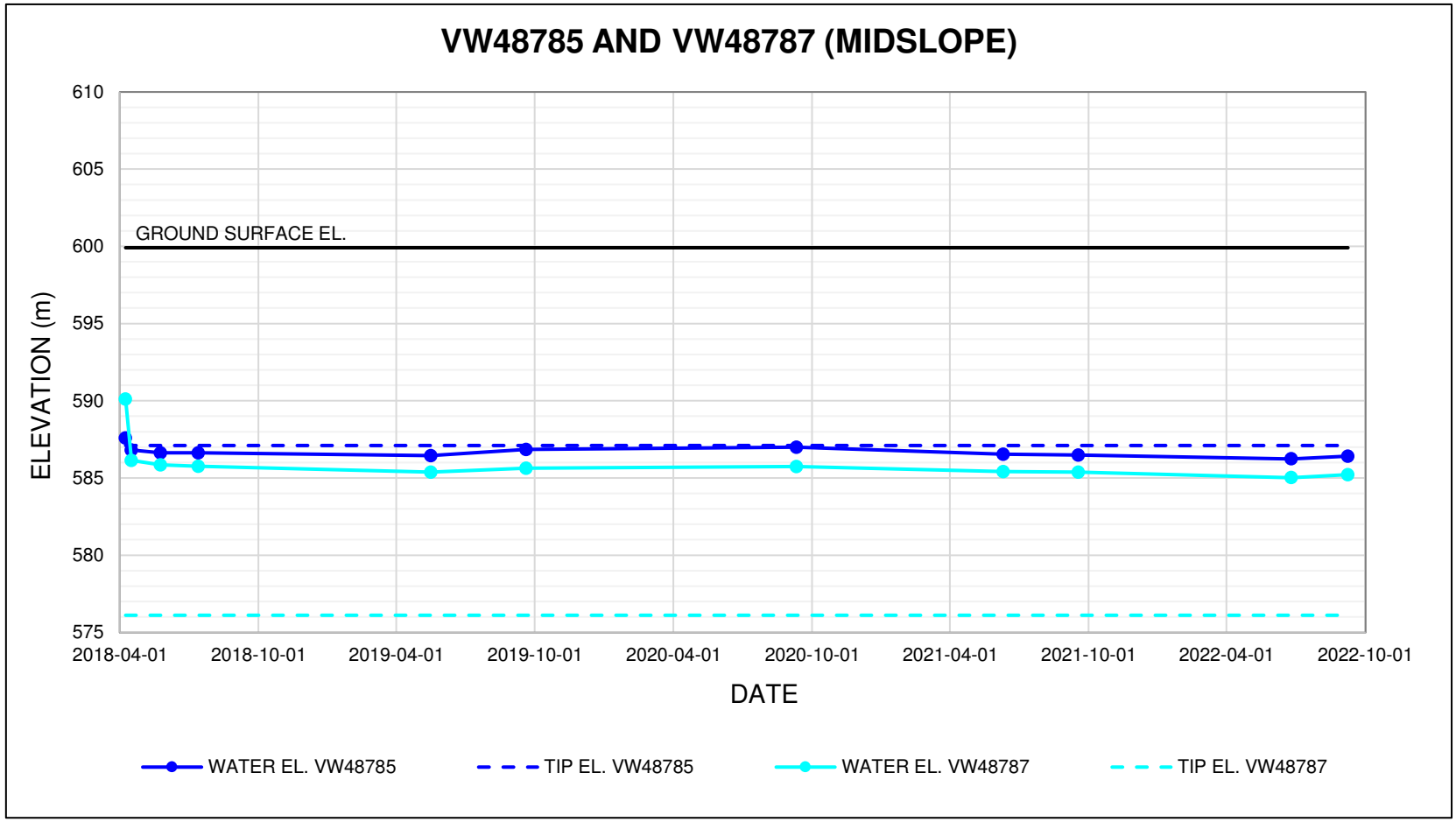
PROJECT
CENTRAL REGION GEOHAZARD RISK MANAGEMENT PLAN

TITLE
Piezometer Data
C062 - Vermillion Backslope
Hwy 40:02, km 2.889

SCALE

PROJECT No. A05116A02

FIG No.



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Piezometer Data
C062 - Vermillion Backslope
Hwy 40:02, km 2.889

SCALE	PROJECT No.	FIG No.
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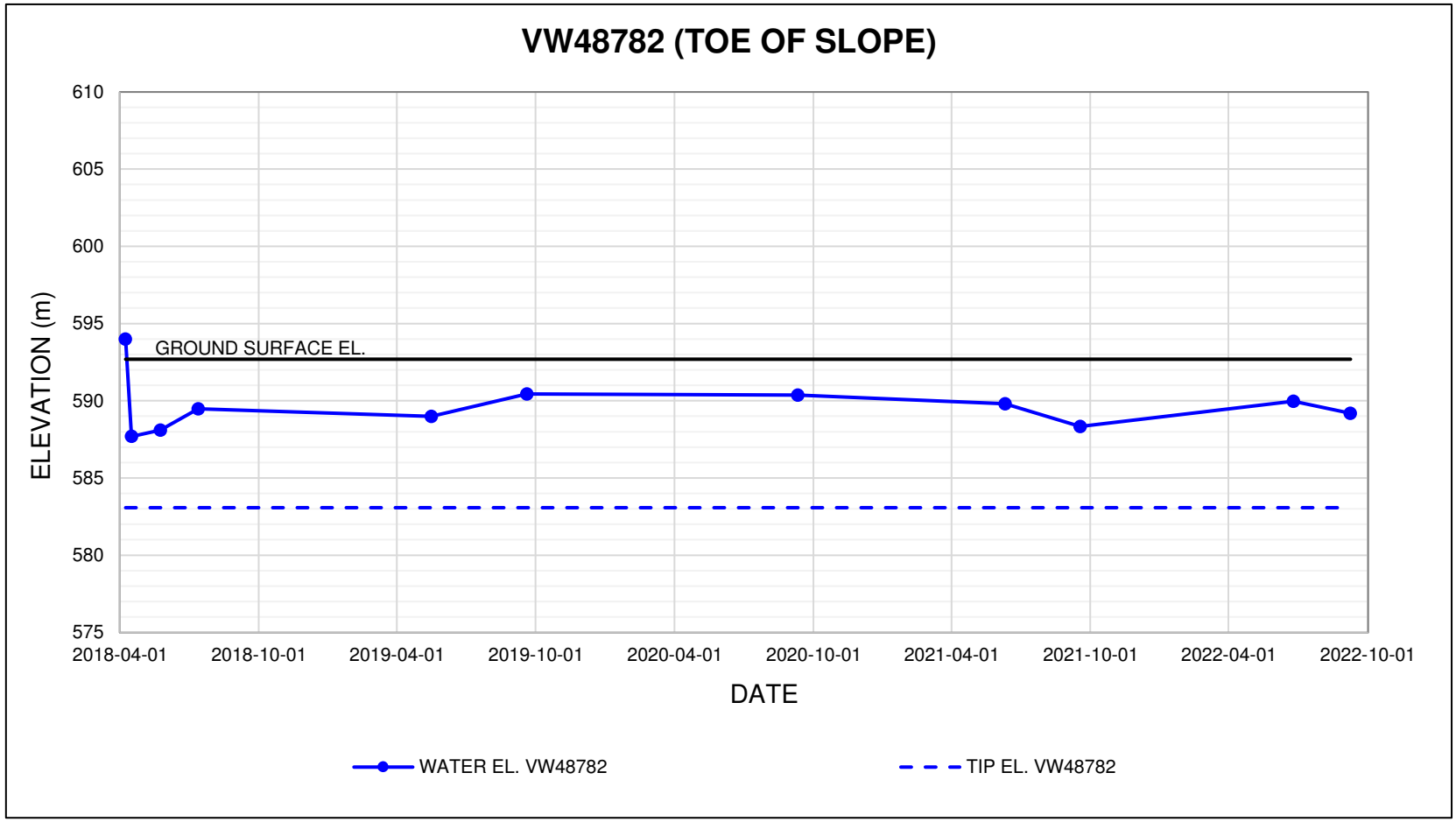

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SCALE	PROJECT No.	FIG No.
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