

Project Number: 6-CD109.55

Landslide Monitoring Report – Dickson Street

6 April 2023

CONFIDENTIAL



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Document Details:

Date: 6/04/2023
Reference: 6-CD109.55
Status: Final

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Document History and Status

Revision	Date	Author	Reviewed by	Approved by	Status
A	6/04/2023	Bryce Harrison/Christopher Hall	Latasha Templeton	Abdul Obaid	Final

Revision Details

Revision	Details
A	Final



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Disclaimers and Limitations

This report (**'Report'**) has been prepared by WSP New Zealand Limited exclusively for Dunedin City Council (**'Client'**) in relation to the landslide monitoring at selected sites in Dunedin (Landslide Monitoring Long-Term SoW DCC Reference 9662). The scope of this report is to present the survey monitoring results and recommendations for future surveys for the site (**'Purpose'**). The findings in this Report are based on and subject to the assumptions specified in the Report. WSP accepts no liability whatsoever for any reliance on or use of this Report, in whole or in part, for any use or purpose other than the Purpose or any use or reliance on the Report by any third party.

Executive Summary

A recent survey of the Dickson Street site has been undertaken in September 2022 to assess the extent of movements compared with previous surveys. Deformations found to exceed the accuracy of the survey (± 15 mm horizontal, ± 25 mm vertical) are presented in Table 1.

Table 1: Summary of recorded displacements for the Dickson Street site.

	Horizontal	Vertical
Displacements from the previous survey	N/A	N/A
Displacements from the base survey	16 – 57 mm	34 – 52 mm

The results indicate that deformation is continuing. We recommend the next survey to be undertaken between mid-2023 and mid-2024 and a review of the viability of remote monitoring be completed in conjunction with WSP.

1 Introduction

WSP New Zealand Limited (WSP) have been commissioned by Dunedin City Council (DCC) to undertake monitoring of 12 landslide sites around Dunedin. The purpose of monitoring is to identify the trend and magnitude of movements and provide recommendations for future monitoring.

This report presents a summary of the factual survey monitoring results for the Dickson Street site, as well as monitoring recommendations. A mark displacement diagram is provided in Appendix A.

2 Survey Monitoring

2.1 Monitoring History

The first survey at Dickson Street was established and measured in June 1997. Monitors have been undertaken roughly every two years since. In 2021, an iron spike was installed in the footpath opposite the playground at 500 Portobello Road. In this survey, five additional monitor marks were installed in the survey area to improve coverage. Two were in grass verges on Dickson Street, while three were installed in within the property boundary of 26 Dickson Street.

A survey of the site was completed in January 2022, however these results were not reported on at the time due to budget constraints.

2.2 Methodology

This year's round of survey monitoring was undertaken by a WSP Surveyor on 2nd September 2022. Three Trimble R8 receivers were used for the survey, initially logging static GPS to establish a baseline, and then roving to make RTK measurements. The geodetic parameters adopted for this survey have been included in Appendix B

2.2.1 Field Survey

A base station logging static while sending RTK signal was set up on the iron spike (IS101) in Portobello Rd for the duration of the survey. A second receiver was then moved around nearby marks AFF3, A23K, and a new nail in the playground (102) to create static baselines by logging for 10 minutes.

A roving R8 was used for RTK measurements on monitor marks. In previous years, a 2-metre pole was used to measure with a small stabilising tripod; however, in this survey a full-sized wooden tripod was utilised to minimise error in plumbing. RTK shots were taken for 3 minutes to allow for a precise solution. This involved taking one shot for 90 seconds, waiting 60 seconds to allow satellite changes, then taking another 90 second shot with the receiver rotated 180 degrees. Doing this allows for a real time field assessment of the precision of the survey by comparing the two measurements.

2.2.2 Office Processing

Static baselines were processed with RINEX data from fixed Continually Operating Reference Stations OUSD and DUND in Trimble Business Centre. The coordinate result of the static baselines will be held fixed in future surveys, although this position will be checked by static baselines in each survey. This base station coordinate was fixed to create RTK vectors to monitoring marks, from which final monitor coordinates are derived.

2.3 Accuracy

The survey has been undertaken to the following accuracy:

- Horizontal position: +/- 15mm (@ 95% CI)
- Vertical position: +/- 25mm (@ 95% CI)

2.4 Future Monitoring

The methodology used in this survey round is appropriate and should be repeated in future. New marks installed are sufficient to quantify movements in the mapped landslide zone, although discretion should be exercised about potential movement outside the zone. The next survey should take place in late 2023.

3 Monitoring Results

The cumulative results spreadsheet is presented in Appendix D. A summary of the monitoring results is presented in Table 2. Although height movements are positive from the baseline survey, they are negative compared to previous survey, indicating general subsidence (within survey tolerances). Directional movements are towards the harbour, as expected, is also within tolerance.

Table 2: Summary of deformation monitoring results since the previous and base surveys.

	Deformation since previous survey		Deformation since base survey	
	Horizontal	Vertical	Horizontal	Vertical
Average*	< 15mm	<30 mm	29 mm	42 mm
Maximum	< 15 mm	< 30 mm	57 mm	52 mm

* Deformations less than the accuracy of the survey (± 15 mm horizontal, ± 25 mm vertical) were excluded when calculating averages.

4 Rainfall Data

A summary of the rainfall data since the previous survey is presented in Figure 1. The rainfall data was retrieved from the NIWA (National Institute of Water and Atmospheric Research) National Climate Database website ([CliFlo.niwa.co.nz](https://climate.niwa.co.nz)) using the Musselburgh Station (Agent ID #15752).

Mean monthly rainfall is calculated for the “Dunedin” area using data between 1981 and 2010 (source: <https://niwa.co.nz/education-and-training/schools/resources/climate/meanrain>).

A significant rainfall during July 2022 is evident in Figure 5, whereby 235 mm was recorded in the calendar month, including 97.6 mm on 12 – 13 July and 94.6 mm on 26 – 28 July 2022.

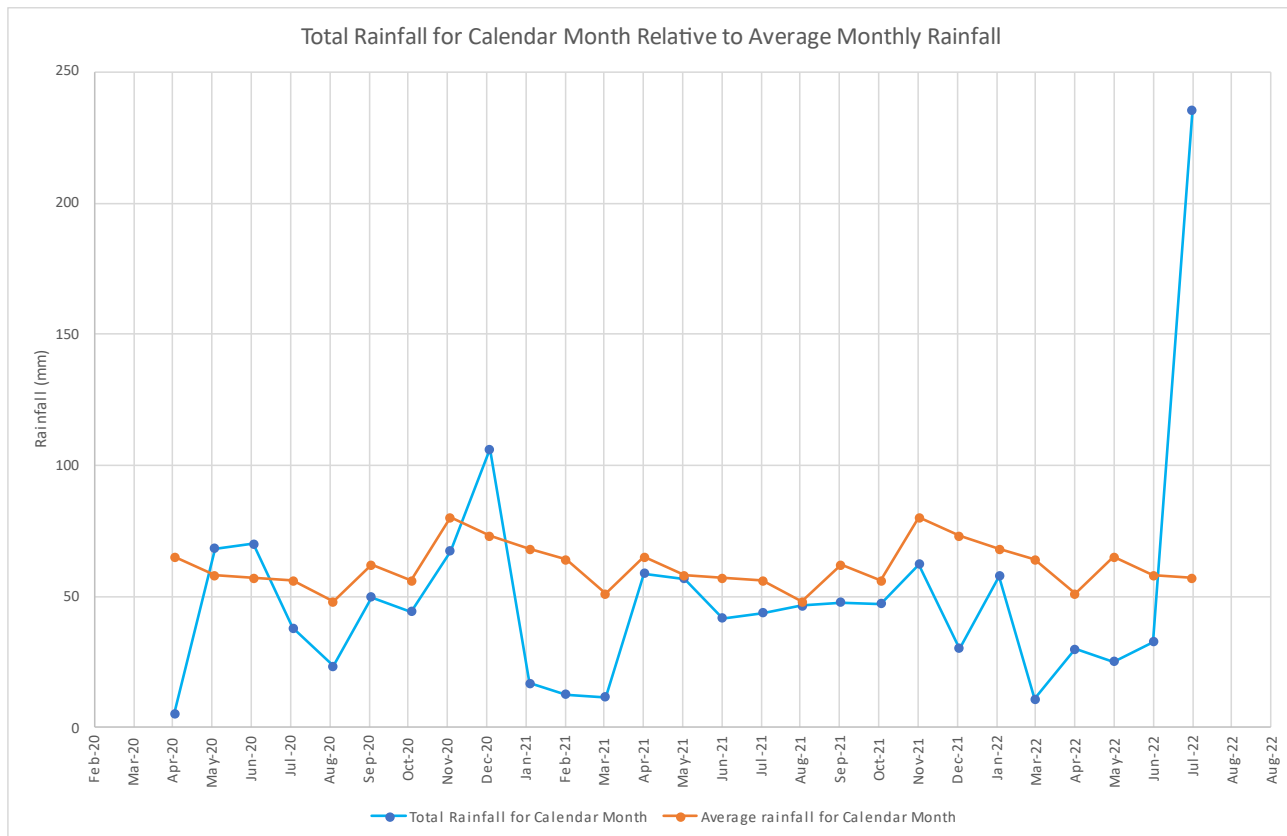


Figure 1: Measured monthly rainfall compared with average monthly rainfall (CliFlo.niwa.co.nz).

5 Conclusions and Recommendations

The maximum displacements recorded since the base survey was completed are as follows:

- 57 mm horizontal,
- 52 mm vertical.

When analysing survey data back to 1997, it appears the long-term deformation rate is negligible, while the majority of recorded deformation occurs during discrete episodes. However, much of the deformation reported during 2010 – 2017 has not been carried through to the most recent surveys, suggesting possible inconsistencies in the survey method or processing. In addition, positive vertical deformation is being reported across all survey marks, which is atypical of landslides. Maximum deformations recorded since the base survey are still relatively minor when compared with the accuracy of the survey. Due to the above, the existing survey data prior to 2021 is not considered to be reliable. It is recommended surveys continue at yearly or 2-yearly intervals, using the same survey method described in Section 2, to establish a more reliable history of survey data.

Appendix A

Mark Displacement Diagram

LEGEND

LANDSLIDE - OTAGO REGION (CERTAINTY)

DEFINITE

LIKELY

POSSIBLE

NOT ASSESSED

NO INFORMATION

INDICATIVE LANDSLIDE EXTENTS ARE BASED ON "REVISED LANDSLIDE DATABASE FOR THE COASTAL SECTOR OF THE DUNEDIN CITY DISTRICT" BY BARRELL, D.J.A., SMITH LITTLE, B., GLASSEY, P.J. GNS SCIENCE CONSULTANCY REPORT 2017/41, JULY 2017, SOURCED FROM THE OTAGO REGIONAL COUNCIL (ORC) NATURAL HAZARDS PORTAL.

OTHER

+/- Xmm = CUMULATIVE VERTICAL DISPLACEMENT SINCE THE BASE SURVEY

CUMULATIVE HORIZONTAL DISPLACEMENT SINCE THE BASE SURVEY (1:1000 SCALE)

SURVEY MARKER

1:100 @ A1
1:200 @ A3

REVISION	AMENDMENT	APPROVED	DATE
A	2022 DEFORMATION MONITORING DATA	SK	10/01/2023

Dunedin Office
+64 3 471 5500
Private Bag 1913
Dunedin 9016
New Zealand

CIVIL

SCALES		ORIGINAL SIZE
N.T.S		A1
DRAWN	SURVEYED	APPROVED
J.W	C.H	S.K
DRAWING VERIFIED	DESIGN VERIFIED	APPROVED DATE
C.H	S.K	10/01/2023

2022 SURVEY RESULTS

PROJECT		
DUNEDIN CITY COUNCIL		
DICKSON STREET		
LONG-TERM LANDSLIDE MONITORING		
TITLE		
CUMULATIVE LANDSLIDE DISPLACEMENTS		
DICKSON STREET		
WSP PROJECT NO.	PROJ-ORIG-VOL-LOC-TYPE	SHEET NO.
6-CD109.55	6-CD109.55	C01
		REVISION
		A

Original sheet size A1 (841x594) Plot Date 2023-02-13 at 9:47:22 AM U:\Projects\NZ\6c\6-CD109.55 LTES Long-term Landslide Monitoring\Home\03_Delivery\Site Plans - DWG\80509491_C004 Dickson Street.dwg Layout2

Appendix B

Geodetic Parameters

Coordinate system group:	New Zealand/NZGD1949 (LC)
Zone:	North Taieri
Datum transformation:	New Zealand Geodetic 1949 (LC) (Seven Parameter)
Global reference datum:	NZGD2000
Global reference epoch:	2000
Displacement model:	NZGD2000 Deformation Model (20180701)
Geoid model:	None
RTX calibration:	No

Figure B1: Coordinate System to be maintained.

Method:	Seven Parameter
Translation X:	-59.470 m
Translation Y:	5.040 m
Translation Z:	-187.440 m
Rotation X:	0°00'00.47000"
Rotation Y:	-0°00'00.10000"
Rotation Z:	0°00'01.02400"
Scale factor:	6.333ppm
Local ellipsoid used:	International (NZLC)
Local ellipsoid semi-major axis:	6378399.059 m
Local ellipsoid inverse flattening:	297.000000000

Figure B2: Transformation Parameters to be maintained.

Name:	Transverse Mercator
Origin latitude:	S45°51'41.44810"
Origin longitude:	E170°16'57.32080"
False easting:	300000.000 m
False northing:	700000.000 m
Scale factor:	0.9999600000
South azimuth system:	No
Positive coordinate direction:	North / East

Figure B3: Projection Settings to be maintained.

Geoid Model	
Geoid model:	None
Geoid model file name:	
Geoid model quality:	Unknown quality
Vertical Datum	
Vertical datum:	

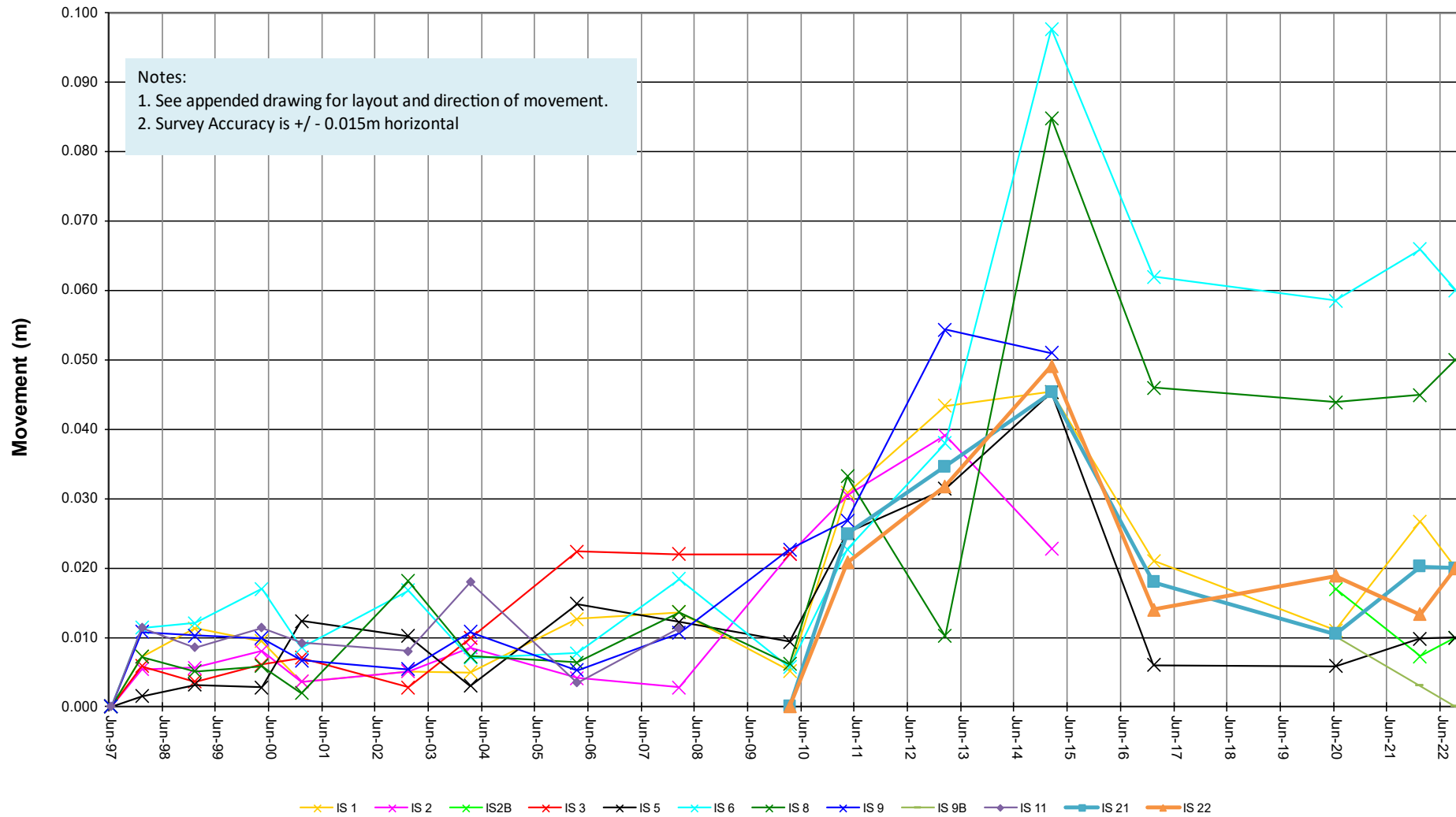
Figure B4: Vertical Datum to be maintained.

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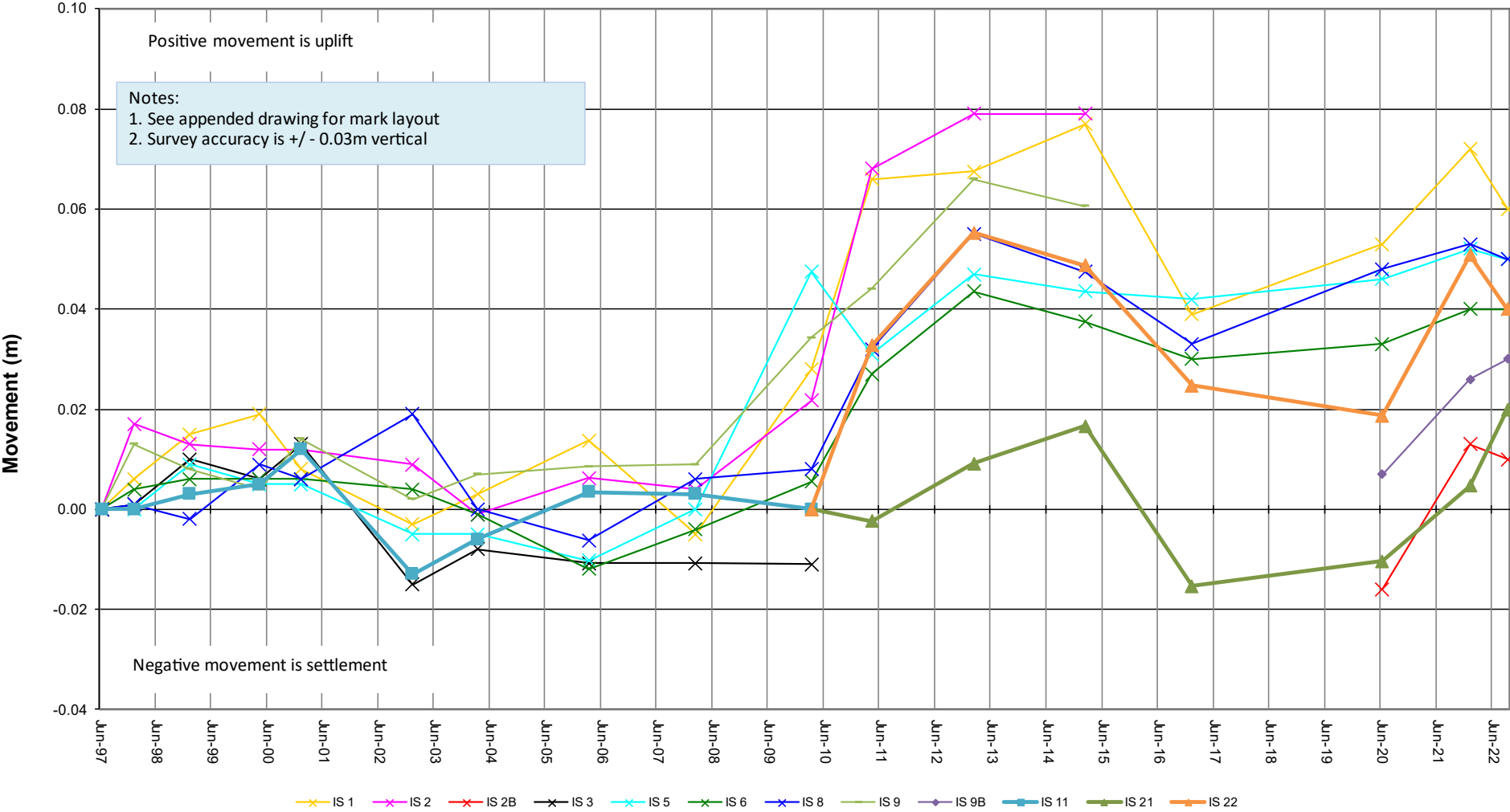
Appendix C

Selected Monitoring Charts

Dickson Street Landslide Monitoring 2022
Chart 1: Cumulative Horizontal Deformation



Dickson Street Landslide Monitoring 2022
Chart 2: Cumulative Vertical Deformation



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Appendix D Cumulative Monitoring Results Spreadsheet

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