Project Number: 6-CD109.55

Landslide Monitoring Report – Brighton Road, Ocean View

24 January 2023

CONFIDENTIAL

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Document Details:

Date: 24/01/2023
Reference: 6-CD109.55
Status: Final

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Document History and Status

Revision	Date	Author	Reviewed by	Approved by	Status
A	24/01/2023	Christopher Hall/Scott Kvick	Latasha Templeton	Abdul Obaid	Final

Revision Details

Revision	Details
A	Final

Contents

List of Figures

List of Tables

List of Appendices

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 survey of the Brighton Road site has been undertaken in August 2022 to assess the extent of movements compared with previous surveys. The main findings are presented in Table 1. The survey marks, where found to exceed the accuracy of the survey (±20 mm Hz, ±25 mm V), are presented in Table 1 below.

Table 1: Summary of recorded displacements.

	Horizontal	Vertical
Displacements from the previous (September 2021) survey	<20 mm	<25 mm
Displacements from the original (September 1998) survey	340 – 1,290 mm	0 – 425 mm

The results indicate that horizontal and vertical movement has reduced relative to previous rates and no appreciable movement has been measured since the previous survey (September 2021). However, our interrogation of previous records suggest a potential episodic (5 – 10 year interval) movement increasing in size at each event that exceeds the annual creeping landslide movement which may indicate an acceleration to a more rapid and damaging failure. Furthermore, site walkover observations have highlighted an area outside of the known landslides considered vulnerable to rapid failure, and numerous open cracks which will likely make the slopes sensitive to high rainfall events.

We recommend further discussion between Dunedin City Council and WSP to discuss the observations and determine if any further works are required.

In addition, we recommend consideration be given to a survey following any significant rainfall event. Without undertaking a close review of deformation relative to daily rainfall, a preliminary threshold has been proposed below as a point for discussion.

- >40 mm in 24 hours;
- >60 mm in 48 hours; or,
- >100 mm in 7 days, as reported by the Musselburgh NIWA weather station, or other equivalent weather monitoring site.

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 Brighton Road site, as well as monitoring recommendations. A mark displacement diagram is provided in Appendix A.

2 Survey Monitoring

2.1 Monitoring History

Survey monitoring of the site has been undertaken since 1998 using total station and since 2008 using GNSS. Previous methodology involved the use of a 3-point site calibration; however, this methodology has been altered to make repeated surveys more consistent. Details of the methodology change are included below. From 2010, the monitor frequency varies between 1 and 2 years. Survey dates are shown in monitoring charts presented in Appendix B.

2.2 Methodology

This survey monitoring round was undertaken by a WSP Surveyor on 5 August 2022. The equipment used consisted of 2 x Trimble R8-3 GNSS receivers, base station logging static and rover in real-time kinematic. Where RTK signal was not available, PPK was used in its place.

2.2.1 Field Survey

The base station was set over IS I and Static GNSS data logged at 1 second rate for approximately 4 hours. All other monitoring and control marks were each observed 3 times for 60 seconds, with 60 second pause between observations. The pole was rotated 120 degrees between each measurement to mitigate the effect of any error in the level bubble.

2.2.2 Office Processing

Survey data was processed using Trimble Business Centre (TBC) software. To align with previous survey work, a 3-point site calibration holding IS A, IS C, and IS I fixed was initially performed to determine if residuals were acceptable.

The calibration results are presented in Table 2 below.

Table 2: Residual differences between GPS and known coordinates.

	Maximum residual	Root Mean Square residual	Point
Horizontal	0.005 m	0.004 m	IS C
Vertical	-0.008 m	0.006 m	IS C
Three-dimensional	0.010 m	0.007 m	IS C

These show differences which are within survey tolerance, proving the marks fit together correctly. In previous surveys, IS B was held fixed instead of IS I. However, due to its poor

conditions for GPS measurement, the coordinate was unreliable and resulted in large residuals when included.

Site calibrations with more than one point fixed cause a rotation and scale factor to be applied to the projection. This means that errors in control coordinates propagate through the network, and the resulting projection is not official, i.e. it is no longer in terms of North Taieri 2000. Therefore, the decision was made to switch methodology to a network adjustment holding only one point fixed, IS I. Attempts were made to connect to LINZ geodetic network marks, in the reference stations OUSD and DUND and the Order 4 mark BD4W. However, these marks revealed that the control marks at Brighton Rd were consistently out of position from their reported coordinates by roughly two metres. Since the difference was a consistent shift rather than an unpredictable error, the Brighton Rd coordinates have been used to maintain methodology. However, it should be noted that this means the survey is not in terms of North Taieri 2000, and this datum has been used for reference only.

2.2.3 Geodetic Parameters

The following geodetic parameters presented in Figures 1 – 3 should be held constant to ensure the results of future monitoring are consistent.

Summary

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

Figure 1: Coordinate system.

Datum Transformation

Method:	Molodensky
Translation X:	0.0000 m
Translation Y:	0.0000 m
Translation Z:	0.0000 m
Local ellipsoid used:	Geodetic Ref System 1980
Local ellipsoid semi-major axis:	6378137.0000 m
Local ellipsoid inverse flattening:	298.257222101

Figure 2: Transformation parameters, local ellipsoid.

Projection

Name:	Transverse Mercator
Origin latitude:	S45°51'41.00000"
Origin longitude:	E170°16'57.00000"
False easting:	400000.0000 m
False northing:	800000.0000 m
Scale factor:	0.9999600000
South azimuth system:	No
Positive coordinate direction:	North / East

Figure 3: Projection settings.

Horizontal Datum: North Taieri 2000

Although North Taieri 2000 is used as the underlying datum, marks measured do not agree with known LINZ control measured away from the site. Therefore, this is not truly in datum, and future surveys should only fix marks that have known coordinates relative to previous monitors.

Vertical Datum: GRS80 Ellipsoidal Heights

2.3 Accuracy

Considering the equipment, methodology and site observing conditions, this survey is considered to meet the following accuracy:

Horizontal position +/- 20 mm (@ 95% CI)
Vertical position +/- 25 mm (@ 95% CI)

Ground movement has occurred when any measurement exceeds the above error tolerances.

2.4 Future Monitoring

Having changed the methodology in this survey to a one point network adjustment, future results should be more consistent and will be in terms of the same datum. Site calibrations should not be used in future because the marks included in previous years may be susceptible to movement. IS C is inside the mapped movement zone, and IS B is unsuitable for GPS due to overhead obstruction. IS I is in a suitable GPS area and far from the movement zone, so it is an ideal starting point for the survey. Control coordinates for other marks should still be compared to measured values to ensure there are no discrepancies.

In future, using a tripod to level the receiver over monitor marks would reduce the plumbing error of a tall pole and improve precision.

3 Monitoring Results

The cumulative results are presented in Appendix C. A summary of the monitoring results are presented in Table 3.

Table 3: Summary of deformation monitoring results since the previous and base surveys.

	Deformation since previous survey		Deformation since base survey	
	Horizontal	Vertical	Horizontal	Vertical
Average	<20 mm [1]	<25 mm [2]	480 mm [1]	-200 mm [2]
Maximum	<20mm	35mm	1,290 mm	-420 mm

Notes:

1. Horizontal deformation average considers only the monitoring points with recorded active movement (M2, M3, M4, M5, M6).
2. Vertical deformation average considers only the monitoring points with recorded active movement (M4, M5, M6).

4 Rainfall Data

A summary of the rainfall data since the previous two surveys is presented in Figure 4.

Data was retrieved from the NIWA (National Institute of Water and Atmospheric Research) National Climate Database website (CliFlo.niwa.co.nz) using the Musselburgh Station (Agent ID #15752). Mean monthly rainfall is calculated for the "Dunedin" area between 1981 and 2010 (source: https://niwa.co.nz/education-and-training/schools/resources/climate/meanrain).

The significant rainfall during July 2022 is evident in Figure 4, whereby 235 mm was recorded in the calendar month, including 97.6 mm on 12 – 13 July and 94.6mm on 26 – 28 July 2022.

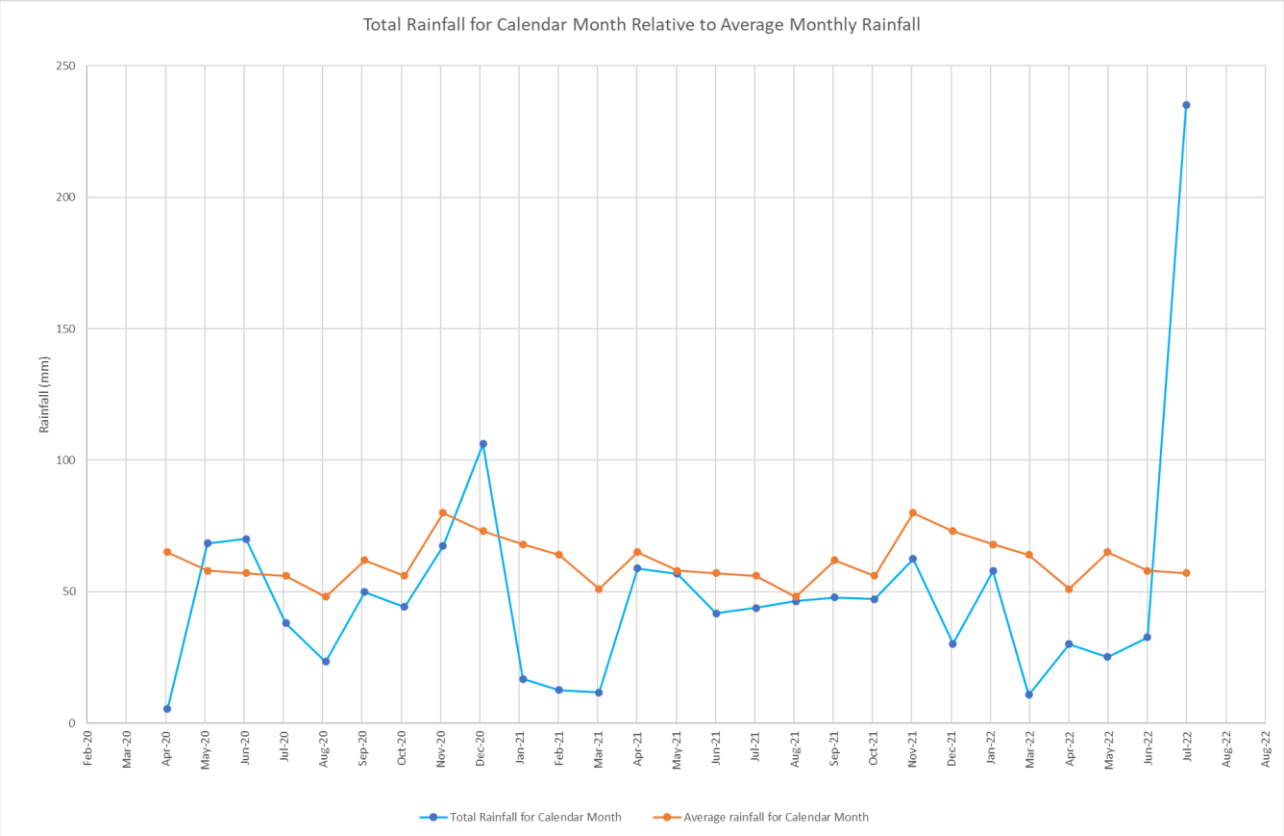

Figure 4: Measured monthly rainfall compared with average monthly rainfall (CliFlo.niwa.co.nz).

5 Site Walkover Observations

A site walkover of the landslide area was undertaken on 9 March 2022 by a WSP Engineering Geologist and a representative from the DCC. The purpose of the walkover was to assess the site conditions relating to the landslide being monitored and inform any risk management decisions made by the DCC in future.

Features observed on site have been annotated on the site plan and photos provided in Appendix E.

- A broad arcuate crown and main scarp was observed at the northern margin of the site (referred to as the primary landslide). The landslide head has dropped by a total of more than 3 m across a number of scarps. Many of the scarps were open by approximately 100 mm at surface. No signs of ongoing or recent deformation were observed. The location of lateral scarps is inferred based on geomorphology.
- A secondary, smaller crown and main scarp was seen within the body of the primary landslide (henceforth referred to as the secondary landslide). Disturbed and wet soil was evident below the main crown, suggesting recent deformation had occurred. Debris at the secondary landslide toe has been overgrown with grass but is inferred based on the geomorphology, as are the lateral scarps. Additional dilation cracks were noted to the west of the secondary landslide crown. Inferred landslide debris appears to have reached as far as the dwelling on #704 Brighton Road.
- Most of the primary landslide toe area featured wet soil and reeds, suggesting that water is ponding before draining away to the sea through a culvert beneath Brighton Road.

6 Conclusions and Recommendations

In conclusion, the maximum displacements recorded since the September 1998 base survey are as follows:

- 1.29 m horizontally,
- 0.42 m vertically.

Survey results indicate the rate of movement has reduced since moderate deformations (up to 0.45 m horizontally, mark M5) were recorded between 2017 and 2018. Limited movement has been noted since 2018 that exceeds the stated survey tolerances.

Previous surveys have shown that appreciable deformations can occur as discrete periods of movement separated by a period of little movement (5 – 10 years). The magnitude of these episodic movements appears to be increasing in size at each event. This movement is specifically associated with the primary landslide discussed in Section 5 and may indicate an acceleration to a more rapid and damaging failure.

Dilation cracks observed at the primary landslide crown are likely to make it more sensitive to high rainfall events. In addition, the presence of dilation cracks west of the secondary landslide crown indicate the soil below may be prone to rapid failure, also likely associated with a high rainfall event, which could result in debris being deposited in a manner similar to that inferred of the secondary landslide, i.e. has the potential to affect the properties below.

On this basis, it is recommended a follow-up survey is completed on at least a 12-monthly interval, and consideration be given to an increase in frequency following significant rainfall events. Without undertaking a close review of deformation relative to daily rainfall, a preliminary threshold has been proposed below as a point for discussion.

- >40 mm in 24 hours;
- >60 mm in 48 hours; or,
- >100 mm in 7 days, as reported by the Musselburgh NIWA weather station, or other equivalent weather monitoring site.

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
0 1 2 3 4 5 6 7 8 9 10 m

WORK IN PROGRESS

PRINTED 28/10/2022 11:06:45 AM

REVISION	AMENDMENT	APPROVED	DATE
A	2021 DEFORMATION MONITORING DATA	SK	30/07/2022
B	2022 DEFORMATION MONITORING DATA	SK	28/10/2022

DUNEDIN CITY COUNCIL | kaunihera a-rohe o Ōtepoti

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CIVIL

SCALES: N.T.S
ORIGINAL SIZE: A1
DRAWN: J. WILLIAMS
DESIGNED:
APPROVED: C.H
DRAWING VERIFIED: C.H
DESIGN VERIFIED:
APPROVED DATE: 28/10/2022

2022 SURVEY RESULTS

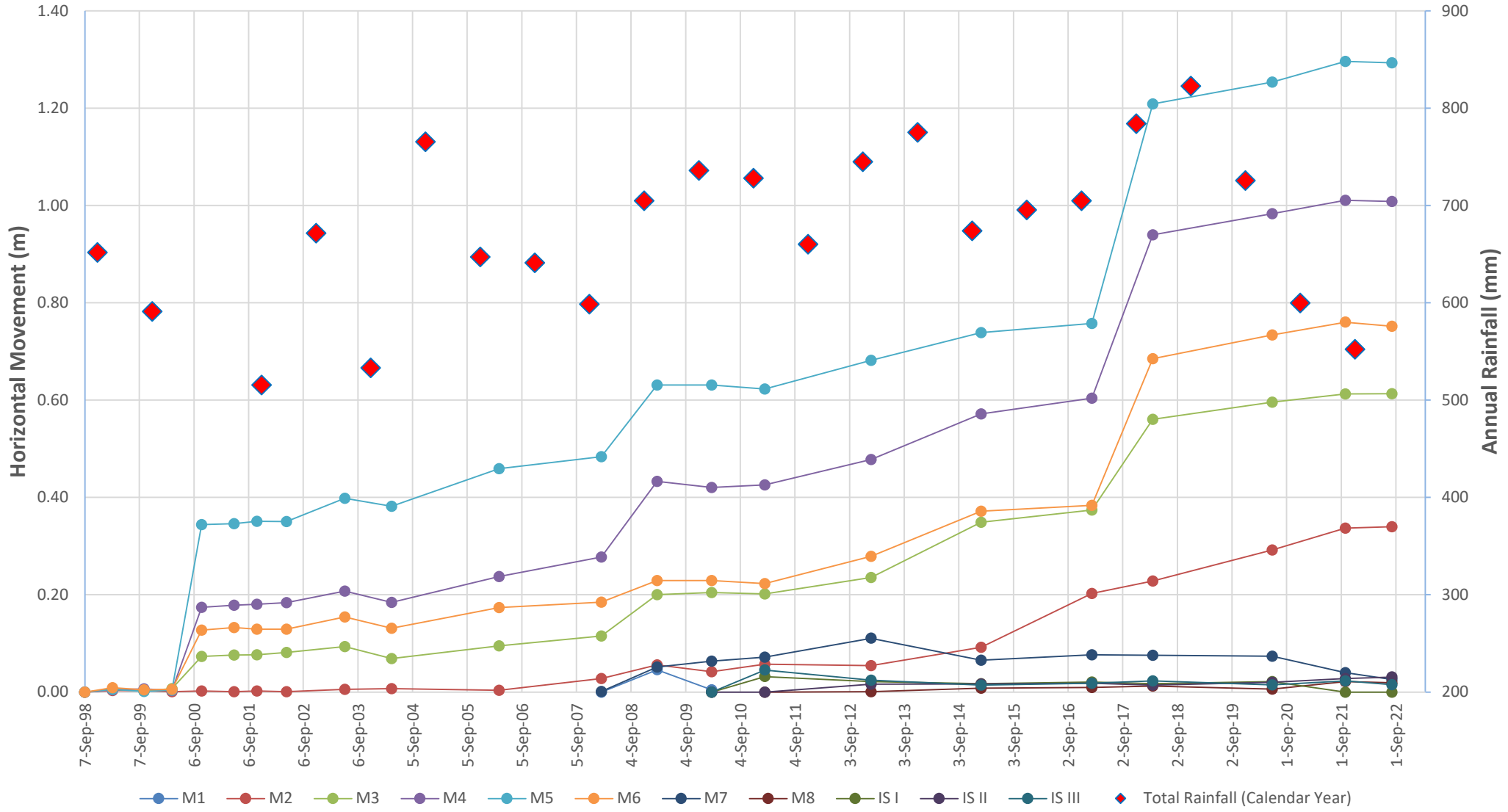
PROJECT
DUNEDIN CITY COUNCIL
BRIGHTON ROAD
LONG-TERM LANDSLIDE MONITORING

TITLE
CUMULATIVE LANDSLIDE DISPLACEMENTS
BRIGHTON ROAD

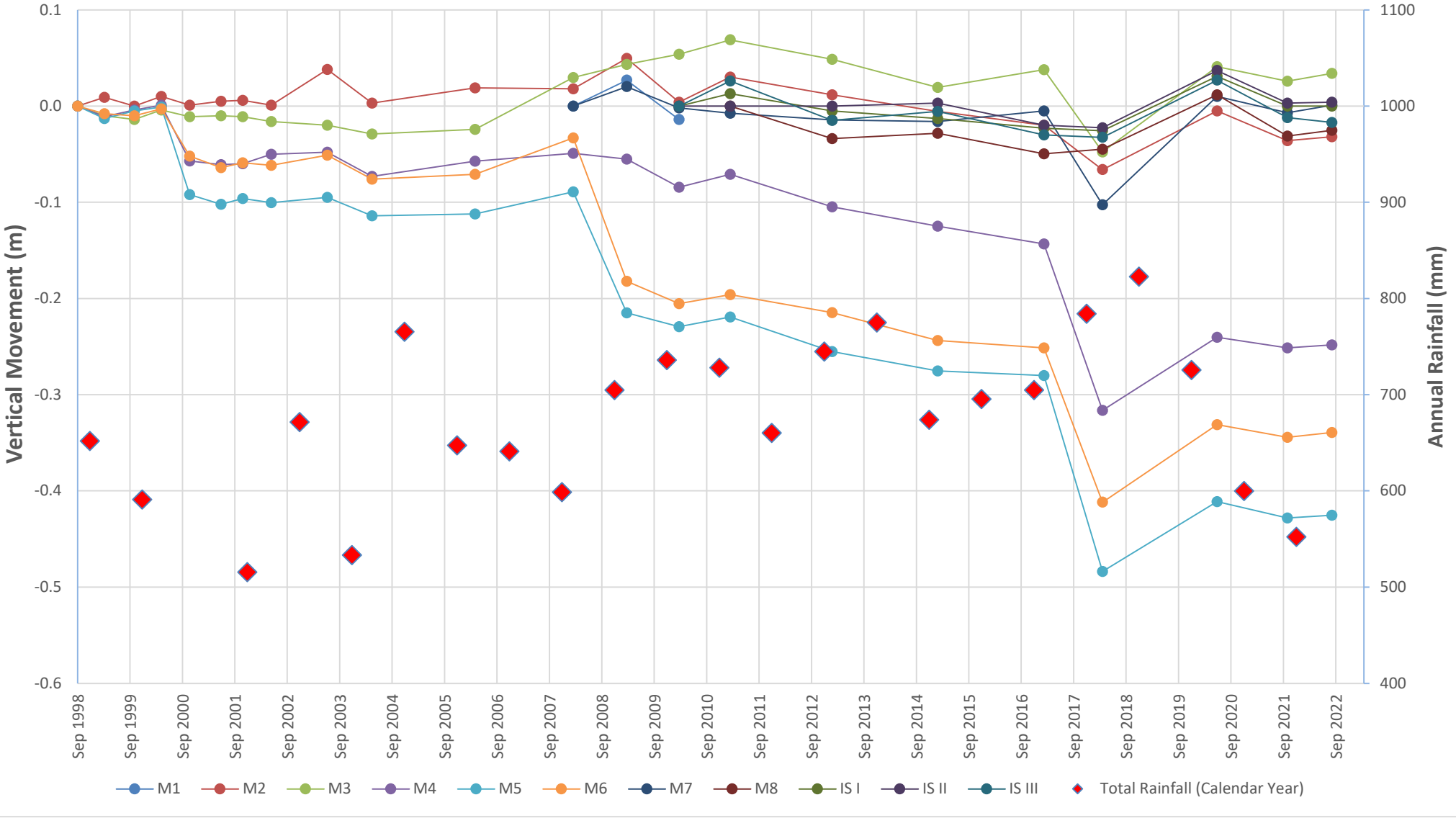
WSP PROJECT NO.	PROJ-ORIG-VOL-LOC-TYPE	SHEET NO.	REVISION
6-CD109.55	6-CD109.55	C01	B

Appendix B
Selected Monitoring Charts

Brighton Road Landslide Monitoring 1998 - 2022
Chart 1: Cumulative Horizontal Movement



Brighton Road Landslide Monitoring 1998 - 2022
Chart 2: Cumulative Vertical Movement



Appendix C
Cumulative Monitoring Results Spreadsheet

Survey 05/08/22				**Present to Previous (29/09/2021)**					**Present to Original (7/09/1998)**				
Mark	mN	mE	Height	dN	dE	Azim.	Dist	dRL	dN	dE	Azim.	Dist	dRL
M1		MARK DESTROYED											
M2	791646.881	405758.447	18.360	-0.003	0.003	135	0.004	0.004	-0.340	-0.004	181	0.340	-0.032
M3	791699.358	405741.423	42.965	0.000	0.006	90	0.006	0.008	-0.588	0.094	171	0.613	0.034
M4	791698.067	405771.733	41.369	0.004	0.005	51	0.006	0.003	-0.942	0.265	164	1.008	-0.248
M5	791702.227	405806.512	38.447	0.008	0.010	51	0.013	0.003	-1.201	0.600	153	1.293	-0.425
M6	791722.523	405763.656	46.388	0.011	0.006	29	0.013	0.005	-0.801	0.256	162	0.752	-0.339
M7	791767.567	405767.384	62.411	0.013	0.009	35	0.016	0.008	-0.026	0.000	180	0.026	0.001
M8	791516.996	405763.213	14.844	0.008	0.007	41	0.011	0.006	-0.012	0.015	129	0.019	-0.025
ISI	791550.227	405748.121	13.675	0.000	0.000	#DIV/0!	0.000	0.000	0.000	0.000	#DIV/0!	0.000	0.000
ISII	791540.494	405693.776	13.751	0.008	0.005	32	0.009	0.001	-0.002	0.031	94	0.031	0.004
ISIII	791542.183	405779.193	13.537	0.007	0.004	30	0.008	-0.005	-0.015	-0.002	188	0.015	-0.017
ISA	791694.288	406325.528	14.788	0.006	0.004	34	0.007	0.003	-0.136	0.043	162	0.143	-0.001
ISB	791667.105	405627.622	26.546	0.010	-0.005	333	0.011	0.037	0.015	0.042	70	0.045	0.004
ISC	791825.960	405811.479	73.064	0.011	0.006	29	0.013	-0.010	-0.022	0.086	104	0.089	-0.002

Appendix D
Network Adjustment Report

Project file data		User information		Coordinate System	
Name:	U:\ProjectsNZ\6c\6-CD109.55 LTES Long-term Landslide Monitoring\Home\03_Delivery\Brighton Rd\Survey\2022\Processing\TBC\new\221208Brightonv2.vce	Name:		Name:	New Zealand/NZGD2000
		Office operator:		Zone:	North Taieri 2000
Size:	133 KB			Datum:	New Zealand Geodetic 2000
Modified:	19/12/2022 9:06:33 am (UTC:13)			Global reference datum:	NZGD2000
Time zone:	New Zealand Standard Time			Global reference epoch:	2000
Reference number:				Geoid:	
Description:				Vertical datum:	
Comment 1:					
Comment 2:					
Comment 3:					

NetworkAdjustWord

Adjustment Settings

Set-Up Errors

GNSS

Error in Height of Antenna:	0.003 m
Centering Error:	0.000 m

Terrestrial

Error in Height of Instrument	0.003 m
Instrument Centering Error	0.000 m
Error in Height of Target	0.003 m
Target Centering Error	0.000 m

Leveling Weighting

Fixed Standard Errors

Error on 1 km of double leveling	0.0007 m
Error per turn/station setup	0.0000 m

Covariance Display

Horizontal:

Propagated Linear Error [E]:	U.S.
Constant Term [C]:	0.000 m
Scale on Linear Error [S]:	1.960

Three-Dimensional:

Propagated Linear Error [E]:	U.S.
Constant Term [C]:	0.000 m
Scale on Linear Error [S]:	1.960

Adjustment Statistics

Number of Iterations for Successful Adjustment:	2
Network Reference Factor:	0.98
Chi Square Test (95%):	Passed
Precision Confidence Level:	95%
Degrees of Freedom:	129

Post Processed Vector Statistics

Reference Factor:	1.02
Redundancy Number:	53.01
A Priori Scalar:	1.88

Control Coordinate Comparisons

Values shown are control coordinates minus adjusted coordinates.

Point ID	ΔNorthing (Metre)	ΔEasting (Metre)	ΔElevation (Metre)	ΔHeight (Metre)
BD5W	0.992	-0.559	?	?
DUND	0.972	-0.541	?	?
IS A	-0.006	-0.004	?	?
IS B	-0.010	0.005	?	?
IS C	-0.011	-0.006	?	?
IS II	-0.008	-0.005	?	?
IS III	-0.007	-0.004	?	?
OUSD	0.973	-0.545	?	?

Control Point Constraints

Point ID	Type	North σ (Metre)	East σ (Metre)	Height σ (Metre)	Elevation σ (Metre)
IS 100	Grid	Fixed	Fixed		
IS 100	Global			Fixed	
Fixed = 0.000001(Metre)					

Adjusted Grid Coordinates

Point ID	Northing (Metre)	Northing Error (Metre)	Easting (Metre)	Easting Error (Metre)	Elevation (Metre)	Elevation Error (Metre)	Constraint
2	791646.881	0.005	405758.447	0.003	?	?	
3	791699.358	0.004	405741.423	0.003	?	?	
4	791698.067	0.004	405771.733	0.003	?	?	
5	791702.227	0.004	405806.512	0.003	?	?	
6	791722.523	0.005	405763.656	0.003	?	?	
7	791767.567	0.005	405767.384	0.004	?	?	
8	791516.996	0.003	405763.213	0.003	?	?	
BD5W	793063.317	0.008	409229.763	0.006	?	?	
DUND	797474.895	0.008	424425.979	0.006	?	?	
IS 100	791550.227	?	405748.121	?	?	?	NEh
IS A	791694.288	0.004	406325.528	0.003	?	?	
IS B	791667.105	0.003	405627.622	0.003	?	?	
IS C	791825.960	0.005	405811.479	0.004	?	?	
IS II	791540.494	0.003	405693.776	0.003	?	?	
IS III	791542.183	0.003	405779.193	0.003	?	?	
OUSD	799071.972	0.009	417735.572	0.007	?	?	

Adjusted Geodetic Coordinates

Point ID	Latitude	Longitude	Height (Metre)	Height Error (Metre)	Constraint
2	S45°56'11.47192"	E170°21'24.32104"	18.360	0.008	
3	S45°56'09.77272"	E170°21'23.52847"	42.965	0.008	
4	S45°56'09.81361"	E170°21'24.93559"	41.369	0.008	
5	S45°56'09.67783"	E170°21'26.54993"	38.447	0.008	
6	S45°56'09.02173"	E170°21'24.55961"	46.388	0.008	
7	S45°56'07.56265"	E170°21'24.73072"	62.411	0.010	
8	S45°56'15.67874"	E170°21'24.54791"	14.844	0.008	
BD5W	S45°55'25.45743"	E170°24'05.36954"	20.332	0.016	
DUND	S45°53'01.22913"	E170°35'49.83768"	389.896	0.023	
IS 100	S45°56'14.60286"	E170°21'23.84587"	13.675	?	NEh
IS A	S45°56'09.91846"	E170°21'50.64403"	14.788	0.008	
IS B	S45°56'10.82077"	E170°21'18.24699"	26.546	0.009	
IS C	S45°56'05.66999"	E170°21'26.77509"	73.064	0.012	
IS II	S45°56'14.91974"	E170°21'21.32340"	13.751	0.009	
IS III	S45°56'14.86246"	E170°21'25.28866"	13.537	0.008	
OUSD	S45°52'10.23723"	E170°30'39.33832"	29.107	0.029	

Adjusted ECEF Coordinates

Point ID	X (Metre)	X Error (Metre)	Y (Metre)	Y Error (Metre)	Z (Metre)	Z Error (Metre)	3D Error (Metre)	Constraint
2	-4380619.887	0.006	744327.699	0.003	-4560356.519	0.008	0.010	
3	-4380671.062	0.007	744353.713	0.003	-4560337.713	0.006	0.010	
4	-4380674.151	0.006	744323.491	0.003	-4560337.444	0.006	0.009	
5	-4380680.942	0.006	744289.369	0.003	-4560332.429	0.007	0.009	
6	-4380693.556	0.007	744335.003	0.004	-4560324.047	0.006	0.010	
7	-4380737.072	0.008	744338.658	0.004	-4560304.230	0.007	0.011	
8	-4380526.280	0.006	744306.837	0.003	-4560444.321	0.006	0.009	
BD5W	-4382207.536	0.013	741077.583	0.006	-4559369.788	0.012	0.019	
DUND	-4388121.898	0.017	726670.992	0.006	-4556536.387	0.018	0.026	
IS 100	-4380546.478	?	744325.609	?	-4560420.380	?	?	NEh
IS A	-4380746.369	0.006	743774.002	0.003	-4560320.596	0.006	0.009	
IS B	-4380617.821	0.007	744460.073	0.003	-4560348.419	0.007	0.010	
IS C	-4380793.150	0.010	744303.513	0.004	-4560271.243	0.008	0.013	
IS II	-4380530.496	0.007	744378.010	0.003	-4560427.238	0.007	0.010	
IS III	-4380545.911	0.006	744293.986	0.003	-4560425.855	0.007	0.009	
OUSD	-4387890.005	0.021	733420.707	0.008	-4555181.283	0.022	0.032	

Error Ellipse Components

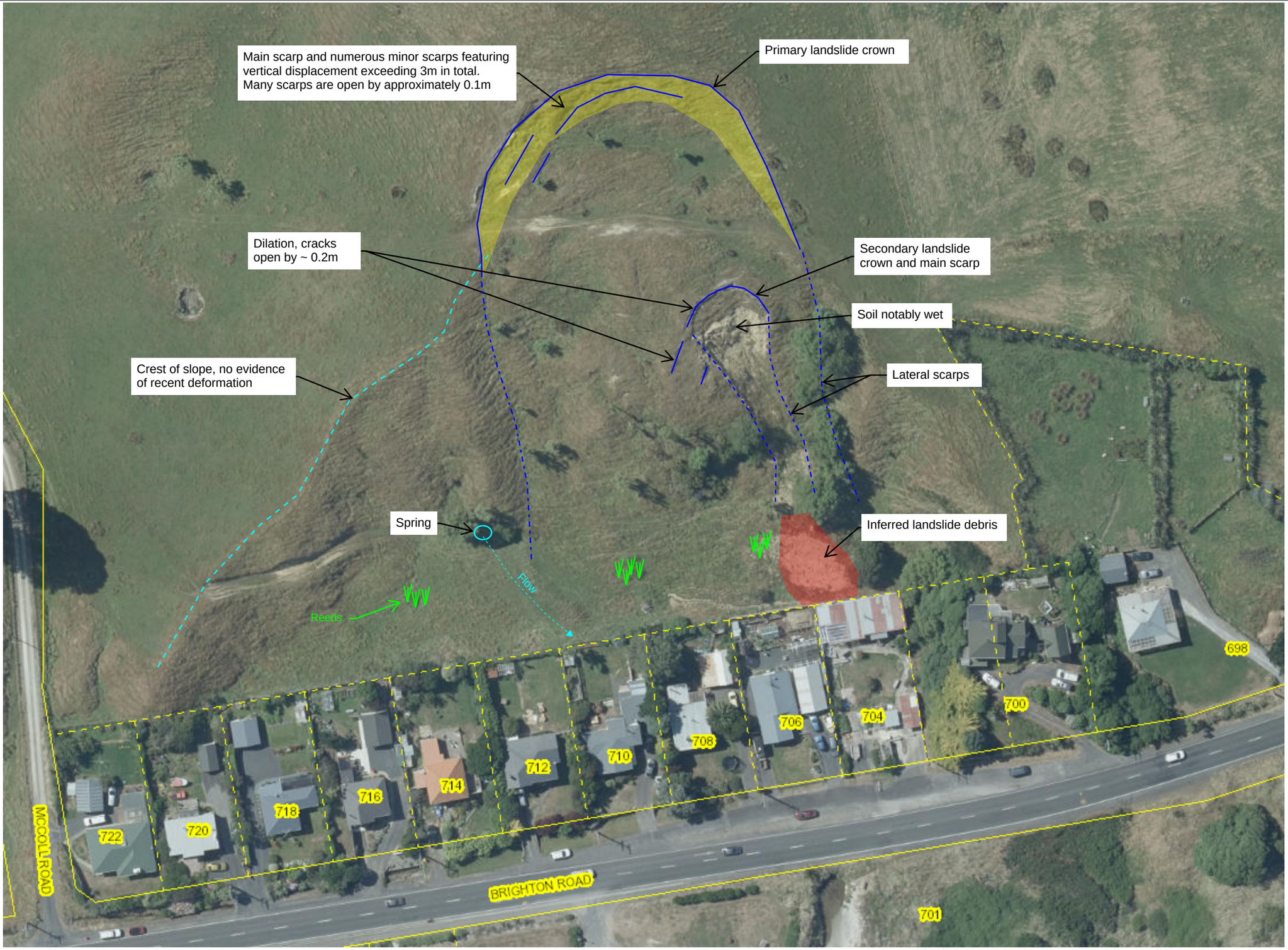
Point ID	Semi-major axis (Metre)	Semi-minor axis (Metre)	Azimuth
2	0.006	0.004	169°
3	0.005	0.004	5°
4	0.005	0.004	2°
5	0.006	0.004	175°
6	0.006	0.004	8°
7	0.006	0.004	11°
8	0.004	0.003	171°
BD5W	0.009	0.008	2°
DUND	0.010	0.008	1°
IS A	0.005	0.004	175°
IS B	0.004	0.004	1°
IS C	0.007	0.005	12°
IS II	0.004	0.003	163°
IS III	0.004	0.003	163°
OUSD	0.012	0.009	179°

Adjusted GNSS Observations

Transformation Parameters

Deflection in Latitude:	0.000 sec (95%)
Deflection in Longitude:	0.000 sec (95%)
Azimuth Rotation:	0.000 sec (95%)
Scale Factor:	1.00000000 (95%)

Appendix E
Site Walkover Plan and Photos



REVISION	AMENDMENT	APPROVED	DATE
A	MARCH 2023 SITE WALKOVER OBSERVATIONS		

DUNEDIN CITY COUNCIL | kaunihera a-rohe o Ōtepoti

wsp
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New Zealand

CIVIL

SCALES: N.T.S
ORIGINAL SIZE: A1
DRAWN: S.K
DESIGNED:
APPROVED:
DRAWING VERIFIED:
DESIGN VERIFIED:
APPROVED DATE:

2022 SURVEY RESULTS

PROJECT
DUNEDIN CITY COUNCIL
BRIGHTON ROAD
LONG-TERM LANDSLIDE MONITORING

TITLE
9 MARCH 2022 SITE WALKOVER OBSERVATIONS

WSP PROJECT NO.	PROJ-ORIG-VOL-LOC-TYPE	SHEET NO.	REVISION
6-CD109.55	6-CD109.55	C01	A

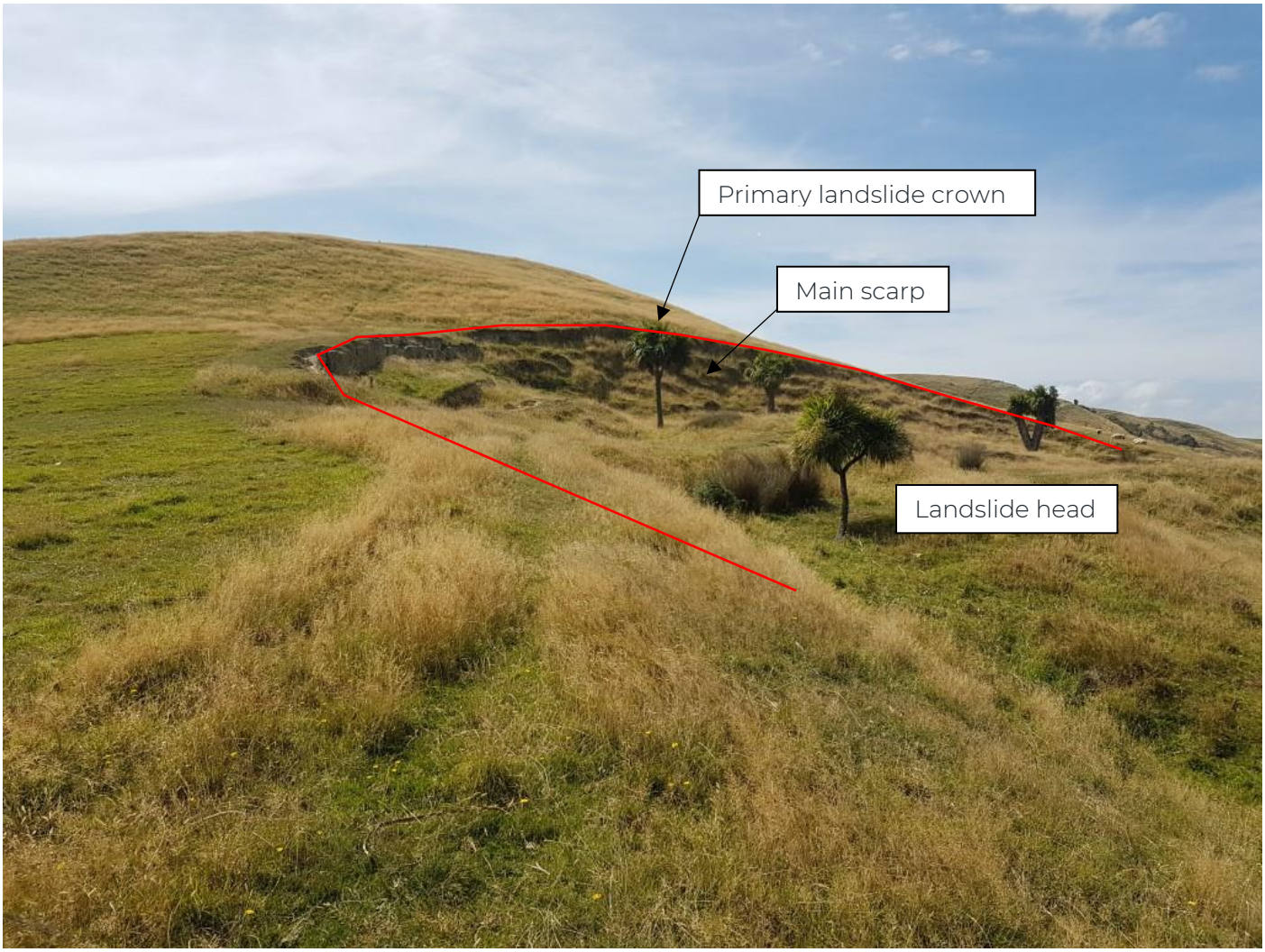

Figure 1: Primary landslide crown shown by the red line, with the main scarp and landslide head area below.

Figure 2: Primary landslide main scarp.

Figure 3: Numerous steps can be seen within the primary landslide main scarp.

Figure 4: Many of the scarps are open to surface water ingress.

Figure 5: Recently mobilised debris below the secondary landslide crown.

Figure 6: Dilation and exposed soil west of the secondary landslide crown.

Figure 7: Mobilised material of the secondary landslide at centre of photo.

Figure 8: Inferred debris (now overgrown with grass) adjacent to the dwelling at #704 Brighton Road.

Figure 9: A number of damp areas at the toe of the primary and secondary landslides.

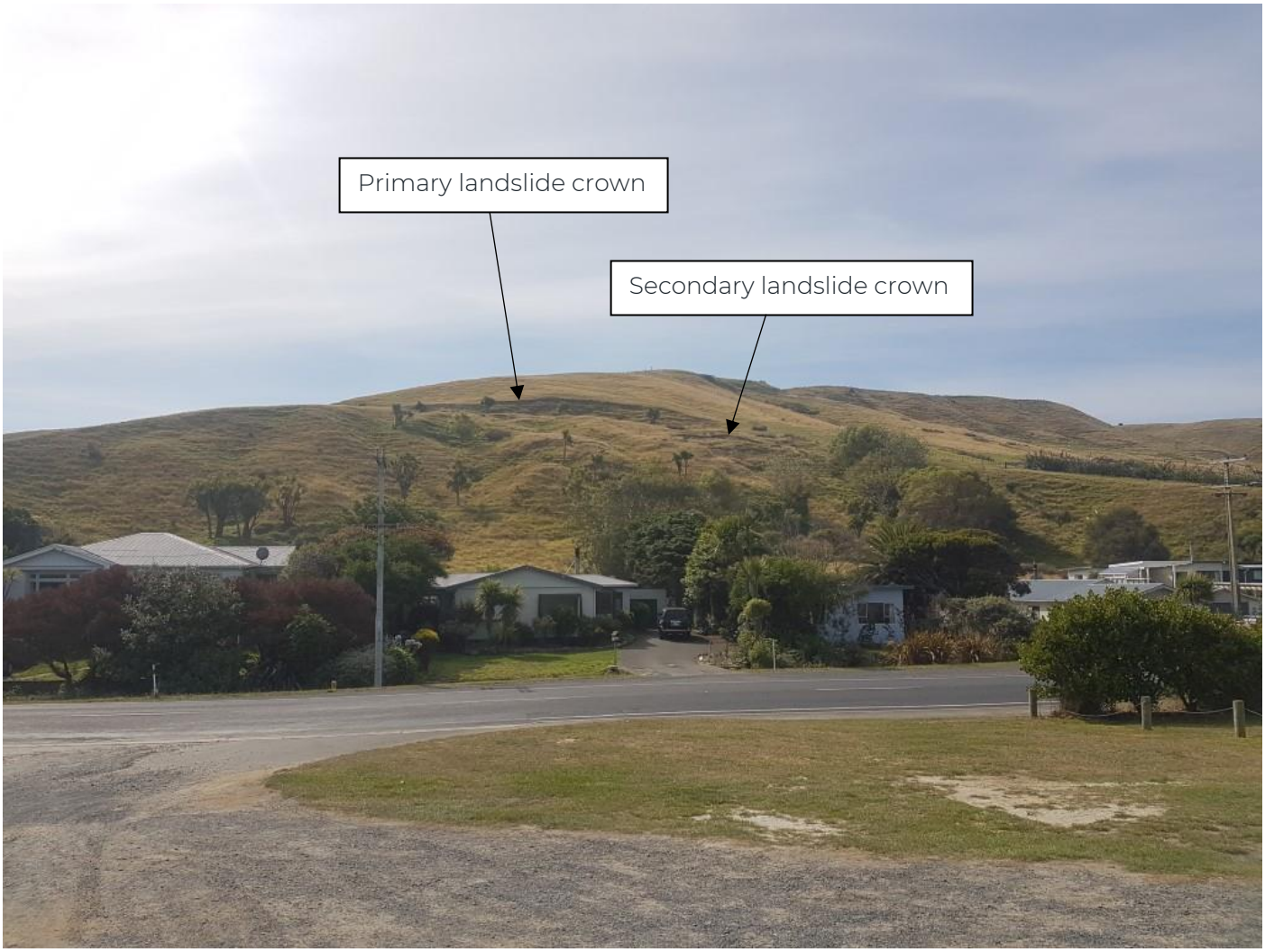

Figure 10: View of the primary and secondary landslides from the south side of Brighton Road.

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