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Landslide Monitoring Report – West Abbotsford

24 January 2023

CONFIDENTIAL

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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

An initial survey of the West Abbotsford landslide site was undertaken in June 2021 to establish the baseline position for deformation markers. Following a period of one year, this report presents the first check survey of the monitoring and control marks, and discusses the methodology and criteria used during the survey. In addition, commentary is provided regarding the resulting deformations. A summary of recorded displacements is provided in Table 1.

Table 1: Summary of recorded displacements.

	Horizontal	Vertical
Displacements from the previous survey	0 – 16 mm	0 – 14 mm

The results indicate no movement across all but 1 mark (AP19), which exceeds the horizontal movement trigger by 1 mm (16mm in total).

As this is only the first check survey, we recommend collecting further data on an annual basis to better inform the nature of potential deformations. We recommend the next survey be undertaken in mid-2023.

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 methodology used on this survey of the West Abbotsford landslide and includes any changes or notes in order to optimise the repeatability for future surveys. A mark displacement diagram is provided in Appendix A.

2 Survey Monitoring

2.1 Monitoring History

Historically, this site has been the subject of a qualitative inspection and assessment (by others) of visible deformation at road level.

2.2 Methodology

In 2021 a baseline quantitative survey was carried out by WSP staff. This first comparative survey was carried out by a WSP Surveyor on 12 August 2022 to quantify any potential deformations. The equipment used were 2 x Trimble R8-3 GNSS receivers.

2.2.1 *Field Survey*

The survey was undertaken using Static GNSS with 20-minute observations at 1 hertz to each monitor mark. Following the advice provided in the 2021 survey report, each mark is now set-up on using a tripod and total station to level and centre over each mark. Previously, this was only done for control marks and a 2m pole was used for monitor marks.

A continuously logging local base station was set up on IS 1 located in Shand Street playground in Green Island. This provides additional constraint via short baselines perpendicular to permanent network base stations OUSD and DUND.

Five additional previously observed control points spread around the site perimeter, outside the expected zone of movement were also observed. The control marks have now been categorised as Primary (OUSD, AG1C, C25W, IS 1) and Secondary (IS 2, IS 3, IS 4) by their proximity to the anticipated zone of movement. Three of the four primary marks are LINZ geodetic marks providing connection to the Site Datum. OUSD is also a continuously operating reference station.

Receiver heights on control points were measured by steel tape. As noted in 2021, C25W has an incorrect published level in the LINZ database level relative to AG1C.

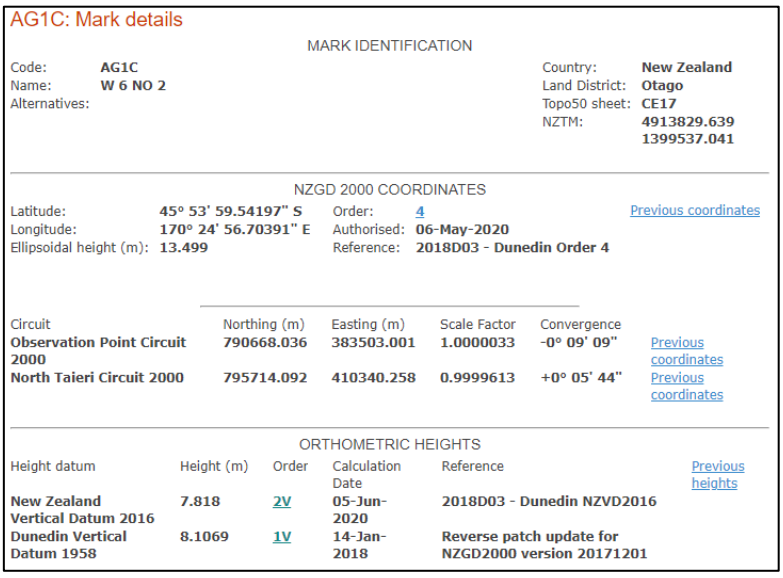
2.2.2 *Office Processing*

Survey data is processed using Trimble Business Centre post-processing software. Static data from permanent base stations OUSD and DUND were combined with the local base station static data from IS 1. A minimally constrained network adjustment was carried out holding control point AG1C fixed horizontally in terms of NZGD2000, North Taieri Circuit projection.

AG1C was also held fixed vertically in terms of the GRS80 ellipsoid height. The NZVD2016 geoid was applied in the background during processing, but ellipsoid heights have been chosen for reporting as a consistent reference system that will be easy to reference and remain in use well into the future.

For some unknown reason, the data logged on mark AP17 was corrupted and did not download for processing on this survey.

The Origin of Survey to be held on future surveys is shown in Figure 1.



AG1C: Mark details

MARK IDENTIFICATION

Code:	AG1C	Country:	New Zealand
Name:	W 6 NO 2	Land District:	Otago
Alternatives:		Topo50 sheet:	CE17
		NZTM:	4913829.639 1399537.041

NZGD 2000 COORDINATES

Latitude:	45° 53' 59.54197" S	Order:	4	Previous coordinates
Longitude:	170° 24' 56.70391" E	Authorised:	06-May-2020	
Ellipsoidal height (m):	13.499	Reference:	2018D03 - Dunedin Order 4	

Circuit	Northing (m)	Easting (m)	Scale Factor	Convergence	
Observation Point Circuit 2000	790668.036	383503.001	1.0000033	-0° 09' 09"	Previous coordinates
North Taieri Circuit 2000	795714.092	410340.258	0.9999613	+0° 05' 44"	Previous coordinates

ORTHOMETRIC HEIGHTS

Height datum	Height (m)	Order	Calculation Date	Reference	Previous heights
New Zealand Vertical Datum 2016	7.818	2V	05-Jun-2020	2018D03 - Dunedin NZVD2016	
Dunedin Vertical Datum 1958	8.1069	1V	14-Jan-2018	Reverse patch update for NZGD2000 version 20171201	

Figure 1: The origin of survey to be held on future surveys.

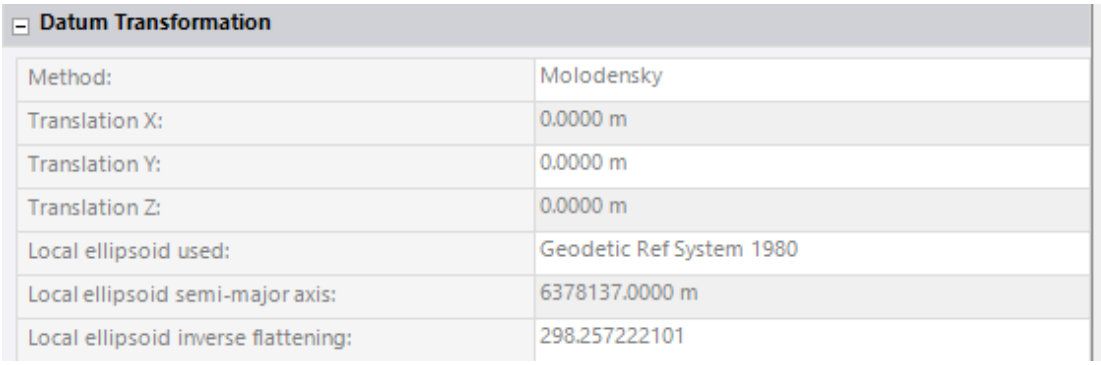
2.2.3 *Geodetic Parameters*

For continuity of future surveys, it is critical the following geodetic parameters presented in Figure 2 to Figure 5 are maintained.

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
Geoid model:	New Zealand Geoid 2016
RTX datum:	No

Figure 2: Coordinate system to be maintained.



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 3: Transformation parameters, local ellipsoid to be maintained.

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 4: Projection settings to be maintained.

Geoid Model	
Geoid model:	New Zealand Geoid 2016
Geoid model file name:	nz2016.ggf
Geoid model quality:	Survey quality
Vertical Datum	
Vertical datum:	

Figure 5: Vertical datum to be maintained (background use only).

2.3 Accuracy

The survey has been undertaken to the following accuracy:

- Horizontal position +/- 15mm (@ 95% CI)
- Vertical position +/- 20mm (@ 95% CI)

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

2.4 Future Monitoring

It is recommended that future survey monitors follow the methodology and geodetic parameters detailed above. Horizontal repeatability and accuracy can be improved by incorporating an additional GNSS receiver logging static set-up over AG1C.

3 Monitoring Results

The cumulative results spreadsheet is presented in Appendix B. A summary of the monitoring results is presented in Table 2.

Table 2: Summary of deformation monitoring results since the previous/base (2021) survey.

	Horizontal	Vertical
Displacements from the previous/base survey	0 – 16 mm	0 – 14 mm

4 Conclusions and Recommendations

Only one mark (AP19, horizontally) exceeds the survey accuracy on this first comparative survey. While the deformations observed are generally less than the accuracy of the measurement, all monitor marks have a downslope direction, on average 161°, which fits with the expected direction of deformation.

Due to the relatively young age of this survey monitoring dataset, and minor movements relative to the accuracy of the survey, no more conclusions can be offered at this early stage.

We recommend future surveys be completed on an annual basis in order to build up the history of data necessary to draw conclusions around land deformation with confidence. The next survey is therefore recommended for August 2023.

Appendix A
Network Diagram

LEGEND

LANDSLIDE - OTAGO REGION (CERTAINTY)

- DEFINITE
- LIKELY
- POSSIBLE
- NOT ASSESSED
- NO INFORMATION

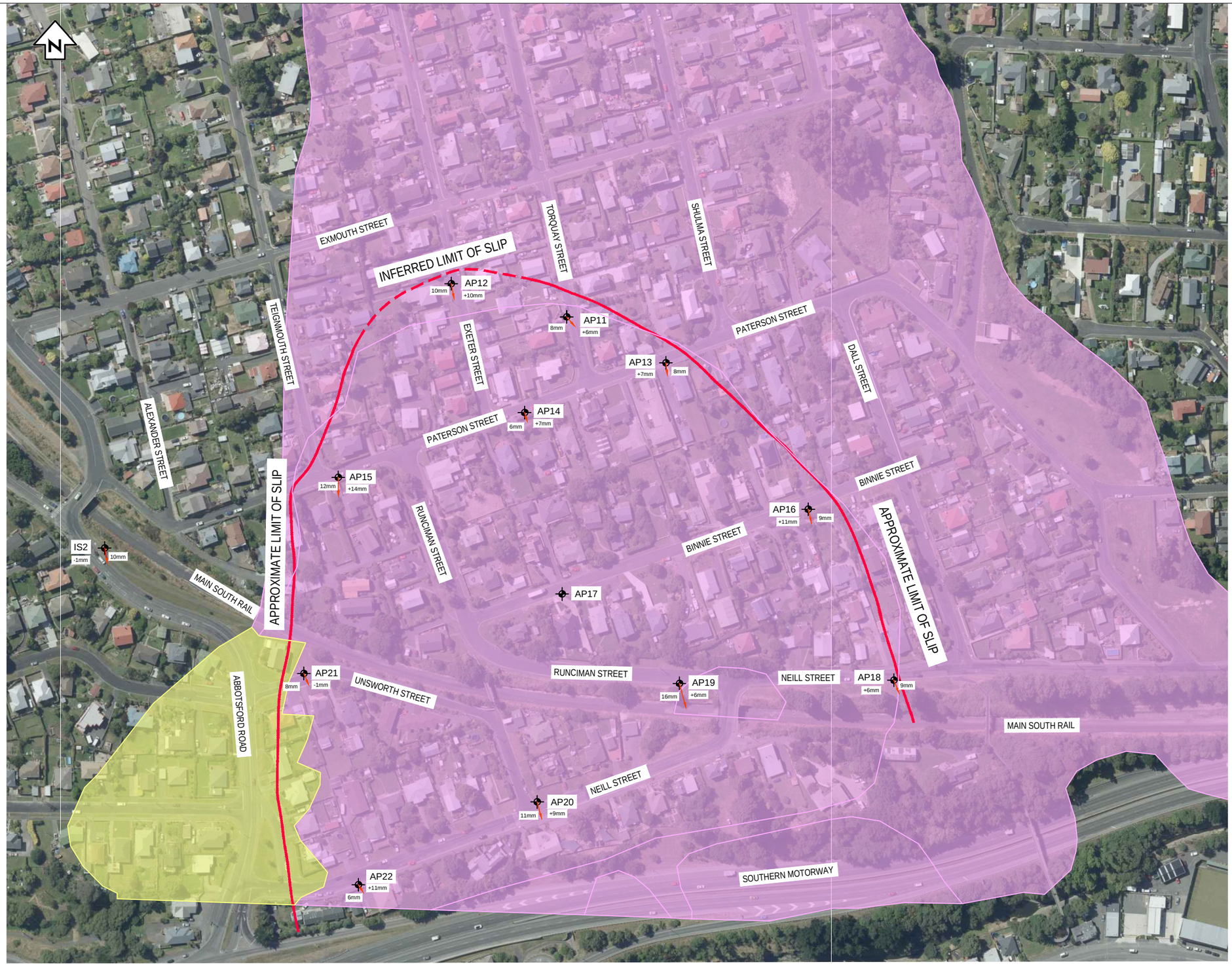
INDICATIVE LANDSLIDE EXTENTS ARE BASED ON "REVISED LANDSLIDE DATABASE FOR THE COASTAL SECTOR OF THE DUNEDIN CITY DISTRICT" BY BARRELL, D.J.A., SMITH LITTLE, B., GLASSEY, P.J. GNS SCIENCE CONSULTANCY REPORT 2017/41, JULY 2017, SOURCED FROM THE OTAGO REGIONAL COUNCIL (ORC) NATURAL HAZARDS PORTAL.

OTHER

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

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

SURVEY MARKER



REVISION	AMENDMENT	APPROVED	DATE
A	2021 DEFORMATION MONITORING DATA	SK	30/07/2022
B	2022 DEFORMATION MONITOTING DATA	SK	10/01/2023

DUNEDIN CITY COUNCIL | kaunihera a-rohe o Ōtepoti

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New Zealand

SURVEY

SCALES 1:1500 | ORIGINAL SIZE 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
WEST ABBOTSFORD
LONG-TERM LANDSLIDE MONITORING

TITLE
CUMULATIVE LANDSLIDE DISPLACEMENTS
WEST ABBOTSFORD

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

Original sheet size A1 (841x594) Plot Date 2023-01-10 at 9:24:23 AM U:\ProjectsNZ\6c\6-CD109.55 LTES Long-term Landslide Monitoring\Home\03_Delivery\Site Plans - DWG\Z1649506_C500 West abbortsford.dwg Layout1

Appendix B
Cumulative Monitoring Results Spreadsheet

WEST ABBOTSFORD

LANDSLIDE MONITORING DATA

SURVEY 2
DATE 12/08/2022

NT2000 Grid Coordinates
GRS80 Ellipsoid Heights

Origin of Coordinates: 795714.092
AG1C 410340.258
13.499 mh

Methodology: Static GNSS
20' @ 1 Hz

SURVEY DATA					PRESENT TO PREVIOUS					PRESENT TO ORIGINAL				
POINT	COMMENTS	NORTHING	EASTING	HEIGHT	Δ N	Δ E	Δ Z	Brng	Dist	Δ N	Δ E	Δ Z	Brng	Dist
AG1C	FIXED	795714.092	410340.258	13.499	0.000	0.000	0.000	-	0.000					
OUSD	Primary Control	799072.946	417735.020	26.156	-0.008	-0.001	0.008	187	0.008					
C25W	Primary Control	795472.374	412098.466	29.601	-0.006	-0.004	0.000	214	0.007					
IS 1	Primary Control	795459.024	411510.391	20.852	-0.003	0.004	0.001	127	0.005					
IS 2	Secondary Control	795778.250	410907.781	42.533	-0.010	0.002	-0.001	169	0.010					
IS 3	Secondary Control	795749.442	411890.874	28.815	-0.009	0.000	0.010	180	0.009					
IS 4	Secondary Control	796329.829	411648.233	95.145	-0.011	0.002	0.007	170	0.011					
AP 11		795922.093	411195.491	55.029	-0.006	0.005	0.006	140	0.008					
AP 12		795942.764	411123.582	54.725	-0.010	0.002	0.010	169	0.010					
AP 13		795893.481	411257.179	51.054	-0.008	0.001	0.007	173	0.008					
AP 14		795862.598	411169.217	50.549	-0.006	0.002	0.007	162	0.006					
AP 15		795822.248	411053.253	46.271	-0.012	0.000	0.014	180	0.012					
AP 16		795802.352	411345.860	45.431	-0.009	0.002	0.011	167	0.009					
AP 17														
AP 18		795696.021	411399.099	37.552	-0.008	0.005	0.006	148	0.009					
AP 19		795694.053	411265.637	38.649	-0.015	0.004	0.006	165	0.016					
AP 20		795620.266	411177.112	30.951	-0.011	0.003	0.009	165	0.011					
AP 21		795700.237	411031.825	35.904	-0.007	0.003	-0.001	157	0.008					
AP 22		795568.804	411065.822	27.989	-0.005	0.003	0.011	149	0.006					

NOTE: Ground movement is considered any measurement greater than 15mm Hz , 20mm Vt

- AP 17 data corrupted, preventing download

wsp.com/nz