MWH

BUILDING A BETTER WORLD

22 April 2015

Dunedin City Council
PO Box 5045
Moray Place
DUNEDIN 9058

Attention: Neil Brown

Dear Sir

Landslide Monitoring 2014/15

We now have completed the annual monitoring programme for 2014/15 and have attached the reports for each site for your information. A brief summary of the results is given below:

Albany Street (12 months)
- Survey currently being reviewed.

Brighton Road (24 months)
- There has been between 46-116mm horizontal movement at marks M2 to M7 since the previous survey.
- Maximum cumulative horizontal movement is 1.25m which has occurred over a 17 year period.
- Next re-survey due in 24 months.

Cargill Street (12 months)
- Tenth re-survey carried out since the baseline was re-established in May 2006.
- No significant movement since the previous survey.
- Next re-survey due in 12 months.

Cockerill Street, Brockville (visual inspection)
- No signs of significant movement.
- Land drainage may be blocked, recommend CCTV survey.
- Next re-survey due 2025.

Dickson Street (24 months)
- Monitoring has been undertaken since June 1997.
- Some movement of 30-78mm since the previous survey.
- Next re-survey due in 24 months.

Howard Street (12 months)
- Monitoring has been undertaken since May 1998.
- No significant movement since the previous survey.
- Next re-survey due in 12 months.

Puketeraki (12 months)
- Survey currently being reviewed.

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The following sites are scheduled to be surveyed in late 2015 or early 2016:

1. Albany Street
2. Cargill Street
3. Churchill Street
4. Howard Street
5. Puketeraki
6. Sidey Street
7. West Abbotsford (Visual Survey)

Our Geotechnical Engineer, Lee Paterson has reviewed each of the survey outputs and has not added any specific comments to this summary. Please feel free to contact either myself or Lee should you require further information.

Albany Street and Puketeraki will follow in due course.

Yours faithfully

Jake Hawker
Survey Technician
MWH New Zealand Limited

Encl.: Reports as listed above

Copy to: Lee Paterson
MWH Dunedin

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Dunedin City Council – Civil Defence
Landslide Monitoring 2014/15
Brighton Road (Survey #17)

The Brighton Landslide monitoring survey was carried out on 2 February 2015. The site is located on the north-west boundary of the Brighton township.

Executive Summary

Since the previous survey undertaken in January 2013 there has been between 46-116mm horizontal movement at marks M2 to M7. There has been no significant movement at the other marks.

The maximum total horizontal movement is 1.25m and this has occurred over a 17 year period. Significant movement of 0.34m has occurred between October 1999 and April 2000 and 0.66m between February 2008 and February 2009. There has been minimal movement outside of these two periods.

It is recommended that the next survey is carried out in 2 years, with visual inspections undertaken if there is a prolonged rain event likely to contribute to instability.

Methodology

The survey this year was undertaken using RTK GPS, consistent with previous surveys undertaken after 2008. Prior to 2008, monitoring was undertaken using conventional total station methods.

A three point horizontal and vertical calibration was carried out in the field holding iron spike (IS) IS A, IS B and IS C fixed.

The estimated accuracy of the RTK survey is ±20mm (horizontal) and ±50mm (vertical).

Monitoring Frequency

The baselines were established in September 1998 with monitoring carried out on the following dates:

DESCRIPTION	SURVEY	DATE	INTERVAL
Baselines established	1	07/09/98	-
Scheduled survey	2	12/03/99	6 months
Scheduled survey	3	07/10/99	7 months
Scheduled survey	4	12/04/00	6 months
Scheduled survey	5	26/10/00	6 months
Scheduled survey	6	01/06/01	8 months
Scheduled survey	7	31/10/01	4 months
Scheduled survey	8	17/05/02	7 months
Scheduled survey	9	11/06/03	13 months
Scheduled survey	10	18/04/04	10 months
Scheduled survey	11	06/04/06	24 months
Scheduled survey	12	18/02/08	22 months
Scheduled survey	13	5/03/09	12 months
Scheduled survey	14	24/02/10	12 months
Scheduled survey	15	15/02/11	12 months
Scheduled survey	16	24/01/13	23 months
Scheduled survey (PRESENT)	17	2/02/15	25 months

Results

Chart 1 shows the cumulative horizontal movement. Over the past two years there has been between 46-116mm horizontal movement at marks M3 to M7. This movement has been in a southerly direction and there has also been between 17-29mm vertical movement at these marks as shown in Chart 2.

Between 2008 and 2009 significant movement occurred (up to 0.76m). This appears to be a one off event and the current results are consistent with trends identified from September 2000 to March 2008, being a horizontal movement rate of 5-13mm per year.

Rainfall Data

The average rainfall at the Green Island weather station, for the 10 year period between 2005-2015, is 740mm per annum. The rainfall quantity during the 2013 year was 755mm and the 2014 year was 772mm.

Conclusion

As detailed there has been a small amount of movement at marks M2 to M7 over the past two years. This is consistent with previous movement that has taken place apart from the events of up to 0.35m (April 2000) and 0.76m (March 2009).

Recommendation

It is recommended that this site be monitored again in 2 years and sooner should any prolonged rain event increase the likelihood of significant movement.

The following have been attached for your information:

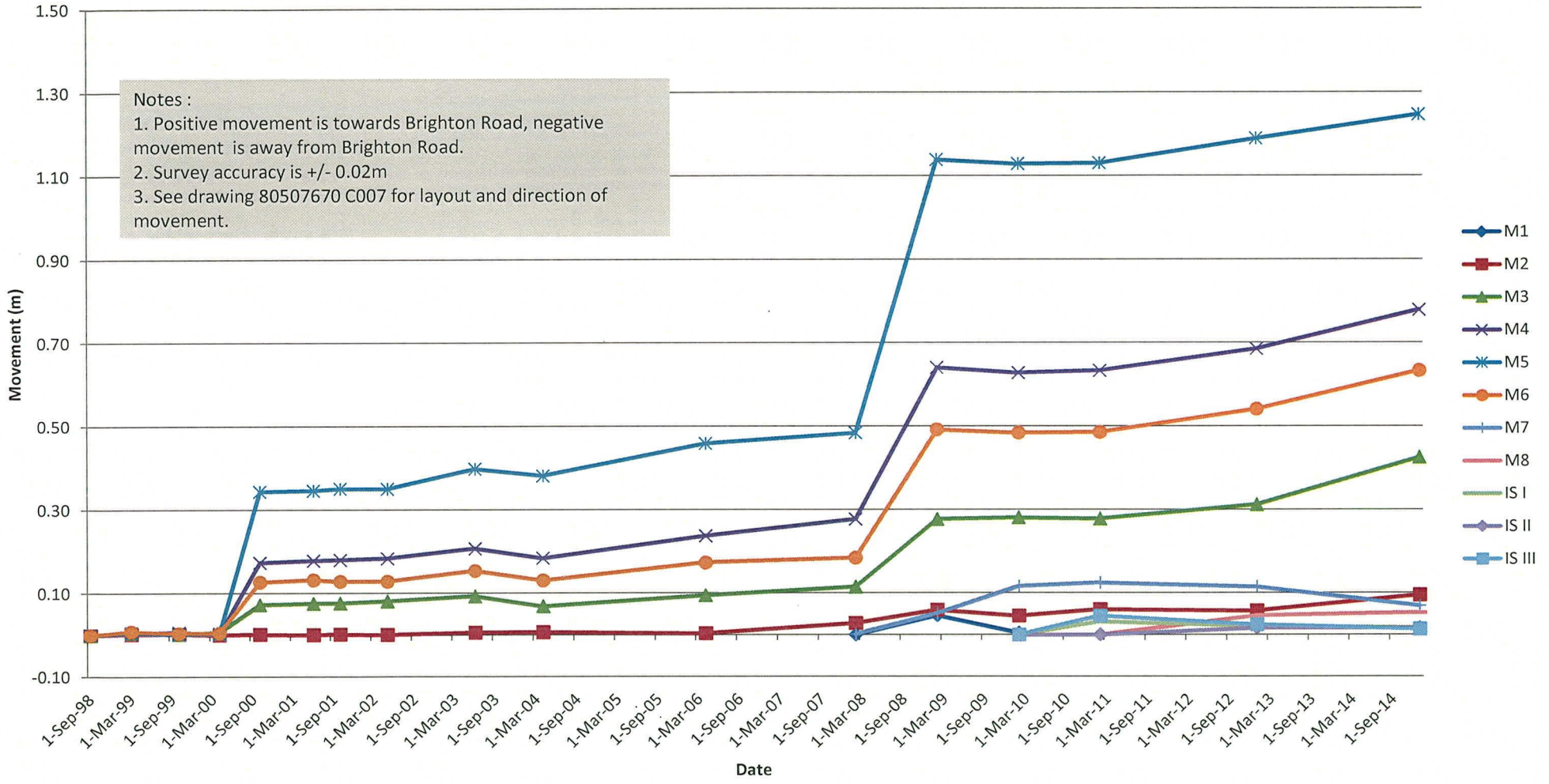
- **Table of results:** showing movement comparative to previous and original surveys
- **Charts 1-2**: showing cumulative horizontal and vertical deformation over time.
- **Deformation Diagram**: Plan of the slide region with vector arrows illustrating cumulative movement from September 1998 to present (February 2015).

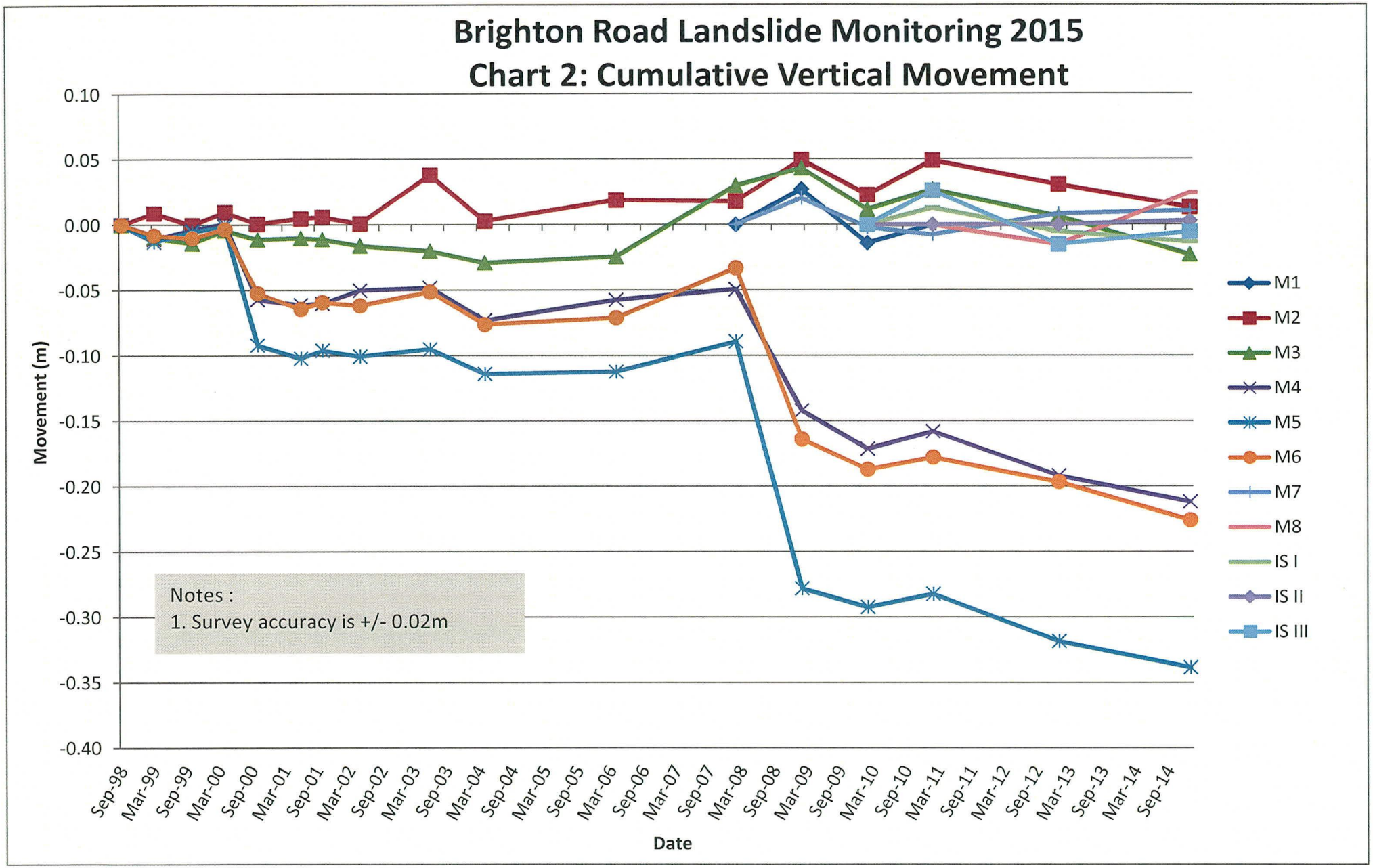
Survey 24/01/15				Present to Previous					Present to Original				
Mark	mN	mE	Height	dN	dE	Azim.	Dist	dRL	dN	dE	Azim.	Dist	dRL
M1	MARK DESTROYED												
M2	791647.135	405758.418	18.387	-0.051	0.008	171	0.051	-0.017	-0.086	-0.034	201	0.096	0.013
M3	791699.615	405741.325	42.951	-0.114	0.017	171	0.116	-0.029	-0.331	-0.004	181	0.426	-0.023
M4	791698.476	405771.563	41.493	-0.092	0.018	169	0.094	-0.020	-0.534	0.095	170	0.779	-0.212
M5	791702.706	405806.227	38.597	-0.053	0.021	158	0.057	-0.020	-0.723	0.314	156	1.247	-0.338
M6	791722.872	405763.490	46.484	-0.089	0.031	160	0.094	-0.029	-0.452	0.090	169	0.635	-0.225
M7	791767.577	405767.321	62.394	0.022	0.040	61	0.046	-0.001	-0.017	-0.063	255	0.070	0.011
M8	791517.003	405763.205	14.841	-0.005	0.007	123	0.009	0.006	-0.005	0.006	128	0.053	0.024
ISI	791550.235	405748.106	13.662	-0.008	0.000	184	0.008	-0.008	0.008	-0.015	297	0.017	-0.013
ISII	791540.507	405693.757	13.750	0.009	-0.004	339	0.010	0.003	0.011	0.012	47	0.017	0.003
ISIII	791542.193	405779.182	13.549	-0.010	0.011	134	0.015	0.010	-0.005	-0.013	247	0.014	-0.005
ISA	791694.42	406325.48	14.79	-0.002	0.001	159	0.002	0.001	-0.005	-0.001	191	0.005	0.001
ISB	791667.09	405627.577	26.525	-0.001	0.006	99	0.006	0.000	-0.003	-0.003	225	0.004	-0.017
ISC	791825.99	405811.39	73.073	0.003	-0.007	294	0.008	0.000	0.007	-0.003	337	0.008	0.007

NOTES:

1. Survey accuracy is ±0.02m
2. Positive movement is towards Brighton Road, negative movement is away from Brighton Road
3. Three point callibration is done on IS A, B and C using 2010 coordinates (when the marks were installed)

Brighton Road Landslide Monitoring 2015
Chart 1: Cumulative Horizontal Movement




Brighton Road Landslide Monitoring 2015
Chart 2: Cumulative Vertical Movement
Movement (m)
0.10
0.05
0.00
-0.05
-0.10
-0.15
-0.20
-0.25
-0.30
-0.35
-0.40
Sep-98
Mar-99
Sep-99
Mar-00
Sep-00
Mar-01
Sep-01
Mar-02
Sep-02
Mar-03
Sep-03
Mar-04
Sep-04
Mar-05
Sep-05
Mar-06
Sep-06
Mar-07
Sep-07
Mar-08
Sep-08
Mar-09
Sep-09
Mar-10
Sep-10
Mar-11
Sep-11
Mar-12
Sep-12
Mar-13
Sep-13
Mar-14
Sep-14
Date
M1
M2
M3
M4
M5
M6
M7
M8
IS I
IS II
IS III
Notes :
1. Survey accuracy is +/- 0.02m

DO NOT SCALE - IF IN DOUBT, ASK

200 mm 150 100 90 80 70 60 50 40 30 20 10 0

ORIGINAL SIZE A1

NOTES:

1.0 CUMULATIVE HORIZONTAL DEFORMATION SHOWN :
2.0 MOVEMENT SHOWN AT A SCALE OF 1:10
3.0 SURVEY CARRIED OUT USING RTK
4.0 SURVEY ACCURACY +/- 0.02M HORIZONTAL
5.0 SURVEY IN TERMS OF NORTH TAIERI GD2000 COORDINATES
6.0 HORIZONTAL 3 POINT CALIBRATION ON IS A, B AND C

10 0 10 20 30 40 50m
SCALE 1:1000

NOT FOR CONSTRUCTION

REV	REVISIONS	DRAWN	CHECKED	APPROVED	DATE

	Name	Date
SURVEYED	JA HAWKER	01/15
DESIGNED	N/A	
DESIGN CHECK	AD ISSACS	04/15
DRAWN	JA HAWKER	04/15
DRAWING CHECK	AD ISSACS	04/15
APPROVED	AJ QUIGLEY	04/15

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DUNEDIN CITY COUNCIL
Kaunihera-a-rohe o Otepoti

DUNEDIN CITY COUNCIL CIVIL DEFENCE
LANDSLIDE MONITORING

BRIGHTON ROAD MONITORING 2015
PLAN

Status Stamp: FOR INFORMATION
Date Stamp: 15/04/2015
SCALES (A1) 1:1000

Drawing No.	Sheet No.	Rev.
80507670	C007	A

XREFS :

P:_2012 Onwards\Dunedin City Council\80000575 DCC Continuing Advice\80507670 DCC CD Landslip Monitoring 14_15\1502 Brighton Rd\CAD

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Dunedin City Council – Civil Defence Landslide Monitoring 2014/15 Cargill Street (Survey #10)

Executive Summary

- This was the ninth survey carried out since the baseline was re-established in May 2006.
- No significant movement has occurred at any of the marks since the last survey in February 2014.
- Next re-survey scheduled for the end of 2015 or early 2016.

General Information

Monitoring of the Cargill Street landslide site was carried out on 5 February 2015. The site is located on the south side of Cargill Street, between Haddon Street and Stuart Street, Dunedin.

Deformation at the site is monitored by measuring changes in the horizontal vertical position and level of pins of a baseline installed in the footpath on the south side of Cargill Street. Baseline offsets are measured using a total station. All the pins are observed and a baseline is drawn between pins 14a and 15b. The offsets are then calculated as a distance from this baseline. The pins are also levelled using a dumpy level and micrometre to enable heights to be measured to four decimal places.

The original baseline was established in December 2000. A new baseline was installed in May 2006 following footpath reinstatement works which destroyed many of the original marks. A relationship between the two baselines was established to maintain continuity of the data.

Monitoring History

Monitoring surveys at the site have been carried out on the following dates:

Description	Survey	Date	Interval
Original baseline established	-	Dec 2000	-
Baseline re-established	0	May 2006	-
Scheduled survey	1	Nov 2006	6 months
Scheduled survey	2	Mar 2007	4 months
Scheduled survey	3	Feb 2008	12 months
Scheduled survey	4	Feb 2009	12 months
Scheduled survey	5	Feb 2010	12 months
Scheduled survey	6	Jan 2011	11 months
Scheduled survey	7	Mar 2012	14 months
Scheduled survey	8	Feb/Mar 2013	12 months
Scheduled survey	9	Mar 2014	12 months
Scheduled survey (PRESENT)	10	Feb 2015	12 months

Network Description

The Control Pins in the survey network are shown on the attached Network Diagram.

Survey Accuracy

The estimated accuracy of the results are:

- Horizontal Position +/- 5mm
- Vertical Position +/- 2mm

Extent of Movement

Chart 1 and 2 show the horizontal and vertical deformation that has occurred since the network was established in February 2000. During the last two surveys pins 4a, 7a and 7b have been replaced. For the cumulative value of these pins we have taken into account the movement that had occurred at the pin before it was destroyed so that we are able to identify any trends.

Chart 1 shows the horizontal deformation that has occurred since the baseline was established in December 2000. It can be seen that the most movement has occurred in the centre of the slip zone, between pins 4b and 7c. The maximum horizontal movement is in the order of 25-30mm occurring at pins 5a, 6a and 7c.

Since the previous survey carried out in February 2013 all of the horizontal movement is within the survey accuracy tolerance. There appears to have been no significant horizontal movement.

Chart 2 shows the vertical deformation that has occurred since the baseline was established in December 2000. The vertical results are consistent with the horizontal results with most of the movement occurring in the centre of the slip zone, between pins 4b and 7c. The maximum vertical movement is in the order of (-ve) 29-36mm.

Pin 7c is showing a reduction in height of 46mm since the previous survey. This pin was replacing pin 7b that was lost due to a dig out in the footpath. This change in height could be due to trench settlement. The rest of the pins are showing 0-3mm movement which is within the estimated accuracy of the survey. There appears to have been no significant vertical movement over the past year.

Rainfall Data

The long term average rainfall for the area is 987mm per annum. Rainfall for the 2014 year was 975m.

Conclusion

Over the past year there doesn't appear to have been any significant horizontal or vertical movement.

Most of the movement that has occurred is in the centre of the slip zone between pins 4b and 8a. The overall trend of horizontal movement is approximately 2mm per year away from the kerb-line and the trend for vertical movement is approximately 2mm settlement per year in this area, these results are consistent with previous years.

Recommendation

Continue with scheduled monitoring with the next survey scheduled at the end of 2015 or early 2016.

The following have been attached for your information:

- **Network Diagram:** Showing the layout of the baseline and the total horizontal and vertical deformation at each mark since the original baseline was established in December 2000.
- **Level and Offsets Spreadsheet**: Listing the observed levels for each mark and the differences compared to both the previous and original surveys.
- **Charts 1 & 2**: Showing horizontal and vertical deformation at each mark over time.

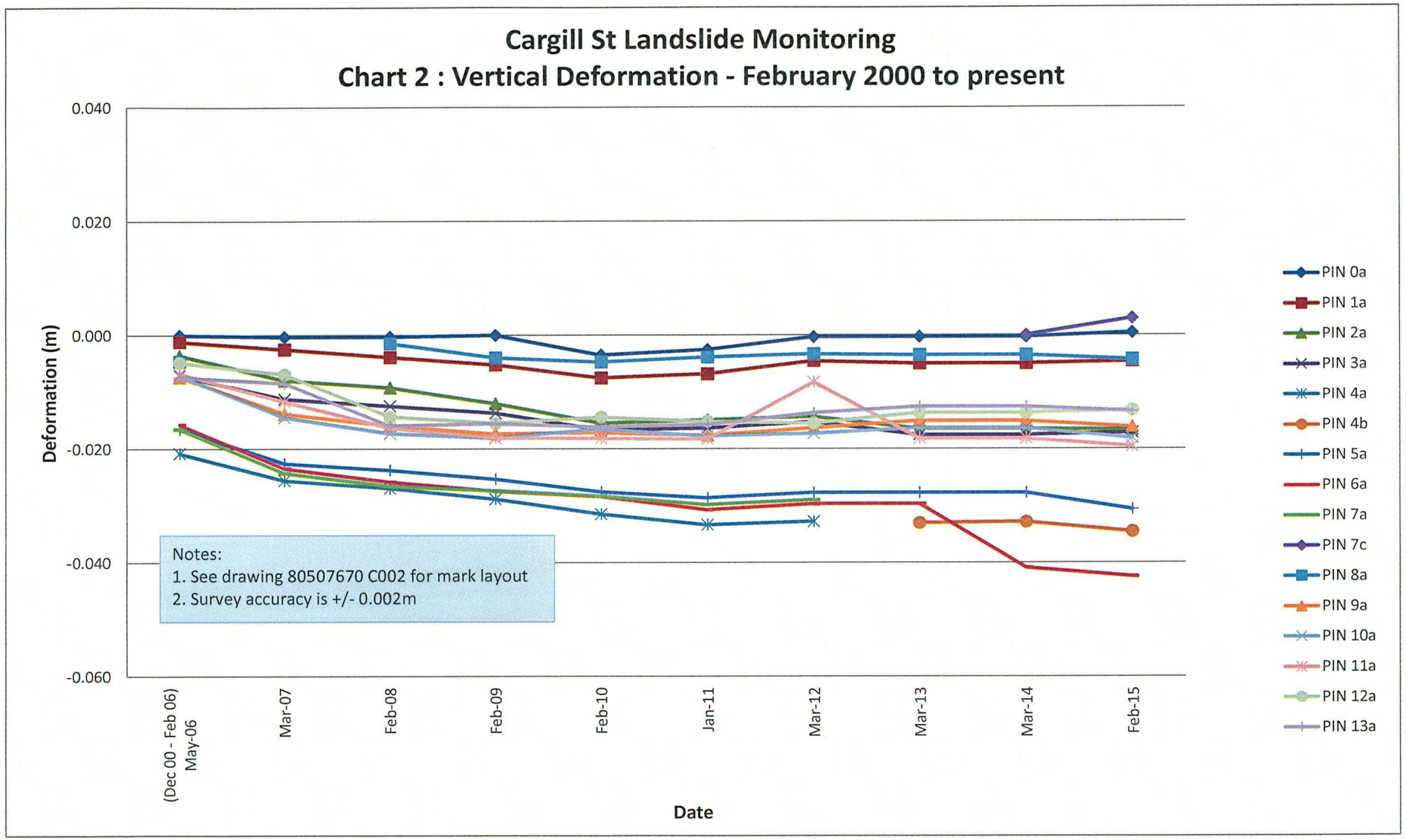
DCC LANDSLIDE MONITORING
CARGILL STREET BASELINE

Original Baseline established December 2000
Baseline re-established in May 2006 due to pins being destroyed
Levels measured by spirit levelling
Baseline offsets measured using robotic total station
Estimated accuracy: +/-5mm horizontal
+/-2mm vertical

Pin 14 is held fixed for levels
A negative offset indicates movement in a southerly direction (towards York Place).

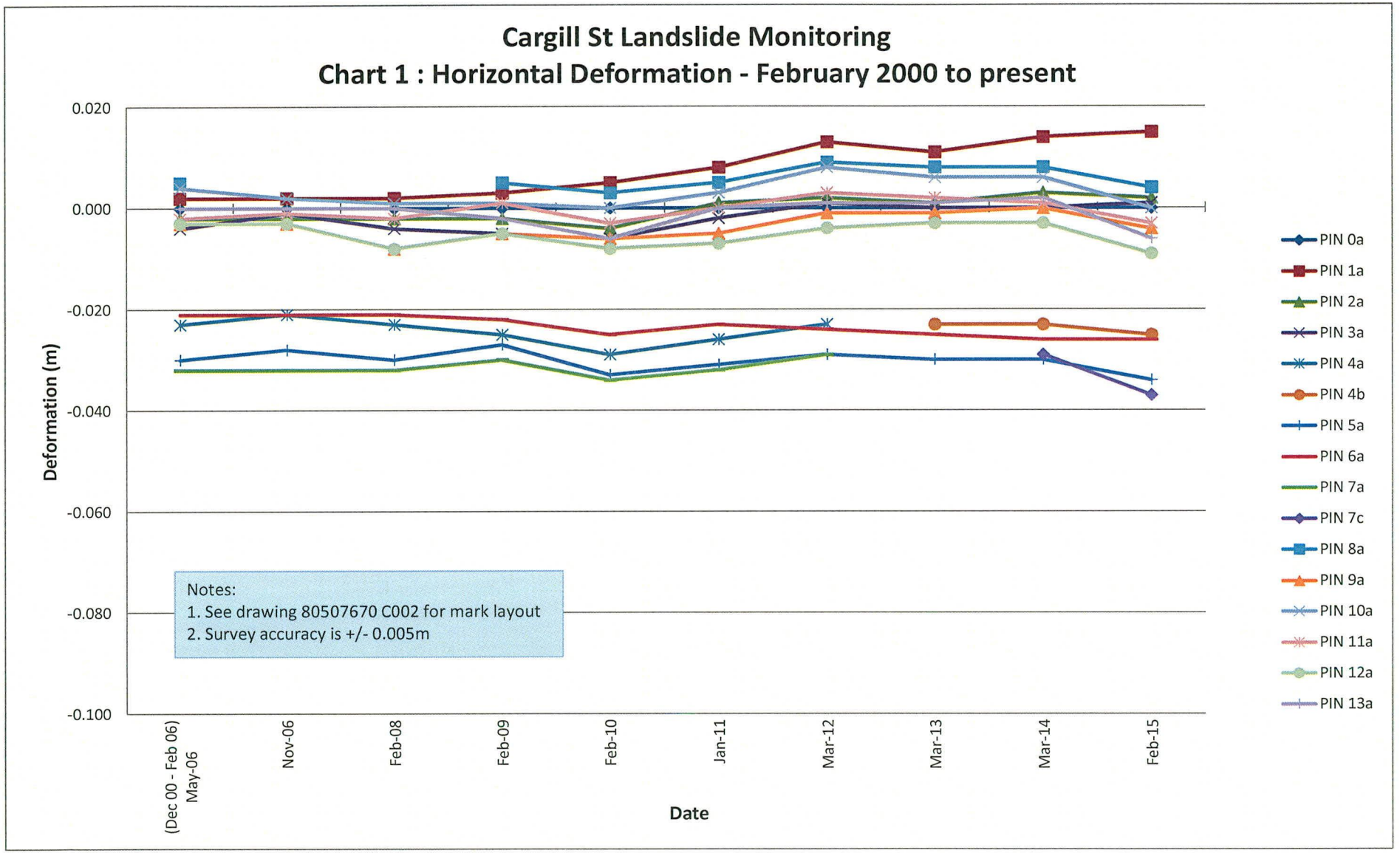
NOTE: Data is flagged where movement is in excess of:
5mm (Hz)
2mm (Vt)

SURVEY 10			Present to Previous		Present to Original	
Survey Date:	31/03/2014		0/01/1900		(Dec 2000)	
Pin #	Height	Offset	dRL	dOffset	dRL	dOffset
PIN 0a	131.019	0.011	0.001	0.001	0.000	**0.011**
PIN 1a	132.569	0.013	0.000	0.001	**-0.005**	**0.015**
PIN 2a	133.001	0.004	0.000	-0.001	**-0.017**	0.002
PIN 3a	133.393	0.005	0.000	0.001	**-0.017**	0.001
PIN 4b	133.890	-0.090	-0.002	-0.002	**-0.034**	**-0.025**
PIN 5a	134.548	-0.004	**-0.003**	-0.004	**-0.031**	**-0.034**
PIN 6a	135.416	-0.005	-0.002	0.000	**-0.042**	**-0.026**
PIN 7c	136.401	0.004	**-0.046**	**-0.008**	**-0.046**	**-0.037**
PIN 8a	137.497	-0.001	-0.001	-0.004	**-0.004**	0.004
PIN 9a	138.478	-0.001	-0.001	-0.004	**-0.016**	-0.004
PIN 10a	139.214	0.002	-0.002	-0.003	**-0.018**	0.003
PIN 11a	140.092	-0.001	-0.001	-0.004	**-0.020**	-0.003
PIN 12a	141.032	-0.001	0.001	-0.001	**-0.013**	-0.004
PIN 13a	141.904	0.002	-0.001	-0.005	**-0.013**	-0.003


Cargill St Landslide Monitoring
Chart 2 : Vertical Deformation - February 2000 to present
Deformation (m)
0.040
0.020
0.000
-0.020
-0.040
-0.060
(Dec 00 - Feb 06)
May-06
Mar-07
Feb-08
Feb-09
Feb-10
Jan-11
Mar-12
Mar-13
Mar-14
Feb-15
Date
Notes:
1. See drawing 80507670 C002 for mark layout
2. Survey accuracy is +/- 0.002m
PIN 0a
PIN 1a
PIN 2a
PIN 3a
PIN 4a
PIN 4b
PIN 5a
PIN 6a
PIN 7a
PIN 7c
PIN 8a
PIN 9a
PIN 10a
PIN 11a
PIN 12a
PIN 13a

Cargill St Landslide Monitoring

Chart 1 : Horizontal Deformation - February 2000 to present



TOTAL DEFORMATION (DECEMBER 2000 TO PRESENT)

KEY:

= POSITIVE VERTICAL DEFORMATION

= NEGATIVE VERTICAL DEFORMATION

= HORIZONTAL DEFORMATION

DEFORMATION ARROWS SCALE : 1:1 (AT A1)
1:2 (AT A3)

NOTES:

1. HORIZONTAL ACCURACY IS ±5mm
2. BASELINE TO MEASURE HORIZONTAL MOVEMENT IS FROM PIN 14A TO PIN 15B
3. VERTICAL ACCURACY IS ±2mm
4. PIN 14A IS THE ORIGIN OF LEVELS (145.887mH). FALSE DATUM.
5. ALL THE PINS WERE REPLACED IN 2006 AND RENAMED WITH SUFFIX "A
6. PINS 4A, 7A AND 15A WERE REPLACED IN 2013 WITH TH SUFFIX "C" DUE TO BEING DESTROYED BY CABLE INSTALLATION."

DO NOT SCALE – IF IN DOUBT, ASK

ORIGINAL SIZE A1

NOT FOR CONSTRUCTION

REV	REVISIONS	DRAWN	CHECKED	APPROVED	DATE

	Name	Date
SURVEYED	JA HAWKER	02/15
DESIGNED		
DESIGN CHECK		
DRAWN	JA HAWKER	02/15
DRAWING CHECK	AD ISSACS	04/15
APPROVED	AJ QUIGLEY	04/15

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DUNEDIN CITY COUNCIL CIVIL DEFENCE
LANDSLIDE MONITORING 2014/15

CARGILL STREET
MONITORING PLAN 2015

Status Stamp: **FOR INFORMATION**

Date Stamp: **16/04/2015**

SCALES **(A1)** 1:250

Drawing No.	Sheet No.	Rev.
80507670	C002	C

XREFS : **x_survey**

P:_2012 Onwards\Dunedin City Council\80000575 DCC Continuing Advice\80507670 DCC CD Landslip Monitoring 14_15\1503 Cargill St

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01 April 2015

Dunedin City Council
P O Box 5054
Moray Place
DUNEDIN 9058

Attention: **Neil Brown**
Manager, Civil Defence & Rural Fires

Dear Sir

DCC CD Landslide Monitoring 2014/15
Cockerell Street Slide, Brockville

The slip spans a number of properties centred about the dwelling of 237 Brockville Road, owned by Mr and Mrs Kirkpatrick. No other dwelling structures lie within the slide mass.

History

- Aerial photographs (1942) pre-dating the housing development show an active slump area with a clearly defined head scarp.
- The slide moved in March / April, 1968, following heavy rain, and claims were lodged with E.W.D. Commission in-respect to 223, 237, 239 Brockville Road and 6 Cockerell St.
- Further damage was apparently reported during 1977 from 6 Cockerell Street.
- Further movements followed exceptionally heavy rain during 4-6 June 1980.
- Concern over the potential on-going movement at the time the slip initiated resulted in temporary evacuation of the properties down-slope on 3, 8, 10 and 12 Cockerell Street

Stabilisations included dewatering of the graben, with gravity drainage through the centre of the slip, and earthworks to effectively fill any remaining cracks or depressions in the graben

The property has been periodically inspected over this period to confirm that no significant re-activation has occurred.

2015 Inspection

Lee Paterson undertook a visual photographic inspection of the property on 1 April 2015, and met the property owner, Mrs L Kirkpatrick, who was the landowner when the 1980 slip occurred.

Mrs Kirkaptrick commented that she has not noted any significant additional crack opening or displacement on the dwelling since the dewatering works were undertaken.

A photographic record is appended to this correspondence.

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Discussion / Recommendations

Drainage Effectiveness

We are concerned that the current drainage, which was designed to positively drain out through the body of the slip (down the driveway) and discharge beyond the slip, appears to be discharging / bubbling up to ground surface at the bottom of the driveway. This may be indicative of a further blockage / breakage within the drain or outlet, and should be investigated, and cleared / repaired if necessary.

We suggest that a CCTV survey of the drainage is undertaken in order to confirm efficacy.

Mass Movement

Whilst the building has signs of cracking, these are in keeping with the history of the structure. We do not believe that there is any reactivation of global movement at this time.

Further Monitoring

We see no reason to undertake more intensive monitoring. Further photographic / visual inspection should be undertaken in 2025.

Yours sincerely

Lee Paterson
Senior Geotechnical Engineer
MWH New Zealand Limited

Encl.: Photo Plates - 2015
Photo Plates - 2005 Inspection

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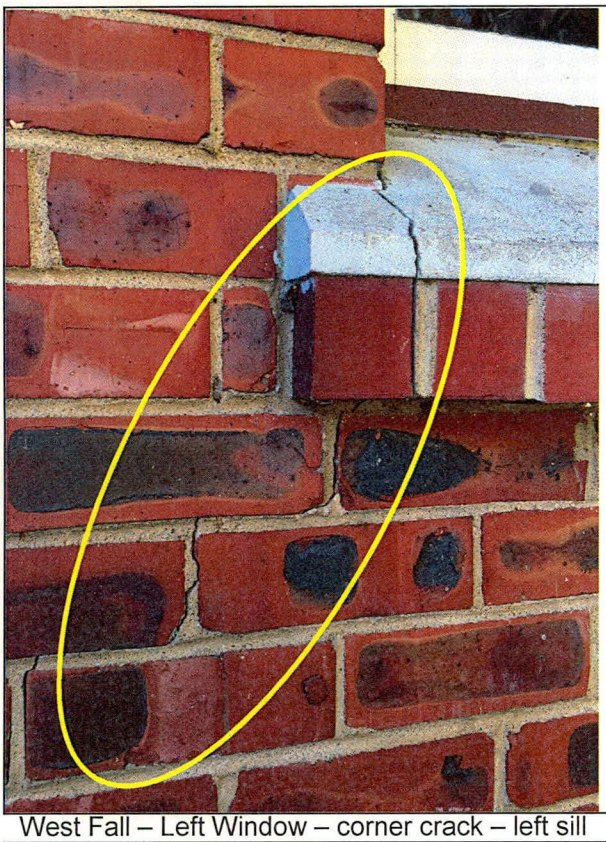
LEVEL 3, JOHN WICKLIFFE HOUSE
265 PRINCES STREET
PO BOX 4, DUNEDIN 9054,
NEW ZEALAND

FACSIMILE 64-3-477 0616
TELEPHONE 64-3-477 0885

Project No. 8 0 5 7 6 7 0 - 1 5 0 7

Date: 1 April 2015 Prepared By: Lee Paterson

Description: DCC CD Landslide Monitoring 2014/15
Cockerell Street Slide, Brockville



West Fall – Left Window – corner crack – left sill

West Fall – Left Window - foundation

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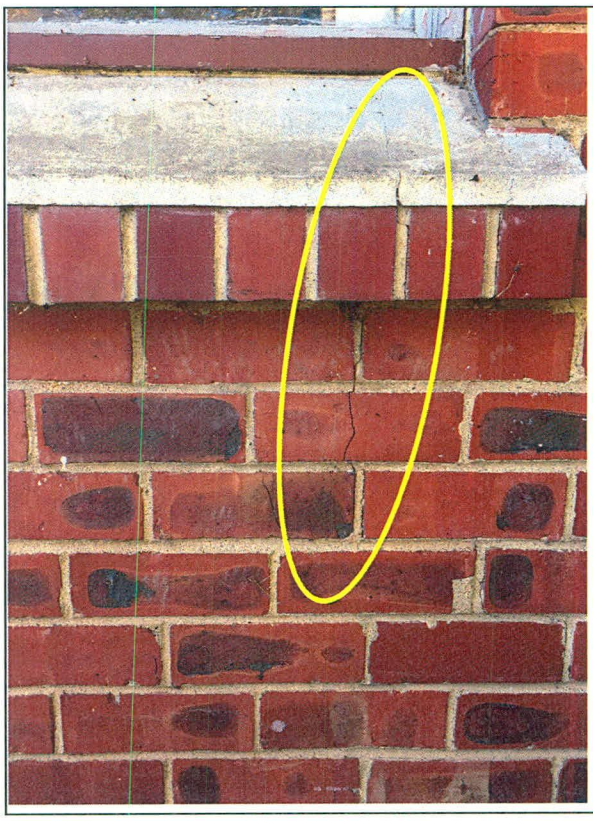
LEVEL 3, JOHN WICKLIFFE HOUSE
265 PRINCES STREET
PO BOX 4, DUNEDIN 9054,
NEW ZEALAND
FACSIMILE 64-3-477 0616
TELEPHONE 64-3-477 0885

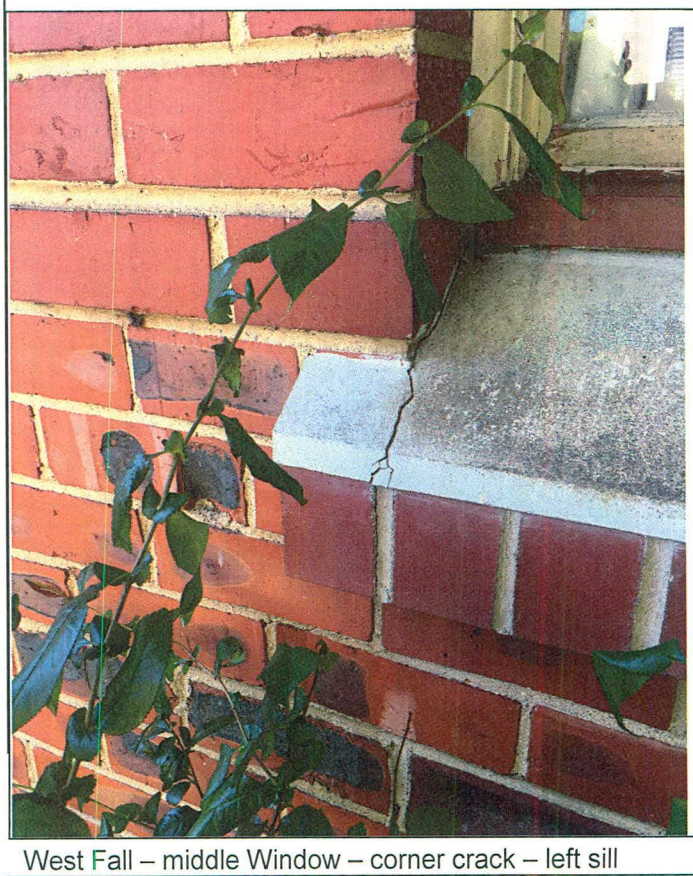
Project No. 8 0 5 7 6 7 0 - 1 5 0 7

Date: 1 April 2015 Prepared By: Lee Paterson

Description: DCC CD Landslide Monitoring 2014/15
Cockerell Street Slide, Brockville



West Fall – Left Window – corner crack – right sill



West Fall – middle Window – corner crack – left sill

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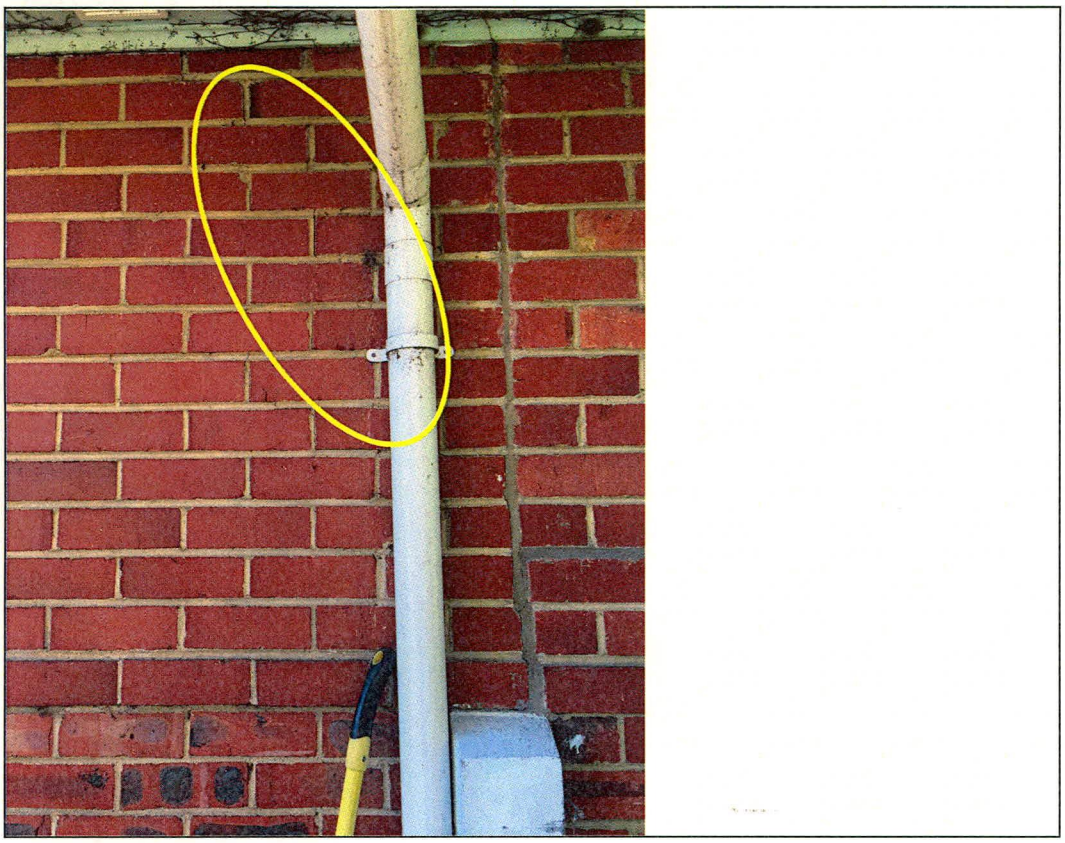
265 PRINCES STREET
PO BOX 4, DUNEDIN 9054,
NEW ZEALAND

FACSIMILE 64-3-477 0616
TELEPHONE 64-3-477 0885

Project No. 805767 0 - 1507

Date: 1 April 2015 Prepared By: Lee Paterson

Description: DCC CD Landslide Monitoring 2014/15
Cockerell Street Slide, Brockville



West Fall – masonry movement joint

West Fall – masonry movement joint

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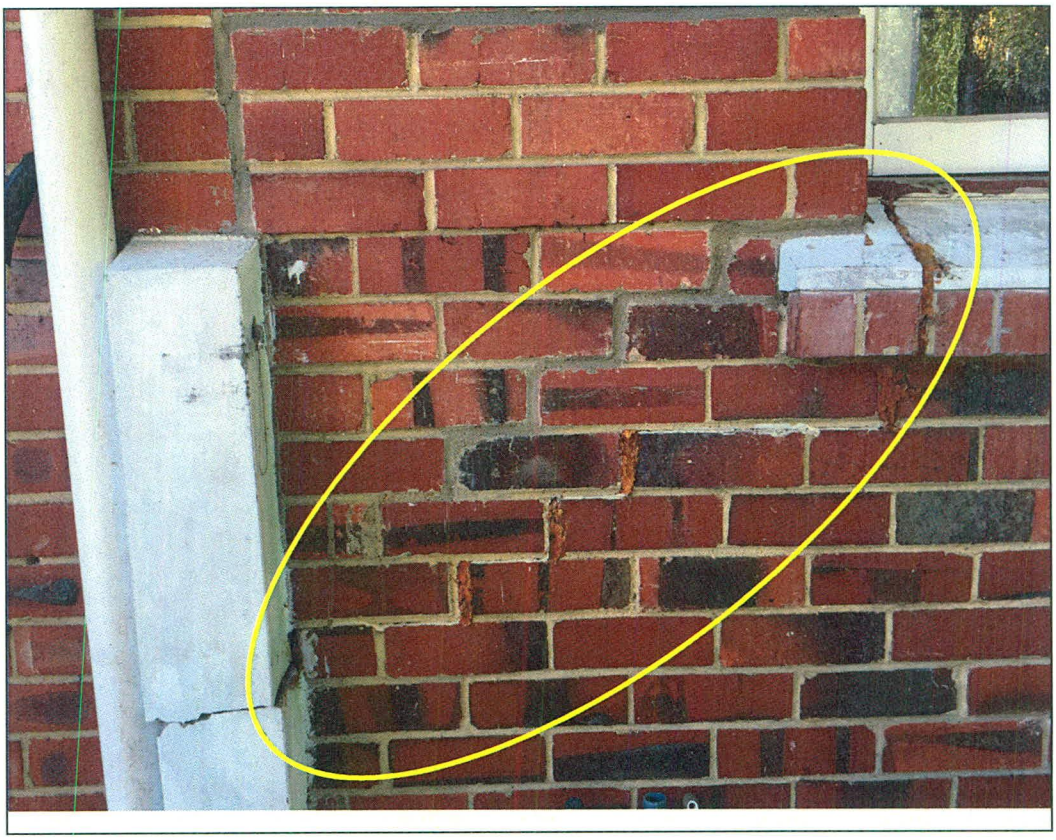
LEVEL 3, JOHN WICKLIFFE HOUSE
265 PRINCES STREET
PO BOX 4, DUNEDIN 9054,
NEW ZEALAND
FACSIMILE 64-3-477 0616
TELEPHONE 64-3-477 0885

Project No. 8 0 5 7 6 7 0 - 1 5 0 7

Date: 1 April 2015 Prepared By: Lee Paterson

Description: DCC CD Landslide Monitoring 2014/15
Cockerell Street Slide, Brockville

West Fall – masonry movement joint- service box



West Fall – Right Window – corner crack – left sill separation

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PO BOX 4, DUNEDIN 9054,
NEW ZEALAND

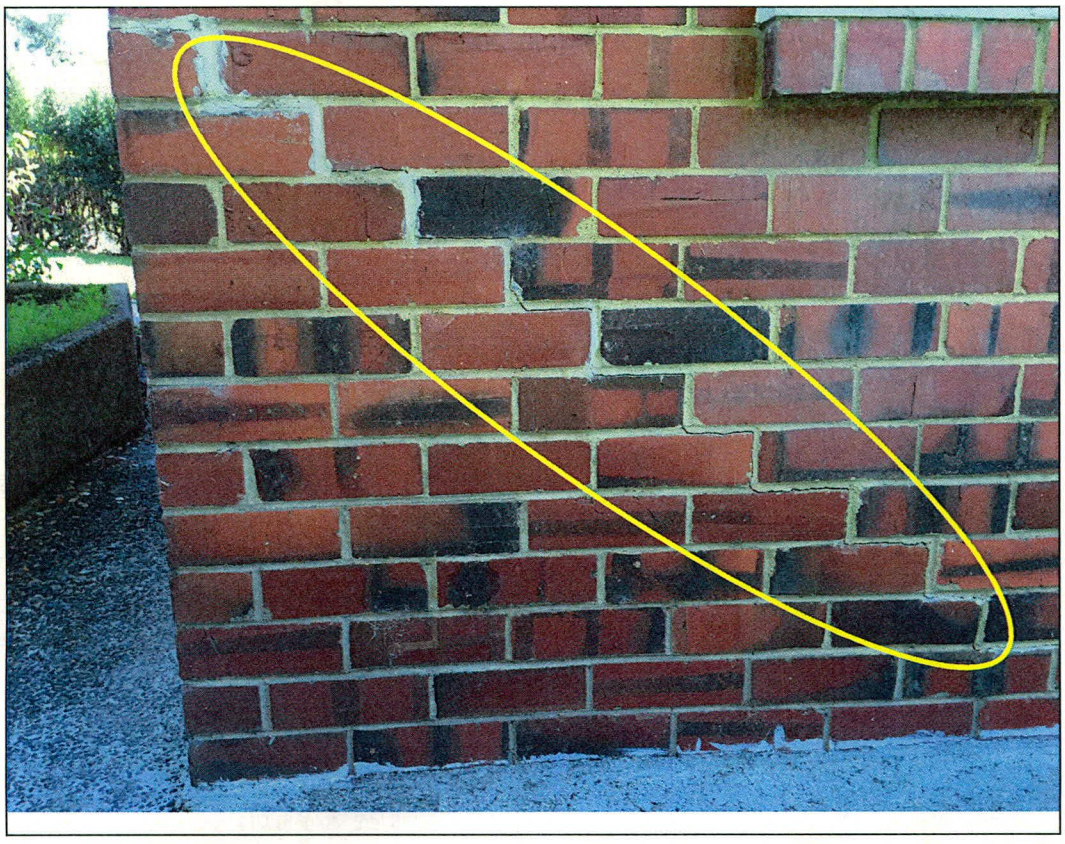
FACSIMILE 64-3-477 0616
TELEPHONE 64-3-477 0885

Project No. 805767 0 - 1507

Date: 1 April 2015 Prepared By: Lee Paterson

Description: DCC CD Landslide Monitoring 2014/15
Cockerell Street Slide, Brockville

West Fall – Right Window – corner crack – left sill separation



SW Corner – filled crack mortar

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TELEPHONE 64-3-477 0885

Project No. 8 0 5 7 6 7 0 - 1 5 0 7

Date: 1 April 2015 Prepared By: Lee Paterson

Description: DCC CD Landslide Monitoring 2014/15
Cockerell Street Slide, Brockville

SE Corner – path separation

NE Corner – path separation

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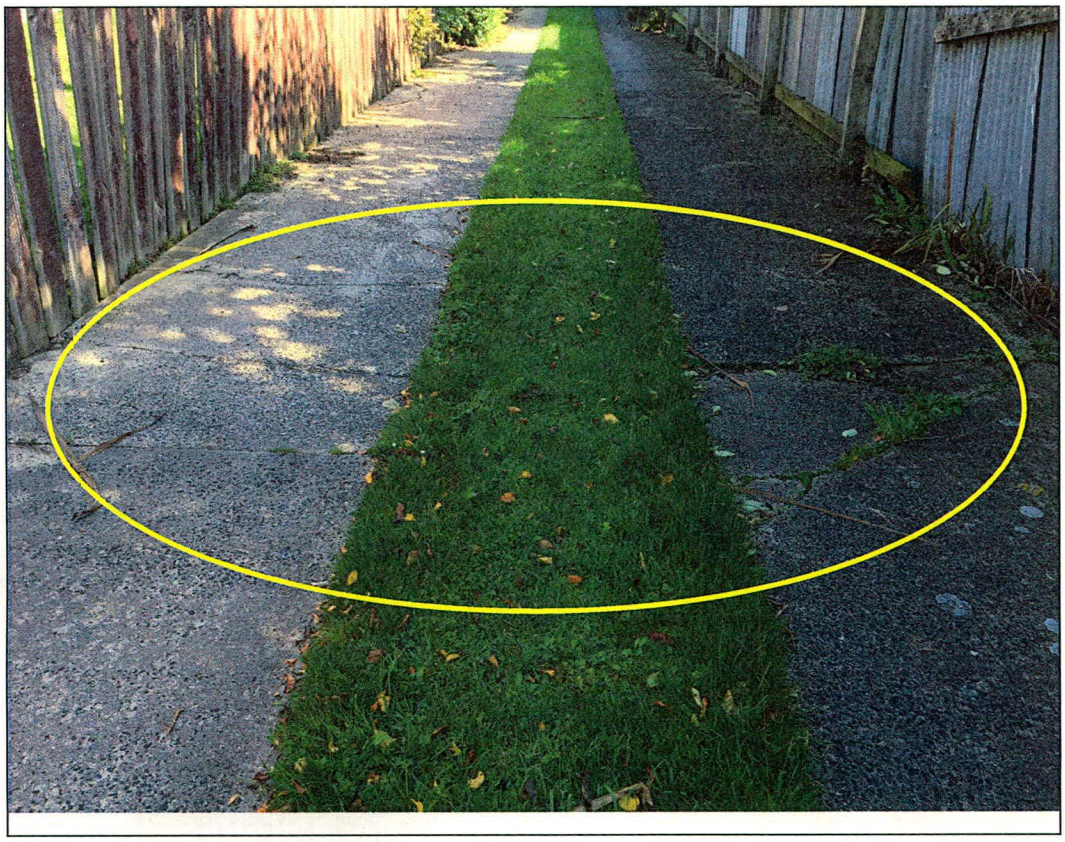
TELEPHONE 64-3-477 0885

Project No. 8 0 5 7 6 7 0 - 1 5 0 7

Date: 1 April 2015 Prepared By: Lee Paterson

Description: DCC CD Landslide Monitoring 2014/15
Cockerell Street Slide, Brockville

Driveway showing discharge of drains to surface



Driveway showing angled paving breakage (former scarp)

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PO BOX 4, DUNEDIN 9054,
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FACSIMILE 64-3-477 0616
TELEPHONE 64-3-477 0885

Project No. 8 0 5 7 6 7 0 - 1 5 0 7

Date: 1 April 2015 Prepared By: Lee Paterson

Description: DCC CD Landslide Monitoring 2014/15
Cockerell Street Slide, Brockville

Rear platform to 239 Brockville – separating concrete wall.

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Dunedin City Council – Civil Defence
Landslide Monitoring 2014/15
Dickson Street

The Dickson Street landslip site is located on the north east hillside above Macandrew Bay. The monitoring of this site was carried out on 23 February 2015 as part of DCC's ongoing landslide monitoring programme.

Executive Summary

The survey results for the Dickson Street landslip site show that there has been consistent movement over the past year.

The re-survey of the site is scheduled for February 2017.

General Information

The Dickson Street landslip site has been monitored since June 1997. As in previous years RTK GPS was used to measure the positions of the marks. The estimated accuracy of the RTK survey is ±5mm (horizontal) and ±10mm (vertical).

A site calibration was used holding Bench Mark (BM) X75 (AFF3) was fixed horizontally and Iron Rod (IR) II DP 15232 (C2A4 was held for the vertical.

The monitoring frequency has historically been every two years.

Extent of Movement

The observed displacements are in the range of 11-78mm for all marks since the previous survey. Most displacement vectors are at or close to the practical limit of accuracy for RTK GPS and our analysis indicates that there is the possibility that some movement might be taking place.

The greatest movement was observed at IS6 (68mm) and IS8 (78mm) which are situated at the top of hummocky ground.

Charts 1 and 2 and the deformation plans (attached) show the cumulative horizontal deformation at all marks since they were installed in 1997.

The Dickson Street site has cumulative movement of between 23-51mm. This has occurred at all marks except IS1, IS6 IS8 and IS9, which are slightly higher at 45-98mm. This movement is generally in a southerly direction. This movement is counter intuitive to the anticipated down-slope direction of movement, being towards the Greenacre Street valley. We will continue to monitor it in future surveys.

Rainfall Data

The long term average rainfall for the area is 676mm per annum. The rainfall for the 2013 year was 660mm and for the 2014 year was 652mm. Both are close to the average rainfall recorded over the past ten years and therefore we consider the results to be unaffected by any significant rainfall event since the last observation.

Conclusion

The general trend of 30-40mm of movement per year. This is consistent with movement back in February 2013.

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Recommendation

A resurvey of the site is currently scheduled for early 2017. A resurvey sooner would be able to confirm if it is moving.

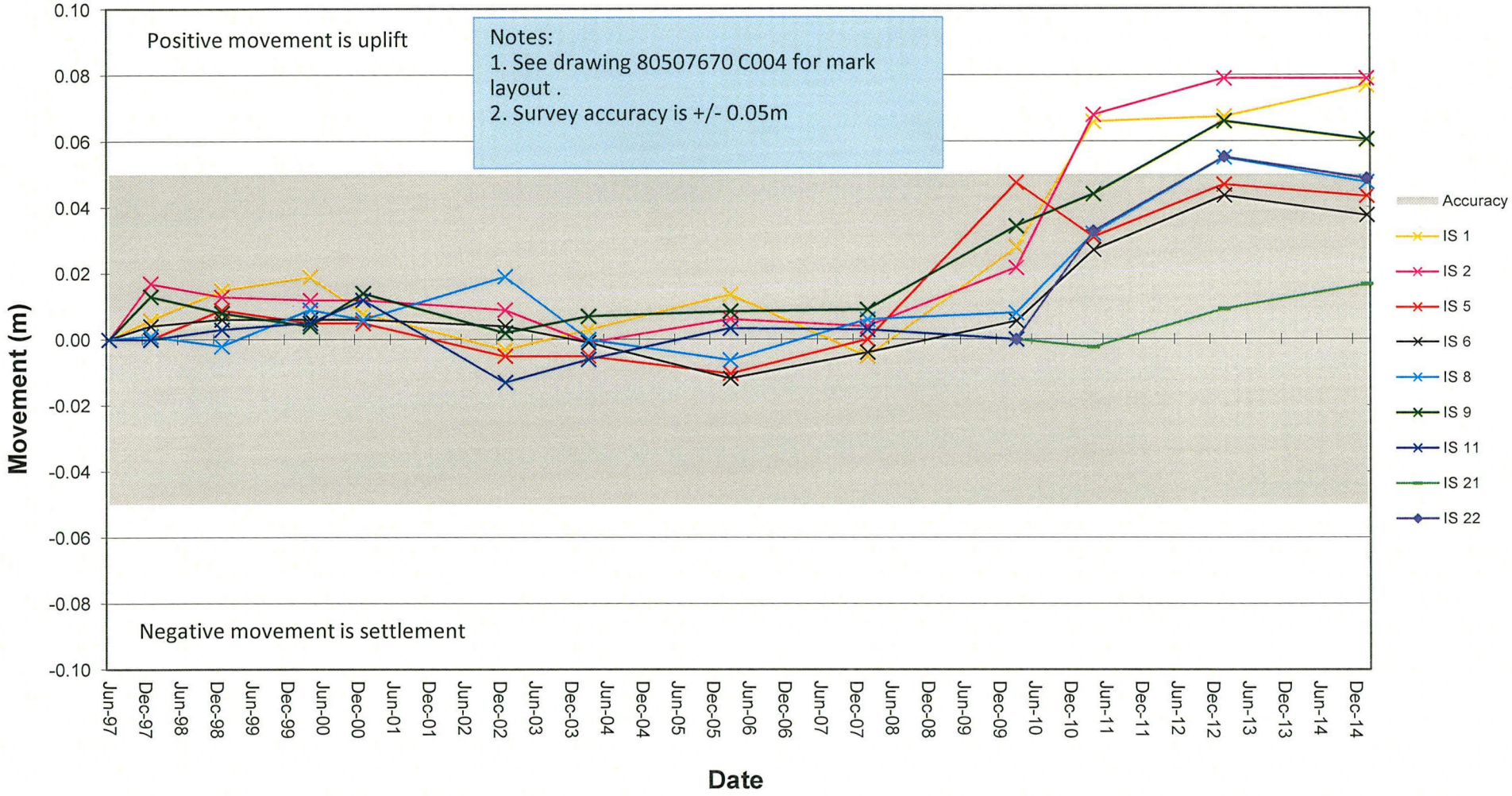
The following have been attached for your information:

- **Monitoring Report Spreadsheets**: recording the cumulative horizontal deformation at the monitoring marks for both sites.
- **Chart 1 (Dickson Street)**: showing cumulative vertical deformation over time.
- **Chart 2 (Dickson Street)**: showing cumulative horizontal deformation over time.
- **Deformation Diagrams**: Plans of the landslip sites with vector arrows illustrating cumulative movement from the original surveys to present (February 2015).

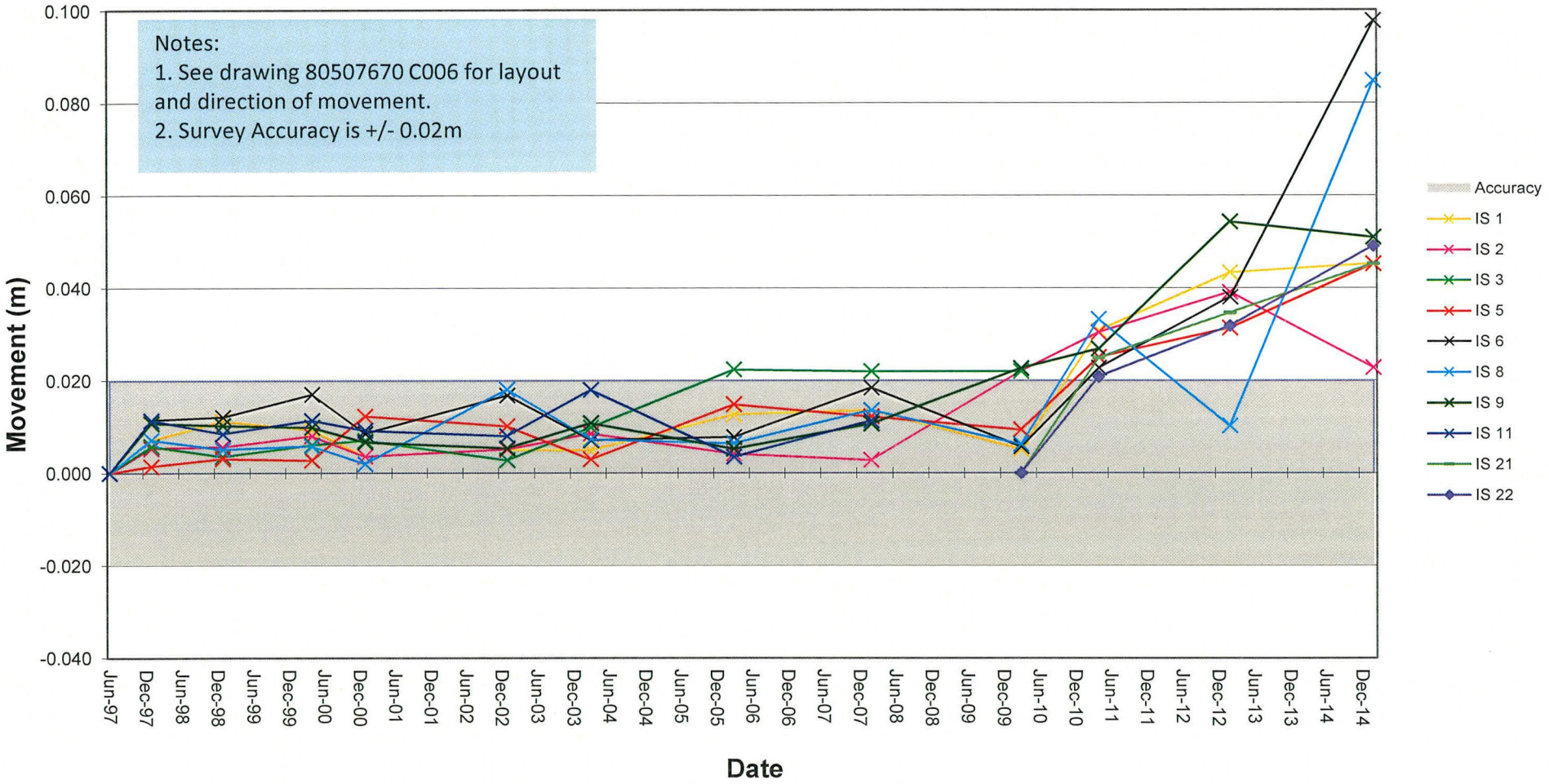
Survey Data Dated 23/02/2015

					Present to Previous					Present to Original				
Point Number	Northing	Easting	Height	Code	dN	dE	Azim.	Dist	dRL	dN	dE	Azim.	Dist	dRL
	NZGD49	NZGD49												
1	698974.489	324733.972	33.674	ISI	-0.005	-0.030	260.538	0.030	0.010	-0.044	-0.011	194.036	0.045	0.077
2	698755.129	324481.359	25.617	ISII	-0.004	-0.026	262.333	0.026	0.000	-0.021	0.009	156.801	0.023	0.079
5	699088.829	325008.978	136.517	ISV	-0.008	-0.028	254.055	0.029	-0.003	-0.039	-0.023	210.530	0.045	0.043
6	699121.067	324811.358	79.070	ISVI	-0.047	-0.049	226.500	0.068	-0.006	-0.084	-0.049	210.109	0.098	0.038
8	699034.388	324842.030	75.685	ISVIII	-0.063	-0.046	216.353	0.078	-0.007	-0.073	-0.044	211.253	0.085	0.047
9	699011.881	324566.914	20.835	ISIX	-0.002	-0.018	263.480	0.018	-0.006	-0.051	0.007	172.108	0.051	0.060
21	699121.857	324588.088	24.992	ISXXI	-0.008	-0.007	219.472	0.011	0.008	-0.041	-0.020	206.565	0.045	0.017
22	698870.869	324795.938	52.163	ISXXII	-0.014	-0.013	222.797	0.018	-0.007	-0.044	-0.022	206.957	0.049	0.049

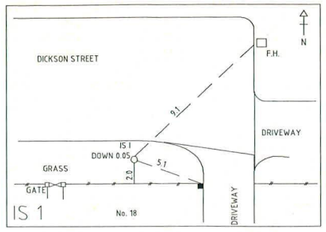
Dickson Street Landslide Monitoring 2015
Chart 1: Cumulative Vertical Deformation

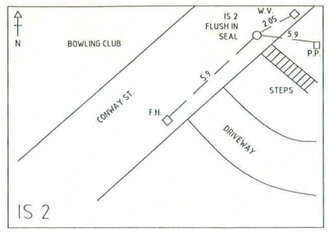


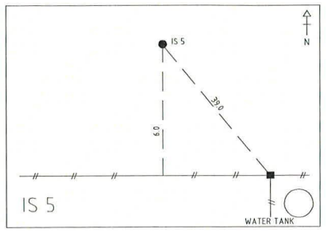
Dickson Street Landslide Monitoring 2015
Chart 2: Cumulative Horizontal Deformation

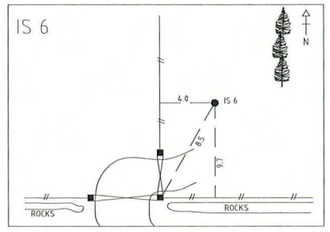


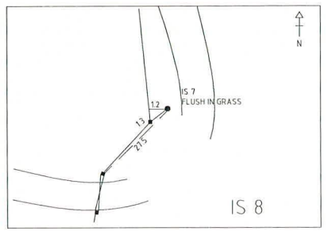
DEFORMATION MARK DIAGRAMS

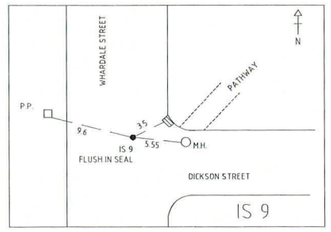


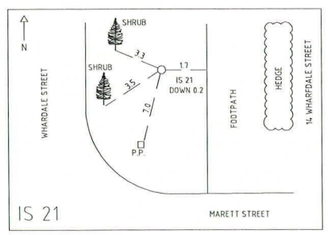


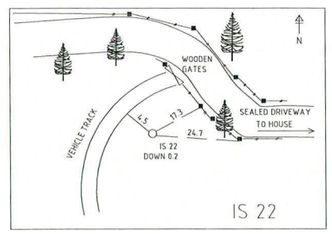












PLAN

SCALE 1 : 2000

SURVEY SCHEDULE

BASELINE SURVEY DATE JUNE 1997
SURVEY 1 MAY 1998
SURVEY 2 JANUARY 1999
SURVEY 3 APRIL 2000
SURVEY 4 JANUARY 2001
SURVEY 5 JANUARY 2003
SURVEY 6 MARCH 2004
SURVEY 7 MARCH 2006
SURVEY 8 FEBRUARY 2008
SURVEY 9 MARCH 2010
SURVEY 10 APRIL 2011
SURVEY 11 FEBRUARY 2013

NOTES:

1. AERIAL PHOTOGRAPHY FLOWN IN 2006/2007
2. MOVEMENT SHOWN IS CUMMULATIVE DEFORMATION ARROWS ARE SHOWN AT 2:1
3. THE SURVEY IS UNDERTAKEN USING RTK GPS. PRIOR TO 2010 STATIC GPS WAS USED.
4. HORIZONTAL ACCURACY IS +/- 20mm
5. VERTICAL ACCURACY IS +/- 50mm

DATUMS

1. LEVELS ARE IN TERMS OF WORLD GEODETIC SYSTEM 1984 ORIGIN OF LEVELS IS OTAGO UNIVERSITY SURVEYING DEPT. OS/2
2. COORDINATES ARE IN TERMS OF GEODETIC DATUM 1949 - A NORTH TAIERI CIRCUIT. ORIGIN OF COORDINATES IS OTAGO UNIVERSITY SURVEYING DEPT. OS/2

50 0 50 100m
SCALE 1:2000

NOT FOR CONSTRUCTION

REV	REVISIONS	DRAWN	CHECKED	APPROVED	DATE

	Name	Date
SURVEYED	JA HAWKER	02/15
DESIGNED	N/A	
DESIGN CHECK		04/15
DRAWN	JA HAWKER	04/15
DRAWING CHECK	AD ISSACS	04/15
APPROVED	AJ QUIGLEY	04/15

MWH

DUNEDIN CITY COUNCIL
Kaunihera-a-rohe o Otepoti

DUNEDIN CITY COUNCIL - CIVIL DEFENCE
LANDSLIDE MONITORING

DICKSON STREET LANDSLIP
DEFORMATION PLAN 2015

Status Stamp: FOR INFORMATION
Date Stamp: 15/04/2015
SCALES (A1) 1:2000
Drawing No.: 80507670
Sheet No.: C006
Rev.: A

XREFS :

P:_2012 Onwards\Dunedin City Council\80000575 DCC Continuing Advice\80507670 DCC CD Landslip Monitoring 14_15\1504 Dickson St\CAD

DO NOT SCALE - IF IN DOUBT, ASK

ORIGINAL SIZE A1

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Dunedin City Council – Civil Defence
Landslide Monitoring 2014/15
Howard Street

The Howard Street landslip site is located on the south east hillside above Howard and Marion Streets in Macandrew Bay. The monitoring of this site was carried out on 3 March 2015 as part of DCC's ongoing landslide monitoring programme.

Executive Summary

The survey results for the Howard Street landslip site show that there has been no significant movement over the past year.

The re-survey of the site is scheduled for June 2016.

General Information

The Howard Street landslip site has been monitored since May 1998. As in previous years RTK GPS was used to measure the positions of the marks. The estimated accuracy of the RTK survey is ±5mm (horizontal) and ±10mm (vertical).

The survey methodology was changed for this survey to give use greater accuracy, all marks were observed for at least 30 minutes and was then processed in Trimble Business Centre.
Bench Mark (BM) X75 (AFF3) was fixed horizontally and Iron Rod (IR) II DP 15232 (C2A4 was held for the vertical, a check shot was carried out on Trig I No. 3 (A23K).

The monitoring frequency has historically been annual, but was increased in frequency to quarterly, briefly following the June 2013 movement. It is now surveyed annually again.

The marks IS6 and IS13 have had other marks installed in the past to replace them. Due to change in methodology these are no longer needed and have not been re surveyed.

Extent of Movement

The observed displacements are in the range of 3-33mm for all marks since the previous survey. Most displacement vectors are at or close to the practical limit of accuracy for RTK GPS and our analysis indicates that these are unlikely to represent significant displacement.

Charts 1 and 2 and the deformation plans (attached) show the cumulative horizontal deformation at all marks since they were installed in 1997/98.

For the Howard Street site cumulative movement of between 39-60mm in a north to north-westerly (downhill) direction has been observed at IS's 8, 9 and 14. These marks located in the paddocks above Howard Street have historically been the most active portion of the landslip area. The general trend in this area is a downhill displacement at a rate of 3-4mm per year.

Rainfall Data

The long term average rainfall for the area is 676mm per annum. The rainfall for the 2013 year was 660mm and for the 2014 year was 652mm. Both are close to the average rainfall recorded over the past ten years and therefore we consider the results to be unaffected by any significant rainfall event since the last observation.

Conclusion

No significant movement has occurred at any of the marks since they were last surveyed (December 2013).

The general trend of <30mm of movement per year in the area above Howard Street continues.

Recommendation

A combined resurvey of both sites is scheduled for mid- 2016.

The following have been attached for your information:

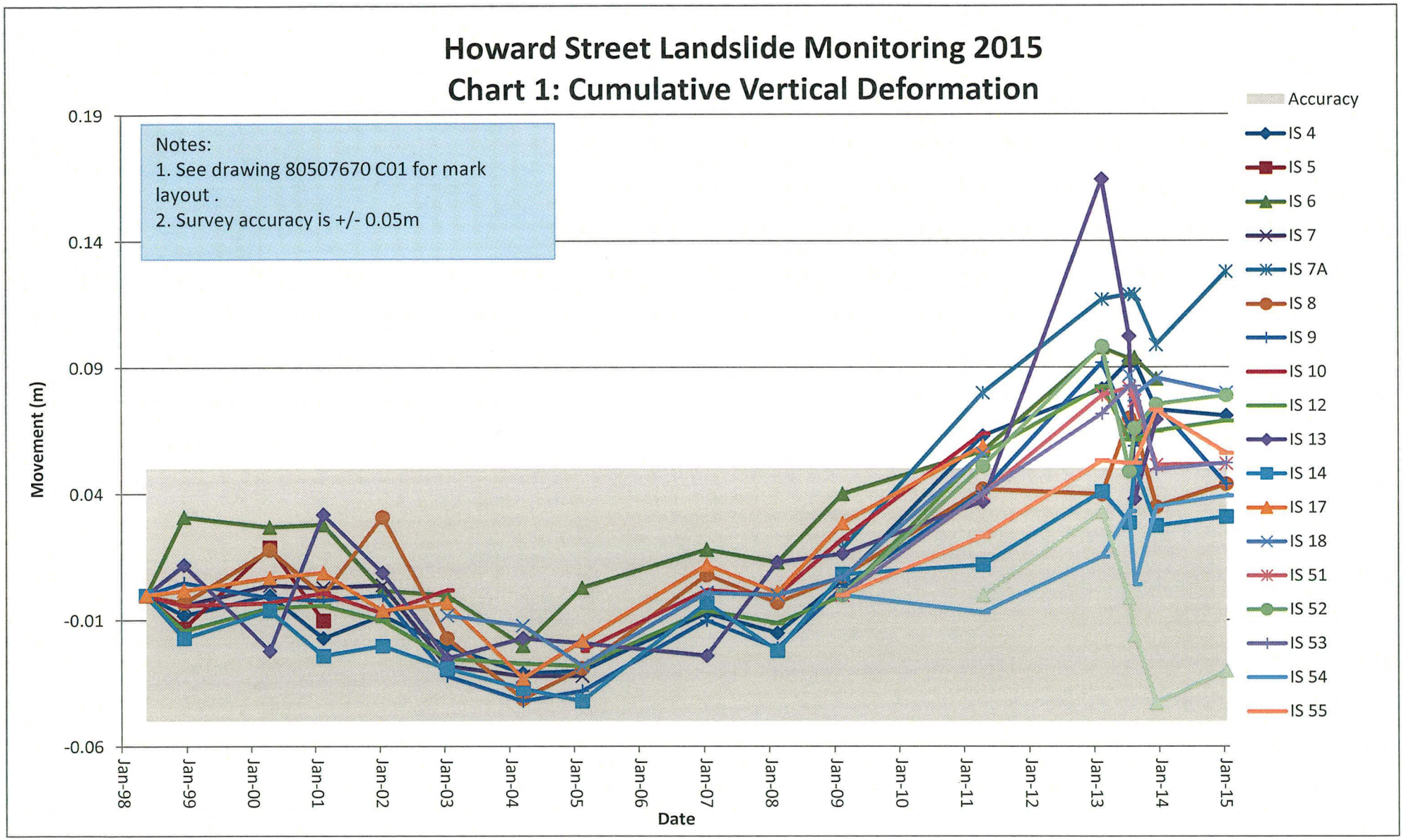
- **Monitoring Report Spreadsheets**: recording the cumulative horizontal deformation at the monitoring marks for both sites.
- **Chart 1 (Howard Street)**: showing cumulative vertical deformation over time.
- **Chart 2 (Howard Street)**: showing cumulative horizontal deformation over time.
- **Deformation Diagrams**: Plans of the landslip sites with vector arrows illustrating cumulative movement from the original surveys to present (February 2015).

Survey Data Dated 02/03/2015

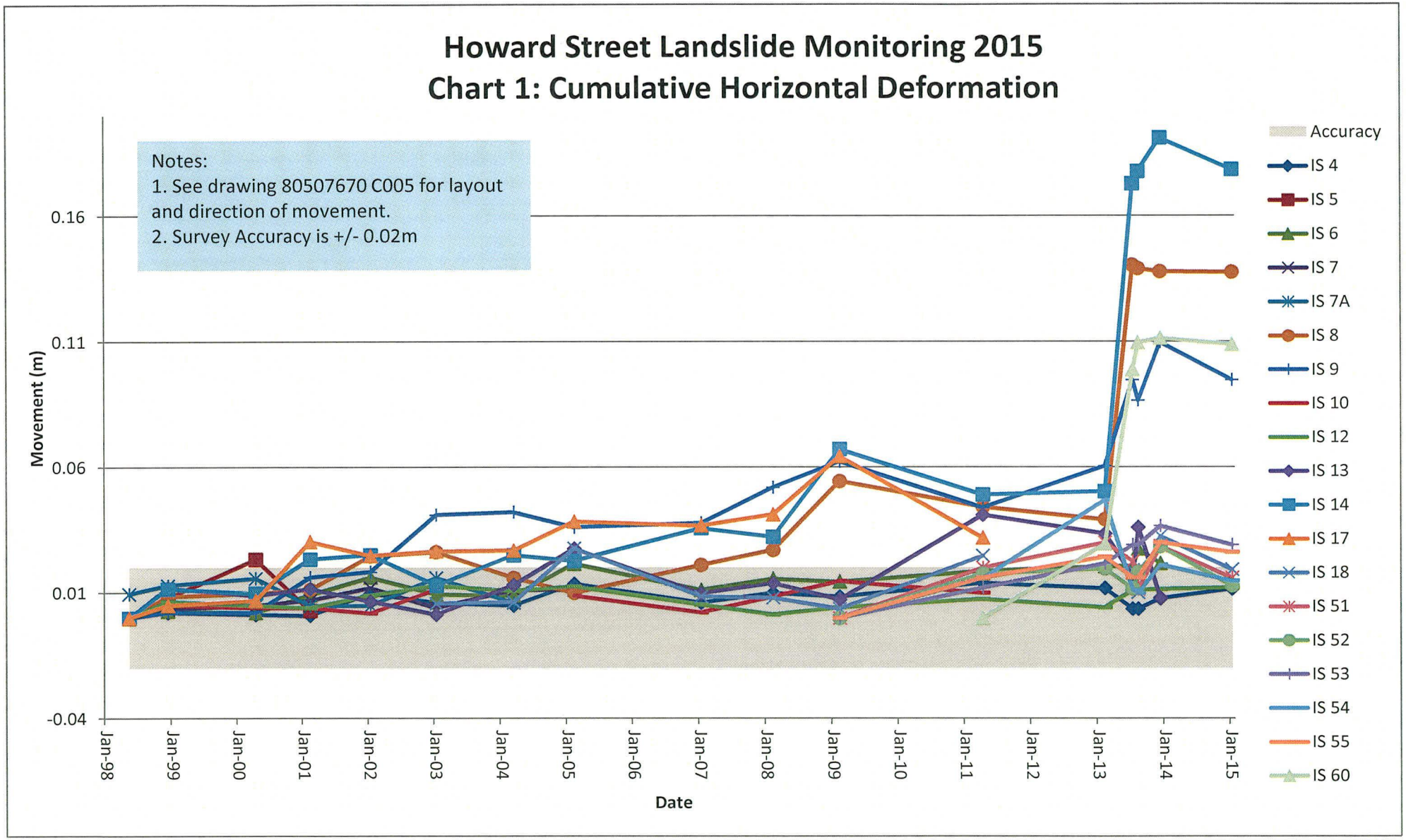
Additional survey

Point Number	Northing NZGD49	Easting NZGD49	Height	Code	Present to previous dN	dE	Azim.	Dist	dRL	Present to original (Data derived from original survey) dN	dE	Azim.	Dist	dRL
AFF3	700335.966	324526.998	7.005	BM X75	0.000	0.000	0.0000	0.000	0.007					
A23K	698553.383	323584.277	8.397	I NO. 3	-0.017	0.004	166.7595	0.017	-0.018					
C2A4	698815.760	324331.855	13.431	IR II	0.011	-0.004	340.0169	0.012	0.000					
OUSD	698908.145	317721.861	25.92	OUSD	-0.010	-0.004	201.8014	0.011	-0.063					
IS4	698161.932	323756.581	88.196	ISIV	0.008	-0.003	342.6460	0.008	-0.002	0.006	-0.010	300.9638	0.012	0.071
IS7A	698021.206	324014.471	168.605	ISVII	-0.010	0.000	180.0000	0.010	0.029	0.006	-0.001	350.5377	0.006	0.128
IT8B	698363.297	324109.702	97.352	ITVIII	-0.011	-0.003	195.2551	0.011	-0.002	0.036	-0.133	285.1457	0.138	0.044
IS9	698265.218	323937.637	87.57	ISIX	-0.017	0.003	168.3664	0.017	-0.032	0.068	-0.066	315.8551	0.095	0.044
IS12	698564.096	323849.759	21.259	ISXII	-0.023	-0.005	193.4486	0.024	0.000 0.004	-0.012	-0.002	189.4623	0.012	0.069
IS14	698385.011	323947.453	60.6	ISXIV	-0.010	0.007	144.4623	0.013	0.004	0.165	-0.068	337.6024	0.178	0.031
IS18	698489.743	323898.094	35.437	ISXVIII	-0.014	0.013	137.1211	0.019	0.000 -0.006	0.018	0.007	21.2505	0.019	0.080
IS51	698396.327	323856.062	43.558	IS 51	-0.008	0.010	128.6598	0.013	0.001	0.007	-0.014	295.7693	0.016	0.052
IT8	698388.189	323779.268	41.071	IS 52	-0.019	0.016	139.8991	0.025	0.003	0.009	0.009	47.3533	0.013	0.079
IS53	698544.443	323694.694	8.716	IS 53	-0.009	-0.003	198.4349	0.009	0.002	0.026	-0.012	335.1906	0.029	0.052
IS54B	698497.797	323955.624	33.16	IS 54	0.030	0.013	23.4287	0.033	0.004	0.015	-0.001	355.1560	0.015	0.039
IS55	698629.991	323833.203	11.463	IS 55	-0.019	-0.006	197.5256	0.020	-0.017	0.004	-0.026	278.7462	0.026	0.056
IS56	698263.135	324011.813	88.885	IS 60	-0.001	0.003	111.8014	0.003	0.013	0.079	-0.074	316.8596	0.109	-0.030

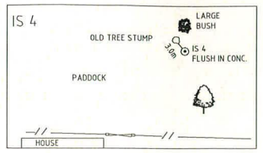
Howard Street Landslide Monitoring 2015
Chart 1: Cumulative Vertical Deformation

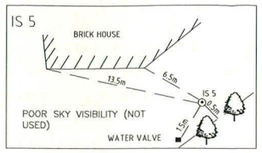


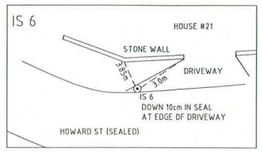
Howard Street Landslide Monitoring 2015
Chart 1: Cumulative Horizontal Deformation

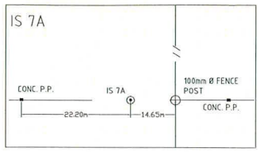


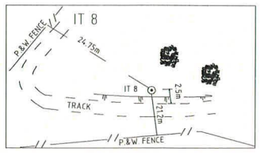
DEFORMATION MARK DIAGRAMS

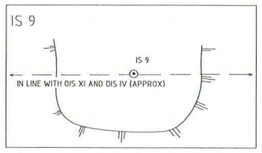


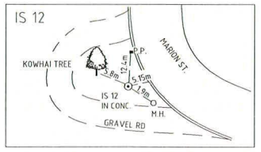


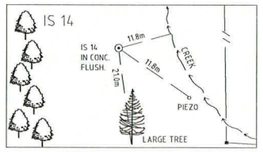


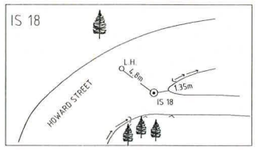


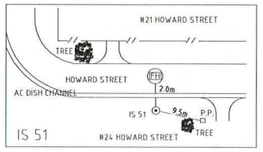


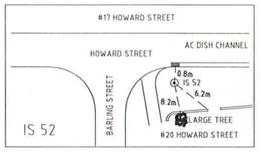


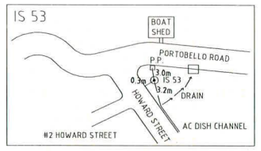


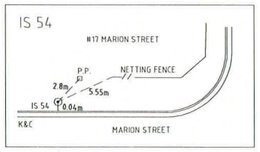


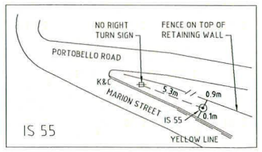












PLAN

SCALE 1 : 2000

SURVEY SCHEDULE

BASELINE SURVEY DATE MAY 1998
SURVEY 1 DECEMBER 1998
SURVEY 2 APRIL 2000
SURVEY 3 FEBUARY 2001
SURVEY 4 FEBUARY 2002
SURVEY 5 JANUARY 2003
SURVEY 6 MARCH 2004
SURVEY 7 FEBUARY 2005
SURVEY 8 JANUARY 2007
SURVEY 9 FEBUARY 2008
SURVEY 10 FEBUARY 2009
SURVEY 11 APRIL 2011
SURVEY 12 FEBRUARY 2013

NOTES:

1. AERIAL PHOTOGRAPHY FLOWN IN 2006/2007
2. MOVEMENT SHOWN IS CUMMULATIVE DEFORMATION ARROWS ARE SHOWN AT 2:1
3. THE SURVEY IS UNDERTAKEN USING RTK GPS. PRIOR TO 2010 STATIC GPS WAS USED.
4. HORIZONTAL ACCURACY IS +/- 20mm
5. VERTICAL ACCURACY IS +/- 50mm

DATUMS

1. LEVELS ARE IN TERMS OF WORLD GEODETIC SYSTEM 1984 ORIGIN OF LEVELS IS OTAGO UNIVERSITY SURVEYING DEPT. OS/2
2. COORDINATES ARE IN TERMS OF GEODETIC DATUM 1949 - A NORTH TAIERI CIRCUIT. ORIGIN OF COORDINATES IS OTAGO UNIVERSITY SURVEYING DEPT. OS/2

50 0 50 100m
SCALE 1:2000

NOT FOR CONSTRUCTION

REV	REVISIONS	DRAWN	CHECKED	APPROVED	DATE

	Name	Date
SURVEYED	JA HAWKER	02/15
DESIGNED	N/A	
DESIGN CHECK	AD ISSACS	04/15
DRAWN	JA HAWKER	04/15
DRAWING CHECK	AD ISSCAS	04/15
APPROVED	AJ QUIGLEY	04/15

MWH

DUNEDIN CITY COUNCIL
Kaunihera-a-rohe o Otepoti

DUNEDIN CITY COUNCIL - CIVIL DEFENCE
LANDSLIDE MONITORING

HOWARD STREET LANDSLIP
DEFORMATION PLAN 2015

Status Stamp: **FOR INFORMATION**
Date Stamp: **14/04/2015**
SCALES **(A1)** 1:2000

Drawing No.	Sheet No.	Rev.
80507670	C005	A

XREFS :

P:_2012 Onwards\Dunedin City Council\80000575 DCC Continuing Advice\80507670 DCC CD Landslip Monitoring 14_15\1505 Howard St\CAD

DO NOT SCALE - IF IN DOUBT, ASK
ORIGINAL SIZE A1