REPORT

Gisborne District Council

Wainui Beach Profile Summary

Tonkin & Taylor

ENVIRONMENTAL AND ENGINEERING CONSULTANTS

REPORT

Gisborne District Council

Wainui Beach Profile Summary

Report prepared for:

GISBORNE DISTRICT COUNCIL

Report prepared by:

Tonkin & Taylor Ltd

Distribution:

GISBORNE DISTRICT COUNCIL	1 PDF copy
Tonkin & Taylor Ltd (FILE)	1 PDF copy

July 2013

T&T Ref: 28735.BP.R3

Table of contents

1	**Introduction**		**1**
2	**Beach profile data**		**1**
3	**Assessment**		**3**
	3.1	Analysis	3
	3.2	Discussion	5
	3.2.1	General	5
	3.2.2	Profile 1	5
	3.2.3	Profile 2	5
	3.2.4	Profile 3	5
	3.2.5	Profile 4	5
	3.2.6	Profile 5	5
	3.2.7	Profile 6	6
	3.2.8	Profile 7	6
	3.2.9	Profile 8	6
	3.2.10	Profile 8A, 8B and 8C	6
	3.2.11	Profile 9	6
	3.2.12	Profile 10	6
	3.2.13	Profile 11	6
	3.2.14	Profile 12	6
	3.2.15	Profile 13	7
	3.2.16	Profile 14	7
4	**Discussion on effects of existing infrastructure**		**7**
5	**Summary and recommendations**		**7**
6	**Applicability**		**8**

Appendix A: **Beach profile summaries**

Appendix B: **Beach profile trends and residuals**

Executive summary

Beach profiles based on cross-section surveys have been undertaken along Wainui Beach since 1974. Tonkin & Taylor has assessed the available profile data and provided trend analysis in this report.

A regression analysis was carried out of the 1 m and 2 m depth contours. These depth contours represent the upper beach level at around MHWS and 1 m above MHWS. These contours can be used to evaluate the position of the beach relative to the benchmark and trends over the period of observation.

The beach profile data set provides a better understanding of beach processes and trends together with data such as LIDAR surveys and aerial photographs. The results show a more dominant erosion trend at the more southern areas of the beach (between profiles 1 and 7) with the remaining beach area more prone to fluctuation rather than a dominant erosion trend.

The results also show that longer data sets provide more useful information as there is substantial change in the trend analysis at profiles 1 to 8 when using the full data set to 2012 rather than to 1999. This includes changes in rate as well as changes in trend from accretion to erosion at Profile 8.

Surveying of the beach profiles, including the dune face and upper beach should continue for the entire beach.

1 Introduction

Beach profiles based on cross-section surveys have been undertaken along Wainui Beach since 1974. The purpose was to measure sand volume on the beach at regular intervals and monitor long term changes.

Tonkin & Taylor has assessed the available profile data and provided trend analysis in this report. Section 2 of this report indicates the location of profiles and survey information including the start and end dates, period of data collection and number of surveys undertaken. Section 3 is dedicated to profile analysis including the maximum and minimum excursion distance, excursion range and profile trend (m/year). Provided in Appendix 1 are 1m and 2m contour and residual plots for each profile.

2 Beach profile data

The available beach profile data indicates four profiles were surveyed in 1974, which was increased to 14 profiles in 1977 (Table 2-1). The profiles were numbered 1-14 starting from the south end of Wainui Beach (Figure A1 and A2). In 1993 three profiles were surveyed between existing profiles 8 and 9. In 1999 data from five additional profiles were collected as part of a one-off survey. Profile analysis of these five additional surveys has not been included in this report.

Prior to January 1999 the main areas of survey was focussed on the intertidal beach, so no detail was surveyed of the dune toe or upper beach position. Since 1999 the majority of the upper beach and lower dune system has been surveyed.

We have not carried out any audit or evaluation of the quality of the beach profile data set and have assumed all datums and elevations have been consistently applied.

Table 2-1 Beach profile survey information

Profile No.	Start date of survey	Last date of survey	Period (years)	Number of surveys
1	15/09/77	17/08/12	34.9	173
2	5/09/74	17/08/12	38.0	177
3	3/08/77	17/08/12	35.0	175
4	3/08/77	17/08/12	35.0	174
5	5/09/74	17/08/12	38.0	176
6	3/08/77	17/08/12	35.0	175
7	5/09/74	17/08/12	38.0	176
8	3/08/77	19/02/08	30.6	159
8A	27/02/93	19/01/99	5.9	15
8B	21/06/93	19/01/99	5.6	14
8C	27/02/93	19/01/99	5.9	11
9	5/09/74	19/01/99	24.4	148
10	3/08/77	19/01/99	21.5	146
11	3/08/77	19/01/99	21.5	147

Profile No.	Start date of survey	Last date of survey	Period (years)	Number of surveys
12	24/11/77	19/01/99	21.2	142
13	3/08/77	19/01/99	21.5	147
14	3/08/77	19/01/99	21.5	147

3 Assessment

3.1 Analysis

A regression analysis was carried out of the 1 m and 2 m depth contours. These depth contours represent the upper beach level at around MHWS and 1 m above MHWS. These contours can be used to evaluate the position of the beach relative to the benchmark and trends over the period of observation. Higher elevations were not able to be assessed reliably before January 1999, so were not included in the analysis.

A regression analysis involved establishing the horizontal location of the contour from the bench mark for each survey, which provides an indication of the fluctuation of beach position at that level. An increasing distance between surveys indicates accretion and a decreasing distance indicates erosion. A linear fit was then applied through the data which provides the trend of shoreline change, in metres per year, of the shoreline, with a positive trend indicating accretion. The residuals show the variation of the beach position, relative to the trend. This shows the variability of the beach, responding to storm events and periods of accretion and erosion.

The resulting linear trend of the full data set at each profile was determined for the two contour locations for each profile location. It was noted that surveys have not been continued since January 1999 for the northern profiles from 8A to 14. Therefore to enable an analysis of trends over the same time period the southern 8 profiles were reanalysed to extend over the same time period as the northern profiles. Table 3-1 provides summaries of the analyses, including the full data set trend and the shorter term trend for the southern profiles (results in brackets). The table also shows the minimum and maximum recorded excursion to show the range of fluctuation in beach position.

Appendix A shows the earliest and most recent surveys together with the maximum, average and minimum envelope resulting from the analysis of the entire data set. The profile survey of January 1999 was also included in Profiles 1 to 8 to enable a comparative assessment to be made with the more northern profiles that did not include more recent surveys. It is noted that the minimum and average beach positions are strongly influenced by the interpolated beach profile data prior to 1999 and may not be a reliable guide to the location of the beach profile within the upper beach and dune areas. Appendix B includes graphical plots that show the fluctuations observed at that level, the linear trend and an excursion plot that shows the movement of the profile around the trend line. The daily trend shown in these plots has been converted to an annual trend in Table 3-1 and colours have been applied to the trend to indicate erosion (rates less than -0.12 m/yr), neutral conditions (rates between -0.12 and 0.12 m year) and accretion (rates greater than 0.12 m/yr). It is noted that trends from the shorter data sets are likely to vary significantly with additional data, as can be seen by comparing the profile trends where the longer term and shorter term data is presented.

Table 3-1 Wainui Beach profile analysis

Profile No.	Contour (m)	Full Set Trend (shorter term trend to Jan 1999) (m/yr)	Min Excursion (m)	Max Excursion (m)	Range (m)
1	1	-0.22 (-0.47)	-5.4	12	17.4
	2	-0.07 (-0.33)	-3.1	4.5	7.6
2	1	-0.18 (-0.51)	-20.8	32.2	53.0
	2	-0.18 (-0.26)	-7.3	28.4	35.7

Profile No.	Contour (m)	Full Set Trend (shorter term trend to Jan 1999) (m/yr)	Min Excursion (m)	Max Excursion (m)	Range (m)
3	1	-0.22 (-0.51)	-22.9	31.8	54.7
	2	-0.37 (-0.66)	-11.2	14.72	25.9
4	1	-0.15 (-0.18)	-20.9	30.8	51.7
	2	-0.18 (-0.26)	-8.1	28.2	36.3
5	1	-0.04 (-0.11)	-20.6	26.8	47.4
	2	-0.07 (-0.07)	-7.2	39.8	46.9
6	1	-0.22 (-0.02)	-24.5	28.4	52.9
	2	-0.26 (-0.22)	-13.3	22.3	35.6
7	1	0.04 (0.22)	-25.7	28.2	53.9
	2	0.07 (0.29)	-14.6	31.1	45.7
8	1	-0.04 (0.07)	-17.6	21.5	39.1
	2	-0.01 (0.18)	-13.5	23.3	36.9
8A	1	(4.80)	-13.9	11.2	25.0
	2	(4.27)	25.3	-12.9	38.1
8B	1	(1.46)	-18.5	19.9	38.3
	2	(-2.01)	-20.3	33.5	53.9
8C	1	(4.31)	-29.5	27.0	56.5
	2	(0.44)	-34.8	26.1	60.9
9	1	(0.29)	-33.4	26.5	59.9
	2	(0.55)	-22.1	28.1	50.1
10	1	(-0.07)	-10.0	25.1	35.0
	2	(-0.07)	-5.14	25.4	30.5
11	1	(-0.18)	-14.5	52.4	66.9
	2	(-0.11)	-5.7	34.2	39.9
12	1	(-0.11)	-24.8	32.9	57.2
	2	(-0.07)	-23.7	30.5	54.2
13	1	(0.29)	-23.7	28.7	52.4
	2	(0.44)	-15.3	36.3	51.6
14	1	(0.66)	-22.2	25.5	47.7
	2	(0.58)	13.1	19.0	32.6

3.2 Discussion

3.2.1 General

The results show a more dominant erosion trend at the more southern areas of the beach (between profiles 1 and 7) with the remaining beach area more prone to fluctuation rather than a dominant erosion trend.

3.2.2 Profile 1

The 1 m contour information shows a rapid retreat occurred in 1981 with the beach levels appearing to fluctuate but with a lesser erosion trend. The 2m contour shows a similar trend although the horizontal excursion is more seaward from 2007, presumably as a result of protection works carried out at this location. Erosion trends were greater with the shorter data set to January 1999. The range of beach fluctuations are relatively small at this location (17.4 m to 7.6 m for the 1 m and 2 m contour respectively) which is also to be expected due to the more gravelly beach sediment.

3.2.3 Profile 2

Both the 1 m and 2 m contours show a reasonably uniform rate of shoreline retreat over the period of beach surveys (-0.18 m/year). The 1991 period of erosion is clearly evident as is a more seaward shoreline resulting from the protection works. Erosion trends were greater with the shorter data set to January 1999. The range of beach fluctuations are significantly greater that Profile 1, but a similar trend of reducing rates of fluctuation higher up the beach face (53 m and 35.7 m for 1 m and 2 m contours respectively).

3.2.4 Profile 3

A higher rate of shoreline retreat is recorded from the beach profile data, with -0.37 m/yr recorded at the 2 m contour, although a slightly lower rate of -0.22 m/yr lower down the beach face. The Gabion work can be seen to reduce the landward retreat of the beach profile, while there are still periods where the beach accretes. Erosion trends were greater with the shorter data set to January 1999. The range of beach fluctuations is 54.7 m and 25.9 m for 1 m and 2 m contours respectively.

3.2.5 Profile 4

A rate of shoreline retreat of -0.18 m/yr recorded at the 2 m contour, although a slightly lower rate of -0.15 m/yr lower down the beach face. The Gabion work can be seen to reduce the landward retreat of the beach profile, while there are still periods where the beach accretes. Erosion trends were slightly greater with the shorter data set to January 1999. The range of beach fluctuations is 51.7 m and 36.3 m for 1 m and 2 m contours respectively.

3.2.6 Profile 5

A lower rate of shoreline retreat is observed here, with -0.07 m/yr recorded at the 2 m contour and -0.04 m/yr lower down the beach face. The Gabion work can be seen to reduce the landward retreat of the beach profile, while there are still periods where the beach accretes. Erosion trends were of a similar order of magnitude with the shorter data set to January 1999. The range of beach fluctuations is similar at the two contours, with 47.4 m and 46.9 m recorded for 1 m and 2 m contours respectively, although typically the beach operates in a much narrower band of around 15 m at the 2 m depth contour.

3.2.7 Profile 6

A rate of shoreline retreat of -0.26 m/yr is recorded at the 2 m contour and -0.22 m/yr lower down the beach face. Erosion trends were of a similar order of magnitude with the shorter data set to January 1999. The range of beach fluctuations is 52.9 m and 35.6 m recorded for 1 m and 2 m contours respectively, although typically the beach operates in a much narrower band of around 20 m at the 2 m contour.

3.2.8 Profile 7

A rate of slight shoreline accretion of 0.07 m/yr is recorded at the 2 m contour and 0.04 m/yr lower down the beach face. Accretion trends were higher with the shorter data set to January 1999. The range of beach fluctuations is 53.9 m and 45.7 m recorded for 1 m and 2 m contours respectively.

3.2.9 Profile 8

A rate of slight shoreline retreat of -0.01 m/yr is recorded at the 2 m contour and -0.04 m/yr lower down the beach face. However, this small rate may suggest this area is more within the range of dynamically stable. The trend was for accretion with the shorter data set to January 1999. The range of beach fluctuations is 39.1 m and 36.9 m recorded for 1 m and 2 m contours respectively.

3.2.10 Profile 8A, 8B and 8C

These data sets are too short for meaningful analysis and are presented for completeness.

3.2.11 Profile 9

A rate of shoreline accretion of 0.55 m/yr is recorded at the 2 m contour and 0.29 m/yr lower down the beach face between the period of September 1974 and January 1999. This may be due to the installation of the Hamanatua Stream training works, encouraging sand deposition at this location. The range of beach fluctuations is 59.9 m and 50.1 m recorded for 1 m and 2 m contours respectively.

3.2.12 Profile 10

A small rate of shoreline erosion of -0.07 m/yr is recorded both at the 1m and 2 m contour between the period of August 1977 and January 1999. The range of beach fluctuations is 35.0 m and 30.5 m recorded for 1 m and 2 m contours respectively.

3.2.13 Profile 11

A rate of shoreline erosion of -0.11 m/yr is recorded at the 2m and -0.18 at the 1 m contour between the period of August 1977 and January 1999. The range of beach fluctuations is 66.9 m and 39.9 m recorded for 1 m and 2 m contours respectively.

3.2.14 Profile 12

A rate of shoreline erosion of -0.07 m/yr is recorded at the 2m and -0.11 at the 1 m contour between the period of November 1977 and January 1999. The range of beach fluctuations is 57.2 m and 54.2 m recorded for 1 m and 2 m contours respectively.

3.2.15 Profile 13

A rate of shoreline accretion of 0.44m/yr is recorded at the 2m and 0.29 at the 1 m contour between the period of November 1977 and January 1999. The range of beach fluctuations is 52.4 m and 51.6 m recorded for 1 m and 2 m contours respectively.

3.2.16 Profile 14

A rate of shoreline accretion of 0.58 m/yr is recorded at the 2m and 0.66 m/yr at the 1 m contour between the period of November 1977 and January 1999. The range of beach fluctuations is 47.7 m and 32.6 m recorded for 1 m and 2 m contours respectively.

4 Discussion on effects of existing infrastructure

The existing infrastructure is of variable quality and condition. The main purpose of the protection works was to prevent further landward retreat of the dune and backshore area. Previous reports have provided more depth descriptions of the various protection types, but typically they have not been designed with full understanding of the wave forces and beach profile change and therefore tend to require reasonable levels of maintenance to maintain their effectiveness. Therefore, in most cases, it is the ongoing maintenance works of the structure, rather than the structure themselves that “holds the line”.

With ongoing erosion trends, it is likely that the existing protection works will become periodically more exposed to wave forces as, at the southern end the beach levels will not return to the previous levels. Therefore, we anticipate increased damage and requirements for maintenance. In addition, in areas where there is more sandy dune along the backshore, rather than weak cliff geology, the structures may begin to have an impact on the adjacent shoreline, either through impoundment (holding back sediment from the backshore that would otherwise be in the system) or by end wall or groyne effects where there is additional localised erosion as a result of the protection structure.

5 Summary and recommendations

The beach profile data set provides a better understanding of beach processes and trends together with data such as LIDAR surveys and aerial photographs. The results show a more dominant erosion trend at the more southern areas of the beach (between profiles 1 and 7) with the remaining beach area more prone to fluctuation rather than a dominant erosion trend. The results also show that longer data sets provide useful information as there is substantial change in the trend analysis at profiles 1 to 8 when using the full data set to 2012 rather than to 1999. This includes changes in rate as well as changes in trend from accretion to erosion at Profile 8.

Surveying of the beach profiles, including the dune face and upper beach should continue for the entire beach. It may be possible to extract LIDAR profiles to give a representation of the beach profile at the time of that survey.

6 Applicability

This report has been prepared for the benefit of Gisborne District Council with respect to the particular brief given to us and it may not be relied upon in other contexts or for any other purpose without our prior review and agreement.

Tonkin & Taylor LTD

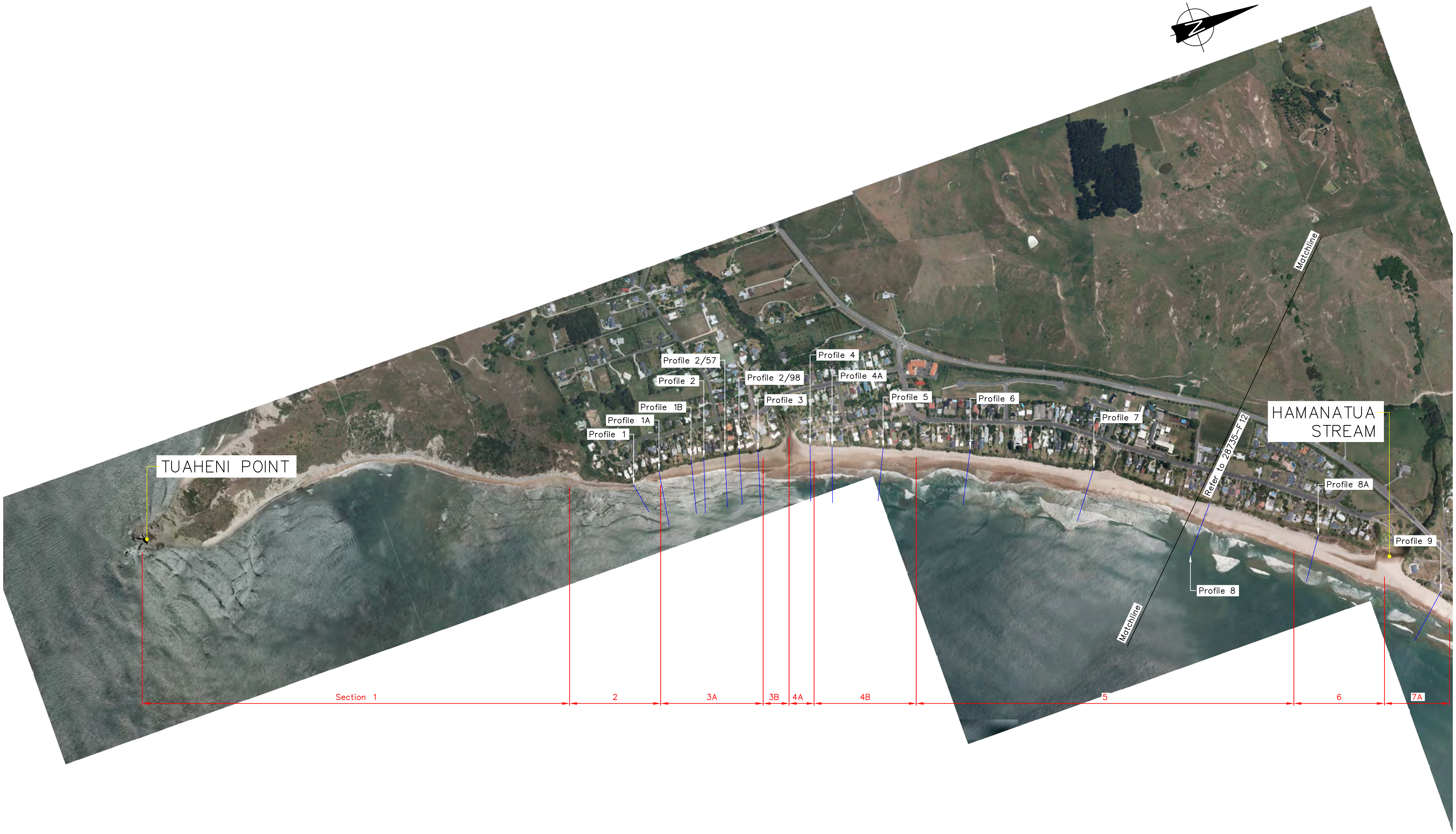
Environmental and Engineering Consultants

Report prepared by:	Authorised for Tonkin & Taylor Ltd by:
....	....
James McKenzie	Tim Fisher
Richard Reinen-Hamill	Project Director

RRH:rrh

P:\28735\WorkingMaterial\RRH20130607.bpanalysis.R3a.docx

Appendix A: Beach profile summaries



NOTES:

1. Aerial photo supplied by Gisborne District Council

SCALE 1: 10,000

0 100 200 300 400 500 (m)

Tonkin & Taylor
Environmental and Engineering Consultants
105 Carlton Gore Road, Newmarket, Auckland
www.tonkin.co.nz

DRAWN	EAA	Jul. 13
DRAFTING CHECKED		
APPROVED		
CADFILE : \\28735–FA1.dwg		
SCALES (AT A3 SIZE) 1: 10000		
PROJECT No. 28735		

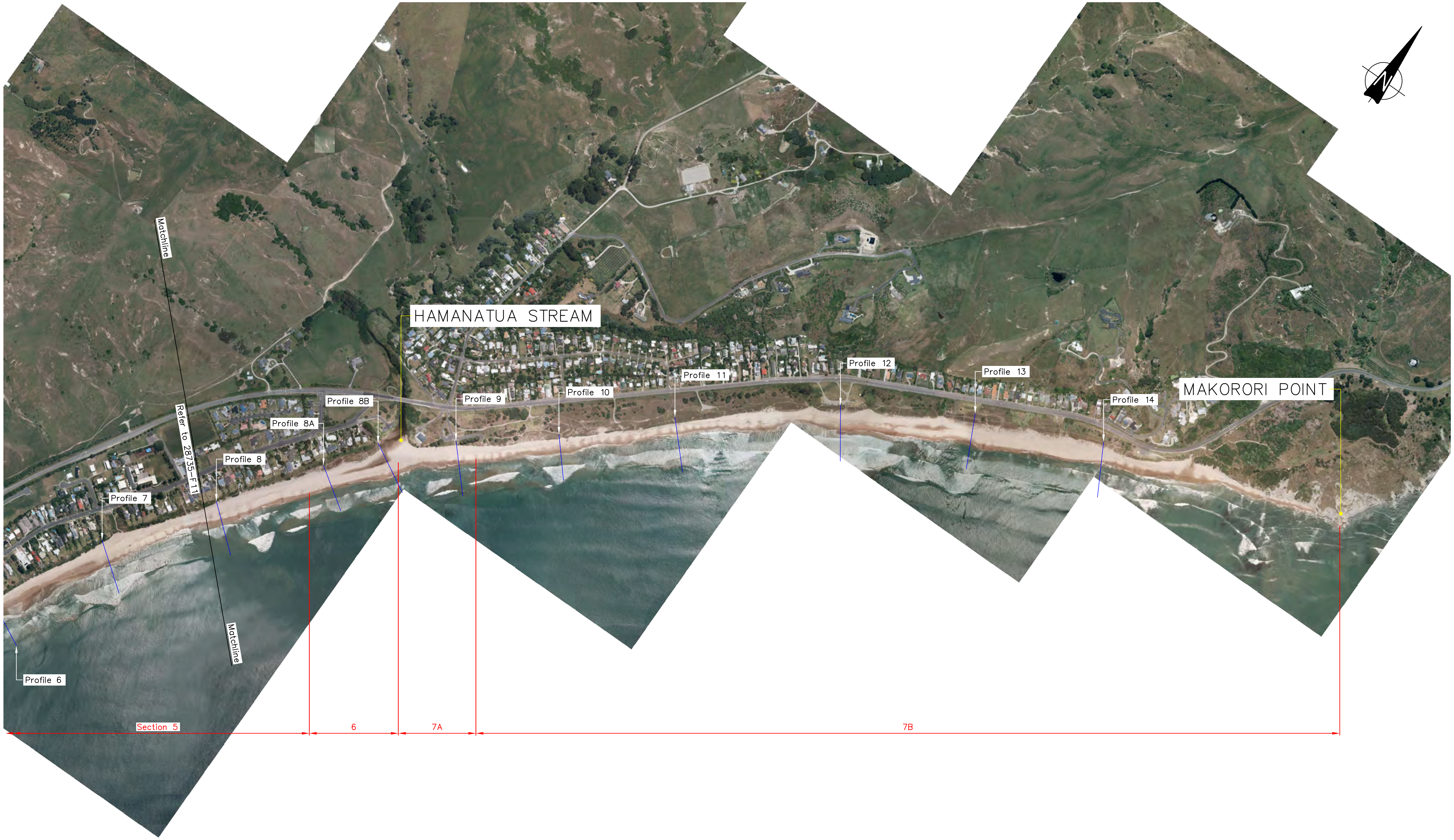
GISBORNE DISTRICT COUNCIL
WAINUI BEACH MANAGEMENT STRATEGY

Plan – Sheet 1

FIG. No. Figure A1

REV. 0

L:\28735\WorkingMaterial\CAD\Figures\28735-FA1.dwg, FA1, 22/07/2013 3:10:14 p.m., eaa, 1:1



NOTES:

1. Aerial photo supplied by Gisborne District Council

SCALE 1: 10,000

0 100 200 300 400 500 (m)

Tonkin & Taylor
Environmental and Engineering Consultants
105 Carlton Gore Road, Newmarket, Auckland
www.tonkin.co.nz

DRAWN	EAA	Jul. 13
DRAFTING CHECKED		
APPROVED		
CADFILE : \\28735–FA2.dwg		
SCALES (AT A3 SIZE) 1: 10000		
PROJECT No. 28735		

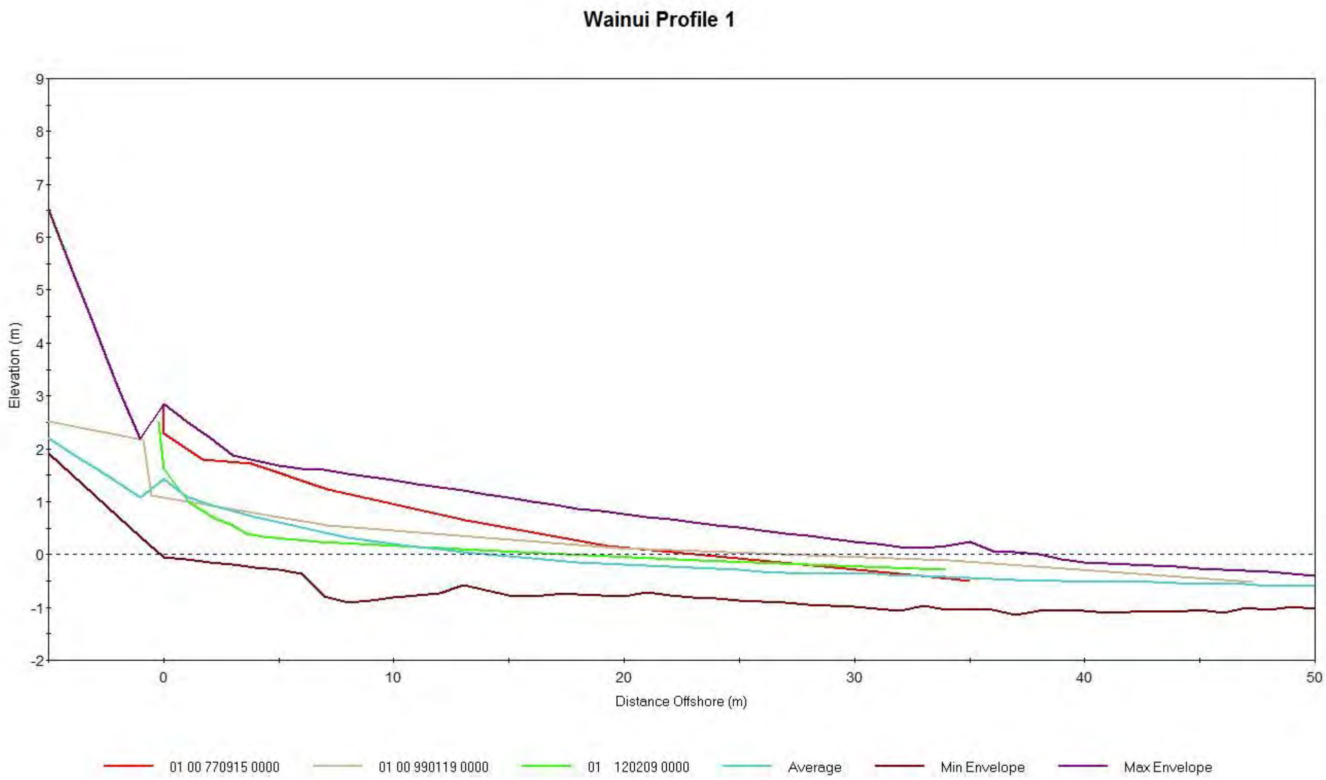
GISBORNE DISTRICT COUNCIL
WAINUI BEACH MANAGEMENT STRATEGY

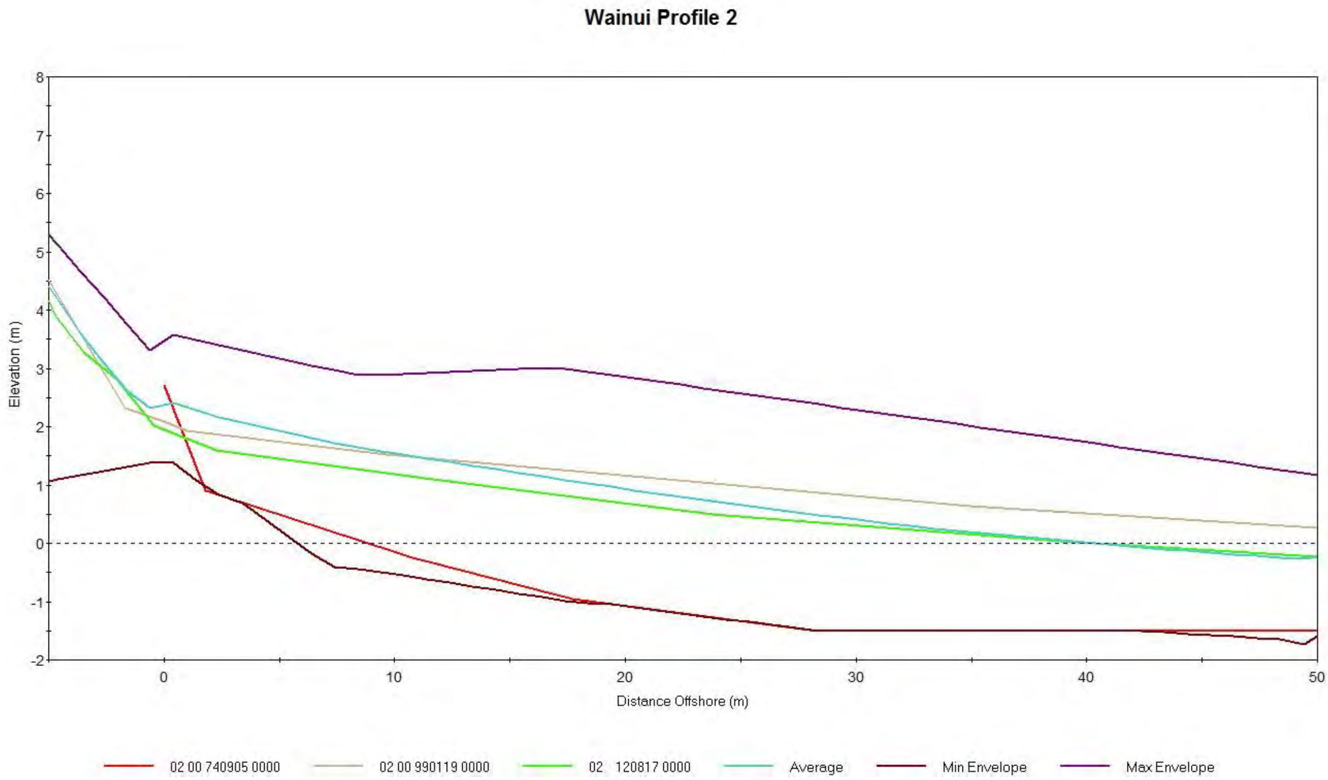
Plan – Sheet 2

FIG. No. Figure A2

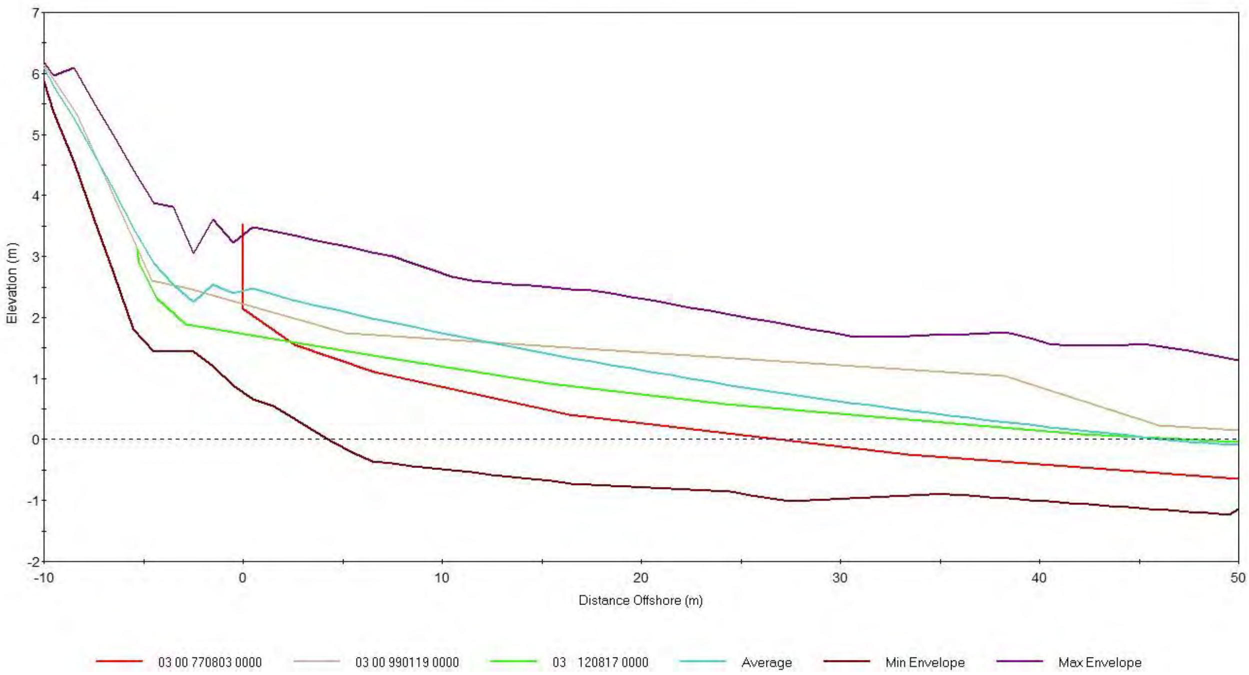
REV. 0

L:\28735\WorkingMaterial\CAD\Figures\28735-FA2.dwg, FA2, 22/07/2013 3:12:56 p.m., eaa, 1:1

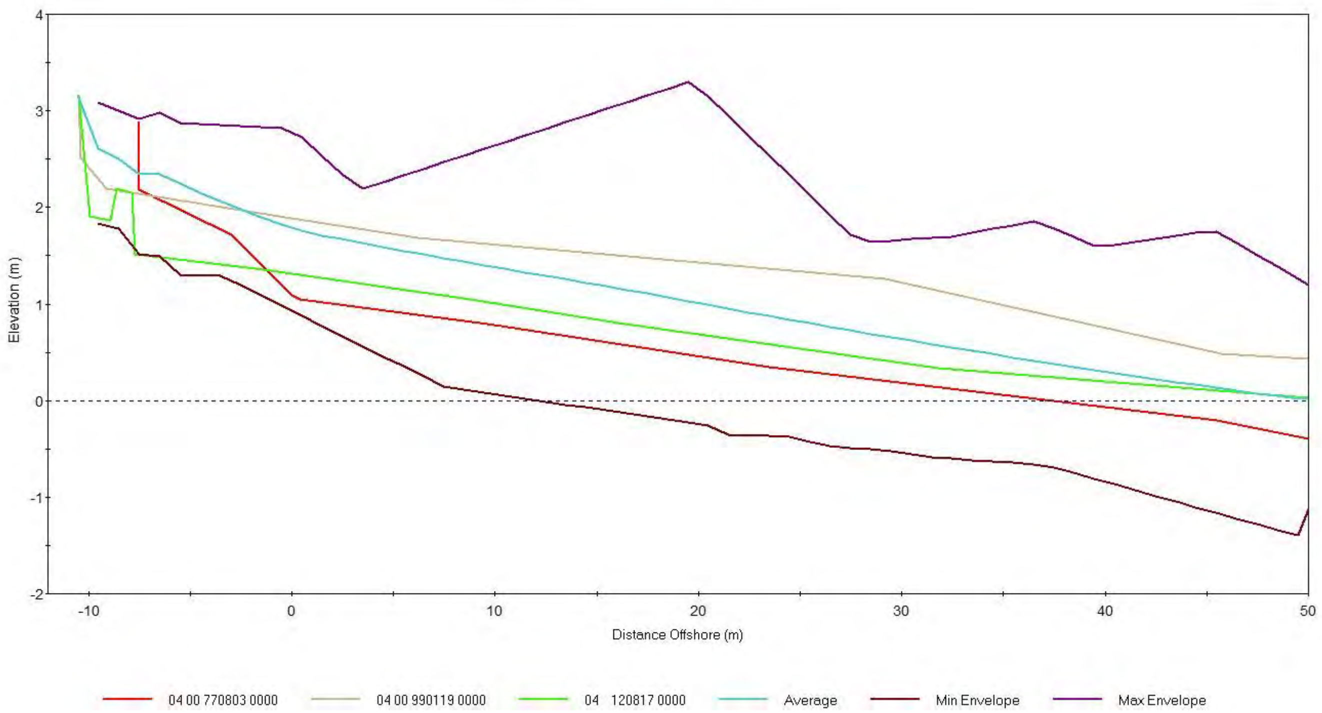

Wainui Profile 1
Elevation (m)
Distance Offshore (m)
01 00 770915 0000
01 00 990119 0000
01 120209 0000
Average
Min Envelope
Max Envelope


Wainui Profile 2
Elevation (m)
Distance Offshore (m)
02 00 740905 0000
02 00 990119 0000
02 120817 0000
Average
Min Envelope
Max Envelope

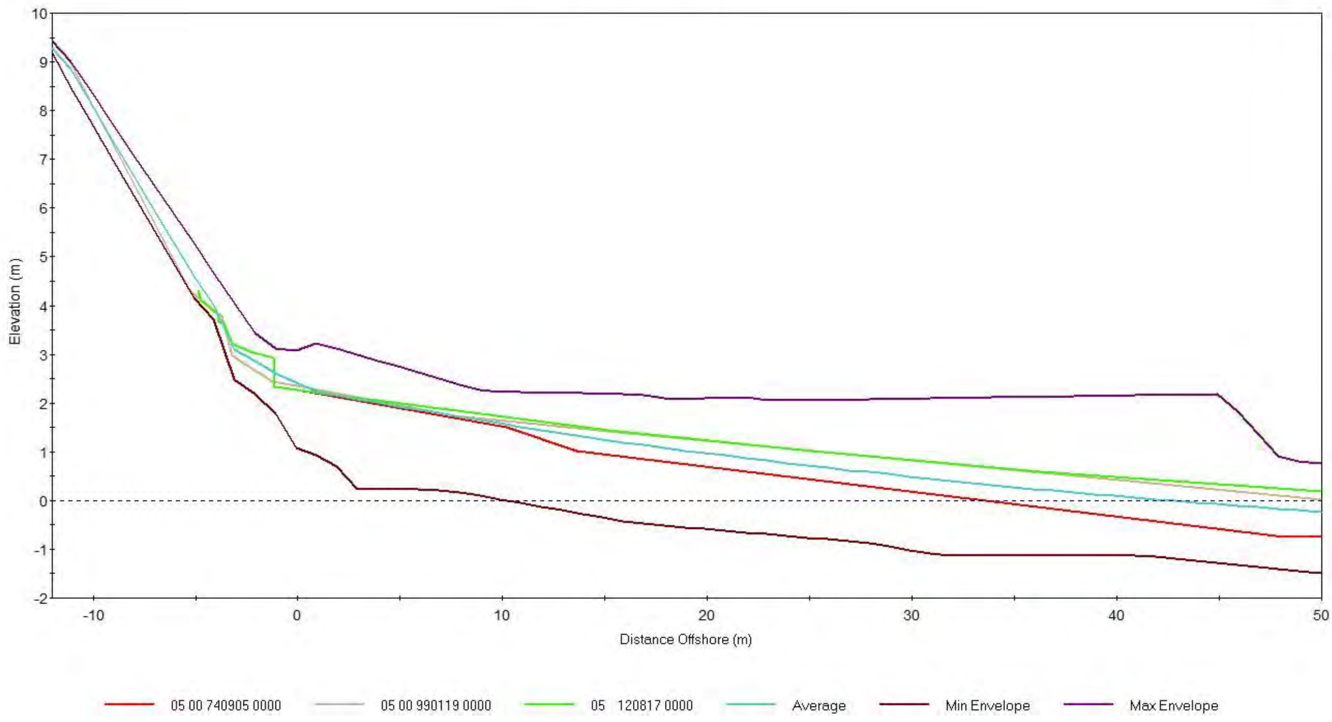
Wainui Profile 3



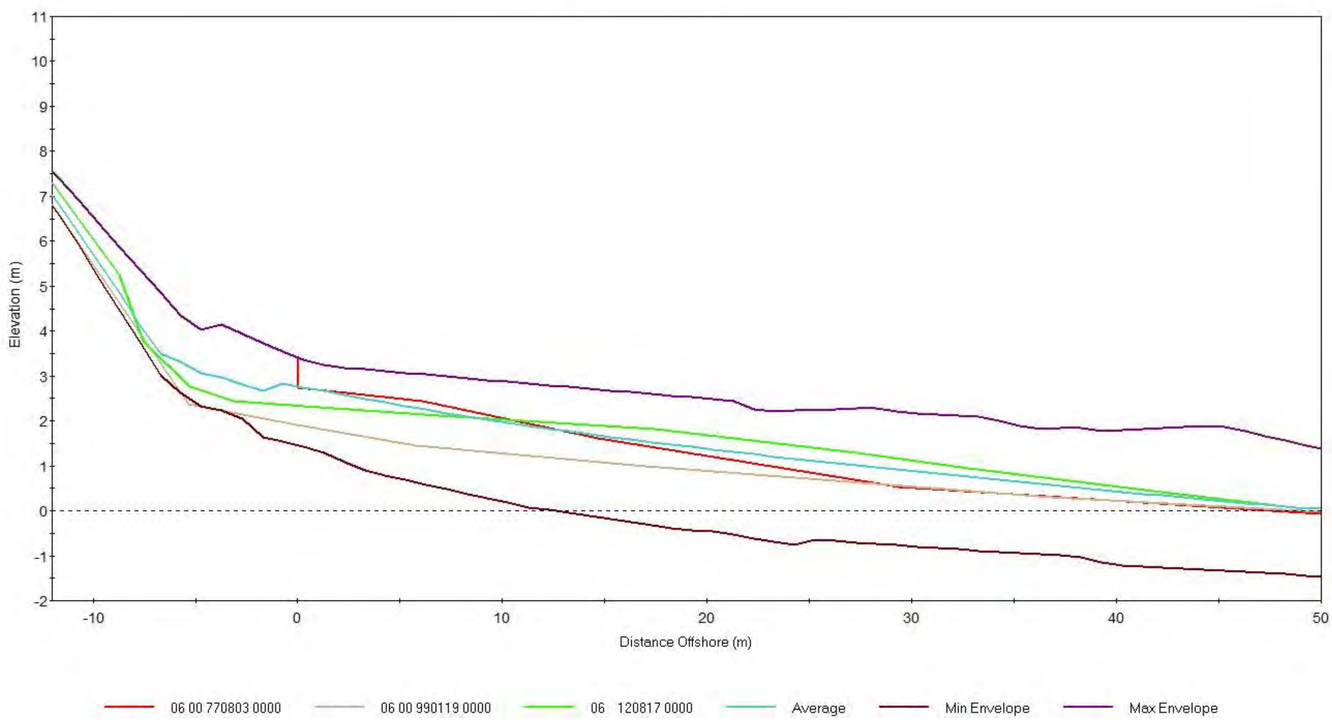
Wainui Profile 4



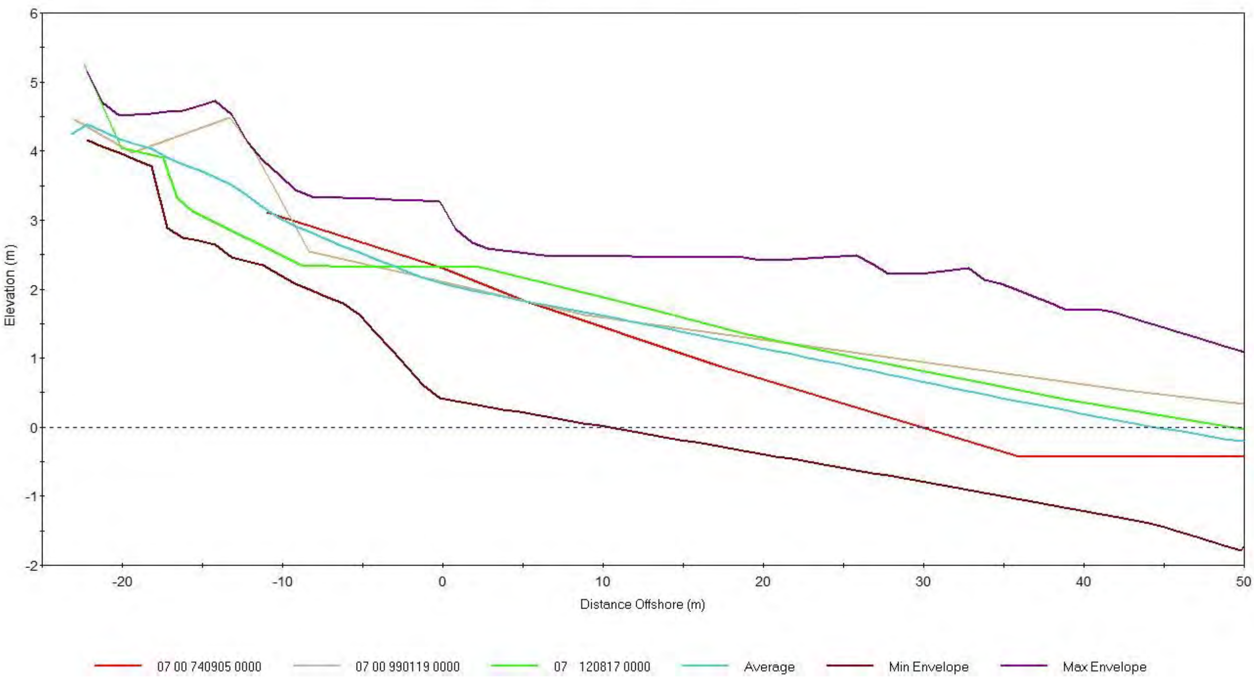
Wainui Profile 5



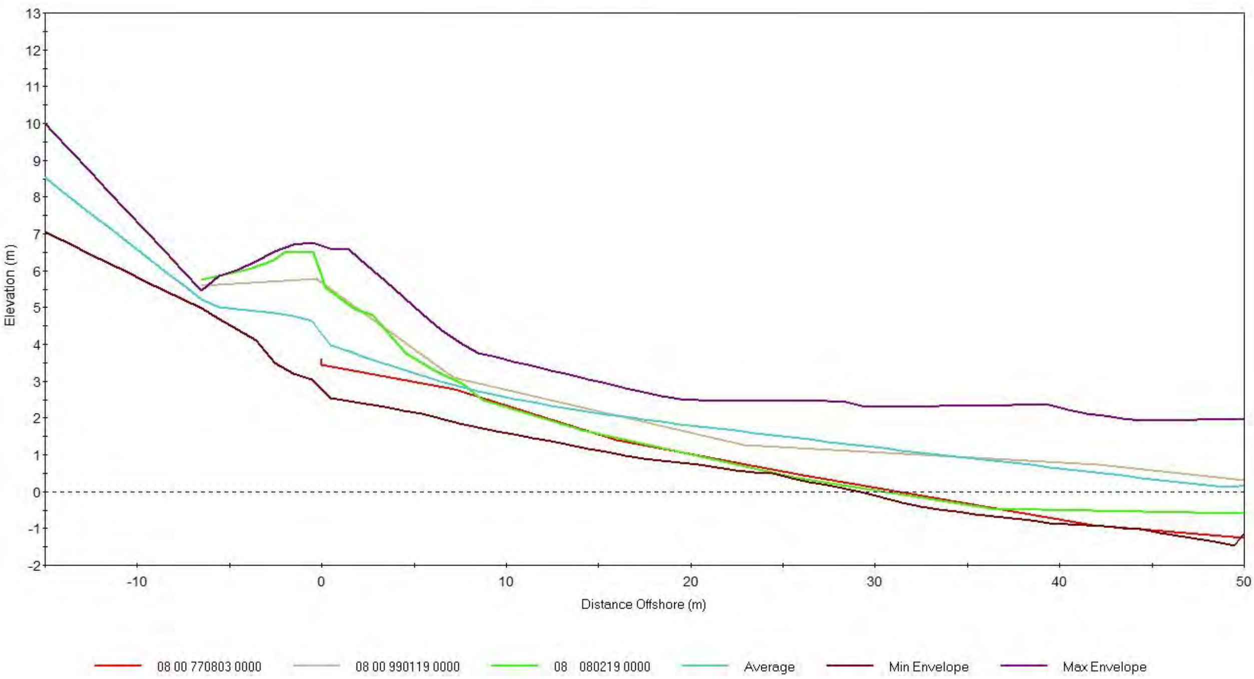
Wainui Profile 6



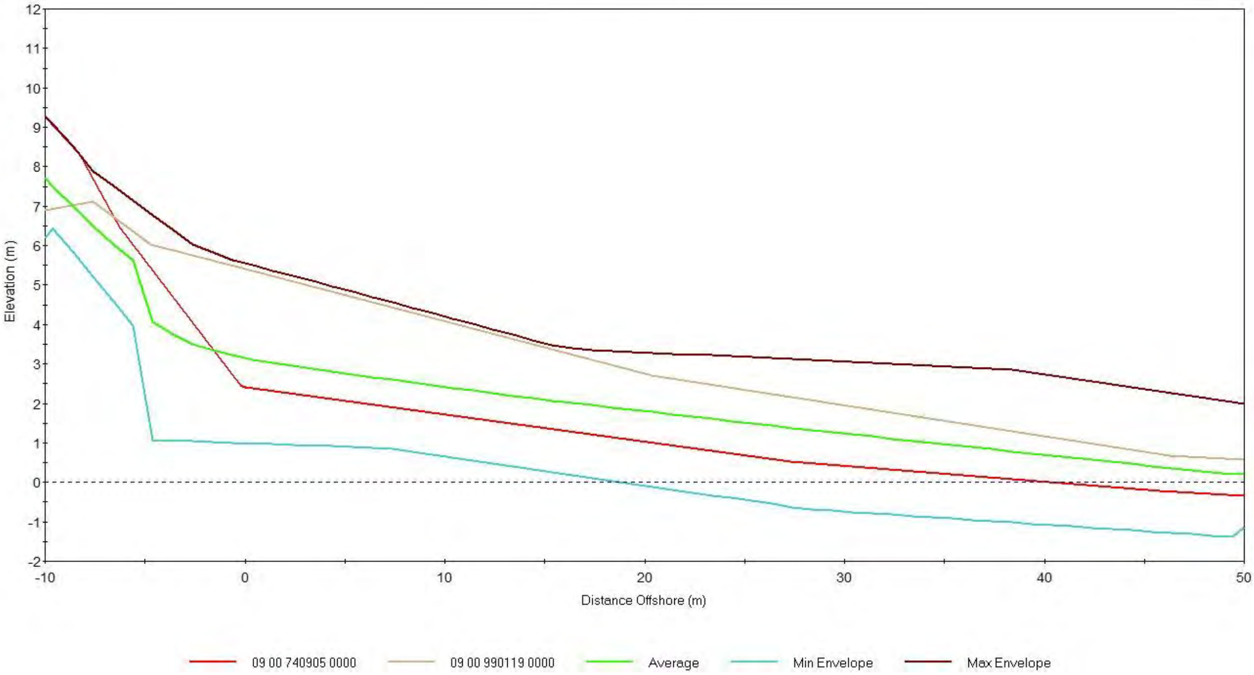
Wainui Profile 7



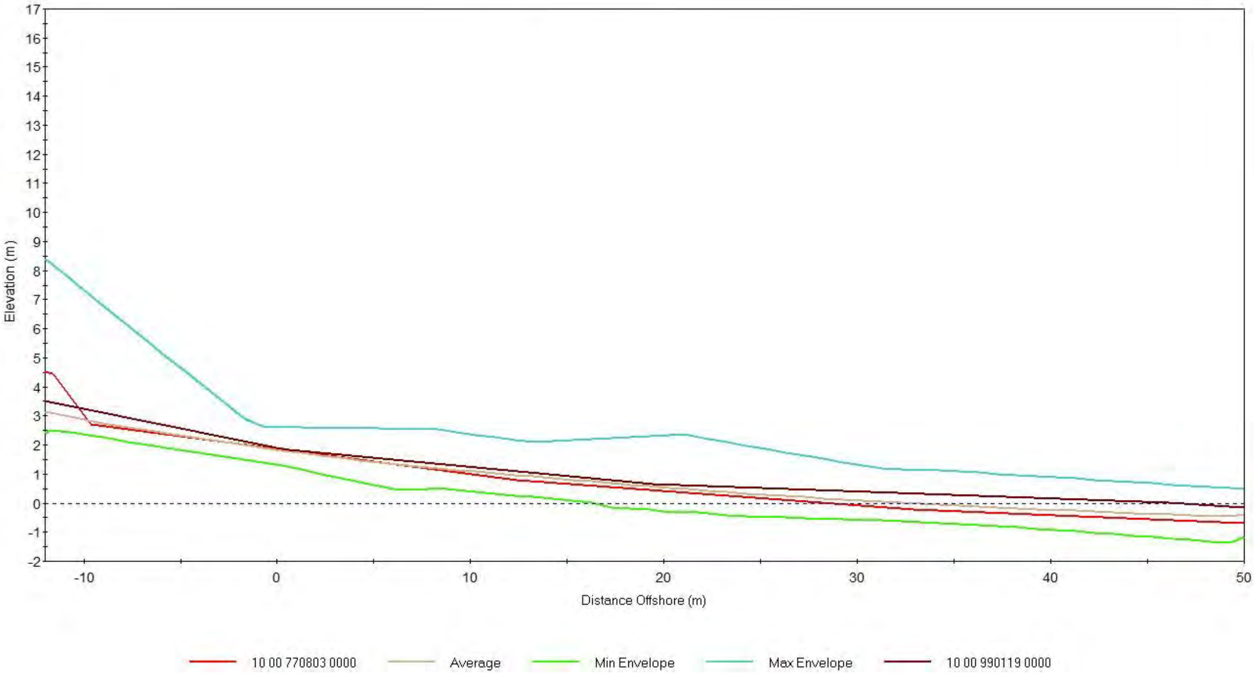
Wainui Profile 8



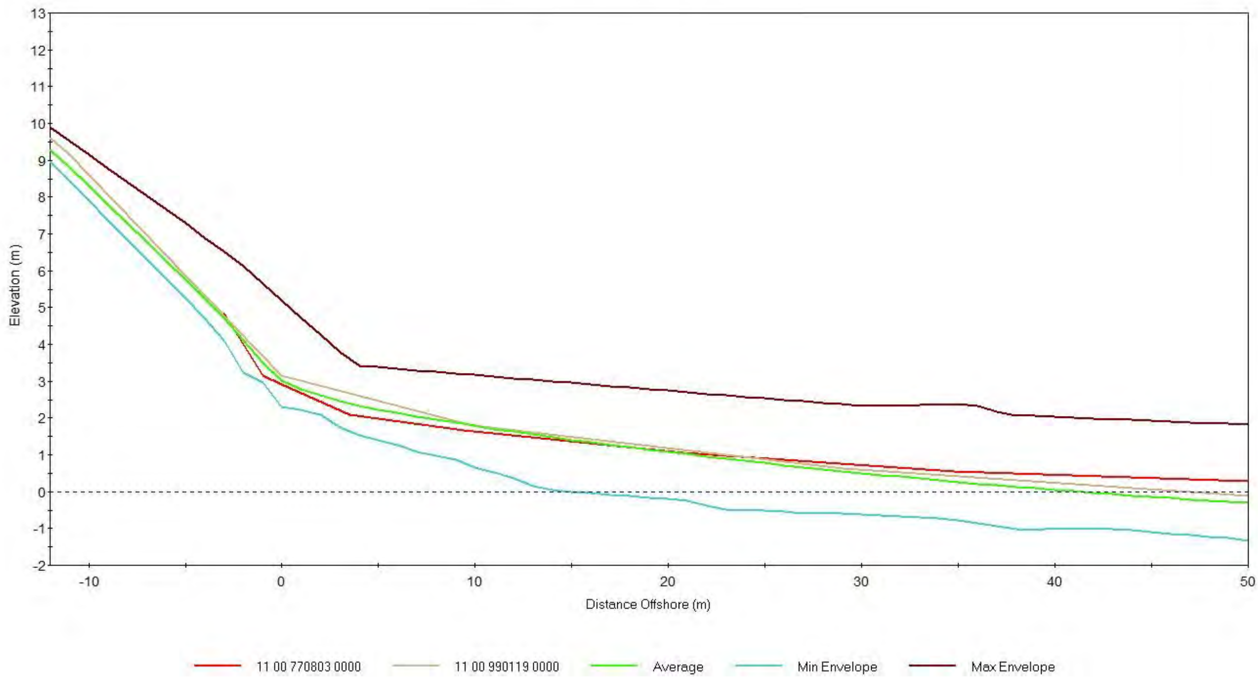
Wainui Profile 9



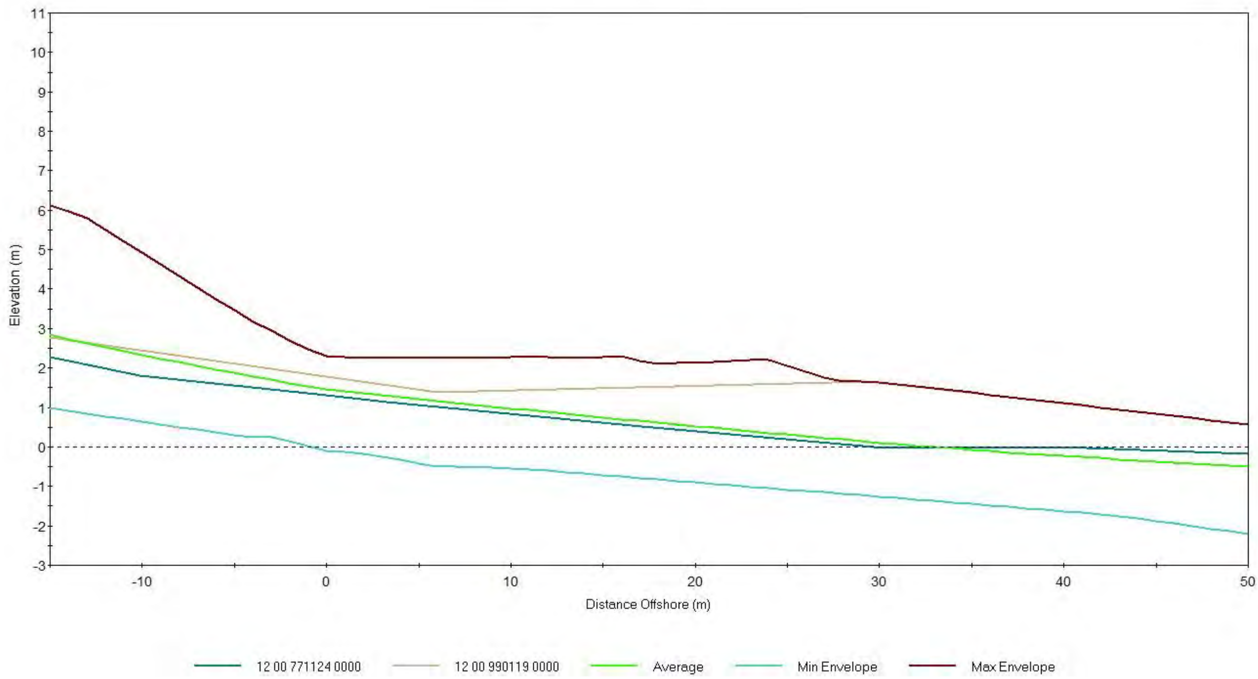
Wainui Profile 10



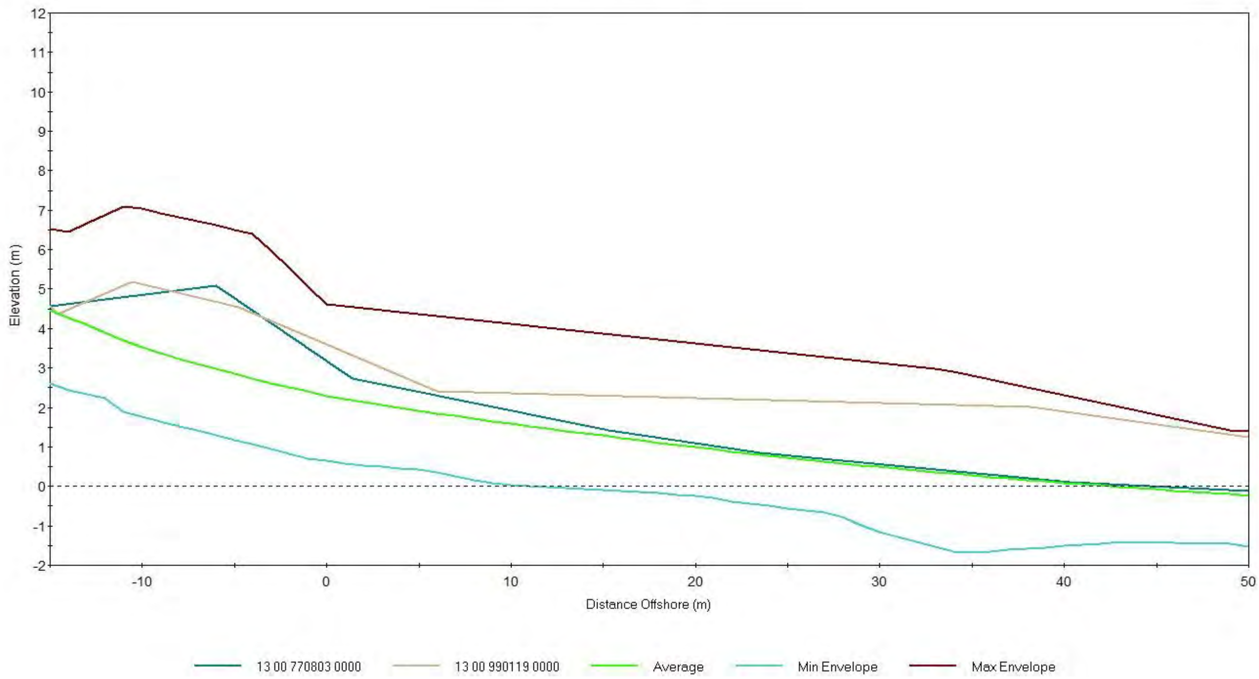
Wainui Profile 11



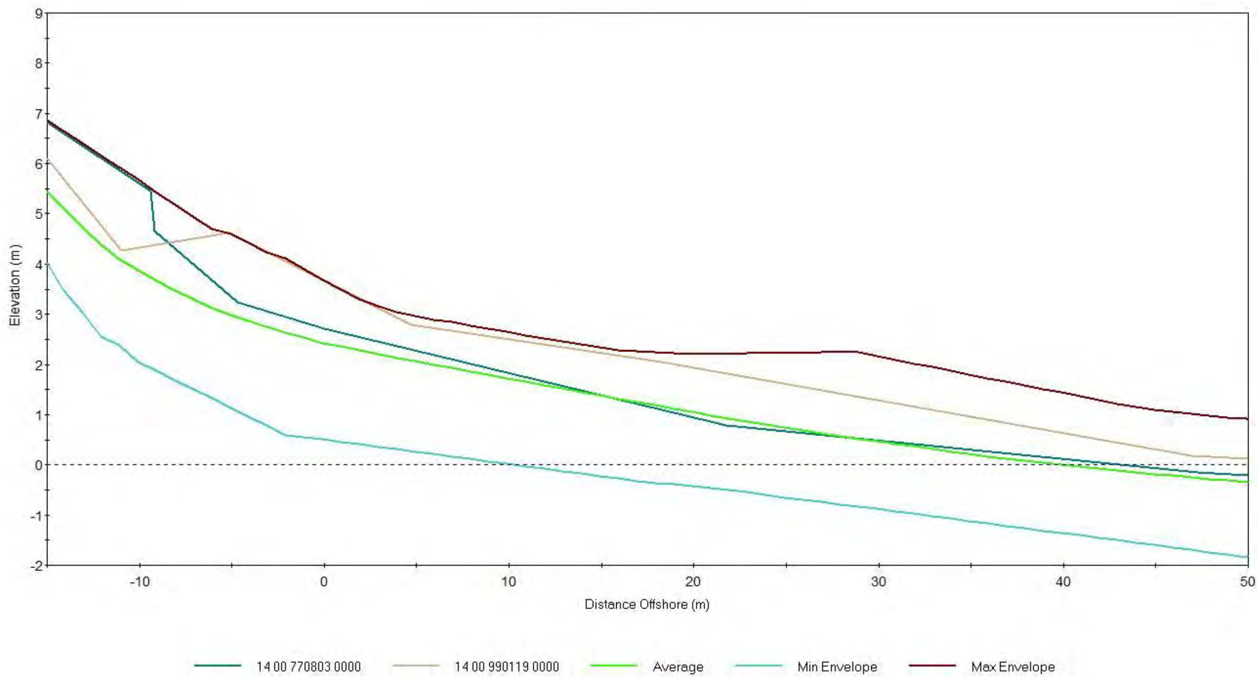
Wainui Profile 12



Wainui Profile 13



Wainui Profile 14



Appendix B: Beach profile trends and residuals

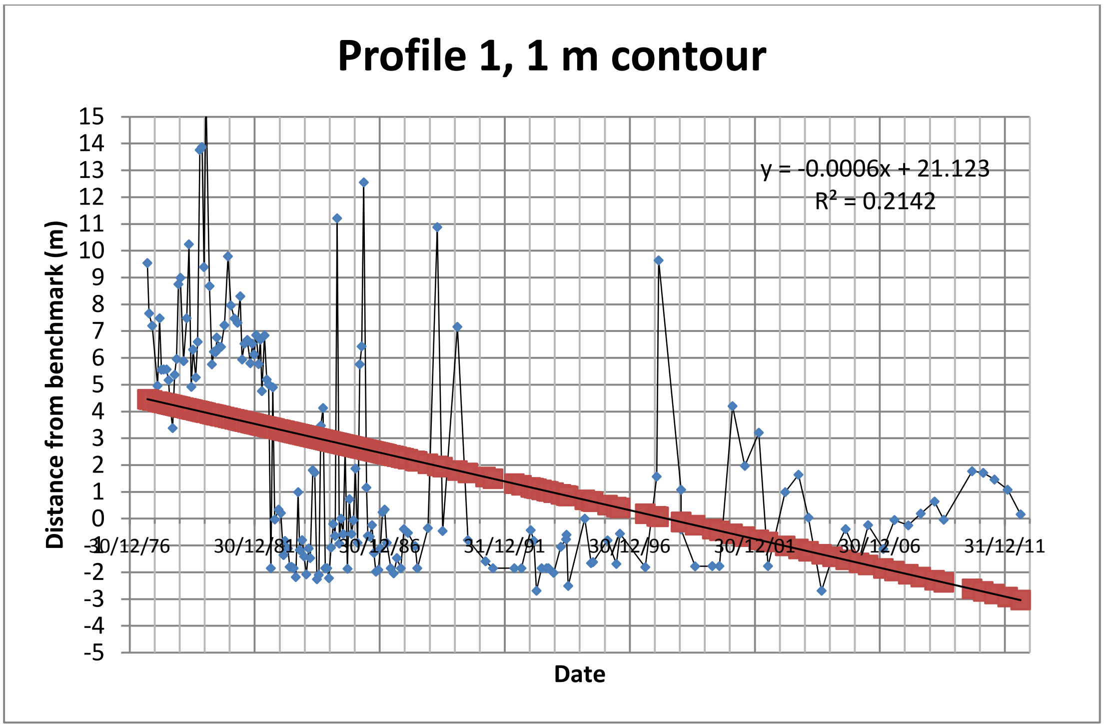


Figure 1 Profile 1, 1m contour trend analysis

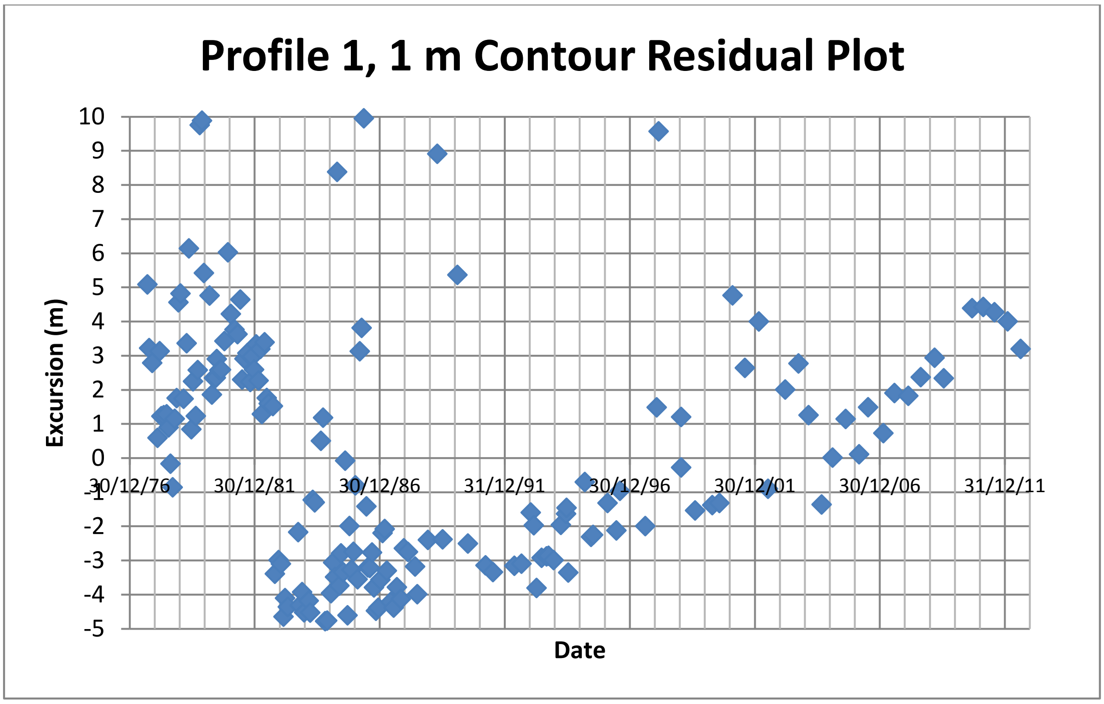


Figure 2 Profile 1, 1m contour residual plot

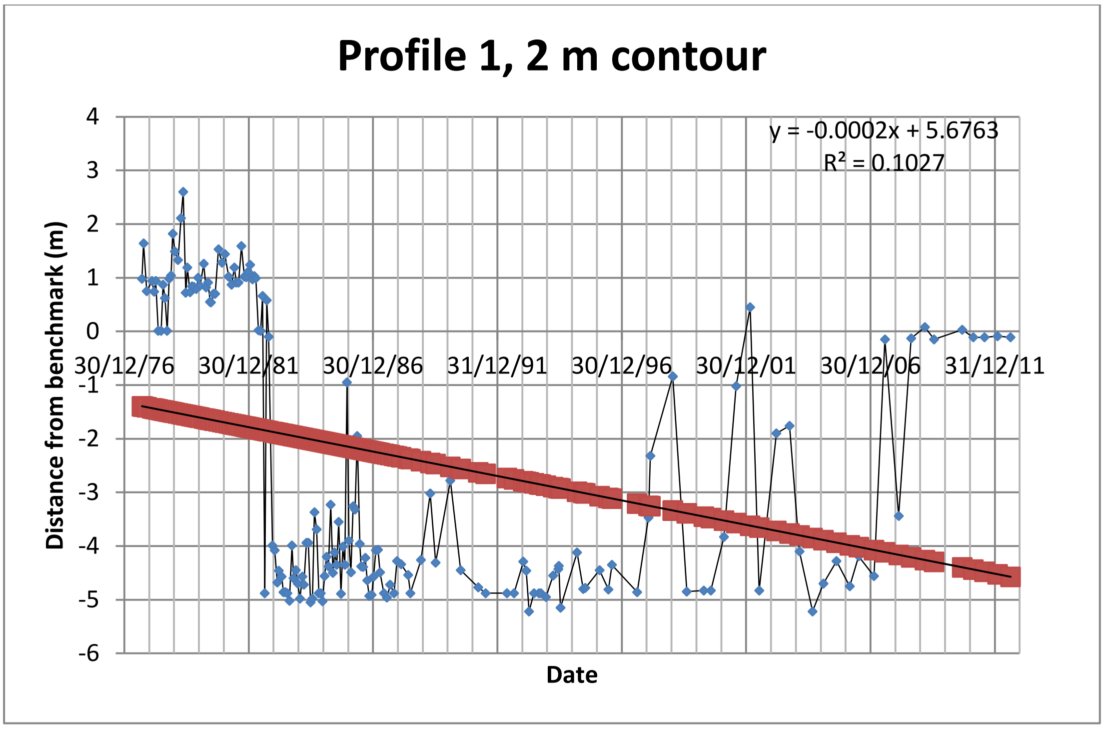


Figure 3 Profile 1, 2m contour trend analysis

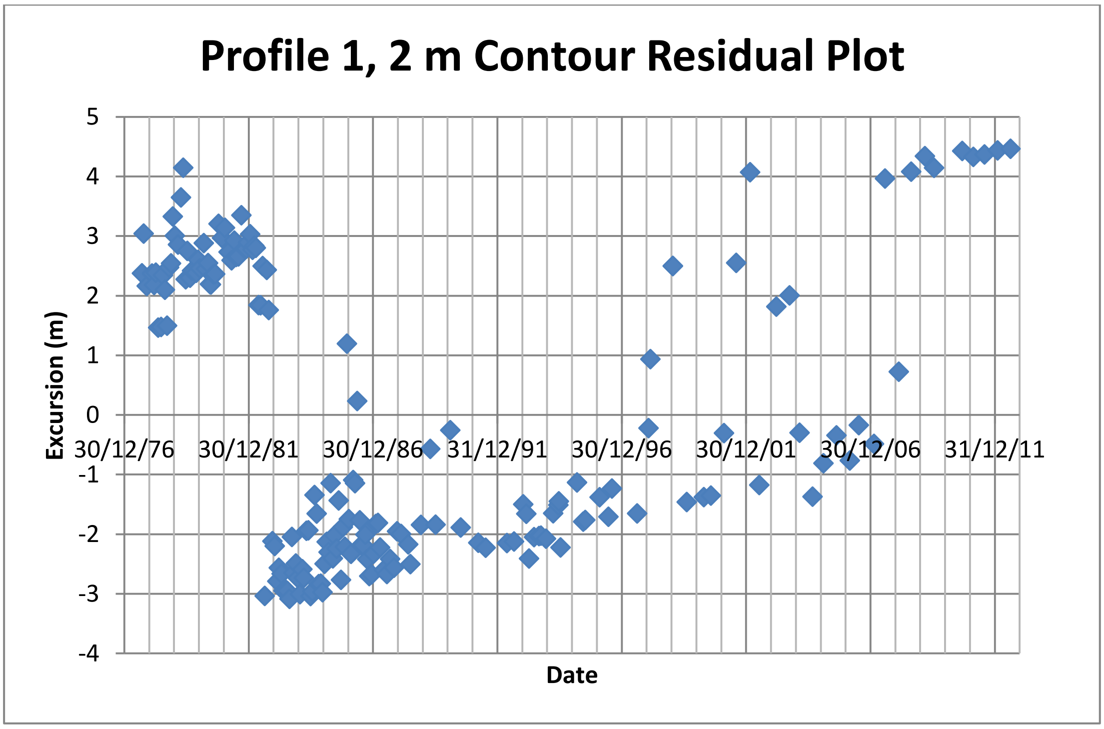


Figure 4 Profile 1, 2m contour residual plot

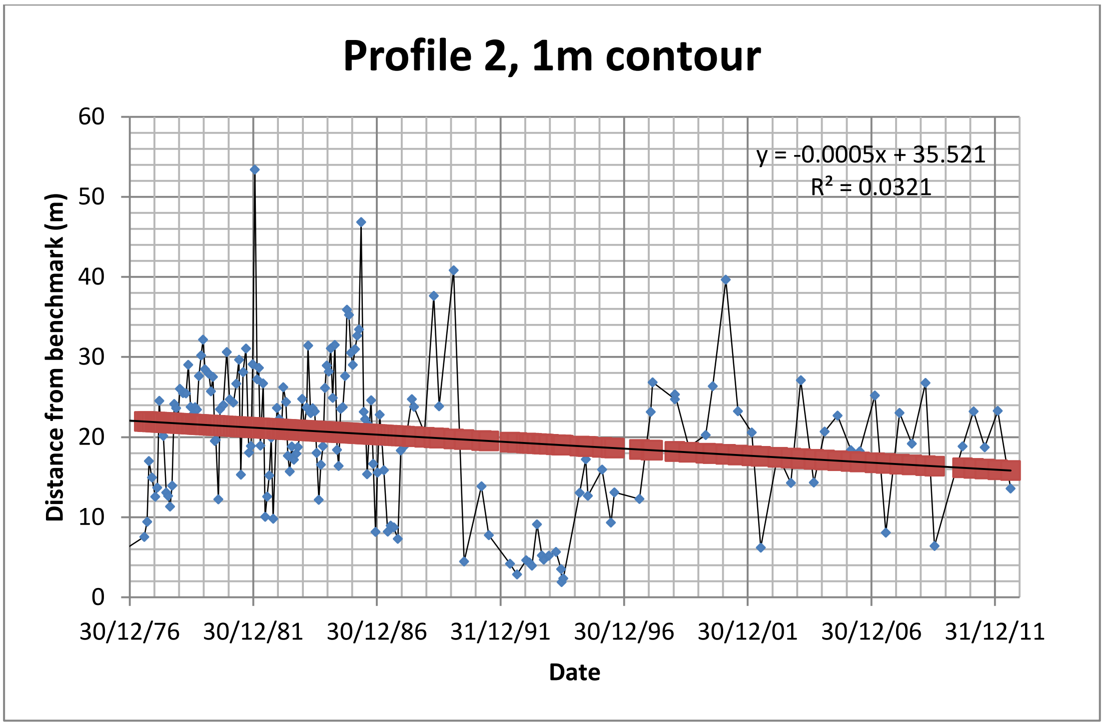


Figure 5 Profile 2, 1m contour trend analysis

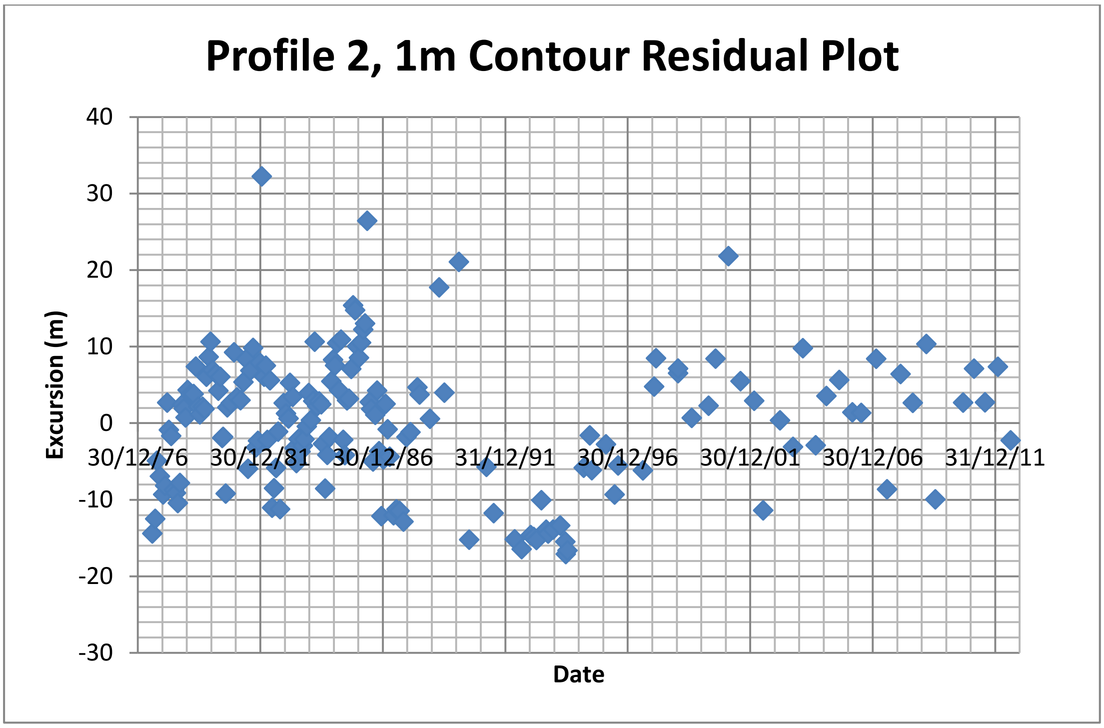


Figure 6 Profile 2, 1m contour residual plot

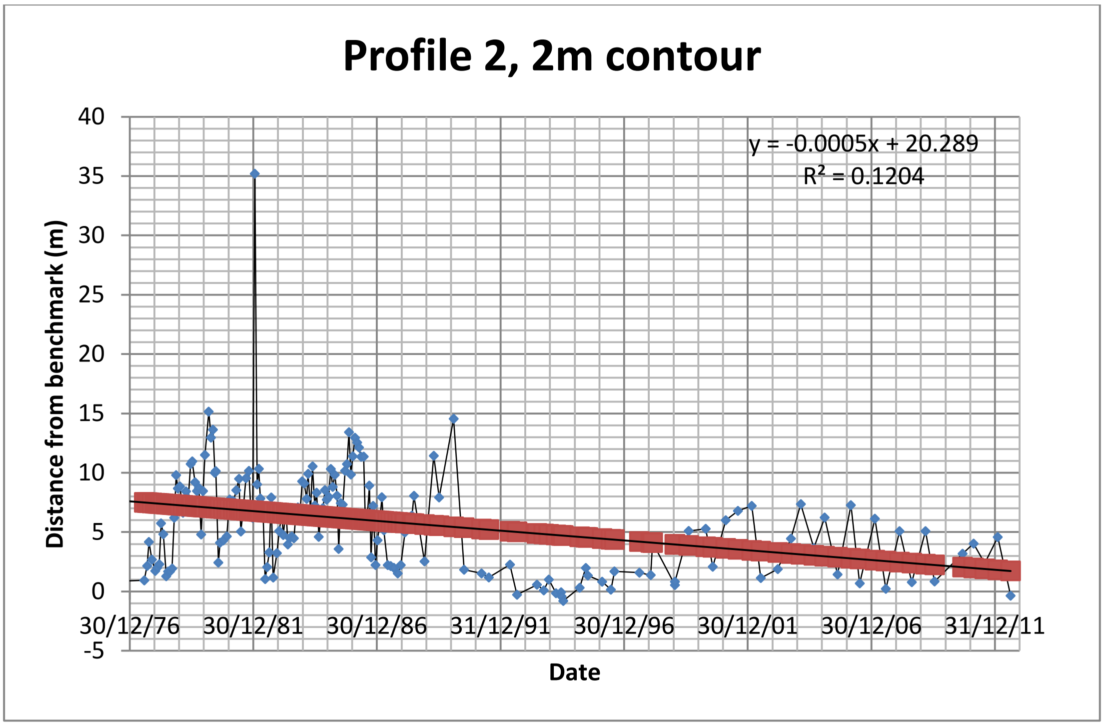


Figure 7 Profile 2, 2m contour trend analysis

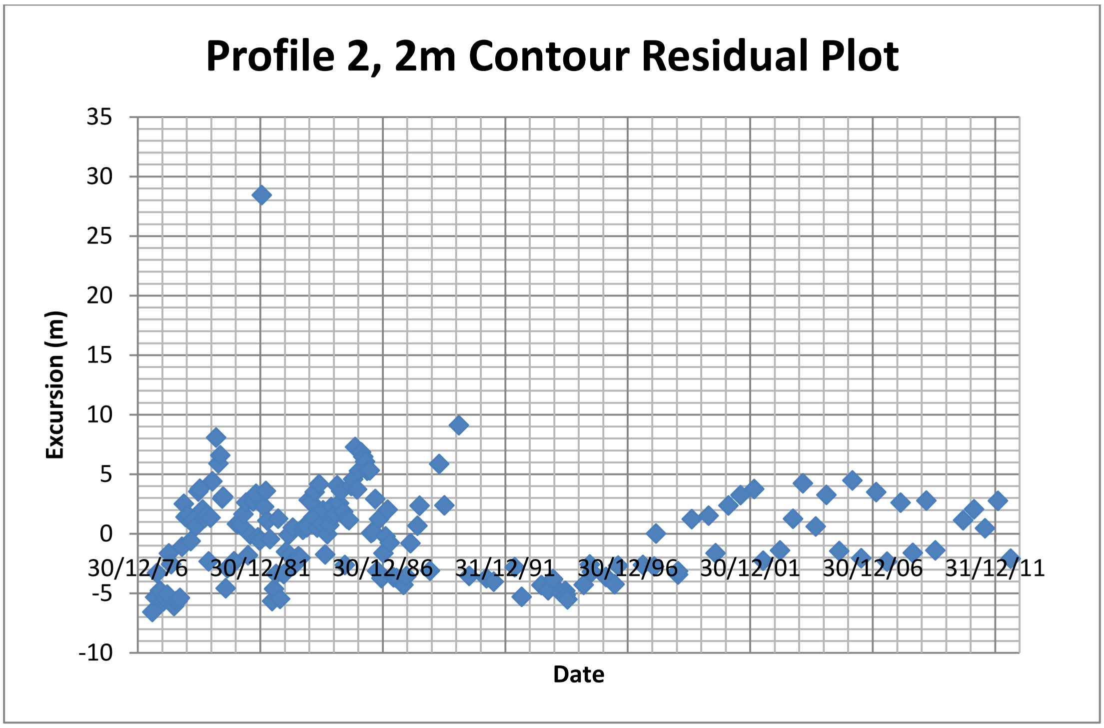


Figure 8 Profile 2, 2m contour residual plot

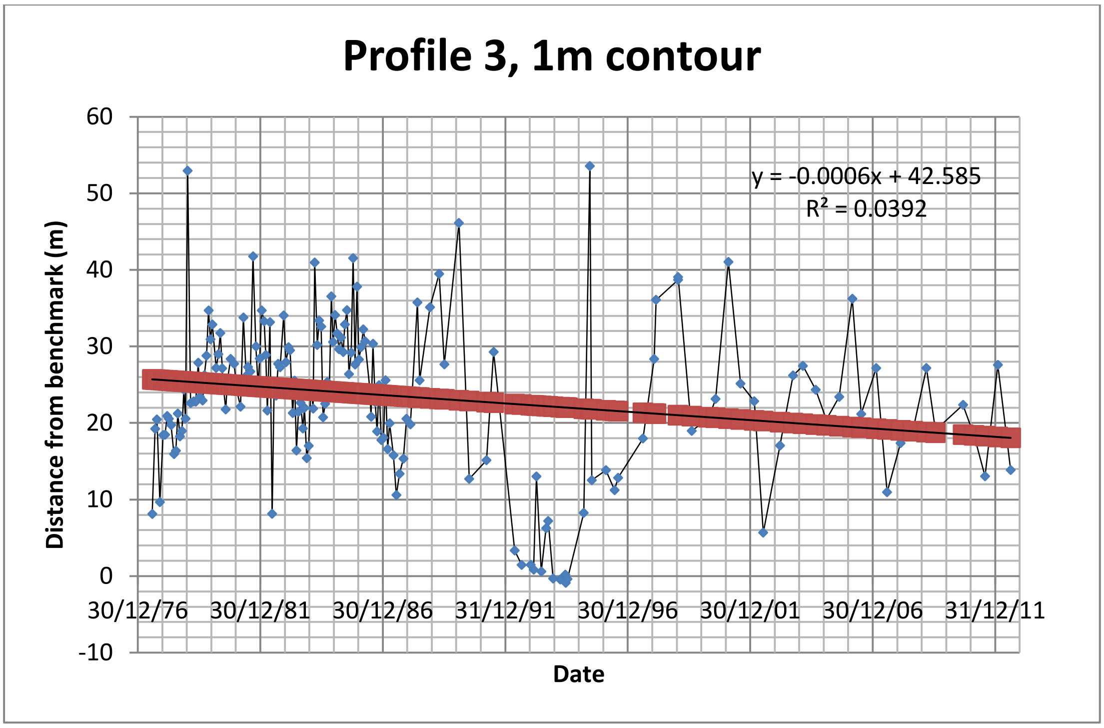


Figure 9 Profile 3, 1m contour trend analysis

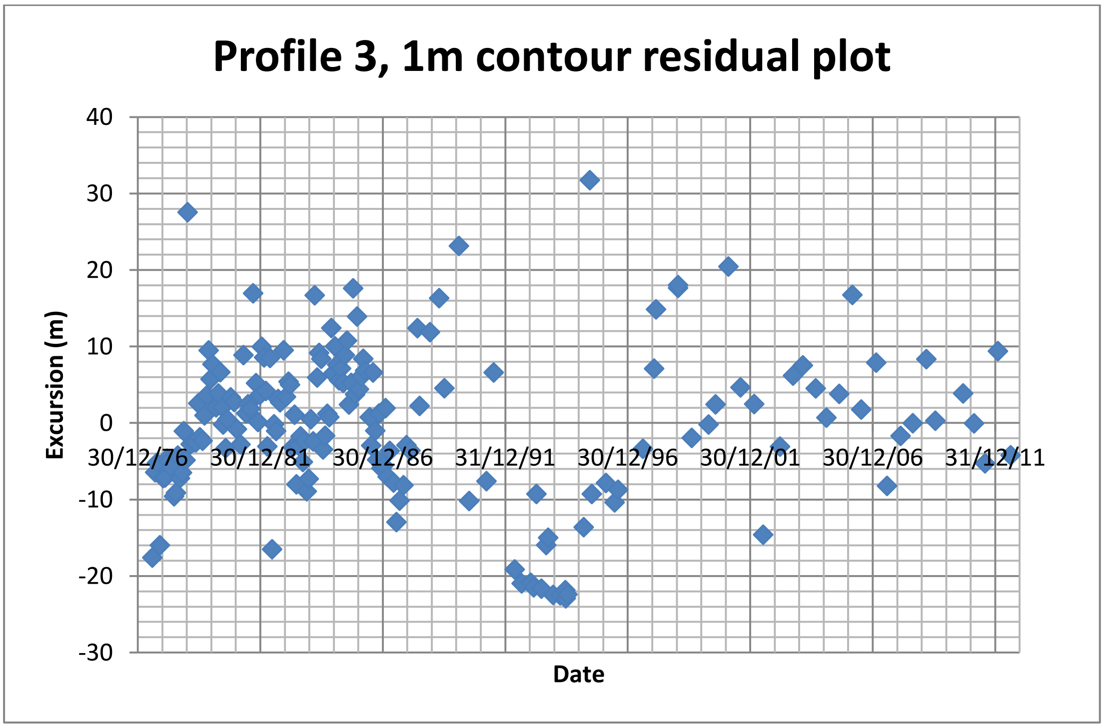


Figure 10 Profile 3, 1m contour residual plot

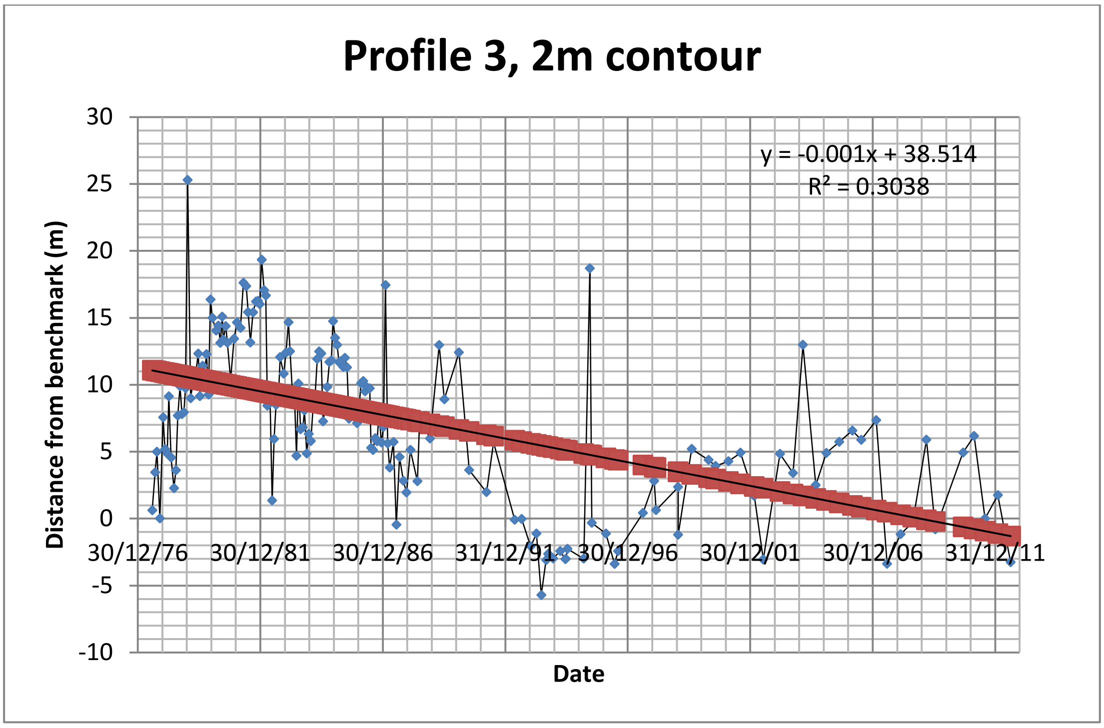


Figure 11Profile 3, 2m contour trend analysis

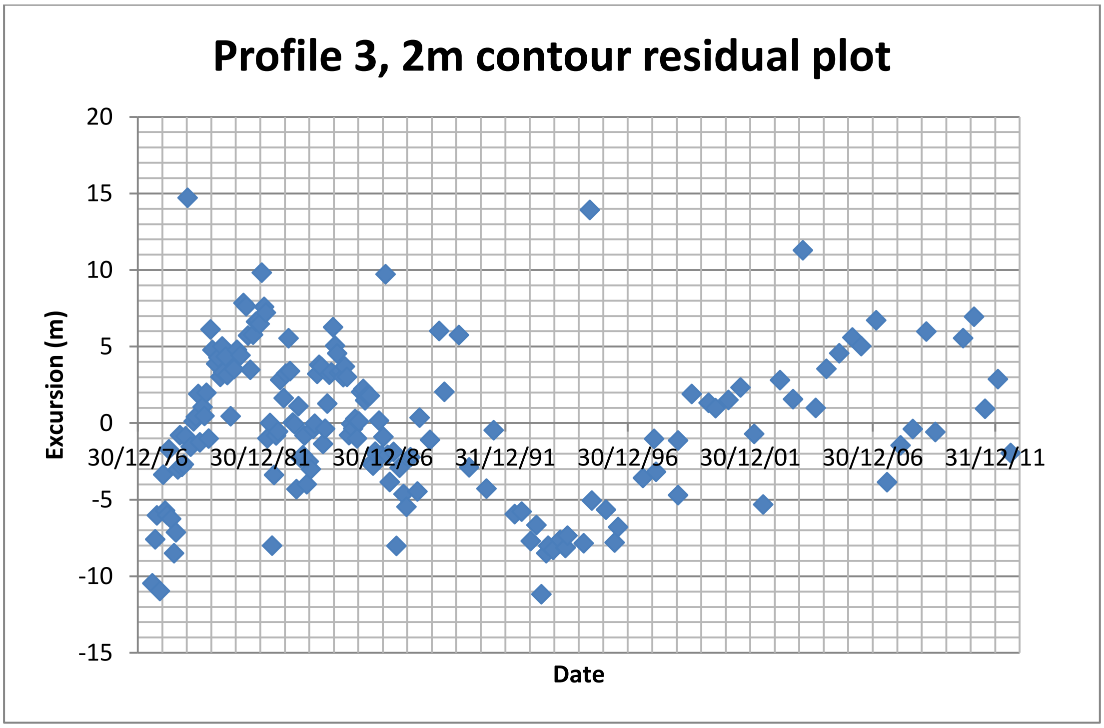


Figure 12 Profile 3, 2m contour residual plot

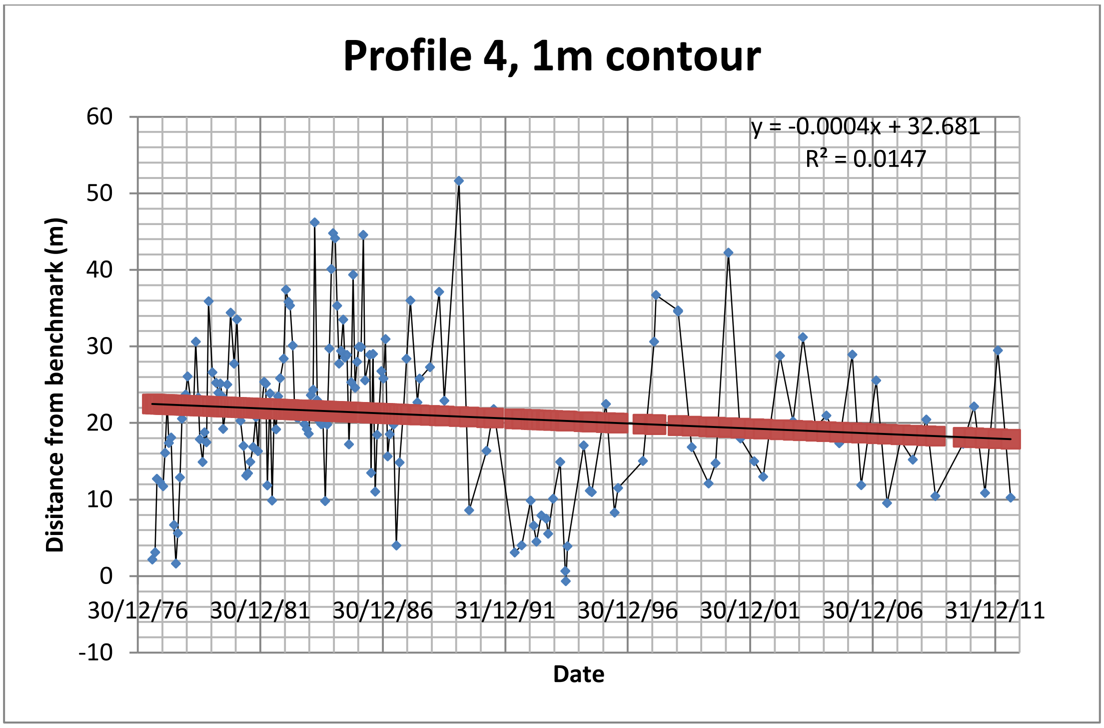


Figure 13 Profile 4, 1m contour trend analysis

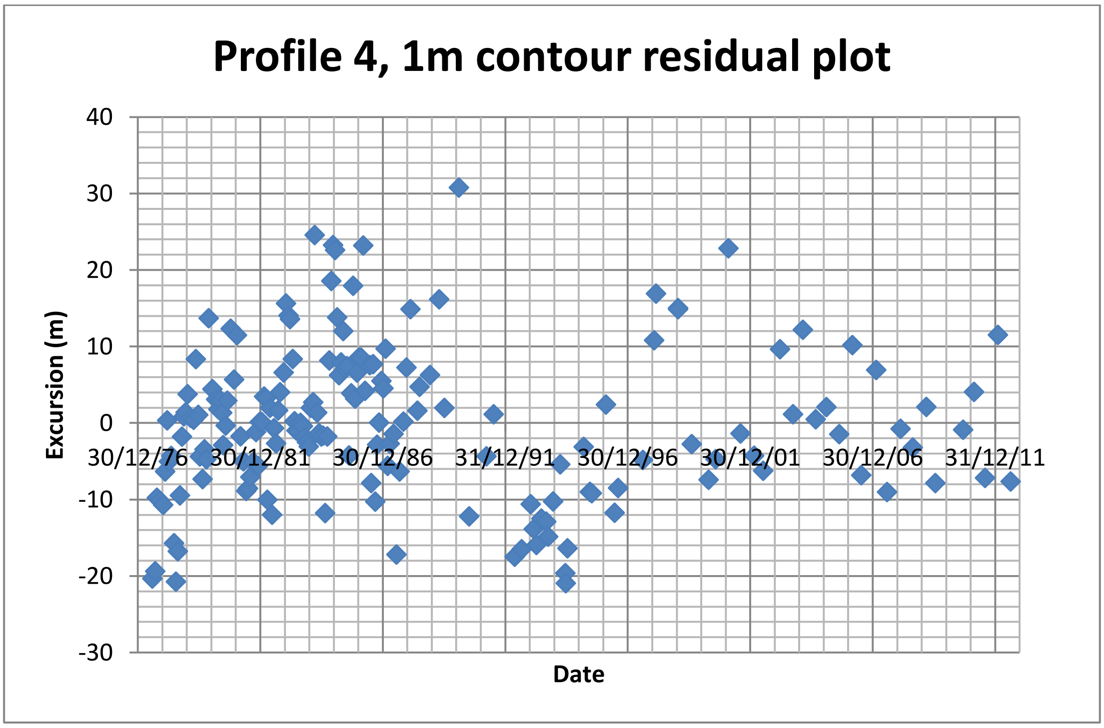


Figure 14 Profile 4, 1m contour residual plot

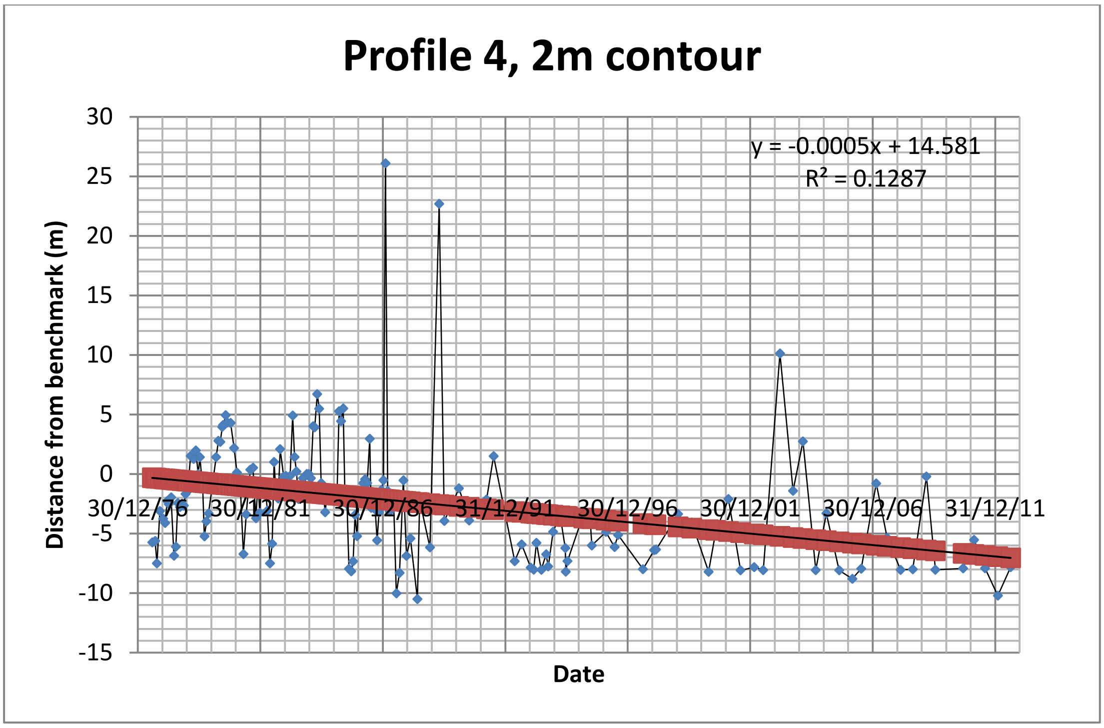


Figure 15 Profile 4, 2m contour trend analysis

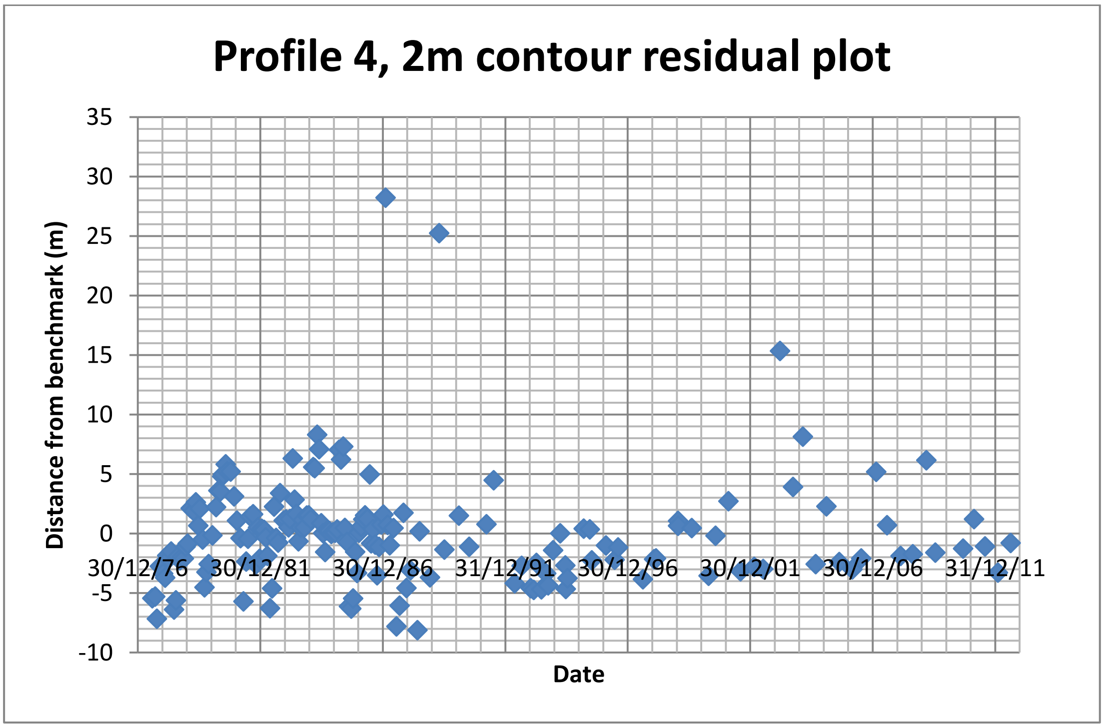


Figure 16 Profile 4, 2m contour residual plot

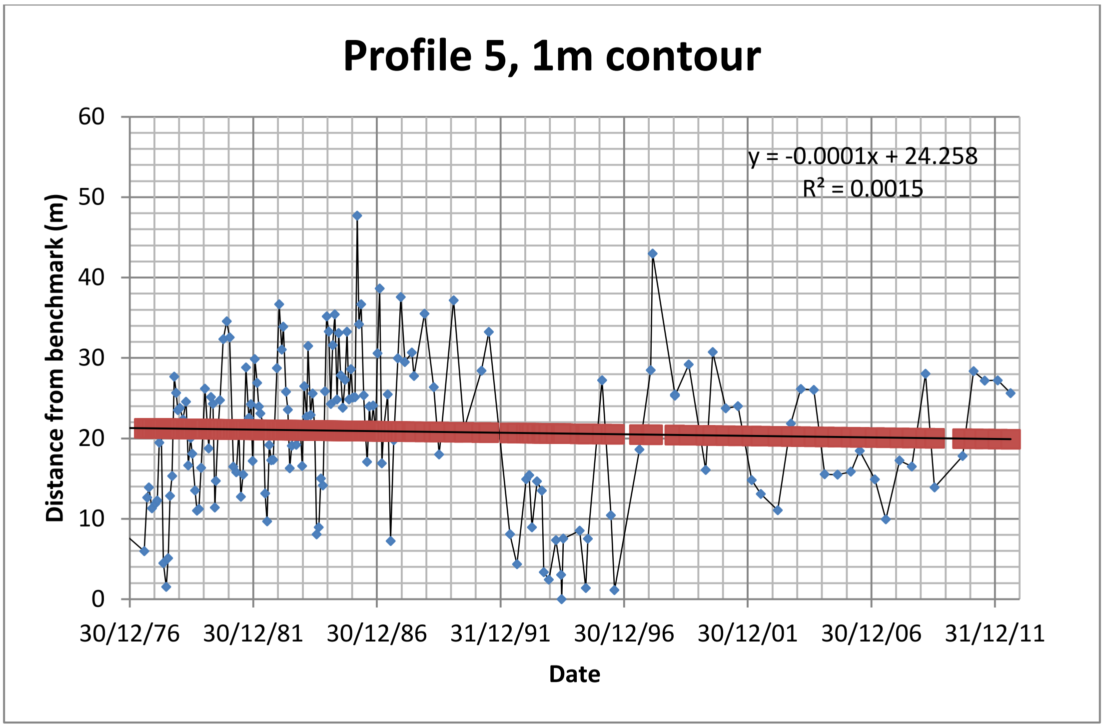


Figure 17 Profile 5, 1m contour trend analysis

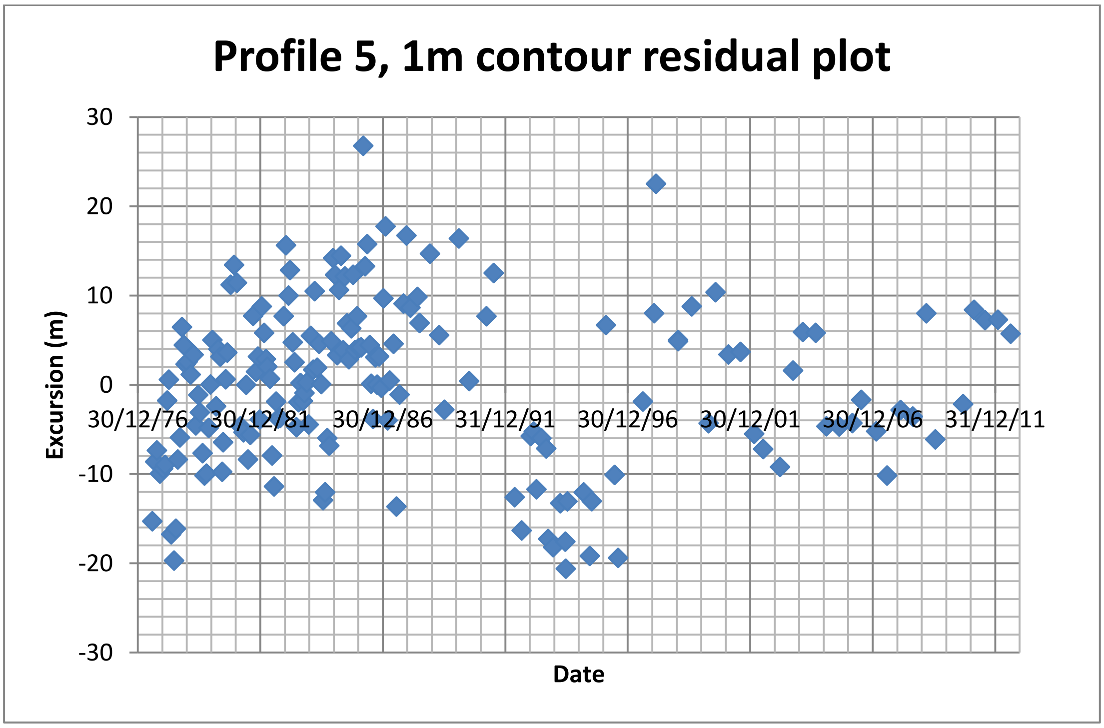


Figure 18 Profile 5, 1m contour residual plot

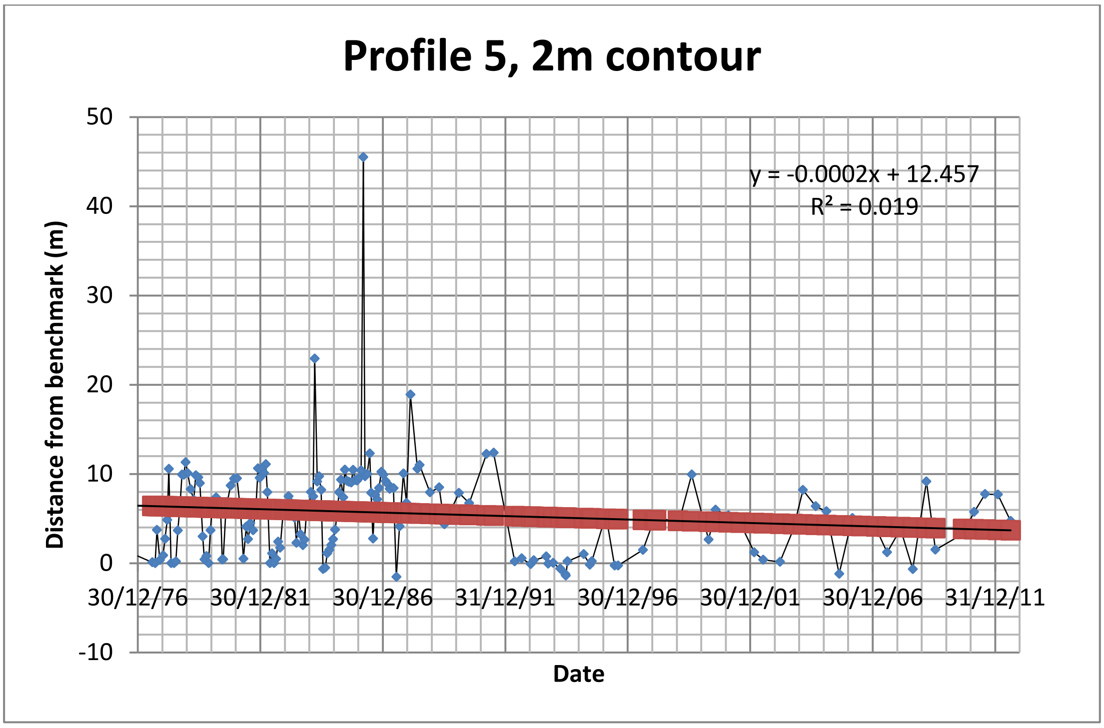


Figure 19 Profile 5, 2m contour trend analysis

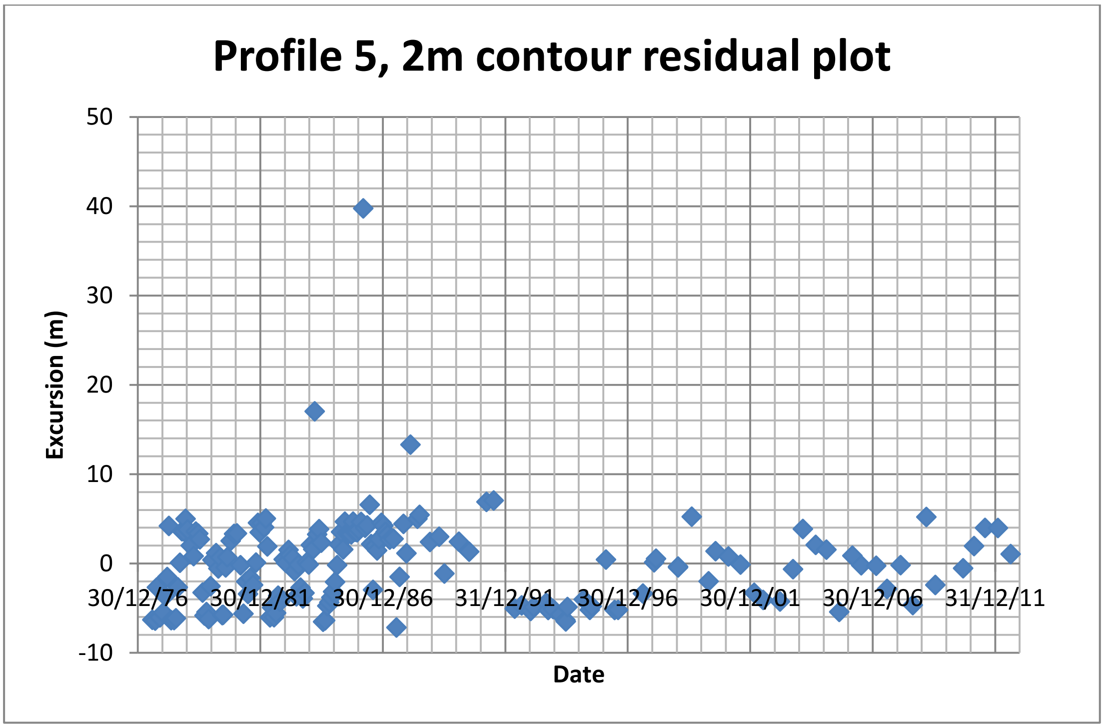


Figure 20 Profile 5, 2m contour residual plot

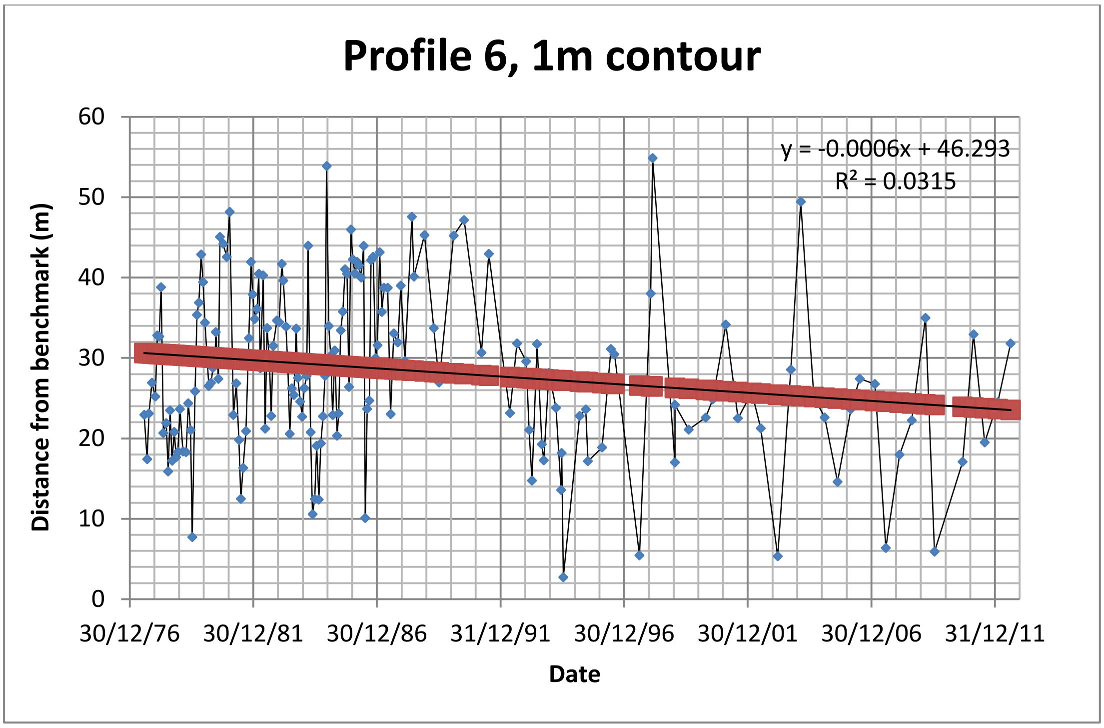


Figure 21 Profile 6, 1m contour trend analysis

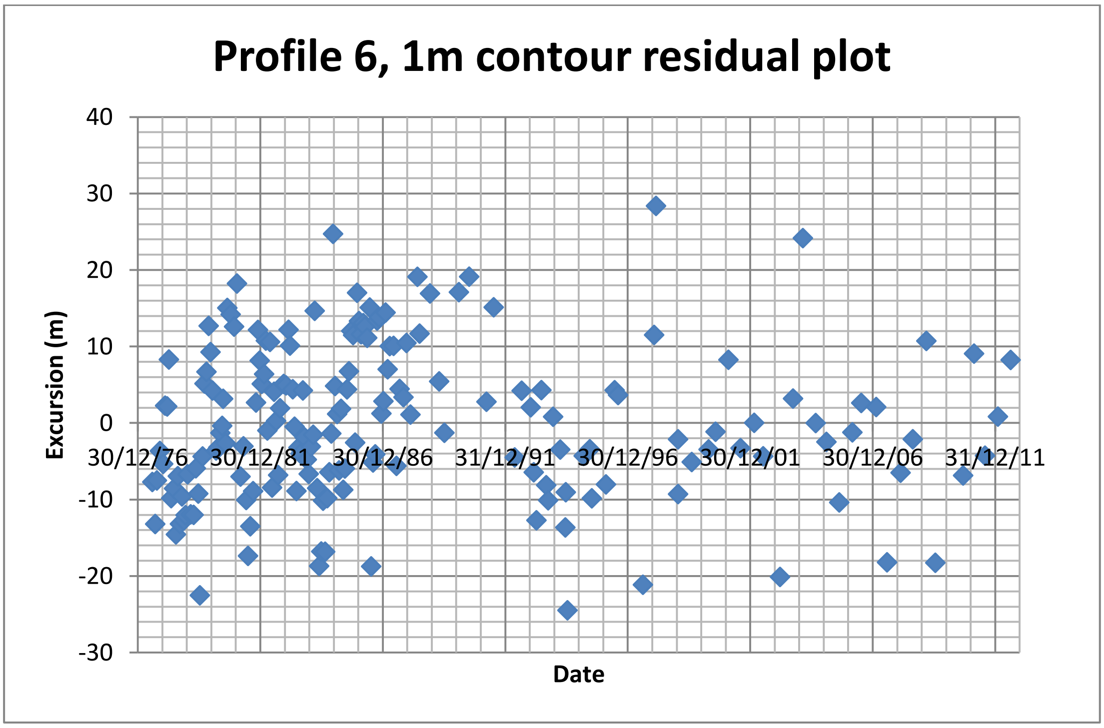


Figure 22 Profile 6, 1m contour residual plot

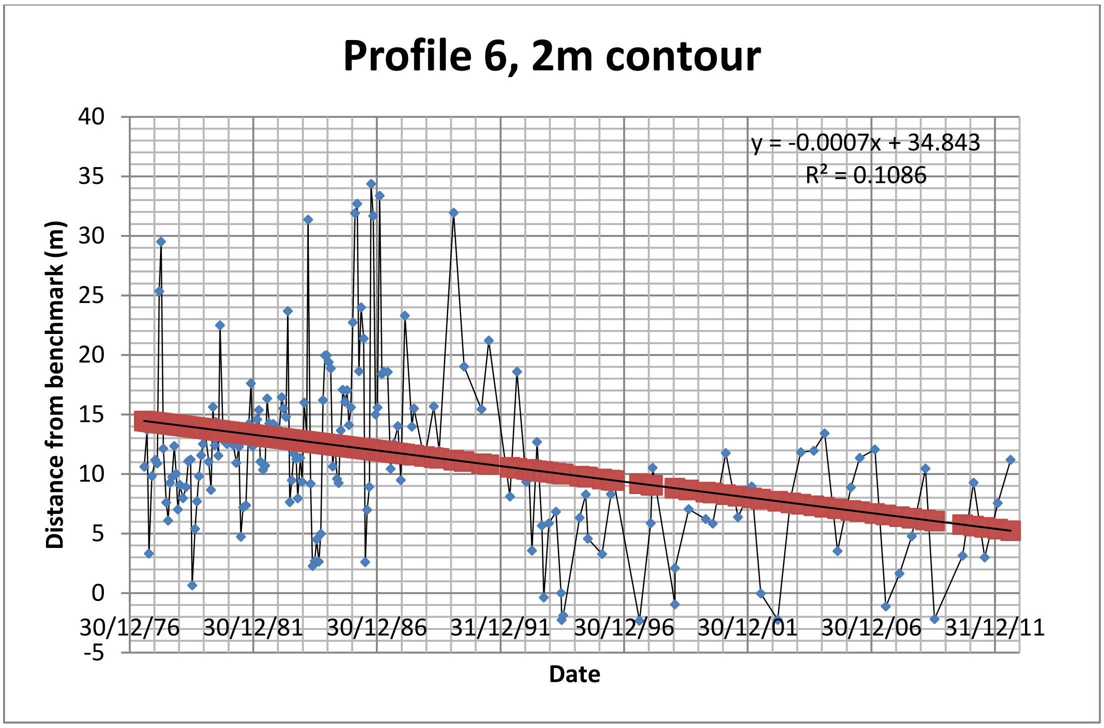


Figure 23 Profile 6, 2m contour trend analysis

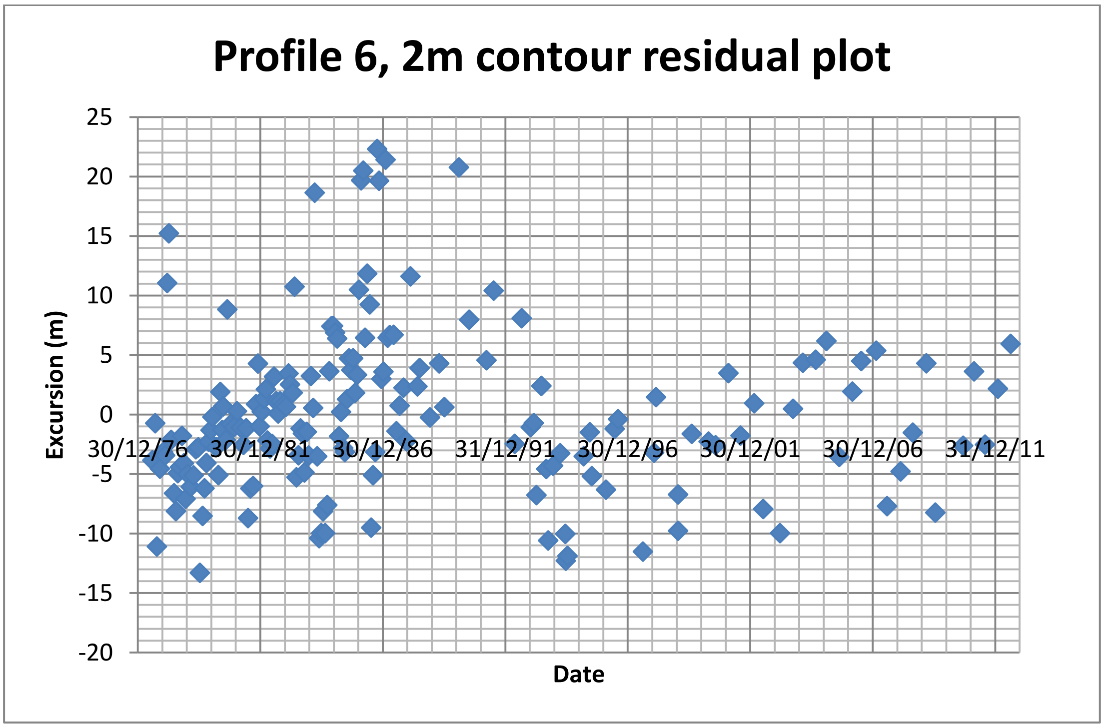


Figure 24 Profile 6, 2m contour residual plot

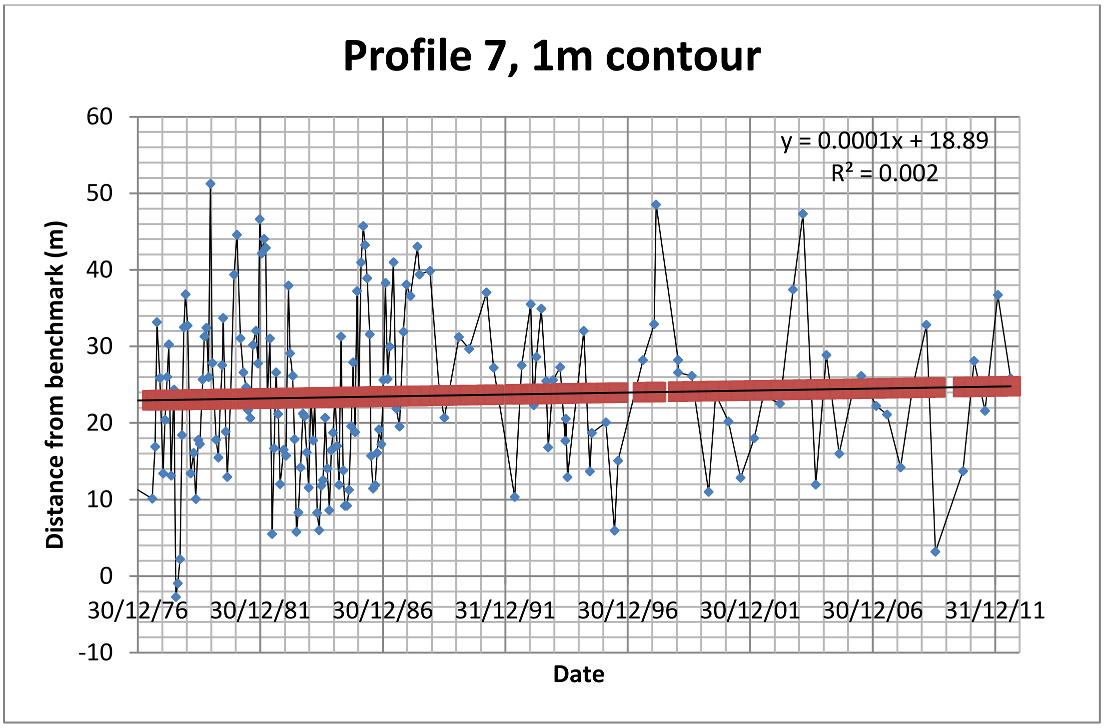


Figure 25 Profile 7, 1m contour trend analysis

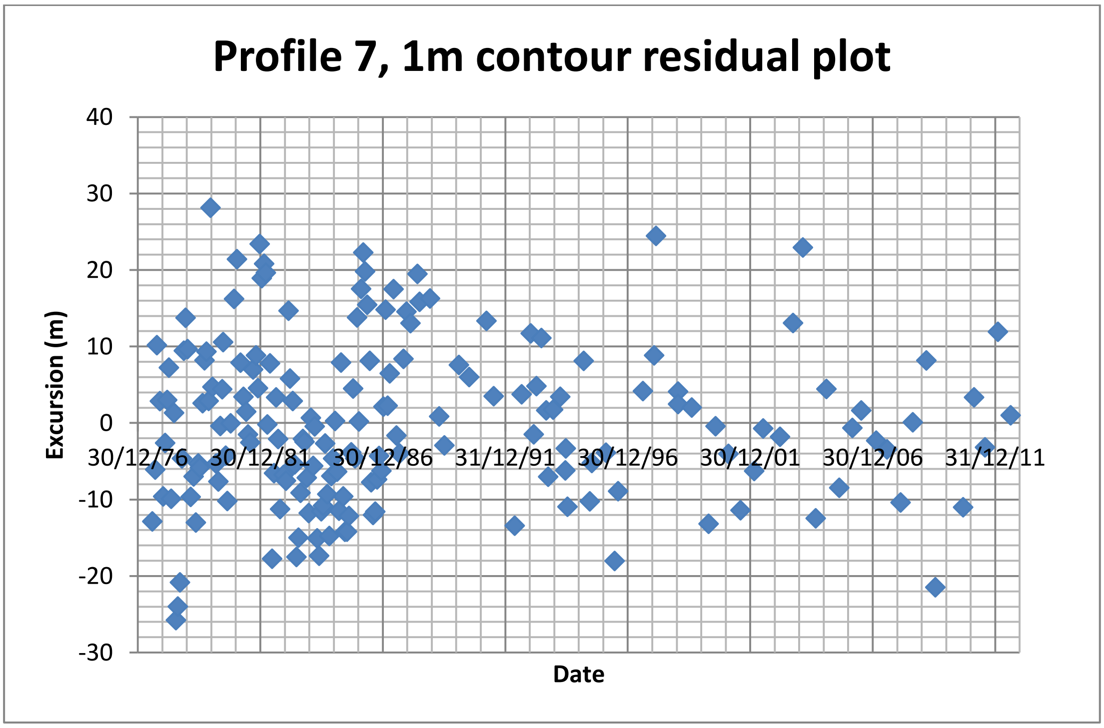


Figure 26 Profile 7, 1m contour residual plot

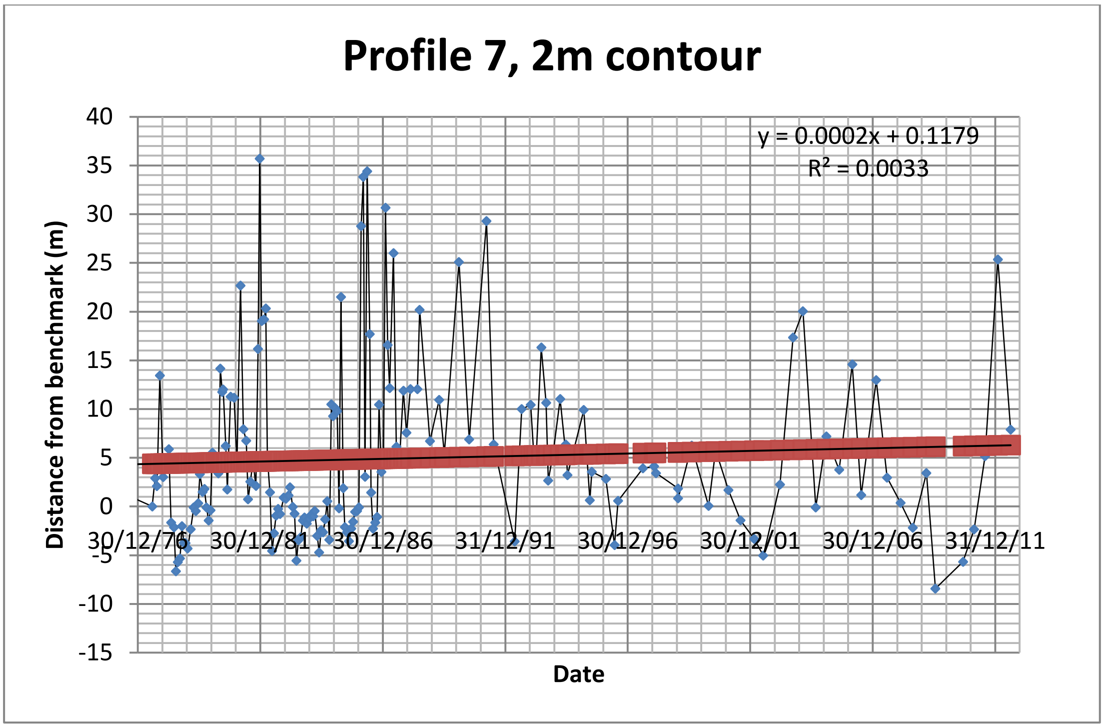


Figure 27 Profile 7, 2m contour trend analysis

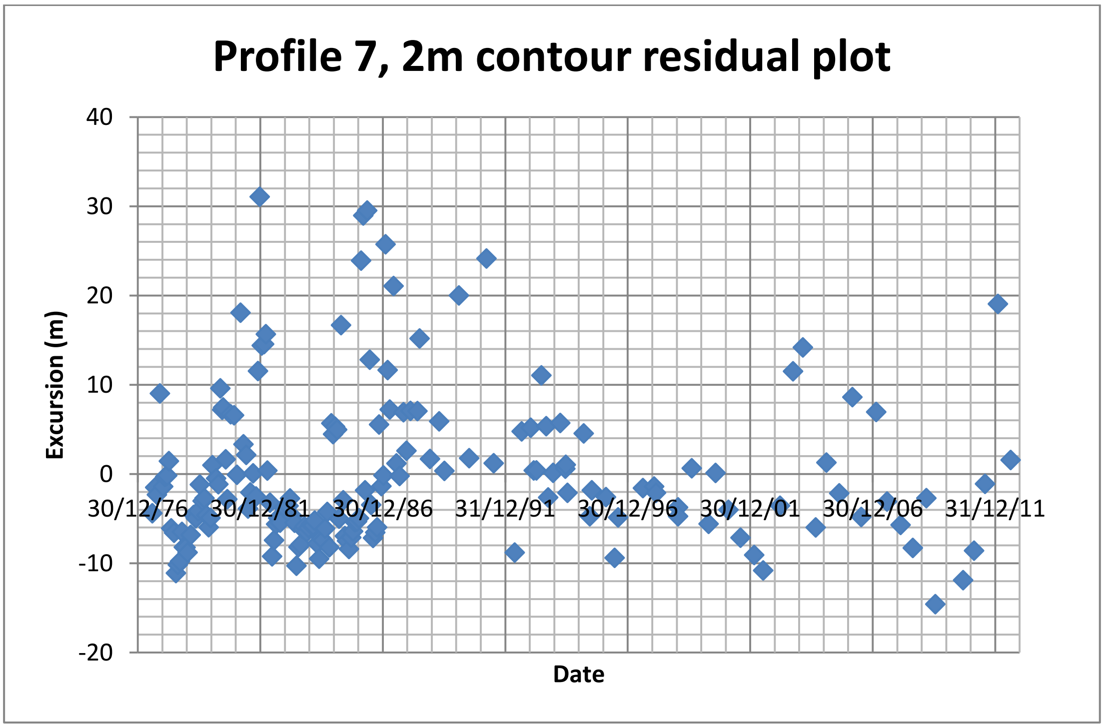


Figure 28 Profile 7, 2m contour residual plot

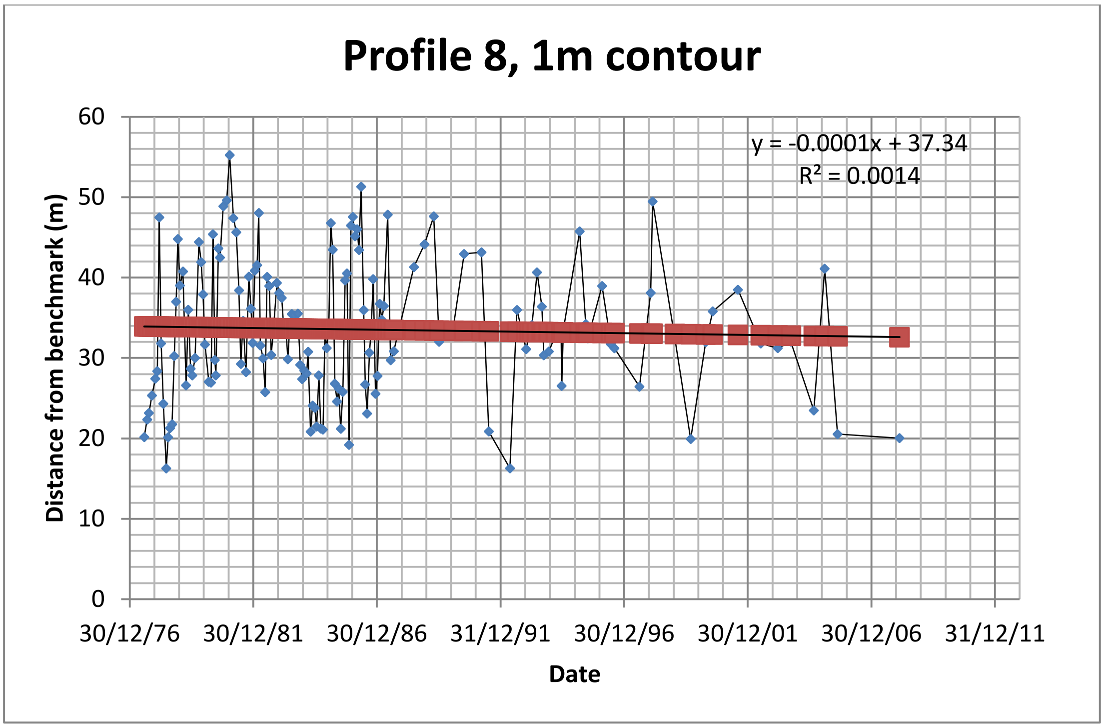


Figure 29 Profile 8, 1m contour trend analysis

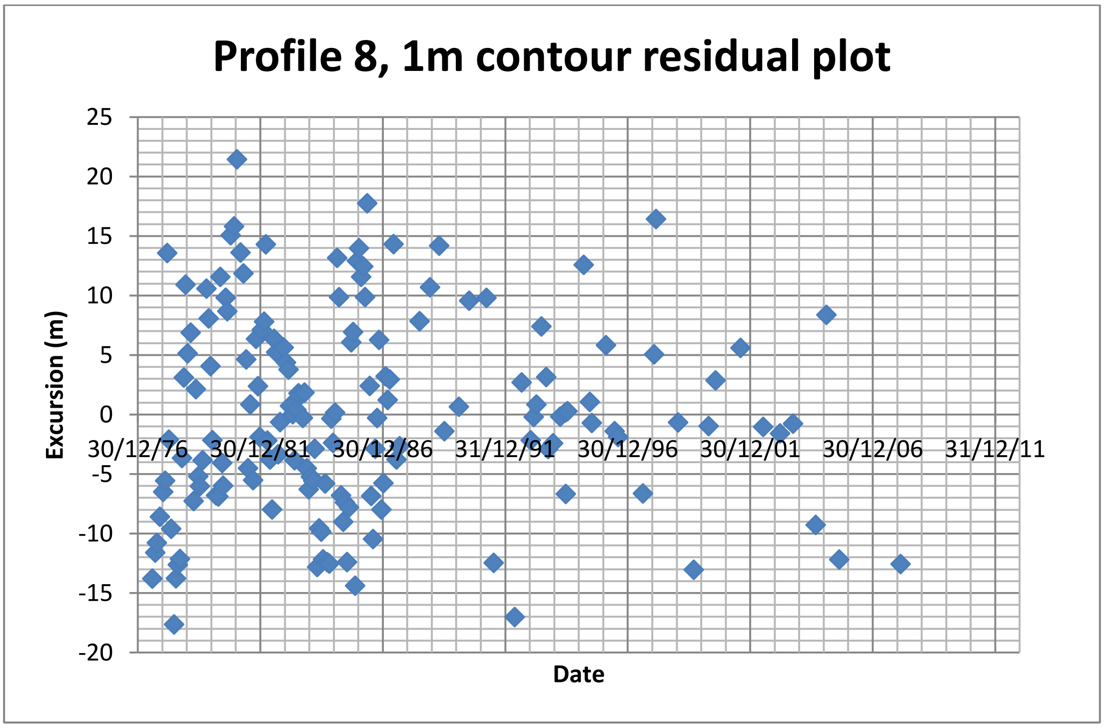


Figure 30 Profile 8, 1m contour residual plot

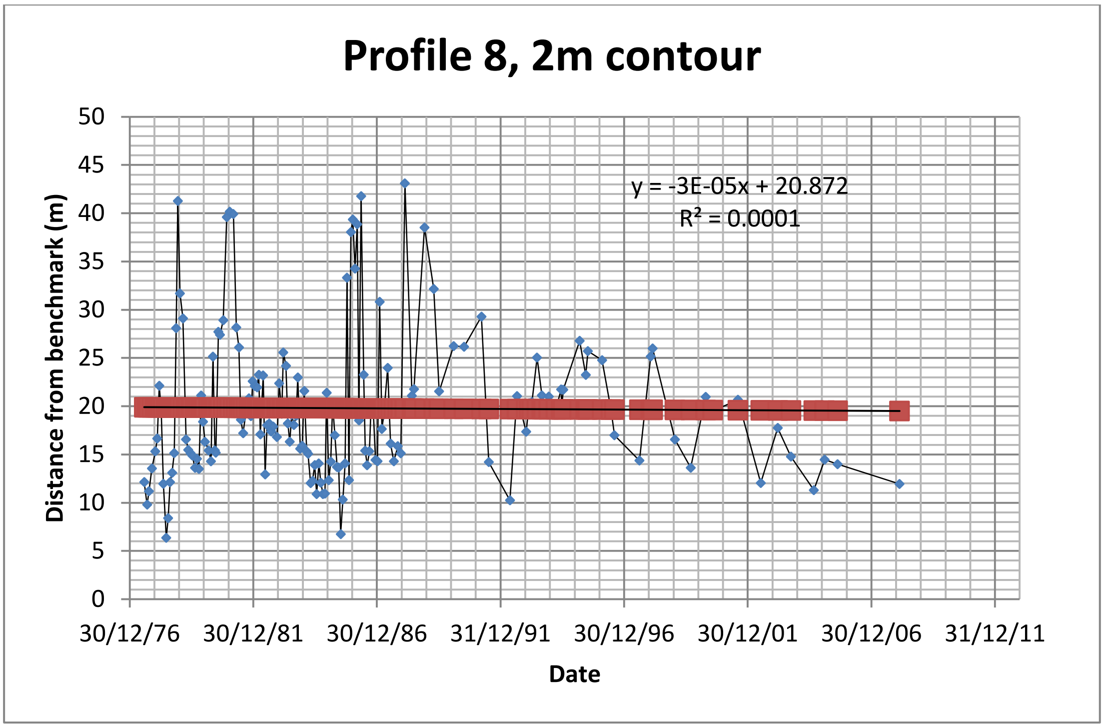


Figure 31 Profile 8, 2m contour trend analysis

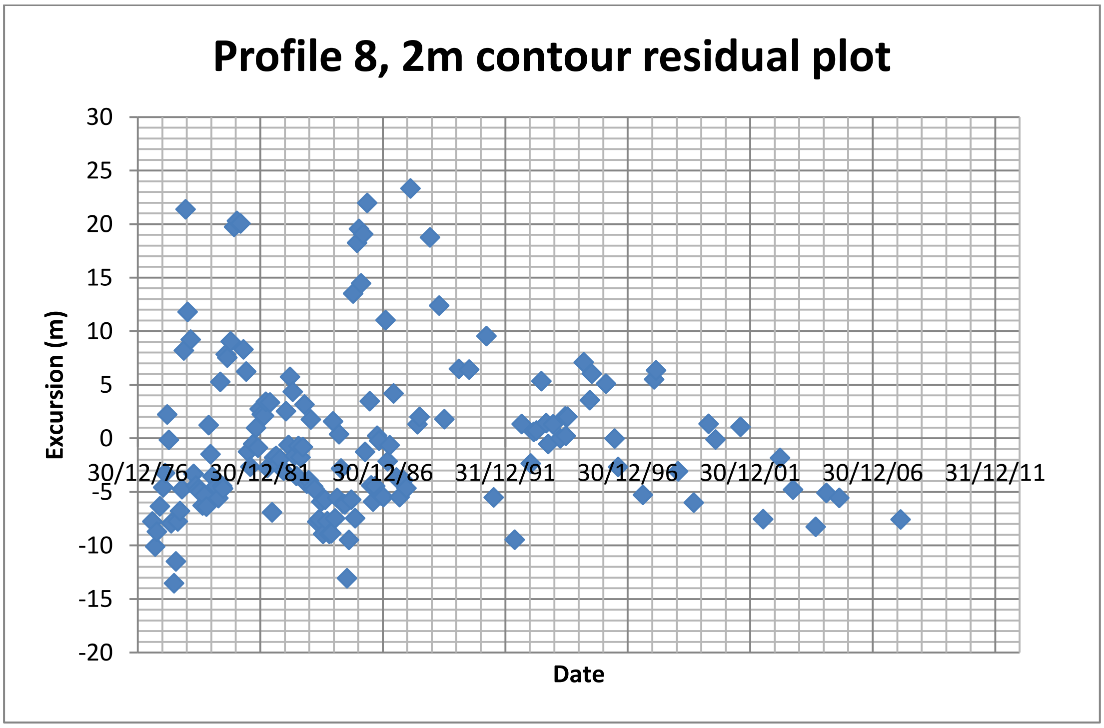


Figure 32 Profile 8, 2m contour residual plot

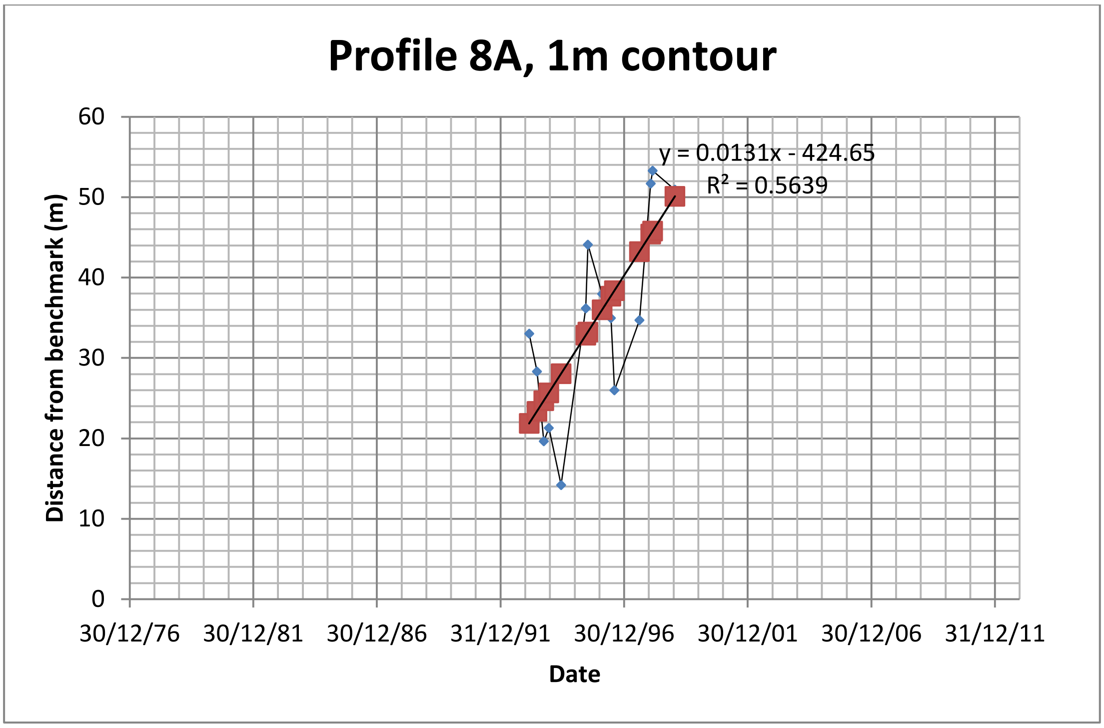


Figure 33 Profile 8A, 1m contour trend analysis

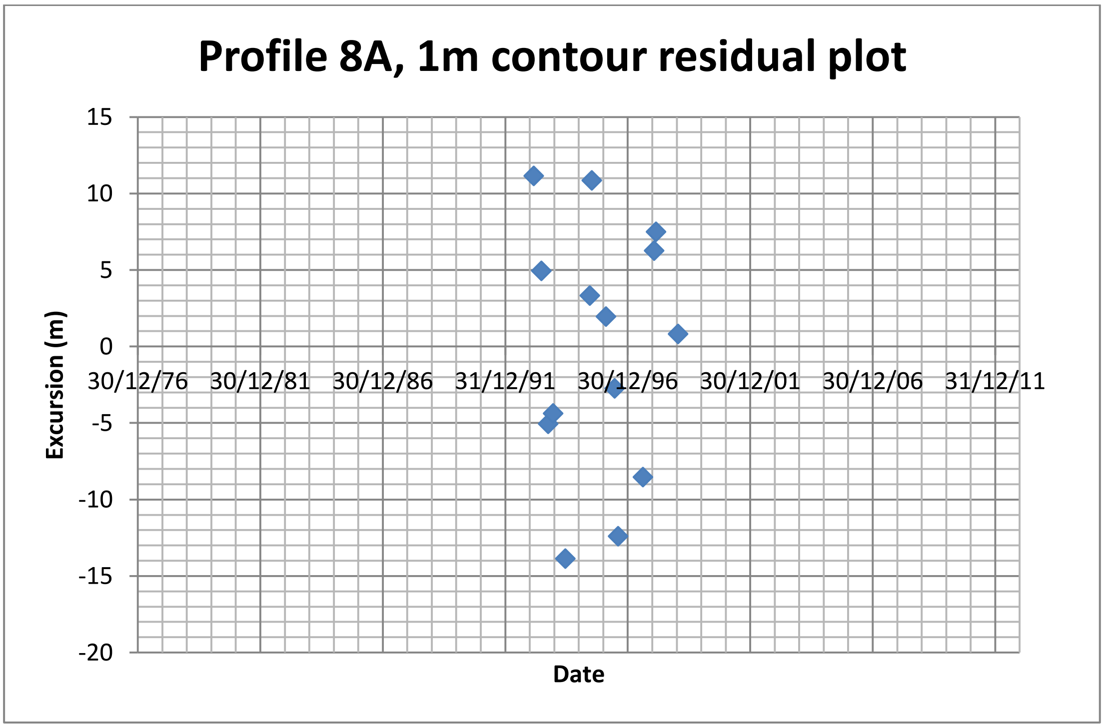


Figure 34 Profile 8A, 1m contour residual plot

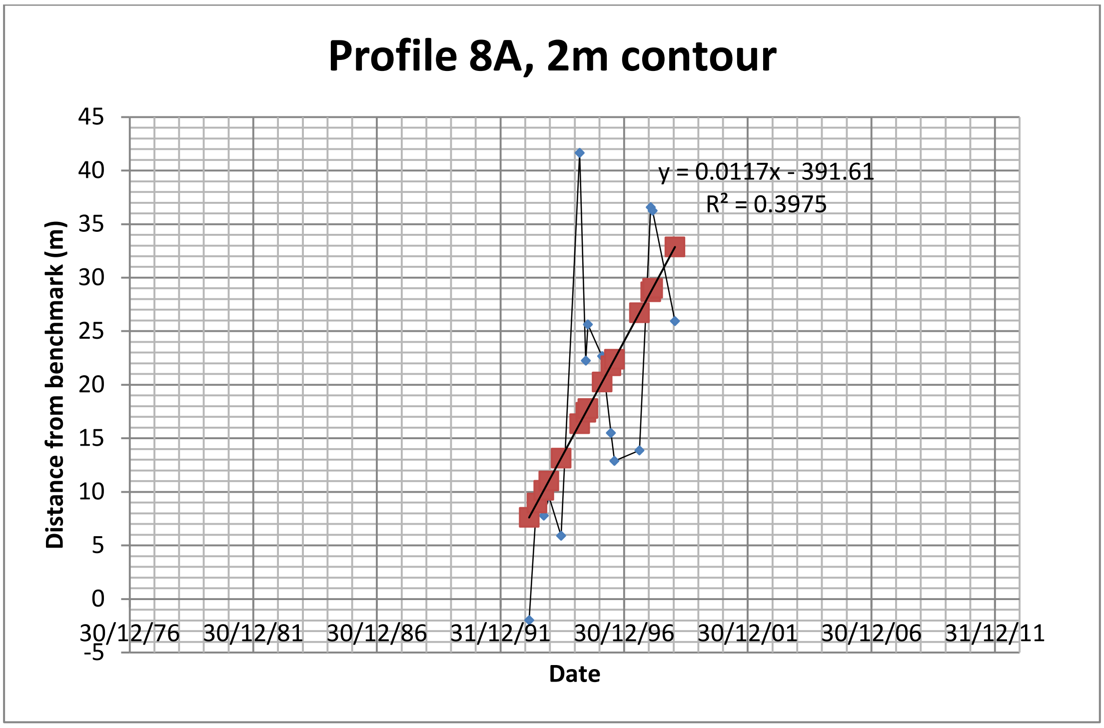


Figure 35 Profile 8A, 2m contour trend analysis

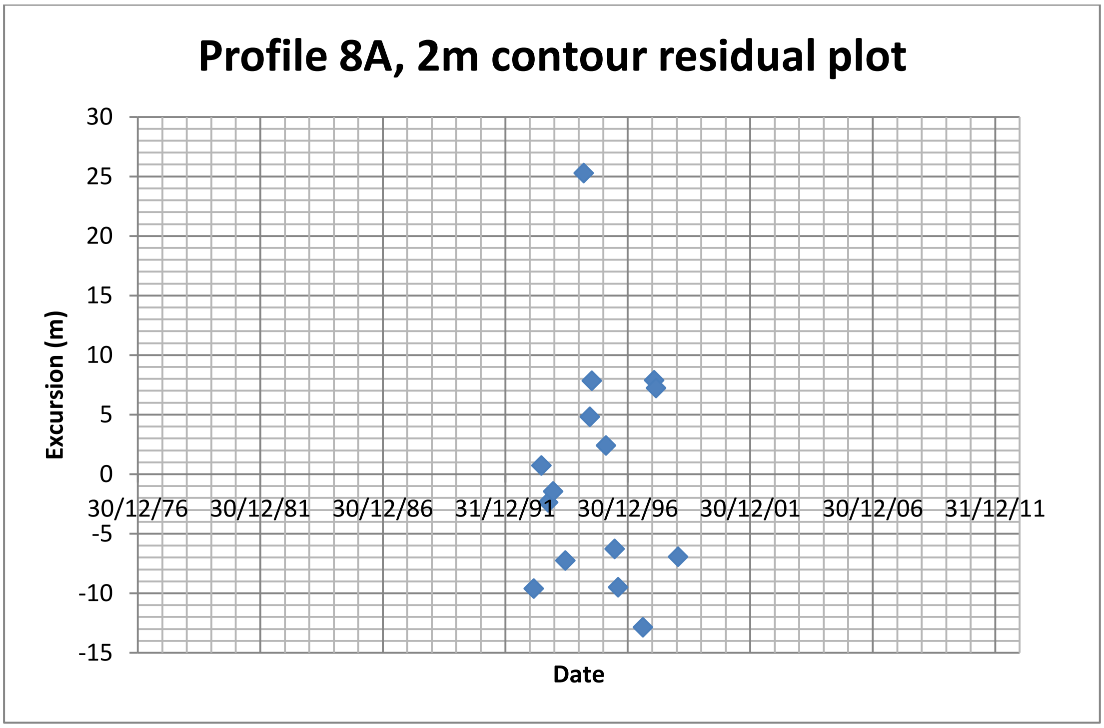


Figure 36 Profile 8A, 2m contour residual plot

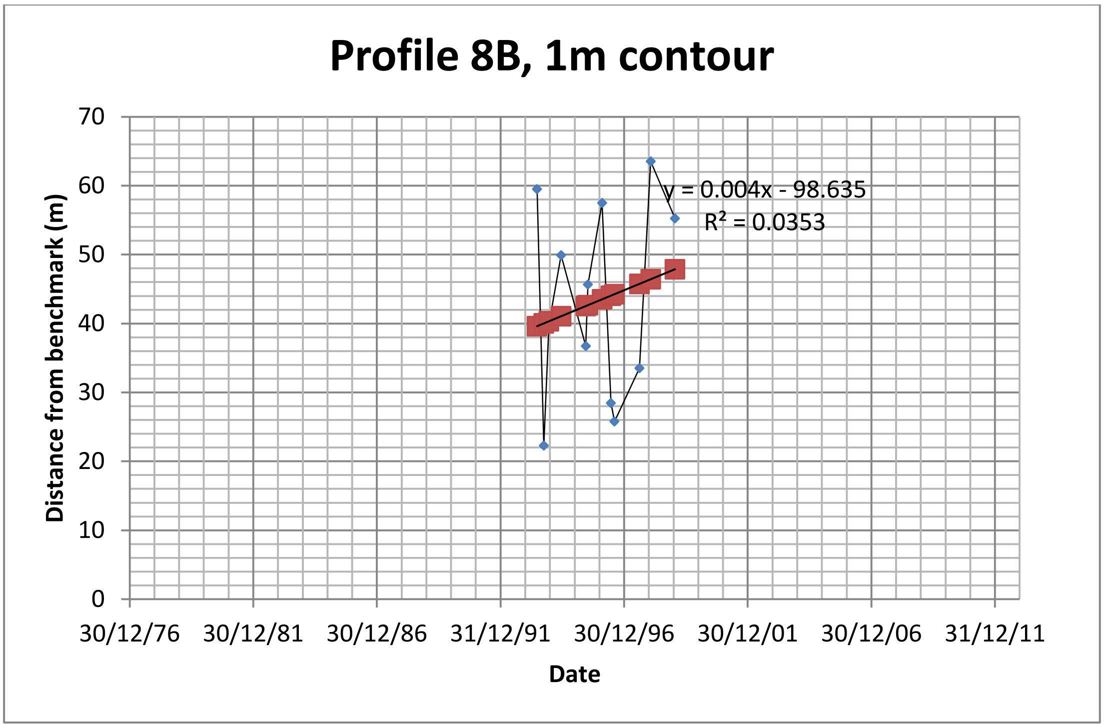


Figure 37 Profile 8B, 1m contour trend analysis

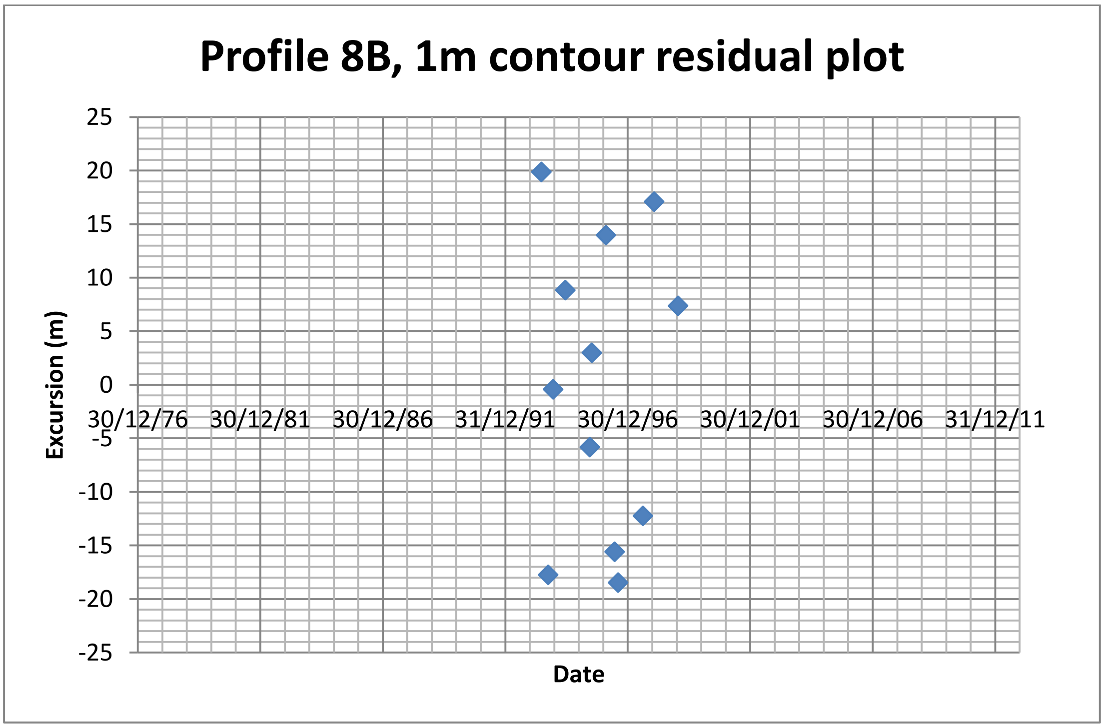


Figure 38 Profile 8B, 1m contour residual plot

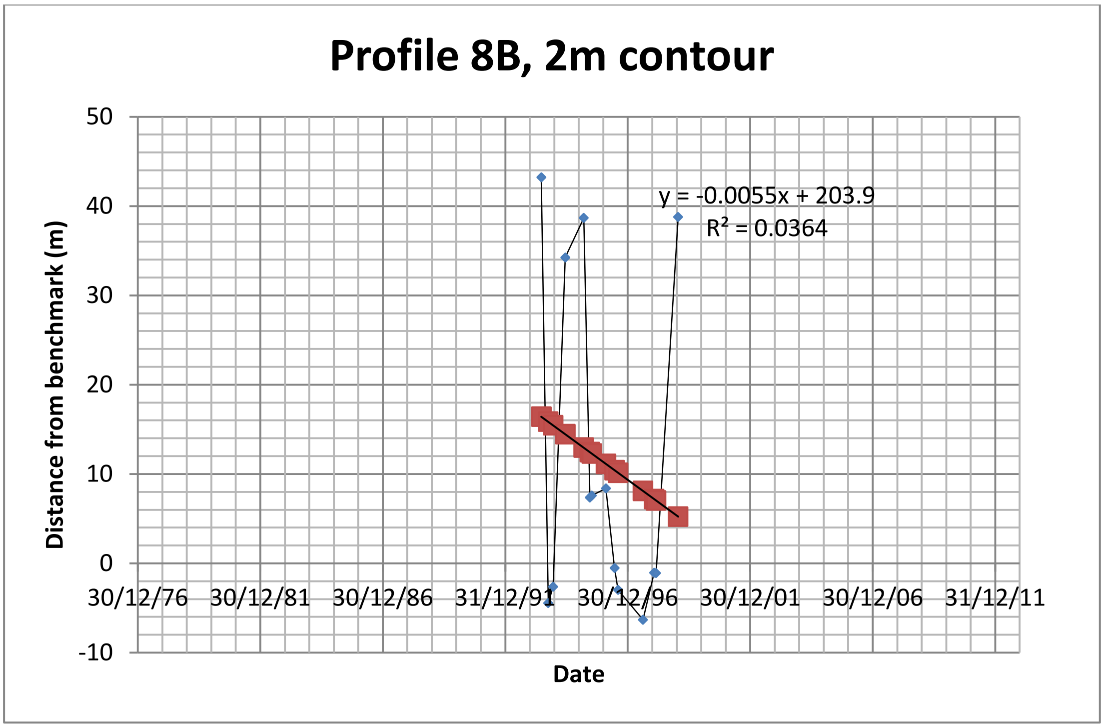


Figure 39 Profile 8B, 2m contour trend analysis

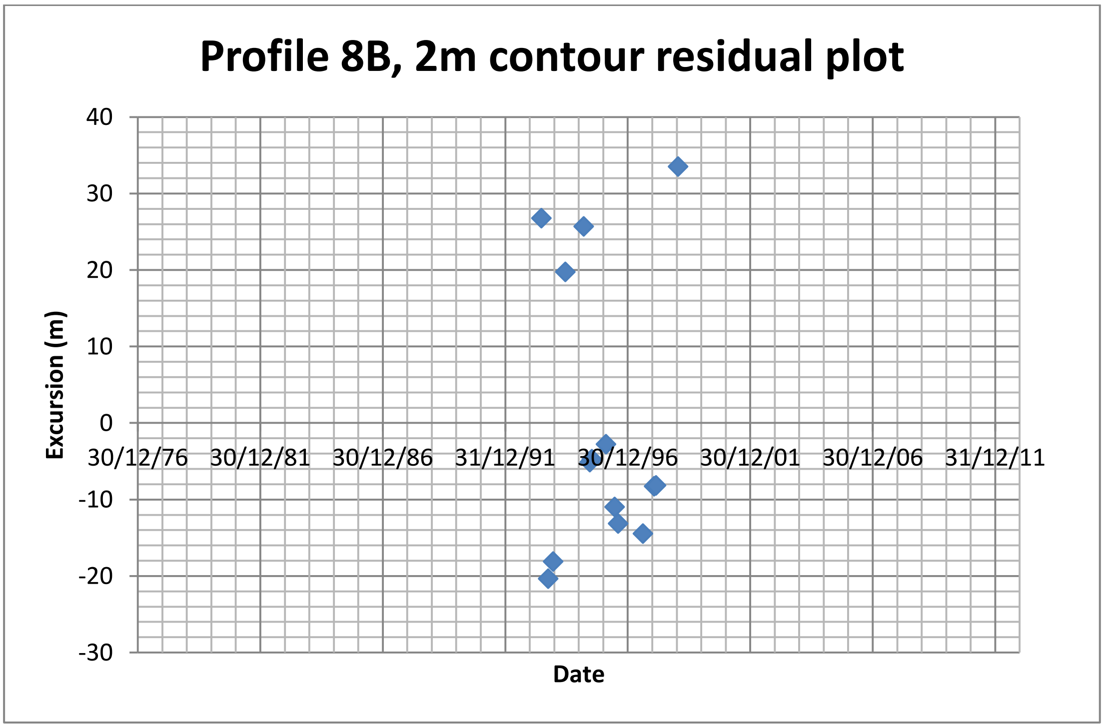


Figure 40 Profile 8B, 2m contour residual plot

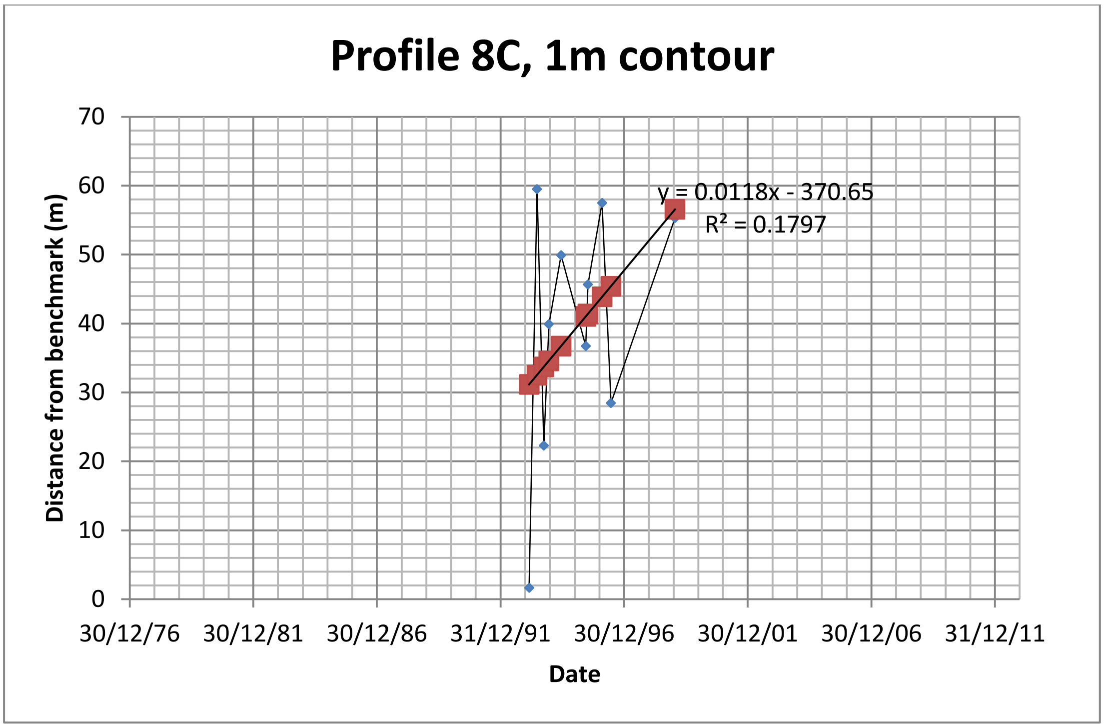


Figure 41 Profile 8C, 1m contour trend analysis

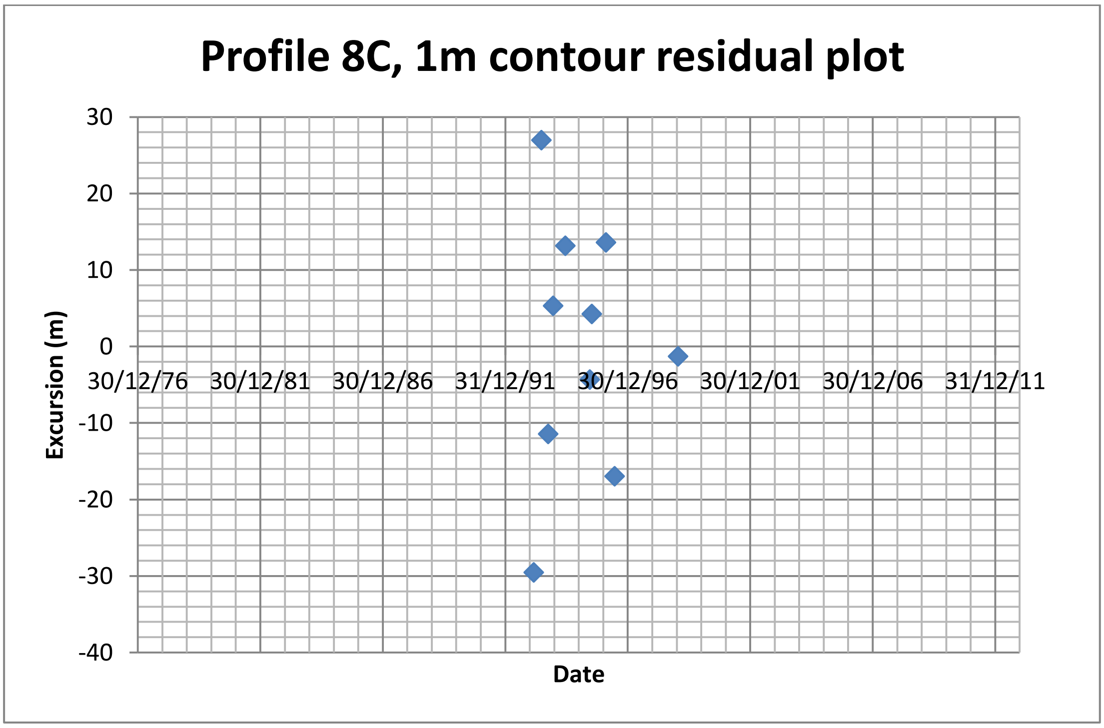


Figure 42 Profile 8C, 1m contour residual plot

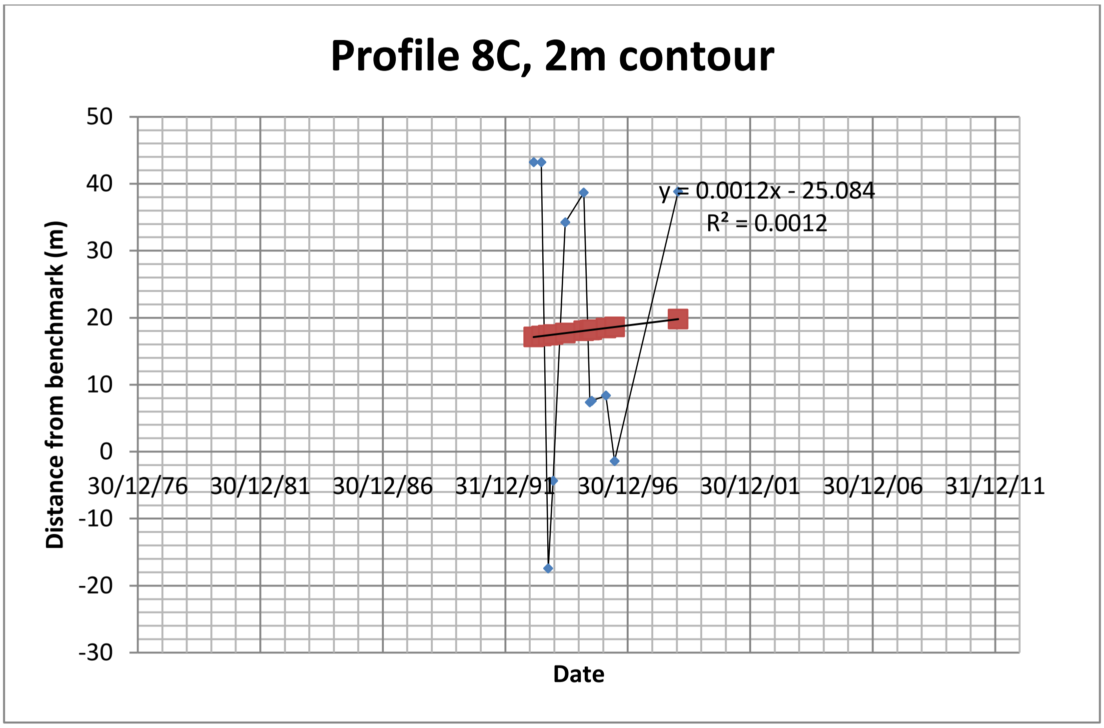


Figure 43 Profile 8C, 2m contour trend analysis

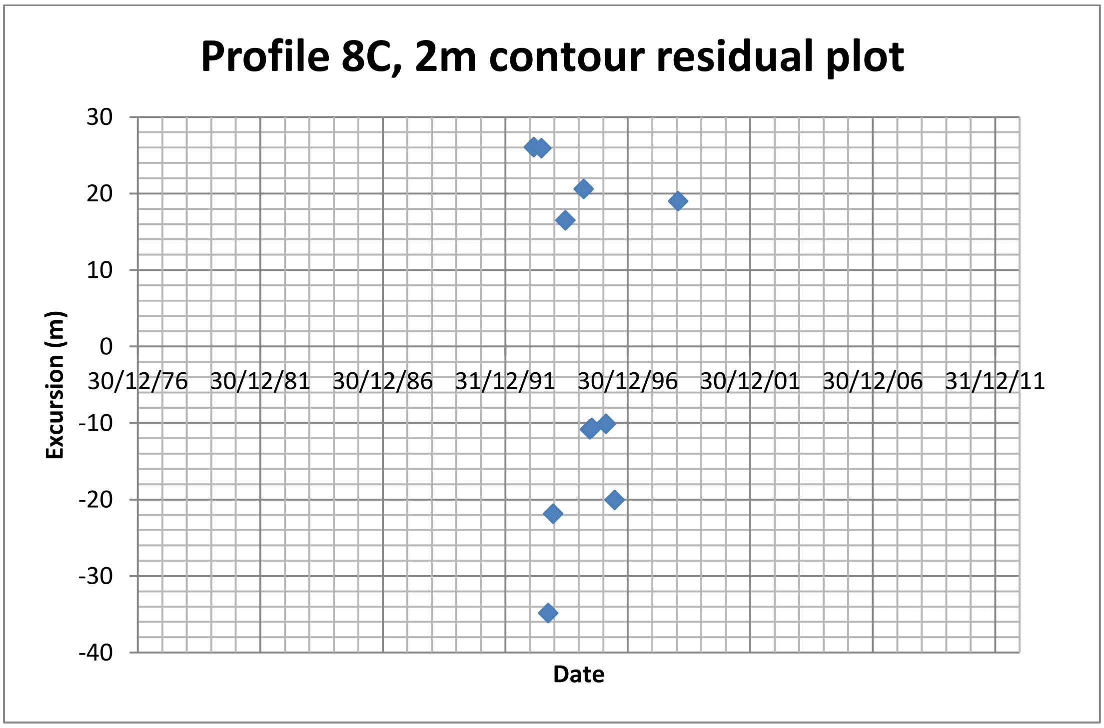


Figure 44 Profile 8C, 2m contour residual plot

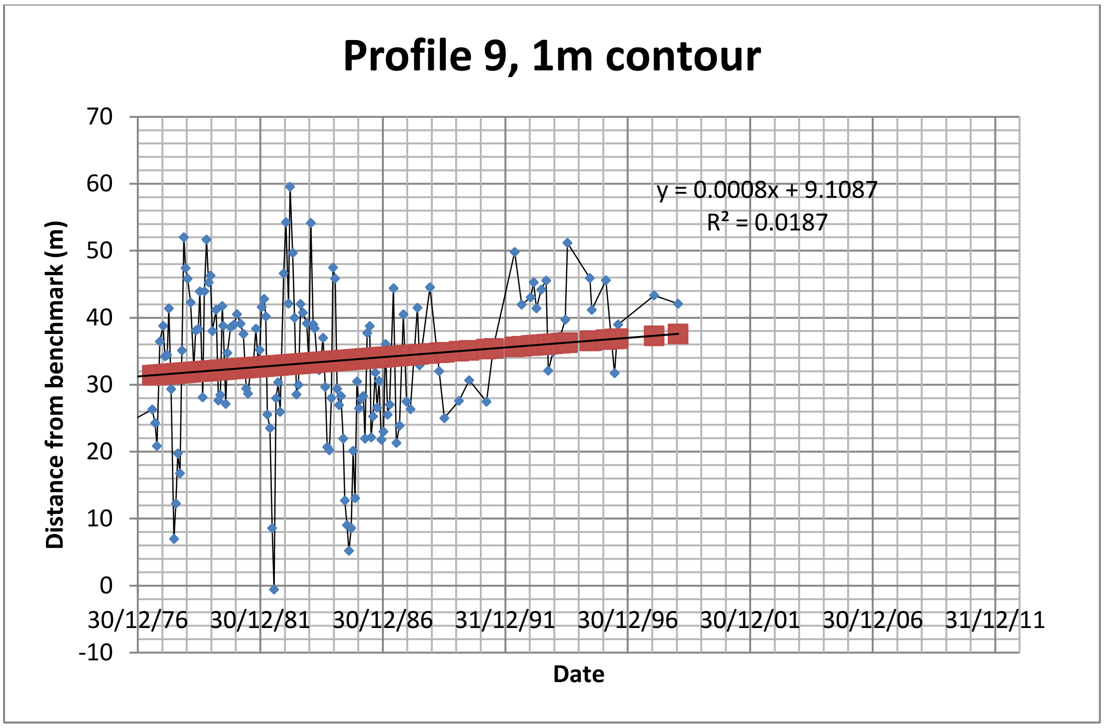


Figure 45 Profile 9, 1m contour trend analysis

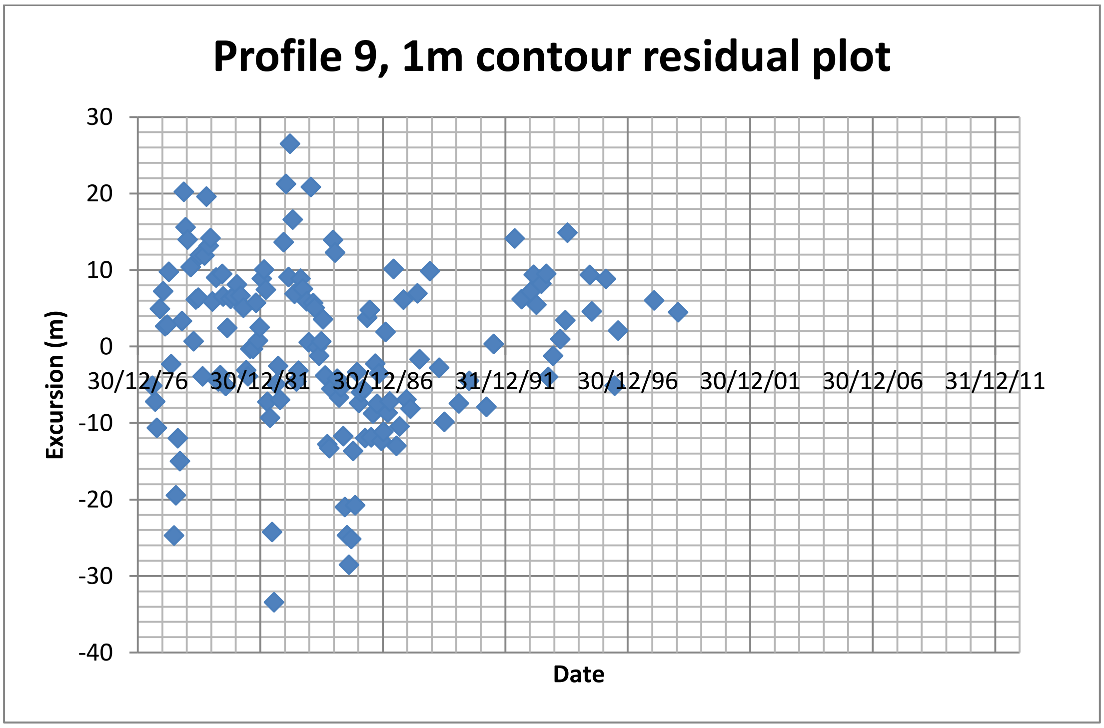


Figure 46 Profile 9, 1m contour residual plot

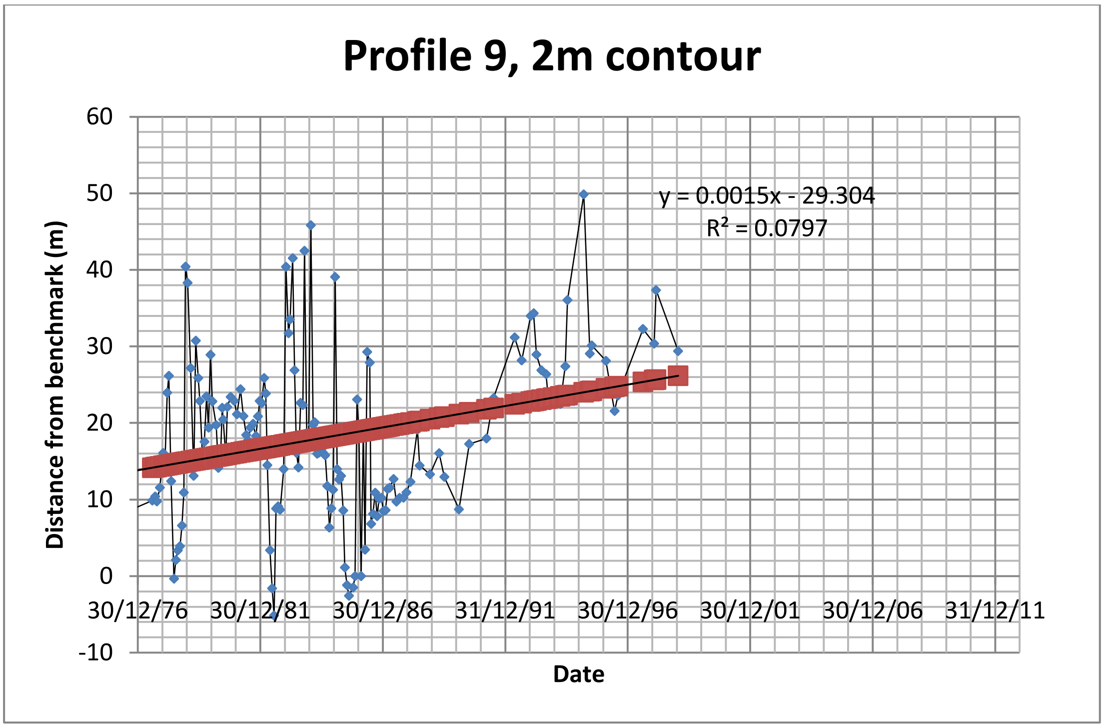


Figure 47 Profile 9, 2m contour trend analysis

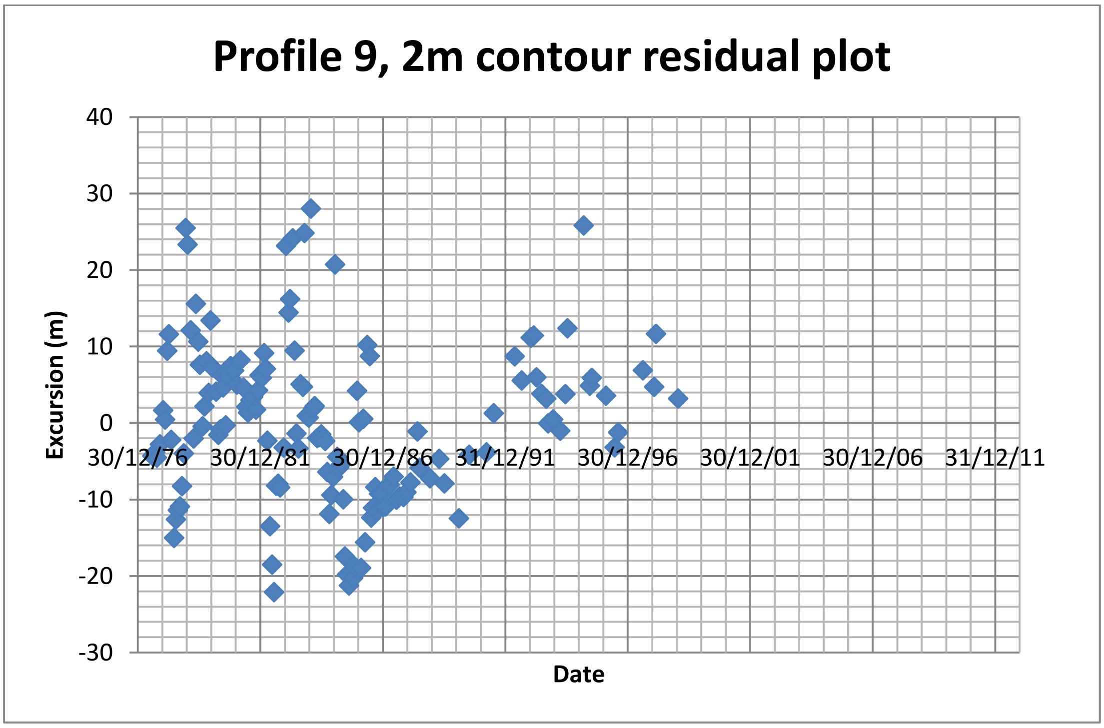


Figure 48 Profile 9, 2m contour residual plot

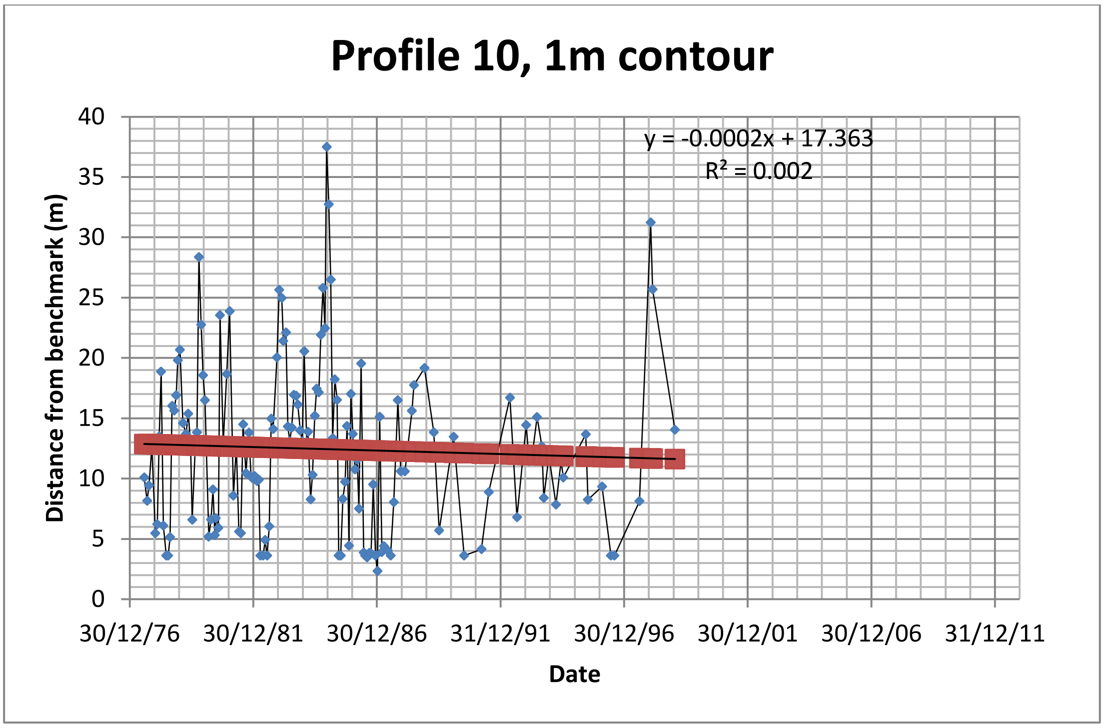


Figure 49 Profile 10, 1m contour trend analysis

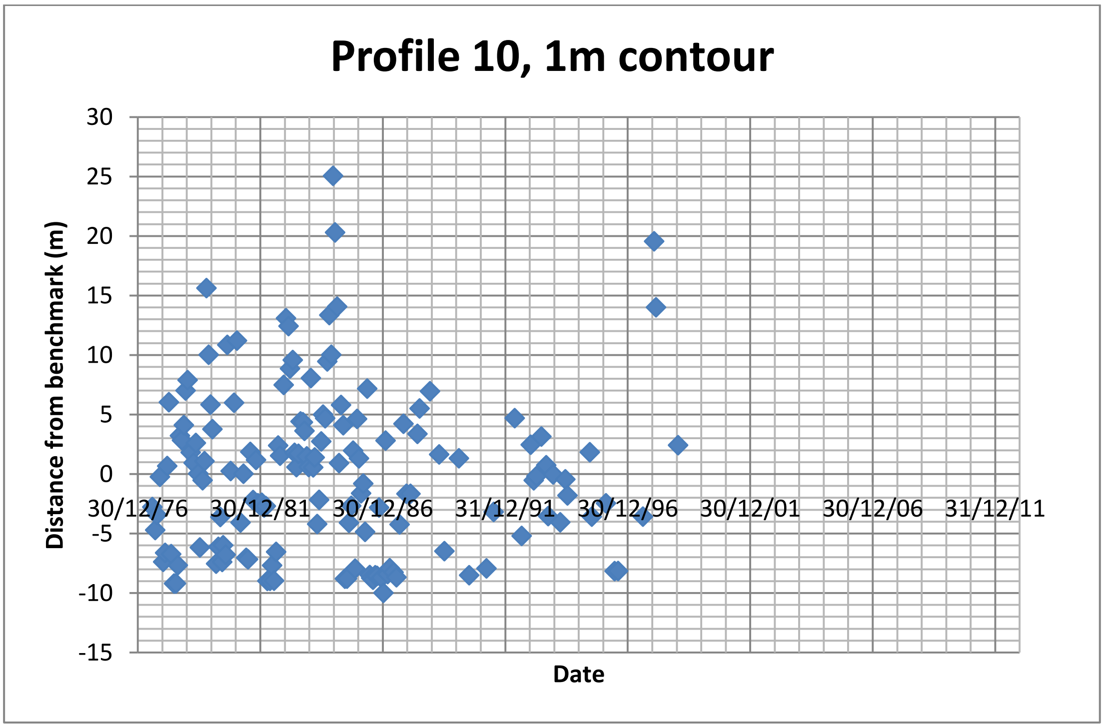


Figure 50 Profile 10, 1m contour residual plot

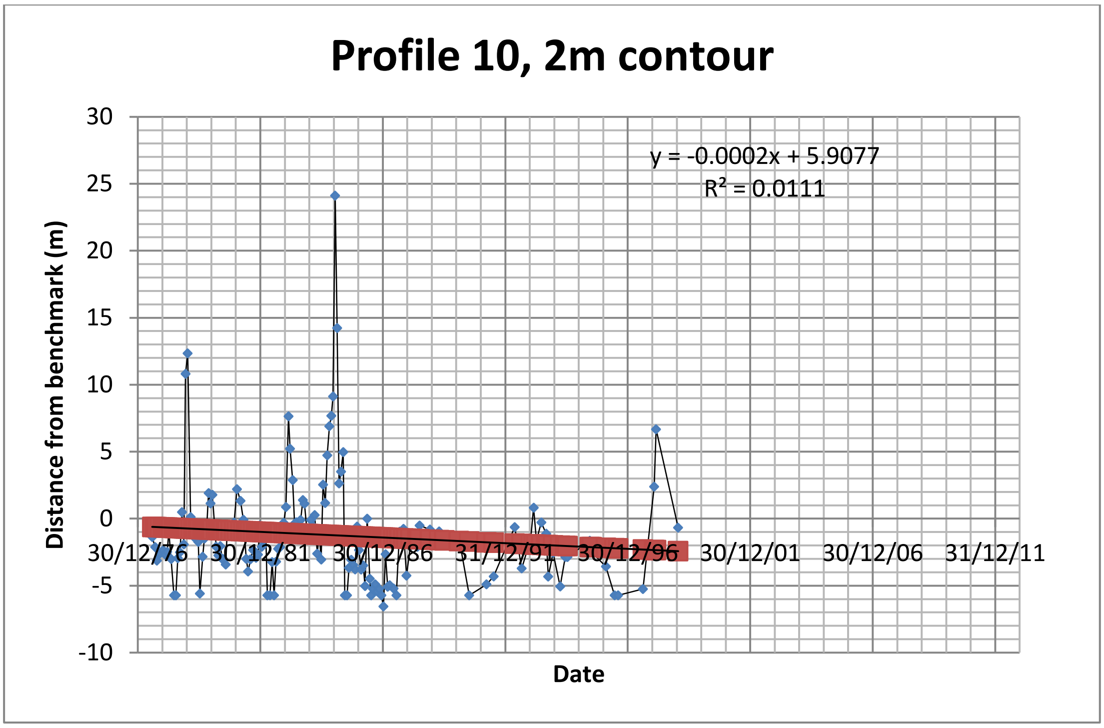


Figure 51 Profile 10, 2m contour trend analysis

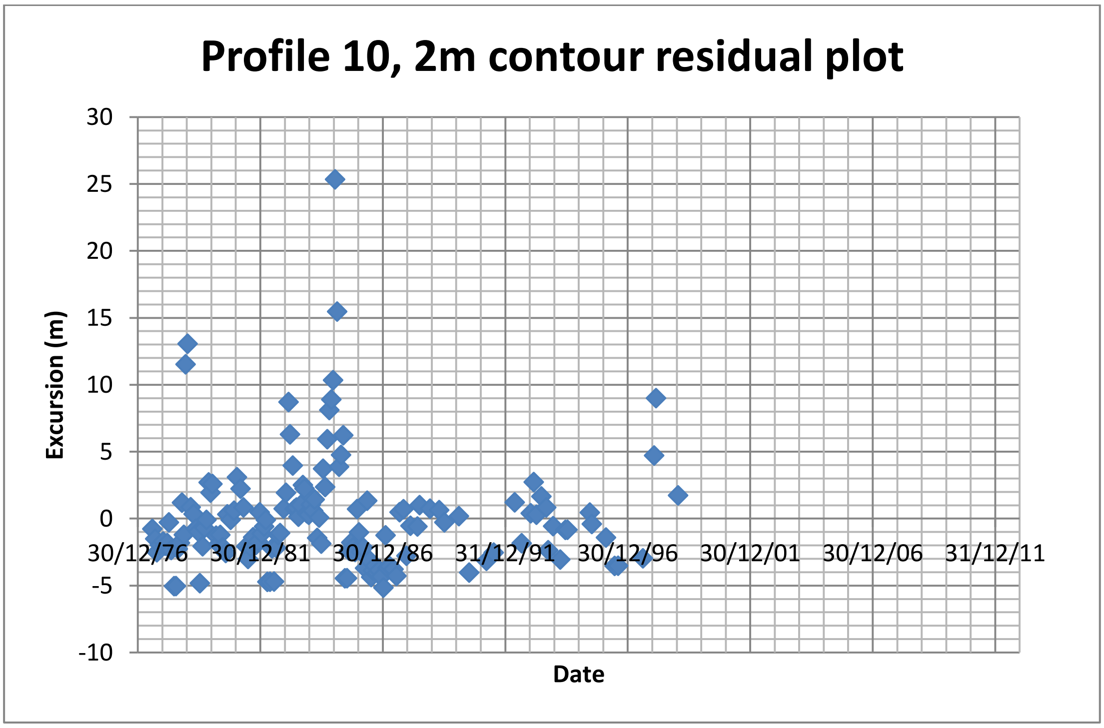


Figure 52 Profile 10, 2m contour residual plot

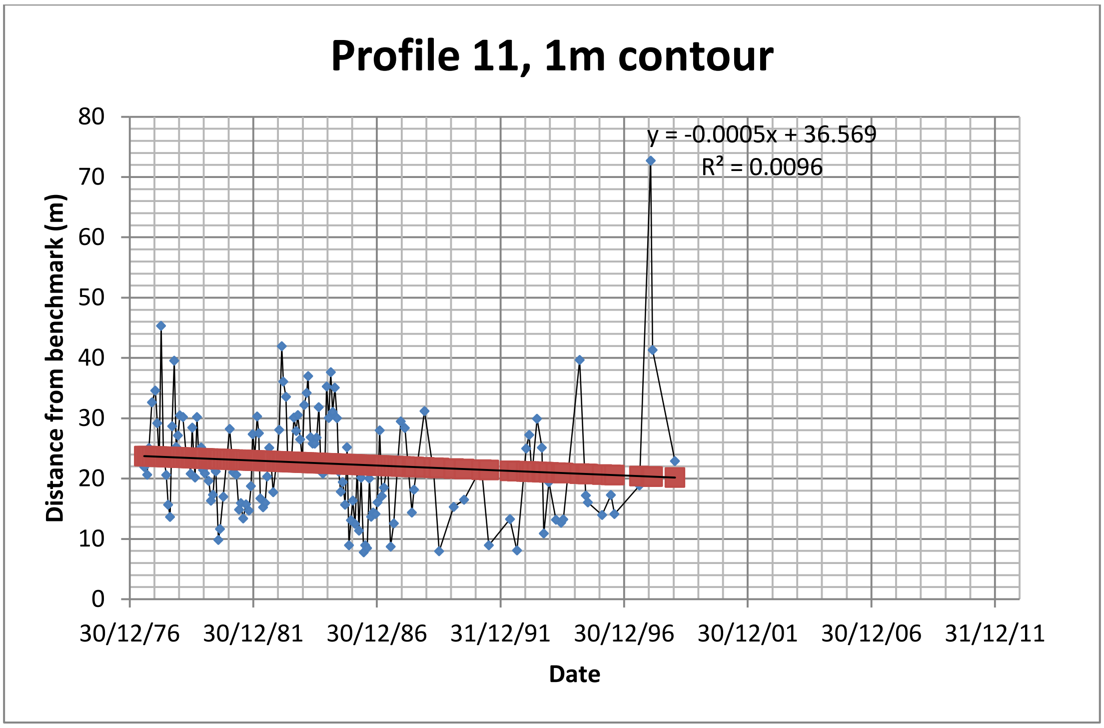


Figure 53 Profile 11, 1m contour trend analysis

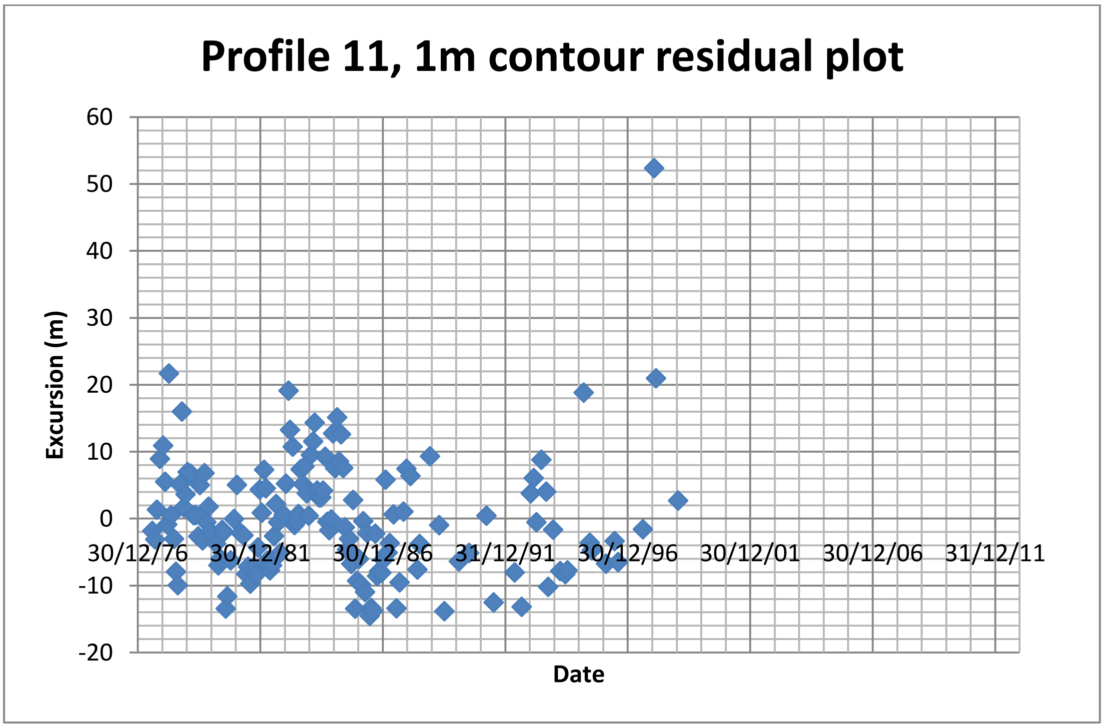


Figure 54 Profile 11, 1m contour residual plot

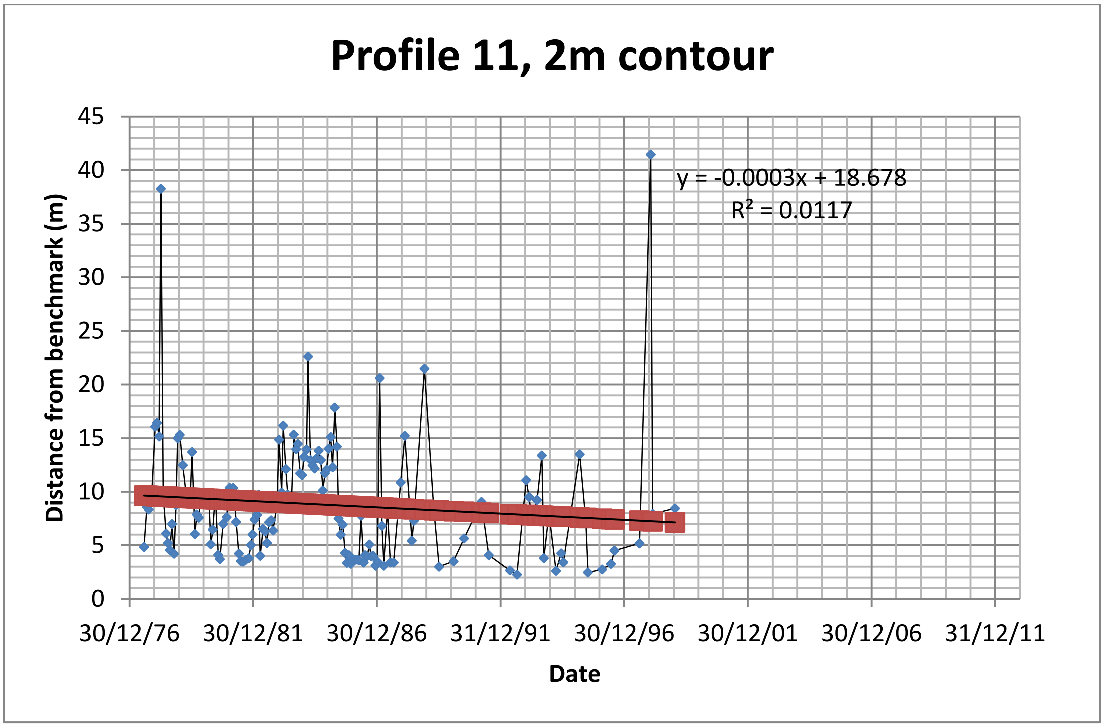


Figure 55 Profile 11, 2m contour trend analysis

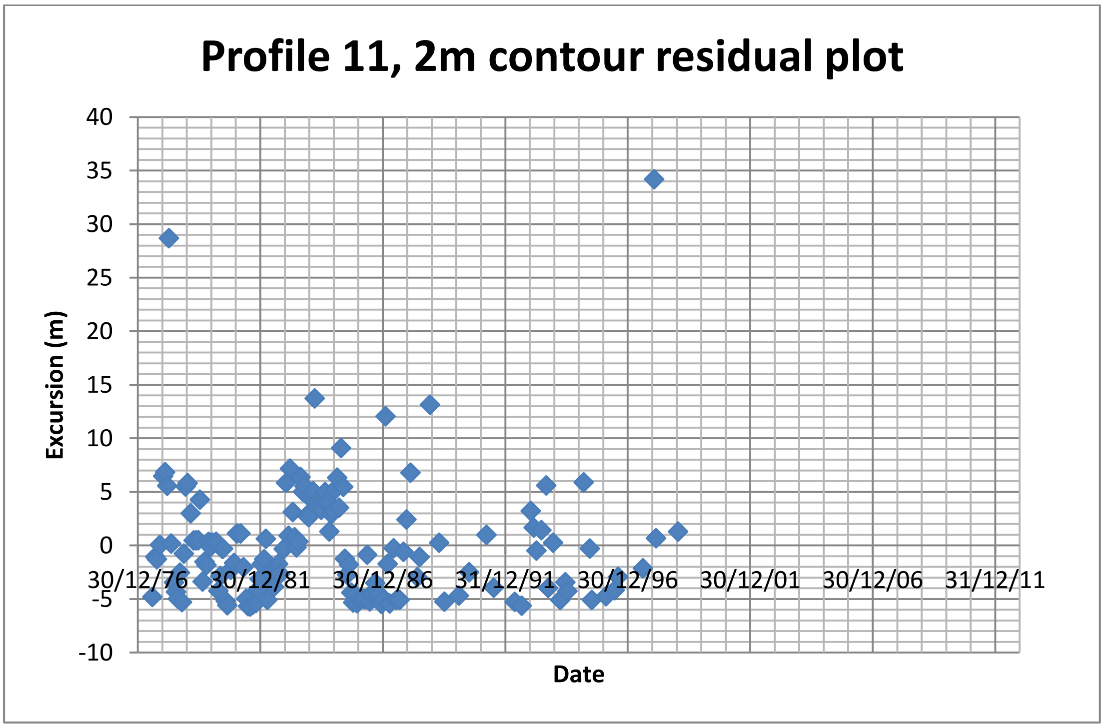


Figure 56 Profile 11, 2m contour residual plot

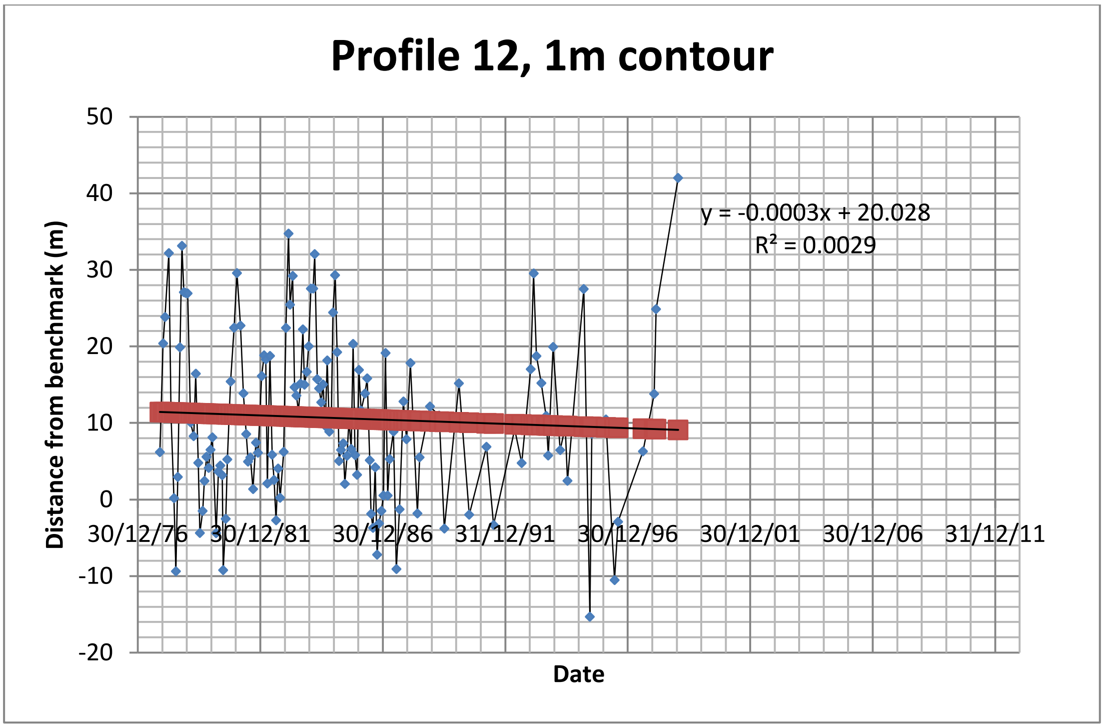


Figure 57 Profile 12, 1m contour trend analysis

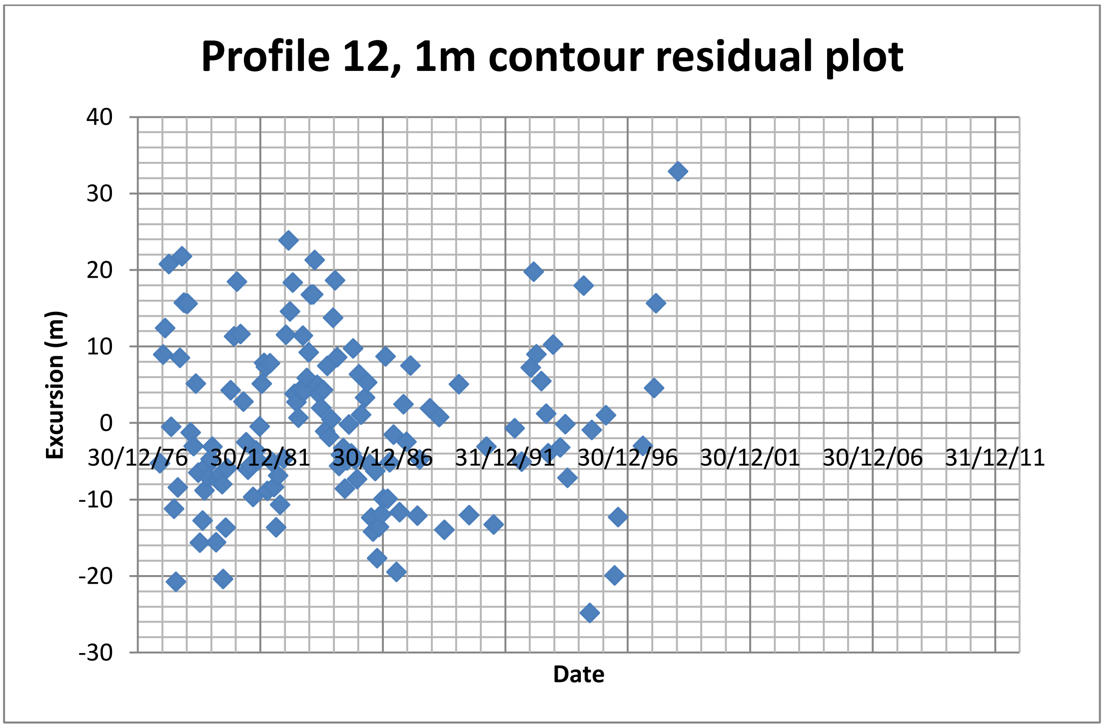


Figure 58 Profile 12, 1m contour residual plot

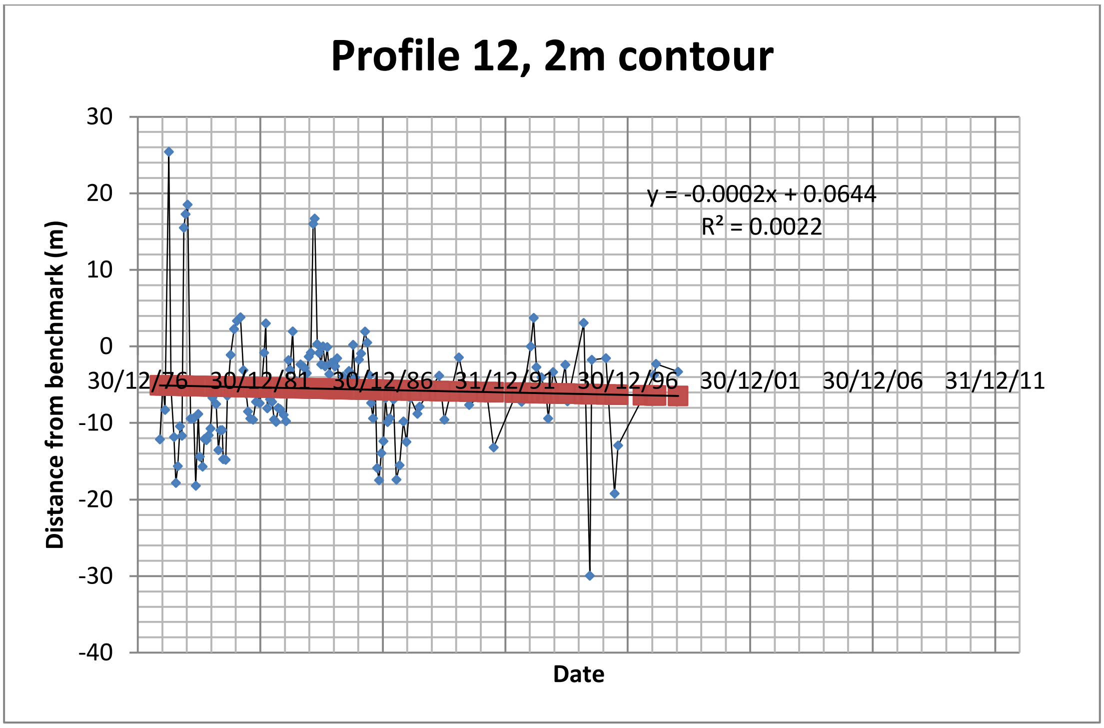


Figure 59 Profile 12, 2m contour trend analysis

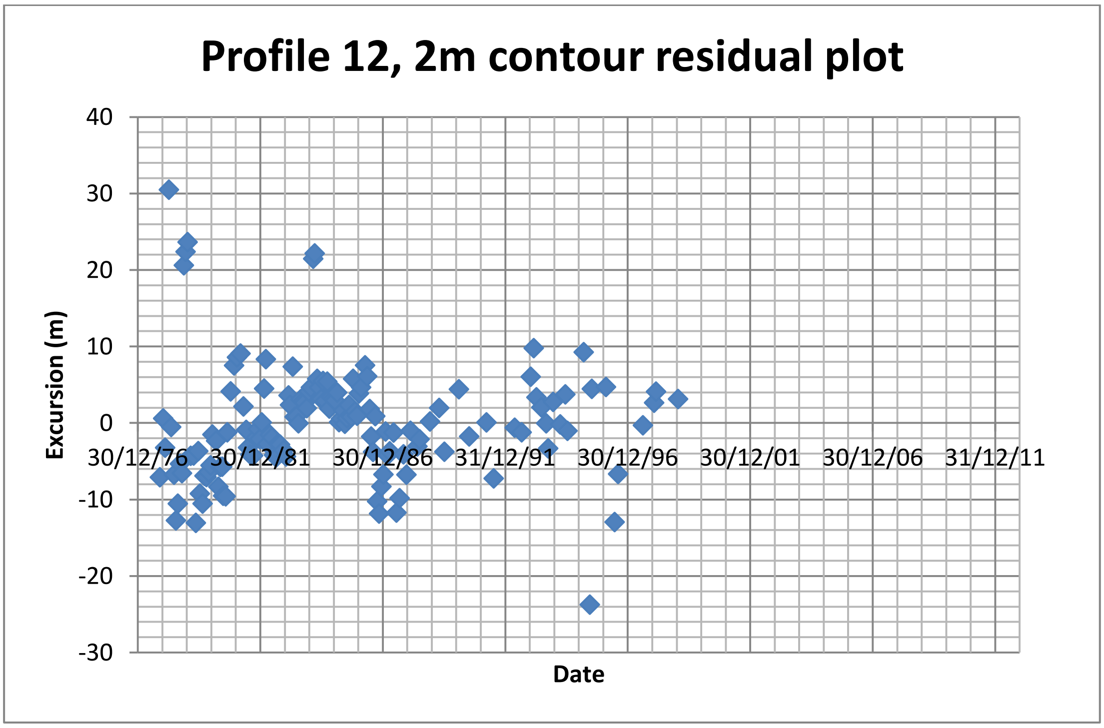


Figure 60 Profile 12, 2m contour residual plot

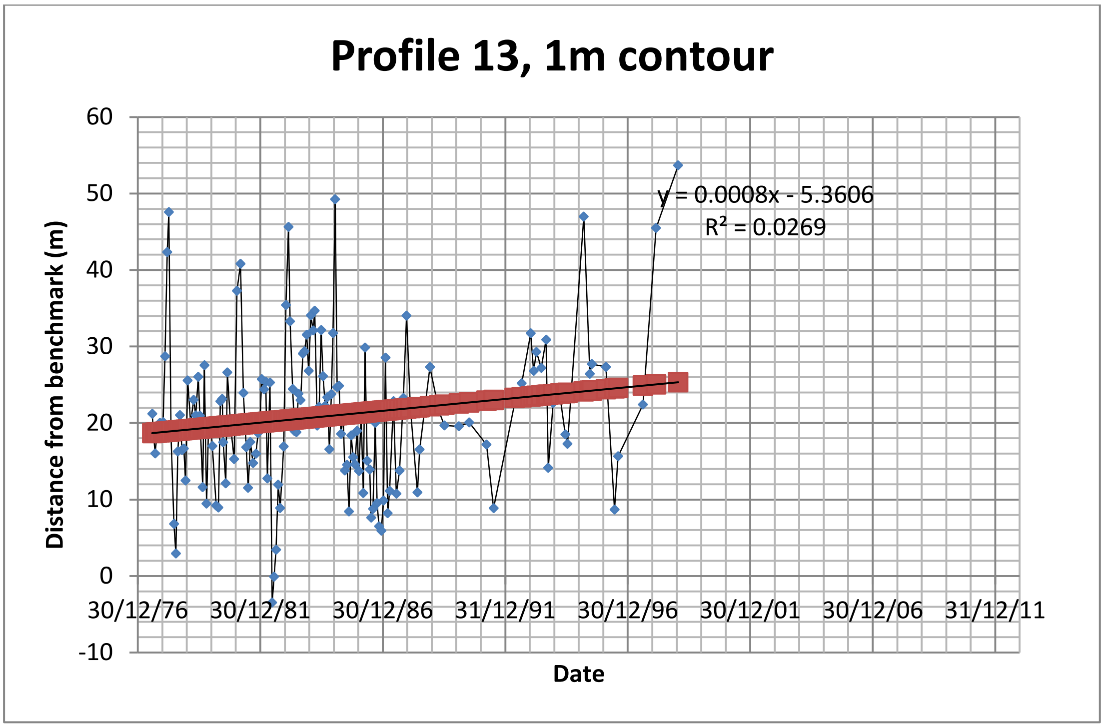


Figure 61 Profile 13, 1m contour trend analysis

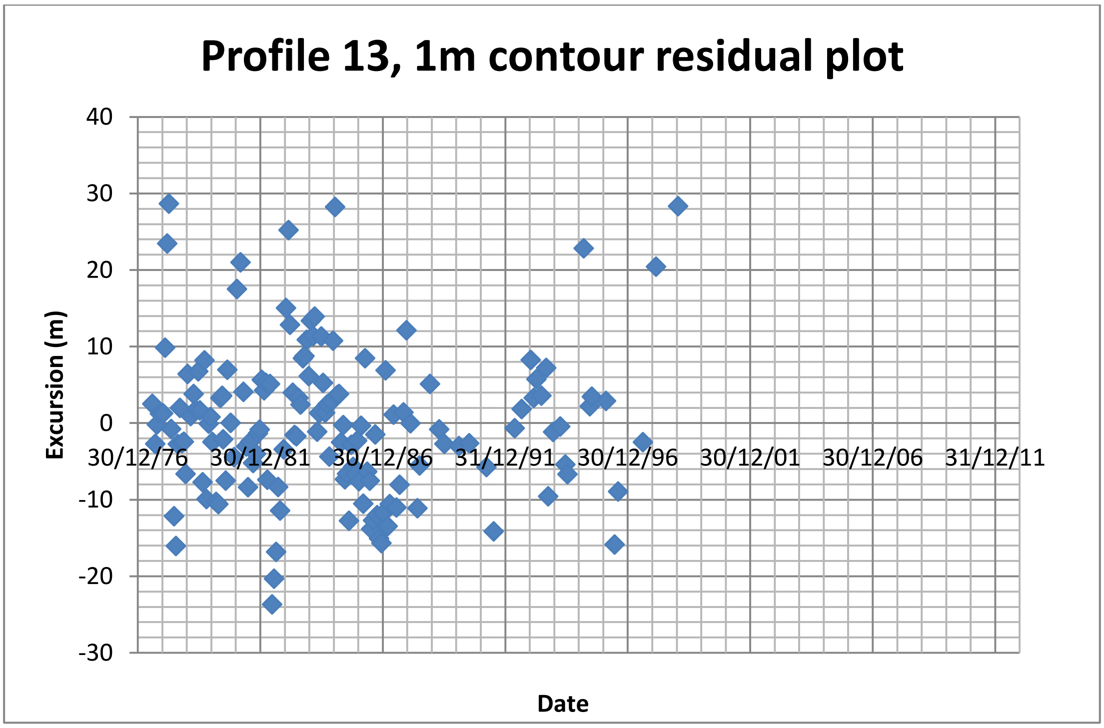


Figure 62 Profile 13, 1m contour residual plot

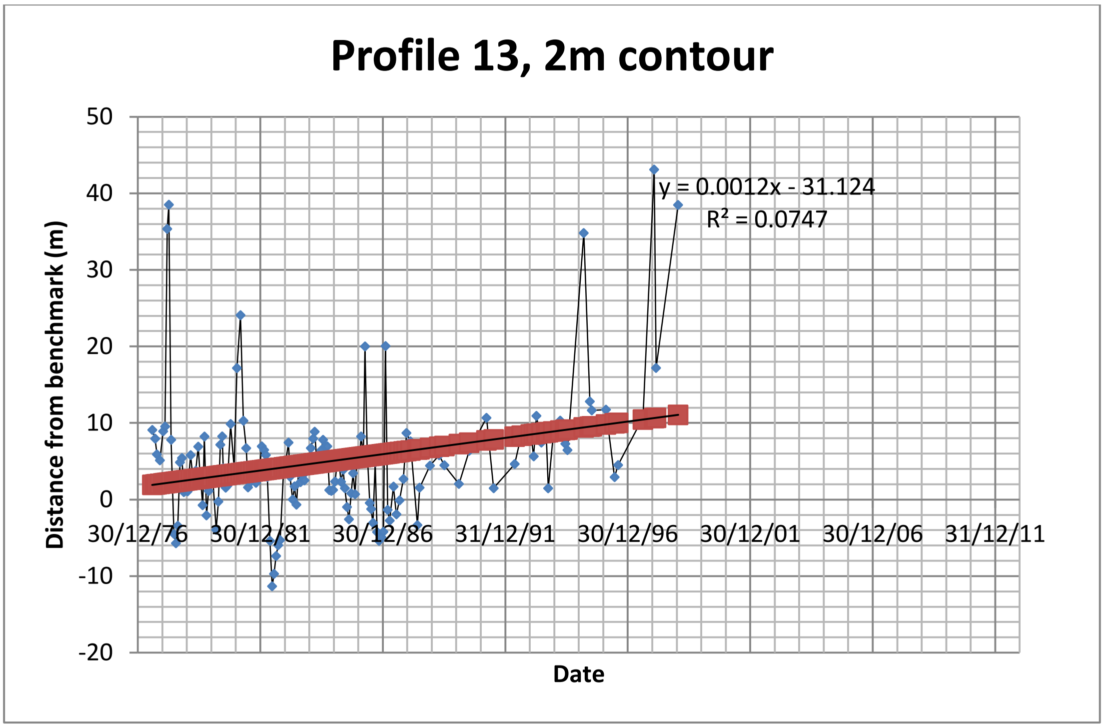


Figure 63 Profile 13, 2m contour trend analysis

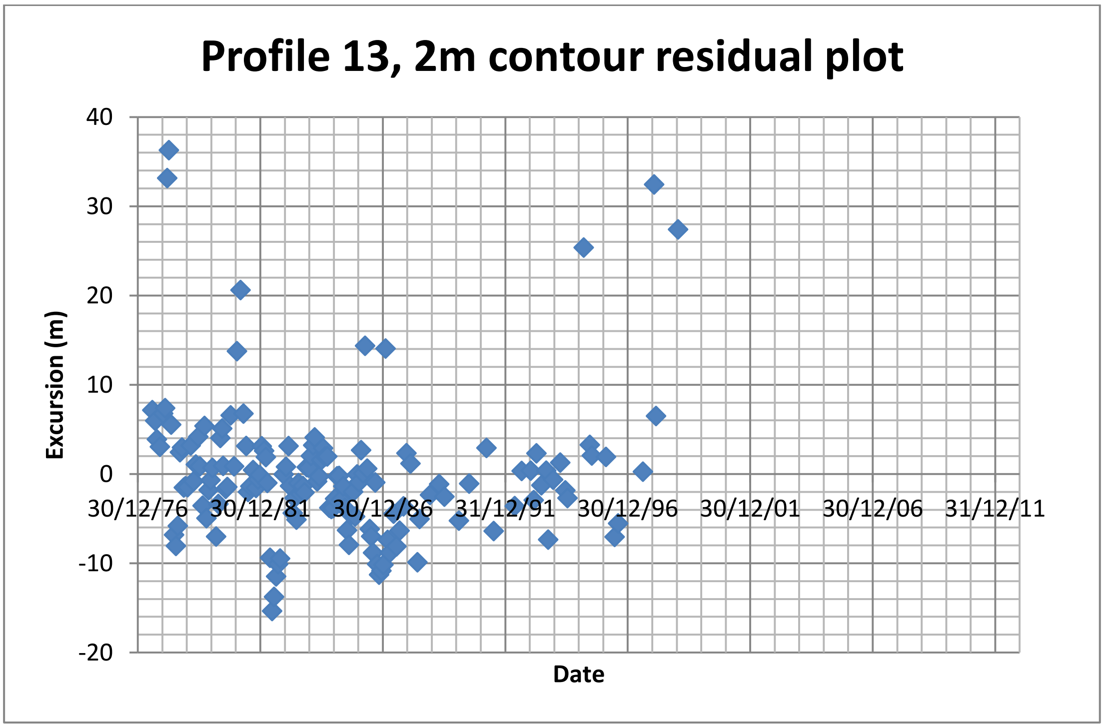


Figure 64 Profile 13, 2m contour residual plot

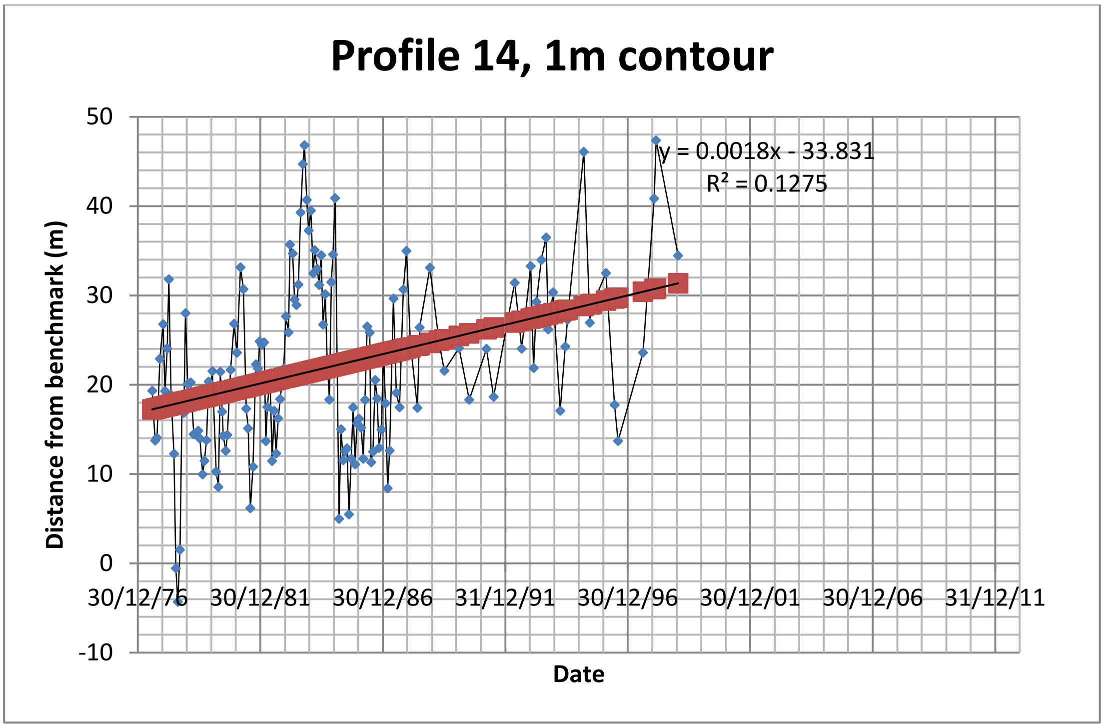


Figure 65 Profile 14, 1m contour trend analysis

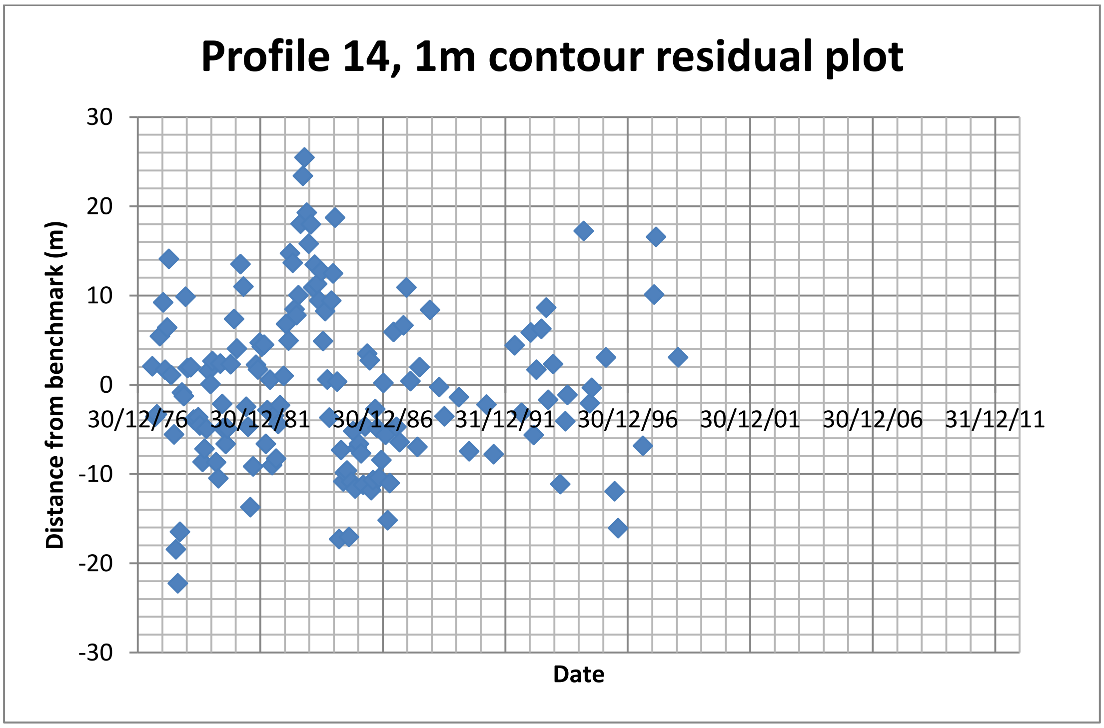


Figure 66 Profile 14, 1m contour residual plot

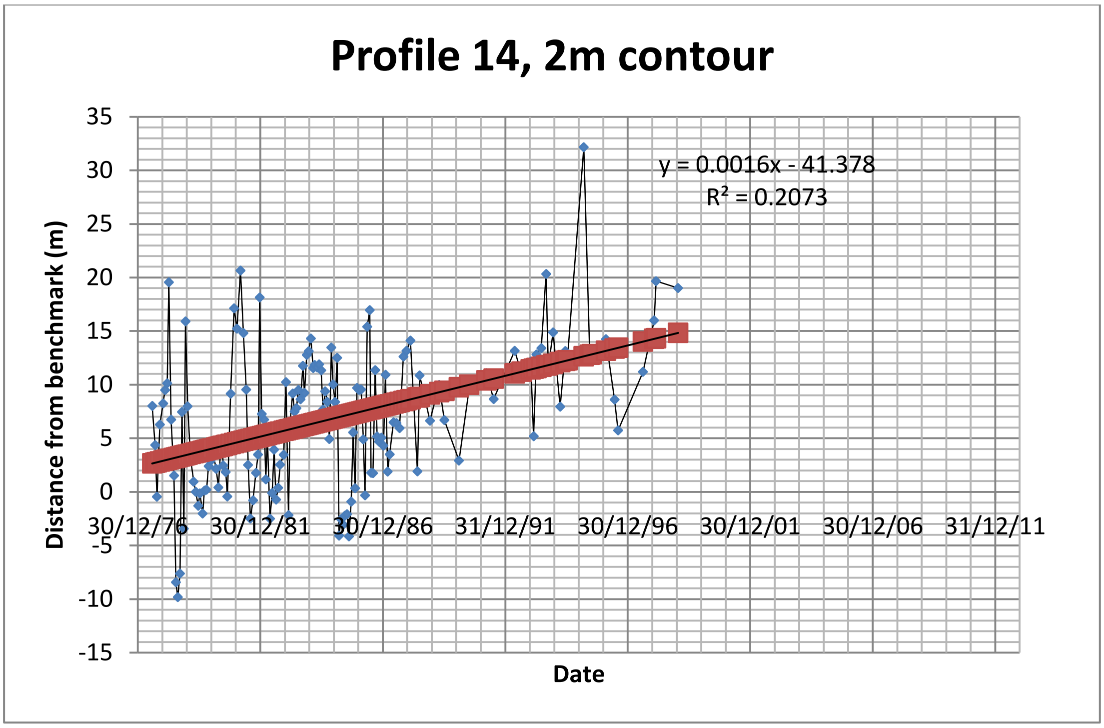


Figure 67 Profile 14, 2m contour trend analysis

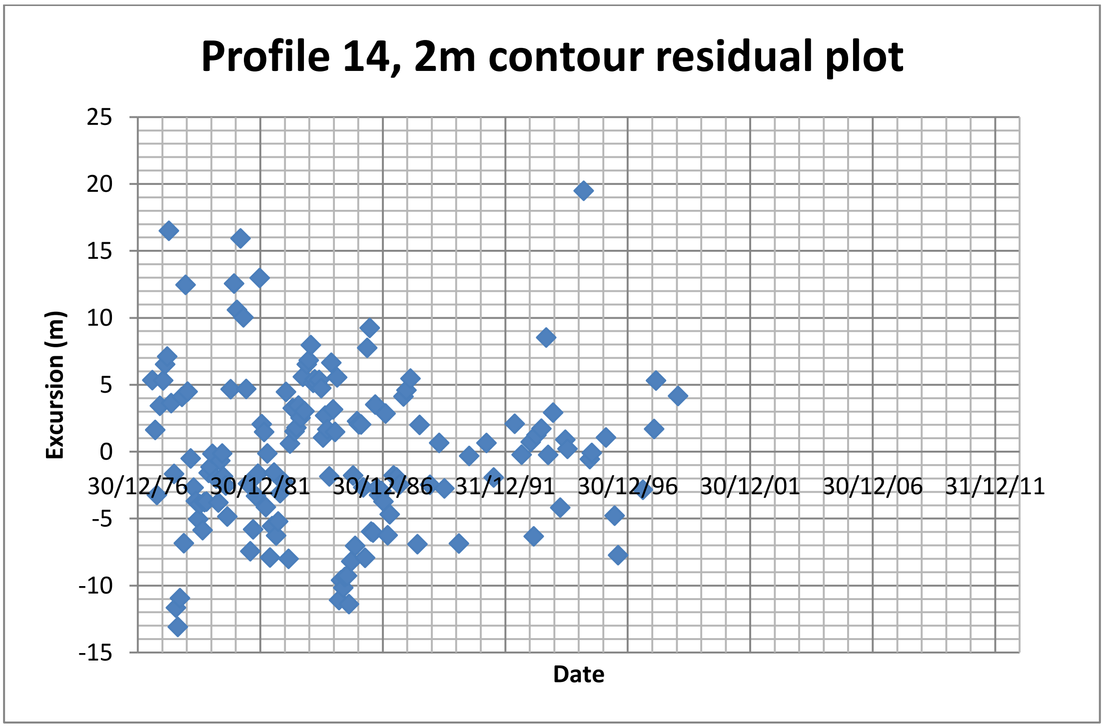


Figure 68 Profile 14, 2m contour residual plot

www.tonkin.co.nz

ENVIRONMENTAL AND ENGINEERING CONSULTANTS