# Shoreline Monitoring in Tory Channel and Queen Charlotte Sound

FINAL REPORT

November 2006 – April 2009

Report prepared for the Marlborough District Council

by

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## 1. Introduction

In an agreement between Marlborough District Council and Auckland UniServices Limited, dated 25 January 1997, Auckland UniServices Ltd, was engaged to establish and report on a shoreline monitoring programme in Tory Channel and Queen Charlotte Sound. Initially, the programme was for three years, involving six sets of surveys. Progress reports were provided every six months (following a survey of shoreline profiles), concluding with a final report in December 1999. The programme was then extended through to April 2002 with a further five surveys, concluding with a final report following the April 2002. A contract for a further two surveys (November 2002 and April 2003) was negotiated in late 2002. In November 2003 a new contract was negotiated with James Cook University, Australia for the analysis of surveys in November 2003, April 2004, November 2004, April 2005, November 2005 and April 2006, concluding with a summary report, following Dr Kevin Parnell's move to that University. In February 2007, an extension to the contract provided for the analysis of surveys undertaken in November 2006, April 2007, November 2007, April 2008, November 2008 and April 2009, followed by a summary report (this document).

Marlborough District Council entered into an agreement with Ayson and Partners, Surveyors, of Blenheim, to maintain the shoreline profiles and to undertake the required surveys, under the direction of Dr Kevin Parnell.

## 2. Profile locations and methods

Details of the selection of survey sites, establishment of profiles, benchmarks and datums, and survey methodology are in the final report of the first contract period. Profile descriptions are also in that report. The location of the 21 profiles is shown in Figure 1, and their positions are detailed in Table 1. Positions are with respect to the WGS84 ellipsoid. A list of currently used benchmarks and their levels is in Appendix 1. A visual impression of the profiles can be obtained from the photographs in Section 4 and in Appendix 2.

## Table 1: Profile positions

| Pr | Name | Lat ° | Lat ' | Lat " | Long° | Long ' | Long " |
|---|---|---|---|---|---|---|---|
| 1 | Picton Foreshore | 41 | 17 | 17.6 | 174 | 0 | 25.1 |
| 2 | The Snout at Picton Point | 41 | 15 | 46.5 | 174 | 2 | 10.9 |
| 3 | Double Bay | 41 | 13 | 10.3 | 174 | 11 | 36.7 |
| 4 | Ngaionui Bay (C Thomas) | 41 | 14 | 16.5 | 174 | 11 | 8.5 |
| 5 | Blackmore's at Waikawa | 41 | 15 | 50.0 | 174 | 2 | 58.2 |
| 6 | Moioio Island 2 | 41 | 14 | 39.4 | 174 | 12 | 56.9 |
| 7 | Moioio Island 1 | 41 | 14 | 39.6 | 174 | 12 | 56.3 |
| 8 | Bob's Bay | 41 | 16 | 31.3 | 174 | 1 | 1.0 |
| 9 | Te Awaiti | 41 | 12 | 28.8 | 174 | 17 | 16 |
| 10 | Tipi Bay | 41 | 13 | 40.2 | 174 | 17 | 12.8 |
| 11 | Long Island | 41 | 7 | 22.3 | 174 | 16 | 12.6 |
| 12 | Clark Point | 41 | 8 | 12.6 | 174 | 17 | 30.7 |
| 13 | Slip Beach | 41 | 15 | 0.0 | 174 | 9 | 8.3 |
| 14 | Ngaionui Point | 41 | 14 | 27.6 | 174 | 10 | 46.2 |
| 15 | Te Weka Bay | 41 | 14 | 58.3 | 174 | 11 | 34.0 |
| 16 | McMillan's Bay | 41 | 14 | 45.5 | 174 | 12 | 11.4 |
| 17 | McMillan's Side | 41 | 14 | 43.5 | 174 | 12 | 9.6 |
| 18 | Dieffenbach West | 41 | 14 | 13.4 | 174 | 8 | 9.4 |
| 19 | Curious Monkey | 41 | 14 | 28.8 | 174 | 6 | 14.4 |
| 20 | Patten's Passage | 41 | 10 | 56.9 | 174 | 15 | 47.4 |
| 21 | Blumine Island | 41 | 9 | 37.0 | 174 | 14 | 4.4 |

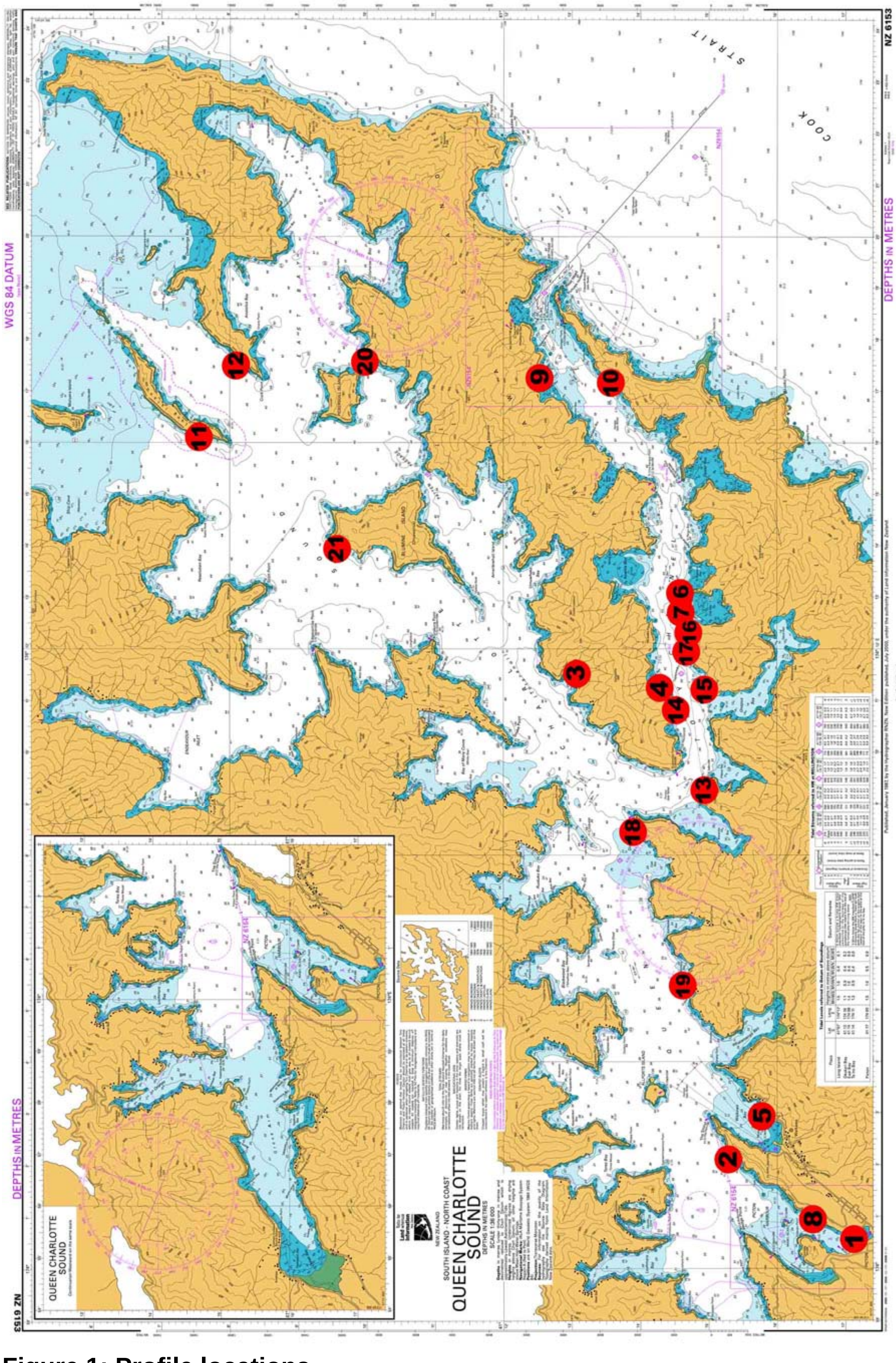



**Figure 1: Profile locations**

## 3. Vessel operations affecting the profile sites

Vessels carrying passengers and freight between Wellington and Picton, have operated the Tory Channel/Queen Charlotte Sound route for many years. In late 1994, fast vessel operations started using the route alongside the conventional ferries. Until 2000, various fast ferries operated over the summer months, after which an almost continuous service using fast vessels ran until April 2005. However, in December 2000 the Marlborough District Council enacted a bylaw that had the effect of slowing fast ferries to 18 knots while in the Sounds, so after that time the fast ferries operated at their normal service speed only outside the Marlborough Sounds. The Bylaw did not apply to conventional vessels. Fast ferries have not operated on the Wellington – Picton route since early 2005. Figure 2 shows the time periods over which various vessels have operated. Other vessels, both large and small, also use the route.

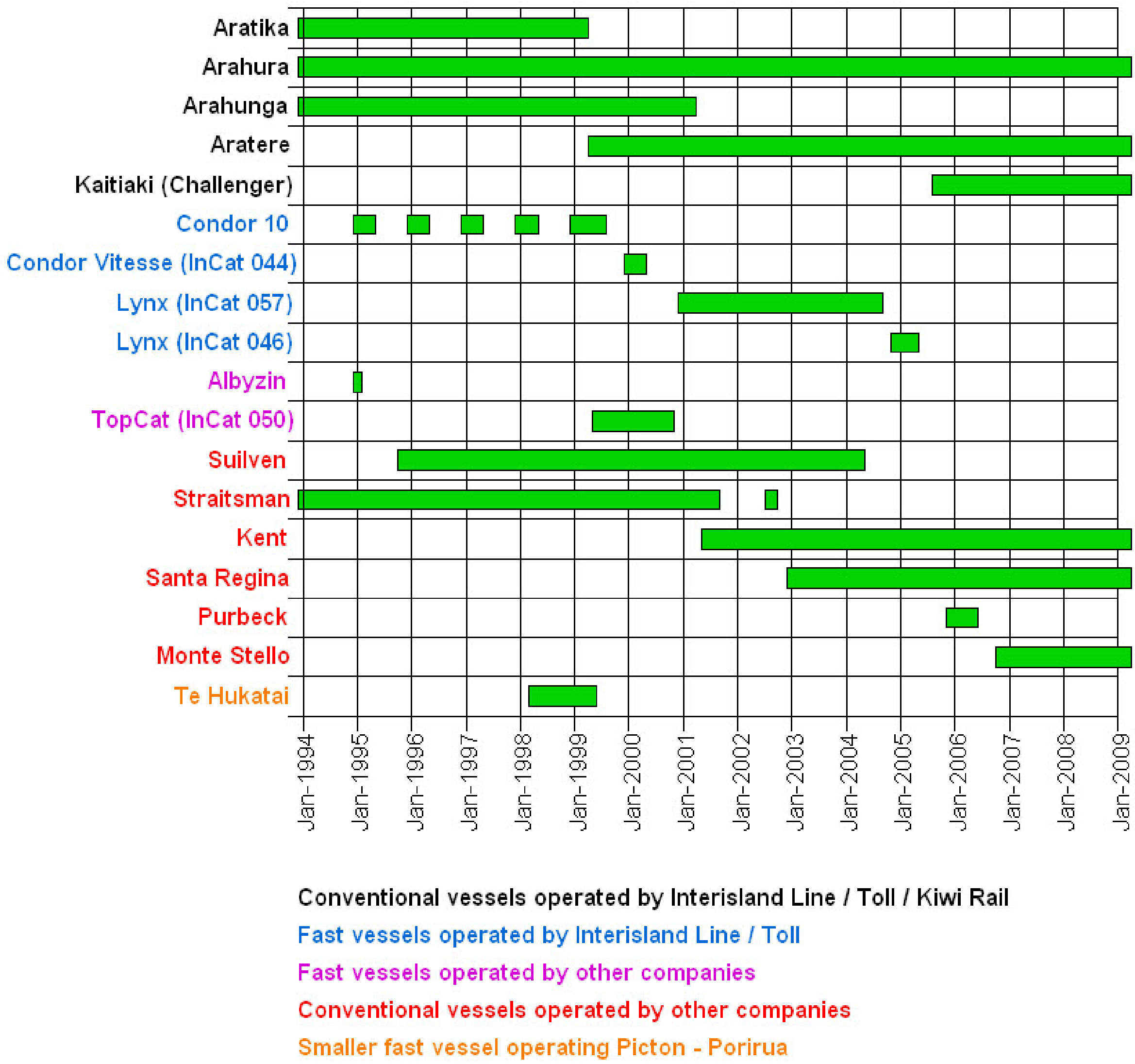


**Figure 2: Vessels using the Tory Channel/Queen Charlotte Sound route on regular inter-island services**

## 4. Profile analyses

In this section, data are presented for each profile and along with an interpretation of the changes that have occurred. Each profile analysis is accompanied by three pages of figures. The first page has photographs of the profile site taken from about 20 meters each side looking back towards the profile line (taken in April 2009) at the top. At the bottom of the first page is a diagram of profile lines at the start of the monitoring programme in April 1997, the end of the first contract (November 1999), the end of the second contract period (April 2002), the end of the third contract(May 2006), and at the end of the current contract (April 2009) . The second page comprises a 'spaghetti' diagram showing the 25 surveys of the profiles (April 1997, November 1997, April 1998, November 1998, April 1999, November 1999, April/May 2000, November 2000, June 2001, November 2001 and April 2002, November 2002, April 2003, November 2003, April 2004, November 2004, April 2005, November 2005, May 2006, November 2006, April 2007, November 2007, April 2008, November 2008, April 2009) in the upper section, and in the lower section, a different view of the same data commonly known as an 'Excursion Distance Analysis'. The final page shows beach volume data ($m^3$ per linear meter of beach) presented as a graph and a table. The limits for the calculations are determined as shown in Figure 3 and Table 2. The upper beach limit was a point on the upper beach landward of any profile change (if possible) or at the upper limit of the profile measurement. Because changes at the lower beach can indicate erosion, a measurement based on elevation is appropriate. This was taken at profile closure depth if this was evident, or at a point which was reached on most surveys. Where a profile did not reach the chosen lower limit, a value was estimated based on linear extrapolation or on values measured before and after a missing data point.

**Table 2: Volume calculation limits**

| Prof. | Name | Upper beach limit (m) | Lower beach limit (m) |
|---|---|---|---|
| 1 | Picton Foreshore | 6.87 | -0.50 |
| 2 | The Snout at Picton Point | 0.00 | -1.00 |
| 3 | Double Bay | -1.50 | -1.00 |
| 4 | Ngaionui Bay (C Thomas) | -2.00 | -0.25 |
| 5 | Blackmore's at Waikawa | 2.30 | -0.75 |
| 6 | Moioio Island 2 | -2.00 | -1.50 |
| 7 | Moioio Island 1 | 0.00 | -1.50 |
| 8 | Bob's Bay | 0.00 | -1.00 |
| 9 | Te Awaiti | 0.30 | -1.50 |
| 10 | Tipi Bay | 0.00 | -1.25 |
| 11 | Long Island | 0.00 | -0.75 |
| 12 | Clark Point | 0.00 | -0.25 |
| 13 | Slip Beach | -1.00 | -1.25 |
| 14 | Ngaionui Point | -2.00 | -0.75 |
| 15 | Te Weka Bay | 2.00 | -1.50 |
| 16 | McMillan's Bay | 0.00 | -0.75 |
| 17 | McMillan's Side | -2.00 | -0.75 |
| 18 | Dieffenbach West | 0.00 | -0.50 |
| 19 | Curious Monkey | 0.00 | -0.50 |
| 20 | Patten's Passage | 0.00 | -0.50 |
| 21 | Blumine Island | 0.00 | -0.50 |

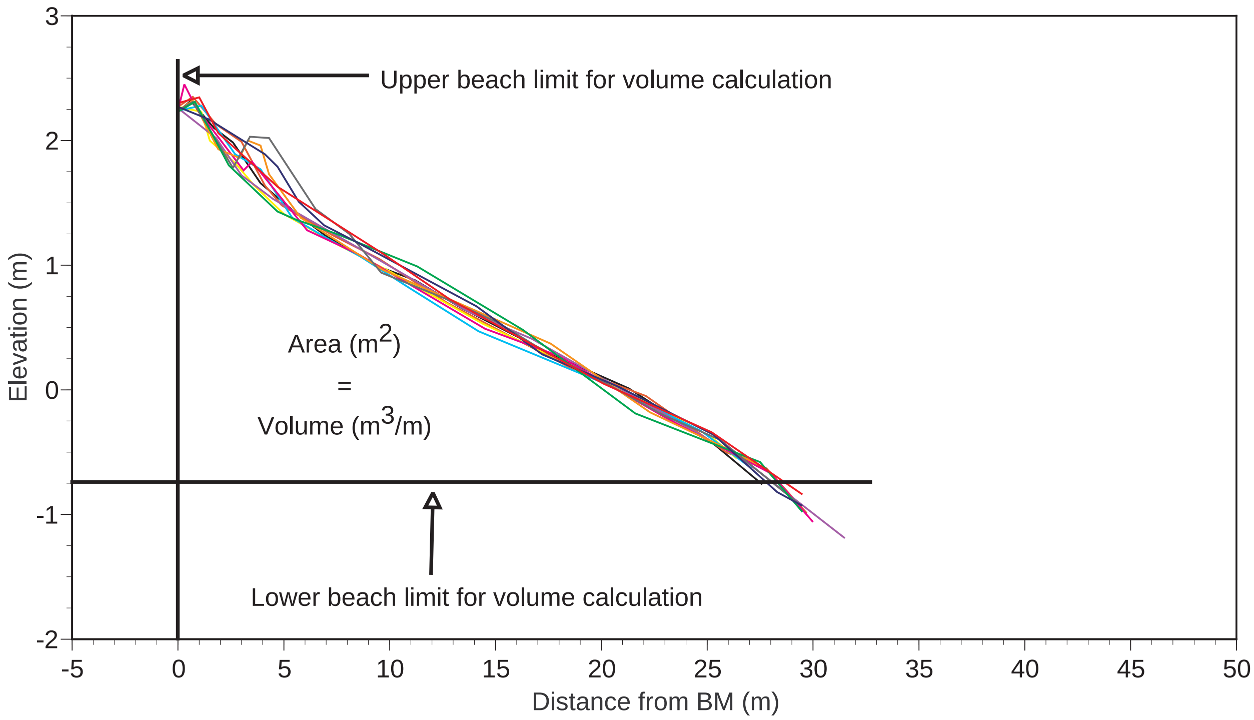
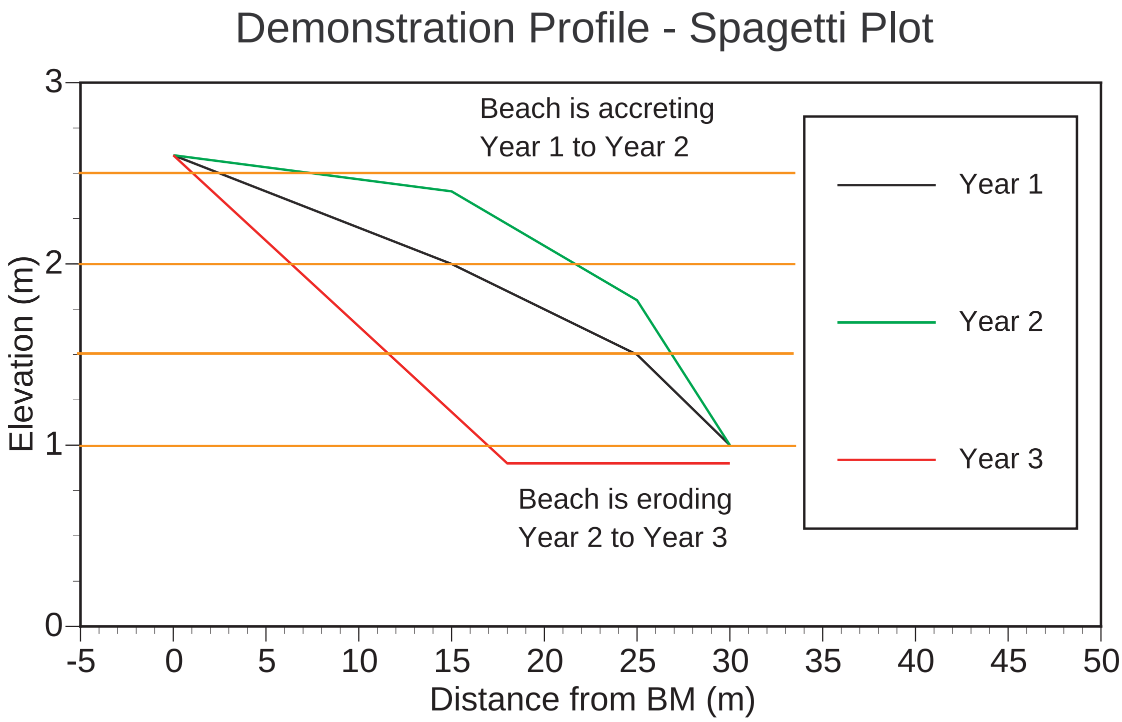



**Figure 3: Volume calculation methodology**

The ‘spaghetti’ plots of profiles are useful for establishing envelopes of change of the beach shape, but interpretations of changes which have occurred are difficult, due to the clutter of lines that are present. As the data set grows, any useful interpretation based on these plots becomes almost impossible. Excursion distance plots use exactly the same data plotted as a time series, and makes interpretation of beach changes easier. Excursion distance analysis is a method by which three dimensional data sets (distance, height and time) can be illustrated as two dimensional plots. It can be undertaken with either distance or height on the vertical axis, although having distance on the vertical axis is more useful for most purposes. Excursion distances are calculated by determining a set of height values for which calculations will be made. These values are normally equally spaced and in the following figures, are shown in the box on the right hand side of the graph. These numbers are in units of metres above or below the datum (in this case approximate MSL). Using linear interpolation the horizontal distance from the datum is calculated for each of the height values, and these are plotted as a time series with time on the horizontal axis. For each survey this provides a “point contour map” of the profile, and when plotted as a time series, an indication of how levels change through time. The graphs provide a lot of information. If two lines converge, the beach is getting steeper at those contour heights. If two lines diverge, the beach is getting flatter. If the lines trend seaward (increasing values on the distance axis), the beach is accreting. If the lines trend landward, the beach is eroding. Figure 4 attempts to show the methodology of Excursion Distance Analysis.



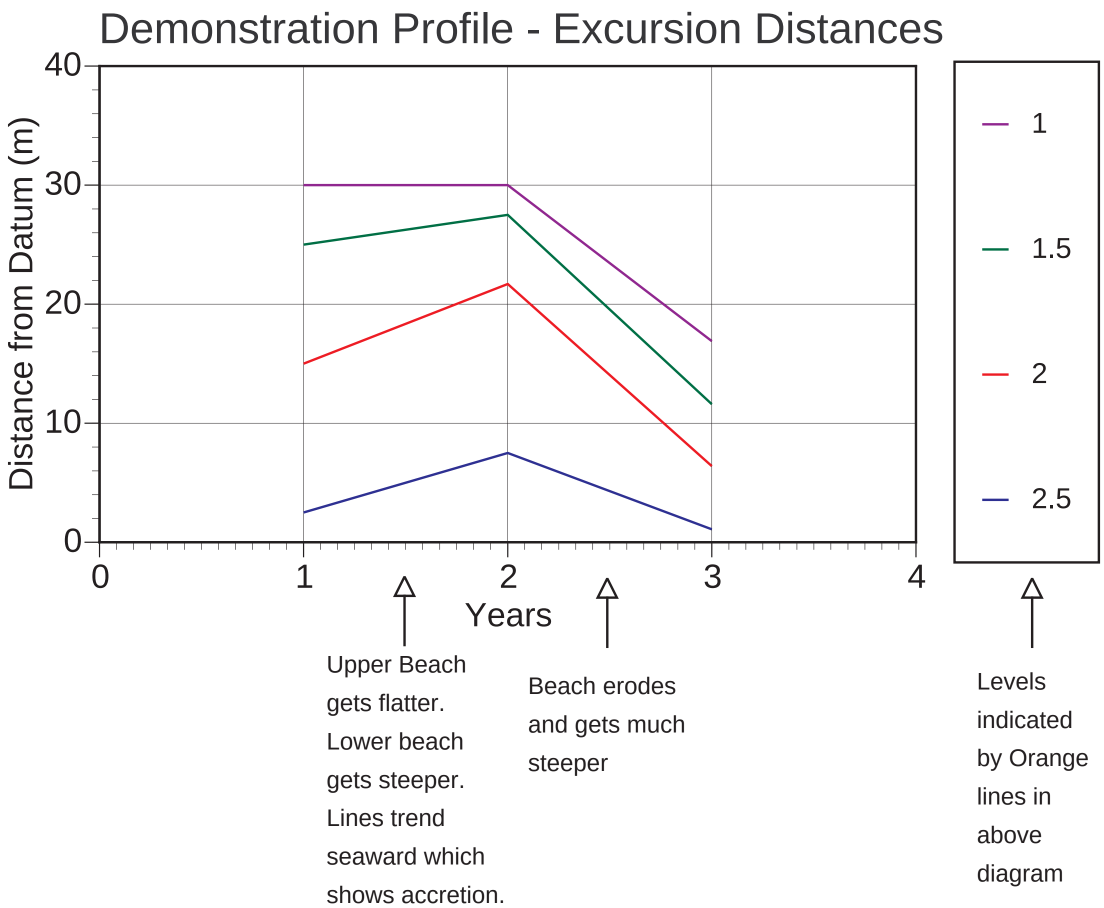
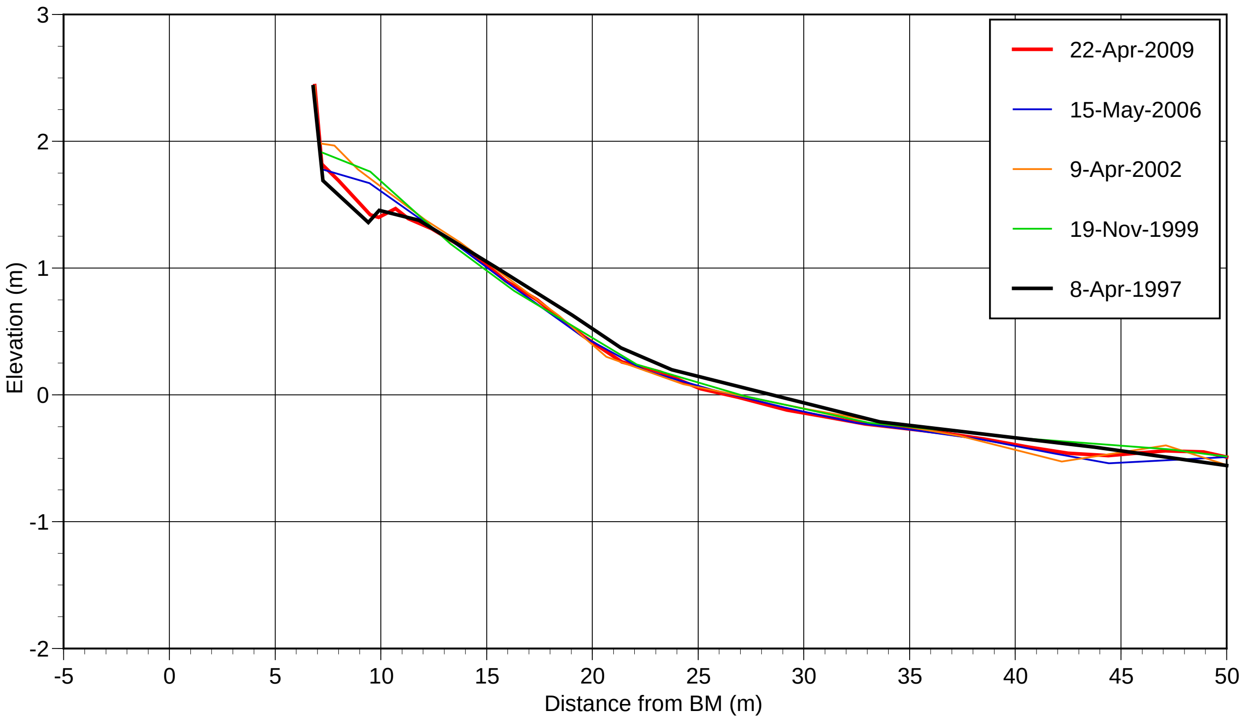




**Figure 4 : Excursion Distance Analysis  Demonstration**

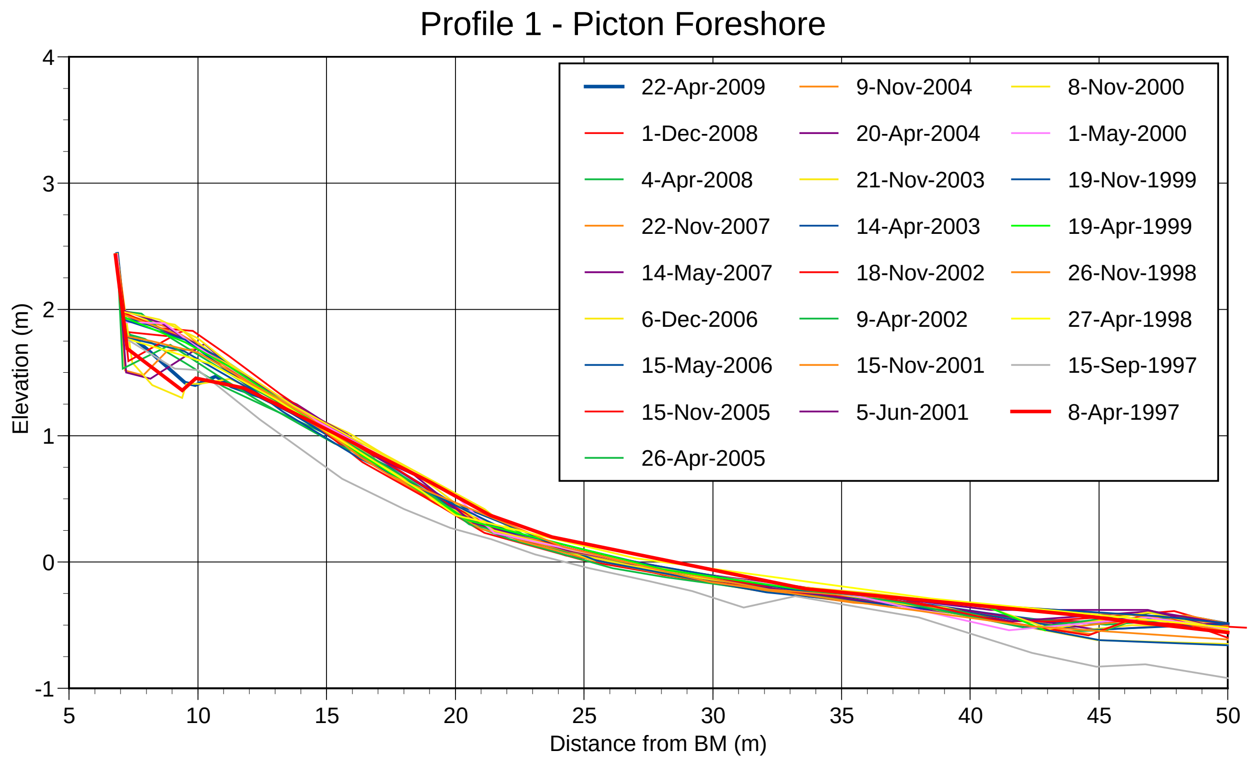
## *Profile 1 – Picton Foreshore*

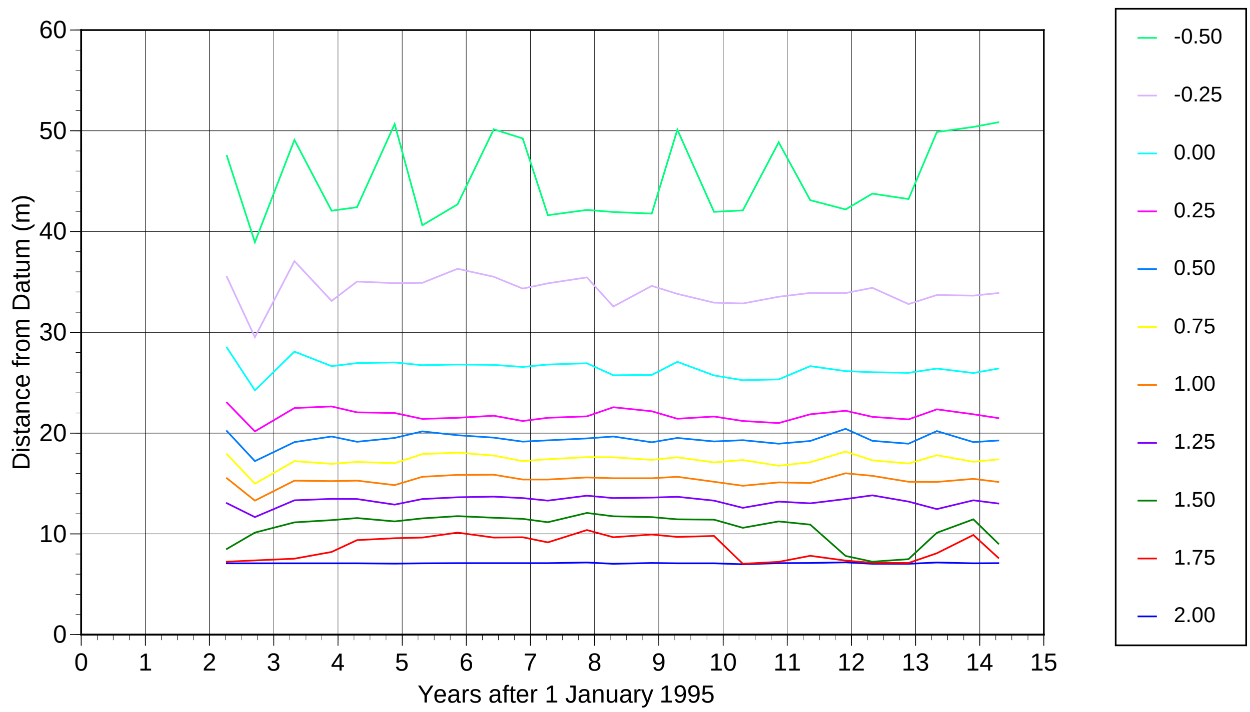
The Picton Foreshore underwent extensive modification with the improvement of the landward side of the retaining wall in late 1997. Sediments on the beach comprise both natural marine sediments and river sand deposited in a beach nourishment programme.

I do not know if further nourishment has taken place since late 1997 or early 1998. If further nourishment has taken place, then the rate of nourishment is clearly appropriate. If there has been no renourishment, then the beach has been very stable since that time. Beach volume has maintained a relatively narrow range since April 1998, between 29.1 $m^3/m$ and 32.9 $m^3/m$. There has been no apparent change in sediment characteristics. There is no indication that the seawall has had an adverse effect on beach stability. There is no indication that waves caused by vessel wash in the inner harbour are having an adverse effect on the Picton foreshore beach.

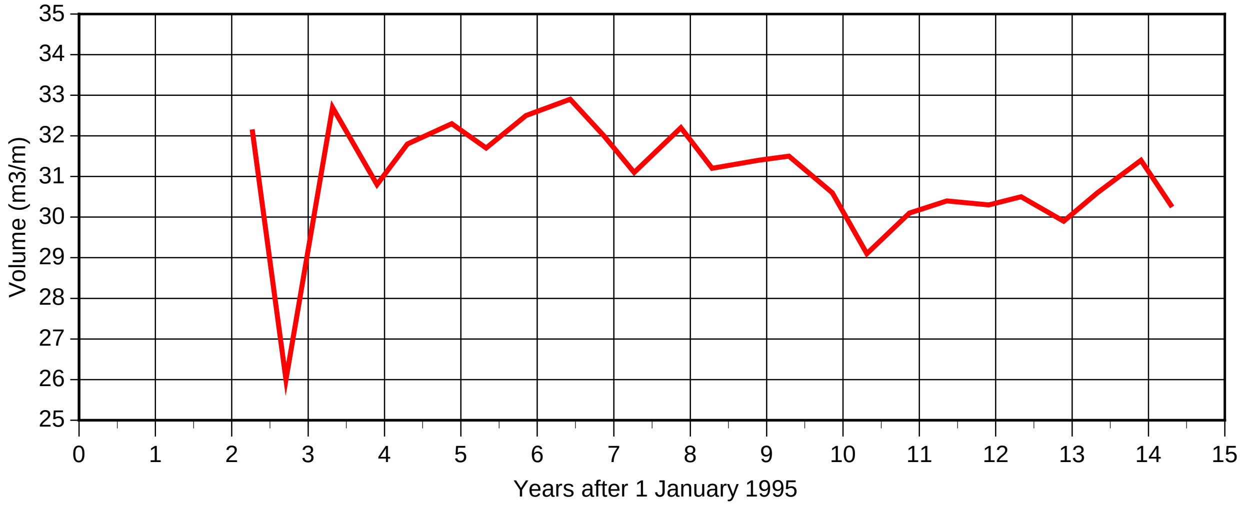



**Profile 1: Picton Foreshore**




**Profile 1: Picton Foreshore**

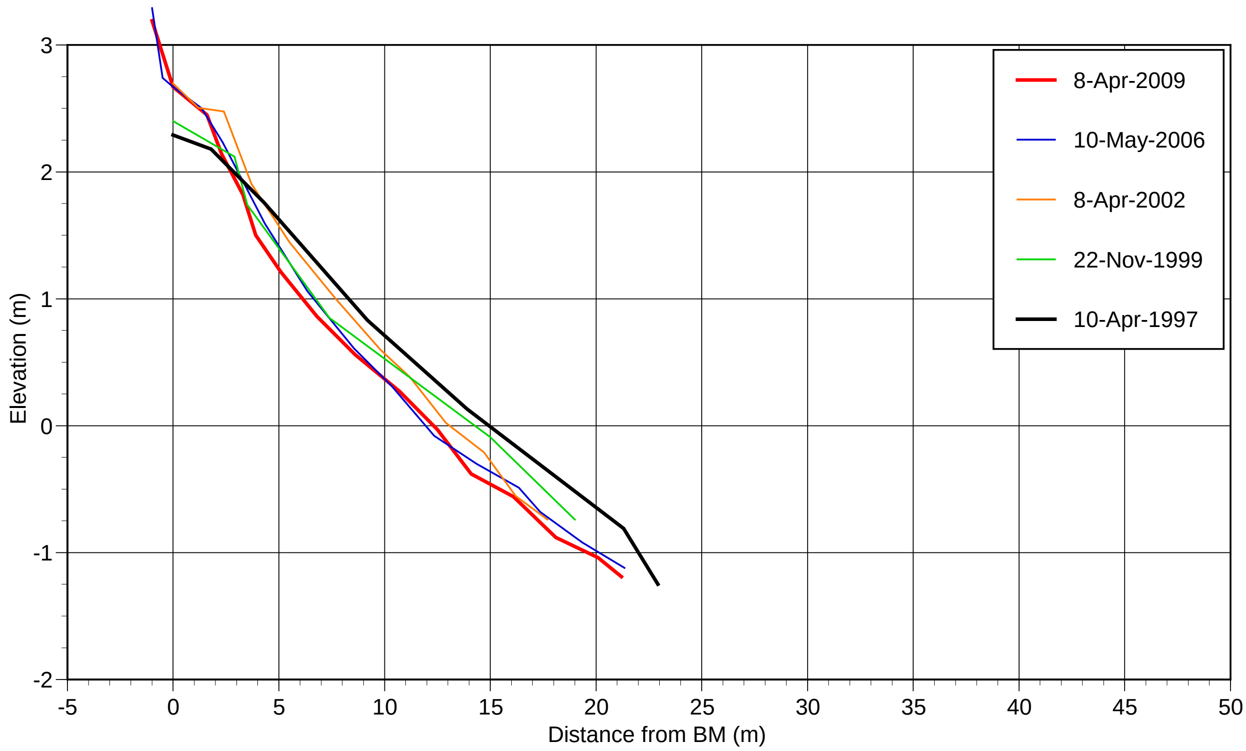



| Date | Years after 1/1/95 | Volume ($m^3$/m) |
|---|---|---|
| 8-Apr-97 | 2.27 | 32.1 |
| 15-Sep-97 | 2.71 | 26.0 |
| 27-Apr-98 | 3.32 | 32.7 |
| 26-Nov-98 | 3.90 | 30.8 |
| 19-Apr-99 | 4.30 | 31.8 |
| 19-Nov-99 | 4.88 | 32.3 |
| 1-May-00 | 5.33 | 31.7 |
| 8-Nov-00 | 5.85 | 32.5 |
| 5-Jun-01 | 6.43 | 32.9 |
| 15-Nov-01 | 6.87 | 32.0 |
| 9-Apr-02 | 7.27 | 31.1 |
| 18-Nov-02 | 7.88 | 32.2 |
| 14-Apr-03 | 8.29 | 31.2 |
| 21-Nov-03 | 8.89 | 31.4 |
| 20-Apr-04 | 9.29 | 31.5 |
| 9-Nov-04 | 9.86 | 30.6 |
| 26-Apr-05 | 10.31 | 29.1 |
| 15-Nov-05 | 10.87 | 30.1 |
| 15-May-06 | 11.36 | 30.4 |
| 06-Dec-06 | 11.91 | 30.3 |
| 14-May-07 | 12.33 | 30.5 |
| 22-Nov-07 | 12.89 | 29.9 |
| 04-Apr-08 | 13.33 | 30.6 |
| 01-Dec-08 | 13.90 | 31.4 |
| 22-Apr-09 | 14.29 | 30.3 |

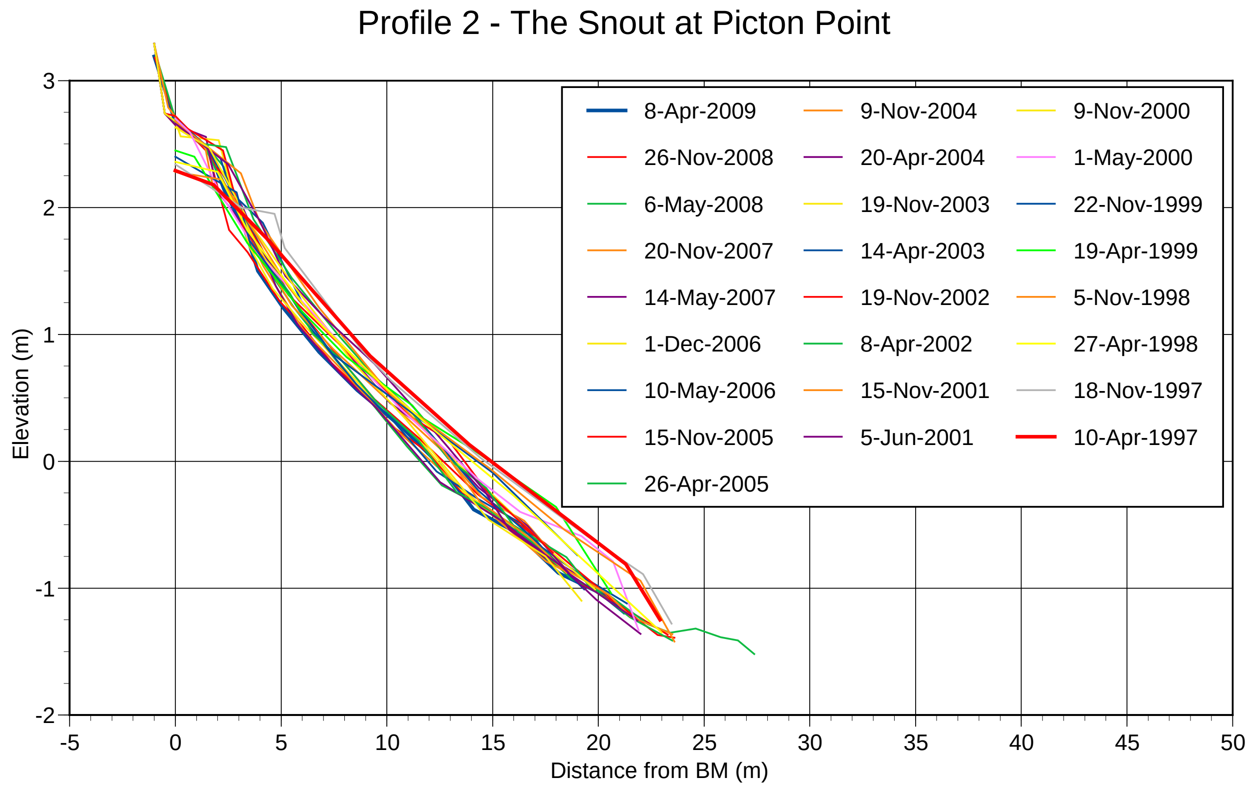
**Profile 1: Picton Foreshore**

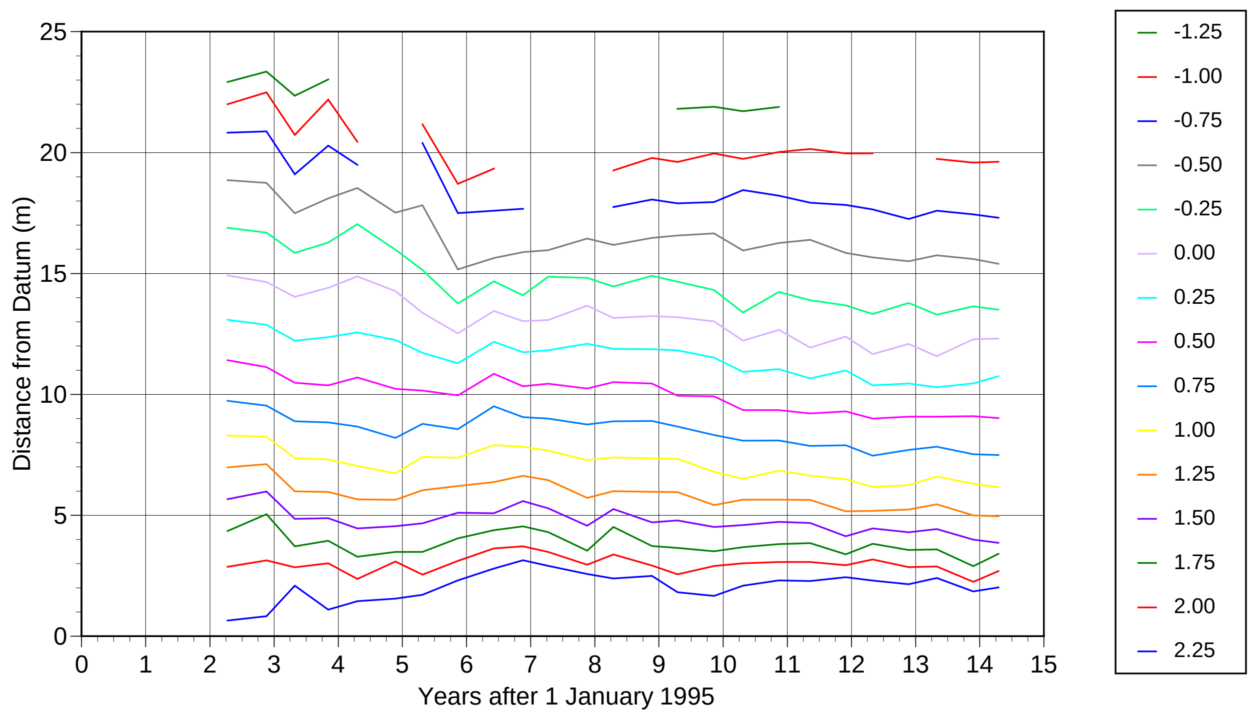
*Profile 2 – The Snout at Picton Point*

Since April 1997, the profile has retreated and significantly steeped, seen particularly by the convergence of lines on the EDA plots. The major cause has been the slow migration of the deepwater channel in a shoreward direction. Beach volumes have followed an almost linear trend of loss over the same period, with the loss of over $6m^3/m$. There have been no apparent changes to sediment composition. The reason for the channel migration is not clear, although the site does receive considerable wake energy.

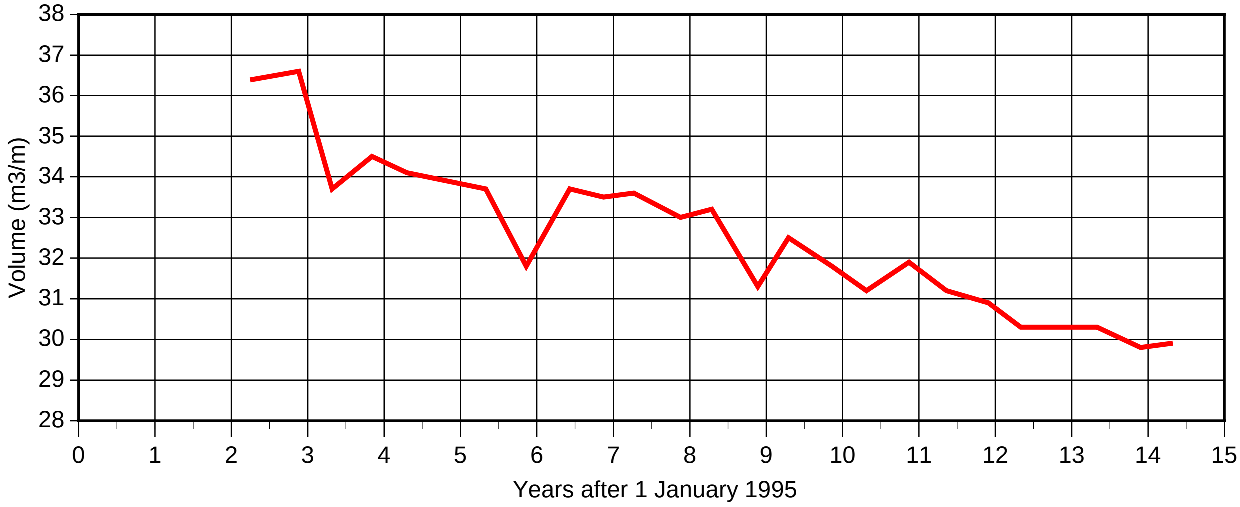



**Profile 2: The Snout at Picton Point**




**Profile 2: The Snout at Picton Point**

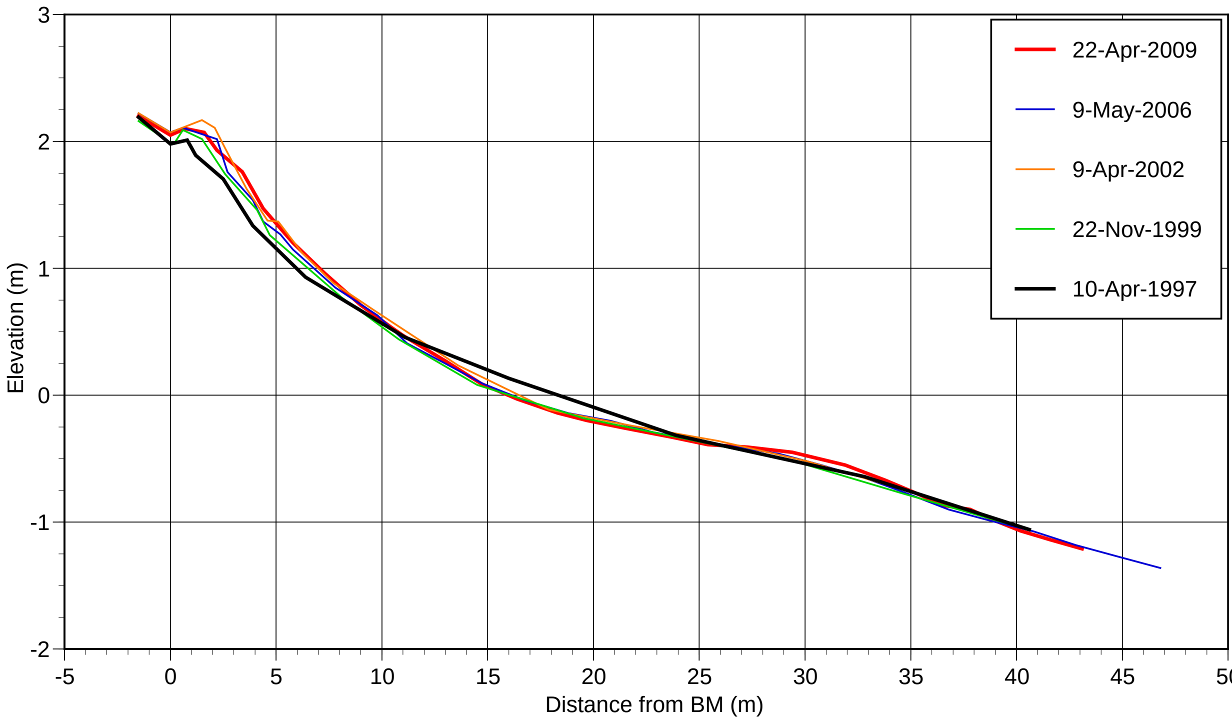



| Date | Years after 1/1/95 | Volume ($m^3$/m) |
|---|---|---|
| 10-Apr-97 | 2.28 | 36.4 |
| 18-Nov-97 | 2.88 | 36.6 |
| 27-Apr-98 | 3.32 | 33.7 |
| 5-Nov-98 | 3.84 | 34.5 |
| 19-Apr-99 | 4.30 | 34.1 |
| 1-May-00 | 5.33 | 33.7 |
| 1-May-00 | 5.33 | 33.7 |
| 9-Nov-00 | 5.86 | 31.8 |
| 5-Jun-01 | 6.43 | 33.7 |
| 15-Nov-01 | 6.87 | 33.5 |
| 8-Apr-02 | 7.27 | 33.6 |
| 19-Nov-02 | 7.88 | 33.0 |
| 14-Apr-03 | 8.29 | 33.2 |
| 19-Nov-03 | 8.89 | 31.3 |
| 20-Apr-04 | 9.29 | 32.5 |
| 9-Nov-04 | 9.86 | 31.8 |
| 26-Apr-05 | 10.31 | 31.2 |
| 15-Nov-05 | 10.87 | 31.9 |
| 01-Dec-06 | 11.91 | 30.9 |
| 14-May-07 | 12.33 | 30.3 |
| 20-Nov-07 | 12.89 | 30.3 |
| 06-May-08 | 13.33 | 30.3 |
| 26-Nov-08 | 13.90 | 29.8 |
| 08-Apr-09 | 14.29 | 29.9 |

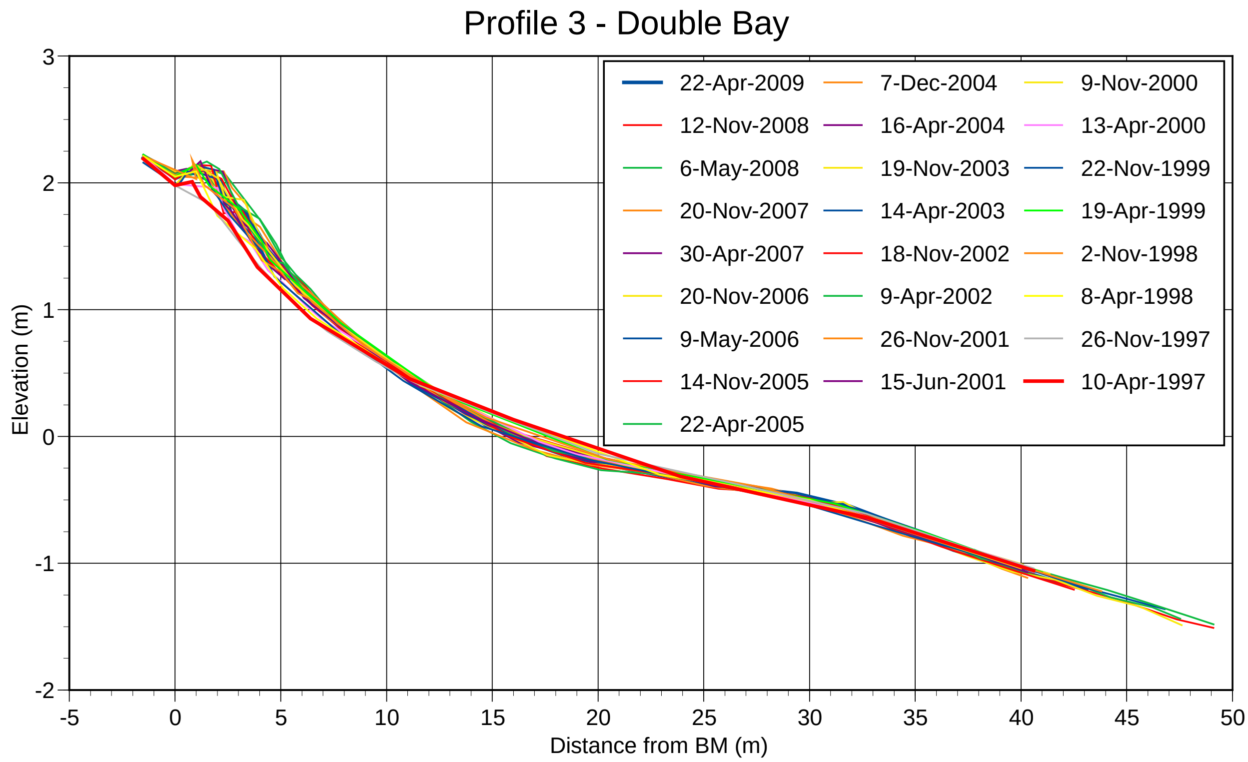
**Profile 2: The Snout at Picton Point**

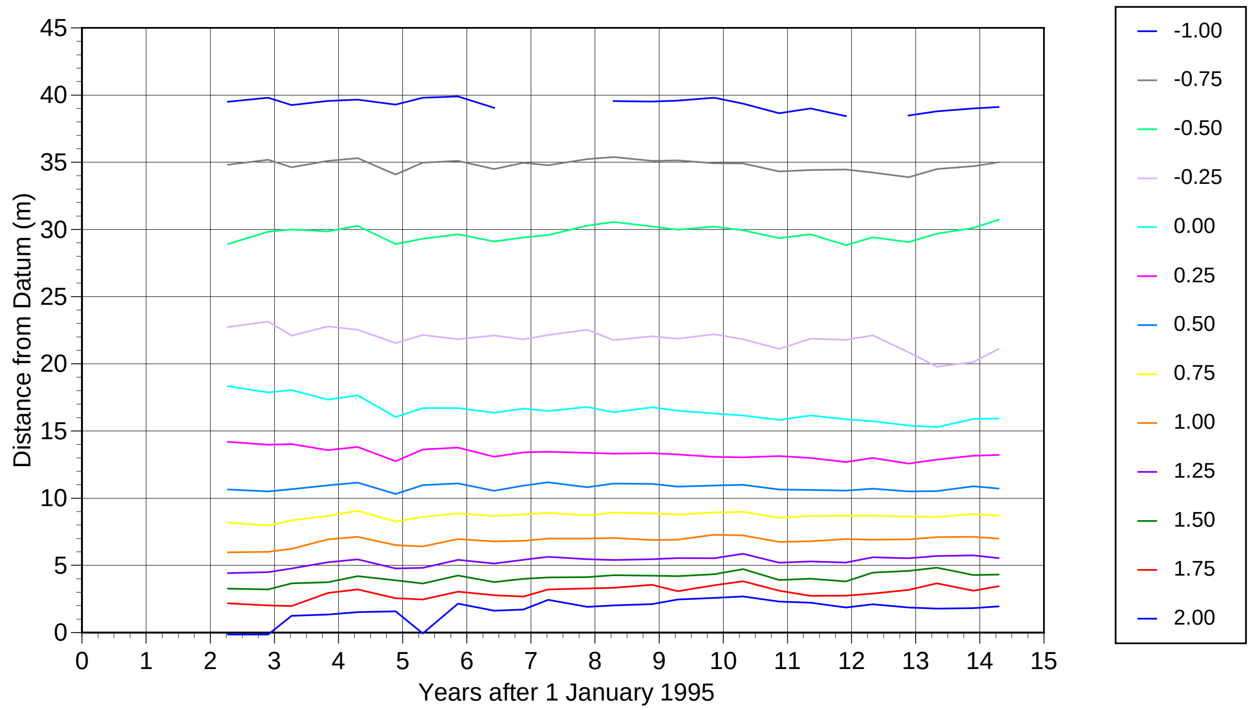
### *Profile 3 – Double Bay*

The Double Bay beach profile has changed within a very narrow range over the period April 1997 to April 2009. The most recent profile data sits close to the centre of the long-term sweep, with beach volume in 2009 being almost the same as it was in April 1997. There has been a minor steeping of the beach with the construction of a berm and a minor lowering of the mid-beach surface, although this peaked in 2002, and there may be an erosion trend developing. The profiles clearly reach closure depth at about -0.5m. In recent times, a (very thin) fining of the surficial sediment appears to have reversed.

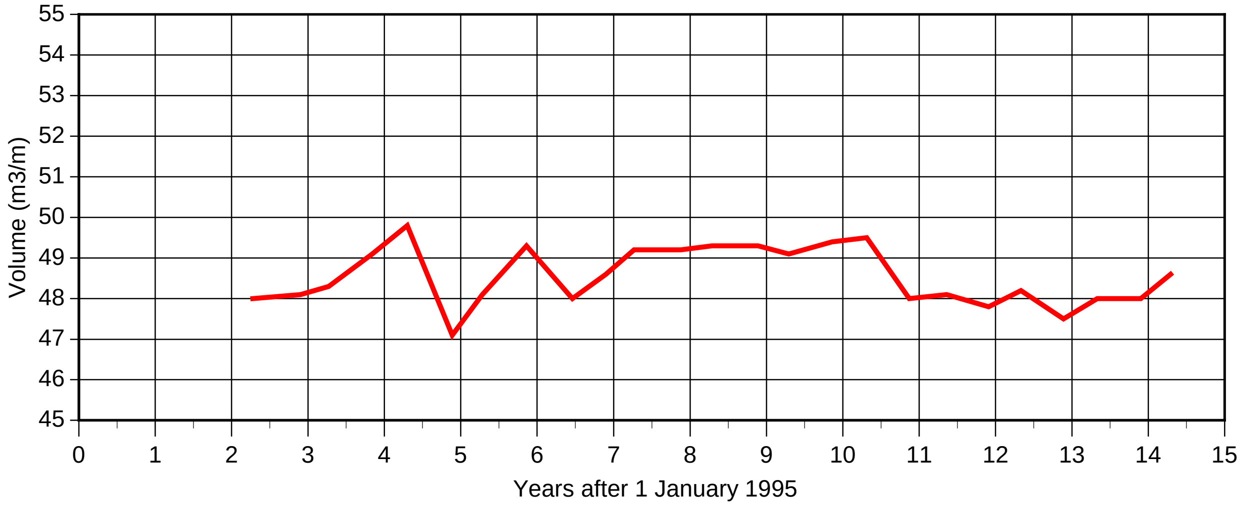



**Profile 3: Double Bay**




**Profile 3: Double Bay**

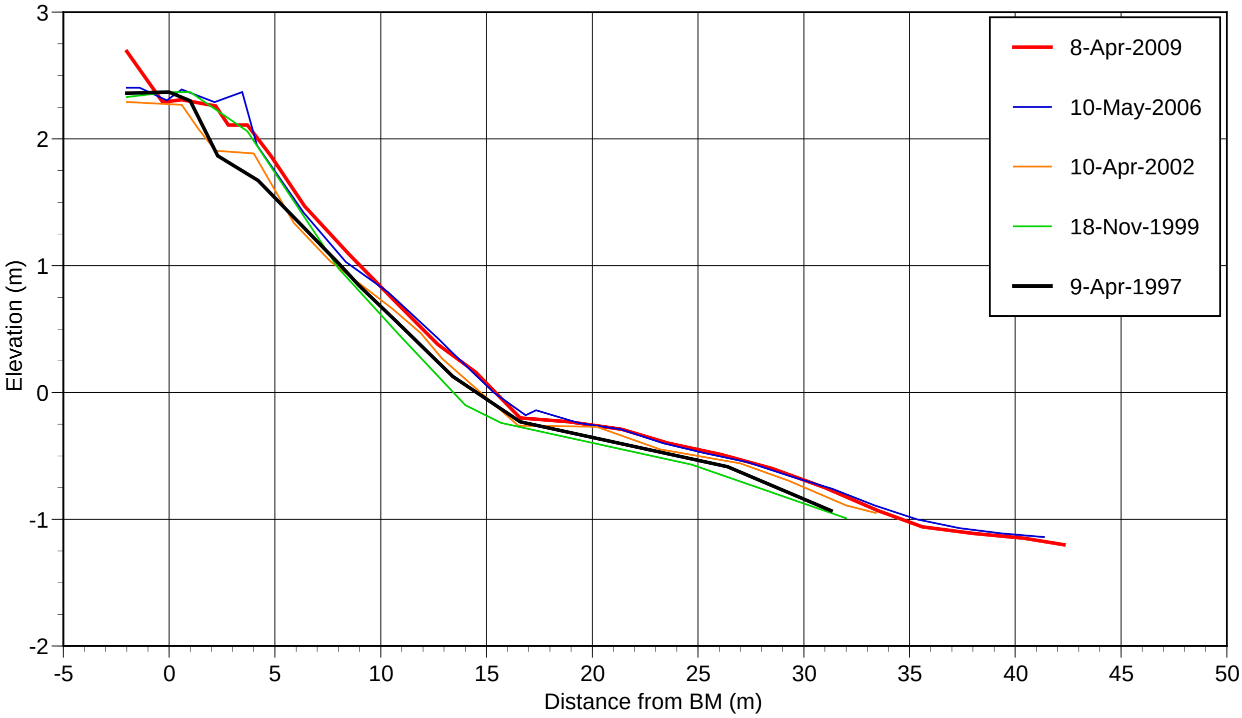



| Date | Years after 1/1/95 | Volume ($m^3$/m) |
|---|---|---|
| 10-Apr-97 | 2.28 | 48.0 |
| 26-Nov-97 | 2.90 | 48.1 |
| 8-Apr-98 | 3.27 | 48.3 |
| 2-Nov-98 | 3.84 | 49.1 |
| 19-Apr-99 | 4.30 | 49.8 |
| 22-Nov-99 | 4.89 | 47.1 |
| 13-Apr-00 | 5.28 | 48.1 |
| 9-Nov-00 | 5.86 | 49.3 |
| 15-Jun-01 | 6.46 | 48.0 |
| 26-Nov-01 | 6.90 | 48.6 |
| 9-Apr-02 | 7.27 | 49.2 |
| 18-Nov-02 | 7.88 | 49.2 |
| 14-Apr-03 | 8.29 | 49.3 |
| 19-Nov-03 | 8.89 | 49.3 |
| 16-Apr-04 | 9.29 | 49.1 |
| 7-Dec-04 | 9.86 | 49.4 |
| 22-Apr-05 | 10.31 | 49.5 |
| 14-Nov-05 | 10.87 | 48.0 |
| 9-May-06 | 11.36 | 48.1 |
| 20-Nov-06 | 11.91 | 47.8 |
| 30-Apr-07 | 12.33 | 48.2 |
| 20-Nov-07 | 12.89 | 47.5 |
| 06-May-08 | 13.33 | 48.0 |
| 12-Nov-08 | 13.90 | 48.0 |
| 22-Apr-09 | 14.29 | 48.6 |

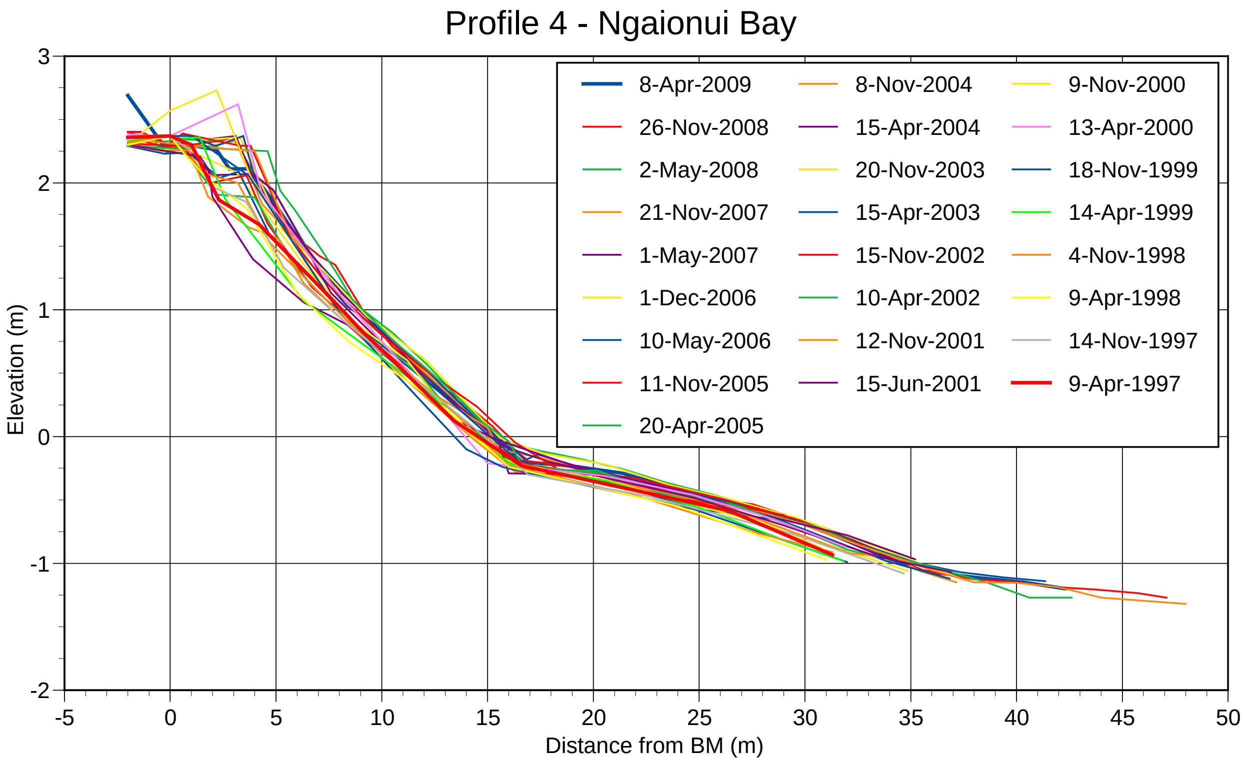
**Profile 3: Double Bay**

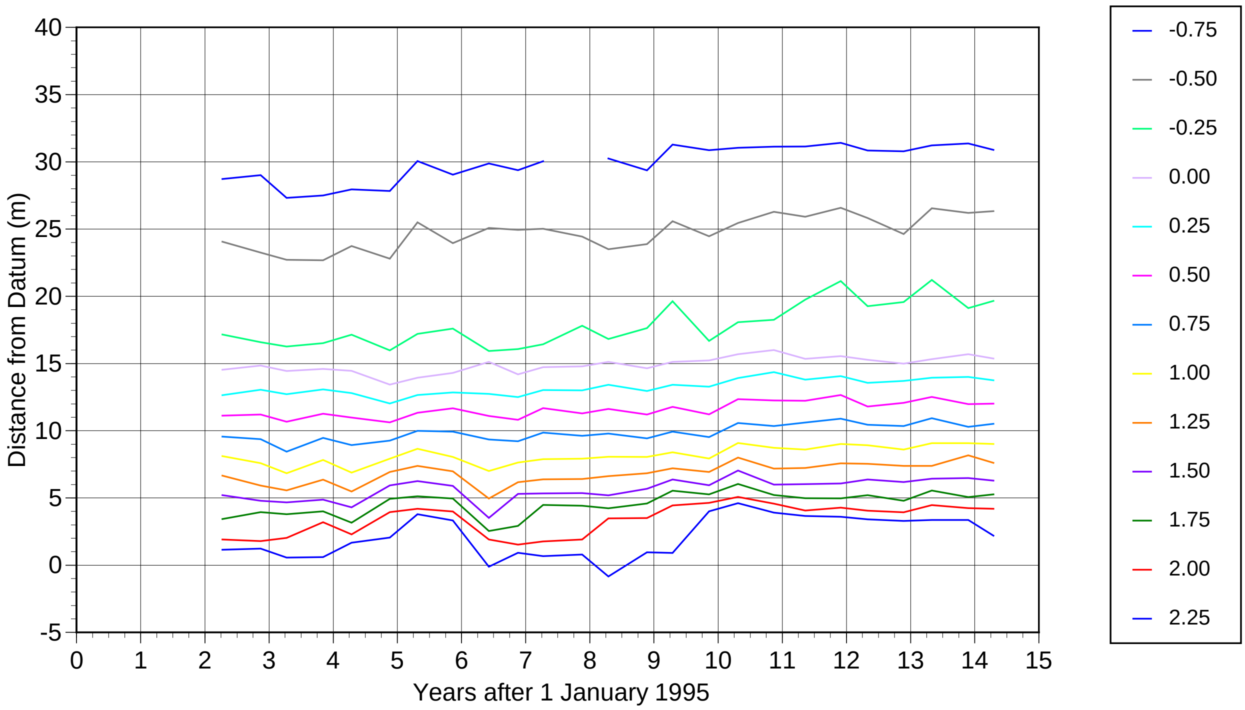
*Profile 4 – Ngaionui Bay*

The long-term history of this site has been discussed in previous reports. The site is complicated by relatively frequent human modifications (although the nature of any works and their frequency in recent times is not known). It is also complicated by the presence of a landslide at the western end of the beach, with sediment redistribution within the compartment. It was very clear that fast ferry operation contributed to significant beach accretion, and that all wakes and natural processes, coinciding with a sediment supply from the slip, have all contributed to slow beach building. However, since 2006, the beach has been relatively stable, with minor adjustments to the beach berm. Since 2006, beach volume has varied little.

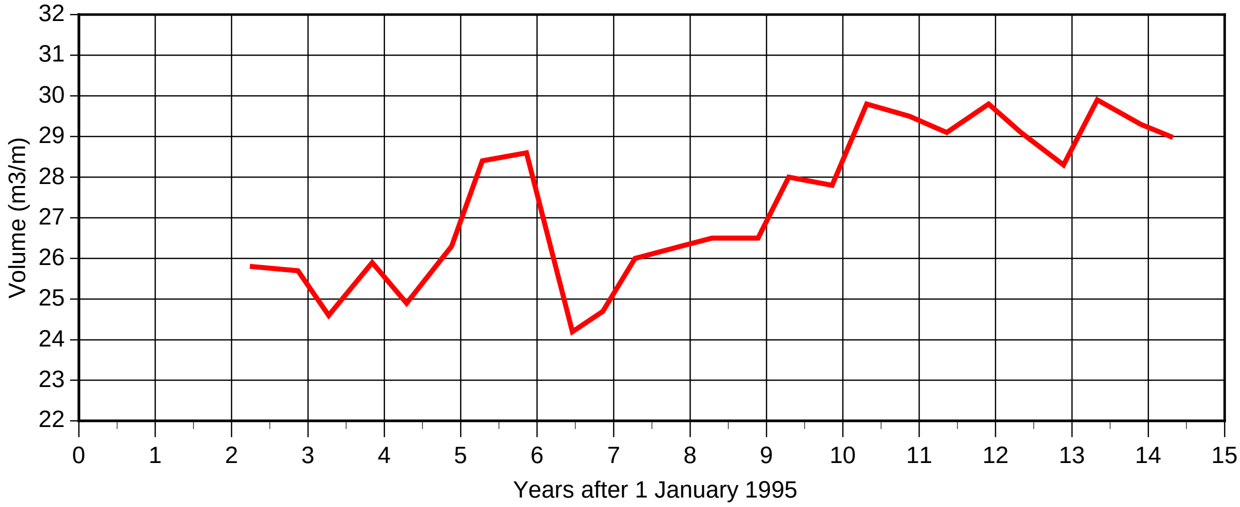



**Profile 4: Ngaionui Bay**




**Profile 4: Ngaionui Bay**

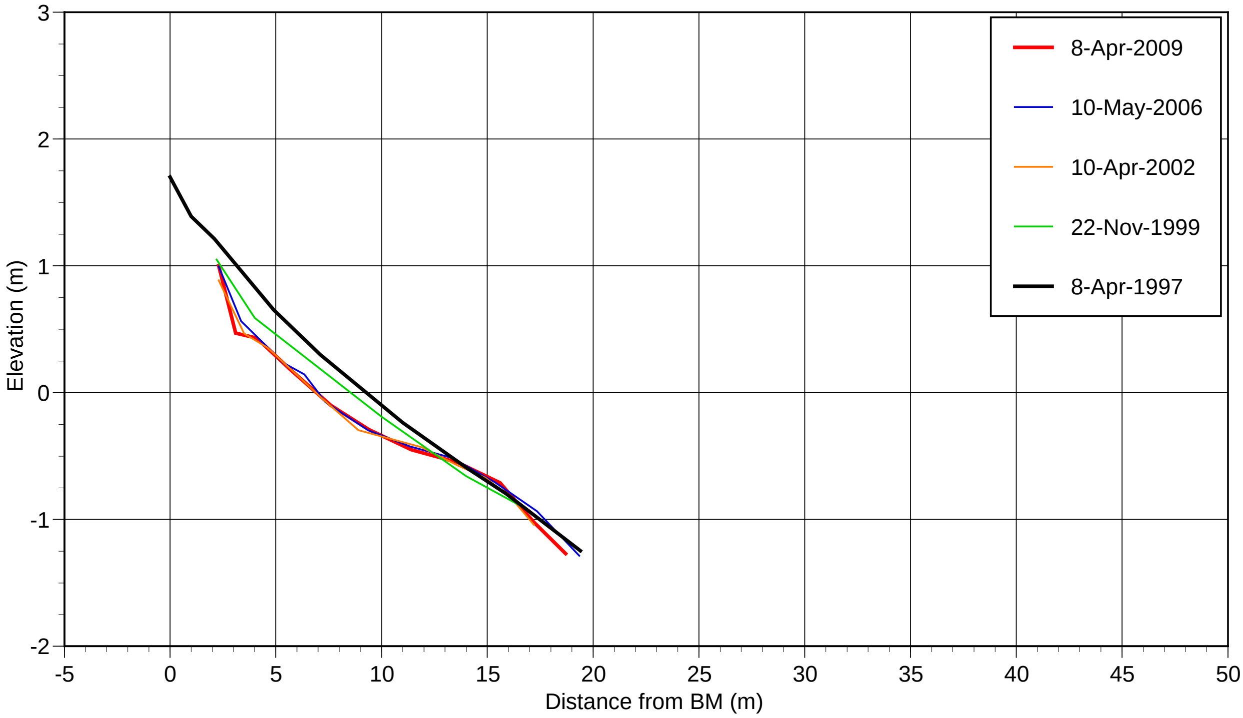



| Date | Years after 1/1/95 | Volume ($m^3$/m) |
|---|---|---|
| 9-Apr-97 | 2.27 | 25.8 |
| 14-Nov-97 | 2.87 | 25.7 |
| 9-Apr-98 | 3.27 | 24.6 |
| 4-Nov-98 | 3.84 | 25.9 |
| 14-Apr-99 | 4.29 | 24.9 |
| 18-Nov-99 | 4.88 | 26.3 |
| 13-Apr-00 | 5.28 | 28.4 |
| 9-Nov-00 | 5.86 | 28.6 |
| 15-Jun-01 | 6.46 | 24.2 |
| 12-Nov-01 | 6.86 | 24.7 |
| 10-Apr-02 | 7.28 | 26.0 |
| 15-Nov-02 | 7.88 | 26.3 |
| 15-Apr-03 | 8.29 | 26.5 |
| 20-Nov-03 | 8.89 | 26.5 |
| 15-Apr-04 | 9.29 | 28.0 |
| 8-Nov-04 | 9.86 | 27.8 |
| 20-Apr-05 | 10.31 | 29.8 |
| 11-Nov-05 | 10.87 | 29.5 |
| 10-May-06 | 11.36 | 29.1 |
| 01-Dec-06 | 11.91 | 29.8 |
| 01-May-07 | 12.33 | 29.1 |
| 21-Nov-07 | 12.89 | 28.3 |
| 02-May-08 | 13.33 | 29.9 |
| 26-Nov-08 | 13.90 | 29.3 |
| 08-Apr-09 | 14.29 | 29.0 |

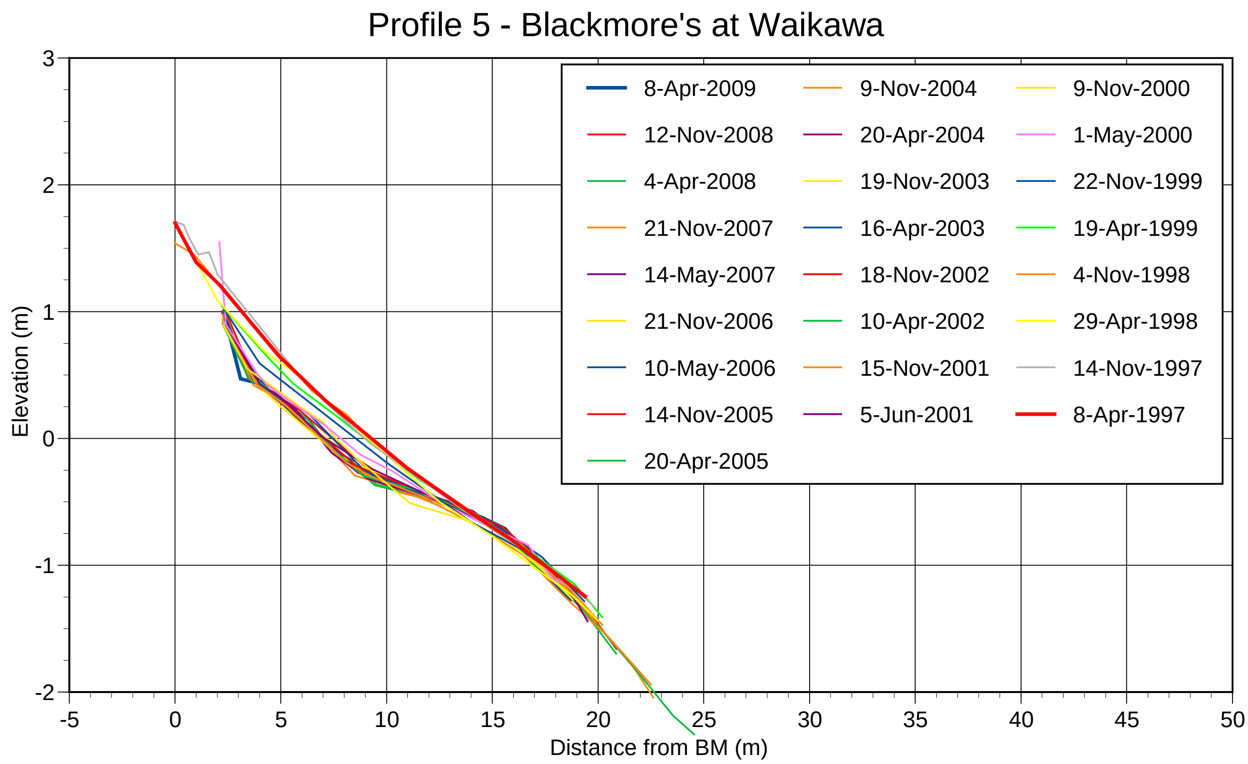
**Profile 4: Ngaionui Bay**

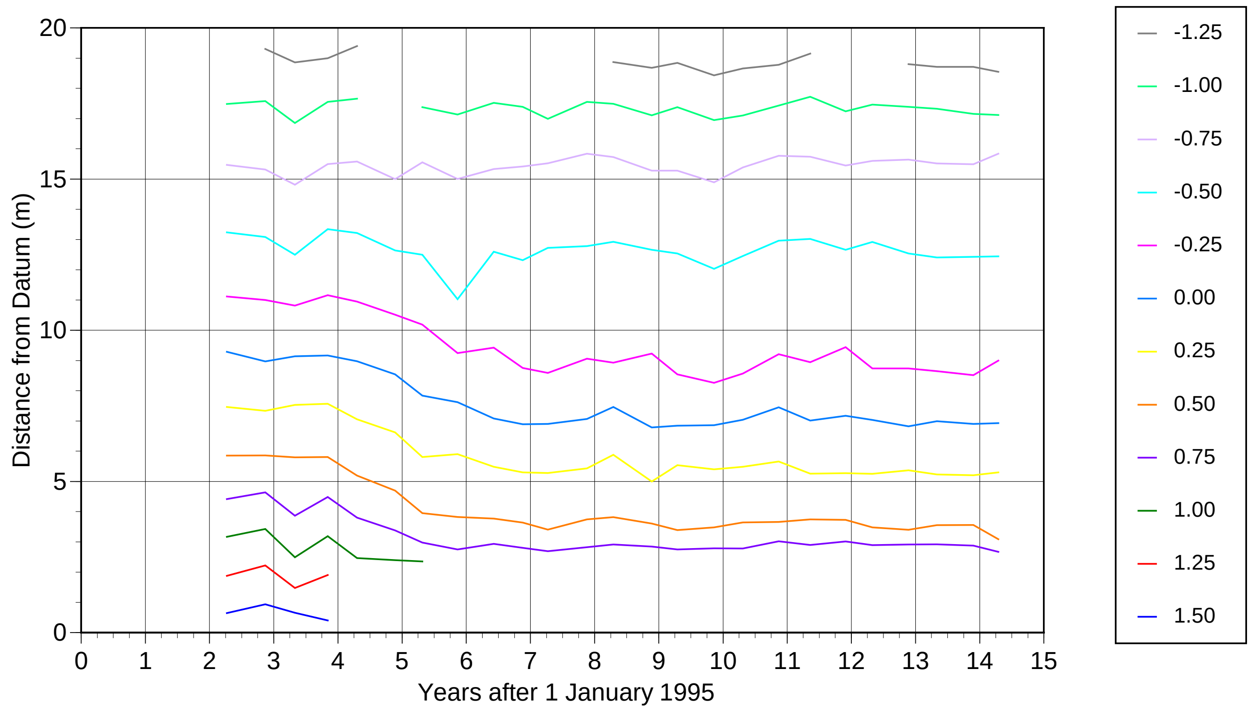
*Profile 5 – Blackmore's at Waikawa*

Between April 1999 and November 1999, sand on the small beach started to disappear. By November 2001, the beach had been stripped to bedrock, and it has remained essentially devoid of sediment since that time. Further loss of sediment is therefore not possible. There has been no recovery since the fast ferries slowed down in December 2000. Minor changes in profiles and volumes recorded since that time are likely to be the result of slightly different survey alignments, and possibly minor changes in sediments on the lower profile.

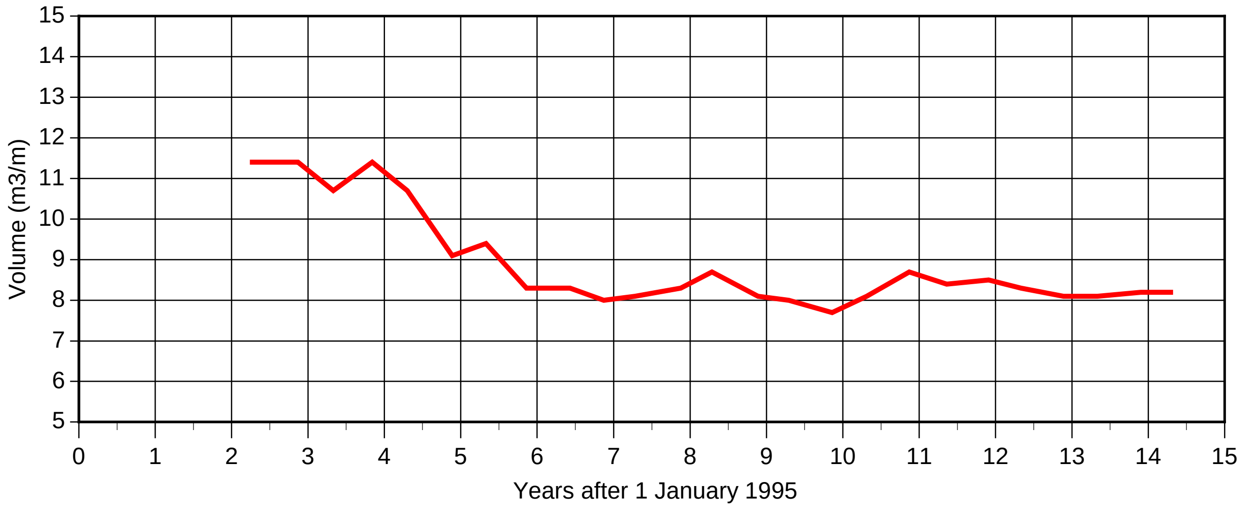



**Profile 5: Blackmore's at Waikawa**




**Profile 5: Blackmore's at Waikawa**




| Date | Years after 1/1/95 | Volume ($m^3$/m) |
|---|---|---|
| 8-Apr-97 | 2.27 | 11.4 |
| 14-Nov-97 | 2.87 | 11.4 |
| 29-Apr-98 | 3.33 | 10.7 |
| 4-Nov-98 | 3.84 | 11.4 |
| 19-Apr-99 | 4.30 | 10.7 |
| 22-Nov-99 | 4.89 | 9.1 |
| 1-May-00 | 5.33 | 9.4 |
| 9-Nov-00 | 5.86 | 8.3 |
| 5-Jun-01 | 6.43 | 8.3 |
| 15-Nov-01 | 6.87 | 8.0 |
| 10-Apr-02 | 7.28 | 8.1 |
| 18-Nov-02 | 7.88 | 8.3 |
| 16-Apr-03 | 8.29 | 8.7 |
| 19-Nov-03 | 8.89 | 8.1 |
| 20-Apr-04 | 9.29 | 8.0 |
| 9-Nov-04 | 9.86 | 7.7 |
| 20-Apr-05 | 10.31 | 8.1 |
| 14-Nov-05 | 10.87 | 8.7 |
| 10-May-06 | 11.36 | 8.4 |
| 21-Nov-06 | 11.91 | 8.5 |
| 14-May-07 | 12.33 | 8.3 |
| 21-Nov-07 | 12.89 | 8.1 |
| 04-Apr-08 | 13.33 | 8.1 |
| 12-Nov-08 | 13.90 | 8.2 |
| 08-Apr-09 | 14.29 | 8.2 |

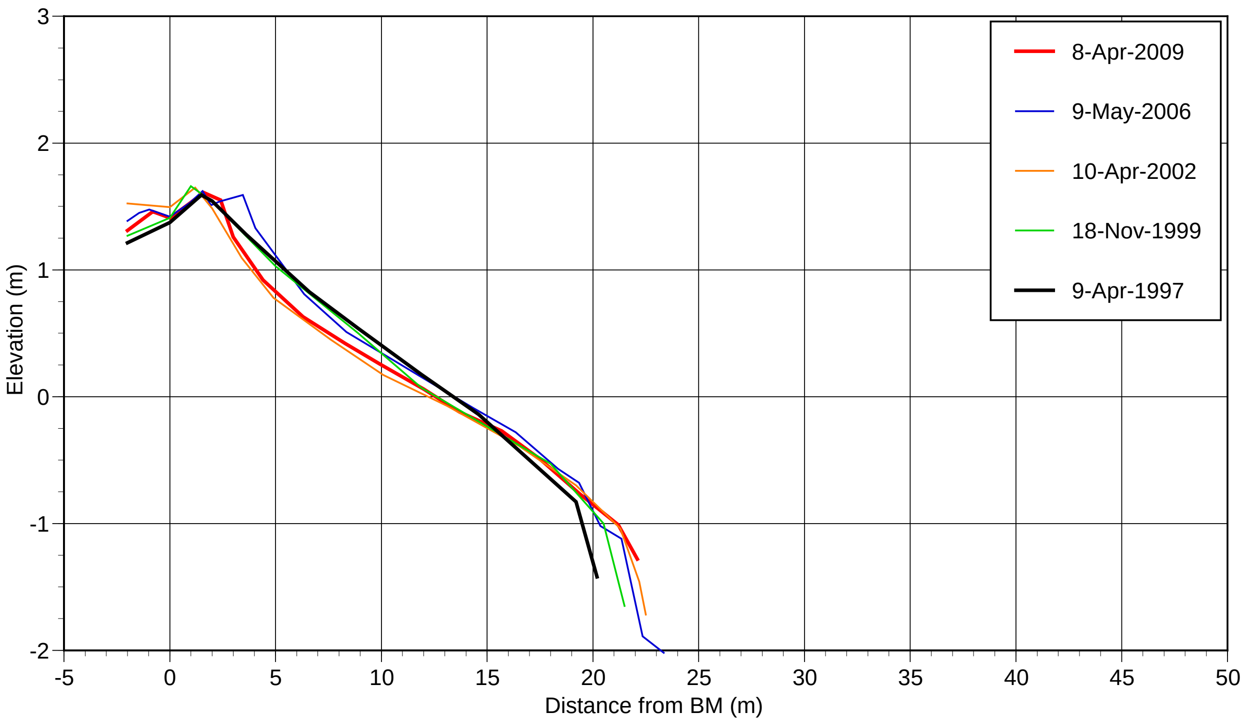
**Profile 5: Blackmore’s at Waikawa**

*Profile 6 – Moioio Island 2*

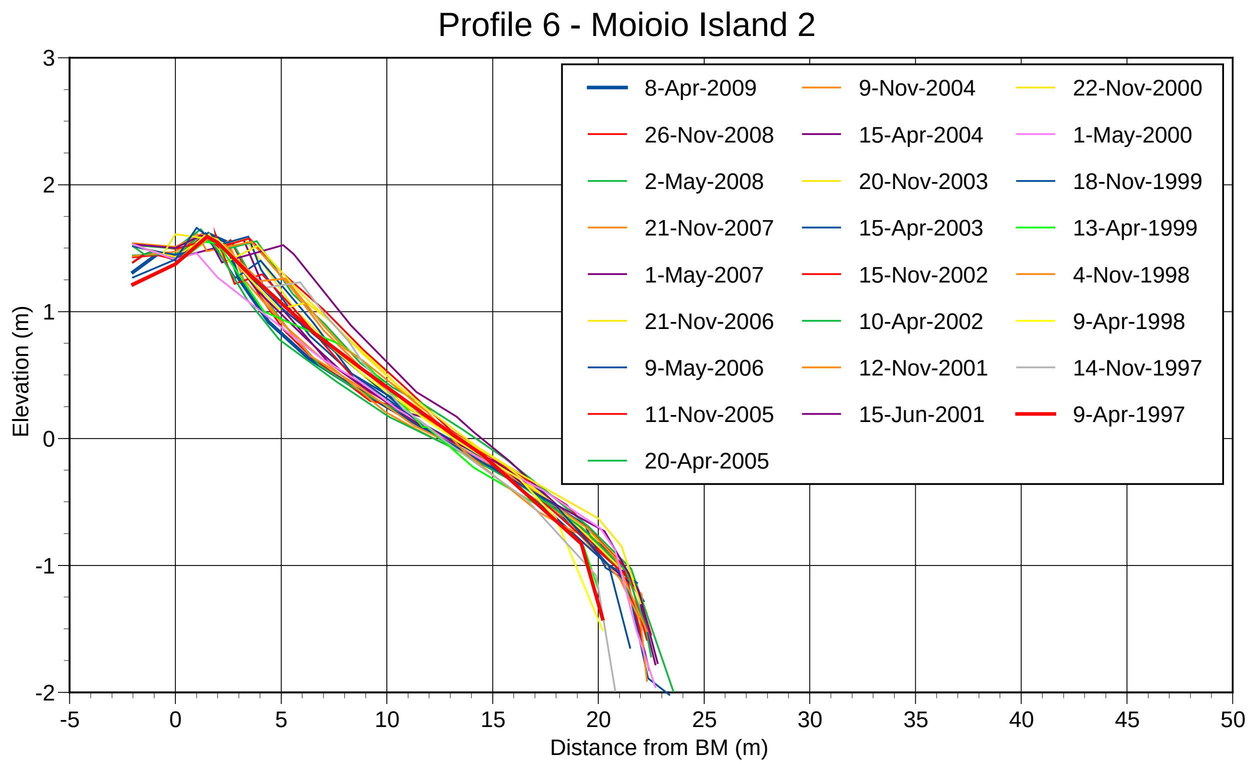
Moioio Island 2 is at the eastern end of the beach on the island, near the slip that has been of considerable concern to Te Ati Awa. This profile has a record going back to November 1995 and until 1999 the beach profile demonstrated seasonality, with a build up of a berm on the upper beach over the winter months, and its removal over the summer months, after which time, seasonal patterns have not been evident. The beach experienced significant accretion up to 2005, with a significant reversal for a period between November 2000 and April 2002 (coinciding with the slowing of the fast ferries possible affecting sediment mobility from the slip source). Since 2005, however, the beach has been eroding, particularly on the upper and middle sections. A significant berm remains at the top of the profile, and the lower beach remains extended into the deep water channel.

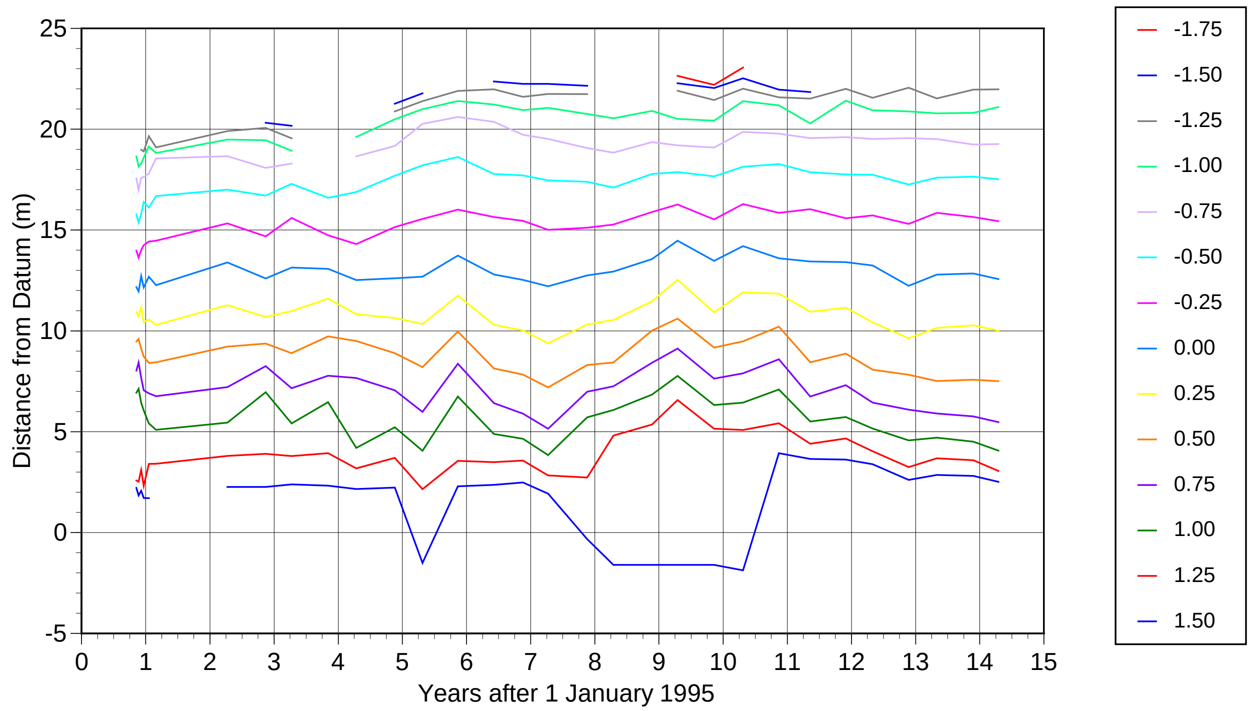
The most significant effect on this profile has almost certainly been the adjacent slip. Major fluctuations in beach shape and volume, and indeed the general accretion, are almost certainly related to sediment supply from periods of activity and inactivity of the slip. It is therefore assumed that the slip has been relatively inactive since 2006.

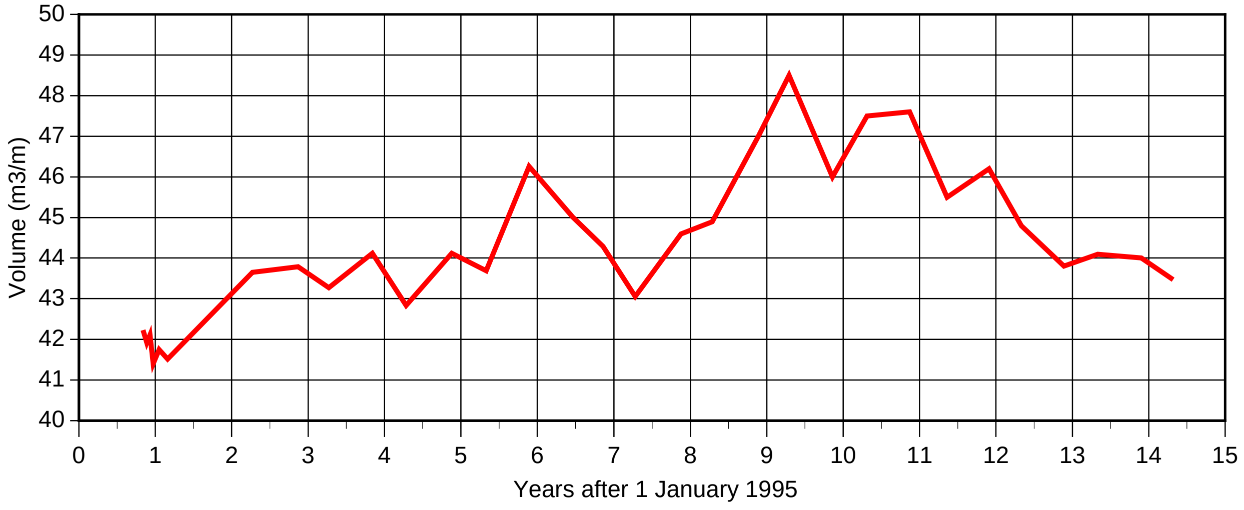



**Profile 6: Moioio Island 2**




**Profile 6: Moioio Island 2**



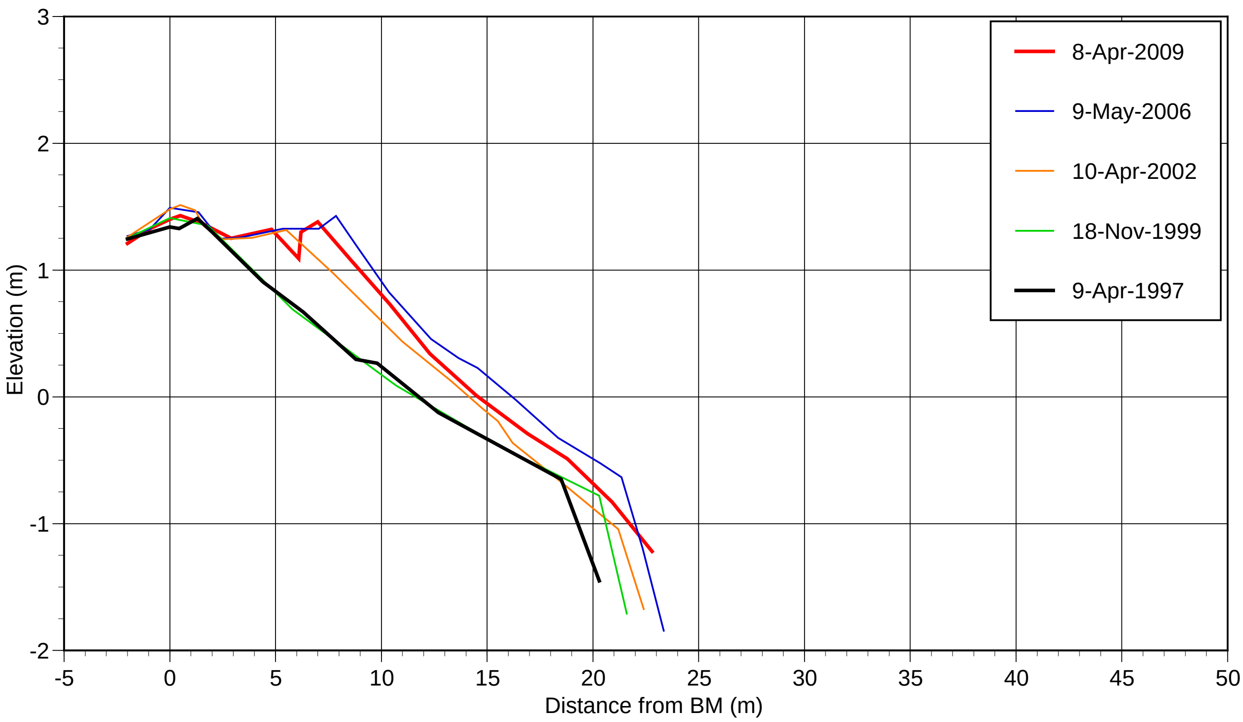

| Date | Years after 1/1/95 | Volume ($m^3/m$) |
|---|---|---|
| 8-Nov-95 | 0.85 | 42.17 |
| 21-Nov-95 | 0.89 | 41.92 |
| 6-Dec-95 | 0.93 | 42.11 |
| 20-Dec-95 | 0.97 | 41.40 |
| 19-Jan-96 | 1.05 | 41.75 |
| 29-Feb-96 | 1.16 | 41.52 |
| 9-Apr-97 | 2.27 | 43.65 |
| 14-Nov-97 | 2.87 | 43.79 |
| 9-Apr-98 | 3.27 | 43.27 |
| 4-Nov-98 | 3.84 | 44.12 |
| 13-Apr-99 | 4.28 | 42.83 |
| 18-Nov-99 | 4.88 | 44.12 |
| 1-May-00 | 5.33 | 43.69 |
| 22-Nov-00 | 5.89 | 46.26 |
| 15-Jun-01 | 6.46 | 45.01 |
| 12-Nov-01 | 6.86 | 44.29 |
| 10-Apr-02 | 7.28 | 43.06 |
| 15-Nov-02 | 7.88 | 44.6 |
| 15-Apr-03 | 8.29 | 44.9 |
| 20-Nov-03 | 8.89 | 47.0 |
| 15-Apr-04 | 9.29 | 48.5 |
| 9-Nov-04 | 9.86 | 46.0 |
| 20-Apr-05 | 10.31 | 47.5 |
| 11-Nov-05 | 10.87 | 47.6 |
| 9-May-06 | 11.36 | 45.5 |
| 21-Nov-06 | 11.91 | 46.2 |
| 01-May-07 | 12.33 | 44.8 |
| 21-Nov-07 | 12.89 | 43.8 |
| 02-May-08 | 13.33 | 44.1 |
| 26-Nov-08 | 13.90 | 44.0 |
| 08-Apr-09 | 14.29 | 43.5 |

**Profile 6: Moioio Island 2**

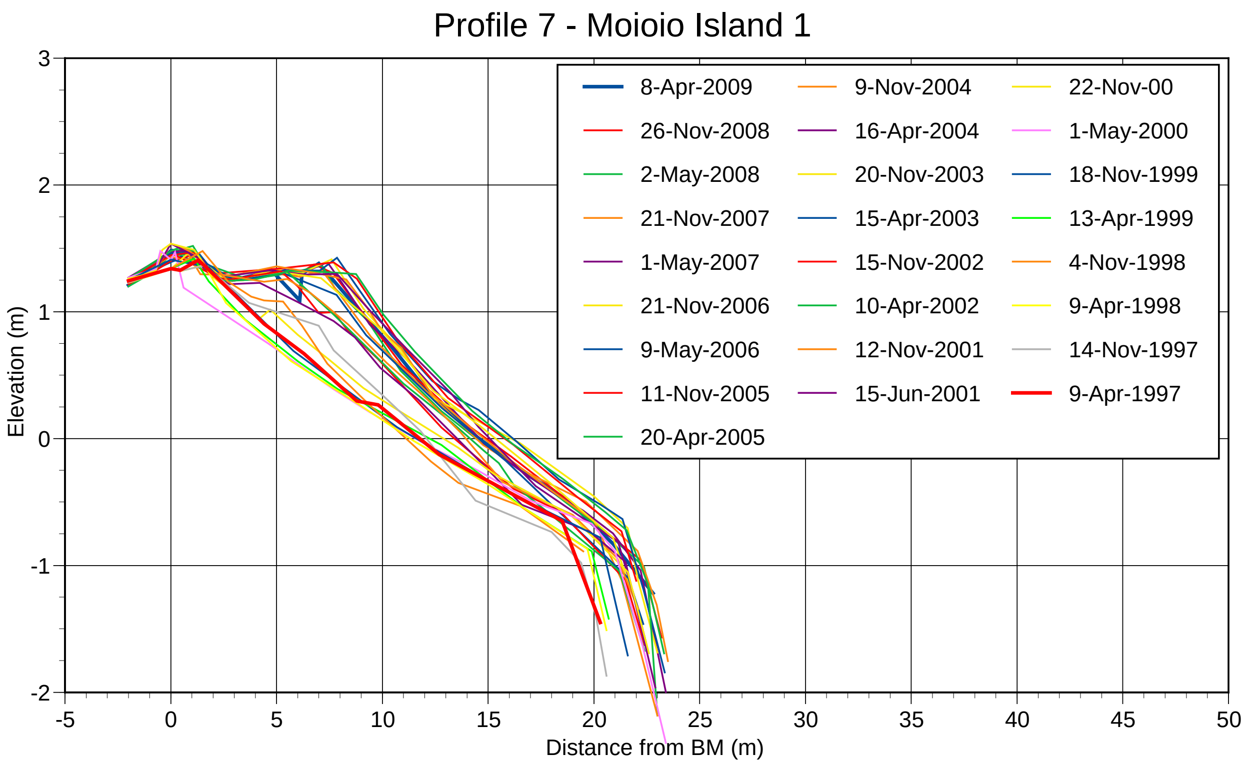
*Profile 7 – Moioio Island 1*

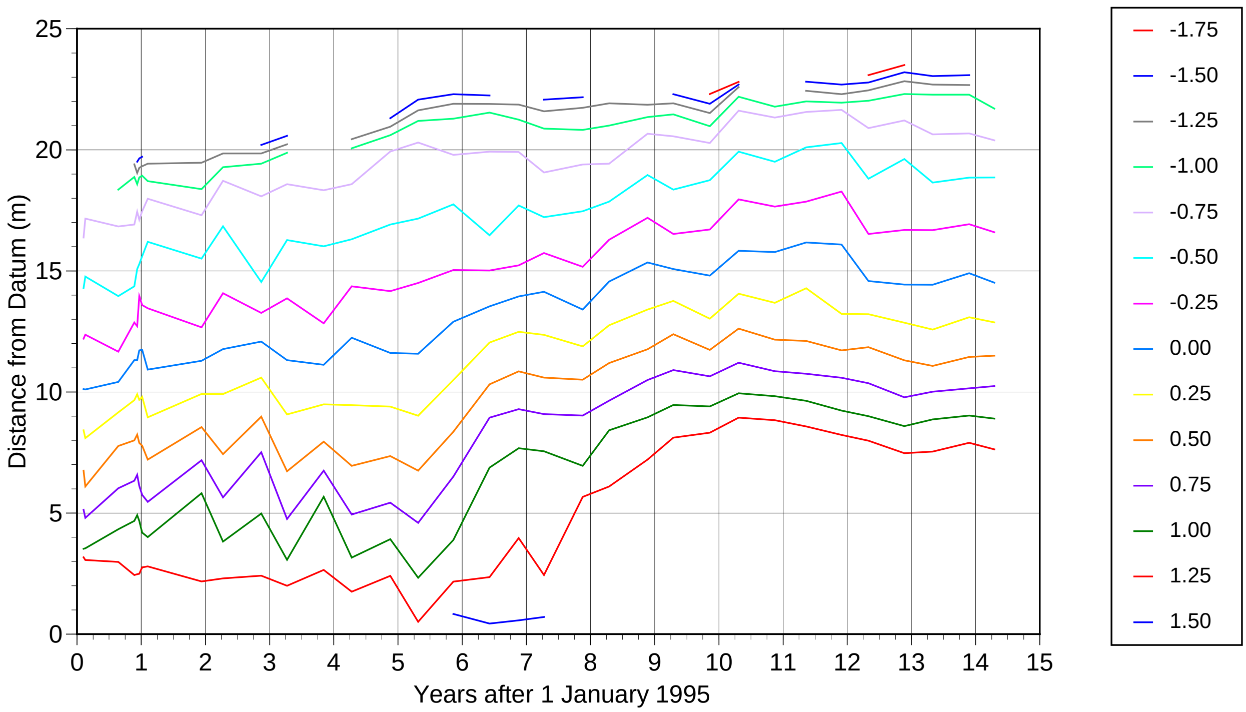
The Moioio Island 1 profile is to the west of Profile 6. There was remarkable seasonality up to the winter of 1999,, with the growth of a berm over winter and its loss over summer. Up until the end of 2000, the upper beach was generally stable, with seasonality, and with the lower beach accreting into the channel. Up to 2006, like Profile 6, the whole profile accreted rapidly with very substantial volume increases. There was substantial accretion of the upper beach between May 2000 and May 2006, with a major increase in volume, particularly between May 2000 and April 2001. Like Profile 6, there has been a reversal since 2006, with the entire profile retreating, although a substantial berm remains. This profile is almost certainly reacting principally to sediment supply.

There is little doubt that the beach changes taking place on this profile are related in part to ferry operation (evidenced by the very strong seasonal signal when fast ferries were operating seasonally), but they are affected significantly by changes to sediment supply. The accretion event observed on Profile 6 between April 2003 and April 2004 is reflected on Profile 7 between November 2004 and April 2005.

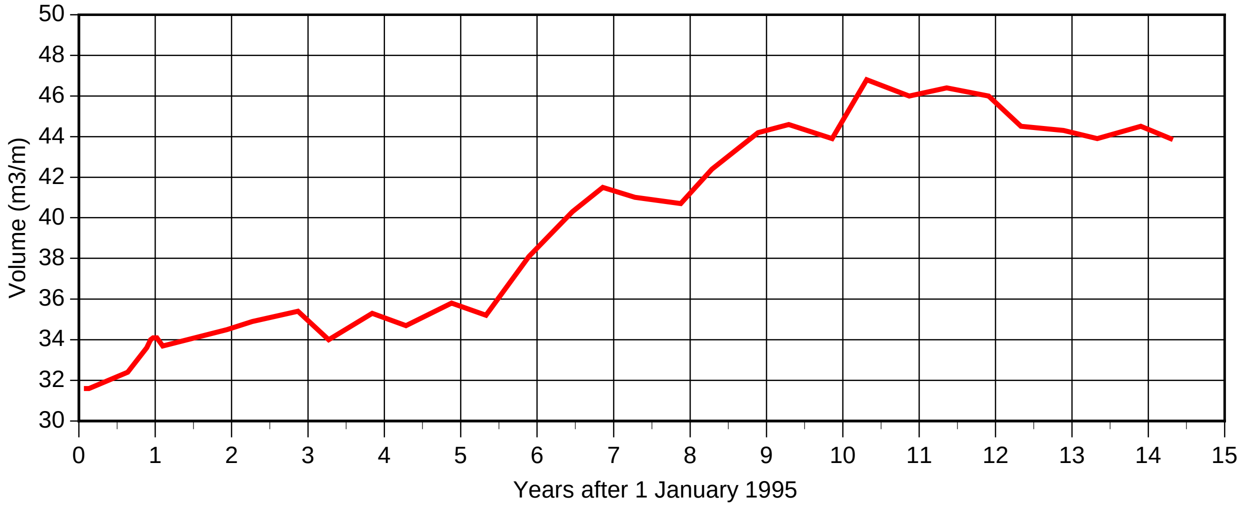



**Profile 7: Moioio Island 1**




**Profile 7: Moioio Island 1**




| Date | Years after 1/1/95 | Volume ($m^3$/m) |
|---|---|---|
| 1977 | | 38.3 |
| 8-Feb-95 | 0.10 | 31.6 |
| 17-Feb-95 | 0.13 | 31.6 |
| 22-Aug-95 | 0.64 | 32.4 |
| 22-Nov-95 | 0.89 | 33.6 |
| 8-Dec-95 | 0.94 | 34.0 |
| 20-Dec-95 | 0.97 | 34.1 |
| 7-Jan-96 | 1.02 | 34.1 |
| 8-Feb-96 | 1.10 | 33.7 |
| 9-Dec-96 | 1.94 | 34.5 |
| 9-Apr-97 | 2.27 | 34.9 |
| 14-Nov-97 | 2.87 | 35.4 |
| 9-Apr-98 | 3.27 | 34.0 |
| 4-Nov-98 | 3.84 | 35.3 |
| 13-Apr-99 | 4.28 | 34.7 |
| 18-Nov-99 | 4.88 | 35.8 |
| 1-May-00 | 5.33 | 35.2 |
| 22-Nov-00 | 5.89 | 38.1 |
| 15-Jun-01 | 6.46 | 40.3 |
| 12-Nov-01 | 6.86 | 41.5 |
| 10-Apr-02 | 7.28 | 41.0 |
| 15-Nov-02 | 7.88 | 40.7 |
| 15-Apr-03 | 8.29 | 42.4 |
| 20-Nov-03 | 8.89 | 44.2 |
| 16-Apr-04 | 9.29 | 44.6 |
| 9-Nov-04 | 9.86 | 43.9 |
| 20-Apr-05 | 10.31 | 46.8 |
| 11-Nov-05 | 10.87 | 46.0 |
| 9-May-06 | 11.36 | 46.4 |
| 21-Nov-06 | 11.91 | 46.0 |
| 01-May-07 | 12.33 | 44.5 |
| 21-Nov-07 | 12.89 | 44.3 |
| 02-May-08 | 13.33 | 43.9 |
| 26-Nov-08 | 13.90 | 44.5 |
| 08-Apr-09 | 14.29 | 43.9 |

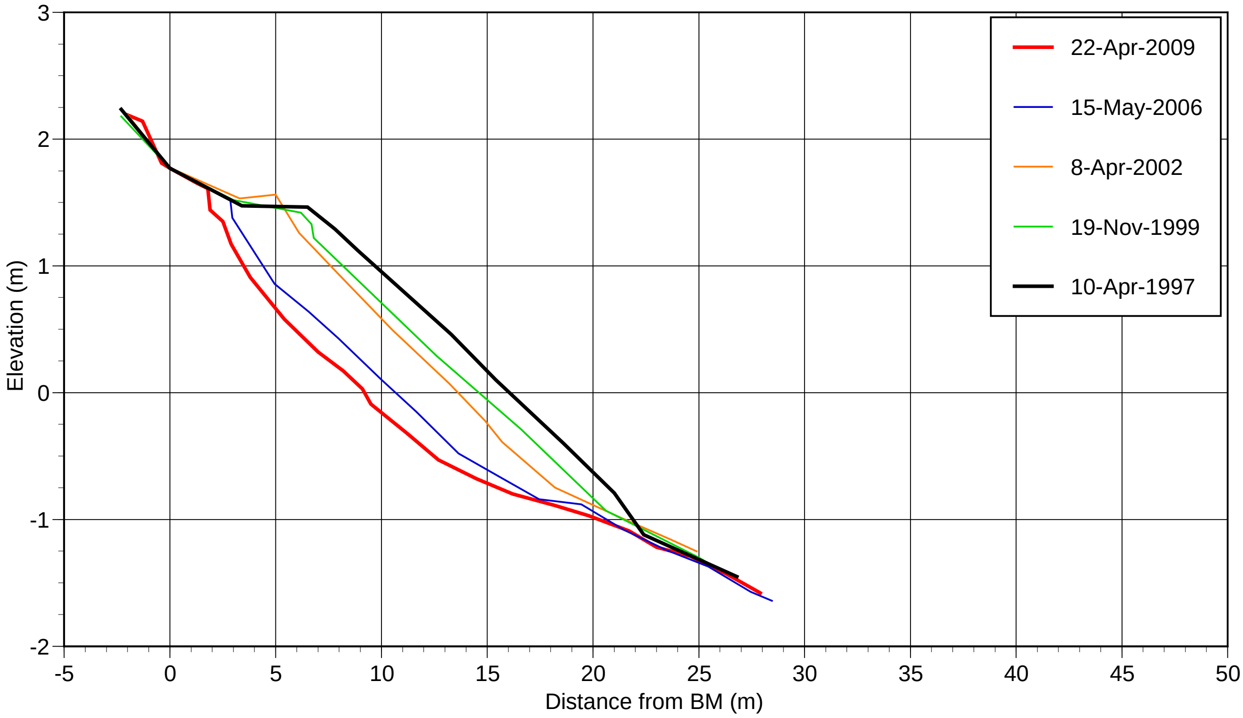
**Profile 7: Moioio Island 1**

*Profile 8 – Bob's Bay*

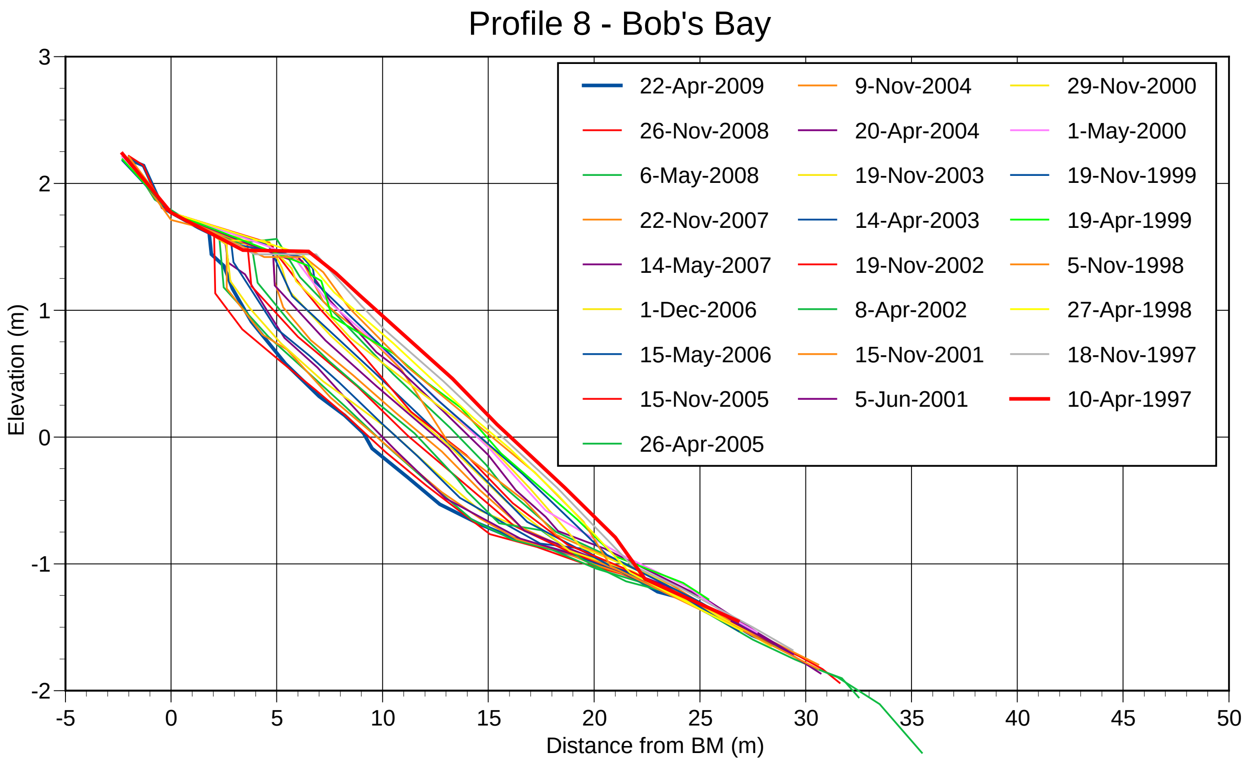
Bob's Bay has demonstrated an almost linear erosion trend since 1995 across the whole beach profile down to the change in slope (and probable closure depth) at about –1 m. Most of the beach has lowered in level by about 1m.  Volume data shows a loss of 17 $m^3$/m since 1995. This erosion is very significant within the context of beaches in this study.  The beach slope has stayed relatively constant.

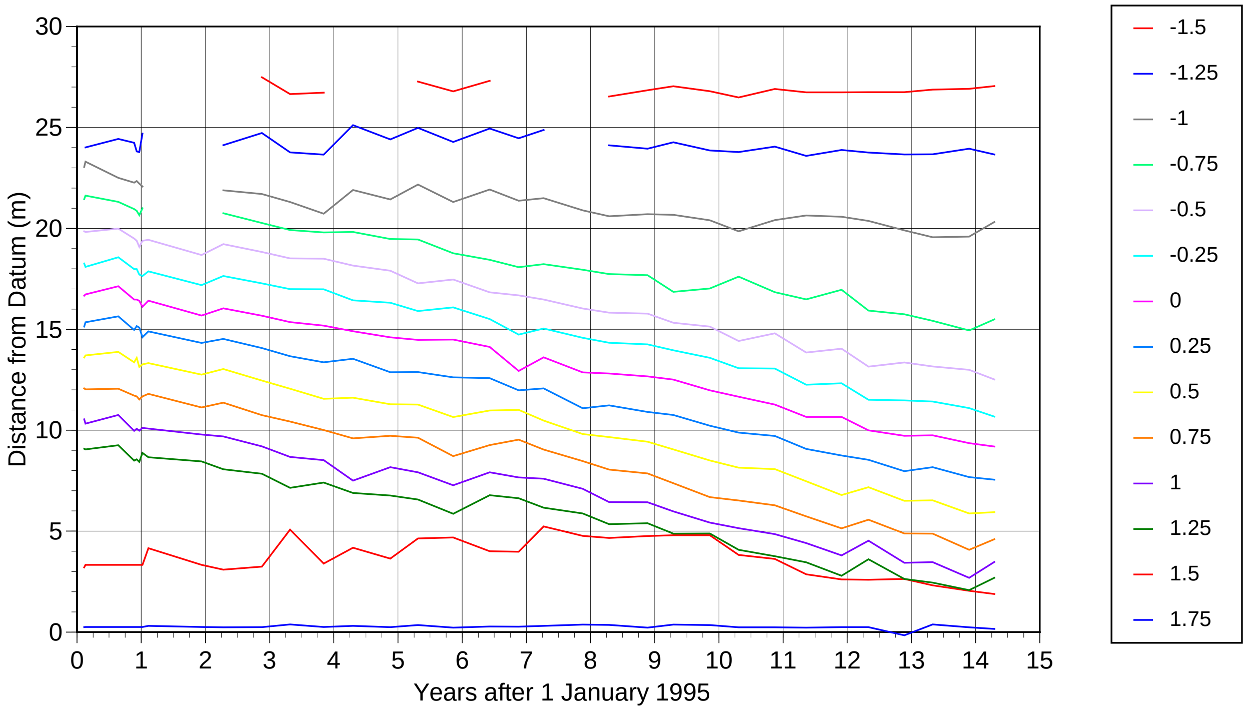
The location of this profile is at the northern end of the beach, adjacent to a headland of significance to Te Ati Awa. It may be that the erosion is accompanied by accretion elsewhere in the embayment.

The cause of the erosion is not known.  The site is well inside Mabel Island, and all major shipping movements should be at low speed with small wakes.  There is also limited fetch, so natural waves should also be small. The mechanism of sediment transport away from the profile line, and where the sediment goes could be investigated if erosion at this particular point becomes of concern.

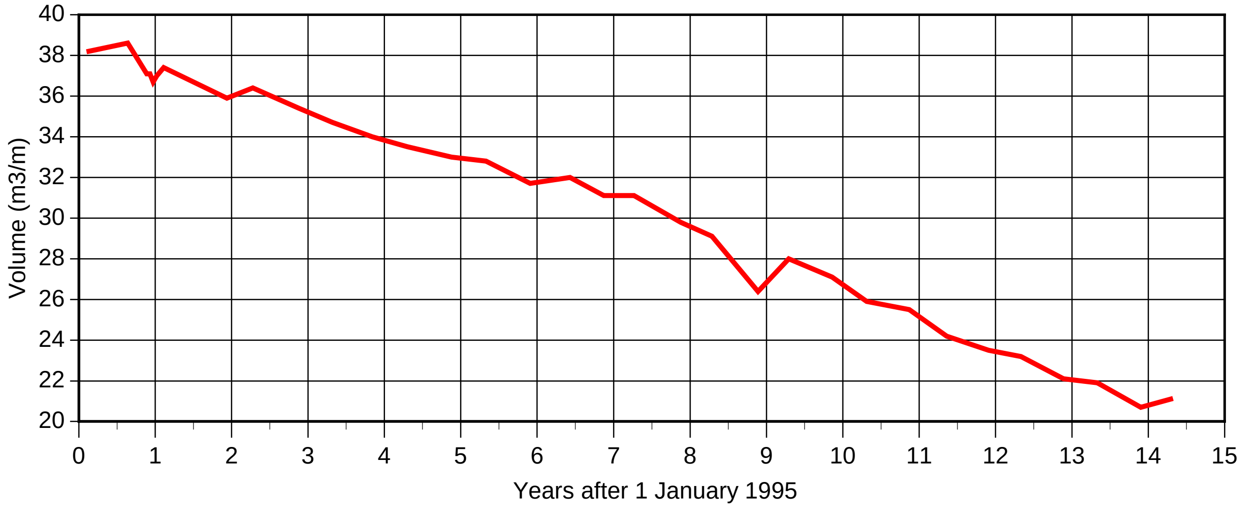



**Profile 8: Bobs Bay**




**Profile 8: Bobs Bay**

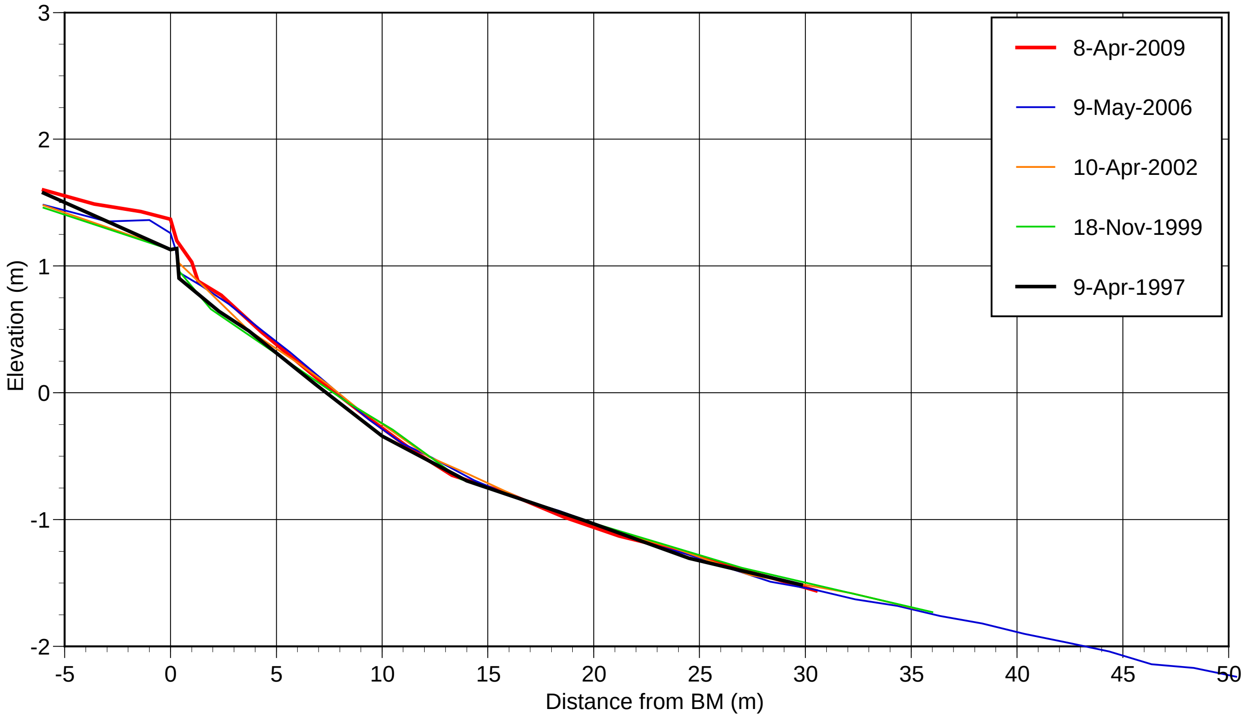



| Date | Years after 1/1/95 | Volume ($m^3/m$) |
|---|---|---|
| 17-Feb-95 | 0.13 | 38.2 |
| 22-Aug-95 | 0.64 | 38.6 |
| 21-Nov-95 | 0.89 | 37.1 |
| 7-Dec-95 | 0.93 | 37.1 |
| 20-Dec-95 | 0.97 | 36.7 |
| 7-Jan-96 | 1.02 | 37.0 |
| 10-Feb-96 | 1.11 | 37.4 |
| 10-Dec-96 | 1.94 | 35.9 |
| 10-Apr-97 | 2.28 | 36.4 |
| 18-Nov-97 | 2.88 | 35.4 |
| 27-Apr-98 | 3.32 | 34.7 |
| 5-Nov-98 | 3.84 | 34.0 |
| 19-Apr-99 | 4.30 | 33.5 |
| 19-Nov-99 | 4.88 | 33.0 |
| 1-May-00 | 5.33 | 32.8 |
| 29-Nov-00 | 5.91 | 31.7 |
| 5-Jun-01 | 6.43 | 32.0 |
| 15-Nov-01 | 6.87 | 31.1 |
| 8-Apr-02 | 7.27 | 31.1 |
| 19-Nov-02 | 7.88 | 29.8 |
| 14-Apr-03 | 8.29 | 29.1 |
| 19-Nov-03 | 8.89 | 26.4 |
| 20-Apr-04 | 9.29 | 28.0 |
| 9-Nov-04 | 9.86 | 27.1 |
| 26-Apr-05 | 10.31 | 25.9 |
| 15-Nov-05 | 10.87 | 25.5 |
| 15-May-06 | 11.36 | 24.2 |
| 01-Dec-06 | 11.91 | 23.5 |
| 14-May-07 | 12.33 | 23.2 |
| 22-Nov-07 | 12.89 | 22.1 |
| 06-May-08 | 13.33 | 21.9 |
| 26-Nov-08 | 13.90 | 20.7 |
| 22-Apr-09 | 14.29 | 21.1 |

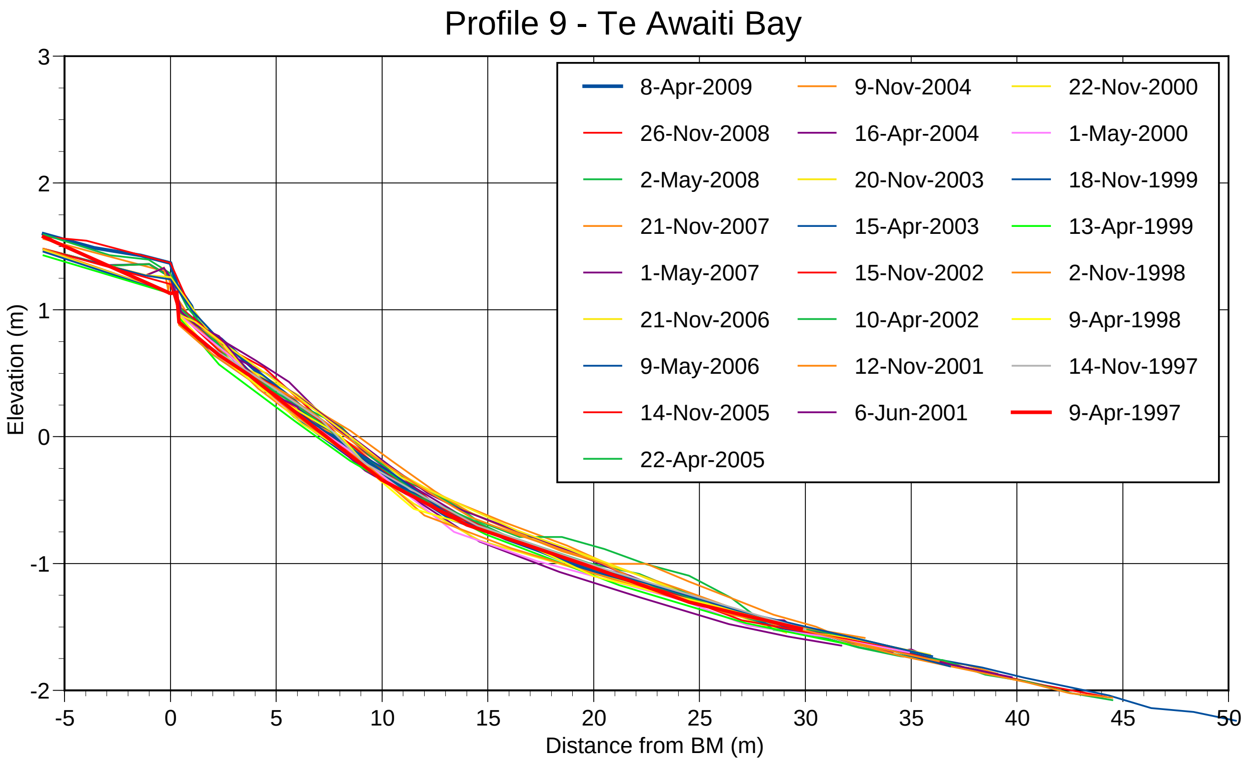
**Profile 8: Bobs Bay**

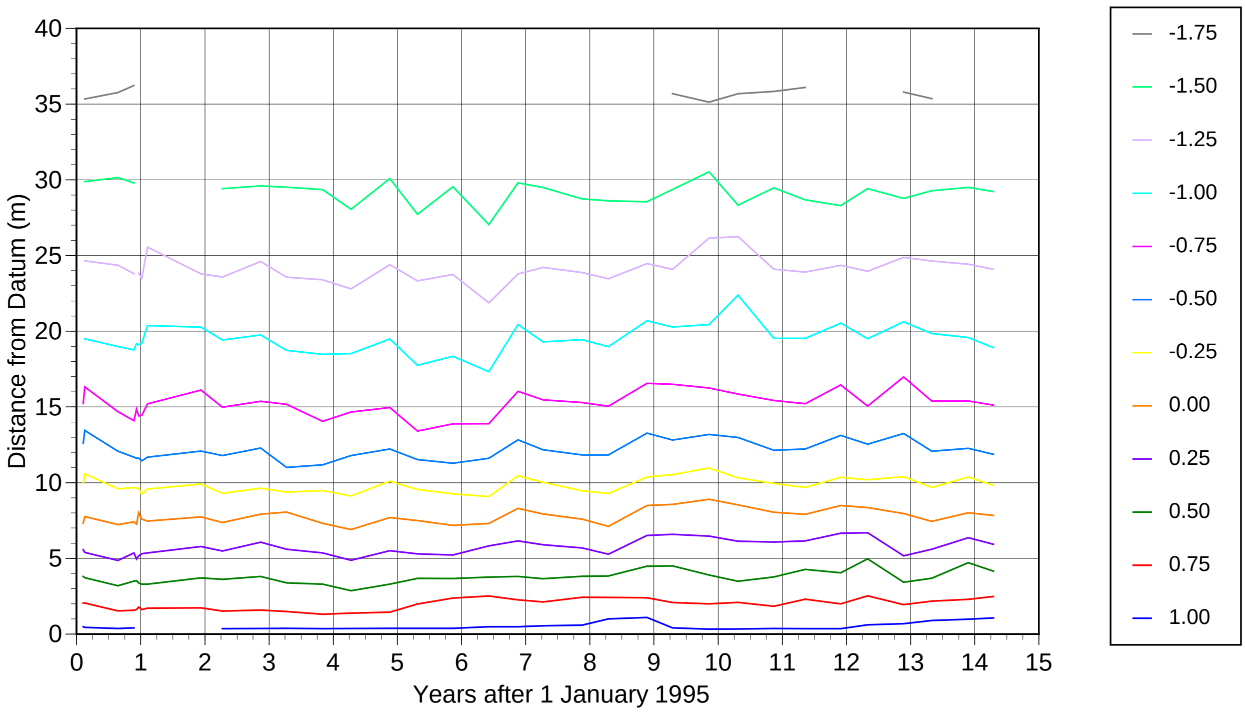
### *Profile 9 – Te Awaiti Bay*

Despite frequent changes in surficial sediments (more common up to 2003), with the deposition and removal of a small quantity of fine sediment, the beach profile has changed little. Beach volumes were relatively stable up until 2001, but then increased significantly, possibly coinciding with the slowing of the fast ferries. Volumes have reduced slightly since peaking in 2004, but some redistribution of sediment has occurred with deposition at the top of the beach. Photographs indicate that the sediment deposited at the top of the beach may have an aeolian origin.

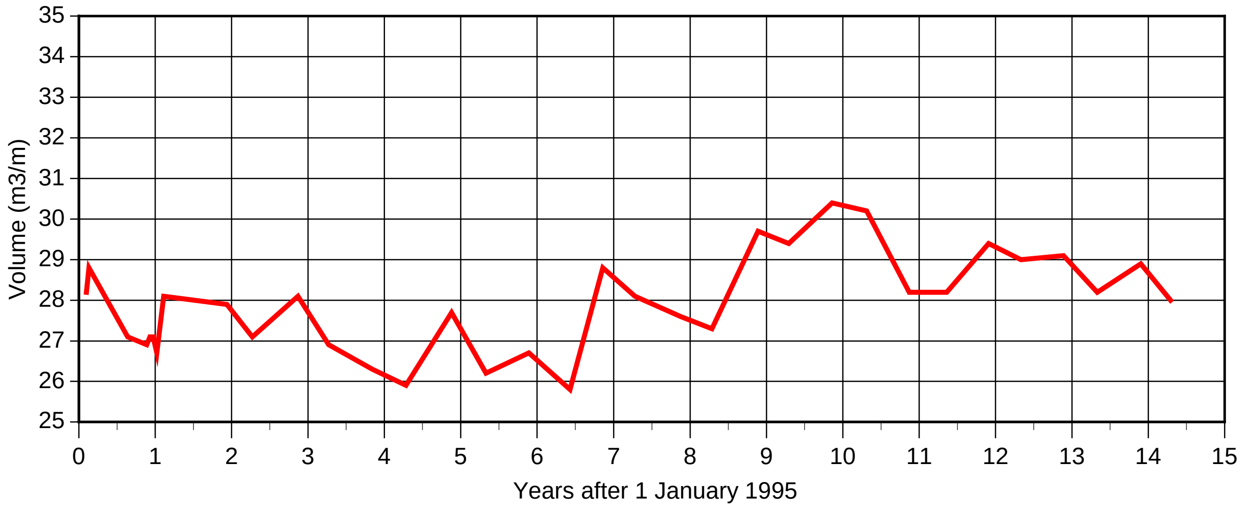



**Profile 9: Te Awaiti Bay**




**Profile 9: Te Awaiti Bay**

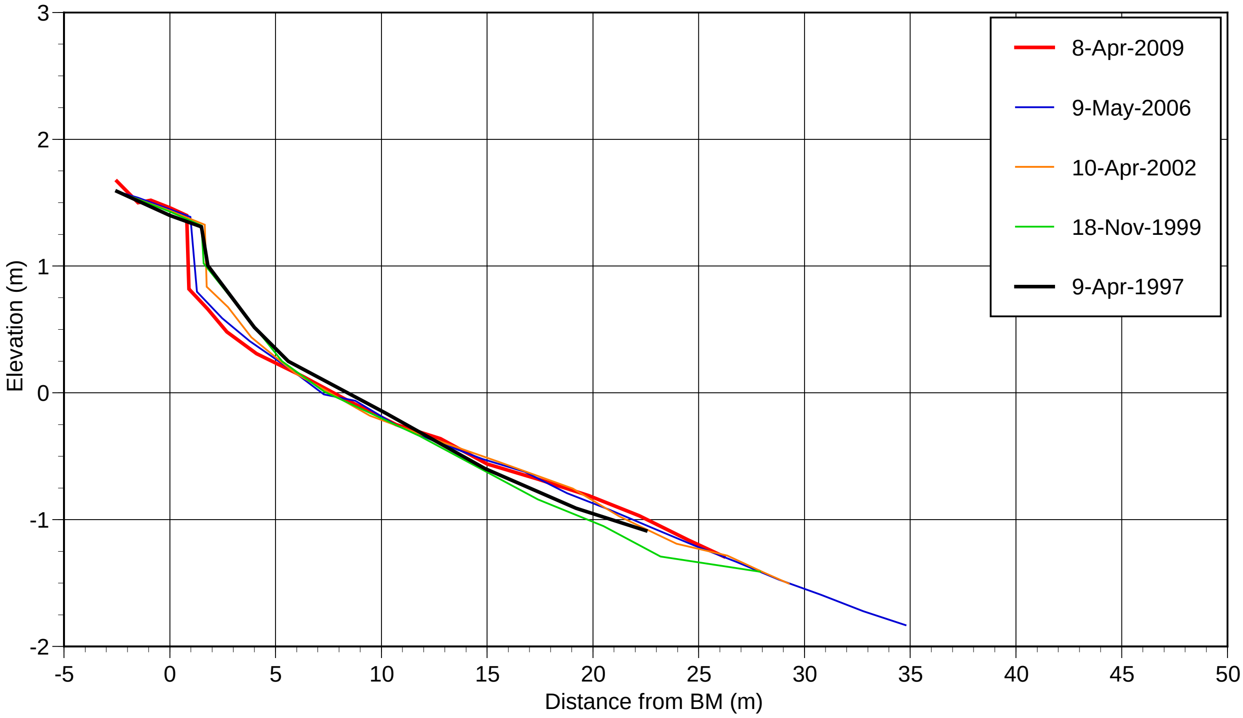



| Date | Years after 1/1/95 | Volume ($m^3$/m) |
|---|---|---|
| 8-Feb-95 | 0.10 | 28.2 |
| 17-Feb-95 | 0.13 | 28.8 |
| 23-Aug-95 | 0.64 | 27.1 |
| 22-Nov-95 | 0.89 | 26.9 |
| 7-Dec-95 | 0.93 | 27.1 |
| 20-Dec-95 | 0.97 | 27.1 |
| 7-Jan-96 | 1.02 | 26.7 |
| 9-Feb-96 | 1.11 | 28.1 |
| 9-Dec-96 | 1.94 | 27.9 |
| 9-Apr-97 | 2.27 | 27.1 |
| 14-Nov-97 | 2.87 | 28.1 |
| 9-Apr-98 | 3.27 | 26.9 |
| 2-Nov-98 | 3.84 | 26.3 |
| 13-Apr-99 | 4.28 | 25.9 |
| 18-Nov-99 | 4.88 | 27.7 |
| 1-May-00 | 5.33 | 26.2 |
| 22-Nov-00 | 5.89 | 26.7 |
| 6-Jun-01 | 6.43 | 25.8 |
| 12-Nov-01 | 6.86 | 28.8 |
| 10-Apr-02 | 7.28 | 28.1 |
| 15-Nov-02 | 7.88 | 27.6 |
| 15-Apr-03 | 8.29 | 27.3 |
| 20-Nov-03 | 8.89 | 29.7 |
| 16-Apr-04 | 9.29 | 29.4 |
| 9-Nov-04 | 9.86 | 30.4 |
| 22-Apr-05 | 10.31 | 30.2 |
| 14-Nov-05 | 10.87 | 28.2 |
| 9-May-06 | 11.36 | 28.2 |
| 9-May-06 | 11.36 | 28.2 |
| 21-Nov-06 | 11.91 | 29.4 |
| 01-May-07 | 12.33 | 29.0 |
| 21-Nov-07 | 12.89 | 29.1 |
| 02-May-08 | 13.33 | 28.2 |
| 26-Nov-08 | 13.90 | 28.9 |

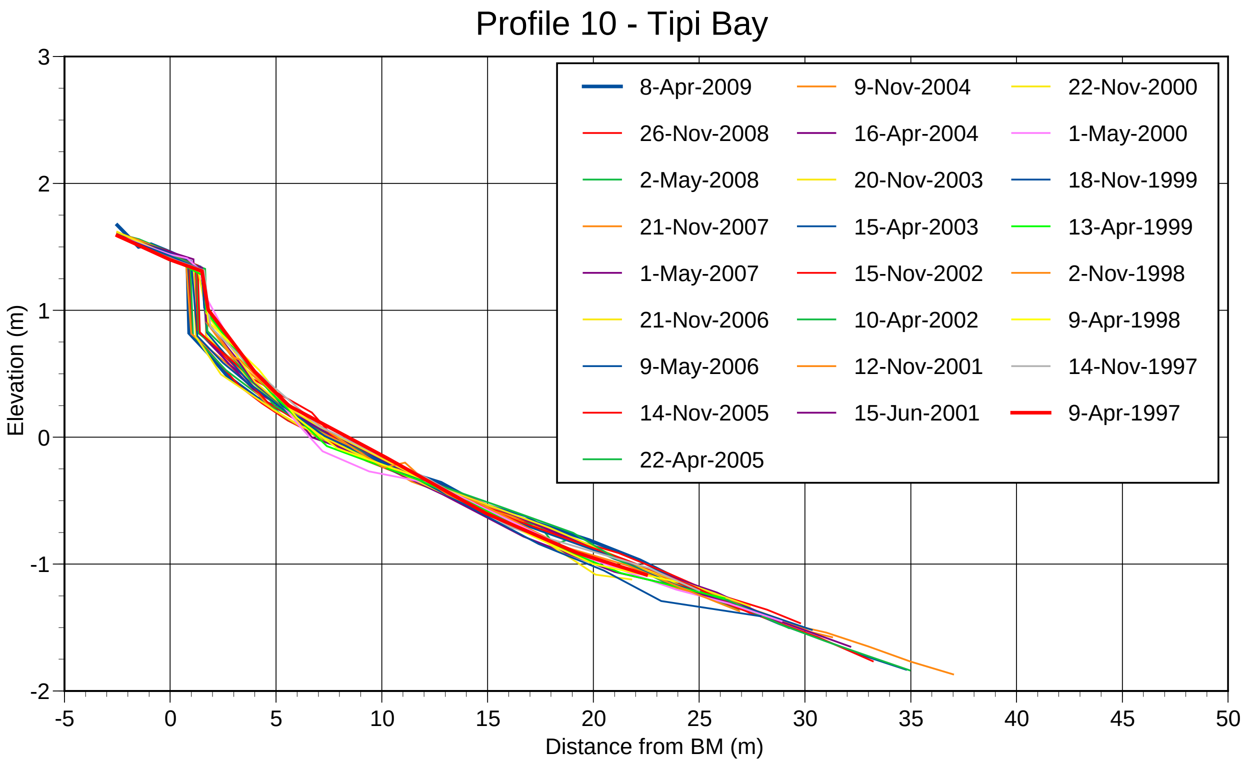
**Profile 9: Te Awaiti Bay**

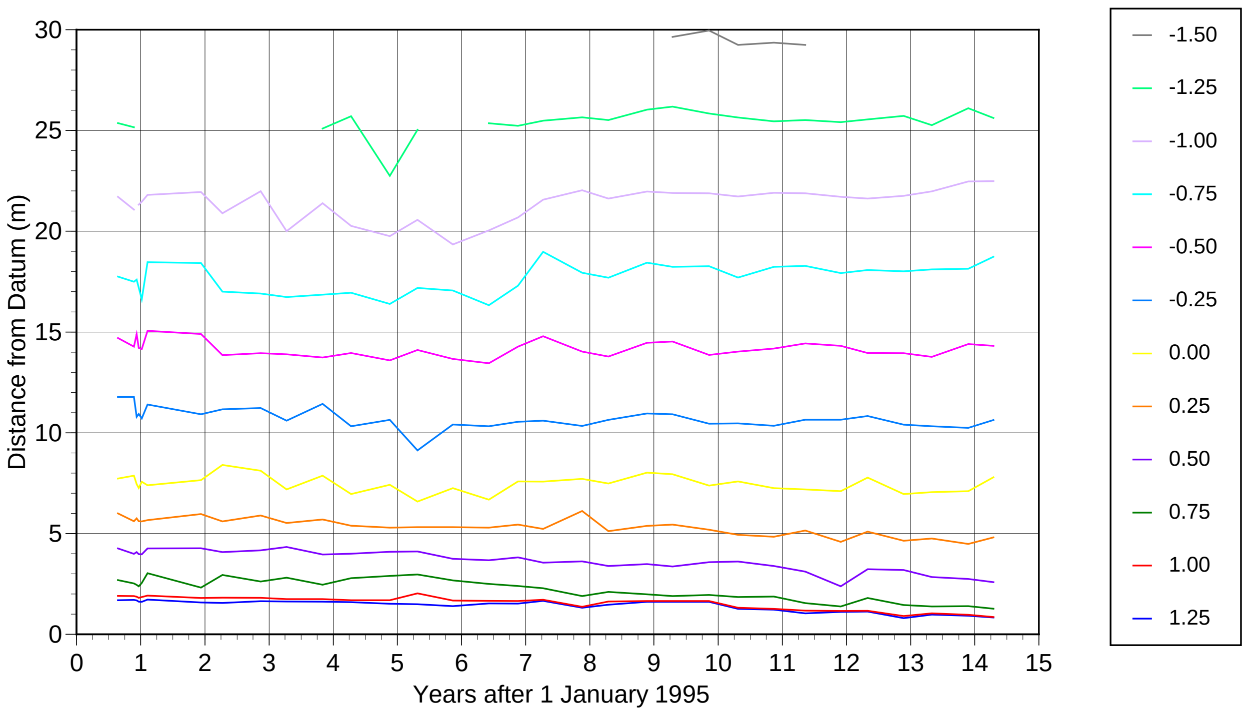
### *Profile 10 – Tipi Bay*

There has been some retreat of the upper beach scarp (approximately 1m) and a corresponding increase in the level of the middle to lower beach, but the changes have generally been minor. Because of the relatively coarse nature of the sediments, the placement of the survey staff can have significant impact on the apparent appearance of the profile line. Overall, beach volumes have reduced only a little.

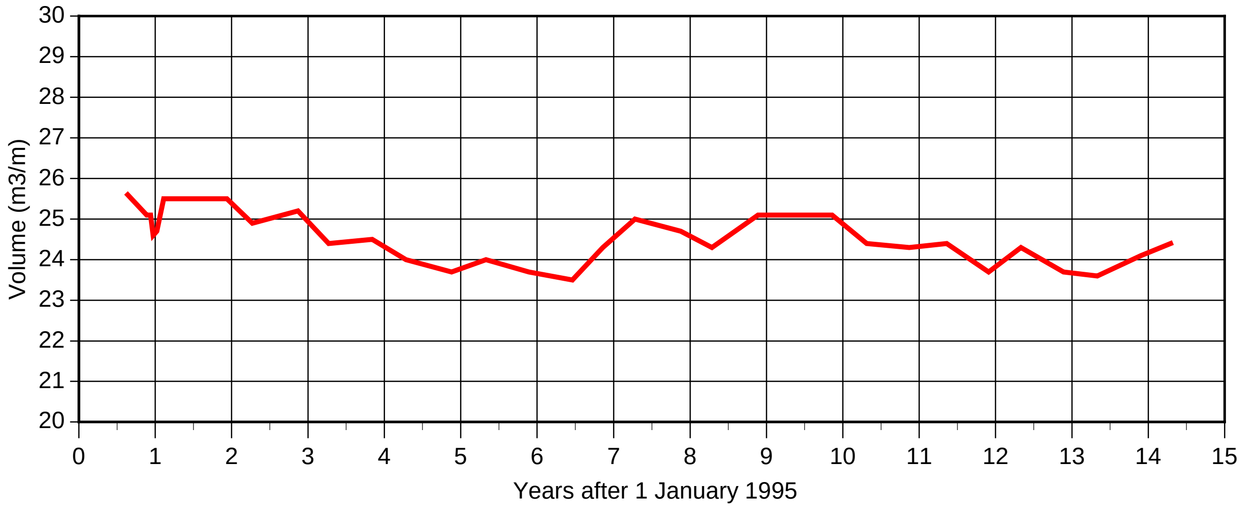



**Profile 10: Tipi Bay**




**Profile 10: Tipi Bay**



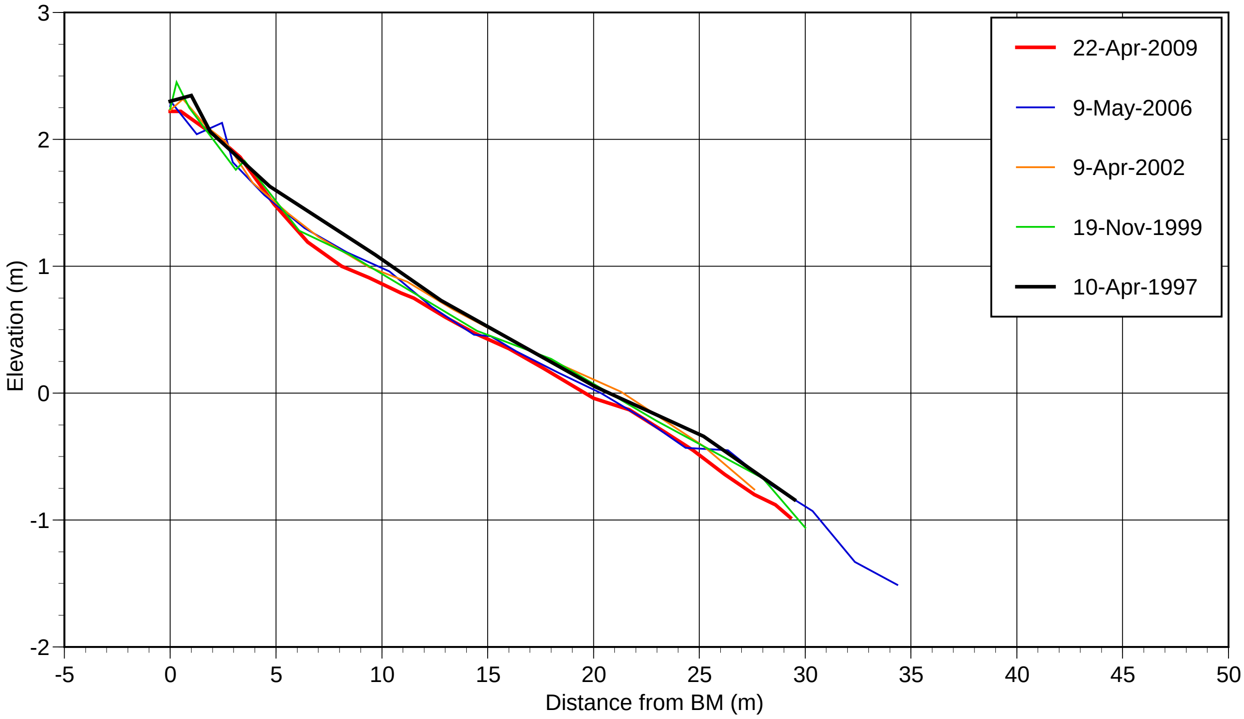

| Date | Years after 1/1/95 | Volume ($m^3/m$) |
|---|---|---|
| 23-Aug-95 | 0.64 | 25.6 |
| 22-Nov-95 | 0.89 | 25.1 |
| 8-Dec-95 | 0.94 | 25.1 |
| 20-Dec-95 | 0.97 | 24.6 |
| 7-Jan-96 | 1.02 | 24.7 |
| 9-Feb-96 | 1.11 | 25.5 |
| 9-Dec-96 | 1.94 | 25.5 |
| 9-Apr-97 | 2.27 | 24.9 |
| 14-Nov-97 | 2.87 | 25.2 |
| 9-Apr-98 | 3.27 | 24.4 |
| 2-Nov-98 | 3.84 | 24.5 |
| 13-Apr-99 | 4.28 | 24.0 |
| 18-Nov-99 | 4.88 | 23.7 |
| 1-May-00 | 5.33 | 24.0 |
| 22-Nov-00 | 5.89 | 23.7 |
| 15-Jun-01 | 6.46 | 23.5 |
| 12-Nov-01 | 6.86 | 24.3 |
| 10-Apr-02 | 7.28 | 25.0 |
| 15-Nov-02 | 7.88 | 24.7 |
| 15-Apr-03 | 8.29 | 24.3 |
| 20-Nov-03 | 8.89 | 25.1 |
| 16-Apr-04 | 9.29 | 25.1 |
| 9-Nov-04 | 9.86 | 25.1 |
| 22-Apr-05 | 10.31 | 24.4 |
| 14-Nov-05 | 10.87 | 24.3 |
| 9-May-06 | 11.36 | 24.4 |
| 21-Nov-06 | 11.91 | 23.7 |
| 01-May-07 | 12.33 | 24.3 |
| 21-Nov-07 | 12.89 | 23.7 |
| 02-May-08 | 13.33 | 23.6 |
| 26-Nov-08 | 13.90 | 24.1 |
| 08-Apr-09 | 14.29 | 24.4 |

**Profile 10: Tipi Bay**

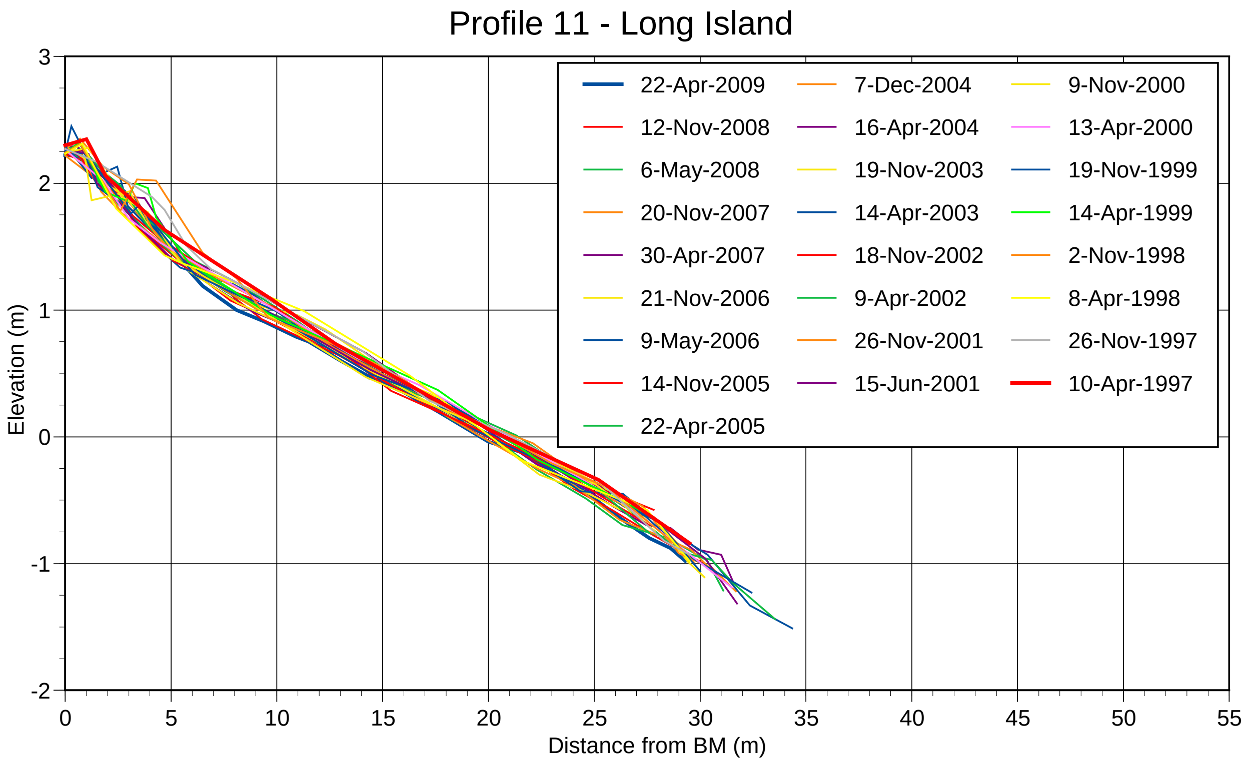
*Profile 11 – Long Island*

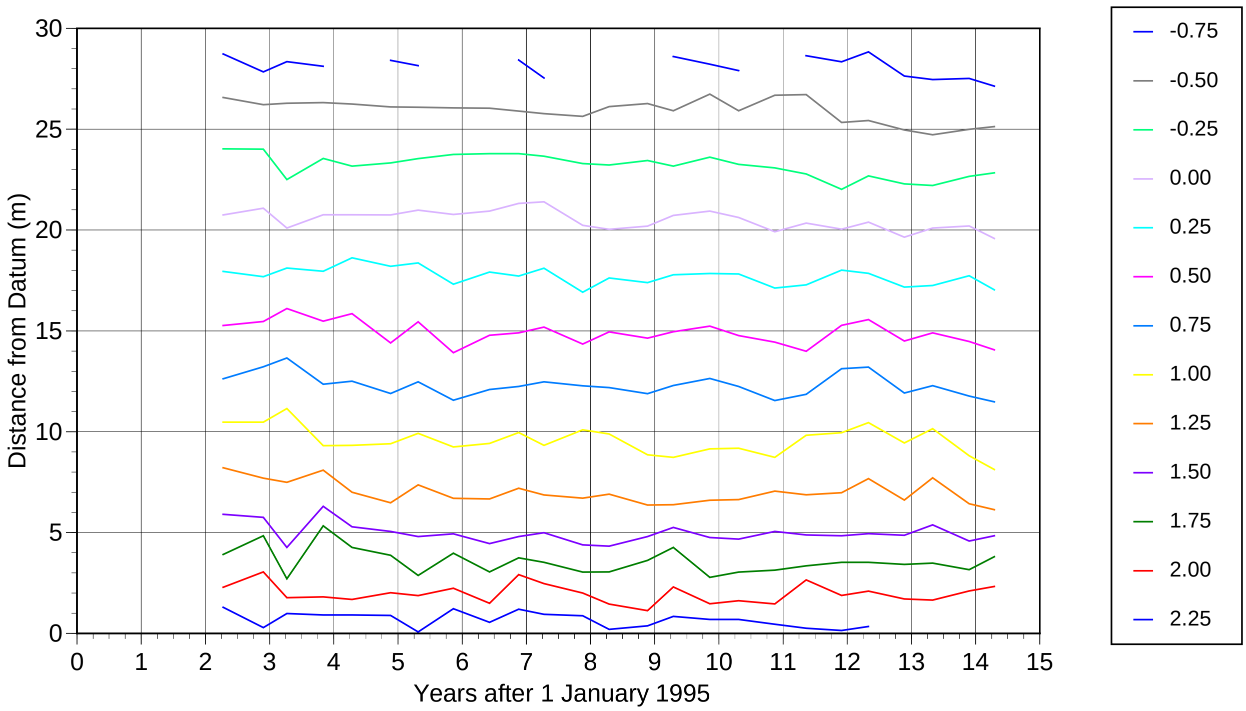
The Long Island profile is relatively exposed to storm events that cause waves to propagate through the northern entrance to Queen Charlotte Sound. There is considerable variability in the level of the upper beach, with the build up and removal of a berm, although this has been less evident since about 2000. The level of the middle and lower beach also shows some variability, but with no obvious seasonal trends. There has been an overall decrease in sediment volume over the last 12 years. There are no significant sedimentary trends.

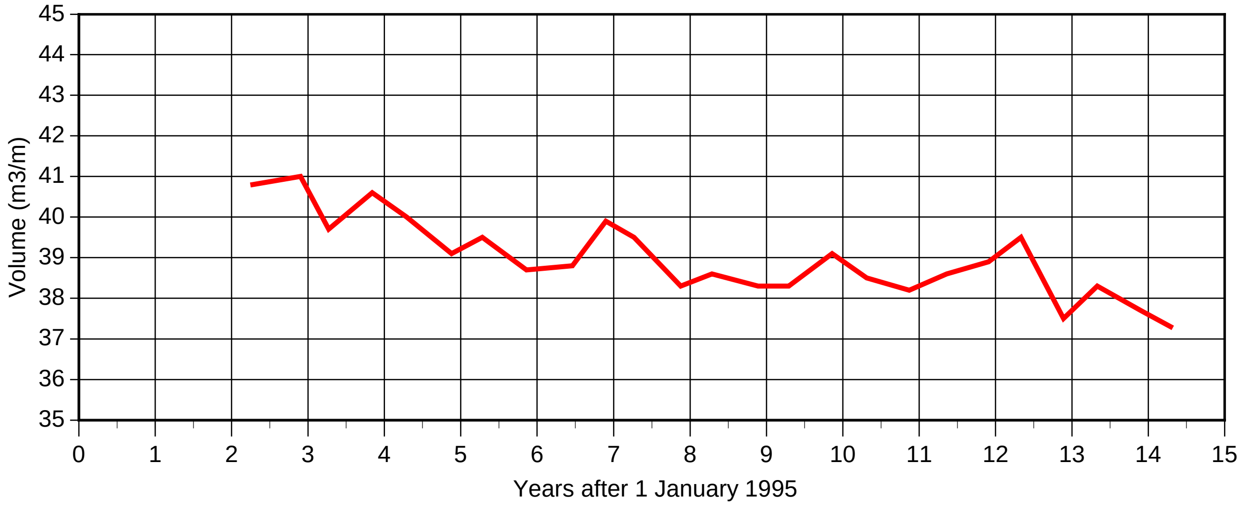



**Profile 11: Long Island**




**Profile 11: Long Island**



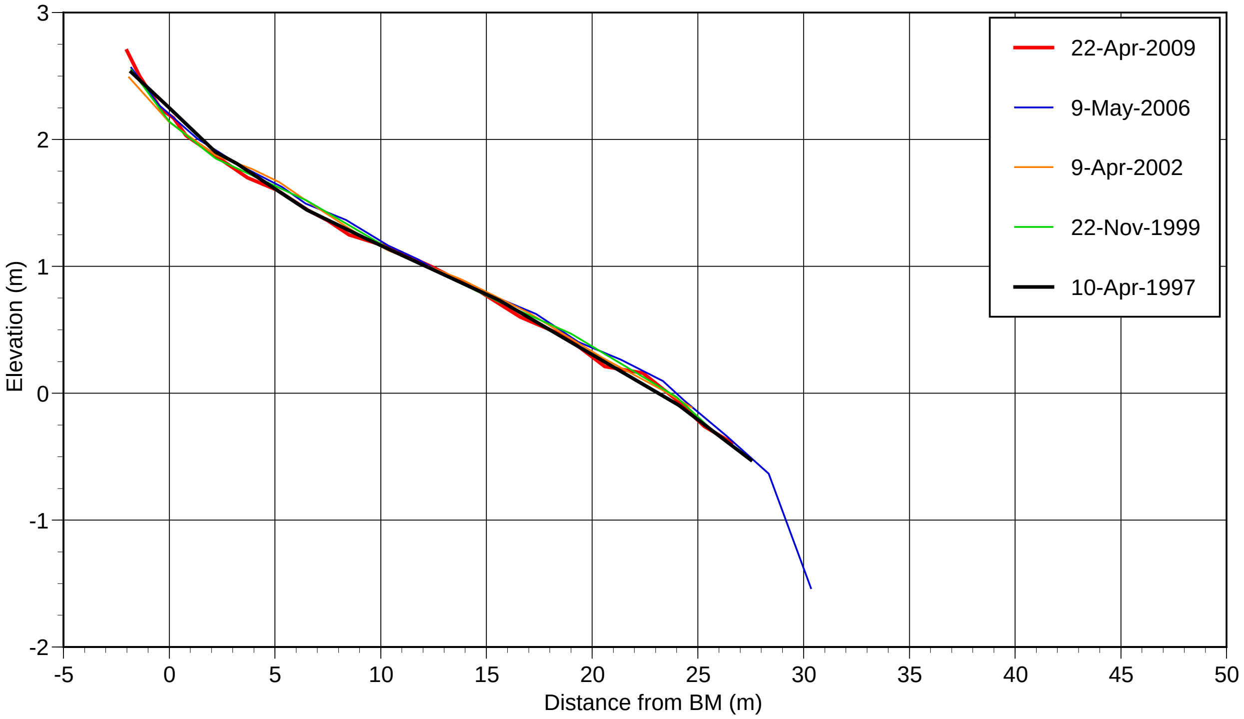

| Date | Years after 1/1/95 | Volume ($m^3$/m) |
|---|---|---|
| 10-Apr-97 | 2.28 | 40.8 |
| 26-Nov-97 | 2.90 | 41.0 |
| 8-Apr-98 | 3.27 | 39.7 |
| 2-Nov-98 | 3.84 | 40.6 |
| 14-Apr-99 | 4.29 | 40.0 |
| 19-Nov-99 | 4.88 | 39.1 |
| 13-Apr-00 | 5.28 | 39.5 |
| 9-Nov-00 | 5.86 | 38.7 |
| 15-Jun-01 | 6.46 | 38.8 |
| 26-Nov-01 | 6.90 | 39.9 |
| 9-Apr-02 | 7.27 | 39.5 |
| 18-Nov-02 | 7.88 | 38.3 |
| 14-Apr-03 | 8.29 | 38.6 |
| 19-Nov-03 | 8.89 | 38.3 |
| 16-Apr-04 | 9.29 | 38.3 |
| 7-Dec-04 | 9.86 | 39.1 |
| 22-Apr-05 | 10.31 | 38.5 |
| 14-Nov-05 | 10.87 | 38.2 |
| 9-May-06 | 11.36 | 38.6 |
| 21-Nov-06 | 11.91 | 38.9 |
| 30-Apr-07 | 12.33 | 39.5 |
| 20-Nov-07 | 12.89 | 37.5 |
| 06-May-08 | 13.33 | 38.3 |
| 12-Nov-08 | 13.90 | 37.7 |
| 22-Apr-09 | 14.29 | 37.3 |

**Profile 11: Long Island**

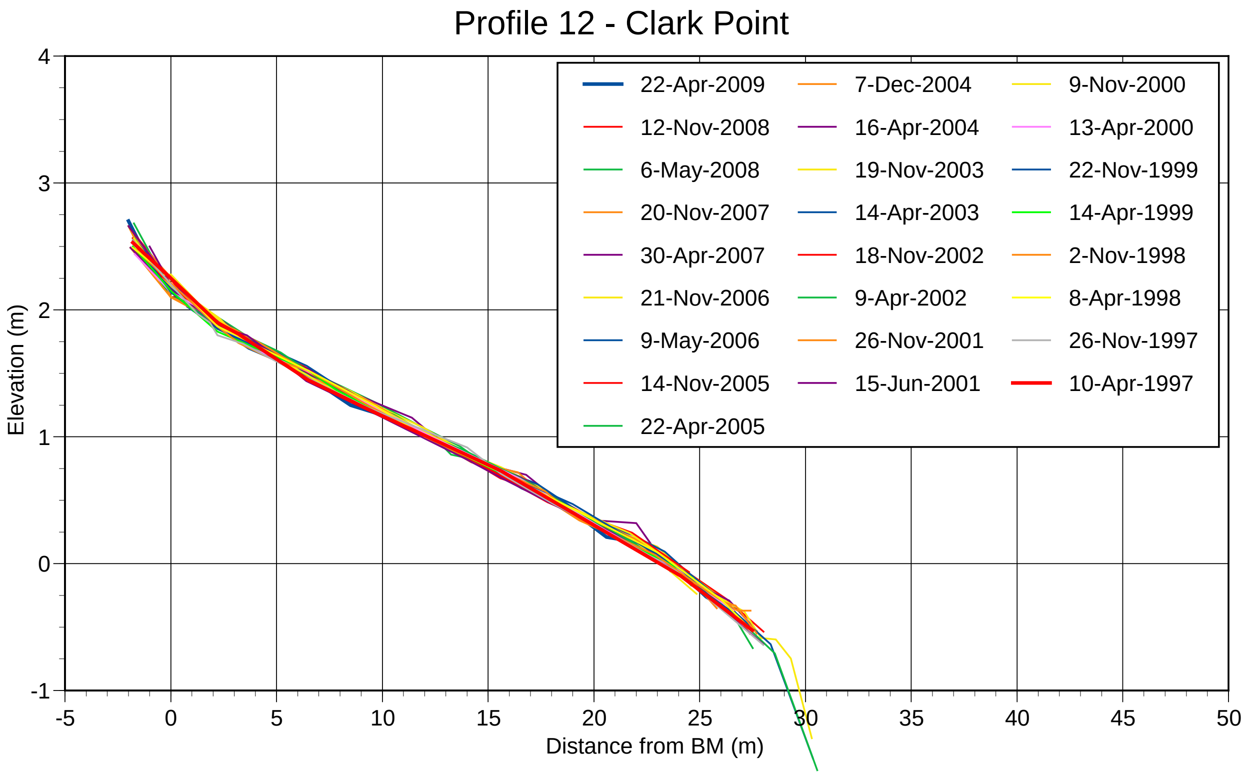
*Profile 12 – Clark Point*

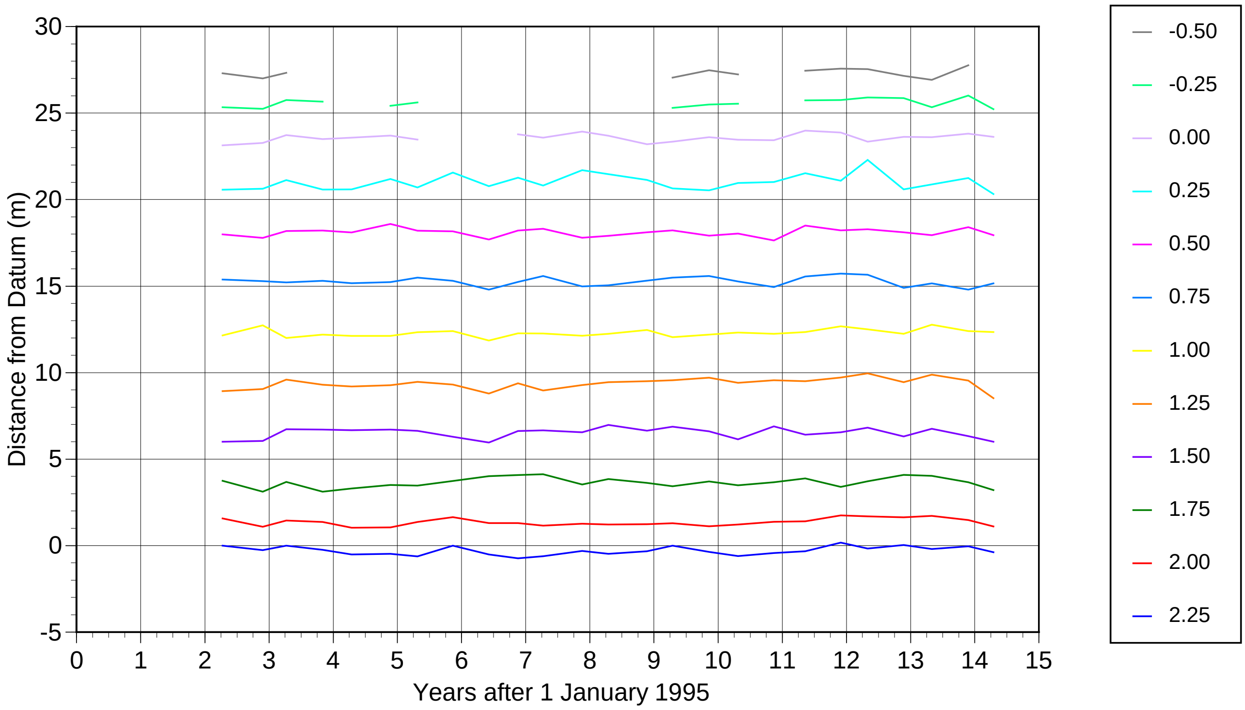
This profile, with a similar aspect to Profile 11 (Long Island), has shown no significant change in level, volume or sedimentary characteristics since 1997.

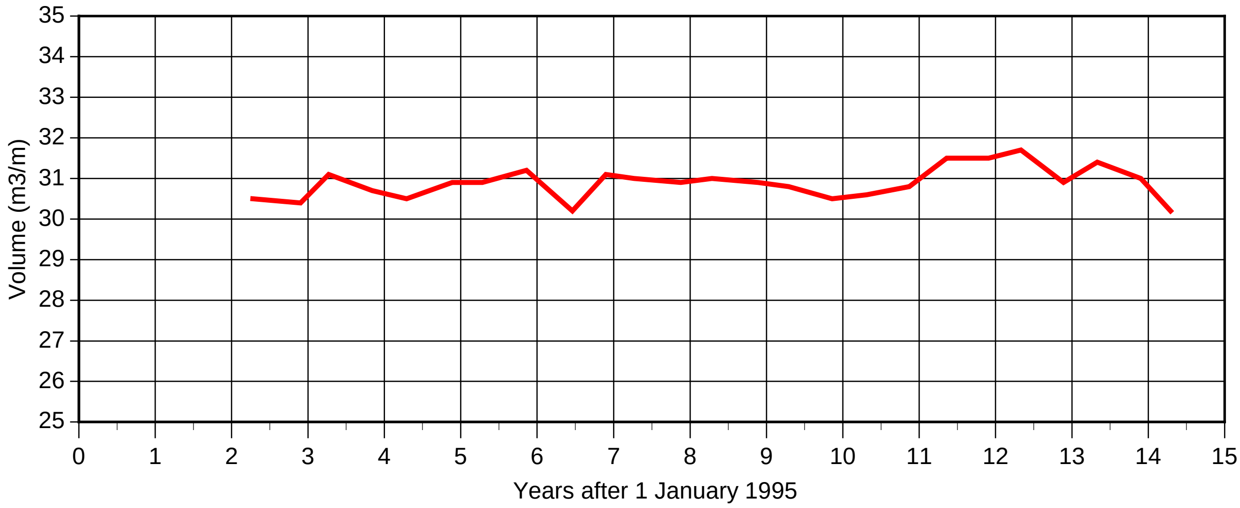



**Profile 12: Clark Point**




**Profile 12: Clark Point**




| Date | Years after 1/1/95 | Volume ($m^3/m$) |
|---|---|---|
| 10-Apr-97 | 2.28 | 30.5 |
| 26-Nov-97 | 2.90 | 30.4 |
| 8-Apr-98 | 3.27 | 31.1 |
| 2-Nov-98 | 3.84 | 30.7 |
| 14-Apr-99 | 4.29 | 30.5 |
| 22-Nov-99 | 4.89 | 30.9 |
| 13-Apr-00 | 5.28 | 30.9 |
| 9-Nov-00 | 5.86 | 31.2 |
| 15-Jun-01 | 6.46 | 30.2 |
| 26-Nov-01 | 6.90 | 31.1 |
| 9-Apr-02 | 7.27 | 31.0 |
| 18-Nov-02 | 7.88 | 30.9 |
| 14-Apr-03 | 8.29 | 31.0 |
| 19-Nov-03 | 8.89 | 30.9 |
| 16-Apr-04 | 9.29 | 30.8 |
| 7-Dec-04 | 9.86 | 30.5 |
| 22-Apr-05 | 10.31 | 30.6 |
| 14-Nov-05 | 10.87 | 30.8 |
| 9-May-06 | 11.36 | 31.5 |
| 21-Nov-06 | 11.91 | 31.5 |
| 30-Apr-07 | 12.33 | 31.7 |
| 20-Nov-07 | 12.89 | 30.9 |
| 06-May-08 | 13.33 | 31.4 |
| 12-Nov-08 | 13.90 | 31.0 |
| 22-Apr-09 | 14.29 | 30.2 |

**Profile 12: Clark Point**

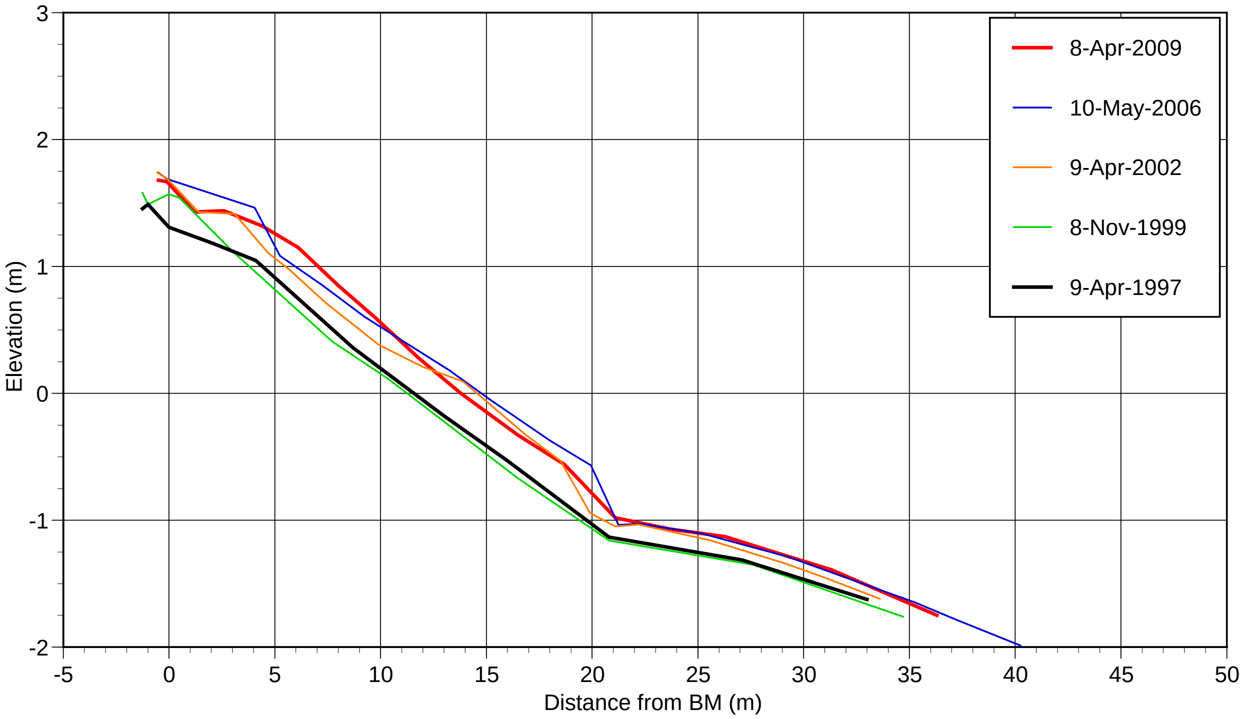
*Profile 13 – Slip Beach*

Slip Beach demonstrated considerable variability between 1995 and April 1998 when it reached its lowest level. Up until the end of 2000, there was variability but in the context of accretion. Between 2000 and 2006 there was less variability, but with continued accretion. Since 2006 the beach has been relatively stable from year to ear, but with very significant seasonality, with accretion over the summer, and sediment loss over the winter. Overall, however, the beach is in a considerably accreted state compared to the 1997.

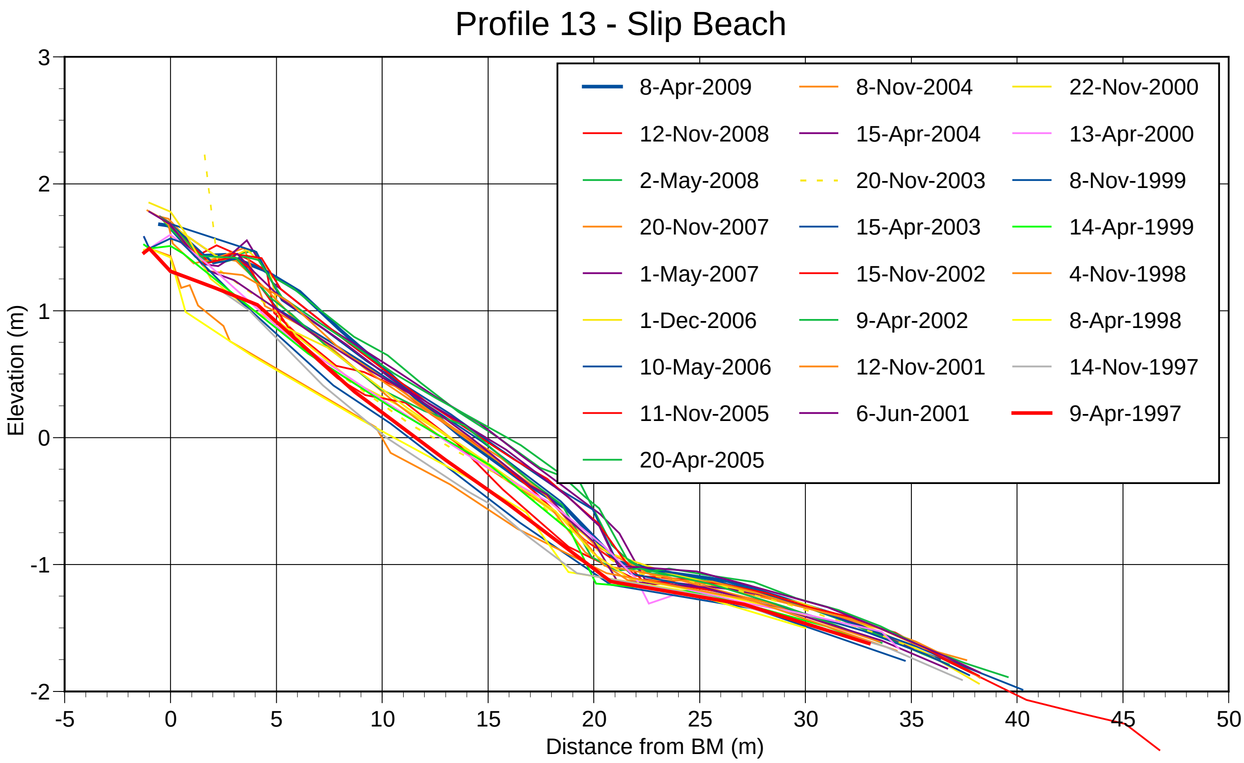
The photographs indicate that the dominant sediment type is sand with some small cobbles and pebbles.

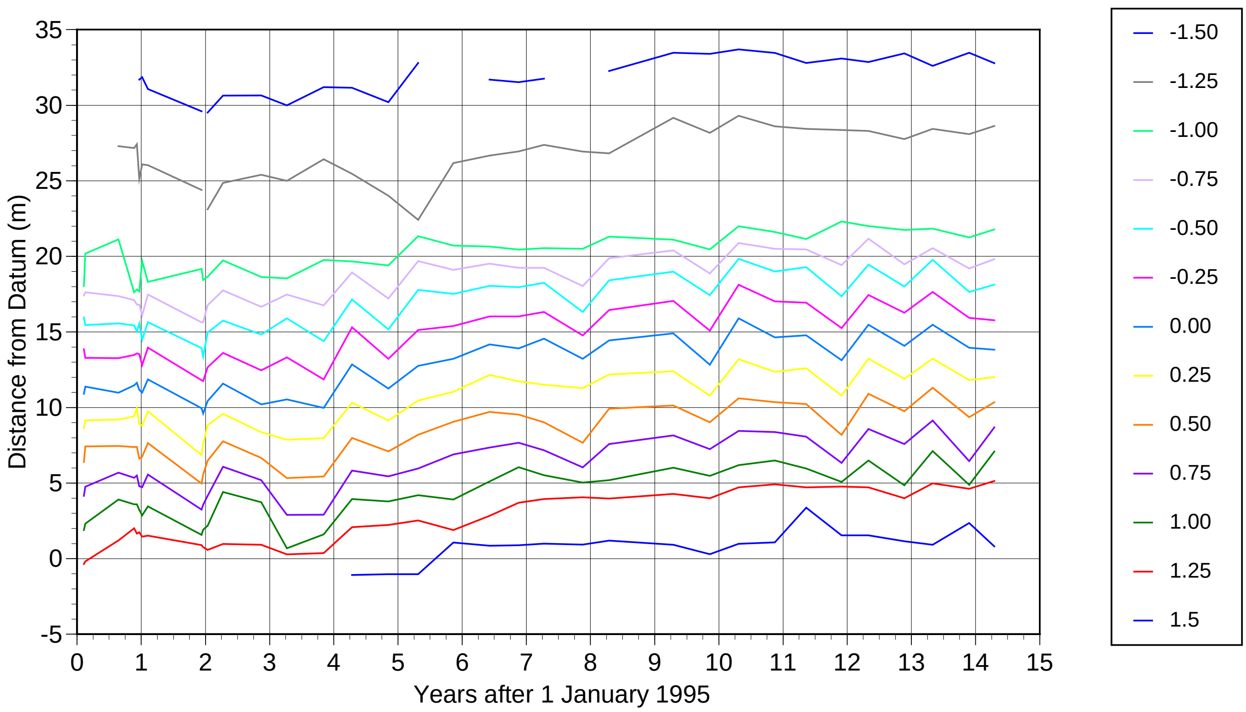
Although no obvious relationships between ferry operations and beach change were able to be determined, it is apparent that the considerable variability in the profile ceased about the same time as fast ferry operations ceased. Slip beach has a considerable fetch into Queen Charlotte Sound to the north, and natural waves may be substantial. However, wave measurements at this site have indicated substantial wake events that continue for unusually long periods of time.

Because of its unusual exposure, extreme seasonality, unusual wakes and, for the area, fine sediments, this location continues to be of particular interest.

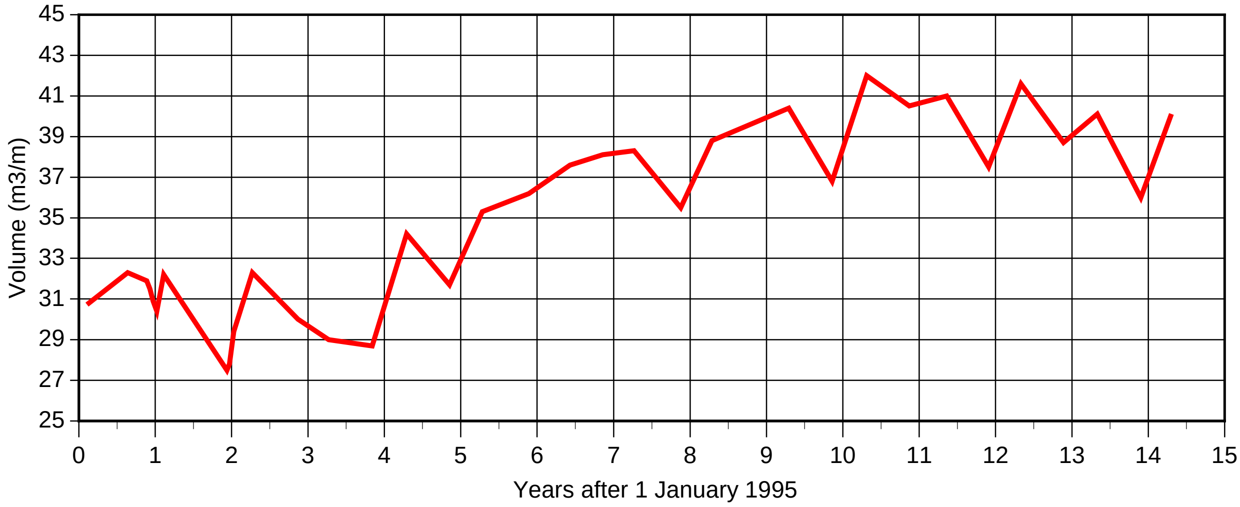



**Profile 13: Slip Beach**




**Profile 13: Slip Beach**



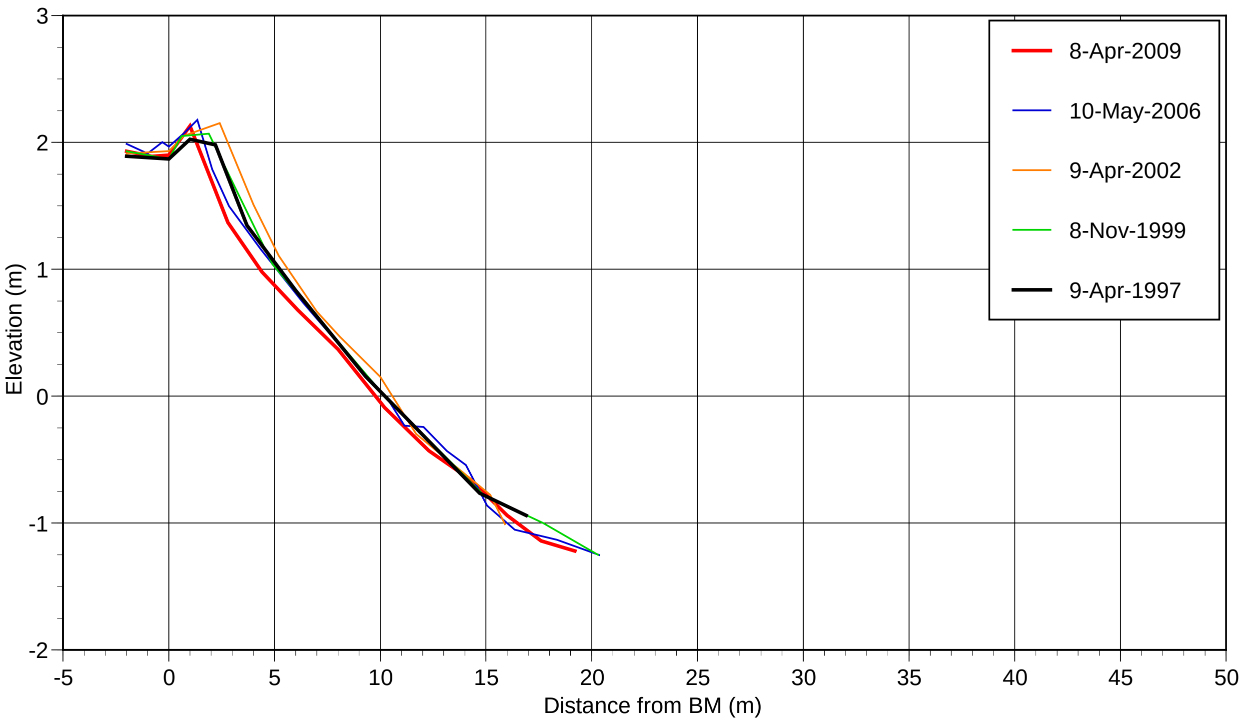

| Date | Years after 1/1/95 | Volume ($m^3$/m) |
|---|---|---|
| 17-Feb-95 | 0.13 | 30.8 |
| 22-Aug-95 | 0.64 | 32.3 |
| 21-Nov-95 | 0.89 | 31.9 |
| 7-Dec-95 | 0.93 | 31.5 |
| 20-Dec-95 | 0.97 | 30.9 |
| 7-Jan-96 | 1.02 | 30.4 |
| 9-Feb-96 | 1.11 | 32.2 |
| 9-Dec-96 | 1.94 | 27.5 |
| 19-Dec-96 | 1.97 | 27.8 |
| 13-Jan-97 | 2.03 | 29.4 |
| 9-Apr-97 | 2.27 | 32.3 |
| 14-Nov-97 | 2.87 | 30.0 |
| 8-Apr-98 | 3.27 | 29.0 |
| 4-Nov-98 | 3.84 | 28.7 |
| 14-Apr-99 | 4.29 | 34.2 |
| 8-Nov-99 | 4.85 | 31.7 |
| 13-Apr-00 | 5.28 | 35.3 |
| 22-Nov-00 | 5.89 | 36.2 |
| 6-Jun-01 | 6.43 | 37.6 |
| 12-Nov-01 | 6.86 | 38.1 |
| 9-Apr-02 | 7.27 | 38.3 |
| 15-Nov-02 | 7.88 | 35.5 |
| 15-Apr-03 | 8.29 | 38.8 |
| 20-Nov-03 | 8.89 | No data |
| 15-Apr-04 | 9.29 | 40.4 |
| 8-Nov-04 | 9.86 | 36.8 |
| 20-Apr-05 | 10.31 | 42.0 |
| 11-Nov-05 | 10.87 | 40.5 |
| 10-May-06 | 11.36 | 41.0 |
| 01-Dec-06 | 11.91 | 37.5 |
| 01-May-07 | 12.33 | 41.6 |
| 20-Nov-07 | 12.89 | 38.7 |
| 02-May-08 | 13.33 | 40.1 |
| 12-Nov-08 | 13.90 | 36.0 |
| 08-Apr-09 | 14.29 | 40.0 |

**Profile 13: Slip Beach**

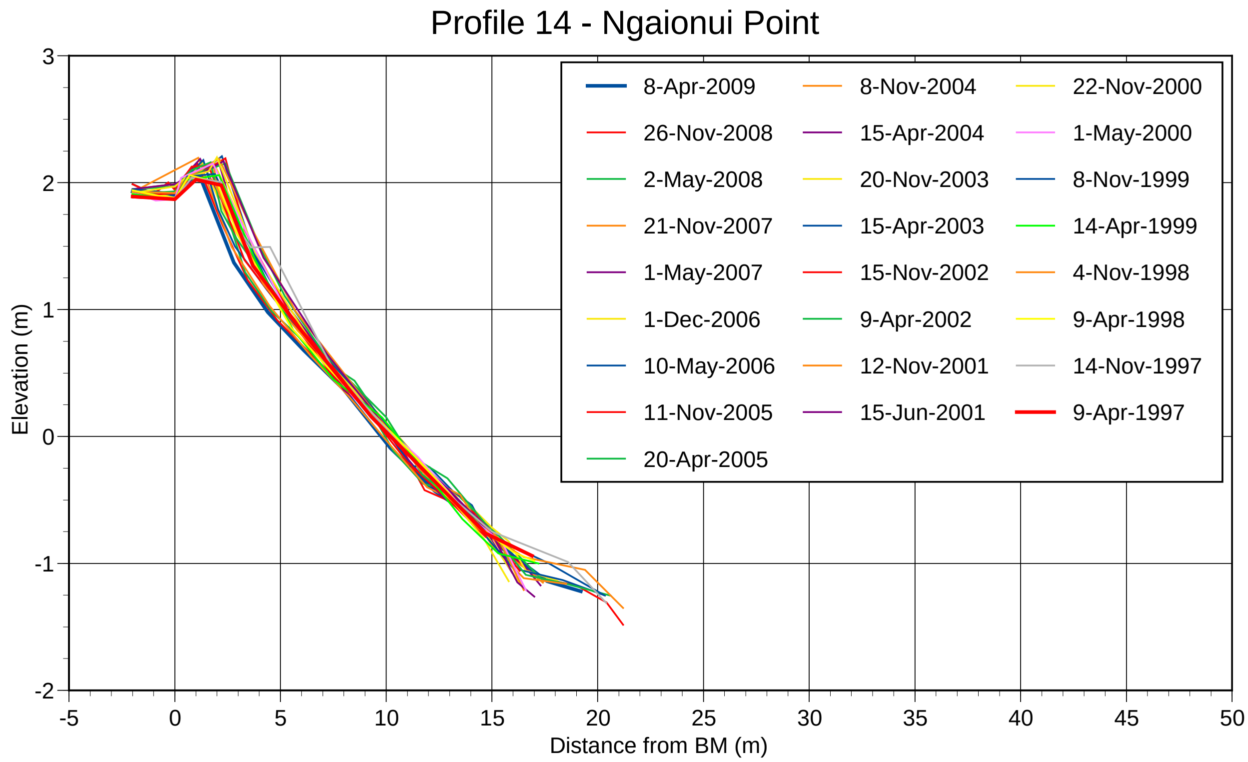
*Profile 14 – Ngaionui Point*

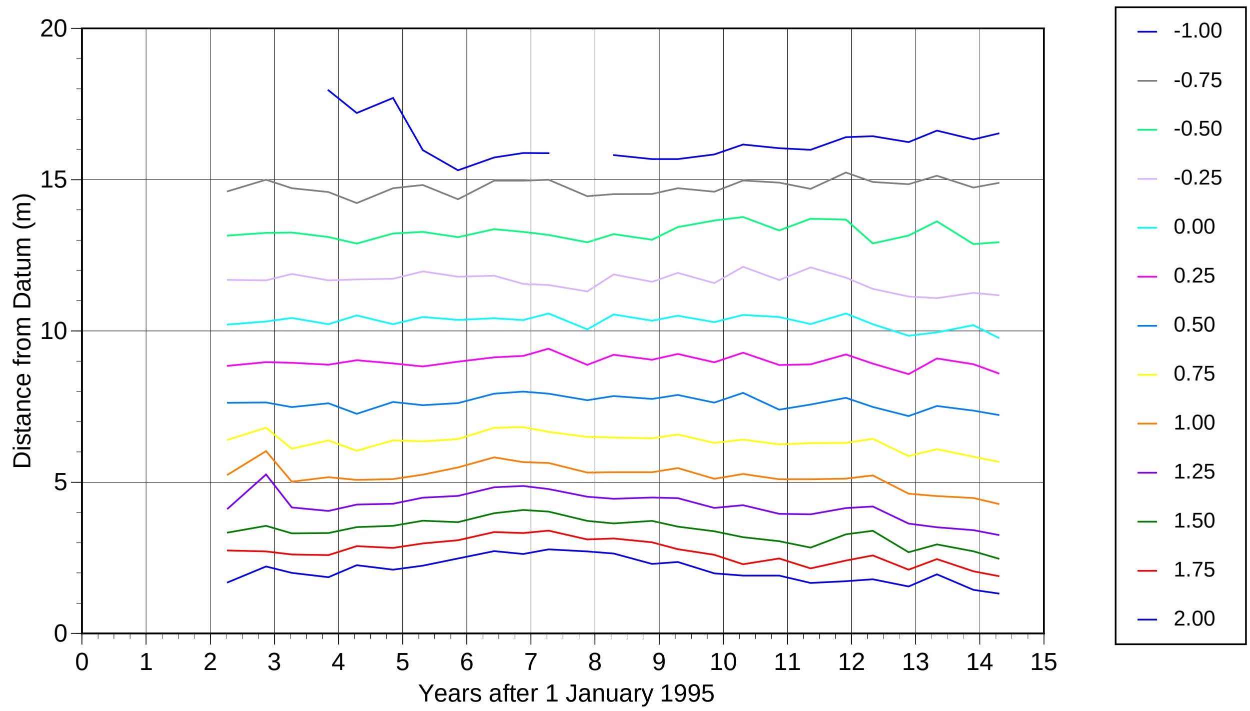
Given its proximity to the sailing line of vessels in Tory Channel, the beach at Ngaionui Point probably changed significantly when the fast ferry first started operation, and that the beach form has generally held since that time. There was a slow trend towards accretion up until about April 2002, and a trend of erosion since that time, reflecting the start of a return to pre-fast ferry conditions. The beach is now lower than at the start of surveys. However, it is unknown what its status is compared to the situation prior to fast ferry operation.

Apparent changes at the very lower beach are probably the result of different survey placement. There have been no significant changes in sediments.

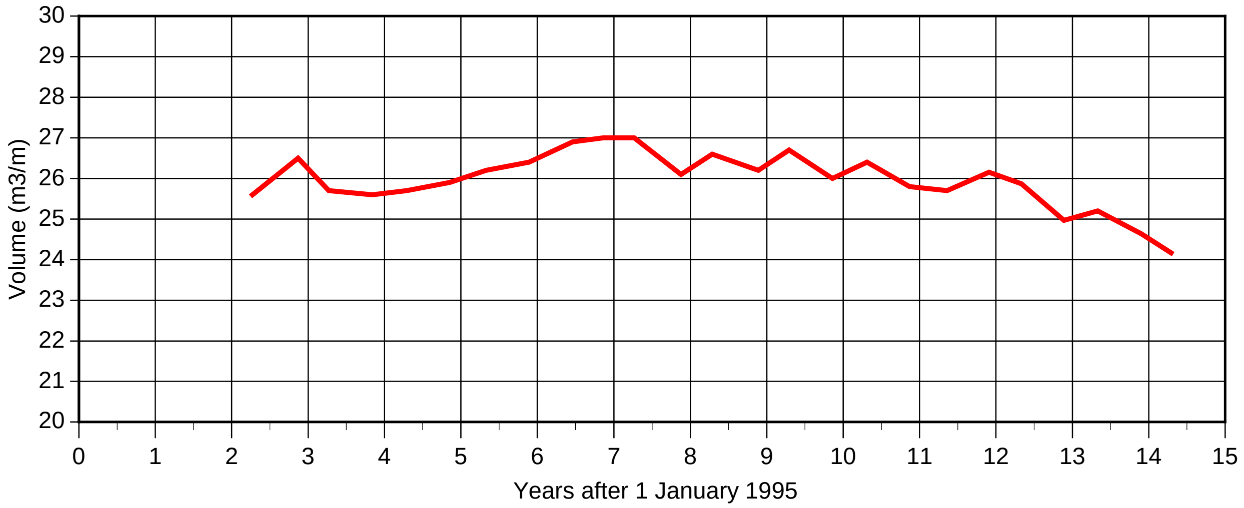



**Profile 14: Ngaionui Point**




**Profile 14: Ngaionui Point**



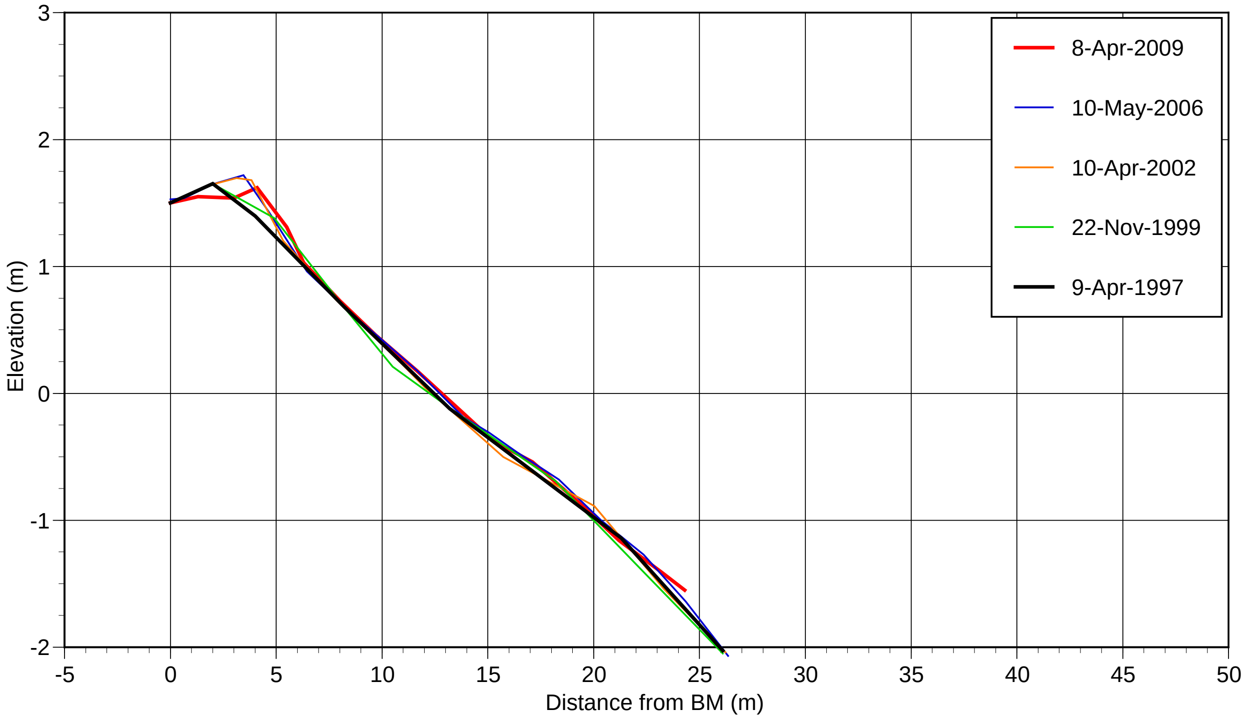

| Date | Years after 1/1/95 | Volume ($m^3$/m) |
|---|---|---|
| 9-Apr-97 | 2.27 | 25.6 |
| 14-Nov-97 | 2.87 | 26.5 |
| 9-Apr-98 | 3.27 | 25.7 |
| 4-Nov-98 | 3.84 | 25.6 |
| 14-Apr-99 | 4.29 | 25.7 |
| 8-Nov-99 | 4.85 | 25.9 |
| 1-May-00 | 5.33 | 26.2 |
| 22-Nov-00 | 5.89 | 26.4 |
| 15-Jun-01 | 6.46 | 26.9 |
| 12-Nov-01 | 6.86 | 27.0 |
| 9-Apr-02 | 7.27 | 27.0 |
| 15-Nov-02 | 7.88 | 26.1 |
| 15-Apr-03 | 8.29 | 26.6 |
| 20-Nov-03 | 8.89 | 26.2 |
| 15-Apr-04 | 9.29 | 26.7 |
| 8-Nov-04 | 9.86 | 26.0 |
| 20-Apr-05 | 10.31 | 26.4 |
| 11-Nov-05 | 10.87 | 25.8 |
| 10-May-06 | 11.36 | 25.7 |
| 01-Dec-06 | 11.91 | 26.15 |
| 01-May-07 | 12.33 | 25.87 |
| 21-Nov-07 | 12.89 | 24.97 |
| 02-May-08 | 13.33 | 25.20 |
| 26-Nov-08 | 13.90 | 24.64 |
| 08-Apr-09 | 14.29 | 24.17 |

**Profile 14: Ngaionui Point**

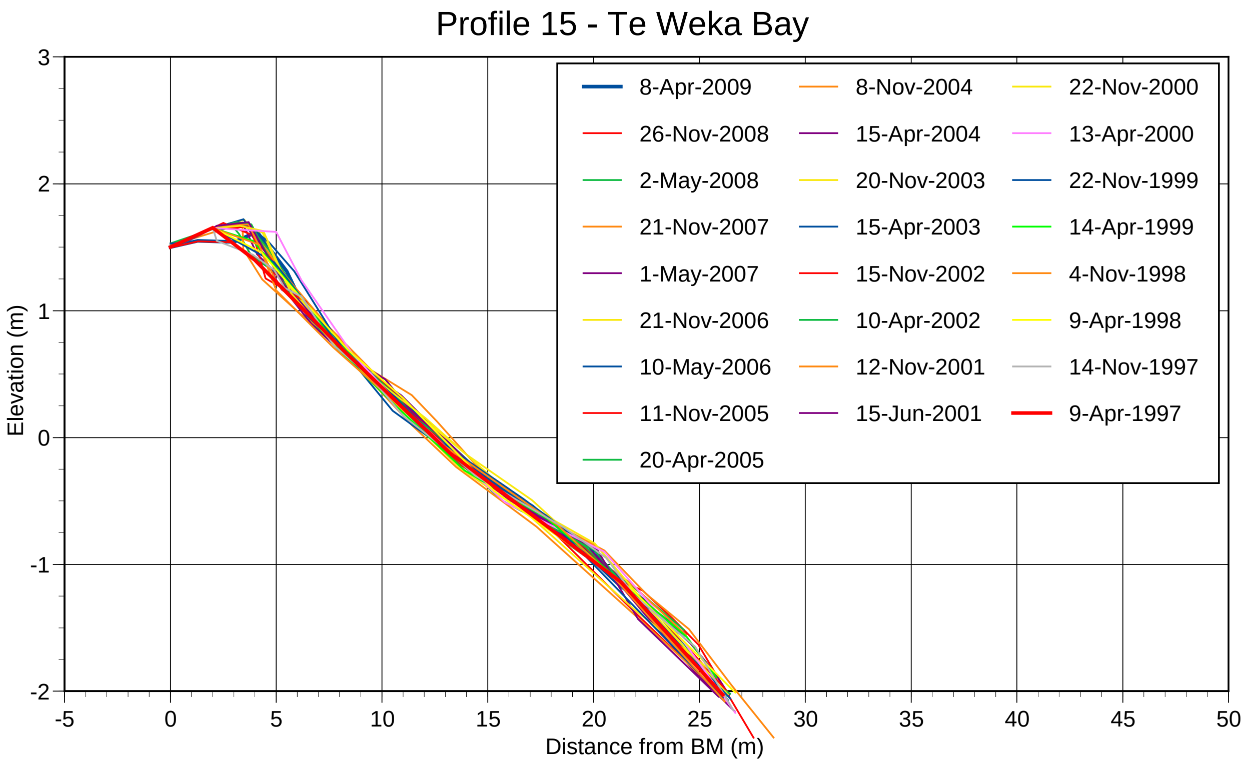
*Profile 15 – Te Weka Bay*

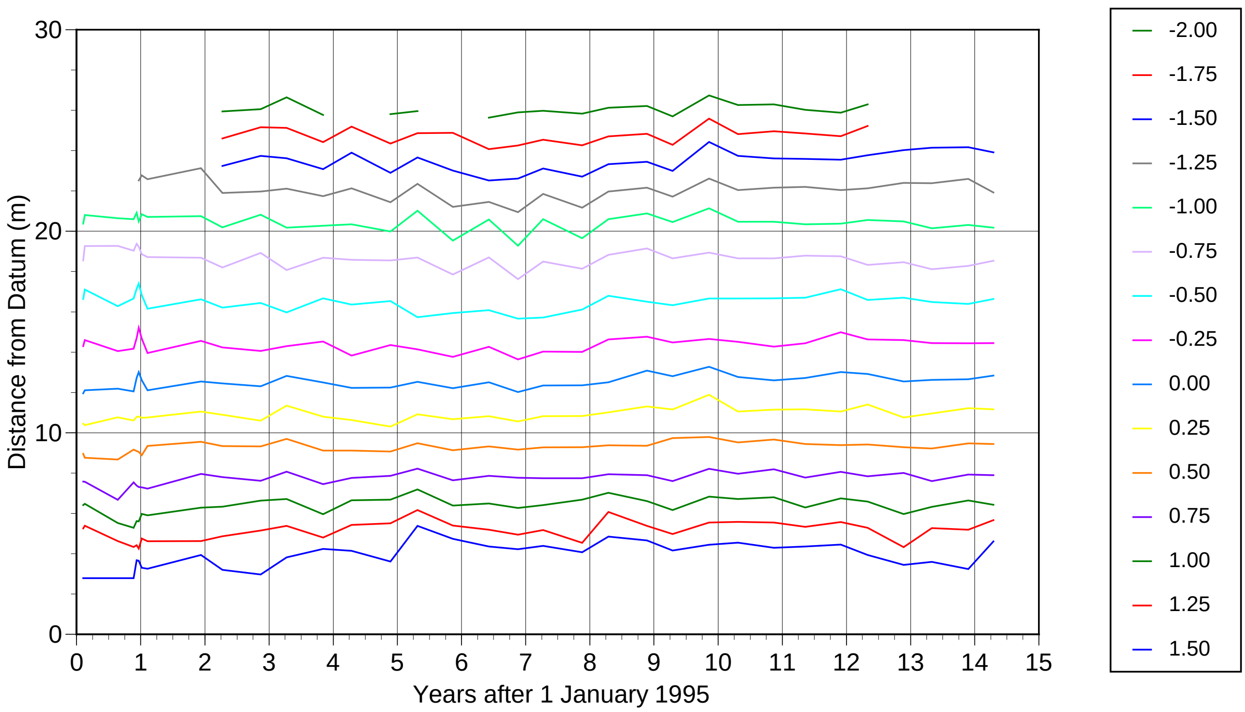
The Te Weka Bay profile, has been generally stable over the 2006-2009 survey period, and since surveys began. The development of an upper beach berm and the reduction in level of the middle beach during the period of fast ferry operation is evident (reaching a peak in April 2000).  The berm has remained generally intact since that time

There have been no significant changes in sediment characteristics.

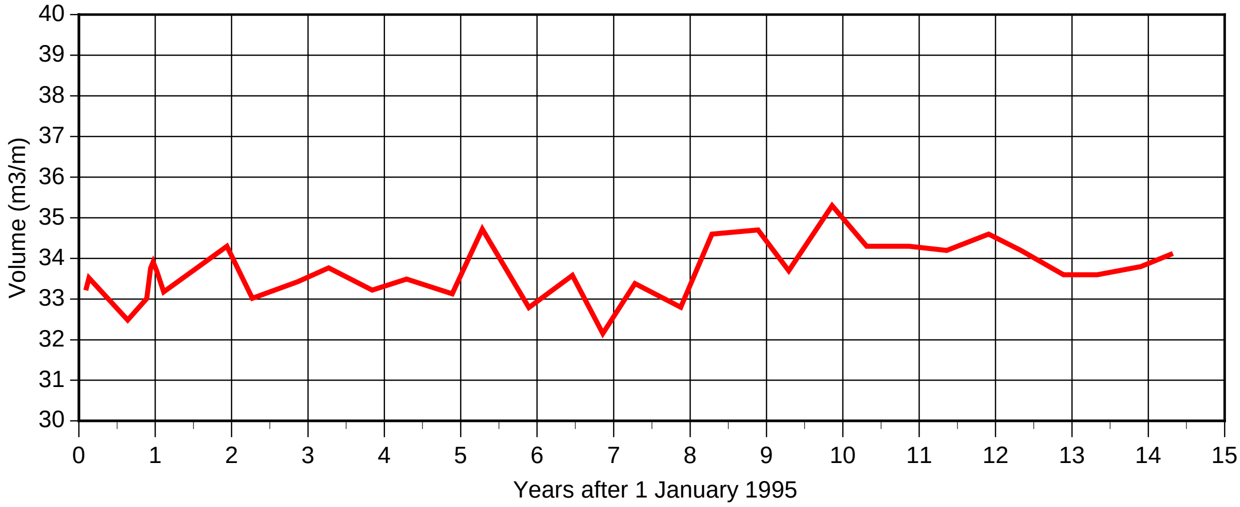



**Profile 15: Te Weka Bay**




**Profile 15: Te Weka Bay**




| Date | Years after 1/1/95 | Volume ($m^3$/m) |
|---|---|---|
| 8-Feb-95 | 0.10 | 33.27 |
| 17-Feb-95 | 0.13 | 33.52 |
| 22-Aug-95 | 0.64 | 32.48 |
| 21-Nov-95 | 0.89 | 33.01 |
| 8-Dec-95 | 0.94 | 33.76 |
| 20-Dec-95 | 0.97 | 33.91 |
| 7-Jan-96 | 1.02 | 33.68 |
| 9-Feb-96 | 1.11 | 33.17 |
| 9-Dec-96 | 1.94 | 34.30 |
| 9-Apr-97 | 2.27 | 33.02 |
| 14-Nov-97 | 2.87 | 33.43 |
| 9-Apr-98 | 3.27 | 33.77 |
| 4-Nov-98 | 3.84 | 33.22 |
| 14-Apr-99 | 4.29 | 33.49 |
| 22-Nov-99 | 4.89 | 33.13 |
| 13-Apr-00 | 5.28 | 34.72 |
| 22-Nov-00 | 5.89 | 32.79 |
| 15-Jun-01 | 6.46 | 33.58 |
| 12-Nov-01 | 6.86 | 32.15 |
| 10-Apr-02 | 7.28 | 33.38 |
| 15-Nov-02 | 7.88 | 32.8 |
| 15-Apr-03 | 8.29 | 34.6 |
| 20-Nov-03 | 8.89 | 34.7 |
| 15-Apr-04 | 9.29 | 33.7 |
| 8-Nov-04 | 9.86 | 35.3 |
| 20-Apr-05 | 10.31 | 34.3 |
| 11-Nov-05 | 10.87 | 34.3 |
| 10-May-06 | 11.36 | 34.2 |
| 21-Nov-06 | 11.91 | 34.6 |
| 01-May-07 | 12.33 | 34.2 |
| 21-Nov-07 | 12.89 | 33.6 |
| 02-May-08 | 13.33 | 33.6 |
| 26-Nov-08 | 13.90 | 33.8 |
| 08-Apr-09 | 14.29 | 34.1 |

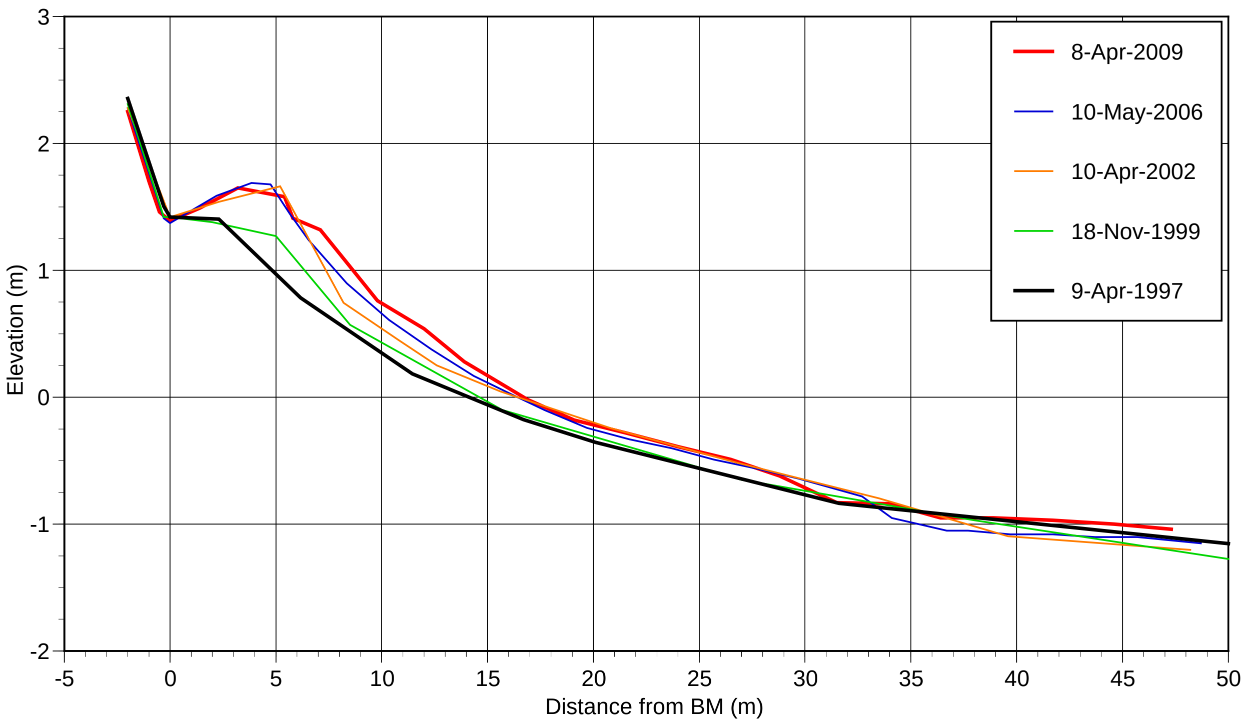
**Profile 15: Te Weka Bay**

*Profile 16 – McMillan’s Bay*

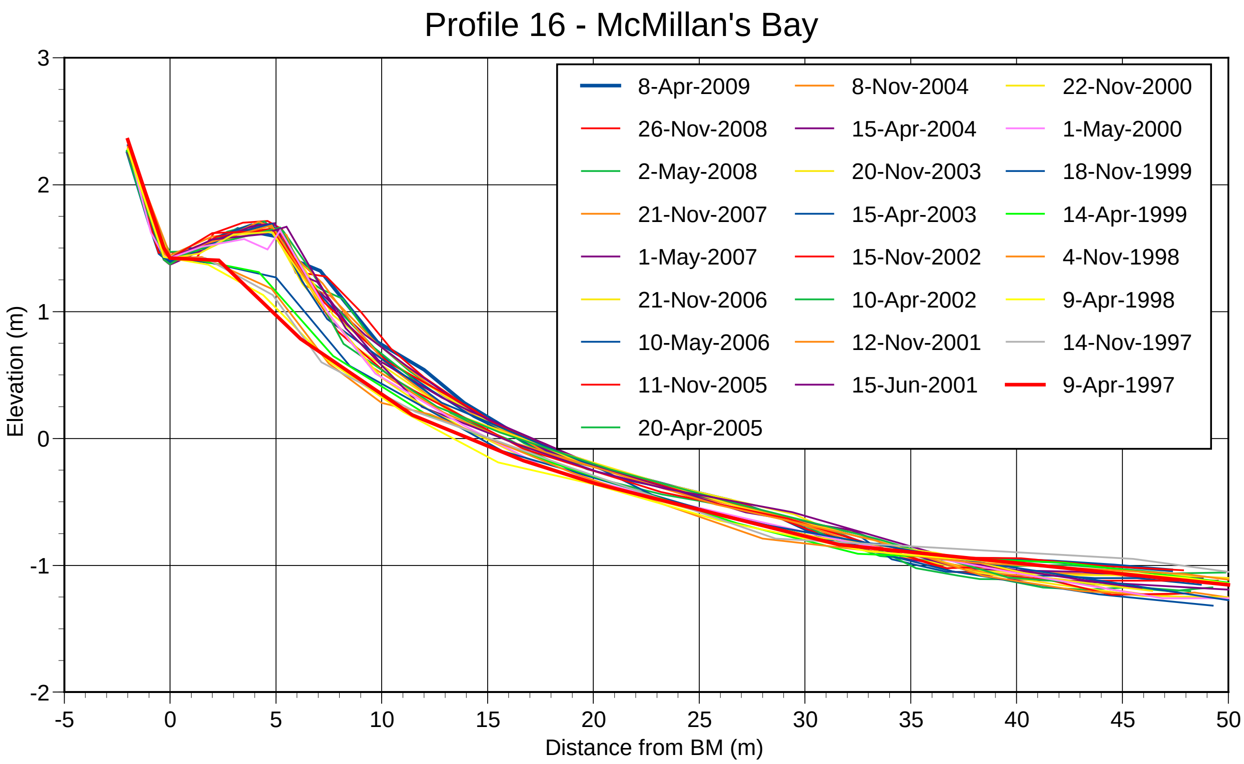
Up until November 1999 there had been a gradual accretion of the upper McMillan’s Bay profile. The accretion was mainly comprised of gravels that were moving along the beach from the direction of Arrowsmith Point, although there had been some rise in the middle beach level, due to deposition of sand. Between November 1999 and May 2000 a major increase in the height of the upper beach berm occurred, with a very large deposit of gravel, again coming from the direction of Arrowsmith Point. This deposit has remained almost unchanged since that time. The upper to middle beach has continued to build with the deposition of sand. The lower beach has been relatively stable, apparent changes probably being the result of minor differences in survey line.

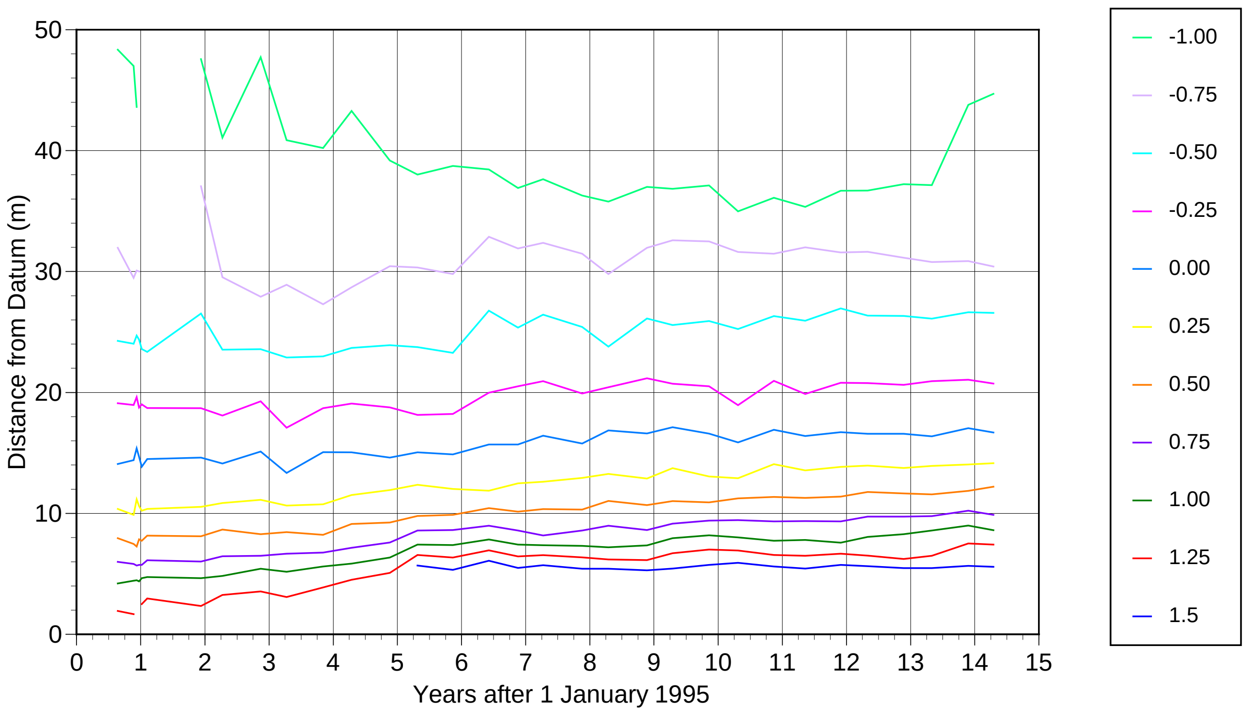
This profile line is clearly being influenced by longshore transport of gravels from west to east. It may also be that there is transport of sand either onshore or alongshore. It is most likely that the mechanism of accretion is the result of ferry generated wake waves. The rate of accretion dropped markedly about the time the fast ferry operation ceased, probably the result of a reduced ability of the waves to transport sediment.

McMillan’s Bay is quite unusual in the context of the Tory Channel, being wide and with a relatively small slope. It has a wide ‘surf’ zone, unlike almost all other shorelines in the area.

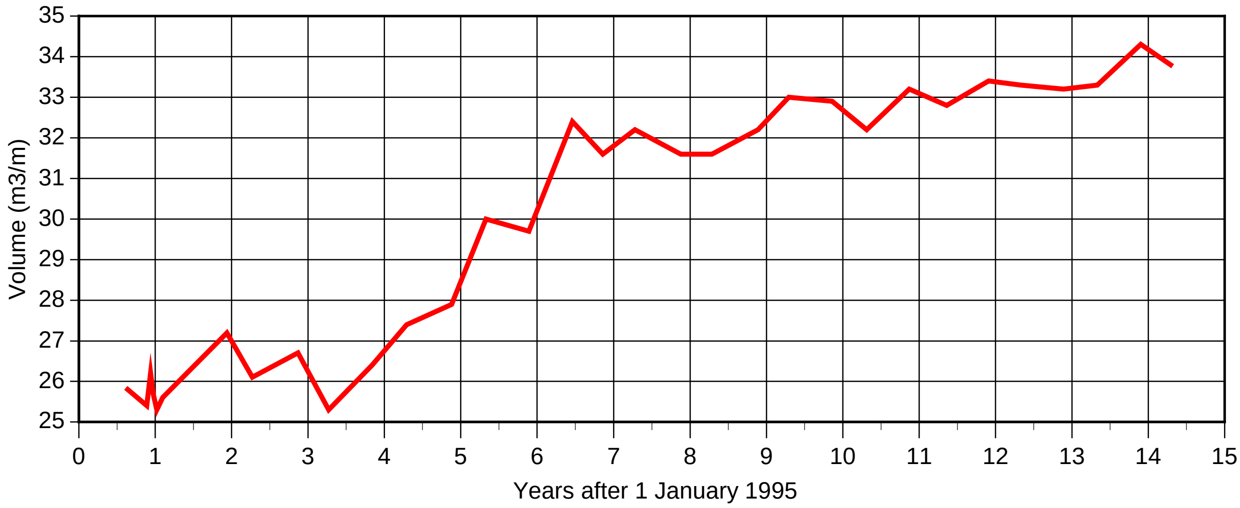



**Profile 16: McMillan's Bay**




**Profile 16: McMillan’s Bay**




| Date | Years after 1/1/95 | Volume ($m^3$/m) |
|---|---|---|
| 22-Aug-95 | 0.64 | 25.8 |
| 21-Nov-95 | 0.89 | 25.4 |
| 8-Dec-95 | 0.94 | 26.2 |
| 21-Dec-95 | 0.97 | 25.7 |
| 7-Jan-96 | 1.02 | 25.3 |
| 8-Feb-96 | 1.10 | 25.6 |
| 9-Dec-96 | 1.94 | 27.2 |
| 9-Apr-97 | 2.27 | 26.1 |
| 14-Nov-97 | 2.87 | 26.7 |
| 9-Apr-98 | 3.27 | 25.3 |
| 4-Nov-98 | 3.84 | 26.4 |
| 14-Apr-99 | 4.29 | 27.4 |
| 18-Nov-99 | 4.88 | 27.9 |
| 1-May-00 | 5.33 | 30.0 |
| 22-Nov-00 | 5.89 | 29.7 |
| 15-Jun-01 | 6.46 | 32.4 |
| 12-Nov-01 | 6.86 | 31.6 |
| 10-Apr-02 | 7.28 | 32.2 |
| 15-Nov-02 | 7.88 | 31.6 |
| 15-Apr-03 | 8.29 | 31.6 |
| 20-Nov-03 | 8.89 | 32.2 |
| 15-Apr-04 | 9.29 | 33.0 |
| 8-Nov-04 | 9.86 | 32.9 |
| 20-Apr-05 | 10.31 | 32.2 |
| 11-Nov-05 | 10.87 | 33.2 |
| 10-May-06 | 11.36 | 32.8 |
| 21-Nov-06 | 11.91 | 33.4 |
| 01-May-07 | 12.33 | 33.3 |
| 21-Nov-07 | 12.89 | 33.2 |
| 02-May-08 | 13.33 | 33.3 |
| 26-Nov-08 | 13.90 | 34.3 |
| 08-Apr-09 | 14.29 | 33.8 |

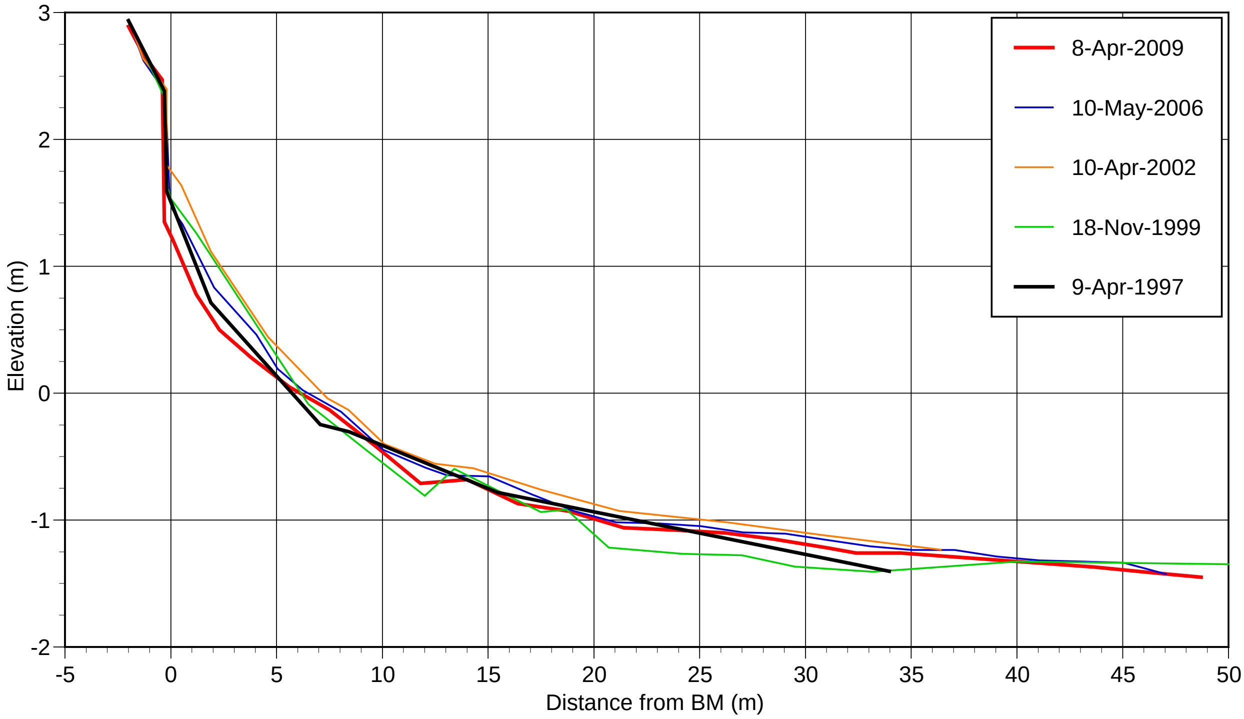
**Profile 16: McMillan’s Bay**

### *Profile 17 – McMillan's Side*

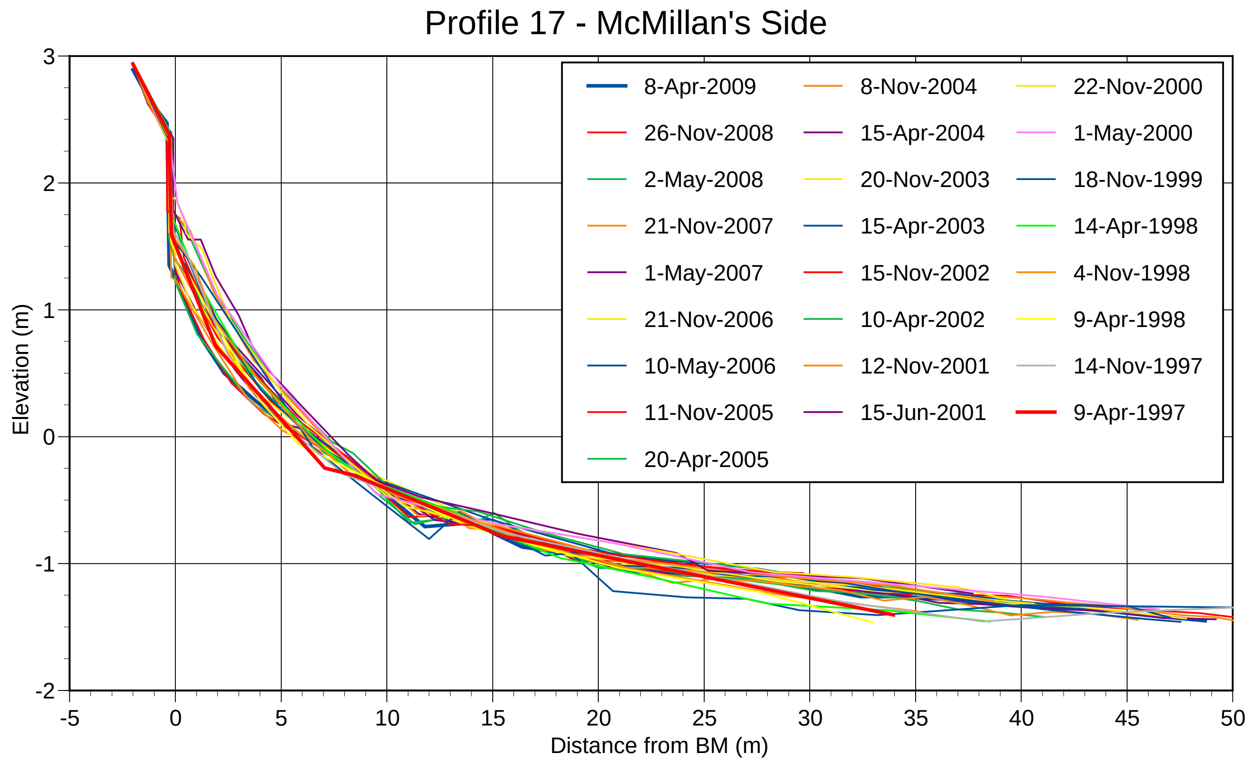
Between November 1999 and May 2000, at the same time as there was a major increase in the volume of the berm on Profile 16, there was a very significant deposition of sediment on the lower profile on Profile 17. Up until this time, the profile had been generally stable, with some accumulation on the upper beach, and perhaps some minor adjustments elsewhere on the profile line.

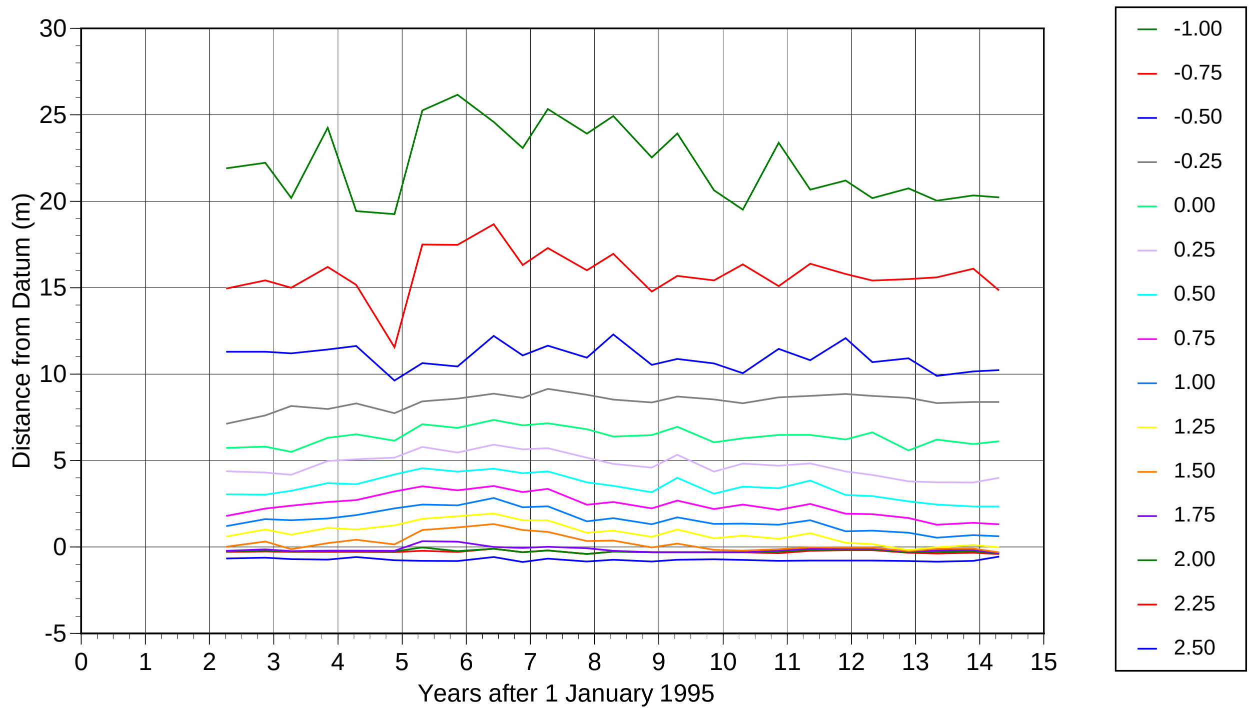
Beach volumes increased until 2001, with most of the accumulation on the lower profile. Since that time volumes have decreased, with most loss coming from the mid to upper beach. There is no indication of erosion at the upper beach scarp.

The reason for the major deposition between November 1999 and May 2000, reflected also on Profile 16, is unknown. However, there must have been a significant increase in sediment supply, perhaps a slip in the vicinity of Arrowsmith Point. After fast ferry operation ceased in 2000, there was a change from sediment accumulation to sediment loss, which has continued through to 2009. This occurred at the same time as a change from sediment accumulation to stability on Profile 16. Changes in this profile reflect changes in vessel operations, but there also appears to be a sediment supply control.

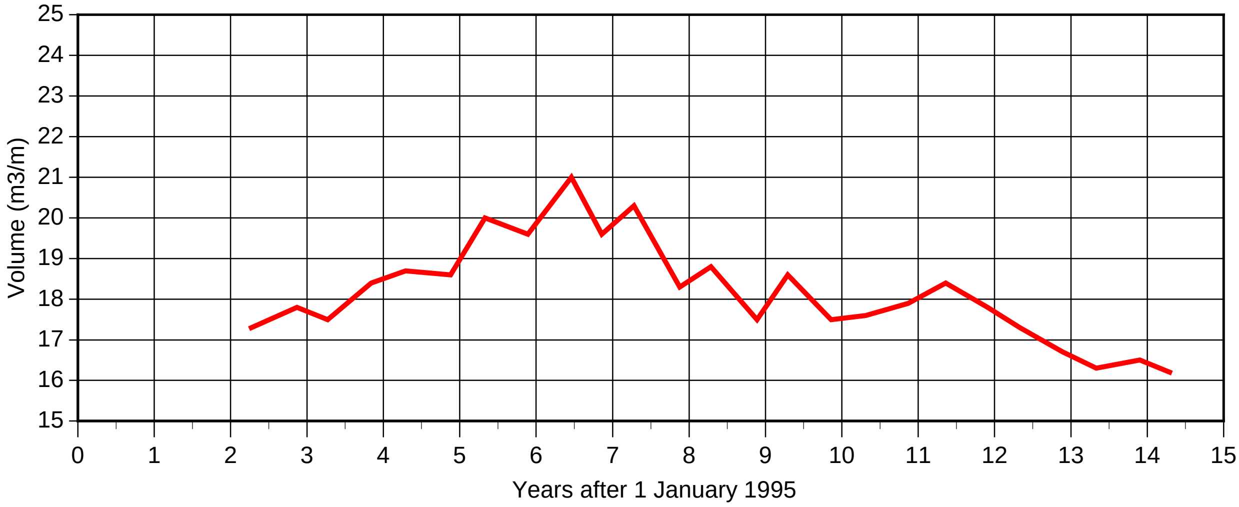



**Profile 17: McMillan's Side**




**Profile 17: McMillan's Side**



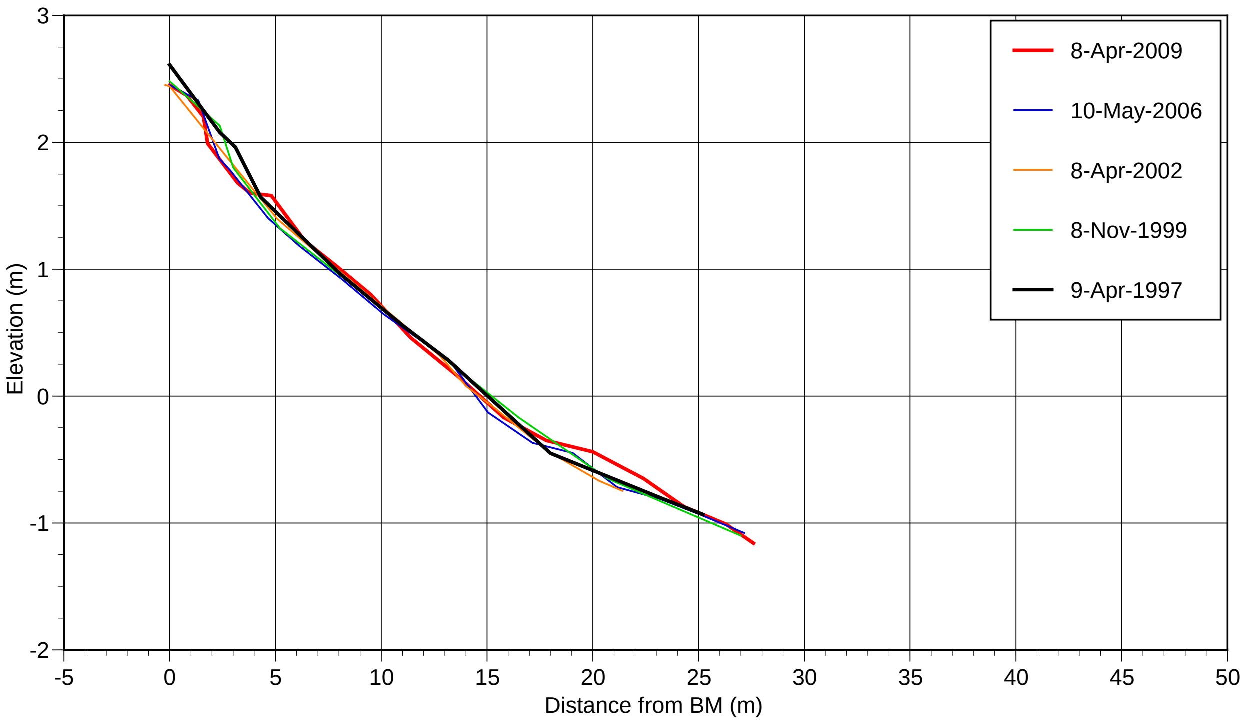

| Date | Years after 1/1/95 | Volume ($m^3/m$) |
|---|---|---|
| 9-Apr-97 | 2.27 | 17.3 |
| 14-Nov-97 | 2.87 | 17.8 |
| 9-Apr-98 | 3.27 | 17.5 |
| 4-Nov-98 | 3.84 | 18.4 |
| 14-Apr-99 | 4.29 | 18.7 |
| 18-Nov-99 | 4.88 | 18.6 |
| 1-May-00 | 5.33 | 20.0 |
| 22-Nov-00 | 5.89 | 19.6 |
| 15-Jun-01 | 6.46 | 21.0 |
| 12-Nov-01 | 6.86 | 19.6 |
| 10-Apr-02 | 7.28 | 20.3 |
| 15-Nov-02 | 7.88 | 18.3 |
| 15-Apr-03 | 8.29 | 18.8 |
| 20-Nov-03 | 8.89 | 17.5 |
| 15-Apr-04 | 9.29 | 18.6 |
| 8-Nov-04 | 9.86 | 17.5 |
| 20-Apr-05 | 10.31 | 17.6 |
| 11-Nov-05 | 10.87 | 17.9 |
| 10-May-06 | 11.36 | 18.4 |
| 21-Nov-06 | 11.91 | 17.8 |
| 01-May-07 | 12.33 | 17.3 |
| 21-Nov-07 | 12.89 | 16.7 |
| 02-May-08 | 13.33 | 16.3 |
| 26-Nov-08 | 13.90 | 16.5 |
| 08-Apr-09 | 14.29 | 16.2 |

**Profile 17: McMillan's Side**

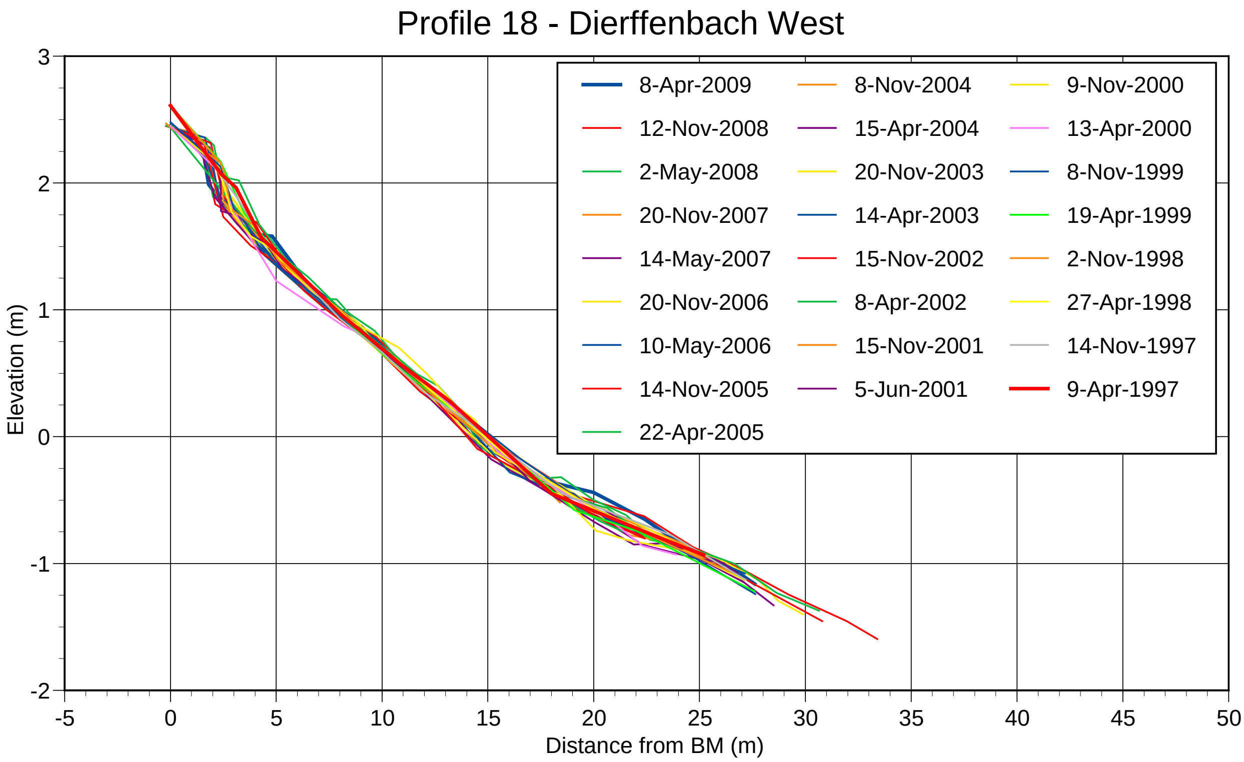
*Profile 18 – Dieffenbach West*

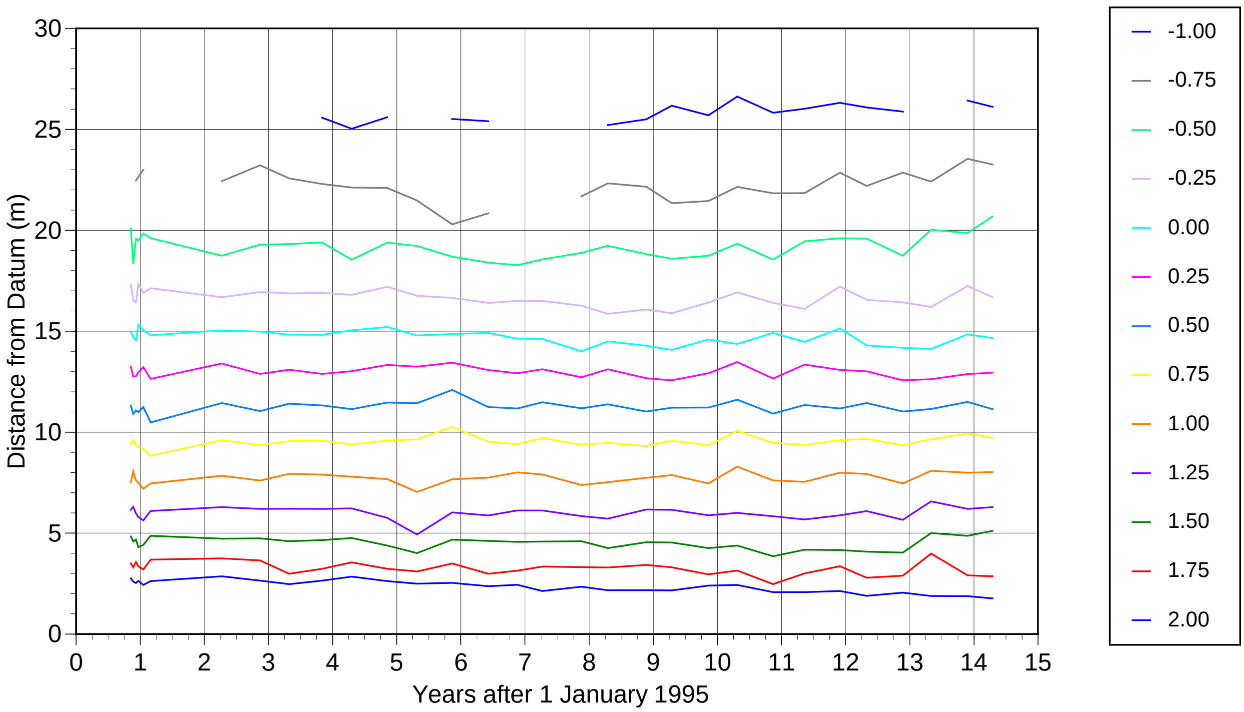
There has been no significant change in the profile shape or in sediment volume since 1997. At times there is more sand on the beach, and it has been more persistent in recent times.

During 2000 a small cottage was built at the northern end of this beach, and in 2003 a boatshed was built and a minimal wooden seawall constructed adjacent to the profile line.  The seawall does not appear to be affecting beach processes, but it is also not providing any significant protection to the land.

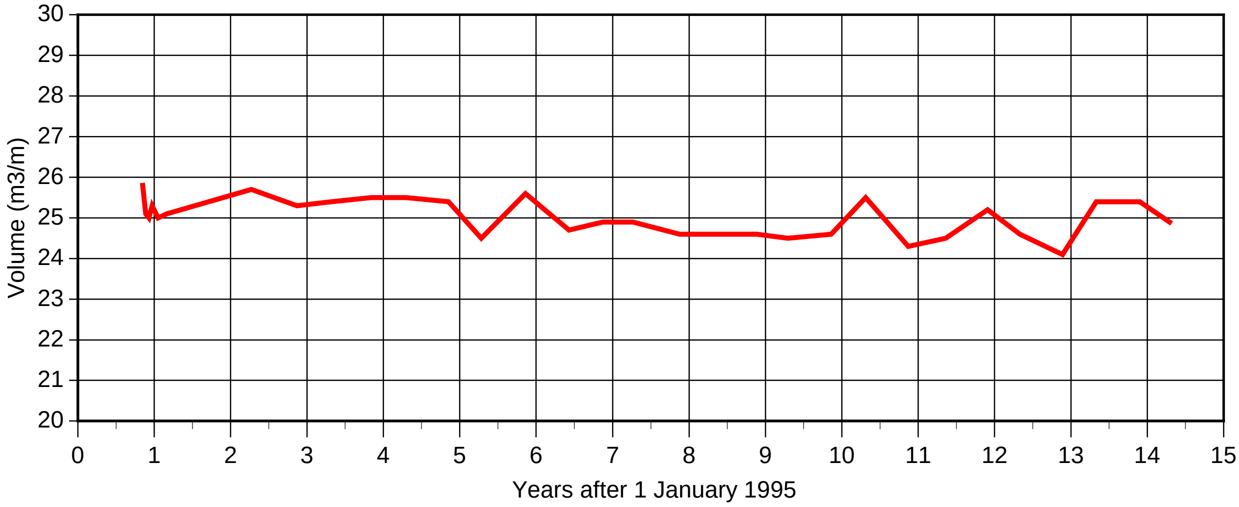



**Profile 18: Dieffenbach West**




**Profile 18: Dieffenbach West**




| Date | Years after 1/1/95 | Volume ($m^3/m$) |
|---|---|---|
| 8-Nov-95 | 0.85 | 25.8 |
| 21-Nov-95 | 0.89 | 25.1 |
| 7-Dec-95 | 0.93 | 25.0 |
| 20-Dec-95 | 0.97 | 25.3 |
| 19-Jan-96 | 1.05 | 25.0 |
| 29-Feb-96 | 1.16 | 25.1 |
| 9-Apr-97 | 2.27 | 25.7 |
| 14-Nov-97 | 2.87 | 25.3 |
| 27-Apr-98 | 3.32 | 25.4 |
| 2-Nov-98 | 3.84 | 25.5 |
| 19-Apr-99 | 4.30 | 25.5 |
| 8-Nov-99 | 4.85 | 25.4 |
| 13-Apr-00 | 5.28 | 24.5 |
| 9-Nov-00 | 5.86 | 25.6 |
| 5-Jun-01 | 6.43 | 24.7 |
| 15-Nov-01 | 6.87 | 24.9 |
| 8-Apr-02 | 7.27 | 24.9 |
| 15-Nov-02 | 7.88 | 24.6 |
| 14-Apr-03 | 8.29 | 24.6 |
| 20-Nov-03 | 8.89 | 24.6 |
| 15-Apr-04 | 9.29 | 24.5 |
| 8-Nov-04 | 9.86 | 24.6 |
| 22-Apr-05 | 10.31 | 25.5 |
| 14-Nov-05 | 10.87 | 24.3 |
| 10-May-06 | 11.36 | 24.5 |
| 20-Nov-06 | 11.91 | 25.2 |
| 14-May-07 | 12.33 | 24.6 |
| 20-Nov-07 | 12.89 | 24.1 |
| 02-May-08 | 13.33 | 25.4 |
| 12-Nov-08 | 13.90 | 25.4 |
| 08-Apr-09 | 14.29 | 24.9 |

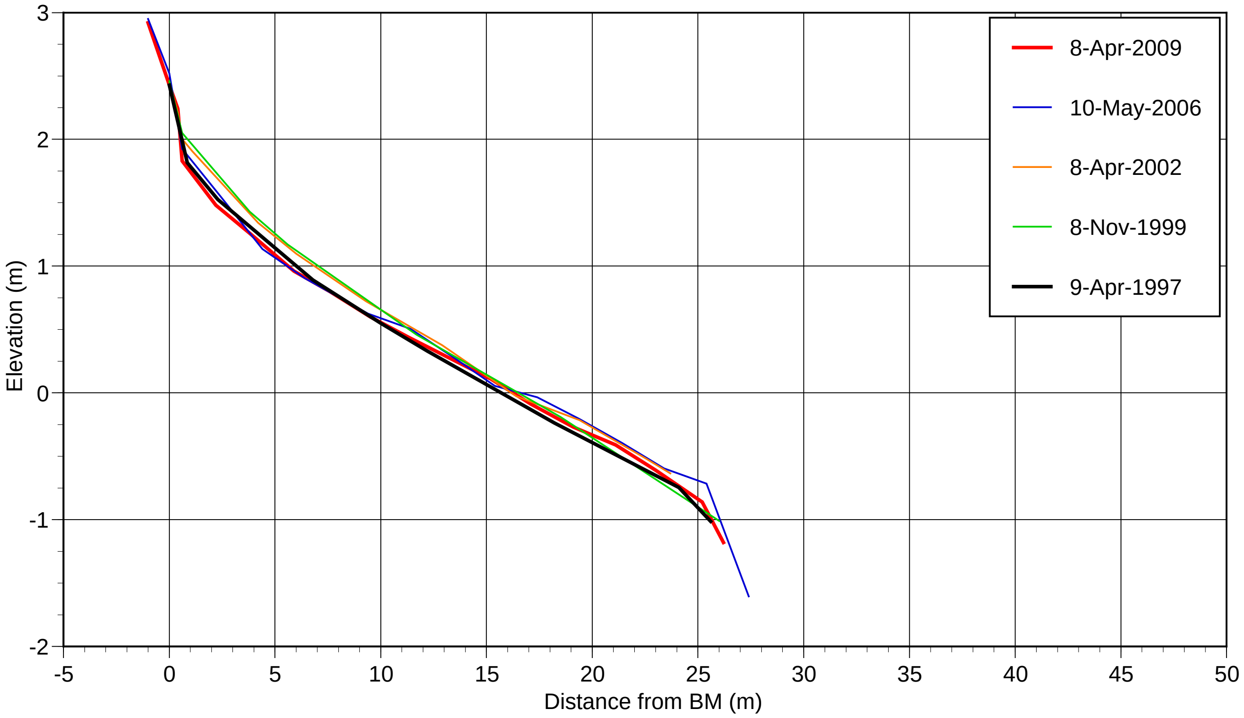
**Profile 18: Dieffenbach West**

*Profile 19 – Curious Monkey*

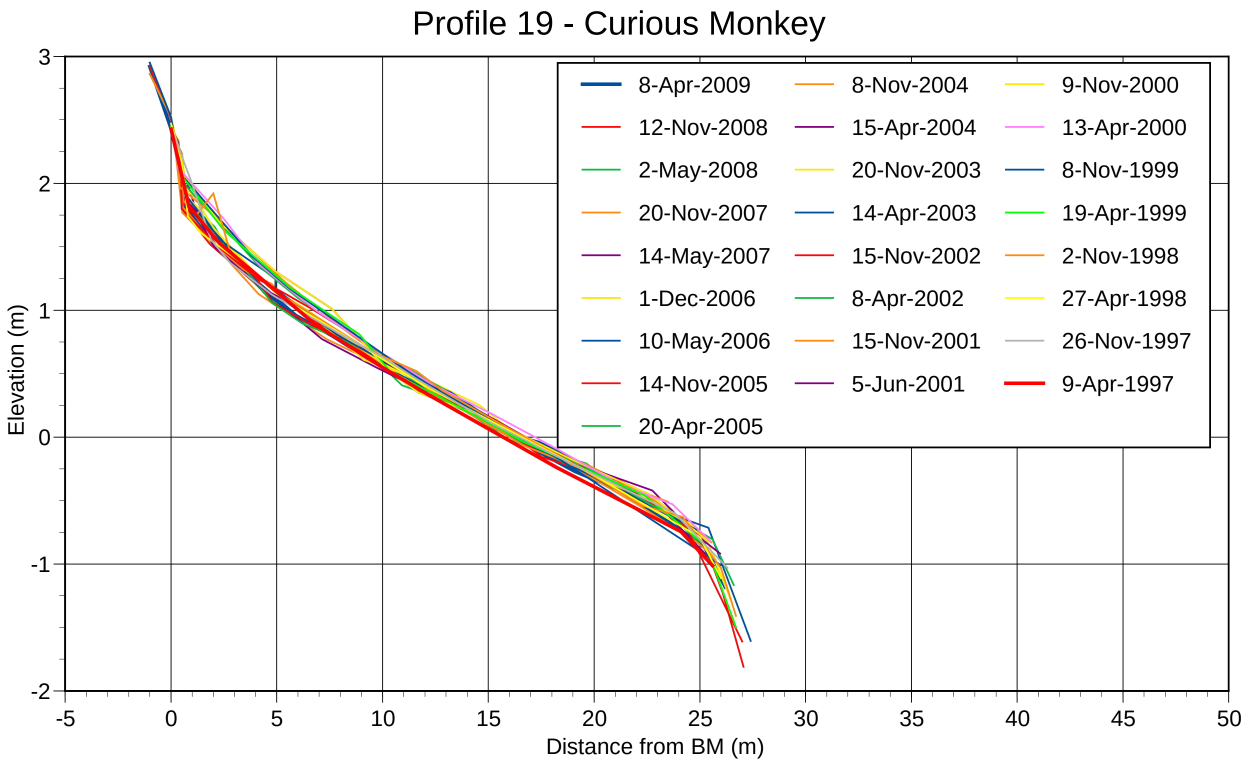
Overall the beach has been stable since 1997.  However, there was slow accretion through to the end of 2000, and slow erosion since that time, the change coinciding with fast ferry operation ceasing.

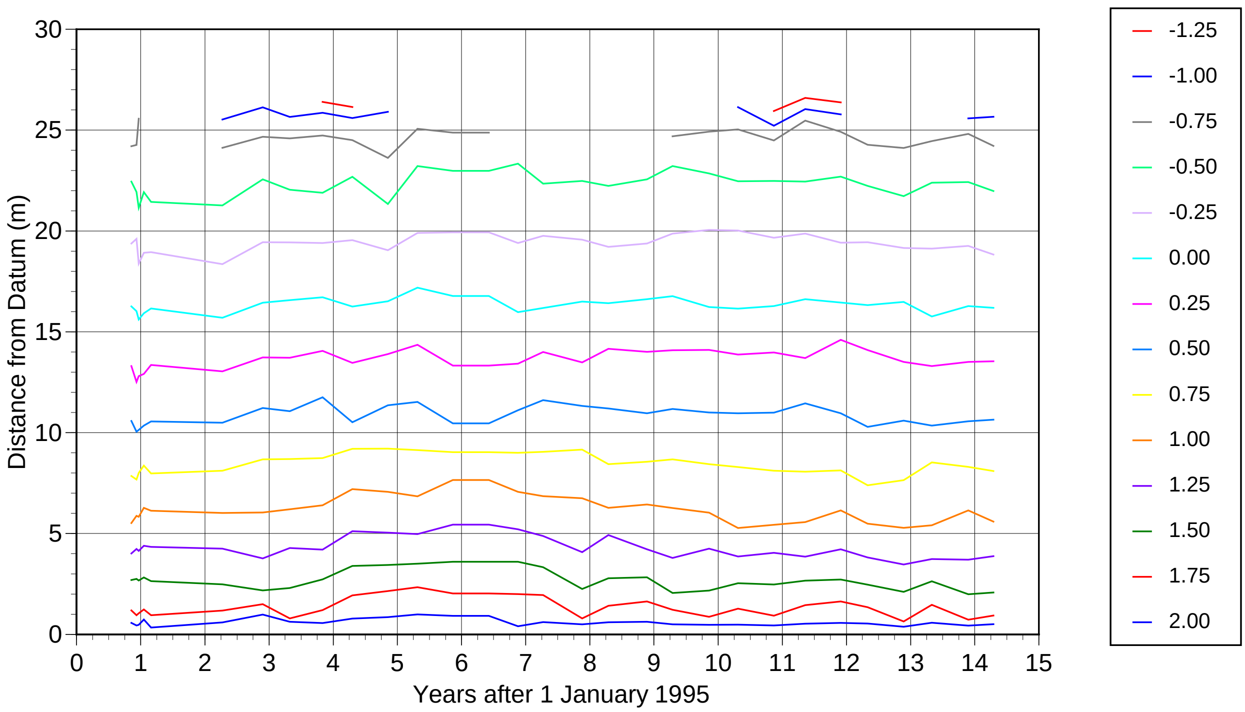
There have been no notable changes in sediment characteristics.

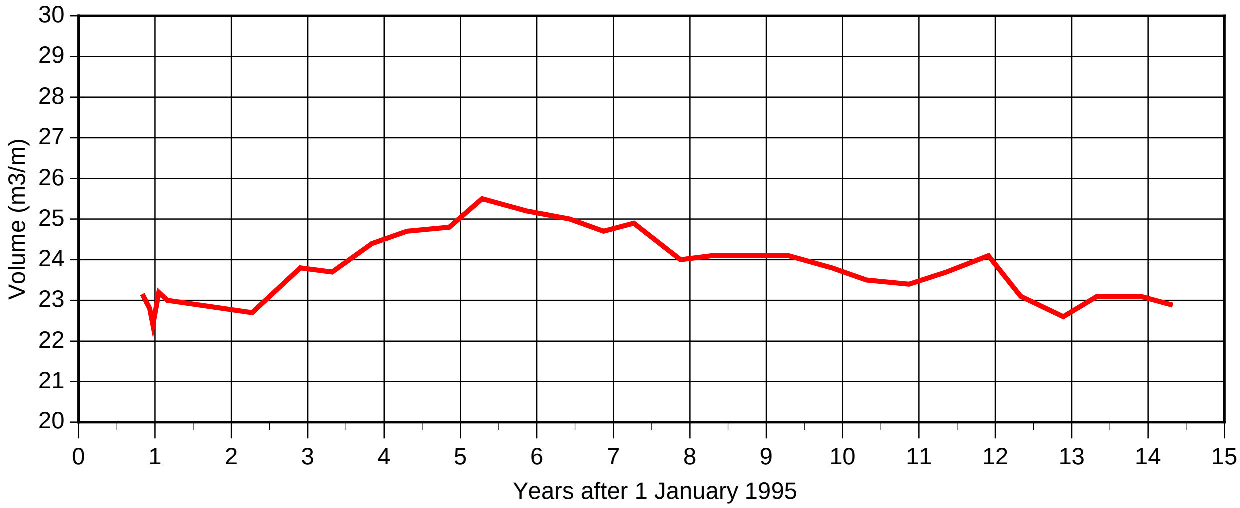



**Profile 19: Curious Monkey**




**Profile 19: Curious Monkey**

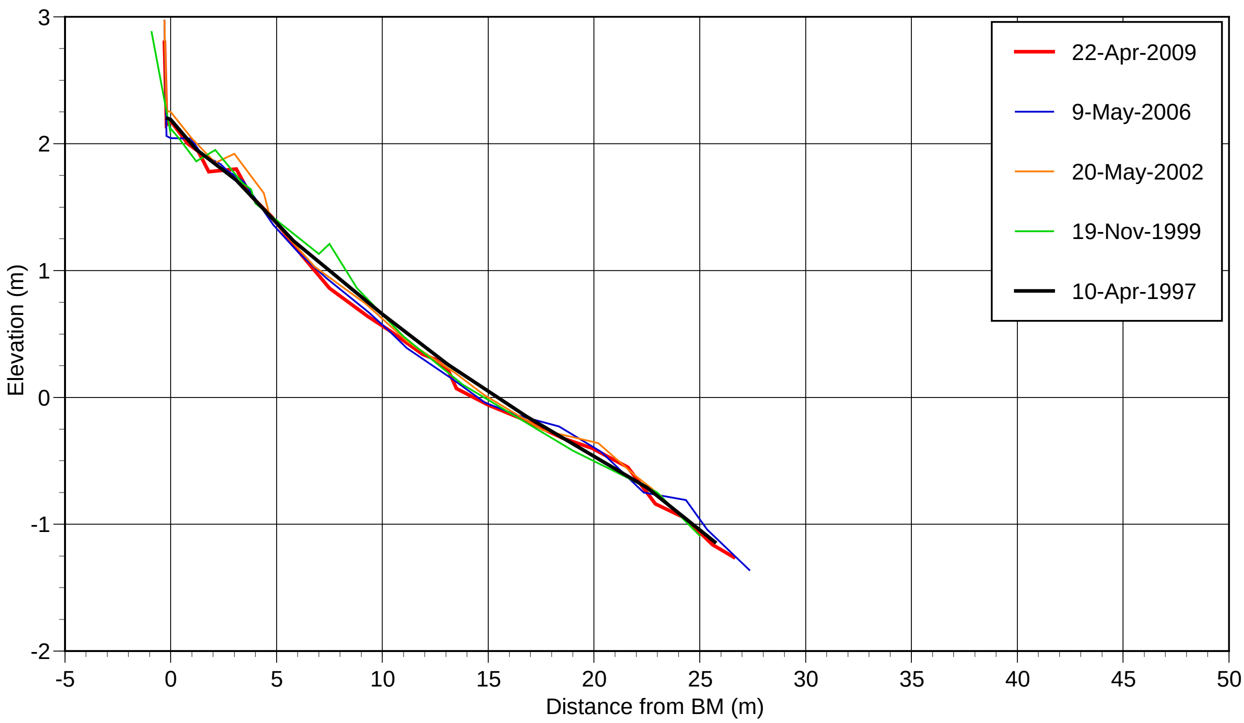



| Date | Years after 1/1/95 | Volume ($m^3$/m) |
|---|---|---|
| 8-Nov-95 | 0.85 | 23.1 |
| 7-Dec-95 | 0.93 | 22.8 |
| 20-Dec-95 | 0.97 | 22.4 |
| 19-Jan-96 | 1.05 | 23.2 |
| 29-Feb-96 | 1.16 | 23.0 |
| 9-Apr-97 | 2.27 | 22.7 |
| 26-Nov-97 | 2.90 | 23.8 |
| 27-Apr-98 | 3.32 | 23.7 |
| 2-Nov-98 | 3.84 | 24.4 |
| 19-Apr-99 | 4.30 | 24.7 |
| 8-Nov-99 | 4.85 | 24.8 |
| 13-Apr-00 | 5.28 | 25.5 |
| 9-Nov-00 | 5.86 | 25.2 |
| 5-Jun-01 | 6.43 | 25.0 |
| 15-Nov-01 | 6.87 | 24.7 |
| 8-Apr-02 | 7.27 | 24.9 |
| 15-Nov-02 | 7.88 | 24.0 |
| 14-Apr-03 | 8.29 | 24.1 |
| 20-Nov-03 | 8.89 | 24.1 |
| 15-Apr-04 | 9.29 | 24.1 |
| 8-Nov-04 | 9.86 | 23.8 |
| 20-Apr-05 | 10.31 | 23.5 |
| 14-Nov-05 | 10.87 | 23.4 |
| 10-May-06 | 11.36 | 23.7 |
| 01-Dec-06 | 11.91 | 24.1 |
| 14-May-07 | 12.33 | 23.1 |
| 20-Nov-07 | 12.89 | 22.6 |
| 02-May-08 | 13.33 | 23.1 |
| 12-Nov-08 | 13.90 | 23.1 |
| 08-Apr-09 | 14.29 | 22.9 |

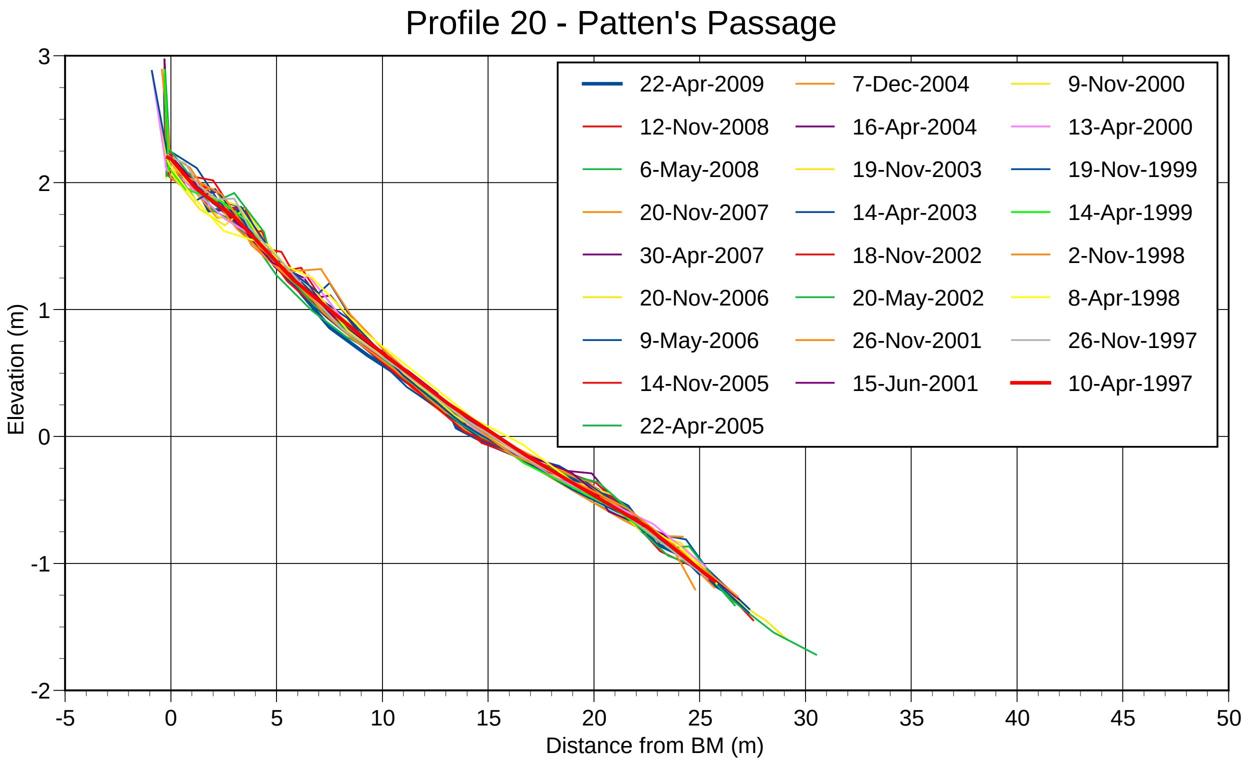
**Profile 19: Curious Monkey**

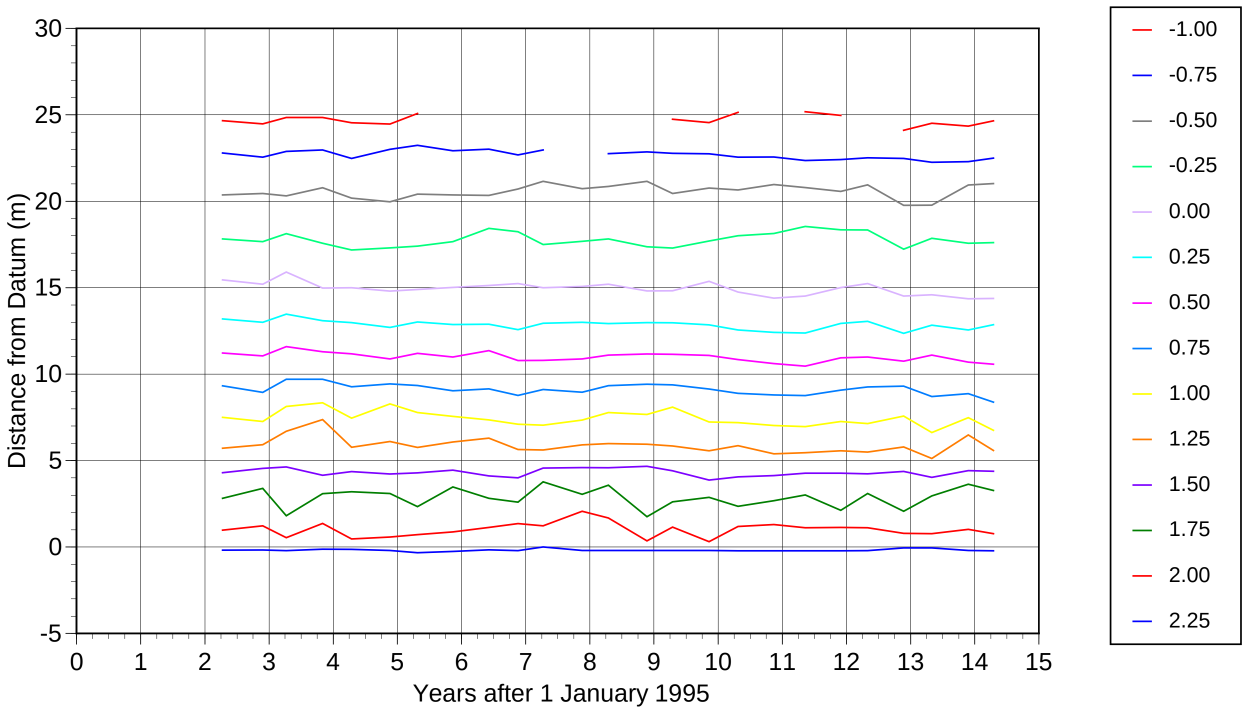
*Profile 20 – Patten's Passage*

There is considerable variability on the upper and middle beach, but overall stability, with perhaps an erosion trend in recent years. Small berms build and are removed on the upper beach, with no particular seasonal pattern. Sediments are gravels and sands, and there is frequent banding, but no significant trends are obvious.

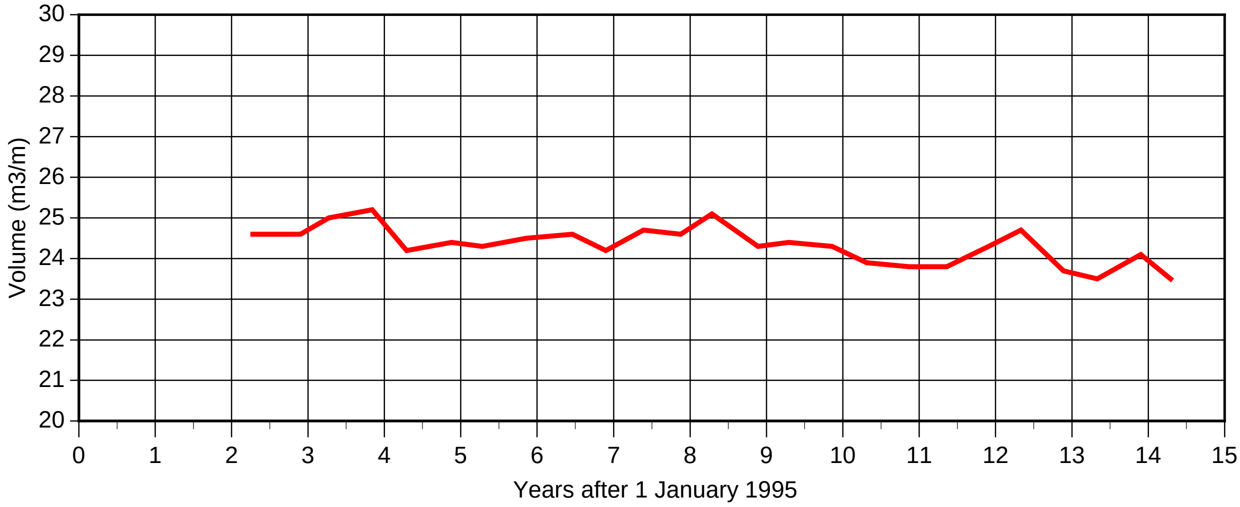



**Profile 20: Patten's Passage**




**Profile 20: Patten’s Passage**

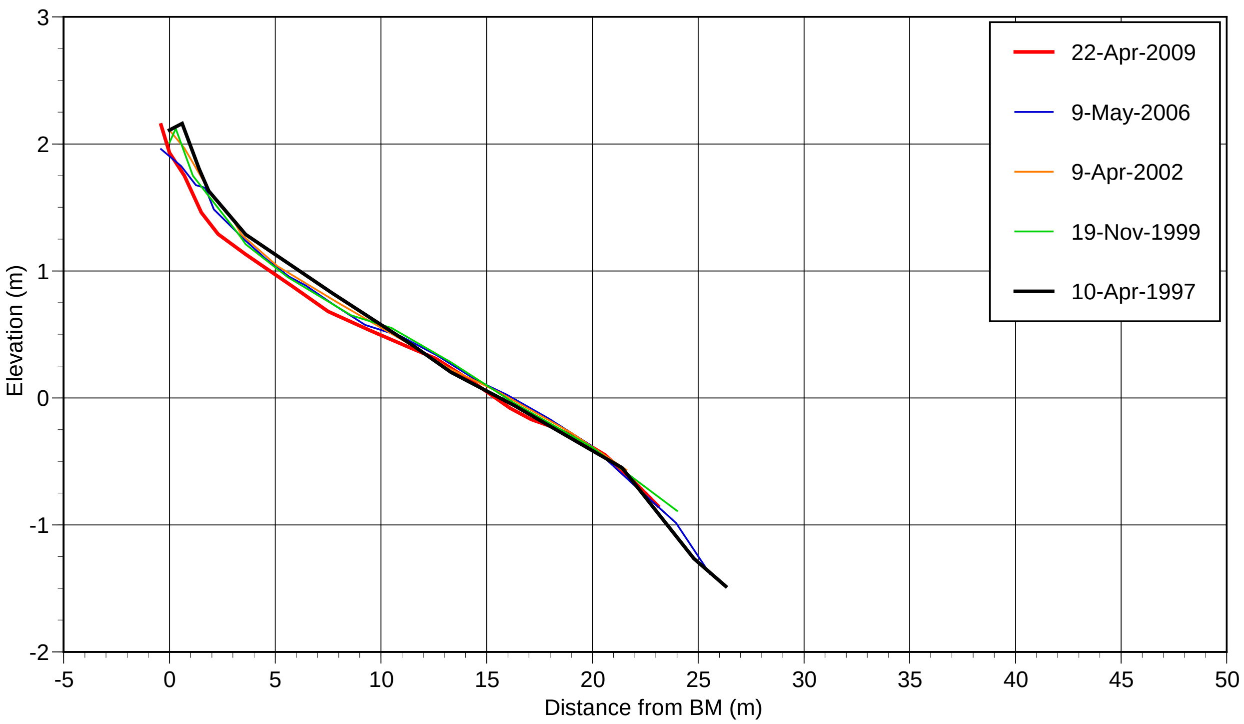



| Date | Years after 1/1/95 | Volume ($m^3/m$) |
|---|---|---|
| 10-Apr-97 | 2.28 | 24.6 |
| 26-Nov-97 | 2.90 | 24.6 |
| 8-Apr-98 | 3.27 | 25.0 |
| 2-Nov-98 | 3.84 | 25.2 |
| 14-Apr-99 | 4.29 | 24.2 |
| 19-Nov-99 | 4.88 | 24.4 |
| 13-Apr-00 | 5.28 | 24.3 |
| 9-Nov-00 | 5.86 | 24.5 |
| 15-Jun-01 | 6.46 | 24.6 |
| 26-Nov-01 | 6.90 | 24.2 |
| 20-May-02 | 7.39 | 24.7 |
| 18-Nov-02 | 7.88 | 24.6 |
| 14-Apr-03 | 8.29 | 25.1 |
| 19-Nov-03 | 8.89 | 24.3 |
| 16-Apr-04 | 9.29 | 24.4 |
| 7-Dec-04 | 9.86 | 24.3 |
| 22-Apr-05 | 10.31 | 23.9 |
| 14-Nov-05 | 10.87 | 23.8 |
| 9-May-06 | 11.36 | 23.8 |
| 20-Nov-06 | 11.91 | 24.3 |
| 30-Apr-07 | 12.33 | 24.7 |
| 20-Nov-07 | 12.89 | 23.7 |
| 06-May-08 | 13.33 | 23.5 |
| 12-Nov-08 | 13.90 | 24.1 |
| 22-Apr-09 | 14.29 | 23.5 |

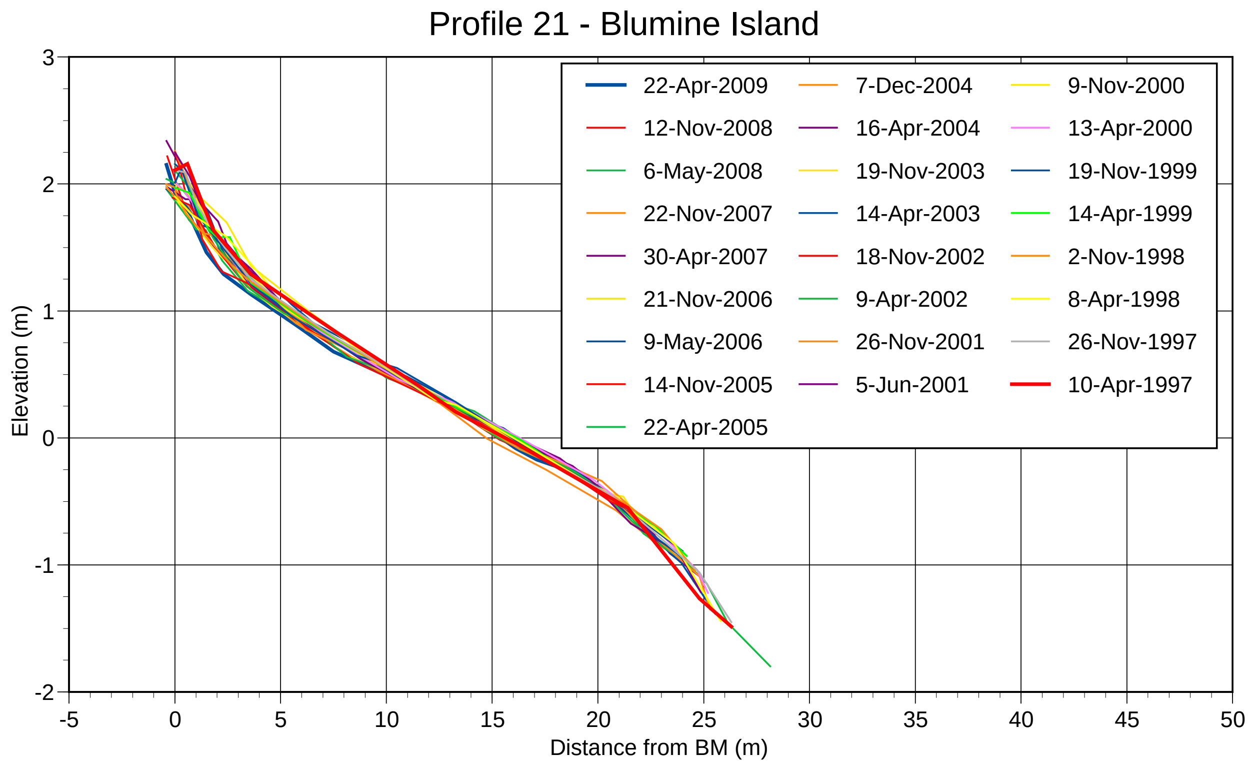
**Profile 20: Patten's Passage**

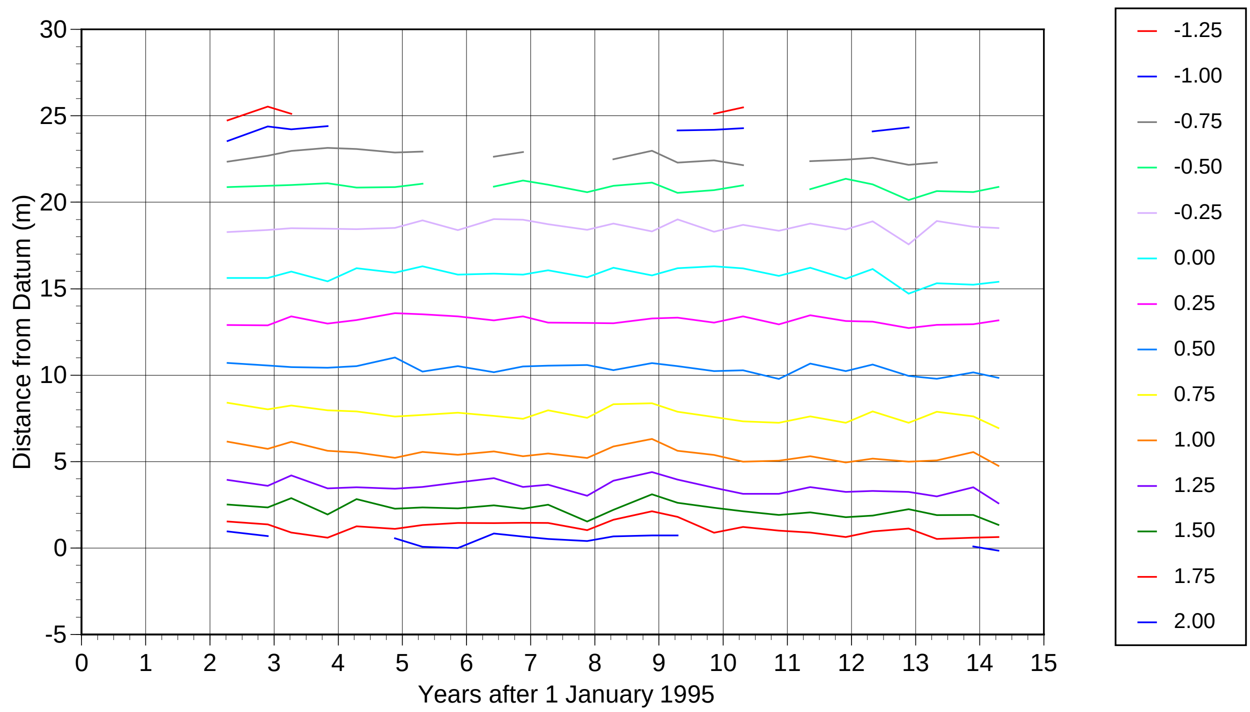
### *Profile 21 – Blumine Island*

Blumine Island has a similar aspect to the Patten’s Passage profile. Up until 2003 changes were generally minor, with no seasonality shown. Since 2003, there has been a slow erosion trend, with some seasonality. Significant erosion at the beach scarp at the top of the beach has been reported by the surveyors in the last year, and the profile line has been extended landward to cope with this. There are insufficient data to report on this change at the present time.

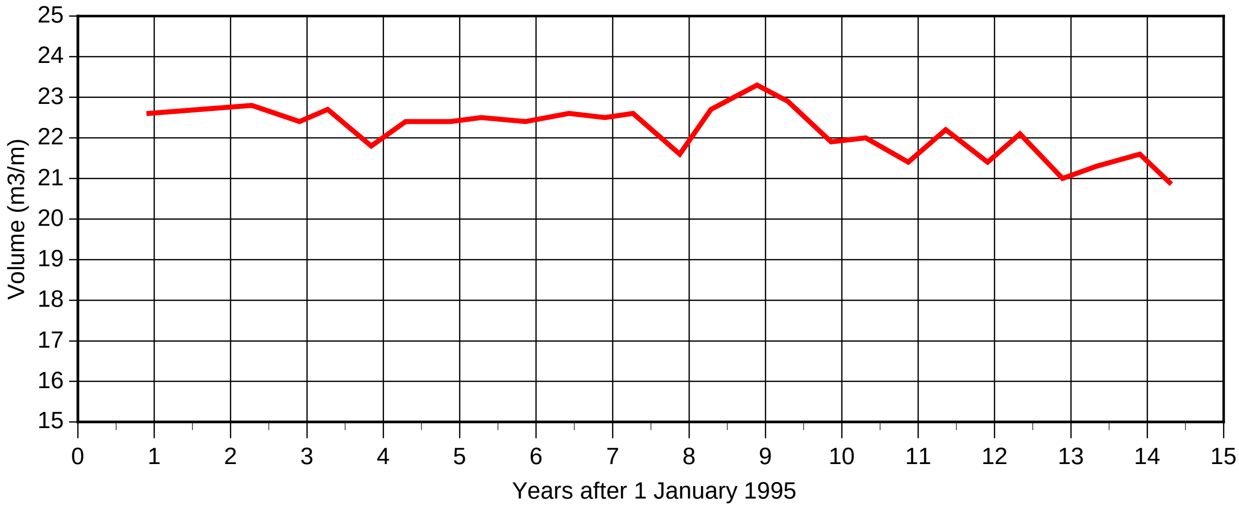



**Profile 21: Blumine Island**




**Profile 21: Blumine Island**




| Date | Years after 1/1/95 | Volume ($m^3$/m) |
|---|---|---|
| 7-Dec-95 | 0.93 | 22.6 |
| 10-Apr-97 | 2.28 | 22.8 |
| 26-Nov-97 | 2.90 | 22.4 |
| 8-Apr-98 | 3.27 | 22.7 |
| 2-Nov-98 | 3.84 | 21.8 |
| 14-Apr-99 | 4.29 | 22.4 |
| 19-Nov-99 | 4.88 | 22.4 |
| 13-Apr-00 | 5.28 | 22.5 |
| 9-Nov-00 | 5.86 | 22.4 |
| 5-Jun-01 | 6.43 | 22.6 |
| 26-Nov-01 | 6.90 | 22.5 |
| 9-Apr-02 | 7.27 | 22.6 |
| 18-Nov-02 | 7.88 | 21.6 |
| 14-Apr-03 | 8.29 | 22.7 |
| 19-Nov-03 | 8.89 | 23.3 |
| 16-Apr-04 | 9.29 | 22.9 |
| 7-Dec-04 | 9.86 | 21.9 |
| 22-Apr-05 | 10.31 | 22.0 |
| 14-Nov-05 | 10.87 | 21.4 |
| 9-May-06 | 11.36 | 22.2 |
| 21-Nov-06 | 11.91 | 21.4 |
| 30-Apr-07 | 12.33 | 22.1 |
| 22-Nov-07 | 12.89 | 21.0 |
| 06-May-08 | 13.33 | 21.3 |
| 12-Nov-08 | 13.90 | 21.6 |
| 22-Apr-09 | 14.29 | 20.9 |

**Profile 21: Blumine Island**

## 5. Summary of beach changes and the effects of vessel wakes

This summary is divided into three sections, comprising those sites that are conceivably influenced by vessels travelling in Tory Channel and Inner Queen Charlotte Sound (on the ferry sailing route), those sites in the outer Queen Charlotte Sound, and the Picton foreshore site, which is possibly influenced by vessels moving within the port area.

*a) Picton foreshore*

There is no indication that this site is affected by vessel operation, with the beach being relatively stable despite being highly modified. However, I do not have data on the timing and extent of any renourishment programmes.

*b) Sites in outer Queen Charlotte Sound*

There are five profiles located at sites in the outer Queen Charlotte Sound: Double Bay, Long Island, Clark Point, Patten’s Passage and Blumine Island. The sites in outer Queen Charlotte Sound are not influenced by ferry traffic, although some are on the sailing line of larger vessels using Shakespeare Bay. All five sites have remained generally stable over the survey period since April 1997. Long Island has demonstrated a trend of slow erosion since surveys began. Clark Point has been very stable. The other three sites may be showing signs of an erosion trend since about 2003/4. The reason for this is not known.

*c) Sites in Tory Channel and inner Queen Charlotte Sound*

Many of the sites on the ferry route have exhibited change. However, trends or seasonality consistency between sites is not generally apparent. It is possible to make tentative links between the changing beach shape and vessel operational regimes at individual sites. Sites seem to be primarily influenced by local factors, particularly with respect to sediment supply.

Two sites have demonstrated consistent erosion. Blackmore’s at Waikawa has been stripped to bedrock, and therefore no further erosion is likely. Bob’s Bay is located on the ferry route, but at a position where ferries are likely to be operating relatively slowly as they arrive in, or leave, Picton. There has been a consistent erosion trend across the whole profile. The particular circumstances that lead to erosion at this site are not understood, although the high number of boats of all types passing this point may be a factor.

Four profiles exhibit no significant change or trend. These are Te Awaiti, Te Weka Bay and Tipi Bay in Tory Channel, and Dieffenbach West on the inner Queen Charlotte Sound.

The Curious Monkey site showed a change from minor accretion to minor erosion coinciding with fast ferry operation ceasing, although overall changes are small. Ngaionui Point, a site very close to the vessel travel line, particularly on the Wellington to Picton journey, shows a change from accretion to erosion in 2002, perhaps indicating a slow return to pre fast ferry morphology.

Profile 2, The Snout at Picton Point, shows accretion at the top of the profile and significant erosion at the bottom, and therefore a steepening of the beach profile. The deep water channel is clearly cutting into the shoreline at this point. The reason may be related to vessel traffic, or may be entirely natural.

Ngaionui Bay and Slip Beach show a trend of beach building, although in both cases, the rate of accumulation has slowed or perhaps ceased since about 2003. In the case of Ngaionui Bay, issues of sediment supply and human interventions complicate the interpretation. Slip Beach demonstrates the most variability of any of the profiles. And there now appears to be a distinct seasonal pattern developing.

McMillan’s Bay and McMillan’s Side, were relatively stable with a small amount of accretion until an event in 1999/2000 when a large amount of sediment accumulated on both profiles. Significant rates of accretion continued until the beginning of 2001, after which time the rate has reduced on the McMillan’s Bay profile and erosion has been evident on the McMillan's Side profile. It is probable that the patterns relate to a mass movement event towards Arrowsmith Point, and significant sediment transport capability due primarily to fast ferry operation, although I have no direct evidence for this.

Moioio Island is an unusual case, being a beach adjacent to a major landslide, and being towards the back of the island, not directly facing the vessel track. Seasonality was evident when the fast ferries were operating seasonally. Both profiles show that the beach is extending into the deep water channel over time (a process that takes a lot of sediment), and generally accreting. Both profiles reached their maximum accreted extent in 2006, and have cut back a little since that time. These profiles are almost certainly influenced by changes in ferry operations, being almost completely sheltered from natural wind generated waves. However, the sediment supply from the landslide (which may be affected by vessel wakes) is likely to dominate the beach behaviour.

At the time of the summary report in 2002 it was concluded that with the exception of Bob's Bay near Picton, the beaches on the ferry route were accreting (or are stable) as opposed to eroding, although it was equally clear that local circumstances (particularly sediment supply) play a very significant role. It is now becoming clear that on some profiles a change from accretion to relative stability (McMillan's Bay, Slip Beach, Ngaionui Bay), or accretion to erosion (Ngaionui Point, McMillan's Side, Curious Monkey) occurred at about, or soon after, the time fast ferry operation was restricted to 18 knots in December 2000. Although a definitive conclusion may never be possible, the results support the understanding that the fast ferry wakes resulted in rapid sediment buildup at the top of the beach on most beaches along the ferry route. However, it is now becoming clear that under the current vessel operational regimes, either stability (with the newly inherited morphology remaining) or a return to pre fast ferry morphology is occurring

## 6. Recommendations

The beach monitoring programme has been underway for over 12 years, and has been through a range of vessel operation changes. Beach monitoring requires a long term commitment to provide value. The value of the monitoring programme comes in understanding how beaches of the region function, both in response to vessel wakes and in response to natural events.

Although changes caused by the introduction of the fast ferries were never captured (although it is assumed that they caused rapid accretion particularly on gravel beaches), it is now possible to conclude that their removal has resulted in a slow reversal of this trend.

Profiles in the outer Queen Charlotte Sound, off the ferry route, were established to provide an element of control, and in response to the possibility of significant boat traffic using port facilities in Shakespeare Bay, using the northern entrance to Queen Charlotte Sound. These profiles have been generally stable, and it was previously concluded that they were likely to remain stable unless driving forces change (such as a significant change is vessel traffic, or significant sea level change). However, there is now an indication that a slow erosion trend may be emerging. I had previously recommended that these sites could probably be abandoned, or the frequency of survey reduced. I now believe that they should be retained, but the frequency of survey could be reduced to once per year.

Profile 5 (Blackmore's at Waikawa) was established at the request of Council. This site demonstrated erosion, but is now stripped to bedrock, but it is unlikely that the reason for the loss of sand is ever going to be known. As previously noted, I see no good reason for maintaining this site.

Profile 1 (Picton Foreshore) does not seem to be changing, and certainly not with respect to vessel traffic. In terms of the purposes of this monitoring programme, continued monitoring is probably unnecessary, although there may be other reasons to continue. If this site is continued, provision of other data, such as the dates and amounts of maintenance nourishment or other construction or maintenance activity, are required.

Other sites in Tory Channel and inner Queen Charlotte Sound continue to provide good data. The possible return to pre fast ferry conditions on some profiles is of significant interest.

The Bob's Bay profile has been continuously eroding. Erosion may be caused by all vessel wakes in the high traffic area near Picton (including the many small boats that pass quite close to the shore at this point), but may be entirely natural. Should erosion at this site be of particular concern, another profile towards the southern end of the bay should be established, to determine if the whole beach is eroding or if sediment is being redistributed within the embayment. In the longer term, some process studies could be considered.

In summary, the following changes to the monitoring programme could be considered:

1. *Reducing the frequency of survey of the profiles in outer Queen Charlotte Sound,* The disadvantage of reducing the frequency is that if profile markers are lost, they will be harder to reinstate in the future.
2. *Abandoning the Blackmore's at Waikawa site*.
3. *Reconsidering the purpose and value of the Picton Foreshore site*.
3. *Establish a second profile towards the other end of the beach at Bob's Bay*, should the continued erosion be of particular concern.
4. *Establish quality vertical control for profile benchmarks*. The survey lines have never had very good vertical control. The zero datum level used has been established independently for each profile, sometimes from water level measurements and assumed tidal curves, and sometimes for consistency with data sets collected by other groups (such as Kirk and Single). It would be very useful if the profiles were able to be tied together. RTK-GPS technology is now available to enable this to be done, although the topography of the area will make the task difficult. Undertaking such a survey would have the additional benefit of enabling survey lines to be accurately reconstructed should permanent marks be lost.

I am happy to discuss these recommendations with Council staff.

# Appendix 1

## Survey Benchmarks as at April 2009

Levels used in this report are in BOLD

| Pr | Name | Peg | Dist | Ayson RL | KP RL | Kirk RL | SL RL | Notes |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | | |
| 1 | Picton Foreshore | Seawall | 6.87 | | | | **2.440** | Top of wall |
| 1 | Picton Foreshore | C | 0.00 | | | | **2.550** | C" hole in grey stone |
| | | | | | | | | |
| 2 | The Snout at Picton Point | IT | -1.00 | 10.34 | | | **3.293** | |
| 2 | The Snout at Picton Point | W | 0.00 | 10.00 | | | **2.950** | |
| | | | | | | | | |
| 3 | Double Bay | W | -1.50 | 10.74 | | | **2.720** | |
| 3 | Double Bay | IT | 0.00 | 10.00 | | | **1.980** | |
| | | | | | | | | |
| 4 | Ngaionui Bay (C Thomas) | W | -2.00 | 10.32 | | | **2.690** | |
| 4 | Ngaionui Bay (C Thomas) | IT | -2.5 | 10.02 | | | **2.39** | |
| | | | | | | | | |
| 5 | Blackmore's at Waikawa | Nail | 0.00 | 10.00 | | | **1.900** | In round post |
| | | | | | | | | |
| 6 | Moioio Island 2 | W | -2.00 | | 0.33 | | **1.740** | Based on Kirk and SL Difference |
| 6 | Moioio Island 2 | 0IS A | 0.00 | | 0.00 | | **1.410** | KP Peg |
| | | | | | | | | |
| 7 | Moioio Island 1 | W | -2.00 | 10.36 | | 1.70 | **1.700** | |
| 7 | Moioio Island 1 | IT | 0.00 | 10.00 | | 1.34 | **1.340** | |
| | | | | | | | | |
| 8 | Bob's Bay | W | -2.00 | 11.19 | | 2.96 | **2.959** | |
| 8 | Bob's Bay | IT | 0.00 | 10.00 | | 1.77 | **1.769** | |
| | | | | | | | | |
| 9 | Te Awaiti | W | -6.00 | 10.87 | | 2.01 | **2.006** | |
| 9 | Te Awaiti | IT | 0.00 | 10.00 | | 1.13 | **1.133** | |
| | | | | | | | | |
| 10 | Tipi Bay | W | -2.50 | 10.65 | | 2.19 | **2.188** | |
| 10 | Tipi Bay | IT | -1.5 | 10.02 | | 1.56 | **1.56** | |
| | | | | | | | | |
| 11 | Long Island | W | 0.00 | 10.00 | | | **2.840** | |
| 11 | Long Island | IT | -2.50 | 9.30 | | | **2.140** | |
| | | | | | | | | |
| 12 | Clark Point | IT | 0.00 | 10.00 | | | **1.620** | |
| 12 | Clark Point | OISA | 2.20 | 9.77 | | | **1.393** | Biol peg |
| 12 | Clark Point | W | 6.50 | | | | | Biol peg ??? |
| | | | | | | | | |
| 13 | Slip Beach | IT | -0.55 | 10.25 | | 1.74 | **1.740** | |
| 13 | Slip Beach | W | -0.10 | 10.51 | | 2.00 | **2.000** | |
| | | | | | | | | |
| | | | | | | | | |

| Pr | Name | Peg | Dist | Ayson RL | KP RL | Kirk RL | SL RL | Notes |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | | |
| 14 | Ngaionui Point | W | -2.00 | 10.52 | | | **2.386** | |
| 14 | Ngaionui Point | IT | 0.00 | 10.00 | | | **1.870** | |
| | | | | | | | | |
| 15 | Te Weka Bay | IT | 0.00 | 10.00 | | 1.50 | **1.498** | |
| | | | | | | | | |
| 16 | McMillan's Bay | W | -2.00 | 11.49 | | 2.91 | **2.908** | |
| 16 | McMillan's Bay | IT | 0.00 | 10.00 | | 1.42 | **1.418** | |
| | | | | | | | | |
| 17 | McMillan's Side | IT | -2.00 | 11.15 | | | **2.938** | Based on Kirk and SL Difference |
| 17 | McMillan's Side | W | -1.3 | 11.48 | | | **3.263** | |
| | | | | | | | | |
| 18 | Dieffenbach West | OIS A | 0.00 | -0.09 | | | **2.520** | Reestablished after disturbance |
| 18 | Dieffenbach West | W | -0.2 | -0.04 | | | **2.570** | Reestablished after disturbance |
| | | | | | | | | |
| 19 | Curious Monkey | W | -1.00 | | 1.18 | | **3.700** | |
| 19 | Curious Monkey | OIS A | 0.00 | | 0.00 | | **2.520** | KP peg |
| 20 | Patten's Passage | IT | -1.10 | 10.85 | | | **3.488** | KP peg |
| 20 | Patten's Passage | W | 0.00 | 10.00 | | | **2.640** | KP peg |
| | | | | | | | | |
| 21 | Blumine Island | W | -0.40 | 0.45 | | | **2.66** | KP peg |
| 21 | Blumine Island | Railway iron | 3.60 | | 0.23 | | **2.440** | KP peg |
| 21 | Blumine Island | IS(new) | -5.5 | 2.60 | | | **4.81** | |

# Appendix 2

# Profile Photographs

Photographs are taken looking alongshore from both sides of the profile line, looking back towards the profile line.  The profile line is approximately 20m from the camera, and appears in all photographs.