

South West Regional Coastal Monitoring Programme

BMP REPORT 2011

Burton Freshwater

BMP 03
2011

Plymouth Coastal Observatory

University of Plymouth

Drake Circus

Plymouth

PL4 8AA

Tel: +44 (0)1752 586156

e-mail: coastal.observatory@plymouth.ac.uk

Website: www.channelcoast.org

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Author: **G.Kaye**

Checked By: **N.Sykes**

Approved By: **M. Hutchings**

Southwest Strategic Regional Coastal Monitoring Programme

Beach Management Plan Report 2011 – Burton Freshwater

1. Introduction

Burton Freshwater is a beach situated on the south west Dorset coastline and is located in West Chesil. The Beach Management Plan (BMP) covers the area 1.4km east from West Bay harbour and extends to the west of Burton Cliffs, approximately 0.9km of beach frontage. The beach is predominantly comprised of shingle, with some small localised areas of sand. Freshwater Beach has high amenity value due to the presence of the Freshwater Holiday Park situated immediately inshore. This caravan park hosts in excess of 800 caravan pitches and over 13 acres of land reserved for camping and further caravan pitches. The holiday park contributes an estimated 50 million pounds annually to the local economy, making it a valued asset. The estimated savings associated with reducing inshore flooding at Burton Freshwater has been estimated by DEFRA to be between £100, 000 and £300, 000, over a period of 100 years.

1.1 Coastal processes

The coastline of West Chesil is highly influenced by waves and storm conditions. There are primarily two types of waves which affect the coastline in this area: Swell waves originating from the North-East Atlantic and wind generated waves. Swell waves become more significant, increasing easterly from West Bay. The west of Chesil is relatively sheltered from significant swell waves in comparison to the east. As a result of the dynamic wave climate influencing Freshwater Beach, littoral transport is highly susceptible to changes. Drift reversal has been known to occur with changes in wave direction and storm waves (SCOPAC, 2004). Long shore drift is generally west to east, however as this is highly sensitive to wave conditions. East Cliff and Burton Cliff (Figure 1) are Sandstone vertical cliffs, which neighbour Freshwater Beach. These are both currently receding, contributing small amounts of material to the beach. Freshwater Holiday Park has reclaimed land at the western end of the beach using large amounts of soil. This has been covered with shingle, creating an artificially steep beach (Figure 1)



Figure 1. Exposed soil at the area of reclaimed beach in the west.

There are currently two main areas of concern at Burton Freshwater:

1.2 Beach area

Burton Freshwater beach acts as a barrier protecting Freshwater Holiday Park and properties behind from flooding (Figure 1). In the past the protective barrier has been breached and consequently the property situated behind the beach has been flooded. Reclamation of beach area by Freshwater Holiday Park has contributed to the narrowing of the beach, disappearance of the beach crest and the development of an artificially steep beach profile. As a result of these changes, wave overtopping periodically occurs causing flooding. The Environment Agency currently carries out re-profiling works at Freshwater Beach.

At present there is no design profile specific to Freshwater beach, The Environment Agency use 'standard of protection' figures designed for East Beach. The standard of protection figures are applicable for all of the profiles at Freshwater beach, with the exception of three profiles situated in the area of reclaimed land. The profiles located here were analysed using worse case scenario figures.

Revised figures (2009, BMP)	Standard	Emergency
Inshore slope ratio	1 in 6	NA
Upper seaward slope ratio	1 in 4	NA
Lower seaward slope ratio	1 in 8	1 in 6
Crest height	< 8m ODN	< 7.5m ODN
Crest width	< 13.5m	< 10m

Table 1. Required standards of protection and action trigger levels

The Environment Agency carried out re-profiling and recycling activities regularly at Freshwater Beach (Table 2). Excess material at Freshwater Beach was regularly deposited at West Bay until 2005, when it was decided that replenishment was no longer required. Profiles have been re-profiled at Freshwater Beach where the need was required; this was decided according to the figures in Table 1. Decisions regarding re-profiling are also made on survey observations carried out by the Environment Agency and PCO.

1.3 River Bride

The River Bride which runs through the eastern section of the beach is another major source of flooding. Flooding and overtopping events occur when the river mouth becomes blocked with shingle following south westerly storm events. Water percolation throughout the beach clears shingle blockages from the river mouth; however it is currently unknown how long this process takes (Figure 3). The Environment Agency periodically clears the river mouth of shingle, approximately 10 to 12 times a year. The owner of the Freshwater Holiday Park has been known to undertake works when the need arises.

Date	Profiles	Deposited (m ²)	Extracted (m ²)	Comments
03/10/2006	6a00648	0	-50	Extraction of sediment from River Bride, as river channel was blocked and defence was depleted. Sediment was deposited on profiles to return them to original height.
	6a00649	0	-75	
	6a00650	112.5	-75	
	6a00651	112.5	-75	
	6a00652	112.5	-75	
	6a00658	50	-75	
10/02/2008	6a00651	76.68	-80.77	Extraction of sediment from River Bride, as river channel was blocked and defence was depleted. Sediment was deposited on profiles to return them to original height.
	6a00652	76.68	-80.77	
	6a00653	76.68	-80.77	
	6a00654	76.68	-80.77	
	6a00655	76.68	-80.77	
	6a00656	76.68	-80.77	
02/04/2008	6a00648	0	-27	Extraction was in response to a large storm on the 10/03/2008. Sediment was deposited on profiles to return them to original height.
	6a00649	0	-27	
	6a00650	36.5	-27	
	6a00651	36.5	-27	
	6a00652	36.5	-27	
	6a00653	36.5	-27	
	6a00654	36.5	-27	
	6a00655	36.5	-27	
	6a00656	36.5	-27	
	6a00657	36.5	-27	

Table 2. Deposited and extracted amounts of sediment along profiles. All works were carried out by the Environment Agency from 2006 to 2008.



Figure 3. Percolation of water from the blocked River Bride.

The 2009 BMP report recognised that there is a lack of recorded observations of the river mouth. Thus far no system appears to have been put in place to record any removal works at the river mouth, by either the Environment Agency or the owner of Freshwater Holiday Park; therefore no figures are available to supplement information within this report (Environment Agency BMP, August 2009). It has been advised in the 2009 BMP report that works should be taken to unblock the river mouth when shingle at the river mouth is $\geq 5\text{mODN}$. Inundation and potential flooding can occur when the river level reaches ≥ 1 metre (Figure 2). The 2009 BMP recommends that the orientation of the river should be maintained in a south-easterly direction in order to combat siltation associated with south-westerly storms and long-shore drift reversal.

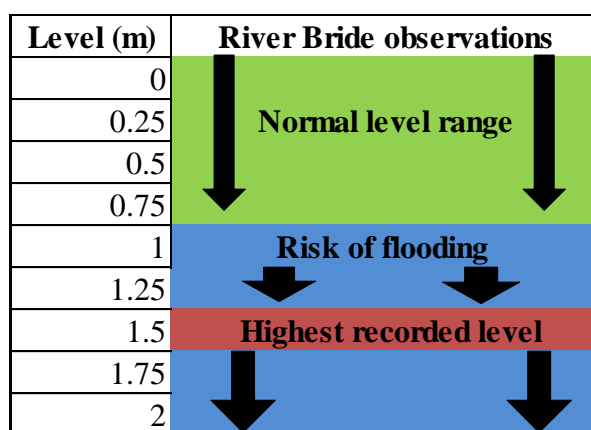


Figure 2. River Bride flood risk levels

1.4 Scheme Design

In response to these issues, a flood defence scheme was implemented by the Environment Agency in the early 1990's. The scheme included the construction of a floodwall, a flood embankment, and drainage outlet. The scheme was designed to cause as little disruption to the Freshwater Holiday Park as possible, and was designed with a 50 year lifespan. The SMP

policy at Freshwater Beach in the past has been 'Do nothing', however due to the activities carried out at the Freshwater beach this designation needed re-classifying. At present the draft SMP 2 for South Devon and Dorset has updated Freshwater to a 'managed realignment' site. This would allow for the beach to rollback with the nearby cliffs, reducing the risk of inland flooding. An additional sea defence would be constructed to support the realignment.

1.5 Further Information

The first beach surveys for the Southwest Regional Coastal Monitoring Programme took place during the spring of 2007 and changes are reported until spring 2010. This, coupled with the historic Environment Agency data from 2004, provides a short time base over which beach changes have been monitored. Detailed interpretation and decision-making is not advisable on the basis of these short-term changes, since the changes may not be representative of longer-term trends.

It must be appreciated that the accuracies of each measurement system must be taken into account when drawing conclusions, particularly from the difference models. In the case of topographic difference models from RTK GPS surveys, the accuracy of each data point is $\pm 0.03\text{m}$ and therefore differences of $\pm 0.06\text{m}$ can generally be considered as "real", whilst smaller changes may be an artefact of the measuring system, and are considered to be "No Change". Difference plots show changes $>\pm 0.25\text{m}$, which should be indicative of areas of genuinely measurable change. Smaller changes may also be present but these are filtered from the analysis to provide clarity. This report displays difference models only where detailed analysis suggests that the changes are real but, nevertheless, the user should approach the results as indicative, unless reinforced overtime or with other information.

Where lidar has provided the source data sets, the modelling is less precise. Each lidar cell value has a plan position representative of a 1m^2 grid. It is not reasonable to expect to observe changes with positional accuracy of better than 1-2m therefore. Profiles of steep slopes may suggest that the changes "bounce" back and forth. This is an artefact of the accuracy of the source data. Lidar is particularly ineffective at identifying sharp edges or steep slopes *e.g.* cliffs, seawalls. Despite these limitations in accuracy the changes shown indicate an overview of profile change, but to a lower precision than the RTK data. The location of the regularly surveyed profiles superimposed on the difference plots indicates how representative these profiles might be of overall changes.

It *must* be emphasised that this is the first BMP report of a series and that changes identified are indicative only of short-term trends. As the programme progresses, more detailed and meaningful reporting will be possible. Accordingly, this report should be considered as a preliminary assessment.

2. Hydrodynamic data

a. Waves

A Directional WaveRider buoy was deployed at West Bay on the 1st November 2006. The full wave reports are given at Annex A.

b. Tides

A WaveRadar Rex Tide gauge was installed at West Bay Harbour on 25th January 2008.

The full tide report is given at Annex B.

4. Survey data – bathymetric

The first swath bathymetric survey of West Bay was completed between June 2007 and October 2008. No further analysis will be carried out until after the next baseline survey in 2011. For this reason a DTM of the bathymetric data has been included.

<u>Annex A</u>	West Bay Interim Wave Report
<u>Annex B</u>	West Bay Harbour Tide Report
<u>Annex C</u>	N/A
<u>Annex D</u>	N/A
<u>Annex E</u>	N/A
<u>Annex F</u>	Topographic Survey Report for Burton Freshwater
<u>Annex G</u>	N/A
<u>Explanatory Notes</u>	

References

South Devon and Dorset Coastal Advisory Group: 2010, *Shoreline, Management Plan Review (SMP2) Durlston Head to Rame Head: Summary of Draft Final SMP, September 2010*, Halcrow

Environment Agency South Wessex Region, 2009, *East Beach & Freshwater Beach Management Plan version 2.0, 13th August 2009*

SCOPAC, 2004, *Sediment transport study* [online]
<http://www.scopac.org.uk/scopac%20sediment%20db/index.htm>, 2004, accessed: 01/03/2010

West Dorset District Council, 2000, *West Bay Coastal Defence & Harbour improvements scheme: East and West Beach Management Plan, November 2000*

Babtie Group Ltd, 1997, *Chesil Beach Investigation Final Report, June 1997*

Figure 1. Map of Burton Freshwater



West Bay Waverider Buoy

Location

OS: 347123 E 88451 N

WGS84: Latitude: 50° 41.596 ' N Longitude: 002° 44.998 ' W

Water Depth

Approx. 10m CD

Instrument Type

Datawell Waverider Buoy Mk III

Data Quality

C1(%)	Sample interval
96	30 minutes

Monthly Means

All times are GMT

West Bay June 2008 to May 2009						
Month	H _s (m)	T _p (s)	T _z (s)	Direction (°)	SST (°C)	No. of days
June	0.61	7.6	4.0	216	14.6	28
July	0.84	6.5	3.8	209	16.3	29
August	1.00	5.9	4.0	213	17.2	29
September	0.81	7.3	4.2	195	16.3	29
October	1.06	7.1	4.4	213	14.6	30
November	0.79	7.5	4.2	205	11.5	28
December	0.73	8.4	4.6	202	8.8	29
January	1.33	11.0	5.5	208	7.1	31
February	0.69	11.8	5.3	210	7.0	28
March	0.72	8.7	4.3	212	8.3	31
April	0.67	8.9	4.7	209	10.4	29
May	0.80	8.2	4.1	208	12.5	30

Tables and plots of these values, together with the minimum and maximum values and the standard deviation are available on the website.

Highest events in 2008/9									
Date/Time	H _s	T _p	T _z	Dir.	Water level elevation (OD)	Tidal stage (hrs re HW)	Tidal range (m)	Tidal surge* (m)	Max. surge* (m)
17-Jan-2009 22:00	4.24	9.1	6.7	218	1.43	HW -1	2.49	-	-
04-Oct-2008 20:30	4.02	8.3	6.7	221	1.82	HW -1	3.11	0.26	0.51
13-Dec-2008 05:30	3.87	8.3	6.3	205	1.79	HW -1	3.54	-0.03	0.42
25-Jan-2009 03:00	3.82	8.3	6.3	207	0.73	HW -3	2.41	-	-
09-Nov-2008 19:30	3.77	8.3	6.5	215	-0.27	HW +5	2.09	0.29	0.43

* Tidal information is obtained from the nearest recording tide gauge (the WaveRadar Rex at West Bay Harbour). The surge shown is the residual at the time of the highest H_s. The maximum tidal surge is the largest positive surge during the storm event.

Distribution plots

The distribution of wave parameters is shown in the accompanying graphs of:

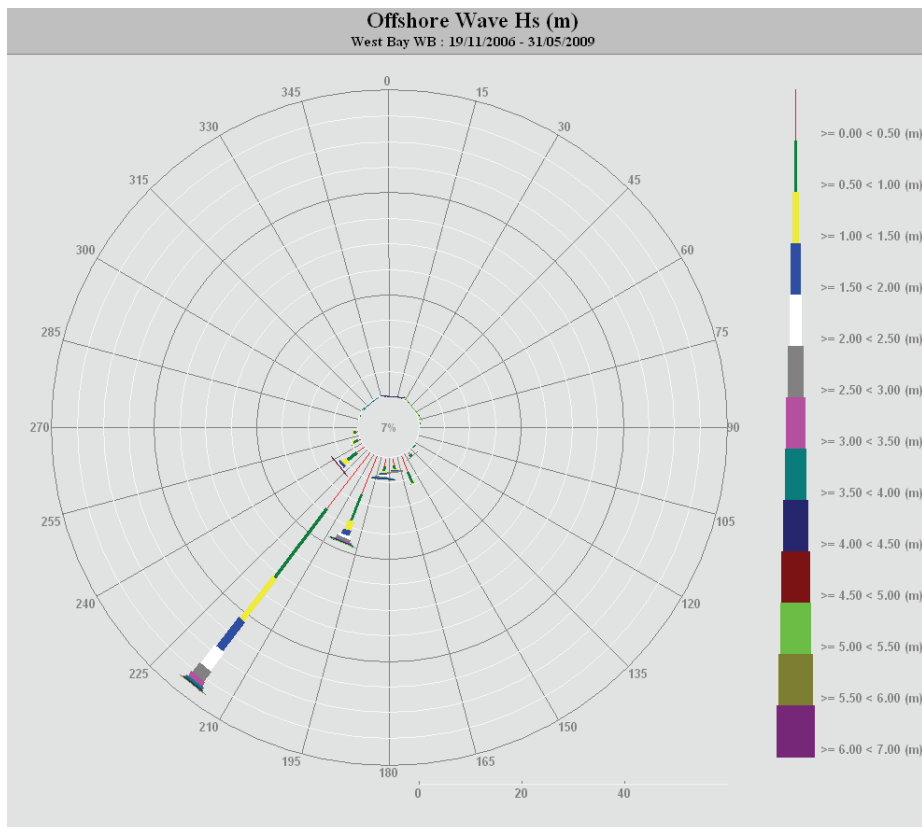
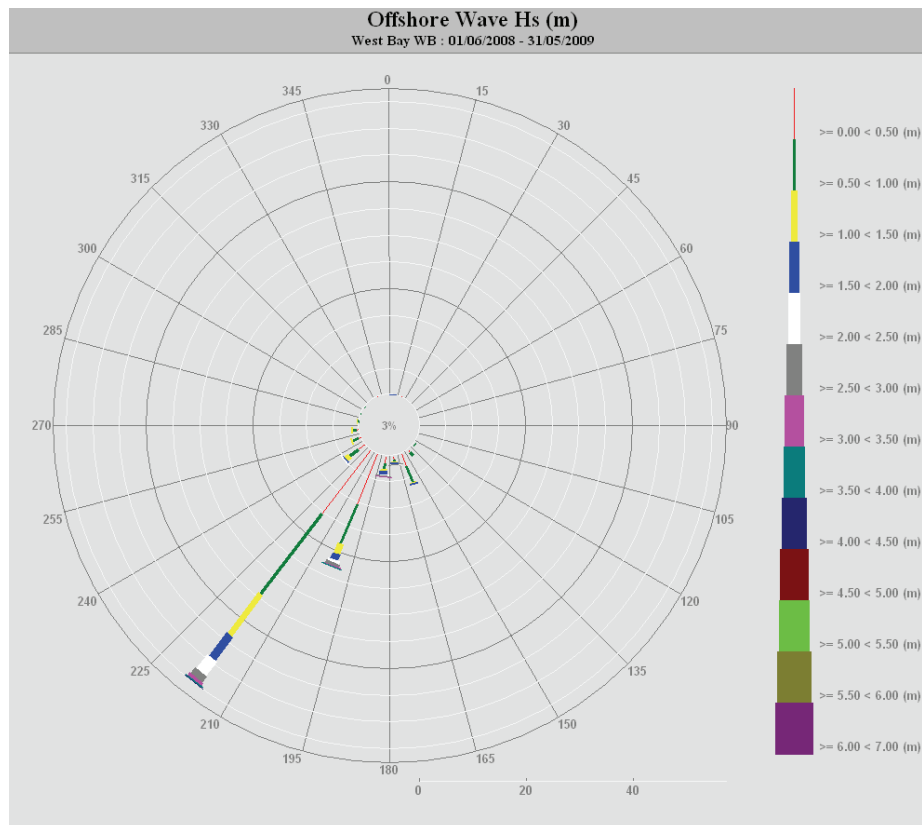
- Wave rose (Direction vs. H_s) for reporting year and for all measured data
- Percentage of occurrence of H_s and T_z from June 2008 to May 2009
- Monthly time series of significant wave height (the red line is the storm threshold)
- Incidence of storms during the reporting period and all previous years. Storms are defined using the Peaks-over-Threshold method. The highest H_s of each storm is shown.

Summary

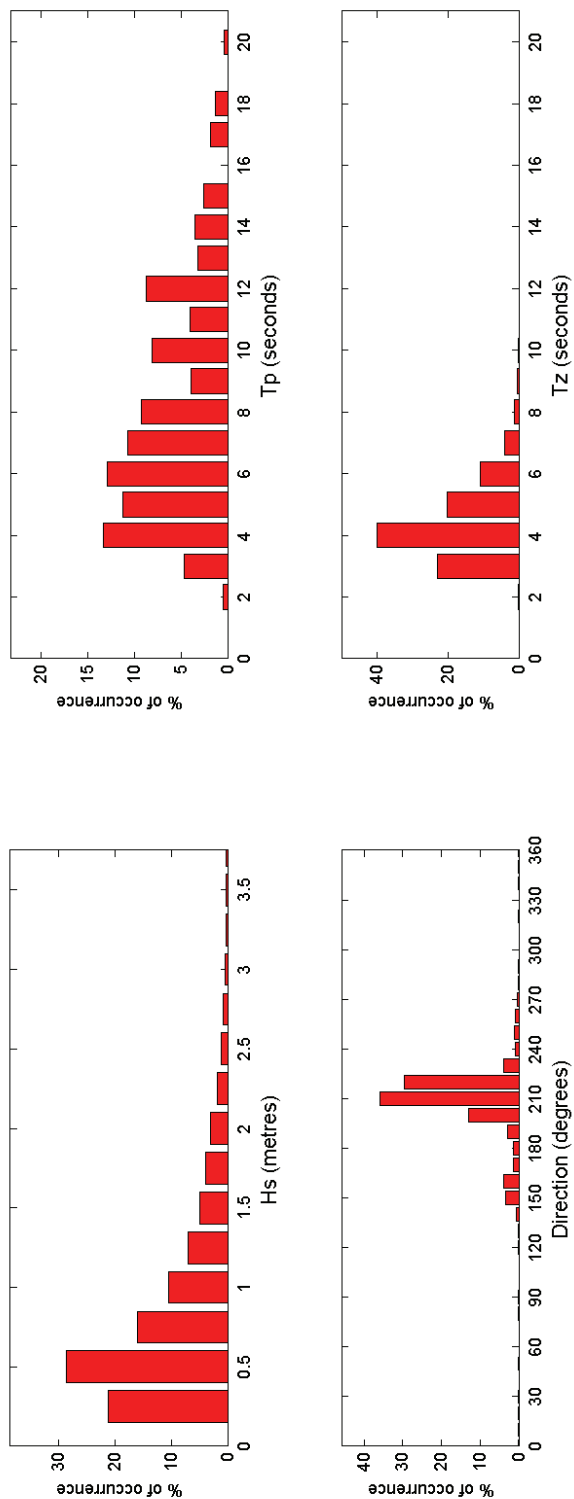
This reporting year experienced a similar number of storms as the last year, but with less high waves, and concentrated from October to March. Wave direction was predominantly from a SWbS direction.

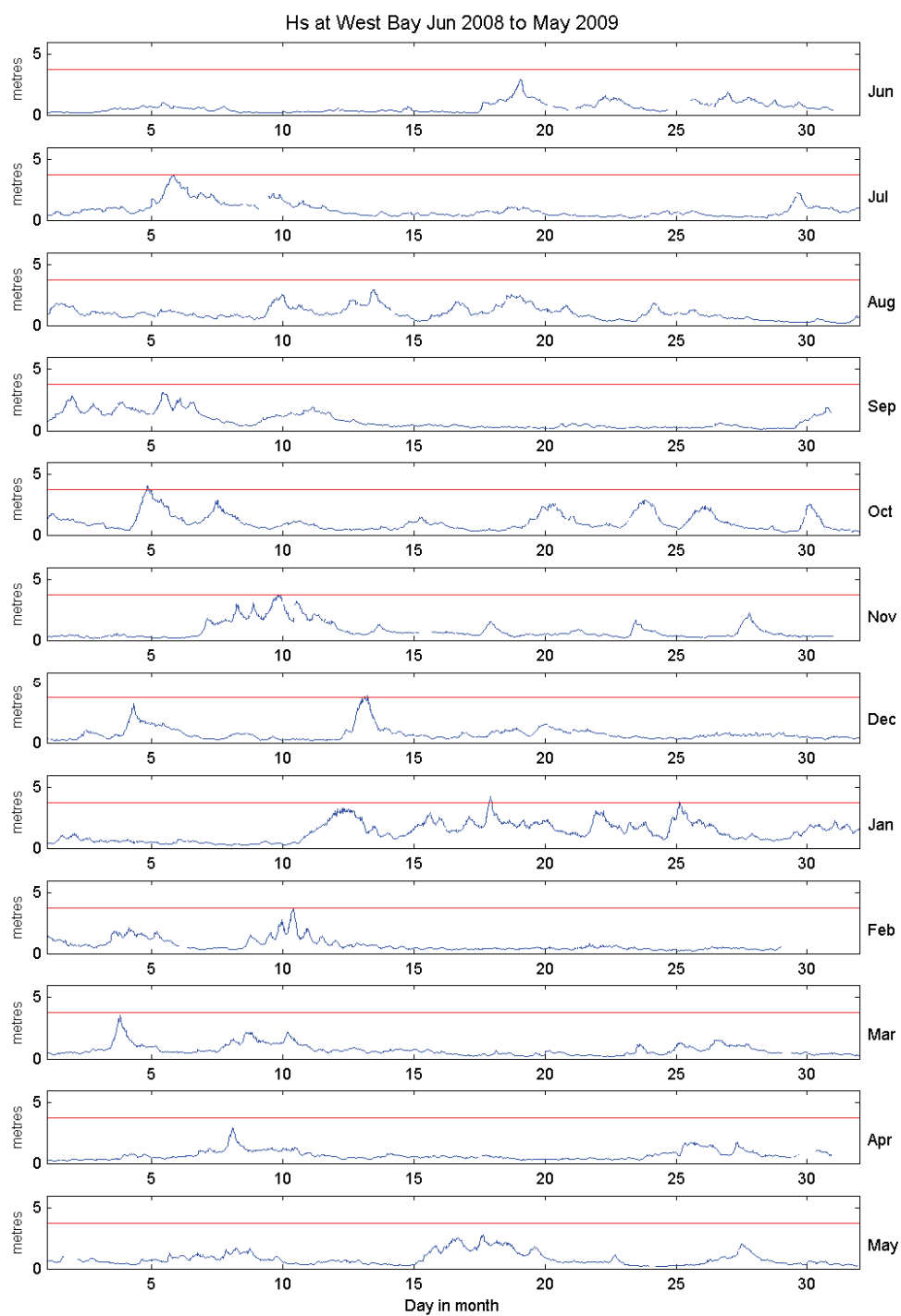
Acknowledgements

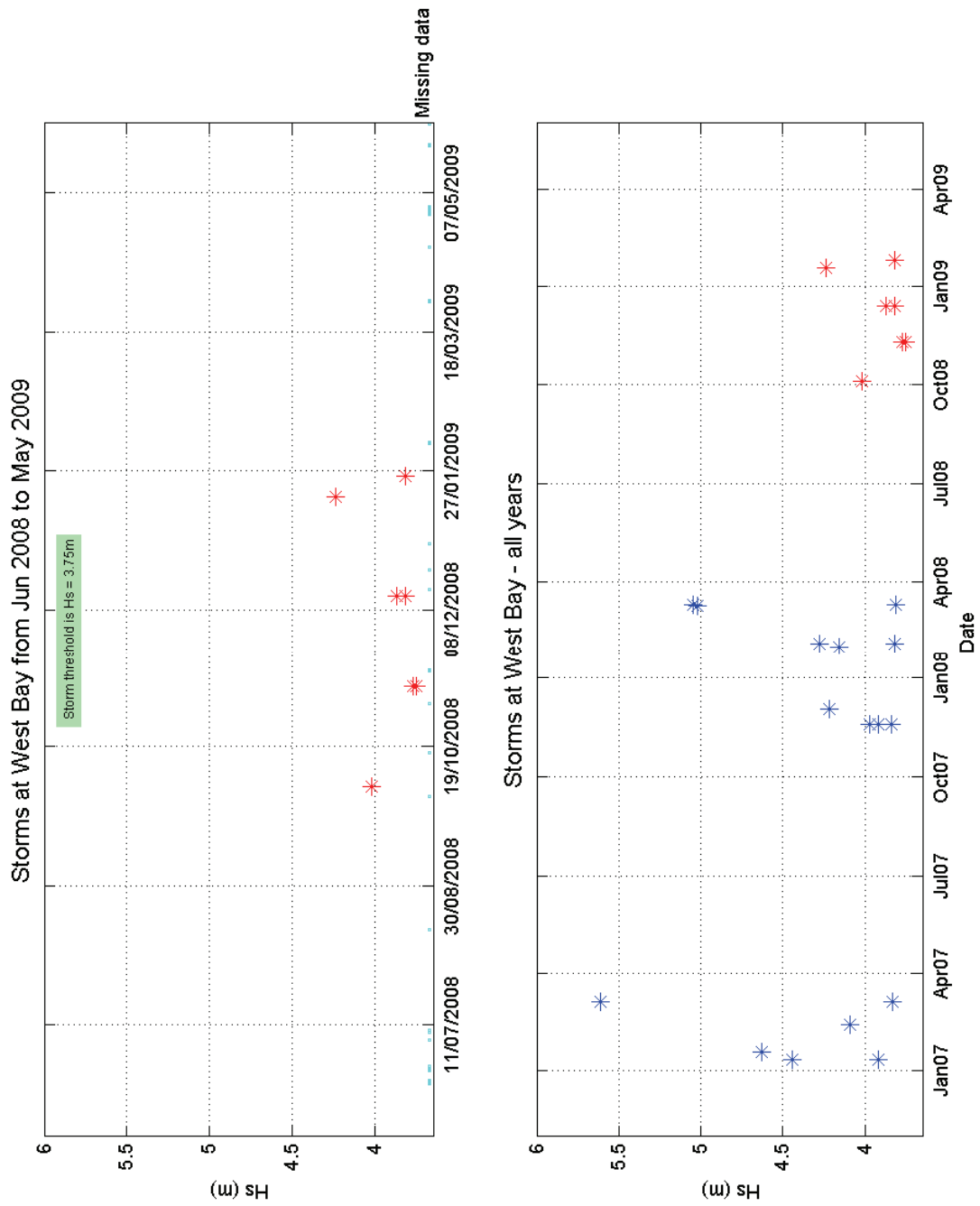
TASK2000 tidal prediction software was kindly provided by the Permanent Service for Mean Sea Level (PSMSL), Proudman Oceanographic Laboratory.



West Bay Jun 2008 to May 2009







West Bay Harbour Tide Gauge

Location

OS: 346142.9E 90195.31N

WGS84 Latitude: 50° 42.532' N Longitude: 002° 45.846' E

West Bay Harbour, inner end of western breakwater

Instrument

Rosemount WaveRadar Rex



TGZ



Benchmark	OS Co-ordinates	Description
TGBM	4.607 OD	Top of horizontal S/S frame
TGZ =	4.647m above Ordnance Datum (Newlyn)	
TGZ =	6.897m above Admiralty Chart Datum	
TGZ =	0.040m above TGBM	

Datum information

Tidal elevations are measured reference to Ordnance Datum (Newlyn). The height of Chart Datum at Bridport relative to Ordnance Datum is -2.25m (Admiralty Tide Tables, Supplementary Table III).

Survey information

The site was last surveyed on 7 January 2008.

Site Characteristics

The breakwater is on open coast. Spring tidal range is 2.5m. Some wave reflection can occur around the breakwater and harbour entrance.

Service history

The radar became operational on 31 January 2008. No re-calibration of the instrument is required.

Measurements

The Rex is a Frequency Modulated Continuous Wave radar, sampling at 4Hz. Tidal elevations are derived, every 10 minutes, as the one minute average of the 4Hz readings. The time stamp is the start of the measuring burst.

Data Quality

C1(%)	Sample interval	Missing days
88	10 minutes	01-02 Mar, 01 May, 25 Jun, 01 Jul, 01 Oct, 01, 14, 20,21 Dec

Residuals and Elevations

Residuals and Elevations (OD and CD) for the whole year are shown in Figures 1 to 3 respectively. Tidal elevations are derived as the one minute average of the 4Hz readings. The time stamp is the start of the measuring burst.

Statistics

All times GMT

Month	Surge maxima		Surge minima	
	Value (m)	Date/Time	Value (m)	Date/Time
January	-	-	-	-
February	0.63	05-Feb-2008 00:30	-0.43	12-Feb-2008 05:40
March	1.10	10-Mar-2008 05:20	-0.47	04-Mar-2008 07:50
April	0.35	29-Apr-2008 20:20	-0.44	01-Apr-2008 18:00
May	0.20	28-May-2008 11:10	-0.31	05-May-2008 14:00
June	0.35	19-Jun-2008 01:30	-0.35	08-Jun-2008 15:40
July	0.54	05-Jul-2008 15:30	-0.31	23-Jul-2008 05:30
August	0.47	18-Aug-2008 12:00	-0.32	22-Aug-2008 18:10
September	0.58	05-Sep-2008 16:30	-0.37	26-Sep-2008 09:30
October	0.51	30-Oct-2008 02:00	-0.32	10-Oct-2008 07:10
November	0.54	10-Nov-2008 09:40	-0.48	24-Nov-2008 22:10
December	0.63	04-Dec-2008 04:40	-0.52	26-Dec-2008 23:40

Month	Extreme maxima		Extreme minima	
	Elevation (OD)	Date/Time	Elevation (OD)	Date/Time
January	-	-	-	-
February	2.16	23-Feb-2008 08:10	-1.94	10-Feb-2008 01:50
March	2.22	09-Mar-2008 07:00	-1.91	23-Mar-2008 00:30
April	2.16	08-Apr-2008 08:00	-2.03	07-Apr-2008 12:40
May	2.08	06-May-2008 19:20	-1.96	06-May-2008 12:10
June	2.07	04-Jun-2008 18:50	-1.68	06-Jun-2008 01:10
July	2.21	04-Jul-2008 19:30	-1.62	22-Jul-2008 14:20
August	2.22	03-Aug-2008 20:20	-1.79	04-Aug-2008 01:30
September	2.21	01-Sep-2008 20:00	-1.94	18-Sep-2008 01:20
October	2.17	16-Oct-2008 19:20	-1.76	17-Oct-2008 00:50
November	2.00	13-Nov-2008 18:20	-1.78	13-Nov-2008 23:50
December	2.09	13-Dec-2008 06:10	-1.79	15-Dec-2008 13:40

Month	Mean Sea Level	
	No. of days	MSL (OD)
January	-	-
February	29	0.194
March	29	0.207
April	30	0.192
May	30	0.192
June	29	0.170
July	30	0.249
August	31	0.255
September	30	0.232
October	30	0.266
November	30	0.237
December	27	0.156

10 Highest Values in 2008 ¹			
Surge		Extreme	
Value (m)	Date/Time	Elevation (OD) (surge component)	Date/Time
1.10	10-Mar-2008 05:20	2.22 (-0.04)	09-Mar-2008 07:00
0.77	10-Mar-2008 03:30	2.22 (0.02)	03-Aug-2008 20:20
0.63	05-Feb-2008 00:30	2.21 (0.11)	04-Jul-2008 19:30
0.63	03-Feb-2008 15:50	2.21 (0.02)	01-Sep-2008 20:00
0.63	04-Dec-2008 04:40	2.18 (0.11)	09-Mar-2008 20:30
0.58	05-Sep-2008 16:30	2.17 (0.01)	16-Oct-2008 19:20
0.57	29-Mar-2008 18:30	2.17 (0.09)	05-Jul-2008 20:40
0.54	10-Nov-2008 09:40	2.16 (0.02)	15-Oct-2008 19:10
0.54	05-Jul-2008 15:30	2.16 (0.04)	18-Aug-2008 19:40
0.53	10-Nov-2008 14:10	2.16 (0.00)	10-Mar-2008 07:30

Year	Annual surge maxima		Annual extreme maxima		Annual Mean Sea Level (OD)	Recovery rate (%)
	Value (m)	Date	Elevation (OD) (surge component)	Date		
2008	1.10	10-Mar-2008 05:20	2.22 (-0.038)	09-Mar-2008 07:00	0.215	88

General

The time series of 10 minute tidal elevations for one year is quality-checked, flagged and archived. The archived time series is continuous and monotonic, with missing data given as 9999. The missing data shown are days where the entire 24 hours of data are missing.

Monthly **extreme maxima/minima** are the maximum and minimum water levels from all measured data for that month. Monthly **surge maxima/minima** (residuals) are calculated in a similar manner from the time series of residuals. Residuals are derived as the measured tidal elevation minus the predicted tidal elevation.

The monthly Mean Sea Level is calculated as the average of all readings for the given month. The annual MSL is the average of all readings for the given year. These average values should not be used for any purpose without consideration of the recovery rate.

Acknowledgements

TASK2000 tidal prediction software was kindly provided by Proudman Oceanographic Laboratory.

¹ Due to the requirements of the Harbour owners, the Rex is sited at a lower elevation than ideal, and a combination of high surge, high spring tides and significant wave action can cause the instrument to be swamped. This appears to have happened on 10 March 2008, and accordingly the elevations given in the tables below may be an under-estimate of the actual tidal levels.

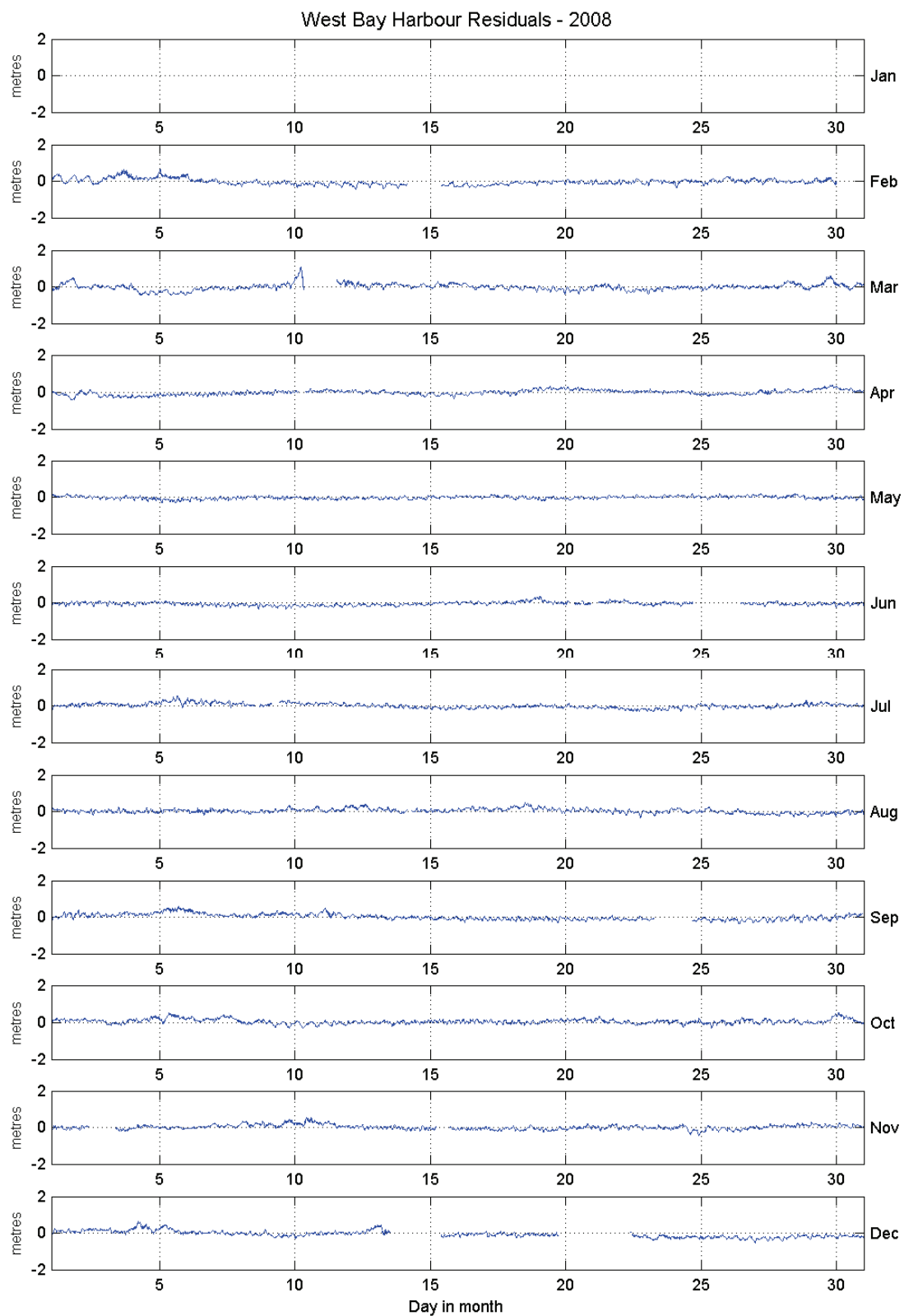


Figure 1 Residuals for 2008

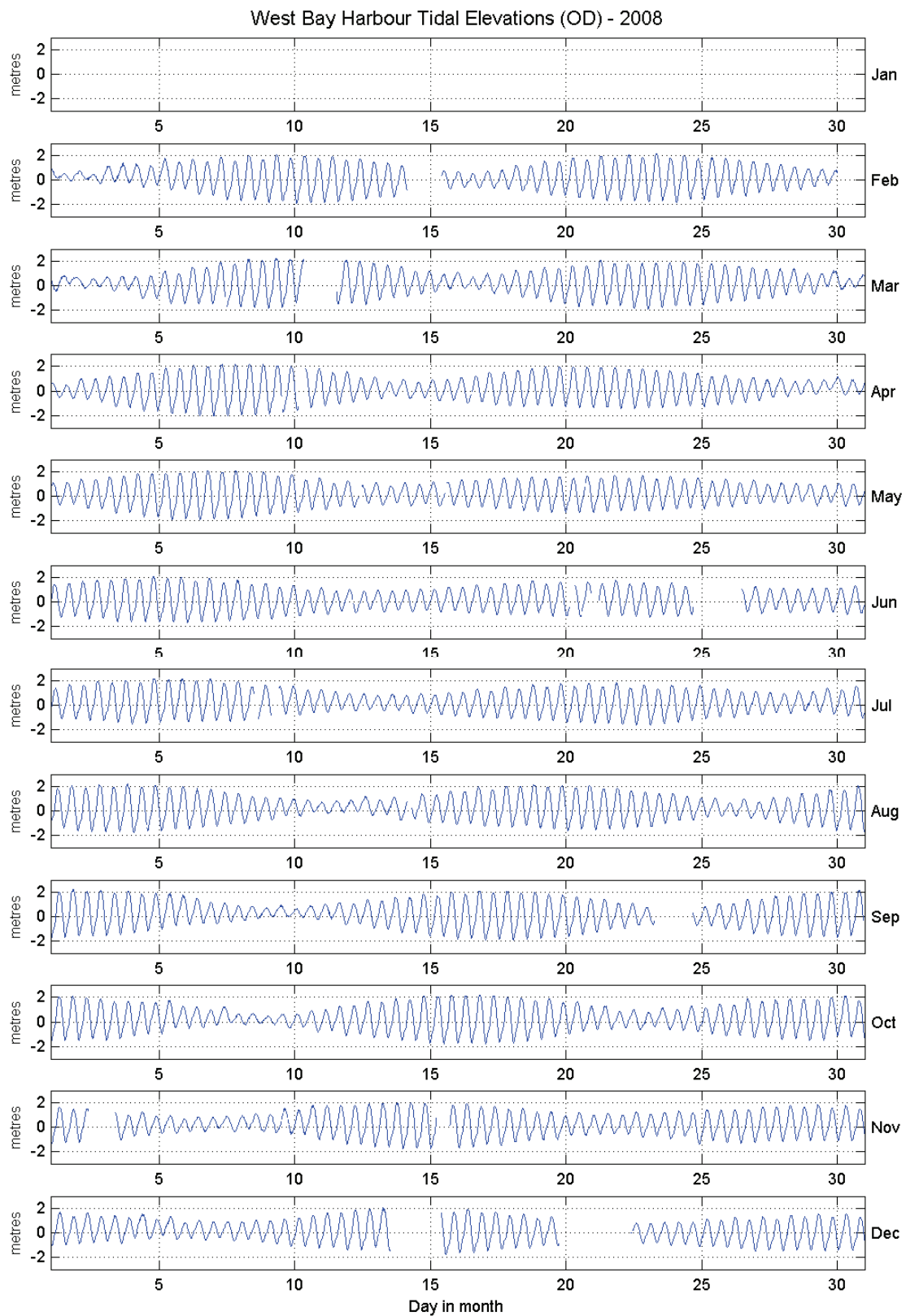


Figure 2 Tidal elevations relative to Ordnance Datum for 2008

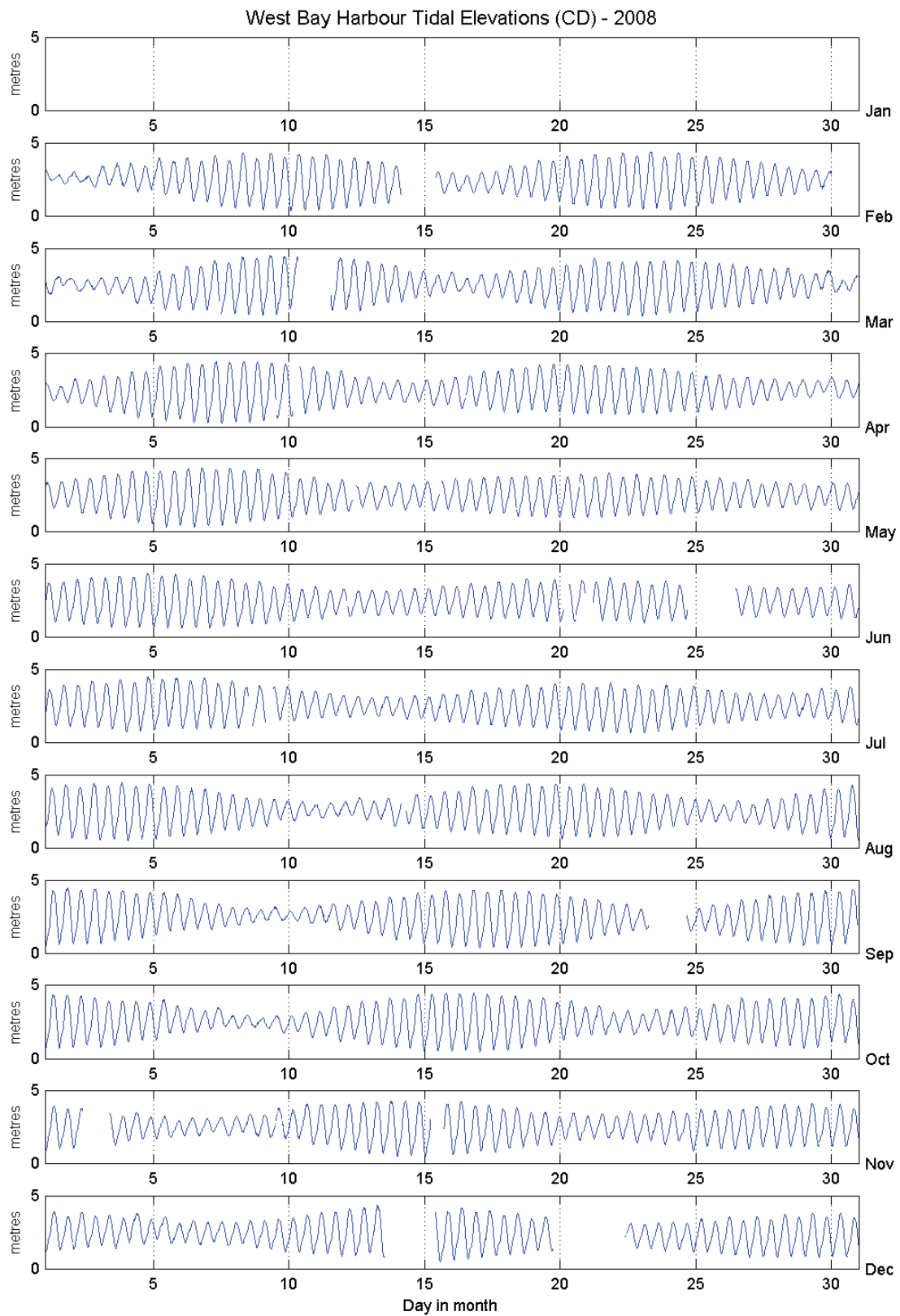


Figure 3 Tidal elevations relative to Chart Datum for 2008

Annex F – Topographic Survey Report for Burton Freshwater

1. Introduction

Analysis has been conducted using annual baseline surveys collected since the Programme's commencement in 2007.

Historic data collected by the Environment Agency has also been included in this report to provide a more comprehensive analysis for Burton Freshwater. The 2004 survey data has been used as the baseline survey for the area. Topographic profiles used by the Environment Agency correspond to profiles used by Plymouth Coastal Observatory.

Data has been analysed from 2004 to spring 2011. Data analysis is limited to those profiles which have historic data.

Historic LiDAR data collected by the Environment Agency has also been included within this report.

A full time series of plotted beach profiles are shown superimposed on and relative to a Master Profile for each profile location (on the accompanying CD). The Master Profile provides the basis for calculation of beach cross-section area changes. In general, changes are measured relative to the Mean Low Water Springs (MLWS) level. In cases (such as post-storm surveys) where this level cannot be reached, the Master Profile is placed at the lowest level achieved by all profiles in the management unit (Figure 4). The trend in cross-sectional area (CSA) is presented as a graph for each profile (Figure 5).

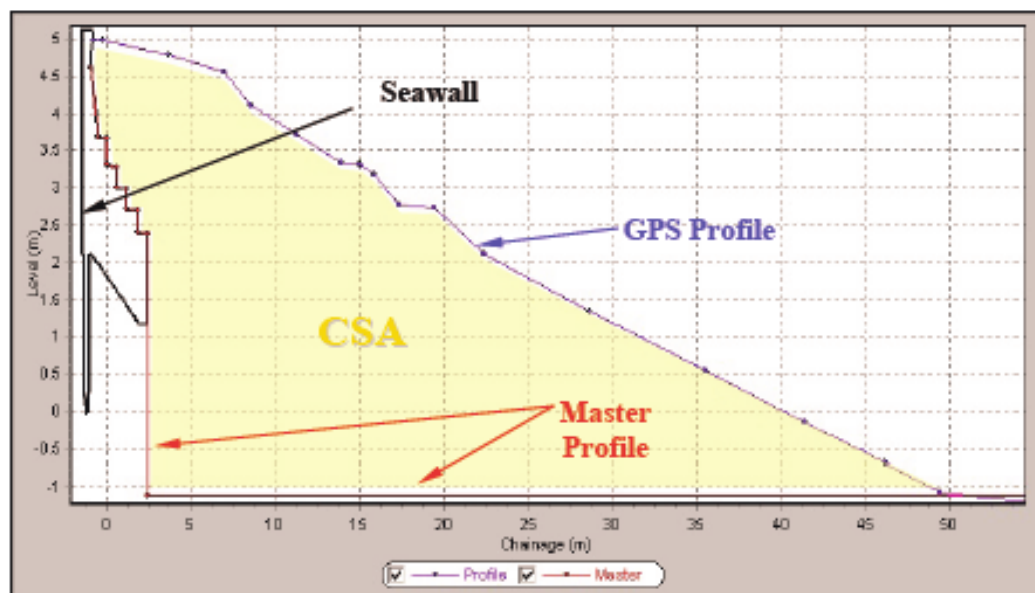


Figure 4: Example Master Profile with CSA calculated from the surveyed GPS Profile

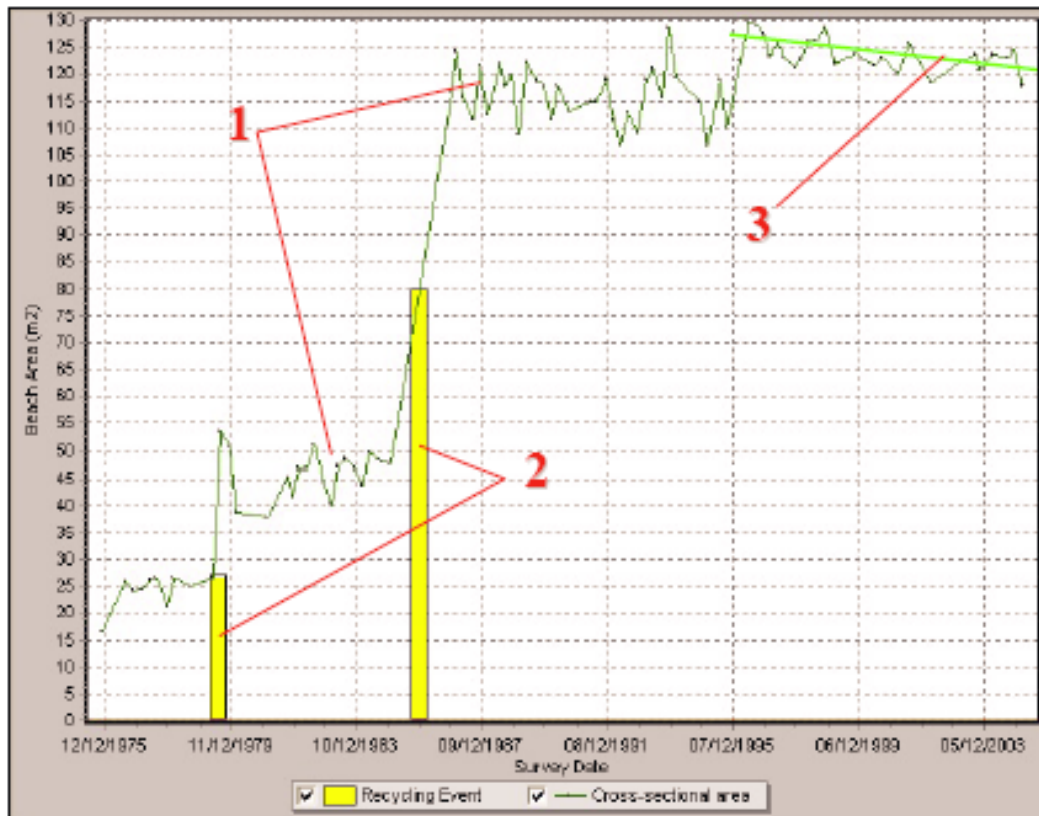


Figure 5: Example of Beach Profile Trend Analysis

- 1. Beach Cross-Sectional Area (CSA)**
- 2. Replenishment Activities**
- 3. Mathematically Derived Trend line**

As part of the monitoring programme specification, beach management plan (BMP) surveys are conducted for Burton Freshwater annually. BMP surveys include a full profile survey at 50m intervals and continuous spot height data collected at approximately 1m intervals across the whole beach to the level of MLWS. This continuous data also includes a feature code for each spot height data point recorded. The feature code data is used to provide a sediment distribution map.

A topographic difference model has been produced based on the spot height elevations for each BMP survey. The spot height data has been processed into a grid model and successive models have been subtracted from one another to produce a difference model for the management unit. The spot height data from each survey has also been used to approximate the level of MHW (Mean High Water) and MLW (Mean Low Water).

2. Condition of process sub-cell

The Beach Change Summary maps contain an at-a-glance condition of Burton Freshwater, with the lines representing the average accretion, no change or erosion for where there is topographic data.

Spring 2010 to Spring 2011

All three profiles have eroded, although the central profile has lost only 5% of its CSA.

August 2007 to July 2008

During the year most profiles showed little change apart from two (6a00654 and 6a00651) which showed minor erosion of -4m^2 .

Summer 2004 to Spring 2011

Most of the profiles show little net change since 2004 however, the central section of beach has experienced notable erosion.

4. Storm Event Performance

During the reporting period two post storm surveys have been undertaken at Burton Freshwater.

During the 28th November 2009, torrential winds and rain caused widespread flooding across the South West region. Wind speeds reached Beaufort scale force 6 and the maximum wave height reached up to 5 metres.

The storm event which occurred on the 13th January 2011 was similar to the above. Wind speeds reached force 6 and significant wave height reached 4 metres.

18th October 2009 to Post Storm survey 28th November 2009

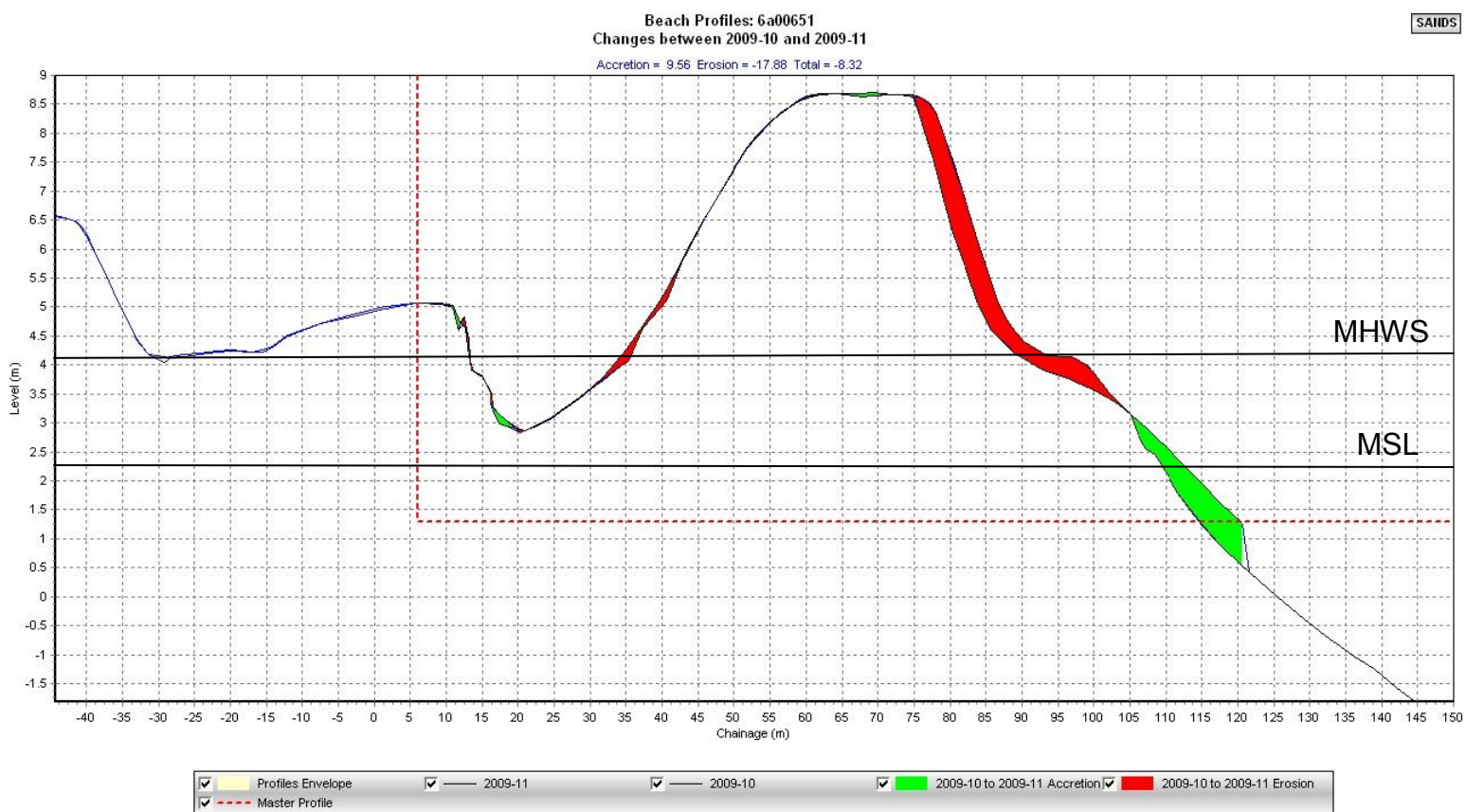


Figure 6. 6a00651 Pre-storm and post storm difference October 2009 and November 2009

The barrier face experienced some draw down from the crest to the survey extent.

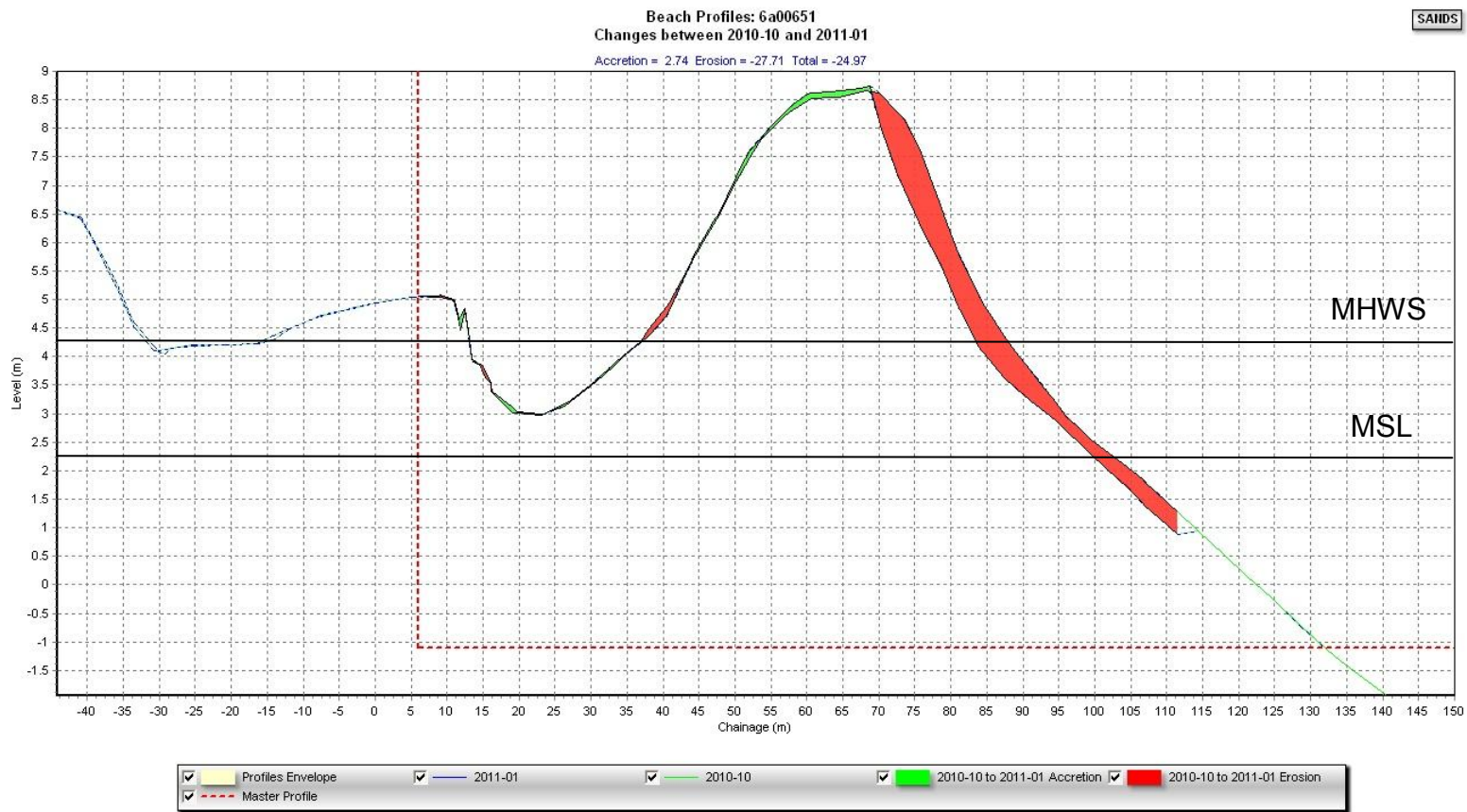


Figure 7. 6a00651 Pre-storm and post storm difference July 2010 and January 2011

The barrier face has receded and gained a small amount of material on the landward side of the crest. The barrier has narrowed by approximately 10 metres.



Figure 8. Profile 6a00652 Pre-storm June 2009

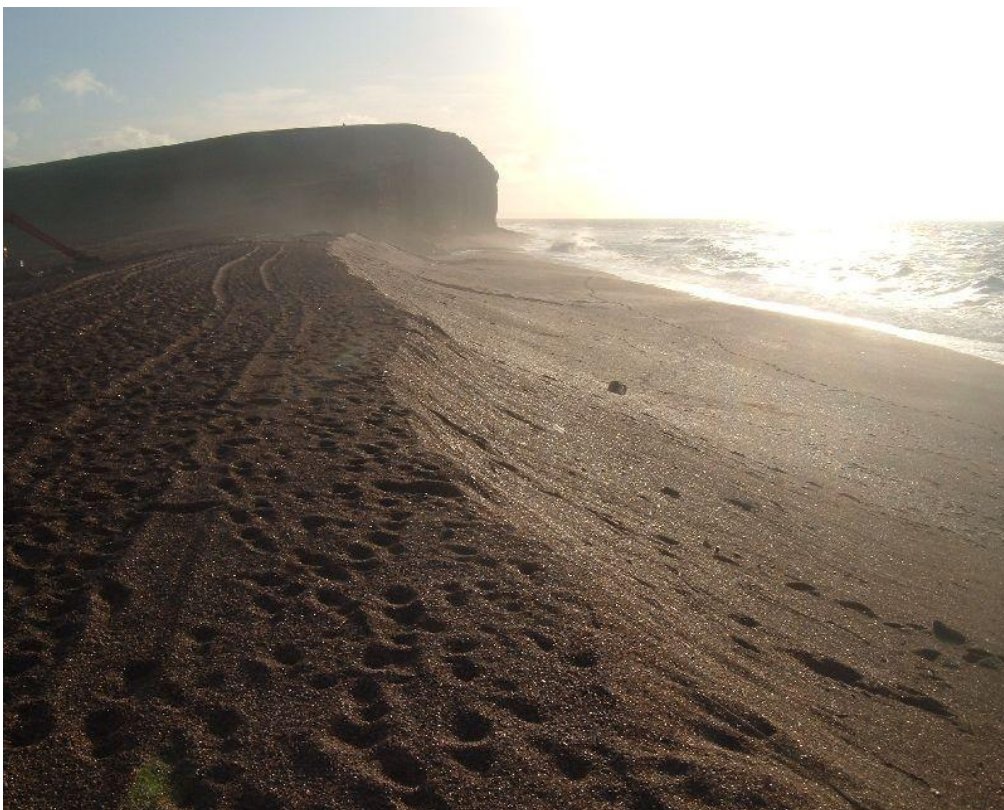


Figure 9. Profile 6a00652 Post-storm November 2009

The slope has receded and has become more gently inclined.



Figure 10. Profile 6a00652 Pre-storm July 2010



Figure 11. Profile 6a00652 Post-storm January 2011

The slope has further receded and flattened.

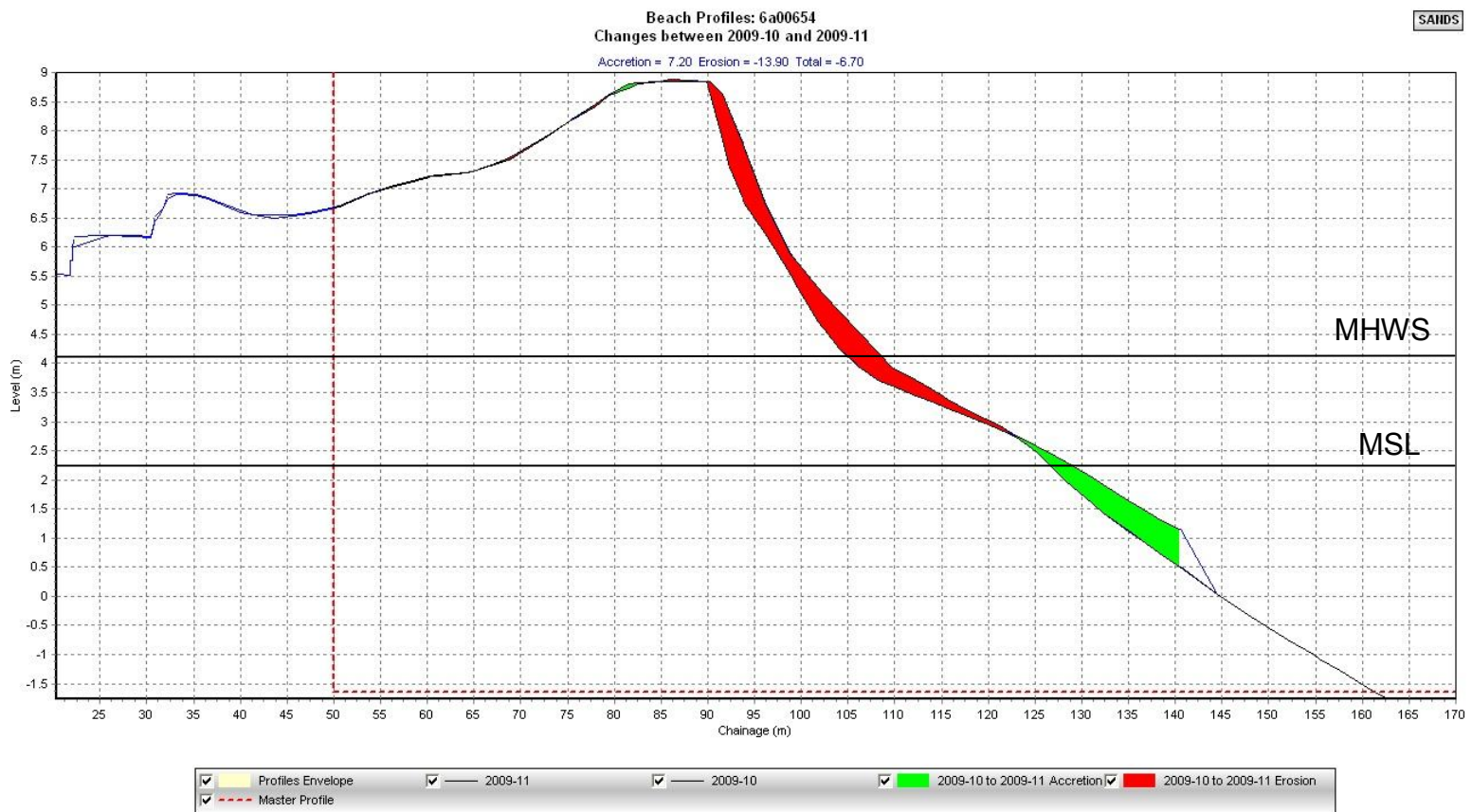


Figure 12. Profile 6a00654 pre-storm and post-storm difference October 2009 and November 2009

A similar pattern to profile 6a00651 (October 2009 and November 2009) was observed.

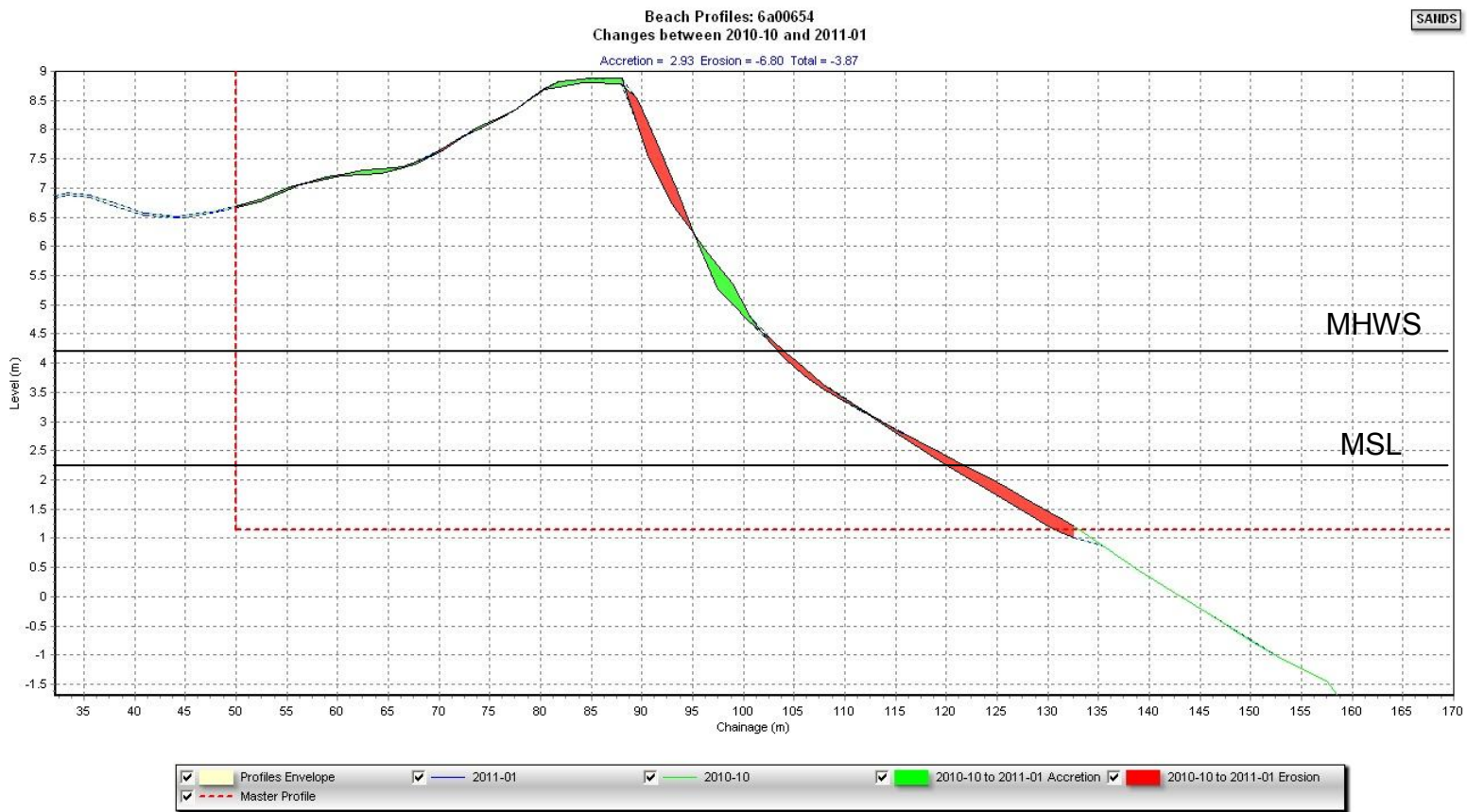


Figure 13. Profile 6a00654 pre-storm and post-storm difference July 2010 and January 2011

There has been draw down of material from the top of the crest. The barrier has changed little in shape since the 2009 post-storm survey.

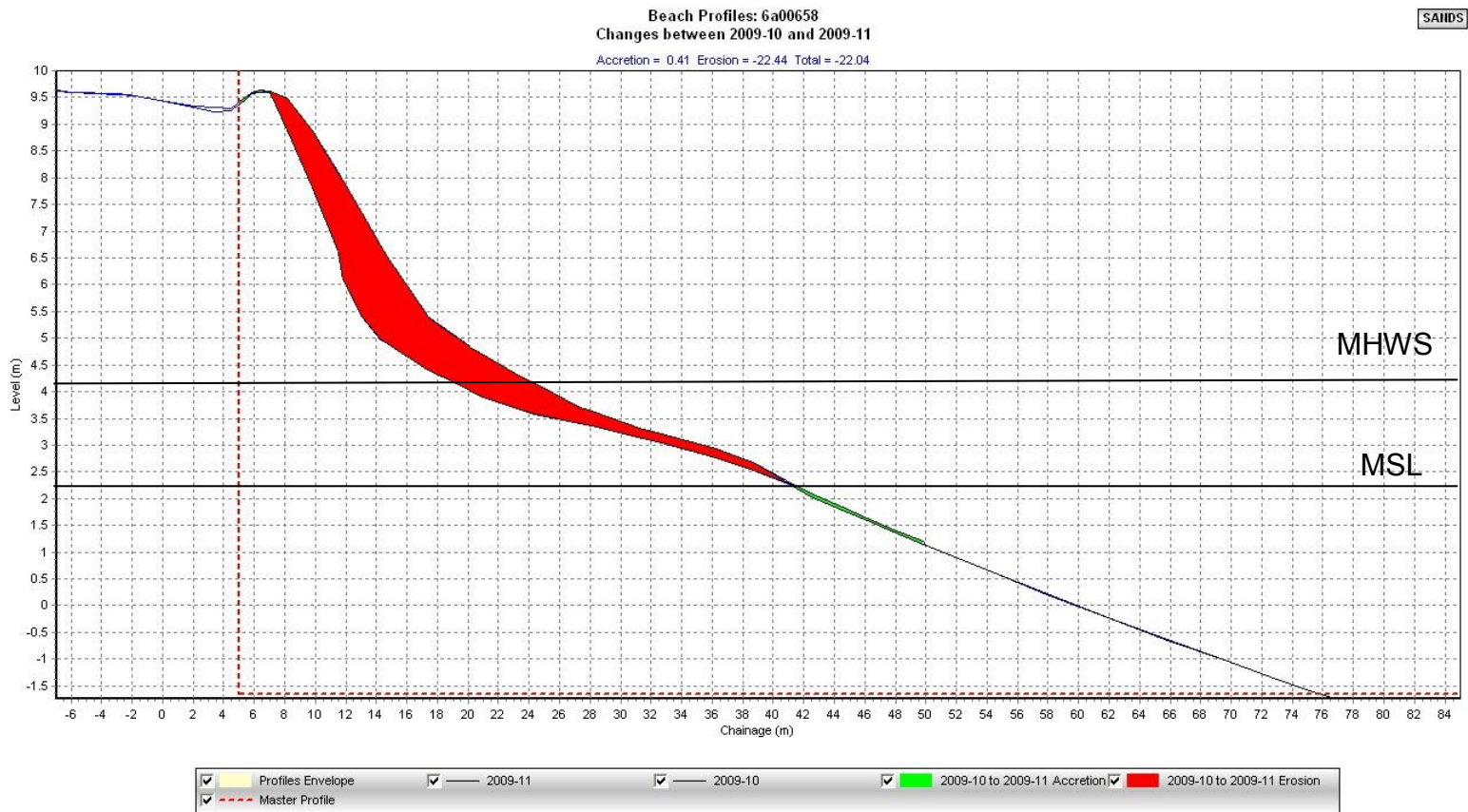


Figure 14. Profile 6a00658 pre-storm and post-storm difference October 2009 and November 2009

The majority of the barrier face has eroded, although there was little net deposition below the survey level (at approximately 1.3 metres).

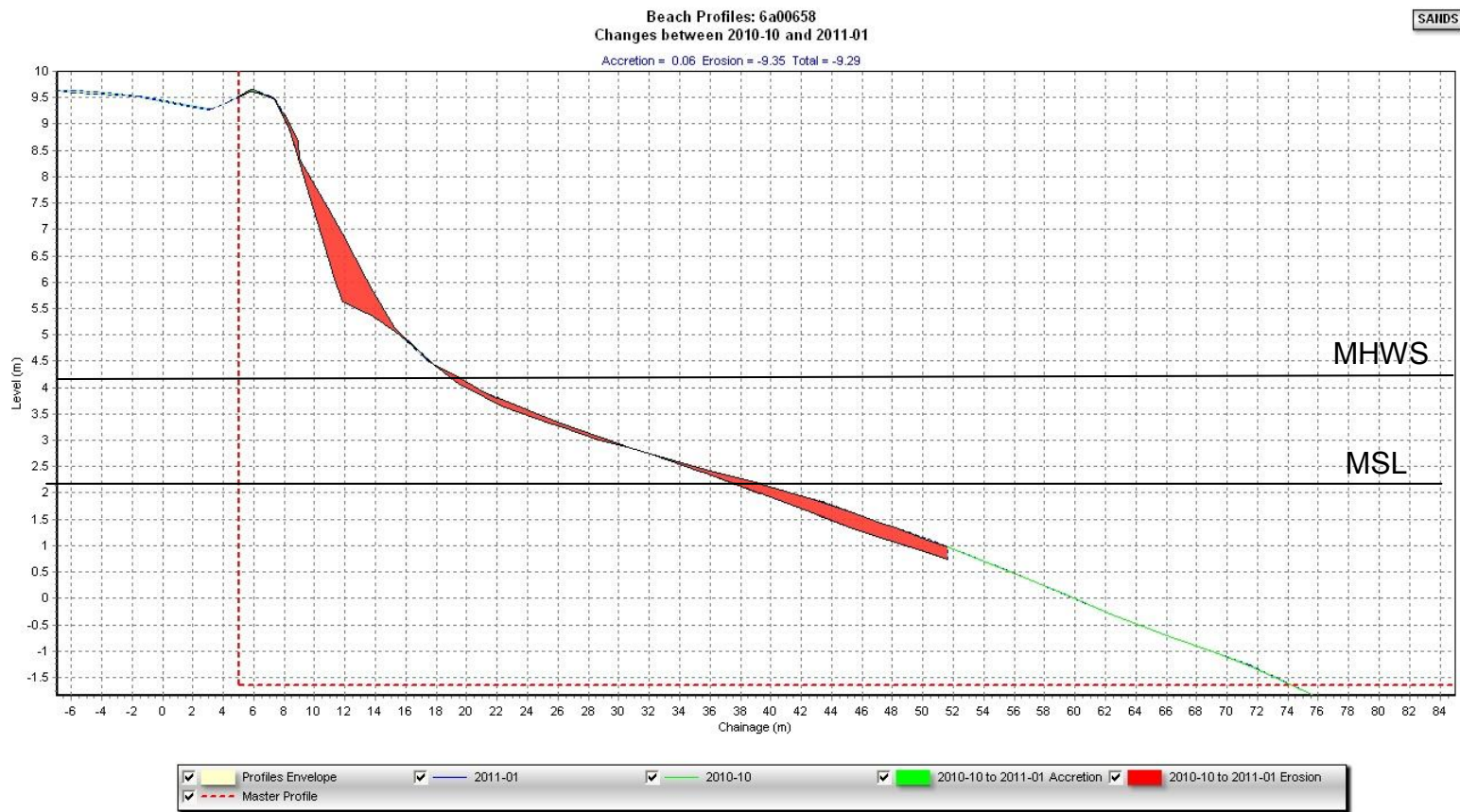


Figure 15. Profile 6a00658 pre-storm and post-storm difference July 2010 and January 2011

The beach crest has receded and has narrowed by approximately 2 meters since the 2009 post-storm analysis.

6. Topographic difference models

June 2009 to July 2010

There is evidence of crest erosion along the whole length of the beach. This is not marked by build up of sediments lower on the foreshore, suggesting that either most sediment has been transported alongshore, or below the survey level. Build up of material can be observed along the bank of the River Bride.

Net Sediment Balance above MLWS from 2009 to 2010: -10609m^3

July 2008 to June 2009

Crest erosion can be observed along the entire length of the beach. There are some patches of accretion on the seaward of side of the crest, suggesting some of the material has been transported onto the beach slope. A prominent area of erosion can be noted around the bank of the River Bride.

Net Sediment Balance above MLWS from 2008 to 2009: -4399m^3

June 2007 to July 2010

Erosion is landward increasing and is most prominent at the beach crest. Beyond the beach crest there is little change. Erosion around the bank of the River Bride can be observed.

Net Sediment Balance above MLWS from 2007 to 2010: -37654m^3

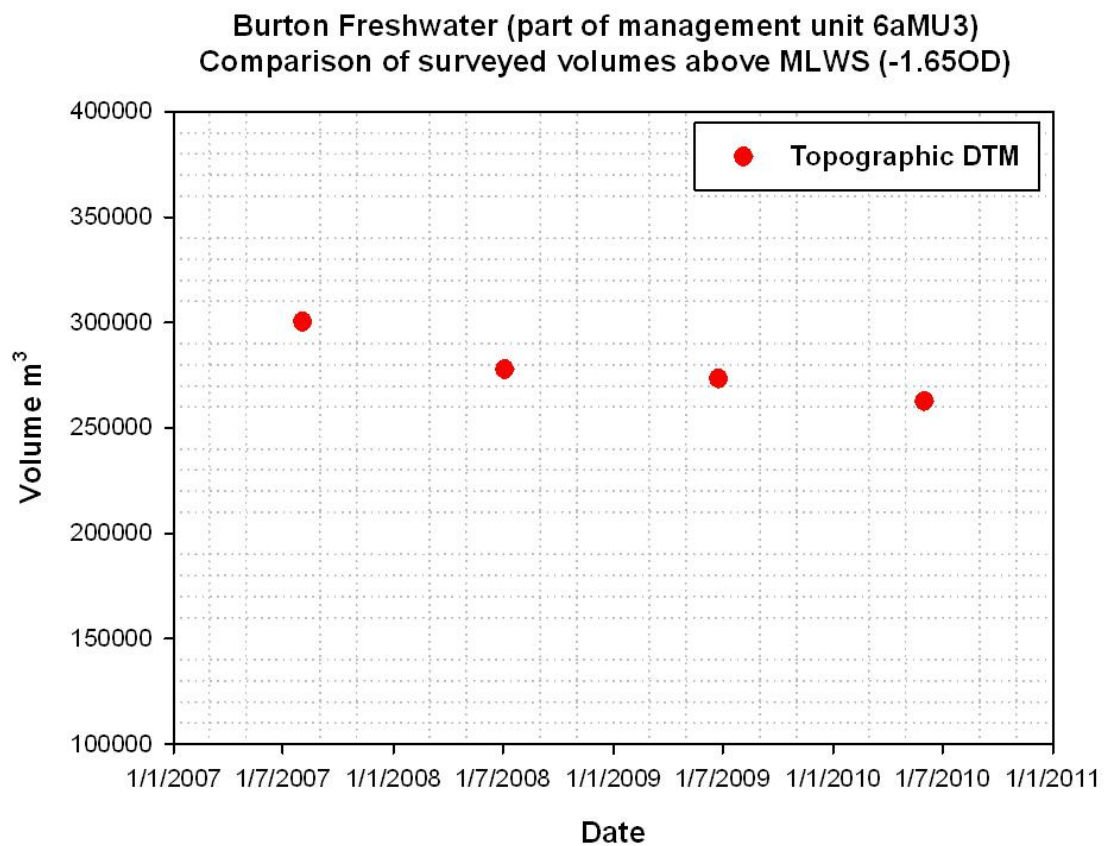


Figure 16.

Burton Freshwater beach lost volume between 2007 and 2008. After this the beach has remained relatively stable.

9. Changes in MHW elevation

The position of the MHW line has changed very little since 2006 however; there is some accretion around the mouth of the River Bride.

10. Profile behaviour

Lower seaward slope									
Profile	6a00651	6a00652	6a00653	6a00654	6a00655	6a00656	6a00657	6a00658	6a00659
Aug-07	1 in 5	1 in 5	1 in 5	1 in 9	1 in 7	1 in 7	1 in 7	1 in 9	1 in 11
Jul-08	1 in 5	1 in 7	1 in 8	1 in 8	1 in 7	1 in 8	1 in 9	1 in 8	1 in 8
Jun-09	1 in 4	1 in 6	1 in 3	1 in 9	1 in 10	1 in 8	1 in 9	1 in 8	1 in 9
	Emergency level								
	Action level								
Upper seaward slope									
Profile	6a00651	6a00652	6a00653	6a00654	6a00655	6a00656	6a00657	6a00658	6a00659
Aug-07	1 in 6	1 in 6	1 in 6	1 in 6	1 in 5	1 in 3	1 in 3	1 in 3	1 in 3
Jul-08	1 in 5	1 in 5	1 in 4	1 in 4	1 in 4	1 in 3	1 in 3	1 in 3	1 in 2
Jun-09	1 in 5	1 in 4	1 in 6	1 in 5	1 in 5	1 in 3	1 in 3	1 in 3	1 in 1.25
	Emergency level								
	Action level								

Table 3.
Slope ratios and trigger levels for Freshwater Beach.

The Environment Agency put several slope ratio thresholds in place, in order to determine when to undertake re-profiling maintenance (Table 1.). Slope ratios have been calculated from surveys between August 2007 and June 2009 (Table 3.). Profile 6a00649 has been omitted as it crosses the River Bride and therefore deviates from the stated standards of protection.

In the past it has been noted that profiles in the west (6a00657, 6a00658 and 6a00659) are artificially steeper than those in the east. This is due to the encroachment of the caravan park on to the beach.

As can be observed in Table 3, seaward profiles have become progressively less inclined towards the reclaimed section of the beach. However, upper seaward slopes are still extremely steep (approximately 1:1). The combination of the artificial slope and narrow crest width (measuring no more than 6 metres across all 3 profiles) indicates that this section of beach is more susceptible to erosion, over topping and inshore flooding.

Lower and Upper seaward slopes in the central and eastern section vary between 1:3 and 1:6. Crests are much wider at this end of the beach ranging from 10 to 15 metres. These findings compare with those observed in the 2009 BMP Report.

EXPLANATORY NOTES

Change in Cross-sectional Area (CSA)

The annual change in cross-sectional area is calculated as the difference in CSA between two surveys, expressed as a percentage change compared to the earlier CSA.

$$\frac{CSA_1 - CSA_2}{CSA_2} \times 100 \quad \text{eqn(1)}$$

Where CSA_1 = most recent springtime survey and CSA_2 = spring survey previous year. Therefore an annual change of -14% represents erosion during the last year of 14% of the area of last year's survey.

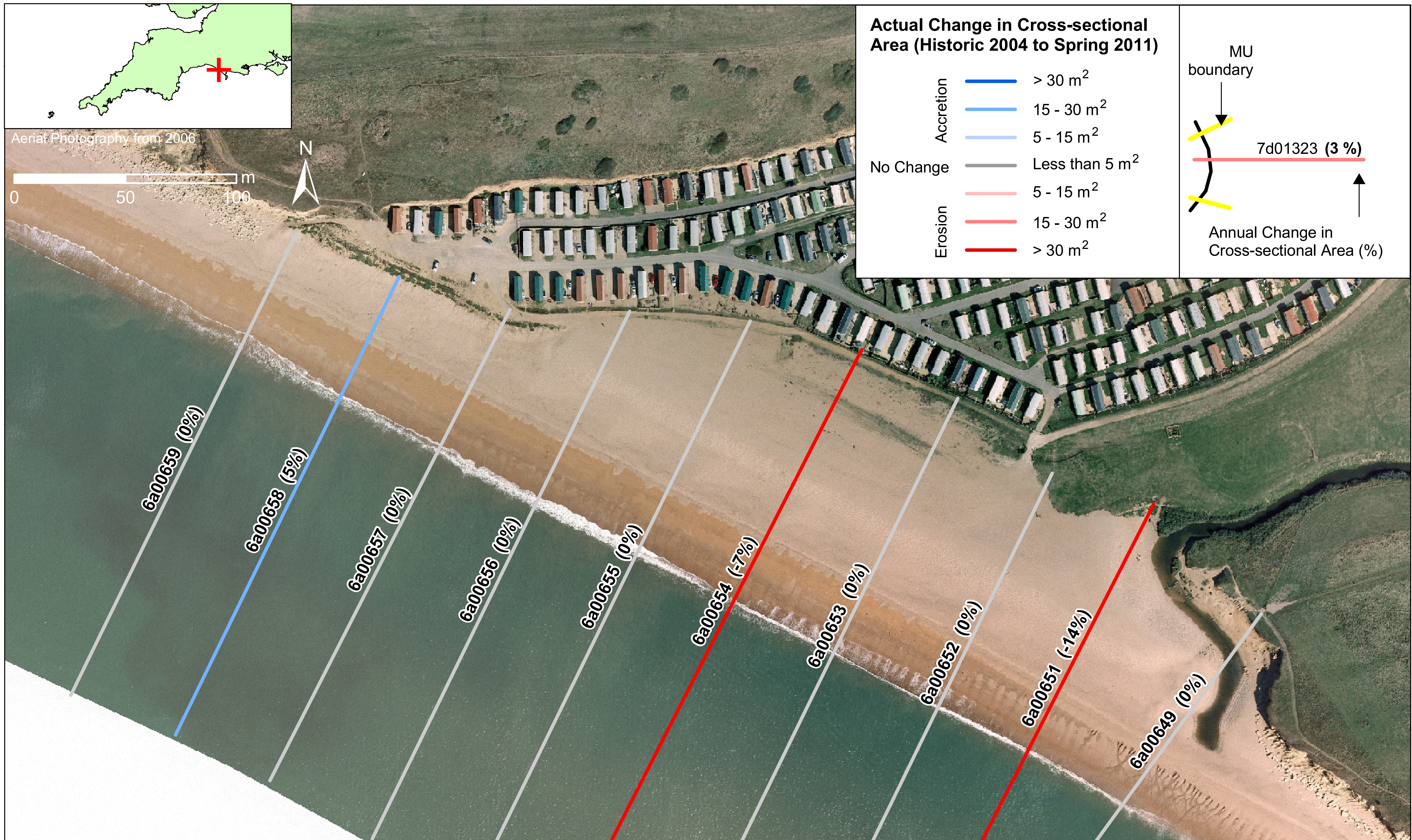
Net Sediment Calculation

The value derived from this calculation represents the volume change in m^3 across each individual management unit over time. The initial volumes are derived from the Digital Terrain Models made for consecutive baseline topographic surveys. Both models are clipped to cover the same area, then a volume above the MLWS plane is calculated for each DTM. The net sediment change is calculated as

$$Vol_1 - Vol_2 \quad \text{eqn(2)}$$

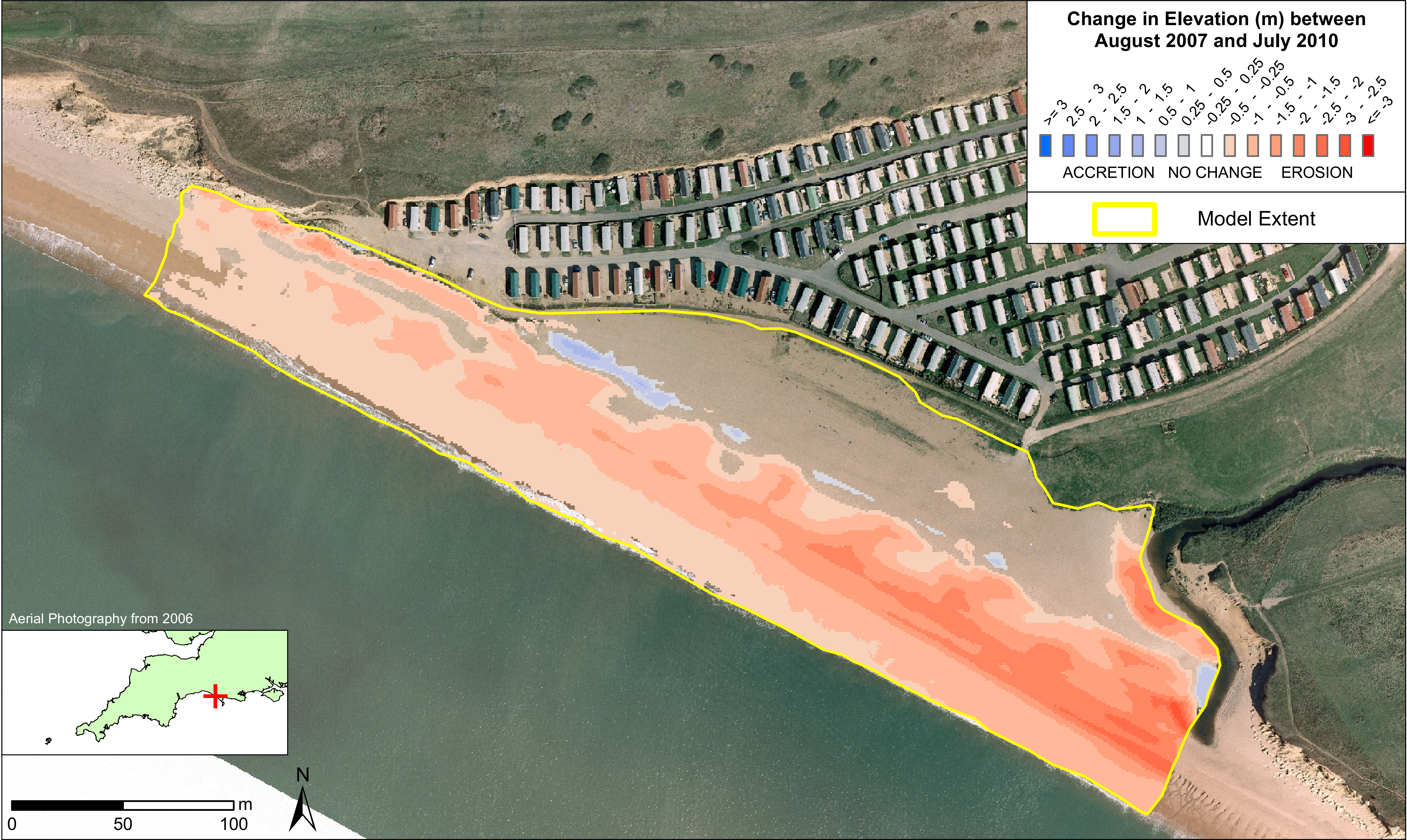
Where Vol_1 = most recent DTM model volume and Vol_2 = earlier DTM model volume. Therefore a net change of $-19730m^3$ represents erosion since the earlier survey.



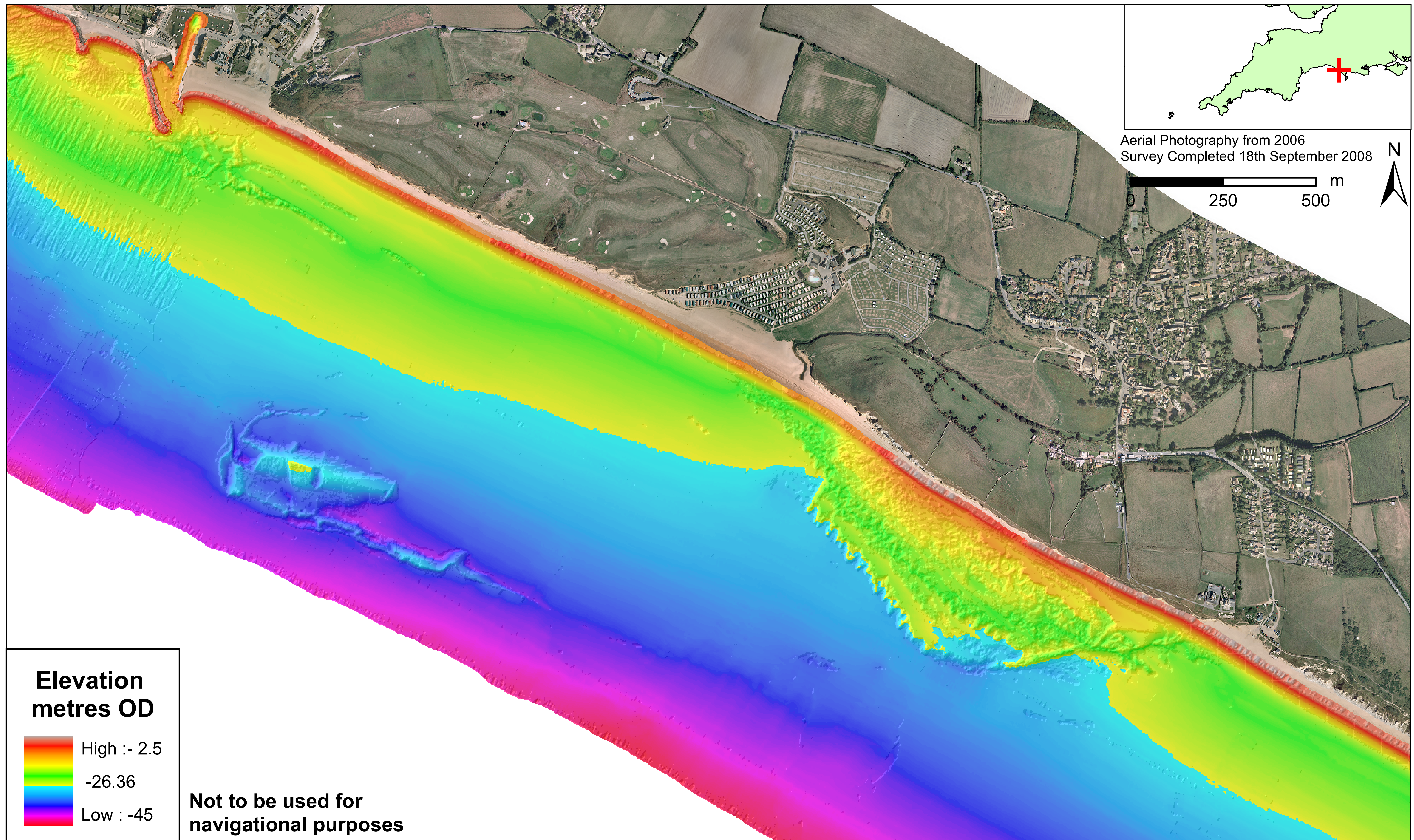






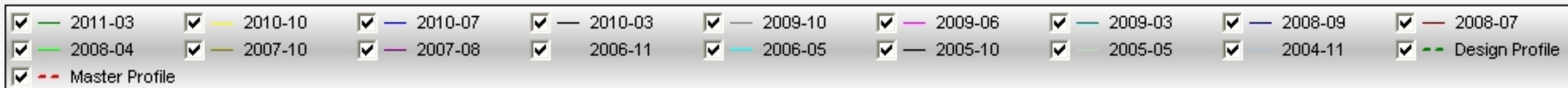
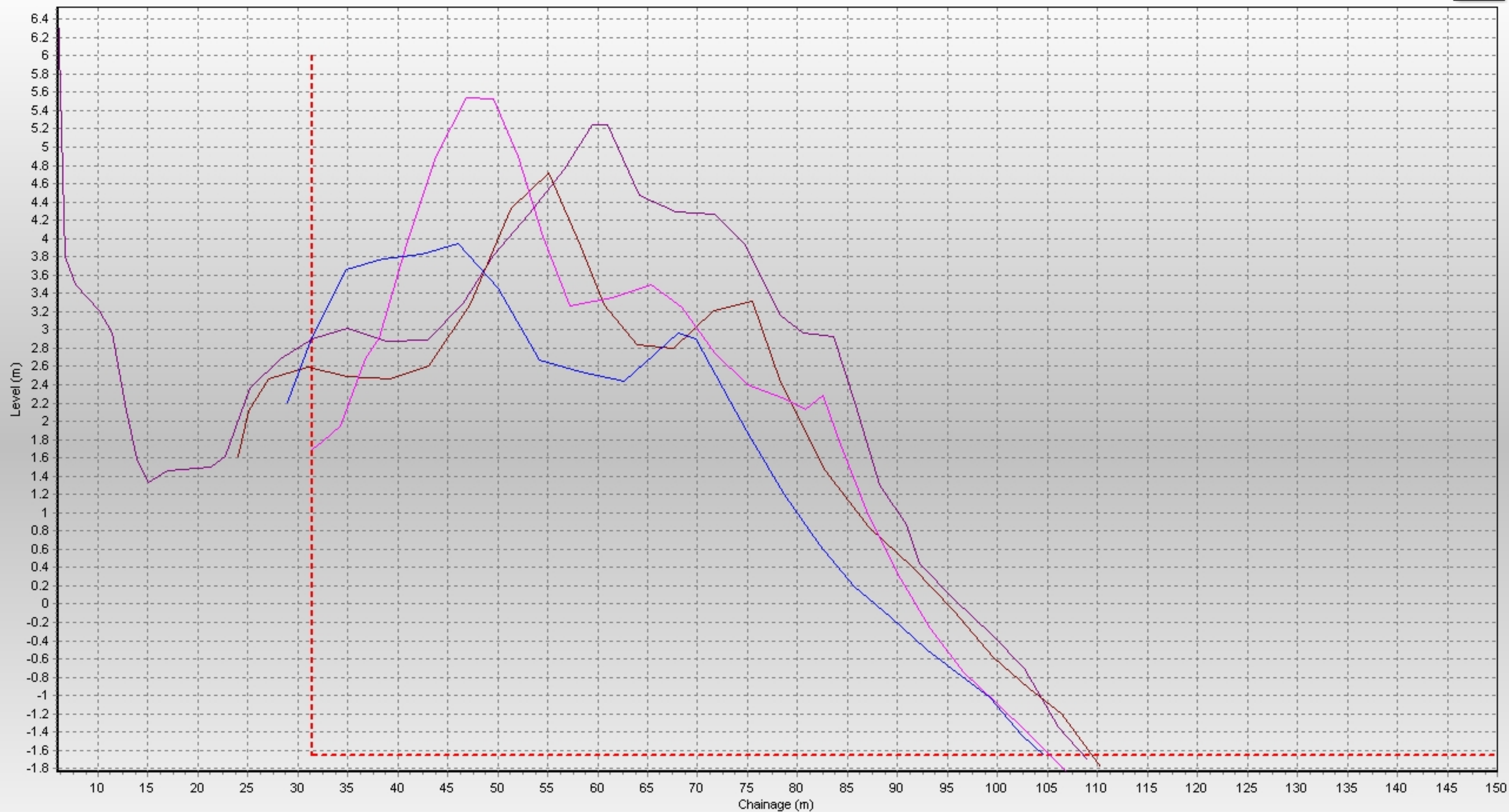


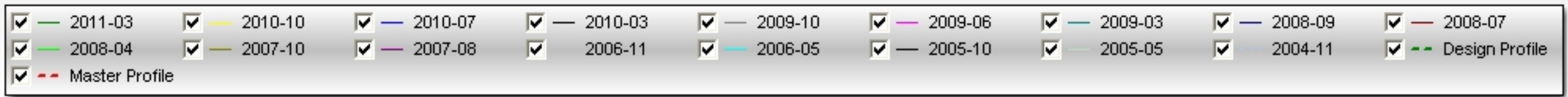




Beach Profiles: 6a00649

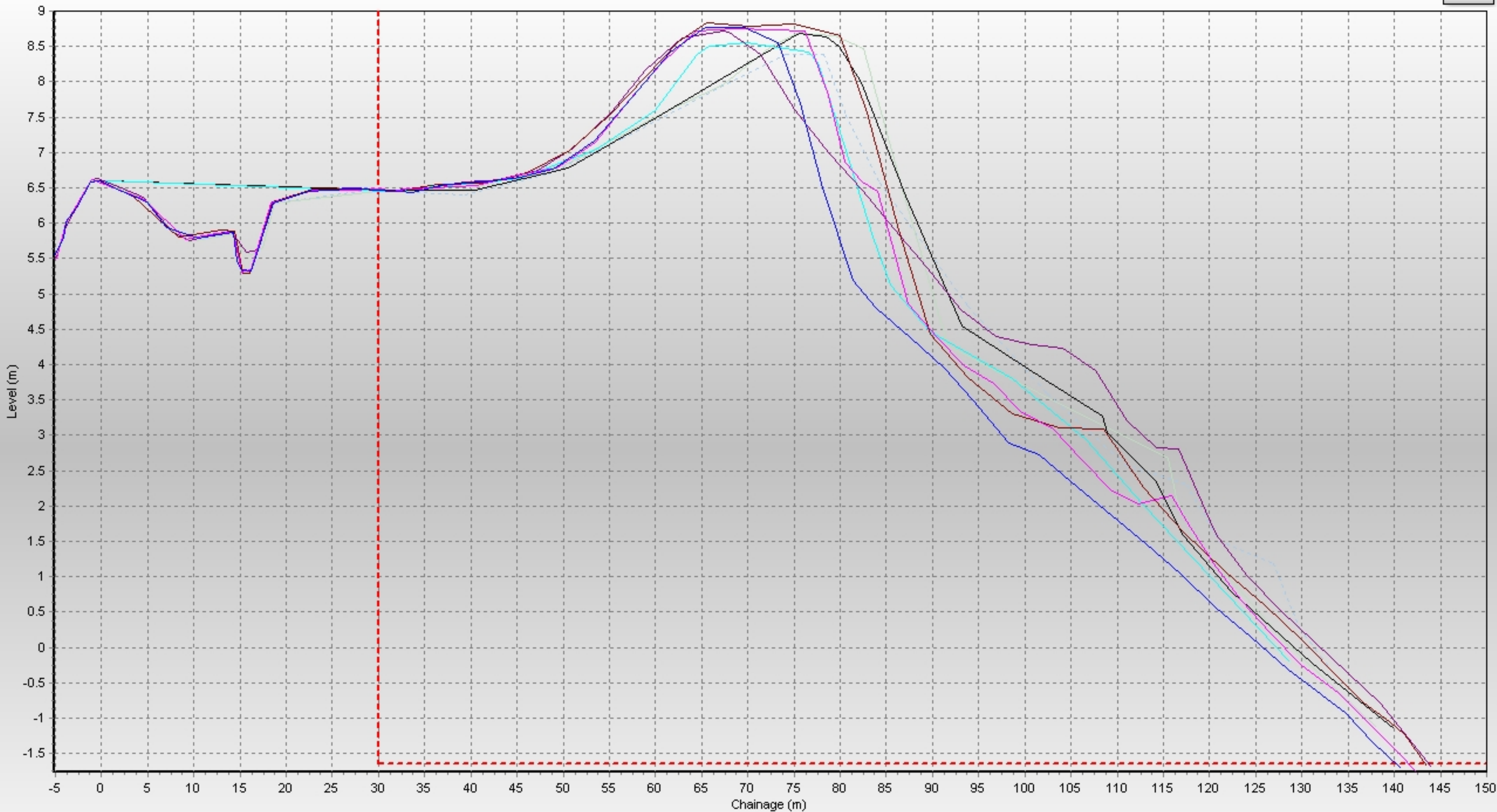
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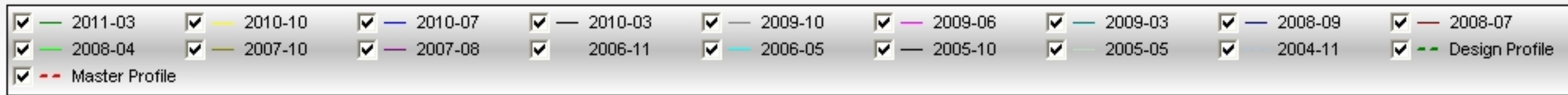


Beach Profiles: 6a00652

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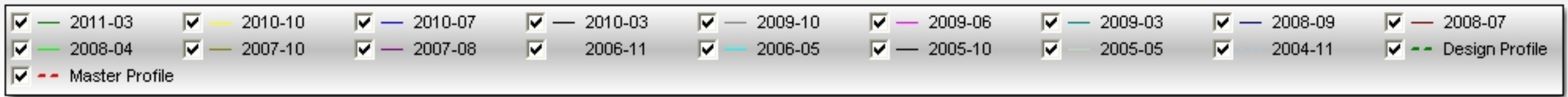
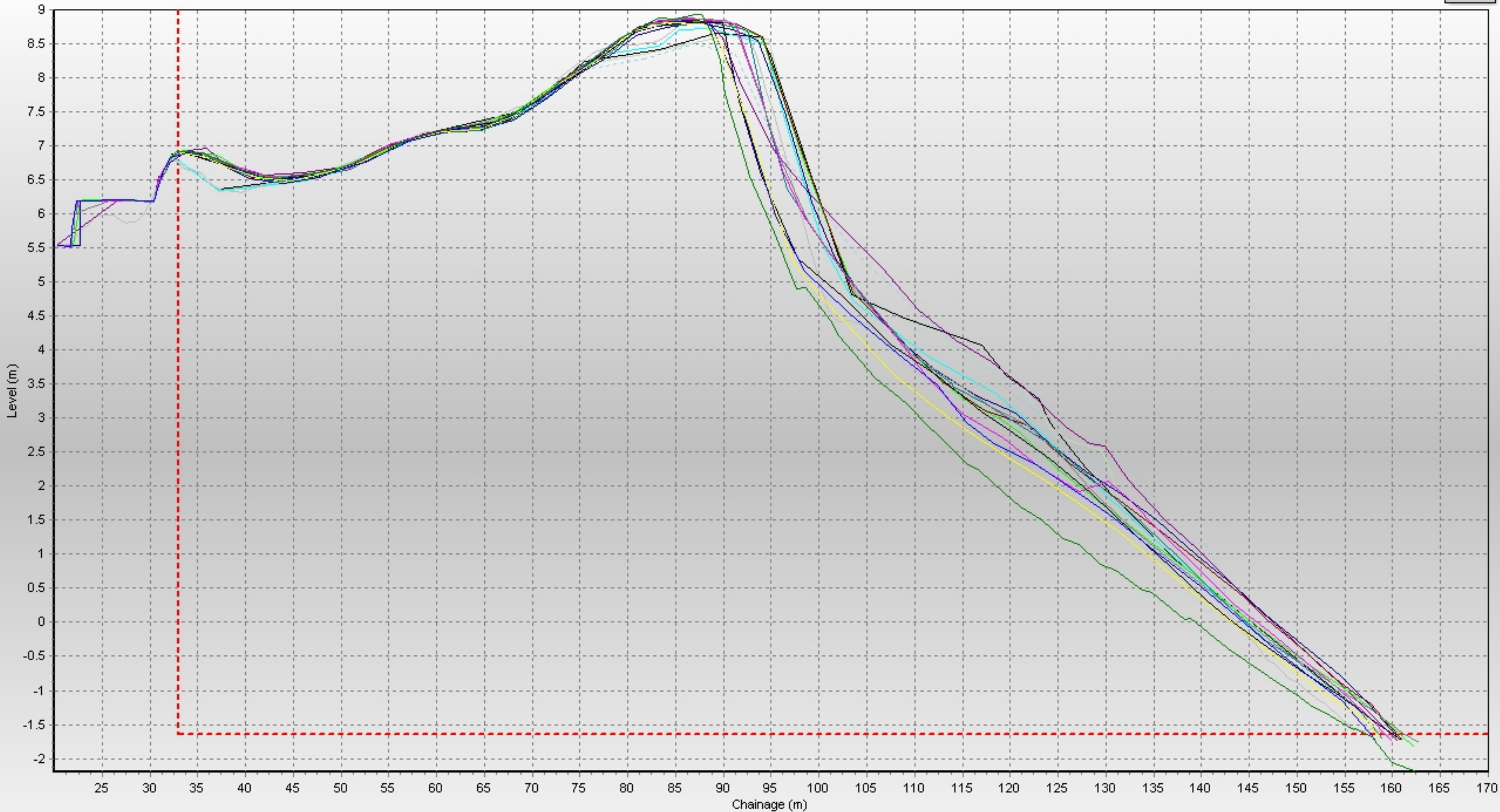


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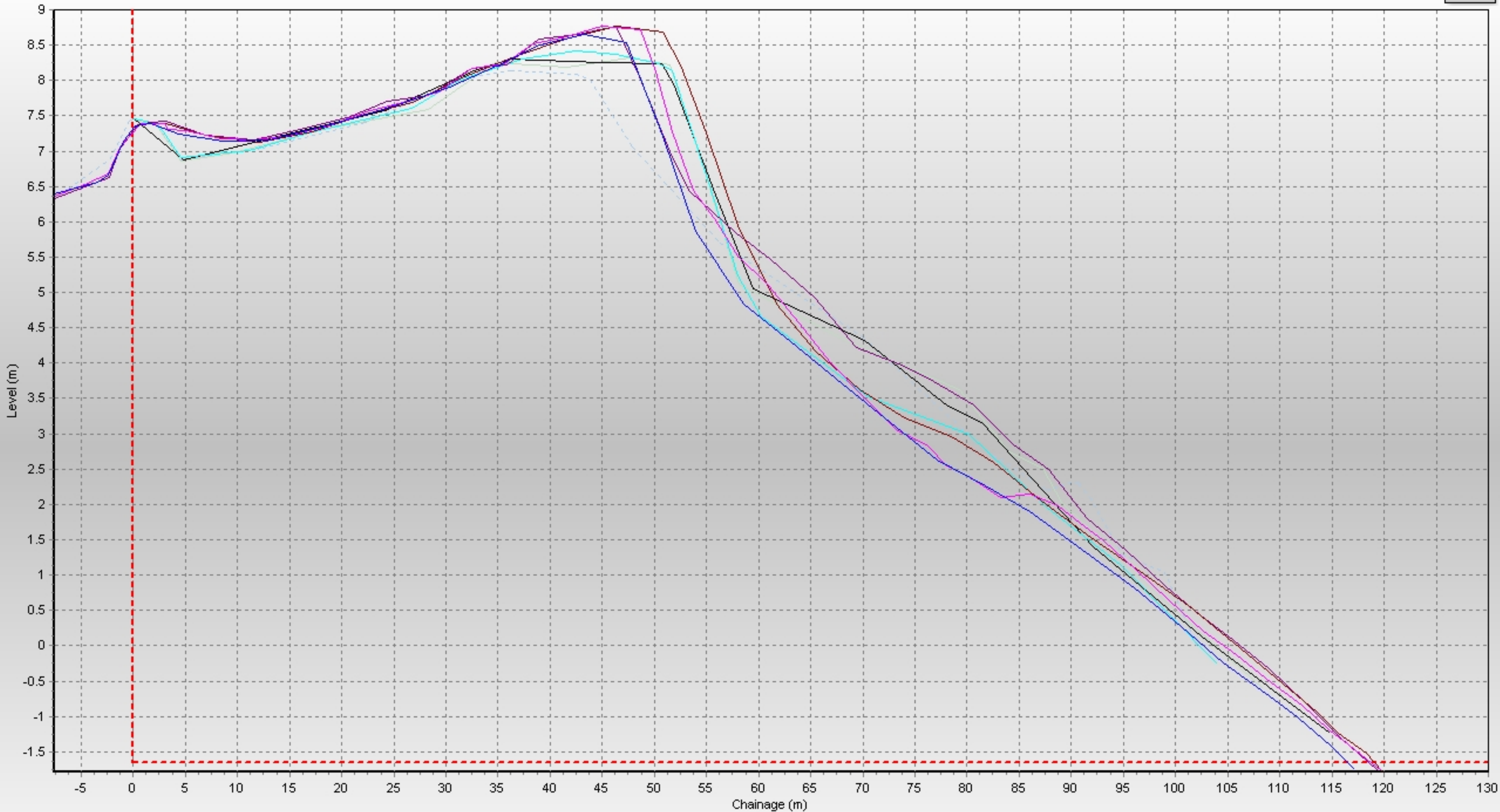
Beach Profiles: 6a00654

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Beach Profiles: 6a00655

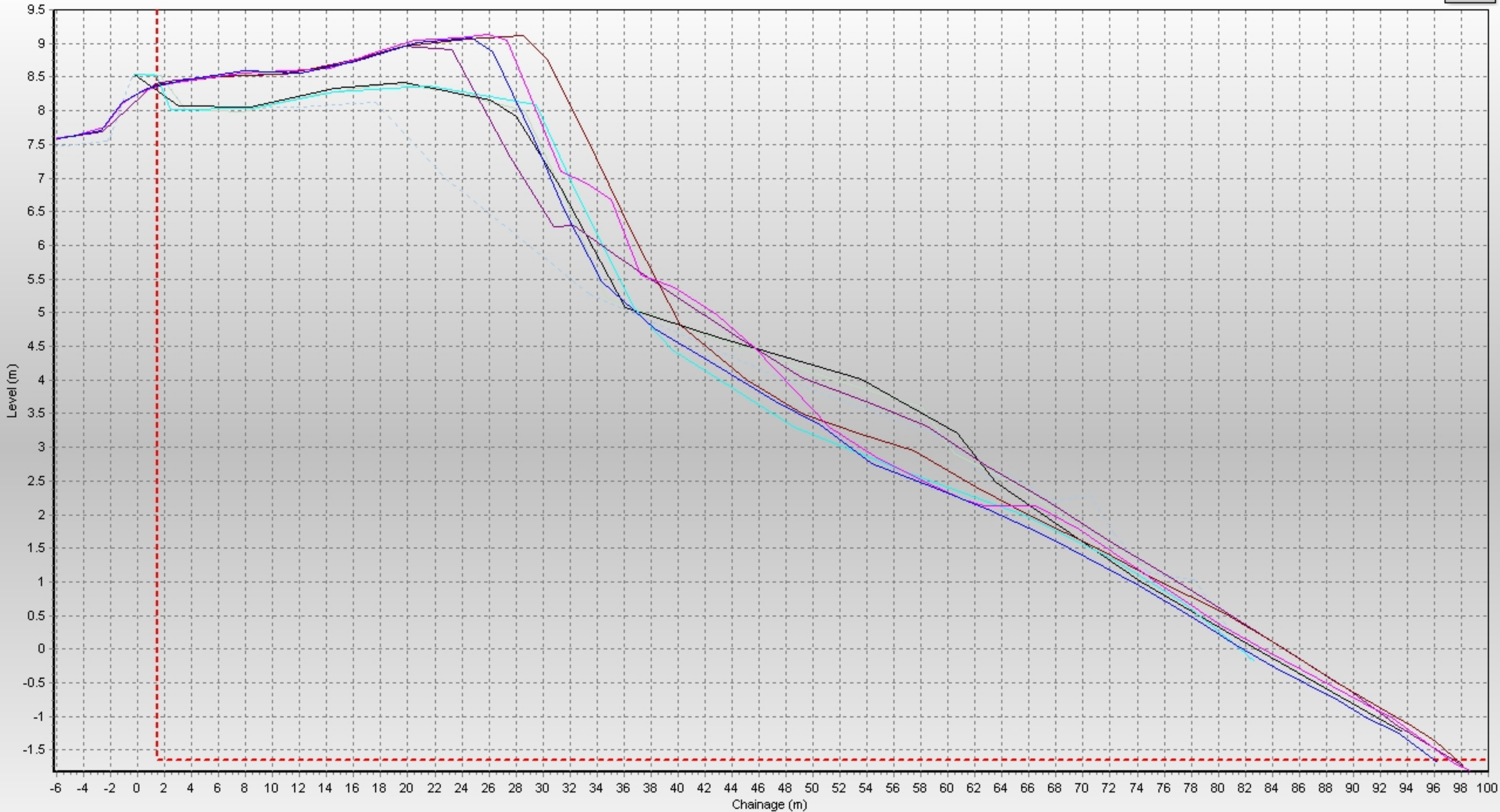
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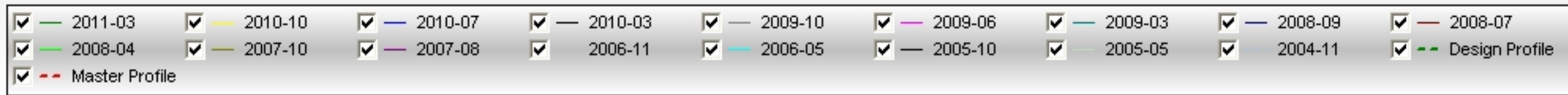
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Beach Profiles: 6a00656

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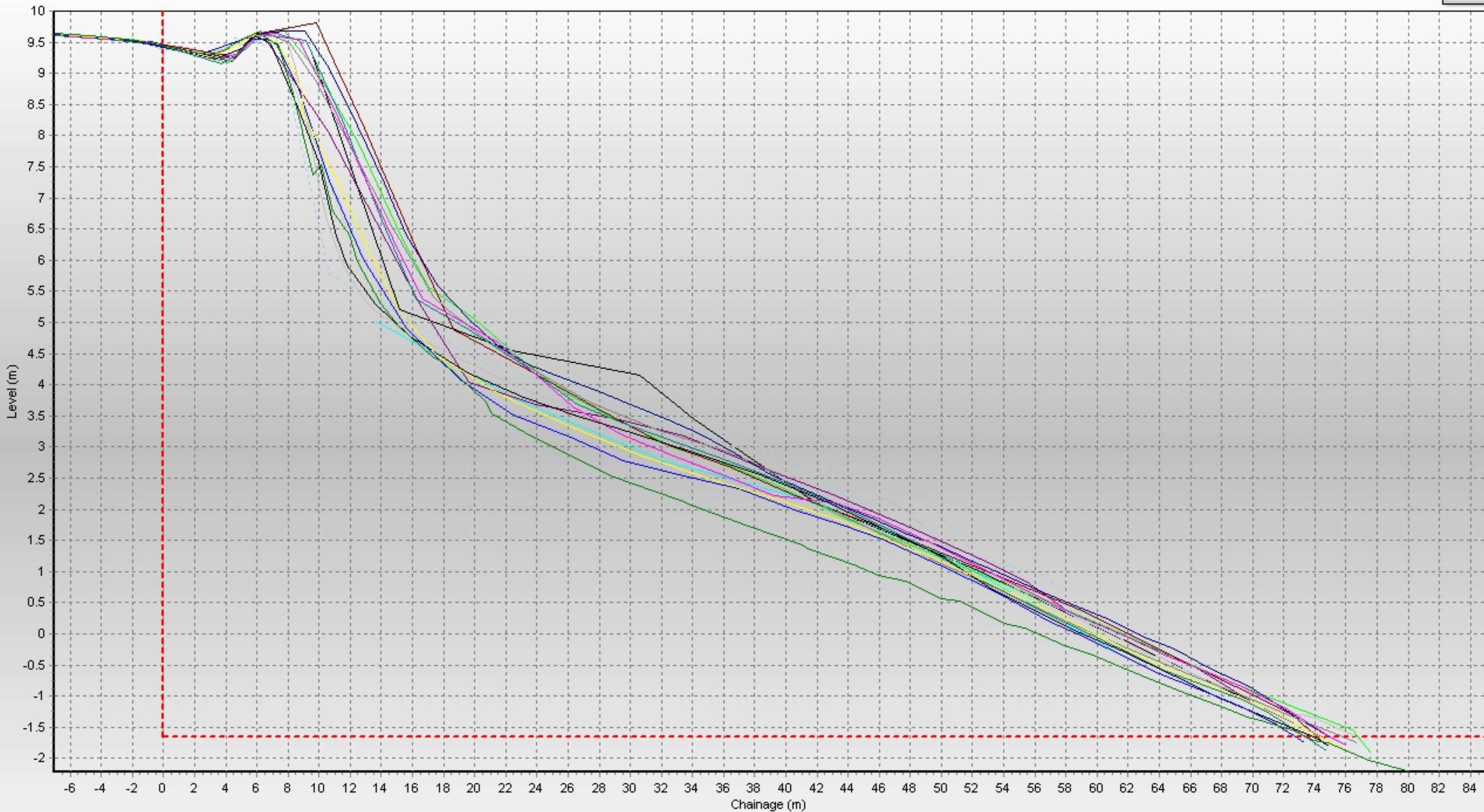


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Beach Profiles: 6a00658

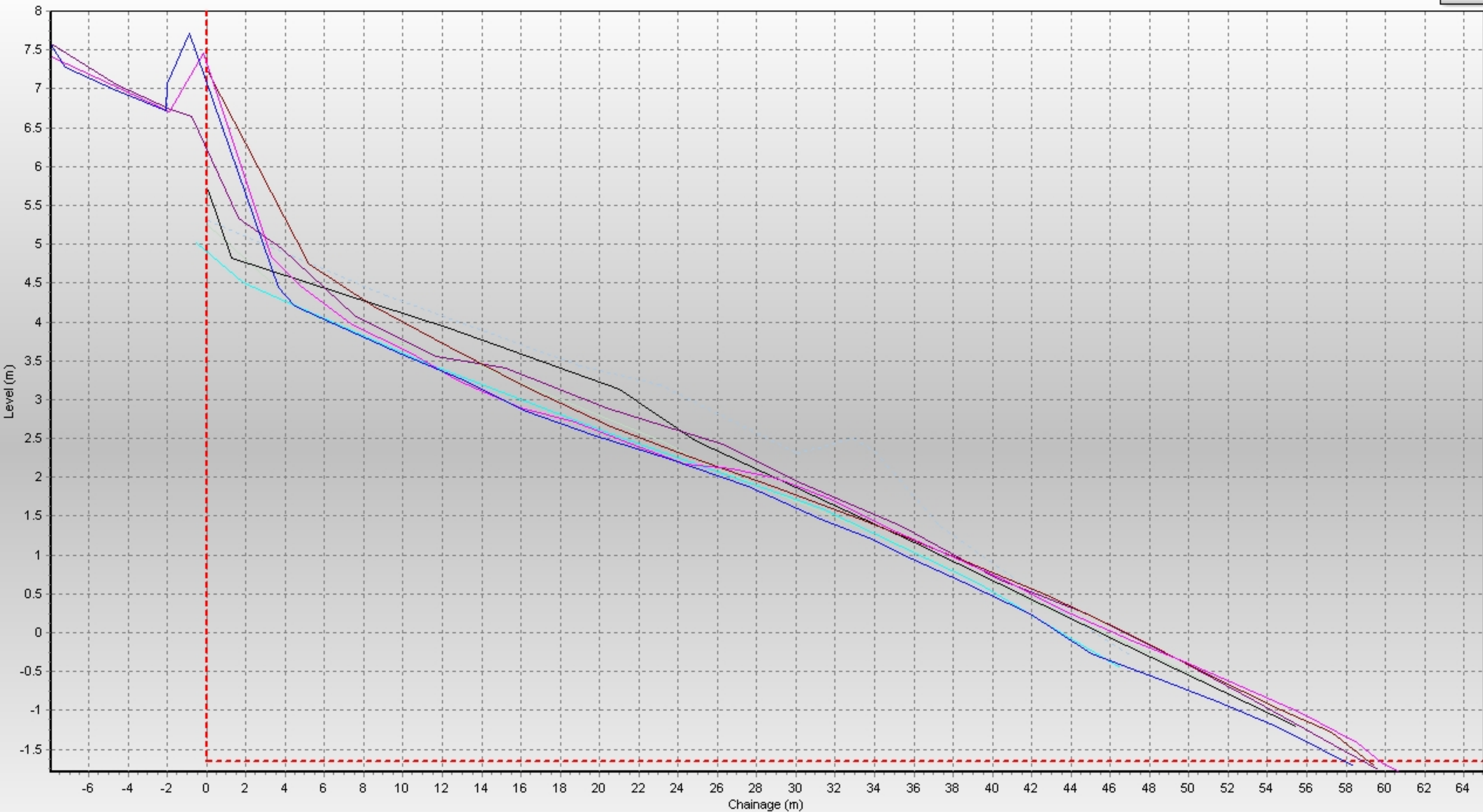
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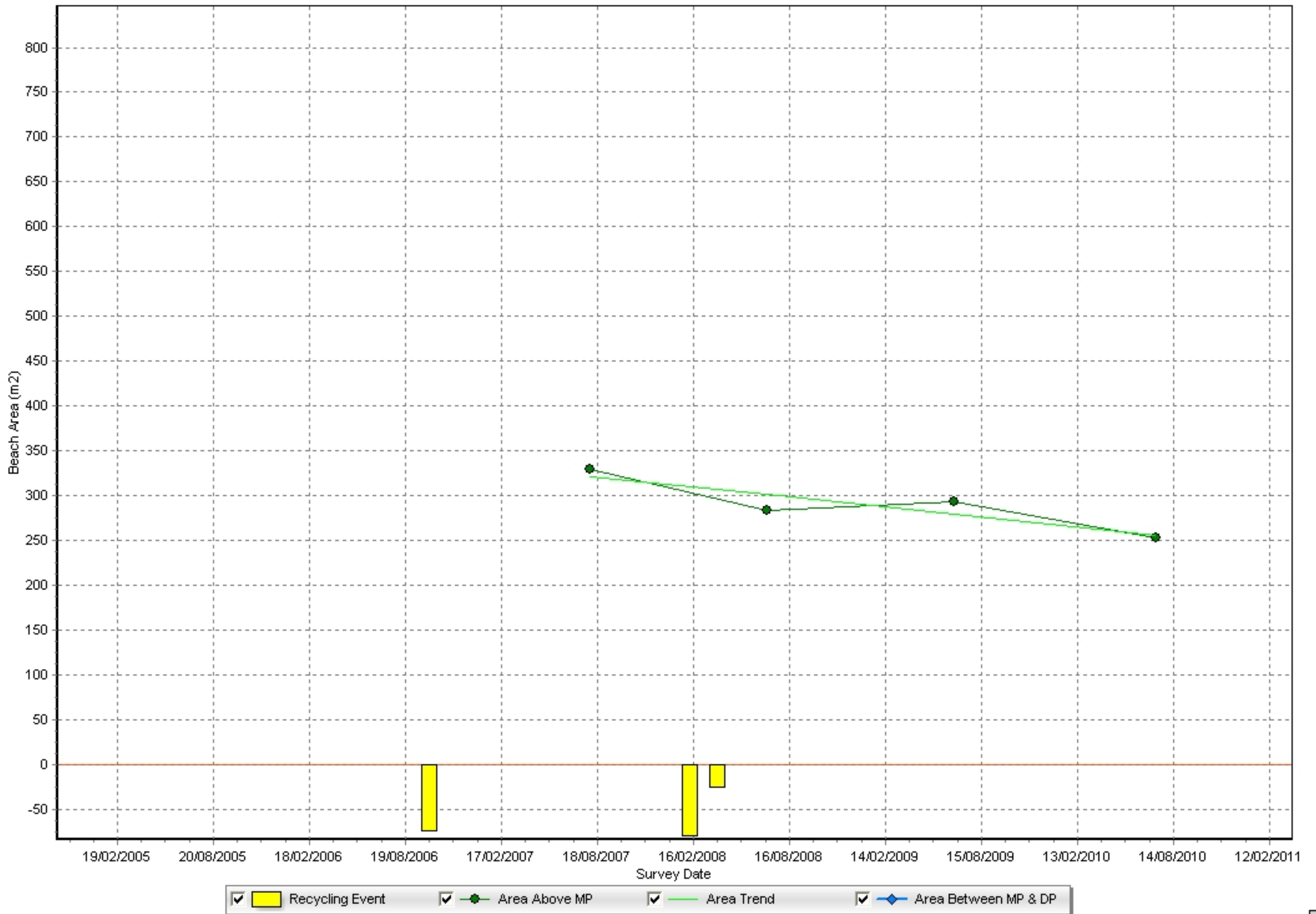
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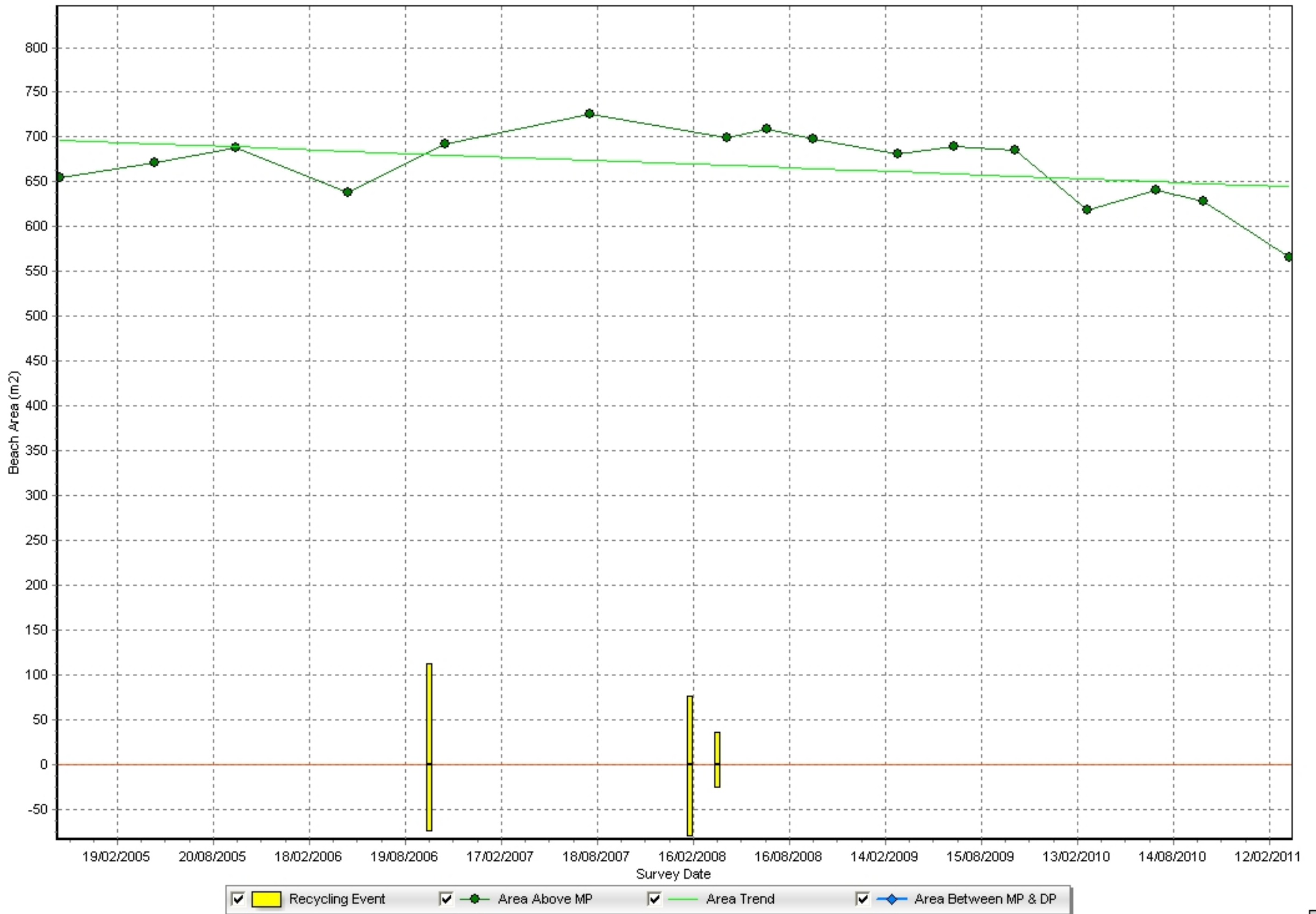


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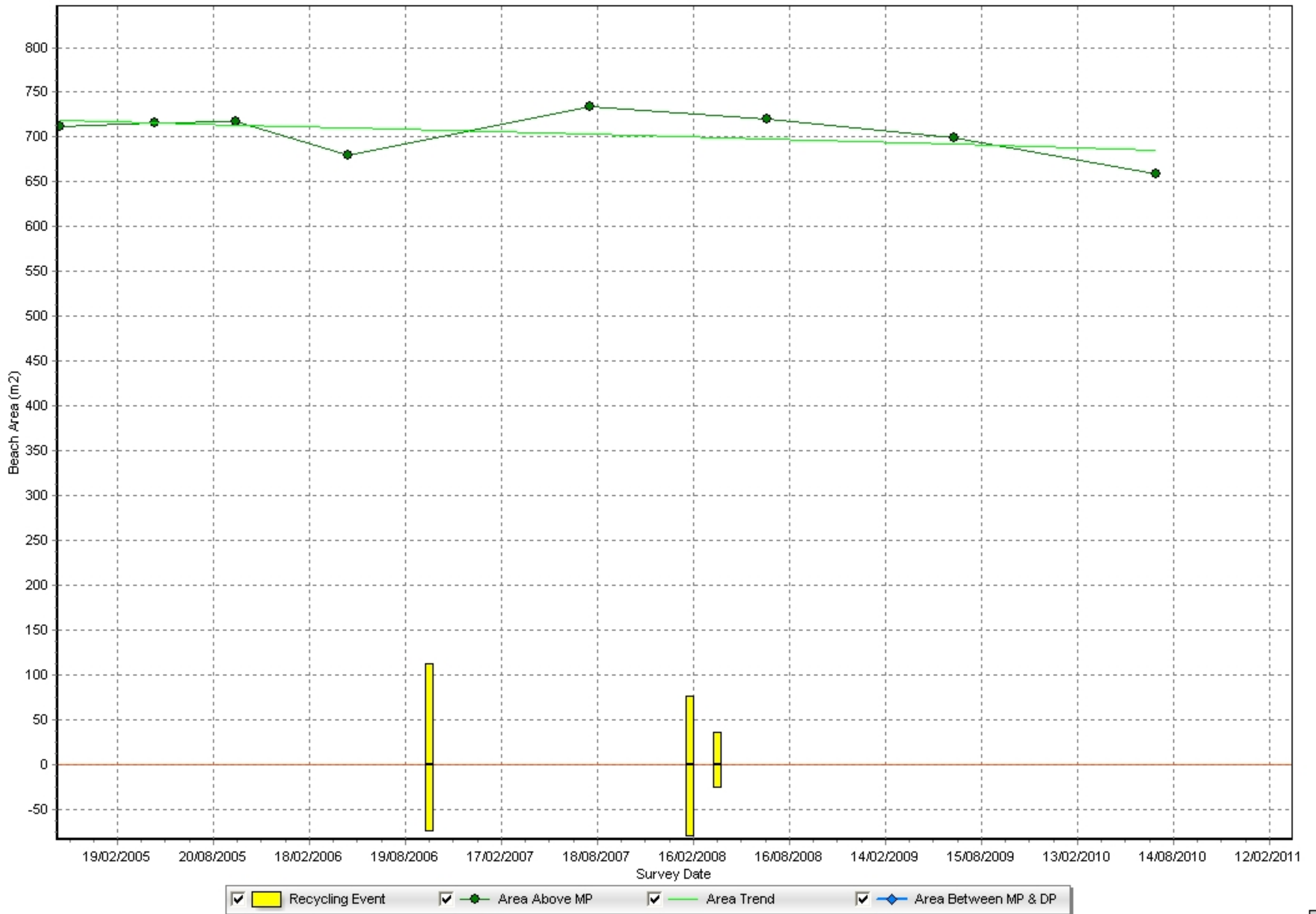
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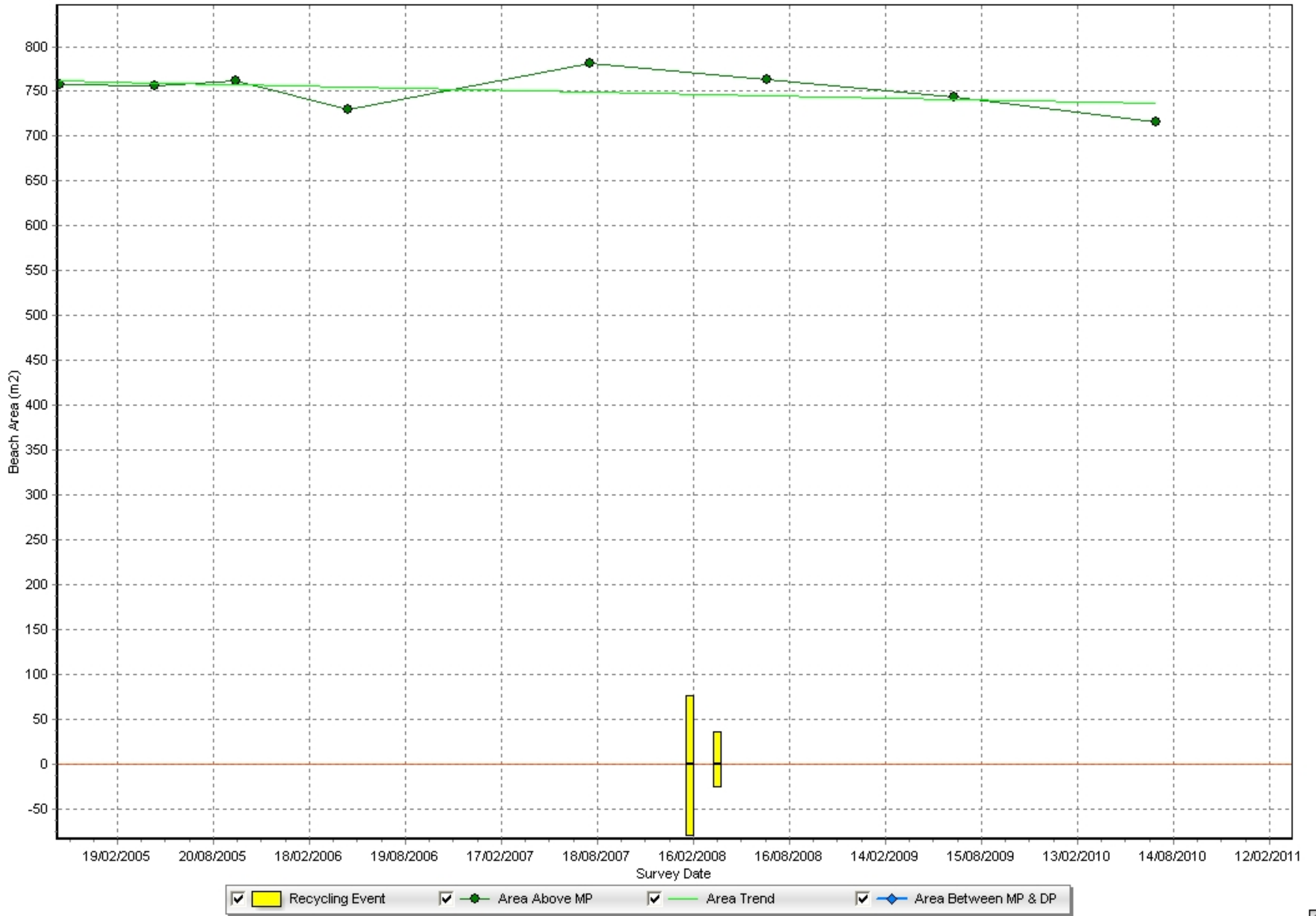
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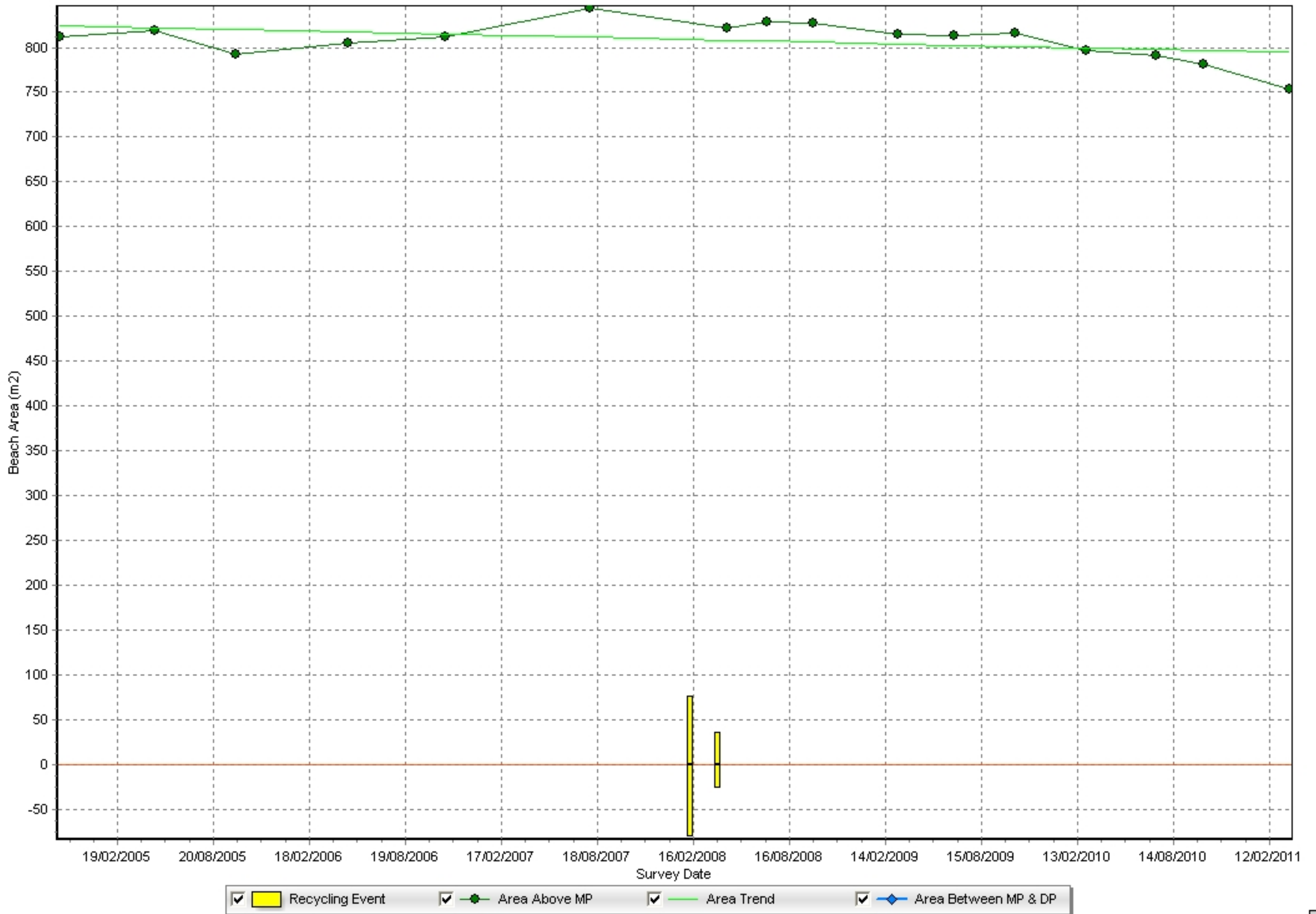
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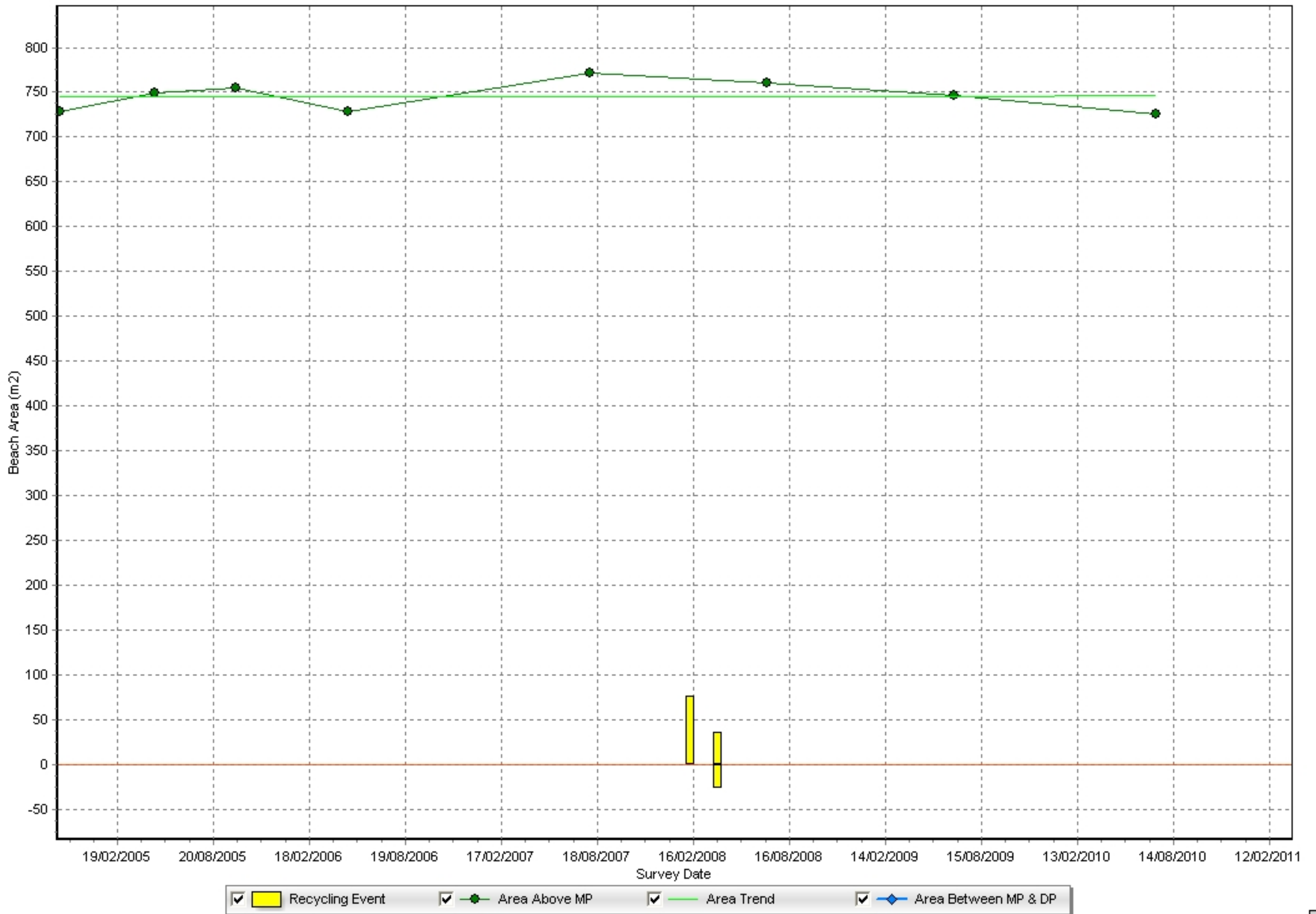
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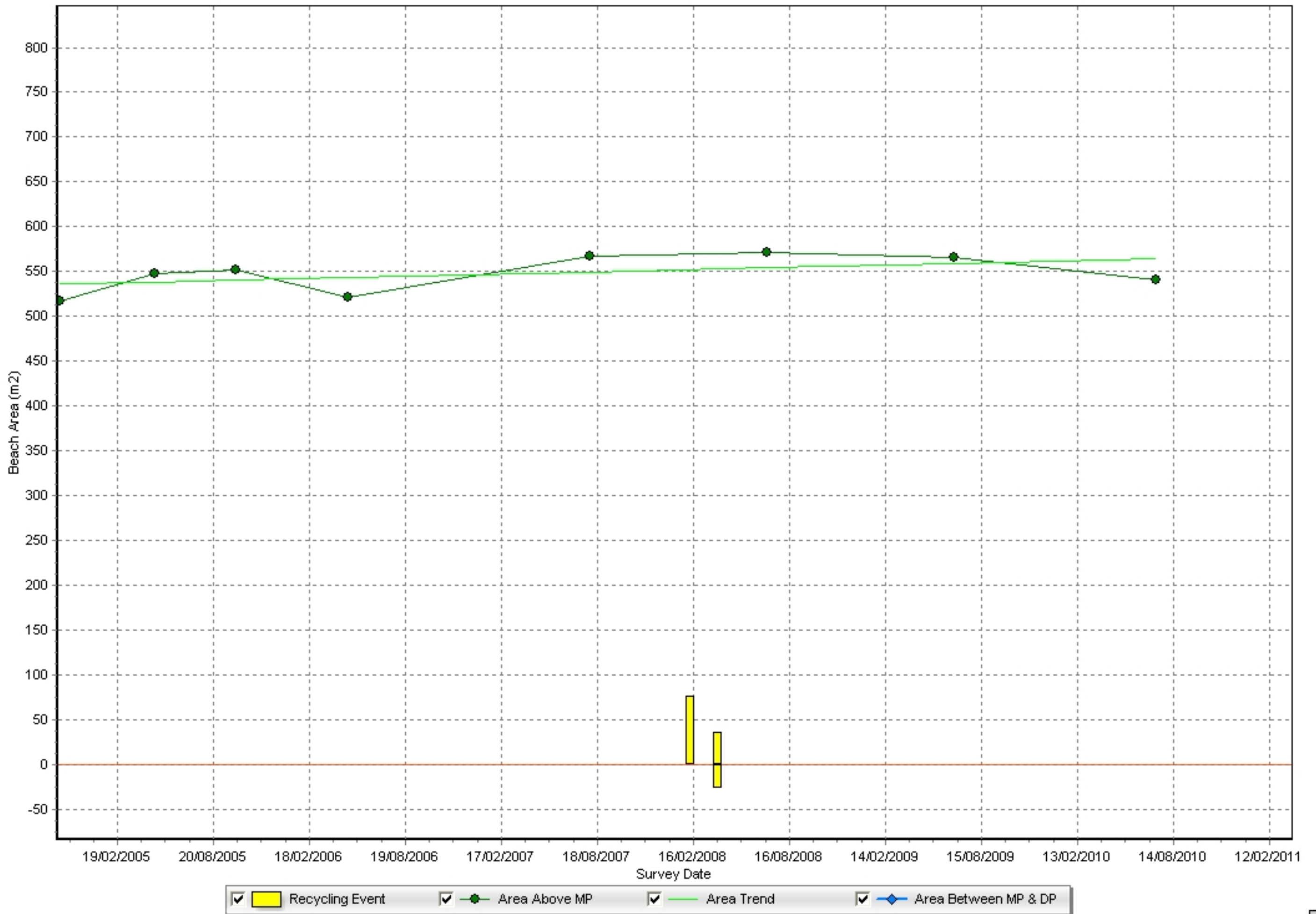
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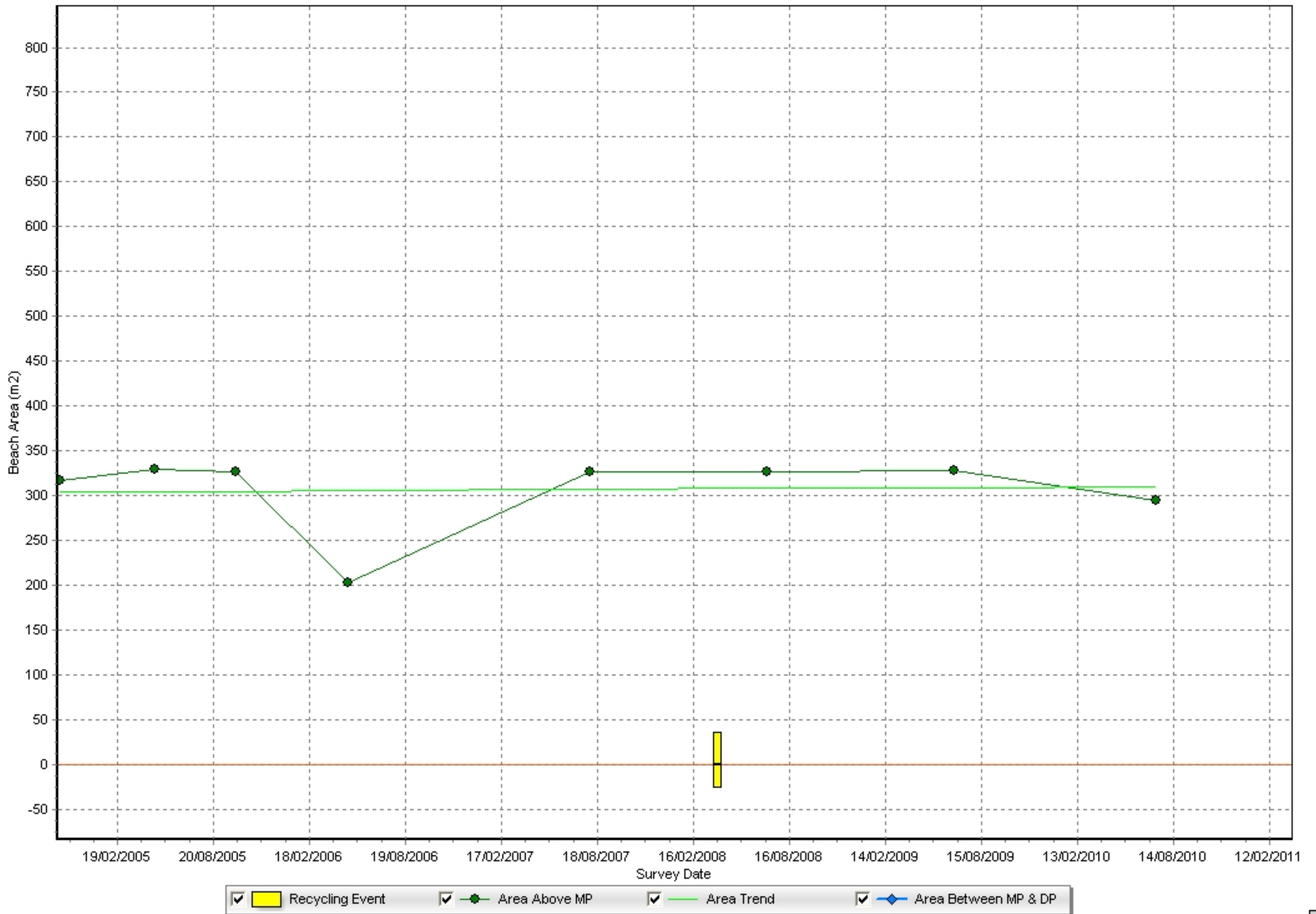
Area Above MP Trend: Accreting at 0.089 m2/Year



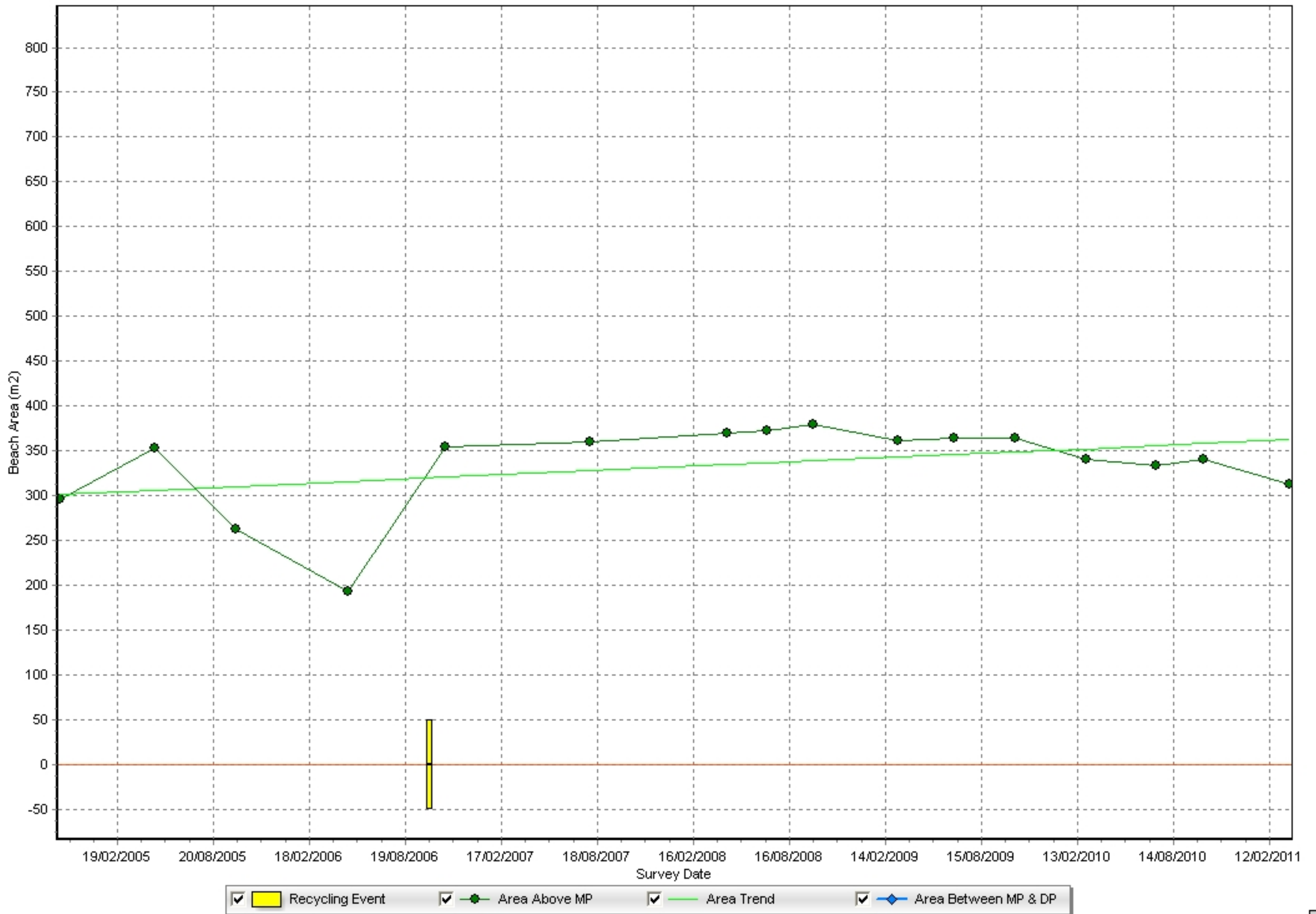
Area Above MP Trend: Accreting at 4.887 m²/Year



Area Above MP Trend: Accreting at 1.171 m²/Year



Area Above MP Trend: Accreting at 9.505 m2/Year



Area Above MP Trend: Eroding at -0.455 m²/Year

