

**Cell 1 Regional Coastal Monitoring Programme
Analytical Report 7: 'Full Measures' Survey 2014**



**County Durham Council
Final Report**

February 2015

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Abbreviations and Acronyms

Acronym / Abbreviation	Definition
AONB	Area of Outstanding Natural Beauty
DGM	Digital Ground Model
HAT	Highest Astronomical Tide
LAT	Lowest Astronomical Tide
MHWN	Mean High Water Neap
MHWS	Mean High Water Spring
MLWS	Mean Low Water Neap
MLWS	Mean Low Water Spring
m	metres
ODN	Ordnance Datum Newlyn

Water Levels Used in Interpretation of Changes

Water Level Parameter	Water Level (m AOD)			
	River Tyne to Frenchman's Bay	Frenchman's Bay to Souter Point	Souter Point to Chourdon Point	Chourdon Point to Hartlepool Headland
1 in 200 year	3.41	3.44	3.66	3.91
HAT	2.85	2.88	3.18	3.30
MHWS	2.15	2.18	2.48	2.70
MLWS	-2.15	-2.12	-1.92	-1.90

Source: *River Tyne to Flamborough Head Shoreline Management Plan 2.*
Royal Haskoning, February 2007.

Glossary of Terms

Term	Definition
Beach nourishment	Artificial process of replenishing a beach with material from another source.
Berm crest	Ridge of sand or gravel deposited by wave action on the shore just above the normal high water mark.
Breaker zone	Area in the sea where the waves break.
Coastal squeeze	The reduction in habitat area which can arise if the natural landward migration of a habitat under sea level rise is prevented by the fixing of the high water mark, e.g. a sea wall.
Downdrift	Direction of alongshore movement of beach materials.
Ebb-tide	The falling tide, part of the tidal cycle between high water and the next low water.
Fetch	Length of water over which a given wind has blown that determines the size of the waves produced.
Flood-tide	Rising tide, part of the tidal cycle between low water and the next high water.
Foreshore	Zone between the high water and low water marks, also known as the intertidal zone.
Geomorphology	The branch of physical geography/geology which deals with the form of the Earth, the general configuration of its surface, the distribution of the land, water, etc.
Groyne	Shore protection structure built perpendicular to the shore; designed to trap sediment.
Mean High Water (MHW)	The average of all high waters observed over a sufficiently long period.
Mean Low Water (MLW)	The average of all low waters observed over a sufficiently long period.
Mean Sea Level (MSL)	Average height of the sea surface over a 19-year period.
Offshore zone	Extends from the low water mark to a water depth of about 15 m and is permanently covered with water.
Storm surge	A rise in the sea surface on an open coast, resulting from a storm.
Swell	Waves that have travelled out of the area in which they were generated.
Tidal prism	The volume of water within the estuary between the level of high and low tide, typically taken for mean spring tides.
Tide	Periodic rising and falling of large bodies of water resulting from the gravitational attraction of the moon and sun acting on the rotating earth.
Topography	Configuration of a surface including its relief and the position of its natural and man-made features.
Transgression	The landward movement of the shoreline in response to a rise in relative sea level.
Updrift	Direction opposite to the predominant movement of longshore transport.
Wave direction	Direction from which a wave approaches.
Wave refraction	Process by which the direction of approach of a wave changes as it moves into shallow water.

Preamble

The Cell 1 Regional Coastal Monitoring Programme covers approximately 300km of the north east coastline, from the Scottish Border (just south of St. Abb's Head) to Flamborough Head in East Yorkshire. This coastline is often referred to as 'Coastal Sediment Cell 1' in England and Wales (Figure 1). Within this frontage the coastal landforms vary considerably, comprising low-lying tidal flats with fringing salt marshes, hard rock cliffs that are mantled with glacial sediment to varying thicknesses, softer rock cliffs and extensive landslide complexes.

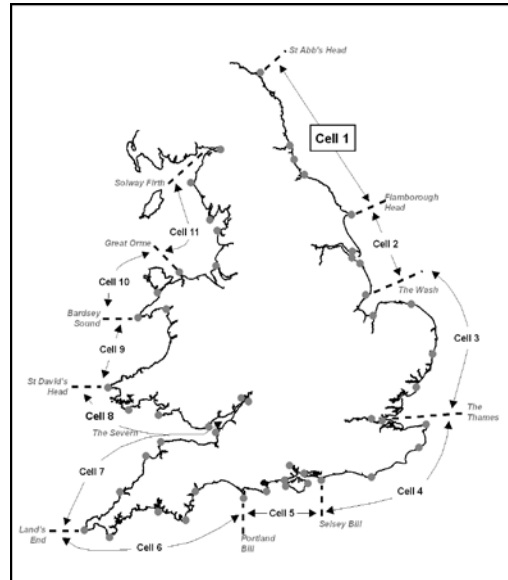


Figure 1 Sediment Cells in England and Wales

The work commenced with a three-year monitoring programme in September 2008 that was managed by Scarborough Borough Council on behalf of the North East Coastal Group. This initial phase has been followed by a five-year programme of work, which started in October 2011. The work is funded by the Environment Agency, working in partnership with the following organisations:



The original three year programme of work was undertaken as a partnership between Royal Haskoning, Halcrow and Academy Geomatics. For the current five year programme of work the data collection associated with beach profiles, topographic surveys and cliff top surveys is being undertaken by Academy Geomatics. The analysis and reporting for the programme is being undertaken by Halcrow (rebranded as CH2M HILL since 2013).



The main elements of the Cell 1 Regional Coastal Monitoring Programme involve:

- beach profile surveys
- topographic surveys
- cliff top recession surveys
- real-time wave data collection
- bathymetric and sea bed characterisation surveys
- aerial photography
- walk-over surveys

The beach profile surveys, topographic surveys and cliff top recession surveys are undertaken as a 'Full Measures' survey in autumn/early winter every year. Some of these surveys are then repeated the following spring as part of a 'Partial Measures' survey.

Each year, an Analytical Report is produced for each individual authority, providing a detailed analysis and interpretation of the 'Full Measures' surveys. This is followed by a brief Update Report for each individual authority, providing ongoing findings from the 'Partial Measures' surveys. Annually, a Cell 1 Overview Report is also produced. This provides a region-wide summary of the main findings relating to trends and interactions along the entire Cell 1 frontage.

To date the following reports have been produced:

Table 1 Analytical, Update and Overview Reports Produced to Date

Year		Full Measures		Partial Measures		Cell 1 Overview Report
		Survey	Analytical Report	Survey	Update Report	
1	2008/09	Sep-Dec 08	May 09	Mar-May 09		-
2	2009/10	Sep-Dec 09	Mar 10	Feb-Mar 10	July 10	-
3	2010/11	Aug-Nov 10	Feb 11	Feb-Apr 11	Aug 1	Sep 11
4	2011/12	Sep 2011	Aug 12	Mar-May 12	Feb 13	
5	2012/13	Sept 2012	Feb 13	Mar-Apr 13	May 2013	
6	2013/14	Oct 2013	Feb 14	Mar-Apr 14	July 14	
7	2014/15	Nov 2014	Feb 15 (*)			

(*) The present report is **Analytical Report 7** and provides an analysis of the 2014 Full Measures survey for County Durham Council's frontage.

In addition, separate reports are produced for other elements of the programme as and when specific components are undertaken, such as wave data collection, bathymetric and sea bed sediment data collection, aerial photography, and walk-over visual inspections.

For purposes of analysis, the Cell 1 frontage has been split into the sub-sections listed in the Table 2.

Table 2 Sub-divisions of the Cell 1 Coastline

Authority	Zone
Northumberland County Council	Spittal A
	Spittal B
	Goswick Sands
	Holy Island
	Bamburgh
	Beadnell Village
	Beadnell Bay
	Embelton Bay
	Boulmer
	Alnmouth Bay
	High Hauxley and Druridge Bay
	Lynemouth Bay
	Newbiggin Bay
	Cambois Bay
Blyth South Beach	
North Tyneside Council	Whitley Sands
	Cullercoats Bay
	Tynemouth Long Sands
	King Edward's Bay
South Tyneside Council	Littehaven Beach
	Herd Sands
	Trow Quarry (incl. Frenchman's Bay)
	Marsden Bay
Sunderland Council	Whitburn Bay
	Harbour and Docks
	Hendon to Ryhope (incl. Halliwell Banks)
Durham County Council	Featherbed Rocks
	Seaham
	Blast Beach
	Hawthorn Hive
	Blackhall Colliery
Hartlepool Borough Council	North Sands
	Headland
	Middleton
	Hartlepool Bay
Redcar & Cleveland Borough Council	Coatham Sands
	Redcar Sands
	Marske Sands
	Saltburn Sands
	Cattersty Sands (Skinningrove)
Scarborough Borough Council	Staithes
	Runswick Bay
	Sandsend Beach, Uppgang Beach and Whitby Sands
	Robin Hood's Bay
	Scarborough North Bay
	Scarborough South Bay
	Cayton Bay
	Filey Bay

1. Introduction

1.1 Study Area

Durham County Council's frontage extends from Ryhope Dene to Crimdon Beck. For the purposes of this report and for consistency with previous reporting, it has been sub-divided into five areas, namely:

- Featherbed Rocks
- Seaham (Dawdon)
- Blast Beach
- Hawthorn Hive
- Blackhall Colliery

1.2 Methodology

Along Durham County Council's frontage, the following surveying is undertaken:

- Full Measures survey annually (since 2008) each autumn/early winter comprising:
 - Beach profile surveys along eight. transect lines
- Partial Measures survey annually (since 2009) each spring comprising:
 - Beach profile surveys along five. transect lines
- Cliff top survey bi-annually at:
 - Seaham (Dawdon)

The location of these surveys is shown in Figure 2. The 2013 Full Measures survey was undertaken along this frontage on 22nd November and 23rd November 2013. At Blackhall the weather was rainy with a gentle breeze from the south, the sea state was moderate. At Easington and Seaham there were light showers during the survey with a light breeze from the south and the sea state was moderate.

All data have been captured in a manner commensurate with the principles of the Environment Agency's *National Standard Contract and Specification for Surveying Services* and stored in a file format compatible with the software systems being used for the data analysis, namely SANDS and ArcGIS. This data collection approach and file format is comparable to that being used on other regional coastal monitoring programmes, such as in the South East and South West of England.

Upon receipt of the data from the survey team, they are quality assured and then uploaded onto the programme's website for storage and availability to others and also input to SANDS and GIS for subsequent analysis.

The Analytical Report is then produced following a standard structure for each authority. This involves:

- description of the changes observed since the previous survey and an interpretation of the drivers of these changes (Section 2);
- documentation of any problems encountered during surveying or uncertainties inherent in the analysis (Section 3);
- recommendations for 'fine-tuning' the programme to enhance its outputs (Section 4); and
- providing key conclusions and highlighting any areas of concern (Section 5).

Data from the present survey are presented in a processed form in the Appendices.

1.3 Uncertainties in data and analysis

While uncertainty due to survey accuracy or systematic error is likely to be present in all datasets, the work is carefully managed to ensure data are as accurate as possible and results are not misleading. Error may arise from the limits of precision of survey techniques used, from low accuracy measurements being taken or from systematic failings of equipment.

For beach profiles and topographic surveys, all incoming data are checked allowing systematic errors to be identified, and removed from plots and subsequent analysis. The accuracy of these surveys is not known, but it is likely that all measurements are correct to $\pm 0.1\text{m}$. Therefore, changes are less than $\pm 0.1\text{m}$ are ignored and greyed out in the topographic change plots. For cliff top erosion surveys, there are commonly problems in precisely recognising the cliff edge due to vegetation growth and the convex shape of the feature. Errors manifest themselves as results that suggest the cliff edge has advanced, which is very unlikely unless a toppling failure has been initiated, but the block has not yet fully detached. The accuracy of cliff top surveys are also unknown, but it is assumed that each measurement is accurate to $\pm 0.1\text{m}$.

These limits of accuracy mean that comparison of annual or biannual data can be of limited value if the measured change is less than or equal to the assumed error. However, all results become more significant over longer time periods when the errors in measurement in years 1 and x are averaged over the monitoring period:

$$\text{Error rate of change per year} = \frac{\text{Error in first measurement} + \text{Error in last measurement}}{\text{Years between measurements}}$$

The effect of averaging error over different monitoring periods is summarised in Table 3, which assumes that each annual survey is accurate to 0.1m.

Table 3 Error bands for long-term calculations of change.

Years between surveys	Error in inter-survey comparison ($\pm\text{m}/\text{yr}$)
1	0.200
2	0.100
3	0.067
4	0.050
5	0.040
5	0.033
7	0.029
8	0.025
9	0.022
10	0.020

While considering the uncertainty in comparing and analysing change between monitoring data sets it is also relevant to raise caution about drawing conclusions about short or longer term trends. Clearly the longer the data set the more confidence that can be given to likely ranges of beach changes and trends in change. Potential for seasonal, annual and longer term cycles need to be considered. Studies of long term monitoring data sets for other coastal and estuarial data have established that there are long period cyclical trends related to the 18.6 years lunar nodal cycle which need to be accounted for. Simply put this means that although the Cell 1 monitoring programme now has data in some locations up to 11 years, another 8 to 10 years of consistent data is needed before confidence can be given in trends from the analysis. In the context of this report "Longer Term Trends" are mentioned in each section and it should be noted that this is based on simple visual interpretation of the available data since the current programme began, and is generally based on only 5 years of data.

2. Wave Data and Interpretation

2.1 Introduction

Wave monitoring data relevant to the Cell 1 Regional Coastal Monitoring Programme is available from one offshore regional wave buoy located at Tyne and Tees and three regional wave buoys, which are further inshore at Newbiggin, Whitby and Scarborough. The Tyne Tees buoy is managed by Cefas as part of the WaveNet system, while the three inshore buoys is managed by Scarborough BC as part of the Cell 1 monitoring programme.

An assessment of baseline wave data is presented in the 2011 Wave Data Analysis Report, which reviewed all readily available data in the region. In 2014 a wave data update report updated the baseline with analysis of the wave data collected under the programme for 2013, including the 5th and 6th December storm. That report was further updated in 2015 to include the records from 2014. In order to help put the beach and cliff changes discussed in this report into context analysed storm data for the wave buoys is presented in this section.

The longest consistent relevant wave data record in the Cell 1 region is from the WaveNet Tyne Tees buoy deployed under the national coastal monitoring programme by Cefas. Data has been downloaded from WaveNet and loaded into SANDS for analysis alongside the beach and cliff monitoring data. Results from analysis of the data to extract details of significant storms are presented in Table 4 below.

To aid interpretation of the results in Table 4 alternate years have been shaded and the storm with the largest peak wave height each year has been highlighted in bold. The annual storm with the highest wave energy at peak has also been highlighted in bold red text as this depends on wave period as well as wave height and so is not always the same as the largest wave height, e.g. in 2009 and 2010.

Table 4: SANDS Storm Analysis at Tyne/Tees WaveNet Buoy (updated to include data to 7th Dec 2014)

General Storm Information							At Peak					Total Energy (KJ/m)
StartTime	EndTime	Dur (hr)	Peak of Storm	Mean Dir	No of Events	Mean Direction Vector	Hs (m)	Tp (s)	Tz (s)	Dir	Energy @ Peak (KJ/m/s)	
19/03/2007 10:30	21/03/2007 05:30	43	20/03/2007 14:30	23	64	78.2	6.2	12.4	8.5	23	1.7E+04	1.4E+07
25/06/2007 20:30	26/06/2007 13:30	17	26/06/2007 10:00	54	18	77.3	4.4	8.6	7.2	23	4.0E+03	1.7E+06
26/09/2007 03:00	27/09/2007 05:00	26	26/09/2007 19:00	11	33	79.7	4.6	11.6	7.6	6	7.8E+03	3.6E+06
08/11/2007 20:00	12/11/2007 15:00	91	09/11/2007 08:30	16	58	77.7	6.2	13.3	9.0	6	1.9E+04	1.6E+07
19/11/2007 03:30	25/11/2007 21:30	162	23/11/2007 05:00	88	52	76.8	4.9	10.7	7.6	17	7.6E+03	6.8E+06
08/12/2007 03:00	10/12/2007 14:30	59.5	08/12/2007 03:30	106	8	82.9	4.1	10.7	7.6	17	5.4E+03	7.5E+05
03/01/2008 10:30	04/01/2008 01:30	15	03/01/2008 23:30	77	24	14.6	4.2	9.1	7.6	62	4.2E+03	2.5E+06
01/02/2008 15:00	02/02/2008 09:30	18.5	02/02/2008 8	41	30	80.1	6.0	13.8	9.0	17	1.9E+04	8.7E+06
10/03/2008 08:30	10/03/2008 12:30	4	10/03/2008 11:00	146	9	307.5	4.6	8.1	6.5	141	3.8E+03	7.3E+05
17/03/2008 15:00	25/03/2008 03:00	180	22/03/2008 05:00	81	58	82.1	7.9	12.4	9.0	6	2.7E+04	1.7E+07
05/04/2008 22:00	07/04/2008 05:00	31	06/04/2008 19:00	49	20	83.1	4.6	11.7	7.6	6	7.9E+03	3.0E+06
20/07/2008 16:00	21/07/2008 09:30	17.5	20/07/2008 23:30	15	8	76.0	4.2	9.9	7.6	11	4.9E+03	9.1E+05
03/10/2008 03:00	03/10/2008 20:30	17.5	03/10/2008 16:30	55	17	76.7	4.7	11.4	7.6	23	8.1E+03	2.8E+06
21/11/2008 04:00	25/11/2008 12:30	104.5	22/11/2008 11:30	15	112	75.8	6.0	13.1	8.5	11	1.7E+04	2.2E+07

General Storm Information							At Peak					Total Energy (KJ/m)
StartTime	EndTime	Dur (hr)	Peak of Storm	Mean Dir	No of Events	Mean Direction Vector	Hs (m)	Tp (s)	Tz (s)	Dir	Energy @ Peak (KJ/m/s)	
10/12/2008 12:00	13/12/2008 18:00	78	13/12/2008 08:00	109	37	332.1	4.9	8.4	7.2	129	4.7E+03	4.0E+06
31/01/2009 16:30	03/02/2009 09:00	64.5	02/02/2009 09:22:00	84	57	7.2	5.8	9.6	8.5	84	8.7E+03	8.1E+06
23/03/2009 22:30	28/03/2009 20:30	118	28/03/2009 09:16:30	217	14	89.4	5.3	8.4	7.6	6	5.4E+03	1.3E+06
10/07/2009 01:30	10/07/2009 02:30	1	10/07/2009 09:01:30	13	2	78.7	4.2	10.0	7.2	11	5.0E+03	2.3E+05
29/11/2009 20:30	30/11/2009 15:00	18.5	30/11/2009 09:00:30	18	36	72.7	6.0	9.4	8.0	11	9.0E+03	5.9E+06
17/12/2009 10:30	18/12/2009 05:00	18.5	17/12/2009 09:19:30	64	36	26.3	5.4	10.7	8.0	68	9.4E+03	5.7E+06
30/12/2009 09:00	30/12/2009 23:00	14	30/12/2009 09:12:30	84	24	7.7	5.1	7.6	7.2	90	4.1E+03	2.3E+06
06/01/2010 05:30	06/01/2010 11:00	5.5	06/01/2010 00:06:30	30	10	63.6	4.2	10.7	7.2	11	5.7E+03	1.1E+06
29/01/2010 10:30	30/01/2010 00:30	14	29/01/2010 00:22:30	9	21	81.9	5.4	8.6	8.0	6	6.0E+03	2.1E+06
26/02/2010 22:30	27/02/2010 02:30	4	27/02/2010 00:01:00	18	7	72.4	4.6	8.5	7.6	17	4.2E+03	7.0E+05
19/06/2010 07:00	20/06/2010 08:30	25.5	19/06/2010 00:20:00	21	49	69.2	5.4	10.7	7.6	23	9.4E+03	8.5E+06
29/08/2010 14:00	30/08/2010 06:30	16.5	30/08/2010 00:01:00	243	17	92.8	4.7	8.6	7.6	6	4.7E+03	1.6E+06
06/09/2010 22:30	07/09/2010 16:00	17.5	07/09/2010 00:15:30	101	22	353.2	4.6	8.8	8.0	90	4.5E+03	2.3E+06
17/09/2010 07:00	17/09/2010 18:30	11.5	17/09/2010 00:08:30	10	17	80.7	4.7	11.0	8.0	11	7.5E+03	2.9E+06
24/09/2010 03:00	26/09/2010	45	24/09/2010 00:10:00	21	80	71.6	5.3	10.2	8.0	11	8.0E+03	1.2E+07
20/10/2010 02:00	24/10/2010 16:30	110.5	20/10/2010 00:10:00	13	16	78.2	4.2	11.2	7.2	17	6.4E+03	1.8E+06
08/11/2010 14:00	09/11/2010 20:30	30.5	09/11/2010 00:10:00	88	58	3.0	5.6	8.8	8.0	73	6.9E+03	7.8E+06
17/11/2010 11:00	17/11/2010 18:30	7.5	17/11/2010 00:12:00	136	9	322.4	4.7	7.7	6.9	129	3.7E+03	8.1E+05
29/11/2010 19:30	02/12/2010 08:30	61	29/11/2010 00:21:00	80	45	11.8	5.1	9.4	7.6	56	6.3E+03	5.4E+06
16/12/2010 15:00	17/12/2010 06:30	15.5	17/12/2010 00:03:30	12	22	79.1	4.6	10.5	7.6	17	6.4E+03	2.8E+06
23/07/2011 14:00	24/07/2011 11:00	21	24/07/2011 01:03:00	23	39	67.1	4.7	10.7	7.6	17	7.2E+03	5.8E+06
24/10/2011 18:30	25/10/2011 09:30	15	25/10/2011 01:09:30	103	26	348.5	4.1	9.5	6.9	79	4.2E+03	2.6E+06
09/12/2011 08:30	09/12/2011 10:00	1.5	09/12/2011 01:08:30	7	3	84.0	4.1	11.9	8.0	6	6.7E+03	4.8E+05
05/01/2012 16:00	06/01/2012 05:00	13	06/01/2012 02:03:00	12	19	79.0	4.6	10.5	7.6	17	6.4E+03	2.6E+06
03/04/2012 13:30	04/04/2012 10:30	21	03/04/2012 02:17:30	66	38	25.1	5.6	8.1	7.6	56	5.9E+03	5.5E+06
24/09/2012 08:30	25/09/2012 10:30	26	25/09/2012 02:01:30	74	50	16.7	4.7	10.3	8.0	62	6.6E+03	7.4E+06
26/10/2012 16:30	27/10/2012 14:30	22	26/10/2012 02:23:00	12	34	79.4	4.9	12.8	7.6	11	1.1E+04	4.9E+06
05/12/2012 16:00	15/12/2012 01:30	225.5	14/12/2012 02:19:30	78	31	18.4	5.4	8.8	7.6	96	6.4E+03	4.5E+06
20/12/2012 06:00	21/12/2012 14:30	32.5	20/12/2012 02:23:00	101	56	348.4	5.6	9.5	8.0	96	8.0E+03	8.8E+06
18/01/2013 18:30	22/01/2013 06:00	83.5	21/01/2013 03:10:00	81	54	9.2	6.7	9.4	8.5	84	1.1E+04	1.1E+07
06/02/2013 08:00	07/02/2013 06:00	22	06/02/2013 03:12:30	47	38	81.6	5.4	10.0	7.6	11	8.2E+03	6.1E+06
07/03/2013 21:00	10/03/2013 21:30	72.5	08/03/2013 03:04:00	67	37	24.6	4.9	9.0	7.6	73	5.4E+03	4.3E+06
18/03/2013 09:00	25/03/2013 00:30	159.5	23/03/2013 03:14:30	85	153	5.1	6.0	10.2	8.0	90	1.0E+04	2.8E+07
23/05/2013 18:00	24/05/2013 12:00	18	23/05/2013 03:22:30	13	32	77.5	6.7	10.5	8.5	17	1.4E+04	7.1E+06

General Storm Information							At Peak					
StartTime	EndTime	Dur (hr)	Peak of Storm	Mean Dir	No of Events	Mean Direction Vector	Hs (m)	Tp (s)	Tz (s)	Dir	Energy @ Peak (KJ/m/s)	Total Energy (KJ/m)
10/09/2013 13:00	10/09/2013 19:30	6.5	10/09/2013 14:00	11	14	79.3	4.4	9.2	7.2	11	4.6E+03	1.5E+06
09/10/2013 22:30	11/10/2013 09:00	34.5	10/10/2013 17:00	68	62	79.8	5.4	10.7	7.6	22	9.4E+03	1.2E+07
29/11/2013 22:30	30/11/2013 06:30	8	30/11/2013 00:30	42	17	84.5	5.6	10.7	8.0	11	1.0E+04	3.3E+06
05/12/2013 14:00	07/12/2013 04:30	38.5	06/12/2013 20:00	24	59	80.8	4.7	14.3	9.0	6	1.3E+04	1.2E+07
27/12/2013 09:30	27/12/2013 12:30	3	27/12/2013 10:00	218	3	249.3	4.1	6.1	6.5	202	1.8E+03	1.3E+05
05/02/2014 04:00	05/02/2014 18:00	14	05/02/2014 05:30	139	9	318.4	4.4	7.8	6.9	129	3.3E+03	7.2E+05
12/02/2014 20:00	14/02/2014 19:00	47	12/02/2014 21:00	183	8	275.6	4.6	7.5	6.5	141	3.2E+03	7.8E+05
21/10/2014 22:00	22/10/2014 01:30	3.5	21/10/2014 23:00	6	5	84.4	4.4	9.6	7.6	6	5.0E+03	6.0E+05

The storms mostly arrive from the north to northeast direction, 0 to 40 degrees, which has the longest fetch, but there are also a significant number of storms from other directions, particularly 80 to 140 degrees.

Comparing the annual storm records it can be seen that 2010 had the most storms (13). In 2010 the largest storm had an incident direction of 73 degrees which is unusual. We might therefore expect that the alongshore drift on the Cell 1 beaches in 2010 may have been atypical with unusual changes from the storm conditions. This was noted in several of the 2010 Full Measures reports.

The year with the fewest storms was 2011. This was reflected by accretion recorded in a number of the annual Full Measures reports.

The winter of 2012 to 2013 appears to have suffered with larger storms than usual, with the second largest peak wave height (7.3m) recorded on 23rd March 2013. The longest duration storm in the record was from 5th to 15th December 2012 (226.5 hours).

The storm on the 5th to 7th December 2013, was particularly notable. Although this event did not have such large waves as the 23rd March 2013 storm, it had a high peak energy and exceptionally long wave period at 14.3 seconds. The 6th December 2013 storm was also accompanied by a significant storm surge with recorded water levels around 1.75m higher than predicted tides. The combined high water levels and large waves causing significant damage to many coastal defences and beaches.

2.2 Wave data for the Hartlepool frontage.

There are no data from the Hartlepool frontage, but the two local buoys on the Scarborough Borough Council frontage, at Whitby and Scarborough that were deployed in January 2013 provide relevant data. Analysed storm data for these two buoys is presented in Tables 5 and 6.

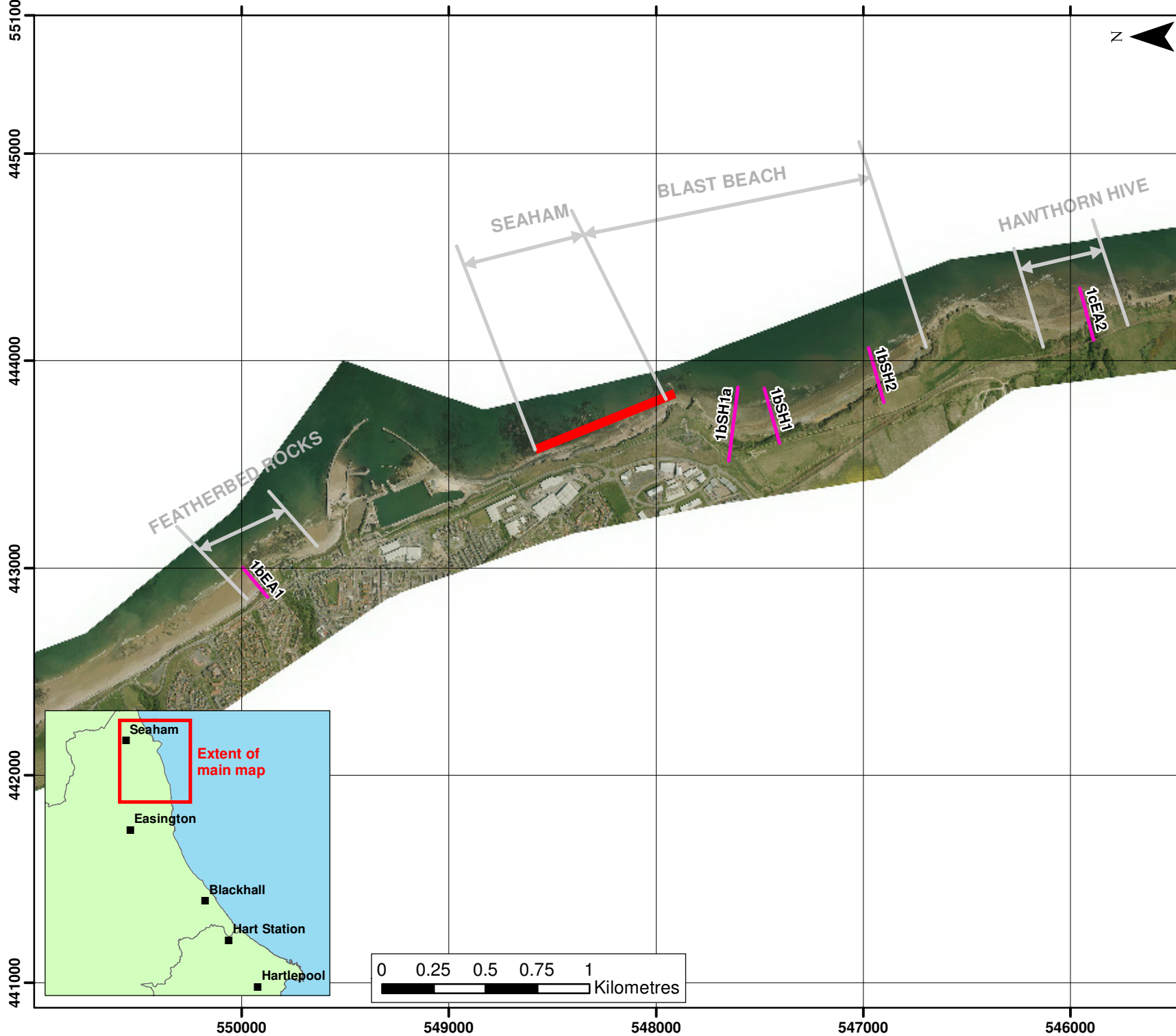
Overall the data for the storms recorded at Scarborough and Whitby are comparable in terms of wave height, period and energy. The highest energy storm recorded at Whitby was the 5th and 6th of December 2013 storm. The second most severe storm at Whitby in terms of wave height and energy was on the 10th October 2013, this is the most severe storm recorded in the Scarborough dataset.

Table 5: Storm analysis for Scarborough WB (data 17/01/2013 to 31/10/2014)

General Storm Information							At Peak					Total Energy (KJ/m)
Start Time	End Time	Dur (hr)	Peak of Storm	Mean Dir	No of Events	Mean Direction Vector	Hs (m)	Tp (s)	Tz (s)	Dir	Energy @ Peak (KJ/m/s)	
21/01/2013 02:00	21/01/2013 20:00	18	21/01/2013 13:00	68	35	22	5.1	9.3	7.8	65	6.4E+03	4.5E+06
06/02/2013 13:30	07/02/2013 02:00	12.5	06/02/2013 17:00	14	15	77	4.3	9.3	7.4	17	4.5E+03	1.7E+06
22/03/2013 20:00	24/03/2013 23:00	51	23/03/2013 15:30	74	99	16	5.1	9.9	7.7	65	7.1E+03	1.4E+07
23/05/2013 21:30	24/05/2013 10:30	13	24/05/2013 00:30	19	27	71	5.7	9.9	8.5	18	9.0E+03	4.9E+06
10/09/2013 13:00	10/09/2013 22:30	9.5	10/09/2013 19:30	13	19	77	5.0	8.4	7.3	13	4.9E+03	2.3E+06
10/10/2013 02:00	11/10/2013 06:30	28.5	10/10/2013 23:00	28	56	72	5.8	10.5	8.0	21	1.1E+04	1.1E+07
Data missing for 5 th / 6 th December 2013 storm as buoy was off station												
14/10/2014 03:00	14/10/2014 06:00	3	14/10/2014 04:30	61	4	33	4.4	7.6	6.7	61	3.2E+03	3.2E+05

Table 6: Storm analysis for Whitby WB (data 17/01/2013 to 31/10/2014)

General Storm Information							At Peak					Total Energy (KJ/m)
StartTime	EndTime	Duration (hr)	Peak of Storm	Mean Dir	No of Events	Mean Direction Vector	Hs (m)	Tp (s)	Tz (s)	Dir	Energy @ Peak (KJ/m/s)	
21/01/2013 02:30	22/01/2013 03:00	24.5	21/01/2013 14:30	64	38	27	5.0	9.3	8.2	61	6.0E+03	5.0E+06
06/02/2013 11:00	07/02/2013 04:00	17	06/02/2013 18:30	17	35	73	4.8	9.9	7.1	16	6.4E+03	4.3E+06
08/03/2013 03:30	11/03/2013 05:30	74	11/03/2013 04:00	58	12	36	4.3	8.4	7.1	45	3.7E+03	1.1E+06
18/03/2013 18:30	24/03/2013 17:30	143	23/03/2013 13:00	70	95	20	5.2	9.3	8.2	72	6.6E+03	1.2E+07
23/05/2013 21:00	24/05/2013 12:30	15.5	24/05/2013	20	27	70	5.8	10.5	8.3	24	1.0E+04	5.0E+06
10/09/2013 14:00	10/09/2013 22:30	8.5	10/09/2013 16:00	19	17	72	4.4	9.3	6.9	24	4.6E+03	1.8E+06
10/10/2013 01:30	11/10/2013 06:30	29	11/10/2013	30	57	69	5.7	11.2	8.3	31	1.1E+04	1.1E+07
30/11/2013	30/11/2013 06:30	6.5	30/11/2013 03:30	16	13	75	4.8	10.5	7.4	20	7.1E+03	2.1E+06
05/12/2013 20:00	06/12/2013 22:00	26	06/12/2013 19:30	20	45	71	4.7	14.0	9.1	32	1.2E+04	8.2E+06
14/10/2014 04:30	14/10/2014 05:30	1	14/10/2014 05:30	52	2	40	4.1	7.0	6.5	53	2.3E+03	1.2E+05



KEY

Topographic Profiles

- Annual
- 6 monthly

Topographic Surveys

- 6 monthly
- yearly
- 5 yearly

Cliff Top Monitoring Pegs

- 50m centres
- 100m centres
- 300m centres

(Indicative survey extents shown)

Client: North East Coastal Group

Project: Cell 1 Regional Coastal Monitoring Programme 2011 to 2016

**Figure 2 - Map 1
Survey Locations
Featherbed Rocks to
Hawthorne Hive
Durham County Council**

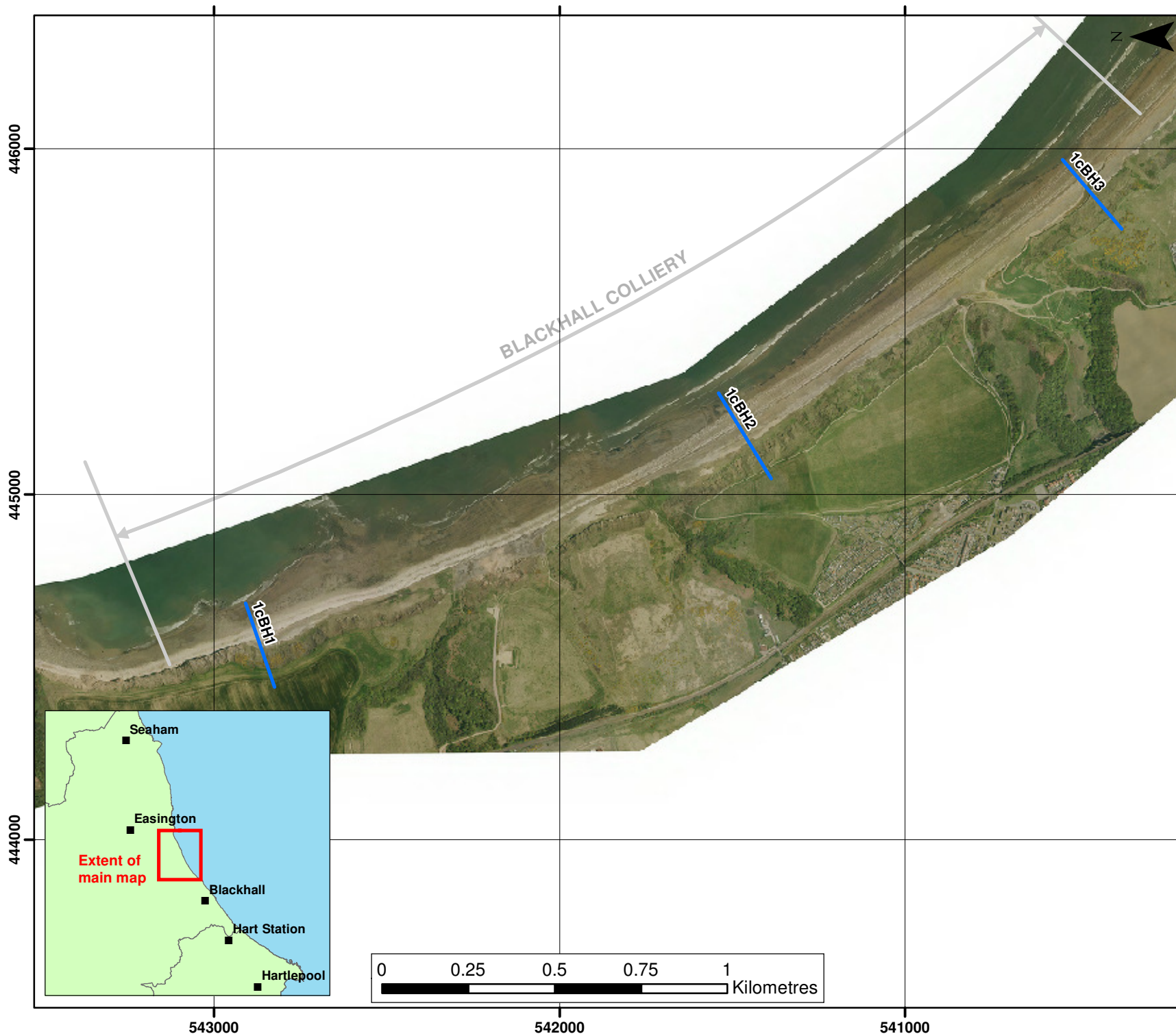
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Full Measures Survey
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Photography courtesy of North East Coastal Observatory
www.northeastcoastalobservatory.org.uk



KEY

Topographic Profiles

- Annual
- 6 monthly

Topographic Surveys

- 6 monthly
- yearly
- 5 yearly

Cliff Top Monitoring Pegs

- 50m centres
- 100m centres
- 300m centres

(Indicative survey extents shown)

Client: North East Coastal Group

Project: Cell 1 Regional Coastal Monitoring Programme 2011 to 2016

**Figure 2 - Map 2
Survey Locations
Blackhall Colliery
Durham County Council**

Analytical Report 7
Full Measures Survey
Autumn 2014

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3. Analysis of Survey Data

3.1 Featherbed Rocks

Survey Date	Description of Changes Since Last Survey	Interpretation
23 rd Nov 2014	<p>Beach Profiles:</p> <p>One beach profile line 1bEA1, located at Featherbed Rocks (Appendix A), has been monitored since March 2009. The profile extends across the cliff top and cliff face then extends across the promenade, rock armour sea defence and beach. At the base of the sea wall rock armour extends as far as 80m chainage. Previous surveys have shown accumulations of material at the base of the revetment but this has not been present since the 2012 Full Measures survey.</p>	<p>The rocky nature of this foreshore means it is unlikely to undergo significant changes in morphology unless sediment is deposited upon it. A veneer beach has previously been present here but has not been present since the 2012 Full Measures survey.</p> <p>Longer term trends: The profile for November 2014 is one of the lowest recorded and exposed the rocky shore platform along much of its length. This is the same as the 2013 Full Measures survey and the previous two partial measures surveys. Prior to this a thin veneer beach existed over the rocks.</p>

3.2 Seaham (Dawdon)

Survey Date	Description of Changes Since Last Survey	Interpretation
<p>November 2014</p>	<p>Cliff-top Survey:</p> <p>Three ground control points have been established along the cliff top at Dawdon (Figure B1). The separation between any two points is nominally 300m. These cliff top surveys are intended to inform on erosion rates of the undefended sea cliffs extending south of the rock armour revetment to the south of Seaham Harbour.</p> <p>The cliff top surveys at Dawdon are undertaken bi-annually. Measurements are taken from a fixed ground control point along a fixed bearing to the edge of the cliff top. Appendix B provides information about the ground control points and results from between the 2008 (baseline) cliff top survey and the current (November 2014) survey.</p> <p>Between April 2014 and November 2014 two of the posts showed little or no change, with the remaining post retreating by 0.2m.</p> <p>Appendix C provides results from the November 2014 survey, showing the distance from the ground control point to the edge of the cliff top along the defined bearing and changes in position since the November 2008 baseline survey.</p>	<p>Only one of the three monitoring locations showed retreat during summer 2014 indicating the cliffs have been locally active.</p> <p>Longer term trends: Long-term recession rates calculated from the data collected since November 2008 show retreat at 0.2m/yr for Points 1 and 3 at the margins of the bay and no change at Point 2 in the centre of the bay.</p>

3.3 Blast Beach

Survey Date	Description of Changes Since Last Survey	Interpretation
23 rd Nov 2014	<p>Beach Profiles:</p> <p>Blast Beach is covered by three beach profile lines (Appendix A).</p> <p>Profile 1bSH1a was added to the programme during the Full Measures survey in September 2009. It is located to the north of the previously-established 1bSH1. All three profiles along Blast Beach exhibit similar forms, with a rock cliff, wide colliery spoil beach with a distinct low cliff at its eroding seaward edge, and a mixed gravel and sand foreshore extending to MLW.</p> <p>1bSH1a has a very similar profile to the previous year as far as the eroding face of the spoil deposit at 140m chainage. Between 140m chainage and 155m there has been little change in the beach profile. From 165m to 215m a gravel berm has accumulated which is comprised of coarser sediment in the most seaward 15m. This has raised the beach level by up to 1.5m and it is now at its highest level since monitoring began. From 215m chainage to the end of the survey at 260m chainage the beach has changed very little because of dominance of boulders on this part of the beach.</p> <p>Profile 1bSH1 is similar to all of the previous surveys to the beach crest at 75m. Between 75m and 155m chainage the beach has accreted by up to 1m particularly between 105m and 155m chainage. However this represents a slight reduction in beach level from the April 2014 survey. From 150m chainage to the end of the survey at 165m the beach has changed very little due to the rocky foreshore. This profile is currently near its highest level recorded.</p> <p>Profile 1bSH2 is largely similar to the previous surveys as far as the current beach crest at 120m chainage. The crest in the beach has shown progressive erosion since 2009, with the crest retreating by around 20m. The beach from 125m to 185m chainage had eroded by 0.5m since October 2013, although it has accreted slightly since the April 2014 survey. Rock is exposed seaward of 175m chainage to the end of the survey at 200m chainage. The beach is near its lowest level since monitoring began.</p>	<p>The cliffs behind Blast Beach are currently inactive due to the protective effect of colliery spoil that fronts them. The crest of the spoil material on profiles 1bSH1 and SH1a has remained reasonably stable since 2009. Profile 1bSH2 has been progressively eroding since 2009.</p> <p>The beaches at profiles 1bSH1 and SH1a are both high, due to a gravel berm accumulating seaward of the colliery spoil. Profile 1bSH2 has retreated uniformly, with the beach gradient remaining stable while the beach retreats. This indicates a northward drift of sediment within the bay.</p> <p>Longer term trends: The sea cliffs will eventually reactivate as on-going erosion of the colliery spoil removes the protection it affords to the cliffs. This is most likely to occur at the southern end of the bay where the spoil is most rapidly eroding. The accumulating sediment seaward of the colliery spoil in the northern part of the bay will offer the cliffs more protection.</p>

3.4 Hawthorne Hive

Survey Date	Description of Changes Since Last Survey	Interpretation
23 rd November 2014	<p>Beach Profiles:</p> <p>Hawthorne Hive is monitored by beach profile 1cEA2 (Appendix A).</p> <p>Dense vegetation meant that the start of this profile could not be surveyed and as a result it starts was at 95m chainage. In October 2013 the mound of material which separates the outlet channel of Hawthorne Burn from the beach had been eroded, but a small depression associated with the channel was present in 2014, but overall the beach had accreted by 0.6m between 95m and 110m chainage.</p> <p>The survey photographs show that the channel is now north of the survey profile line and does not cross it. Between HAT at 110m and 150m chainage the beach has eroded by 0.7m since October 2013 but accreted slightly since April 2014. From 150m chainage to the end of the survey at 210m the beach has remained stable, due to the exposure of the rocks on the lower shore.</p>	<p>The beach is near its lowest level since monitoring began. Material has accumulated where the outflow channel of Hawthorne Burn formerly cut across the profile. The majority of the channel is now situated to the north of the profile and has persisted in this position since October 2013.</p> <p>Longer term trends: The beach level was around 2m lower when compared to previous surveys from December 2008. The beach level has only recovered slightly since April 2014. Limited cliff erosion occurs in this section and therefore sediment supply is limited to erosion of colliery spoil that is likely to be too fine-grained to persist on the beach. Storm events which may block the channel and varying flows in Hawthorne Burn are likely to continue to episodically block the channel and change its course across the beach.</p>

3.5 Blackhall Colliery

Survey Date	Description of Changes Since Last Survey	Interpretation
22 nd Nov 2014	<p>Beach Profiles:</p> <p>Blackhall Colliery is covered by three beach profile lines (Appendix A). As at Blast Beach, profiles are dominated by colliery spoil and exhibit similar forms with a rock cliff, wide spoil beach with a distinct cliff at the eroding face of the colliery spoil, and a gravel and sand foreshore that extends to MLW.</p> <p>1cBH1 is located near Horden Point and shows that the face of the colliery spoil has receded by around 3m, reducing the elevation of the beach between 140m and 143m chainage by 1.2m. Immediately seaward of this face, a berm has accumulated as far as 150m chainage through accretion of the beach by up to 1m. The beach profile from 150m chainage to the end of the survey at 225m chainage has changed little and shows the same concave profile as in 2013. The beach is at its lowest level since 2008.</p> <p>Profile 1cBH2 exhibits no change in the cliff profile, but the cliffed-edge of the spoil beach has eroded landwards by a further 2m since September 2013, leaving around c.43m to the cliff toe. The rate of erosion was slightly less than the year before. However, the beach in the intertidal zone has accreted by up to 1m since September 2013 and the gradient of the beach has lessened slightly. The beach level is roughly in the middle of all those previously recorded as far as 230m chainage, and nearly at its highest level recorded seaward of this.</p> <p>The profile 1cBH3 shows that since 2008 there has been episodic migration, infilling and scouring of the outflow of Castle Eden Burn, which crosses the profile. There has been limited recession of the landward bank of the channel. The channel has partially infilled since September 2013 with the seaward part of the channel infilling with up to 2m of sediment between 150m and 160m chainage and to a lesser degree as far as 170m chainage where the new beach crest is situated. From here to 200m chainage the beach has eroded by 0.5m. From 200m chainage to the end of the survey at 235m chainage the beach has remained stable overall.</p>	<p>The more northerly two profiles at Blackhall Colliery show a similar trend. The profile above HAT stays stable while the crest of the spoil has receded and accumulation has occurred further seaward.</p> <p>At 1cBH3, the berm in the upper beach between the outflow channel has been rolled back towards the shore, partly infilling the channel itself and the lower beach as eroded. The channel is likely erode these relatively loose sediments under high flows.</p> <p>Longer term trends: The surveys show that the spoil beach along much of the Blackhall Colliery shore continues to provide effective protection to the backing cliffs. However, spoil beach is eroding landwards, particularly in the more northerly parts of the bay. At 1cBH2 and 1cBH3, the rate of retreat of the face of colliery spoil in 2014 has reduced, most likely due to accumulations of sediment in the upper beach seaward of the spoil face.</p>

4. Problems Encountered and Uncertainty in Analysis

The cliff top position surveys at Dawdon are assumed to have a limit of accuracy of $\pm 0.1\text{m}$ due to the techniques used. The accuracy of short-term recession data are therefore limited, but longer-term recession rates will become more reliable as further data is obtained (see section 1.3).

There are gaps in Sections 1cBH1 and 1cBH2 at Blackhall due to dense vegetation and a small landslip. Dense vegetation meant that the start of Section 1cEA2 at Hawthorn Hive could not be measured and at Blast Beach the top and bottom of 1bSH1a and the top of 1bSH2 could not be measured due to dense vegetation.

5. Recommendations for 'Fine-tuning' the Monitoring Programme

No changes are recommended at the present time.

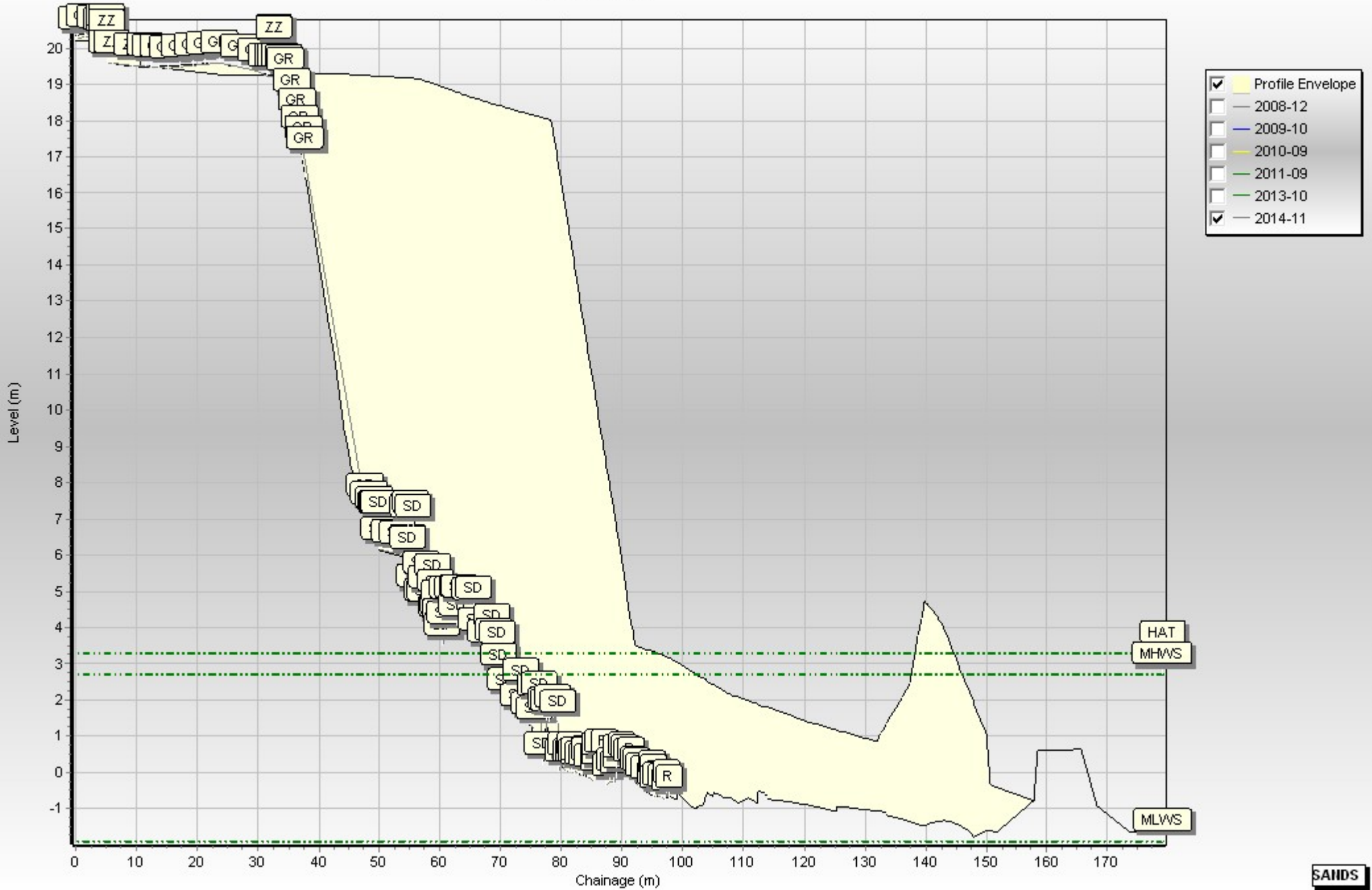
6. Conclusions and Areas of Concern

- At Featherbed Rocks the rocky shore platform continues to be exposed and the veneer beach present in earlier surveys has not been present since Autumn 2012.
- At Seaham cliffs there has been recession along ground control points 1 and 3 of 0.2m/yr since the records began in November 2008. No significant change has occurred at ground control point 2. Further years of data collection will help to understand the long term trends on these cliffs and the stability of the bay.
- At the Blast Beach and Blackhall colliery spoil still prevents the sea from acting directly at the natural cliff toe. In the south of the bay the spoil deposit is eroding and it is expected that the cliffs, which are currently protected by the colliery spoil, will reactivate in coming years. This is also likely to happen in the north of the bay but is likely to take longer as the beach is accumulating here and will slow erosion of the protective veneer of colliery spoil.
- At Hawthorne Hive the levels on the foreshore are very low, around 2m lower than in 2008, but they have recovered since April 2014. The channel on the beach continues to be slightly north of the profile line, but can still be seen in photographs.
- At Blackhall Colliery, the seaward face of the colliery spoil deposit continues to erode in the northern part of the bay. In the southern of the bay, the beach crest has been rolled back causing substantial infilling of the outflow channel of Castle Eden Burn. The channel is likely to scour these sediments again under high flows, but become infilled again by wave action under storm conditions.

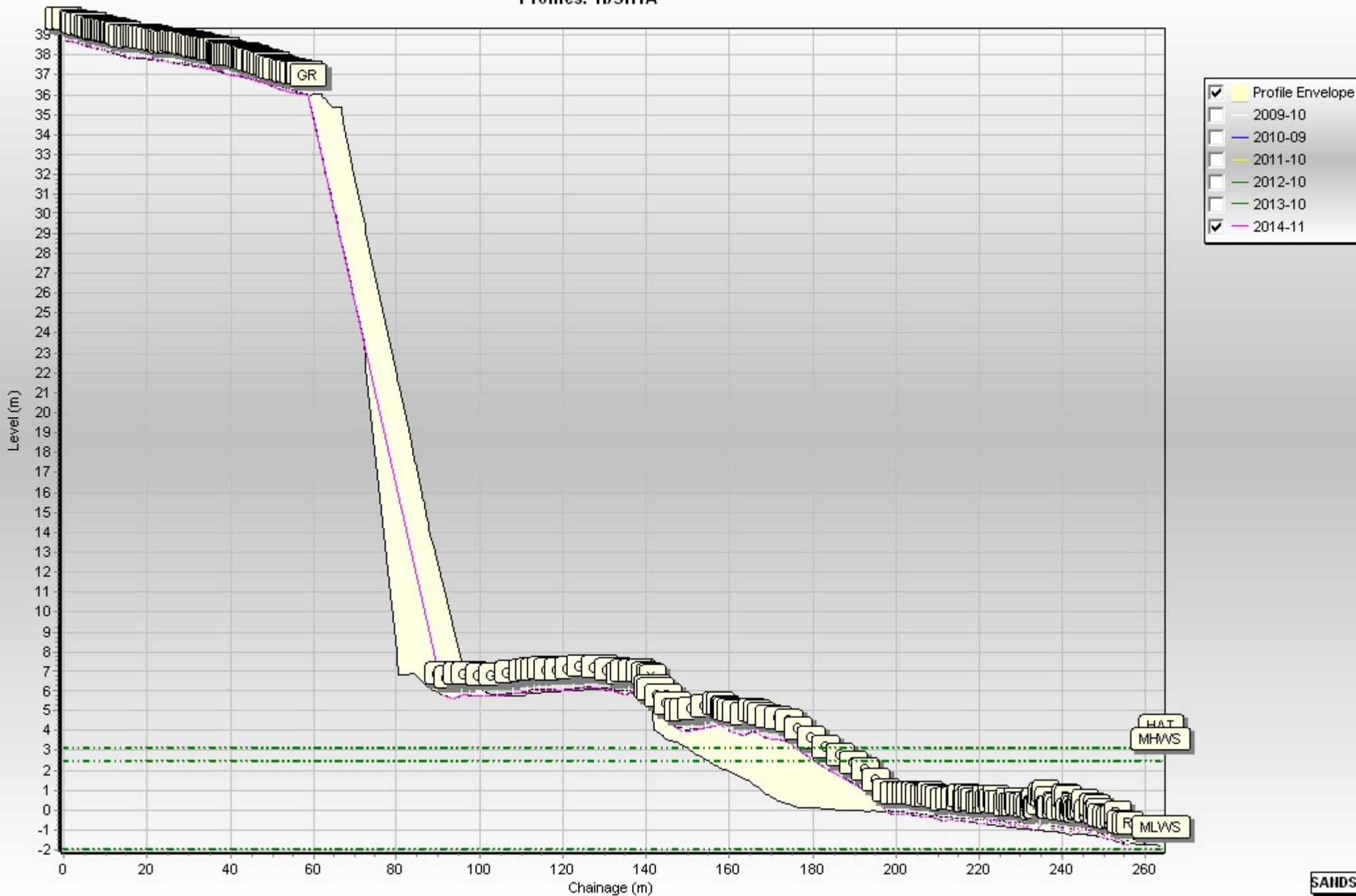
Appendices

Appendix A
Beach Profiles

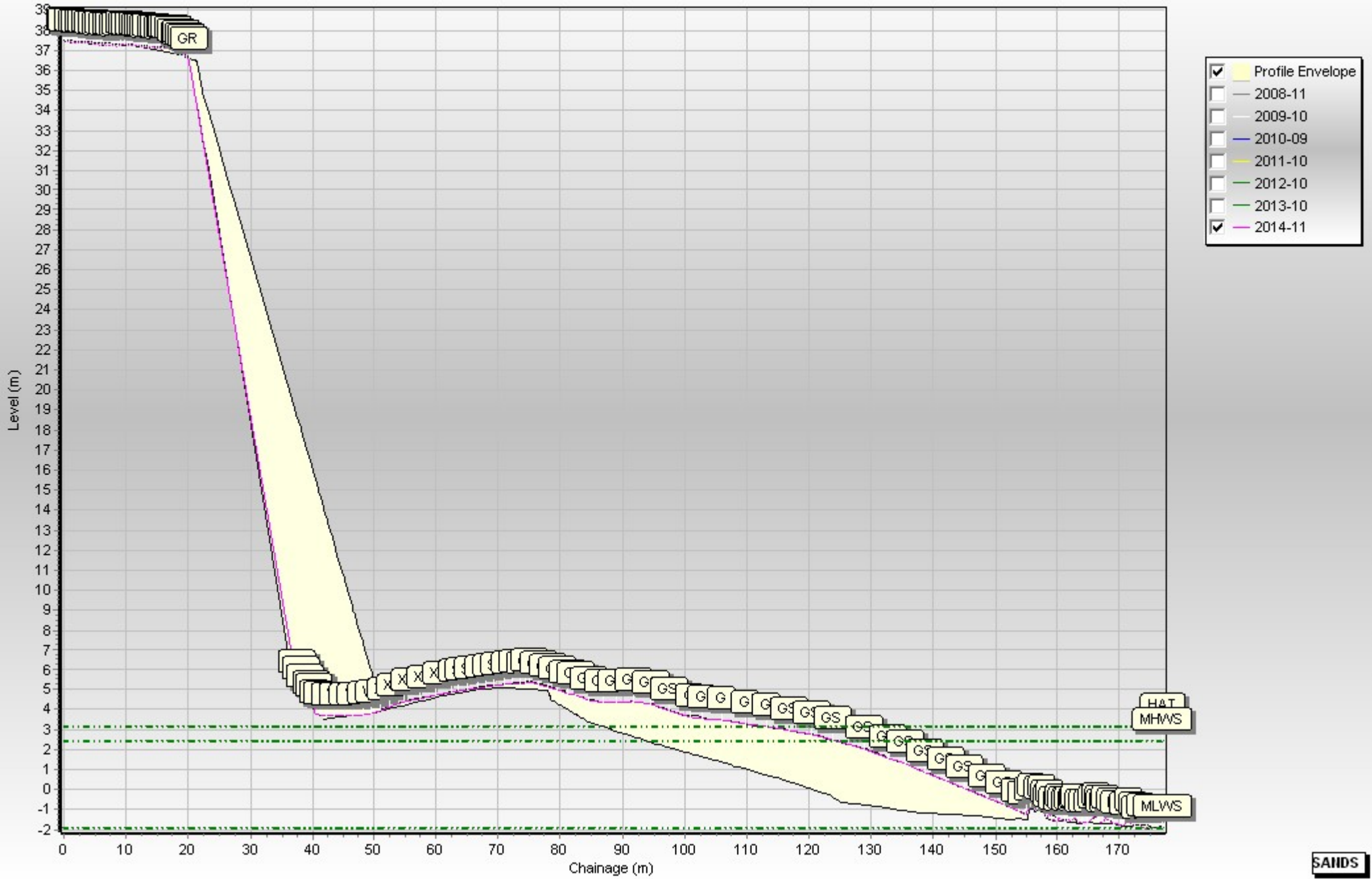
Profiles: 1bEA1



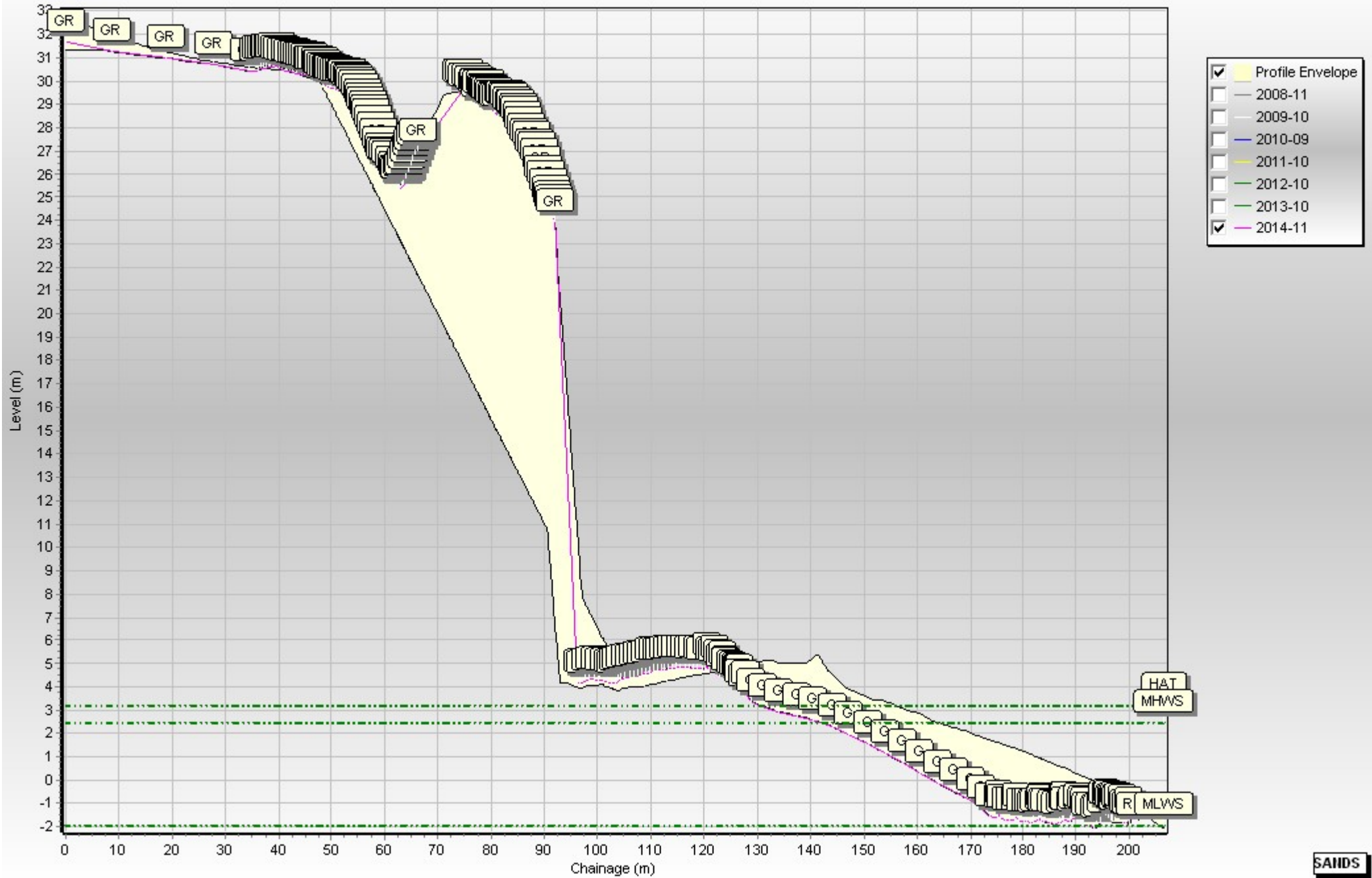
Profiles: 1bSH1A



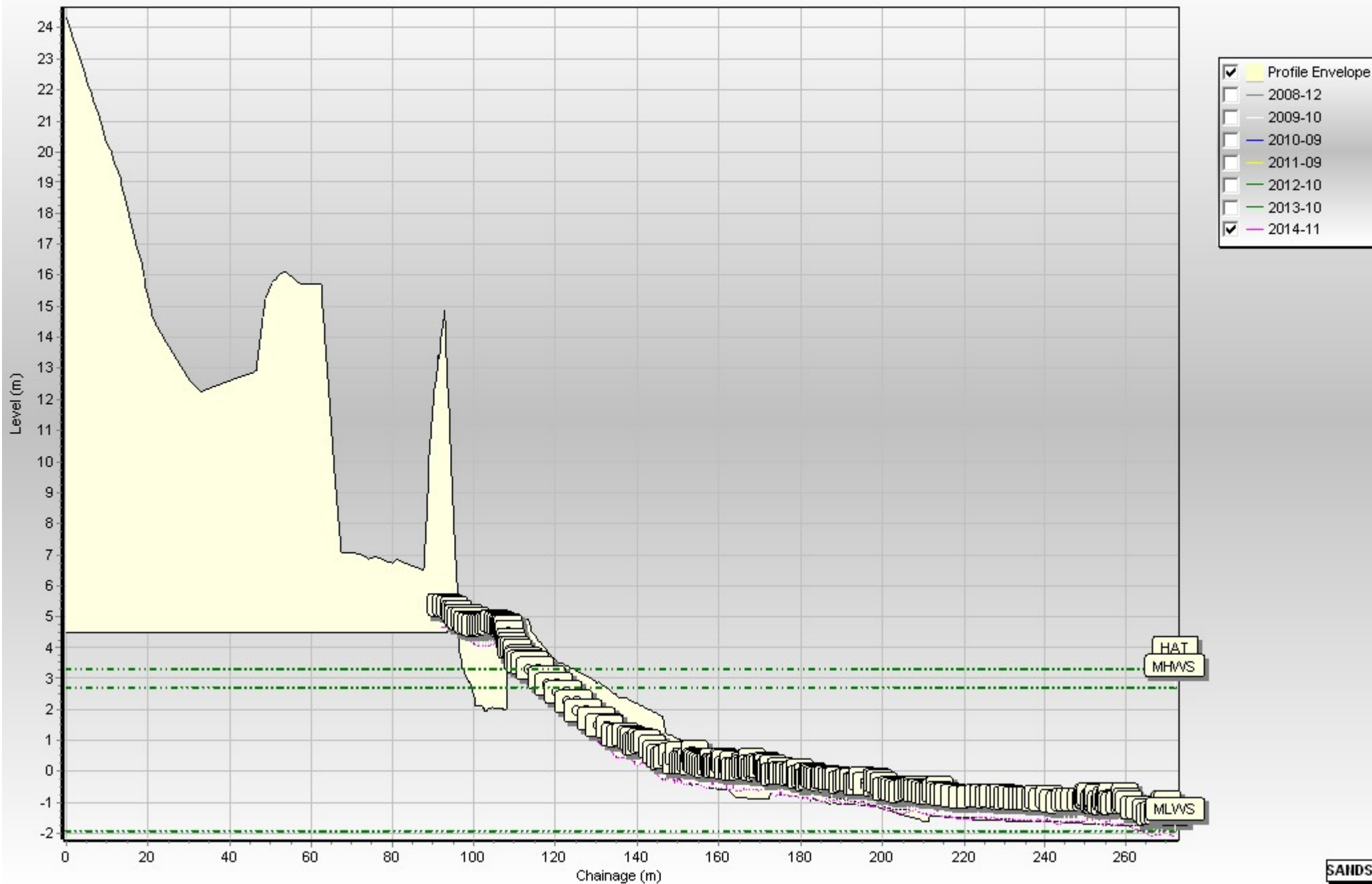
Profiles: 1bSH1



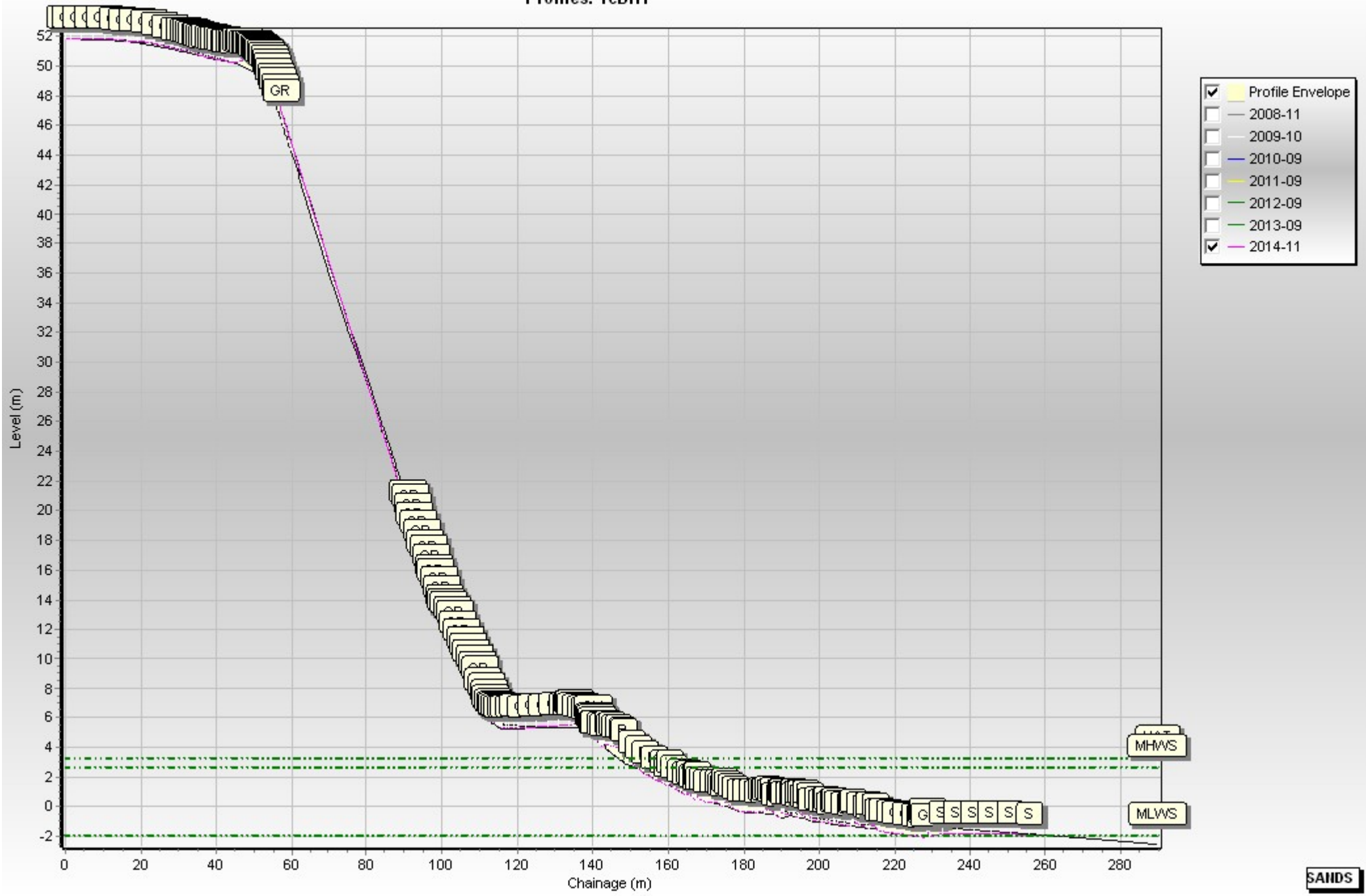
Profiles: 1bSH2



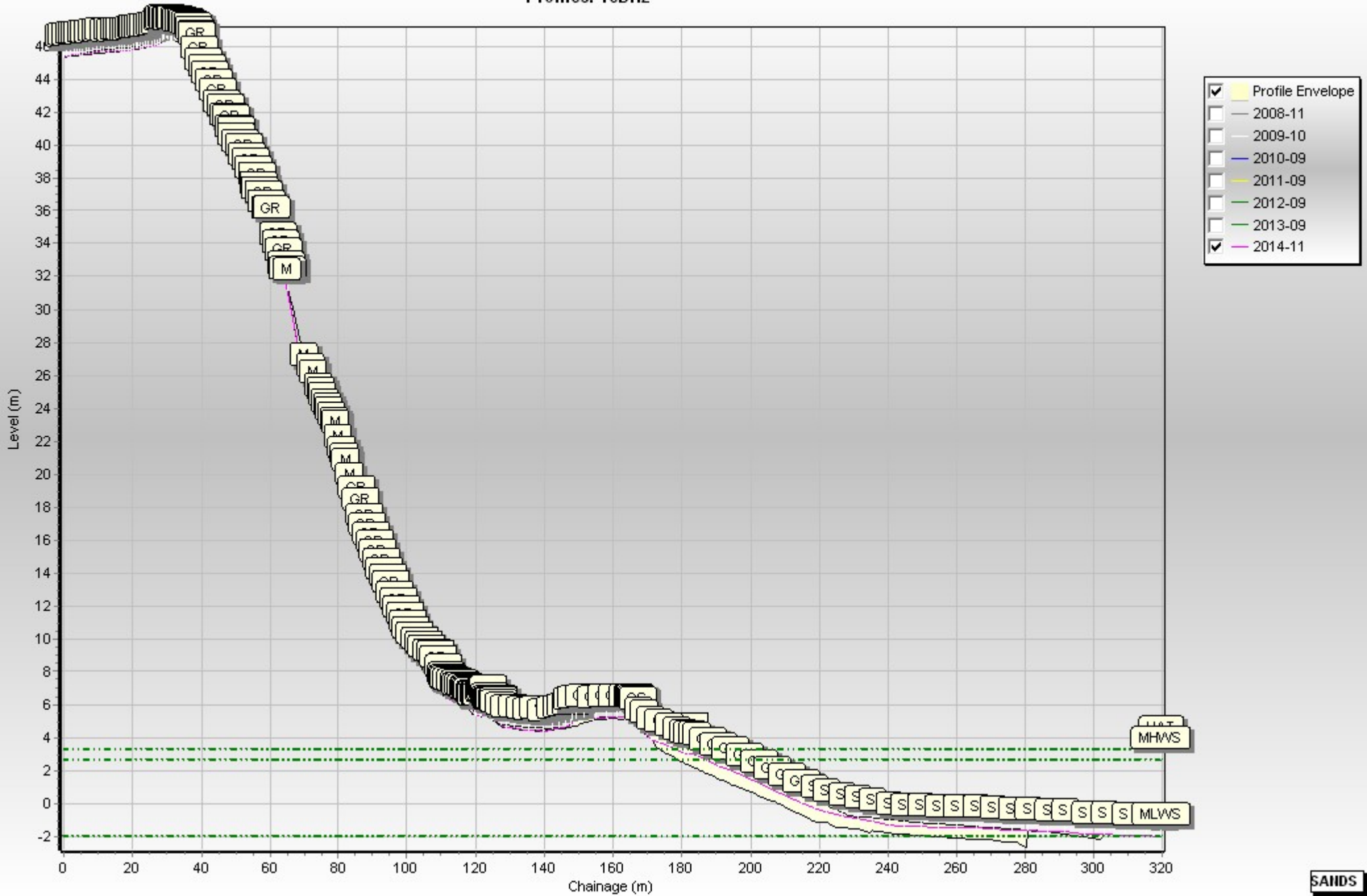
Profiles: 1cEA2



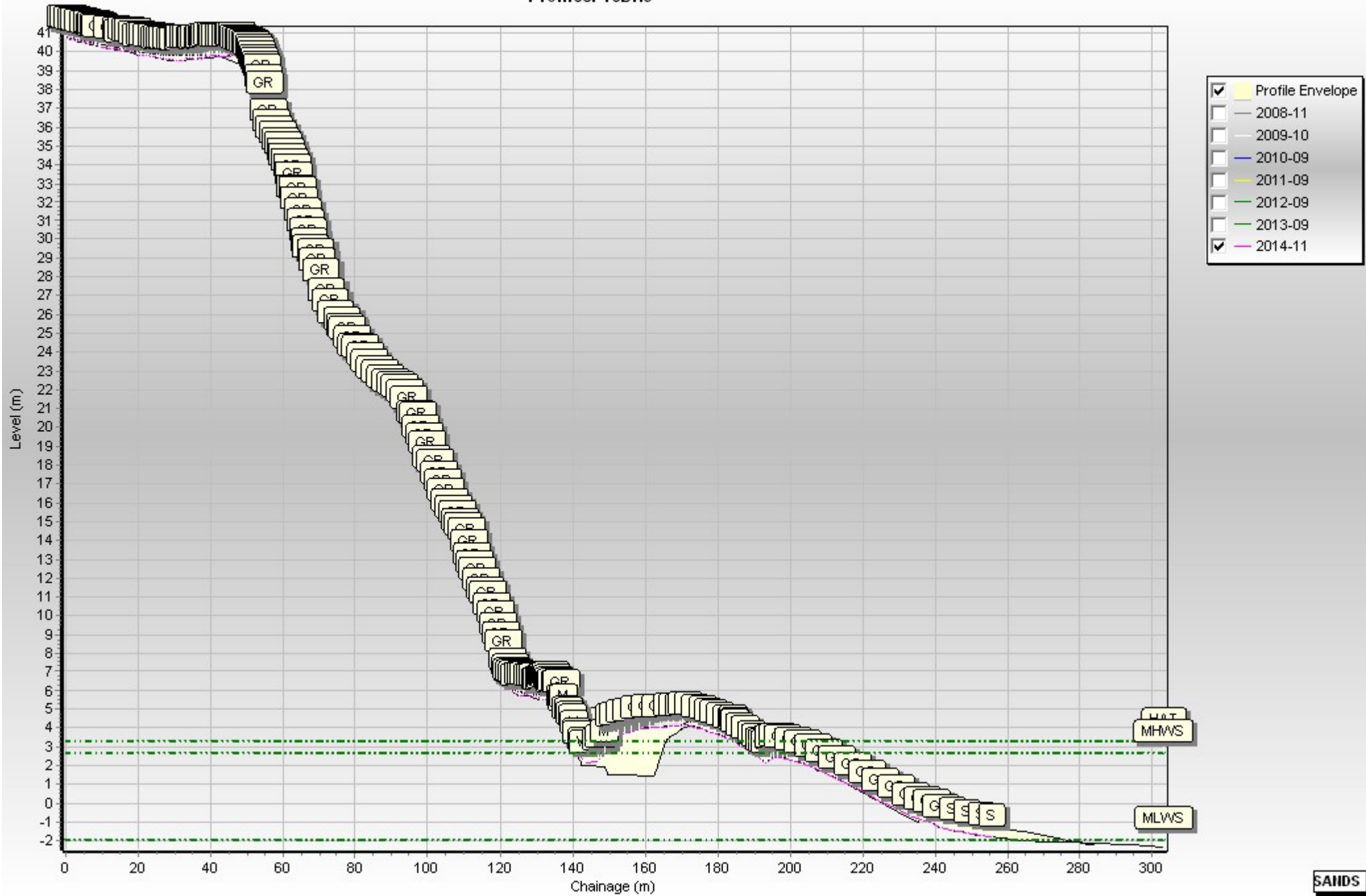
Profiles: 1cBH1



Profiles: 1cBH2



Profiles: 1cBH3



Appendix B
Cliff Top Survey

Cliff Top Survey

Seaham

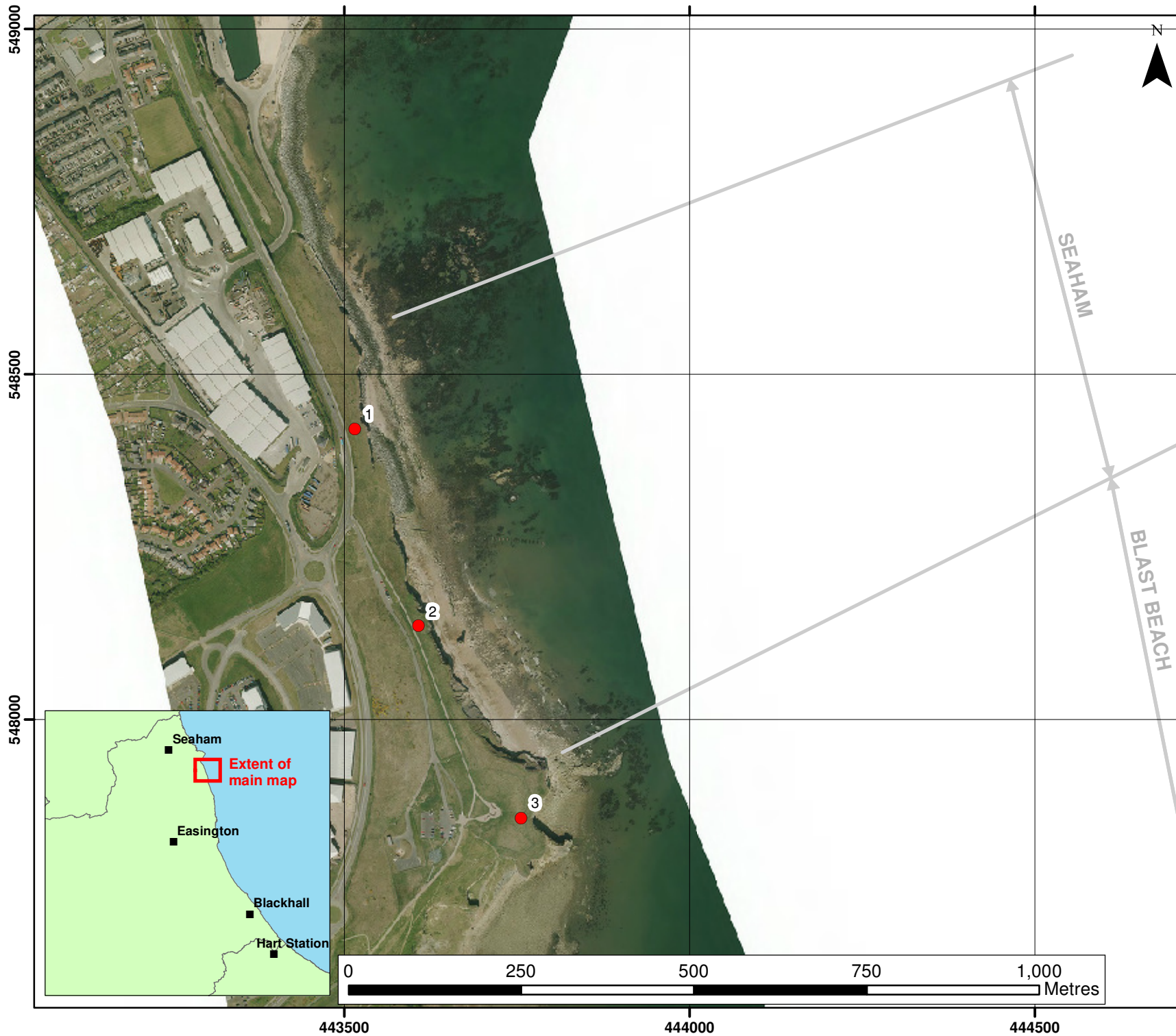
Three ground control points have been established on the Seaham frontage (Figure B1). The maximum separation between any two points is nominally 300m.

The cliff top surveys at Seaham are undertaken biannually. Measurements are taken from a fixed ground control point along a fixed bearing to the edge of the cliff top.

Table B1 provides baseline information about these ground control points and results from the 2008 (baseline) survey showing the position from the ground control point to the edge of the cliff top along the defined bearing. Future reports will show results from subsequent surveys and provide a means of assessing erosion since the baseline survey.

Table B1 – Cliff Top Surveys at Seaham

Ground Control Point Details				Distance to Cliff Top (m)			Total Erosion (m)		Erosion Rate (m/year)
Ref	Easting	Northing	Bearing (°)	Baseline Survey (Nov 2008)	Previous Survey (Apr 2014)	Present Survey (Nov 2014)	Baseline (Nov 2008) to Present (Nov 2014)	Previous (Apr 2014) to Present (Nov 2014)	Baseline (Nov 2008) to Present (April 2014)
1	443515.4	548421.7	70	16.1	15.2	15.0	-1.1	-0.2	-0.2
2	443607.8	548136.3	90	13.3	13.4	13.4	0.1	0.0	0.0
3	443756.1	547858.5	95	14.8	13.5	13.5	-1.3	0.0	-0.2



KEY

- Ground Control Points

Client: North East Coastal Group

Project: Cell 1 Regional Coastal Monitoring Programme 2011 to 2016

**Appendix B - Map 1
Ground Control Points
Seaham
Durham County Council**

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Full Measures Survey
Autumn 2014

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