Cell 1 Regional Coastal Monitoring Programme
Analytical Report 8: 'Full Measures' Survey 2015

South Tyneside Council

South Tyneside Council
Final Report

February 2016

Contents

Appendices

List of Figures

List of Tables

Authors	
Alex Bellis	CH2M
Dr Paul Fish – Review of Draft	CH2M
Dr Andy Parsons – Approval of Final	CH2M

Disclaimer

CH2M (formerly Halcrow) has prepared this report in accordance with the instructions of our client Scarborough Borough Council (SBC) for the client's sole and specific use. Any other persons who use any information contained herein do so at their own risk. This report is a review of coastal survey information made available by SBC. The objective of this report is to provide an assessment and review of the relevant background documentation and to analyse and interpret the coastal monitoring data. Halcrow has used reasonable skill, care and diligence in the interpretation of data provided to them and accepts no responsibility for the content, quality or accuracy of any Third party reports, monitoring data or further information provided either to them by SBC or, via SBC from a Third party source, for analysis under this term contract.

Raw data analysed in this report is available to download via the project's webpage: www.northeastcoastalobservatory.org.uk. The North East Coastal Observatory does not "license" the use of images or data or sign license agreements. The North East Coastal Observatory generally has no objection to the reproduction and use of these materials (aerial photography, wave data, beach surveys, bathymetric surveys), subject to the following conditions:

1. North East Coastal Observatory material may not be used to state or imply the endorsement by North East Coastal Observatory or by any North East Coastal Observatory employee of a commercial product, service, or activity, or used in any manner that might mislead.

2. North East Coastal Observatory should be acknowledged as the source of the material in any use of images and data accessed through this website, please state "Image/Data courtesy of North East Coastal Observatory". We recommend that the caption for any image and data published includes our website, so that others can locate or obtain copies when needed. We always appreciate notification of beneficial uses of images and data within your applications. This will help us continue to maintain these freely available services. Send e-mail to Robin.Siddle@scarborough.gov.uk

3. It is unlawful to falsely claim copyright or other rights in North East Coastal Observatory material.

4. North East Coastal Observatory shall in no way be liable for any costs, expenses, claims, or demands arising out of the use of North East Coastal Observatory material by a recipient or a recipient's distributees.

5. North East Coastal Observatory does not indemnify nor hold harmless users of North East Coastal Observatory material, nor release such users from copyright infringement, nor grant exclusive use rights with respect to North East Coastal Observatory material.

6. North East Coastal Observatory material is not protected by copyright unless noted (in associated metadata). If copyrighted, permission should be obtained from the copyright owner prior to use. If not copyrighted, North East Coastal Observatory material may be reproduced and distributed without further permission from North East Coastal Observatory.

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
		2.88
HAT	2.85	2.18
MHWS	2.15	-2.12
MLWS	-2.15	

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.

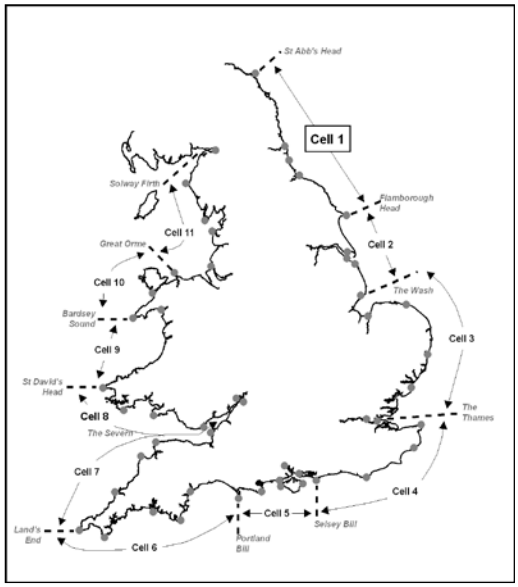


Figure 1 Sediment Cells in England and Wales

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 CH2M.

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	Sept-Dec 08	May 09	Mar-May 09		-
2	2009/10	Sept-Dec 09	Mar 10	Feb-Mar 10	July 10	-
3	2010/11	Aug-Nov 10	Feb 11	Feb-Apr 11	Aug 11	Sept 11
4	2011/12	Oct-Nov 11	Oct 12	Mar - May 12	Feb 13	-
5	2012/13	Nov 12	Mar 13	Mar 13	June 13	
6	2013/2014	Nov 13	Feb 14	Apr 14	July 14	
7	2014/15	Nov 14	Feb 15	Apr 15	July 15	
8	2015/16	Nov 15	Feb 16 (*)			

(*) The present report is **Analytical Report 8** and provides an analysis of the 2015 Full Measures survey for South Tyneside 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)
	Staithes
Scarborough Borough Council	Staithes
	Runswick Bay
	Sandsend Beach, Upgang Beach and Whitby Sands
	Robin Hood's Bay
	Scarborough North Bay
	Scarborough South Bay
	Cayton Bay
	Filey Bay

1. Introduction

1.1 Study Area

South Tyneside Council's frontage extends from the mouth of the River Tyne Estuary to the outfall south of Whitburn. For the purposes of this report and for consistency with previous reporting, it has been sub-divided into four areas, namely:

- Littlehaven Beach
- Herd Sands
- Trow Quarry (incl. Frenchman's Bay)
- Marsden Bay

1.2 Methodology

Along South Tyneside Council's frontage, the following surveying is undertaken:

- Full Measures survey annually each autumn comprising:
    - Beach profile surveys along 17 transect lines (commenced 2008)
    - Topographic survey along Littlehaven Beach (commenced 2010)
    - Topographic survey along Herd Sands (commenced 2008
    - Topographic survey along Trow Quarry (commenced 2008*)
- Partial Measures survey annually each spring comprising:
    - Beach profile surveys along 11 transect lines (commenced 2008)
    - Topographic survey along Littlehaven Beach (commenced 2010)
- Cliff top survey bi-annually at:
    - Cliff top survey at Trow Quarry (incl. Frenchman's Bay) (commenced 2008)

*Please note that the 2008 surveys at beach profiles 1bSS11, 1bSS12 and 1bSS13 were found to be undertaken at a different location to all the profiles surveyed since then. For this reason, the 2008 profiles have been excluded from analysis undertaken in this report.

For all cliff-top surveys prior to Full Measures 2011, data was reported separately in Trow Quarry Coastal Defence Scheme - Monitoring Plan Year 2 (available from South Tyneside Council). The data was saved in '.kmz' format for plotting and comparison in GoogleEarth. For the present survey report, this data has been visualised in GIS, which revealed the quality was variable and reliable interpretations of cliff change could not be made. For this reason, the 'kmz' files are not presented or analysed as part of the present report. Therefore, cliff top survey data collected from Full Measures survey (autumn 2011) going forward is presented in this report.

The location of these surveys is shown in Figure 2. The Full Measures survey was undertaken along this frontage between 9th and 12th November 2015. During this time the weather conditions ranged from overcast to cloudy with rainy spells. Wind speeds ranged from Force 3 to Force 4 and the sea state varied from moderate to rough.

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 ±0.1m. Therefore, changes less than ±0.1m 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 can 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 ±0.1m.

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 bands in inter-survey comparison (±m/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 to 10 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 wave buoy located at Tyne and Tees deployed under the national monitoring programme and three Cell 1 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 are managed by Scarborough BC as part of the Cell 1 monitoring programme.

An assessment of baseline wave data was presented in the Cell 1 2011 Wave Data Analysis Report, which reviewed all readily available wave data in the region. Wave data update reports for 2013-14 and 2014-15 provide an update to the baseline with analysis of the wave data collected under the programme between 2011 and March 2015. These wave data reports are also available from the reports page on the Cell 1 monitoring website: http://www.northeastcoastalobservatory.org.uk/Default.aspx?view=pnlTexts&text=Reports

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 which includes storm analysis for data collected up to the end of November 2015, extending the wave analysis to cover the period prior to the Full Measure surveys.

An overview plot of wave height data from the three Cell 1 wave buoys is shown in Figure 3. Note that there were significant gaps in the data at both Scarborough and Whitby, but the record is nearly continuous from Newbiggin. There were a large number of small storms over the winter of 2014-15 with the largest wave heights occurring in mid-October 2014 and beginning of February 2015. A storm with significant wave heights over 4m occurred in early September, just before the 2015 Full Measures survey data were collected.

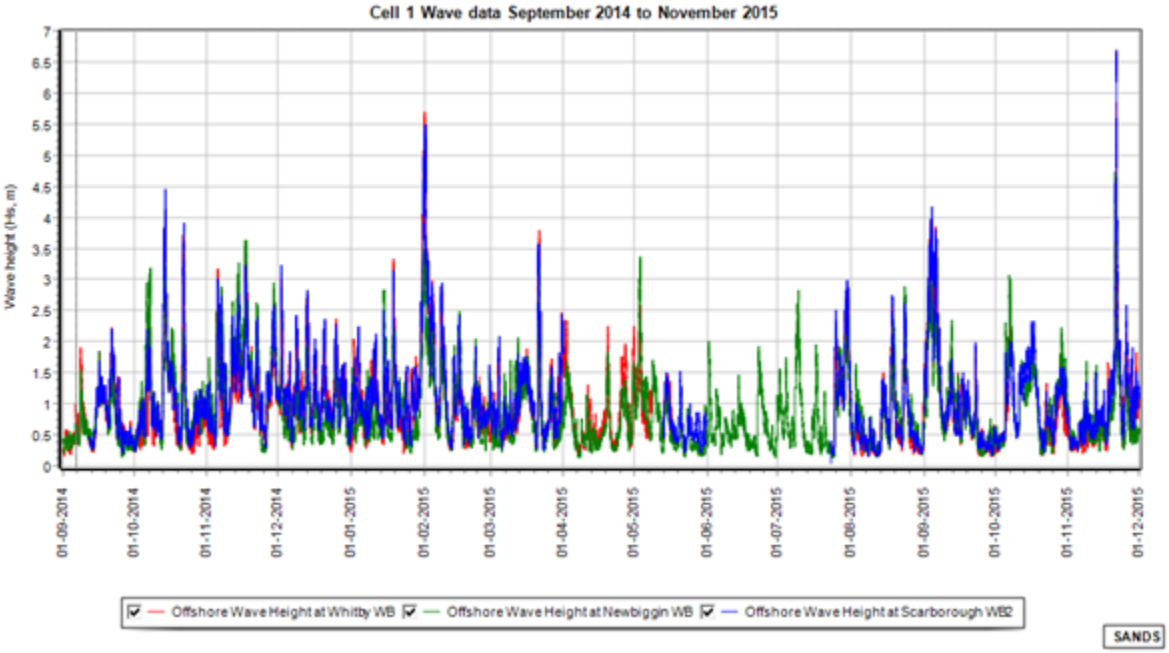


Figure 3 Wave monitoring data from the three Cell 1 wave buoys

2.2 Tyne/Tees WaveNet Buoy storms analysis

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 and results of a SANDS Storms analysis is 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 2007 and 2008.

Table 4 SANDS Storm Analysis at Tyne/Tees WaveNet Buoy

General Storm Information							At Peak					
Start Time	**End Time**	**Dur (hr)**	**Peak of Storm**	**Mean Dir (°)**	**No Events**	**Mean Dir Vector (°)**	**Hs (m)**	**Tp (s)**	**Tz (s)**	**Dir (°)**	**Energy @ Peak (KJ/m/s)**	**Total Energy (KJ/m)**
19/03/2007 10:30	21/03/2007 05:30	43	20/03/2007 14:30	23	64	78.2	6.2	14.8	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	10.3	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	13.8	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**	15.9	**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	12.7	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	12.8	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	10.9	7.6	62	4.2E+03	2.5E+06
01/02/2008 15:00	02/02/2008 09:30	18.5	02/02/2008	41	30	80.1	6.0	16.4	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	9.6	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**	14.8	**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	13.9	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	11.8	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	13.6	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	15.6	8.5	11	1.7E+04	2.2E+07
10/12/2008 12:00	13/12/2008 18:00	78	13/12/2008 08:00	109	37	332.1	4.9	10.0	7.2	129	4.7E+03	4.0E+06
31/01/2009 16:30	03/02/2009 09:00	64.5	02/02/2009 22:00	84	57	7.2	5.8	11.4	8.5	84	8.7E+03	8.1E+06
23/03/2009 22:30	28/03/2009 20:30	118	28/03/2009 16:30	217	14	89.4	5.3	10.0	7.6	6	5.4E+03	1.3E+06
10/07/2009 01:30	10/07/2009 02:30	1	10/07/2009 01:30	13	2	78.7	4.2	11.9	7.2	11	5.0E+03	2.3E+05
29/11/2009 20:30	**30/11/2009 15:00**	**18.5**	**30/11/2009 00:30**	**18**	**36**	**72.7**	**6.0**	11.2	**8.0**	**11**	**9.0E+03**	**5.9E+06**
17/12/2009 10:30	18/12/2009 05:00	18.5	17/12/2009 19:30	64	36	26.3	5.4	12.7	8.0	68	**9.4E+03**	5.7E+06
30/12/2009 09:00	30/12/2009 23:00	14	30/12/2009 12:30	84	24	7.7	5.1	9.0	7.2	90	4.1E+03	2.3E+06
06/01/2010 05:30	06/01/2010 11:00	5.5	06/01/2010 06:30	30	10	63.6	4.2	12.7	7.2	11	5.7E+03	1.1E+06
29/01/2010 10:30	30/01/2010 00:30	14	29/01/2010 22:30	9	21	81.9	5.4	10.2	8.0	6	6.0E+03	2.1E+06
26/02/2010 22:30	27/02/2010 02:30	4	27/02/2010 01:00	18	7	72.4	4.6	10.1	7.6	17	4.2E+03	7.0E+05
19/06/2010 07:00	20/06/2010 08:30	25.5	19/06/2010 20:00	21	49	69.2	5.4	12.7	7.6	23	**9.4E+03**	8.5E+06
29/08/2010 14:00	30/08/2010 06:30	16.5	30/08/2010 01:00	243	17	92.8	4.7	10.3	7.6	6	4.7E+03	1.6E+06
06/09/2010 22:30	07/09/2010 16:00	17.5	07/09/2010 15:30	101	22	353.2	4.6	10.5	8.0	90	4.5E+03	2.3E+06

General Storm Information							At Peak					
Start Time	End Time	Dur (hr)	Peak of Storm	Mean Dir (°)	No Events	Mean Dir Vector (°)	Hs (m)	Tp (s)	Tz (s)	Dir (°)	Energy @ Peak (KJ/m/s)	Total Energy (KJ/m)
17/09/2010 07:00	17/09/2010 18:30	11.5	17/09/2010 08:30	10	17	80.7	4.7	13.1	8.0	11	7.5E+03	2.9E+06
24/09/2010 03:00	26/09/2010	45	24/09/2010 10:00	21	80	71.6	5.3	12.1	8.0	11	8.0E+03	1.2E+07
20/10/2010 02:00	24/10/2010 16:30	110.5	20/10/2010 10:00	13	16	78.2	4.2	13.4	7.2	17	6.4E+03	1.8E+06
08/11/2010 14:00	**09/11/2010 20:30**	**30.5**	**09/11/2010 10:00**	**88**	**58**	**3.0**	**5.6**	10.5	**8.0**	**73**	**6.9E+03**	**7.8E+06**
17/11/2010 11:00	17/11/2010 18:30	7.5	17/11/2010 12:00	136	9	322.4	4.7	9.2	6.9	129	3.7E+03	8.1E+05
29/11/2010 19:30	02/12/2010 08:30	61	29/11/2010 21:00	80	45	11.8	5.1	11.2	7.6	56	6.3E+03	5.4E+06
16/12/2010 15:00	17/12/2010 06:30	15.5	17/12/2010 03:30	12	22	79.1	4.6	12.5	7.6	17	6.4E+03	2.8E+06
23/07/2011 14:00	**24/07/2011 11:00**	**21**	**24/07/2011 03:00**	**23**	**39**	**67.1**	**4.7**	12.8	**7.6**	**17**	**7.2E+03**	**5.8E+06**
24/10/2011 18:30	25/10/2011 09:30	15	25/10/2011 09:30	103	26	348.5	4.1	11.3	6.9	79	4.2E+03	2.6E+06
09/12/2011 08:30	09/12/2011 10:00	1.5	09/12/2011 08:30	7	3	84.0	4.1	14.2	8.0	6	6.7E+03	4.8E+05
05/01/2012 16:00	06/01/2012 05:00	13	06/01/2012 03:00	12	19	79.0	4.6	12.5	7.6	17	6.4E+03	2.6E+06
03/04/2012 13:30	04/04/2012 10:30	21	03/04/2012 17:30	66	38	25.1	5.6	9.7	7.6	56	5.9E+03	5.5E+06
24/09/2012 08:30	25/09/2012 10:30	26	25/09/2012 01:30	74	50	16.7	4.7	12.3	8.0	62	6.6E+03	7.4E+06
26/10/2012 16:30	27/10/2012 14:30	22	26/10/2012 23:00	12	34	79.4	4.9	15.3	7.6	11	1.1E+04	4.9E+06
05/12/2012 16:00	15/12/2012 01:30	225.5	14/12/2012 19:30	78	31	18.4	5.4	10.5	7.6	96	6.4E+03	4.5E+06
20/12/2012 06:00	**21/12/2012 14:30**	**32.5**	**20/12/2012 23:00**	**101**	**56**	**348.4**	**5.6**	11.3	**8.0**	**96**	**8.0E+03**	**8.8E+06**
18/01/2013 18:30	22/01/2013 06:00	83.5	21/01/2013 10:00	81	54	9.2	6.7	11.2	8.5	84	1.1E+04	1.1E+07
06/02/2013 08:00	07/02/2013 06:00	22	06/02/2013 12:30	47	38	81.6	5.4	11.9	7.6	11	8.2E+03	6.1E+06
07/03/2013 21:00	10/03/2013 21:30	72.5	08/03/2013 04:00	67	37	24.6	4.9	10.7	7.6	73	5.4E+03	4.3E+06
18/03/2013 09:00	25/03/2013 00:30	159.5	23/03/2013 14:30	85	153	5.1	6.0	12.1	8.0	90	1.0E+04	2.8E+07
23/05/2013 18:00	**24/05/2013 12:00**	**18**	**23/05/2013 22:30**	**13**	**32**	**77.5**	**6.7**	12.5	**8.5**	**17**	**1.4E+04**	**7.1E+06**
10/09/2013 13:00	10/09/2013 19:30	6.5	10/09/2013 14:00	11	14	79.3	4.4	11.0	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	12.7	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	12.7	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	17.0	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	7.3	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	9.3	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**	8.9	**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	11.5	7.6	6	**5.0E+03**	6.0E+05
31/01/2015 08:30	01/02/2015 19:30	35.0	31/01/15 23:30	78	71	88.7	6.2	13.1	8.0	6	1.3 E+4	1.4 E+7
03/09/2015 05:30:00	04/09/2015 06:00:00	24.5	03/09/2015 18:30:00	13	15	78.1	4.4	10.5	6.8	11	4.2 E+3	1.6 E+6
21/11/2015 01:30:00	**21/11/2015 14:30:00**	**13.0**	**21/11/2015 05:30:00**	**72**	**27**	**85.9**	**7.1**	**11.8**	**8.5**	**356**	**1.4 E+4**	**5.7 E+6**

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 years with the fewest storms was 2011, 2014 and 2015. In 2011 and 2014 this was reflected by a combination of accretion and overall stability recorded within 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 and 6th 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 storm was also accompanied by a significant storm surge with recorded water levels around 1.75m higher that predicted tides in some locations. The combined high water levels and large waves causing significant damage to many coastal defences and beaches in the north east.

The 2014 storms did appear to have an influence on beach behaviour, as shown by the profile analysis included within the 2014 Full Measures reports, with the movement of material across and along the beach. Dune toe erosion was more dominant than in previous years and could be explained by particularly high tides rather than storm erosion alone.

During 2015 there were only three storms with peak wave heights above the threshold, but all had large wave heights and much greater wave energy than the 2014 storms. The South Tyneside surveys were undertaken two months after the 3rd/4th September 2015 storm, and before the 21st November 2015 storm, therefore the sediment redistribution patterns cannot be tied with the latter of these storms and it is difficult to confidently connect the beach sediment redistribution patterns to the earlier storm. However, the accretion of sediment towards the south of Herd Sands seen in the Long Term difference plot and erosion in the centre of the bay may at least in part reflect the effects of the September storm.

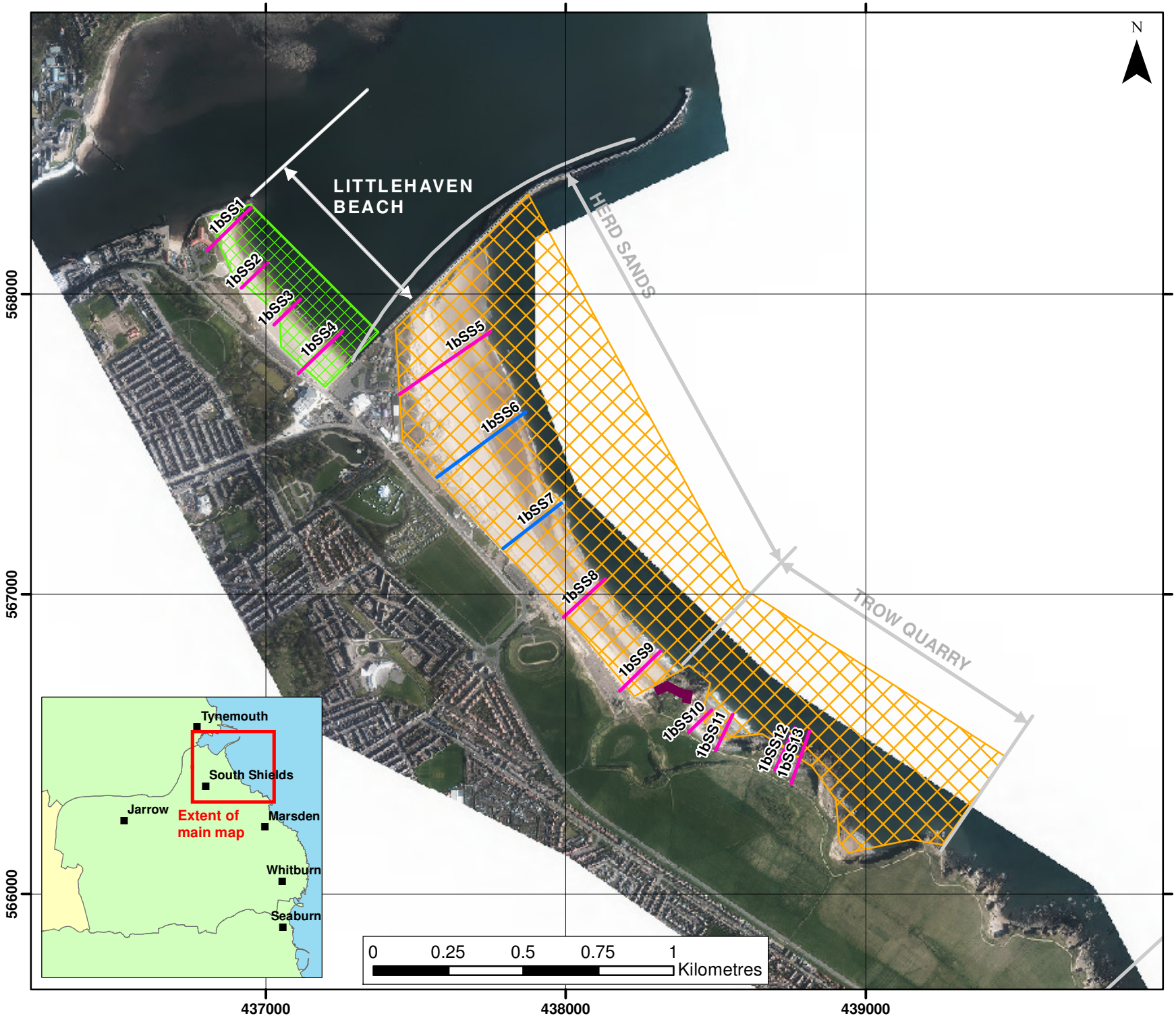
2.3 Newbiggin Cell 1 wave buoy storms analysis

The Cell 1 regional monitoring wave buoy on the Northumberland Council frontage at Newbiggin-by-the-Sea was deployed in January 2013. Analysed storm data for this buoy is presented in Table 5.

Table 5 SANDS Storm Analysis at Newbiggin Wave Buoy

General Storm Information							At Peak					
Start Time	**End Time**	**Dur (hr)**	**Peak of Storm**	**Mean Dir (°)**	**No Events**	**Mean Dir Vector (°)**	**Hs (m)**	**Tp (s)**	**Tz (s)**	**Dir (°)**	**Energy @ Peak KJ/m/s**	**Total Energy (KJ/m)**
06/09/2013 18:30:00	06/09/2013 22:30:00	4.0	06/09/2013 22:30:00	47	8	44.9	3.1	9.1	5.9	48	1.5 E+3	3.2 E+5
10/10/2013 00:30:00	**14/10/2013 08:00:00**	**103.5**	**10/10/2013 18:30:00**	**47**	**65**	**43.7**	**4.2**	**11.8**	**7.0**	**46**	**4.7 E+3**	**5.0 E+6**
30/11/2013 01:00:00	30/11/2013 05:00:00	4.0	30/11/2013 05:00:00	38	5	54.9	3.1	11.1	7.4	37	2.4 E+3	3.1 E+5
06/12/2013 01:30:00	06/12/2013 21:30:00	20.0	06/12/2013 16:30:00	47	27	44.4	3.2	16.7	8.5	53	5.7 E+3	2.5 E+6

General Storm Information							At Peak					
Start Time	**End Time**	**Dur (hr)**	**Peak of Storm**	**Mean Dir (°)**	**No Events**	**Mean Dir Vector (°)**	**Hs (m)**	**Tp (s)**	**Tz (s)**	**Dir (°)**	**Energy @ Peak KJ/m/s**	**Total Energy (KJ/m)**
01/01/2014 16:30:00	01/01/2014 17:30:00	1.0	01/01/2014 17:30:00	142	2	329.2	3.1	8.3	5.8	118	1.3 E+3	6.1 E+4
19/01/2014 05:30:00	**20/01/2014 10:30:00**	**29.0**	**19/01/2014 20:00:00**	**69**	**48**	**21.3**	**4.2**	**11.8**	**8.7**	**70**	**4.9 E+3**	**3.9 E+6**
29/01/2014 04:00:00	05/02/2014 21:30:00	185.5	05/02/2014 18:30:00	100	63	350.2	3.8	10.0	6.7	114	2.8 E+3	3.7 E+6
12/02/2014 16:00:00	14/02/2014 19:30:00	51.5	12/02/2014 18:00:00	126	7	329.3	3.4	9.1	5.9	118	1.9 E+3	2.6 E+5
26/03/2014 23:00:00	28/03/2014 01:00:00	26.0	27/03/2014 00:00:00	73	12	20.1	3.4	11.1	6.7	68	2.9 E+3	7.6 E+5
07/10/2014 17:00:00	07/10/2014 21:00:00	4.0	07/10/2014 18:00:00	67	6	23.6	3.2	13.3	9.8	66	3.5 E+3	5.4 E+5
13/10/2014 21:30:00	14/10/2014 03:00:00	5.5	14/10/2014 00:00:00	78	9	16.5	3.3	8.3	6.1	76	1.4 E+3	3.2 E+5
13/11/2014 19:00:00	17/11/2014 13:30:00	90.5	17/11/2014 08:00:00	70	28	20.8	3.6	11.1	6.8	65	3.2 E+3	1.8 E+6
31/01/2015 22:00:00	01/02/2015 11:30:00	13.5	01/02/2015 00:00:00	36	26	53.7	3.4	11.8	6.7	41	3.2 E+3	1.7 E+6
21/03/2015 14:30:00	21/03/2015 16:00:00	1.5	21/03/2015 16:00:00	45	3	47.5	3.2	11.1	7.1	44	2.4 E+3	1.8 E+5
03/05/2015 08:30:00	03/05/2015 16:00:00	7.5	21/03/2015 16:00:00	111	13	342.9	3.2	9.1	6.6	107	1.7 E+3	4.9 E+5
07/10/2015 06:30:00	07/10/2015 10:00:00	3.5	03/05/2015 14:30:00	66	3	25.4	3.1	10.5	8.0	63	2.0 E+3	1.6 E+5
21/11/2015 02:30:00	**21/11/2015 11:00:00**	**8.5**	**07/10/2015 06:30:00**	**39**	**18**	**51.3**	**4.6**	**11.1**	**7.1**	**38**	**5.1 E+3**	**1.8 E+6**



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

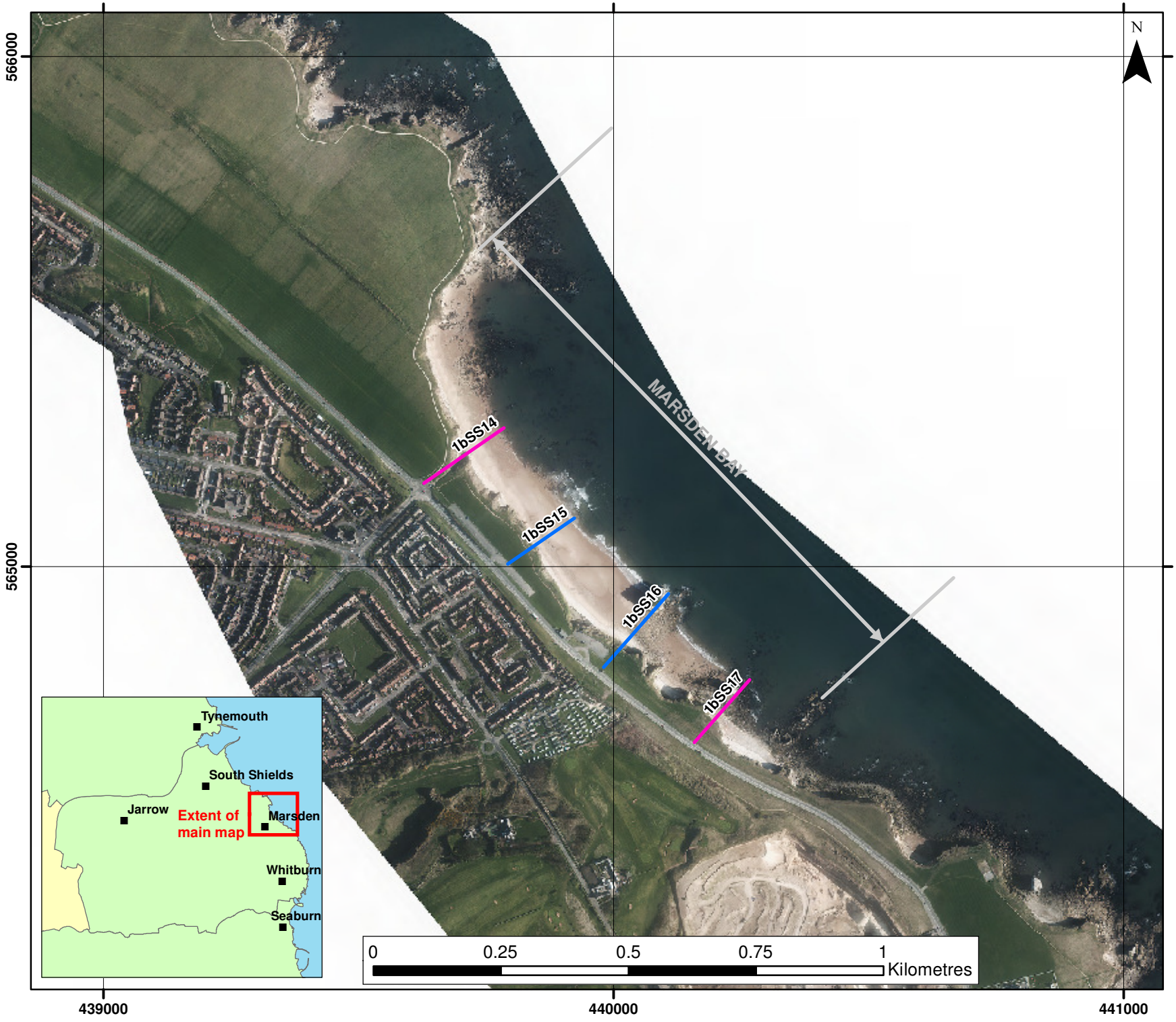
Project: Cell 1 Regional Coastal Monitoring Programme 2011 to 2016

Figure 2- Map 1 Survey Locations Littlehaven Beach to Trow Quarry South Tyneside Council

Analytical Report 8
Full Measures Survey
Autumn 2015

Halcrow Group Ltd, Lyndon House, 62 Hagley Road, Edgbaston, Birmingham, B16 8PE

Tel: +44 (0)121 456 2345
Fax: +44(0)121 456 1569
www.ch2m.com



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
Marsden Bay
South Tyneside Council

Analytical Report 8
Full Measures Survey
Autumn 2015

Halcrow Group Ltd, Lyndon House, 62 Hagley Road, Edgbaston, Birmingham, B16 8PE

Tel: +44 (0)121 456 2345
Fax: +44(0)121 456 1569
www.ch2m.com

3. Analysis of Survey Data

3.1 Littlehaven Beach

Survey Date	Description of Changes Since Last Survey	Interpretation
Nov 2015	**Beach Profiles:** Littlehaven Beach is covered by four beach profile lines for the Full Measures survey, spaced between South Groyne and South Pier (Appendix A). The previous survey was the Partial Measures survey undertaken in April 2015 and the previous Full Measures survey was undertaken in November 2014. Profiles 1bSS1 and 1bSS3 were last surveyed during the Partial Measures spring survey, 2015. Profiles 1bSS2 and 1bSS4 were last surveyed during the Full Measures autumn survey, 2014. Profile **1bSS1** is located to the north of Littlehaven beach, in the lee of a rocky outcrop and South Groyne. The dunes have remained stable since the last survey. Beach levels have fallen by up to 0.2m to expose more of the rocky outcrop between 130m and 150m chainage. Compared to earlier surveys, the beach is near its lowest level on record, but the dune front is at its most seaward position. Profiles **1bSS2 to 1bSS4** extend seawards from the new sea wall that was completed since the Full Measures survey in April 2014. At profile **1bSS2**, beach levels from the seawall to a chainage of 15m have fallen by <0.1m. Between 15m chainage and 45m chainage the beach level has increased by up to 0.5m, forming a distinctive berm with its crest at c.25m chainage. Beach levels have fallen by up to 0.2m between 45m and 75m chainage and increased by a similar amount between 80m chainage and the end of the profile at 105m chainage. Overall, the beach is at a medium level compared to earlier surveys. At profile **1bSS3**, the berm crest above HAT has been rolled back by c.5m with a related increase in beach level of up to 0.5m between 25m and 5m chainage. The beach level is unchanged between 5m chainage and 30m chainage. Beach levels have fallen by up to 0.5m between 30m and 60m chainage and increased seaward of this by up to 0.3m to create a more undulating foreshore than the straighter profile seen at the last survey. Upper beach levels are high compared to earlier surveys, and the foreshore is at a medium – low level	The beach at Littlehaven has had some time to adjust since construction of the new seawall in April 2014. The beach to the north, at profile **1bSS1,** is relatively stable, although sand is migrating landward and accreting at the dune front. In the south of the survey area, the berm crests above HAT appear to have become more pronounced and changes in the foreshore have been variable. **Longer term trends:** The beach profiles are at variable positions relative to past levels. In general they are within the boundaries of previous surveys indicating the new seawall has not adversely affected sediment movements. Profile 1bSS1 shows signs of progressive steepening, but is not currently a cause for concern.

Survey Date	Description of Changes Since Last Survey	Interpretation
	At profile **1bSS4**, beach levels between the seawall and a chainage of 105m generally increased. The biggest changes are between 75m and 105m chainage where the berm height has increased slightly and its seaward face has accreted by up to 0.6m. At the crest of this berm some cobble-small boulder sized material is exposed (see Plate 1), which is assumed to be the upper part of the bank of coarse material (see Plate 2) visible in earlier photographs, partially buried through accretion on the foreshore. Between 105m and 135m the beach level has fallen by up to 0.4m. Seaward of 135m there has been a limited amount of deposition to increase the beach level in the lower foreshore. These changes result in the foreshore seaward of the cobble-boulder deposit now being steeper and straighter than in previous surveys. Overall the beach is at a medium to low level compared to earlier surveys,	
Nov 2015	**Topographic Survey:** Littlehaven Beach is covered by bi-annual topographic survey between the South Groyne and the South Pier, which commenced in March 2010. Data from the most recent topographic survey (Full Measures, autumn 2015) have been used to create a DGM (Appendix B – Map 1a) using GIS. A difference plot has also been produced using the DGM (Appendix B – Map 1b) produced from the last produced topographic survey (Partial Measures, spring 2015) and the present survey. Except for in the dunes in the far northwest of the survey area (where erosion and deposition are of limited extent and patchy), change on the beach is in shore-parallel, linear strips and less than ±0.6m. There is a strip of accretion in the lower foreshore in the centre of the bay, backed by an area of erosion in the upper foreshore throughout the bay. This is backed by a strip of accretion in the upper beach, which is continuous except at the very back of the beach in the distal ends of the bay where there are some areas of erosion. **Longer Term Topographic Trends Autumn 2010 to Autumn 2015:** The long term difference plot (Appendix B – Map 1c), which compares surveys before and after remodelling of the seawall shows a general pattern for beach accretion at the northern end of the bay (including at the dune front, where increases are >1m in places) and foreshore, with erosion being	Comparison of the present topographic survey with the previous Partial Measures (spring, 2015) shows that the beach is generally stable with shore-parallel bands of elevation change which reflect seasonal redistributions of material throughout across the beach as bars. **Long term topographic trends Autumn 2010 to Autumn 2015:** The plot shows a general pattern for beach accretion at the northern end of the bay and erosion at the southern end of the bay. There is a band of erosion in the upper foreshore which tapers out towards the northern end of the bay. This, in conjunction with corresponding strips of accretion in the lower foreshore and upper beach which taper southwards, indicate a northward movement of sediment since the baseline survey combined with seasonal movements of sediment across the beach. Compared to the baseline survey, the beach level at the seaward of the where the former seawall was situated (now in the middle beach) has lowered

Survey Date	Description of Changes Since Last Survey	Interpretation
	concentrated in the upper foreshore and towards the sea wall, particularly in the south of the survey area.	slightly and the gradient of the beach overall has reduced.

Plate 1 – Survey photograph 1bSS4_20151112_N9

Plate 2 – Survey photograph 1bSS4_20140428_N7

3.2 Herd Sands

Survey Date	Description of Changes Since Last Survey	Interpretation
Nov 2015	**Beach Profiles:** Herd Sands is covered by five beach profile lines for the Full Measures survey (Appendix A). Profiles 1bSS5, 1bSS8 to 1bSS9 were last surveyed during the Partial Measures spring survey, 2015. Profiles 1bSS6 and 1bSS7 were last surveyed during the Full Measures autumn survey 2014. Profile **1bSS5** is located to the north of Herd Sands and is in the lee of the breakwater. Sand fences were constructed on these dunes in 2012 to encourage accretion. The dunes have largely retained a similar form to the previous survey, showing that the defences are helping to stabilise the dunes on the landward of side of the path. As noted in earlier surveys, some of these fences have fallen down. On the seaward side of the path, an embryonic dune present in the previous survey has been eroded but the foredune on its landward side has increased slightly, suggesting a landward movement of blown sand here. Change between 112m and 140m chainage is <0.2m. Between 160m chainage and 240m chainage the elevation of a berm (with its crest just above HAT) and its seaward face have been lowered by up to 0.8m, reducing the prominence of the berm crest and causing accretion of up to 0.4m in its lee between 140m and 160m chainage. Changes seaward of this are <0.2m and have served to straighten the foreshore profile. Overall the profile is at a high level compared to earlier surveys except in the very uppermost part of the beach (between 115m and 125m chainage) where the profile is at its lowest on record. At profile **1bSS6**, the elevation of the landward face of the most seaward dune ridge has fallen by up to 0.4m. since the last survey. The seaward face of this dune ridge has changed little. The flat surface of the upper beach above HAT between 100m and 140m chainage has accreted slightly (0.2m), but the berm at its seaward edge has reduced in elevation by a similar amount. The foreshore has generally experienced limited accretion (<0.2m) except at its most seaward extent where erosion has occurred. This indicates a movement of sediment from the foreshore towards the back of the beach over the last 12 months. Overall, the beach and dunes are at a high level compared to earlier surveys, except on toe of the most seaward dune ridge, which remains at its most landward extent. At profile **1bSS7**, located at the centre of Herd Sands, the two large berms present in the previous profile have eroded, with the depressions on their landward side infilling to create a straighter foreshore profile. Two lower berm crests now exist in the upper beach, one at HAT (100m chainage)	The pattern of change at Herd Sands is complex. There has been accretion on the face of stabilised dunes and on the upper beach, but prominent berm and runnel features present in the last survey have been smoothed out, with the foreshore returning to a concave form seen in earlier surveys. **Longer term trends:** Beach levels generally remain at medium to high levels compared to earlier surveys. Only the dune toe at profile 1bSS6 is at its most landward extent on record and not a cause for concern.

Survey Date	Description of Changes Since Last Survey	Interpretation
	and another more rounded one further up the beach at 3.8m OD. Overall the beach level is relatively high compared to earlier surveys. At profile **1bSS8**, beach levels immediately in front of the seawall have increased by c.0.2m, as far as 22m chainage. , Seaward of this point the beach elevation has fallen by as much as 1.3m between 22m chainage and 130m chainage, changing the berms and runnel which were previously present to at smoothly concave profile. The lower foreshore seaward of 130m has accreted by up to 0.8m, extending the beach toe seaward by c.20m. Overall the foreshore profile has flattened and the beach overall is at a medium to high level compared to earlier surveys. Profile **1bSS9** is located at the southern end of Herd Sands. The dune profile fronting the car park remains unchanged. The beach profile changes follow a very similar pattern to those at profile 1bSS8, with the upper beach accreting by c.0.2m between the dune toe at 20m chainage and 50m chainage (just above HAT). Between 50m chainage and 140m chainage beach elevation has fallen by up to 0.8m, eroding a runnel with berms on its landward and seaward sides, and leaving the whole beach with a smoothly concave profile. The beach toe has also extended seaward, but to a more limited extent than at profile 1bSS8. Overall the beach is at a relatively high level compared to earlier surveys.	
Nov 2015	**Topographic Survey:** Herd Sands is covered by an annual topographic survey between the South Pier and Trow Point, which commenced in November 2008. Data from the most recent topographic survey (Full Measures, autumn 2015) have been used to create a DGM (Appendix B – Map 2a) using GIS. A difference plot has also been produced using the DGM (Appendix B – Map 2b) produced from the last topographic survey (Full Measures, autumn 2014) and the present survey. The difference plot shows erosion, mostly <0.5m, of the uppermost part of the beach and seaward dunes towards the north of Herd Sands, with a similar magnitude of accretion in the foreshore. An arcuate area of up to 0.6m of erosion exists in the lower foreshore in the north of the survey area. In the centre of Herd Sands there is an area of erosion on the lower foreshore, separated from a linear strip of erosion by an area of limited accretion. This area of erosion follows the edge of the berm in the upper beach to become shore-parallel in the south of the bay. The area of limited accretion, which	Comparison of the present topographic survey with the previous Full Measures (autumn, 2014) shows widespread erosion of limited intensity in the dunes and at the dune front, the seaward edge of the upper beach and the lower foreshore. This is mirrored by accretion in the upper foreshore. The most southerly end of the beach has experienced significant accretion (>1m). This may be a natural change, but could relate to clearance of sand from paths. **Longer term topographic trends Autumn 2010 to Autumn 2015:** shows accretion being dominant, particularly at the seaward edge of the upper beach. Discontinuous areas of erosion exist in the foreshore, but overall this indicates a picture of sediment

Survey Date	Description of Changes Since Last Survey	Interpretation
	separates the areas of erosion, becomes more intense (>1m) and extensive across the beach towards the southern end of the bay. **Longer Term Topographic Trends Autumn 2010 to Autumn 2014:** The long term difference plot (Appendix B – Map 2c) shows overall accretion throughout most of Herd Sands. The more seaward extents of the upper beach have accreted by as much as 2m in a shore parallel strip. Several relatively extensive areas of erosion, with elevation changes mostly <0.5m, exist in the lower foreshore. There is also patchy erosion at the dune toe and within the dunes. Over some areas of limited extent this erosion is >1m, but mirrored by a similar level of accretion elsewhere in the dunes.	movement from the foreshore to the upper beach and dunes over the long term.

3.3 Trow Quarry (incl. Frenchman's Bay)

Survey Date	Description of Changes Since Last Survey	Interpretation
Nov 2015	**Beach Profiles:** Trow Quarry is covered by four beach profile lines for the Full Measures survey (Appendix A), two in Graham's Sand and two in Southern Bay. The previous survey was the Partial Measures survey undertaken in April 2015. Profiles **1bSS10** and **1bSS11** are located in Graham's Bay. At profile **1bSS10** the backshore has remained stable. Beach levels have fallen seaward of HAT across the foreshore, through the removal of up to 0.4m of sand, except at the most seaward extent of the profile where the level of the lower foreshore has increased by c.0.2m. Above HAT and in the upper foreshore, the beach is relatively low and at medium-low levels in the lower foreshore. At profile **1bSS11**, the profile has remained stable. The small changes in level between a chainage of 30m and 40m are most likely attributable to the movement of cobbles rather than a change in beach level. Profile **1bSS12** and **1bSS13** are located in Southern Bay. At both locations the beach profile has remained stable since the previous survey. Apparent changes in the profile likely derive from minor movement of cobbles or differences in the exact placement of survey points.	At both Graham's Bay and Southern Bay, the cliff and rock revetment have remained stable. At Graham's Bay, the northern part of the beach has dropped, with draw-down of material to the lower foreshore, but to the south the beach has remained fairly stable. At Southern Bay, the rocky foreshore has generally retained the same form and position. **Longer term trends:** Overall the beach at Graham's Bay and Southern Bay has retained the same form and position since November 2008/March 2009 when surveys began. Movement in the north of Grahams Bay at profile 1bSS10 is within the bounds of previous surveys.
Nov 2015	**Topographic Survey:** Trow Quarry is covered by an annual topographic survey within Graham's Sand, Southern Bay and Frenchman's Bay, which commenced in November 2008. Data from the most recent topographic survey (Full Measures, autumn 2015) have been used to create a DGM (Appendix B – Map 2a) using GIS. A difference plot has also been produced using the DGM (Appendix B – Map 2b) produced from the last topographic survey (Full Measures, autumn 2014) and the present survey.	**Topographic Survey:** The difference plot indicates a movement of sediment from the back of the beach to the foreshore, which is most evident at Graham Sands. This is likely a process of drawdown, which moves sediment from the upper beach to form berms or bars on the foreshore. **Longer Term Topographic Trends Autumn 2010 to Autumn 2015:** The plot indicates a slight long term

Survey Date	Description of Changes Since Last Survey	Interpretation
	The difference plot shows that up to 1m of change has occurred with the dominant pattern being one of falls in elevation at the back of the beach and increases on the foreshore. **Longer Term Topographic Trends Autumn 2010 to Autumn 2014:** The long term difference plot (Appendix B – Map 2c) shows the net change in beach levels between autumn 2010 and autumn 2015. The magnitude of change is similar to that seen in the short term difference plot, but the pattern of change is different and less conclusive with patchy erosion and accretion throughout the three small bays. .	trend for erosion from Southern Bay and Frenchman's Bay, with accretion on the intervening frontage between.
Nov 2015	**Cliff-top Survey:** Cliff top survey data collected for baseline survey (autumn, 2011) and bi-annual surveys since then, including the present Full Measures survey (autumn, 2015) is presented in this report. Six ground control points (numbered points 1 to 6) were established along the cliff top at Trow Point in 2008 to monitor cliff erosion at the site of a former landfill. Note: the numbering of ground control points is not intended to correlate with that of the beach profile lines and reference should be made to Appendix C – Map 1 for the location of ground control points. Measurements are taken from each ground control point along a fixed bearing to the edge of the cliff top. The results from the cliff top monitoring are anticipated to have an accuracy of ±0.1m due to the technique used. The results from the cliff top survey are presented in Appendix C – Table C1, showing the position from the ground control point to the edge of the cliff top along a defined bearing. Results show no erosion greater than the anticipated survey error has been recorded since the last survey. From September 2011 to present, only survey point 1 has recorded erosion greater than the anticipated survey error. 0.2m recession has occurred at this survey point.	Results show that no erosion has been recorded since the last survey, and over the long term, only Ground Control Point 1 has recorded error greater than the survey accuracy. It can be concluded that minimal recession has taken place at the Trow Rocks headland over the survey period.

3.4 Marsden Sands

Survey Date	Description of Changes Since Last Survey	Interpretation
Nov 2015	**Beach Profiles:** Marsden Sands is covered by four beach profile lines for the Full Measures survey (Appendix A). The previous survey was the Partial Measures survey in April 2015 and prior to that the Full Measures survey was completed in November 2014. Profiles 1bSS14 and 1bSS17 were last surveyed during the Partial Measures spring survey, 2015. Profiles 1bSS15 and 1bSS16 were last surveyed during the Full Measures autumn survey, 2014. Profile **1bSS14** is located to the north of the bay and covers the cliff and the former lifeguard station adjacent to the Redwell Steps. The cliff has retained the same form and position since the last survey. The upper beach has accreted by up to 0.5m between the steps and MHWS (125m chainage). The uppermost part of the beach is formed of gravel and sand, presumably a storm deposit. This continues the trend of increasing upper beach levels also seen in the last survey. Beach levels have fallen by up to 0.5m in the upper foreshore to form a runnel (see Plate 3) between 130m and 150m chainage and have increased to by >1m to form a substantial berm (also visible in Plate 3) in the lower foreshore and extend the beach toe seaward considerably. Overall the beach is at a high level compared to earlier surveys. At profile **1bSS15** the profile suggests that the toe of the cliff has advanced seawards slightly but there is no evidence for this in the survey report or photographs. In the last survey the gravel and sand in the upper beach and the rocky shore platform in the foreshore had been exposed due to low beach levels. However, a veneer of sediment, mostly sand, c.0.6m deep has been deposited throughout the profile (see Plate 4). Overall, the profile is at a medium to high level, but relatively low between 80m and 95m chainage where gravel and sand is still exposed. At Profile **1bSS16** there has been no change to the profile except between 70m and 85m chainage where the upper beach level has fallen by 0.5m, due to the erosion of gravel that was previously present to expose cobble-small boulder sized material. Other apparent changes are minimal and most likely artefacts of surveying on very coarse material. Overall the beach is at its lowest level on record.	The more northerly part of Marsden Bay appears to have experienced accretion throughout most of the profile, whereas changes are minimal further south, where there is less mobile sediment available. It is possible that the gravel removed from 1bSS16 has moved further south to 1bSS17 under storm conditions. **Longer term trends:** The sandier beaches in the north of the bay are high compared to earlier surveys. Further south, there is little sand and therefore the underlying coarser sediment and the shore platform is exposed, indicating a general trend of movement of sediment towards the north.

Survey Date	Description of Changes Since Last Survey	Interpretation
	Profile **1bSS17** is located to the south of the bay. There has been an increase in beach level of up to 0.7m in the upper beach. The survey data indicates that this is 'rock' but the survey photographs clearly show that this is gravel deposit which has accumulated at the back of the beach. Otherwise, the profile which crosses rocky platform and boulders with small pockets of sand remains unchanged. Whilst the profile is low compared to earlier surveys, the range of change on the foreshore over the period records have been collected is small and therefore this does not represent a major departure from previous surveys.	

Plate 3 – Survey photograph 1bSS14_20151112_N17

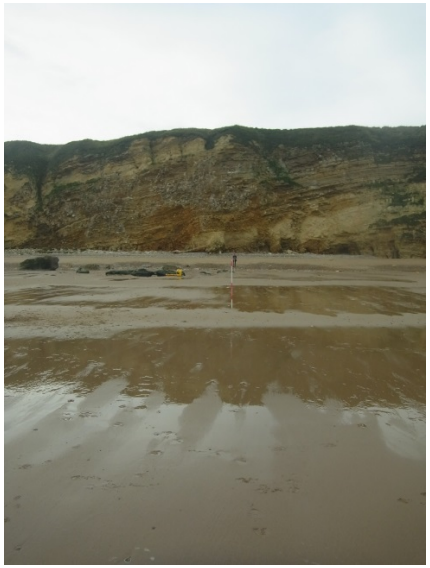


Plate 4 - Survey photograph 1bSS15_20151112_Up3

4. Problems Encountered and Uncertainty in Analysis

Individual Profiles

The survey report notes the following:
"Unable to measure part of Section SS16 due to difficult ground conditions.

Topographic Survey

The survey report states '*the combination of poor low tides and strong seas resulted in poor level coverage on areas of bedrock in Trow Quarry and Frenchman's Bay'*

Cliff Top Surveys

Surveying any cliff top is difficult due to the need for a consistent interpretation of the cliff edge in successive surveys, which can be challenging, especially when vegetation is thick. For these reasons, it has been assumed that any changes of ±0.2m may be considered as being within margin of error of the surveying technique and that any indication of an advancing cliff line is error.

No cliff recession has been recorded at Trow Quarry since records began, but visual inspection indicates that small rock falls have occurred. The data reflects the episodic nature of rock falls through time and the uneven distribution of events along the cliff.

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

No changes are recommended at the present time.

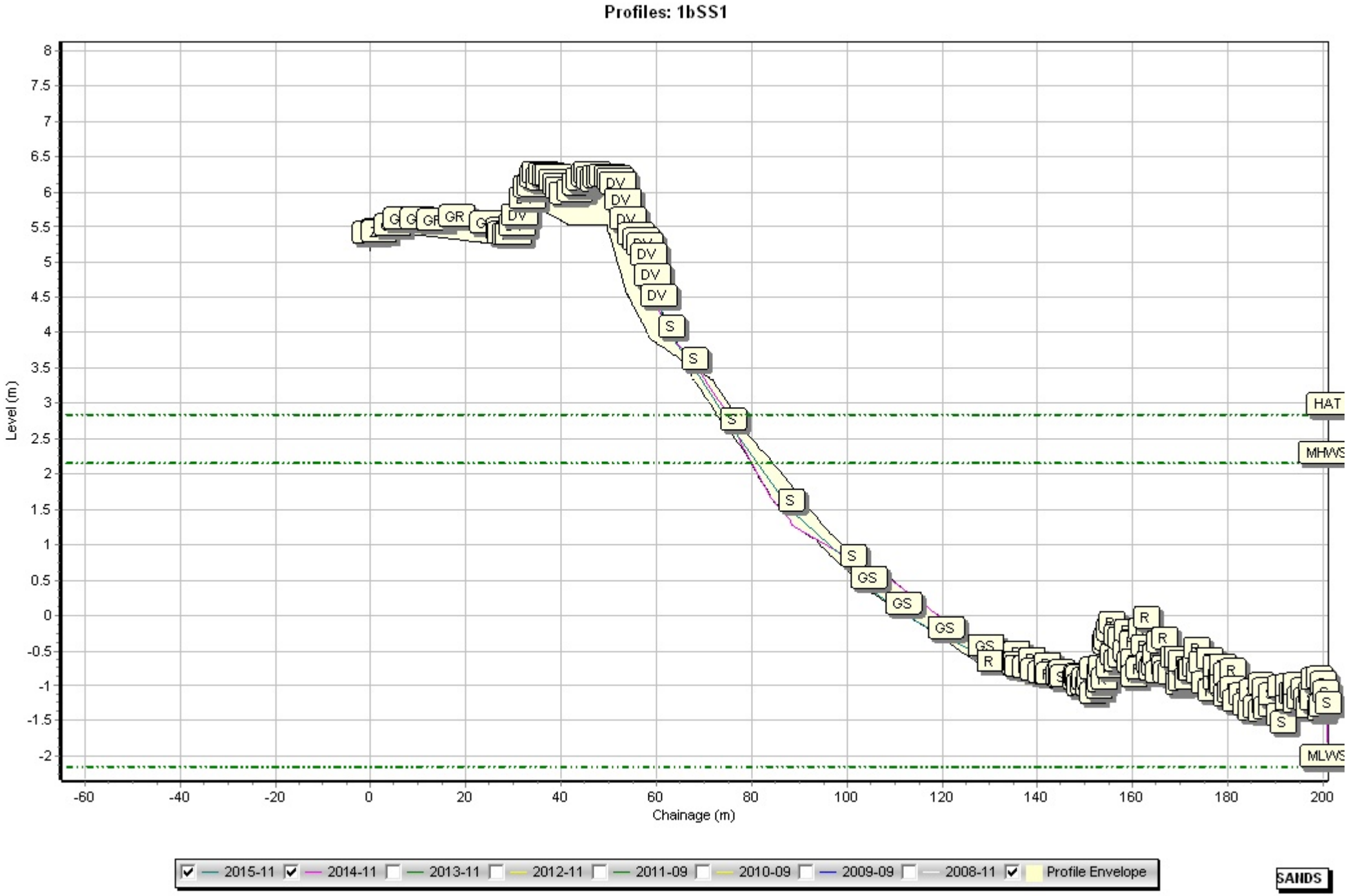
6. Conclusions and Areas of Concern

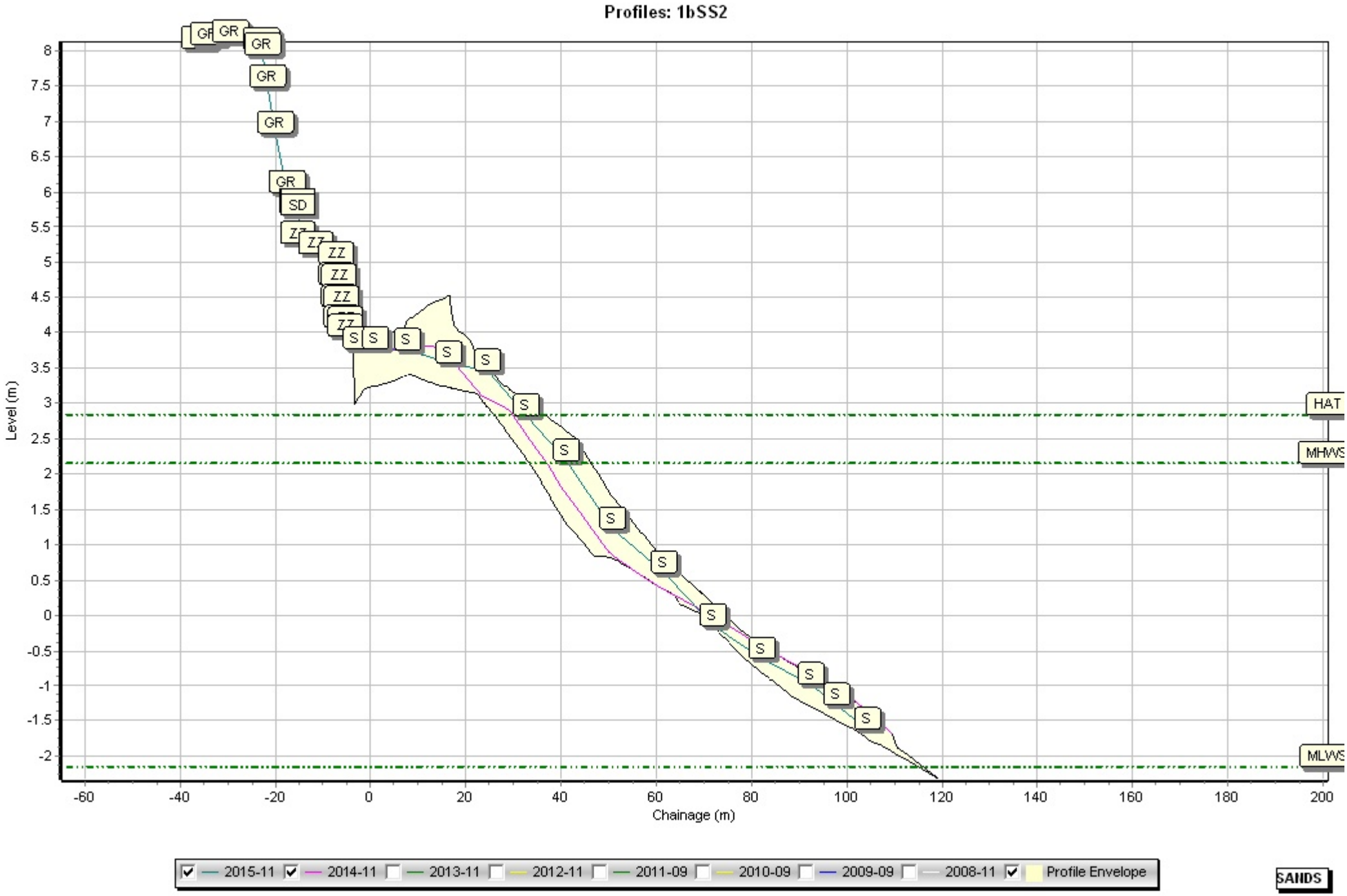
- At Littlehaven Beach, the recorded profiles and topographic survey present no causes for concern. 1bSS1 shows signs of progressive steepening, with sand moving from the foreshore and welding to the dune front. The short term picture indicates seasonal redistribution of sand within the bay, and the long term picture a general movement of sediment northwards.
- At Herd Sands the recorded profiles present no causes for concern, and beach profiles remain at medium to high levels. The long term difference plot indicates that accretion has been dominant at Herd Sands relative to the baseline survey.
- At Trow Quarry, the recorded profiles show no causes for concern. The cliffs at Trow Point appear to have been stable and the data does not indicate cause for concern.
- At most of Marsden Bay, the recorded profiles present no causes for concern, although those in the southern part of the bay are near their lowest levels and those in the north much higher, indicating a general northwards concentration of sediment.

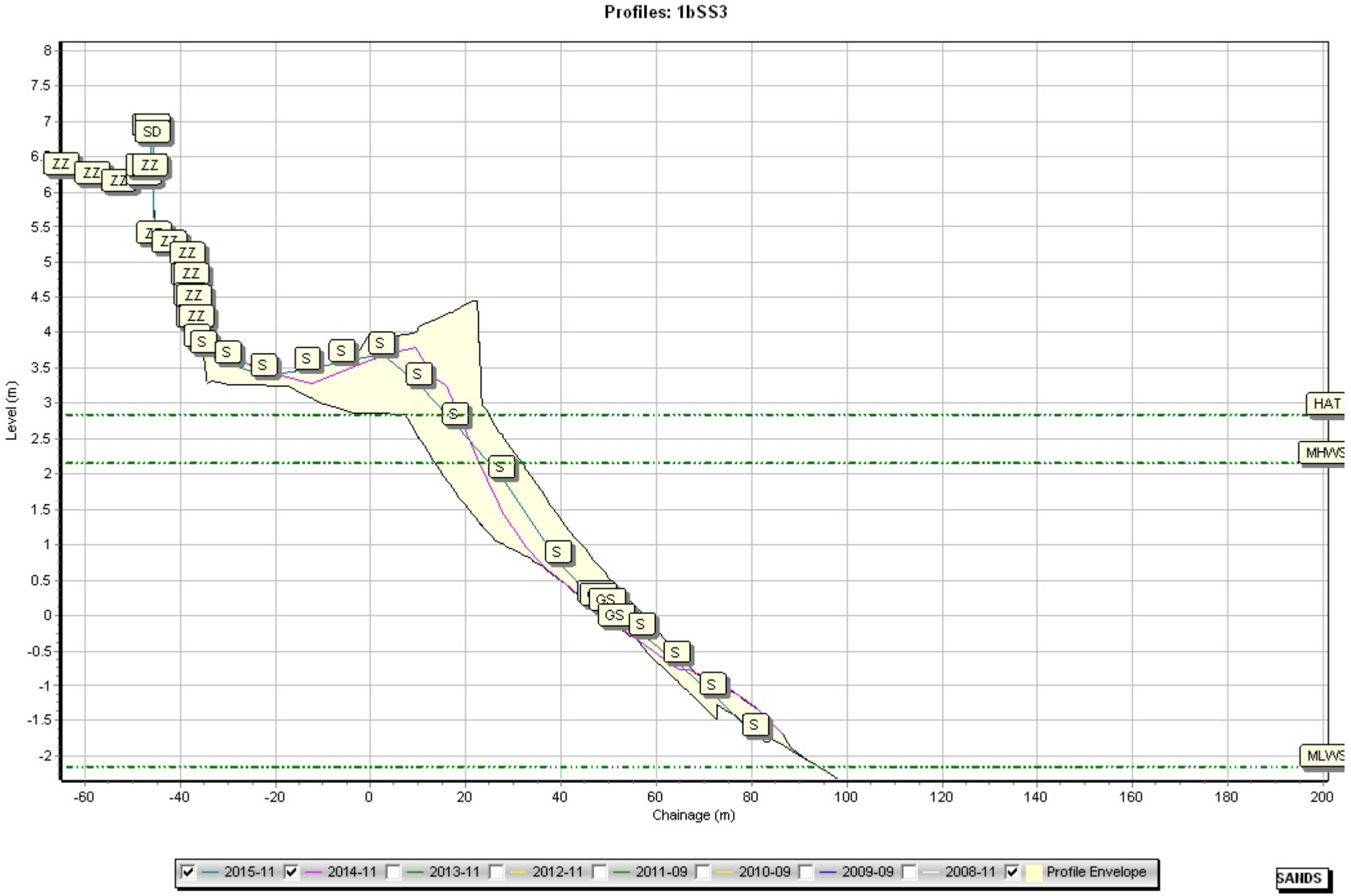
Appendices

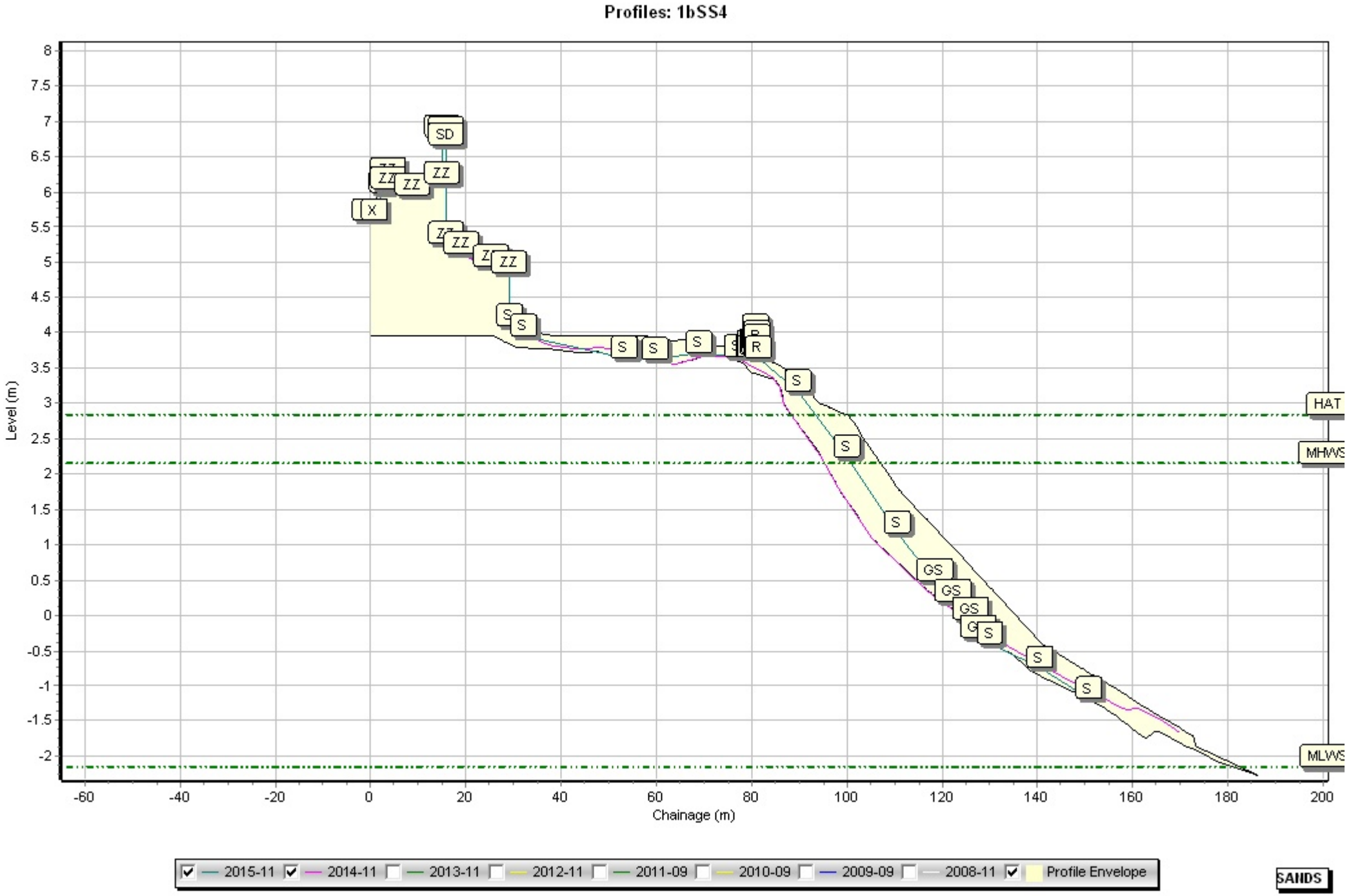
Appendix A

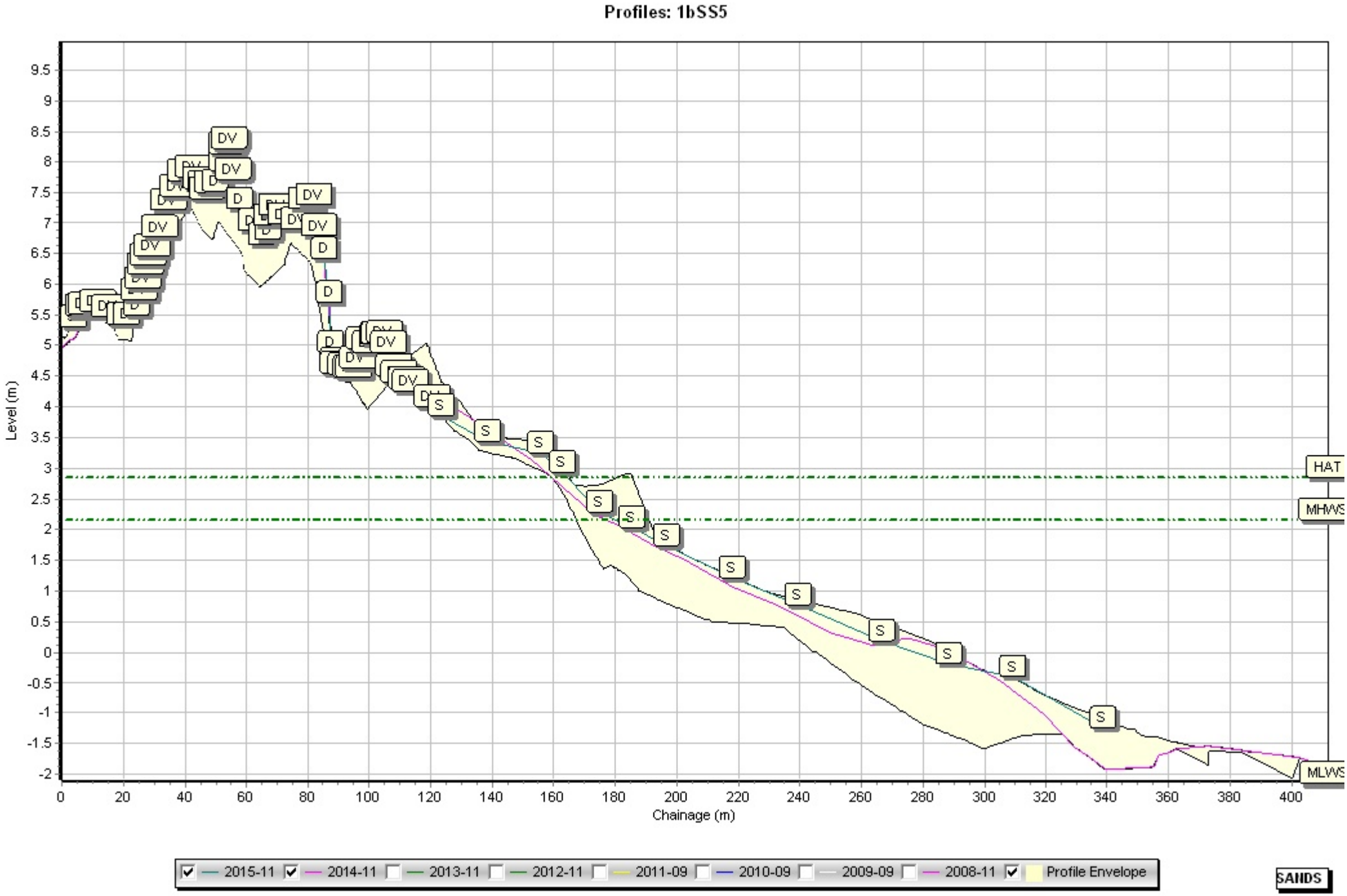
Beach Profiles

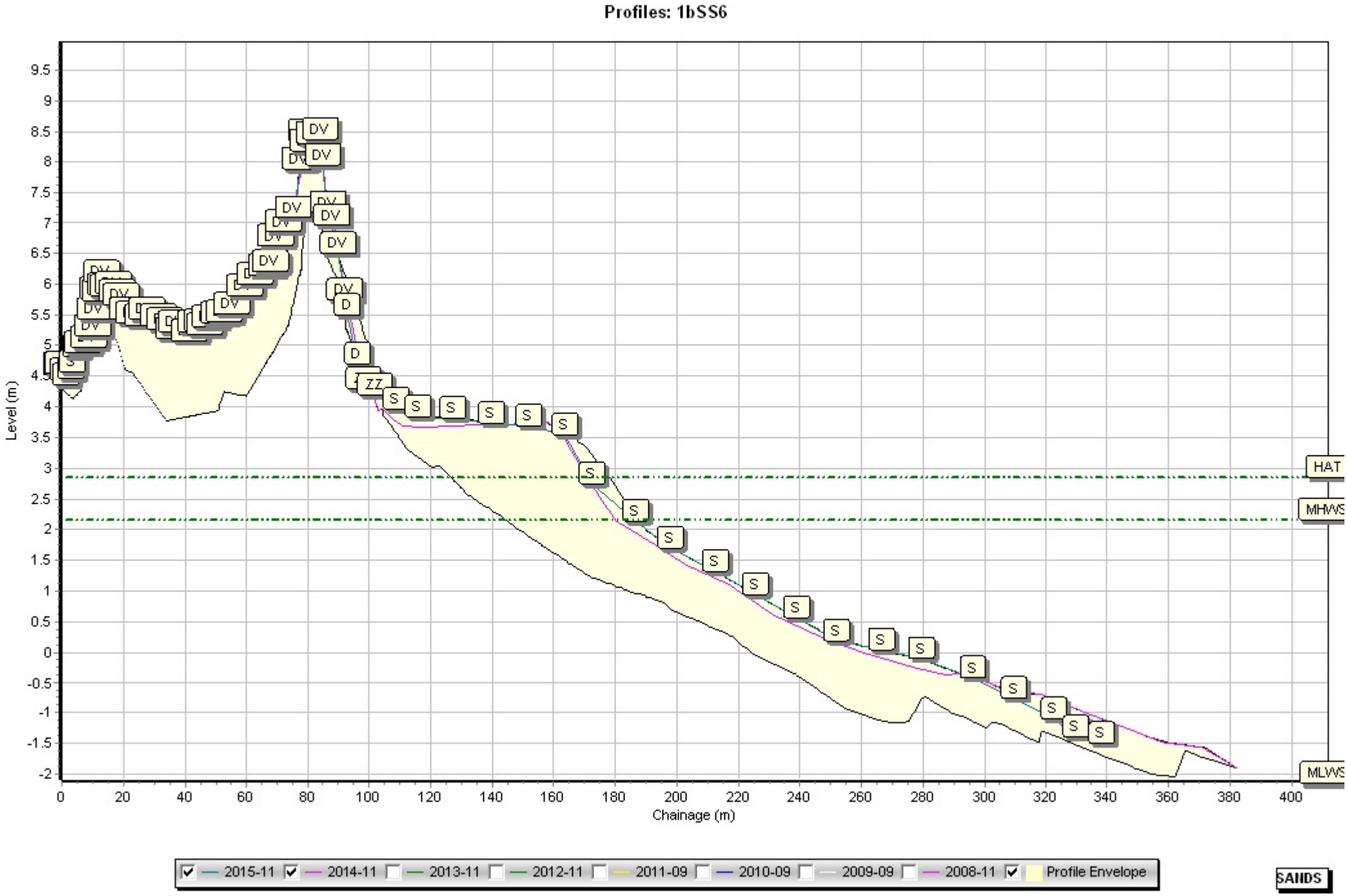

Profiles: 1bSS1
Level (m)
Chainage (m)
HAT
MHWS
MLWS
2015-11
2014-11
2013-11
2012-11
2011-09
2010-09
2009-09
2008-11
Profile Envelope
SANDS

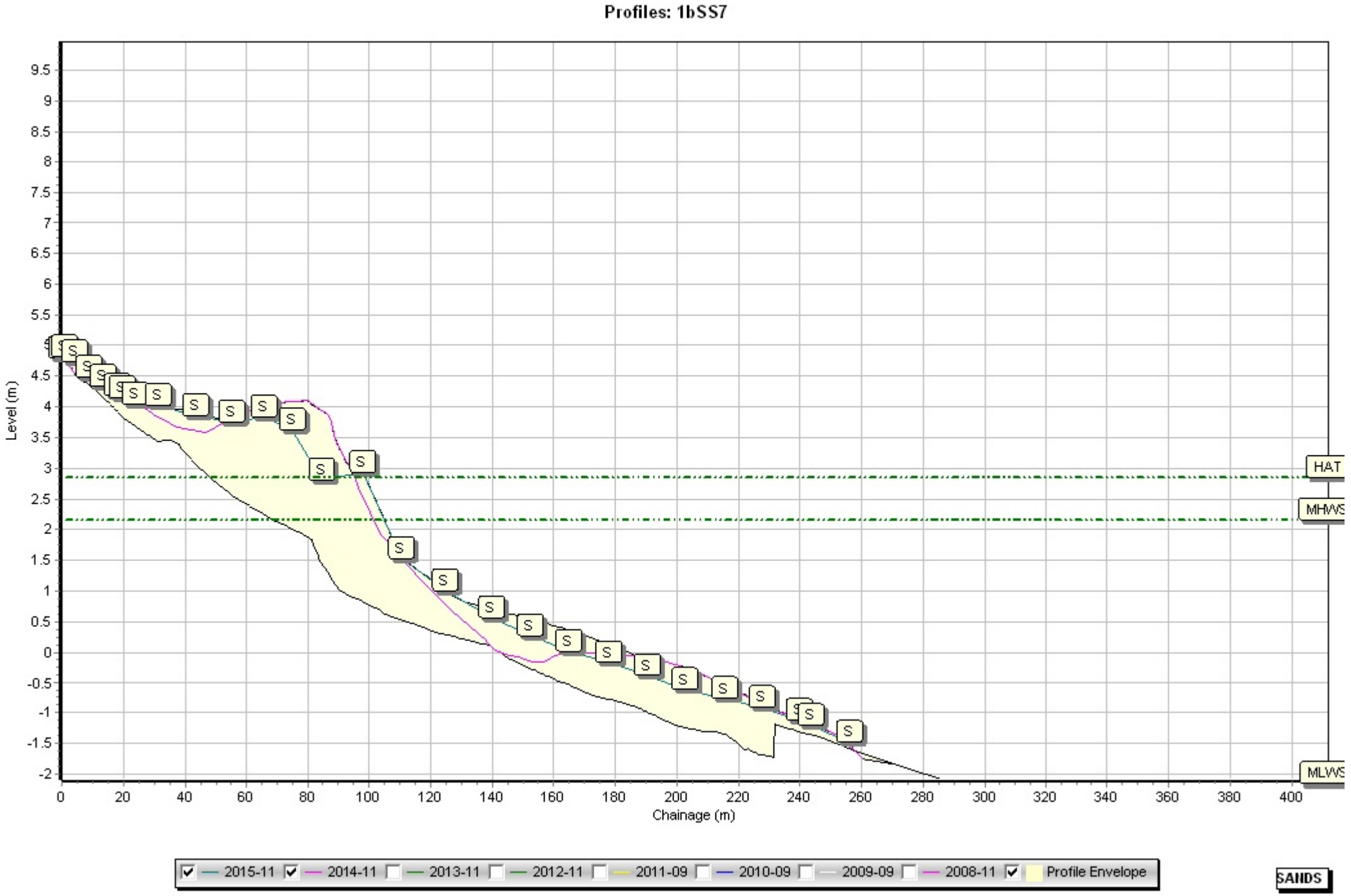

Profiles: 1bSS2
Level (m)
Chainage (m)
HAT
MHWS
MLWS
2015-11
2014-11
2013-11
2012-11
2011-09
2010-09
2009-09
2008-11
Profile Envelope
SANDS


Profiles: 1bSS3
Level (m)
Chainage (m)
HAT
MHWS
MLWS
2015-11
2014-11
2013-11
2012-11
2011-09
2010-09
2009-09
2008-11
Profile Envelope
SANDS

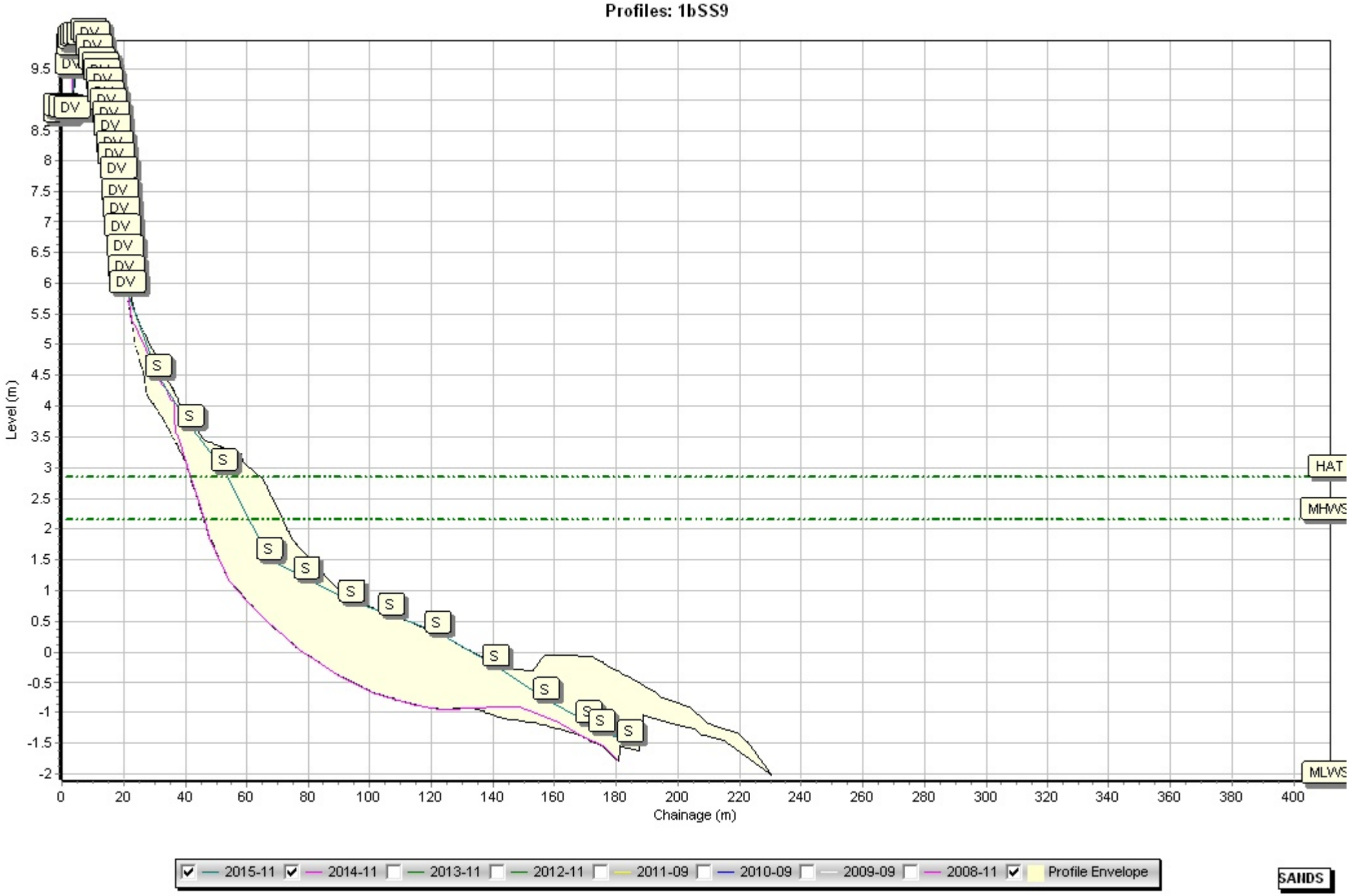

Profiles: 1bSS4
Level (m)
Chainage (m)
HAT
MHWS
MLWS
SD
ZZ
X
S
R
GS
2015-11
2014-11
2013-11
2012-11
2011-09
2010-09
2009-09
2008-11
Profile Envelope
SANDS

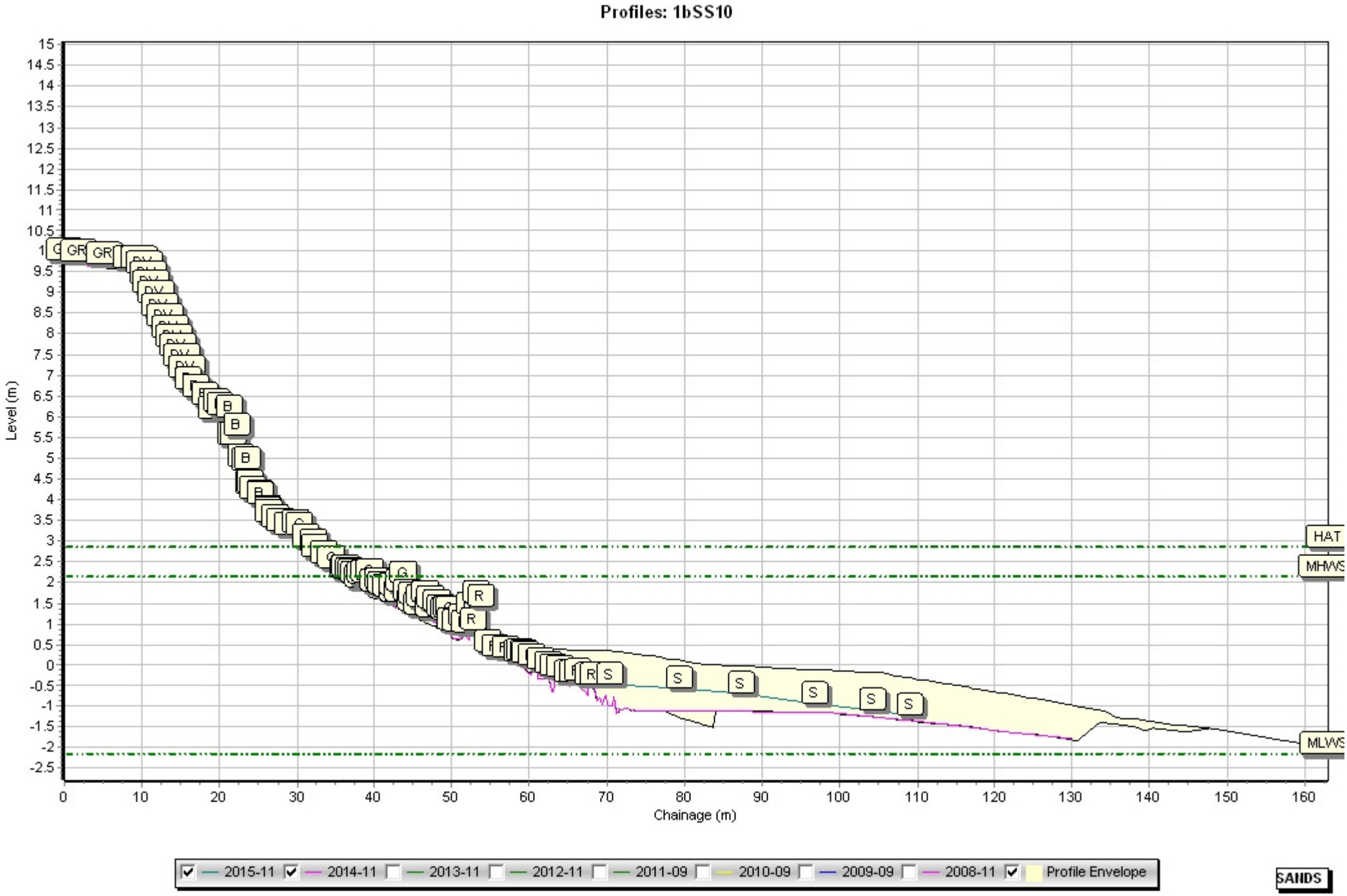

Profiles: 1bSS5
Level (m)
Chainage (m)
HAT
MHWS
MLWS
2015-11
2014-11
2013-11
2012-11
2011-09
2010-09
2009-09
2008-11
Profile Envelope
SANDS

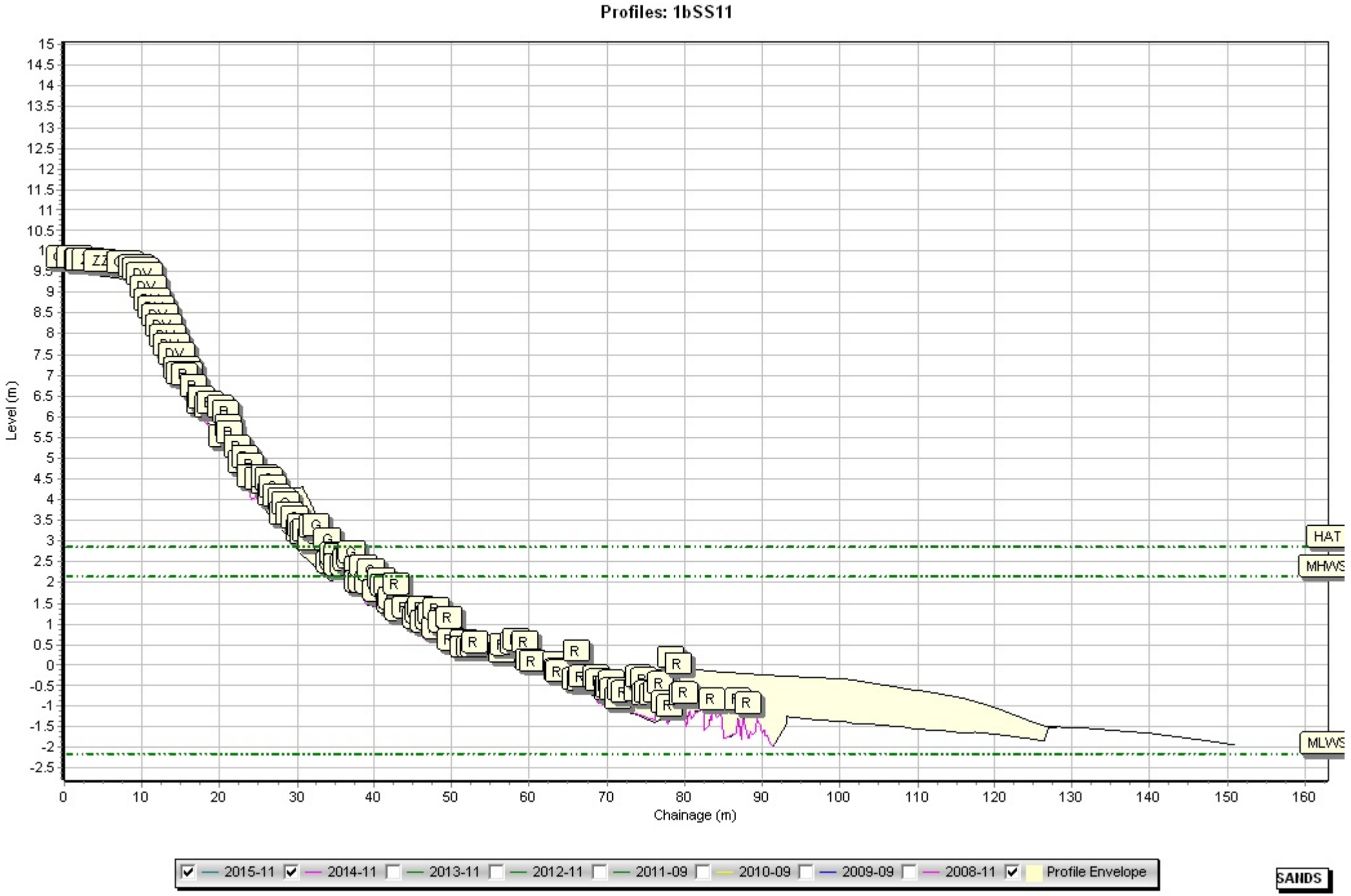

Profiles: 1bSS6
Level (m)
Chainage (m)
HAT
MHWS
MLWS
2015-11
2014-11
2013-11
2012-11
2011-09
2010-09
2009-09
2008-11
Profile Envelope
SANDS

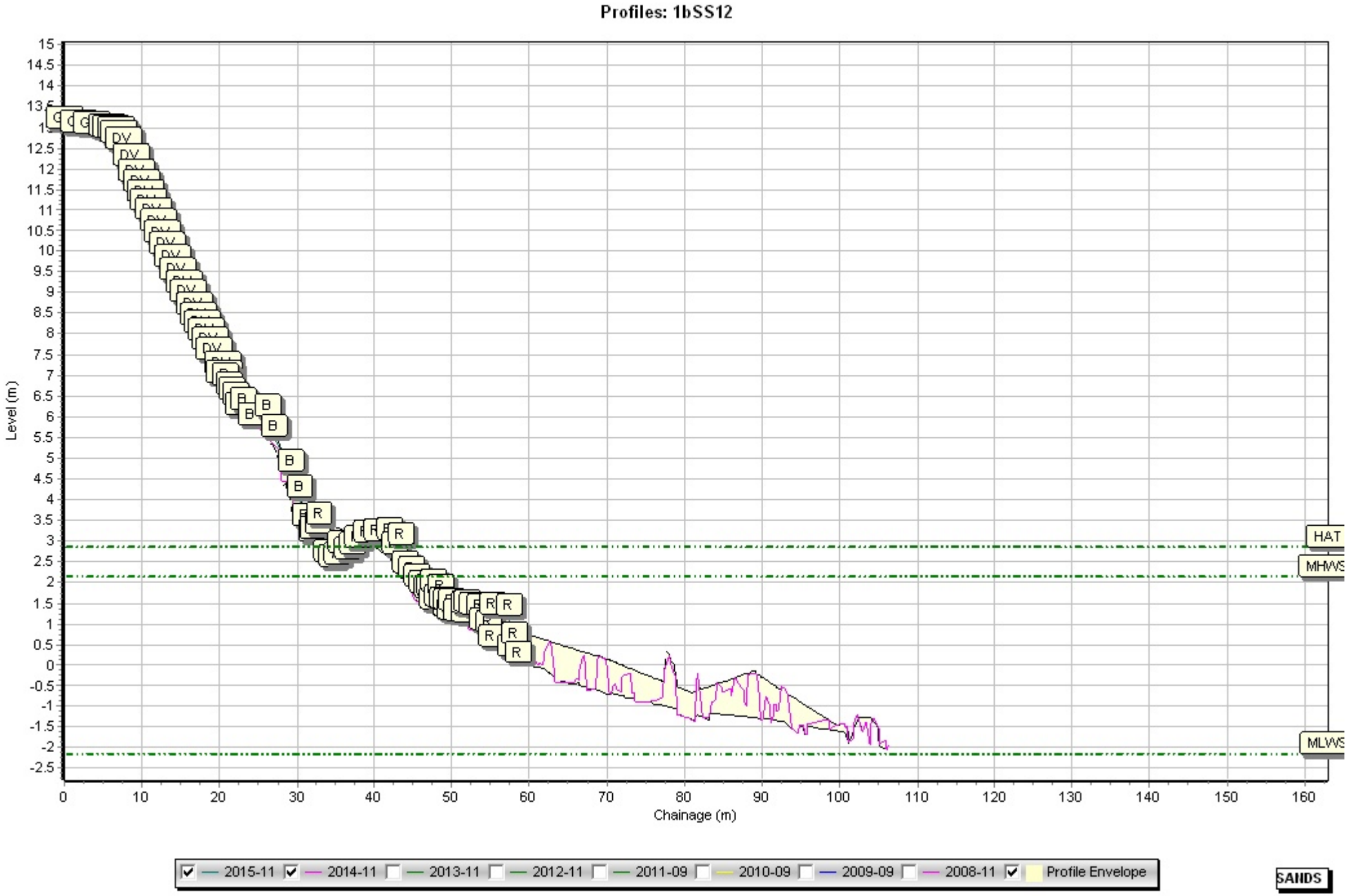

Profiles: 1bSS7
Level (m)
Chainage (m)
HAT
MHWS
MLWS
2015-11
2014-11
2013-11
2012-11
2011-09
2010-09
2009-09
2008-11
Profile Envelope
SANDS

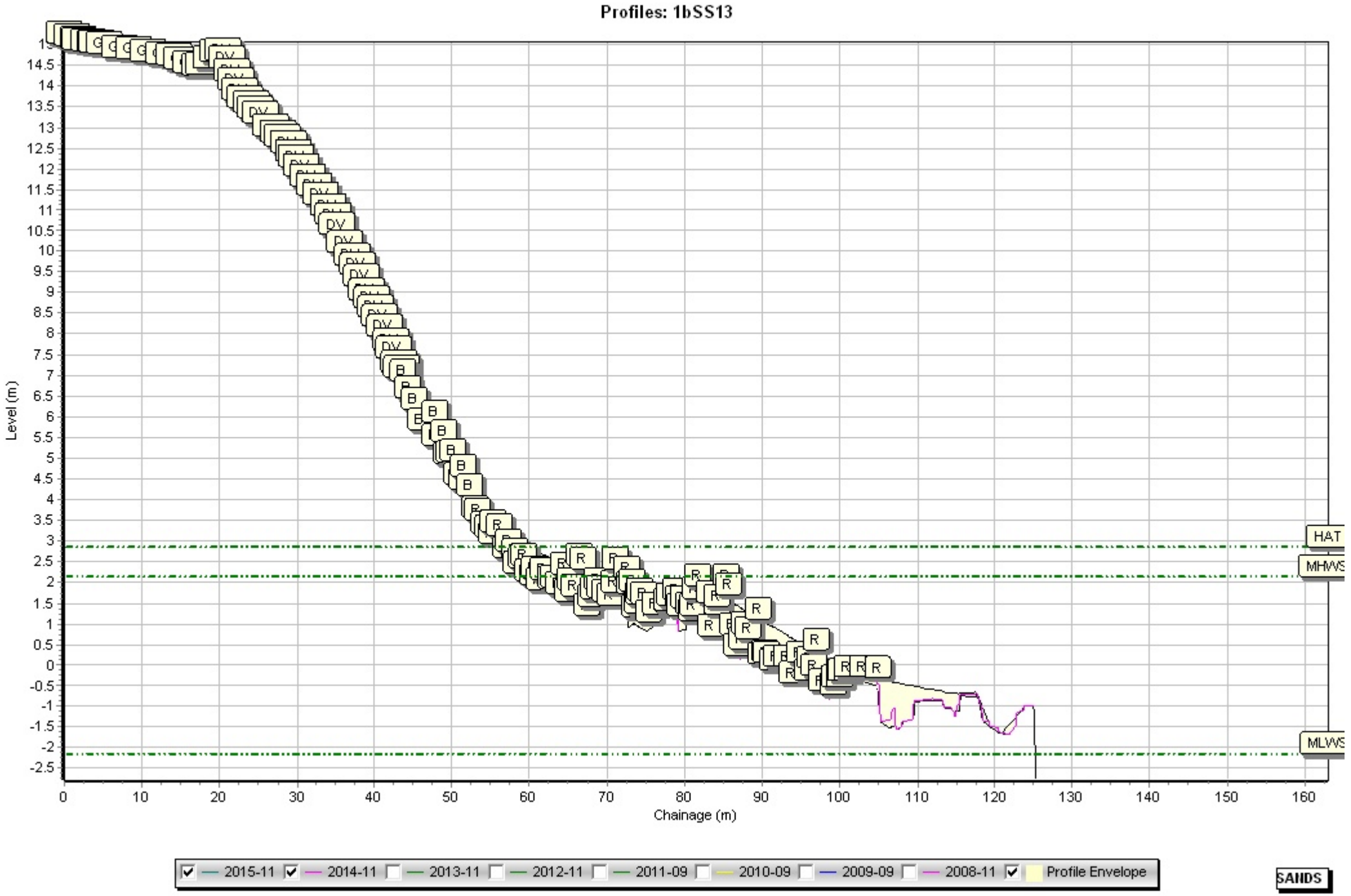

Profiles: 1bSS8
Level (m)
Chainage (m)
HAT
MHWS
MLWS
2015-11
2014-11
2013-11
2012-11
2011-09
2010-09
2009-09
2008-11
Profile Envelope
SANDS


Profiles: 1bSS9
Level (m)
Chainage (m)
DV
S
HAT
MHWS
MLWS
2015-11
2014-11
2013-11
2012-11
2011-09
2010-09
2009-09
2008-11
Profile Envelope
SANDS

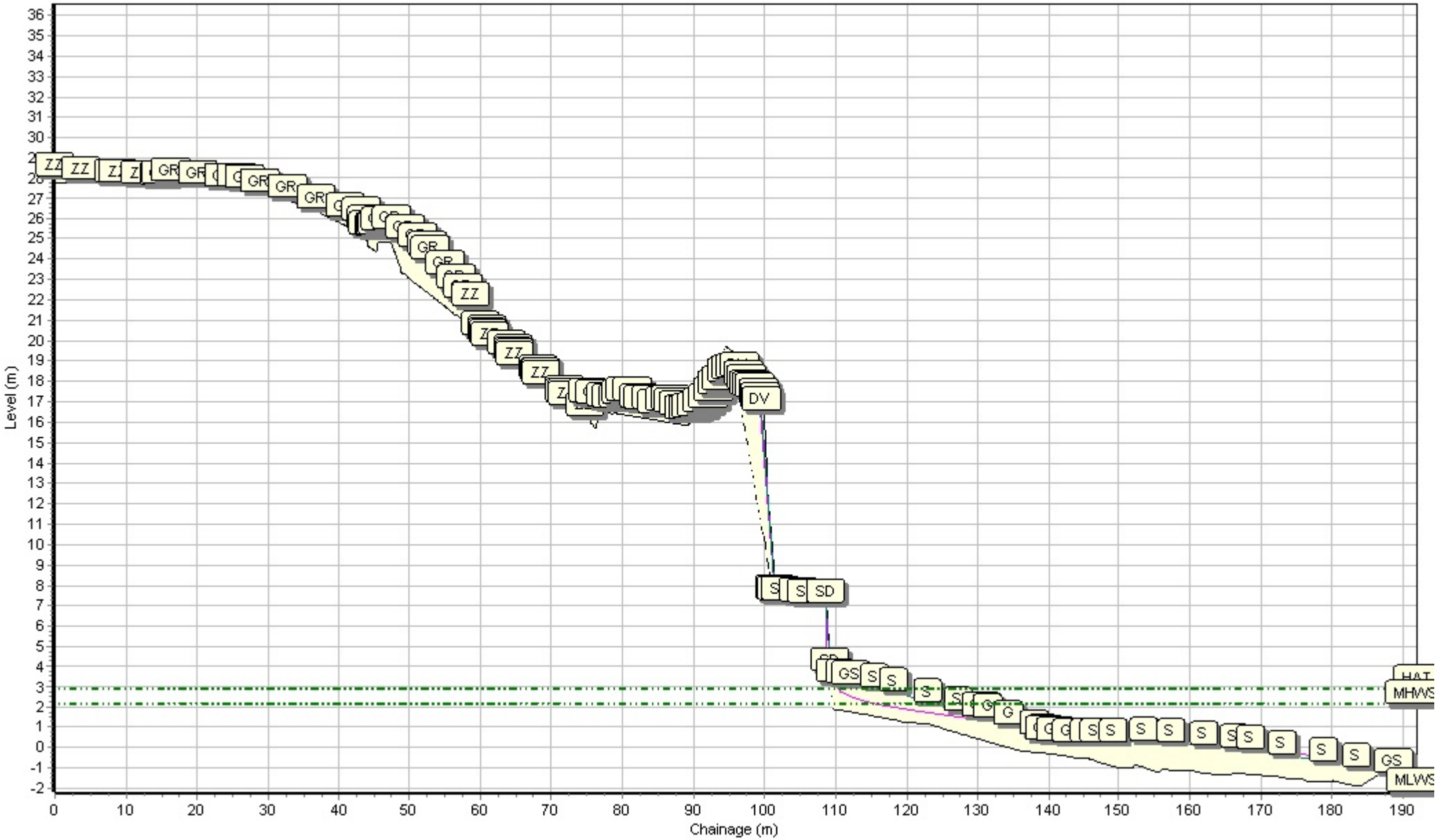

Profiles: 1bSS10
Level (m)
Chainage (m)
HAT
MHWS
MLWS
GR
B
R
S
2015-11
2014-11
2013-11
2012-11
2011-09
2010-09
2009-09
2008-11
Profile Envelope
SANDS


Profiles: 1bSS11
Level (m)
Chainage (m)
HAT
MHWS
MLWS
2015-11
2014-11
2013-11
2012-11
2011-09
2010-09
2009-09
2008-11
Profile Envelope
SAIDS

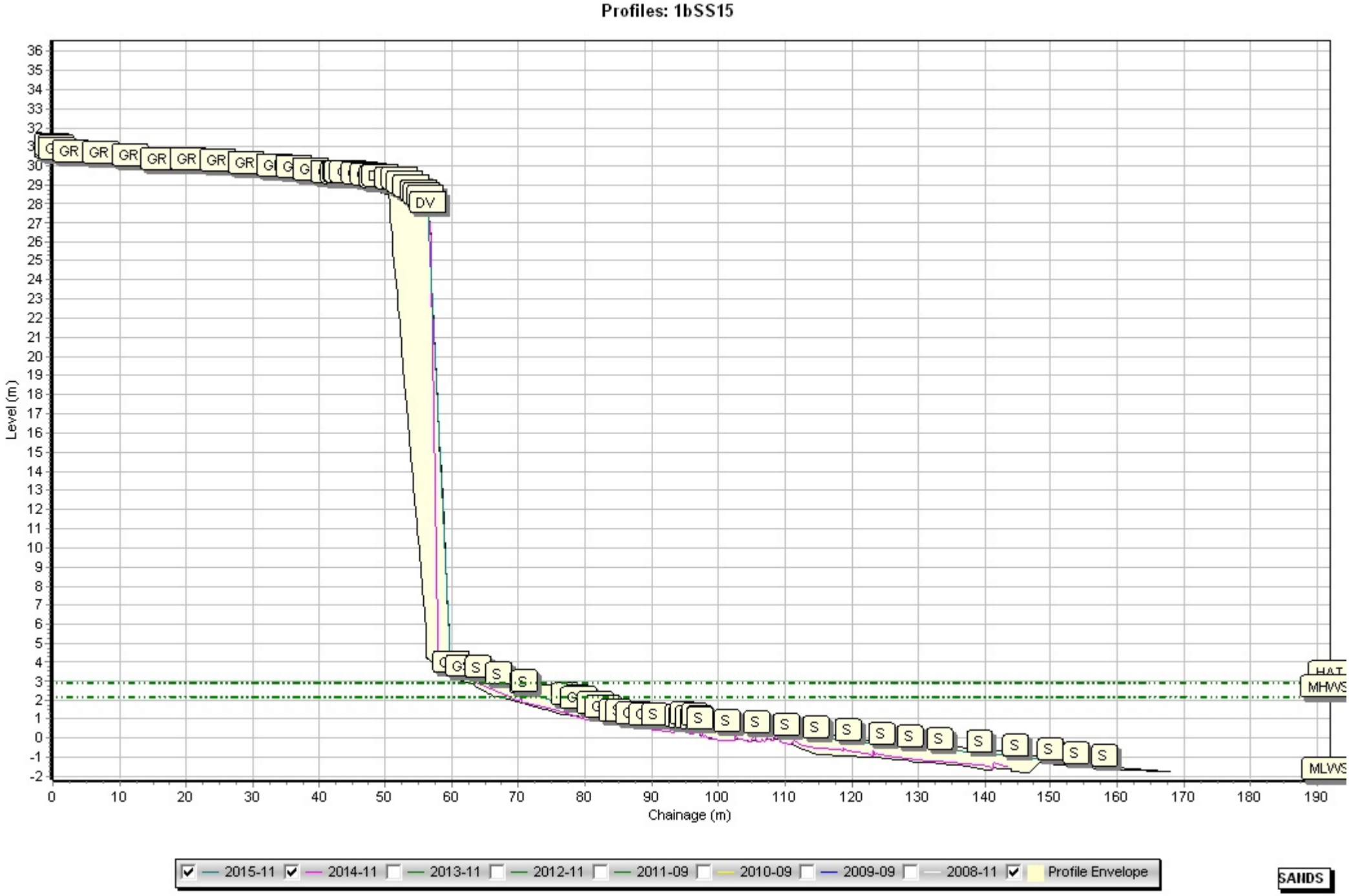

Profiles: 1bSS12
Level (m)
Chainage (m)
HAT
MHWS
MLWS
2015-11
2014-11
2013-11
2012-11
2011-09
2010-09
2009-09
2008-11
Profile Envelope
SANDS

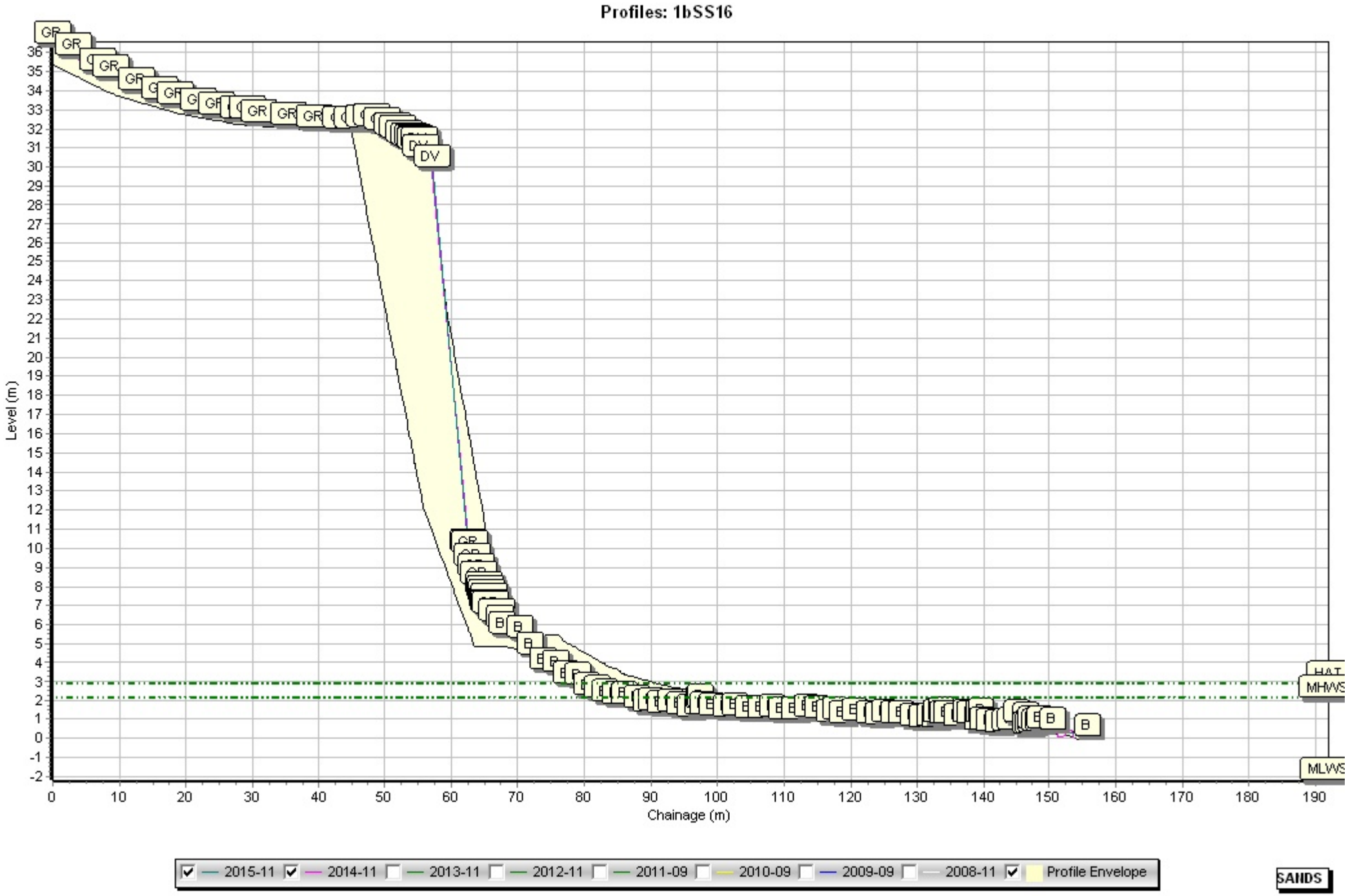

Profiles: 1bSS13
Level (m)
Chainage (m)
HAT
MHWS
MLWS
2015-11
2014-11
2013-11
2012-11
2011-09
2010-09
2009-09
2008-11
Profile Envelope
SANDS

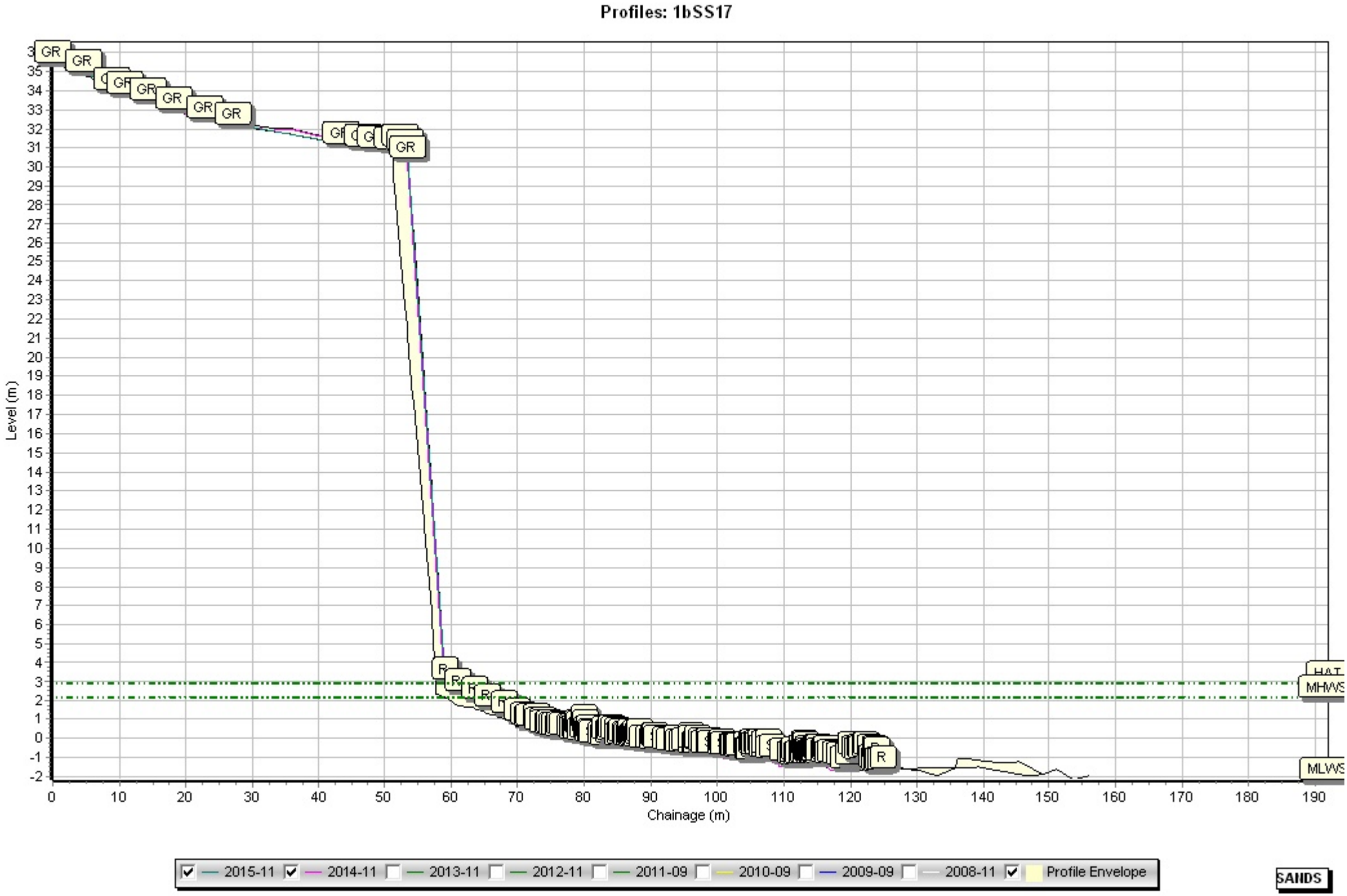
Profiles: 1bSS14



SANDS


Profiles: 1bSS15
Level (m)
Chainage (m)
DV
HAT
MHWS
MLWS
2015-11
2014-11
2013-11
2012-11
2011-09
2010-09
2009-09
2008-11
Profile Envelope
SANDS


Profiles: 1bSS16
Level (m)
Chainage (m)
GR
DV
B
MHWS
MLWS
2015-11
2014-11
2013-11
2012-11
2011-09
2010-09
2009-09
2008-11
Profile Envelope
SANDS

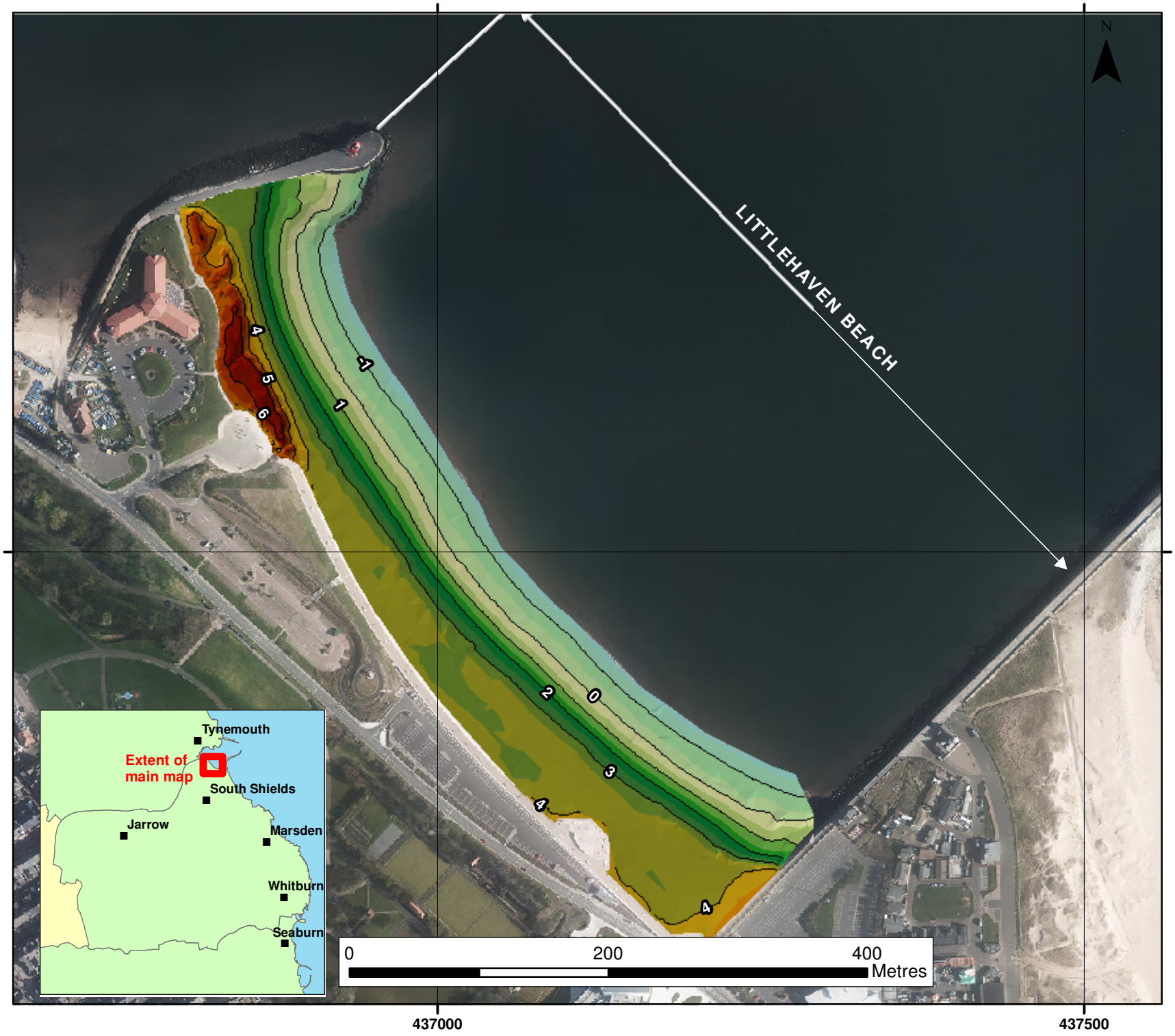

Profiles: 1bSS17
Level (m)
Chainage (m)
GR
R
HAT
MHWS
MLWS
2015-11
2014-11
2013-11
2012-11
2011-09
2010-09
2009-09
2008-11
Profile Envelope
SANDS

The following sediment feature codes are used on some profile plots:

Code	Description
S	Sand
M	Mud
G	Gravel
GS	Gravel & Sand
MS	Mud & Sand
B	Boulders
R	Rock
SD	Sea Defence
SM	Saltmarsh
W	Water Body
GM	Gravel & Mud
GR	Grass
D	Dune (non-vegetated)
DV	Dune (vegetated)
F	Forested
X	Mixture
FB	Obstruction
CT	Cliff Top
CE	Cliff Edge
CF	Cliff Face
SH	Shell
ZZ	Unknown

Appendix B

Topographic Survey



KEY

Elevation (mOD)

- 6.5 - 7
- 6 - 6.5
- 5.5 - 6
- 5 - 5.5
- 4.5 - 5
- 4 - 4.5
- 3.5 - 4
- 3 - 3.5
- 2.5 - 3
- 2 - 2.5
- 1.5 - 2
- 1 - 1.5
- 0.5 - 1
- 0 - 0.5
- -0.5 - 0
- -1 - -0.5
- -1.5 - -1
- -2 - -1.5
- Contour 1m

Client: North East Coastal Group

Project: Cell 1 Regional Coastal Monitoring Programme 2011 to 2016

Appendix B - Map 1a
Topographic Survey
Littlehaven Beach
SouthTyneside Council

Analytical Report 8
Fulll Measures Survey
Autumn 2015

ch2m

Halcrow Group Ltd, Lyndon House, 62 Hagley Road, Edgbaston, Birmingham, B16 8PE

Tel: +44 (0)121 456 2345
Fax: +44(0)121 456 1569
www.ch2m.com

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

KEY Spring 2015 and Autumn 2015 Change in elevation (m)

<-2	Loss
-2 - -1.75	
-1.75 - -1.5	
-1.5- -1.25	
-1.25 - -1	
-1 - -0.75	
-0.75 - -0.5	
-0.5 - -0.25	
-0.25 - -0.1	
-0.1 - 0	Change < 0.1 m
0 - 0.1	
0.1 - 0.25	Gain
0.25 - 0.5	
0.5 - 0.75	
0.75 - 1	
1 - 1.25	
1.25 - 1.5	
1.5 - 1.75	
1.75 - 2	
>2	

Contours of change

Client: North East Coastal Group
Project: Cell 1 Regional Coastal Monitoring Programme 2011 to 2016

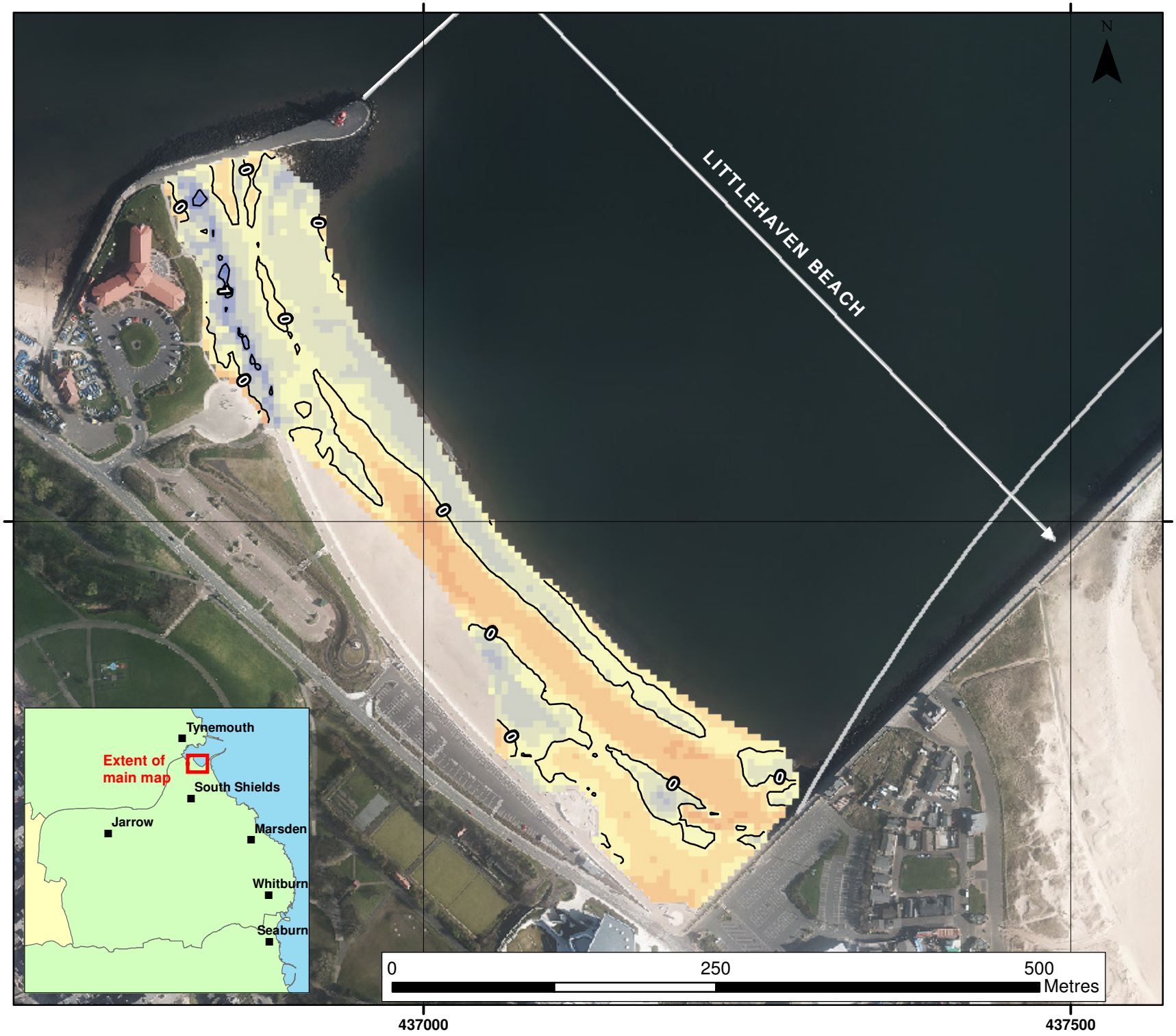
Appendix B- Map 1b Short-term Elevation Change Littlehaven SouthTyneside Council

Analytical Report 8
Full Measures Survey
Autumn 2015

ch2m

Halcrow Group Ltd, Lyndon House, 62 Hagley Road, Edgbaston, Birmingham, B16 8PE

Tel: +44 (0)121 456 2345
Fax: +44(0)121 456 1569
www.ch2m.com



KEY Autumn 2010 and Autumn 2015 Change in elevation (m)

<-2	Loss
-2 - -1.75	
-1.75 - -1.5	
-1.5- -1.25	
-1.25 - -1	
-1 - -0.75	
-0.75 - -0.5	
-0.5 - -0.25	
-0.25 - -0.1	
-0.1 - 0	Change < 0.1 m
0 - 0.1	
0.1 - 0.25	
0.25 - 0.5	
0.5 - 0.75	
0.75 - 1	
1 - 1.25	Gain
1.25 - 1.5	
1.5 - 1.75	
1.75 - 2	
>2	

Contours of change

Client: North East Coastal Group
Project: Cell 1 Regional Coastal Monitoring Programme 2011 to 2016

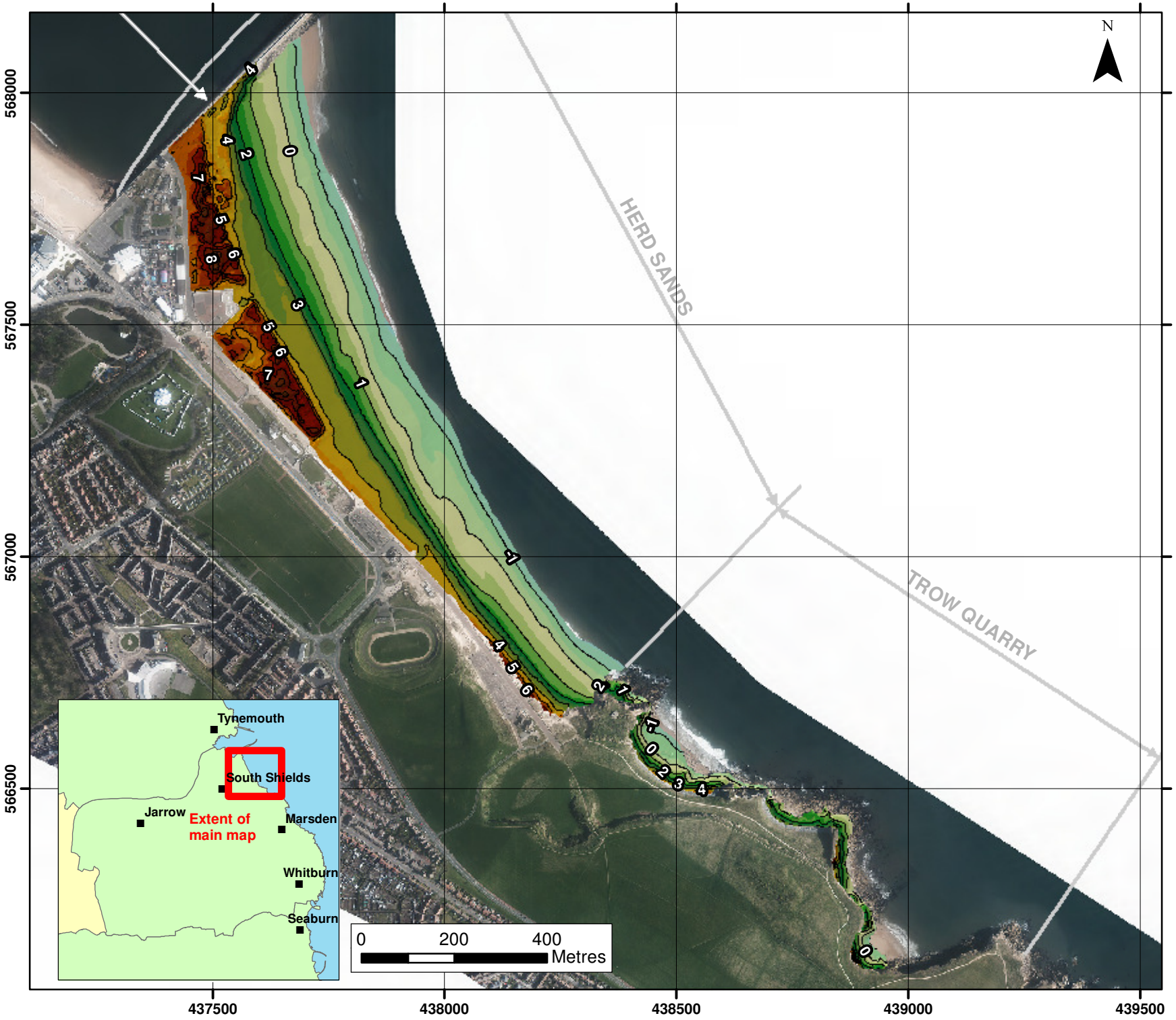
Appendix B- Map 1c
Long-term Elevation Change
Littlehaven
SouthTyneside Council

Analytical Report 8
Full Measures Survey
Autumn 2015

ch2m

Halcrow Group Ltd, Lyndon House, 62 Hagley Road, Edgbaston, Birmingham, B16 8PE

Tel: +44 (0)121 456 2345
Fax: +44(0)121 456 1569
www.ch2m.com



KEY

Elevation (mOD)

12.5 - 13	5 - 5.5
12 - 12.5	4.5 - 5
11.5 - 12	4 - 4.5
11 - 11.5	3.5 - 4
10.5 - 11	3 - 3.5
10 - 10.5	2.5 - 3
9.5 - 10	2 - 2.5
9 - 9.5	1.5 - 2
8.5 - 9	1 - 1.5
8 - 8.5	0.5 - 1
7.5 - 8	0 - 0.5
7 - 7.5	-0.5 - 0
6.5 - 7	-1 - -0.5
6 - 6.5	-1.5 - -1
5.5 - 6	-2 - -1.5

— Contour 1m

Client: North East Coastal Group

Project: Cell 1 Regional Coastal Monitoring Programme 2011 to 2016

Appendix B - Map 2a
Topographic Survey
Herd Sands and Trow Quarry
South Tyneside Council

Analytical Report 8
Full Measures Survey
Autumn 2015

ch2m

Halcrow Group Ltd, Lyndon House, 62 Hagley Road, Edgbaston, Birmingham, B16 8PE

Tel: +44 (0)121 456 2345
Fax: +44(0)121 456 1569
www.ch2m.com

KEY Autumn 2014 and Autumn 2015 Change in elevation (m)

- <-2
- -2 - -1.75
- -1.75 - -1.5
- -1.5- -1.25
- -1.25 - -1
- -1 - -0.75
- -0.75 - -0.5
- -0.5 - -0.25
- -0.25 - -0.1
- -0.1 - 0
- 0 - 0.1
- 0.1 - 0.25
- 0.25 - 0.5
- 0.5 - 0.75
- 0.75 - 1
- 1 - 1.25
- 1.25 - 1.5
- 1.5 - 1.75
- 1.75 - 2
- >2

Loss

Change < 0.1 m

Gain

Contours of change

Client: North East Coastal Group
Project: Cell 1 Regional Coastal Monitoring Programme 2011 to 2016

Appendix B- Map 2b Short-term Elevation Change Herd Sands and Trow Quarry SouthTyneside Council

Analytical Report 8
Full Measures Survey
Autumn 2015

Halcrow Group Ltd, Lyndon House, 62 Hagley Road, Edgbaston, Birmingham, B16 8PE

Tel: +44 (0)121 456 2345
Fax: +44(0)121 456 1569
www.ch2m.com

KEY Autumn 2010 and Autumn 2015
Change in elevation (m)

<-2	Loss
-2 - -1.75	
-1.75 - -1.5	
-1.5- -1.25	
-1.25 - -1	
-1 - -0.75	
-0.75 - -0.5	
-0.5 - -0.25	
-0.25 - -0.1	
-0.1 - 0	Change < 0.1 m
0 - 0.1	
0.1 - 0.25	Gain
0.25 - 0.5	
0.5 - 0.75	
0.75 - 1	
1 - 1.25	
1.25 - 1.5	
1.5 - 1.75	
1.75 - 2	
>2	

Contours of change

Client: North East Coastal Group
Project: Cell 1 Regional Coastal Monitoring Programme 2011 to 2016

Appendix B- Map 2c Long-term Elevation Change Herd Sands and Trow Quarry SouthTyneside Council

Analytical Report 8
Full Measures Survey
Autumn 2015

Halcrow Group Ltd, Lyndon House, 62 Hagley Road, Edgbaston, Birmingham, B16 8PE

Tel: +44 (0)121 456 2345
Fax: +44(0)121 456 1569
www.ch2m.com

Appendix C

Cliff Top Survey

Cliff Top Survey

Trow Quarry

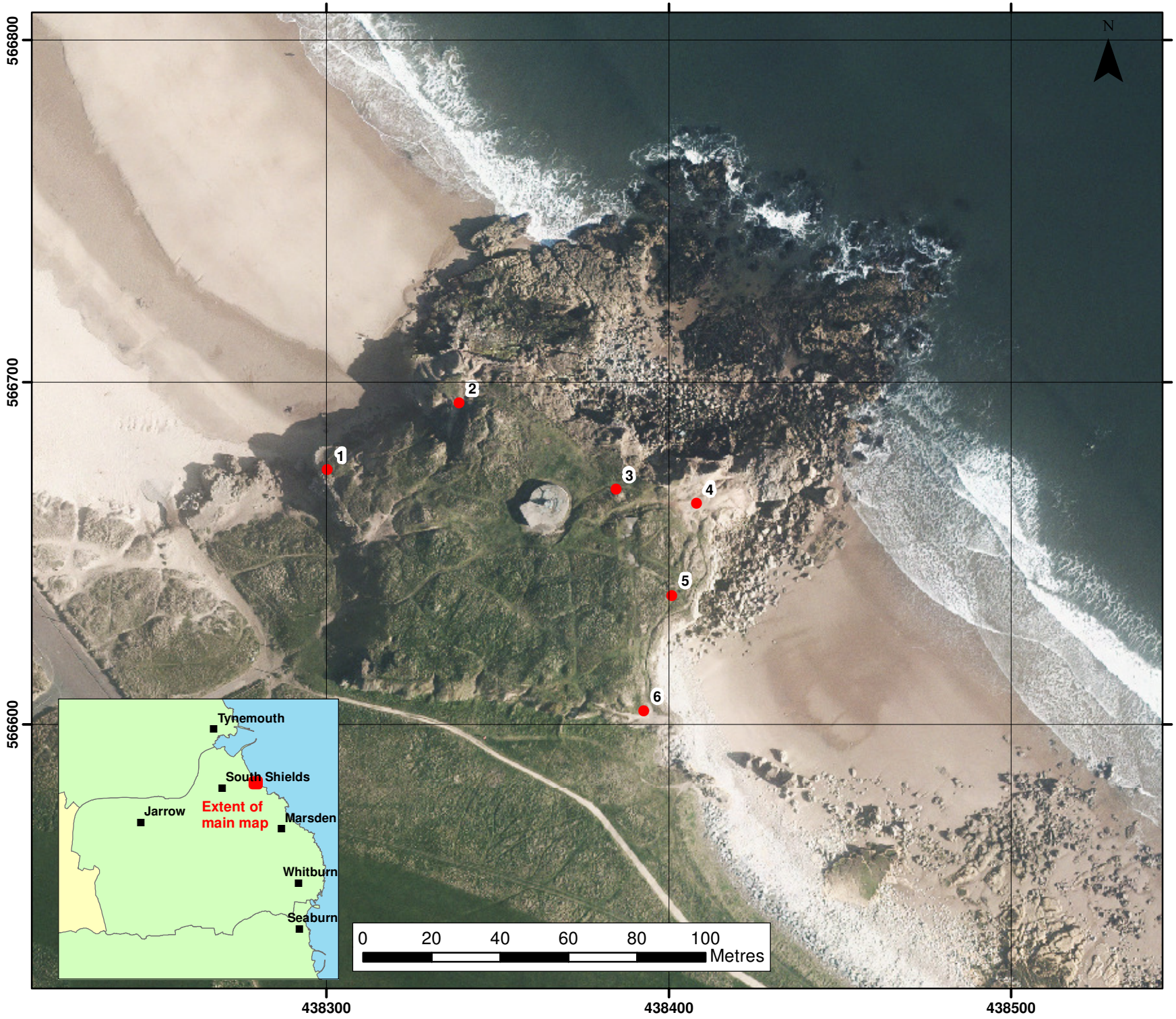
Six ground control points have been established at Trow Quarry (Figure C1). The maximum separation between any two points varies along the coast, reflecting the degree of risk from the erosion.

The cliff top surveys at Trow Quarry are undertaken bi-annually. Measurements are taken from a fixed ground control point along a fixed bearing to the edge of the cliff top.

Table C1 provides baseline information about these ground control points and results from the 2011 (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 C1 – Cliff Top Surveys at Trow Quarry

Ground Control Point Details	Distance to Cliff Top (m)			Total Erosion (m)		Erosion Rate (m/year)
Ref	Baseline Survey (Sept 2011)	Previous Survey (Apr 2015)	Present Survey (Nov 2015)	Baseline (Sept 2011) to Present (Nov 2015)	Previous Survey (Apr 2015) to Present (Nov 2015)	Baseline (Sept 2011) to Present (Nov 2015)
1	7.0	6.9	6.9	-0.2	0.0	0.0
2	9.4	9.3	9.9	0.5	0.6	0.1
3	7.0	7.1	7.0	0.0	-0.1	0.0
4	10.5	10.5	10.6	0.1	0.1	0.0
5	7.0	7.6	7.6	0.5	0.0	0.1
6	10.2	10.1	10.3	0.1	0.1	0.0



KEY

- Cliff top survey locations

Client: North East Coastal Group

Project: Cell 1 Regional Coastal Monitoring Programme 2011 to 2016

Appendix C- Map 1
Cliff Top Survey
Trow Quarry
South Tyneside Council

Analytical Report 8
Full Measures Survey
Autumn 2015

Halcrow Group Ltd, Lyndon House, 62 Hagley Road, Edgbaston, Birmingham, B16 8PE

Tel: +44 (0)121 456 2345
Fax: +44(0)121 456 1569
www.ch2m.com