Cell 1 Regional Coastal Monitoring Programme
Analytical Report 6: 'Full Measures' Survey 2013

North Tyneside Council
Final Report

North Tyneside Council

February 2014

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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
HAT	3.1
MHWS	2.4
MLWS	-1.9

Source: *Scottish Border to River Tyne Shoreline Management Plan 2.* Royal Haskoning, May 2009.

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.

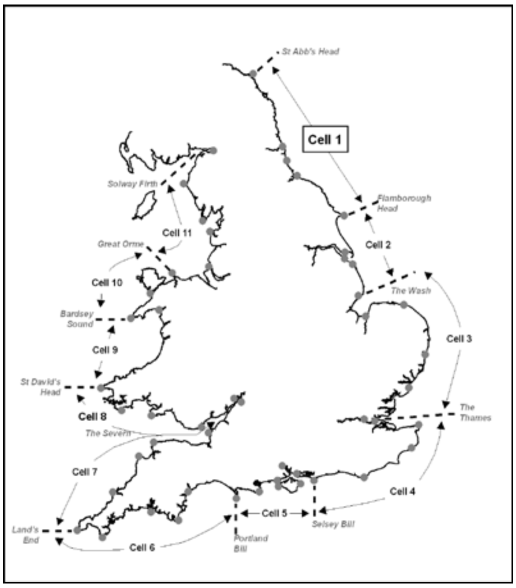


Figure 1 Sediment Cells in England and Wales

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:

Northumberland County Council
North Tyneside Council
South Tyneside Council
Northumberland Coast Area of Outstanding Natural Beauty
Sunderland City Council
Durham County Council
Redcar & Cleveland Borough Council
Hartlepool Borough Council
Borough of Scarborough – A great place to live, work & play
East Riding of Yorkshire Council
Environment Agency
Natural England
The National Trust

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 every year (referred to as winter in previous reporting). 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	Jul 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	Sept-Oct 12	Feb 13	Mar – Apr 13	Jun 13	
6	2013/14	Sept-Oct 13	Feb 14 (*)			

(*) The present report is **Analytical Report 6** and provides an analysis of the 2013 'baseline' Full Measures survey for North 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

North Tyneside Council's frontage extends from Hartley (just south of Blythe) in the north to River Tyne in the south. For the purposes of this report and for consistency with previous reporting, it has been sub-divided into four areas, namely:

- Whitley Sands
- Cullercoats Bay
- Tynemouth Long Sands
- King Edward's Bay

1.2 Methodology

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

- Full Measures survey annually each autumn comprising:
    - Beach profile surveys along eight transect lines (commenced 2002)
    - Beach profile surveys along an additional two transects (commenced 2010)
    - Topographic survey along Whitley Sands (commenced 2010)
    - Topographic survey along Tynemouth Long Sands (commenced 2011)

- Partial Measures survey annually each spring comprising:
    - Beach profile surveys along all ten transect lines (commenced 2010)

The location of these surveys is shown in Figure 2. The baseline Full Measures survey was undertaken along this frontage between 2nd October 2013 and 2nd November 2013. During this time the weather conditions were cloudy and dry but the wind conditions and sea state varied; refer to the survey reports for details of the weather conditions.

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:

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

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 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 will update the baseline with analysis of the wave data collected under the programme for 2013, including the 5th and 6th December storm. 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 3 below.

To aid interpretation of the results in Table 3 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

General Storm Information					At Peak			
Start Time	End Time	Duration (Hours)	Peak of Storm	Mean Direction Vector (Degrees)	Hs (m)	Tp (s)	Direction (Degrees)	Energy @ Peak (KJ/m/s)
19/03/2007 10:30	21/03/2007 05:30	43	20/03/2007 14:30	79.0	6.2	12.4	22	11759.3
25/06/2007 20:00	26/06/2007 13:30	17.5	26/06/2007 10:00	81.6	4.4	8.6	22	2832.6
26/09/2007 03:00	27/09/2007 05:00	26	26/09/2007 19:00	80.4	4.6	11.6	6	5488.7
08/11/2007 20:00	**12/11/2007 15:00**	**91**	**09/11/2007 08:30**	**78.7**	**6.2**	**13.4**	**6**	**13698.9**
19/11/2007 03:30	25/11/2007 21:30	162	23/11/2007 05:00	78.8	4.9	10.7	17	5353.7
08/12/2007 03:00	10/12/2007 14:30	59.5	08/12/2007 03:30	85.1	4.1	10.8	17	3816.4
03/01/2008 10:30	04/01/2008 01:30	15	03/01/2008 23:30	14.8	4.2	9.1	62	2964.9
01/02/2008 15:00	02/02/2008 09:30	18.5	02/02/2008	80.9	6.0	13.8	17	13641.7
10/03/2008 08:30	10/03/2008 12:30	4	10/03/2008 11:00	307.6	4.6	8.0	141	2631.9
17/03/2008 15:00	**25/03/2008 03:00**	**180**	**22/03/2008 05:00**	**83.8**	**7.9**	**12.4**	**6**	**19123.9**
05/04/2008 22:00	07/04/2008 05:00	31	06/04/2008 19:00	83.8	4.6	11.6	6	5520.5
20/07/2008 16:00	21/07/2008 09:30	17.5	20/07/2008 23:30	75.9	4.2	9.9	11	3492.5
03/10/2008 03:00	03/10/2008 20:30	17.5	03/10/2008 16:30	82.4	4.7	11.4	22	5728.4
21/11/2008 04:00	25/11/2008 12:30	104.5	22/11/2008 11:30	75.8	6.0	13.1	11	12267.5

General Storm Information					At Peak			
Start Time	**End Time**	**Duration (Hours)**	**Peak of Storm**	**Mean Direction Vector (Degrees)**	**Hs (m)**	**Tp (s)**	**Direction (Degrees)**	**Energy @ Peak (KJ/m/s)**
10/12/2008 12:00	13/12/2008 18:00	78	13/12/2008 08:00	331.9	4.9	8.3	129	3286.2
31/01/2009 16:30	03/02/2009 09:00	64.5	02/02/2009 22:00	7.1	5.8	9.5	84	6078.5
23/03/2009 20:30	28/03/2009 20:30	120	28/03/2009 18:30	89.7	4.9	9.3	0	4053.0
10/07/2009 01:30	10/07/2009 02:30	1	10/07/2009 01:30	78.8	4.2	9.9	11	3504.3
29/11/2009 20:00	**30/11/2009 15:00**	**19**	**30/11/2009 00:30**	**73.4**	**6.0**	**9.4**	**11**	**6331.4**
17/12/2009 10:30	18/12/2009 05:00	18.5	17/12/2009 19:30	26.4	5.4	10.6	68	**6549.5**
30/12/2009 09:00	30/12/2009 23:00	14	30/12/2009 12:30	7.7	5.1	7.5	90	2866.0
06/01/2010 05:30	06/01/2010 11:00	5.5	06/01/2010 06:30	63.7	4.2	10.7	11	4044.1
29/01/2010 10:30	30/01/2010 00:30	14	29/01/2010 22:30	83.9	5.4	8.6	6	4258.2
26/02/2010 22:30	27/02/2010 02:30	4	27/02/2010 01:00	72.6	4.6	8.5	17	2925.7
19/06/2010 07:00	20/06/2010 08:30	25.5	19/06/2010 20:00	69.4	5.4	10.7	22	**6611.8**
29/08/2010 14:00	30/08/2010 06:30	16.5	29/08/2010 22:30	91.8	4.9	8.9	0	3715.5
06/09/2010 22:30	07/09/2010 16:00	17.5	07/09/2010 15:30	353.3	4.6	8.8	90	3192.5
17/09/2010 07:00	17/09/2010 18:30	11.5	17/09/2010 08:30	80.8	4.7	11.0	11	5323.3
24/09/2010 03:00	26/09/2010	45	24/09/2010 10:00	73.1	5.3	10.1	11	5564.7
20/10/2010 02:00	24/10/2010 16:30	110.5	20/10/2010 10:00	78.3	4.2	11.3	17	4514.5
08/11/2010 14:00	**09/11/2010 20:30**	**30.5**	**09/11/2010 10:00**	**3.1**	**5.6**	**8.8**	**73**	**4870.6**
17/11/2010 11:00	17/11/2010 18:30	7.5	17/11/2010 12:00	322.2	4.7	7.8	129	2646.0
29/11/2010 19:30	02/12/2010 08:30	61	29/11/2010 21:00	11.8	5.1	9.4	56	4474.2
16/12/2010 15:00	17/12/2010 06:30	15.5	17/12/2010 03:30	80.2	4.6	10.5	17	4504.6
23/07/2011 14:00	**24/07/2011 11:00**	**21**	**24/07/2011 03:00**	**67.5**	**4.7**	**10.8**	**17**	**5082.6**
24/10/2011 18:30	25/10/2011 09:30	15	25/10/2011 09:30	348.5	4.1	9.5	79	2986.1
09/12/2011 08:30	09/12/2011 10:00	1.5	09/12/2011 08:30	84.4	4.1	11.9	6	4669.0
05/01/2012 15:30	06/01/2012 05:00	13.5	06/01/2012 00:30	81.4	4.5	9.9	14	3896.6
03/04/2012 13:30	04/04/2012 10:30	21	04/04/2012 03:00	26.5	5.7	8.4	90	4510.0
24/09/2012 07:30	25/09/2012 11:00	27.5	24/09/2012 17:30	17.2	5.3	9.3	77	4786.2
26/10/2012 12:00	27/10/2012 15:00	27	26/10/2012 23:00	78.9	4.9	12.9	11	**7839.9**
05/12/2012 15:00	**15/12/2012 01:30**	**226.5**	**14/12/2012 18:30**	**39.6**	**6.1**	**8.4**	**107**	**5080.9**
20/12/2012 06:00	21/12/2012 14:30	32.5	20/12/2012 23:30	347.3	6.0	8.8	103	5436.3
18/01/2013 17:30	22/01/2013 07:30	86	21/01/2013 09:30	7.6	6.8	9.3	83	7978.4
06/02/2013 08:00	07/02/2013 08:30	24.5	06/02/2013 12:30	82.6	5.6	9.9	11	6039.7
07/03/2013 21:00	11/03/2013 04:00	79	08/03/2013 04:00	24.3	5.1	8.4	82	3667.4
18/03/2013 07:00	**25/03/2013 02:00**	**163**	**23/03/2013 10:30**	**4.5**	**7.3**	**9.3**	**89**	**9164.3**

General Storm Information					At Peak			
Start Time	End Time	Duration (Hours)	Peak of Storm	Mean Direction Vector (Degrees)	Hs (m)	Tp (s)	Direction (Degrees)	Energy @ Peak (KJ/m/s)
23/05/2013 18:00	24/05/2013 12:00	18	23/05/2013 22:30	77.5	6.7	10.5	17	**9678.4**
10/09/2013 13:00	10/09/2013 19:30	6.5	10/09/2013 14:00	79.3	4.4	9.2	11	3237.0
29/11/2013 22:30	30/11/2013 05:30	7	30/11/2013 00:30	82.8	5.6	10.7	11	7071.5
05/12/2013 14:00	07/12/2013 04:30	38.5	06/12/2013 20:00	80.4	4.7	14.3	6	8937.4
27/12/2013 09:30	27/12/2013 12:30	3	27/12/2013 10:00	249.3	4.1	6.1	202	1237.4

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.

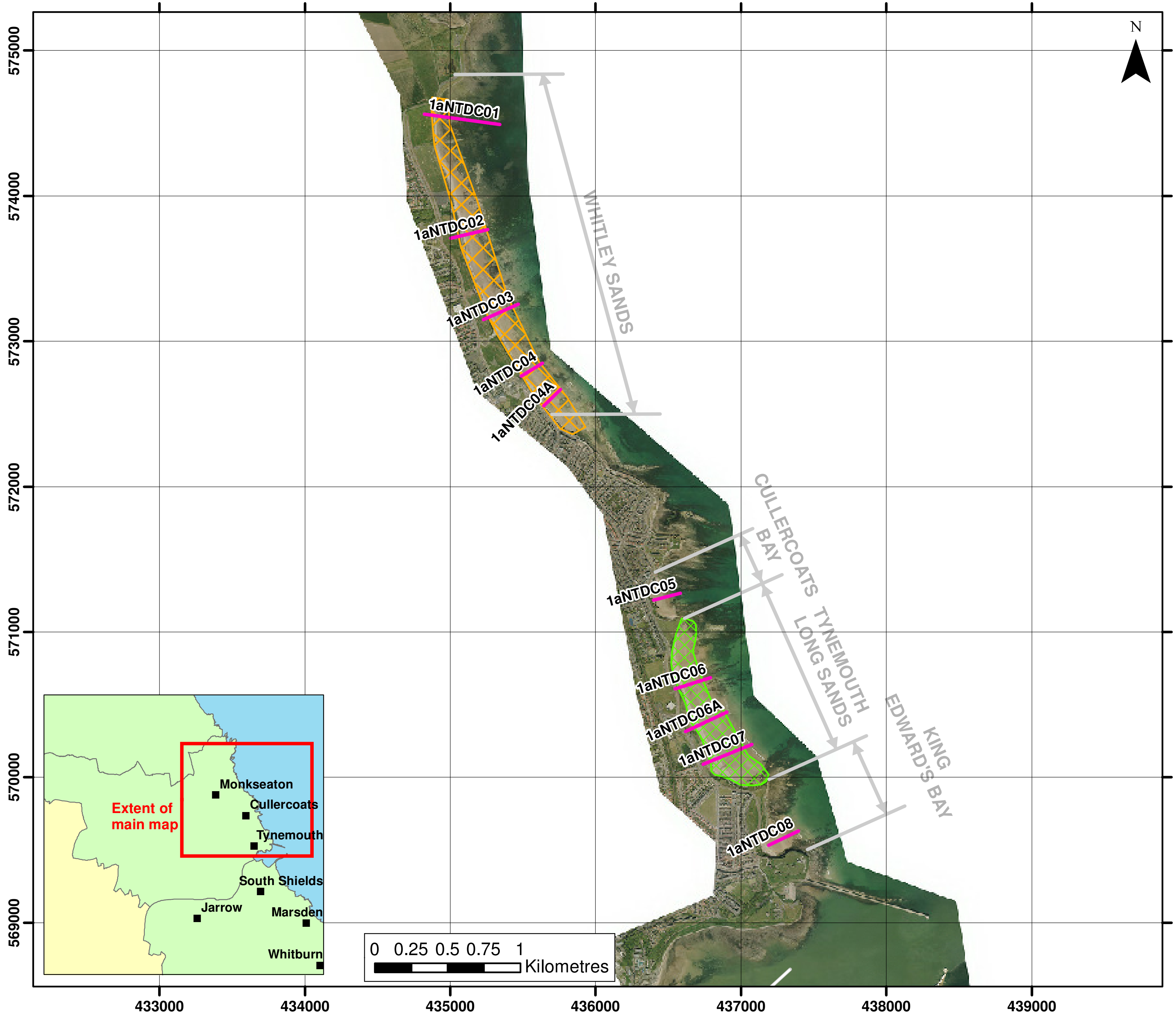
Comparing the annual storm records it can be seen that 2010 had the most storms (13). In 2010 the largest storm had an incident direction of 73 degrees which is unusual. We might therefore expect that the alongshore drift on the Cell 1 beaches in 2010 may have been atypical with unusual changes from 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 autumn 2013 survey data were collected between 2nd October and 2nd November, a considerable time after the 10th September storm and therefore should not be impacted by recent storms.

The storm on the 5th to 7th December, 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. However, the autumn 2013 full-measures survey data set which is assessed in this report was collected before this, in October and November and as no post storm surveys were available the impacts will be seen until the spring 2014 Partial Measures surveys.



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
Whitley Sands
to King Edward's Bay
North Tyneside Council

Analytical Report 6
Full Measures Survey
Autumn 2013

CH2MHILL. Halcrow

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3. Analysis of Survey Data

3.1 Whitley Sands

Survey Date	Description of Changes Since Last Survey	Interpretation
Sept 2013	**Beach Profiles:** Whitley Sands is covered by five beach profile lines for the Full Measures survey (Appendix A). Four of these (1aNTDC01 to 1aNTDC04) were initially surveyed in April 2002 and were surveyed annually to 2009 (full measures, autumn 2009). Since then, they have been surveyed bi-annually. From March 2010 (partial measures, spring 2010) onwards, an additional beach profile line (NTDC04A) has been surveyed at the southern end of the frontage for the same time periods listed above. All profiles were last surveyed in March 2013 for the partial measures survey. **1aNTDC01** is located in the north of Whitley Sands, along the undefended cliffs just to the south of Trinity Road Car Park. There is only a small change in beach profile since the March survey but in general the beach has accreted, with beach levels rising at the base of the cliff (down to 45m chainage) but only by up to 0.2m. Between 70m and 145m chainage the beach levels have risen to a greater degree, by up to 0.3m. There has been little change along other parts of the profile. Profile **1aNTDC02** is located to the north of Whitley Sands opposite the seawall. A general increase in beach levels can be observed in this profile since the March survey. Beach levels from the toe of the cliff to 152m chainage have increased by up to 0.75m. Lower on the profile however the toe has dropped, with sand cover lost and a greater area of rock being exposed. This profile is now close in form to that of the September 2012 survey, supporting comments in the 2012 full measures report that the March profile may have been a post storm profile. Profile **1aNTDC03** is located at the centre of Whitley Sands. The beach profile has steepened since the March survey with beach levels increasing at the top of the profile but decreasing towards the seaward extent of the profile. At the top of the profile, between 30m and 65m chainage, the beach level has risen by up to 0.3m, while beach levels from chainage 65m to the seawards end of the profile have then fallen by up to 0.6m. At profile **1aNDC04** a similar pattern can be identified as for **1aNTDC03**. The beach profile has steepened with beach levels increasing slightly (by about 0.2m) between 22m and 58m chainage but	Along the length of Whitley Sands, the trends observed at each profile are similar. The upper beach has accreted, whilst the lower beach has eroded or remained unchanged, leading to a steeper beach profile. It was noted in the previous full measures report (autumn 2012) that storm conditions had resulted in the movement of material from the upper beach to the lower beach. The movement of material observed in this 2013 full measures survey indicates post storm recovery has taken place, with the material previously moved down the beach being returned to the upper beach. **Longer term trends:** At all locations, beach levels are within the bounds of previous changes; however profiles towards the southern end of Whitely Beach are currently towards the lower end of the profile envelope.

Survey Date	Description of Changes Since Last Survey	Interpretation
	decreasing by 0.5m or more from 58m chainage to the seaward end of the profile. Profile **1aNTDC04a** is located to the south of Whitley Sands. Similarly to other profiles along the southern part of the bay, beach levels have increased at the toe of the seawall, but unlike the other profiles the beach levels have not fallen towards the seaward end of the profile. The shingle section of upper beach (from the seawall to 17m chainage) has increased by about 1m. There is no significant change in beach level seaward of 17m chainage, where the rock remains exposed as it was in the March survey.	
Nov 2013	**Topographic Survey:** Whitley Sands is covered by an annual topographic survey, which commenced in October 2010. Data from the most recent topographic survey (full measures, autumn 2013) have been used to create a digital ground model (DGM) (Appendix B – Map 1a) using a GIS. A difference plot has also been produced using the DGM (Appendix B – Map 1b) produced from the last produced topographic survey (full measures, autumn 2012) and the present survey. The difference plot shows the central part of the bay has a variable pattern of change comprising (i) a linear zone of erosion along much of the length of the lower beach, extending to cover the whole width of the beach at the Southern end of Whitley Bay; and (ii) a linear zone of accretion running parallel to the zone of reduced elevation, which extends to cover the whole width of the beach at the northern end (iii) intermittent narrow strips of erosion at the back of the beach. In contrast, the northern section of the bay is almost entirely accreting, while the southernmost part of the bay is almost entirely eroding The trends in the central part of the beach indicate that sand bars has moved up the beach over the calmer summer period. The erosion at the very southern end of the bay and accretion to the north, indicates a potential northerly movement of sediment. This is supported by the survey notes which reported exposed rock and low sand levels towards the southern end of the bay. The SMP notes that sediment movement is generally in a southerly direction. The trend indicated by the autumn 2013 survey is the opposite to that described in the SMP. **Longer Term Topographic Trends Autumn 2010 to Autumn 2013:**	The trends observed from the beach profiles are replicated in the topographic survey. There is erosion at the very southern end of the bay and accretion to the north, indicating a potential northerly movement of sediment. This is supported by the survey notes which reported exposed rock and low sand levels towards the southern end of the bay There is a trend of erosion at the toe of the beach but accretion on the upper beach, indicating that the bar feature has been moved up the beach during the calmer summer period. Comparison of the present topographic survey with the previous survey shows that the trends observed during the past 12 months are the opposite of those observed between autumn 2011 and autumn 2012, when storm conditions resulted in the movement of material from the upper beach to the lower beach. It is therefore likely that this movement of material up the beach indicates post storm recovery. **Longer term topographic trends Autumn 2010 to Autumn 2012:** The plot shows a general trend across the beach of increasing beach levels along the

Survey Date	Description of Changes Since Last Survey	Interpretation
	The long term difference plot (Appendix B – Map 1c) shows the net change in beach levels between autumn 2010 and autumn 2013. The pattern of change is very similar to that seen in the last 6 months, but with a greater magnitude of change. The plot shows a general trend of increased beach levels at the very north of the bay (over 1m net accretion mid=profile) and decreased beach levels at the southern end (upto 2m erosion at MLW) . Along the middle of the beach there is a trend of decreasing beach level at the beach toe and beach level increase towards the middle of the slope and the back of the beach. At around profile 1aNTDC02 there is a decrease in beach level at the back of the beach.	backshore and middle beach and reducing beach levels along the middle and lower beach. The very southern end of the bay shows a reduction in beach levels, while the northern end of the bay shows increased beach levels. The accretion/ stability of the northern part of the bay is a trend which has been noted in previous full measures survey reports.

3.2 Cullercoats Bay

Survey Date	Description of Changes Since Last Survey	Interpretation
Oct 2013	**Beach Profiles:** Cullercoats Bay is covered by one beach profile line for the Full Measures survey (Appendix A). This was surveyed annually each autumn between 2002 and 2009. From spring 2010 onwards, it has been surveyed bi-annually. The cliff top position along **1aNTDC05** has remained constant since surveys began in April 2002, but there are apparent changes along the cliff face where the toe has moved seawards by 0.25m to 0.5m. Both this survey report and the previous survey report note '*cliff not measured at section 5 due to dangerous access*'. It is therefore more likely that the changes observed are related to the location of survey points measured rather than cliff movement. From the cliff toe to 46m chainage, beach levels have fallen by approximately 0.3m and rocks which were previously covered have been exposed. Seaward of 46m, beach levels have increased, with the greatest increase towards the toe of the beach where up to 1.1m increase in level is observed and a bar has formed.	As in previous surveys the surveyors report that the cliff has not been surveyed due to dangerous access. It is therefore considered that changes on the cliff face/dune toe may be an artefact of the survey point locations. The beach level has generally increased across the profile with the main area of accretion being observed at the seaward end of the profile. **Longer term trends:** The lower beach at Cullercoats Bay has accreted since the previous survey. The profile is within the limits of earlier surveys for much of its length, but the accretion at the toe is notably higher than all surveys recorded to date.

3.3 Tynemouth Long Sands

Survey Date	Description of Changes Since Last Survey	Interpretation
Oct 2013	**Beach Profiles:** Tynemouth Long Sands is covered by three beach profile lines for the Full Measures survey (Appendix A). Profiles **1aNTDC06** and **1aNTDC07** were initially surveyed annually each autumn between 2002 and 2009. A third profile, **1aNTDC06A**, has been added in the centre of the frontage after that. From spring 2010 (partial measures) onwards, they have been surveyed bi-annually. **1aNTDC06** is located approximately 150m south of the access road/ramp towards the north of the bay. Beach levels have increased at the cliff toe and also between 115m and 150m chainage, by approximately 0.5m to 1m. This has resulted in a more even beach with a steeper upper section. The remainder of the profile has remained stable. At profile **1aNTDC06A**, the dune-cliff face has not significantly changed in form or position. Since the last survey, beach levels have remained fairly stable but with small a increase in the upper profile in the order of 0.5m (80m to 130m chainage) and a small decrease at the seaward end (150m chainage and seawards) also in the region of 0.5m. This has resulted in some beach steepening. It is noted in the survey report that the middle section of this profile could not be measured due to seed protection fences. Profile **1aNTDC07** is located approximately 50m south of the access route through the dunes towards the southern end of the bay. No changes in form or position of the dune-cliff face were recorded since the last survey. The profile presents a similar trend to**1aNTDC06A,** with accretion in the upper profile of about 0.3m between 95m and 225m chainage and erosion on the lower profile of up to 0.7m from 225m chainage to the seaward end of the profile. This has led to steepening of the beach profile.	Since the last survey the dunes have retained the same form and position. A trend of slight beach steeping can be identified in all three profiles within Tynemouth Long Sands, with a small degree of accretion of the upper beach and erosion of the lower beach. **Longer term trends:** Overall, the beaches have remained stable. This is consistent with the surveys taken since the partial measures survey in autumn 2008. It should be noted that the seaward end of the profile for **1aNTDC06A** and **1aNTDC07** is lower than that measured in previous surveys.
October 2103	**Topographic Survey:** Tynemouth Long Sands is covered by a bi-annual topographic survey, which commenced in October 2010. Data from the most recent topographic survey (full measures, autumn 2012) have been used to create a digital ground model (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 produced topographic survey	Since the last survey, there have been only minor changes in level with some areas showing no change. The lower beach has tended to reduce in level, while the middle of the beach has increased, indicating that material has been moved up the beach. **Longer term topographic trends Autumn 2010 to Autumn 2013:** The plot shows a general reduction in

Survey Date	Description of Changes Since Last Survey	Interpretation
	(partial measures, spring 2013) and the present survey. In particular, the difference plot shows: (i) a small reduction in beach elevation as a strip running along the lower beach (ii) a narrow strip of slightly reduced elevation across the dune toe (iii) a strip of increase in beach elevation along the middle of the beach, which is wider to the south and is split by a strip of reduced elevation to the north. The Long Sands survey report also notes slips evident on the face of dunes, the presence of a spring in a deep channel at the south end of the beach, and at the southern end of the bay (location 436576 570640) excavation of the dune toe was taking place where a sand bag wall was sunk into the ground and reseeding is to be carried out. These patterns indicate crosshore movement of material up the beach slope. **Longer Term Topographic Trends Autumn 2010 to Autumn 2013:** The long term difference plot (Appendix B – Map 2c) shows the net change in beach levels between autumn 2010 and autumn 2013. The plot shows a general reduction in beach elevation of up to 1m across most of the beach, and a band of increased beach elevation near MLW in the northern half of the bay. The majority of the back of beach has experienced net erosion.	beach elevation of up to 1m, with a narrow band of increased beach elevation (slightly over 1m) running along the toe of the beach from the north to the centre of the bay. These long-term changes are of a similar magnitude to those recorded in seasonal changes, suggesting a dynamic beach with limited net change.

3.4 King Edward's Bay

Survey Date	Description of Changes Since Last Survey	Interpretation
Oct 2013	**Beach Profiles:** King Edward's Bay is covered by one beach profile line for the Full Measures survey (Appendix A). This was surveyed annually between 2002 and 2009. From spring 2010 onwards, it has been surveyed bi-annually. At profile **1aNTDC08**, beach levels across the profile have fluctuated since the last survey, with a reduction in beach levels at the top, middle and toe of the profile but sections of increased beach levels between. The berm at the toe of the profile has reduced producing a smoother profile. No clear trend of erosion or accretion can be identified since the last survey.	Since the last survey, the beach at King Edward's Bay shows no clear trend of erosion or accretion. **Longer term trends:** The beach profile remains similar in form and position to that observed since October 2010. The berms observed in 2009 and earlier have decreased in height, resulting in a flatter profile which has remained stable since 2010. The most recent 2013 profile remains within the bounds of previous profile surveys, although the upper beach is towards the lower bounds of the survey envelope.

4. Problems Encountered and Uncertainty in Analysis

Individual Profiles

At profile 1aNTDC05 the cliff was not measured due to dangerous access. This cliff was noted to have been dangerous in previous reports, and consideration should be given to changing the location of this profile.

At profile 1aNTDC06, mud slips were observed and dune stabilization works were underway which may impact upon the profile shape.

At profiles 1aNTDC06a and 1aNTDC07, seed protection fences erected for dune stabilisation works prevented the surveyor from measuring the middle section of the profile. This was also noted in the 2013 partial measures report for profile 1aNTDC06a, and the previous full and partial measures reports for 1aNTDC07.

Topographic Survey

At Long Sands the topographic survey report notes that at 436576, 570640, at the time of the survey, the dune front was being excavated and a sand bag wall sunk into the ground. The area is then to be re-seeded to help stabilise the steep dunes. The report also notes that new fences are being installed to protect the re-seeded areas. As a result access to some areas of the beach was restricted during the topographic survey.

5. Recommendations for ‘Fine-tuning’ the Monitoring Programme

No changes are recommended at the present time.

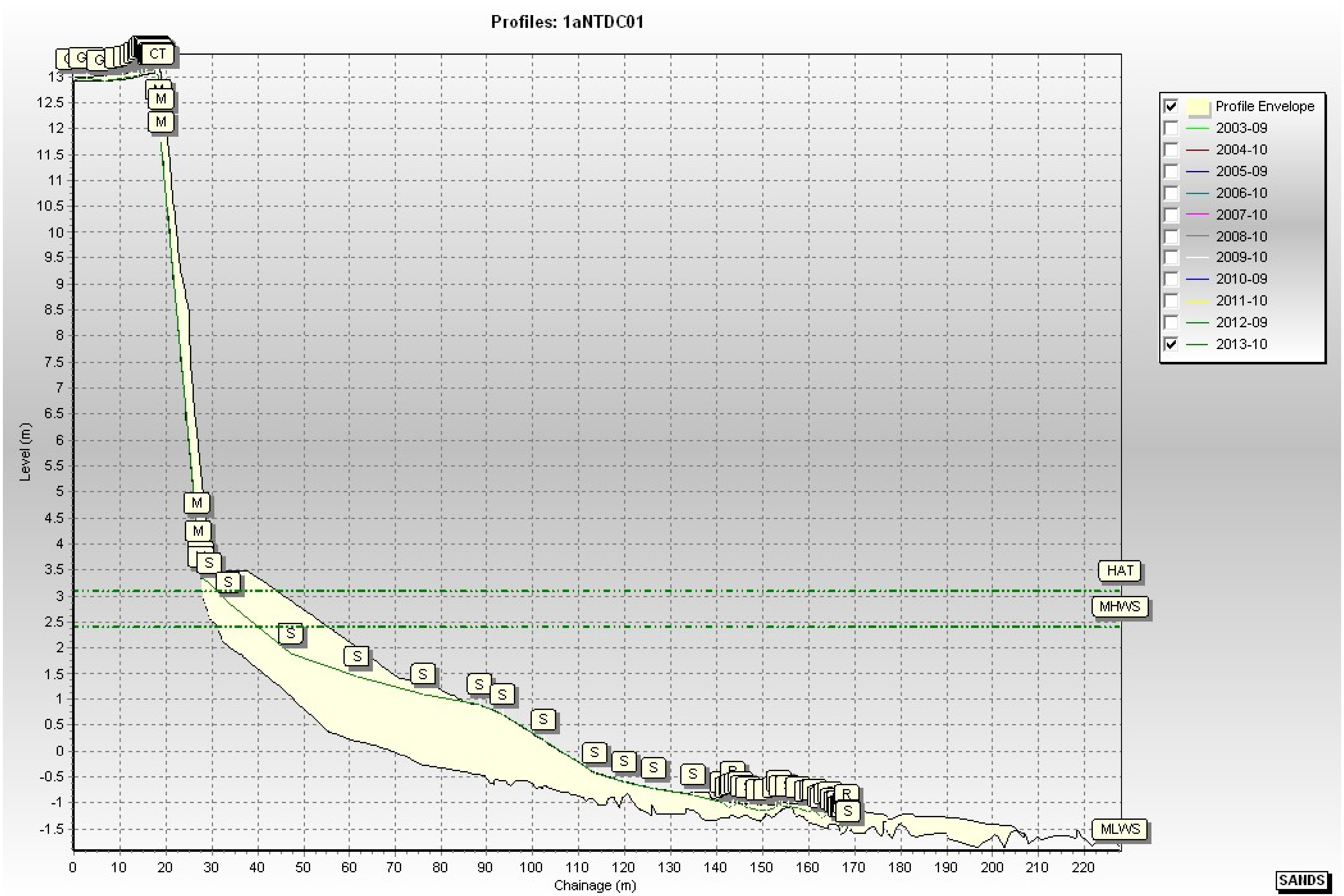
6. Conclusions and Areas of Concern

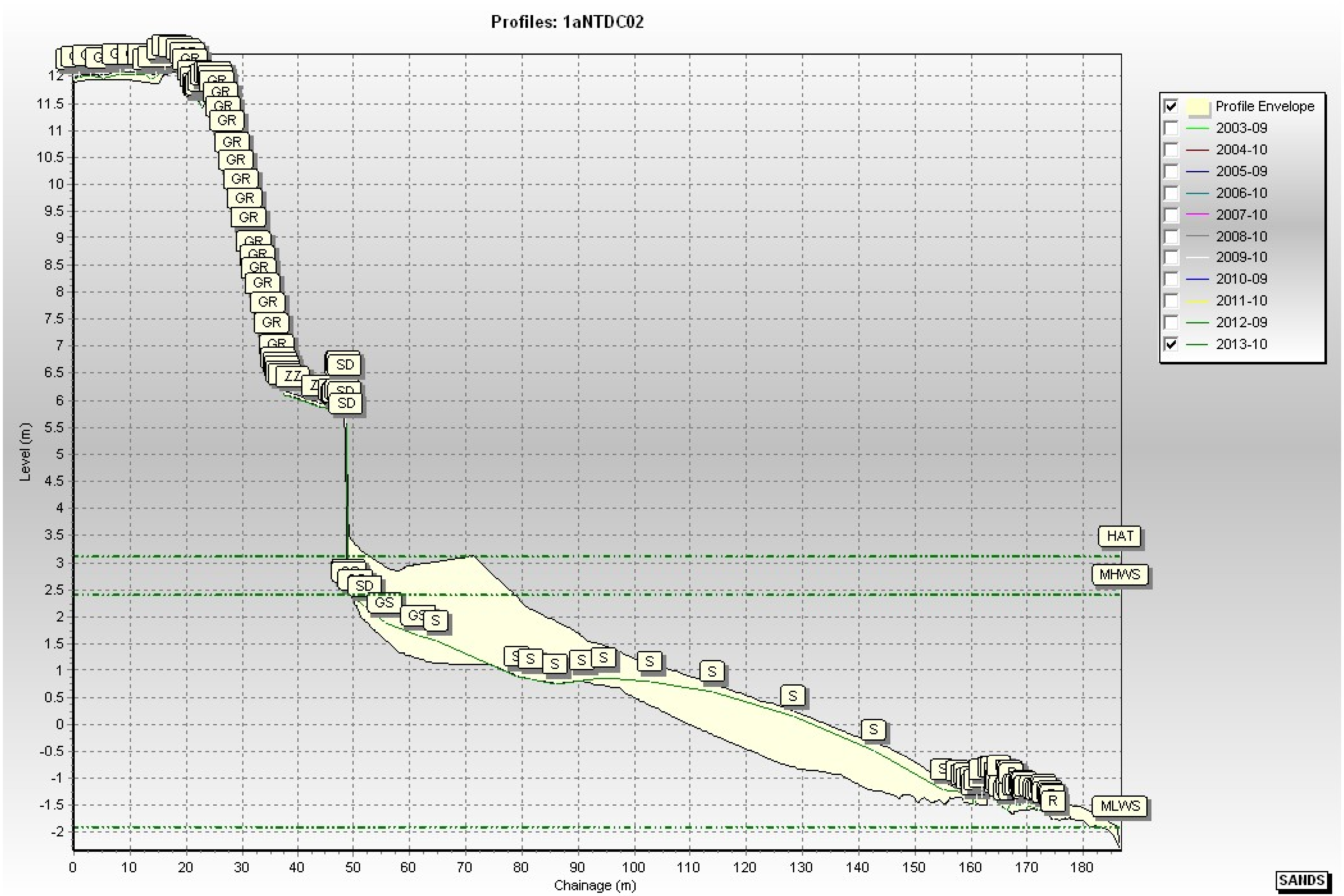
- At Whitley Sands, the recorded profiles present no causes for concern. Although the profiles at the southern end of the beach are towards the lower part of the profile envelope they are not low enough to raise concerns and the existing monitoring scheme is sufficient to identify any future lowering or recovery.
- At Cullercoats Bay, at profile 1aNTDC05, the cliff was not measured due to dangerous access. Access to this profile is noted to have been dangerous in the previous reports and consideration should be given to changing the location of this survey.
- Elsewhere along Cullercoats Bay, the recorded profiles present no cause for concern and demonstrated a trend of accretion.
- At Tynemouth Long Sands, the beach profiles have steepened. At profiles1aNTDC06A and 1aNTDC07 this has result in a lowering of the profile toe to a level below all previous surveys. The data indicates that this material has moved up the beach rather than offshore. This is not a cause for concern but the profiles should continue to be monitored.
- Elsewhere along Tynemouth Long Sands the recorded profiles and topographic survey present no cause for concern.
- At King Edward’s Bay, the recorded profiles present no cause for concern.

Appendices

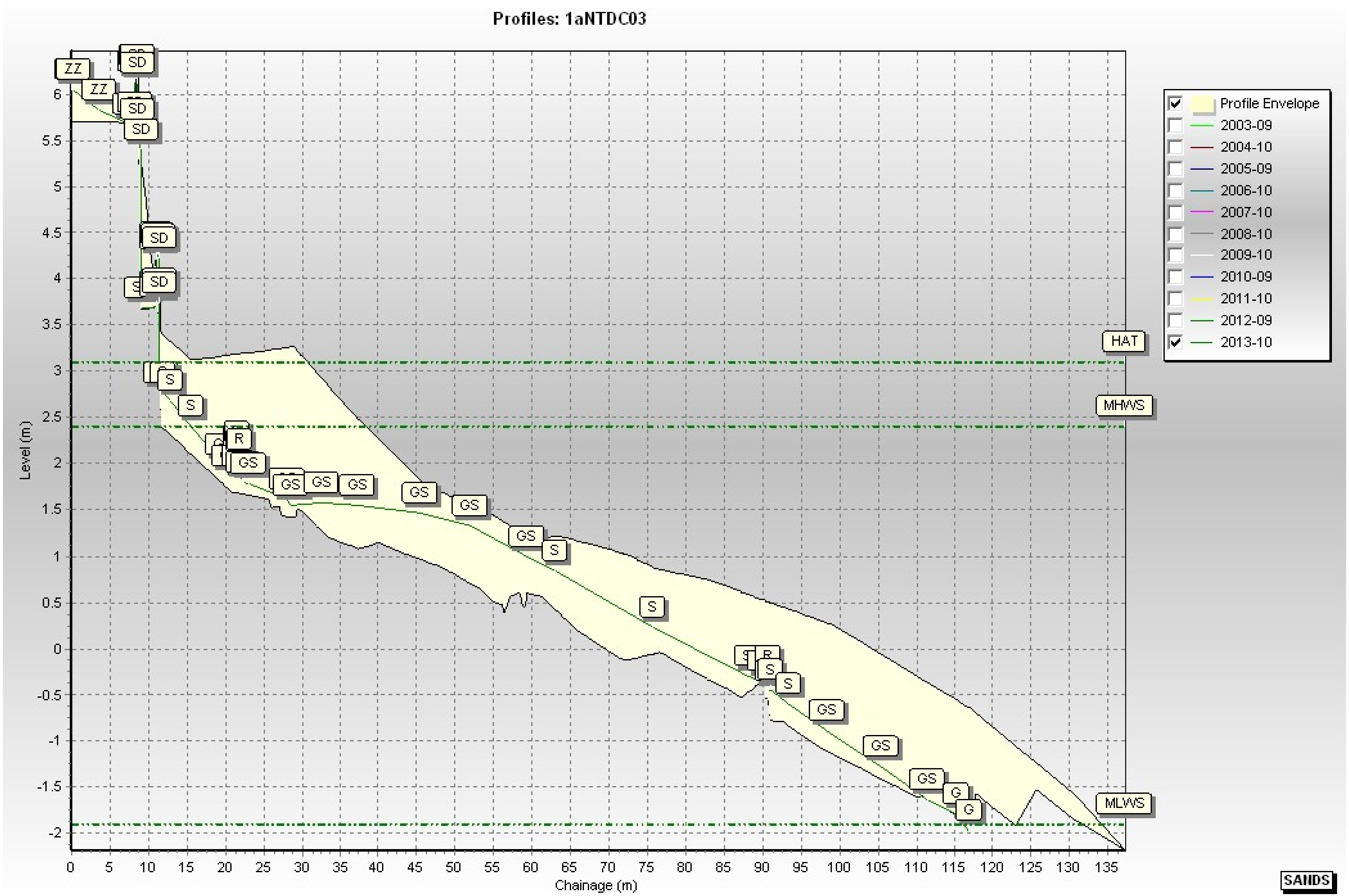
Appendix A

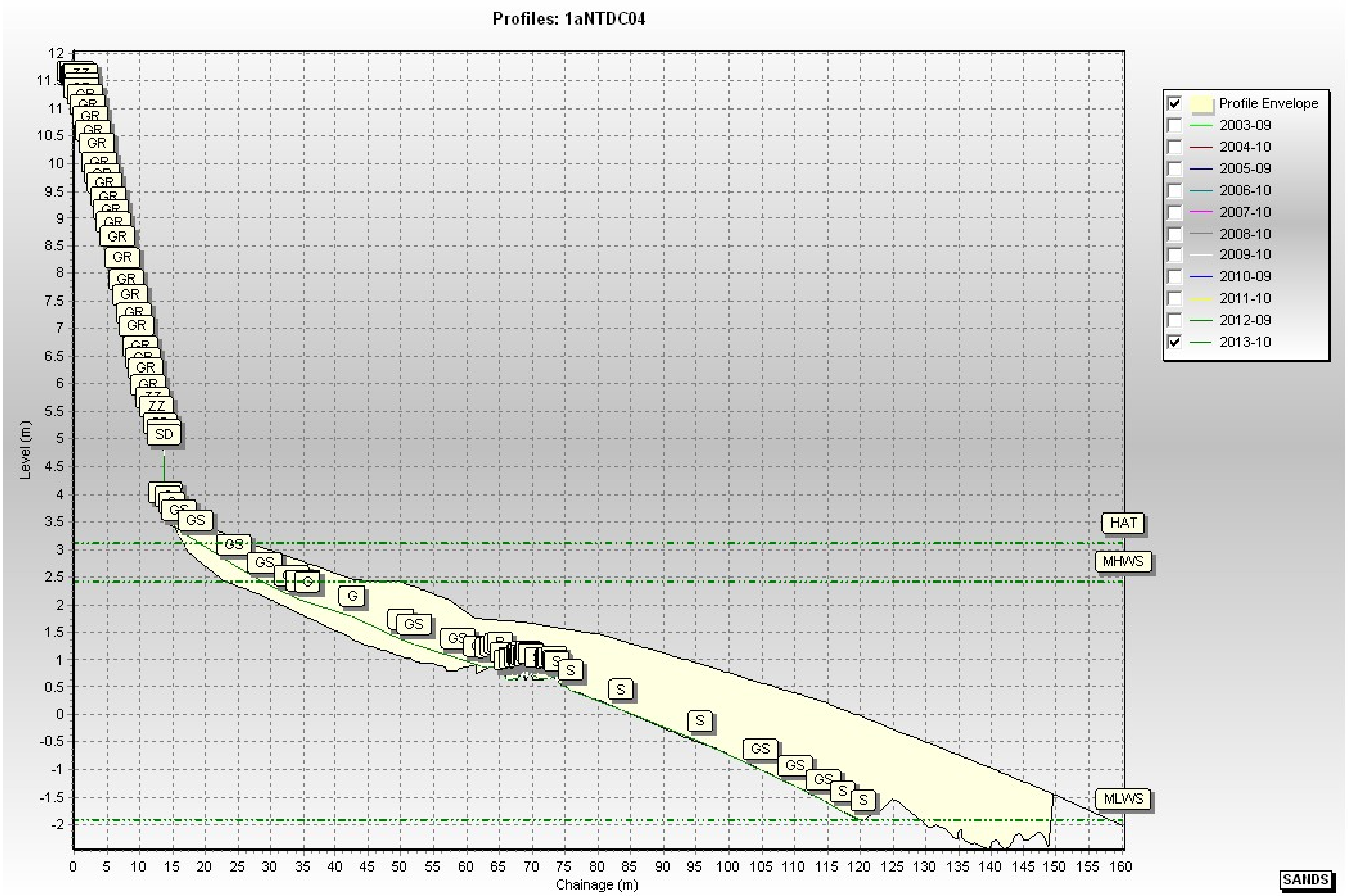
Beach Profiles

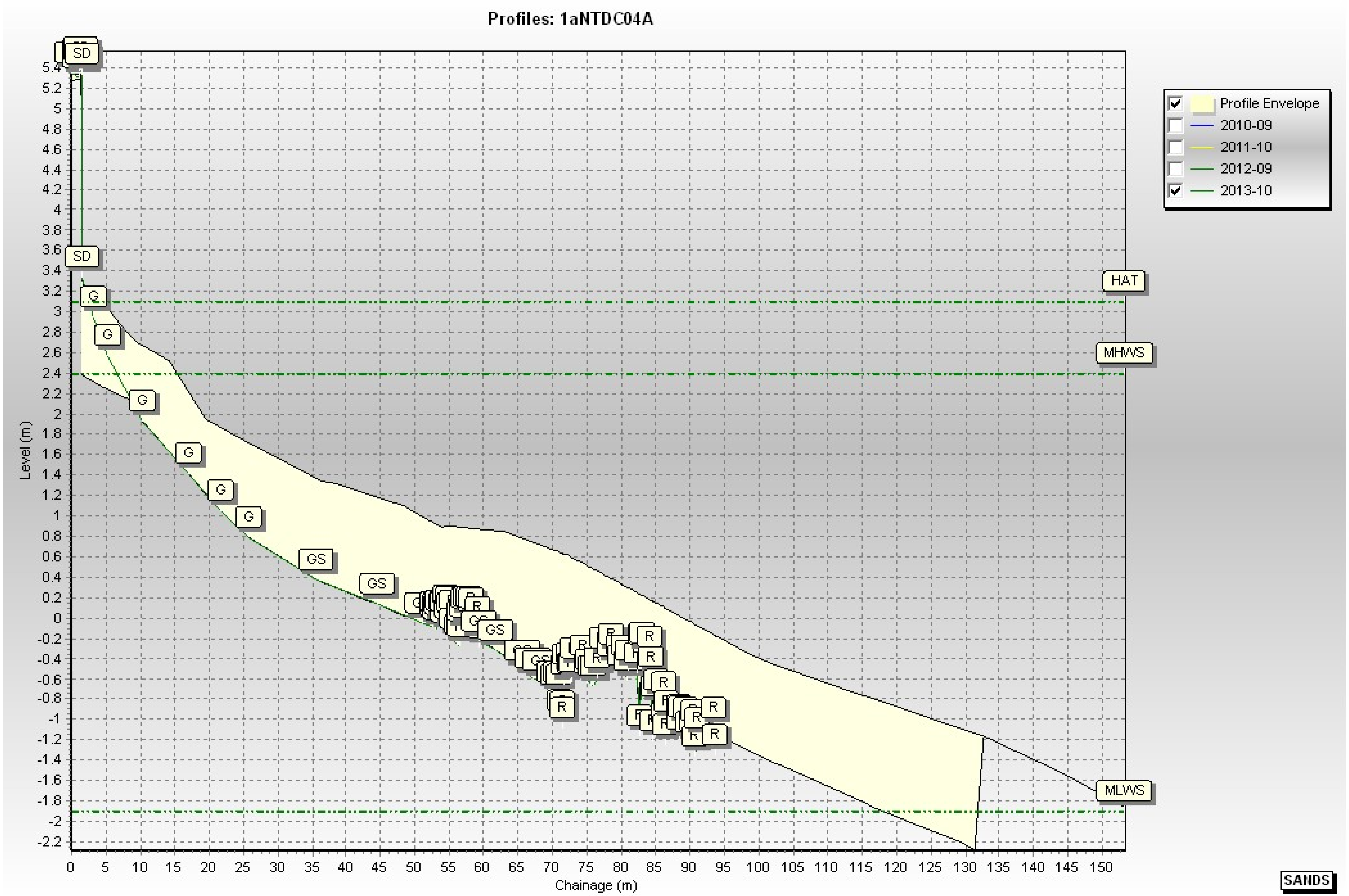

Profiles: 1aNTDC01
Level (m)
Chainage (m)
Profile Envelope
2003-09
2004-10
2005-09
2006-10
2007-10
2008-10
2009-10
2010-09
2011-10
2012-09
2013-10
HAT
MHWS
MLWS
SANDS



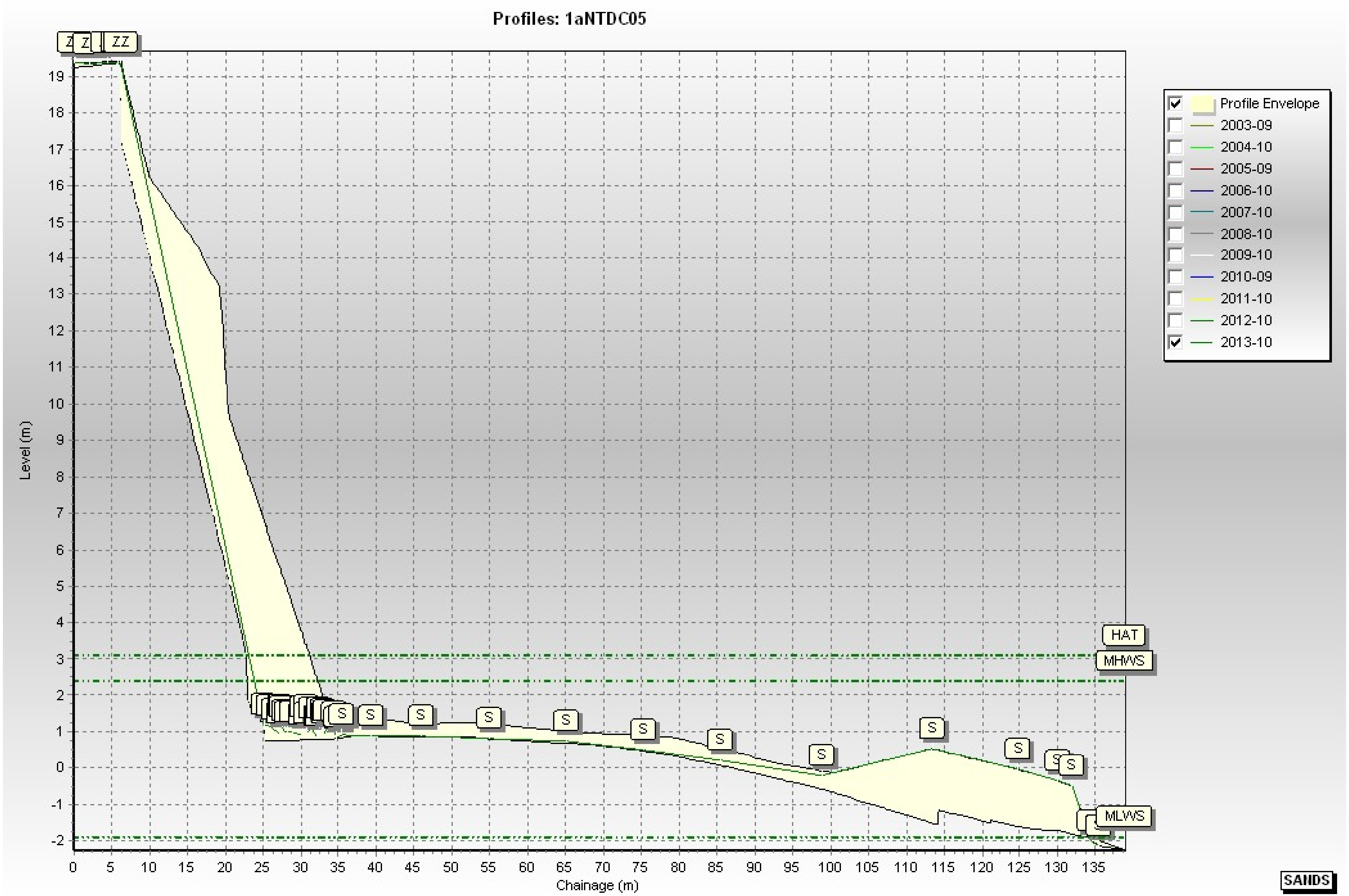
Profiles: 1aNTDC02
Level (m)
Chainage (m)
Profile Envelope
2003-09
2004-10
2005-09
2006-10
2007-10
2008-10
2009-10
2010-09
2011-10
2012-09
2013-10
HAT
MHWS
MLWS
GR
SD
ZZ
GS
S
R
SANDS


Profiles: 1aNTDC03
Level (m)
Chainage (m)
Profile Envelope
2003-09
2004-10
2005-09
2006-10
2007-10
2008-10
2009-10
2010-09
2011-10
2012-09
2013-10
HAT
MHWS
MLWS
SANDS

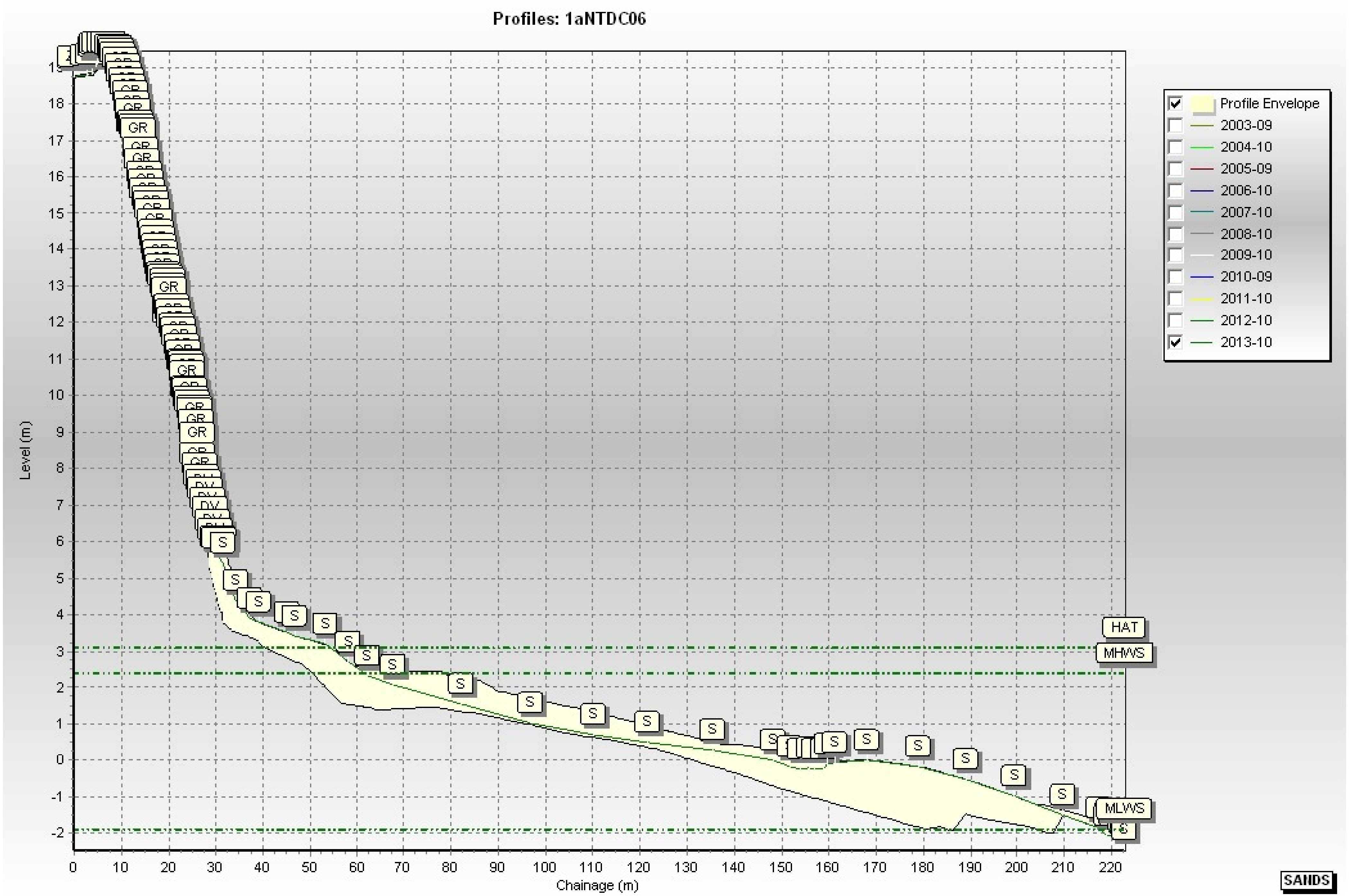

Profiles: 1aNTDC04
Level (m)
Chainage (m)
Profile Envelope
2003-09
2004-10
2005-09
2006-10
2007-10
2008-10
2009-10
2010-09
2011-10
2012-09
2013-10
HAT
MHWS
MLWS
SANDS



Profiles: 1aNTDC04A
Profile Envelope
2010-09
2011-10
2012-09
2013-10
HAT
MHWS
MLWS
Level (m)
Chainage (m)
SANDS



Profiles: 1aNTDC05
Profile Envelope
2003-09
2004-10
2005-09
2006-10
2007-10
2008-10
2009-10
2010-09
2011-10
2012-10
2013-10
HAT
MHWS
MLWS
Level (m)
Chainage (m)
SANDS



Profiles: 1aNTDC06
Level (m)
Chainage (m)
Profile Envelope
2003-09
2004-10
2005-09
2006-10
2007-10
2008-10
2009-10
2010-09
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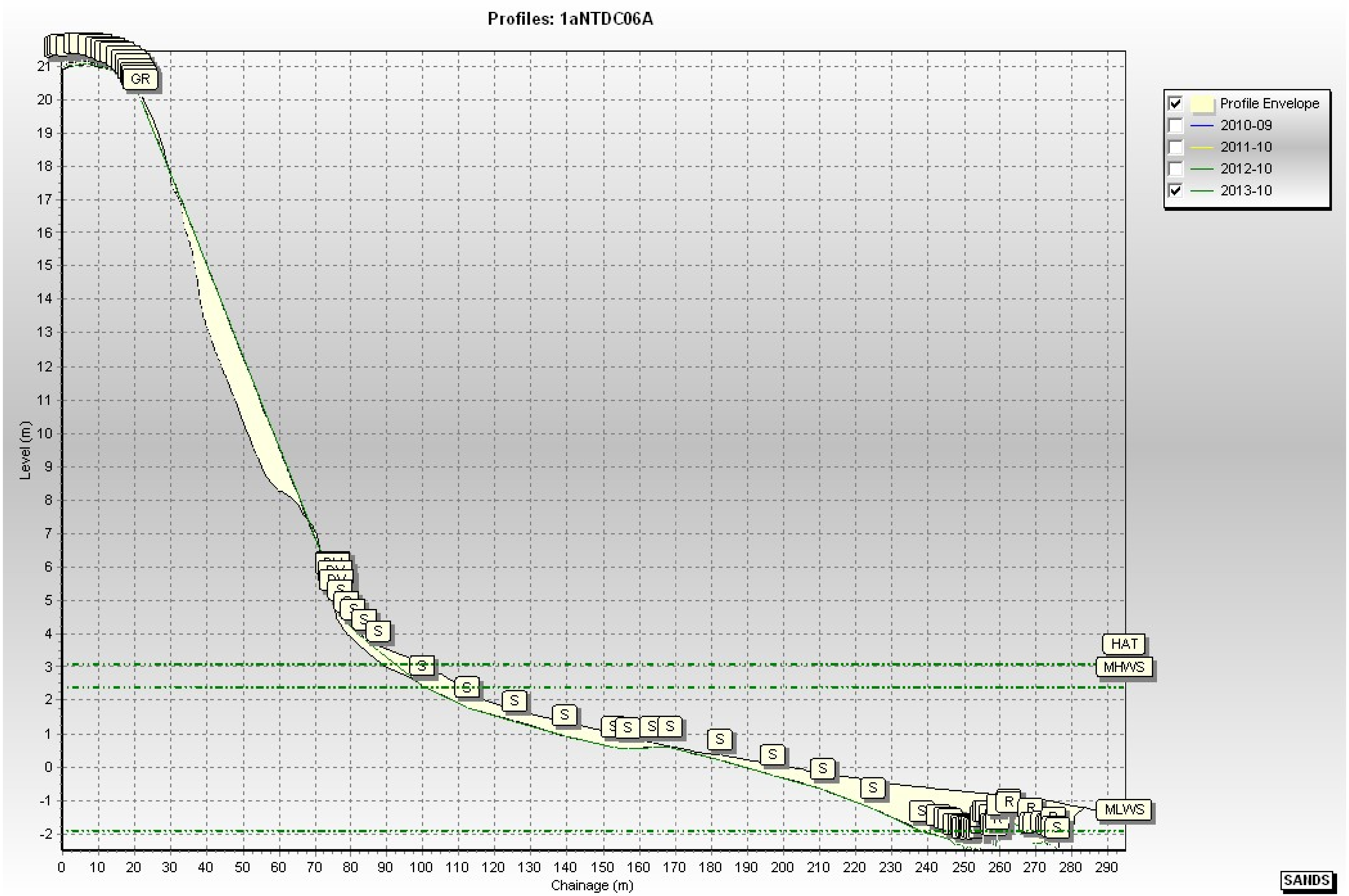
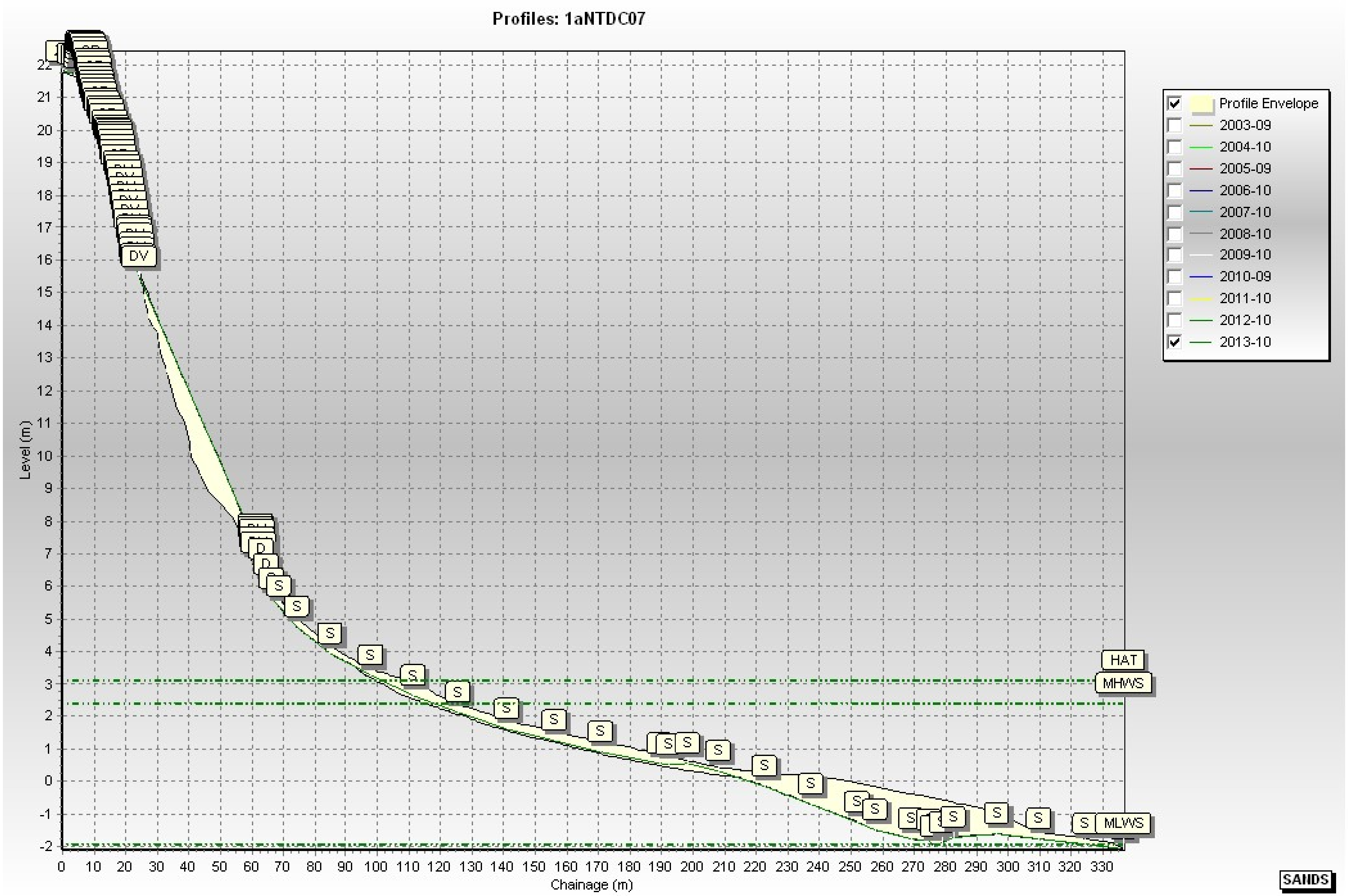
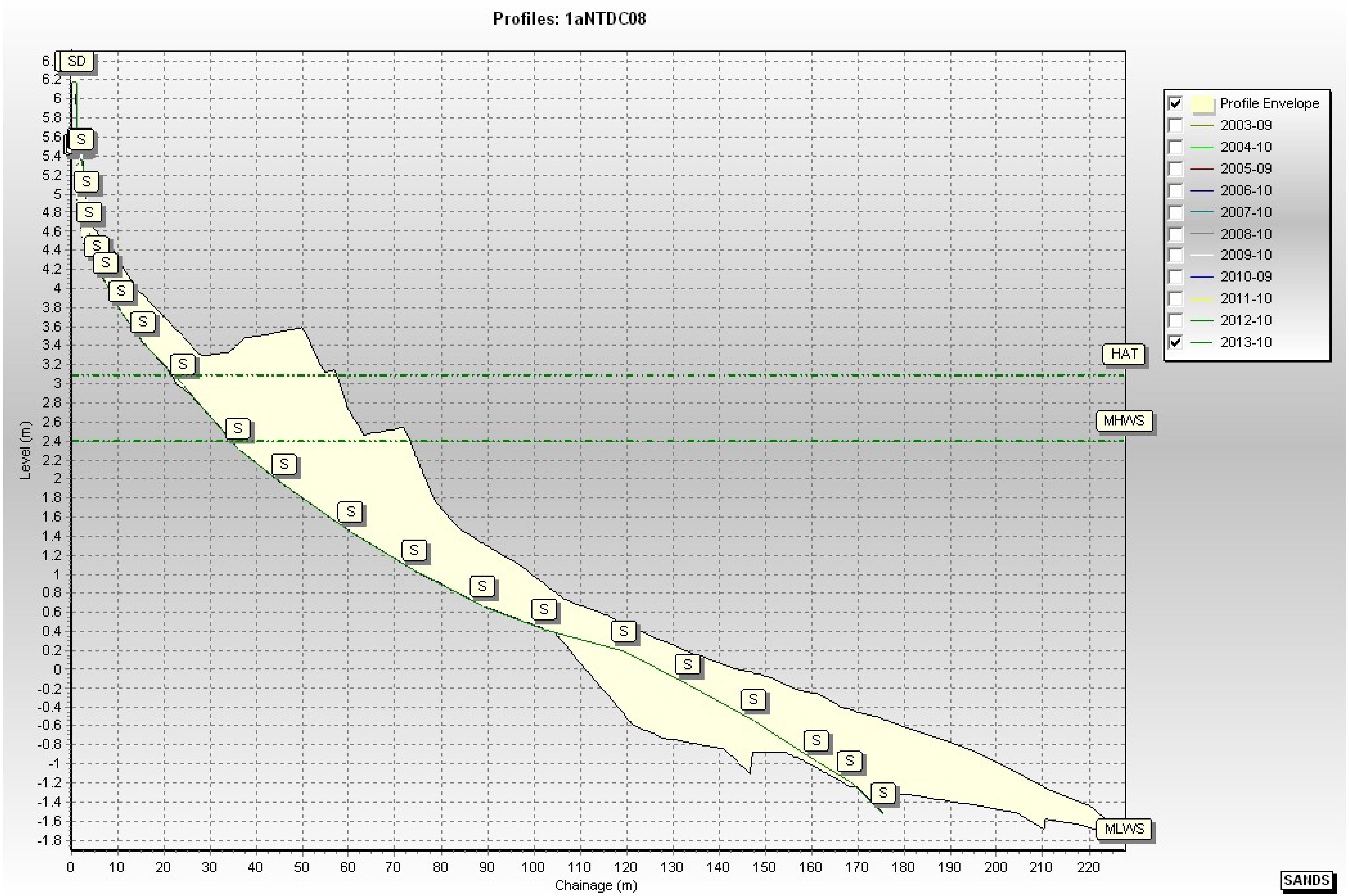
2012-10
2013-10
HAT
MHWS
MLWS
GR
DV
S
SANDS


Profiles: 1aNTDC06A
Level (m)
Chainage (m)
Profile Envelope
2010-09
2011-10
2012-10
2013-10
GR
S
R
HAT
MHWS
MLWS
SANDS



Profiles: 1aNTDC07
Level (m)
Chainage (m)
Profile Envelope
2003-09
2004-10
2005-09
2006-10
2007-10
2008-10
2009-10
2010-09
2011-10
2012-10
2013-10
HAT
MHWS
MLWS
DV
S
SANDS



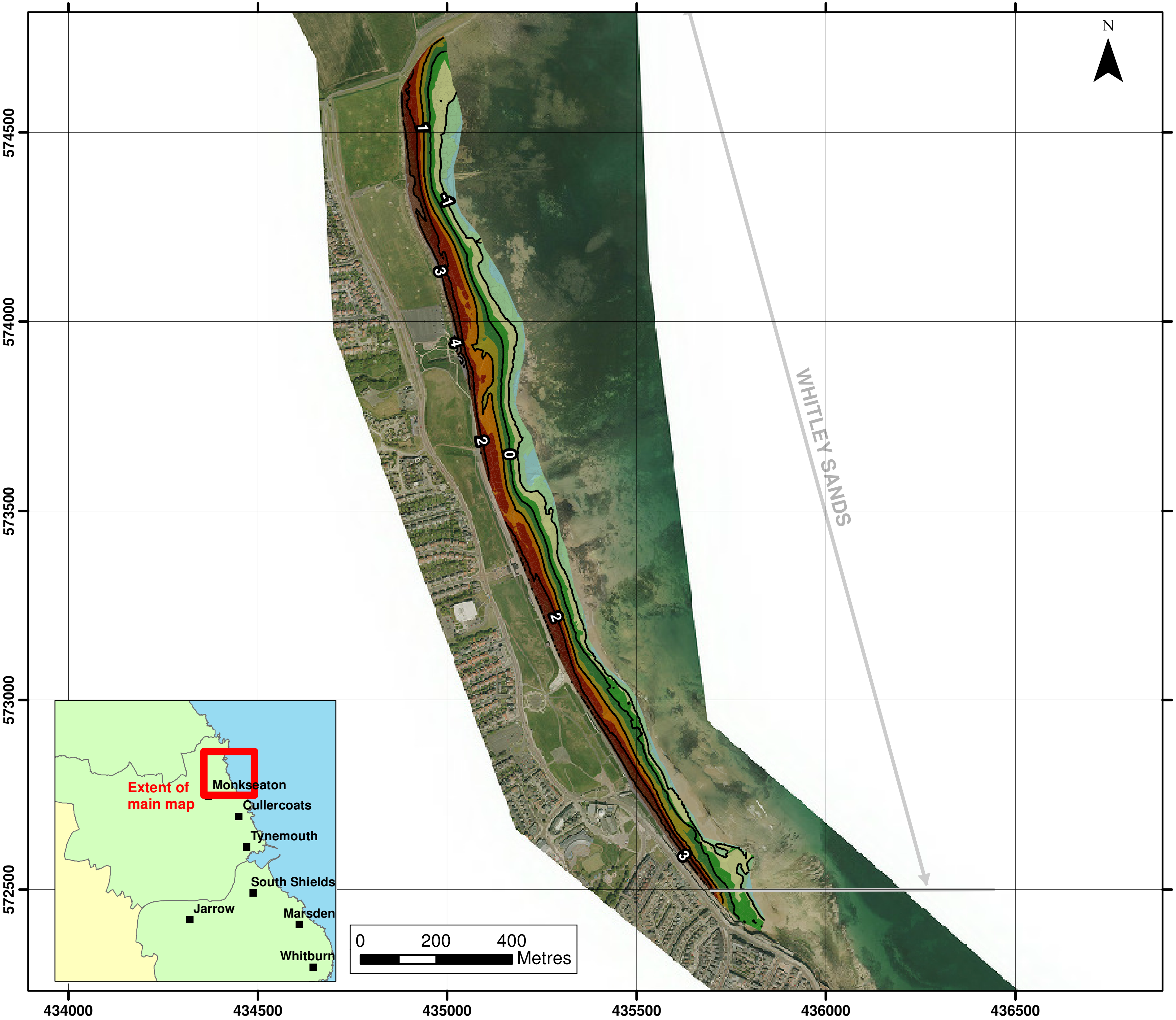
Profiles: 1aNTDC08
SD
S
HAT
MHWS
MLWS
Level (m)
Chainage (m)
Profile Envelope
2003-09
2004-10
2005-09
2006-10
2007-10
2008-10
2009-10
2010-09
2011-10
2012-10
2013-10
SANDS

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 (m OD)

- 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 Whitley Sands North Tyneside Council

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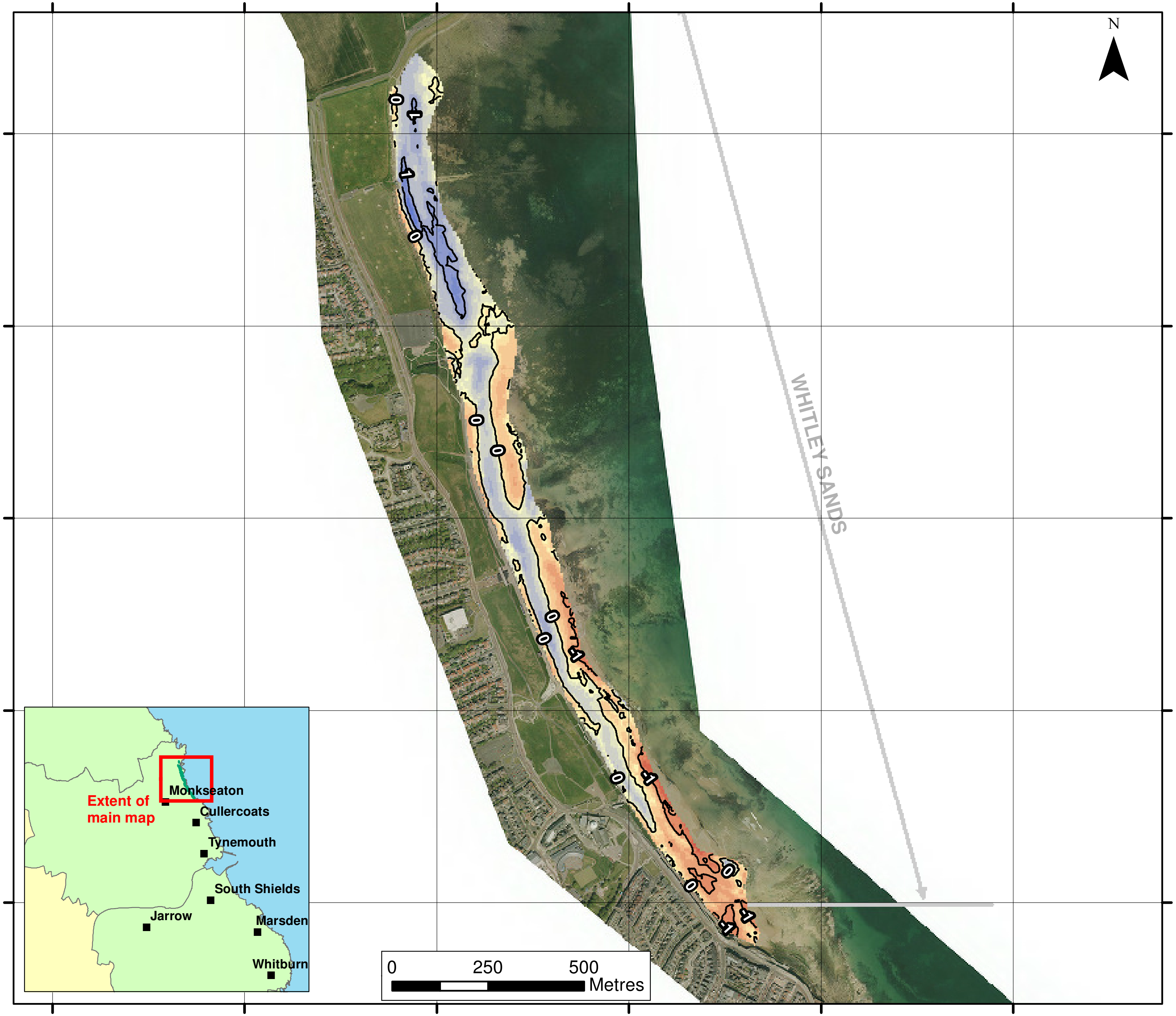

KEY Autumn 2012 and Autumn 2013
Change in elevation (m)

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 Whitley Sands North Tyneside Council

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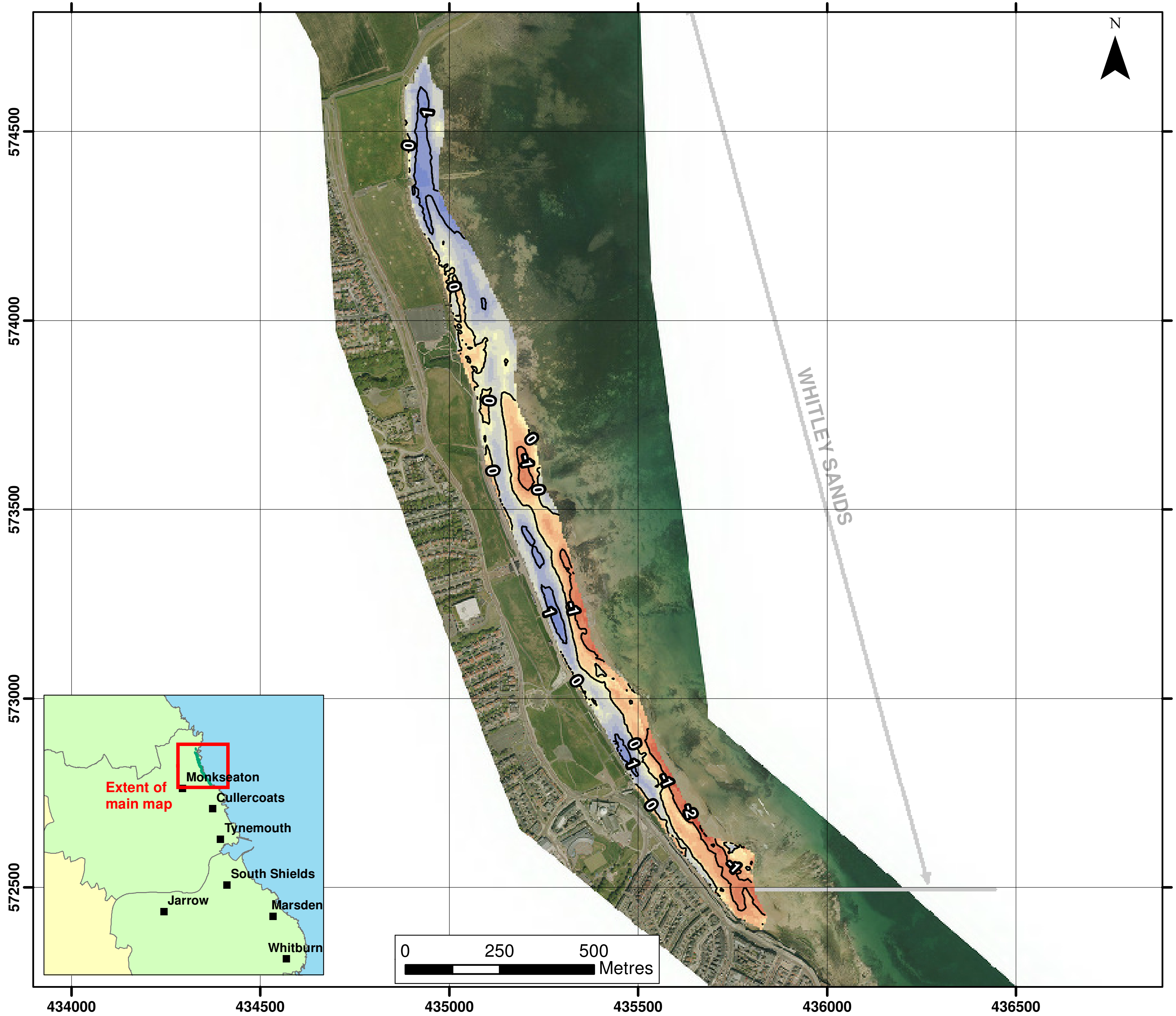

KEY Autumn 2010 and Autumn 2013
Change in elevation (m)

<-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 1c
Long-term Elevation Change
Whitley Sands
North Tyneside Council

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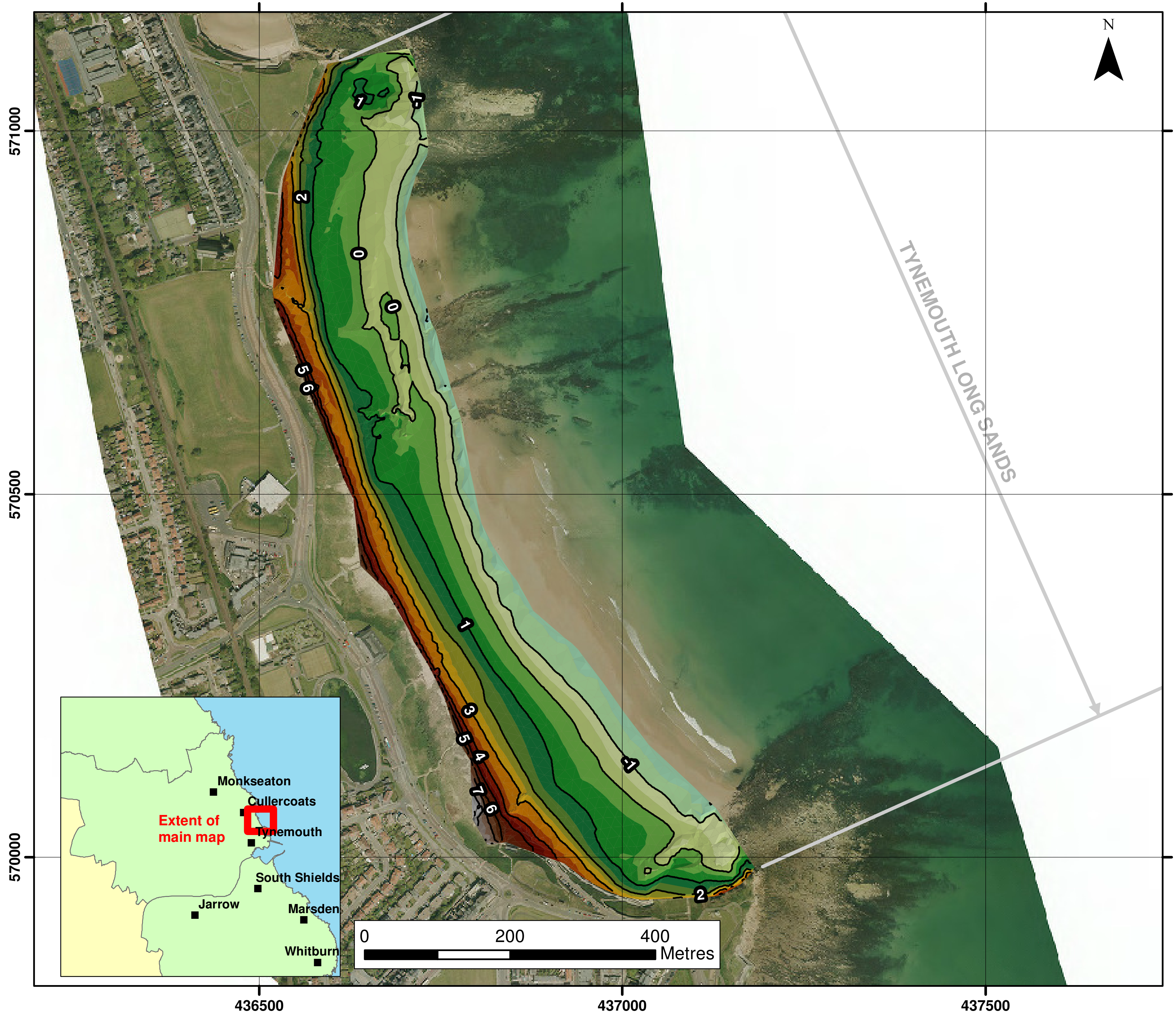

KEY

Elevation (m OD)

9.5 - 10	3.5 - 4
9 - 9.5	3 - 3.5
8.5 - 9	2.5 - 3
8 - 8.5	2 - 2.5
7.5 - 8	1.5 - 2
7 - 7.5	1 - 1.5
6.5 - 7	0.5 - 1
6 - 6.5	0 - 0.5
5.5 - 6	-0.5 - 0
5 - 5.5	-1 - -0.5
4.5 - 5	-1.5 - -1
4 - 4.5	-2 - -1.5
	-2.5 - -2
	Contour 1m

Client: North East Coastal Group

Project: Cell 1 Regional Coastal Monitoring Programme 2011 to 2016

Appendix B - Map 2a
Topographic Survey
Tynemouth Long Sands
North Tyneside Council

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Photography courtesy of North East Coastal Observatory
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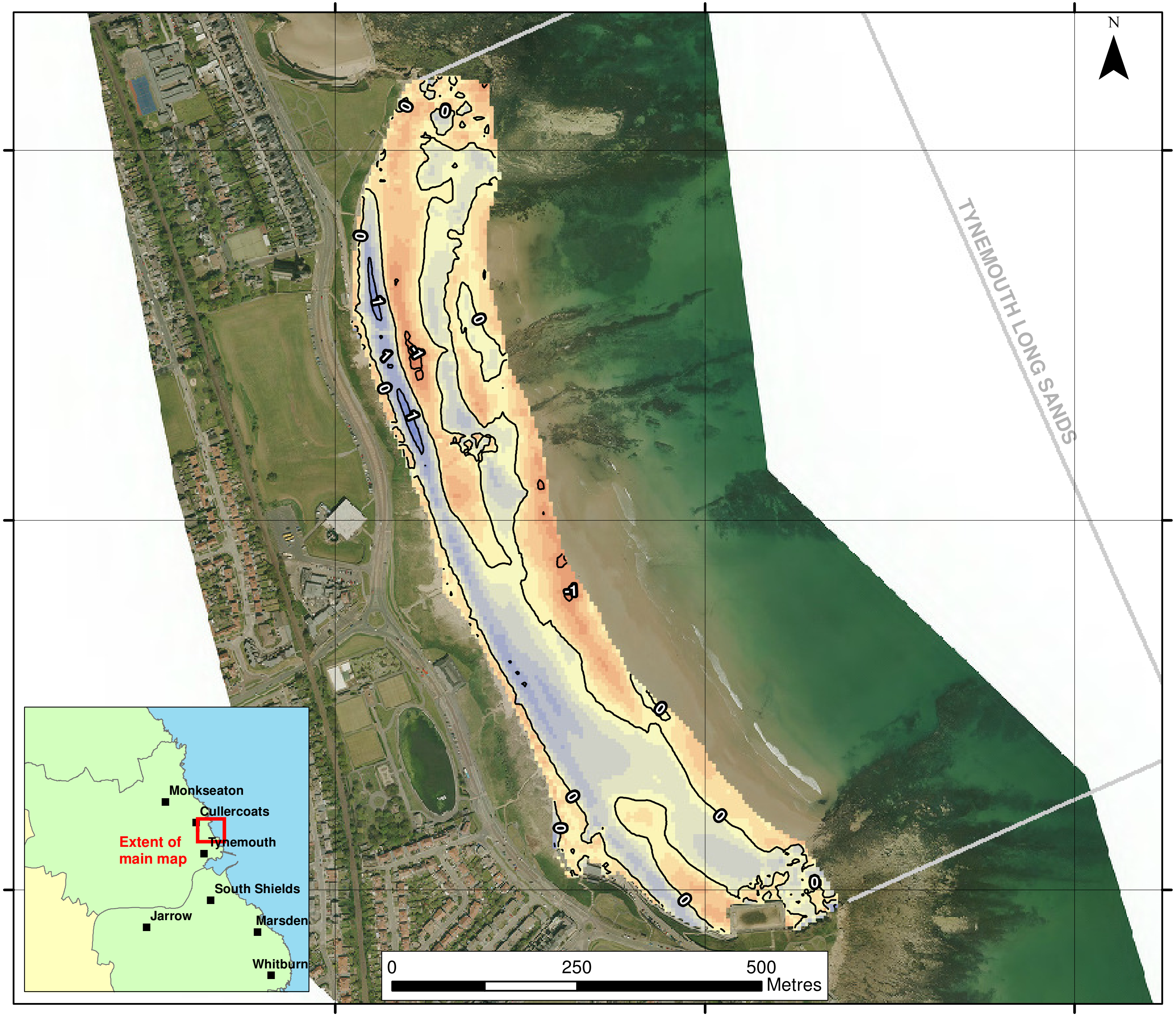

KEY
Spring 2013 and Autumn 2013
Change in elevation (m)

<-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 2b
Short-term Elevation Change
Tynemouth Long Sands
North Tyneside Council

Analytical Report 6
Full Measures Survey
Autumn 2013

CH2MHILL
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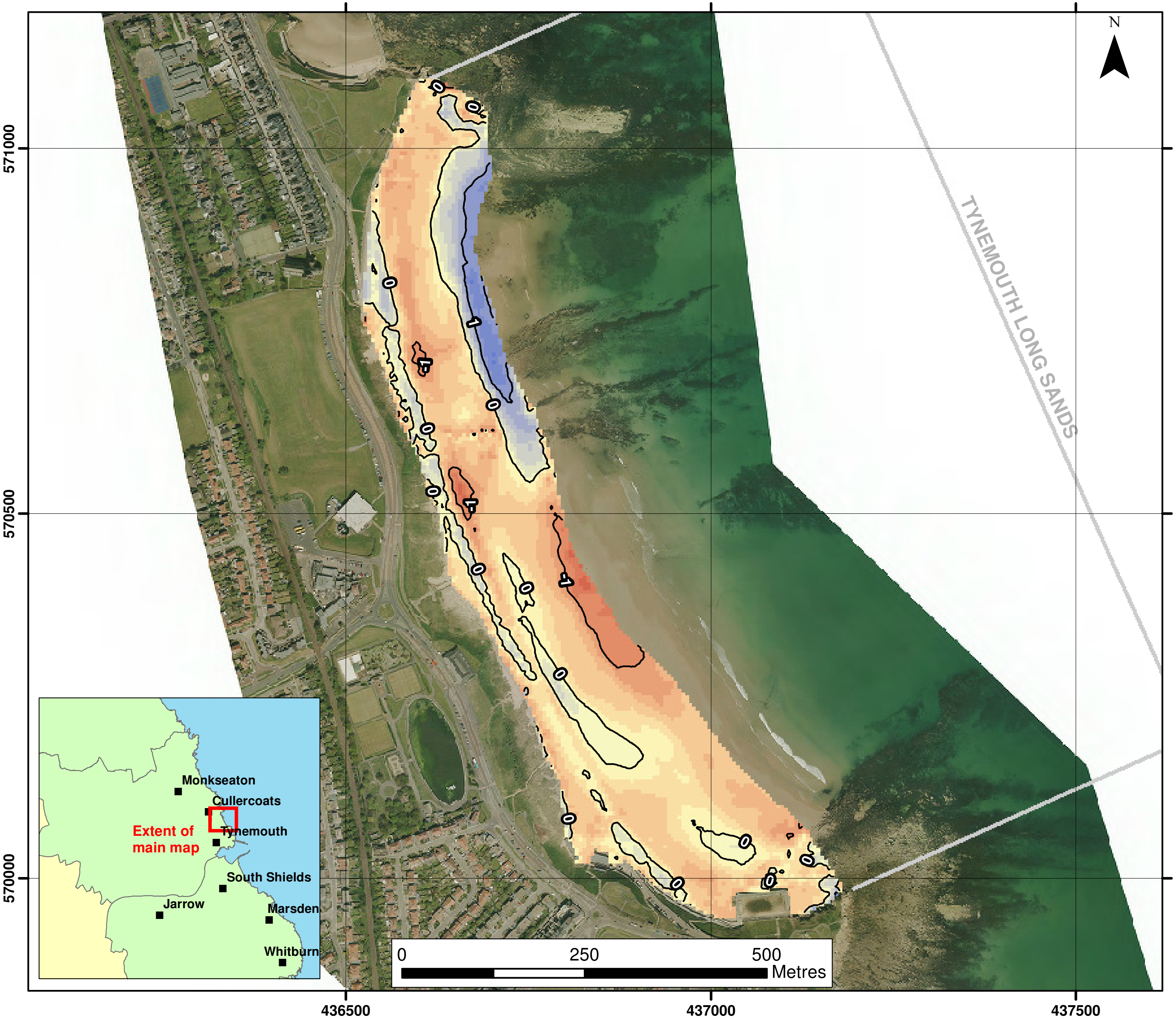

KEY Autumn 2011 and Autumn 2013
Change in elevation (m)

Change (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
Tynemouth Long Sands
North Tyneside Council

Analytical Report 6
Full Measures Survey
Autumn 2013

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