Cell 1 Regional Coastal Monitoring Programme
Analytical Report 5: 'Full Measures' Survey 2012

Hartlepool Borough Council
Final Report

March 2013

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Authors	
Lily Booth	Halcrow
Dr Paul Fish	Halcrow
Dr Andy Parsons	Halcrow

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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 (m AOD)			
Water Level Parameter	**River Tyne to Frenchman's Bay**	**Frenchman's Bay to Souter Point**	**Souter Point to Chourdon Point**	**Chourdon Point to Hartlepool Headland**
1 in 200 year	3.41	3.44	3.66	3.91
HAT	2.85	2.88	3.18	3.30
MHWS	2.15	2.18	2.48	2.70
MLWS	-2.15	-2.12	-1.92	-1.90
	Water Level (m AOD)			
Water Level Parameter	**Hartlepool Headland to Saltburn Scar**	**Skinningrove**	**Hummersea Scar to Sandsend Ness**	**Sandsend Ness to Saltwick Nab**
1 in 200 year	3.87	3.86	4.1	3.88
HAT	3.25	3.18	3.15	3.10
MHWS	2.65	2.68	2.65	2.60
MLWS	-1.95	-2.13	-2.15	-2.20

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.

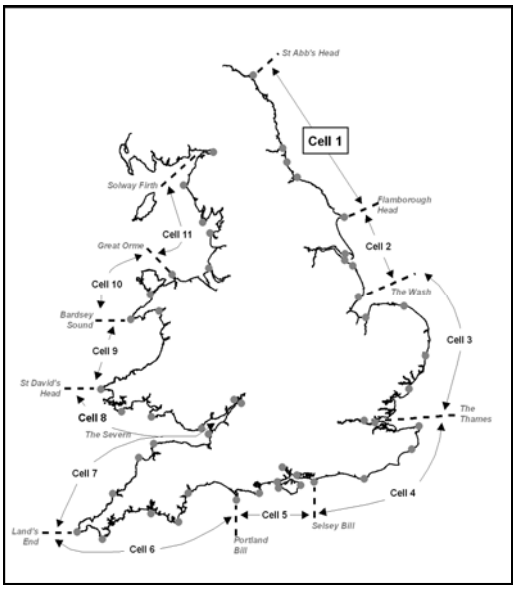


Figure 1 Sediment Cells in England and Wales

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:

Northumberland County Council
Northumberland Coast AONB
North Tyneside Council
South Tyneside Council
Sunderland City Council
Durham County Council
Redcar & Cleveland Borough Council
Hartlepool Borough Council
Whitby Scarborough Filey 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.

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

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

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

Each year, an Analytical Report is produced for each individual authority, providing a detailed analysis and interpretation of the 'Full Measures' surveys.

This is followed by a brief Update Report for each individual authority, providing ongoing findings from the 'Partial Measures' surveys.

Annually, a Cell 1 Overview Report is also produced. This provides a region-wide summary of the main findings relating to trends and interactions along the entire Cell 1 frontage.

To date the following reports have been produced:

Table 1 Analytical, Update and Overview Reports Produced to Date

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

(*) The present report is **Analytical Report 5** and provides an analysis of the 2012 Full Measures survey for Hartlepool Borough Council's frontage.

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

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

Table 2 Sub-divisions of the Cell 1 Coastline

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

Hartlepool Borough Council's frontage extends from Crimdon Beck in the north, to the North Gare Breakwater in the south. For the purposes of this report, it has been sub-divided into four areas, namely:

- North Sands
- Hartlepool Headland
- Middleton
- Hartlepool Bay

1.2 Methodology

Along Hartlepool Borough Council's frontage, the following surveying is undertaken:

- Full Measures survey annually each autumn/early winter comprising:
    - Beach profile surveys along nine transect lines
    - Topographic survey along part of North Sands (referred to as Hartlepool North or 'HN')
    - Topographic survey along Middleton (referred to as Hartlepool Central or 'HC')
    - Topographic survey along Hartlepool Bay (referred to as Hartlepool South or 'HS')
- Partial Measures survey annually each spring comprising:
    - Beach profile surveys along 9 no. transect lines
- Additionally, every five years (starting with 2008 as the baseline year), the Full Measures topographic survey at Hartlepool North is extended to fully cover the whole of North Sands and Hartlepool Headland with a topographic survey. This extends across the boundary of jurisdiction between Hartlepool Borough Council and County Durham Council.

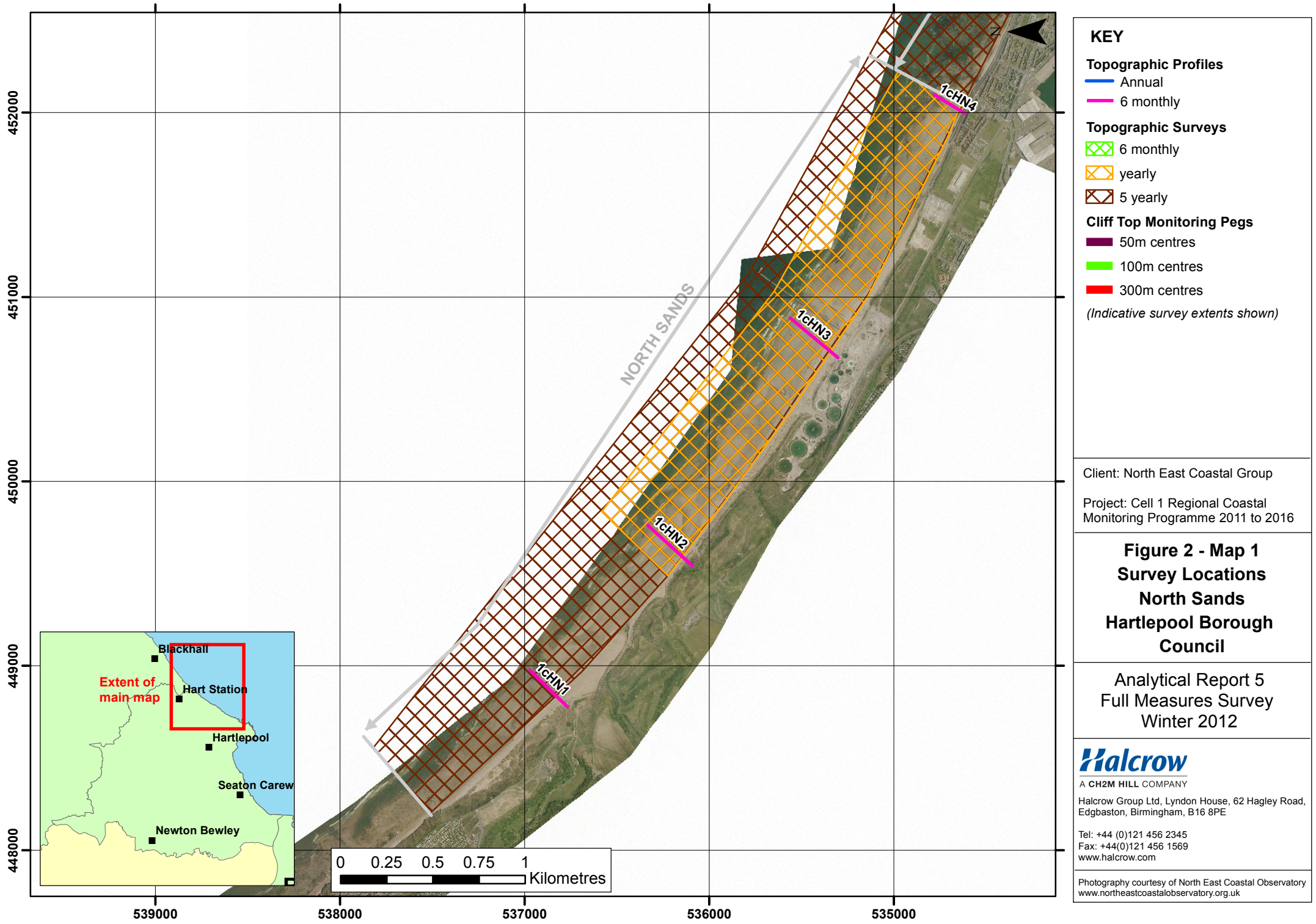
The location of these surveys is shown in Figure 2. The 2011 Full Measures survey was undertaken along this frontage on 17th, 27th September, 1st, 15th and 16th October 2012. During this time weather conditions varied considerably. The survey reports from Academy Geomatics document details of the weather conditions over this survey period.

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.



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)

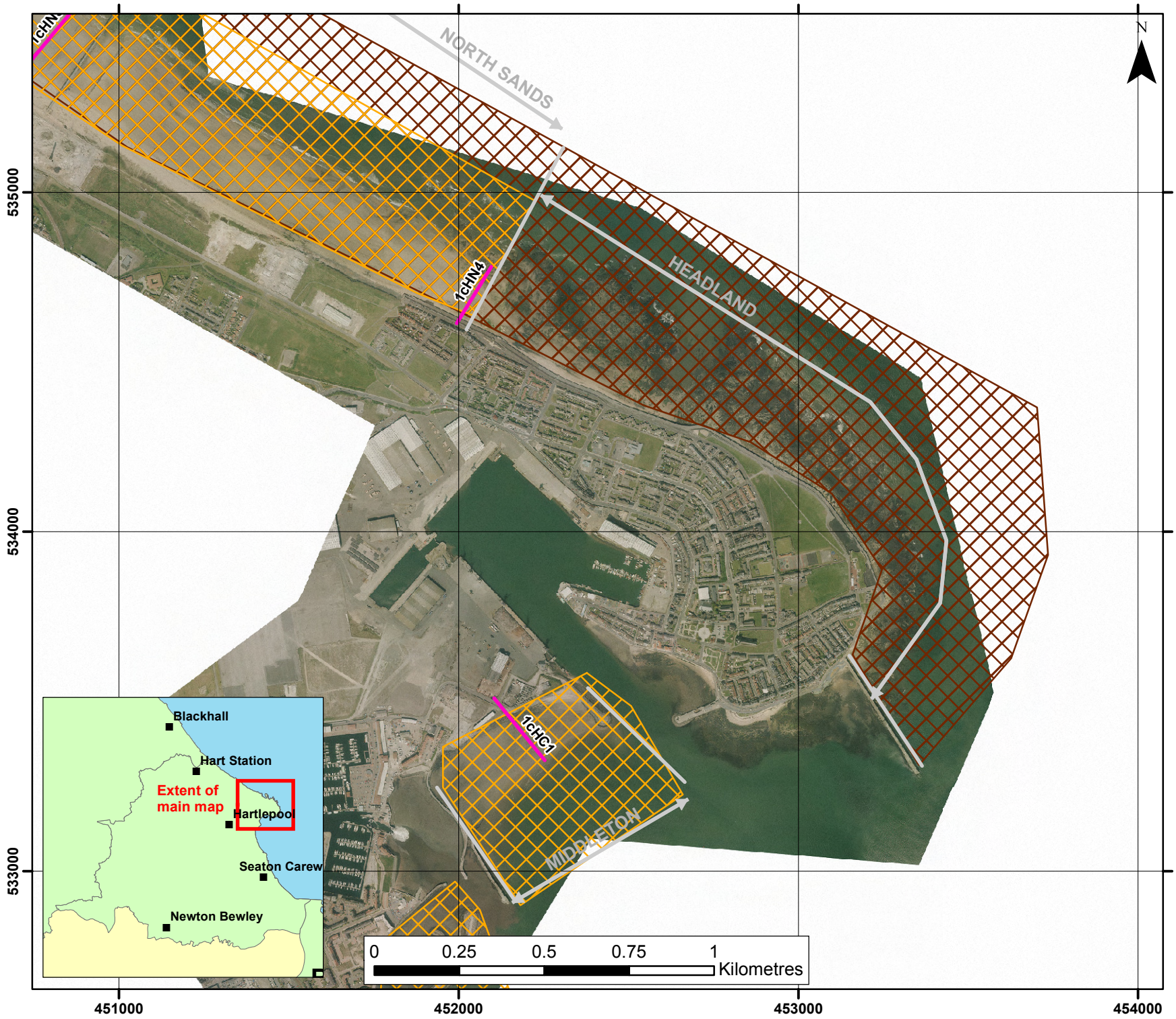
Client: North East Coastal Group

Project: Cell 1 Regional Coastal Monitoring Programme 2011 to 2016

Figure 2 - Map 1 Survey Locations North Sands Hartlepool Borough Council

Analytical Report 5
Full Measures Survey
Winter 2012

Halcrow
A CH2M HILL COMPANY
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.halcrow.com



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Cliff Top Monitoring Pegs

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

(Indicative survey extents shown)

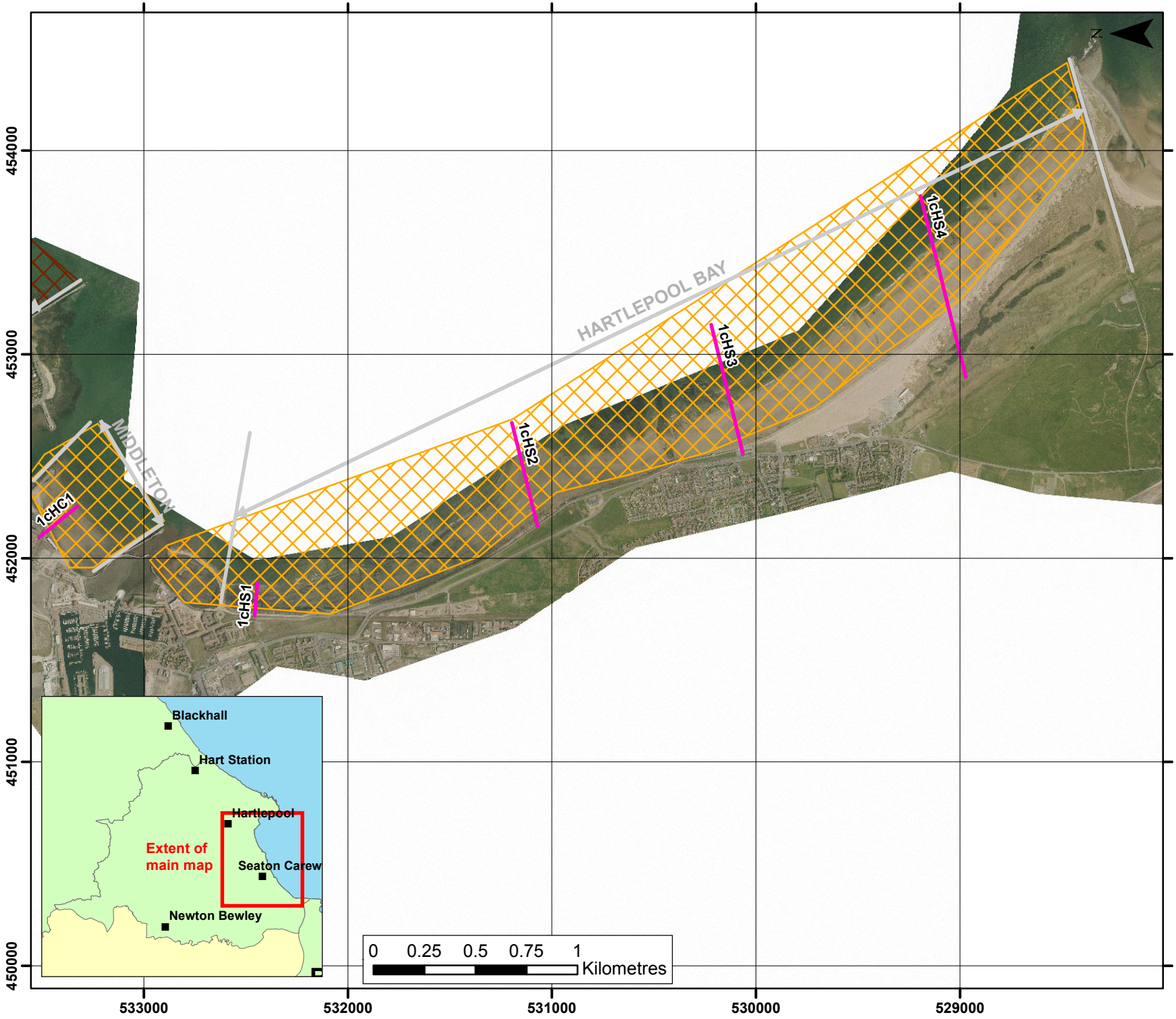
Client: North East Coastal Group

Project: Cell 1 Regional Coastal Monitoring Programme 2011 to 2016

Figure 2 - Map 2
Survey Locations
Headland and Middleton
Hartlepool Borough Council

Analytical Report 5
Full Measures Survey
Winter 2012

Halcrow
A CH2M HILL COMPANY
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.halcrow.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 3
Survey Locations
Hartlepool Bay
Hartlepool Borough Council

Analytical Report 5
Full Measures Survey
Winter 2012

Halcrow
A CH2M HILL COMPANY
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.halcrow.com

2. Analysis of Survey Data

2.1 North Sands

Survey Date	Description of Changes Since Last Survey	Interpretation
27th Sept 2012	**Beach Profiles:** North Sands is covered by four beach profile lines during the Full Measures survey (Appendix A). Profile **1cHN1** is located within Durham County Council's jurisdiction, about 400m north of the outfall of Crimdon Beck, but has been reported here so changes can be interpreted in association with those observed elsewhere along North Sands at HN2, HN3 and HN4. At **1cHN1** the beach above HAT has changed very little. Below the level of HAT, the berm that was present in September 2011 and March 2012 has been eroded and beach levels have dropped by 0.4m. From chainage 110m to 140m the beach remained stable. From 140m chainage to the end of the profile the two berms which had developed in March 2012 had flattened, resulting in a loss of up to 0.6m of material over the summer. At Profile **1cHN2** the mound of material which was at the base of the dunes had flattened. The upper beach has accreted by 0.6m between 55m and 70m chainage. Between 80m and 100m chainage the beach had eroded by 0.5m. From 110m to 210m the beach has eroded by 0.4m. The rest of the profile has remained stable over the summer of 2012. Profile **1cHN3** has developed a fore-dune since 2008. The fore-dune has accreted by 0.3m since March 2012. The rest of the beach has remained stable with the majority of accretion and erosion being within ±0.1m. At Profile **1cHN4** the section above MHWS was stable over the summer of 2012. The beach from 25m to 70m has accreted by 0.3m since March 2012. Between 70m and 95m the beach has eroded by 0.1m over the summer. Between 100m and 140 the beach had formed into a mound and accreted by 0.5m. At the extent of the survey the rocks were exposed.	The North Sands frontage became flattened and lost any mounds of material which were on the beach in March 2012. The beach at profile HN3 remained stable. The fore-dune continued to grow, which is a process commonly associated with accretion and stability of the dunes. The topographic plots for Winter 2012/13 shows that the banks that were present in 2011 were no longer present, which supports the observations made in the beach profile analysis. The difference plots show a patchy redistribution of sediment volume change on the North Sands frontage. The areas of accretion and erosion appeared to be equal in area with no indication of significant net change. **Longer term trends**: The changes observed in the 2011 Full Measures Report were much more obviously shore parallel and there was less patchy variation than in the 2012 survey. Again the more pronounced accretion and erosion was observed in the northern half of the frontage, whereas the southern

Survey Date	Description of Changes Since Last Survey	Interpretation
	Topographic Survey: North Sands is covered by an annual topographic survey. Data from the 2012 Full Measures survey have been used to create a DGM (Appendix B – Map 1a) using a Geographic Information System (GIS) computer software package. The plot shows that the berms that were present in the 2011 survey are no longer present, which supports the similar observations made in the beach profile analysis. In the winter of 2012. The majority of the frontage is characterised by shore-parallel contours. In the north-west half of the frontage contours highlight two streams with channels running across the beach. The GIS has also been used to calculate the differences between the Autumn 2011 and Autumn 2012 topographic survey, as shown in Appendix B – Map 1b, to identify areas of net erosion and accretion. During the 12 months to the 2012 Full Measures survey, North Sands shows a mixed pattern of accretion and erosion. South of the jetty the distribution of accretion and erosion is almost equal. The centre of the southern half has accreted by up to 0.6m. The erosion in the southern half is centred on the rock at the edge of the survey and close to the jetty, up to 0.4m of material was lost. The northern half is dominated by erosion, although there are patches of accretion. The erosion is concentrated in an area in the centre of the northern half where a loss of up to 1m was recorded, although erosion of around 0.5m was more widespread. The accretion was observed in two strips, one close to the shore and one at the offshore extent of the survey. Both areas of accretion where shore parallel bands with accretion of up to 1m. **Long Term Topographic Trends Autumn 2008 to Autumn 2012:** The long term difference plots (Appendix B – Map 1c) provide information on net of change in beach levels between Autumn 2008 and Autumn 2012 in North Sands. The plot shows a clear difference between the northwest and southeast side of the jetty. On the northwest side the pattern of change shows shore-parallel bands of accretion and erosion of up to 1.5m. In the southeast there is an area of erosion of around 0.5m immediately next to the jetty that continues for c. 500m of beach, beyond which is an area of accretion of up to 0.75m.	frontage changes were more muted. Overall widespread low-level changes observed suggest that the sediment is being redistributed across the frontage. **Autumn 2008 to Autumn 2012 trends** There is a clear difference between the patchy erosion to the south of the jetty and shore parallel changes to the north. The magnitude of change over the four years covered by the long term difference plot is within a range of 2m. As a result the changes observed between 2008 and 2012 are of a similar magnitude to those observed over the recent surveys between 2011 and 2012. This observation suggests that there is a good balance between incoming and outgoing sediment in this beach system. There are no areas of significant erosion and accretion over the four year plot, which were not observed in the annual change plots.

2.2 Middleton

Survey Date	Description of Changes Since Last Survey	Interpretation
17th Sept 2012	**Beach Profiles:** Middleton is covered by one beach profile line during the Full Measures survey (Appendix A). The beach at Profile **1cHC1** was high in the landward half and low in the seaward half compared to the surveys dating back to 2008. The profiles show that the beach level at the sea wall is 1.4m higher than in September 2010, which is when the beach was at its lowest recorded point. Down the beach from the seawall at 45m to 120m chainage the beach has accreted by 0.2m. Between 130m and 190m chainage the beach has eroded by 0.5m over the summer.	The changes along most of the beach profile are within the bounds of previously recorded change. The beach was much flatter than recorded in March 2012. **Longer term trends**: the beach has an observed increase in steepness as you move east. This change was also apparent in the 2010 and 2011 Full Measures plots. The prevailing processes in 2011 and 2012 have acted to exacerbate the difference in beach levels with erosion on the steepest part close to the harbour wall. On the western side of the bay on the shallow slope accretion has occurred. It is likely that the eastern side of Middleton will come under greater pressure form coastal processes with more severe waves causing erosion. It will be interesting to see how this develops through the coming years. **Autumn 2008 to Autumn 2012 trends** The long term plot of change between 2008 and 2012 shows that erosion is focused on the eastern part of the bay. This data correlates with the trend for beach steepening observed at this location. The back of the beach at this location is accreting slightly, and this is most marked in the area near the breakwater.
	Topographic Survey: Middleton is covered by an annual topographic survey between Middleton Jetty and North Pier. Data from the 2011 Full Measures survey have been used to create a DGM (Appendix B – Map 2a) using Geographic Information System (GIS) software. The beach contours recorded in Winter 2012/13 show a difference in the steepness of the beach at each end of the frontage. The beach closest to the harbour breakwaters is steep. At the western part of the beach has a much shallower slope and is smooth with no berms present. These observations are very similar to those reported in the 2010 and 2011 Full Measures Report. The GIS has also been used to calculate the differences between the Autumn 2011 and Autumn 2012 topographic surveys, as shown in Appendix B – Map 2b, to identify areas of net erosion and accretion. Through 2012, the beach is dominated by a band of erosion which runs sub parallel to the shore. The erosion was most severe in the eastern third of the bay, where up to 1m of loss was recorded. Accretion of up to 0.5m was noted at the back of the beach and in the western half of the bay. This means that the difference in beach slopes in each half of Middleton has continued to develop since 2010. **Long Term Topographic Trends Autumn 2008 to Autumn 2012:** The long term plot of change at Middleton (Appendix B – Map 2b) shows net erosion overall with the largest recorded erosion being 1.25m in the middle of an erosive patch which dominates the eastern third of the bay. Across the rest of the frontage the erosion was around 1m between 2008 and 2012.	

Survey Date	Description of Changes Since Last Survey	Interpretation
	There is localised accretion at the back of the beach and close to the defence in the northeast of the bay of up to 0.5 to 0.75m.	

2.3 Hartlepool Bay

Survey Date	Description of Changes Since Last Survey	Interpretation
16th Oct 2012	**Beach Profiles:** Hartlepool Bay is covered by four beach profile lines during the Full Measures survey (Appendix A). Profile **1cHS1** is located approximately 150m south of the root of the South Pier. The profile starts at the wall to the rear of the promenade and extends across the promenade, over the fronting concrete splash wall and down the sloping face of the rock armour revetment before reaching the beach. It then gently slopes down to low water. The profile for September 2012 is among one of the lowest profiles observed since March 2009. The March and October 2012 profiles are the same until 40m chainage. From 40m to 70m chainage the beach has eroded up to half a metre, exposing rocks on the foreshore. For the remainder of the profile the beach levels remained the same. Profile **1cHS2** was high in October 2012 compared to beach profiles taken since March 2009. Above MHWS very little has changed. Close to the HAT level there is a spike in the profile which could be a rock from the defence. From 20m to 40m chainage the beach has accreted by around 0.6m. The rest of the profile has remained stable with the accretion and erosion within a range of ±0.2m At profile **1cHS3** the March 2012 and October 2012 profiles are within ±0.2m of each other between 0m and 150m chainage. A new sea wall was built at this location and the March 2012 and October 2012 profiles show the new section. Between 150m and 200m chainage a mound which had formed in March 2012 was eroded from the beach resulting in a loss of ±0.2m. Beyond 200m chainage the beach profiles are similar. The profile **1cHS4** is located further south, around 1km north of the North Gare breakwater. It is in the area of undefended dunes at Seaton Sands. The profile covers approximately 350m of dunes before reaching the open coast. The Dune section looks reasonably stable. A fore-dune has accreted by 0.5m since March 2012. The rest of the beach has remained stable overall with accretion and erosion being within ±0.2m. **Topographic Survey:** Hartlepool Bay is covered by an annual topographic survey between the South Pier and the North Gare	The October 2012 beach levels present a mixed picture of accretion and erosion. HS1 had eroded and the level was one of the lowest recorded, the profile had rocks exposed on the foreshore platform. Beach lowering is common in front of seawalls. There was no evidence of progressive lowering but the frontage will continue to be monitored. HS2 had accreted and was amongst the highest profiles recorded at that beach. HS3 remained stable with little change since March 2011 HS4 had formed a fore-dune, which is a sign of continuing erosion. The dunes behind the profile are assumed to be stable. The topographic difference plot has been divided into three sections. The north and south sections had a patchy redistribution of change but the erosion and accretion was modest. Change in the central section was of greater magnitude, with isolated patches of accretion on the beach in front of Seaton Carew of up to 2m. **Longer term trends**: The beach behaviour is was variable in 2012 with no clear patterns of accretion or erosion. This was a similar trend to that observed in the 2011 Full Measures Report. The beach in front of the defended section appeared

Survey Date	Description of Changes Since Last Survey	Interpretation
	Breakwater. Data from the 2012 Full Measures survey have been used to create a DGM (Appendix B – Map 3a) using a Geographic Information System (GIS) computer software package. The plot shows the two smaller bays within the log-form Hartlepool Bay. There is a slight headland or promontory in the shoreline at Carr House Sands in the lee of Long Scar rocks between Hartlepool and Seaton Carew. For the rest of the bay the contours indicate a gently sloping beach slope. The GIS has also been used to calculate the differences between Autumn 2011 and Autumn 2012 topographic survey, as shown in Appendix B – Map 3b, to identify areas of erosion and accretion. The changes recorded over 2012 are very patchy, with no overall pattern. In the northern third of Hartlepool Bay the changes to the beach can be divided into two areas, divided by a sub parallel band of very little change. The northern area of erosion covers the north and the lower foreshore, where there was erosion of up to 0.3m. Adjacent to that there was small scale accretion of up to 0.3m on the south and upper foreshore. The change in regime between erosion to the north and accretion to the south is divided by a diagonal line of little or no change. Very little change has occurred within the Marina near Hartlepool. The central third of the bay, between Long Scar and Seaton Carew has a very patchy distribution of change. The pattern of losses and gains are a poorly defined sequence of shore parallel bands of accretion and erosion. The accretion and erosion observed on the beach are within a range of ±0.5m between Autumn 2011 and Autumn 2012. There are isolated areas of the beach close to Seaton Carew where the beach has accreted by up to 2m and the foreshore in front of the Seaton Carew frontage is more generally accretionary than its surrounding areas. The southern third of the frontage between Seaton Carew and the North Gare Breakwater also has weak shore parallel bands of accretion and erosion. The areas of the beach where accretion or erosion have occurred are almost equal and the amount of change is within a range of ±0.3m. **Long Term Topographic Trends Autumn 2010 to Autumn 2012:** The net changes observed between the first full measures survey in 2010 and the most recent in Autumn 2012 are shown in Appendix B – Map 3c. The plot shows a patchy distribution of accretion and erosion. Hartlepool Bay is made up of two separate, smaller, bays which dictate coastal behaviour. In general, the alignment of these bays determines the pattern of change, with the northern parts of the bays experiencing net erosion (up to 0.5m) and the south experiencing net accretion (up to 0.75m).	to be eroding while the beach in front of the dunes was healthy or accreting. This generalised pattern was supported by the topographic change plots. The pattern of behaviour will continue to be monitored to assess the longer term trends. The topographic difference plots for 2012 are more dominated by erosion than the plots for 2011, when there had been accretion overall. The pattern of weak shore parallel bands, indicating ridge-runnel systems, have been observed in both 2011 and 2012. **Autumn 2010 to Autumn 2012 trends** The long term difference plots show a patchy distribution of accretion and erosion in the two years since 2010. Hartlepool Bay comprises two smaller bays. There is a general pattern of erosion in the north of these bays and accretion in the south, which reflects the impact of refraction of the dominant north-easterly waves.

3. Problems Encountered and Uncertainty in Analysis

Beach profile HN1 is located within Durham County Council's jurisdiction but has been reported here so changes can be interpreted in association with those observed elsewhere along North Sands, along HN2, HN3 and HN4. In October 2012 new sea defences were being built at Hartlepool south and the construction works were affecting the beach, with large excavations and spoil heaps present.

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

No changes are needed at the present time.

5. Conclusions and Areas of Concern

- The North Sands frontage became flattened and lost the mounds of material which were on the beach in March 2012. The topographic plots for winter 2012 shows that the banks which were present in 2011 were no longer present, which supports the observations made in the beach profile analysis. The areas of accretion and erosion appeared to be equal in area during 2012 so there were no net changes at this location. The long term difference plots show that there is a clear difference between the patchy erosion to the south of the jetty and shore parallel changes to the north. There are no causes for concern on this frontage.
- At Middleton, beach profiles show that there is large variability in the level of the beach. The beach level had recovered since it was at its lowest recorded point in September 2010. The topographic change plots show that the beach has an observed increase in steepness as you move east. The long term plot of change between 2008 and 2012 shows that the most severe erosion is centred on the eastern third of the bay.
- Hartlepool Bay has shown variability in the beach profiles and topographic change plots. The topographic difference plots for 2012 are more dominated by erosion than the plots for 2011, when there had been accretion overall. The pattern of weak shore parallel bands has been observed in both 2011 and 2012. However, there is no clear pattern of change in the long-term erosion plots. There is no cause for concern at the Hartlepool Bay

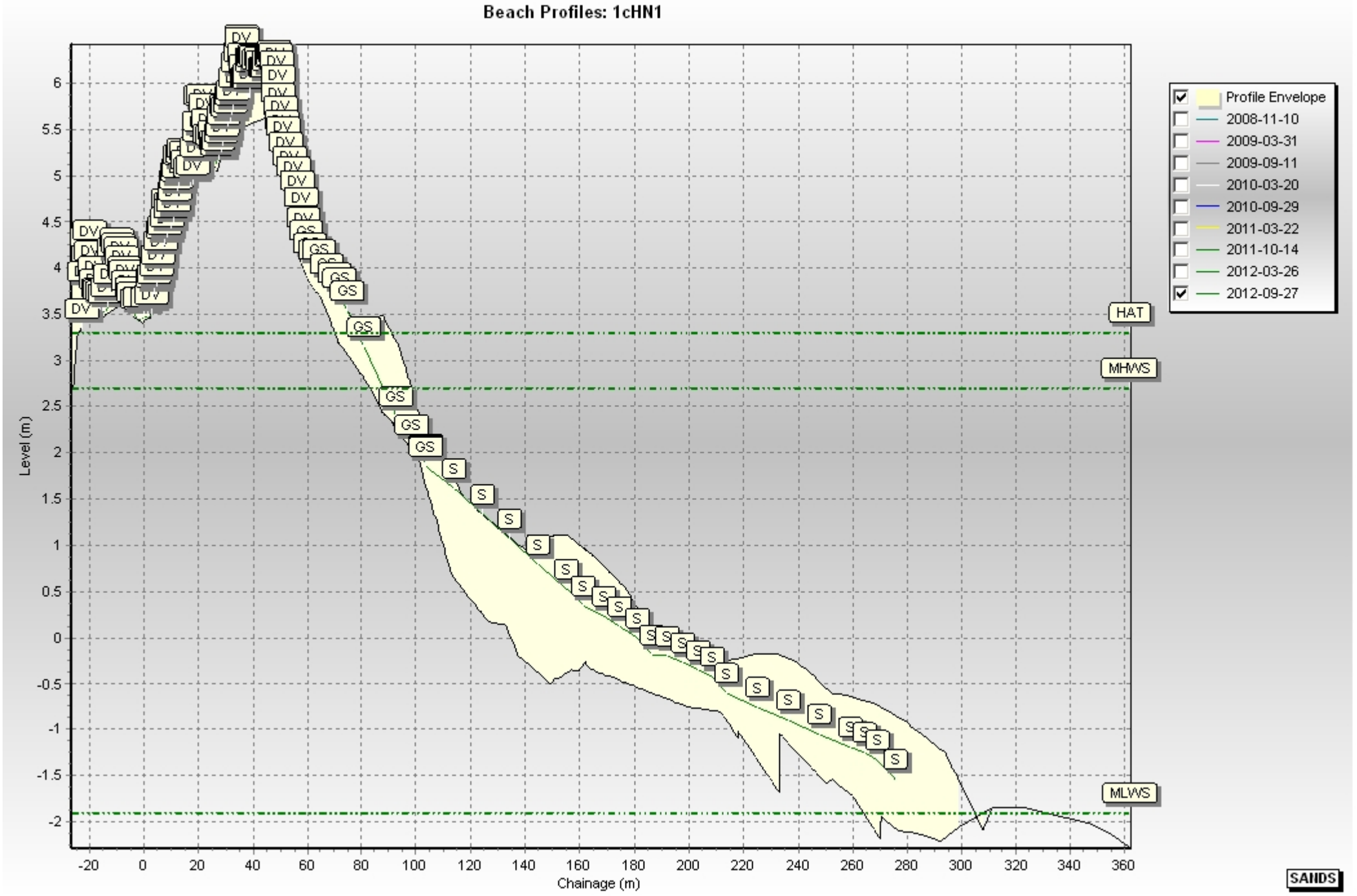
Appendices

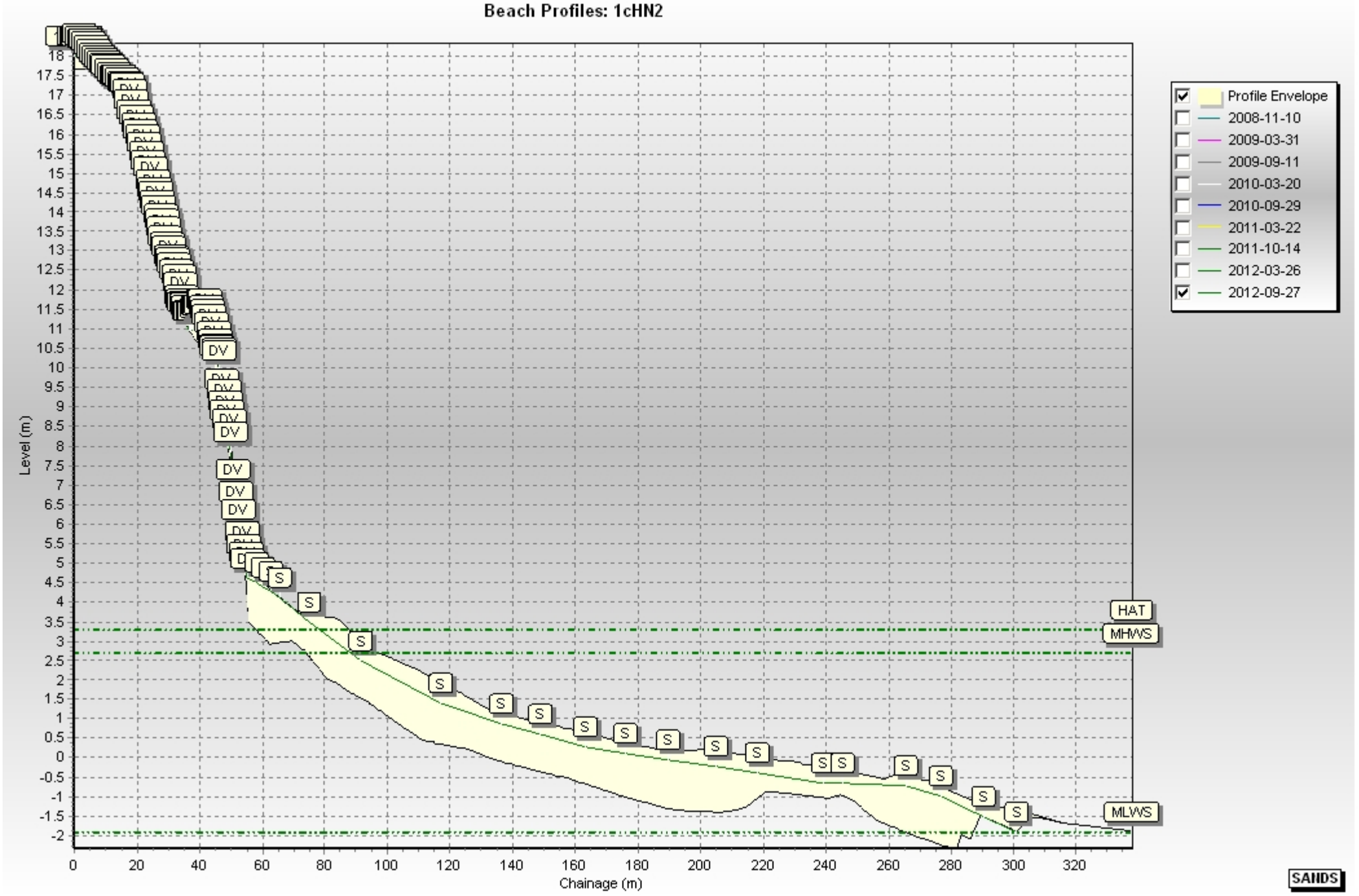
Appendix A

Beach Profiles

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


Beach Profiles: 1cHN1
Profile Envelope
2008-11-10
2009-03-31
2009-09-11
2010-03-20
2010-09-29
2011-03-22
2011-10-14
2012-03-26
2012-09-27
HAT
MHWS
MLWS
Level (m)
Chainage (m)
SANDS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Level (m)
Chainage (m)
Profile Envelope
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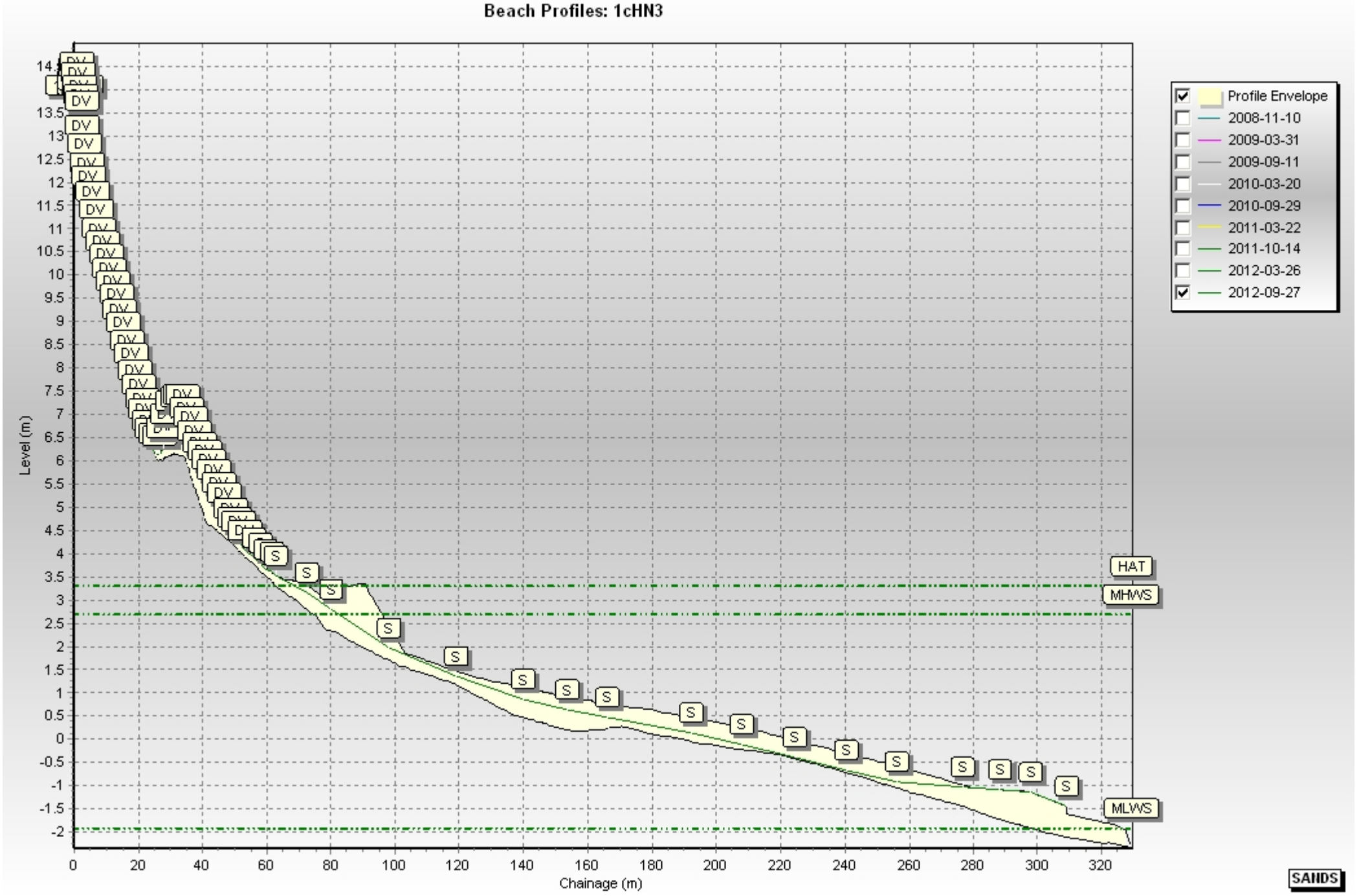
2009-03-31
2009-09-11
2010-03-20
2010-09-29
2011-03-22
2011-10-14
2012-03-26
2012-09-27
HAT
MHWS
MLWS
DV
S
SANDS


Beach Profiles: 1cHN3
Profile Envelope
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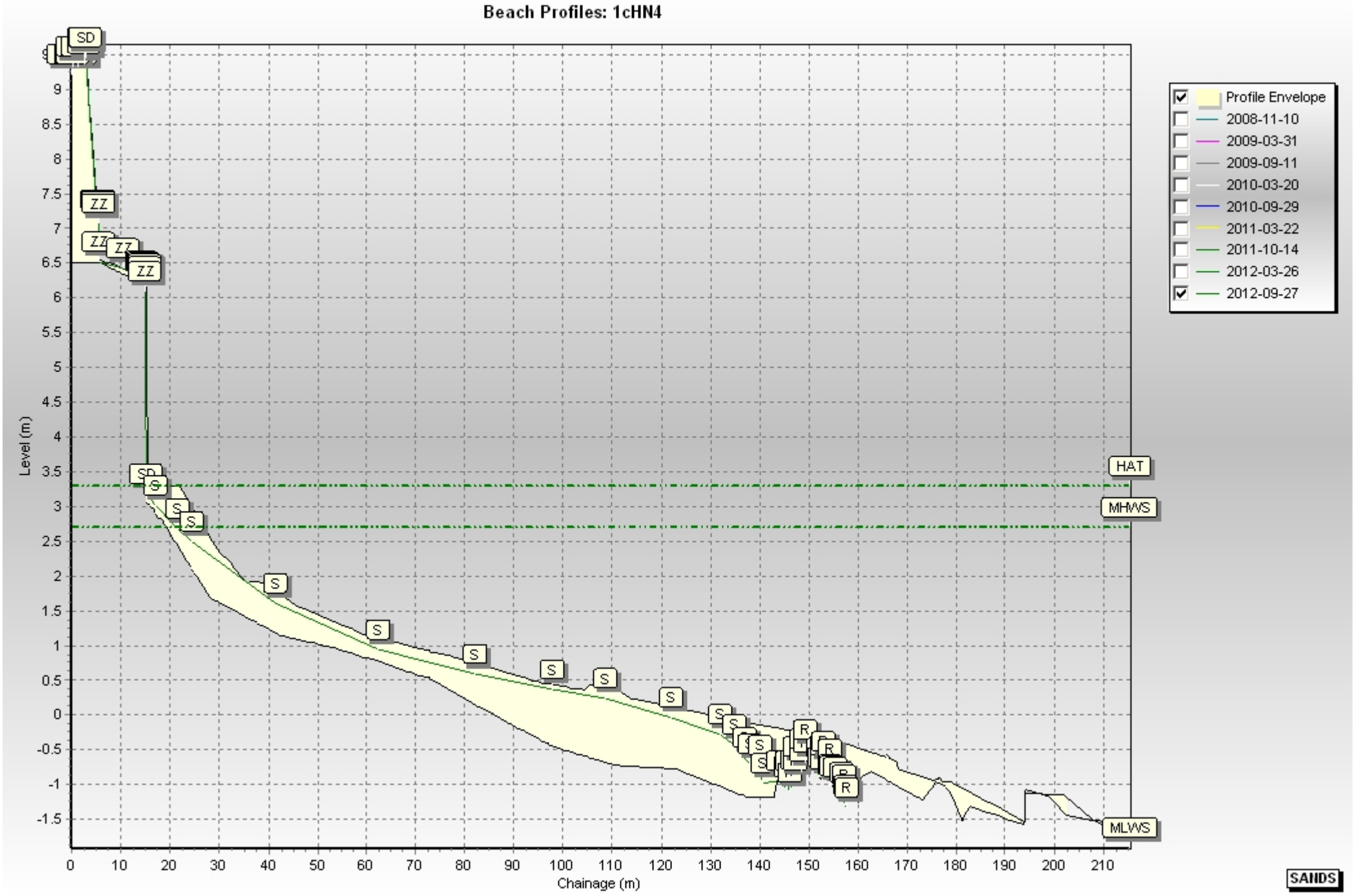
2009-09-11
2010-03-20
2010-09-29
2011-03-22
2011-10-14
2012-03-26
2012-09-27
Level (m)
Chainage (m)
HAT
MHWS
MLWS
DV
S
SANDS


Beach Profiles: 1cHN4
Profile Envelope
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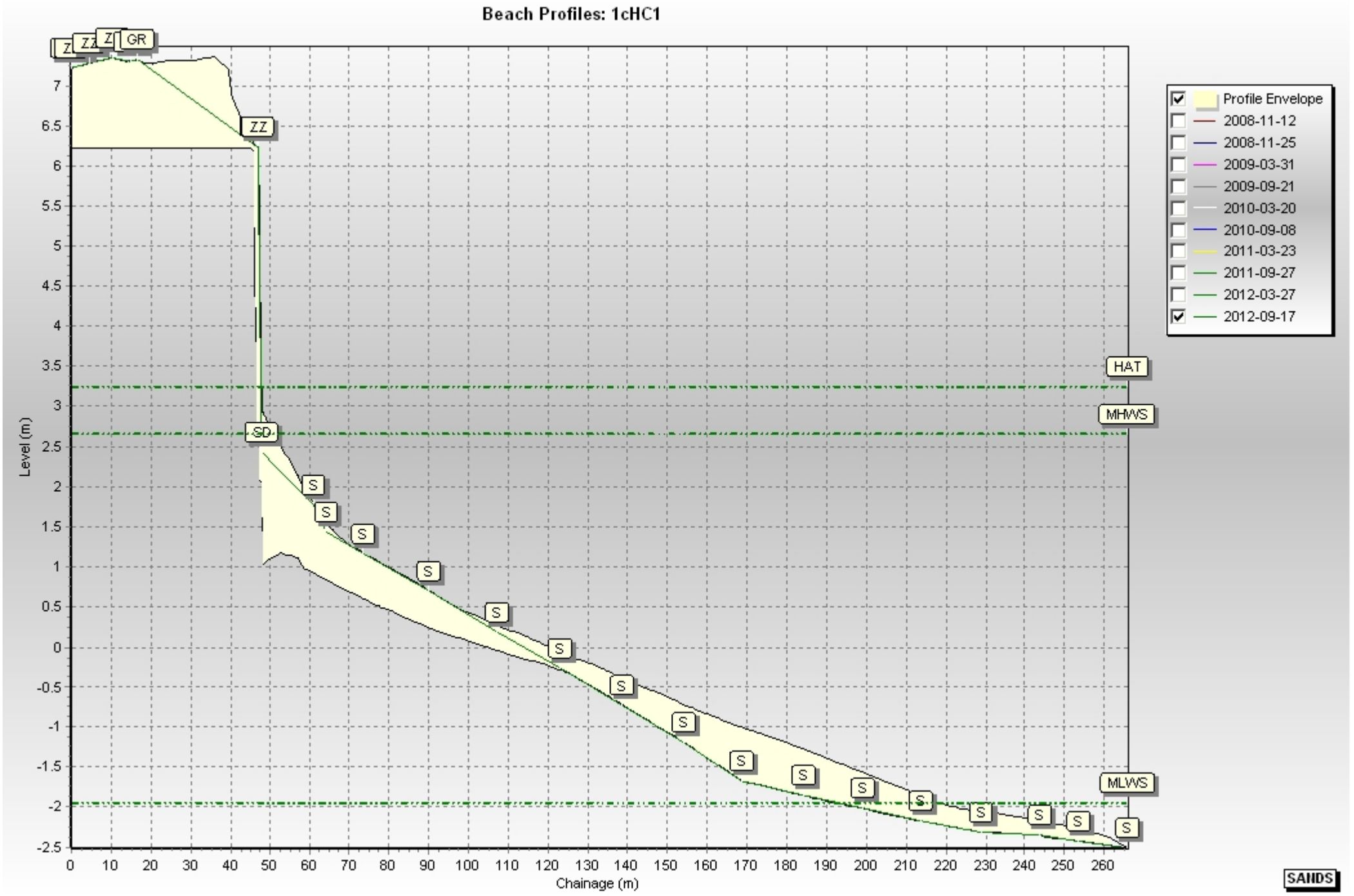
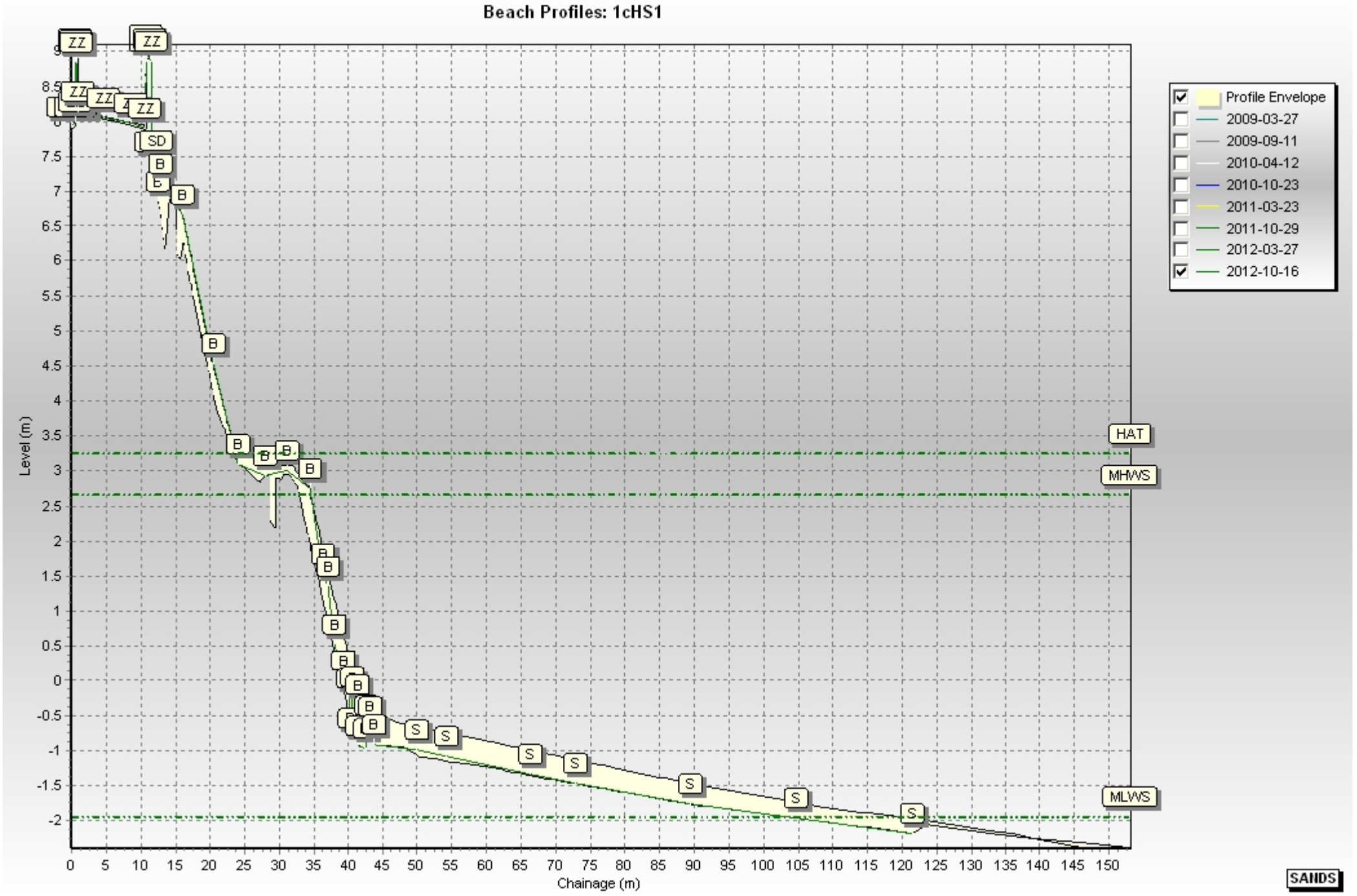
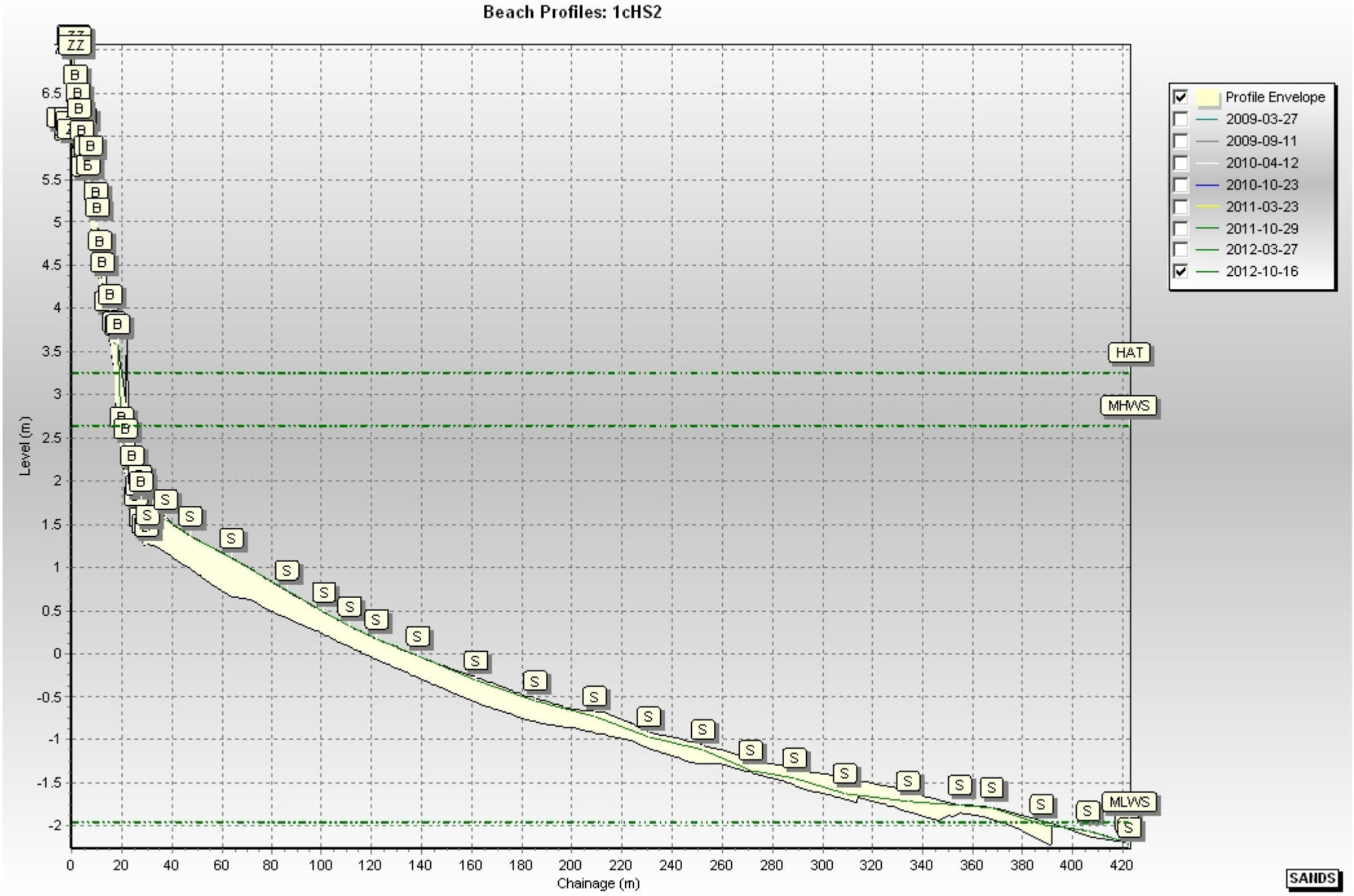
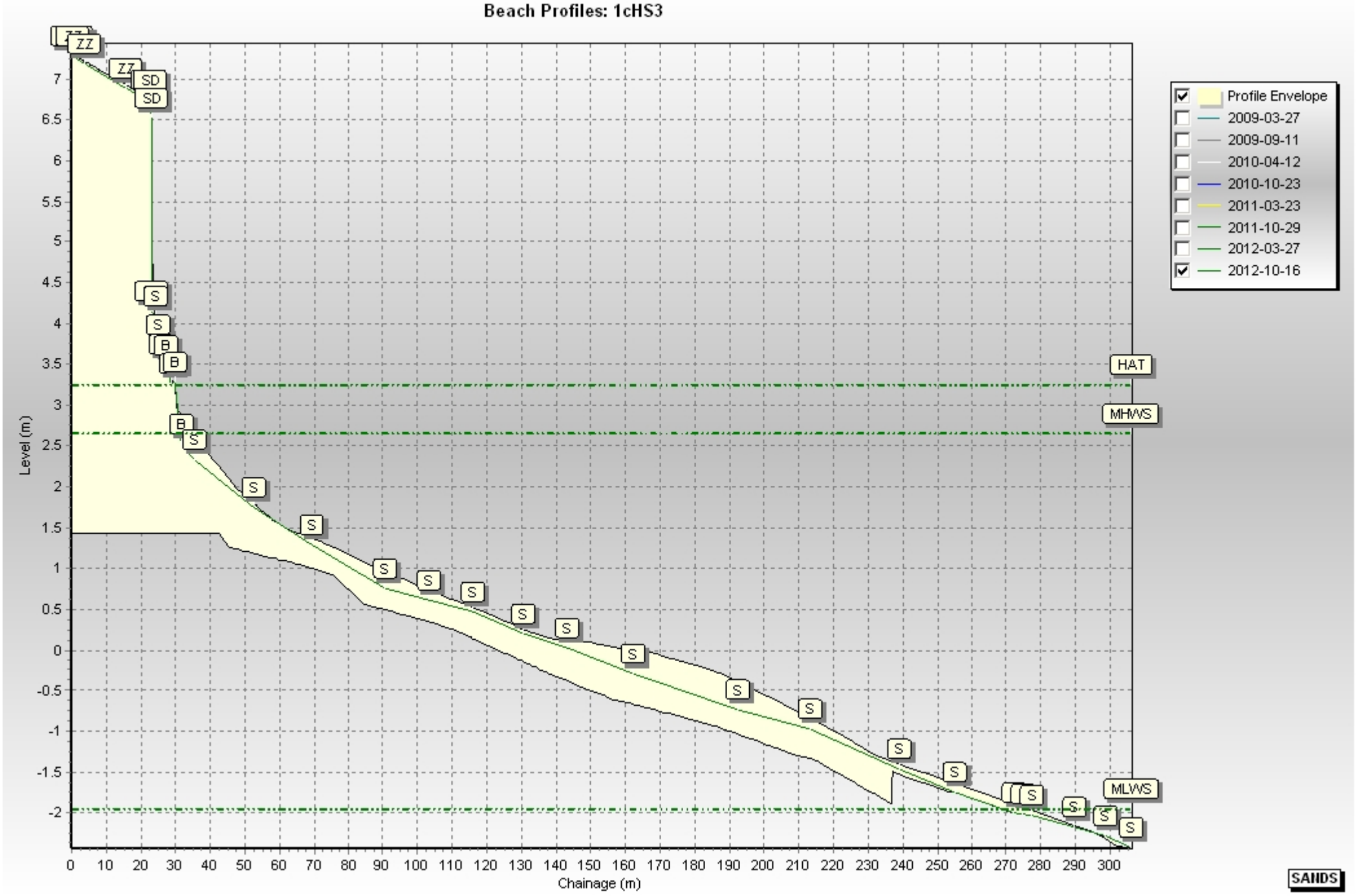
2009-03-31
2009-09-11
2010-03-20
2010-09-29
2011-03-22
2011-10-14
2012-03-26
2012-09-27
HAT
MHWS
MLWS
Level (m)
Chainage (m)
SANDS


Beach Profiles: 1cHC1
GR
ZZ
SD
S
HAT
MHWS
MLWS
Profile Envelope
2008-11-12
2008-11-25
2009-03-31
2009-09-21
2010-03-20
2010-09-08
2011-03-23
2011-09-27
2012-03-27
2012-09-17
Level (m)
Chainage (m)
SANDS


Beach Profiles: 1cHS1
Profile Envelope
2009-03-27
2009-09-11
2010-04-12
2010-10-23
2011-03-23
2011-10-29
2012-03-27
2012-10-16
HAT
MHWS
MLWS
Level (m)
Chainage (m)
SANDS


Beach Profiles: 1cHS2
Profile Envelope
2009-03-27
2009-09-11
2010-04-12
2010-10-23
2011-03-23
2011-10-29
2012-03-27
2012-10-16
HAT
MHWS
MLWS
Level (m)
Chainage (m)
SANDS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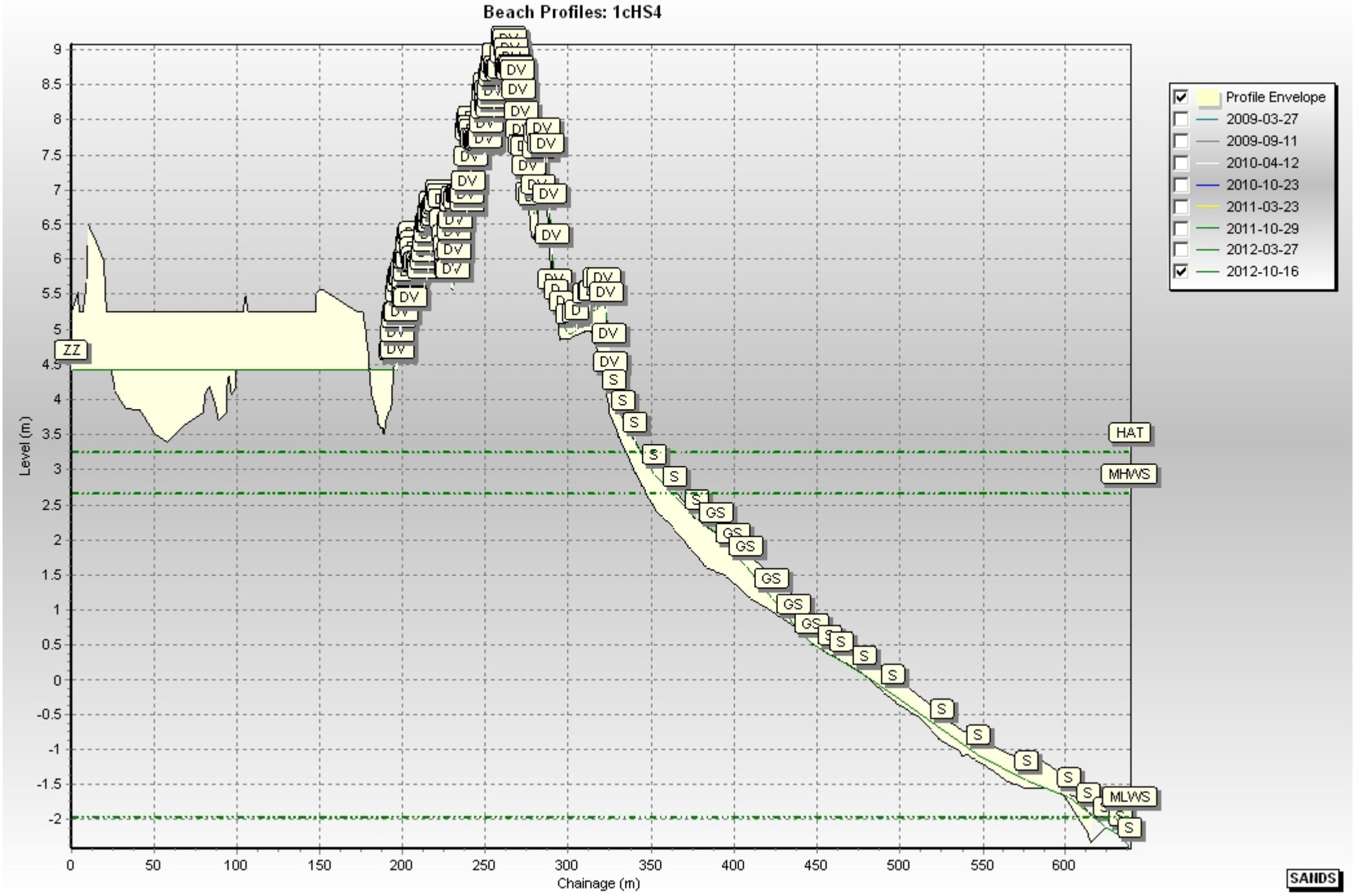
Profile Envelope
2009-03-27
2009-09-11
2010-04-12
2010-10-23
2011-03-23
2011-10-29
2012-03-27
2012-10-16
HAT
MHWS
MLWS
Level (m)
Chainage (m)
SANDS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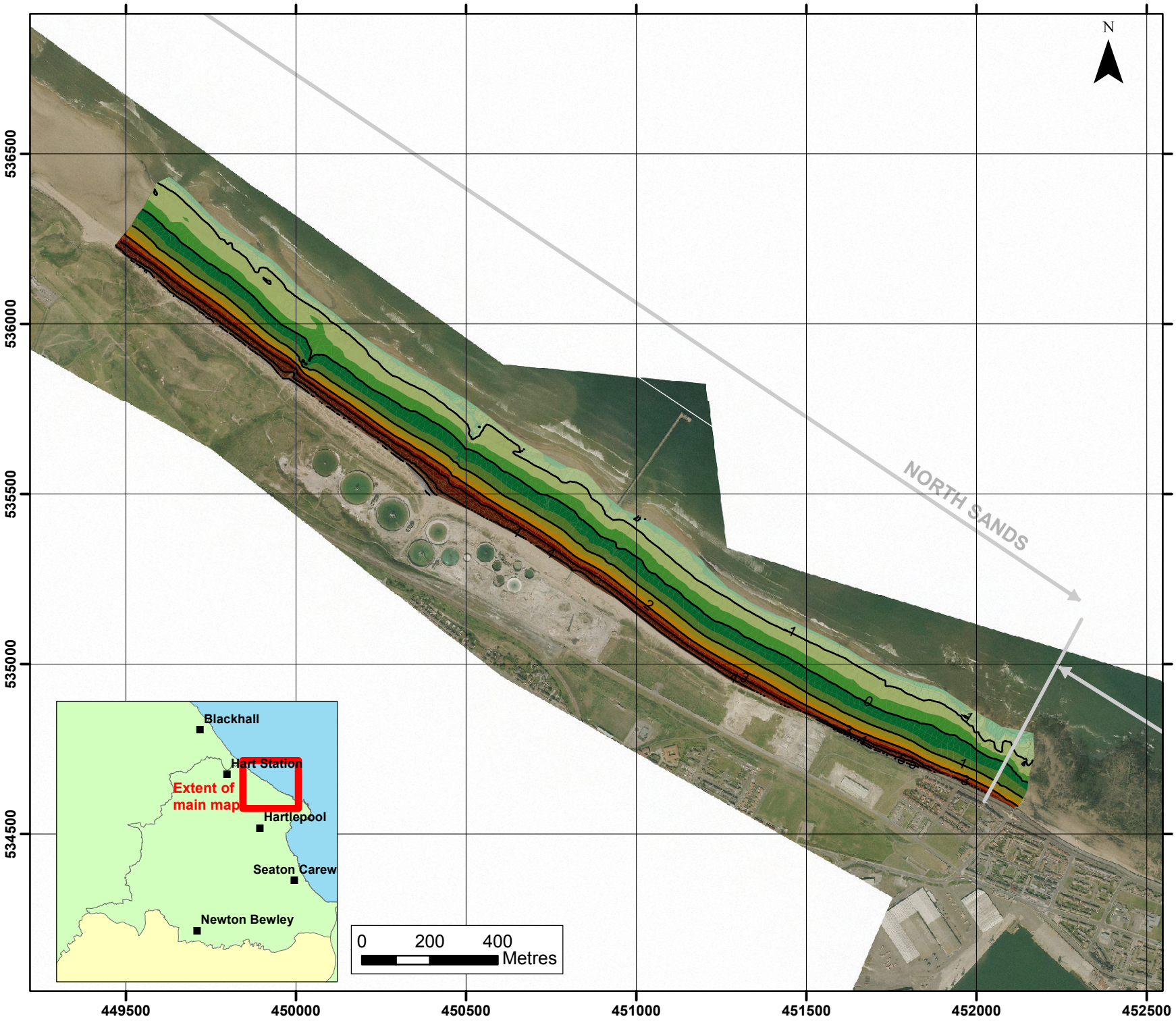
Level (m)
Chainage (m)
Profile Envelope
2009-03-27
2009-09-11
2010-04-12
2010-10-23
2011-03-23
2011-10-29
2012-03-27
2012-10-16
ZZ
DV
S
GS
HAT
MHWS
MLWS
SANDS

Appendix B

Topographic Survey



KEY

Elevation (m OD)

- 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
- -2.5 - -2
- Contour 1m

Client: North East Coastal Group

Project: Cell 1 Regional Coastal Monitoring Programme 2011 to 2016

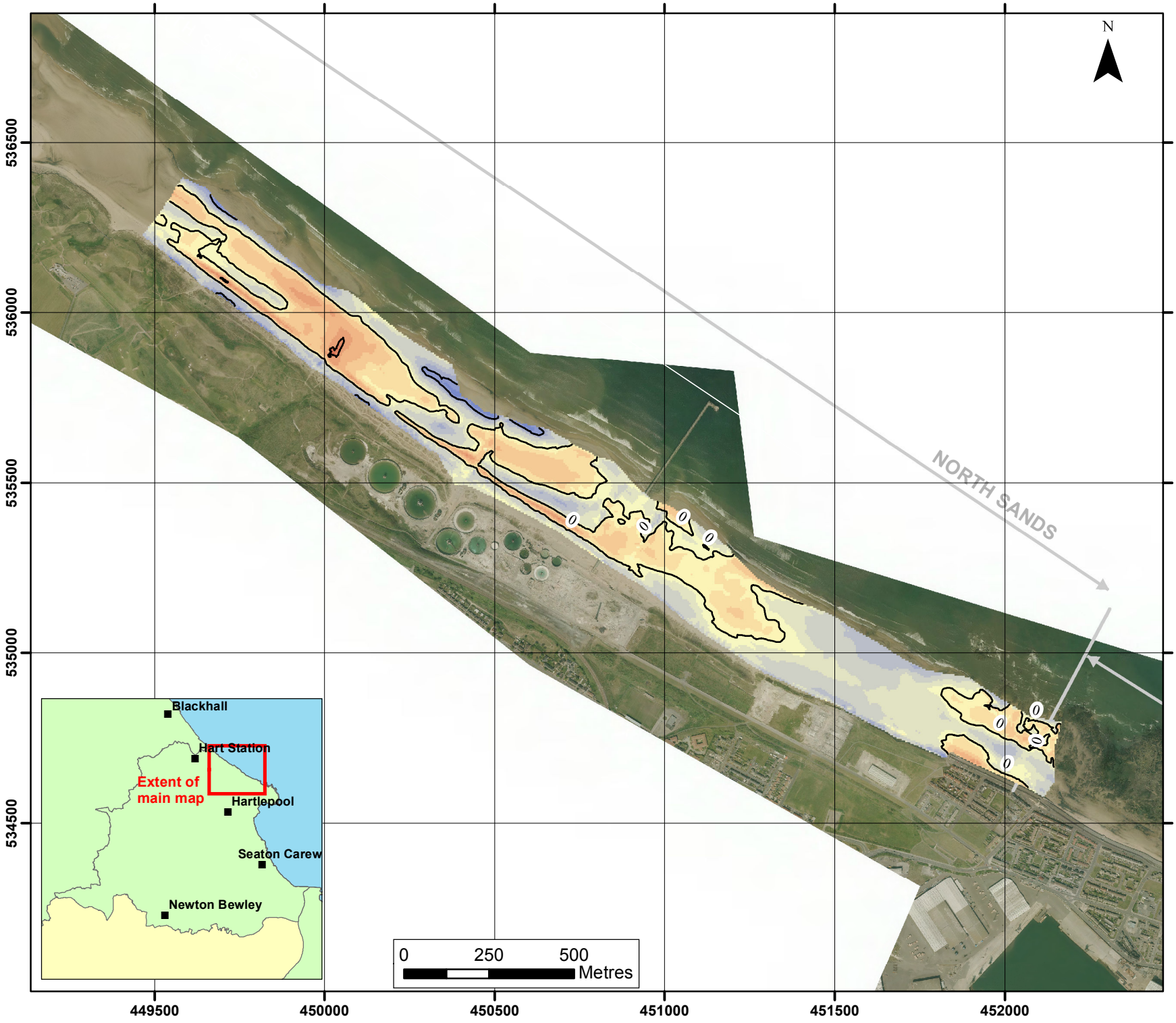
Appendix B - Map 1a
Topographic Survey
North Sands
Hartlepool Borough Council

Analytical Report 5
Full Measures Survey
Winter 2012

Halcrow
A CH2M HILL COMPANY

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.halcrow.com



KEY Autumn 2011 and Autumn 2012
Change in elevation (m OD)

- <-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 1b
Short-term Elevation change
North Sands
Hartlepool Borough Council

Analytical Report 5
Full Measures (Autumn) Surveys 2011 to 2012

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A CH2M HILL COMPANY

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

Tel: +44 (0)121 456 2345
Fax: +44(0)121 456 1569
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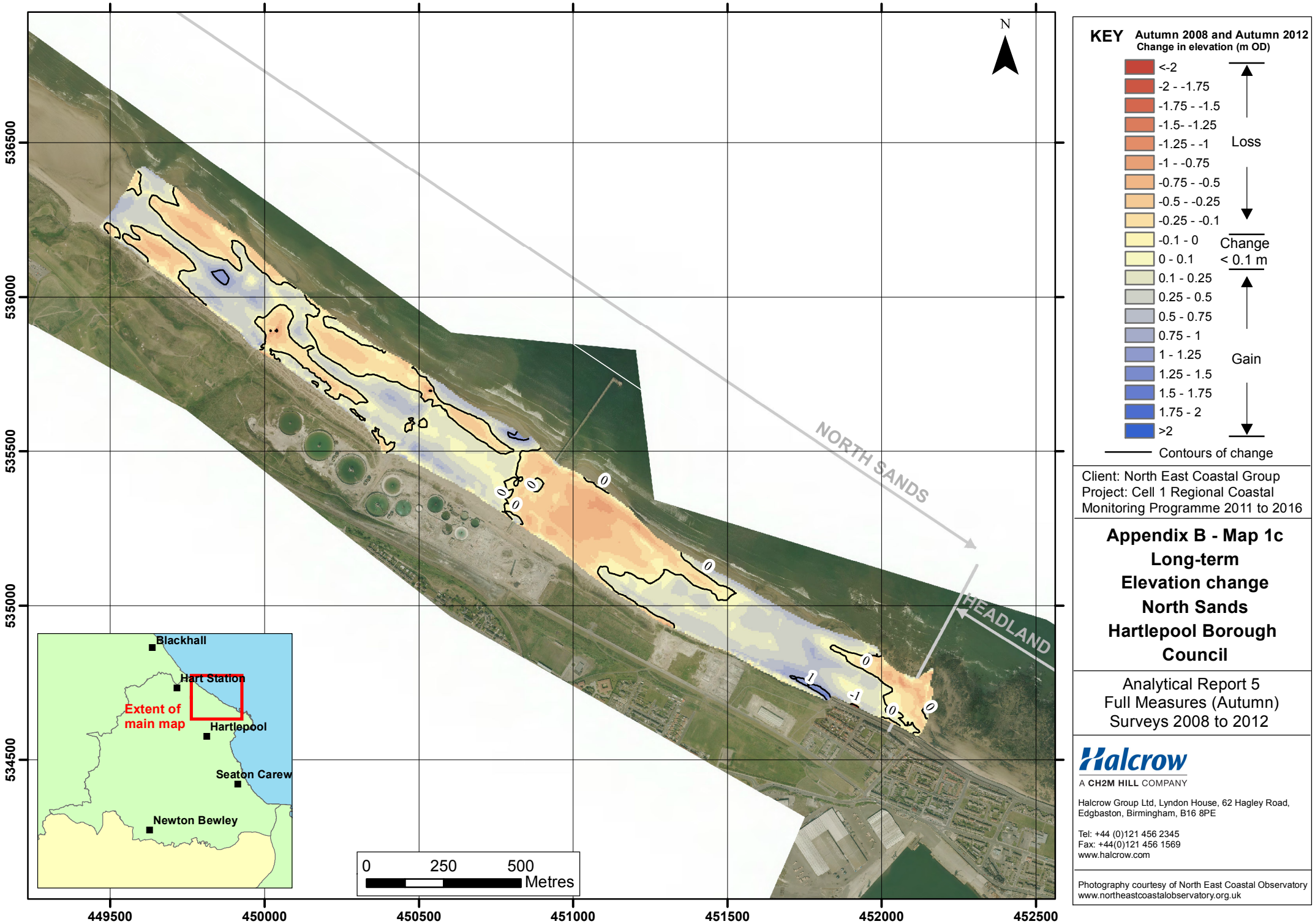
Photography courtesy of North East Coastal Observatory
www.northeastcoastalobservatory.org.uk



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

Appendix B - Map 1c
Long-term Elevation change
North Sands
Hartlepool Borough Council

Analytical Report 5
Full Measures (Autumn) Surveys 2008 to 2012

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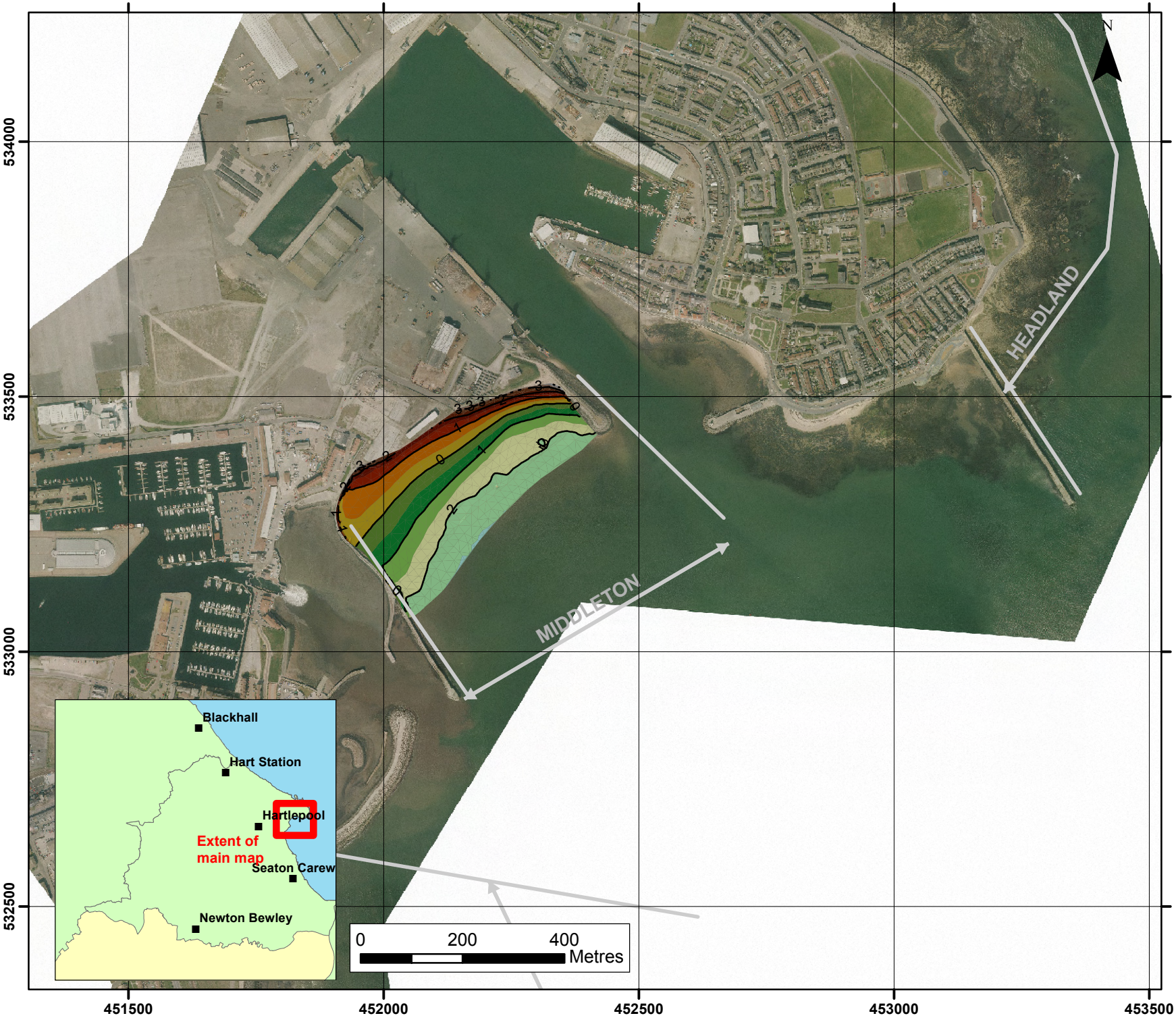
Halcrow Group Ltd, Lyndon House, 62 Hagley Road, Edgbaston, Birmingham, B16 8PE

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



KEY

Elevation

- 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
- -2.5 - -2
- -3 - -2.5
- Contour 1m

Client: North East Coastal Group

Project: Cell 1 Regional Coastal Monitoring Programme 2011 to 2016

Appendix B - Map 2a Topographic Survey Headland and Middleton Hartlepool Borough Council

Analytical Report 5
Full Measures Survey
Winter 2012

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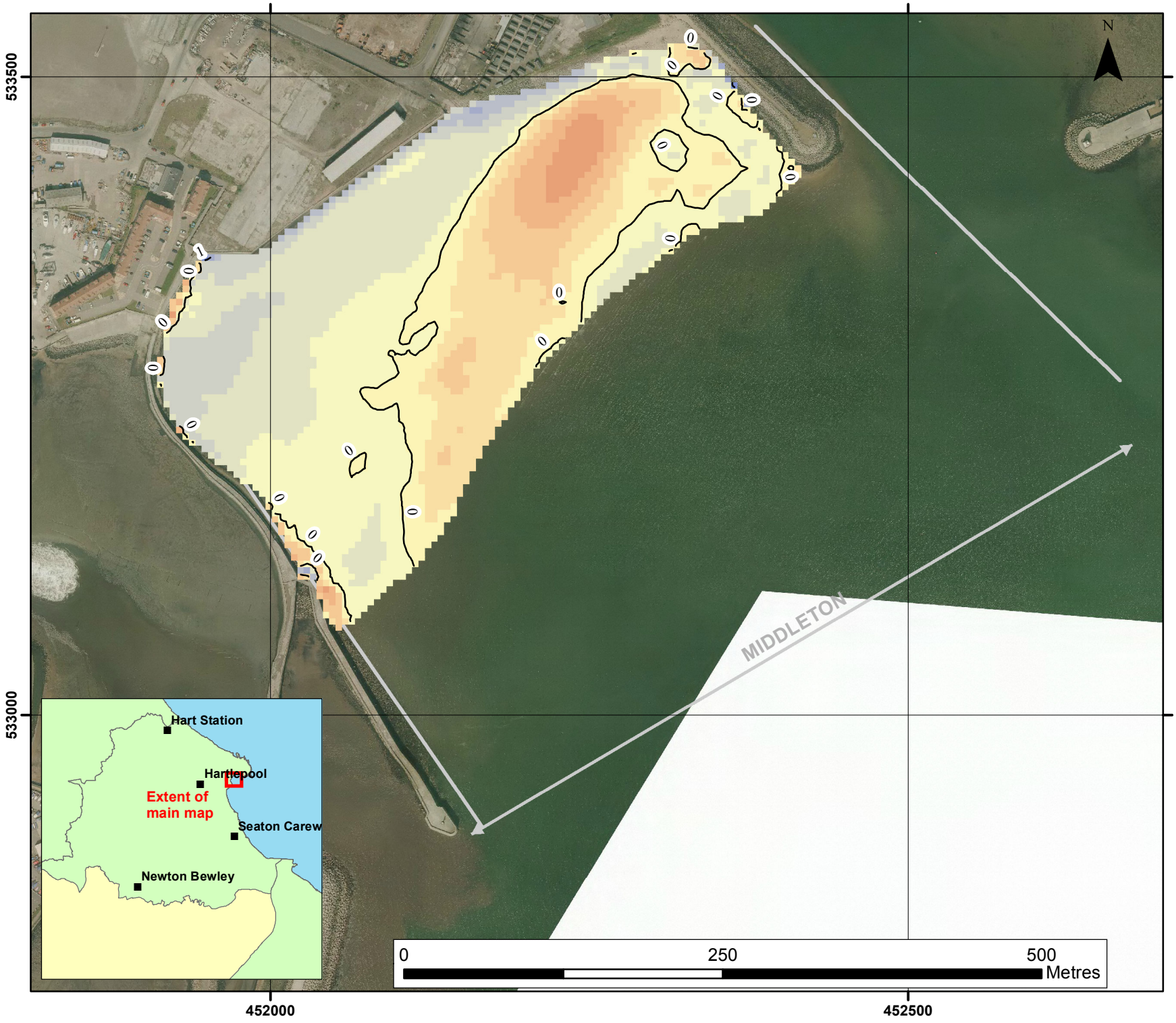
A CH2M HILL COMPANY

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.halcrow.com



KEY Autumn 2011 and Autumn 2012
Change in elevation (m OD)

<-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 Headland and Middleton Hartlepool Borough Council

Analytical Report 5
Full Measures (Autumn)
Suverys 2011 to 2012

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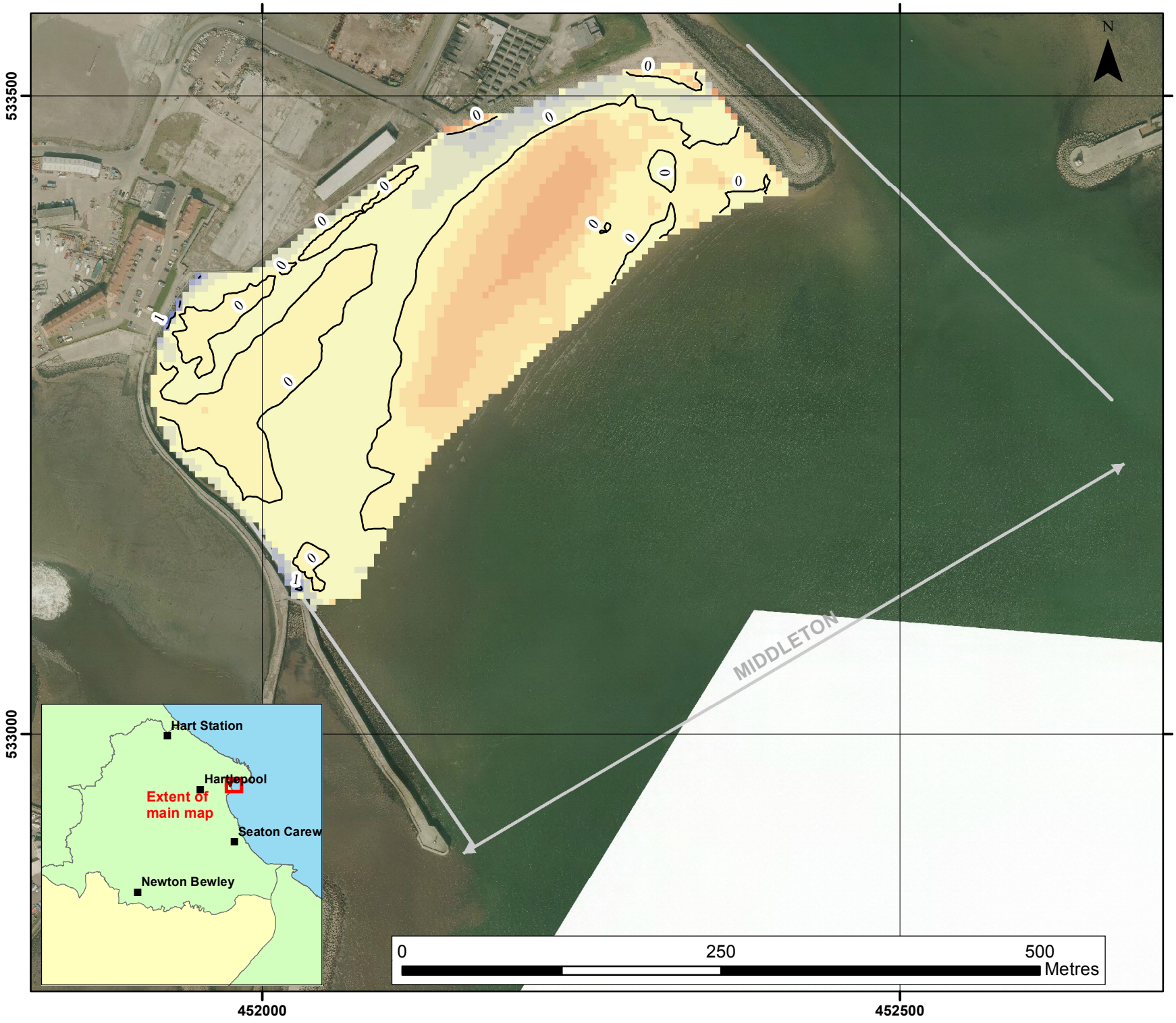
Fax: +44(0)121 456 1569
www.halcrow.com



KEY Autumn 2008 and Autumn 2012
Change in elevation (m OD)

<-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
Headland and Middleton
Hartlepool Borough Council

Analytical Report 5
Full Measures (Autumn) Surveys 2008 to 2012

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

Tel: +44 (0)121 456 2345
Fax: +44(0)121 456 1569
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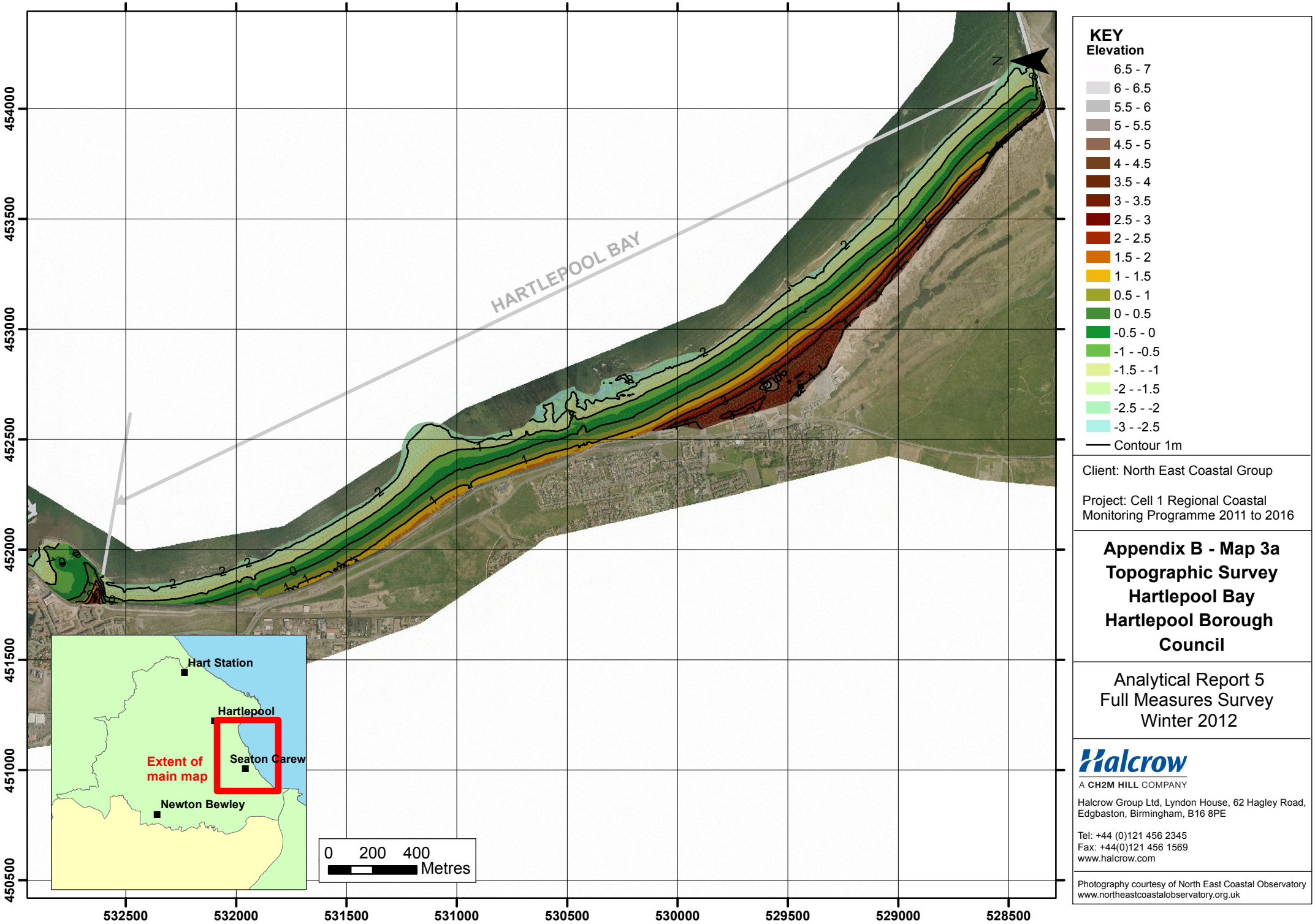

Client: North East Coastal Group

Project: Cell 1 Regional Coastal Monitoring Programme 2011 to 2016

Appendix B - Map 3a Topographic Survey Hartlepool Bay Hartlepool Borough Council

Analytical Report 5
Full Measures Survey
Winter 2012

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

Tel: +44 (0)121 456 2345
Fax: +44(0)121 456 1569
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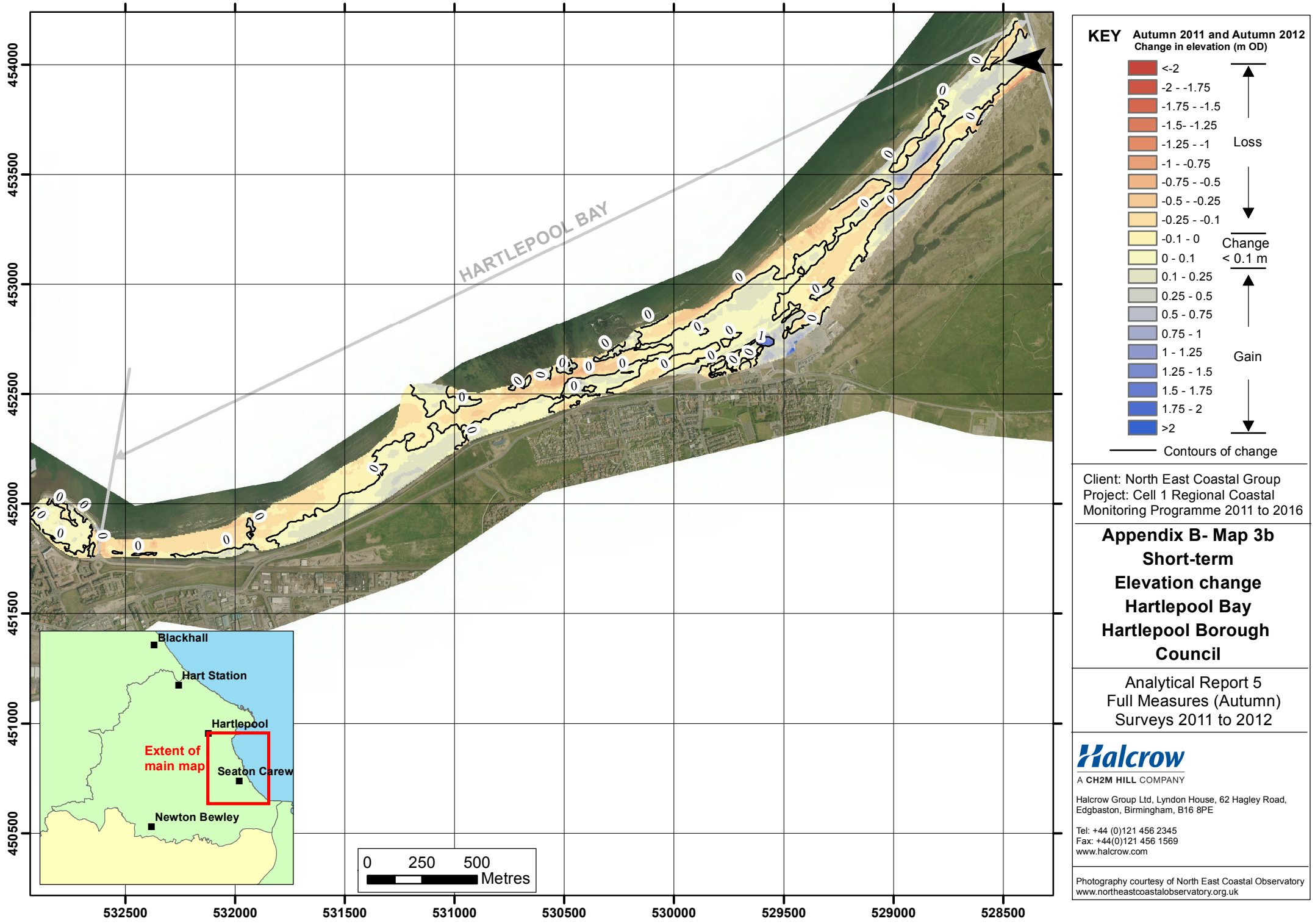


Client: North East Coastal Group
Project: Cell 1 Regional Coastal Monitoring Programme 2011 to 2016

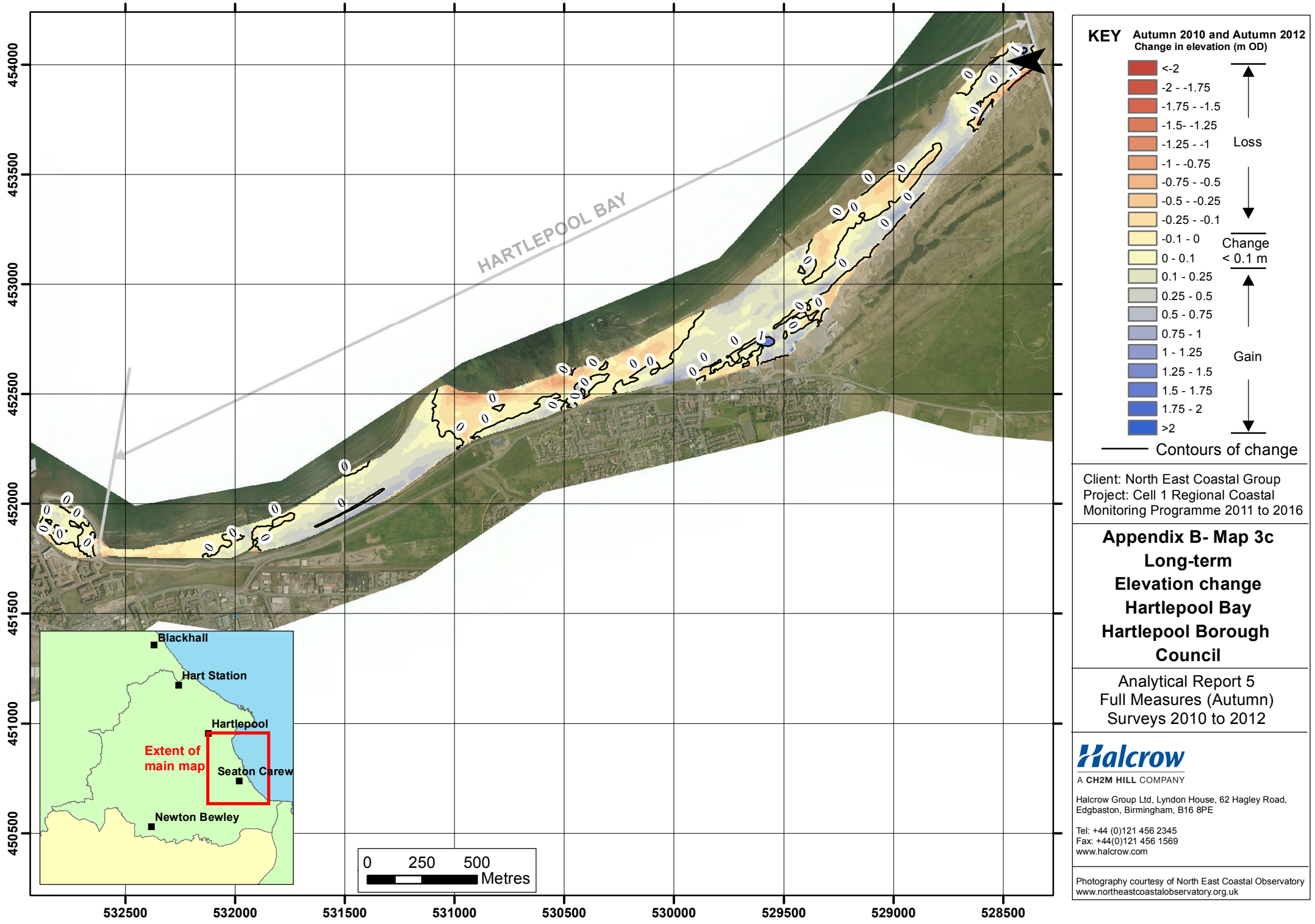
Appendix B- Map 3b
Short-term Elevation change
Hartlepool Bay
Hartlepool Borough Council

Analytical Report 5
Full Measures (Autumn) Surveys 2011 to 2012

Halcrow
A CH2M HILL COMPANY

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.halcrow.com



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

Appendix B- Map 3c
Long-term Elevation change
Hartlepool Bay
Hartlepool Borough Council

Analytical Report 5
Full Measures (Autumn) Surveys 2010 to 2012

Halcrow
A CH2M HILL COMPANY

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

Tel: +44 (0)121 456 2345
Fax: +44(0)121 456 1569
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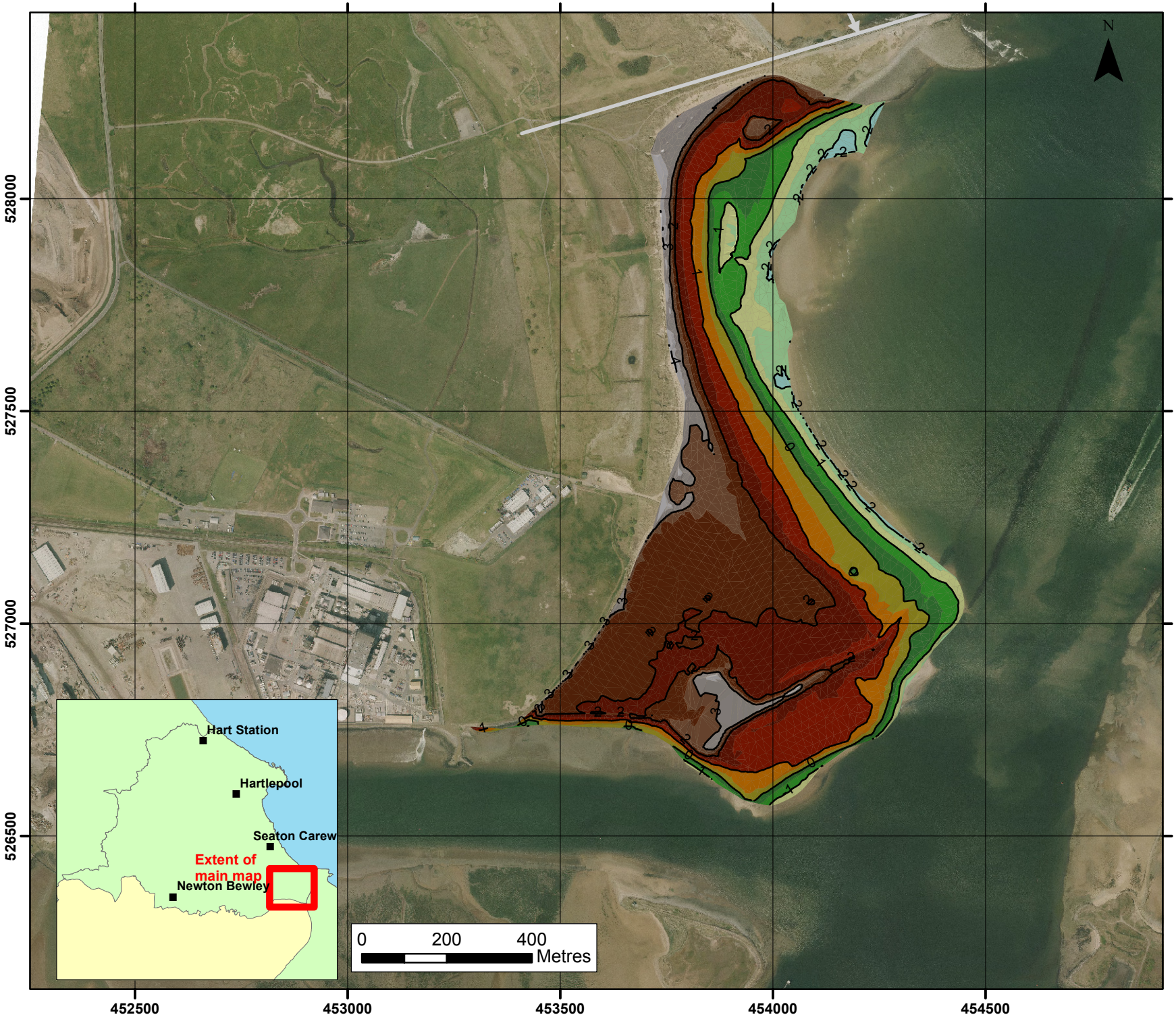

KEY

Elevation

- 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
- -2.5 - -2
- Contour 1m

Client: North East Coastal Group

Project: Cell 1 Regional Coastal Monitoring Programme 2011 to 2016

Appendix B - Map 4a
Topographic Survey
North Gare
Hartlepool Borough Council

Analytical Report 5
Full Measures Survey
Winter 2012

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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.halcrow.com