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Cell 1 Regional Coastal Monitoring Programme Update Report 5: 'Partial Measures' Survey 2013

Redcar and Cleveland Council Final Report

June 2013

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Authors	
Lily Booth	Halcrow
Dr Paul Fish – Review of Draft	Halcrow
Dr Andy Parsons – Approval of Final	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	**Hartlepool Headland to Saltburn Scar**	**Skinningrove**	**Hummersea Scar to Sandsend Ness**	**Sandsend Ness to Saltwick Nab**
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
Water Level Parameter	**Water Level (m AOD) Saltwick Nab to Hundale Point**	**Hundale Point to White Nab**	**White Nab to Filey Brigg**	**Filey Brigg to Flamborough Head**
HAT	3.10	3.05	3.05	3.10
MHWS	2.60	2.45	2.45	2.50
MLWS	-2.20	-2.35	-2.35	-2.30

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).

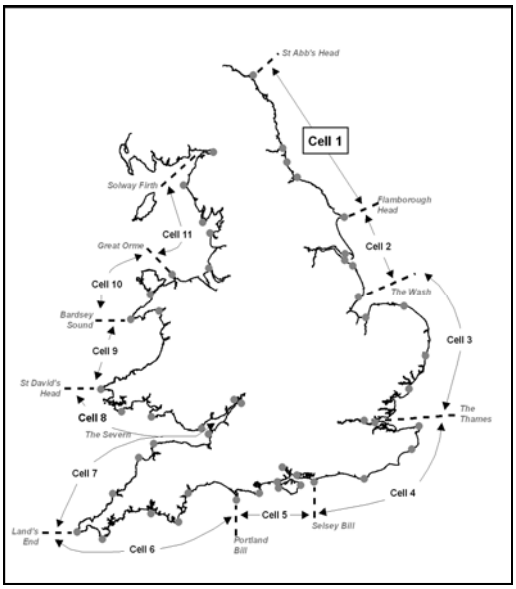


Figure 1 Sediment Cells in England and Wales

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.

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	Jul 10	
3	2010/11	Aug-Nov 10	Feb 11	Feb-Apr 11	Aug 11	Sep 11
4	2011/12	Sep-Oct 11	Oct 12	Mar-May 12	Feb 13	
5	2012/13	Sep 2012	Mar 13	Feb- Mar 13	May 13(*)	

(*) The present report is **Update Report 5** and provides an analysis of the 2013 Partial Measures survey for Redcar and Cleveland Council's frontage.

1. Introduction

1.1 Study Area

South Gare Breakwater at the mouth of the River Tees estuary to Cowbar Nab at Staithes. For the purposes of this report, it has been sub-divided into four areas, namely:

- Coatham Sands
- Redcar Sands
- Marske Sands
- Saltburn Sands
- Cattersty Sands (Skinningrove)
- Staithes [1]

1.2 Methodology

Along Redcar & Cleveland 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 Coatham Sands
    - Topographic survey along Redcar Sands
    - Topographic survey along Marske Sands
    - Topographic survey along Saltburn Sands
    - Topographic survey at Skinningrove along Cattersty Sands

- Partial Measures survey annually each spring comprising:
    - o Beach profile surveys along nine transect lines
    - o Topographic survey along Redcar Sands
    - o Topographic survey along Saltburn Sands
    - o Topographic survey at Skinningrove along Cattersty Sands

- Cliff top survey (biannually) at:
    - Staithes

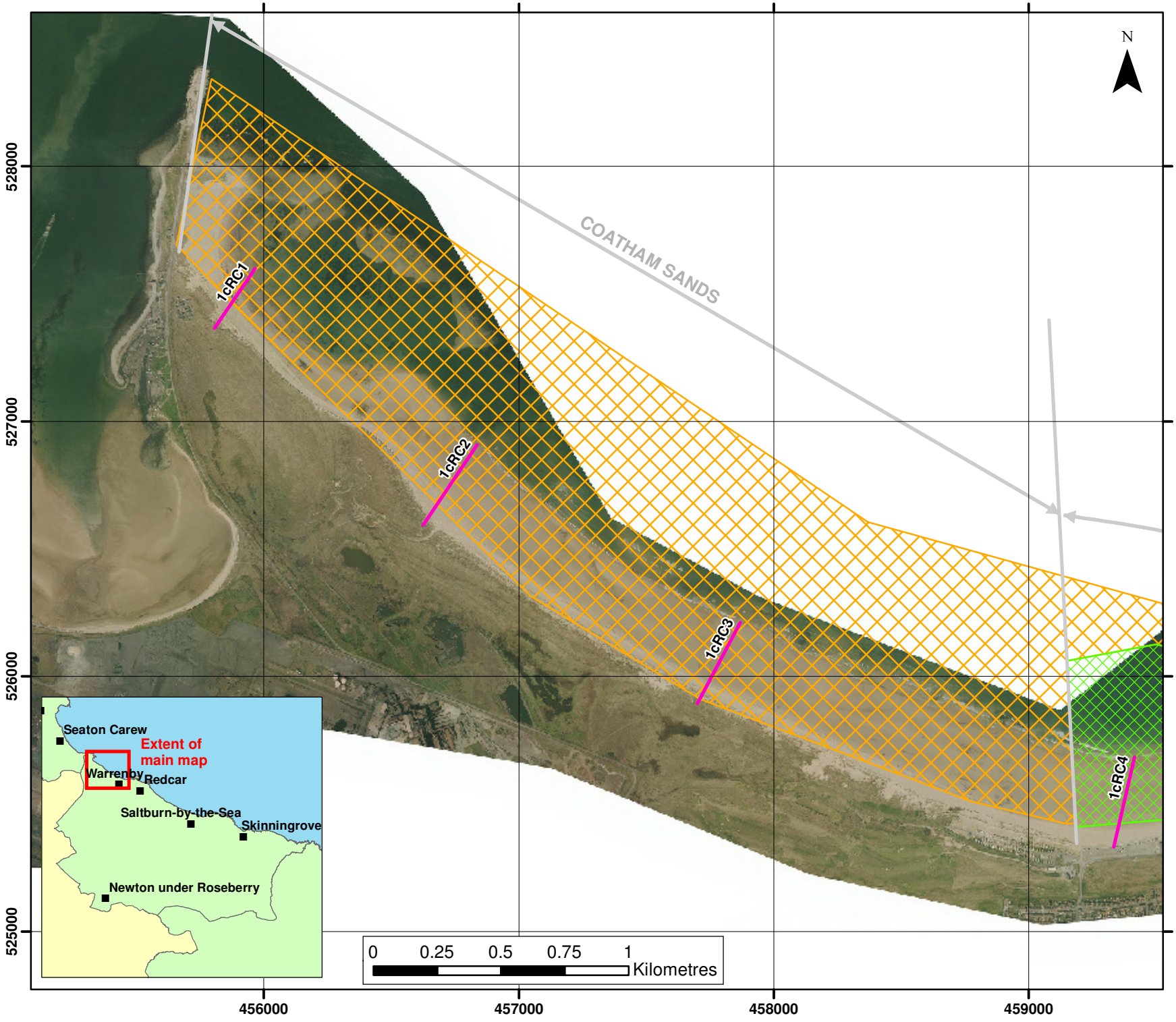
The location of these surveys is shown in Figure 2. The Partial Measures survey was undertaken along this frontage between 27th February and 29th April 2013. During the surveys the weather was mostly dry and the sea state was clam to moderate; refer to the survey reports for details of the weather conditions over this survey period.

The Update Report presents the following:

- 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] The Staithes frontage straddles the boundary of jurisdiction of Redcar & Cleveland and Scarborough Borough Councils



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)

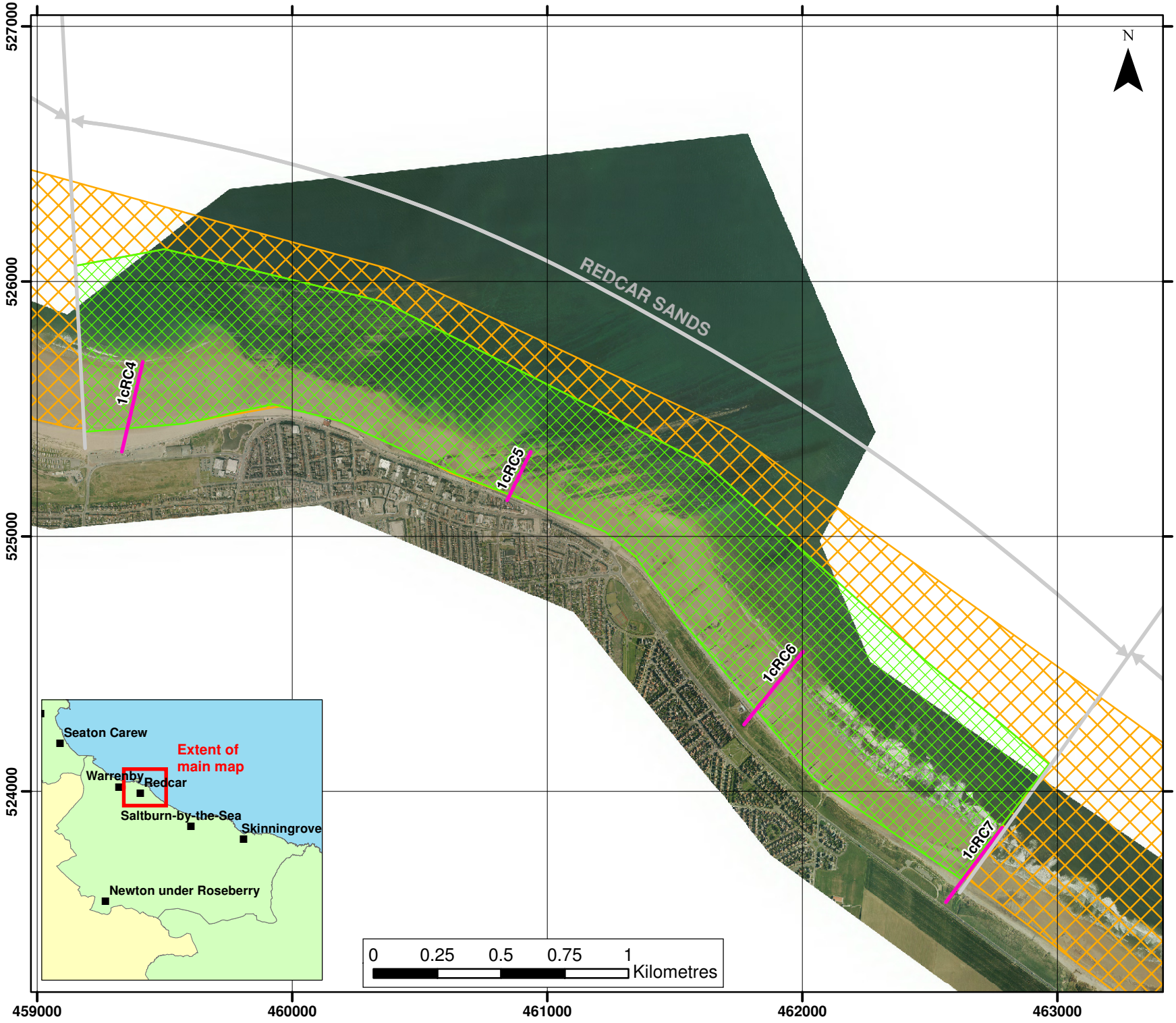
Client: North East Coastal Group

Project: Cell 1 Regional Coastal Monitoring Programme 2011 to 2016

Figure 2 - Map 1
Survey Locations
Coatham Sands
Redcar & Cleveland Borough Council

Update Report 5
Partial Measures Survey
Spring 2013

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 2
Survey Locations
Redcar Sands
Redcar & Cleveland Borough Council

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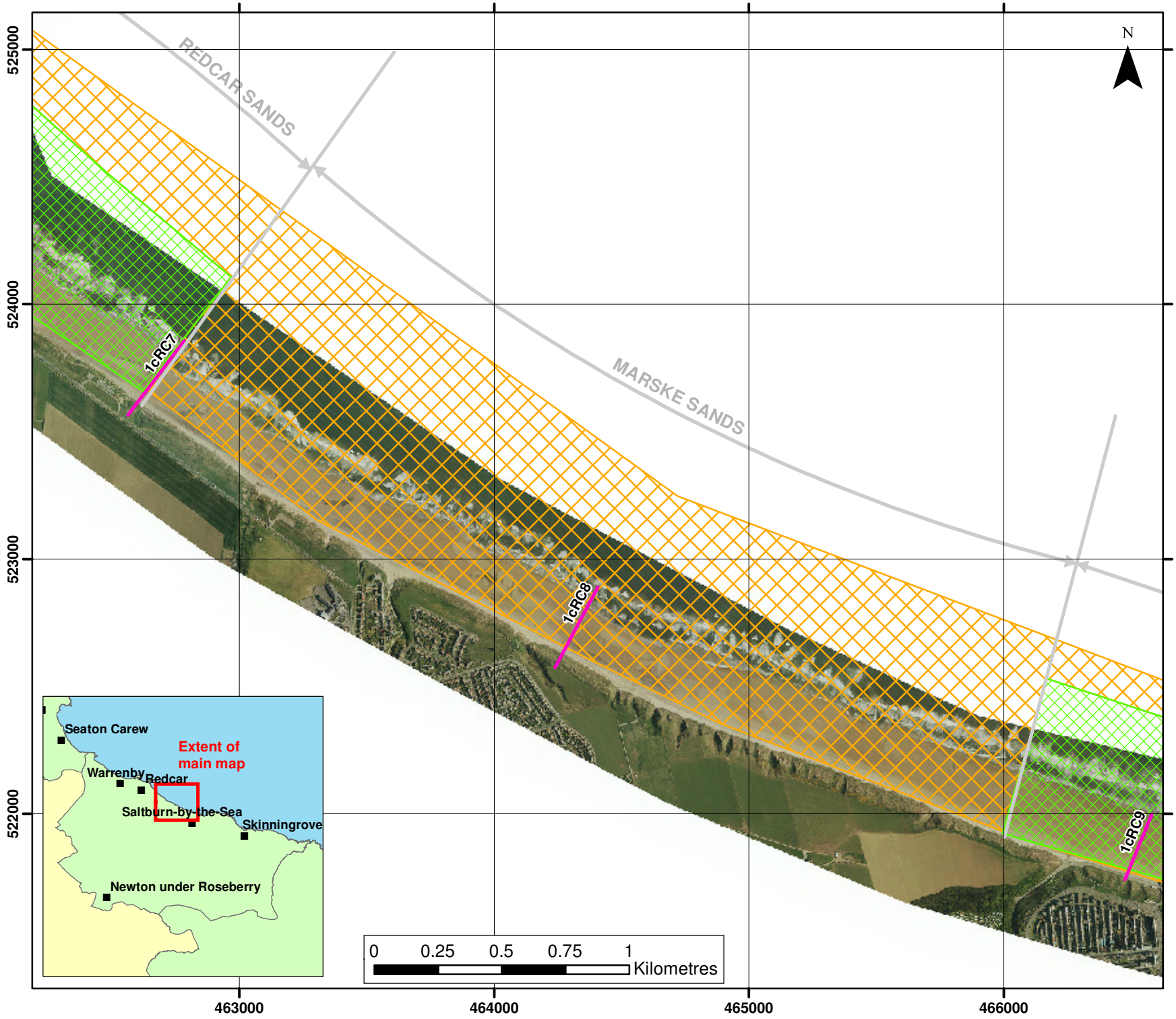
Spring 2013

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
Marske Sands
Redcar & Cleveland Borough Council

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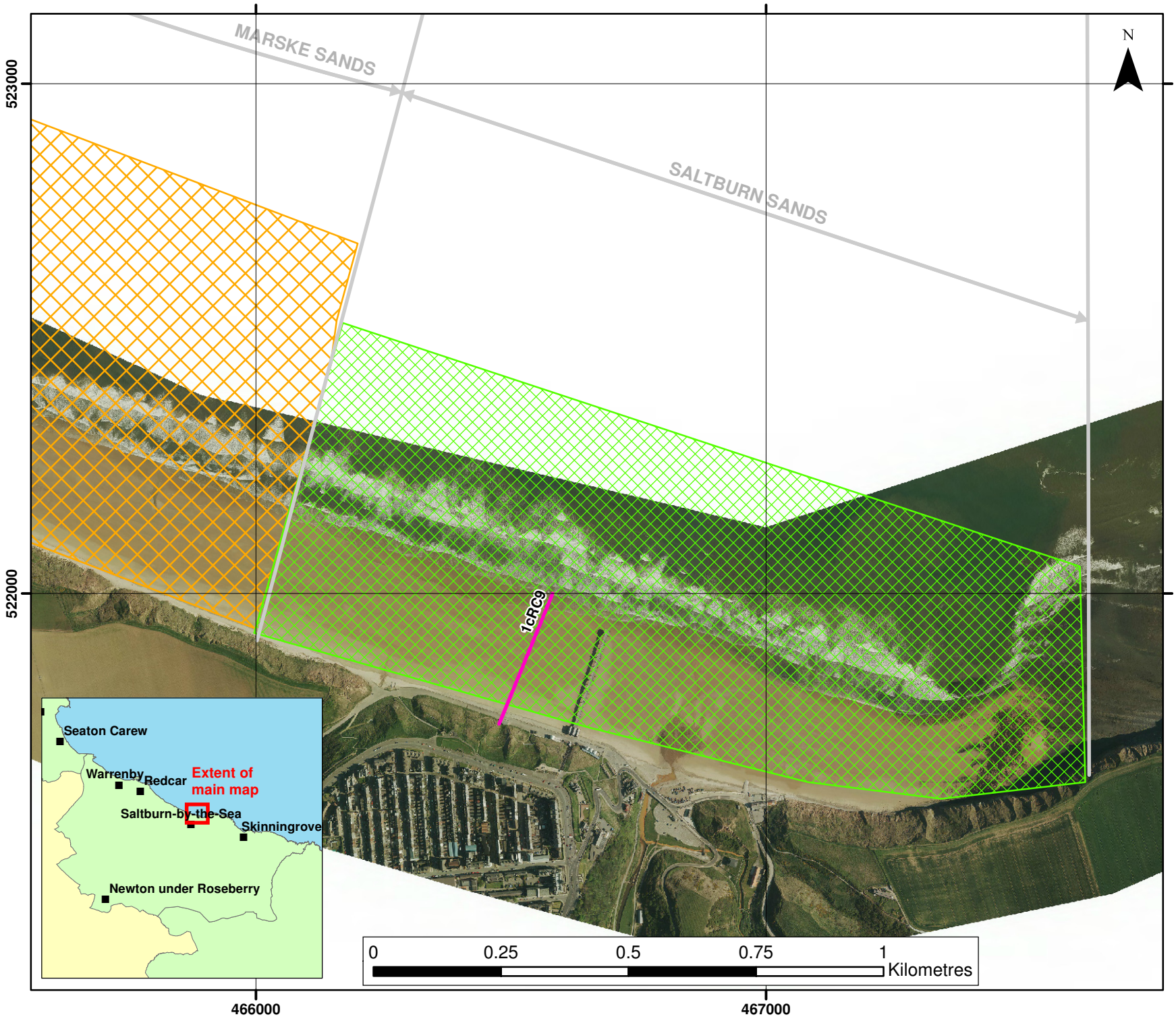
Halcrow
A CH2M HILL COMPANY
Halcrow Group Ltd, Lyndon House, 62 Hagley Road, Edgbaston, Birmingham, B16 8PE
Tel: +44 (0)121 456 2345
Fax: +44(0)121 456 1569
www.halcrow.com



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 4
Survey Locations
Saltburn Sands
Redcar & Cleveland Borough Council

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Spring 2013

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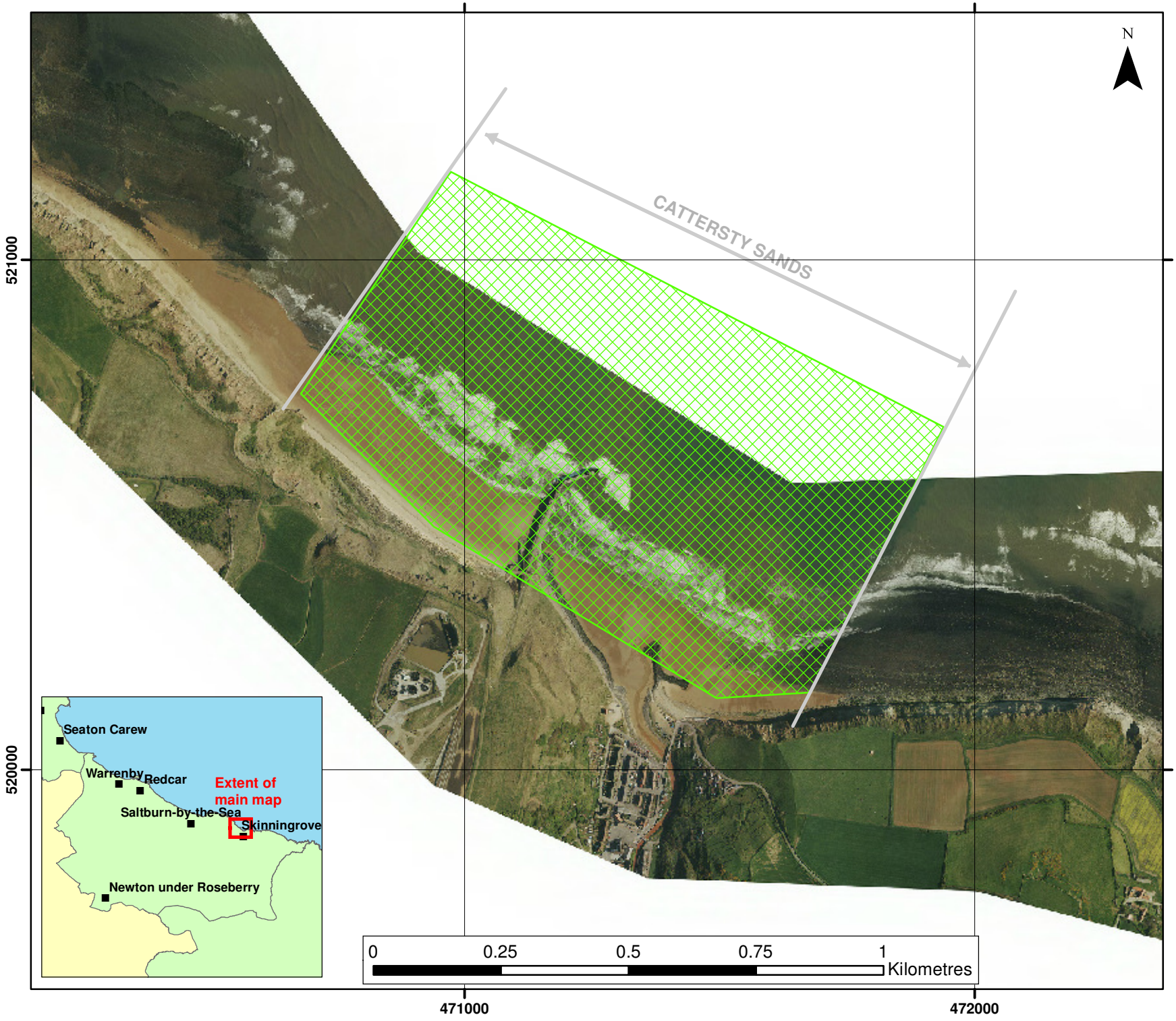
A CH2M HILL COMPANY

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

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

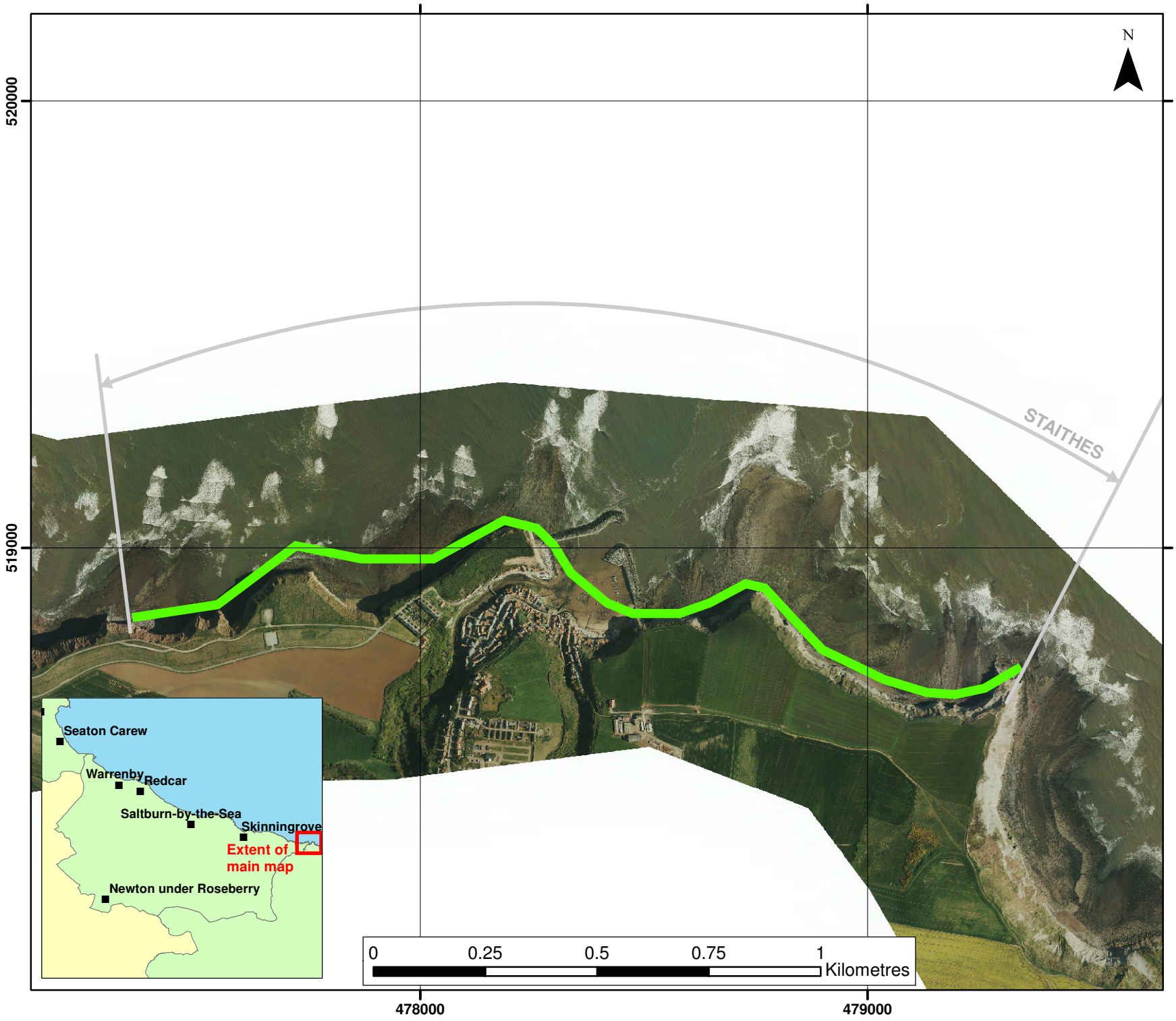
Project: Cell 1 Regional Coastal Monitoring Programme 2011 to 2016

Figure 2 - Map 5
Survey Locations
Cattersty Sands
Redcar & Cleveland Borough Council

Update Report 5
Partial Measures Survey
Spring 2013

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 6
Survey Locations
Staithes
Redcar & Cleveland Borough Council

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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 Coatham Sands

Survey Date	Description of Changes Since Last Survey	Interpretation
1st march 2013	**Beach Profiles:** Coatham Sands is covered by four beach profiles during the Partial Measures survey (RC1 to RC4; Appendix A) that were last surveyed in October 2011. **Profile RC1** is located approximately 300m south east of the South Gare Breakwater, in the lee of the German Charlies. The profile showed that the dunes were stable. The accumulation of material between the toe of the dunes and the HAT level accreted by 0.6m between October 2012 and March 2013. The berm which was present in October between HAT (110m chainage) and 180m chainage was lost and the beach level dropped by 0.6m. Below 180m chainage to the end of the survey a large berm is present. The berm is higher than any of the profiles recoded since 2008 and is 1.5m above the level of the beach in October 2012. Along **profile RC2** dune levels remained healthy and the dunes accreted. The beach above MHWS did not change significantly between October 2012 and March 2013. Below MHWS (110 to 250m chainage) the beach dropped by around 0.2m. From 250m chainage to the end of the survey two berms have formed on the beach, although the maximum elevation of these was similar to the October 2012 profile. **Profile RC3** showed no significant change above MHWS. Below MHWS the beach had eroded by 0.5m since October 2012 and is at the lowest seen since 2008. Two mounds of material were shown in the March 2013 near MLWS although the other profiles back to 2008 all show flat profiles on this part of the beach. Below MHWS the beach appears to have lost around 1m of material, probably associated with berm migration. At **profile RC4** the March 2013 beach level and gradient is within the lower range of recorded profiles since 2008. There is very little change above MHWS, below that the beach level has dropped by around 0.2m since October 2012.	At Profile RC1 the berm which was present close to HAT and MHWS in the October 2012 survey was lost by March. However, material had been gained above HAT and on the fore dune. The spring 2013 profiles also show a very high berm close to the MLWS tide level which is higher than any profile since 2008. RC2 and 3 show no significant change above the MHWS. Both profiles have gained berms of material over the winter of 2012/13 close to MLWS, whereas the majority of the profiles since 2008 are flat. RC 4 is very similar to the previous profiles dating back to 2008, which shows stability. **Longer term trends:** At RC1 the fore dunes are accreting which could be a precursor to dune accretion. The toe of the beach close to MLWS appears to have been progressively accreting since 2008 and it is now 2.2m higher than the November 2008 profile. Both RC2 and RC3 have had accretion on the dunes and lower beach while the mid beach has been the lowest since 2008. The level of the beach at Profile RC4 in March 2013 was well within the envelope of other vales, the profile appeared to be steeper than previous surveys. The beach level was low and similar to the level recorded in November 2008.

2.2 Redcar Sands

Survey Date	Description of Changes Since Last Survey	Interpretation
1st March 2013	**Beach Profiles:** Redcar Sands is covered by three beach profiles (RC5 to RC7; Appendix A), with RC7 being approximately on the boundary with the Marske Sands area. They were last surveyed in October 2011. At **profile RC5** the construction of a new sea defence was on going, resulting in the profile changing between 0m and 15m chainage. Since October 2012 the beach has flattened and accreted by 0.2m, which is the highest level reached since 2008. The part of the beach with the rock outcrops remains similar between October 2012 and March 2013 although there was accretion on the landward side. Below the rock outcrop the beach has accreted by up to 0.5m and is higher than any of the other profiles since 2008. . A new sea defence is being built at **profile RC6** and consequently the profile has changed above MHWS. The survey notes state there was no access to the start of RC6 because site fencing obstructed the path. Near MLWS the October 2012 profile and March 2013 profile are similar. Between 80m chainage and 225m chainage the beach had eroded by up to 0.5m. Below 22m the beach has accreted by 0.3m between October 2012 and March 2013. At **profile RC7** above MHWS the profile is similar to the profile from October 2012, but with a small (0.2m) area of erosion close to the HAT level. Between 100m and 230m chainage the beach level has dropped by 0.5m. As a result the beach is close to its lowest level compared to the profiles since 2008. From 230m chainage to the end of the profile at MLWS the March beach level has accreted by 0.8m since October 2012. The level of the lower beach is the highest since 2008.	A new defence has been built on this section so the beach is likely to have been altered during the construction process. Future profile analysis should be cautions about interpretation of the 2011 and 2012 data and establish a new baseline following the completion of the works on construction of the defences. All of the profiles in this section show erosion in the mid beach and accretion in the lower beach as material is drawn down over the winter months. The amount of erosion on the beach and the size of the mound of material on the lower beach shows that this process has been particularly dominant over the winter of 2012/13. RC7 shows some erosion of the coastal slope on the HAT level so that shows wave attack operating over the winter period. **Longer term trends:** All of the profiles show that the sediment moved down the beach in response to winter conditions. Parts of the beaches are the highest or lowest compared to the profiles dating back to 2008 but this is unlikely to be a linear trend. The beaches are expected to be built up again over the summer of 2013.
1st March 2013	**Topographic Survey:** Redcar Sands is covered by a 6-monthly topographic survey. Data have been used to create a DGM (Appendix B – Map 1a). The DGM shows that the topography in front of the two headlands at each end of the bay has a shallow slope but that the centre of the bay is steeper.	The predominant trend for Redcar between autumn 2012 and spring 2013 is erosion, which is a typical beach response to winter storms. The erosion tended to be centred on the upper beach close to the shore, where material is drawn-down to near MLW or

Survey Date	Description of Changes Since Last Survey	Interpretation
	The DGMs show that most changes along Redcar Sands between Autumn 2012 and Spring 2013 are within a range of ±1m. The largest change was over 1m of accretion close to Coatham Rocks on the west side of the Redcar frontage. Up to 0.75m of erosion was noted in the west of the study area and in the Ayton Hole frontage. There was around 0.5m of accretion on Redcar rocks, where they meet the shoreline. From Redcar Sands east to the end of the survey the coast is dominated erosion of around 0.5m. There is a shore-parallel patch of accretion of up to 0.5m on the low water tide line.	offshore. There were areas of accretion on the seaward extent of the survey for much of the frontage. Accretion was also observed close to the rock outcrops in the bay close to Ayton Hole and at Coatham Rocks. **Longer term trends:** The Autumn 2012 to Spring 2013 plot is not directly comparable with the difference plot for the same period last year due to the newly constructed defences. The long term difference plot produced for the 2012 Full Measures report shows a similar pattern of accretion at the low tide level and erosion on the mid and upper beach. As a result the autumn 2012 to spring 2013 plot shows that the conditions over the Winter of 2012/13 are similar to the prevailing conditions between autumn 2008 and autumn 2012. The beaches appear to have been flattening with the offshore rocks being foci of the changes.

2.3 Marske Sands

Survey Date	Description of Changes Since Last Survey	Interpretation
1st March 2013	**Beach Profiles:** Marske Sands is covered by two beach profiles during the Partial Measures survey (RC7 to RC8; Appendix A), with RC7 being approximately on the boundary with the Redcar Sands area. **Profile RC7** is located along The Stray and has been discussed in Section 2.2. **Profile RC8** is very similar to the previous profiles above the HAT level (70m chainage). Between 70m and 140m chainage the beach is low compared to the previous profiles and 0.3m lower than the October 2012 profile. Below 140m chainage two mounds of material have formed on the lower beach. The beach level is still 0.5m below the October 2012 profile. The level drops even lower toward the MLWS extent of the profile.	Both RC7 and RC8 show that the beach has dropped in the mid beach and that berms have formed in the lower beach **Longer term trends:** The March 2013 profiles show the beaches at their lowest levels at many points across RC7 and RC8. It is anticipated that this is a reaction to a particularly severe winter of 2012/13 and that the beach levels will recover by the next survey.

2.4 Saltburn Sands

Survey Date	Description of Changes Since Last Survey	Interpretation
1st March 2013	**Beach Profiles:** Saltburn Sands is covered by one beach profile (RC9; Appendix A). Overall **Profile RC 9** has eroded and is at its lowest recoded level since 2008. The beach in October 2012 was the highest recorded and was 0.2m higher than the March 2013 profile. At the end of the profile the level of the beach recoded in March 2013 drops even lower and is 0.4m below the October 2012 level.	Both RC 8 and 9 show stability between October 2011 and March 2012. **Longer term trends:** The general trend at this location is stability, with the majority of the fluctuations observed at the bottom of the beach.
1st March 2013	**Topographic Survey:** Saltburn Sands is covered by a 6-monthly topographic survey. Data have been used to create a DGM (Appendix B – Map 2a) the beach topography consists of shore parallel contours, with a small change on the beach at the mouth of the channel. This DGM has been compared against the previous (Autumn 2012) survey in Appendix B – Map 2b. The DGMs show that since Autumn 2012 the beach has eroded by up to 0.75m across the western two-thirds of the beach. There are patches of accretion close to the mouth of the stream (0.25m change), Penny Hole on the foreshore (up to 0.75m change) and at the eastern extent of the survey (0.5m) change. There were also isolated spots of accretion close to the toe of the cliff. There is a second patch of erosion between Penny Hole and the eastern extent o the survey where up to 0.75m of erosion has occurred.	The beach has eroded by up to 0.75m across much of the frontage. Isolated areas of accretion were centred on the eastern third of the bay. The surveyor noted that “due to the weather around the time of survey the river at Saltburn was in spate, clearing and creating a channel were it issues onto the beach. Also, streams of water observed flowing over the top of the cliffs at Saltburn, where there were numerous rock falls”. The rock falls may explain the patches of accretion close to the toe of the cliff. **Longer term trends:** The pattern of erosion over the winter of 2013 shows erosion in the west and accretion in the east of the sands.

2.5 Cattersty Sands

29th April 2013	**Topographic Survey:** Cattersty Sands is covered by a 6-monthly topographic survey. Data have been used to create a DGM (Appendix B – Map 2a). This DGM has been compared against the previous (autumn 2012) survey in Appendix B – Map 2b. The DGMs show that over the winter erosion dominated the bay. There was erosion of 0.75m on the eastern side of the breakwater and over 1m on the western side of the bay. There were localised patches of accretion of 0.5m on the seaward extent and close to the mouth of the river. The surveyor noted that there were "a number of recent land slips on cliffs were evident".	Overall the beach appears to have eroded, the beach level should recover over the summer months. **Longer term trends:** The full measures report for 2012 includes a plot of the differences in height between autumn 2008 and autumn 2012. The long term difference plot shows accretion throughout the frontage and in the middle of the beach. On the seaward and landward extent, as well as the mouth of the river the beach has eroded. The plot of difference over the winter of 2012/13 is the reversal of this trend shown in the long term difference plot. Thus the beach may recover from the erosion shown on the most recent plot.

2.6 Staithes

7th March 2013	**Cliff-top Survey:** Twenty ground control points have been established at Staithes for the purposes of cliff top monitoring. The separation between any two points is a nominal 100 m. The cliff top surveys at Staithes are undertaken bi-annually. Data collection involves a distance offset measurement from the ground control point to the cliff edge along a fixed bearing. Appendix C provides results from the March 2013 survey, showing the distance from the ground control point to the edge of the cliff top along the defined bearing and changes in position since the November 2008 baseline survey and the previous September 2012 survey. The results provided in Appendix C show few of the locations have erosion greater than the assumed error. Eight profiles eight show erosion of 0.1m-0.3m.	The recorded changes to the cliff top between September 2012 and March 2013 are small. There have been no large failures which have affected the cliff top. There may have been steepening of the cliff face which could lead to a larger failure next year. **Longer term trends:** Table C1 in Appendix C presents the erosion rates calculated from the data collected since 2008. The results show that 14 of the points have a rate of change of ±0.1m/yr. Five profiles show growth. Only Point 13 one profile shows an average recession rate of more than 0.1m/yr the calculated error, which is 0.5m/yr since Nov 2008.
April to June 2013	**Durham University Laser Scanning:** The Cowbar Nab cliff is subject to monthly high-resolution laser scanning surveys by Durham University that are used to precisely monitor the locations and rates of erosion. The baseline document was included in the previous full measures report. An update on erosion during April to June 2013 is provided here. Three surveys have been undertaken, allowing difference models to be calculated for two periods of Intervening time: 25 April 2013 to 23 May 2013, and 23 May 2013 to 13 June 2013. The results of the analysis are presented in Appendix D.	The data indicate limited erosion of the glacial sediments that cap the cliff and localised, small losses from a single bedrock layer of the cliff face. In all areas, total losses do not exceed c. 0.1m. Review of oblique photography from 2010 indicates the presence of vegetation on the glacial sediments where erosion is shown to have taken place and therefore the recoded change needs to be treated with caution. Two accumulations of material are visible at the toe of the cliff. The right feature is rock armour placed to protect the cliff from further erosion and the left feature is a deposit from a rockfall that predates the laser scanning monitoring. Limited erosion is indicated to be taking place on either of these cliff toe accumulations. **Longer Term Trends** Although the cliff has remained between April 2013 and May 2013 there is a chance that the cliff could collapse over the coming winter.

3. Problems Encountered and Uncertainty in Analysis

Topographic Survey

There were only isolated issues with the survey. The surveyor noted that sea defence construction is almost complete around the area of Redcar town with works continuing at the south end of the groynes and around the theatre.

The weather around the time of the surveys meant that at Saltburn the stream across the bay was in spate and the cliffs looked like they were eroding.

Due to the weather around the time of survey the river at Saltburn was in spate, clearing and creating a channel were it issues onto the beach. Also, streams of water observed flowing over the top of the cliffs at Saltburn, where there were numerous small landslides. The dunes to the north of the defensive wall at Saltburn show signs of fissures, slippage. Erosion has created several sand cliffs at the foot of these dunes, some up to 2m in height.

Profile RC6 now has new sea wall defence, which has resulted in the change to the profile. Offshore, foundations for a wind farm are currently being installed.

Cliff Top Surveys

The cliff top surveys at Staithes are assumed to have a limit of accuracy of ± 0.1 m due to the methodology. At many locations cliff advance is shown, which indicates problems precisely identifying the cliff edge. As the monitoring progresses, it is likely that underlying patterns in erosion will become evident. More reliable assessments of cliff recession will be derived from analysis of time-series remote sensing data planned for later in 2013. A high quality baseline survey, comprising LiDAR and aerial photography, was collected in 2010, a repeat survey was completed in Sept/Oct 2012 and a second repeat survey is planned for 2014. These data will be analysed to give more accurate information on the behaviour of the cliffs in a separate report

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

Redcar & Cleveland Borough Council have commissioned Durham University to undertake analysis of regular terrestrial laser scan surveys of Cowbar Nab. The increased accuracy and resolution of data from laser scanning, and the increase frequency of surveys, will enable a very detailed appreciation of changing conditions and thereby further inform management planning.

5. Conclusions and Areas of Concern

- At Coatham Sands, the recorded profiles show stability overall and as a result there are no causes for concern.
- At Redcar Sands, all of the profiles in this section show erosion in the mid-beach and accretion in the lower beach as material is drawn down over the winter months. The topographic change plots also show this pattern of seasonal erosion.
- At Marske Sands, the recorded profiles show the beaches at their lowest levels at many points on the beach. It is anticipated that this is a reaction to the winter of 2012/13 and that the beach levels will recover over the next six months
- At Saltburn Sands, the beach profiles show seasonal variation and the topographic plots show more severe erosion. The changes in the beach are expected to relate to a period of severe winter storm in 2012/13.
- At Cattersty Sands, the results of the topographic survey show erosion, but this is expected to represent seasonal draw-down.
- At Staithes, the records of cliff erosion show no erosion, although there is concern over the reliability of these data. There is always the potential for the rockfalls to occur, particularly after periods of wet weather or frosts.

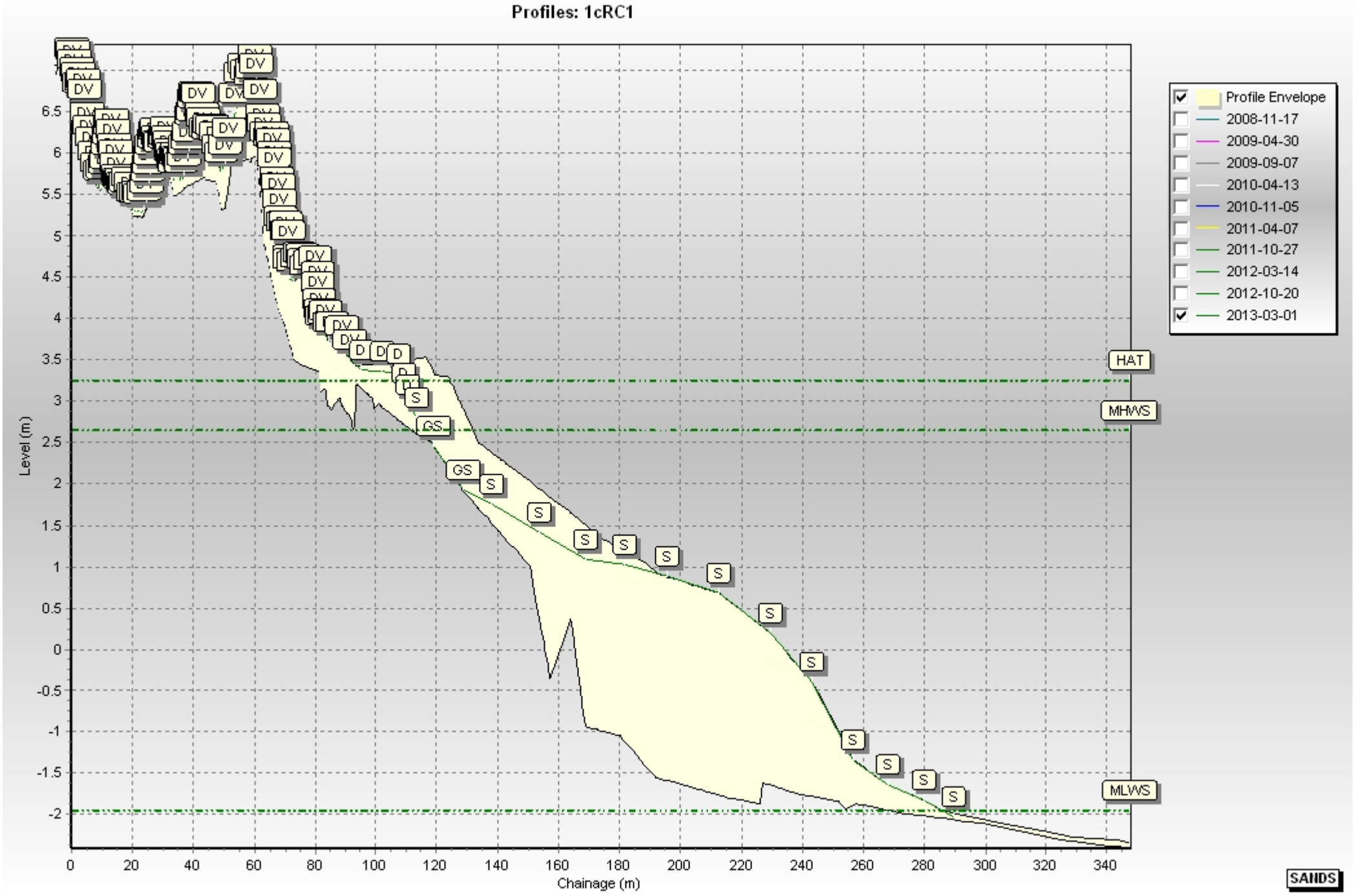
Appendices

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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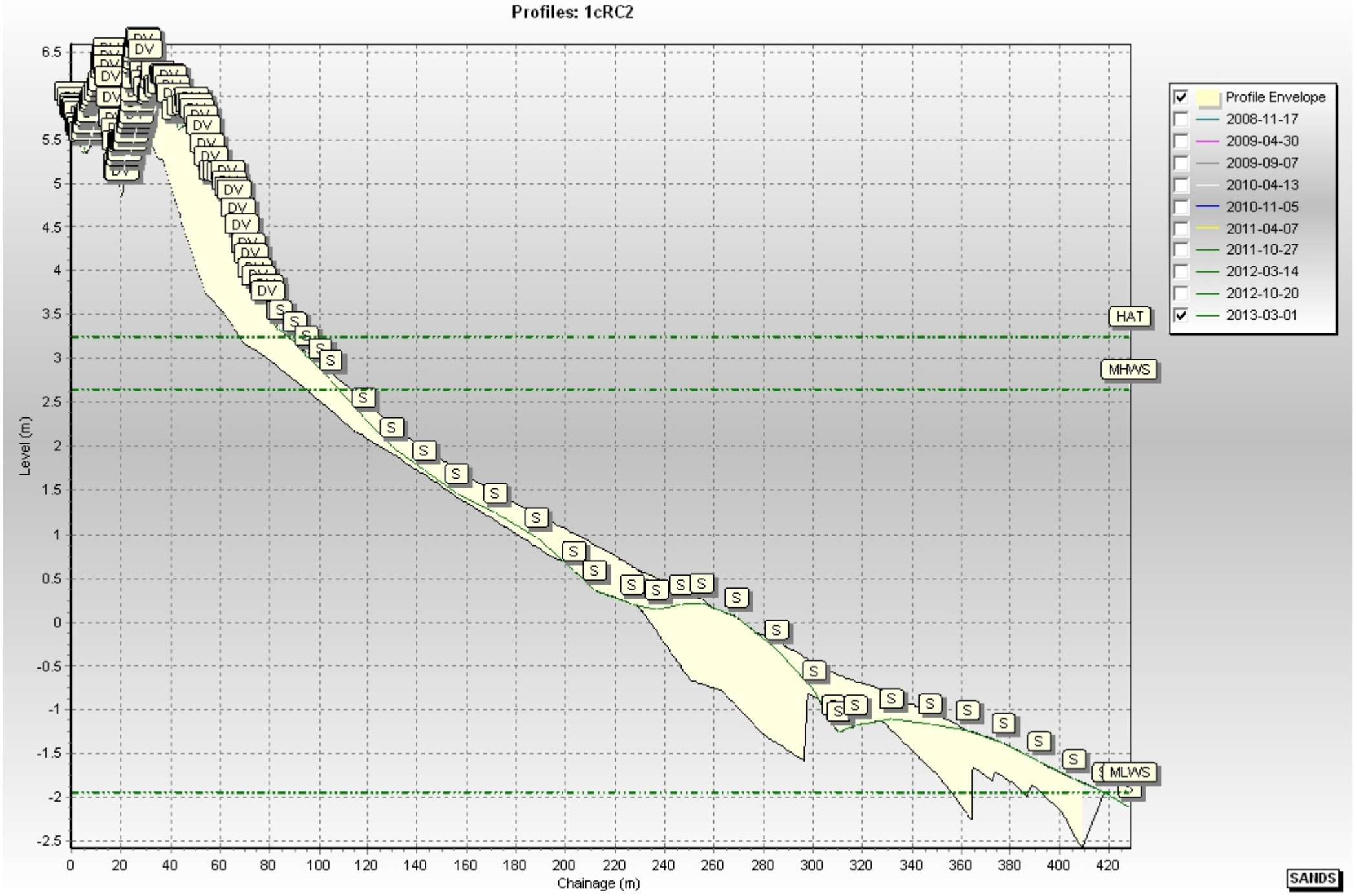
HAT
MHWS
MLWS
Level (m)
Chainage (m)
SANDS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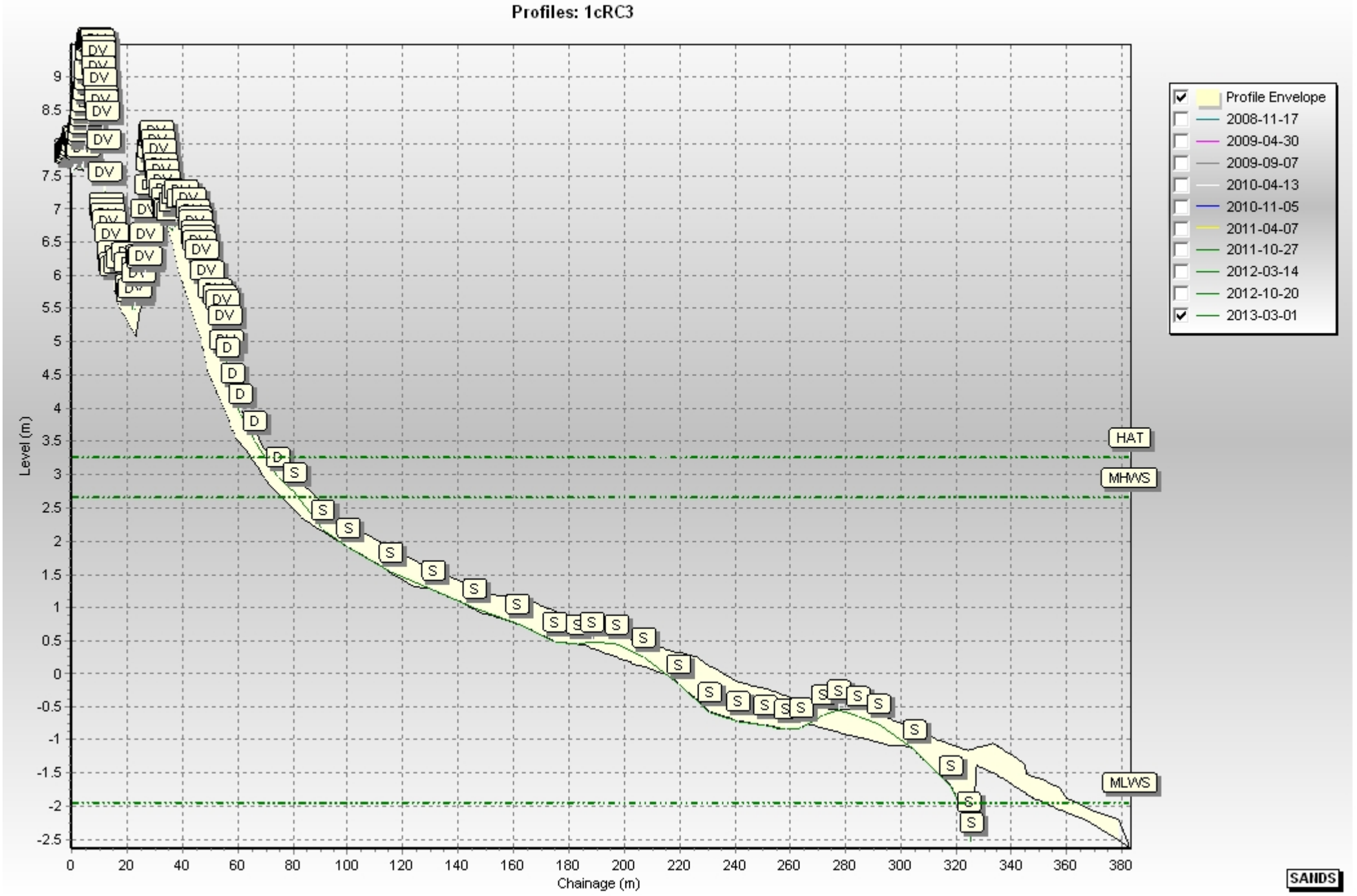
HAT
MHWS
MLWS
Level (m)
Chainage (m)
SANDS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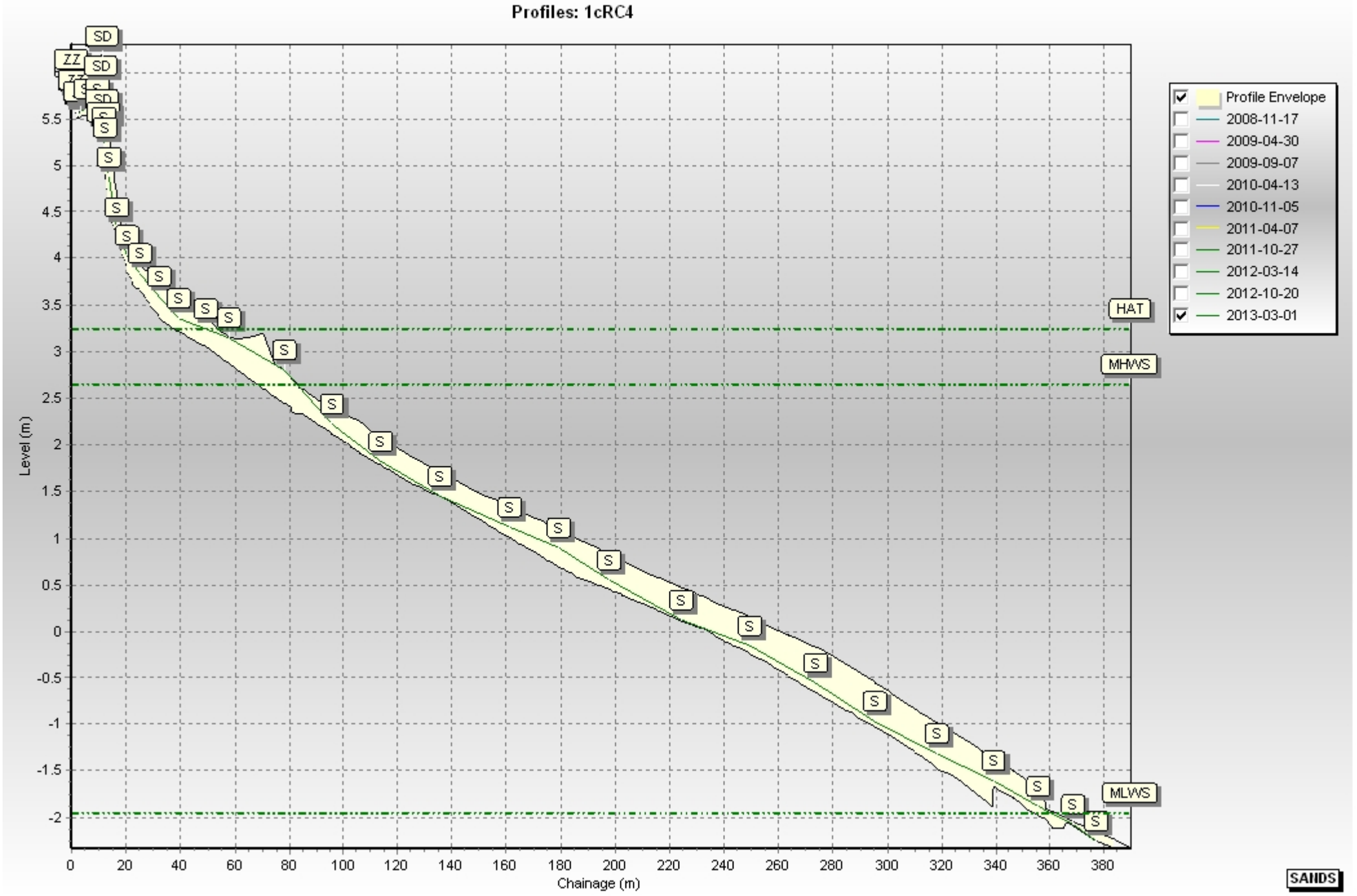
Level (m)
Chainage (m)
SANDS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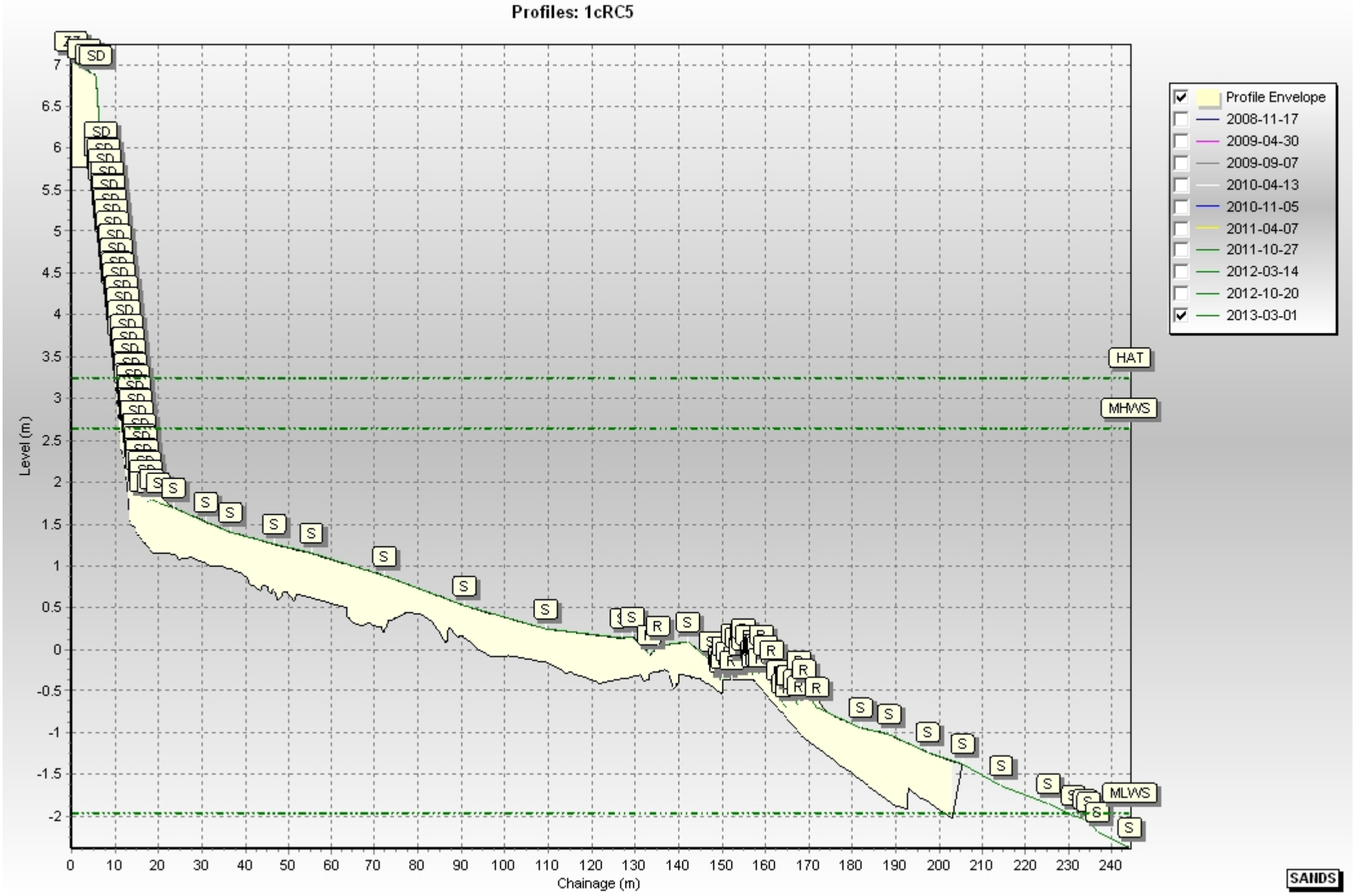
MLWS
Level (m)
Chainage (m)
SANDS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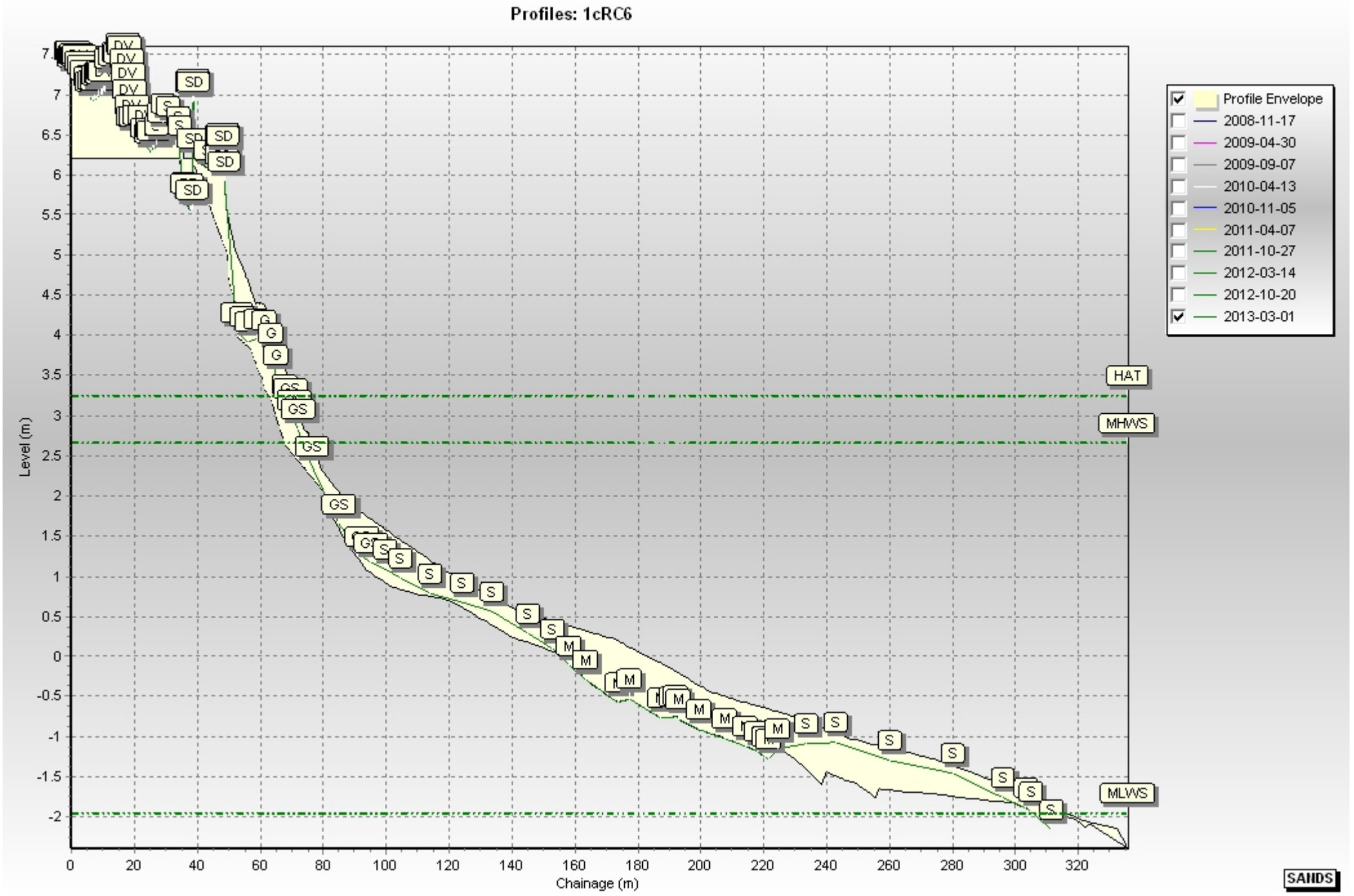
MLWS
SD
S
R
Level (m)
Chainage (m)
SANDS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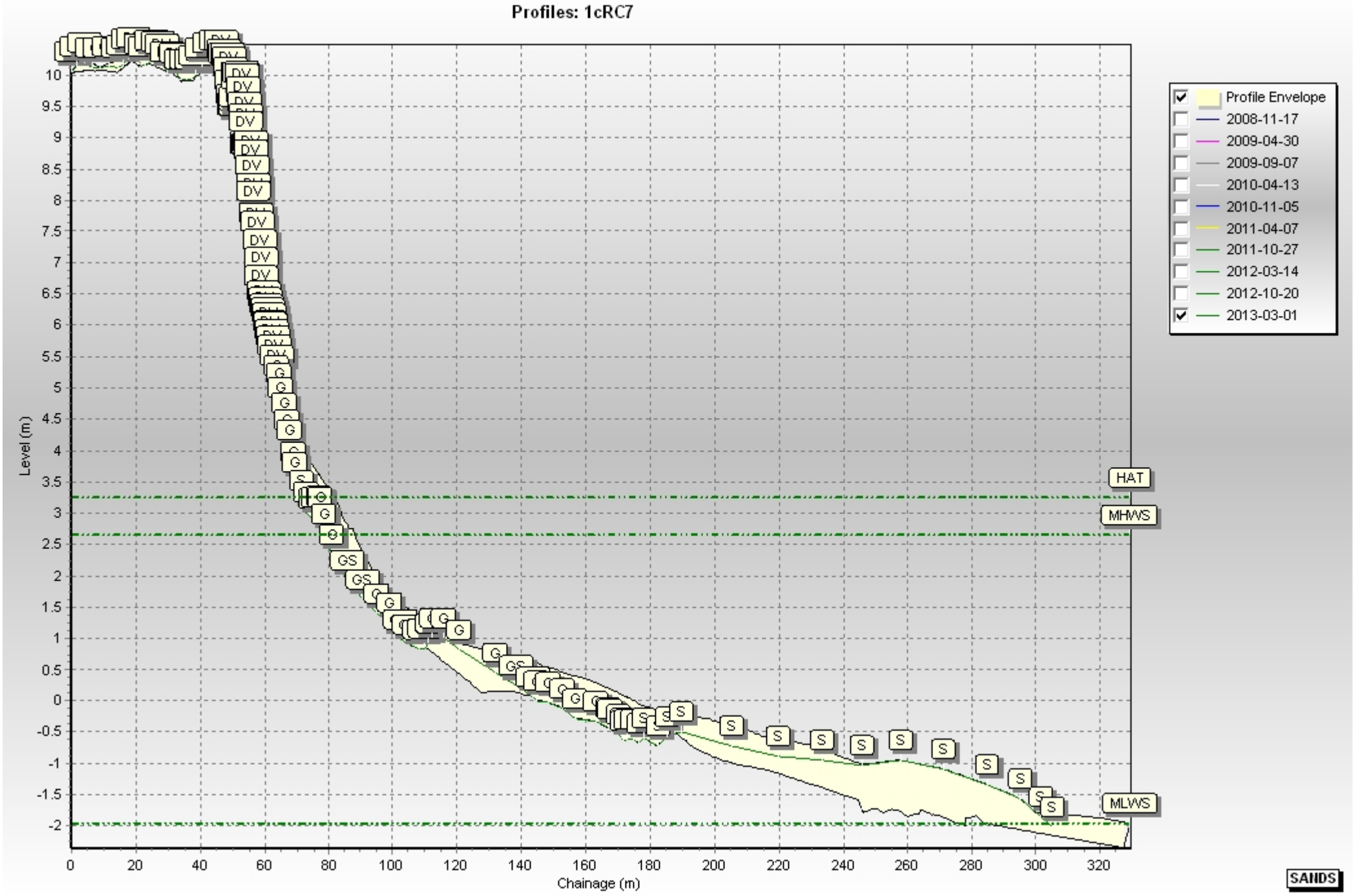
HAT
MHWS
MLWS
Level (m)
Chainage (m)
SANDS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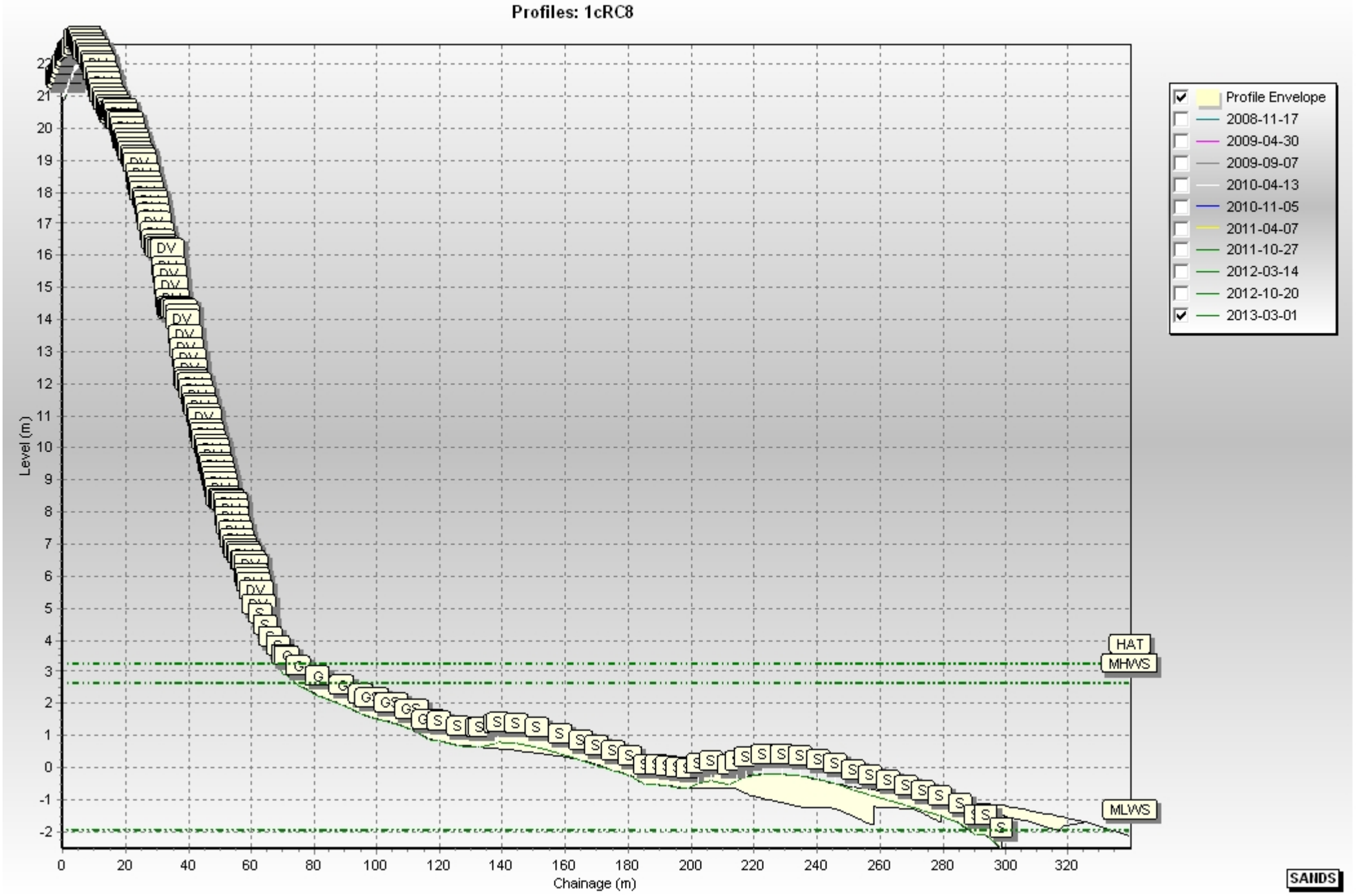
MLWS
Level (m)
Chainage (m)
SANDS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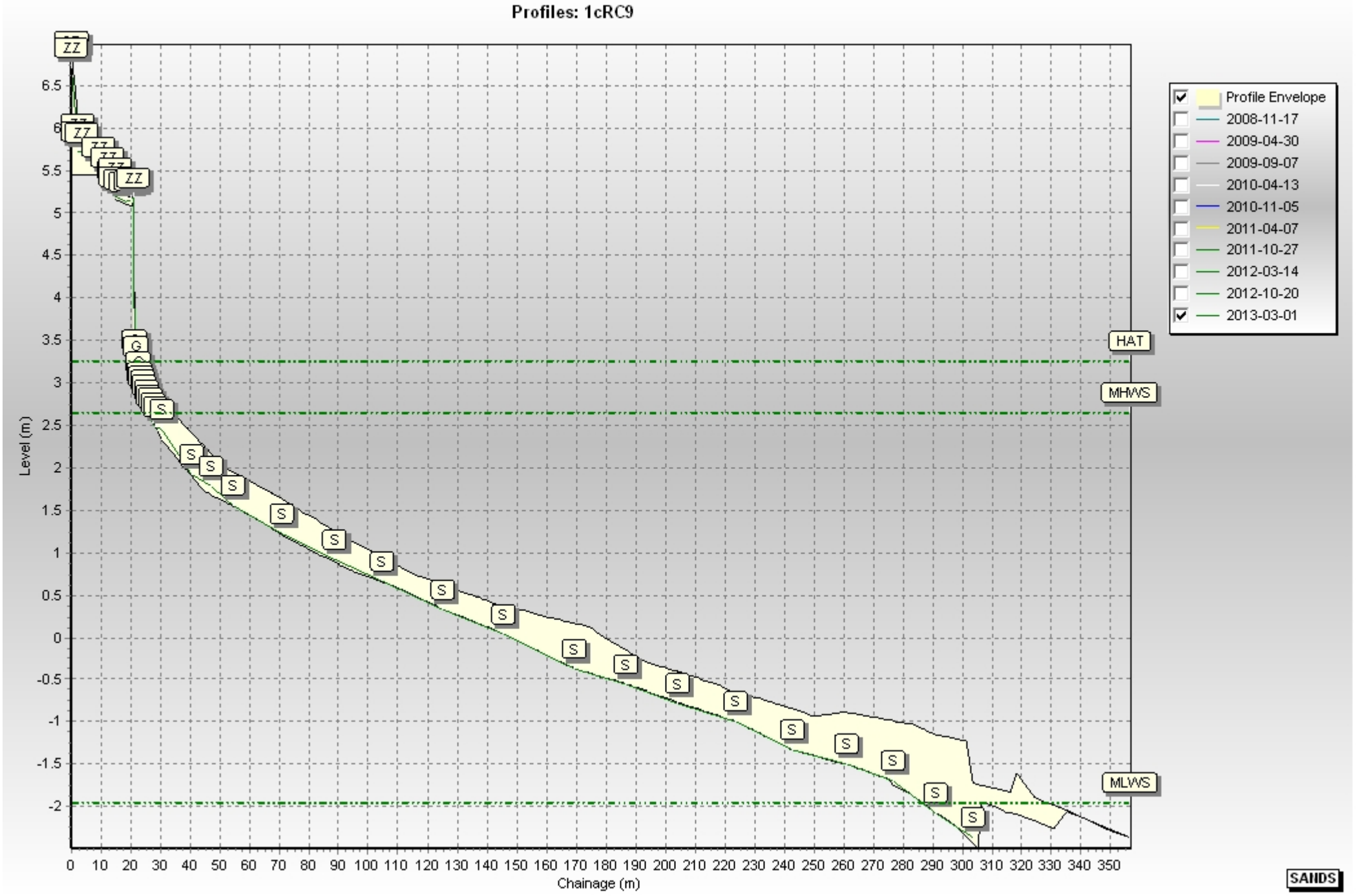
2013-03-01
Level (m)
Chainage (m)
HAT
MHWS
MLWS
DV
G
S
SANDS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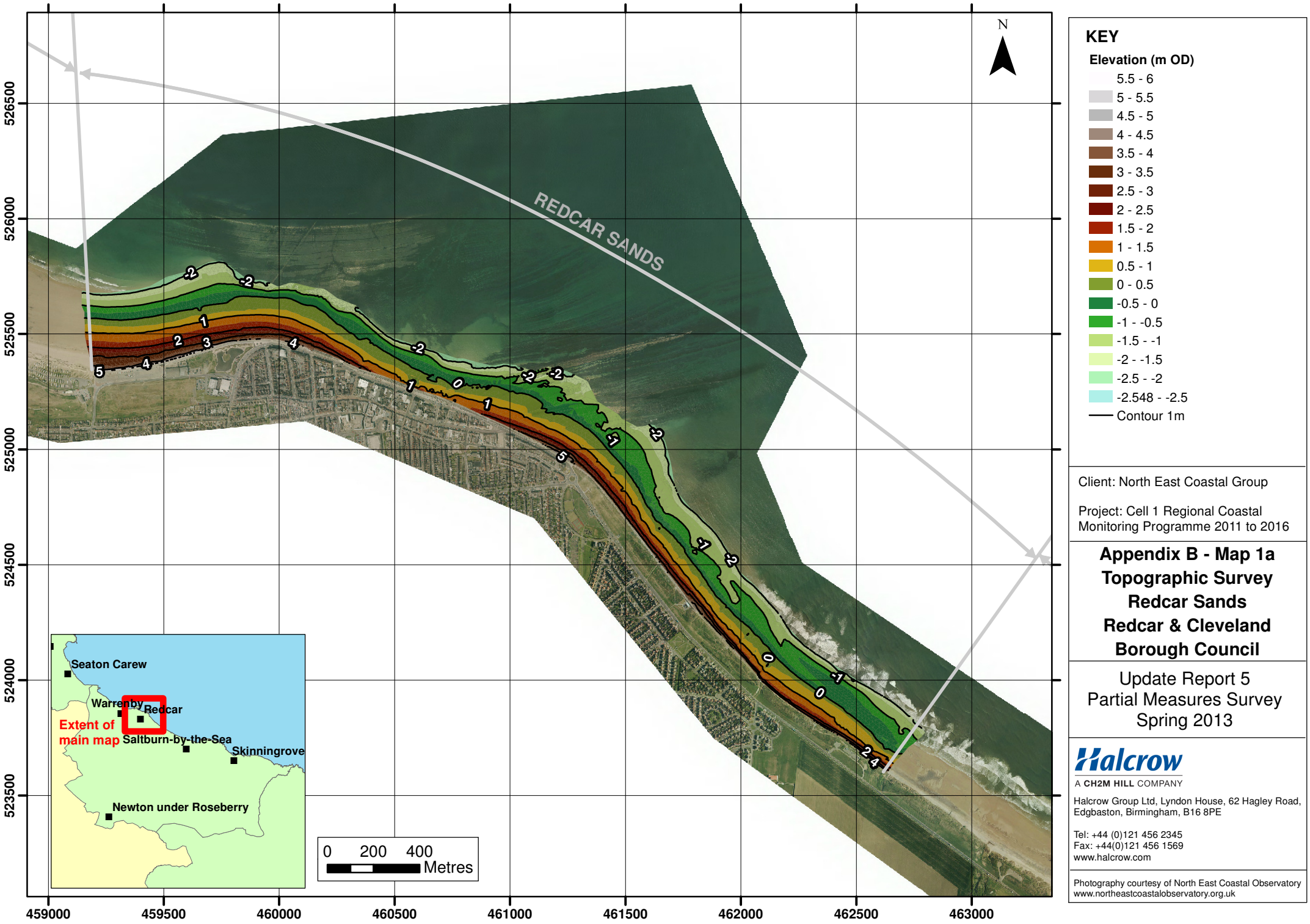
2011-10-27
2012-03-14
2012-10-20
2013-03-01
HAT
MHWS
MLWS
Level (m)
Chainage (m)
SANDS

Appendix B

Topographic Survey



KEY

Elevation (m OD)

- 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
- -2.548 - -2.5
- Contour 1m

Client: North East Coastal Group

Project: Cell 1 Regional Coastal Monitoring Programme 2011 to 2016

Appendix B - Map 1a
Topographic Survey
Redcar Sands
Redcar & Cleveland Borough Council

Update Report 5
Partial Measures Survey
Spring 2013

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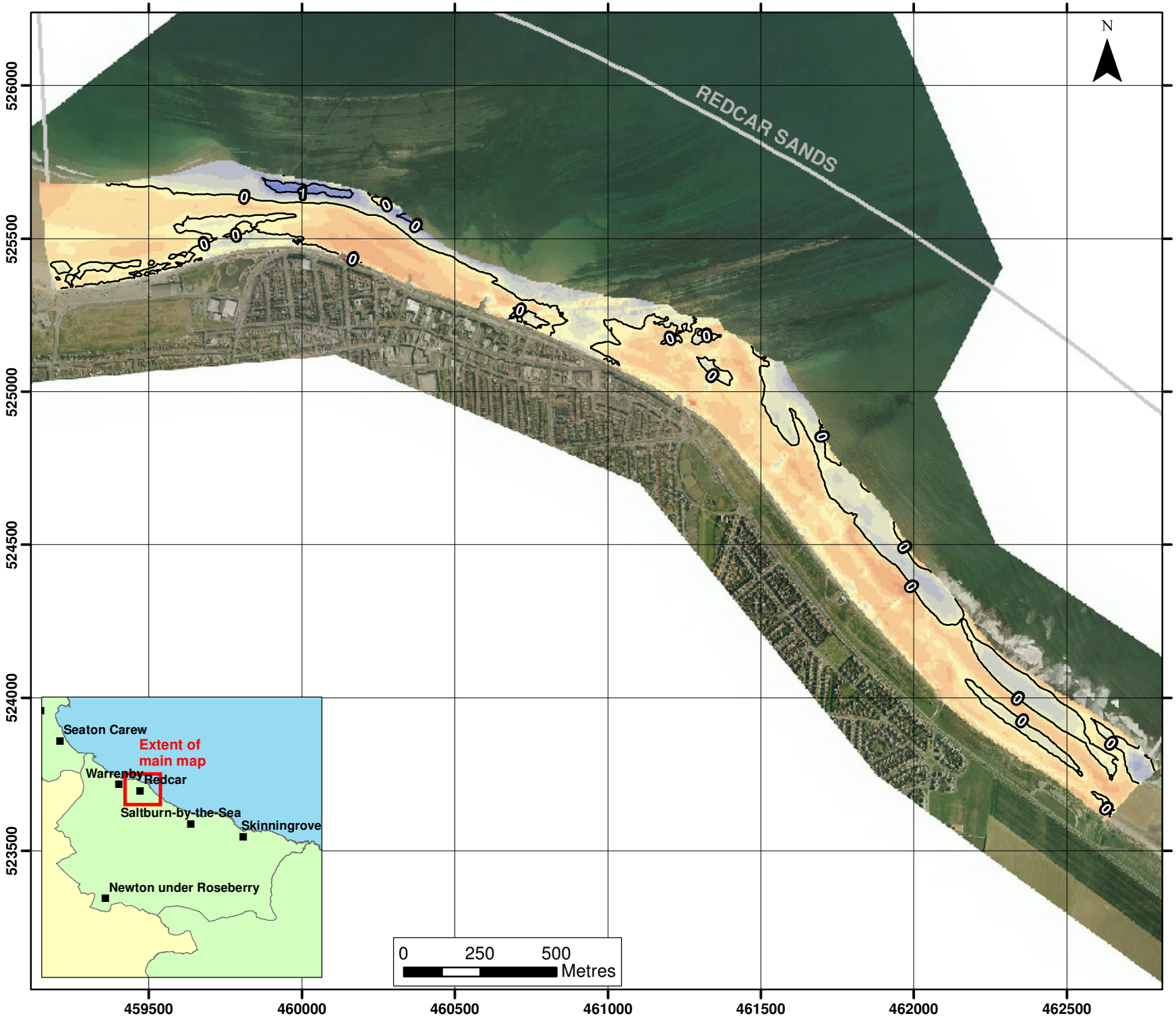
Tel: +44 (0)121 456 2345
Fax: +44(0)121 456 1569
www.halcrow.com



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

Contours of change

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

Appendix B- Map 1b
Short-term Elevation Change
Redcar Sands
Redcar & Cleveland Borough Council

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Partial Measures Survey
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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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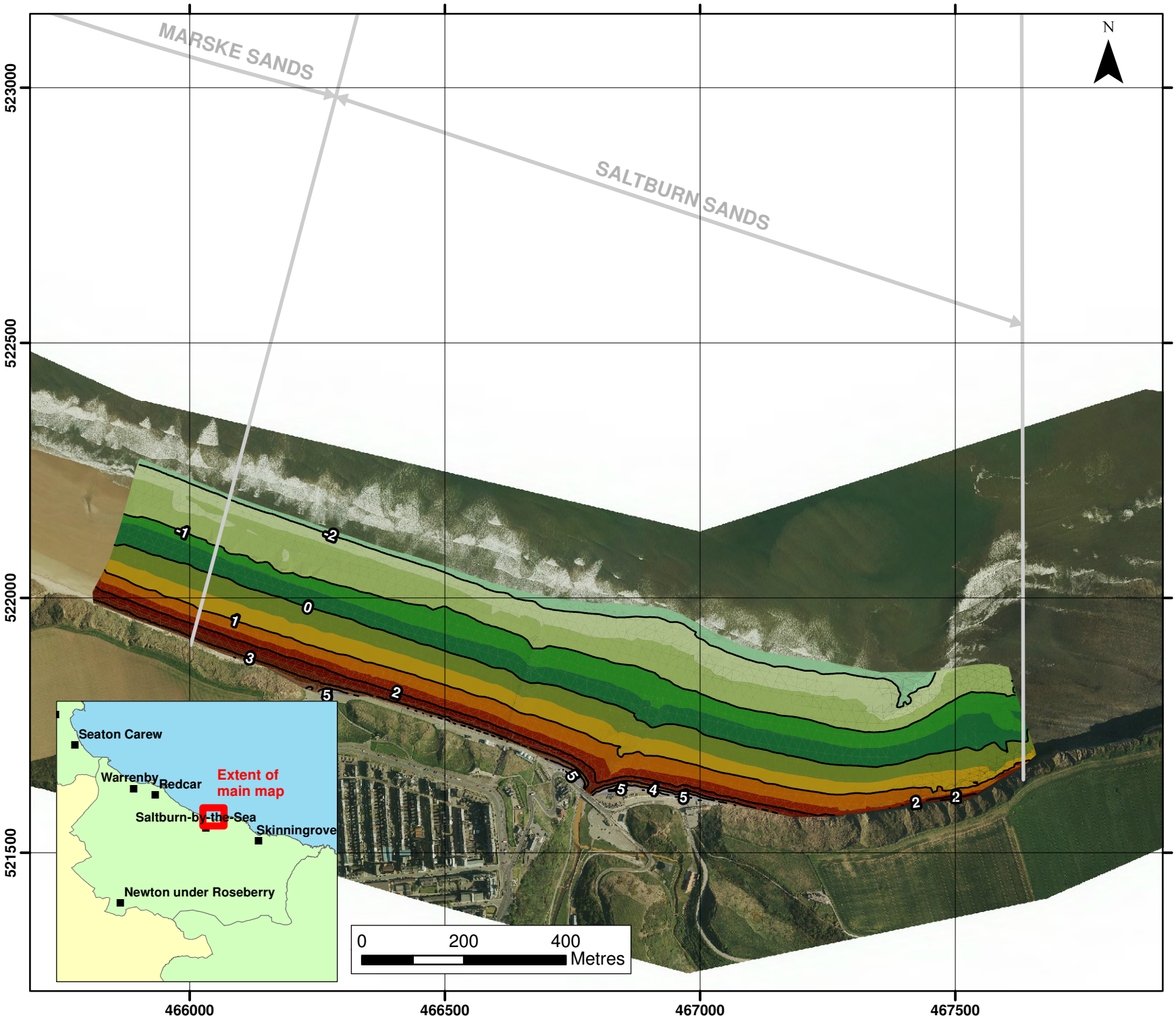

KEY

Elevation (m OD)

- 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
- -2.548 - -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
Saltburn Sands
Redcar & Cleveland Borough Council

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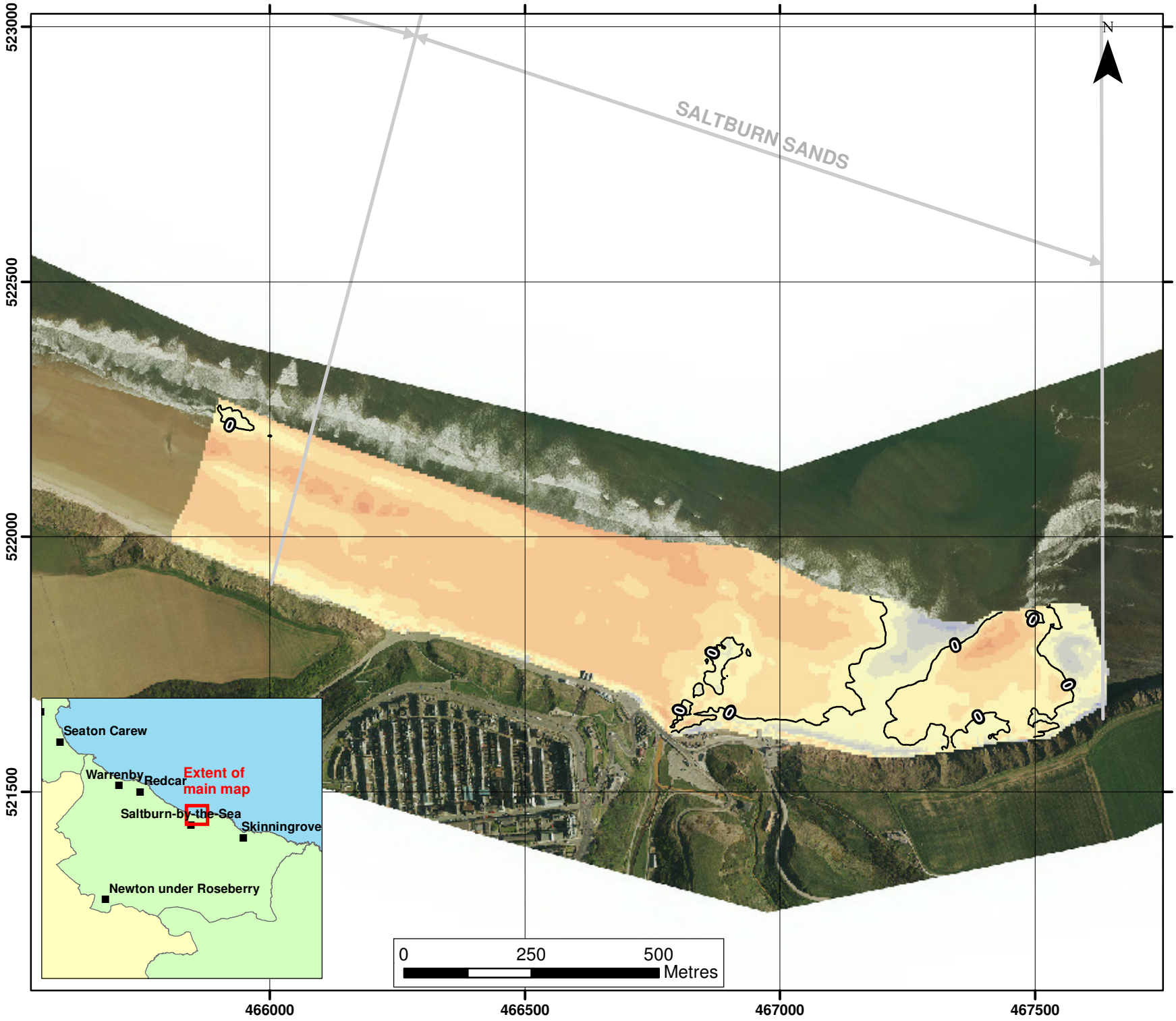

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<-2	Loss
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-1.25 - -1	
-1 - -0.75	
-0.75 - -0.5	
-0.5 - -0.25	
-0.25 - -0.1	
-0.1 - 0	Change < 0.1 m
0 - 0.1	
0.1 - 0.25	Gain
0.25 - 0.5	
0.5 - 0.75	
0.75 - 1	
1 - 1.25	
1.25 - 1.5	
1.5 - 1.75	
1.75 - 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
Saltburn Sands
Redcar & Cleveland Borough Council

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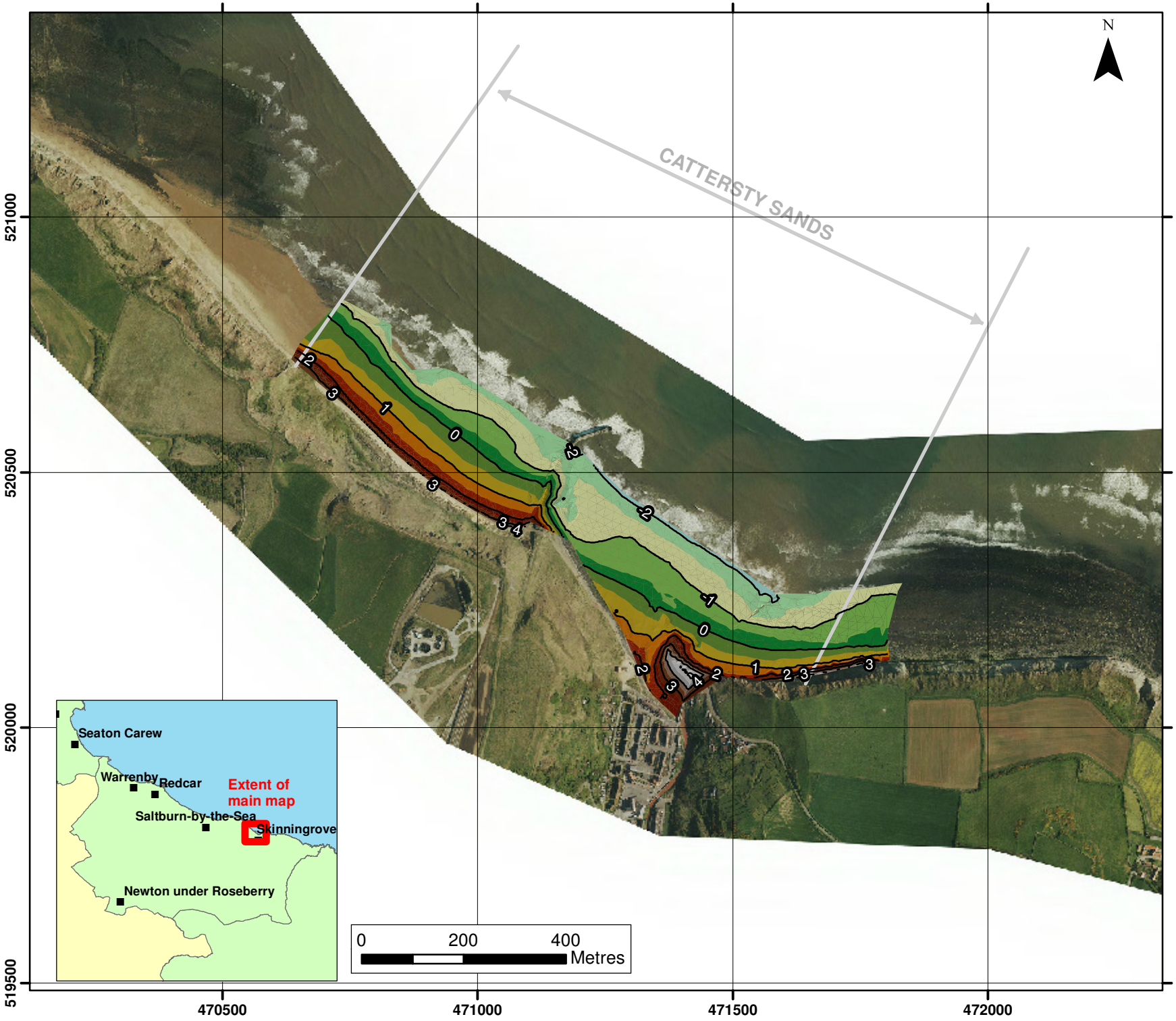

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- 1.5 - 2
- 1 - 1.5
- 0.5 - 1
- 0 - 0.5
- -0.5 - 0
- -1 - -0.5
- -1.5 - -1
- -2 - -1.5
- -2.5 - -2
- Contour 1m

Client: North East Coastal Group

Project: Cell 1 Regional Coastal Monitoring Programme 2011 to 2016

Appendix B- Map 3a Topographic Survey Cattersty Sands Redcar&Cleveland Borough Council

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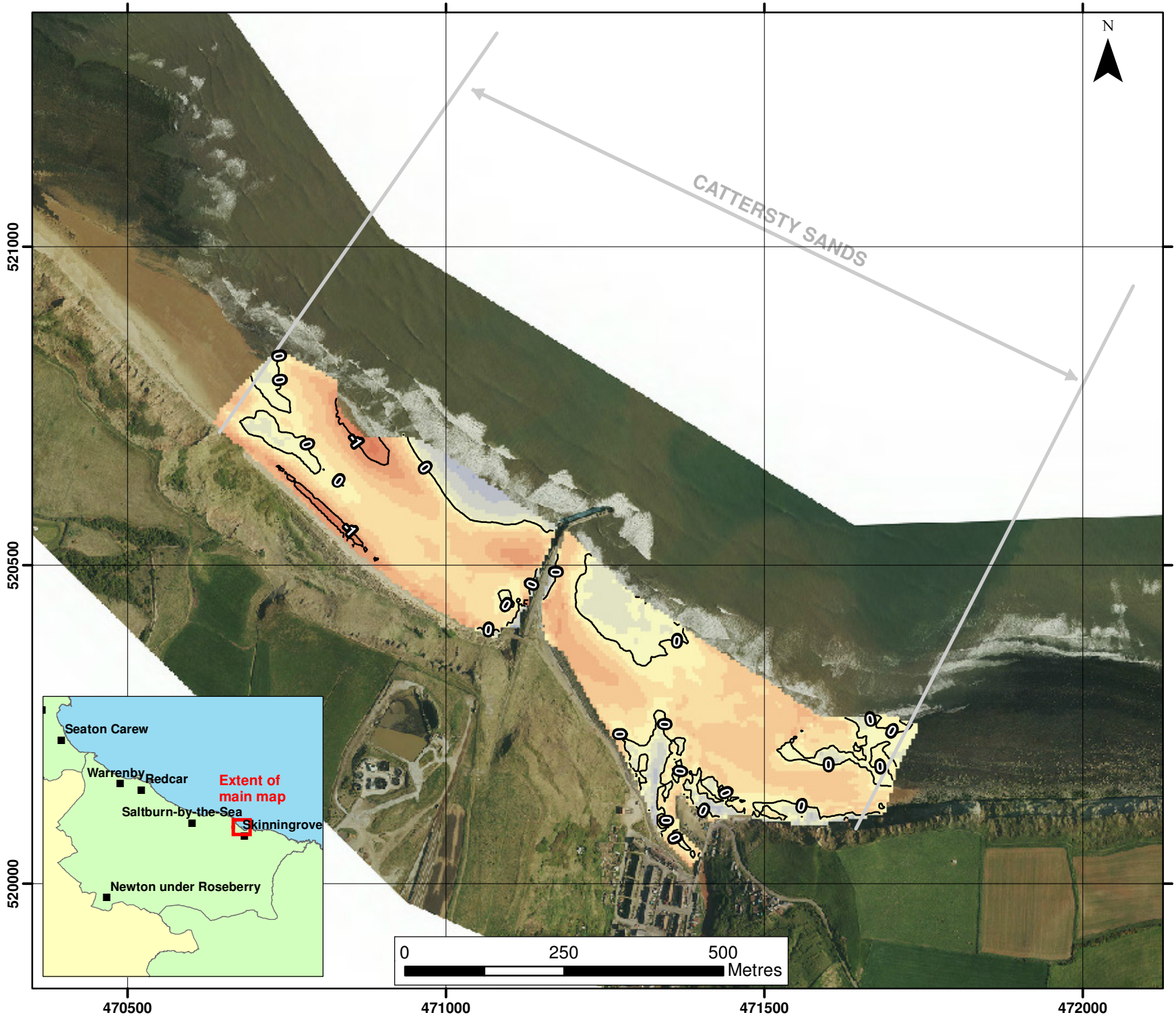

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-0.5 - -0.25	
-0.25 - -0.1	
-0.1 - 0	Change < 0.1 m
0 - 0.1	
0.1 - 0.25	Gain
0.25 - 0.5	
0.5 - 0.75	
0.75 - 1	
1 - 1.25	
1.25 - 1.5	
1.5 - 1.75	
1.75 - 2	
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Contours of change

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

Appendix B - Map 3b
Short-term Elevation Change
Cattersty Sands
Redcar & Cleveland Borough Council

Update Report 5
Partial Measures Survey
Spring 2013

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

Appendix C

Cliff Top Survey

Cliff Top Survey

Staithes

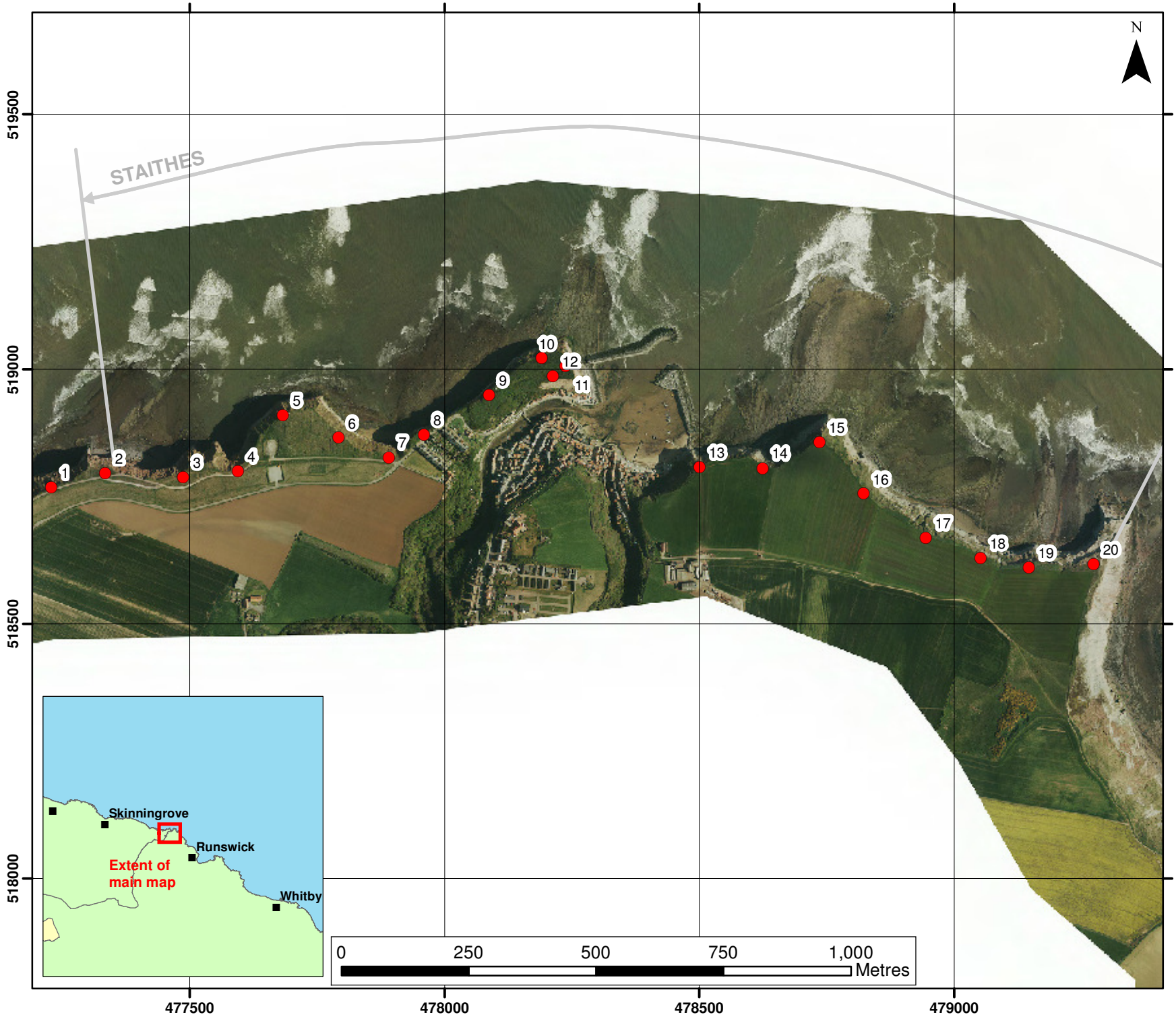
Twenty ground control points have been established at Staithes (Figure C1). The maximum separation between any two points varies along the coast, reflecting the degree of risk from the erosion.

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

Table C1 provides baseline information about these ground control points and results from the November 2008 (baseline) survey showing the position from the ground control point to the edge of the cliff top along the defined bearing. Future reports will show results from subsequent surveys and provide a means of assessing erosion since the baseline survey.

Table C1 – Cliff Top Surveys at Staithes

Ground Control Point Details				Distance to Cliff Top (m)			Total Erosion (m)		Erosion Rate (m/year)
Ref	Easting	Northing	Bearing (º)	Baseline Survey (Nov 2008)	Previous Survey (Sept 2012)	Present Survey (March 2013)	Baseline (Nov 2008) to Present (March 2013)	Previous (Sept 2012) to Present (March 2013)	Baseline (Nov 2008) to Present (March 2013)
1	477228	518769	320	1.9	1.7	1.7	-0.2	0.0	0.0
2	477334	518798	0	10.9	10.8	10.8	-0.1	0.0	0.0
3	477487	518789	350	7.1	8.4	8.3	1.2	-0.1	0.3
4	477594	518801	340	5.9	5.2	5.1	-0.8	-0.1	-0.2
5	477683	518911	350	8.4	9.4	9.2	0.8	-0.2	0.2
6	477792	518867	30	8.6	8.6	8.5	-0.1	-0.1	0.0
7	477891	518828	60	7.7	7.5	7.5	-0.2	0.0	0.0
8	477959	518873	350	8.7	9.8	9.8	1.1	0.0	0.3
9	478088	518950	350	7.6	8.3	8.3	0.7	0.0	0.2
10	478191	519023	340	8.4	8.8	8.8	0.4	0.0	0.1
11	478237	519007	60	6.9	6.7	6.7	-0.2	0.0	0.0
12	478213	518988	150	6.1	6.8	6.5	0.4	-0.3	0.1
13	478501	518809	15	11.4	9.1	9.2	-2.2	0.1	-0.5
14	478624	518807	20	7.5	7.5	7.5	0.0	0.0	0.0
15	478737	518858	60	6.1	6.6	6.4	0.3	-0.2	0.1
16	478823	518757	60	8	9.2	9.0	1.0	-0.2	0.2
17	478944	518671	30	9.3	9.4	9.4	0.1	0.0	0.0
18	479052	518630	20	9.2	9.5	9.4	0.2	-0.1	0.0
19	479147	518610	0	14.2	14.4	14.4	0.2	0.0	0.0
20	479274	518618	20	11.4	11.4	11.4	0.0	0.0	0.0



KEY

- Ground Control Points

Client: North East Coastal Group

Project: Cell 1 Regional Coastal Monitoring Programme 2011 to 2016

Appendix C - Map 1
Ground Control Points
Staithes
Redcar & Cleveland Borough Council

Update Report 5
Partial Measures Survey
Spring 2013

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Fax: +44(0)121 456 1569
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Appendix D

Durham University Laser Scans of Cowbar Nab

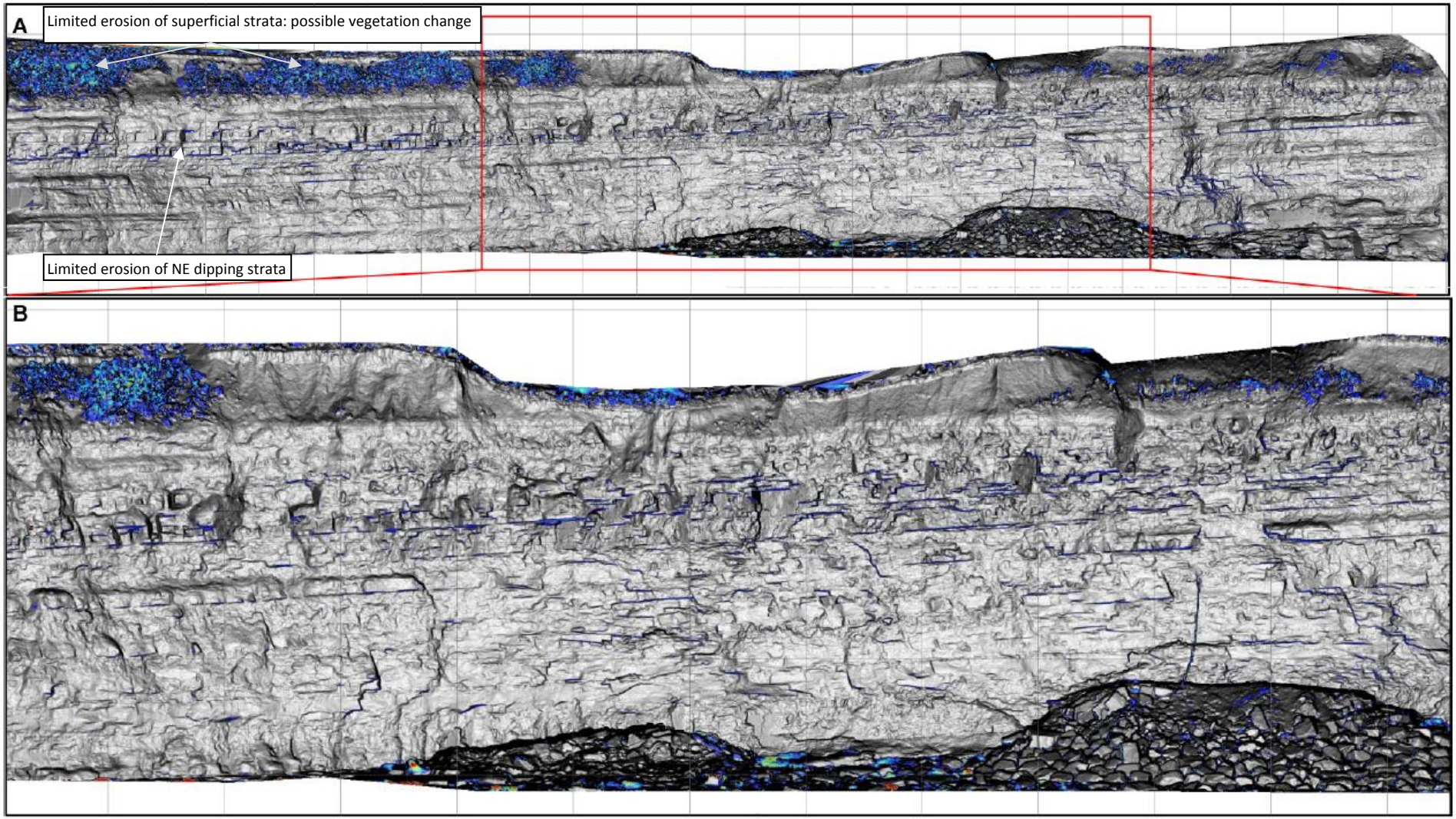

Figure D1: Cliff erosion 25 April 2013 to 23 May 2013. (A) Full cliff scan length section (B) close-up of area indicated by red box. Cold colours (blue) show erosion =>0.1m, and warm colours (red) show erosion up to 2.5m normal to the cliff face.

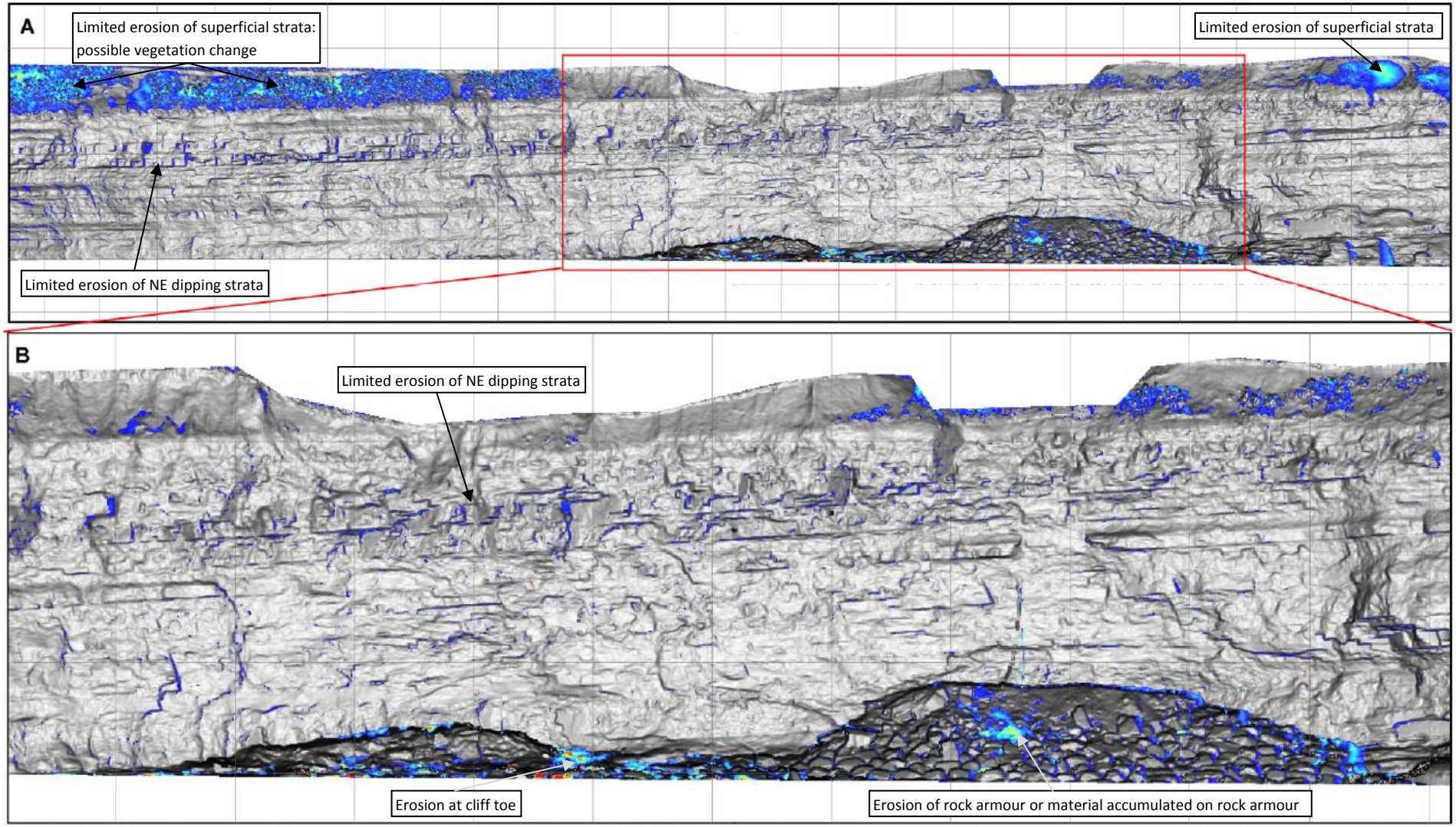

Figure D2: Cliff erosion 23 May 2013 to 13 June 2013. (A) Full cliff scan length section (B) close-up of area indicated by red box. Cold colours (blue) show erosion =>0.1m, and warm colours (red) show erosion up to 2.5m normal to the cliff face.