Cell 1 Regional Coastal Monitoring Programme
Update Report 6: 'Partial Measures' Survey 2014

A great place to live, work & play

Scarborough Council
Final Report

July 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) 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
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**
1 in 200 year	3.88	3.93	3.93	4.04
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).

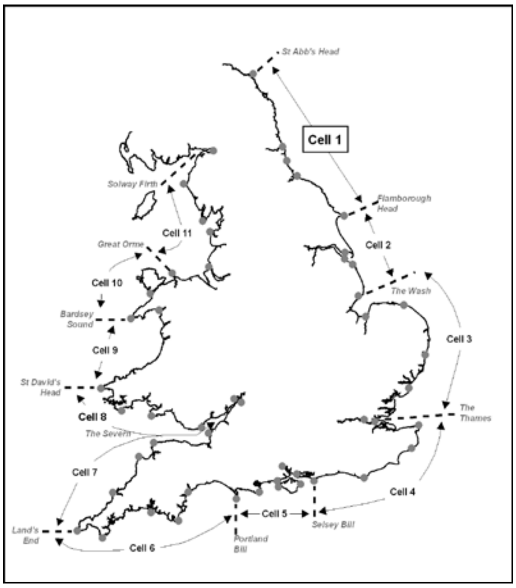


Figure 1 Sediment Cells in England and Wales

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	Sept-Dec 08	May 09	Mar-May 09	June 2009	-
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 12	Mar 13	Apr-May 13	May 13	
6	2013/14	Oct-Nov 13	Feb 14	Mar-April 14	July 14(*)	

(*) The present report is **Update Report 6** and provides an analysis of the 2013 Partial Measures survey for Scarborough Council's frontage.

1. Introduction

1.1 Study Area

Scarborough Council's frontage extends from Staithes Harbour in the north, to Speeton in Filey Bay in the south. For the purposes of this report, it has been sub-divided into eight areas, namely:

- Staithes[1]
- Runswick Bay
- Sandsend Beach, Upgang Beach and Whitby Sands
- Robin Hood's Bay
- Scarborough North Bay
- Scarborough South Bay
- Cayton Bay
- Filey Bay

1.2 Methodology

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

- Full Measures survey annually each autumn/early winter comprising:
    - Beach profile surveys along 20 transect lines
    - Topographic survey at Runswick Bay
    - Topographic survey along the Sandsend to Whitby frontage
    - Topographic survey at Robin Hood's Bay
    - Topographic survey at Scarborough North Bay
    - Topographic survey at Scarborough South Bay
    - Topographic survey at Cayton Bay
    - Topographic survey at Filey Bay
- Partial Measures survey annually each spring comprising:
    - Beach profile surveys along 20 transect lines
    - Topographic survey at Runswick Bay
    - Topographic survey at Robin Hood's Bay
    - Topographic survey at Filey Bay (Town coverage)
- Cliff top survey bi-annually at:
    - Staithes
    - Robin Hoods Bay (new addition Spring 2010)
    - Scarborough South Bay (new addition Spring 2010)
    - Cayton Bay
    - Filey

The location of these surveys is shown in Figure 2. The Partial Measures survey was undertaken along this frontage between 17th March 2014 and 4th April 2014. During this time weather conditions varied considerably; refer to the survey reports for details of the weather conditions over this survey period. Two additional surveys were also undertaken before and after sediment recycling at Scarborough South Bay on 6th May 2014 and 20 May 2014 respectively.

On 5th December 2013 a significant storm surge, driven by strong northerly winds, coincided with one of the highest astronomical tides of the year. A comparison of the recorded water level data for the December 2013 storm surge at North Shields, Whitby and Scarborough has been provided in the second wave data analysis report covering the period 2013 to 2014. Recorded surge residuals from that report show a similar signature at the three sites, with the maximum surge height occurring before high water and the surge increasing in height as it

[1] The Staithes frontage straddles the boundary of jurisdiction of both Redcar & Cleveland Borough Council and Scarborough Borough Council.

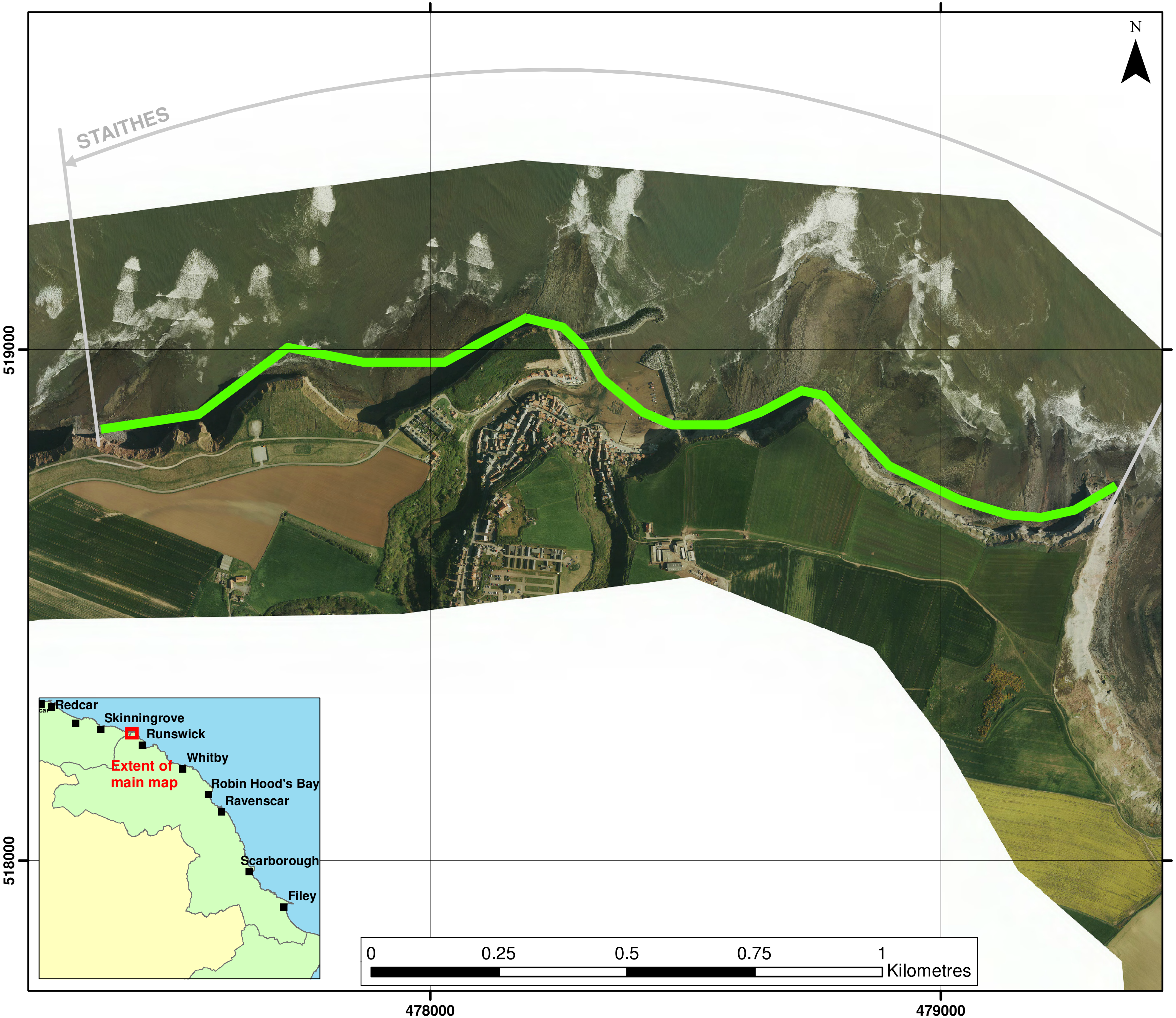
progressed down the coast, from around 1.3m above predicted water level at North Shields to around 1.8m at Whitby and Scarborough. Based on the EA (2011) Coastal Flood Boundary Condition extreme water level data the surge had the follow chance of occurrence each year:

- North Shields: between 1 in 200 and 1 in 500
- Whitby: between 1 in 100 and 1 in 500
- Scarborough: between 1 in 150 and 1 in 500

The Update Report presents the following:

- description of the changes observed since the previous survey and an interpretation of the drivers of these changes, including consideration of the impact of the storm surge (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
Staithes
Scarborough Borough Council

Update Report 6
Partial Measures Survey
Spring 2014

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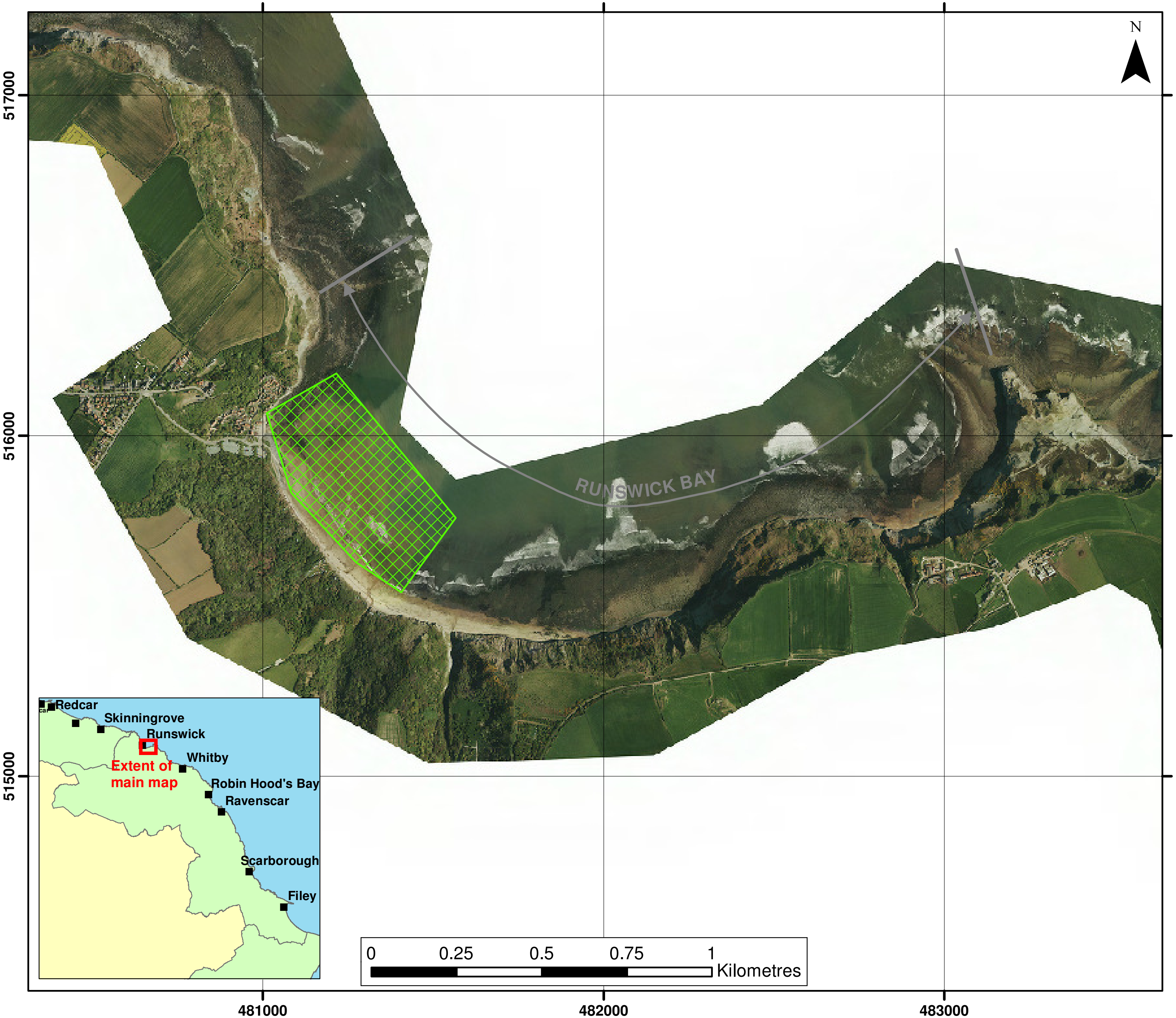

KEY

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
Runswick Bay
Scarborough Borough Council

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Spring 2014

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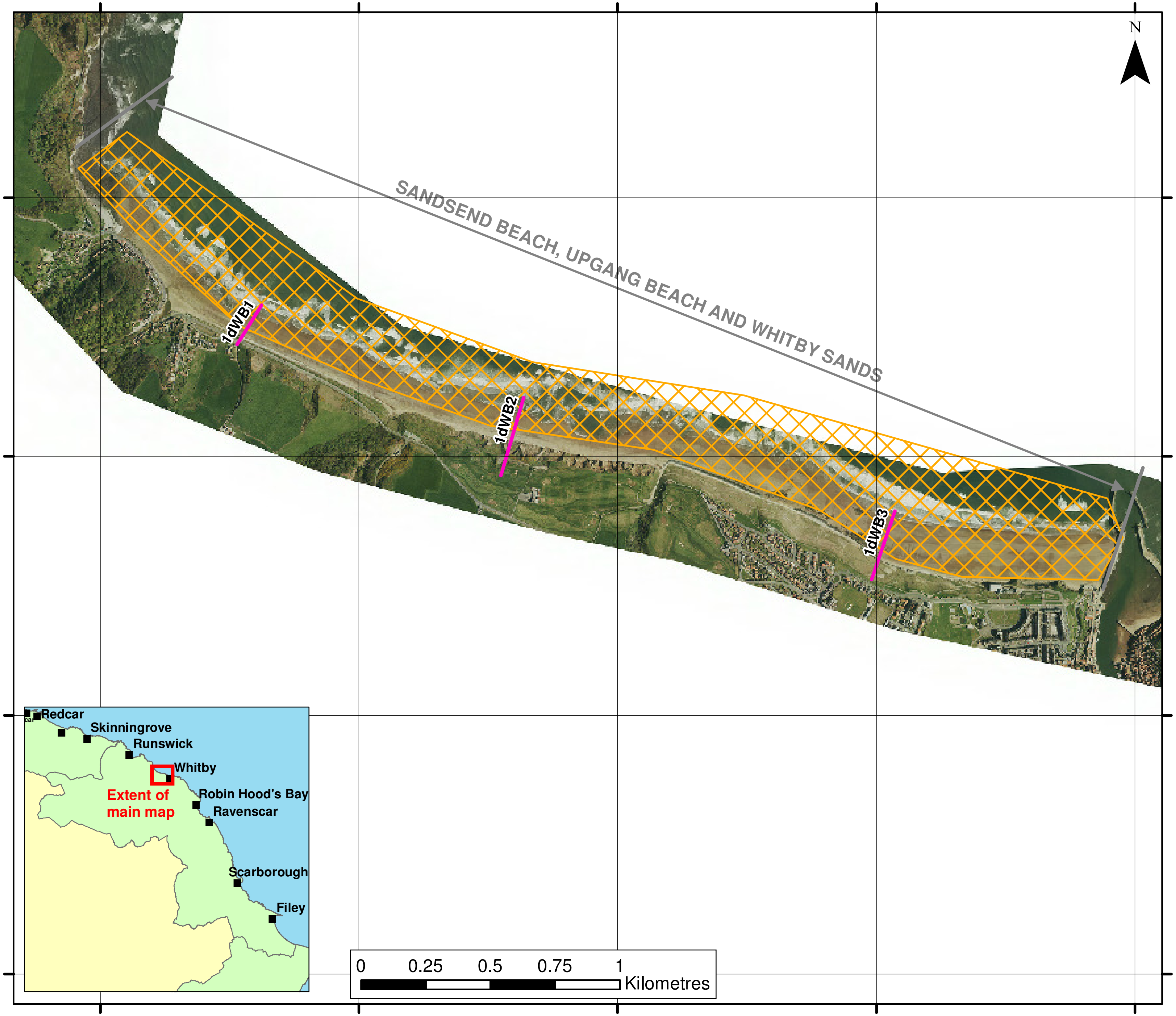

KEY

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
Sandsend to Whitby
Scarborough Borough Council

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Spring 2014

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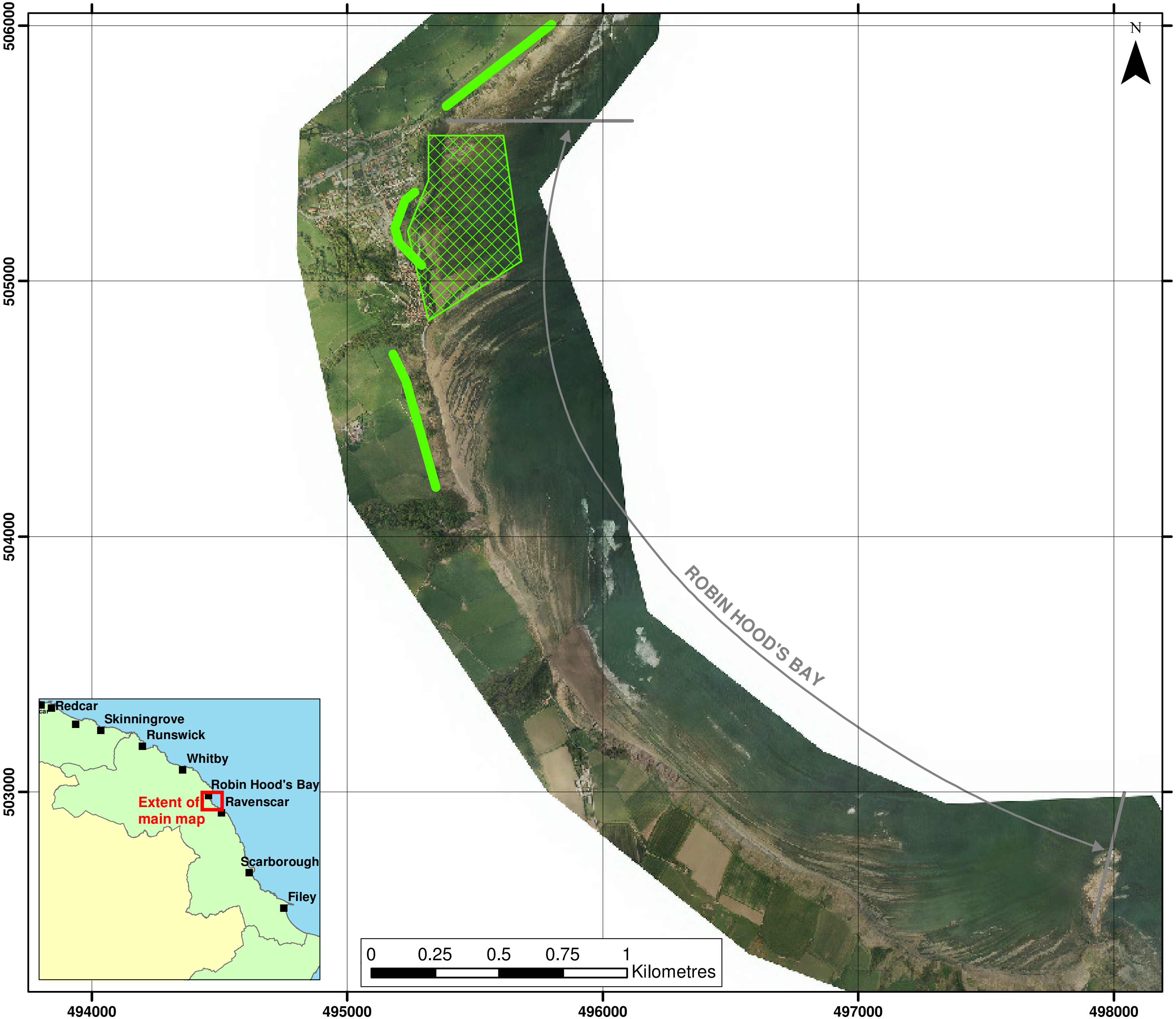

KEY

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
Robin Hood's Bay
Scarborough
Borough Council

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Partial Measures Survey
Spring 2014

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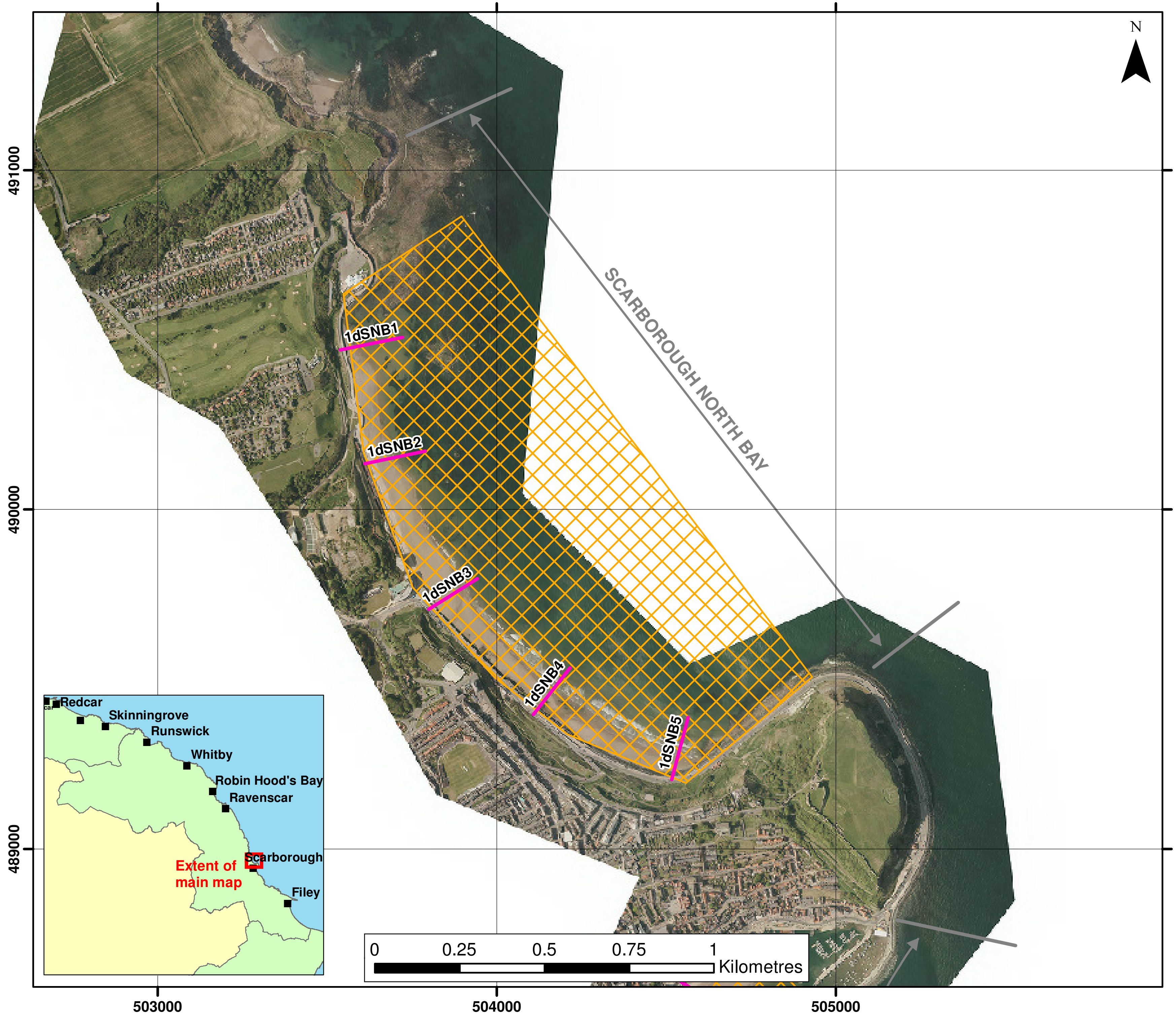

KEY

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
Scarborough North Bay
Scarborough
Borough Council

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Partial Measures Survey
Spring 2014

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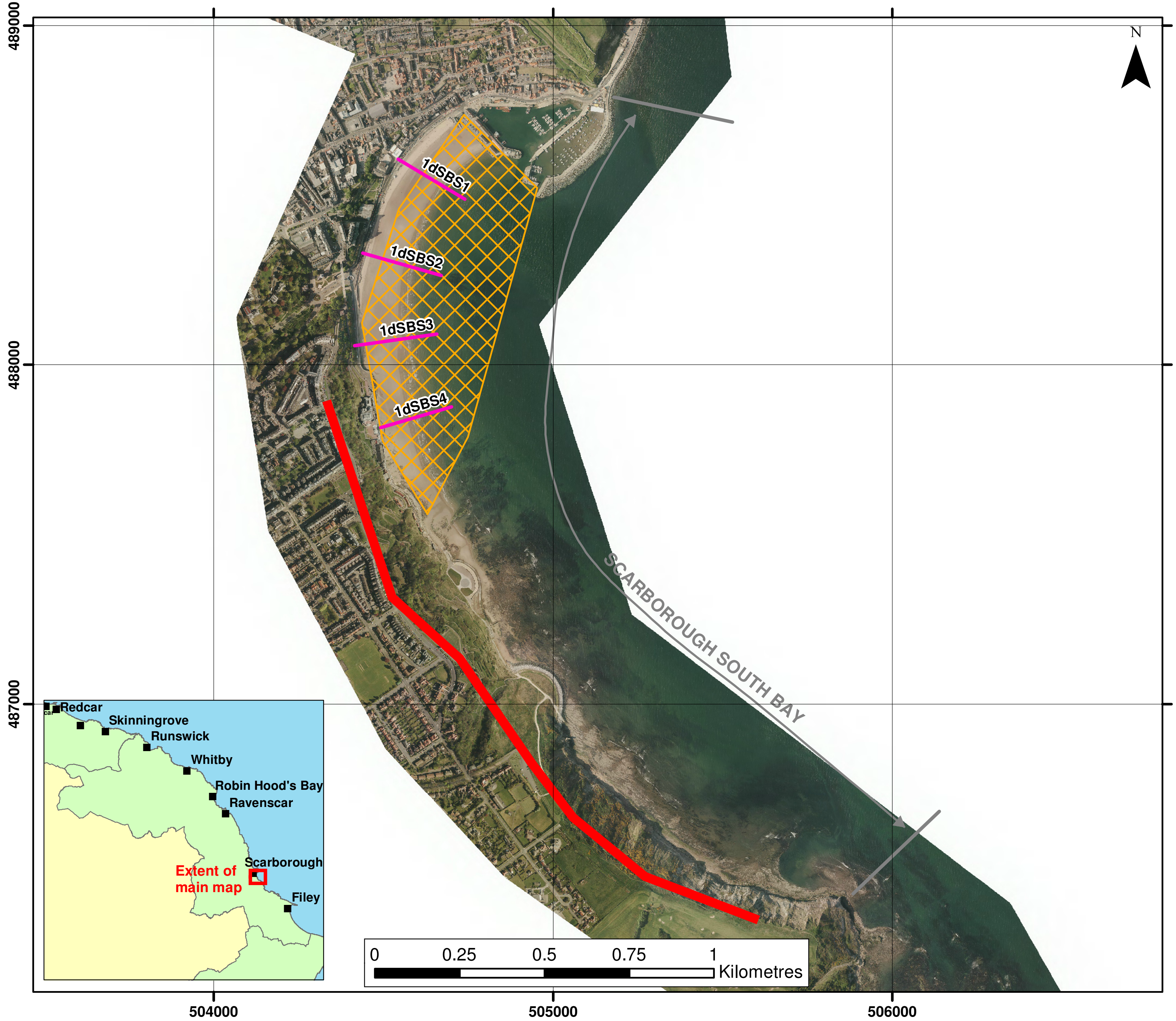

KEY

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
Scarborough South Bay
Scarborough
Borough Council

Update Report 6
Partial Measures Survey
Spring 2014

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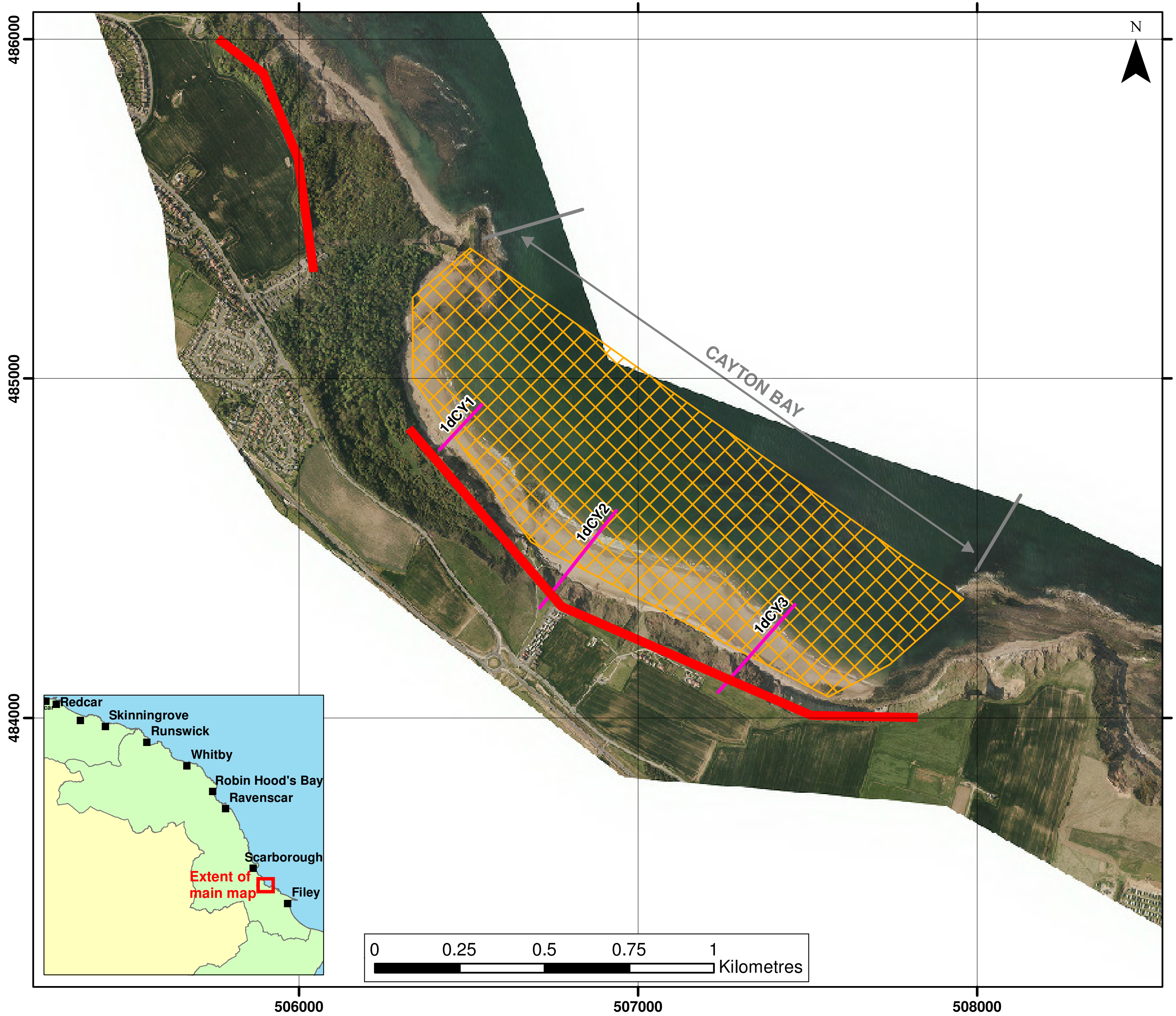

KEY

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 7
Survey Locations
Cayton Bay
Scarborough Borough Council

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Partial Measures Survey
Spring 2014

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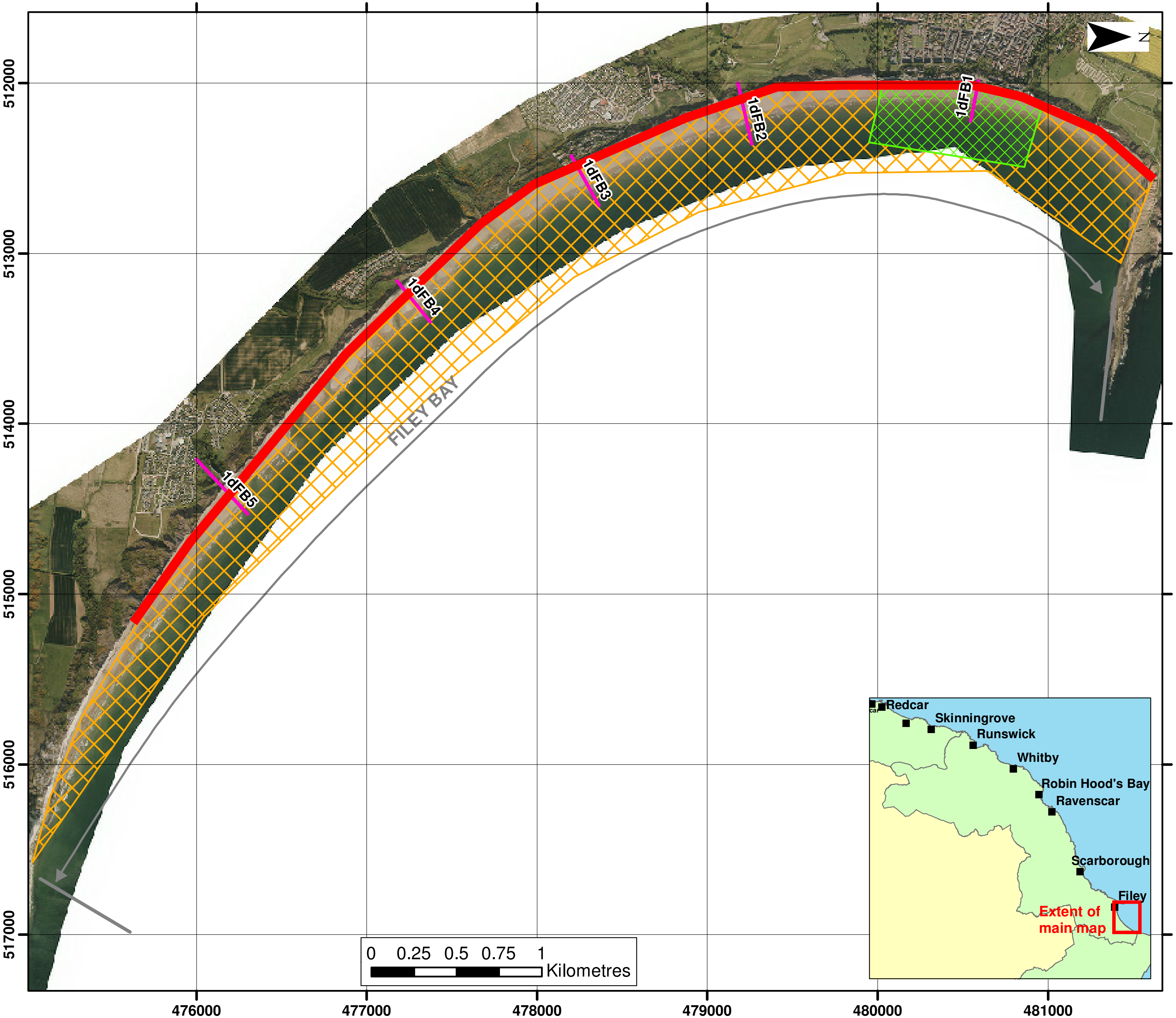

KEY

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 8 Survey Locations Filey Scarborough Borough Council

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2. Analysis of Survey Data

2.1 Staithes

Survey Date	Description of Changes Since Last Survey	Interpretation
9th April 2014	**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 April 2014 survey, showing the distance from the ground control point to the edge of the cliff top along the defined bearing and changes in position since the November 2008 baseline survey and the previous September 2012 survey. The results provided in Appendix C show that none of the profiles have experienced erosion greater than the assumed error of ±0.1m between November 2013 and April 2014. Some profiles indicate cliff advance, which reflects difficulties precisely determining the edge of the cliff top. Calculation of longer-term erosion rates based on the recorded change indicates that 19 of the cliff top survey points recorded changes less than ±0.1m/yr or advances. These data are either statistically insignificant or erroneous. Only location No.13, which is situated above the eastern harbour arm, shows long-term recession, at a rate of 0.4m/yr.	The recorded changes to the cliff top between November 2013 and April 2014 are small. There have been no large failures which have affected the cliff top. **Longer term trends:** Table C1 in Appendix C presents the erosion rates calculated from the data collected since 2008. Only Point 13 profile shows a reliable average recession rate, which is 0.4m/yr since Nov 2008.
March 2013 to March 2014	**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. An update on their work between March 2013 and March 2014 is provided here. Twelve surveys at one-monthly intervals have been undertaken over the last year, allowing difference models to be calculated over the period and for comparison to previous periods dating back to January 2011. The data indicate that:	**Longer Term Trends** Laser scanning surveys suggest an increase in the number of rock falls between 2012-13 and 2013-14 but that no recession of the cliff top occurred. This is consistent with the cliff top monitoring data.

Survey Date	Description of Changes Since Last Survey	Interpretation
	- The maximum recession of the cliff face during any one event was 2.80m, which occurred 6.7m above the cliff toe at a point that had previously experienced undercutting. - Greatest erosion of the cliff face is concentrated in areas not protected by rock armour, although smaller falls do occur in the protected cliff. - Despite the numerous rock falls, no retreat of the cliff top occurred. However, losses below the cliff line indicate a steepening of the cliff that will eventually lead to cliff top failure.	

2.2 Runswick Bay

Survey Date	Description of Changes Since Last Survey	Interpretation
21st March 2014	**Topographic Survey:** Runswick Bay is covered by a 6-monthly topographic survey. A consistently applied GIS processing routine has been used to create a digital ground model (DGM) (Appendix B - Map 1a) and to calculate the differences between the current topographic survey (Spring 2014) and the previous survey (Autumn 2013) to highlight areas and amounts of erosion and deposition. In all cases, a 5m resolution raster grid has been used to identify areas of erosion and accretion. (Appendix B – Map 1b). Appendix B - Map 1b shows changes that are primarily shore-parallel, although erosion is more common in the south of the bay. The lower foreshore has experienced erosion, whereas the upper part of the beach and foreshore has experienced erosion. This and comparison of the contours on the topographic plots indicates a steepening of the beach over the winter. All changes are between ±1m, except for a very small area of accretion south of the slipway just in excess of 1m.In the north of the bay in front of the village, material has been eroded from the middle beach and deposited at the back of the beach and in the lower foreshore.	Material appears to have been driven from the foreshore to the back of the beach, and also eroded from the more southerly parts of the bay and driven northwards. This pattern is not typical for the winter, when beach levels more commonly experience lowering and probably relates to the action of the storm surge, which caused widespread movement of sediment to the back of beach. **Longer term trends:** The data collected since 2008 indicate a general pattern of winter drawdown and spring recovery and highlights the unusual nature of the current findings. It is thought the current beach form relates to the storm surge and is likely to be remodelled over the next 6 to 12 months.

2.3 Sandsend Beach, Upgang Beach and Whitby Sands

Survey Date	Description of Changes Since Last Survey	Interpretation
17th March 2014	**Beach Profiles:** The Sandsend, Upgang and Whitby frontage is covered by three beach profile lines for the Partial Measures survey (Appendix A). The profiles were surveyed in September 2013 (2013 Full Measures) and in two post storm surge surveys on 9 and 18 December 2013. **Profile 1dWB1** is located around 400m south of Sandsend village. The profile above HAT (around 35m chainage) has not changed except for some minor erosion of the vegetated cliff above the concrete sea defence apron at circa 25m chainage that occurred between September 2013 and December 2013. Significant lowering (up to 1m) of the upper beach occurred during the storm surge, but by the 18 December survey this area was already showing signs of recovery. The March 2013 survey shows that the upper beach between 45m and 90m chainage has continued to accrete but has not yet reached the pre-surge level recorded in September 2013. The lower beach and foreshore between 90m and 190m chainage has is now higher than in the September 2013 survey, with a relatively uniform slope. The beach is now well within the range of elevations seen in previous surveys throughout the profile and the profile has a much shallower gradient than those prior to March 2012 and is similar to the majority of more recent surveys. **Profile 1dWB2** is located in the centre of Upgang beach. No changes have occurred from the start of the profile to 80m chainage. Between 80m and 140m chainage, changes to the cliff face are difficult to quantify, as profiles from previous surveys have not covered this section of the profile due to access issues arising from thick vegetation and instability. However, it is clear from photographs and surveyors' comments that this part of the chainage is actively eroding cliffline. Between September 2013 and 9 December 2013, substantial lowering of the upper beach had taken place between 140m and 180m chainage. The 18 December 2013 survey showed beach recovery since 9 December, and this pattern of recovery has continued through to the latest survey. The upper part of the beach between 145m and 155m chainage is now at its second-highest level since monitoring began in 2008. The 9 December profile showed an increase in elevation of 0.6m in the foreshore between 195m and 225m chainage. The 18 December 2013 survey showed this change to be reversing, a pattern which has continued. This section of the profile is now up to 1.4m lower than on 9th December 2013 and 0.6m lower than in the September 2013 survey. The relatively high elevation of the upper beach and low level of the foreshore mean that the beach and foreshore in this profile are at their steepest since monitoring began.	All the profiles show relatively smooth beach profiles that are free of berms and troughs. There and signs of recovery from the severe lowering that occurred in the surge, particularly in the upper beach, but the foreshore remains lower in the more southerly profiles giving comparatively steep profiles. **Longer term trends:** The pattern observed is unusual due to the effects of the surge, which are expected to be short-lived. The most northerly profile, 1dWB1, shows the highest profile compared to the others, whereas the foreshore in the more southerly profiles are relatively low compared to previous surveys, creating very steep profiles.

Survey Date	Description of Changes Since Last Survey	Interpretation
	Profile 1dWB3 is located on Whitby Sands and showed no changes above MHWS. Between September and December 2013, the whole beach profile was lowered, by up to 0.7m in the upper beach between 90m and 190m chainage. The upper beach has partially recovered between 90m and 130m chainage, but gets progressively lower than the September 2013 profile until the end of the survey at 255m chainage where the most recent survey is 1m lower than the September 2013 survey and 0.25m than the 9th December 2013 survey. This gives the beach its steepest profile since monitoring began.	

2.4 Robin Hoods Bay

Survey Date	Description of Changes Since Last Survey	Interpretation
4th April 2014	**Topographic Survey:** Data from the most recent topographic survey (Partial Measures, spring 2014) have been used to create a digital ground model (DGM) (Appendix B – Map 2a) using a Geographical Information System (GIS). A difference plot has also been produced using the DGM (Appendix B – Map 2b) from the last topographic survey (Full Measures, autumn 2013) and the present survey. The difference plot shows changes in level between autumn 2013 and spring 2014. The pattern shows large areas of little or no change (within ±0.25m since autumn 2013) and smaller areas of more severe erosion and deposition that are distributed across the beach. The only areas of significant change are two sections of cliff toe in the northern part of the bay that have accreted by c.1m. The majority of the survey area has experienced limited accretion, but notable areas of erosion exist in front of the sea wall and the defended slipway to the north of the old village.	The larger elevation increases at the cliff toe in the north of the bay are due to cliff falls that were probably triggered by intense winter rainfall. As in previous partial measures surveys, limited change was recorded over the winter, with only subtle evidence for drawdown. This is due to the extensive rock shore platform and thin veneer of sediment. **Longer term trends:** The difference plots show a continuation of the trend of patchy distribution of erosion and accretion. Overall, the observed changes are of limited magnitude and not beyond the range of changes previously seen. The lowering of the foreshore in front of the sea wall should be monitored in future surveys to establish whether this is a persistent pattern or recovery takes place over the summer.
4th April 2014	**Cliff-top Survey:** Thirteen ground control points have been established at Robin Hood's Bay (since 3rd March 2010) to monitor cliff top recession. The separation between any two points is a nominal 200m. The cliff top surveys at Robin Hood's Bay are undertaken bi-annually.Appendix C provides results from the April 2014 survey, showing the distance from the ground control point to the edge of the cliff top along the defined bearing (Appendix C- Map 2) and changes in position since the last survey in September 2012 and the baseline survey in March 2010. The accuracy of the survey technique means change of less than 0.1m is assumed to be error. Taking into account the survey accuracy, none of the monitoring points show erosion since the last survey. Comparison of the latest survey to March 2010 baseline indicates long-term erosion is taking place at two locations. 0.9m/yr is recorded at point 1 and 0.3m/yr at point 5.	Overall the cliff top has been stable since the previous survey in November 2013 with no survey points showing erosion greater than the assumed error. **Longer term trends:** The erosion rates calculated from the observed changes since March 2010 show no erosion at most of the monitoring reports, but localised areas where rates as high as 0.9m/yr have been recorded, which reflects localised and episodic rockfalls.

2.5 Scarborough North Bay

Survey Date	Description of Changes Since Last Survey	Interpretation
18th March 2014	**Beach Profiles:** Scarborough North Bay is covered by five beach profile lines for the Partial Measures survey (Appendix A) that are monitored biannually. The previous surveys were undertaken in September 2013 but further surveys were undertaken on 11 December 2013 following the storm surge event. **Profile 1dSBN1** is located around 200m south of the Sea Life Centre. The profile has not changed between 0m and 10m chainage where sea defences are present. Between 10m and 100m chainage the beach lowered by 0.5m between the September and December 2013 surveys. Following the surge, the beach profile has partially recovered, with March 2014 beach levels between 10m and 55m chainage exceeding those recorded in September 2013 to create a berm in the upper beach. Between 55m and 100m chainage, the beach level is higher than in December 2013 but still 0.2m lower than in September 2013. Between 100m chainage and the end of the December 2013 survey at c.155m chainage, the beach profiles have changed little since September 2013. The March 2014 survey stops around 30m short of the September 2013 survey, suggesting some erosion of the foreshore beyond this point. . **Profile 1dSBN2** is located close to the former chair lift. The upper beach between c.8m and 55m chainage has accreted to a higher level than that seen in September 2013, despite it having been significantly lower in December 2013. Between 55m chainage and the end of the profile at c. 135m, chainage, lowering of the profile by up to 0.8m has occurred to expose rocks which were previously covered by sand between c.115m and 135m chainage. Overall the profile has steepened substantially, but is still amongst the highest recorded. **Profile 1dSBN3** is located near Royal Albert Drive. Above the HAT level there has been no change. The beach between 10m and 30m chainage has been subject to around 1.3m erosion since September 2013 with the beach at the toe of the sea wall being lower than it was in the December 2013 post-surge survey. The surveyors report mentions that the foot of the 'new concrete wall' is visible here and that parts of the newly installed concrete defence were starting to break up. However, a berm has developed in the upper beach with its crest at c.30m chainage and between 30m and 65m chainage the most recent profile is 0.5m higher than in September 2013. However, the foreshore between 65m chainage and the end of the survey is 0.6m lower in the most recent survey than in September 2013, reversing the accretion in the lower foreshore which created a berm here in the December 2013 survey. The	All profiles show a pattern of partial recovery following the December 2013 storm surge, particularly in the upper beach. However, the beach in the centre of the bay appears to have experienced a greater degree of steepening than elsewhere. **Longer term trends:** The beach seems to be generally steeper than in previous surveys and those in the central bay amongst the lowest, but there is evidence for many of the changes that occurred as a result of the December 2013 storm surge having reversed to varying degrees. However, there does appear to be a longer term trend of scour at the toe of sea defences and the net northwards transfer of material.

Survey Date	Description of Changes Since Last Survey	Interpretation
	elevation change between the crest of the berm in the upper beach and the low (in comparison to the most recent surveys) foreshore has created a steeper profile in the previous surveys. The March 2014 profile is one of the lowest since monitoring began, particularly in the lower foreshore. **Profile 1dSBN4** is located at the northern end of Clarence Gardens. Little change has occurred landward of the toe of the sea defences at 25m chainage. Up to 1m of accretion has occurred in the between 25m and 50m chainage to cover rocks that had previously been exposed in this section. A very short section of the profile immediately at the base of the sea wall continues to exist well below the elevation of the berm crest, reflecting the more substantial erosion that was evident here in the December 2013 survey. The shore platform continues to be exposed in a small hollow (visible on survey photographs) between and 50m and 60m chainage, Between 60m and 110m chainage the beach has accreted by 0.5m. Little change has taken place from 155m chainage to the end of the survey at c. 180m chainage, with changes being ±0.2m. **Profile 1dSBN5** is located southern of Clarence Gardens. No changes have taken place since the September 2013 survey as far as the base of the rock armour at c.28m chainage. At the toe of the rock armour, between 28 and 29m chainage, the beach elevation has reduced by 0.3m, continuing the post-surge pattern identified in December 2013. Between 30m and 35m chainage the beach level has recovered and in March 2013 was 0.1m higher than in September 2013. However, beyond 35m chainage to the end of the profile, the beach and foreshore level remains up to 0.3m lower in the March 2014 survey than in September 2013. With the exception of the low point at the base of the rock armour, the current profile is within the range of those in previous surveys.	

2.6 Scarborough South Bay

Survey Date	Description of Changes Since Last Survey	Interpretation
18th March 2014	**Beach Profiles:** Scarborough South Bay is covered by four beach profile lines for the Partial Measures survey (Appendix A). The profiles were surveyed at the last Full Measures survey (September 2013) and after the storm surge on 9 December 2013. Two further surveys before and after beach sediment recycling were undertaken on 6 May 2014 and 20 May 2014. These results are discussed separately below. **Profile 1dSBS1** is located around 250m south of the West Pier. The profile is unchanged to the upper edge of the sea defences at c.13m chainage. Between 13m and 15m chainage 0.3m of sand is accumulated against the sea wall, but levels here are lower than that recorded immediately following the surge. Two berms with an intervening trough present in the Sept 2013 survey between 15m and 40m chainage had been smoothed out by March 2014. A trough present in the lower foreshore in September 2013 between 165m and 225m infilled by a similar amount. All the changes in the profile seaward of 15m chainage are of the same trend as those recorded by the December 2013 survey. **Profile 1dSBS2** is located on the shore fronting St Nicolas cliff. From 5m to 50m chainage minor (<±0.2m) changes have taken place. More significant accretion (0.6m) has taken place between 50m and 100m chainage to infill a trough between and upper and lower berm. Between 130m and 170m chainage the crest of the lower berm present in September 2013 has been eroded by 0.3m. Between 170m and 200m chainage, the beach has accreted by 0.3m. Together these changes smooth out the beach profile. The March 2013 profile is very similar to the December 2013 profile, indicating the majority of these changes occurred during the storm surge. The profile is similar to many of the previous post-winter survey profiles. **Profile 1dSBS3** is located 250m north of the Scarborough Spa complex. No change has taken place landward of the base of the seawall at 10m chainage since September 2013. Two berms were present in the September 2013 survey with crests at ca.45m chainage and 120m chainage, with a trough in-between. Between 15m and 55m chainage the crest of the upper berm has been eroded by 0.6m as has the crest of the lower berm between 100m and 160m chainage. The intervening trough has infilled by a similar amount. Seaward of 160m chainage, the lower foreshore has accreted, but this is beyond the end of the previous survey. The December 2013 survey indicates that most of these changes took place before or during the storm surge event, although more severe erosion of the lower foreshore evident in	Between September 2013 and March 2013, all profiles have experienced flattening to remove berms and troughs that were present in September 2013 survey. This is likely to have been an effect of the surge event and has been commonly seen in the region. Beach levels appear to be lower in the more southerly profiles than the more northerly profiles indicating a likely north-south transfer within the bay. Most of the changes that occurred took place by December 2013 and therefore highly likely to have been driven by storm surge activity. **Longer term trends:** The observed changes in the profiles in South Bay are consistent with the seasonal fluctuations of sediment with a bay system. However, the levels of the profiles, that are particularly low in the south, indicate a northwards transfer of sediment within the bay.

Survey Date	Description of Changes Since Last Survey	Interpretation
	the December 2013 survey has been reversed. The overall impact of the changes is to smoothen the profile. The profile is low in comparison to previous surveys. **Profile 1dSBS4** is located on the beach in front of the Scarborough Spa Complex. The beach level shows a similar pattern to the previous Full Measures survey with berms present in the upper and lower parts of the profile in September 2013 being eroded and the intervening trough infilled, Between the base of the sea wall and c.30m the erosion of 0.4m of sand has exposed rocks at the toe of the sea wall. The accumulation of up to 0.4m of sand between 30m and 90m chainage has infilled the subtle trough between the two berms. The crest of the lower berm has been eroded by 0.3m between 115m and 140m chainage. From 140m chainage to the end of the March 2014 survey at 190m chainage, the beach has accreted but this is beyond the extent of the September 2013 survey. The overall result, as for the other profiles in South Bay is a smoothening of slope profiles. The majority of the changes appear to have taken place by the December 2013 survey, with less change occurring subsequently. The March 2013 profile is relatively low in in the upper beach in comparison to previous survey but within the range of previous profiles in the lower foreshore. **SEDIMENT RECYCLING SURVEY** Profile 1dSBS1 shows a lowering of its profile of 0.7m against the sea wall at 13.5m chainage reducing to no change at 40m chainage, indicating removal of sediment from this area between 6 and 20 May 2014. Profiles 1dSBS2 and 1dSBS3 show increased elevations in the uppermost part of the beach against the sea defences of 0.3 to 0.4m and 1dSBS4 shows a lesser change in the uppermost part of its profile of c.0.2m. Comparison of topographic surveys before and after sediment recycling indicates that c.3,000m^3 of sand was removed from the northwest corner of the beach and placed along the back of the beach between the Spa Complex and St Nicholas Cliff. Comparison of the pre-and post-recycling surveys indicates that the overall volume of the survey area has increased by 2,700m3. However, this is most likely due to sediment being driven onshore from just seaward of the survey area and does not indicate a net gain of sediment to the beach. Figure 3b shows a different plot between the 2013 Full Measures survey and the pre-recycling survey on 6th May 2014. The extensive area of erosion at the back of the beach north of the spa is clear. Figure 4b shows the area from where sediment was removed during recycling (north end of the beach against the sea defences) as an area of loss and the area where the sand was recycled to (from the Spa	

Survey Date	Description of Changes Since Last Survey	Interpretation
	towards St Nicholas Cliff) as an area of relative gain.	
18th March 2014	**Cliff-top Survey:** 13 ground cliff top monitoring control points have been established at Scarborough South Bay and Cornelian Bay to Knipe Point. The separation between points is around 300m. The cliff top surveys at Scarborough South Bay are undertaken bi-annually. Appendix C provides results from the March 2010 baseline survey through to the most recent March 2014 survey, showing the distance from the ground control point to the edge of the cliff top along the defined bearing (Appendix C- Map 3). Error in the technique means change of less than 0.1m cannot be relied on. Calculated advances of the cliff line are also assumed to be error associated with difficulty precisely identify the cliff top, particularly where vegetation is present. The recorded changes between September 2013 and March 2014 show no monitoring points with erosion greater than the levels of error. Over the longer term, two survey points (nos. 11 and 12) show erosion of 0.5m/yr since March 2010.	The cliff monitoring data shows that two of the markers in Cornelian Bay (Numbers 11 and 12) had recession of 2.2m and 1.9m between the March 2010 and March 2014 although this has not increased since the last survey. The rest of Cornelian Bay and South Bay has remained stable. **Longer term trends:** The recession rates for the period of March 2010 to March 2014 are not significant with the exception of Markers 11 and 12 in Cornelian Bay which both show recession rates of 0.5m/yr.

2.7 Cayton Bay

Survey Date	Description of Changes Since Last Survey	Interpretation
20th March 2014	**Beach Profiles:** Cayton Bay is covered by three beach profile lines for the Partial Measures survey (Appendix A). The previous survey was undertaken in September 2013. **Profile 1dCY1** is located on the beach in front of Tenants' Cliff in the north of the Bay. The surveyors report states that 'the top of section 1 cannot be measured due to dense vegetation', although from the survey points taken the cliff top position at around -35m chainage appears not to have changed since the last survey in September 2013. The cliff toe to 10m chainage has changed elevation by ±1m through collapse of the lower part of the cliff and movement of boulders. The upper beach between 10m chainage and 60m chainage has eroded by around 0.5m and the middle beach accreted by a similar amount. There has been erosion of the lower beach of up to 0.6m to expose the underlying shore platform between 95m and the end of the survey at 110m. The beach is relatively low compared to previous surveys, but within the past range. **Profile 1dCY2** is close to the former pumping station in the middle of Cayton Bay. The cliff part of the profile was not surveyed due to unstable ground and the surveyor noted 'soft mudflows, unstable grass and landslips'. The cliff top is unchanged but limited recession of the toe has occurred around c.110m chainage to increase the slope angle. Accretion of 0.5m in the uppermost part of the beach profile between 118m and 128m chainage has occurred, Between 128m chainage and the end of the survey at 340m chainage, berms and troughs that were present in the previous survey have been eroded and infilled by ±0.4m to create a straighter profile. The profile is within the range of those seen in previous surveys. **Profile 1dCY3** is located around 600m southeast of the pumping station. The middle of the cliff section could not be surveyed due to unstable ground and the surveyor noted 'soft mudflows, unstable grass and landslips''. Recession of the toe of the cliff by 1m has occurred at c.123m chainage and the upper beach between 124m and 150m chainage has eroded by 0.4m. The beach has accreted between 150m and 220m chainage by 0.6m to form a berm in the middle beach. Between 220m chainage and the end of the survey, a berm present in the foreshore in the previous survey has been eroded by 0.6m. The beach is relatively low in comparison to previous surveys.	As seen elsewhere, berms and troughs have been removed to create a smoother profile. All beach profiles remain relatively low and there are signs of limited erosion in the toe of the cliff in the southern part of the bay. **Longer term trends:** All profiles are comparatively low, but within the range of profiles previously seen.

Survey Date	Description of Changes Since Last Survey	Interpretation
20th March 2014	**Cliff-top Survey:** Eight ground control points have been established within Cayton Bay for the purposes of cliff top monitoring. The separation between any two points is typically around 300m. The cliff top surveys at Cayton Bay are undertaken bi-annually. Appendix C provides results from the March 2014 survey showing the distance from the ground control point to the edge of the cliff top along the defined bearing and changes in position since the November 2008 baseline survey and the previous September 2013 survey. The accuracy of the technique means results of less than 0.1m are not reliable. Furthermore, indications of an advancing cliff are error related to problems in precise identification of the cliff edge, particularly where vegetation is present. None of the points show cliff recession since September 2013 greater than the 0.1m margin of error.	No detectable erosion of the cliff top has taken place since the last survey in September 2013. However, the erosion of the cliff toe and the instability noted by surveyors and visible in the survey photographs is likely to eventually result in cliff top erosion in coming surveys. **Longer term trends:** The long-term average recession rates show that the cliff top has changed very little since 2008, except at monitoring points 2 and 4 which show cliff top recession rates of 0.9/yr and 0.6m/yr respectively.

2.8 Filey Bay

Survey Date	Description of Changes Since Last Survey	Interpretation
19h March 2014	**Beach Profiles:** Filey Bay is covered by five beach profile lines for the Partial Measures survey (Appendix A). The previous programmed survey (Full Measures 2013) was undertaken on 4 September 2013 and an additional survey was undertaken on 17 December 2013 to record the impacts of the storm surge earlier that month. **Profile 1dFB1** is located in front of Filey town in the north of the bay. Overall the beach profile has straightened to achieve a more constant gradient. The beach profile at the toe of the seawall to 30m chainage is very similar to the September 2013 survey. Between 30m and 55m chainage a berm in the upper beach has been eroded by 0.3m. The beach has accreted by up to 0.4m between 60m and 180m chainage. Between 180m chainage and the end of the survey at 240m chainage, a bar in the lower foreshore has eroded by 0.3m. The beach is reasonably high compared to earlier surveys. **Profile 1dFB2** is located north of Primrose Valley Holiday Village. The surveyor noted 'that the cliff face was 'becoming very difficult to measure due to deep fissures in soil/mud'. Immediately above HAT the cliff toe has retreated by 2m. From HAT at 66m chainage to 84m chainage, the upper beach has been eroded by 0.3m. Between 84m and 103m a trough present in the September 2013 survey has infilled through accretion of 0.6m of gravel and sand. Limited erosion has occurred of a berm crest between 100m and 120m chainage and the beach has accreted between 125m and 215m chainage by 0.8m. Between 215m and the end of the survey, at c300m chainage, the profile is very similar although there are signs of berm beginning to accrete in this zone. The majority of these changes appear to have occurred by the December 2013 survey, although the middle beach appears to have accreted further since December. **Profile 1dFB3** is located in front of Flat Cliffs hamlet. The cliff toe has receded by 2m since September 2013 at around 30m chainage and a gravel and cobble deposit has accumulated against the cliff toe. The remainder of the profile is characterised by two berms between 60m and 120m chainage and 170m and 290m chainage. These berms were both present in the September 2013 survey, but have both accreted by up to 0.7m despite the December 2013 survey showing them having been eroded by the storm surge event.	All the profiles in Filey Bay, with the exception of the most southerly, are relatively high with well developed berms. This is unusual for the region, with most beaches still showing low and smooth profiles following the surge. All the profiles showed smoothing of the profiles following the December 2013 storm surge. The more rapid recovery here could reflect inputs of sediment from cliff recession during the December 2013 storm surge.. **Longer term trends:** Beach levels are comparatively high and may reflect renewed inputs of sediment from cliff erosion during the storm surge event in December 2013. There is evidence of cliff toe recession which may lead to further activity on the cliff and consequently further sediment inputs to the littoral system.

Survey Date	Description of Changes Since Last Survey	Interpretation
	Profile 1dFB4 is located near Humanby Gap. The profile shows that the cliff toe has receded by 3m above the HAT mark. Between HAT and 60m chainage the profile is very similar in March 2013 to September 2013. Between 60m and 130m chainage a trough has infilled through the accretion of 1m of gravel resulting in the seaward movement of the crest of a berm in the upper beach. Little change has occurred between 130m and 160m chainage. Between 160m chainage and the end of the survey at c.240m chainage, the foreshore has eroded by 0.6m, steepening the seaward face of the berm in the lower foreshore. The beach is relatively high except in the lower foreshore in comparison to earlier surveys. The data suggests that changes to the beach profile caused by the surge have now largely been reversed. **Profile 1dFB5** is located close to Reighton Gap. The surveyor noted that the middle of profile 1dFB5 was unable to be measured from 65m to approx 200m chainage, due to vegetation. Little change has occurred at the cliff toe, which has only receded c.1m since September 2013. The upper beach between 222m chainage and 285m chainage has eroded by 0.3m., but recovered since the December 2013 survey following the storm surge. A berm in the middle beach appears to have migrated landward, infilling a trough present in the September 2013 survey and 340m. Between 340m and 420m, erosion of the seaward face of the berm by 0.6m has occurred. The profile now extends to 460m chainage whereas in September 2013 it only extended as far as 420m indicating deposition in the lower foreshore. Little has changed since the December 2013 survey in the lower foreshore, but changes to the upper beach visible in the December 2013 survey, have been reversed with the profile reverting back to one more similar to that seen in September 2013.	
April 2013	**Topographic Survey:** Data from the most recent topographic survey (Partial Measures, spring 2013) have been used to create a digital ground model (DGM) (Appendix B – Map 5a) using a Geographical Information System (GIS). The topographic plot shows the shore parallel bathymetry in front of Filey town. A difference plot has also been produced using the DGM (Appendix B – Map 5b) comparing the last topographic survey (Full Measures, Autumn 2013) to the present survey. The difference plot shows three principal bands of change running parallel to the shore. In front of the sea wall there is a band of erosion which is most severe (>1m lowering) just to the north and south of the paddling pool. In the middle beach there is a wide band of <1m of accretion indicating that the sediment removed from the back of the beach has been redistributed over a wider area than from which	The pattern is a reversal of that seen in the last full measures report, indicating a seasonal change in beach form. The more severe erosion adjacent to the paddling pool is not a concern at the moment, because these were areas that were shown to have experienced significant accretion in previous (Full Measures 2013) survey. **Longer term trends:** The erosion of the upper beach is less noteworthy than the previous winter, despite the December 2013

Survey Date	Description of Changes Since Last Survey	Interpretation
	it has been removed. The final band is one of erosion on the lower foreshore with maximum lowering of 0.5m. This pattern is consistent with that seen in Profile 1cFB1. The only exception to this description is a large, elongate area of limited erosion (≤0.25m elevation change) within the band of accretion in the middle beach at the southern end of the survey area.	storm surge.
April 2013	**Cliff-top Survey:** 23 ground control points were established within Filey Bay for the purposes of cliff top monitoring in November 2008. Additional points were added in September 2010 and March 2011 (as shown in Appendix C – Maps 5 and 6) taking the total number of ground control points within Filey Bay to 28. The maximum separation between any two points is nominally 300m. The cliff top surveys at Filey Bay are undertaken bi-annually. Appendix C provides results from the March 2014 survey showing the distance from the ground control point to the edge of the cliff top along the defined bearing and changes in position since the November 2008 baseline survey and the previous September 2010 survey. The accuracy of the technique means results of less than 0.1m are not reliable. Furthermore, indications of an advancing cliff are erroneous and related to problems in precise identification of the cliff edge, particularly where vegetation is present. Between the September 2013 and the current survey only marker 16 showed recession greater than the margin of error, recording recession of 0.4m.	Over the winter of 2013/14 the marker points show stability overall. The evidence for cliff toe erosion during the surge suggests that cliff headscarp recession may be triggered in the future. **Longer term trends:** The majority of the bay has recession rates of less than 0.1m/yr. Significant recession rates are seen at Point 5, immediately south of the Filey town defences, where 1.2m/yr is recorded; point 7 at Muston Sands shows recession of 0.4m/yr and point 14 between Butcher Haven and Hummanby gap shows recession of 0.2m/yr.

3. Problems Encountered and Uncertainty in Analysis

Individual Profiles

At Upgang Beach, the cliff top and seaward face of the cliff at profile 1dWB2 were not measured due the presence of thick vegetation on the landward side preventing access to the cliff top and deep fissures and soft ground on the active cliff face.

At Filey Bay the cliff section of 1dFB2 was described in the surveyor's report as 'becoming very difficult to measure due to deep fissures in soil/mud' and the middle of profile 1dFB5 was not measured from 65m to approx. 200m chainage due to undergrowth and bushes. The surveyors report also states that the 'top face on section 3 has been destroyed'.

Cliff Top Surveys

At Robin Hoods Bay, the dumping of waste vegetation at monitoring point 5 is a potential source of error.

The aim of cliff monitoring data is to gain a reliable record of the frequency and magnitude of cliff top failures. Data are collected every six months, but previous surveys have had a low accuracy, meaning that survey error is typically greater than any measured short term change. This effect is reducing over time and longer term cliff top erosion patterns are becoming clearer.

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

No changes are recommended at the present time.

5. Conclusions and Areas of Concern

- At Staithes, the records from cliff top monitoring show no recent erosion. Work by Durham University at Cowbar Nab indicates a successive pattern of smaller failures of the cliff that tend to progressively move up the cliff face. No recession of the cliff top has occurred, which is consistent with observations from the cliff top monitoring.
- Runswick Bay does not show typical pattern of winter drawdown, with accumulation occurring at the back of the beach, which may provide some protection against further cliff recession in the short term. Beach sediment also appears to have been driven northwards towards the village.
- At Sandsend, Upgang and Whitby, beach profiles indicate continued recovery since the December 2013 storm surge after initial lowering of the beach, particularly immediately in front of the defences and at the cliff toe. Foreshore lowering in the south of the bay has created steeper profiles.
- At Robin Hoods bay, accumulation on the shore platform against the cliff toe in the north of the bay indicates cliff falls of limited extent over the winter. The cliff tops show no further recession since the last monitoring period. There has been some lowering of the foreshore in front of the sea wall and this should be monitored in future surveys to confirm this is just a seasonal phenomenon rather than a longer term trend. Other beach and foreshore changes are within the expected pattern of seasonal variation.
- At Scarborough North Bay, the beach shows a pattern of recovery since the December 2013 storm surge, particularly in the upper beach. However, the central bay has steepened more than the distal ends and compared to the longer term record of surveys the beach appears to be quite steep as a whole. The survey report indicates that the lower part of the new concrete defence near 1dSBN3 (Scarborough North Bay) was starting to break up. Scour holes appear to be becoming persistent at the base of the sea defences in the south of the bay.
- The trend at Scarborough South Bay is that undulations in the beach profile have been straightened out and that there is a typical winter drawdown pattern where sediment has

been eroded from the upper beach. The more southerly part of the survey area is experiencing much lower beach levels than the north, although the sediment recycling which took place in May 2014 has modified the inequity in beach levels. No change is evident since the last survey of the cliff top monitoring points.

- Beach profiles in Cayton Bay remain relatively low, but not abnormally so given the range of beach profiles from previous surveys, and there are signs of erosion of the cliff toe in the southern part of the bay but this is has not been detected as having impact the cliff top.
- Beach profiles in Filey Bay are generally high and the impacts of the December 2013 storm surge event have been reversed. The changes shown between the last Full Measures survey and the current survey are therefore akin to the normal seasonal variation that might be expected. High beach levels may reflect inputs of sediment from erosion of the toe of the cliff throughout the bay. The same toe erosion has yet to have an impact on the cliff top, but is likely to as oversteepened cliff angles relax through slope failure.

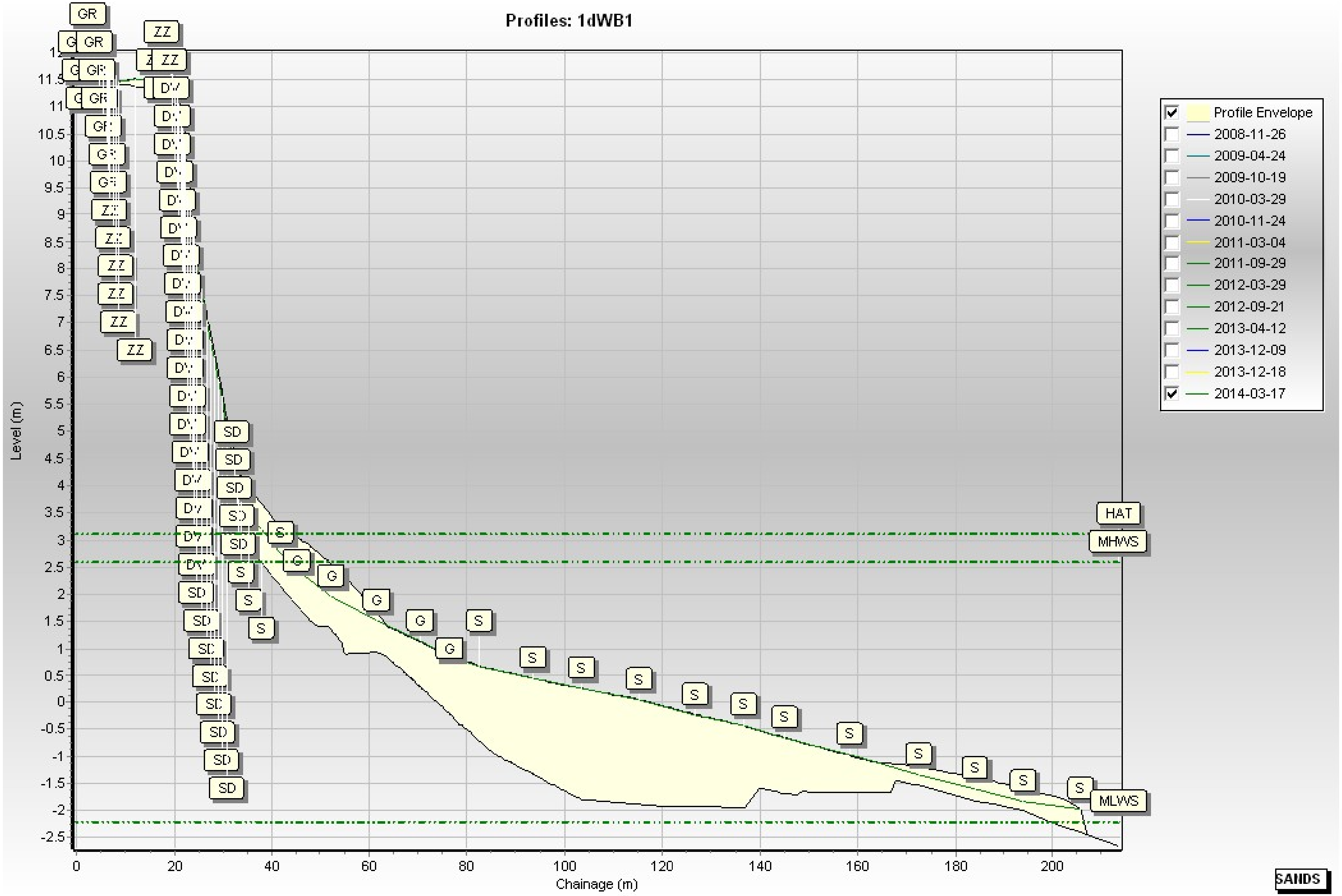
Appendices

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


Profiles: 1dWB1
Level (m)
Chainage (m)
Profile Envelope
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2009-04-24
2009-10-19
2010-03-29
2010-11-24
2011-03-04
2011-09-29
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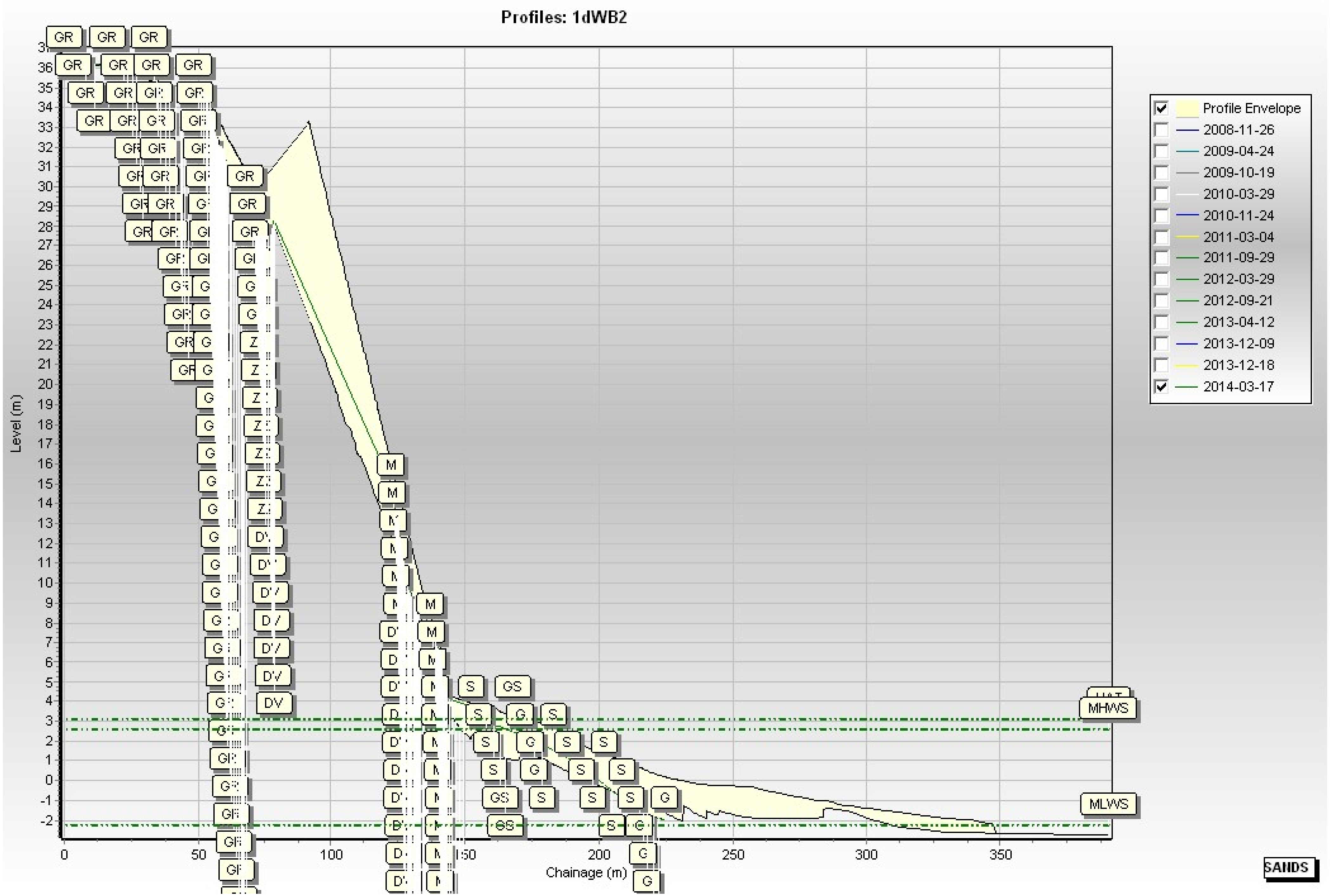
HAT
MHWS
MLWS
SANDS


Profiles: 1dWB2
Level (m)
Chainage (m)
Profile Envelope
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2009-04-24
2009-10-19
2010-03-29
2010-11-24
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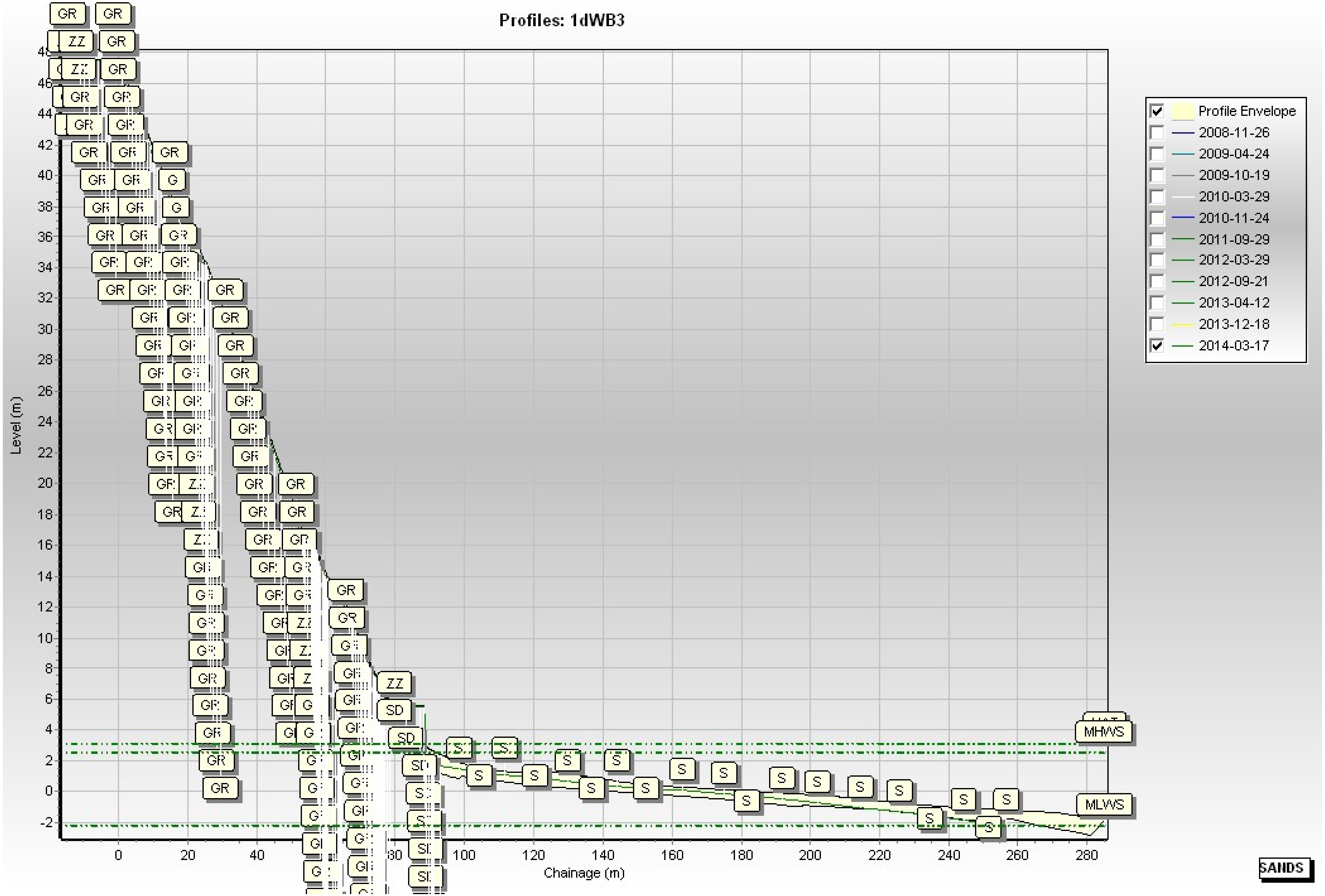
2011-09-29
2012-03-29
2012-09-21
2013-04-12
2013-12-09
2013-12-18
2014-03-17
MHWS
MLWS
SANDS



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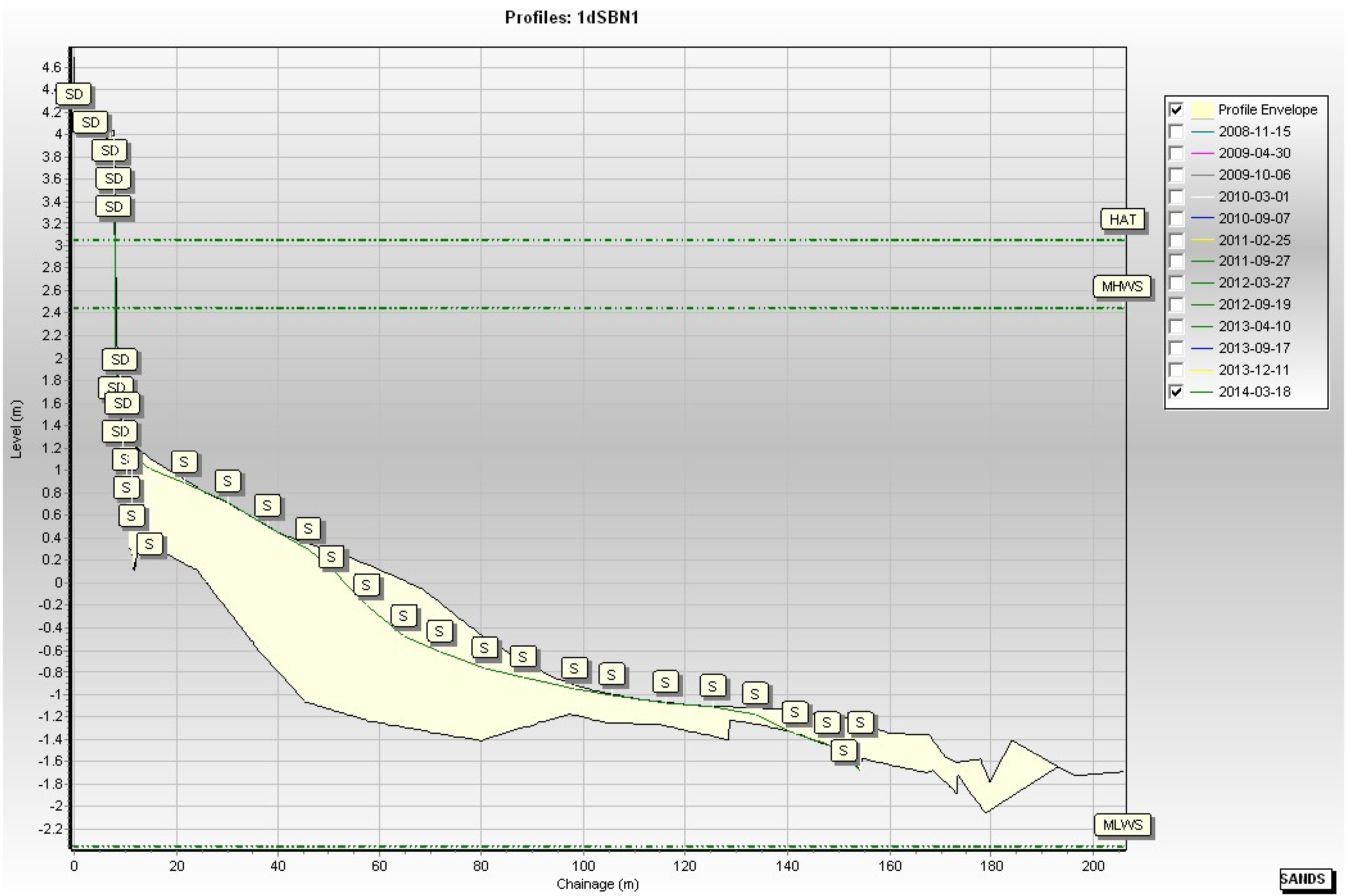
MLWS
SANDS



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2013-09-17
2013-12-11
2014-03-18
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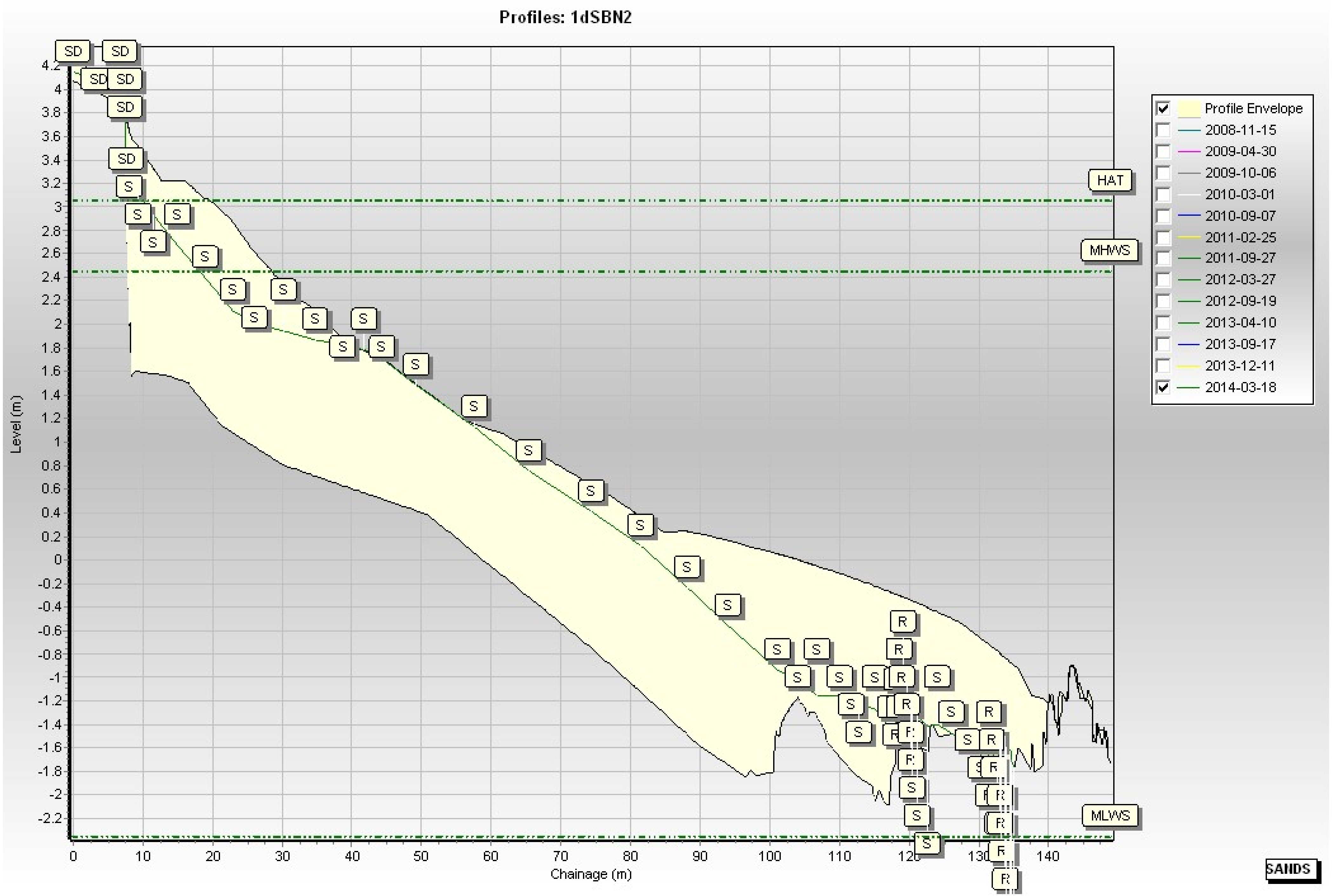
MHWS
MLWS
SANDS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2013-12-11
2014-03-18
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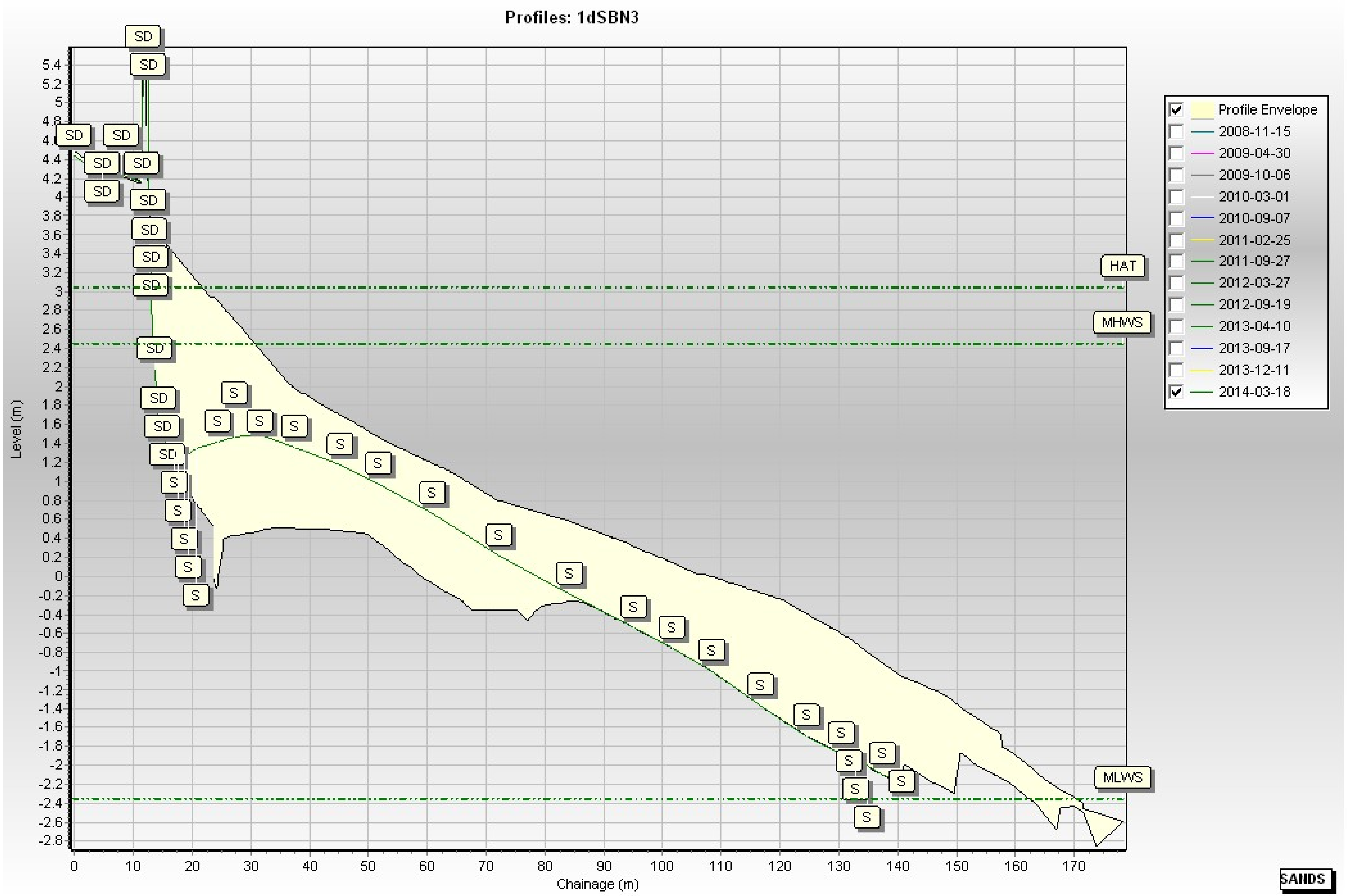
MHWS
MLWS
SANDS



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2013-04-10
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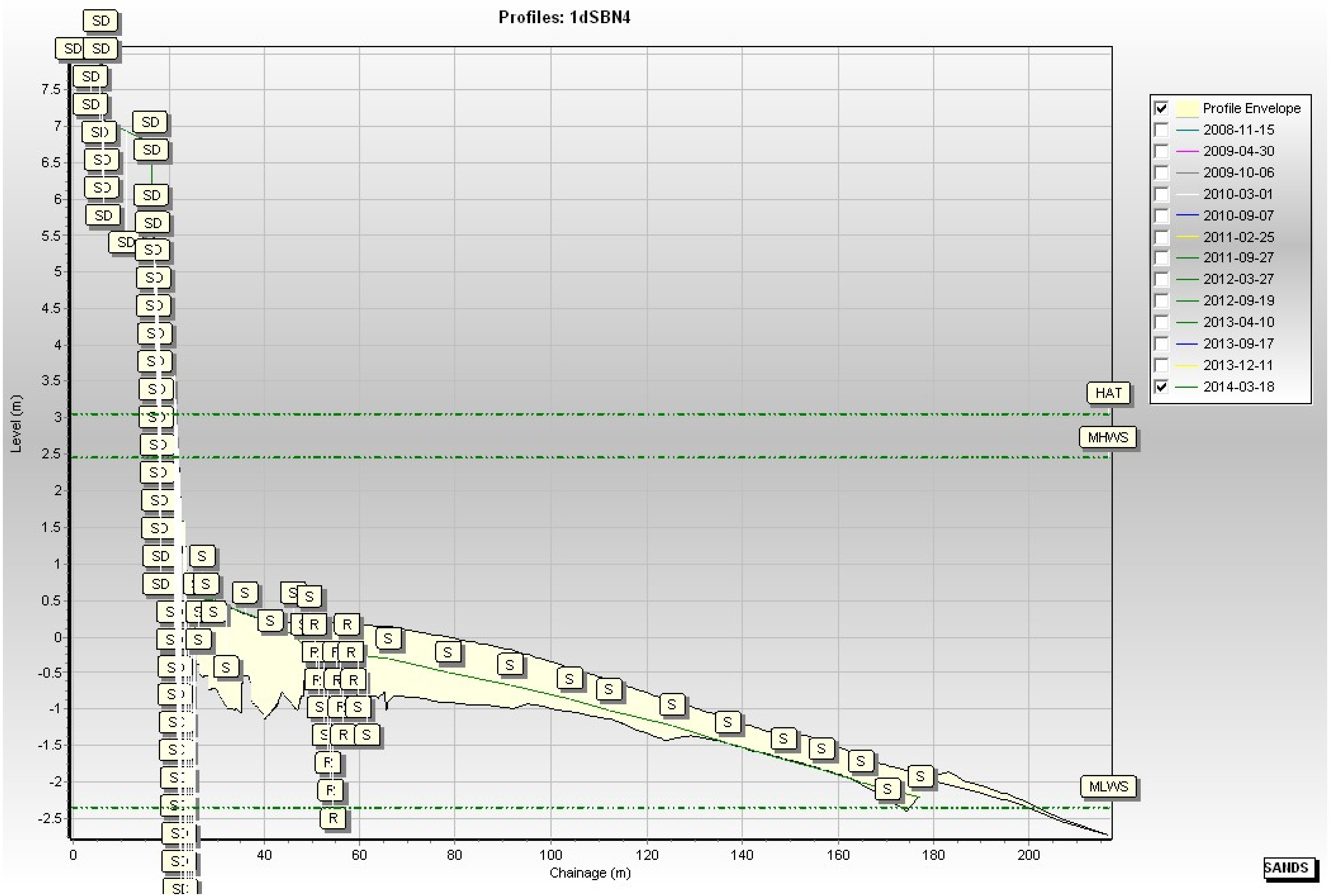
2013-12-11
2014-03-18
HAT
MHWS
MLWS
SANDS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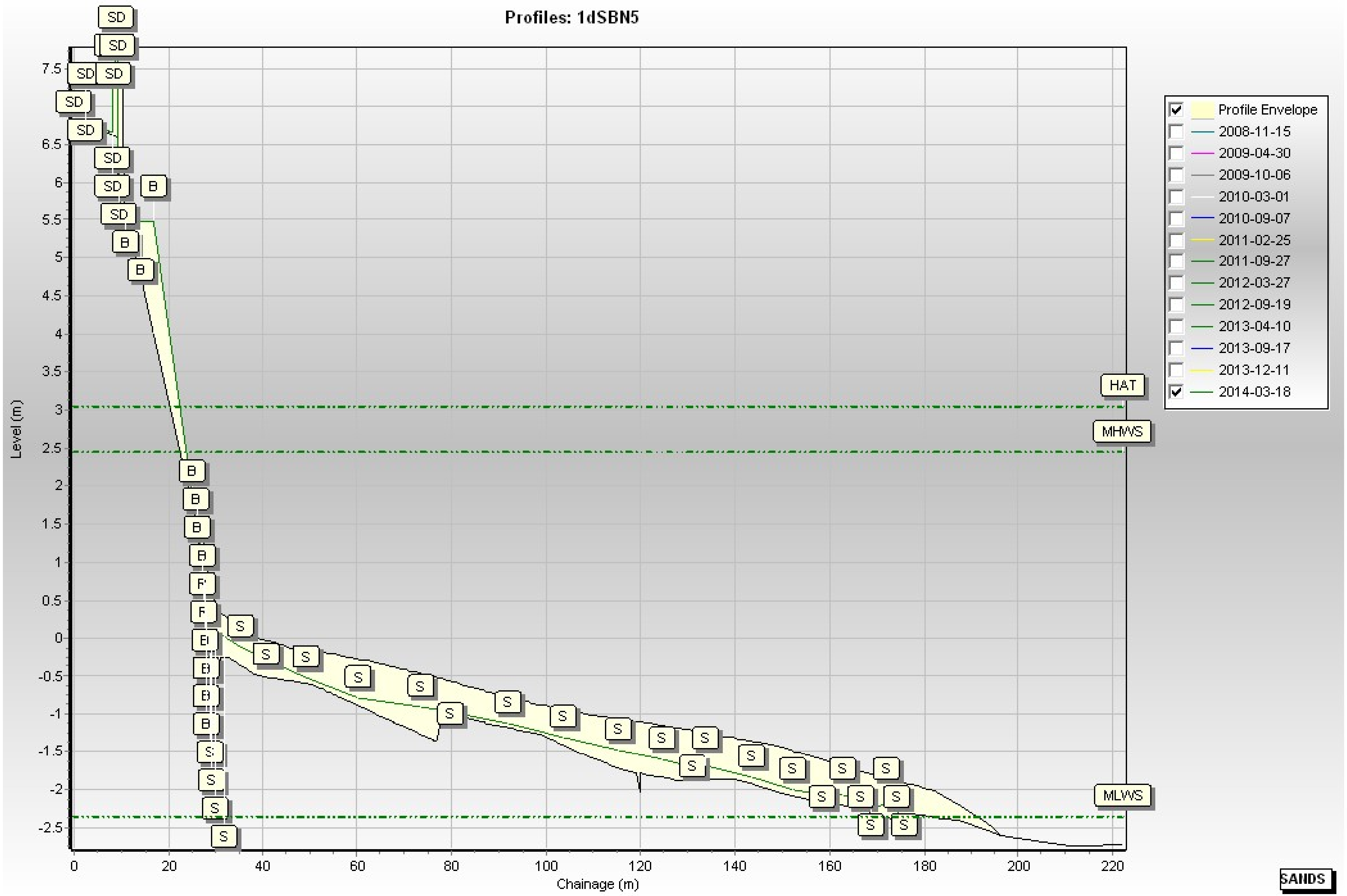
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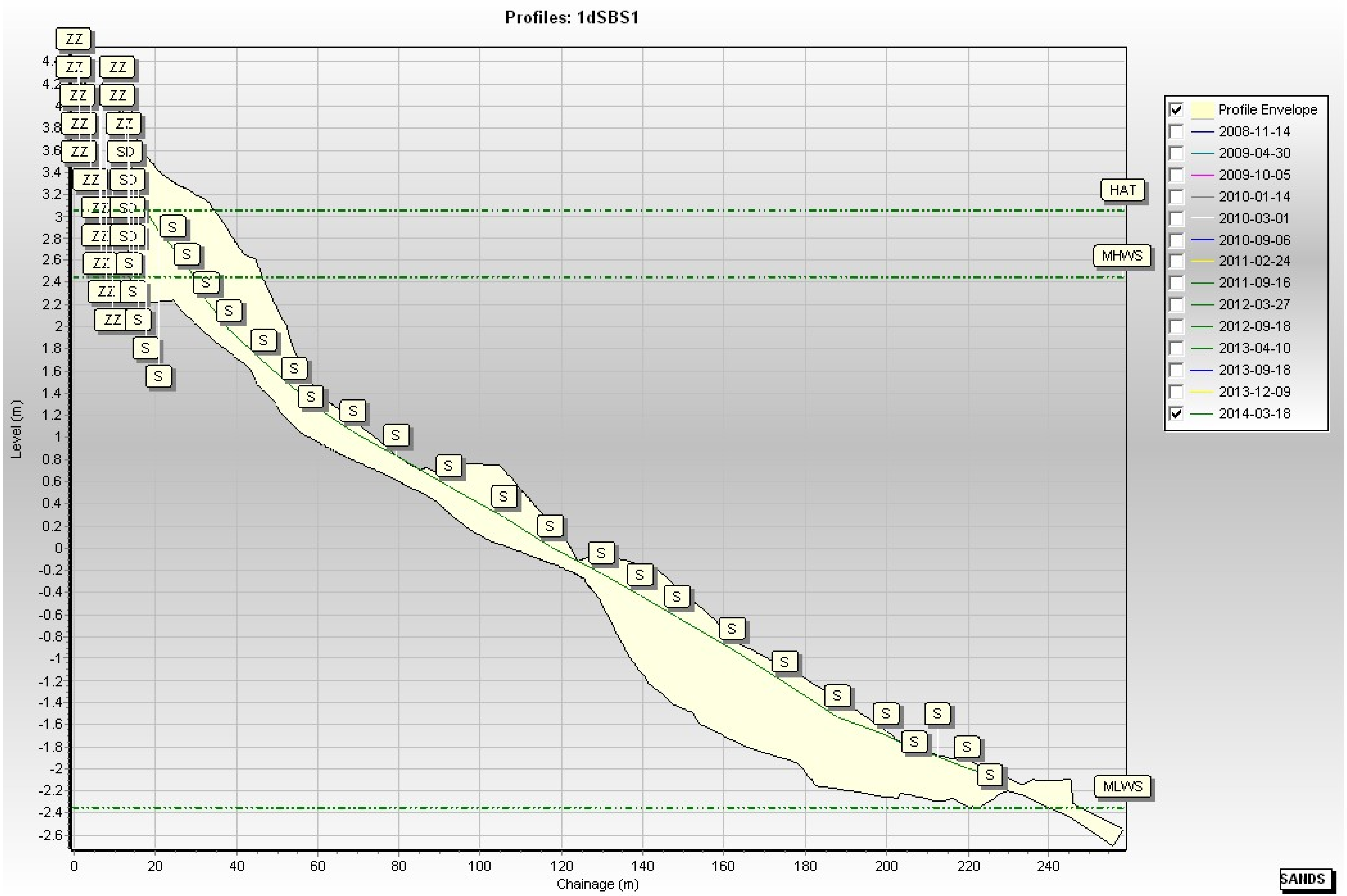
2014-03-18
HAT
MHWS
MLWS
SANDS



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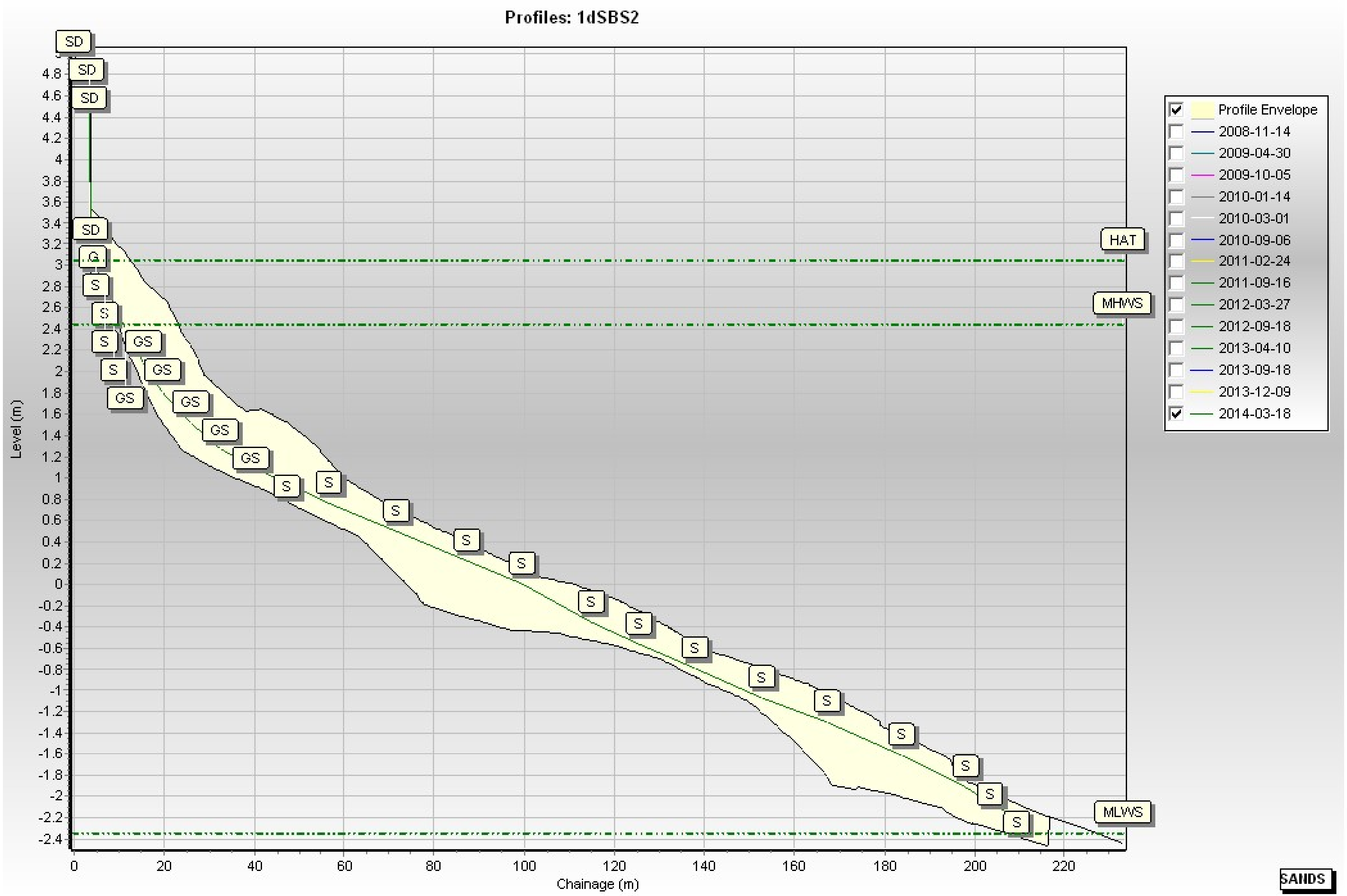

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2013-04-10
2013-09-18
2013-12-09
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HAT
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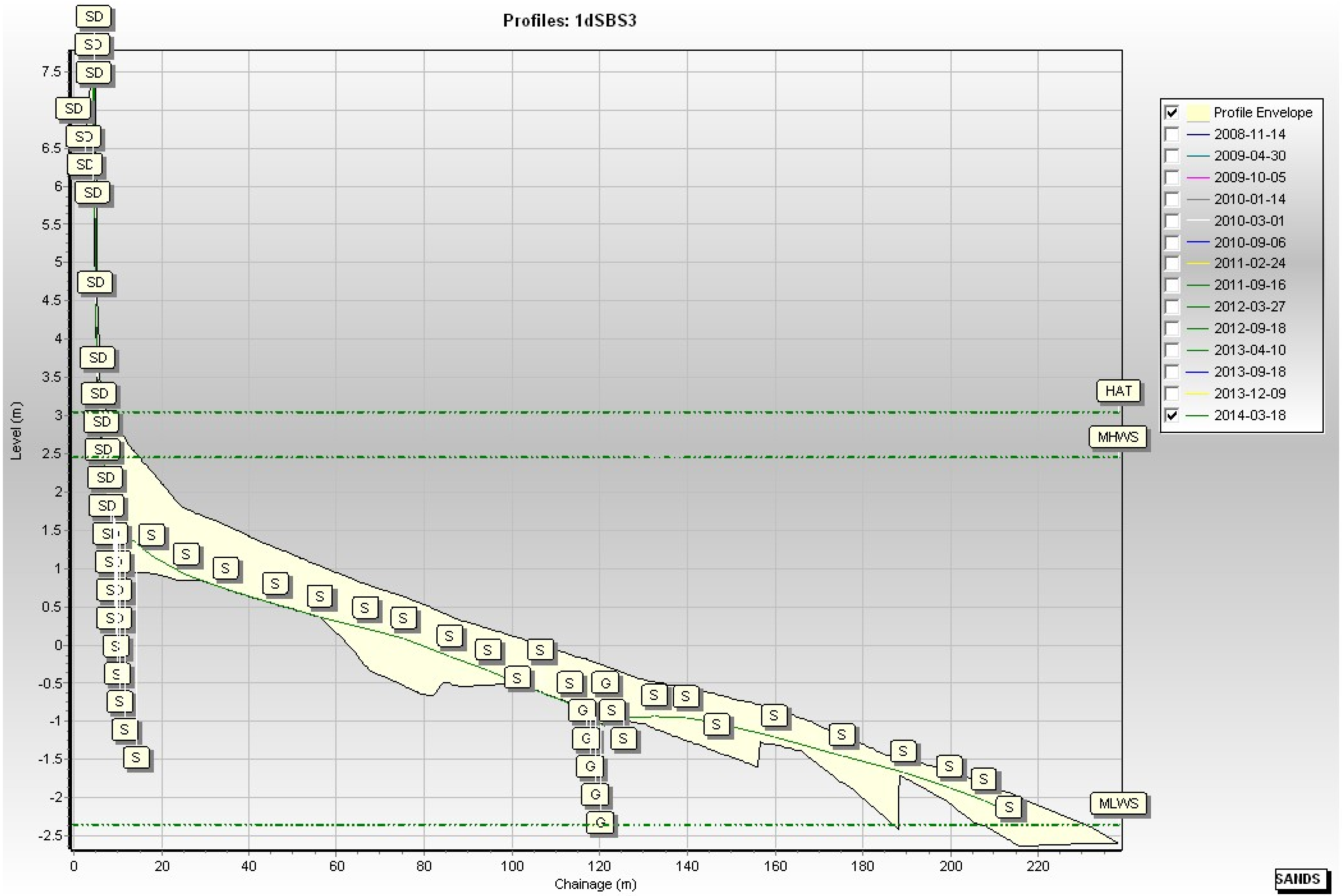
MLWS
SD
G
S
GS
Level (m)
Chainage (m)
SANDS



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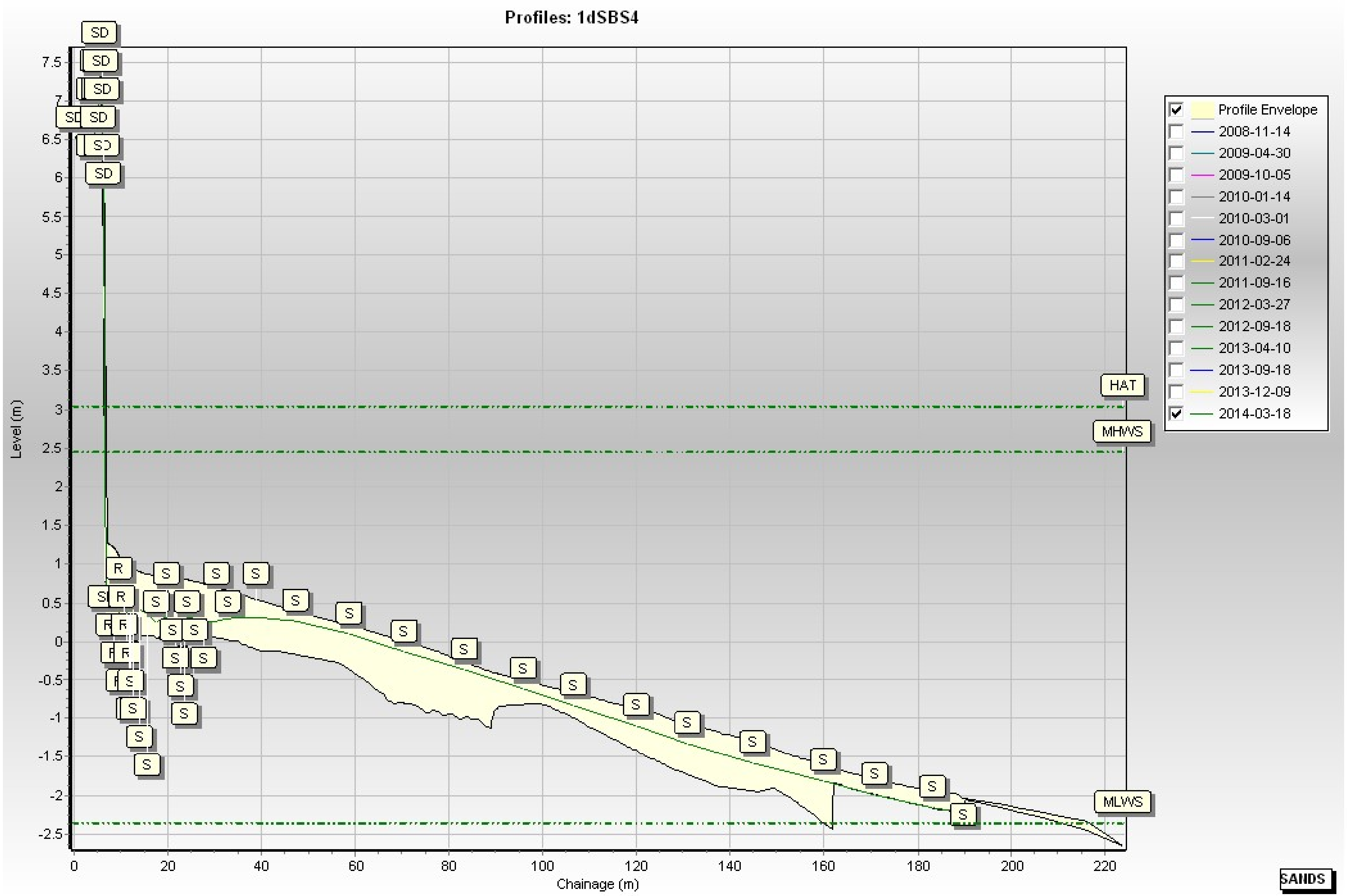
MLWS
SANDS



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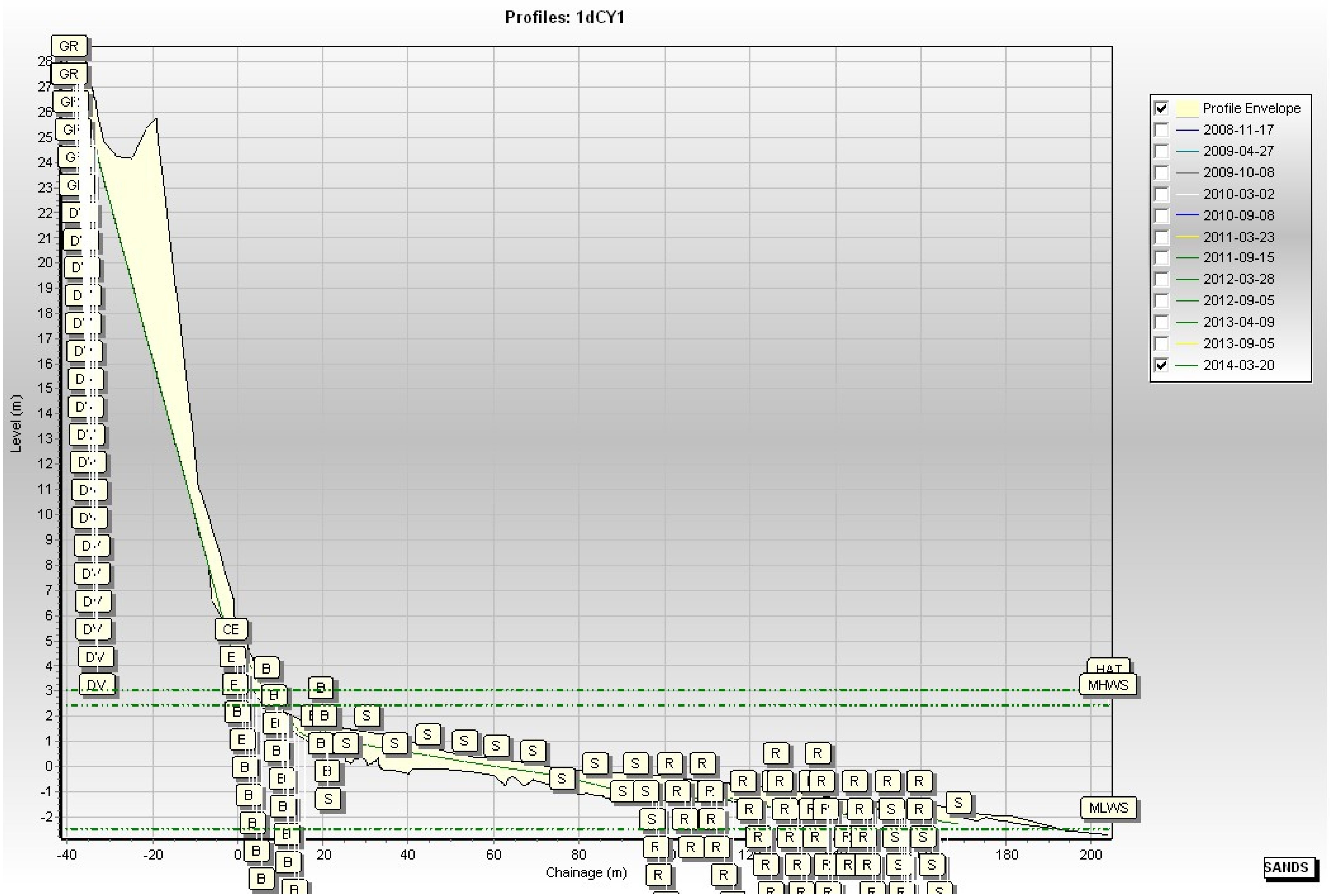
2014-03-18
SANDS



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2014-03-20
HAT
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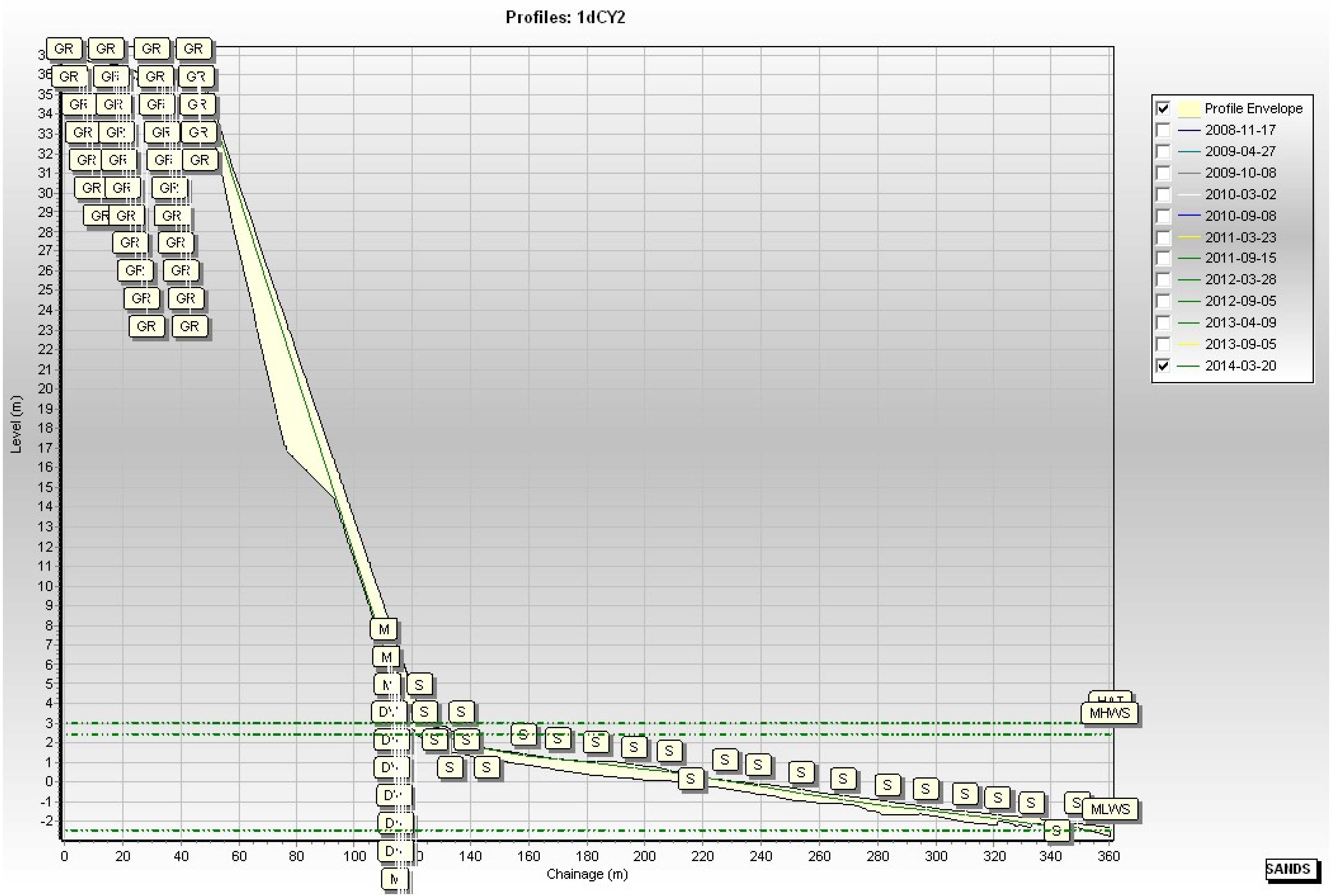
MLWS
SANDS



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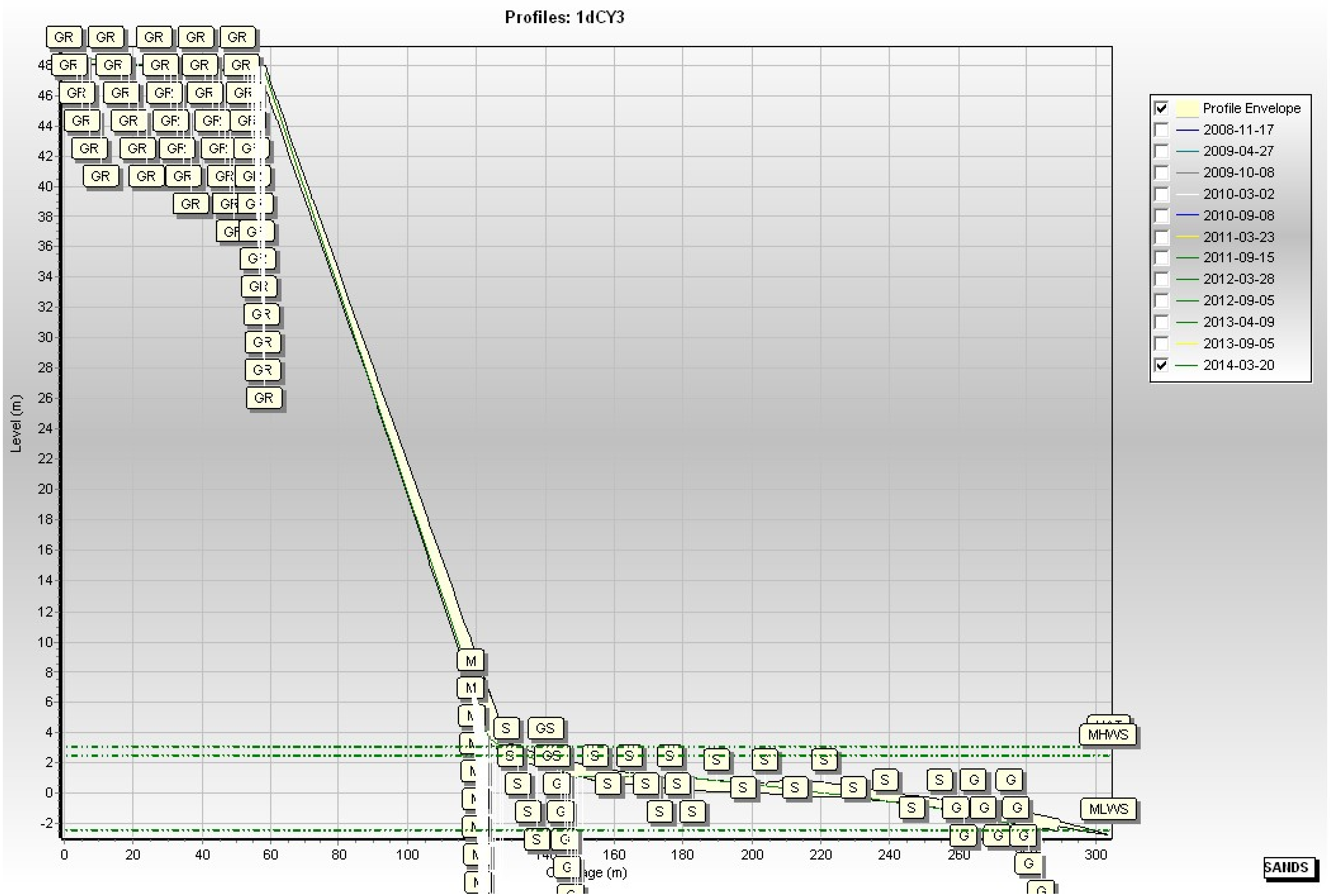

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2014-03-20
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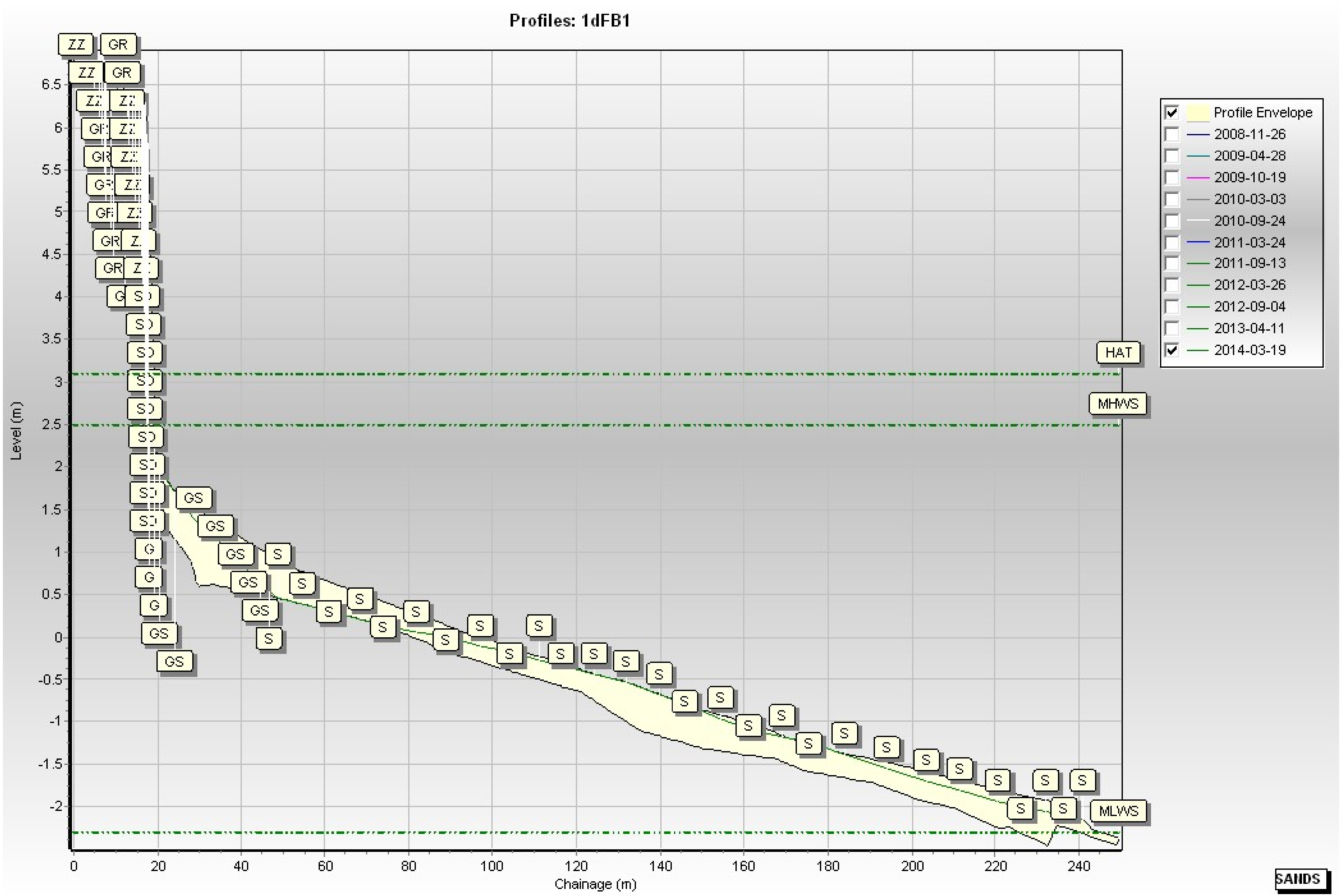
MLWS
SANDS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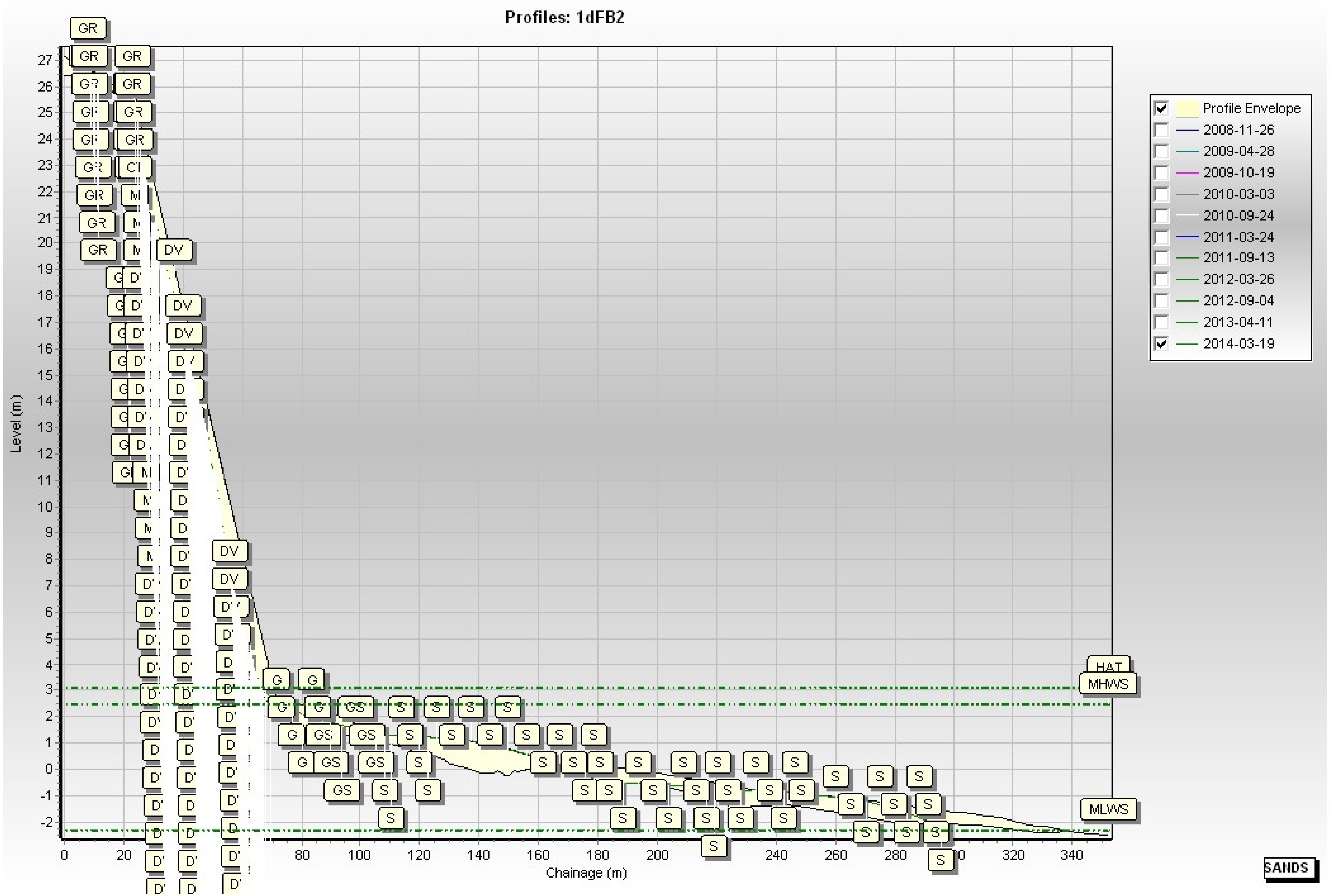
2013-04-11
2014-03-19
HAT
MHWS
MLWS
Level (m)
Chainage (m)
SANDS



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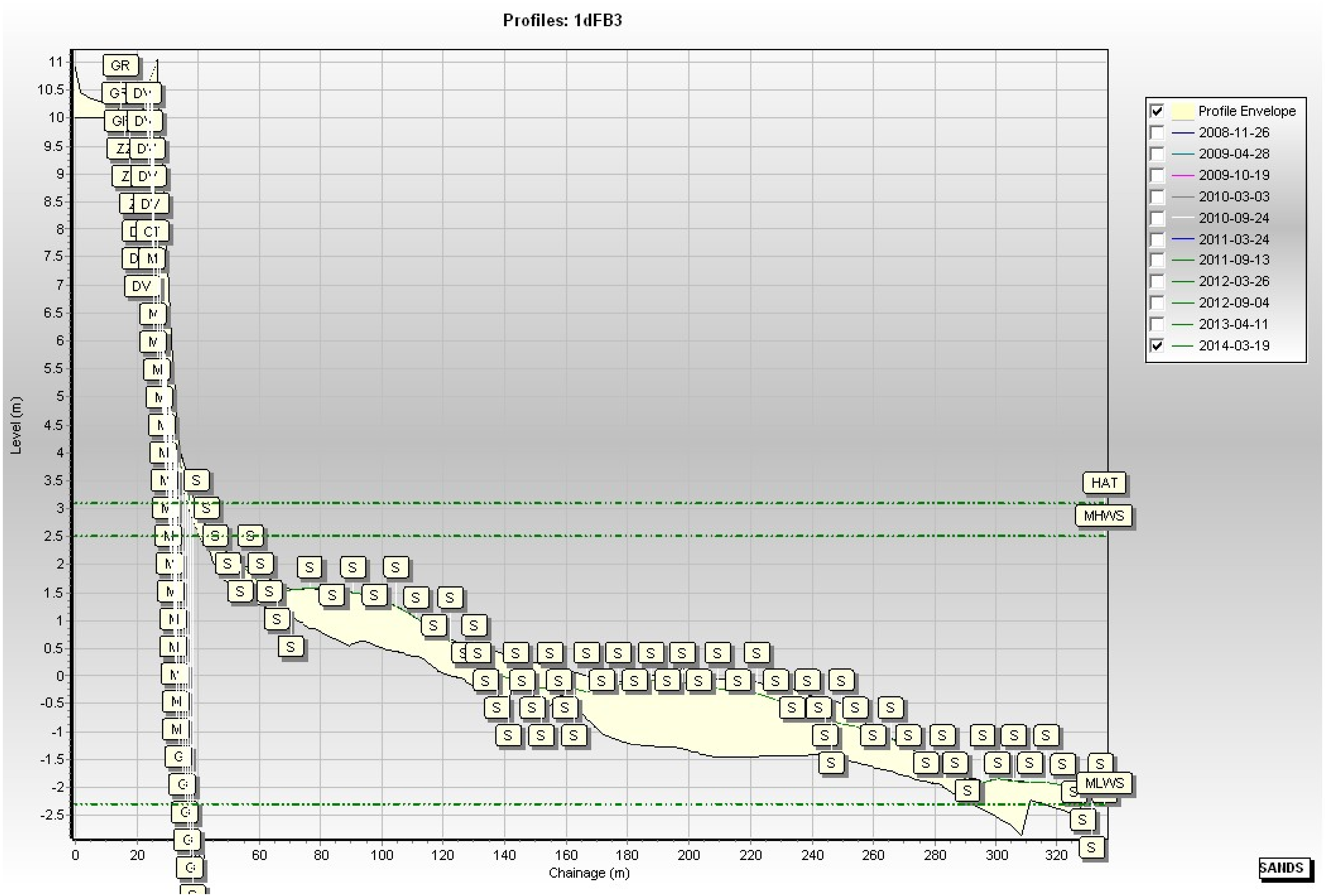
HAT
MHWS
MLWS
SANDS



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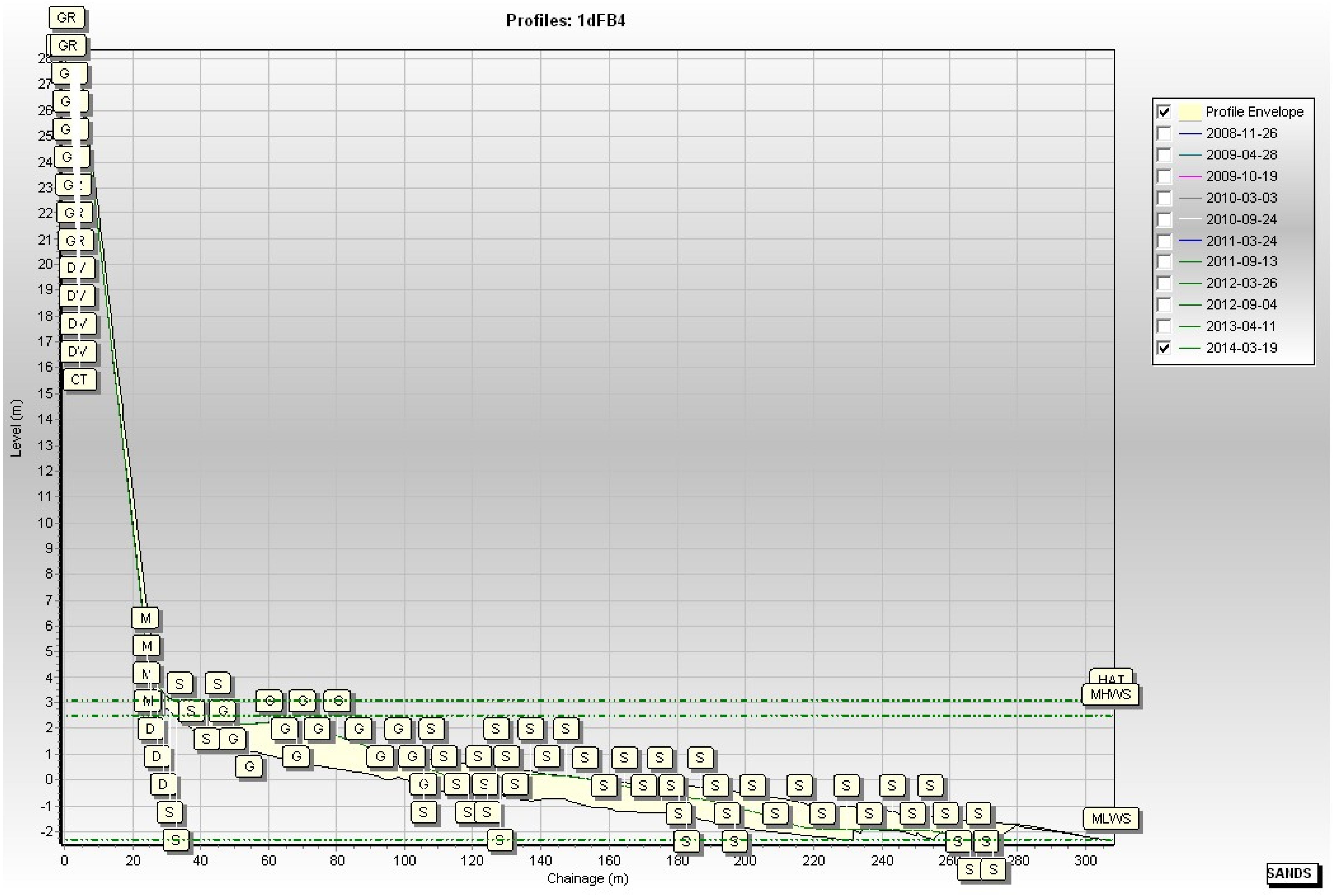
2012-09-04
2013-04-11
2014-03-19
HAT
MHWS
MLWS
SANDS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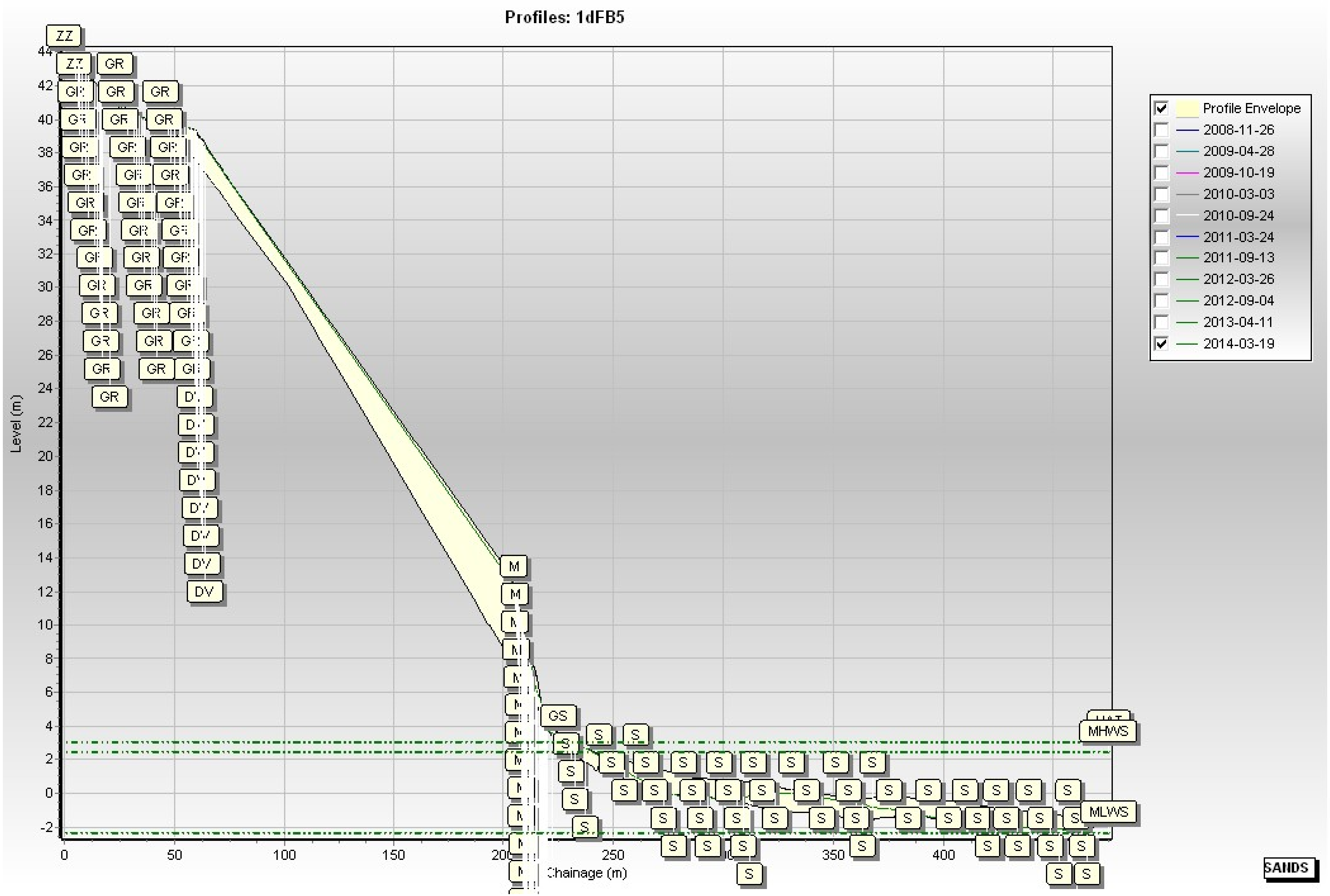
2013-04-11
2014-03-19
HAT
MHWS
MLWS
SANDS



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2010-09-24
2011-03-24
2011-09-13
2012-03-26
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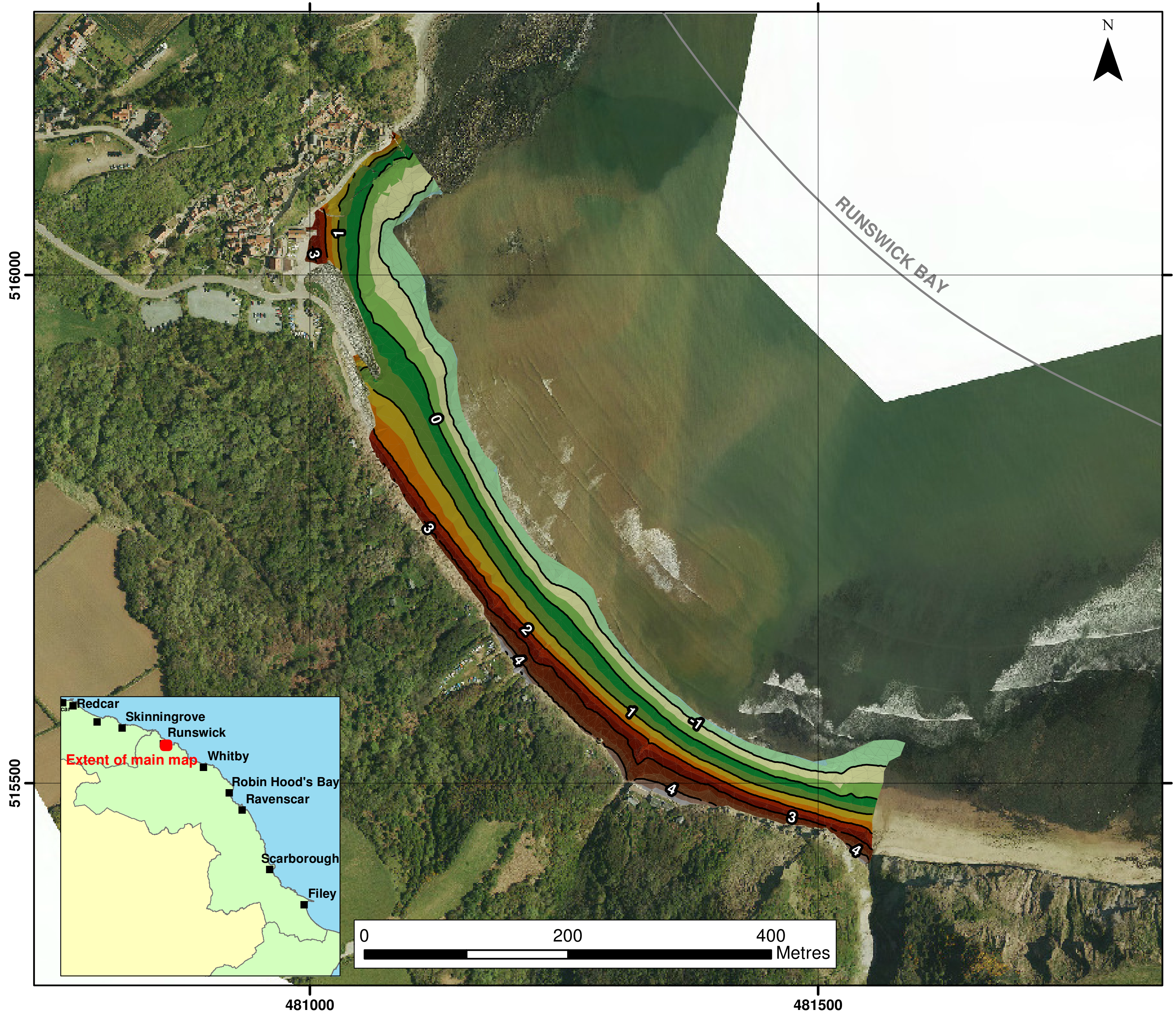
2014-03-19
MHWS
MLWS
SANDS

Appendix B

Topographic Survey



KEY

Elevation (m AOD)

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

Client: North East Coastal Group

Project: Cell 1 Regional Coastal Monitoring Programme 2011 to 2016

Appendix B - Map 1a
Topographic Survey
Runswick
Scarborough
Borough Council

Update Report 6
Partial Measures Survey
Spring 2014

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

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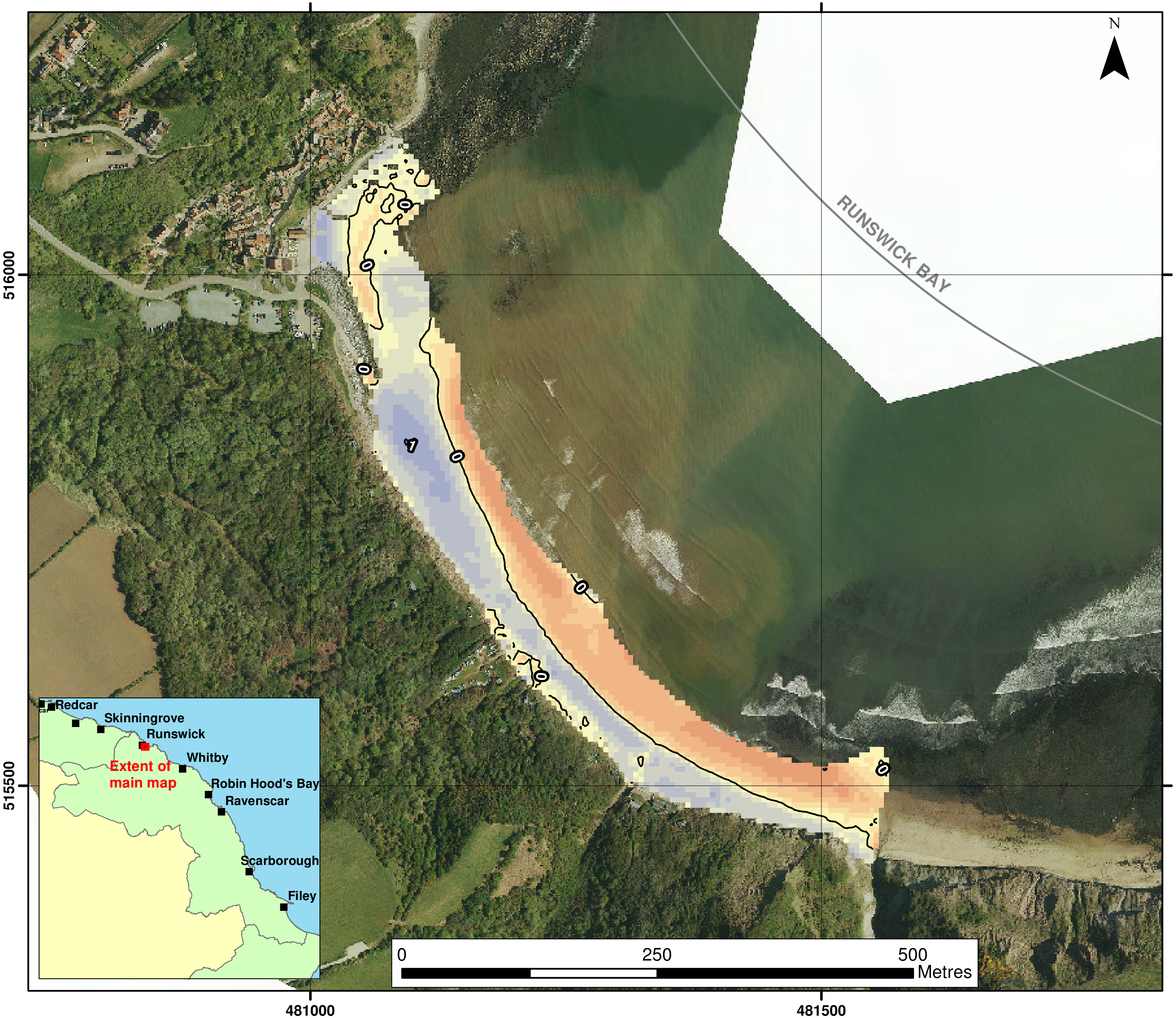

KEY Autumn 2013 and Spring 2014
Change in elevation (m)

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

Loss

Change < 0.1 m

Gain

Contours of change

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

Appendix B - Map 1b
Short-term Elevation Change Runswick
Scarborough Borough Council

Update Report 6
Partial Measures Survey
Spring 2014

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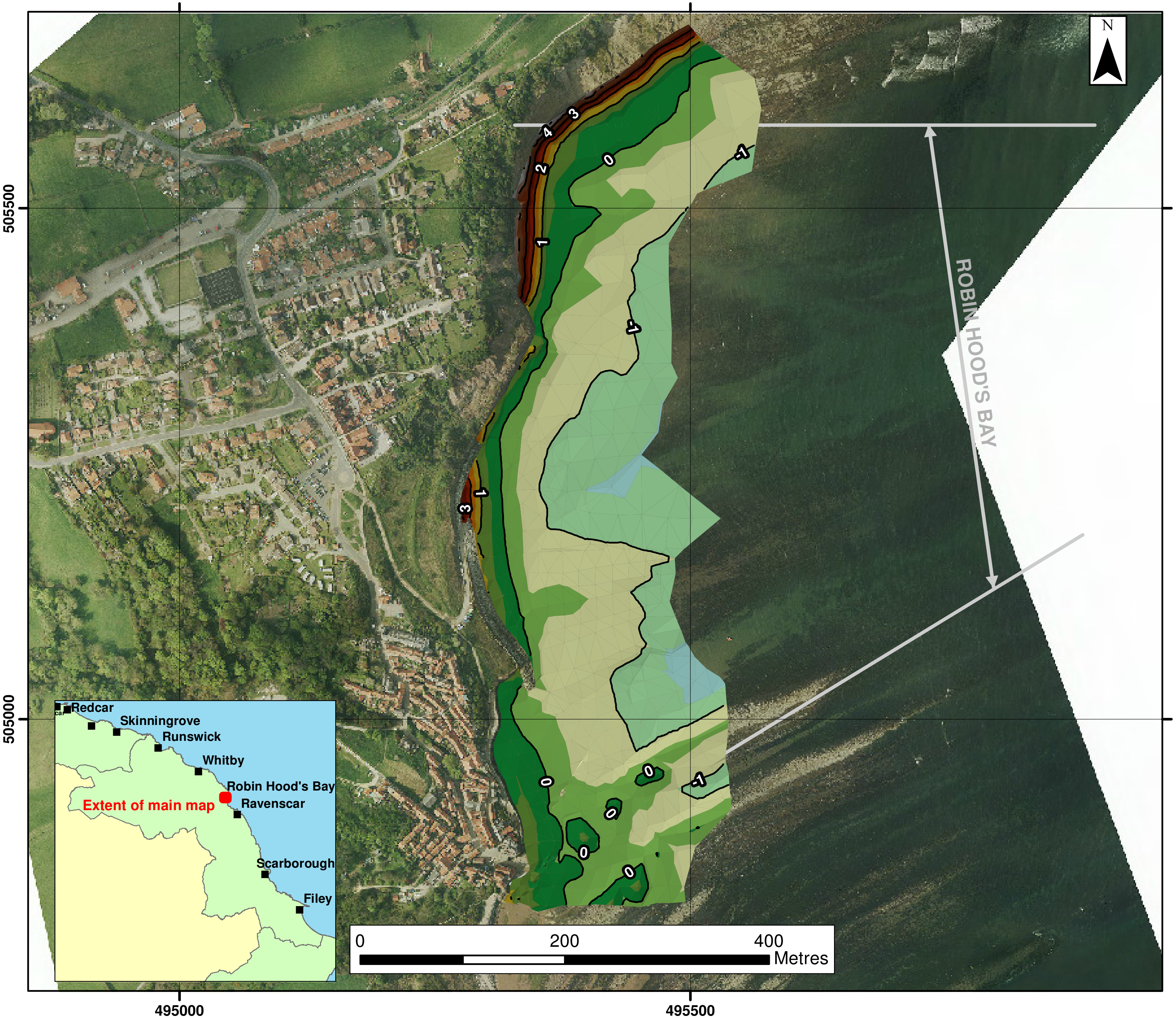

KEY

Elevation (m AOD)

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

Client: North East Coastal Group

Project: Cell 1 Regional Coastal Monitoring Programme 2011 to 2016

Appendix B- Map 2a
Topographic Survey
Robin Hood's Bay
Scarborough Borough Council

Update Report 6
Partial Measures Survey
Spring 2014

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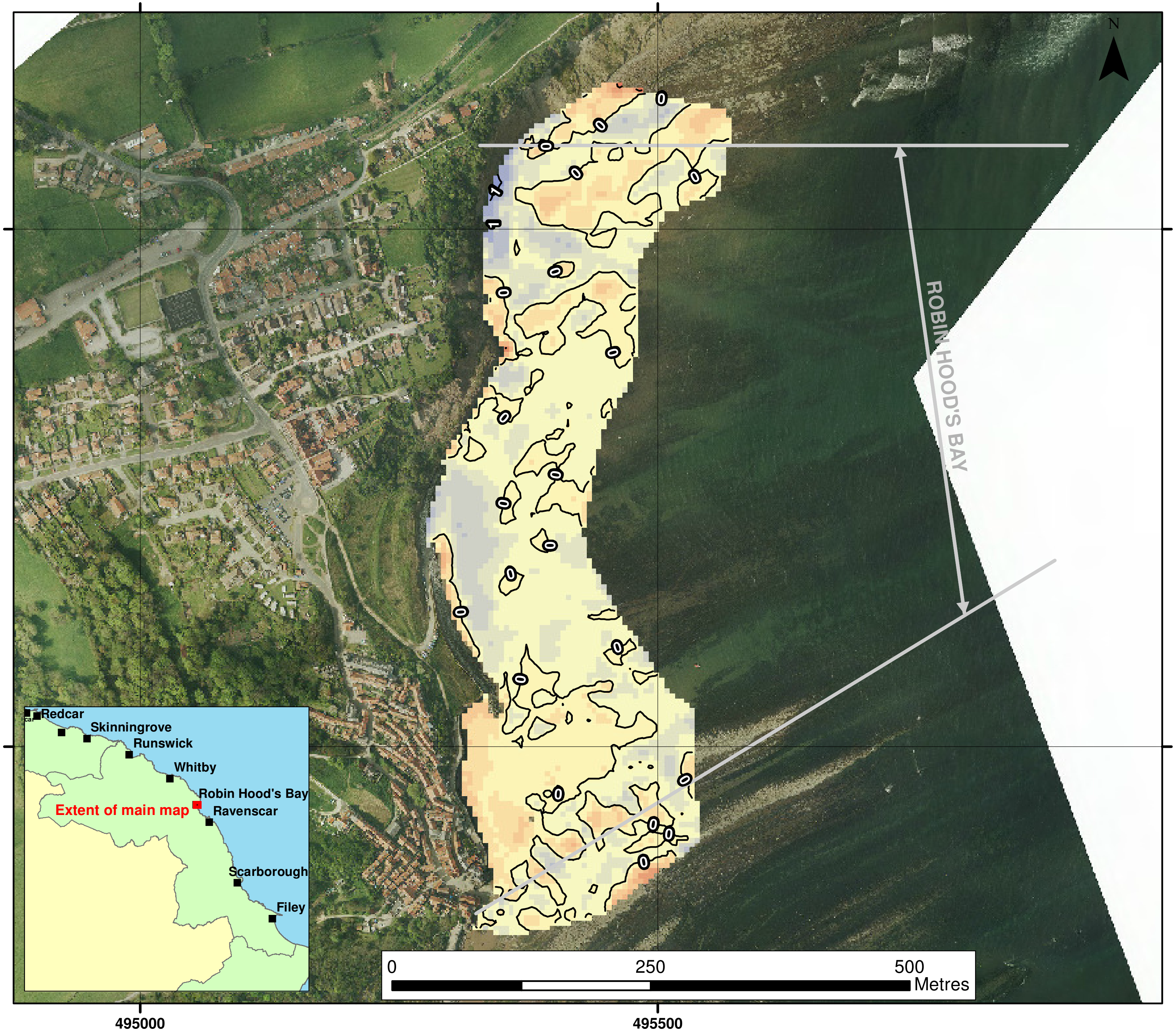

KEY Autumn 2013 and Spring 2014
Change in elevation (m)

<-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
Robin Hood's Bay
Scarborough Borough Council

Update Report 6
Partial Measures Survey
Spring 2014

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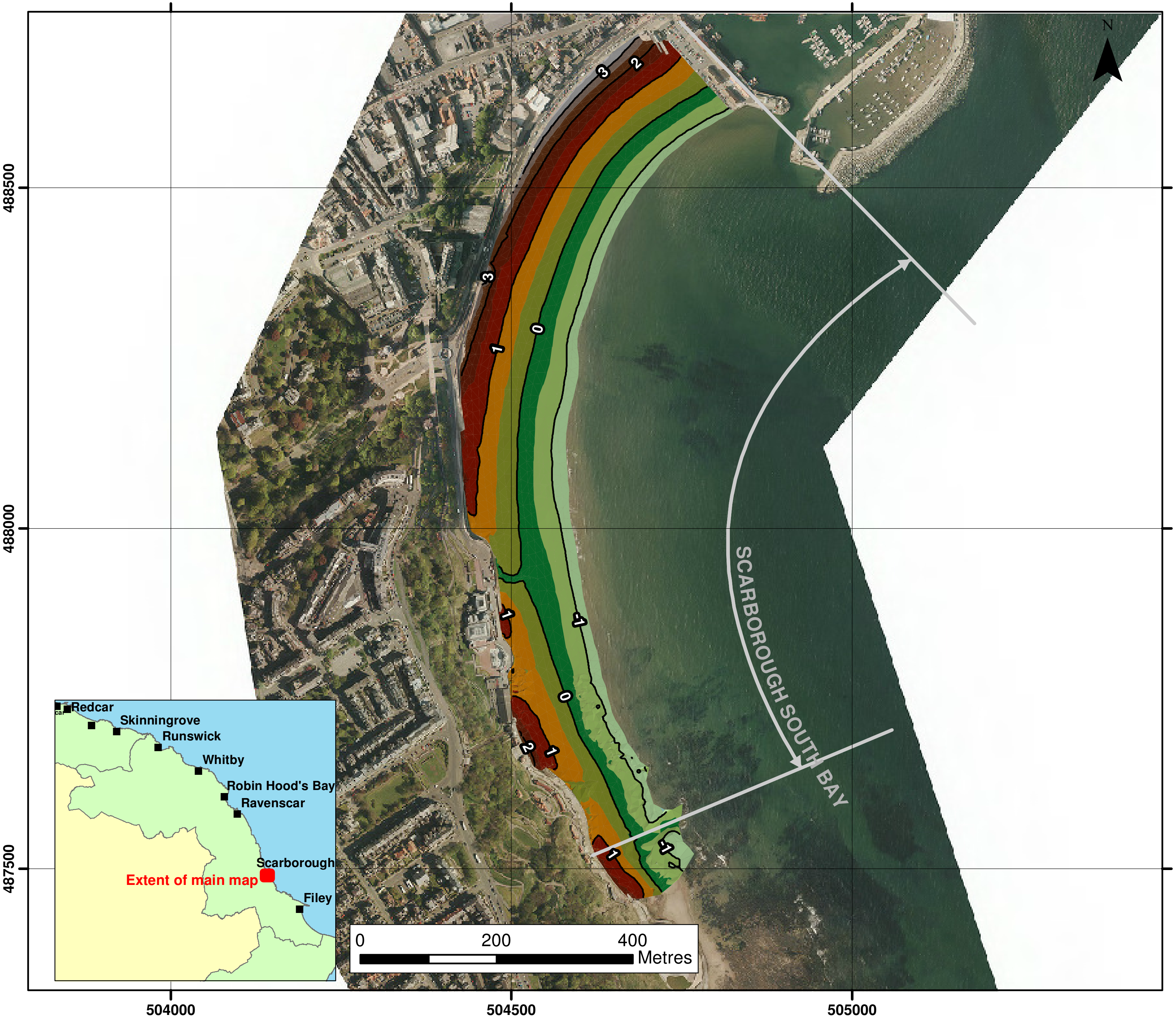

KEY

Elevation (m AOD)

- 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

Elevations are before beach recycling (06/05/2014)

Client: North East Coastal Group

Project: Cell 1 Regional Coastal Monitoring Programme 2011 to 2016

Appendix B- Map 3a
Topographic Survey
Scarborough South
Scarborough Borough Council

Update Report 6
Partial Measures Survey
Spring 2014

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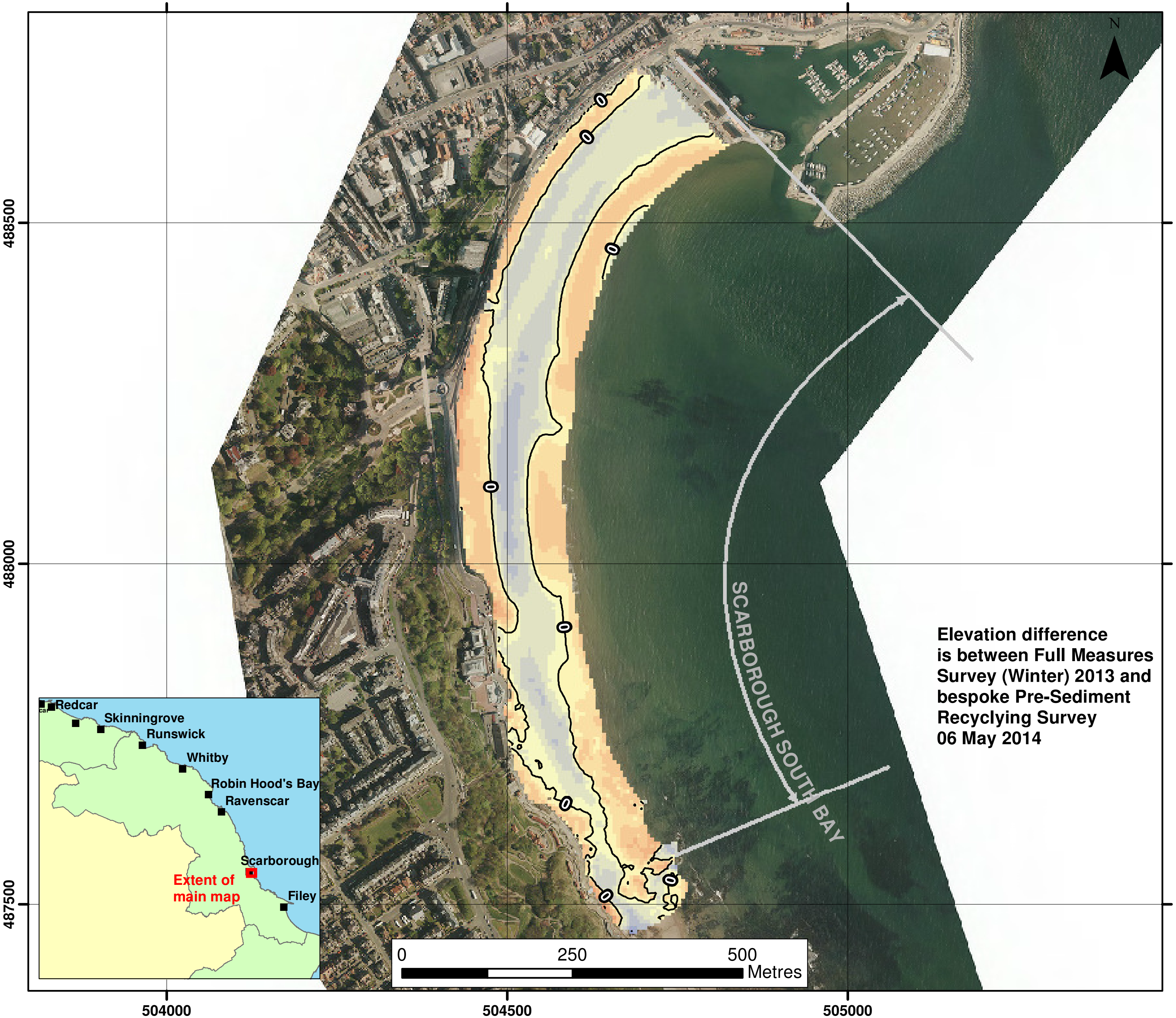

KEY Autumn 2013 and Spring 2014
Change in elevation (m)

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

Loss

Change < 0.1 m

Gain

Contours of change

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

Appendix B- Map 3b
Short-term Elevation Change
Scarborough South
Scarborough Borough Council

Update Report 6
Partial Measures Survey
Spring 2014

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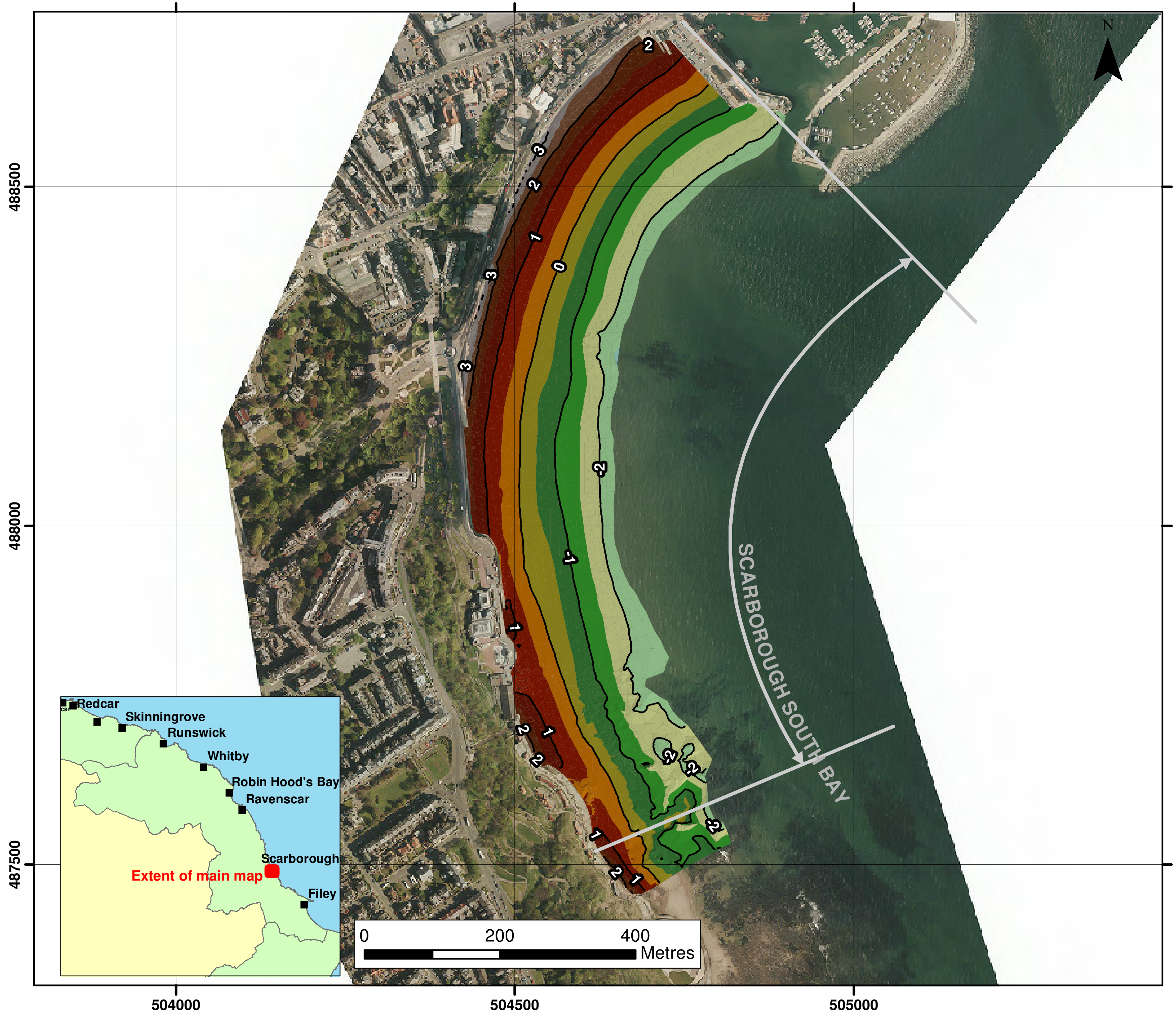

KEY

Elevation

- 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

Elevations are after beach recycling (06/05/2014)

Client: North East Coastal Group

Project: Cell 1 Regional Coastal Monitoring Programme 2011 to 2016

Appendix B- Map 4a
Topographic Survey
Scarborough South
Scarborough Borough Council

Update Report 6
Partial Measures Survey
Spring 2014

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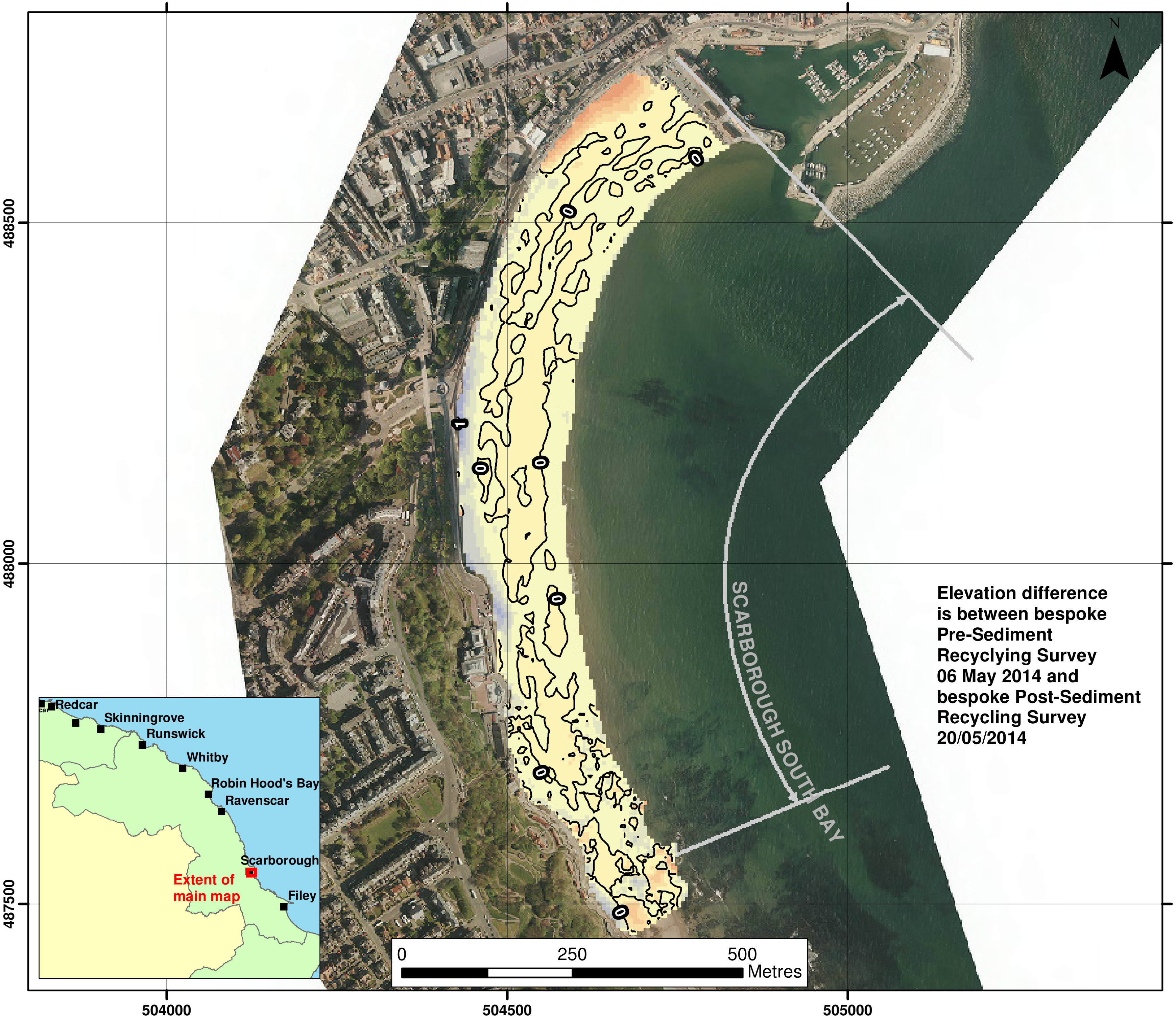

KEY Autumn 2013 and Spring 2014
Change in elevation (m)

<-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 4b
Short-term Elevation Change Scarborough South Scarborough Borough Council

Update Report 6
Partial Measures Survey
Spring 2014

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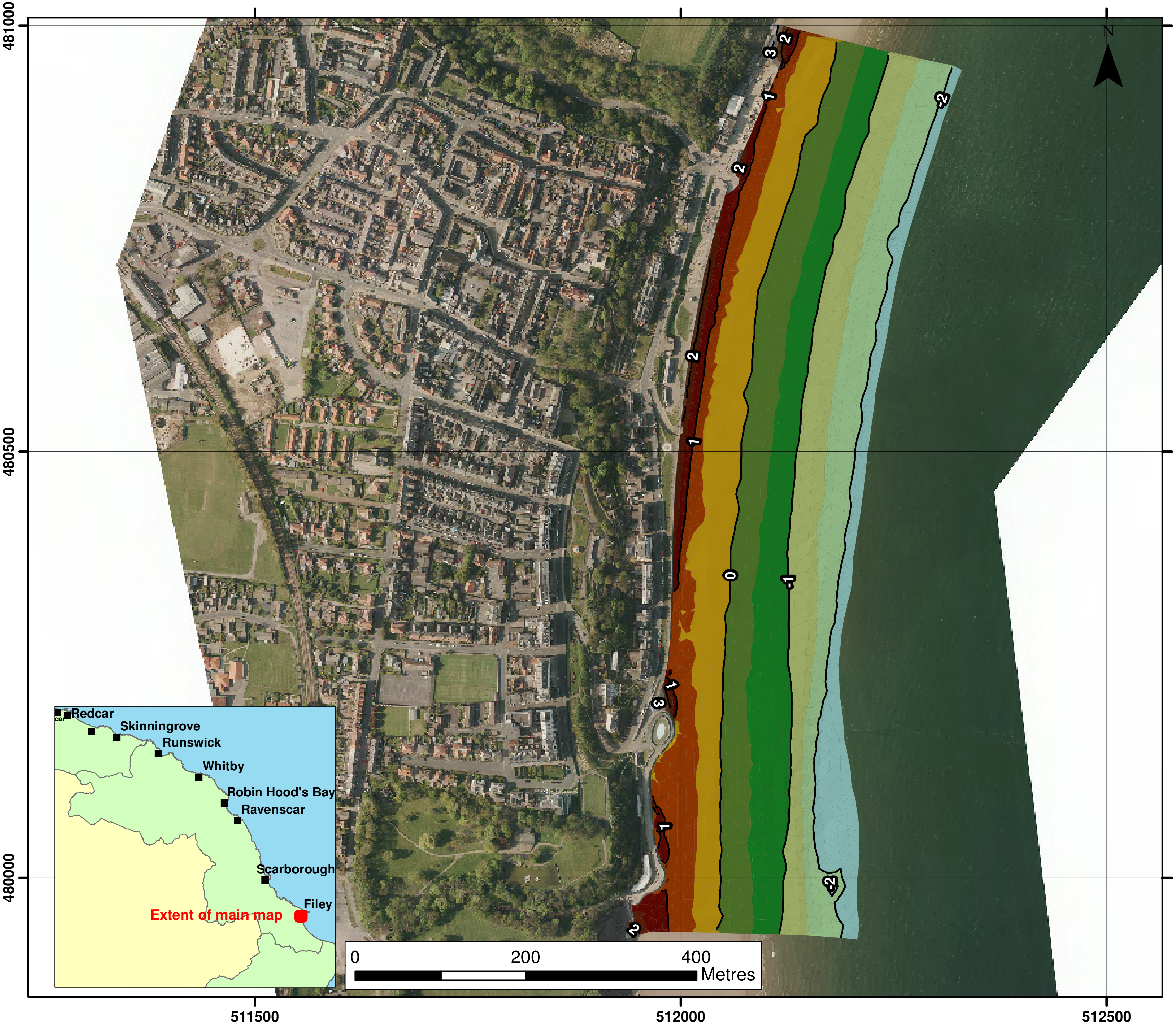

KEY

Elevation (m AOD)

- 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 5a
Topographic Survey
Filey Bay
Scarborough Borough Council

Update Report 6
Partial Measures Survey
Spring 2014

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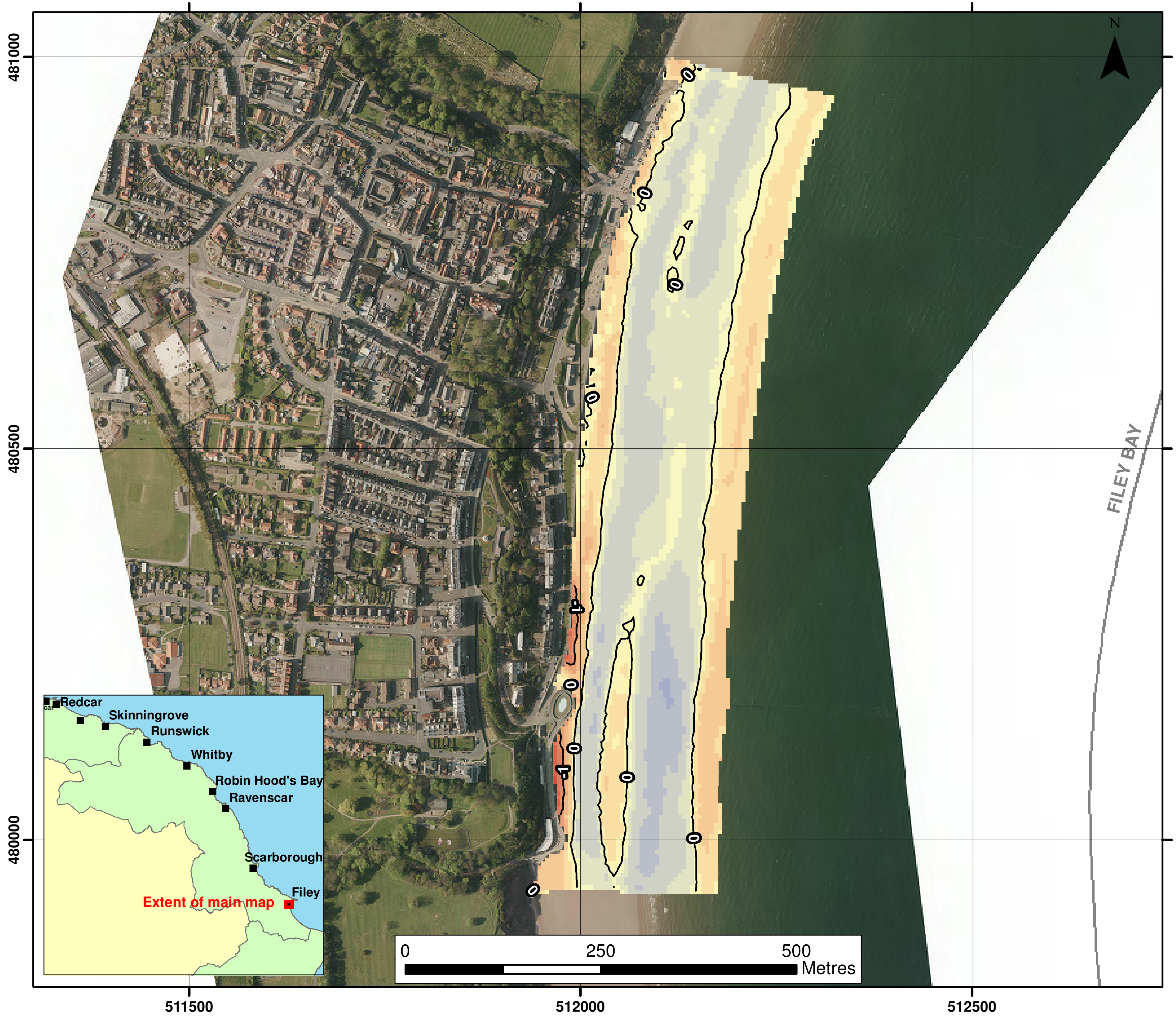

KEY Autumn 2013 and Spring 2014
Change in elevation (m)

<-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 5b
Short-term Elevation Change
Filey
Scarborough Borough Council

Update Report 6
Partial Measures Survey
Spring 2014

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Appendix C

Cliff Top Survey

Cliff Top Survey

Staithes

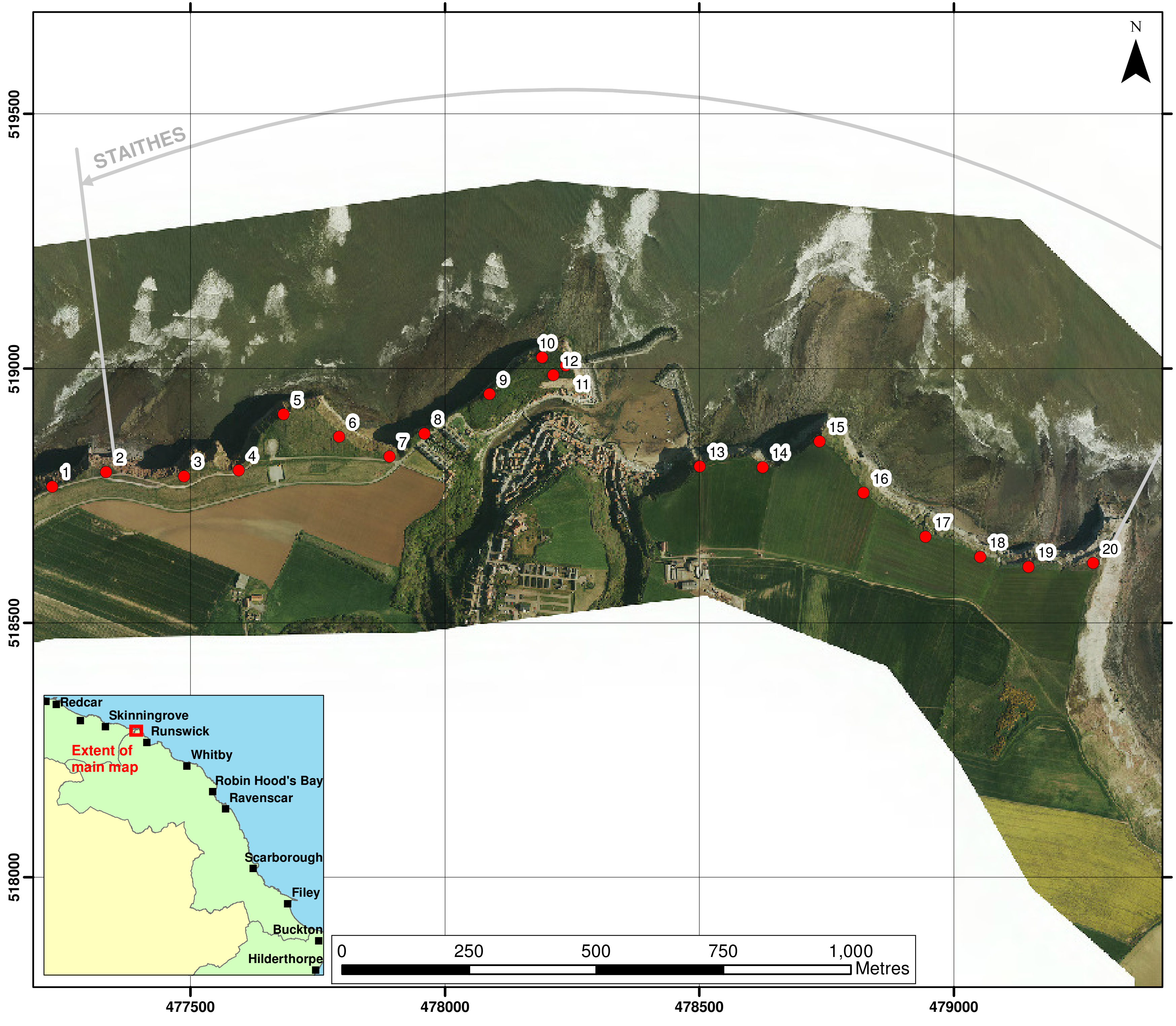
Twenty ground control points have been established at Staithes (Figure C1). The maximum separation between any two points is nominally 100m.

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 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 (Oct 2013)	Present Survey (April 2014)	Baseline (Nov 2008) to Present (April 2014)	Previous (Oct 2013) to Present (April 2014)	Baseline (Nov 2008) to Present (April 2014)
1	477228	518769	320	1.9	1.7	1.7	-0.2	0.0	0.0
2	477334	518798	0	10.9	10.8	10.9	-0.1	0.1	0.0
3	477487	518789	350	7.1	8.5	8.4	1.3	-0.1	0.2
4	477594	518801	340	5.9	5.2	5.1	-0.8	0.0	-0.1
5	477683	518911	350	8.4	8.9	9.4	1.0	0.5	0.2
6	477792	518867	30	8.6	8.5	8.6	0.0	0.0	0.0
7	477891	518828	60	7.7	7.5	7.5	-0.2	0.0	0.0
8	477959	518873	350	8.7	9.9	9.9	1.2	0.0	0.2
9	478088	518950	350	7.6	8.3	8.3	0.7	0.0	0.1
10	478191	519023	340	8.4	8.8	8.8	0.4	0.0	0.1
11	478237	519007	60	6.9	6.7	6.8	-0.2	0.0	0.0
12	478213	518988	150	6.1	6.2	6.7	0.6	0.5	0.1
13	478501	518809	15	11.4	9.2	9.2	-2.2	0.1	-0.4
14	478624	518807	20	7.5	7.5	7.5	0.0	0.0	0.0
15	478737	518858	60	6.1	6.4	6.5	0.4	0.0	0.1
16	478823	518757	60	8	9.3	9.2	1.2	0.0	0.2
17	478944	518671	30	9.3	9.4	9.4	0.1	0.0	0.0
18	479052	518630	20	9.2	9.4	9.4	0.2	0.0	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
Scarborough
Borough Council

Update Report 6
Partial Measures Survey
Spring 2014

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Cliff Top Survey

Robin Hoods Bay

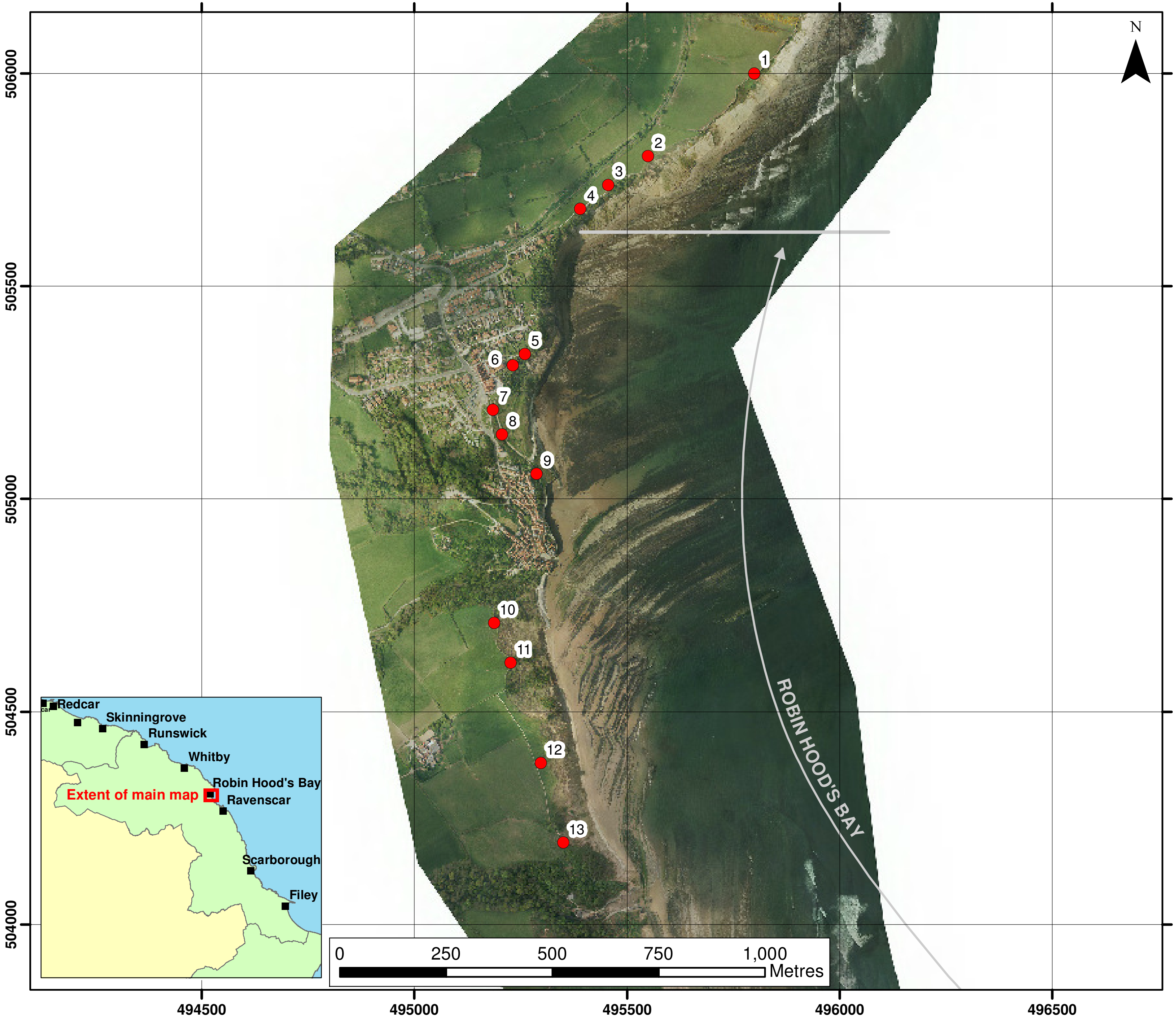
Thirteen ground control points have been established at Robin Hoods Bay (Figure C2). The maximum separation between any two points varies along the coast, reflecting the degree of risk from the erosion. The cliff top surveys at Robin Hoods Bay are undertaken bi-annually. Measurements are taken from a fixed ground control point along a fixed bearing to the edge of the cliff top.

Table C2 provides baseline information about these ground control points and results from the 2010 (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 C2 – Cliff Top Surveys at Robin Hoods Bay

Ground Control Point Details				Distance to Cliff Top (m)			Total Erosion (m)		Erosion Rate (m/year)
Ref	Easting	Northing	Bearing (º)	Baseline Survey (March 2010)	Previous Survey (Nov 2013)	Present Survey (April 2014)	Baseline (March 2010) to Present (April 2014)	Previous (Nov 2013) to Present (April 2014)	Baseline (March 2010) to Present (April 2014)
1	495799.5	506002.2	130	11.6	7.9	7.9	-3.7	0.0	-0.9
2	495549.2	505807.3	135	9.3	9.2	9.2	-0.1	0.0	0.0
3	495456.3	505740	130	5	5.2	5.3	0.3	0.1	0.1
4	495389.9	505683.7	140	6.3	6.3	6.2	-0.1	-0.1	0.0
5	495259.4	505342.5	130	11.3	10.0	10.0	-1.3	0.0	-0.3
6	495231.2	505315.7	95	5.9	5.8	5.8	-0.1	0.0	0.0
7	495184.8	505210.7	85	6.4	6.4	6.8	0.4	0.3	0.1
8	495206.5	505153	75	5	5.1	5.1	0.1	0.1	0.0
9	495287.8	505060.5	80	4.3	4.7	4.9	0.6	0.1	0.1
10	495187.8	504708.8	70	3.1	2.6	2.6	-0.5	0.0	-0.1
11	495226.2	504615.7	120	3.8	3.9	4.0	0.2	0.1	0.0
12	495297.5	504380.2	80	11	11.1	11.1	0.1	0.0	0.0

13	495350.4	504193	55	3.7	3.8	3.8	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 2
Ground Control Points
Robin Hood's Bay
Scarborough
Borough Council

Update Report 6
Partial Measures Survey
Spring 2014

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Cliff Top Survey

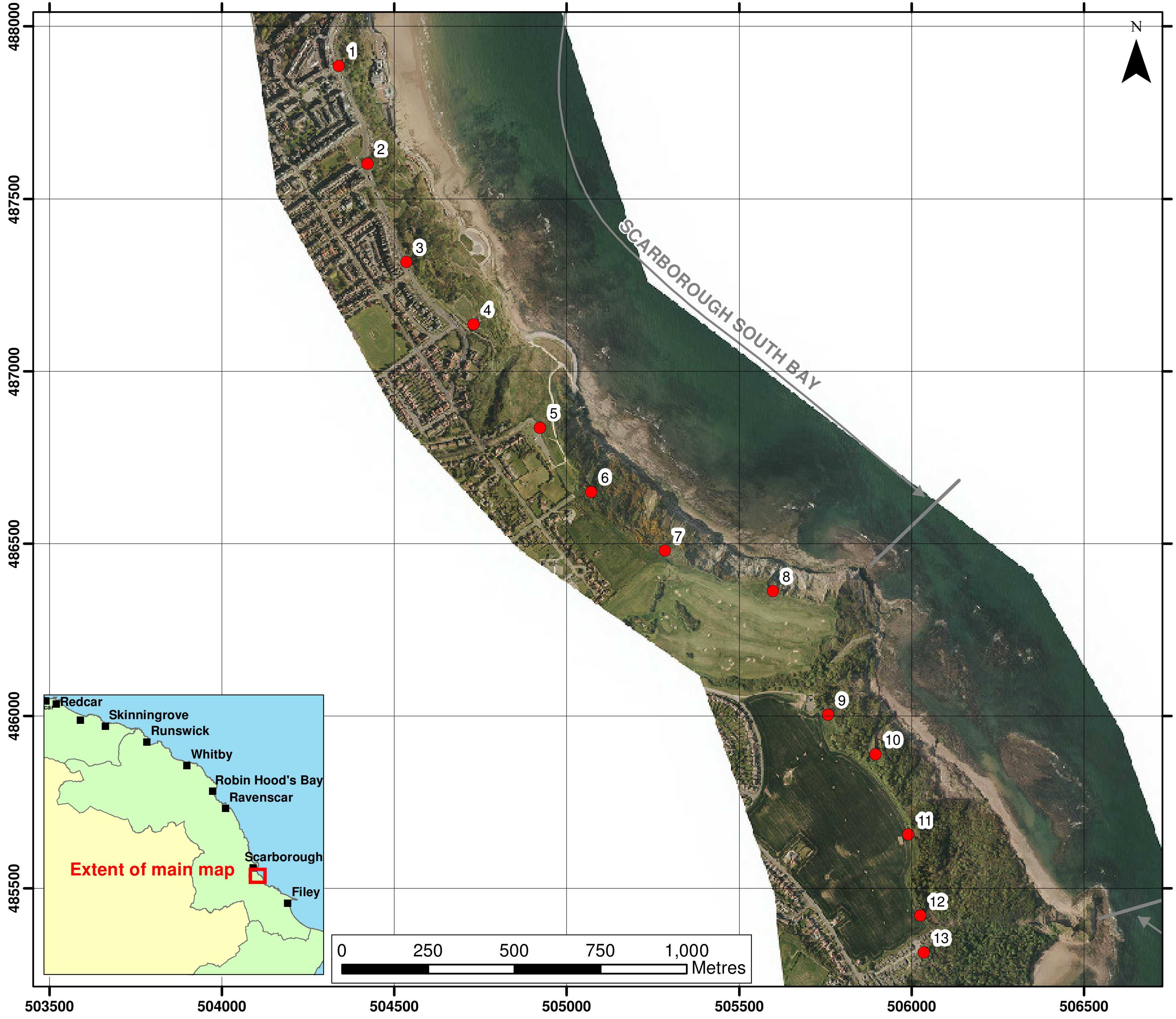
Scarborough South Bay

Thirteen ground control points have been established at Scarborough South Bay (Figure C3). The maximum separation between any two points varies along the coast, reflecting the degree of risk from the erosion. The cliff top surveys at Scarborough South Bay 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 C3 provides baseline information about these ground control points and results from the 2010 (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 C3 – Cliff Top Surveys at Scarborough South Bay

Ground Control Point Details				Distance to Cliff Top (m)			Total Erosion (m)		Erosion Rate (m/year)
Ref	Easting	Northing	Bearing (º)	Baseline Survey (March 2010)	Previous Survey (Sept 2013)	Present Survey (March 2014)	Baseline (March 2010) to Present (March 2014)	Previous (Sept 2013) to Present (March 2014)	Baseline (March 2010) to Present (March 2014)
1	504339.5	487887.3	70	7.0	7.0	7.0	0.0	0.0	0.0
2	504422.3	487603.7	80	4.8	4.8	4.8	0.0	0.0	0.0
3	504534.8	487318.3	40	15.1	15.1	15.1	0.0	0.0	0.0
4	504730.2	487137.9	55	9.6	9.6	9.6	0.0	0.0	0.0
5	504922.9	486837.8	60	8.8	8.6	8.7	-0.1	0.1	0.0
6	505071.1	486652.1	75	3.8	3.9	3.8	0.0	-0.1	0.0
7	505284.3	486480	35	7.0	6.9	7.0	0.0	0.1	0.0
8	505597.9	486363.4	30	8.6	8.6	8.6	0.0	0.0	0.0
9	505758.6	486005.1	45	9.1	8.9	8.9	-0.2	0.0	0.0
10	505896	485889.6	15	14.8	14.9	14.8	0.0	-0.1	0.0
11	505990	485657.1	80	4.7	2.5	2.5	-2.2	0.0	-0.5
12	506024.9	485421.8	55	6.1	4.2	4.2	-1.9	0.0	-0.5
13	506036	485315.3	90	7.0	7.1	7.1	0.1	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 3
Ground Control Points
Scarborough South Bay
Scarborough
Borough Council

Updatel Report 6
Partial Measures Survey
Spring 2014

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Cliff Top Survey

Cayton Bay

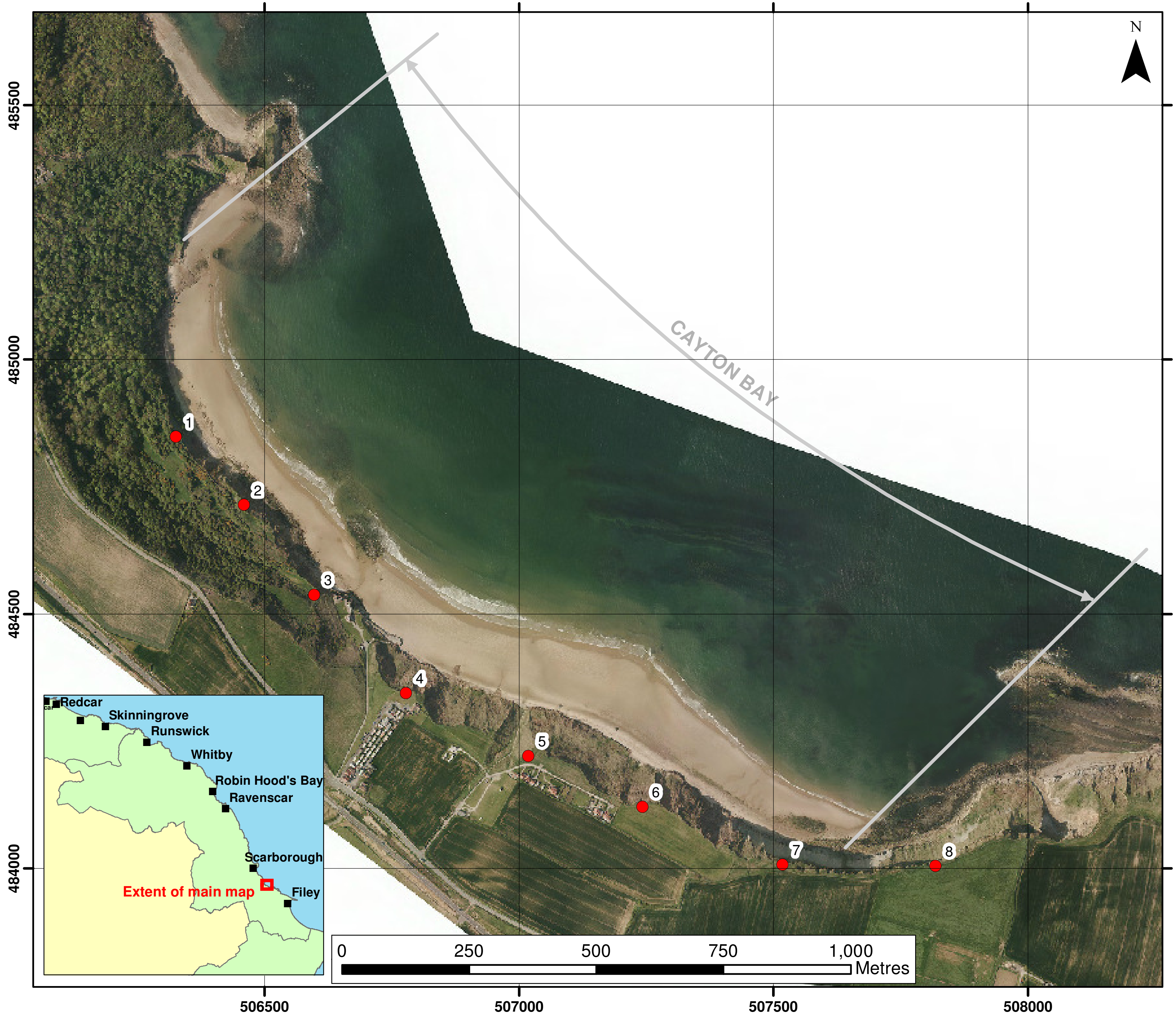
Eight ground control points have been established at Cayton Bay (Figure C4). The maximum separation between any two points varies along the coast, reflecting the degree of risk from the erosion.

The cliff top surveys at Cayton Bay 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 C4 provides baseline information about these ground control points and results from the 2008 (baseline) survey showing the position from the ground control point to the edge of the cliff top along the defined bearing. Future reports will show results from subsequent surveys and provide a means of assessing erosion since the baseline survey.

Table C4 – Cliff Top Surveys at Cayton Bay

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 2013)	Present Survey (March 2014)	Baseline (Nov 2008) to Present (March 2014)	Previous (Sept 2013) to Present (March 2014)	Baseline (Nov 2008) to Present (March 2014)
1	506325.5	484849.7	50	4	3.5	3.7	-0.3	0.3	-0.1
2	506459.4	484715.9	65	5	0.1	0.0	-5.0	-0.1	-0.9
3	506597.4	484538.6	65	5	6.3	6.3	1.3	0.0	0.2
4	506778.1	484345.5	21	9	6.0	6.0	-3.0	0.0	-0.6
5	507018.6	484221.6	342	7.7	8.2	8.1	0.4	-0.1	0.1
6	507242.3	484121.7	2	7.4	6.6	6.5	-0.9	-0.1	-0.2
7	507518.2	484008.2	25	7.5	7.9	7.8	0.3	-0.1	0.1
8	507818.7	484006	1	5.5	5.6	6.2	0.7	0.6	0.1



KEY

● Ground Control Points

Client: North East Coastal Group

Project: Cell 1 Regional Coastal Monitoring Programme 2011 to 2016

Appendix C - Map 4
Ground Control Points
Cayton Bay
Scarborough
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Update Report 6
Partial Measures Survey
Spring 2014

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Cliff Top Survey

Filey Bay

Twenty-eight ground control points have been established in Filey Bay (Figure C5 and C6). The maximum separation between any two points varies along the coast, reflecting the degree of risk from the erosion.

The cliff top surveys at Filey Bay 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 C5 provides baseline information about these ground control points and results from the 2008 (baseline) survey showing the position from the ground control point to the edge of the cliff top along the defined bearing. Future reports will show results from subsequent surveys and provide a means of assessing erosion since the baseline survey.

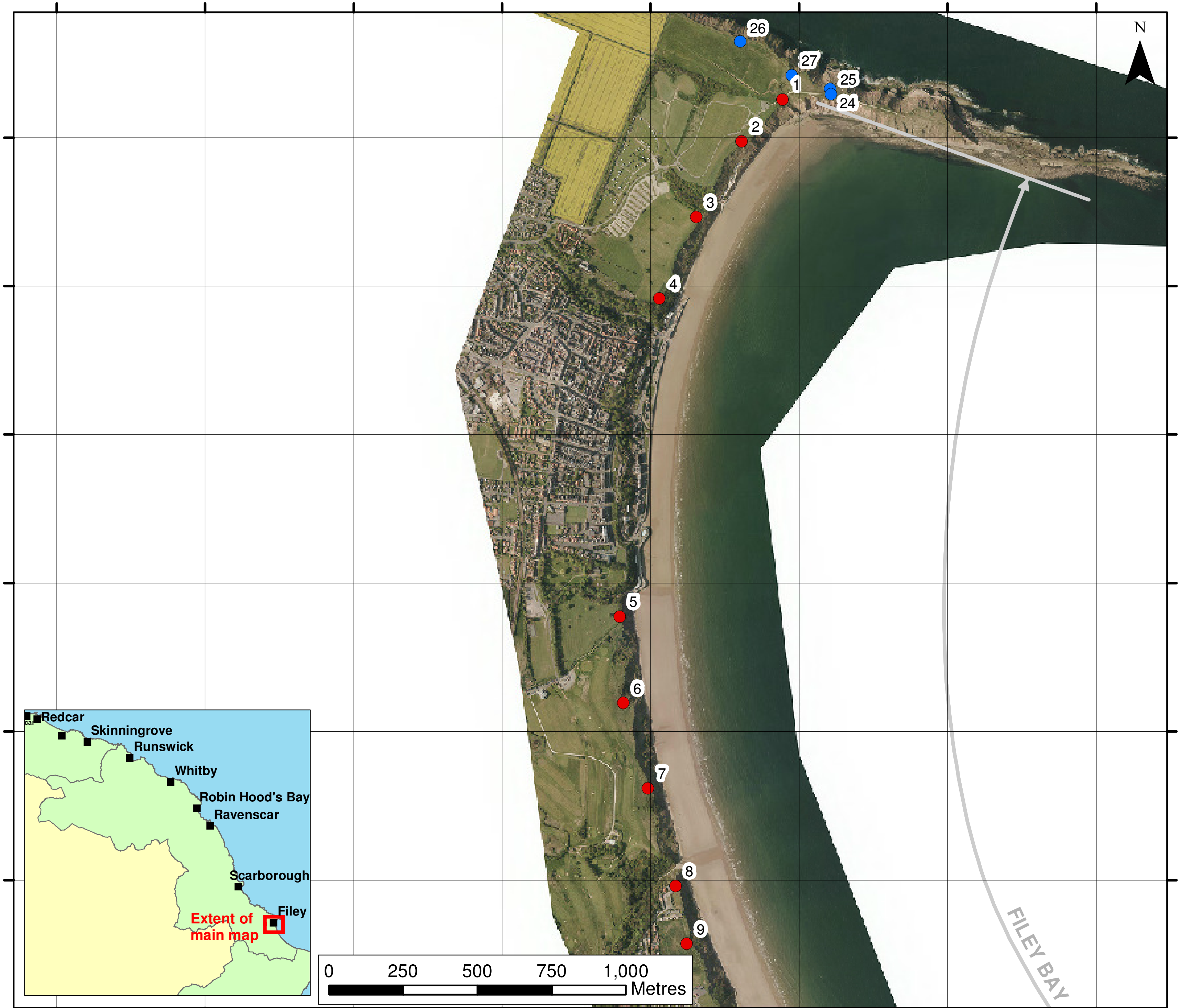
Table C5 – Cliff Top Surveys in Filey Bay

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 2013)	Present Survey (March 2014)	Baseline (Nov 2008) to Present (March 2014)	Previous (Sept 2013) to Present (March 2014)	Baseline (Nov 2008) to Present (March 2014)
1	512444.9	481630.9	130	8.7	8.9	8.8	0.1	0.0	0.0
2	512306.7	481490.3	144	7.6	7.9	7.9	0.3	0.0	0.1
3	512153.6	481234.6	122	8.3	8.5	8.5	0.2	0.0	0.0
4	512029.2	480959.9	115	7.4	7.7	7.6	0.2	-0.1	0.0
5	511895.4	479888	89	7.1	0.9	0.8	-6.3	0.0	-1.2
6	511908.5	479597.1	48	6.7	7.2	7.1	0.4	0.0	0.1
7	511991.4	479310.4	69	6.7	4.7	4.7	-2.0	0.0	-0.4
8	512083.4	478981.5	66	10.2	10.3	10.4	0.2	0.1	0.0
9	512121.3	478786.3	76	8.3	8.4	8.5	0.2	0.1	0.0
10	512226.2	478547.9	74	7.5	7.3	7.2	-0.3	-0.1	-0.1
11	512471.4	478153.5	53	6.6	6.6	7.7	1.1	1.0	0.2

12	512558.9	477901.9	66	7.7	7.8	7.8	0.1	0.0	0.0
12A*	512655.8	477822.4	67	13.9	13.9	13.9	0.0	0.0	0.0
13**	512697.6	477719	34	4.2	0.0	No Data	No Data	No Data	No Data
14	512939.4	477400.9	66	8	7.0	7.1	-1.0	0.0	-0.2
15	513157	477192.7	51	5.2	4.7	4.6	-0.6	-0.1	-0.1
16	513299.5	477024.6	30	7.7	7.5	7.1	-0.6	-0.4	-0.1
17	513507.7	476821.1	34	10.7	10.7	10.7	0.0	0.0	0.0
18	513721	476602.3	31	7.2	7.0	7.1	-0.1	0.1	0.0
19	513916.6	476354.1	51	6.6	6.4	6.4	-0.2	0.0	0.0
20	514174.8	476179.4	32	7	7.2	7.4	0.4	0.1	0.1
21	514471.5	475965.7	66	7.6	7.5	7.6	0.0	0.0	0.0
22	514656.2	475728.8	101	8.1	8.1	8.2	0.1	0.1	0.0
23	514889.5	475537.6	60	9.1	9.1	9.2	0.1	0.0	0.0
24*	512603.7	481665.9	14	19.9	19.9	19.8	-0.1	-0.1	0.0
25*	512607.1	481648.9	184	17.2	17.1	17.1	-0.1	0.0	0.0
26*	512301.9	481825.5	18	11	10.9	11.0	0.0	0.0	0.0
27*	512475.8	481712.1	20	11.6	11.58	11.55	0.0	0.0	0.0

NOTE: *base line for 12A and 24-27 is March 2011

**Surveyor's report has previously stated that 'VMP 13 was unable to be measured due to vegetation growth and land shape change'



KEY

Ground Control Points

Established March 2011

Established Nov 2008

Client: North East Coastal Group

Project: Cell 1 Regional Coastal Monitoring Programme 2011 to 2016

Appendix C - Map 5
Ground Control Points
Filey Bay North
Scarborough
Borough Council

Update Report 6
Partial Measures Survey
Spring 2014

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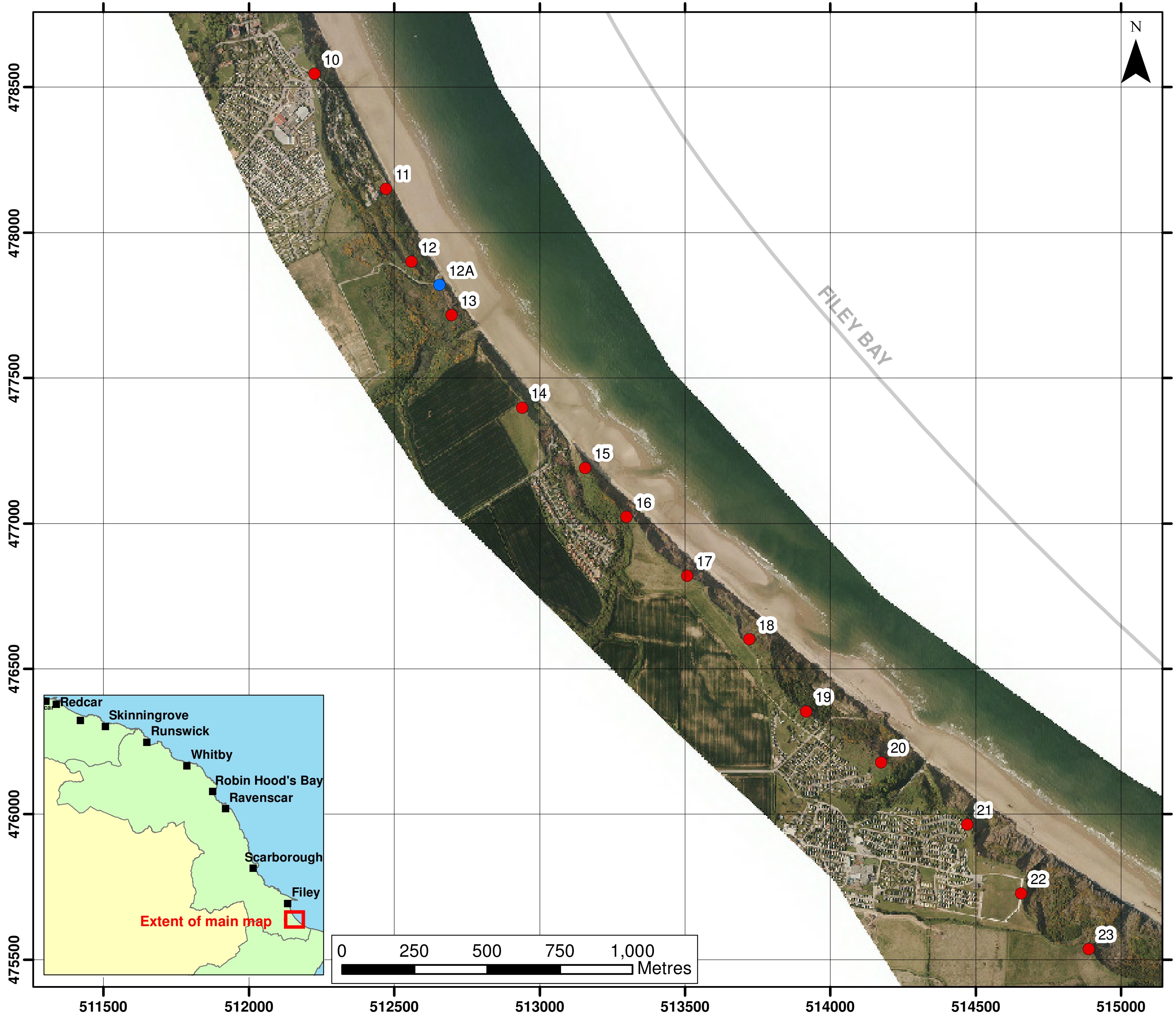

KEY

Ground Control Points

- Established March 2011 (blue)
- Established Nov 2008 (red)

Client: North East Coastal Group

Project: Cell 1 Regional Coastal Monitoring Programme 2011 to 2016

Appendix C - Map 6
Ground Control Points
Filey Bay South
Scarborough
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Spring 2014

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Appendix D

Durham University Laser Scans of Cowbar Nab

COWBAR COASTAL CLIFF MONITORING
STAITHES, N. YORKSHIRE

April 2014

Dr N Rosser

University of Durham

Prepared for and on behalf of:

Redcar and Cleveland Borough Council

c/o Steve Dunning

TABLE OF CONTENTS

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1. Context

- This report summarizes the Year 3 results from an ongoing monitoring program at Cowbar Nab, Staithes, North Yorkshire.
- The monthly monitoring program began in January 2011, and aims to build up a high resolution dataset on cliff face erosion.
- This report considers the results of the study up until March 2014.
- This report establishes the rate of erosion using the best attainable data, and uses this to highlight features observed in the nature of erosion as and when they arise.
- The monitoring program is being undertaken for and on behalf of Redcar and Cleveland Borough Council.

2. Executive Summary

The following tasks have been completed as part of this project in Year 3:

- Monthly high-resolution terrestrial laser scans of the cliff at Cowbar Nab have been undertaken, ongoing since January 2011, from a single position on the foreshore during low tides. Twelve (12) approximately monthly surveys were conducted during this period when tidal conditions allowed.

- Constant monitoring of the site is undertaken using a 3-axis seismometer, and a cliff face environmental monitoring system, allowing environment conditions and the timing of failure to be identified to explain the erosion data presented herein.

- The instrumentation is complemented by an innovative permanent terrestrial laser scanning system to observed changes to the cliff on a daily basis to locate rockfall on a day-to-day timescale. The installation of this equipment is now subject to removal upon request of the landowner.

The following data have been calculated for Year 3:

- A total volume of 460.53 m^3 in 4,815 discrete rockfall events occurred during this period.

- **The area averaged rate of retreat observed in the period March 2013 – March 2014 was 0.519 x 10^{-3} myr^{-1}**.

- **The modeled rate of retreat in the period March 2013 and March 2014 was 0.804 x 10^{-3} myr^{-1}**.

- The lowest monthly volume of rockfall was observed in October 2013 (0.284 m^3).

- The highest monthly volume of rockfall occurred in April 2013 (366.760 m^3).

- The maximum depth (relative to the cliff face) of any single rockfall observed on the cliff face during this period was 2.80 m, which occurred 6.7 m above the cliff toe above a previously undercut section.

- A notable rockfall sequence occurred during the early months of this monitoring period, contiguous with an area of previous failure. In total, this area lost 325.52 m^3 during this monitoring period (equivalent to a cube of dimensions 6.879 m, and 70.68 % of the total rock volume lost during this year). Note that some of the 'event' was captured in the Year 2 report.

- In response to the occurrence of this event, the monitoring frequency was increased to weekly intervals for a period of 4 weeks to mid-May, and then reduced after analysis of this data showed a reduction in the rate of rock loss from this section of the cliff face. Whilst there is no evidence in the monitoring data of the development of a deeper-seated failure, which would threaten the road and / or houses, the area that has experienced the largest rockfall beneath Cowbar Lane has undergone a sequence of change since the start of monitoring, and this is likely to continue. The general trajectory of the development of this failure is up- and across-cliff. The cliff profile in this location is overhanging. Failure depths up to 2.8 m upon this near-vertical cliff have been observed. As this area develops it is likely that failures will continue to this depth and magnitude.

- More widely, failure has been concentrated upon the rock cliff face itself, and no discernable change in the position of the cliff line above was observed during this period.
- Considerable month-on-month variability was observed (standard deviation in monthly total rockfall volumes = 103.9 m^3), with some months (October 2013) showing almost no discernible change.
- The spatial pattern of erosion is commensurate with marine driven erosion at the toe of the cliff, in addition to the continued failure of previously active areas of the cliff expanding. Work on the nature of this process, included outputs from monitoring at Cowbar has been published in Rosser et al., 2013.
- Propagation of existing failure scars, both vertically and laterally, is observed, and such features are likely to continue to develop in this manner in the future. We note that failures from previous years now coalesce, identifying areas of potential future failure.
- The widely jointed sandstone close to the crest of the cliff remains relatively intact compared to the shales and limestone beneath. Failure of the sandstone is likely to be less frequent but of larger magnitude, based upon our observations, which may lead to retreat of the cliff line.
- We observe minimal rockfall directly above the section of rock armor.

In comparison to Year 2, we observe:

- **Area average erosion rates was 37% of that in Year 2.** This decrease is significantly influenced by both the single rockfall reported above, in addition to an extended period of relative quiescence in rockfall activity since, in addition to overprint of interannual variability.
- **Modelled erosion rates show a 107% increase.** This increase represents interannual variability and accounts for the occurrence of the single rockfall reported above.
- The location of erosion in Year 3 is contiguous with areas of the cliff face that experienced erosion in Years 1 & 2, suggesting continued failure, propagation of rockfall scars and erosion of these areas during this most recent period.

The long-term (Year 1 to Year 3 end) erosion rates are as follows for the 39 months of monitoring at this site:

- o **39 month area averaged erosion rate is 1.339 x 10^{-3} myr^{-1}.** This rate is based purely on the rockfalls we observe at site.

- o **39 month modeled erosion rate is 1.293 x 10^{-3} myr^{-1}.** This rate considers the full range of possible rockfall sizes at this site, and will stabilize over time as a more complete range of event sizes is recorded. This approach overcomes the limitations of monitoring only a small area / non representative sample, during a limited time period (see: Barlow *et al.*, (2012) for methodology).

- Since the start of monitoring we observe a total of 906.542 m^3 of rockfall, sourced from 38,925 discrete rockfall events identified from monthly sequential monitoring. Note that the number of discrete areas of rockfall will reduce through time, as failure scars coalesce. Note also that figures provided in interim reports disaggregated volumes by weekly scan intervals, and so effectively double count volumes as compared to monthly scans.

- On average 1,156 discrete rockfall events occur at this site each month (in volumes > 2.5 x 10^{-4} m^3).

- The average monthly volume of rockfall is now 38.22 m^3, equating to 0.17 m^3 / month / m of coastline (equivalent to a cube of dimensions 0.55 m).

- The monthly volume of rockfall for this section of cliff remains on average lower than that observed elsewhere along this coastline (see: Rosser *et al.*, 2013), most likely due to the relatively low (< 30 m) cliff height. Retreat rates per unit area between this site and other monitored elsewhere on this coastline remain comparable in proportion to the cliff height / available rockfall source area.

The following conclusions have been drawn based upon our analysis of monitoring to date:

- There is no indication that the erosion of the cliff at Cowbar is accelerating or deviating away from behavior observed at this site previously. The reduction in rates of erosion reported here represents variability widely observed on such cliffs. This monitoring period demonstrates the possibility for larger-scale rockfall at this site.

- The rates of erosion observed at this site within each month are heavily influence by a low number (commonly < 3) of larger (> 1 m^3) rockfall. Where no such event occurs in any given month, the retreat rates are accordingly low. This year periods with no large events showed very low rates of averaged erosion.

- Continued analysis of the environment data shows limited correlation between environmental forcing and the erosion rates derived. The smallest events show some relationship; the largest events do not. The dominance of largest event on the mean erosion rates will continue to limited such correlation until a longer data set has been established, but in this monitoring period the contribution of the largest rockfall was countered by 8 months of relatively low rockfall activity.

- The concentration of erosion remains focused away from the 'pinch points' at this site, although a focus of activity is developing to the East of the rock armor. We also note that there were only a small number of rockfalls sourced on the section of cliff protected by the rock armour.

- No loss of cliff line was observed during this period, although critically this indicates cliff steepening via rockfall beneath, which will in time result in failure of the cliff top in future. We observe a sequence of larger failures, the development of which should be considered over the coming monitoring period.

- We will continue to refine the monitoring approach at the site, which in the forthcoming period will include real-time processing of the permanent scanning data, and a numerical analysis of the micro-seismic monitoring data.

3. MONITORING RESULTS

a. MONITORING RESULTS YEAR 3

- Table 1 summarizes the survey results from monitoring between January 2011 and March 2014, and reports the results from March 2013 to March 2014. Months since the beginning of the monitoring program (January 2011) are named 1, 2, 3 . . . to 39, with the corresponding date of the survey. The length of each survey epoch is calculated in days since the previous survey, and days since the first survey. For each month the total number of rockfalls and the cumulative total volume of rockfalls measured during this period are calculated, using the method described in previous reports.

- Total change between March 2013 and March 2014 is shown in Figure 1.

- Total change since the start of monitoring (January 2011) is show in Figure 2.

- The following erosion rates are calculated in two ways: (1) The total rockfall volume is averaged across the survey area. This is the conventional and widely used approach, but does not consider the limitations of small sample size, duration or survey area, and hence how representative the observations are of longer term behavior. (2) The modeling approach considers all possible rockfall sizes and overcomes the limitations of a small sample size and monitoring area, and therefore is considered to be more representative of long term behavior. We expect the area average and the modeled erosion rates to converge over time as a wider range of event sizes are included in the analysis.

- The total number of measured rockfalls between March 2013 and March 2014 was 4,815, with a total volume of 460.53 m^3. This equates to an area averaged erosion rate of **0.519×10^{-3} myr^{-1}** over this period.

- The maximum monthly area averaged erosion rate was 4.979 x 10^{-3} myr^{-1} (April, 2013), and the minimum 0.004 x 10^{-3} myr^{-1} (October, 2013).

- The modelled erosion rate for this period is **0.804 x 10^{-3} myr^{-1}**, with a monthly maximum of 2.459 x 10^{-3} myr^{-1} (May 2013) and a minimum of 0.205 x 10^{-3} myr^{-1} (January, 2014). Note that in the modeling we assume a maximum event volume of 2,500 m^3, during a 100-year return period, which has not been exceeded to date.

- We highlight key features of the erosion observed between March 2013 and March 2014 in Figure 1, numbered (1) to (3), and discussed below:

- We observe several areas indicative of the continued development (failure) of rockfall scars that have previously experienced collapse (e.g. Figure 1 (1 – 3)). These are normally vertically and horizontally extensive (> 1 m), but in general shallow in depth relative to the cliff face (< 0.15 m), often associated with release along face-parallel joints or stress relief features.

- Several areas which underwent larger scale (> 1 m^3) failure in Years 1 & 2 continue to show quiescence, with minimal change on the now-exposed intact failure scar rock (e.g. area up and right of (1) in Figure 1). Whilst the fresh face of such areas remains unchanged, such features commonly are seen to extend laterally across the cliff (vertically and horizontally) albeit to a limited extent, as shown in the month by month expansion of rockfall scars (Figure 3).

- Clear evidence of marine driven toe-cut erosion via abrasion and wave hammer is visible (e.g. beneath (1) in Figure 1). This is shown in small-scale change (< *c.* 0.0001 m^3), concentrated in a zone < 2 m from the break in slope at the toe of the cliff. In certain locations, such as Figure 1(1), this abrasion is then seen to propagate vertically up the cliff, resulting in rockfall of a larger magnitude in volume.

- There is a minimal number of rockfall sourced from the section of cliff face directly above the rock armor, labelled in Figure 2, as opposed to those sections of cliff not protected by the rock armor (Figure 2(4)). Those rockfall which have occurred are relatively shallow in depth (< 0.25 m).

- Some change is observed in isolated patches on the surface of the glacial till cap at the top of the cliff. On the Eastern section of the monitored section (Figure 1 - left), much of this change is associated with vegetation growth, rather than mass movements.

- A new rockfall was noted during student fieldwork on the coast on 14th April 2013, triggering further more frequency monitoring and analysis. This data was collected after the submission of the first draft of the Year 2 report to RCBC, but was reported on in the interim due to the failure size. The key features were as follows:

   i. Approximately 27 m in cross-shore width, up to 17 m in height and up to 2.8 m in depth was released from the cliff between March 12th and April 14th (Figure 1(1), & Figures 4 – 6).

   ii. The rockfall occurred directly above an area which has been previously been observed to have experience marine undercutting, and was identified above as a potential location for future loss of material. The position of the rockfall relative to the location of Cowbar Lane is provided in Figure 7 for context.

   iii. The rockfall did not result in the loss of the cliff top at this location, although it is likely that this area will continue to fail, and rockfall scars will coalesce, in the future. The cliff is now undercut and retains a steeper angle and should be continued to be monitoring on a regular monthly basis. There is no visible evidence of a deterioration in the stability of the cliff above the location of this rockfall. Events (1) and (2) in Figure 2 have removed lateral and basal support for the rock mass above, which may in time increase the probability of failure of this section of the cliff. Failure depths to date have been up to 2.8 m, and it is likely that this magnitude of failure depth with continue.

iv. The initial volume of material lost during as a result of this rockfall was identified as 687.1 m^3. Further subsequent analysis revealed that this event multiple failures which span the 2012 – 2013 and this monitoring period as shown in Figure 3 and 6 which describe the evolution of this failure. The failure reported here was 325.5 m^3.

v. The period since this event has been quiet, with fewer rockfalls than have been observed in previous months. As a result the monitored erosion rate for years 1 – 3 is reduced as compared to that for years 1 – 2. The modelled rate is more stable as this accounts for the possibility of larger events such as this.

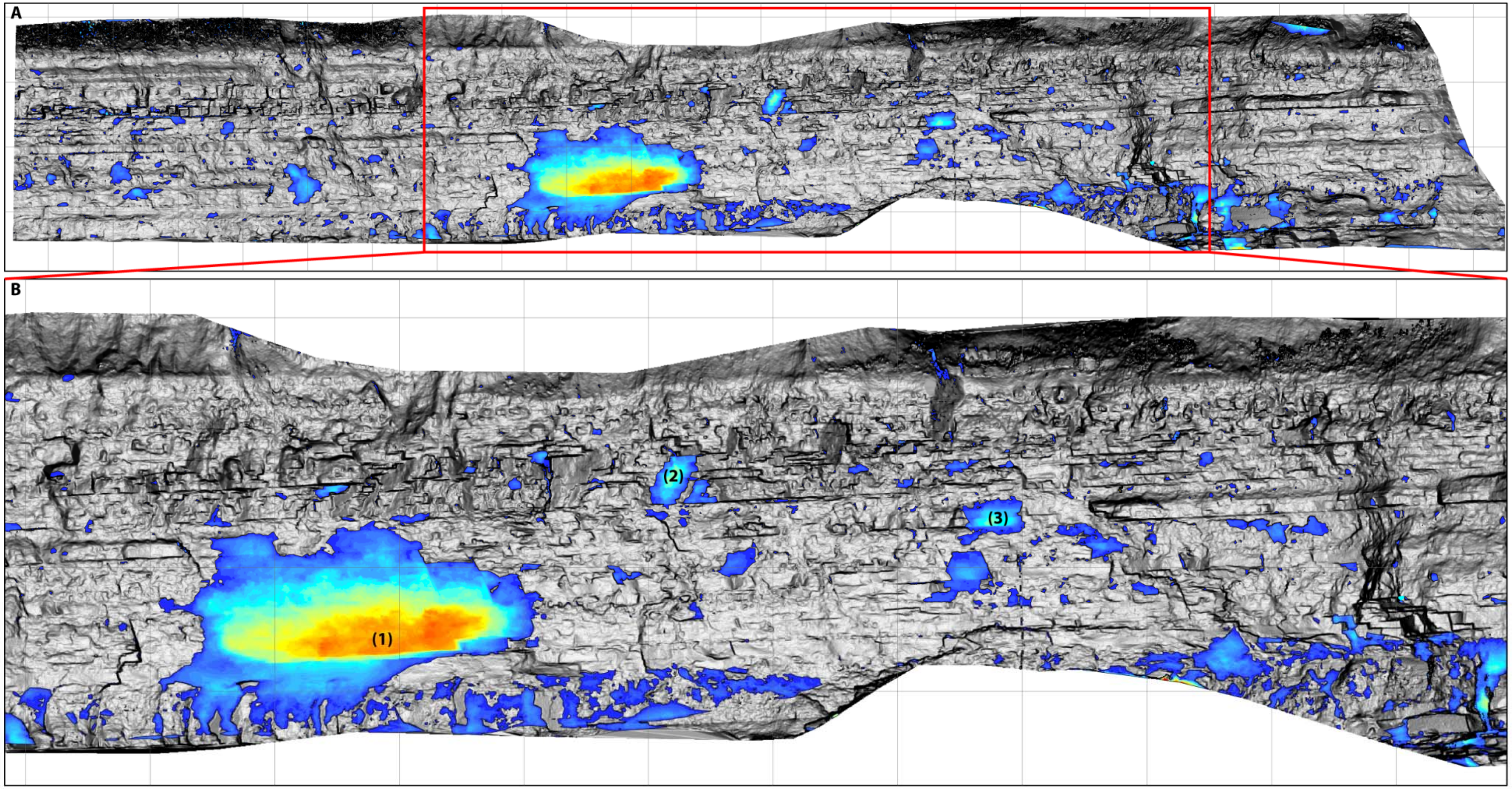

Figure 1. Monitoring erosion at Cowbar Nab between March 2013 and March 2014. **(A)** shows an elevation view of the rock cliff at Cowbar, displayed as if viewed from a point 100 m seaward from the cliff toe on the foreshore. The greyscale image is the slope of the cliff face, to provide indicative topography (hillshade), and the colours show erosion depth normal to the cliff face. Cold colours (blues) show erosion >= 0.1 m (the lower threshold of the change detection), and warm colours (orange to red) show erosion up to 3.5 m relative to the cliff face. The grid interval is 10 m in both horizontal and vertical axis. The red square delimits the extent of the area shown in B. **(B)** shows a close up view of the cliff directly beneath Cowbar Lane. The numerical labels are referred to in the body of the text.

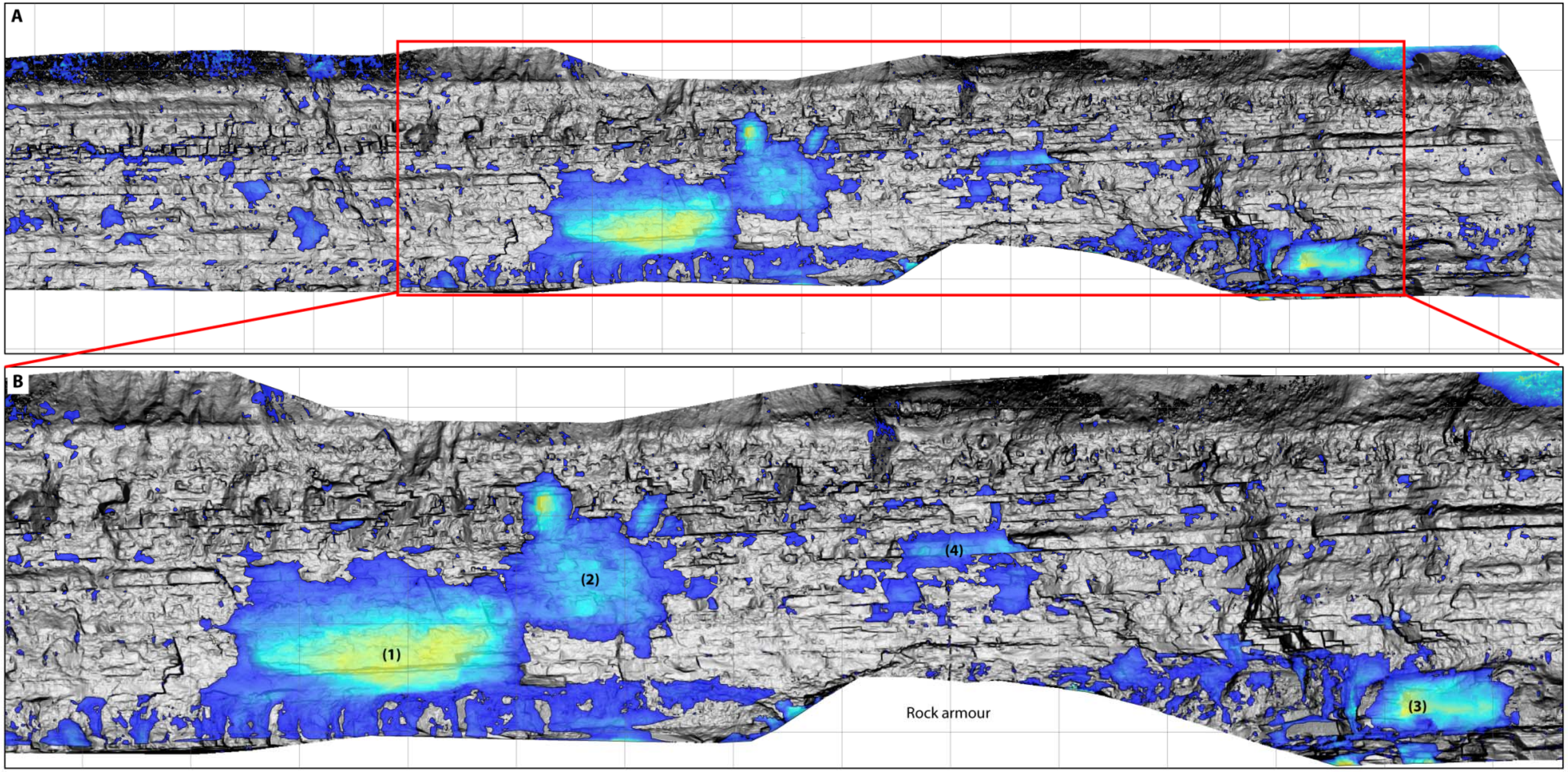

Figure 2. Monitoring erosion at Cowbar Nab between January 2011 and March 2014. **(A)** shows an elevation view of the rock cliff at Cowbar, displayed as if viewed from a point 100 m seaward from the cliff toe on the foreshore. The greyscale image is the slope of the cliff face, to provide indicative topography (hillshade), and the colours show erosion depth normal to the cliff face. Cold colours (blues) show erosion >= 0.1 m (the lower threshold of the change detection), and warm colours (orange to red) show erosion up to 3.5 m relative to the cliff face. The grid interval is 10 m in both horizontal and vertical axis. The red square delimits the extent of the srea shown in B. **(B)** shows a close up view of the cliff directly beneath Cowbar Lane. The numerical labels are referred to in the body of the text.

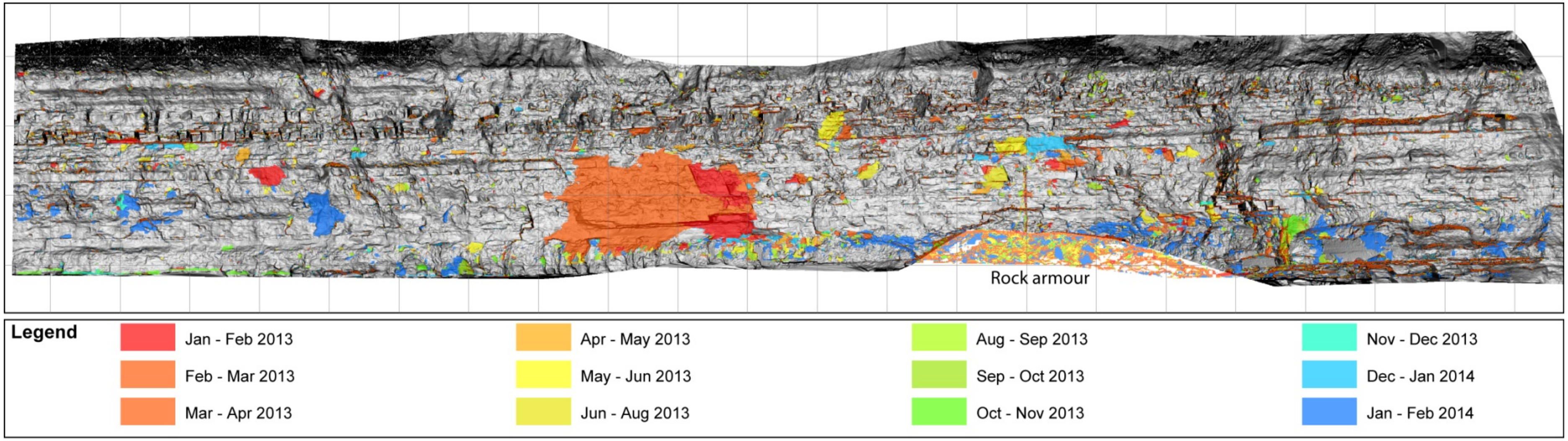

Figure 3. Monitoring erosion at Cowbar Nab between January 2013 and March 2014. The plot shows the the extent of recorded rockfalls for each month between January 2013 and the end of February 2014, each month with a unique colour. The grid interval is 10 m in both horizontal and vertical axis.

Figure 4: Photograph (14/04/13) showing the location and extent of the rockfall observed between 14th March and 14th April, with debris pile below. Note people for scale.

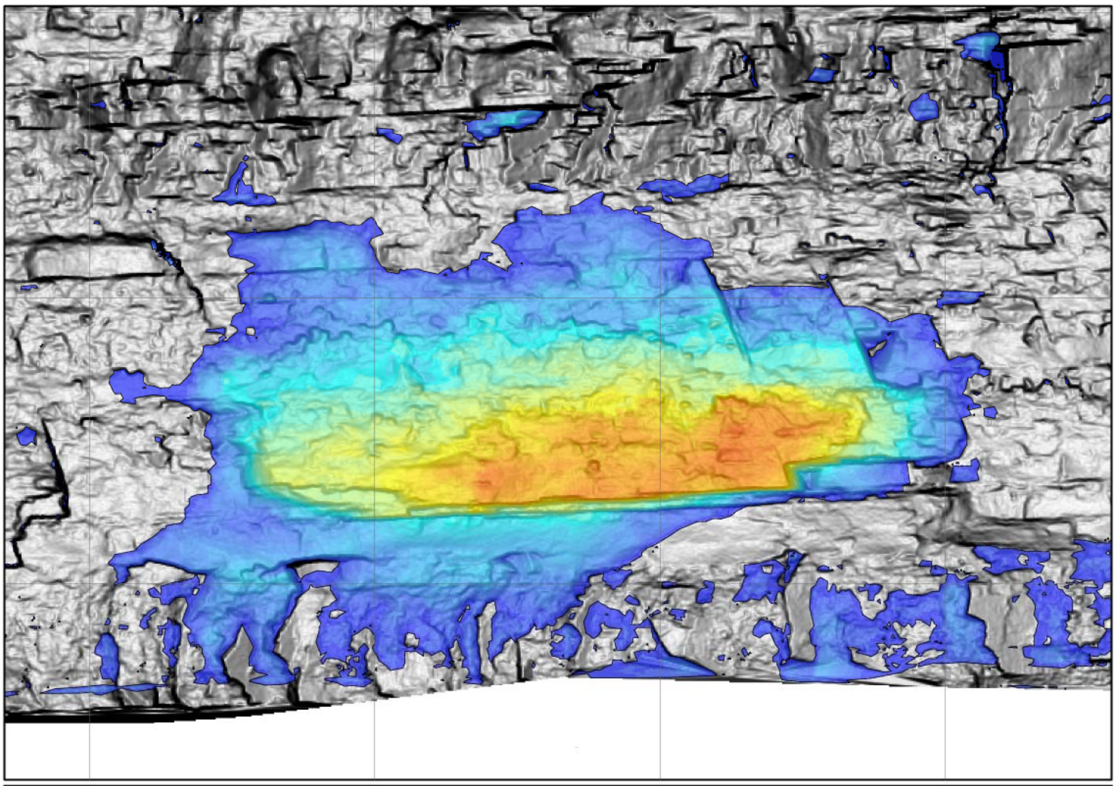

Figure 5: Close up view of rockfall scar recorded between March and April 2013. Image in greyscale shows hillshade for context of the slope topography. The warm colours show a greater depth of erosion, here up to 2.8 m, and cold colours (blues), show erosion greater than or equal to 0.1 m. Grid is 10 m interval in the horizontal and vertical axis.

Erosion depth
2.8 m
0.1 m

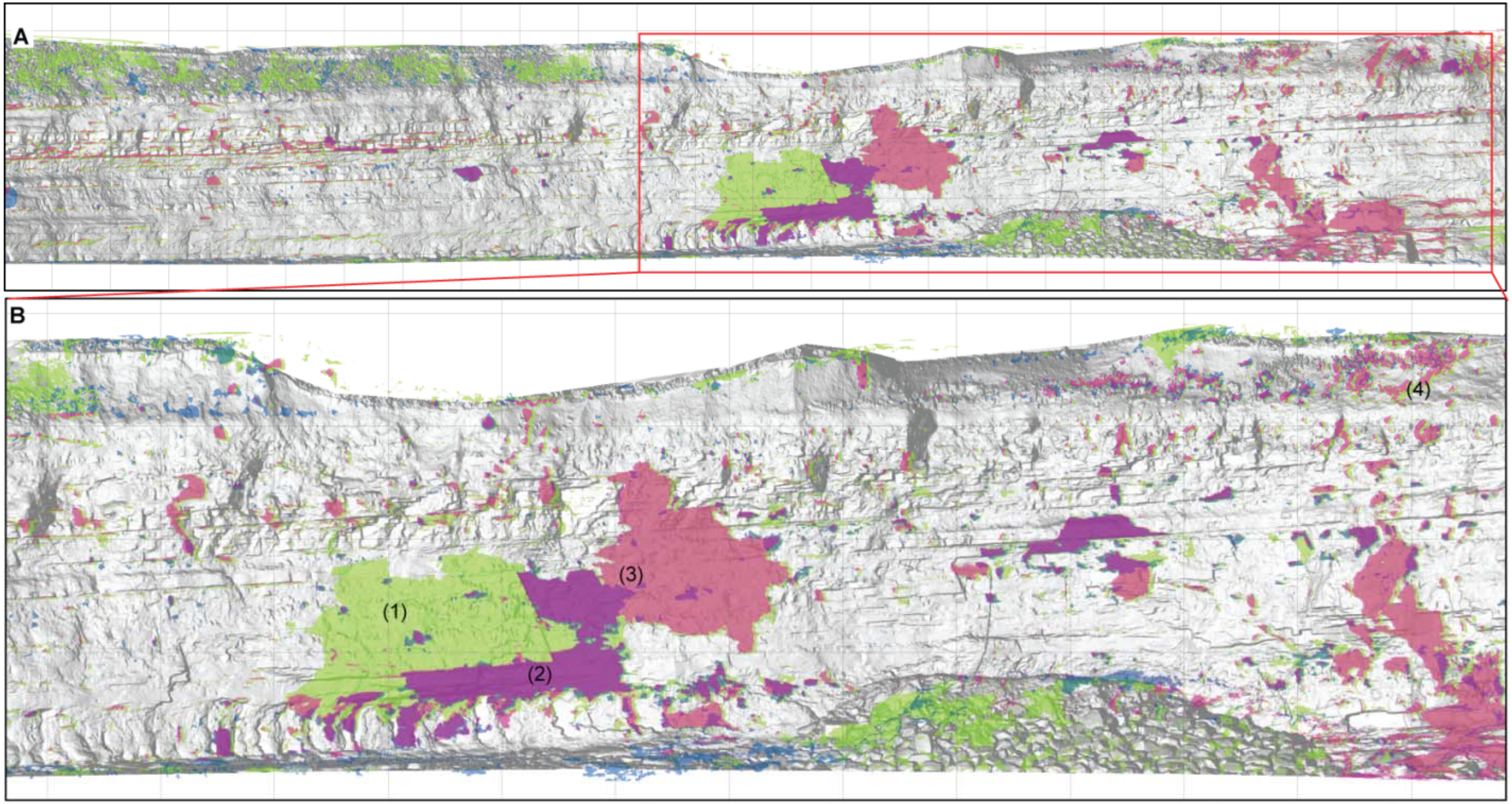

Figure 6. Areas of erosion > 0.1 m normal to the cliff face durign YEAR 1 (14th January 2011 and 26th March 2012) (BLUE), and during YEAR 2 (26th March 2012 and 12th March 2013) (RED), and during April 2013 (12th March to 25th April 2013) (GREEN). PURPLE areas change sections of the cliff face which changes in both Years 1 and 2. **(A)** shows elevation view of the rock cliff at Cowbar, as seen from a point 100 m seaward from the cliff toe on the foreshore. The grey-scale image gives indicative cliff face topography (hillshade). The grid interval is 10 m in bother horizontal and vertical axis. The red square delimits the extent of the section displayed in (B). **(B)** shows a close up view of the section of cliff directly beneath Cowbar Lane. Figure 7 gives the position of the rockfall shown above relative to Cowbar Lane.

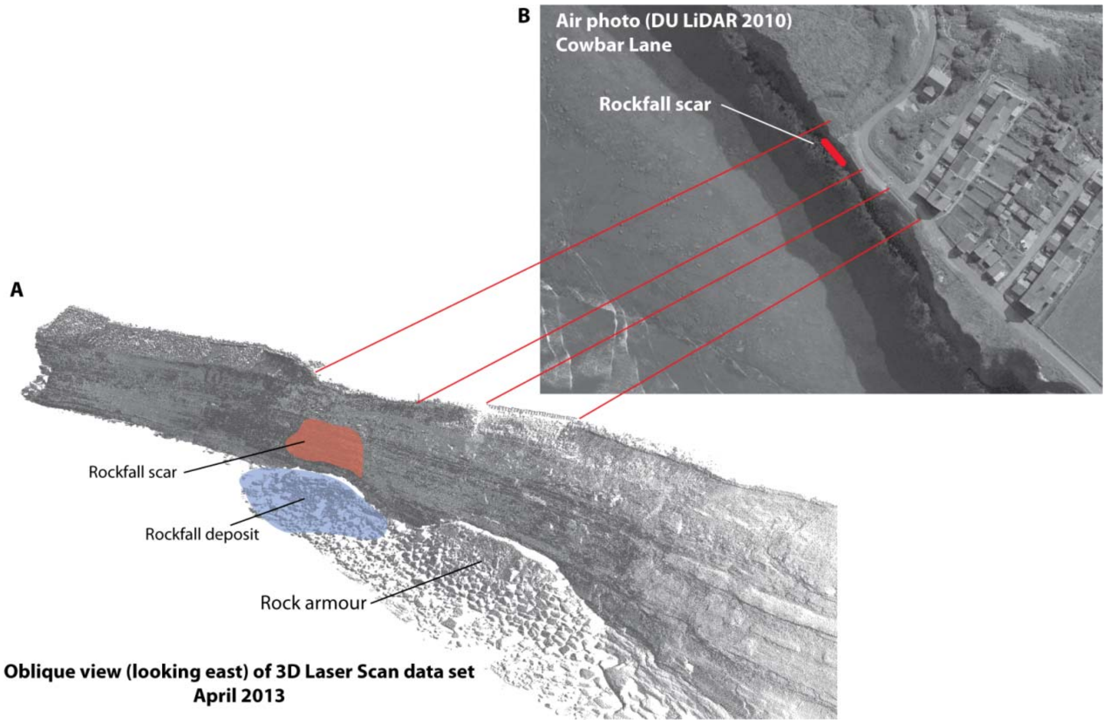

Figure 7. Location of the rockfall relative to Cowbar Lane. **(A)** shows a 3D point cloud collected from the terrestrial laser scanner, viewed obliquely. **(B)** Shows and air photo collected during a LiDAR survey in 2010.

b. Comparison of Years 2 to 3, and long-term erosion rates

- **Area average erosion rates in Year 3 have reduced to 37% during of the Year 2 rate.** This decrease is dominated by the single rockfall reported above, and the period of quiescence thereafter, in addition to the overprint of interannual variability.

- **Modeled erosion rates show a 136% increase during Year 3 and compared to Year 2.** This increase represents both interannual variability and the influence of the single rockfall event reported above, and the following period of relatively minimal erosion.

- With the exception of the rockfall event discussed above, the location of erosion in Year 3 is almost exclusively within the same areas of the cliff face that experience erosion in Years 1 & 2, suggesting continued failure and erosion of these areas.

- The long-term (Year 1 and to Year 3 end) erosion rates are as follows:

    - **39 month area averaged erosion rate is 1.339×10^{-3} myr^{-1}.** This rate is based purely on the rockfalls we observe at site.

    - **39 month modeled erosion rate is 1.293×10^{-3} myr^{-1}.** This rate considers the full range of possible rockfall sizes at this site, and overcomes the limitations of monitoring only a small area / non representative sampling duration.

- Since the start of monitoring we have observed 906.542 m^3 of rockfall.

- On average 1,156 rockfall occur at this site each month (in detectable volumes above 2.5×10^{-5} m^3).

- The average monthly volume of rockfall per month is 38.22 m^3.

- The monthly volume of rockfall for this section of cliff is, on average, lower than that observed elsewhere along this coastline, most likely due to the relatively low (< 30 m) cliff height and hence more limited rockfall source area.

- We highlight key features of the erosion observed between January 2011 and March 2014 in Figure 2, numbered (1) to (4), and discussed below:

    - The largest area of failure captured in Years 1 & 2 (Figure 2 (1, 2)), continues to grow, predominantly laterally across the cliff face. The depth of the failure also increases, suggesting continued failure at this site, to a greater extent compared to that observed in Years 1 & 2. The failure is both joint (structure) and rock-strength controlled as can be seen by the jointed-limited failure perimeter, and is therefore likely to continue developing in a similar manner over coming years. At present we see no indication of continued vertical propagation of this failure which would ultimately result in a failure of the cliff line above. It should however be noted that this failure is steepening this cliff section, which over time will readjust, resulting in failure of the cliff top in the area adjacent to Cowbar Lane. The timescale over which this process may occur is not known, but we note that the highest rates of change observed occur in this location. Other similar features of continued failure are seen in Figure 2(3, 4).

- We see some areas that experience large scale failure (> 1 m^3) in Year 1, but which stall and show no additional change in Year 2 (see overlaps in Figure 6, for example).

- Toe cutting leading to rockfall above, in seen in Figure 2(3), with some evidence of a continued processes of attrition of the toe and then release of material above, where kinematically permissible. At present it remains unlikely that the depth of toe cutting is sufficient to instigate a deeper-seated failure of the rock mass above that would threaten to result in step-back of the cliff line, although continued monitoring may help identify the development of such failures. Such a step back is not beyond what is possible at this site, but remains not probable at present.

- Some evidence of small-scale slumping is seen in the glacial till, but only in isolated positions. Such failures are located in positions of steep till, with sparse vegetation. At present areas that are experiencing this type of failure, are at sections of the cliff line at the greatest distance from Cowbar Lane.

Table 2. Combined erosion rates for Years 1 to 3 for the monitored cliff section. Rates are derived using the methods outlined in the Appendix.

Year	Month	Month	Year	Survey date	Survey epoch length (days)	Running total of days	Number of rockfalls	Total volume of rockfalls (m^3)	Area average erosion rate (x 10 -3 myr^{-1})	m/f modelled erosion rate (x 10-3 myr^{-1})
1	1	January	2011	14/01/2011	0	0	0	0.000	0.000	0.000
	2	February	2011	18/02/2011	35	35	990	31.690	2.770	3.344
	3	March	2011	21/03/2011	31	66	969	31.000	2.710	2.816
	4	April	2011	28/04/2011	38	104	1036	33.150	2.900	1.716
	5	May	2011	20/05/2011	22	126	4	0.130	0.010	0.000
	6	June	2011	17/06/2011	28	154	21	0.680	0.060	0.022
	7	July	2011	21/07/2011	34	188	660	21.110	1.850	0.484
	8	August	2011	25/08/2011	35	223	560	17.930	1.570	2.684
	9	September	2011	27/09/2011	33	256	972	31.110	2.720	4.554
	10	October	2011	21/10/2011	24	280	802	25.660	2.240	4.642
	11	November	2011	17/11/2011	27	307	708	22.650	1.980	3.850
	12	December	2011	19/12/2011	32	339	207	6.620	0.580	0.176
	13	January	2012	17/01/2012	29	368	609	19.480	1.700	1.760
	14	February	2012	23/02/2012	37	405	1323	42.330	3.700	2.816
	15	March	2012	26/03/2012	32	437	1108	35.450	3.100	2.860
	Total after 1 year	-	-	-	-	**437**	**9969**	**318.990**		
	1 year average	-	-	-	**31**	-	**664.6**	**22.790**	**1.992**	**2.115**
2	16	April	2012	18/04/2012	23	460	2074	19.390	1.620	1.480
	17	May	2012	09/05/2012	21	481	1346	24.510	2.950	2.370
	18	June	2012	19/06/2012	41	522	356	3.090	0.360	0.220
	19	July	2012	14/07/2012	25	547	101	2.910	0.330	0.210
	20	August	2012	02/08/2012	19	566	334	2.540	0.390	0.210
	21	September	2012	08/09/2012	37	603	598	7.790	0.880	0.170
	22	October	2012	03/10/2012	25	628	5312	11.150	0.570	0.350
	23	November	2012	15/11/2012	43	671	3231	7.320	0.630	0.360
	24	December	2012	13/12/2012	28	699	227	12.230	0.650	0.450

	25	January	2013	06/01/2013	24	723	2891	2.850	0.510	0.140
	26	February	2013	11/02/2013	36	759	4379	20.240	5.290	1.090
	27	March	2013	12/03/2013	29	788	946	14.930	2.600	2.010
	Total	**-**	**-**	**-**	**-**	**328**	**24141**	**128.950**		
	Average	**-**	**-**	**-**	**29**	**-**	**2368**	**13.040**	**1.398**	**0.755**

	Total over 2 years	**-**	**-**	**-**	**-**	**765**	**34110**	**447.940**		
	2 year average	**-**	**-**	**-**	**31**	**-**	**1222**	**17.228**	**1.718**	**0.009**

	28	April	2013	25/04/2013	44	832	160	366.760	4.979	1.500
	29	May	2013	23/05/2013	28	860	559	1.027	0.014	2.459
	30	June	2013	25/06/2013	33	893	251	7.225	0.098	0.234
	31	July	2013	22/07/2013	27	920	553	8.523	0.116	0.250
	32	August	2013	20/08/2013	29	949	349	6.828	0.093	0.229
	33	September	2013	17/09/2013	28	977	463	40.337	0.548	0.215
3	34	October	2013	21/10/2013	34	1011	641	0.284	0.004	0.384
	35	November	2013	18/11/2013	28	1039	409	7.378	0.100	0.418
	36	December	2013	03/12/2013	15	1054	349	6.862	0.093	0.534
	37	January	2014	17/01/2014	45	1099	517	7.036	0.096	0.205
	38	Febraury	2014	18/02/2014	32	1131	309	1.743	0.024	1.127
	39	March	2014	15/03/2014	25	1156	255	4.600	0.062	2.096
	Total					**1156**	**4815**	**460.530**		
	Average				**30.7**		**401**	**38.217**	**0.519**	**0.010**

	Total over 39 months					**1156**	**38925**	**906.542**		
	39 month average				**30.4**		**963**	**23.856**	**1.339**	**1.293**

4. SUMMARY AND CONCLUSIONS – YEAR 3

The following conclusions have been drawn based upon this analysis:

- **The area averaged rate of retreat in Year 3 alone was 0.519 x 10^{-3} myr^{-1}**.
- **The modeled rate of retreat in Year 3 alone was 0.804 x 10^{-3} myr^{-1}**.
- **The 39 month area averaged erosion rate since the start of monitoring is 1.339 x 10^{-3} myr^{-1}.**
- **The 39 month modeled erosion rate since the start of monitoring is 1.293 x 10^{-3} myr^{-1}.**
- There is no indication that the erosion of the cliff at Cowbar is accelerating or deviating away from behavior observed at this site previously. The fluctuation of erosion rates reported above, both month-on-month and year-on-year, is commensurate with the variability in rockfall patterns observed more widely on this coastline, and beyond.
- This monitoring period has witnessed a rockfall of volume > 300 m^3. Failures of this size are a natural and expected component of coastal cliffs. We note that this area of the monitored cliff section has continued to evolve via a sequence of rockfall since the beginning of the monitoring campaign, and there is no reason to believe that this will cease in future. The trajectory of the rockfall scar appear to be both up- and across-cliff. Further monitoring and close scrutiny of the possible ways in which this failure may develop through time is recommended.
- The concentration of erosion is currently focused away from the 'pinch points' at this site. We observe continued erosion in Year 3 at areas of the cliff that underwent erosion in Years 1 and 2.
- No loss of cliff line was observed during this period, although continued rockfall at the site this indicates cliff steepening, which will in time result in failure of the cliff top. Continued monitoring will help identify where and when this may occur.
- There is no evidence in the monitoring data of the development of a deeper-seated failure which would threaten the road and / or houses above, but we do identify a pattern of rockfalls on the cliff face below.
- We recommend continuation of the monitoring to identify any deviation from the behavior experienced to date.

5. References

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6. DOCUMENT CONTROL SHEET

Project title: Coastal cliff monitoring, Cowbar Nab, Staithes, N. Yorkshire

Revision: 1.1

Status: Revision

Date: 07/04/14

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