Cell 1 Regional Coastal Monitoring Programme
Analytical Report 7 Full Measures Survey 2014

A great place to live, work & play

Scarborough Council
Final Report

February 2015

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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 northeast England coastline, from the Scottish Border (just south of St. Abb's Head) to Flamborough Head in East Yorkshire. This coastline is often referred to as 'Coastal Sediment Cell 1' in England and Wales (Figure 1). Within this frontage the coastal landforms vary considerably, comprising low-lying tidal flats with fringing salt marshes, hard rock cliffs that are mantled with glacial sediment to varying thicknesses, softer rock cliffs and extensive landslide complexes.

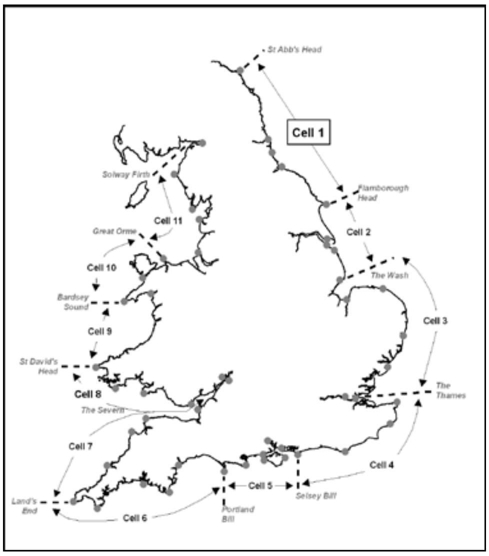

Figure 1 Sediment Cells in England and Wales

The work commenced with a three-year monitoring programme in September 2008 that was managed by Scarborough Borough Council on behalf of the North East Coastal Group. This initial phase has been followed by a five-year programme of work, which started in October 2011. The work is funded by the Environment Agency, working in partnership with the following organisations:

The original three year programme of work was undertaken as a partnership between Royal Haskoning, Halcrow and Academy Geomatics. For the current five year programme of work the data collection associated with beach profiles, topographic surveys and cliff top surveys is being undertaken by Academy Geomatics. The analysis and reporting for the programme is being undertaken by Halcrow (rebranded as CH2M HILL since 2013).

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The main elements of the Cell 1 Regional Coastal Monitoring Programme involve:
- beach profile surveys
- topographic surveys
- cliff top recession surveys
- real-time wave data collection
- bathymetric and sea bed characterisation surveys
- aerial photography
- walk-over surveys

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

Each year, an Analytical Report is produced for each individual authority, providing a detailed analysis and interpretation of the Full Measures surveys. This is followed by a brief Update Report for each individual authority, providing ongoing findings from the Partial Measures surveys. A Cell 1 Overview Report is also produced regularly to provide a region-wide summary of the main findings relating to trends and interactions along the entire Cell 1 frontage.

To date the following reports have been produced:

Table 1 Analytical, Update and Overview Reports Produced to Date

Year		Full Measures		Partial Measures		Cell 1 Overview Report
		Survey	Analytical Report	Survey	Update Report	
1	2008/09	Sep-Dec 08	May 09	Mar-May 09		-
2	2009/10	Sep-Dec 09	Mar 10	Feb-Mar 10	July 10	-
3	2010/11	Aug-Nov 10	Feb 11	Feb-April 11	August 11	Sept 11
4	2011/12	Sept 11	Aug 12	Mar-May 12	Feb 13	
5	2012/13	Sept 12	Mar 13	April-May 13	May 13	
6	2013/14	Sept 13	Feb 14	Mar-April 14	July 14	
7	2014/15	Sept 14	Feb 15 (*)			

(*) The present report is **Analytical Report 7** and provides an analysis of the autumn/winter 2014 Full Measures survey for Scarborough Borough Council's frontage.

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

For purposes of analysis, the Cell 1 frontage has been split into the sub-sections listed in the Table 2. Areas covered in the current report are highlighted

Table 2 **Sub-divisions of the Cell 1 Coastline**

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

1. Introduction

1.1 Study Area

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

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

1.2 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 Hood's Bay (added Spring 2010)
    - Scarborough South Bay (added Spring 2010)
    - Cayton Bay
    - Filey

The location of these surveys is shown in Figure 2. Full Measures surveys were undertaken along this frontage between 9nd and 26th September 2014. The weather was mostly dry, with light breezes and a calm to moderate sea state. For details of the survey conditions refer to the Academy Geomatics survey reports for each location. Information on wave monitoring and the exceptional storms that occurred over the analysis period are provided in Section 2 of this report.

All data have been captured in a manner commensurate with the principles of the Environment Agency's *National Standard Contract and Specification for Surveying Services* and stored in a file format compatible with the software systems being used for the data analysis, namely SANDS and ArcGIS. This data collection approach and file format is comparable to that being used on other regional coastal monitoring programmes, such as in the South East and South West of England.

Upon receipt of the data from the survey team, they are quality assured and then uploaded onto the programme's website for storage and availability to others and also input to SANDS and GIS for subsequent analysis.

The Analytical Report is then produced following a standard structure for each authority. This involves:

- description of the changes observed since the previous survey and an interpretation of the drivers of these changes (Section 2);
- documentation of any problems encountered during surveying or uncertainties inherent in the analysis (Section 3);
- recommendations for 'fine-tuning' the programme to enhance its outputs (Section 4); and
- providing key conclusions and highlighting any areas of concern (Section 5).

Data from the present survey are presented in a processed form in the Appendices.

1.3 Uncertainties in data and analysis

While uncertainty due to survey accuracy or systematic error is likely to be present in all datasets, the work is carefully managed to ensure data are as accurate as possible and results are not misleading. Error may arise from the limits of precision of survey techniques used, from low accuracy measurements being taken or from systematic failings of equipment.

For beach profiles and topographic surveys, all incoming data are checked allowing systematic errors to be identified, and removed from plots and subsequent analysis. The accuracy of these surveys is not known, but it is likely that all measurements are correct to ±0.1m. Therefore, changes are less than ±0.1m are ignored and greyed out in the topographic change plots. For cliff top erosion surveys, there are commonly problems in precisely recognising the cliff edge due to vegetation growth and the convex shape of the feature. Errors manifest themselves as results that suggest the cliff edge has advanced, which is very unlikely unless a toppling failure has been initiated, but the block has not yet fully detached. The accuracy of cliff top surveys are also unknown, but it is assumed that each measurement is accurate to ±0.1m.

These limits of accuracy mean that comparison of annual or biannual data can be of limited value if the measured change is less than or equal to the assumed error. However, all results become more significant over longer time periods when the errors in measurement in years 1 and *x* are averaged over the monitoring period:

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

The effect of averaging error over different monitoring periods is summarised in Table 3, which assumes that each annual survey is accurate to 0.1m.

While considering the uncertainty in comparing and analysing change between monitoring data sets it is also relevant to raise caution about drawing conclusions about short or longer term trends. Clearly the longer the data set the more confidence that can be given to likely ranges of beach changes and trends in change. Potential for seasonal, annual and longer term cycles need to be considered. Studies of long term monitoring data sets for other coastal and estuarial data have established that there are long period cyclical trends related to the 18.6 years lunar nodal cycle which need to be accounted for. Simply put this means that although the Cell 1 monitoring programme now has data in some locations up to 11 years, another 8 to 10 years of consistent data is needed before confidence can be given in trends from the analysis. In the context of this report "Longer Term Trends" are mentioned in each section and it should be noted that this is based on simple visual interpretation of the available data since the current programme began, and is generally based on only 5 years of data.

Table 3. Error bands for long-term calculations of change.

Years between surveys	**Error in inter-survey comparison** (±m/yr)
1	0.200
2	0.100
3	0.067
4	0.050
5	0.040
5	0.033
7	0.029
8	0.025
9	0.022
10	0.020

2. Wave Data and Interpretation.

2.1 Introduction

Wave monitoring data relevant to the Cell 1 Regional Coastal Monitoring Programme is available from one offshore regional wave buoy located at Tyne and Tees and three regional wave buoys, which are further inshore at Newbiggin, Whitby and Scarborough. The Tyne Tees buoy is managed by Cefas as part of the WaveNet system, while the three inshore buoys is managed by Scarborough BC as part of the Cell 1 monitoring programme.

An assessment of baseline wave data is presented in the 2011 Wave Data Analysis Report, which reviewed all readily available data in the region. In 2014 a wave data update report updated the baseline with analysis of the wave data collected under the programme for 2013, including the 5th and 6th December storm. That report was further updated in 2015 to include the records from 2014. In order to help put the beach and cliff changes discussed in this report into context analysed storm data for the wave buoys is presented in this section.

The longest consistent relevant wave data record in the Cell 1 region is from the WaveNet Tyne Tees buoy deployed under the national coastal monitoring programme by Cefas. Data has been downloaded from WaveNet and loaded into SANDS for analysis alongside the beach and cliff monitoring data. Results from analysis of the data to extract details of significant storms are presented in Table 4 below.

To aid interpretation of the results in Table 4 alternate years have been shaded and the storm with the largest peak wave height each year has been highlighted in bold. The annual storm with the highest wave energy at peak has also been highlighted in bold red text as this depends on wave period as well as wave height and so is not always the same as the largest wave height, e.g. in 2009 and 2010.

Table 4: SANDS Storm Analysis at Tyne/Tees WaveNet Buoy (updated to include data to 7th Dec 2014)

General Storm Information							At Peak					
StartTime	***EndTime***	***Dur (hr)***	***Peak of Storm***	***Mean Dir***	***No of Events***	***Mean Direction Vector***	***Hs (m)***	***Tp (s)***	***Tz (s)***	***Dir***	***Energy @ Peak (KJ/m/s)***	***Total Energy (KJ/m)***
19/03/2007 10:30	21/03/2007 05:30	43	20/03/2007 14:30	23	64	78.2	6.2	12.4	8.5	23	1.7E+04	1.4E+07
25/06/2007 20:30	26/06/2007 13:30	17	26/06/2007 10:00	54	18	77.3	4.4	8.6	7.2	23	4.0E+03	1.7E+06
26/09/2007 03:00	27/09/2007 05:00	26	26/09/2007 19:00	11	33	79.7	4.6	11.6	7.6	6	**7.8E+03**	3.6E+06
08/11/2007 20:00	12/11/2007 15:00	91	09/11/2007 08:30	16	58	77.7	**6.2**	**13.3**	**9.0**	**6**	1.9E+04	1.6E+07
19/11/2007 03:30	25/11/2007 21:30	162	23/11/2007 05:00	88	52	76.8	4.9	10.7	7.6	17	7.6E+03	6.8E+06
08/12/2007 03:00	10/12/2007 14:30	59.5	08/12/2007 03:30	106	8	82.9	4.1	10.7	7.6	17	5.4E+03	7.5E+05
03/01/2008 10:30	04/01/2008 01:30	15	03/01/2008 23:30	77	24	14.6	4.2	9.1	7.6	62	4.2E+03	2.5E+06
01/02/2008 15:00	02/02/2008 09:30	18.5	02/02/2008	41	30	80.1	6.0	13.8	9.0	17	1.9E+04	8.7E+06
10/03/2008 08:30	10/03/2008 12:30	4	10/03/2008 11:00	146	9	307.5	4.6	8.1	6.5	141	3.8E+03	7.3E+05
17/03/2008 15:00	25/03/2008 03:00	180	22/03/2008 05:00	81	58	82.1	**7.9**	**12.4**	**9.0**	**6**	2.7E+04	1.7E+07
05/04/2008 22:00	07/04/2008 05:00	31	06/04/2008 19:00	49	20	83.1	4.6	11.7	7.6	6	7.9E+03	3.0E+06
20/07/2008 16:00	21/07/2008 09:30	17.5	20/07/2008 23:30	15	8	76.0	4.2	9.9	7.6	11	4.9E+03	9.1E+05
03/10/2008 03:00	03/10/2008 20:30	17.5	03/10/2008 16:30	55	17	76.7	4.7	11.4	7.6	23	**8.1E+03**	2.8E+06
21/11/2008 04:00	25/11/2008 12:30	104.5	22/11/2008 11:30	15	112	75.8	6.0	13.1	8.5	11	1.7E+04	2.2E+07

General Storm Information							At Peak					
StartTime	***EndTime***	***Dur (hr)***	***Peak of Storm***	***Mean Dir***	***No of Events***	***Mean Direction Vector***	***Hs (m)***	***Tp (s)***	***Tz (s)***	***Dir***	***Energy @ Peak (KJ/m/s)***	***Total Energy (KJ/m)***
10/12/2008 12:00	13/12/2008 18:00	78	13/12/2008 08:00	109	37	332.1	4.9	8.4	7.2	129	4.7E+03	4.0E+06
31/01/2009 16:30	03/02/2009 09:00	64.5	02/02/2009 22:00	84	57	7.2	5.8	9.6	8.5	84	8.7E+03	8.1E+06
23/03/2009 22:30	28/03/2009 20:30	118	28/03/2009 16:30	217	14	89.4	5.3	8.4	7.6	6	5.4E+03	1.3E+06
10/07/2009 01:30	10/07/2009 02:30	1	10/07/2009 01:30	13	2	78.7	4.2	10.0	7.2	11	5.0E+03	2.3E+05
29/11/2009 20:30	30/11/2009 15:00	18.5	30/11/2009 00:30	18	36	72.7	**6.0**	**9.4**	**8.0**	**11**	9.0E+03	5.9E+06
17/12/2009 10:30	18/12/2009 05:00	18.5	17/12/2009 19:30	64	36	26.3	5.4	10.7	8.0	68	**9.4E+03**	5.7E+06
30/12/2009 09:00	30/12/2009 23:00	14	30/12/2009 12:30	84	24	7.7	5.1	7.6	7.2	90	4.1E+03	2.3E+06
06/01/2010 05:30	06/01/2010 11:00	5.5	06/01/2010 06:30	30	10	63.6	4.2	10.7	7.2	11	5.7E+03	1.1E+06
29/01/2010 10:30	30/01/2010 00:30	14	29/01/2010 22:30	9	21	81.9	5.4	8.6	8.0	6	6.0E+03	2.1E+06
26/02/2010 22:30	27/02/2010 02:30	4	27/02/2010 01:00	18	7	72.4	4.6	8.5	7.6	17	4.2E+03	7.0E+05
19/06/2010 07:00	20/06/2010 08:30	25.5	19/06/2010 20:00	21	49	69.2	5.4	10.7	7.6	23	**9.4E+03**	8.5E+06
29/08/2010 14:00	30/08/2010 06:30	16.5	30/08/2010 01:00	243	17	92.8	4.7	8.6	7.6	6	4.7E+03	1.6E+06
06/09/2010 22:30	07/09/2010 16:00	17.5	07/09/2010 15:30	101	22	353.2	4.6	8.8	8.0	90	4.5E+03	2.3E+06
17/09/2010 07:00	17/09/2010 18:30	11.5	17/09/2010 08:30	10	17	80.7	4.7	11.0	8.0	11	7.5E+03	2.9E+06
24/09/2010 03:00	26/09/2010	45	24/09/2010 10:00	21	80	71.6	5.3	10.2	8.0	11	8.0E+03	1.2E+07
20/10/2010 02:00	24/10/2010 16:30	110.5	20/10/2010 10:00	13	16	78.2	4.2	11.2	7.2	17	6.4E+03	1.8E+06
08/11/2010 14:00	09/11/2010 20:30	30.5	09/11/2010 10:00	88	58	3.0	**5.6**	**8.8**	**8.0**	**73**	6.9E+03	7.8E+06
17/11/2010 11:00	17/11/2010 18:30	7.5	17/11/2010 12:00	136	9	322.4	4.7	7.7	6.9	129	3.7E+03	8.1E+05
29/11/2010 19:30	02/12/2010 08:30	61	29/11/2010 21:00	80	45	11.8	5.1	9.4	7.6	56	6.3E+03	5.4E+06
16/12/2010 15:00	17/12/2010 06:30	15.5	17/12/2010 03:30	12	22	79.1	4.6	10.5	7.6	17	6.4E+03	2.8E+06
23/07/2011 14:00	24/07/2011 11:00	21	24/07/2011 03:00	23	39	67.1	**4.7**	**10.7**	**7.6**	**17**	**7.2E+03**	5.8E+06
24/10/2011 18:30	25/10/2011 09:30	15	25/10/2011 09:30	103	26	348.5	4.1	9.5	6.9	79	4.2E+03	2.6E+06
09/12/2011 08:30	09/12/2011 10:00	1.5	09/12/2011 08:30	7	3	84.0	4.1	11.9	8.0	6	6.7E+03	4.8E+05
05/01/2012 16:00	06/01/2012 05:00	13	06/01/2012 03:00	12	19	79.0	4.6	10.5	7.6	17	6.4E+03	2.6E+06
03/04/2012 13:30	04/04/2012 10:30	21	03/04/2012 17:30	66	38	25.1	5.6	8.1	7.6	56	5.9E+03	5.5E+06
24/09/2012 08:30	25/09/2012 10:30	26	25/09/2012 01:30	74	50	16.7	4.7	10.3	8.0	62	6.6E+03	7.4E+06
26/10/2012 16:30	27/10/2012 14:30	22	26/10/2012 23:00	12	34	79.4	4.9	12.8	7.6	11	1.1E+04	4.9E+06
05/12/2012 16:00	15/12/2012 01:30	225.5	14/12/2012 19:30	78	31	18.4	5.4	8.8	7.6	96	6.4E+03	4.5E+06
20/12/2012 06:00	21/12/2012 14:30	32.5	20/12/2012 23:00	101	56	348.4	5.6	9.5	8.0	96	8.0E+03	8.8E+06
18/01/2013 18:30	22/01/2013 06:00	83.5	21/01/2013 10:00	81	54	9.2	6.7	9.4	8.5	84	1.1E+04	1.1E+07
06/02/2013 08:00	07/02/2013 06:00	22	06/02/2013 12:30	47	38	81.6	5.4	10.0	7.6	11	8.2E+03	6.1E+06
07/03/2013 21:00	10/03/2013 21:30	72.5	08/03/2013 04:00	67	37	24.6	4.9	9.0	7.6	73	5.4E+03	4.3E+06
18/03/2013 09:00	25/03/2013 00:30	159.5	23/03/2013 14:30	85	153	5.1	6.0	10.2	8.0	90	1.0E+04	2.8E+07
23/05/2013 18:00	24/05/2013 12:00	18	23/05/2013 22:30	13	32	77.5	6.7	10.5	8.5	17	1.4E+04	7.1E+06

General Storm Information							At Peak					
StartTime	*EndTime*	*Dur (hr)*	*Peak of Storm*	*Mean Dir*	*No of Events*	*Mean Direction Vector*	*Hs (m)*	*Tp (s)*	*Tz (s)*	*Dir*	*Energy @ Peak (KJ/m/s)*	*Total Energy (KJ/m)*
10/09/2013 13:00	10/09/2013 19:30	6.5	10/09/2013 14:00	11	14	79.3	4.4	9.2	7.2	11	4.6E+03	1.5E+06
09/10/2013 22:30	11/10/2013 09:00	34.5	10/10/2013 17:00	68	62	79.8	5.4	10.7	7.6	22	9.4E+03	1.2E+07
29/11/2013 22:30	30/11/2013 06:30	8	30/11/2013 00:30	42	17	84.5	5.6	10.7	8.0	11	1.0E+04	3.3E+06
05/12/2013 14:00	07/12/2013 04:30	38.5	06/12/2013 20:00	24	59	80.8	4.7	14.3	9.0	6	1.3E+04	1.2E+07
27/12/2013 09:30	27/12/2013 12:30	3	27/12/2013 10:00	218	3	249.3	4.1	6.1	6.5	202	1.8E+03	1.3E+05
05/02/2014 04:00	05/02/2014 18:00	14	05/02/2014 05:30	139	9	318.4	4.4	7.8	6.9	129	3.3E+03	7.2E+05
12/02/2014 20:00	14/02/2014 19:00	47	12/02/2014 21:00	183	8	275.6	4.6	7.5	6.5	141	3.2E+03	7.8E+05
21/10/2014 22:00	22/10/2014 01:30	3.5	21/10/2014 23:00	6	5	84.4	4.4	9.6	7.6	6	5.0E+03	6.0E+05

The storms mostly arrive from the north to northeast direction, 0 to 40 degrees, which has the longest fetch, but there are also a significant number of storms from other directions, particularly 80 to 140 degrees.

Comparing the annual storm records it can be seen that 2010 had the most storms (13). In 2010 the largest storm had an incident direction of 73 degrees which is unusual. We might therefore expect that the alongshore drift on the Cell 1 beaches in 2010 may have been atypical with unusual changes from the storm conditions. This was noted in several of the 2010 Full Measures reports.

The year with the fewest storms was 2011. This was reflected by accretion recorded in a number of the annual Full Measures reports.

The winter of 2012 to 2013 appears to have suffered with larger storms than usual, with the second largest peak wave height (7.3m) recorded on 23rd March 2013. The longest duration storm in the record was from 5th to 15th December 2012 (226.5 hours).

The storm on the 5th to 7th December 2013, was particularly notable. Although this event did not have such large waves as the 23rd March 2013 storm, it had a high peak energy and exceptionally long wave period at 14.3 seconds. The 6th December 2013 storm was also accompanied by a significant storm surge with recorded water levels around 1.75m higher that predicted tides. The combined high water levels and large waves causing significant damage to many coastal defences and beaches.

2.2 Wave data for the Scarborough Frontage.

There are two local buoys on the Scarborough Borough Council frontage, at Whitby and Scarborough that were deployed in January 2013. Analysed storm data for these two buoys is presented in Tables 5 and 6.

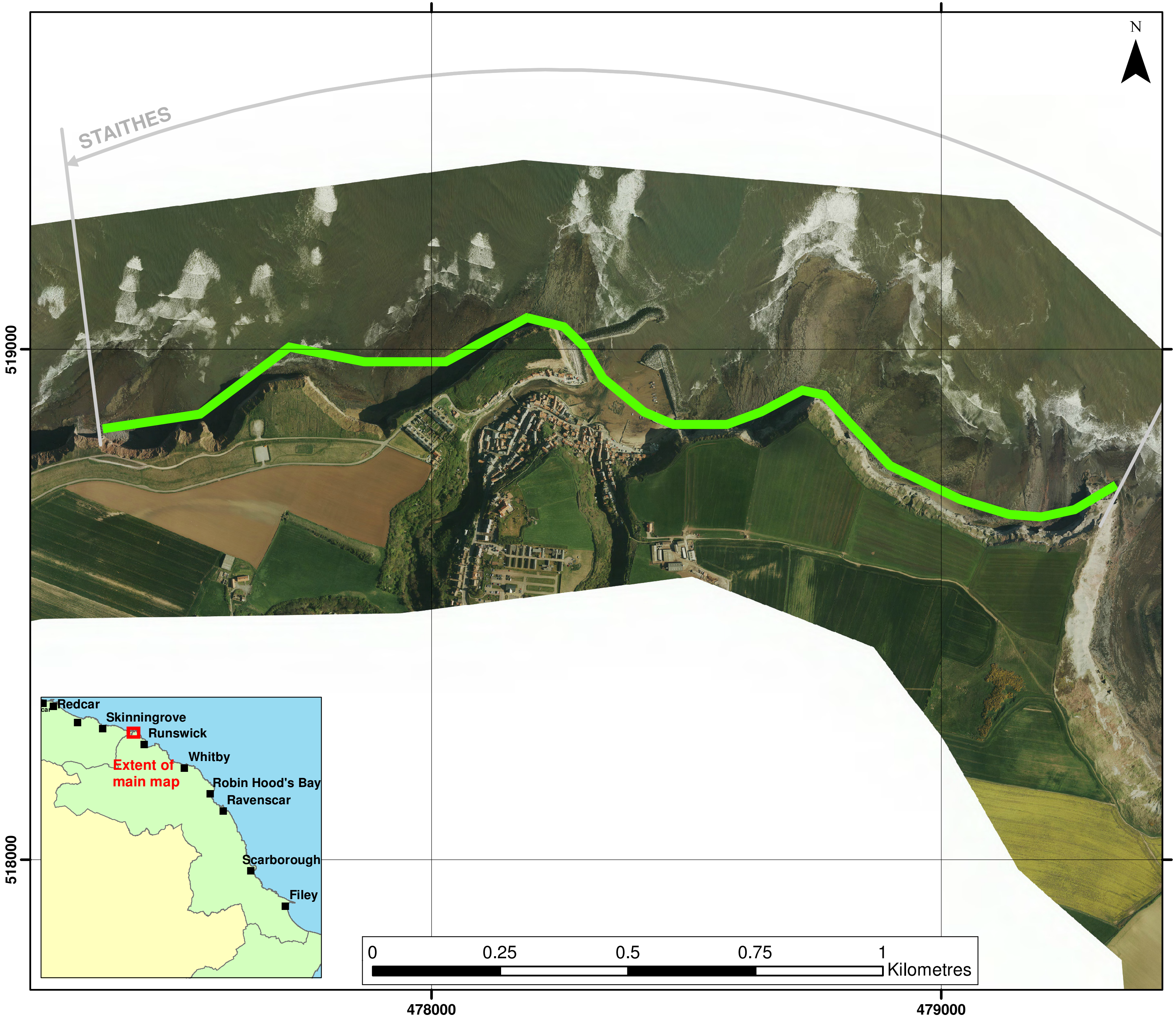
Overall the data for the storms recorded at Scarborough and Whitby are comparable in terms of wave height, period and energy. The highest energy storm recorded at Whitby was the 5th and 6th of December 2013 storm. The second most severe storm at Whitby in terms of wave height and energy was on the 10th October 2013, this is the most severe storm recorded in the Scarborough dataset.

Table 5: Storm analysis for Scarborough WB (data 17/01/2013 to 31/10/2014)

General Storm Information							At Peak					
Start Time	End Time	Dur (hr)	Peak of Storm	Mean Dir	No of Events	Mean Direction Vector	Hs (m)	Tp (s)	Tz (s)	Dir	Energy @ Peak (KJ/m/s)	Total Energy (KJ/m)
21/01/2013 02:00	21/01/2013 20:00	18	21/01/2013 13:00	68	35	22	5.1	9.3	7.8	65	6.4E+03	4.5E+06
06/02/2013 13:30	07/02/2013 02:00	12.5	06/02/2013 17:00	14	15	77	4.3	9.3	7.4	17	4.5E+03	1.7E+06
22/03/2013 20:00	24/03/2013 23:00	51	23/03/2013 15:30	74	99	16	5.1	9.9	7.7	65	7.1E+03	1.4E+07
23/05/2013 21:30	24/05/2013 10:30	13	24/05/2013 00:30	19	27	71	**5.7**	**9.9**	**8.5**	**18**	**9.0E+03**	4.9E+06
10/09/2013 13:00	10/09/2013 22:30	9.5	10/09/2013 19:30	13	19	77	5.0	8.4	7.3	13	4.9E+03	2.3E+06
10/10/2013 02:00	11/10/2013 06:30	28.5	10/10/2013 23:00	28	56	72	5.8	10.5	8.0	21	1.1E+04	1.1E+07
Data missing for 5th / 6th December 2013 storm as buoy was off station												
14/10/2014 03:00	14/10/2014 06:00	3	14/10/2014 04:30	61	4	33	4.4	7.6	6.7	61	3.2E+03	3.2E+05

Table 6: Storm analysis for Whitby WB (data 17/01/2013 to 31/10/2014)

General Storm Information							At Peak					
StartTime	EndTime	Duration (hr)	Peak of Storm	Mean Dir	No of Events	Mean Direction Vector	Hs (m)	Tp (s)	Tz (s)	Dir	Energy @ Peak (KJ/m/s)	Total Energy (KJ/m)
21/01/2013 02:30	22/01/2013 03:00	24.5	21/01/2013 14:30	64	38	27	5.0	9.3	8.2	61	6.0E+03	5.0E+06
06/02/2013 11:00	07/02/2013 04:00	17	06/02/2013 18:30	17	35	73	4.8	9.9	7.1	16	6.4E+03	4.3E+06
08/03/2013 03:30	11/03/2013 05:30	74	11/03/2013 04:00	58	12	36	4.3	8.4	7.1	45	3.7E+03	1.1E+06
18/03/2013 18:30	24/03/2013 17:30	143	23/03/2013 13:00	70	95	20	5.2	9.3	8.2	72	6.6E+03	1.2E+07
23/05/2013 21:00	**24/05/2013 12:30**	**15.5**	**24/05/2013**	**20**	**27**	**70**	**5.8**	**10.5**	**8.3**	**24**	**1.0E+04**	**5.0E+06**
10/09/2013 14:00	10/09/2013 22:30	8.5	10/09/2013 16:00	19	17	72	4.4	9.3	6.9	24	4.6E+03	1.8E+06
10/10/2013 01:30	11/10/2013 06:30	29	11/10/2013	30	57	69	5.7	11.2	8.3	31	1.1E+04	1.1E+07
30/11/2013	30/11/2013 06:30	6.5	30/11/2013 03:30	16	13	75	4.8	10.5	7.4	20	7.1E+03	2.1E+06
05/12/2013 20:00	06/12/2013 22:00	26	06/12/2013 19:30	20	45	71	4.7	14.0	9.1	32	**1.2E+04**	8.2E+06
14/10/2014 04:30	14/10/2014 05:30	1	14/10/2014 05:30	52	2	40	4.1	7.0	6.5	53	2.3E+03	1.2E+05



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

Analytical Report 7
Full Measures Survey
Autumn 2014

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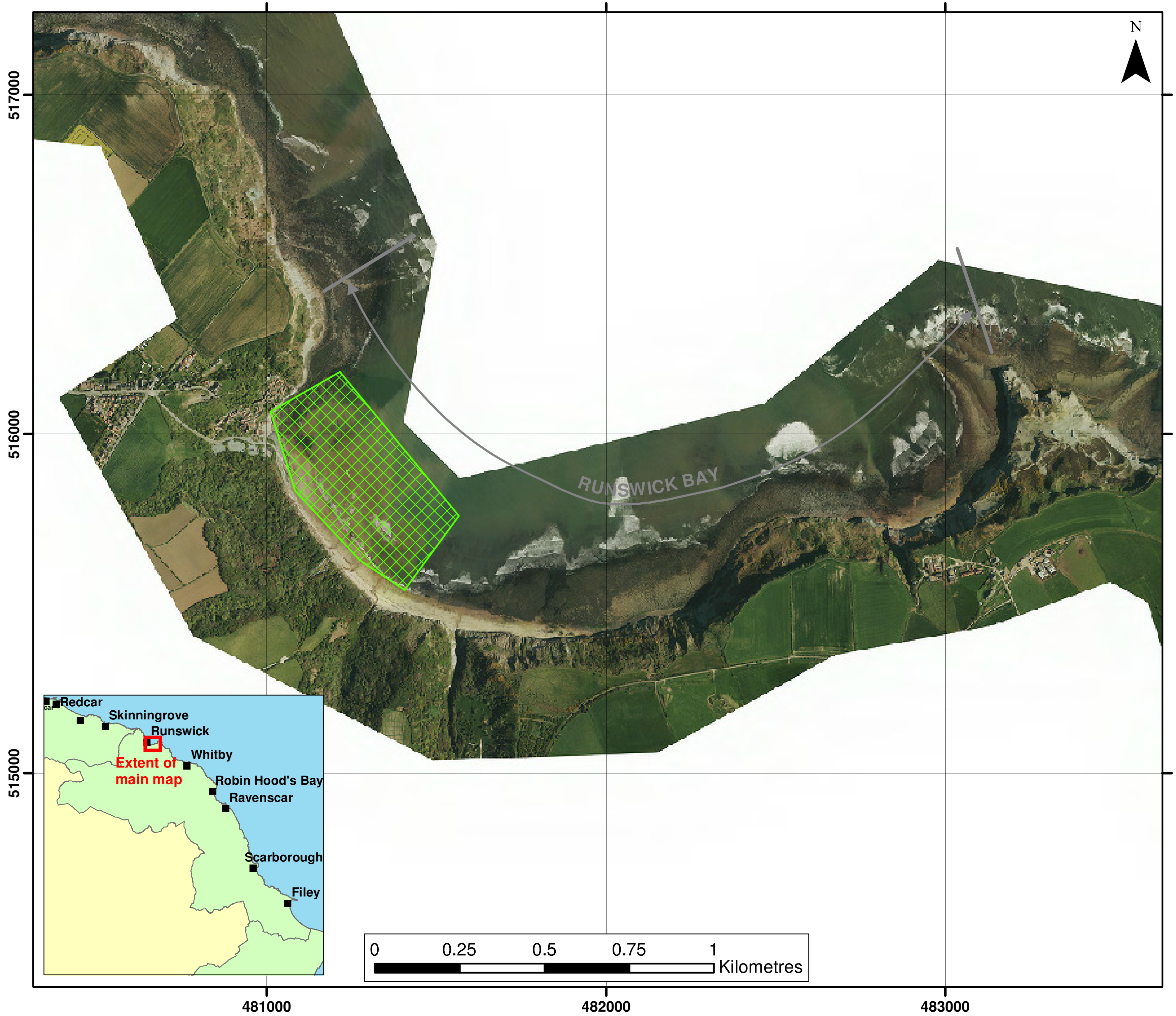

KEY

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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Full Measures Survey
Autumn 2014

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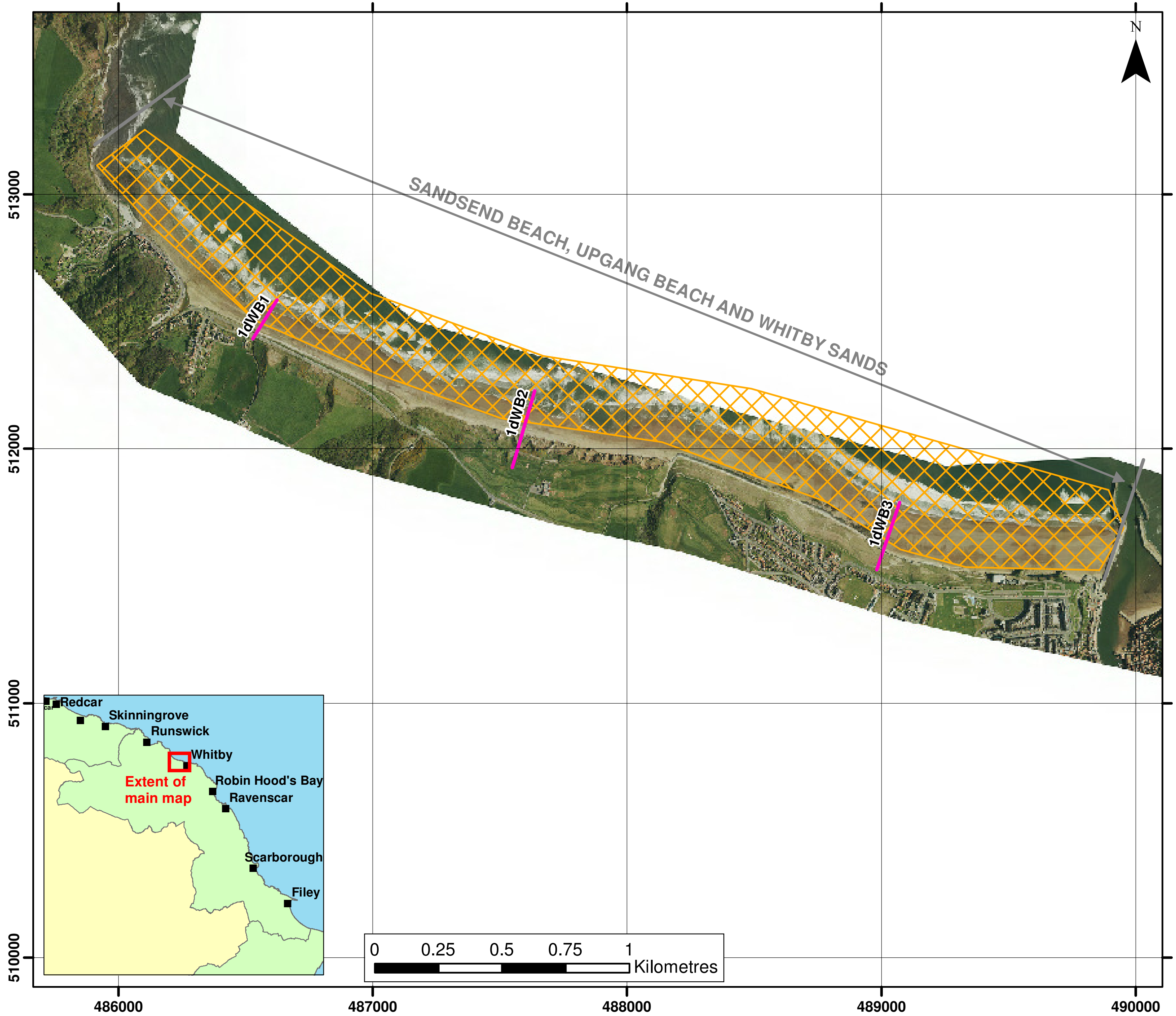

KEY

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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Partial Measures Survey
Autumn 2014

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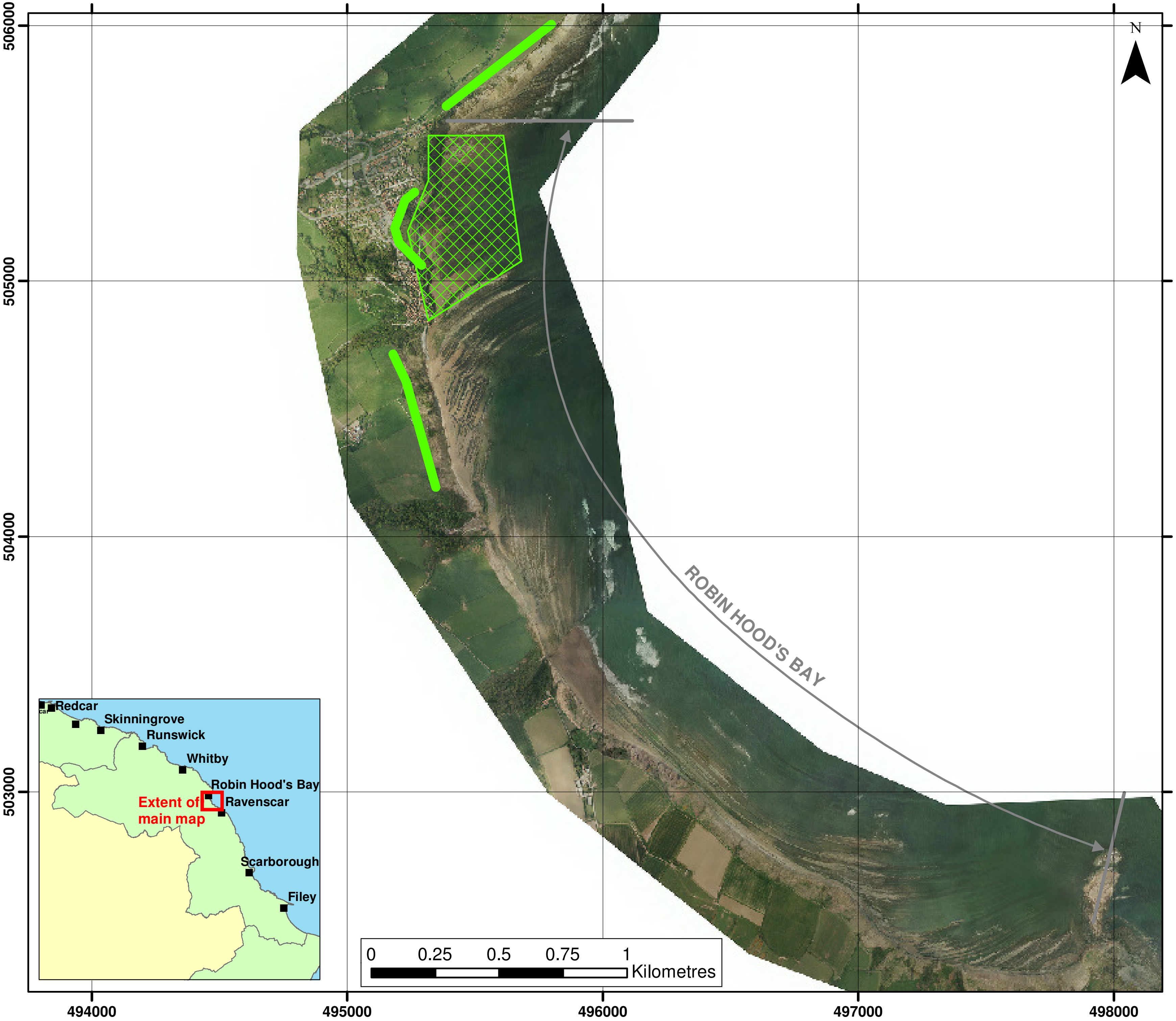

KEY

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

Analytical Report 7
Full Measures Survey
Full 2014

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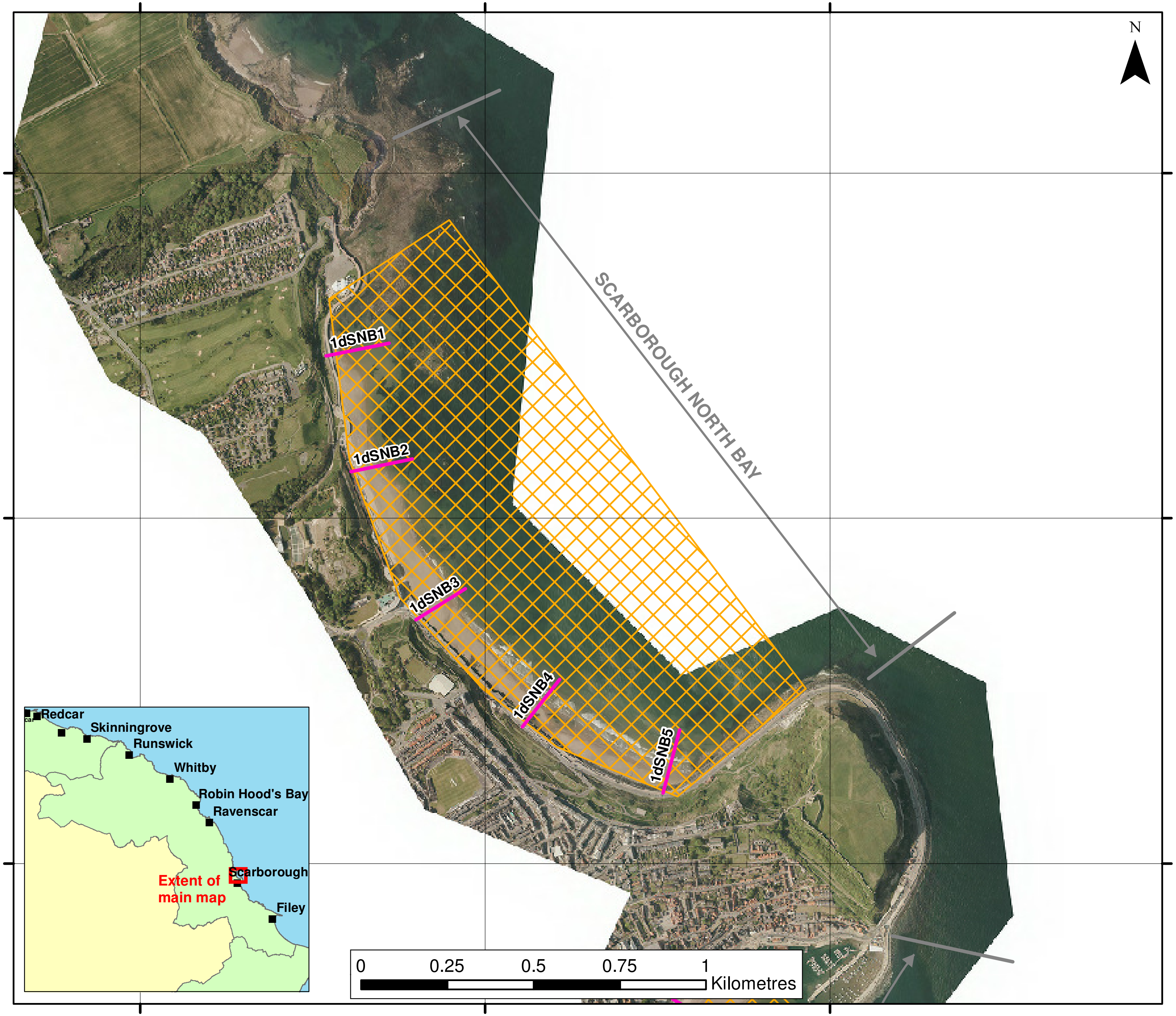

KEY

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

Analytical Report 7
Full Measures Survey
Autumn 2014

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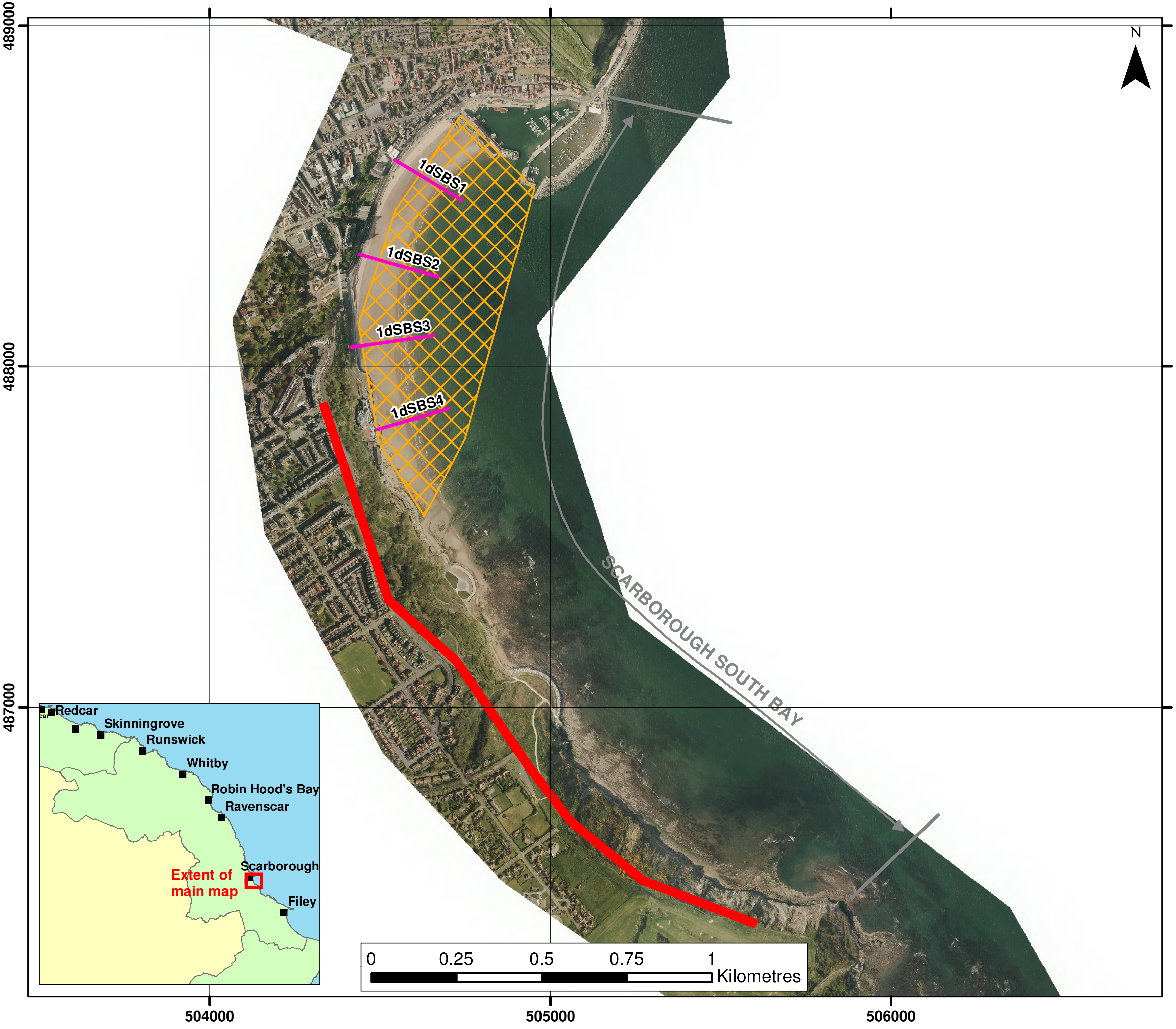

KEY

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

Analytical Report 7
Full Measures Survey
Autumn 2014

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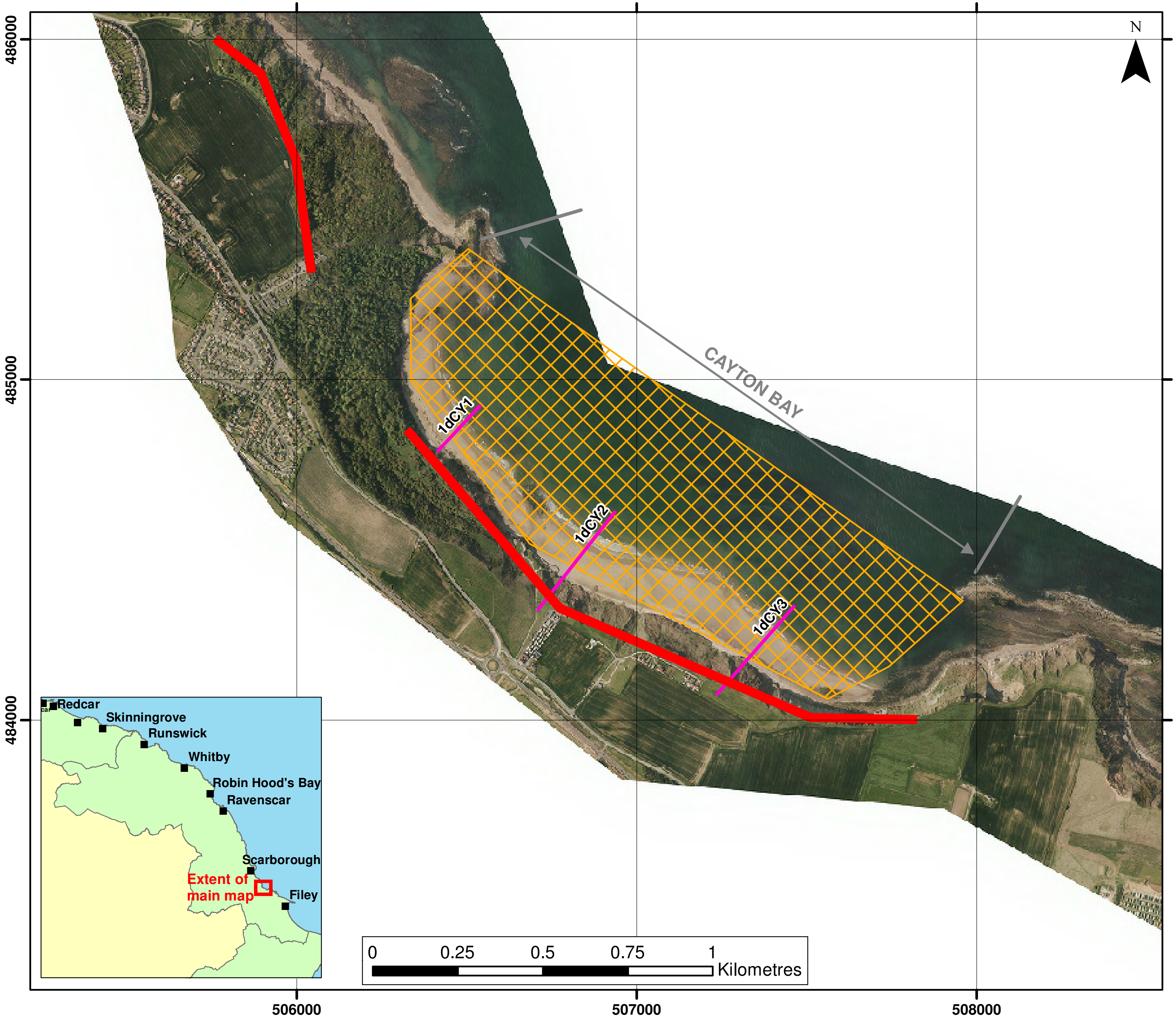

KEY

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

Analytical Report 7
Fulll Measures Survey
Autumn 2014

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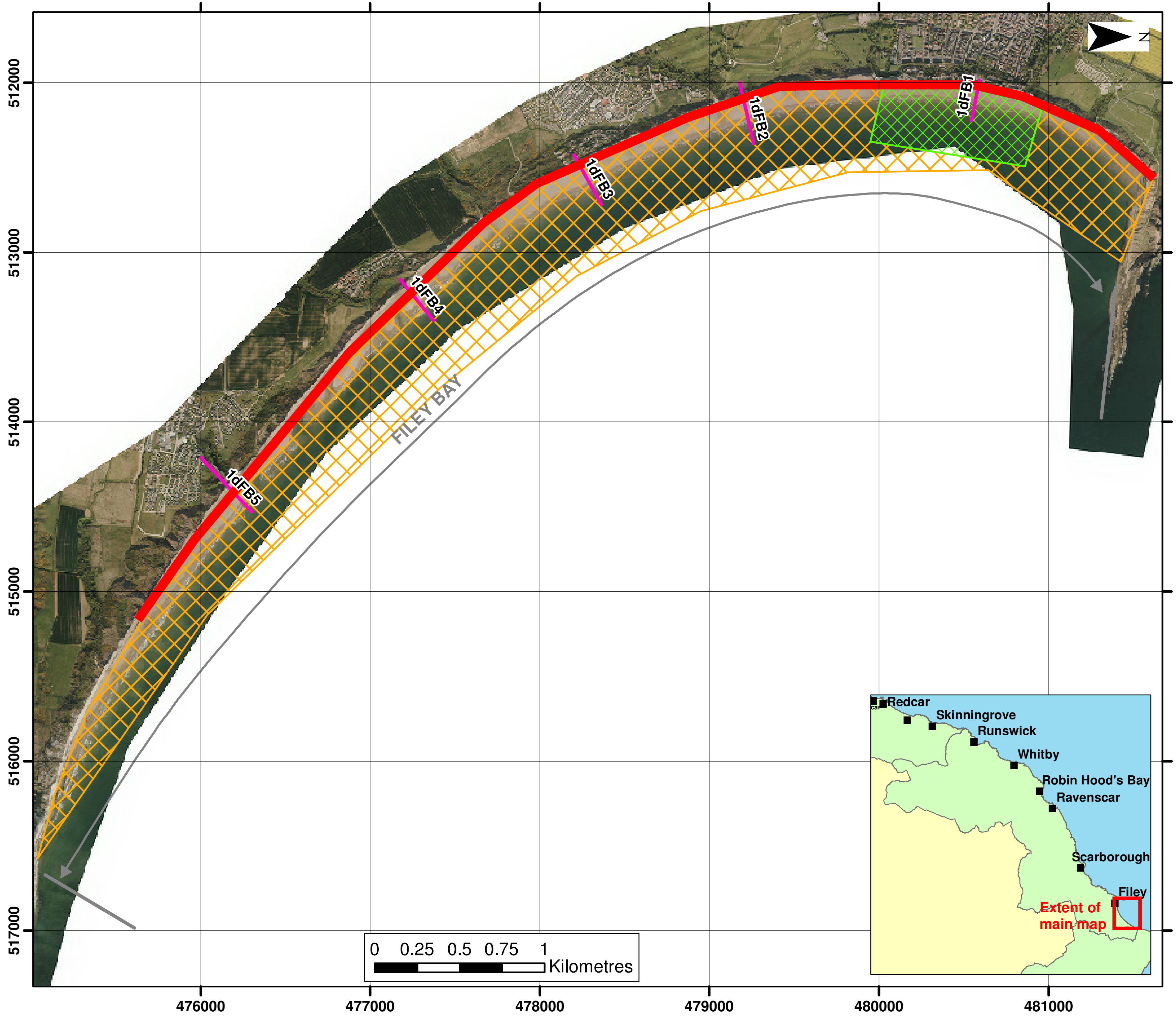

KEY

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

Analytical Report 7
Full Measures Survey
Autumn 2014

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3. Analysis of Survey Data

3.1 Staithes

Survey Date	Description of Changes Since Last Survey	Interpretation
17th Oct 2014	**Cliff-top Survey:** Twenty ground control points have been established at Cowbar and Staithes for biannual cliff top monitoring. Locations 12 to 20 are in the Scarborough Borough Council area. The separation between any two points is around 100 m. Data collection involves a distance offset measurement from the ground control point to the cliff edge along a fixed bearing. Between April 2014 and October 2014 14 of the 20 posts showed change within a range of ±0.1m, which is not considered significant given the error of the technique. Posts 5 and 15, 16 and 20 showed the largest erosion with 0.3 to 0.4m cliff recession recorded. Calculation of longer-term erosion rates based on the recorded change between 2008 and 2014 indicates that seventeen posts on the frontage recorded a change rate within a range of ±0.1m/yr, which is considered to be within the error of the measurement. Post 13 (near the eastern breakwater) shows consistent erosion through the surveys at 0.4m/yr. This pattern was very similar to that observed in the 2013 Full Measures Report. Appendix C provides results from the October 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.	Up to 0.4m of cliff recession was recorded at four of the 20 monitoring points in the 6 months to October 2014. **Longer term trends**: Table C1 shows that survey location 13 has shown the greatest total erosion with a loss of 2.2m (±0.1m) between the November 2008 baseline and October 2014, resulting in a long term average recession rate of 0.4m/yr. This area is above the eastern breakwater and is known to have experienced rock falls previously. All other points are within the margin of error over the longer term.

3.2 Runswick Bay

Survey Date	Description of Changes Since Last Survey	Interpretation
22nd Sept 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 (Autumn 2014) and the previous survey (Spring 2014) 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 three main areas of change on the beach at Runswick Bay. In the north of the bay the foreshore has experienced erosion of up to 1m, whereas a narrow shore parallel strip at the back of the beach has experienced erosion of up to 0.75m. Further south, this continuous band of accretion diverges from the shore and becomes separated from the cliffs by shore-parallel area of beach erosion of up to 0.75m. There is also a small area of accretion at the landward edge of the survey area between the sailing club in the centre of the bay and Barnby Dales. **Long Term Topographic Trends Autumn 2008 to Autumn 2013:** Appendix B - Map 1c shows that the centre of the beach has been dominated by erosion of c. 0.5 m while the upper and lower sections of beach have accreted by up to 1m.	Between March and September 2014 Runswick Bay showed a mixed pattern of erosion and accretion in strips that are slightly oblique to the shoreline. The pattern indicates two contributory patterns – migration of sand bars and a southwards drift of material. **Longer term trends**: As expected the beach has been remodelled since the last survey, which recorded the impact of the December 2013 storm surge. Areas that had accumulated to up to 1m by the March 2014 survey have been eroded by a similar amount and accretion has occurred where previously there was erosion. **Autumn 2008 to Autumn 2014 trends:** The long term difference plots show that centre of the beach is eroding while the upper and lower beach have accreted. In the northern part of the bay, fronting the northern end of the village, there has been up to 1m of erosion, which will cause greater exposure of the sea defences. However, in most other parts of the bay, the upper beach has accreted.

3.3 Sandsend Beach, Upgang Beach and Whitby Sands

Survey Date	Description of Changes Since Last Survey	Interpretation
25th and 26th Sept 2014	**Beach Profiles:** The frontage spanning Sandsend Beach, Upgang Beach, and Whitby Sands is covered by three beach profile lines, spaced between Sandsend and Whitby West Cliff (Appendix A). At profile **1dWB1** no change has occurred as far as 33m chainage. Between 33m and 46m chainage the beach at the toe of the sea defences has eroded by 0.25m since March 2014 but the beach level is similar to that seen in September 2013**.** A berm has formed in the upper beach between 46m and 85m chainage through accretion of around 0.25m of sediment. Between 85m and 160m chainage there has been around 0.6m of erosion and between 160m chainage and the end of the survey at 230m chainage a small berm has formed through the accretion of 0.4m of sand. Overall the beach is at a high level except at the toe of the sea defences where it is at a middle level. At **1dWB2** the profile above the HAT level has not changed significantly except for the development of a berm through accretion of 0.4m of gravel and sand since March 2014. Minor accretion has occurred between 170m and 200m chainage, but the most noticeable change is the development of a large berm in the lower foreshore through the accretion of up to 1m of sand between 200m chainage and the end of the survey at 280m chainage. This has considerably reduced the gradient of the beach compared to previous surveys. At profile **1dWB3** fronting the stabilised face of Whitby West Cliff, from the base of the sea wall at 90m chainage to 150m chainage the beach has accreted by around 0.3m since March 2014. Between 150m and 165m chainage there has been minor erosion of around 0.1m. Between 165m chainage and the end of the survey at 265m chainage there has been 0.5m of accretion. This has led to the development of two subtle berms in the upper and lower beach with a shallow swale in-between. Beach levels are relatively high compared to earlier surveys. **Topographic Survey:** The Sandsend to Whitby frontage is covered by an annual topographic survey, providing continuous data for Sandsend Beach, Upgang Beach, and Whitby Sands. Data have been used to create a DGM	All the profiles are relatively high compared to earlier surveys and there has been a general trend for shallowing of the beach gradient. This is most notable at 1cWB2 on Upgang Beach. The topographic difference plots show a complex spatial pattern of erosion and accretion, however net changes in the centre of the bay are much more pronounced than at the distal ends, suggesting an area of sand bar development and migration. This pattern has been noted in all surveys since 2010. The cliffs of Upgang Beach in the central part of the study area are undefended and erosion provides an important source of material to the beach. It is likely that sediment released by erosion over the winter months is subsequently redistributed across the beach as migrating sand bars. **Longer term trends**: the beach profiles show seasonal variation but no linear trend of accretion or erosion. The 6-monthly topographic difference plots show similar patterns of accretion and erosion in the all surveys although the magnitude of change is less in 2014. **Autumn 2008 to Autumn 2014 trends:** The long term difference plot for the Whitby to Sandsend frontage shows accretion of up to 1m at the margins of the bay and erosion in the middle of the bay. The middle of the bay is also the focus of cliff erosion, and shows active

Survey Date	Description of Changes Since Last Survey	Interpretation
	(Appendix B – Maps 2a and 3a) using GIS. The GIS has also been used to calculate the differences between the current topographic survey DGM (Autumn 2013) and the earlier topographic survey DGM (Autumn 2014), with 5m resolution raster grids (as shown in Appendix B – Maps 2b and 3b), to identify areas of erosion and accretion. Appendix B – Maps 2b and 3b show a varied picture of erosion and accretion with most changes being broadly shore parallel strips. At the margins of the bay changes are more muted and generally less than 1m, whereas on Upgang beach and at the eastern end of Sandsend Beach there are several linear strips where accretion of over 1m has taken place. An extensive area of erosion of up to 1m is present at the base of the cliffs and upper beach just beyond the western end of the West Cliff defences. **Long Term Topographic Trends Autumn 2008 to Autumn 2013:** The long term difference plot shows that Sandsend Beach and Upgang Beach have generally accreted by 0.5 to 1.5m since 2008, while the Whitby Sands has experienced less net change overall. There is a notable area of erosion of 0.5 to 1m at the western margin of Upgang Beach, which is backed by actively eroding cliffs.	mudslides. The sediment supplied by mudslides must either be lost offshore or transported to the east and western margins of the bay.

3.4 Robin Hood's Bay

Survey Date	Description of Changes Since Last Survey	Interpretation
12th Sept 2014	**Topographic Survey:** Robin Hood's Bay is covered by a six-monthly topographic survey. Data have been used to create a DGM (Appendix B - Map 4a) using GIS. The GIS has also been used to calculate the differences between the current topographic survey DGM (Autumn 2014) and the earlier topographic survey DGM (spring 2014), with 5m resolution raster grids (as shown in Appendix B – Map 4b), to identify areas of erosion and accretion. Appendix B - Map 4b shows a very patchy distribution of areas of accretion and erosion since April 2014. Overall, accretion is slightly more dominant and is up to 0.75m across the majority of the bay. However, there are also notable areas of erosion, most notably at Dungeon Hole where there is a linear strip of up to 1m erosion at the base of the cliffs. **Long Term Topographic Trends Autumn 2008 to Autumn 2014:** The plot of difference between 2008 and 2014 (Appendix B - Map 4c) shows a patchy distribution of accretion at the back of the beach and erosion towards MLW, but with no clear net change. **Cliff-top Survey:** Thirteen ground control points have been established at Robin Hood's Bay since March 2010 to monitor cliff recession. The separation between any two points is around 200m. Table C2 shows that two locations showed erosion between April and September 2014, with markers 7 and 9 retreating by more than 0.1m. However, inspection of the survey photos indicates this is due to difficulty locating the cliff edge precisely as the break in slope is quite gentle. Using data recorded between March 2010 and November 2014, calculated erosion rates show little change in all markers except Marker 1 which shows recession of 0.8m/yr. However, this marker has showed very little change since March 2012.	The topographic change plot shows that accretion is the dominant trend in the bay. This is likely to reflect a usual summer pattern of beach building. The erosion at the base of the cliffs at Dungeon Hole is likely the removal of material from earlier failures of the cliff face which has been deposited at the toe. Progressive removal of this material will expose the base of the cliffs to marine action and further cliff recession. Overall the cliff top at Robin Hoods Bay has been stable since April 2014. Even those changes at locations showing apparent recession >0.1m are likely to be attributable to difficulties surveying a subtle break in slope at the cliff edge. **Longer term trends:** The limited change recorded in Robin Hoods Bay is due to the resistant rock platforms and thin, patchy cover of sand. In contrast, the erosional hotspots are likely to correspond to local pockets of more mobile sand adjacent to the shore. **Autumn 2008 to Autumn 2014 trends** Although the long term plot shows patches of accretion and erosion over the past year, only limited change has been observed across much of the bay in the long term. This is because of the thin veneer beach and rocky foreshore. Accretion was recorded on the upper beach close to the northern limit of the survey.

3.5 Scarborough North Bay

Survey Date	Description of Changes Since Last Survey	Interpretation
24th Sept 2014	**Beach Profiles:** Scarborough North Bay is covered by five beach profile lines, distributed between the Sealife Centre at Scalby Mills and Clarence Gardens (Appendix A). Profile **1dSBN1** remains stable at the defended, upper part of the profile. From 10m to 30m chainage, minor accretion of 0.1m of material has occurred since March 2014. From 30m to 95m chainage the beach has eroded by 0.4m to make this part of the beach profile concave. Between 95m and 110m chainage there has been very minor accretion to create a subtle berm. Between 110m and 145m chainage there has been minor erosion of 0.1m chainage. Seaward of 145m chainage the accretion has extended the profile above MLWS to 180m chainage. Overall the changes in this profile are very subtle. The upper beach remains relatively high and the lower beach relatively low and is therefore steep in comparison to most previous surveys. At **1dSBN2** the beach is characterised by a shifting berm in the profile, which can form on the upper or lower beach. In September 2014 the berm is on the upper beach it has accreted by 1m since March 2014. From 60m chainage to the rocks at 117m chainage the level of the beach has dropped by 0.4m. This has exposed the rocky shore platform between 110 and 105m chainage. When compared to the past surveys the upper beach at its highest level recorded and the lower beach nearly at its lowest, giving one of the steepest profiles to date. The beach at profile **1dSBN3** has experienced up to 0.75m accretion at the base of the sea wall as far as 40m chainage since March 2014. Between 40m and 50m chainage there has been little change. Seaward of 50m chainage to the end of the survey at c.165m chainage there has been up to 1m accretion. The upper beach is now at a middle level relative to previous surveys gradually transitioning to a high level further seaward. The gradient of the beach is not particularly steep or shallow compared to previous surveys. The profile at **1dSBN4** has eroded by 0.5m between 25m and 40m chainage since March 2014, to deepen and widen the trough at the base off the sea wall and partly expose the rocky shore platform. Between 40m chainage and 80m chainage accretion of 0.4m has occurred to cover the shore platform.	The majority of profiles are relatively level and the northerly profiles are particularly steep. Scour troughs remain present at the base of the seawall in the more southerly profiles, exposing the rock shore platform, but there is accretion immediately seaward of these scour troughs. The pattern of foreshore erosion and upper beach accretion is likely a product of sediment being driven onshore over the summer by surging waves. The south of the bay shows more muted change, but overall the trend is one of accretion. Results near the former chairlift should be treated with caution as the surveyors noted that beach grooming had occurred in this area. **Longer term trends:** The observed trends in the topographic plots and beach profiles point to overall stability with superimposed seasonal fluctuations. **Autumn 2008 to Autumn 2014 trends:** The erosion and accretion pattern suggests transport of material to the margins of the bay but with a preference for drift towards the north of the bay. This is also the pattern shown in previous surveys. **Post Storm January 2015** In the northern and central bay, the storm appears to have stripped sediment from where it had previously been accreting and driven it both up the beach and

Survey Date	Description of Changes Since Last Survey	Interpretation
	Little change has occurred between 80m and 105m chainage. Seaward of here there has been 0.3m of accretion as far as the end of the survey at 180m chainage. Overall the profile is at a high level in the upper beach and lower foreshore and a middle level in-between. On profile **1dSBN5** the gradient of the beach is similar to the March 2014 survey, but the beach has accreted by up to 0.5m throughout. The beach is at one of its highest levels to date. **Post Storm Survey:** An additional survey was undertaken at Scarborough North Bay on 24th January 2015, atypical sediment movements during early January 2015.The data show the following changes: At **1dSBN1** around 0.2m of sand at the base of the sea wall has been eroded between 10m and 22m chainage. Accretion of up to 0.25m has occurred between 22m and 90m to form a berm in the upper beach and steepen the profile. Erosion of up to 0.15m has occurred between 90m and 155m chainage. Minor accretion has occurred in the lower intertidal zone between 155m chainage and the end of the survey at 180m chainage. The profile in the upper beach remains relatively high, and the foreshore low, in comparison to earlier surveys. At **1dSBN2**, up to 0.7m of sand has accreted against the sea wall between 7.5m and 19m chainage. Accretion has also occurred between 19m and 28m, but is much less (up to 0.2m). Between 29m and 95m chainage, the beach and foreshore have eroded by up to 0.3m. Minor accretion (<0.2m) has occurred in lowest part of the profile between 97m and the end of the survey at 118m chainage. The upper part of the profile is at its highest level, the middle is at a middle level and the toe is at its lowest in comparison to previous surveys. At **1dSBN3**, the beach and upper foreshore have accreted by up to 0.5m between the seawall and 120m chainage. The lower foreshore has eroded by 0.3m between 120m chainage and the end of the profile at 160m chainage. Except at the very seaward end of the survey, the beach is at a relatively high level compared to previous surveys. At **1dSBN4**, further erosion against the seawall has occurred to expose to further deepen and widen the already-present trough and expose the rocky shore platform between 25m and 60m chainage. Minor accretion (up to 0.2m) has occurred between 60m and 110m chainage. Little change has occurred between 110m and the end of the survey at 180m chainage. The upper beach is now at nearly its lowest	towards the centre of the bay, steepening the beach profile in the more northerly profiles. In the south of the bay, there has been less change and in contrast the upper beach has eroded and the foreshore accreted. However, despite these changes, overall the beach profiles in the north of the bay remain high compared to previous surveys and those in the south remain low.

Survey Date	Description of Changes Since Last Survey	Interpretation
	level, but the middle and lower beach are at mid-to-high levels in comparison to earlier surveys. At **1dSBN5**, minor accretion has occurred between the seawall at 27m chainage and 150m chainage. Between 150m chainage and the end of the survey at 180m chainage there has been minor (<0.1m erosion). The whole profile is at, or near, its highest level since monitoring began.	
	Topographic Survey: Scarborough North Bay is covered by an annual topographic survey. Data have been used to create a DGM (Appendix B - Map 5a(i)) with GIS. The GIS has also been used to calculate the differences between the current topographic survey DGM (Autumn 2013) and the earlier topographic survey DGM (Autumn 2012), with 5m resolution raster grids (as shown in Appendix B – Map 5b(i)), to identify areas of erosion and accretion. Appendix B - Map 5b shows that, in the north of the survey area, there is a strong pattern of erosion in the foreshore and accretion in the upper beach, indicating mobile sediment in this part of the bay has been driven towards the back of the beach over the past 12 months **Long Term Topographic Trends Autumn 2008 to Autumn 2014:** The long term topographic plots in Appendix B – Map 5c show that accretion of 1 to 2m in the north of the frontage has been observed over the last six years. The centre of the bay shows erosion generally less than 1m and greatest at the back of the beach near the Watermark Café. The southern extent of the bay shows a mixture of accretion and erosion, which is less severe than further north in the bay. **Post Storm Topographic Survey** Appendix B – Map 5a(ii) shows elevation across the beach following the storm of xxth January 2015. This has been compared to the FM 2014 survey to produce Appendix B Map 5b(ii). This map shows that in the north of the bay there has been extensive erosion in the middle beach and accretion at the very back of the beach against the seawall. In the central bay the lower intertidal zone has been eroded and accretion has occurred in the upper beach, along with accretion of over 1m in the middle beach in front of the semi-circular arrangement of beach huts. In the southern third of the bay, limited accretion (<0.25m) has occurred in the foreshore and limited erosion has occurred in the upper beach.	

3.6 Scarborough South Bay

Survey Date	Description of Changes Since Last Survey	Interpretation
23rd Sept 2014	**Beach Profiles:** Scarborough South Bay is monitored by four beach profiles, between the harbour in the north and the Spa Complex in the south (Appendix A). Sediment recycling took place in May 2014 to address an accumulation of sediment at the north end of the bay and very low beach levels in front of Scarborough Spa. As such, comparisons of short-term change are between May and September 2014. At profile **1dSBS1** up to 0.7m of sediment has accumulated against the sea wall between 15m and 50m chainage. Very little change as taken place (±0.1m) between 50m and 160m chainage. Between 160m chainage and 200m chainage 0.2m of erosion has taken place to form a shallow trough. Seaward of this to the end of the survey accretion of up to 0.2m has occurred to create a subtle berm in the lower foreshore. Overall the upper beach and foreshore are relatively high. The beach at profile at **1dSBS2** has changed very little with only minor erosion or accretion (<0.2m) having taken place throughout the profile since May 2014. The upper beach is at a mid-level and the foreshore is at a low level compared to previous surveys. At profile **1dSBS3** a small scour trough at the base of the seawall between 8m and 15m chainage has been infilled with up to 0.5m of sand since May 2014. Between 30m and 170m chainage, the beach has accreted by up to 0.2m to produce an undulating profile. From 170m chainage to the end of the survey at 230m chainage, there has been erosion of 0.5m in the lower foreshore to steepen the profile at its most seaward extent. The upper beach is at a medium level compared to earlier surveys but the foreshore is relatively low. Profile **1dSBS4** shows very little change relative to May 2014. The profile is fairly straight and the beach is at fairly high level in comparison to surveys prior to the sediment recycling, particularly at the base of the sea wall. **Topographic Survey:** Scarborough South Bay is covered by an annual topographic survey. Data have been used to create a DGM (Appendix B - Map 6a) using GIS. The GIS has also been used to calculate the differences	The level of the beach in the profiles is variable in comparison to previous surveys. The most northerly profile shows an accumulation of sediment in the north of the bay against the sea wall, but relatively little change elsewhere. The short term change plot also shows variable erosion and accretion. The accumulation in the north-east of the survey area is likely a result of sediment being driven up the beach over the summer and the general northwards migration of sediment within the bay. The shore-parallel strip of erosion in front of the Spa indicates that natural processes have moved sediment away from this area after the beach management of May 2014. The cliff top change markers have indicated negligible change at most locations markers. However 0.9m was recorded at one location due to minor failure at a mudslide headscarp. **Longer term trends**: The beach profiles show that beach levels recorded in 2014 were near the middle of their past range. The beach was re-profiled in 2014, but there is already evidence of sediment being moved away from the nourished areas in the middle of the beach and returned to the north from where it had been removed. **Autumn 2008 to Autumn 2014 trends:** The long term difference plot shows widespread by low magnitude

Survey Date	Description of Changes Since Last Survey	Interpretation
	between the current topographic survey DGM (Autumn 2014) and the earlier topographic survey DGM (after sediment recycling in May 2014), with 5m resolution raster grids (as shown in Appendix B – Map 6b), to identify areas of erosion and accretion. Appendix B - Map 6b shows a mixture of erosion and accretion throughout the survey area. In the north of the bay there is an extensive area of erosion in the foreshore and an accumulation of sediment in the upper beach, but these are not very severe (<0.75m). Accretion dominates the centre of the survey area. There is patchy erosion of limited severity in the foreshore in the south of the survey area. At the back of the beach there are three notable shore-parallel strips of erosion; one at the south end of Foreshore Road, one in front of Scarborough Spa (just missed by transect 1dSBS3) and one running from the southern end of the Spa Complex to Clock Café. The erosion in all of these is up to 0.5m **Long Term Topographic Trends Autumn 2008 to Autumn 2014:** The long term plot of change (Appendix B Map 6c) shows that Scarborough South Bay has accretion of c. 0.5m in the north of the bay and in the south fronting the Spa Complex. The middle part ofthw bay is dominated by erosion of c. 0.5m. There is a band of moderate erosion running north to south against the sea wall in the northern part of the survey area. The area of most severe erosion is at the back of the beach just south of Valley Road, where up to 1m lowering has occurred.	erosion in the centre of the survey area of c. 0.5m and slight accretion of c. 0.5m at the foreshore in the north of the bay and in the south of the bay. This indicates that sediment is being moved north and south away from the centre of the bay near Valley Road. Table C3 shows that since March 2010 the majority of the cliff erosion profiles have shown negligible recession. Profiles 11 and 12 show erosion of 0.7 and 0.4 m/year respectively. These points are at the rear of a mudslide system which experiences periodic reactivation or headscarp collapse.
	Cliff-top Survey: Thirteen ground control points have been established at Scarborough South Bay, extending from South Bay to Cayton Bay for the purposes of cliff top monitoring. The separation between any two points is around 300 m. The cliff top surveys at Scarborough South Bay are undertaken bi-annually. Data collection involves a distance offset measurement from the ground control point to the cliff edge along a fixed bearing. Between March and September 2014 ten of the thirteen locations showed change of less than ±0.1m. Two markers had been subject to erosion of up to 0.3m during the summer of 2013. One marker showed 0.9m of recession and inspection of the survey photographs indicates this was a minor collapse of a well vegetated mudslide headscarp in Cornelian Bay. The recession rates calculated for the period from March 2010 to September 2013 give a picture of the change over the longer term. Eleven of the markers have a recession rate of less than 0.1m/yr. Markers	

Survey Date	Description of Changes Since Last Survey	Interpretation
	11 and 12 have shown long-term average erosion rates of 0.7m/yr and 0.4m/yr. Appendix C provides results from the September 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 March 2010 baseline survey. Short-term and long term average recession rates are also provided.	

3.7 Cayton Bay

Survey Date	Description of Changes Since Last Survey	Interpretation
11th Sept 2014	**Beach Profiles:** Cayton Bay is covered by three beach profile lines, distributed between Tenants' Cliff and the south of Cayton Sands (Appendix A). The cliff face at profile **1dCY1** is vegetated and was difficult for the surveyors to access resulting in poor data in the top of the profile. In the rest of the profile, there was little change as far as 20m chainage between March and September 2014. Between 20m and 40m chainage there was up to 0.2m of erosion and between 40m and 100m chainage there was up to 0.3m of deposition. In combination these changes lessen the gradient the upper part of the beach. Between 100m and 160m chainage some there has been deposition of to 0.4m of sand between protruding parts of the rocky shore platform. In the lower intertidal zone there has been deposition of up to 0.5m. Overall the beach is at a medium level. The centre of cliff profile **1dCY2** could not be accessed, so there is low confidence in this part of the data. The survey indicates 1 to 2m of advance of the cliff toe at c.115m chainage since March 2014. Between 130m and 180m chainage the upper beach has accreted by up to 0.5m since March 2014. There was negligible change between 180m and 290m chainage. Between 290m chainage and the end of the survey at 260m chainage accretion of up to 0.3m has created a subtle berm in the lower foreshore. Overall the beach is near its highest level since 2008. The centre of cliff profile **1dCY3** profile could also not be accessed, so there is low confidence in that part of the data. From 118m chainage to 125m chainage there had been minor changes at the cliff toe due to redistribution of cobbles and boulders. From 125m to 135m chainage the beach had eroded by 0.2m and between 135 and 160m accreted by up to 1m to create more convex upper profile to the beach. Between 160m and 230m chainage the beach had eroded by up to 1m and between 230m chainage and the end of the survey at 290m chainage had accreted by around 0.3m. Overall the beach is at a medium to low level, and at its lowest in the upper foreshore compared to earlier surveys. The gradient of the beach is relatively shallow.	The beach profiles show a mixed pattern with highest levels being seen in the centre of the bay and the lowest in the south, and moderate levels in the north. The plot of difference between Autumn 2013 to Autumn 2014 surveys shows variability in the erosion and accretion in the bay. The magnitude of change recorded over 2014 was modest, within the range of seasonal beach fluctuations and with a similar pattern to that seen in the past. This suggests migration of sand bars with no net change in beach level. The cliff top survey data shows that there was stability overall during the summer of 2013. The highest recorded erosion rate is 0.1m/yr. **Longer term trends:** The pattern of migrating sand bars has remained consistent since 2010 indicating seasonal variation in beach level with no net change. The undefended cliffs are a source of sediment, but beach accretion has not been detected. This may be because the sediment supplied is too fine grained to be retained on the beach or is too limited. Over the past two surveys there has been alternating accumulation and deposition at the base of the cliffs, indicating no net trend in erosion or deposition here. The cliff top survey results show little or no erosion. **Autumn 2008 to Autumn 2014 trends:** The

Survey Date	Description of Changes Since Last Survey	Interpretation
	Topographic Survey: Cayton Bay is covered by an annual topographic survey. Data have been used to create a DGM (Appendix B - Map 7a) using GIS. The GIS has also been used to calculate the differences between the current topographic survey DGM (Autumn 2014) and the earlier topographic survey DGM (Autumn 2013), with 5m raster grids (as shown in Appendix B – Map 6b), to identify areas of erosion and accretion. Appendix B - Map 7b shows that the observed changes are weakly shore parallel, and the position of areas of erosion and accretion up and across the beach and foreshore vary with position in the bay. Very little erosion or accretion was in excess of 1m. However, there is a distinct band of erosion at the base of the cliffs in the south of bay which reverses the accretion previously seen between 2012 and 2013. The most widespread erosion overall is in the south of the bay. **Long Term Topographic Trends Autumn 2008 to Autumn 2013:** The long term difference plot in Appendix B – Map 7c indicates that in the long term there has been more erosion at the distal ends of the bay (particularly of the foreshore in the south) and greater accretion in the centre and the north, except for the furthest north part of the survey area fronting the south side of Knipe Point. However, the magnitude of this change is less than 0.5m and of limited extent.	distribution of change on the long term difference plot reflects sediment redistribution within the bay rather than progressive erosion or accretion.
	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 200 m. The cliff top surveys at Cayton Bay are undertaken bi-annually. Data collection involves a distance offset measurement from the ground control point to the cliff edge along a fixed bearing. The results of the cliff top survey are shown in Table C4. Between March and September 2014 seven of the eight profiles showed no discernible change (within the ±0.1m accuracy of the survey). Only Marker 1 in the northern part of Tenants’ Cliff. Shows erosion, but the thick vegetation on this cliff means the result could be error. Long-term erosion rates calculated using data collected since November 2008 show change either	

Survey Date	Description of Changes Since Last Survey	Interpretation
	within the margin of error or advance, indicating survey difficulties, at most points. Markers 2, 4 and 6 show erosion rates >0.1m per year. Appendix C provides results from the September 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.	

3.8 Filey Bay

Survey Date	Description of Changes Since Last Survey	Interpretation
9th and 10th Sept 2014	**Beach Profiles:** Filey Bay is covered by five beach profiles between Filey Sands and Speeton Sands (Appendix A). At profile **1dFB1** fronting Filey seawall, the upper beach between 30m and 120m chainage has accreted by up to 0.3m since March 2014 but there has been only negligible change throughout the rest of the profile. Overall the profile is at a reasonably high level compared to earlier surveys. The changes observed at profile **1dFB2** since March 2014 are predominantly due to the movement of berms on the beach. The beach has not changed above the HAT level at 65m chainage. From 65m to 115m chainage the beach has accreted by 0.3m. Between 115m and 170m erosion of 0.3m has occurred. From 170m to 230m chainage 0.5m of deposition has occurred and between 230m chainage and the end of the survey at 295m chainage there has erosion of up to 0.4m. The overall effect of this has been to smooth out the profile. The upper beach is relatively high compared to previous surveys but the foreshore is at near its lowest level indicating steepening of the profile. At profile **1dFB3**, near Flat Cliffs, the cliff face above HAT remains unchanged. Since March 2014, the profile has been smoothed. Between the HAT level at 40m chainage and 90m chainage the beach has accreted by 0.7m increasing the height of the upper beach. From 90m chainage to 180m chainage a trough has been infilled through the accretion of up to 0.75m of sediment. The lower of the two mounds present in the previous survey has been eroded by up to 0.6m between 180m chainage and 270m chainage. The lower foreshore has been steepened by limited deposition between 270m and 300m chainage and erosion between 300m chainage and the end of the survey at 320m (MLWS). Overall the beach is high relative to earlier surveys, particularly the upper beach as far as 180m chainage where it is at its highest. Profile **1dFB4** at Hunmanby Gap, has accreted by 0.5m from 25m chainage (well above HAT level) as far as 60m chainage since March 2014. Between 60m and 85m chainage a berm has been eroded by 0.2m. From 85m to 130m chainage a trough has infilled through deposition of 0.5m and from 130m to 175m chainage a berm has been eroded by 0.3m. Between 175m and 255m chainage deposition of up to 1m has occurred. From 255m to the end of the profile at 290m chainage, the profile is similar to	The Filey Bay beach profiles show a range of changes. All, except 1dFB5 in the south of the bay, are relatively high and indicate smoother profiles. The relatively low upper beach at 1dFB5 makes the toe of the cliffs more prone to wave attack and recession is possible if the summer experiences storms. All of the profiles are generally within the range of previous results on the upper and lower beach, although the more northerly profiles are relatively high. The topographic change map shows Filey Bay is dominated by shore parallel successive bands of accretion and erosion associated with migrating berms. This is a continuation of the past trend. The difference plot for Filey Town shows a similar pattern of shore parallel strips of accretion and erosion. Erosion is more prevalent on the foreshore and immediately in front of the sea wall, with accretion taking place in the mid-upper beach. This is attributable to seasonal changes and all changes are of low magnitude. The cliff top survey data provided in Table C5 shows erosion at several monitoring points, but the data are likely to be error. **Longer term trends**: compared to the previous long term difference plot from 2013, a pattern of erosion in the south of the bay, accumulation in the centre and

Survey Date	Description of Changes Since Last Survey	Interpretation
	March 2014. Overall the beach is at its highest level throughout much of its profile and undulations present in March 2014 have been removed to give a straighter profile. At profile **1dFB5** has upper beach has eroded by up to 0.8m between 222m (above HAT level) and 255m chainage since March 2014. A trough between 255m and 310 chainage has infilled through deposition of up to 0.9m of sediment. A berm between 310m and 365m chainage has eroded. Deposition of up to 0.5m has occurred between 365m and 430m chainage and remained stable between April and September 2013, with a pattern of local fluctuations about a mean elevation. The lower foreshore between 430m chainage and the end of the survey at 455m chainage has eroded by up to 0.7m. The uppermost part of the beach is at its lowest level but the rest of the profile is at medium to low level, indicating an overall reduction in profile gradient.	more subtle changes in the north of the bay is more evident this year. This suggests there has been a more consistent northwards transfer of sediment from Speeton Sands. **Autumn 2008 to Autumn 2014 trends:** The overall trend in Filey Bay over the last six years indicates that Speeton Sands has undergone erosion and sediment has been transferred northwards to Reighton, Hunmanby and Muston Sands where beach levels are relatively high. The pattern of more muted changes at Filey Sands indicates this area is more influenced by seasonal bar migrations than larger scale transfer of sediment throughout the bay. The magnitude of changes observed in the long term difference plots are mostly less than ±1m over the past six years, although in the centre and south of the bay there are areas of limited extent where the change is >±1m. The results of the first 6 years of cliff top monitoring have mostly showed low rates of retreat that are within the error bands of the technique with erosion rates over the 6 years (less than +/-0.1m/yr). However, control point 5, immediately south of the Filey town defences and at the headscarp of an episodically active mudslide, has a recession rate of 1.1m/yr, marker 7 at Muston Sands has a rate of 0.3m/yr and marker 14 to the north side of Hunmanby Gap has a rate of 0.2m/yr.
	Topographic Survey (Filey Bay): Filey Bay is covered by an annual topographic survey. Data have been used to create a DGM (Appendix B - Maps 8a and 9a) using GIS. The GIS has also been used to calculate the differences between the current topographic survey DGM (Autumn 2014) and the earlier topographic survey DGM (Autumn 2013), with 5m resolution raster grids (as shown in Appendix B – Maps 8b, 9b and 10a) to identify areas of erosion and accretion. Appendix B - Map 8b and 9b shows shore parallel strips of change throughout the survey area, with alternating bands of erosion and accretion. Broadly speaking, erosion has tended to occur near MHW and MLW while the accretion is concentrated in the centre of the beach but there are exceptions to this. There is a subtly higher concentration of erosion in the south of the bay around Reighton Sands with accretion being more dominant towards Filey Town **Topographic Survey (Filey Town):** In addition to the annual survey of Filey Bay, a smaller area fronting Filey Town is re-surveyed every six months to document seasonal patterns. The GIS has been used to calculate the differences between the current (full measures) topographic survey DGM (Autumn 2014) and the earlier (partial measures) topographic survey DGM (spring 2014), with 5m resolution raster grids (as shown in Appendix B – Map 10a), to identify areas of erosion and accretion during the previous 6 months.	

Survey Date	Description of Changes Since Last Survey	Interpretation
	Appendix B - Map 10a shows that there have been areas of roughly shore-parallel accretion and erosion. The highest magnitude change has been observed in a very small area against the seawall immediately south of the paddling pool where up to 1m of material has accreted. The remaining bands of accretion and erosion show a maximum magnitude of change of ±0.5m, with erosion in front of the seawall in the northern part of the frontage and at the seaward edge of the survey, and accretion in between and in the upper beach in the south of the survey area. **Long Term Topographic Trends Autumn 2008 to Autumn 2014:** The long term trends of change in Filey Bay are shown in Appendix B – Maps 8c and 9c. These show that Speeton Sands in the south of the bay has predominantly experienced erosion and Reighton, Hunmanby and Muston Sands in the middle of the bay have experienced accretion since 2008. The picture is more mixed at Filey Sands and northwards as far as the Brigg, where there is a mixture of erosion and deposition, and the magnitude of these changes is less (no change is > ±1m) than further south in the bay. **Filey Town Long Term Trends:** The long term difference plot for the Filey town frontage is in Appendix B Map 10b. The plot shows that there has been erosion of the foreshore towards the south of the frontage and accretion in the north of the frontage since 2008. The magnitude of change is limited and rarely exceeds ±0.25m. The highest magnitude change is area of very limited extent on the slipway immediately north of the paddling pool where there has been accretion of >1m since 2008.	
	Cliff-top Survey: Twenty-eight ground control points have been established within Filey Bay for the purposes of cliff top monitoring. This includes the installation of three additional locations in September 2010: points 12A (as a replacement for point 13 which can no longer be accessed due to vegetation growth), 24 & 25 (to the north of Filey Bay at Filey Brigg). A further replacement for monitoring point 13, 13A, has been added in 2014. The maximum separation between any two points is nominally 300 m. The cliff top surveys at Filey Bay are undertaken every 6 months. Data collection involves a distance offset measurement from the ground control point to the cliff edge along a fixed bearing.	

Survey Date	Description of Changes Since Last Survey	Interpretation
	Between March 2014 and September 2014 twenty-five of the twenty-eight ground control points showed recession less than ±0.1m. Two of the remaining points had shown apparent recession of -0.2. Marker 20 showed recession of 0.5m, however, the surveyor's notes and the photo of this point indicate that this probably relates to error in definition of the cliff edge. Long term rates of change show only six markers have erosion, with rates between 0.1m/yr and 1.1m/yr. The largest erosion rate recorded is at control point 5, to the south of the Filey Town defences. Appendix C provides results from the September 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 baseline survey.	

4. Problems Encountered and Uncertainty in Analysis

Survey accuracy of beach/ cliff profiles

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. It is possible that a more reliable pattern of change will be determined over the longer term. However, in the short term, more reliable assessments of cliff recession can be derived from analysis of time-series remote sensing data. Under this programme a high quality baseline survey, comprising LiDAR and aerial photography, was collected in 2010, a repeat survey was completed in 2012/13 and a second repeat survey is planned for 2015. These data will be analysed to give more accurate information on the behaviour of the cliffs in a separate report. More accurate estimates of long term cliff top change would be possible by comparing results from the current programme to historical aerial photography over the last 50 years.

Parts of Cayton and Filey were inaccessible due to dense vegetation, fallen trees or soft ground and mudflows. At Scarborough North vegetation impeded access to cliff edge at Scalby and beach grooming had recently occurred, as it had at Scarborough South Bay. Finally, at Robin Hoods Bay it was difficult to measure the edge of the cliff due to the fly tipping of garden waste.

Cliff top erosion errors & data capture techniques

The cliff top surveys are in general assumed to have a limit of accuracy of ± 0.1m due to the techniques used and problems have been experienced in precisely locating the cliff edge, due to vegetation growth and the convex profile. Most profiles have now been monitored for six years, and a more reliable picture of change is now emerging that indicates very low rates of erosion, with only occasional and localised examples of erosion exceeding 0.5m/yr.

5. Conclusions and Areas of Concern

The following points have been observed:

- The measurements of the Cowbar and Staithes cliff top shows stability over the summer of 2014 and any minor recession is likely due to small rockfalls or is only apparent recession due to difficulties in precisely locating the cliff edge due to vegetation or a gentle break of slope. Considering the longer term, one point (to the east of the eastern breakwater) has eroded by 2.2m since November 2008, which is the maximum erosion observed for this frontage.
- At Runswick Bay there has been a southwards drift and movement of sediment towards the back of the beach. The longer term analysis of change indicates accumulation near the lifeboat slipway, but erosion in the northernmost part of the village which is likely to leave defences vulnerable to being undermined.
- At Sandsend Beach, Upgang Beach and Whitby Sands the topographic difference plots show a complex distribution of erosion and accretion. However, the losses and gains in the centre of the Bay are much more pronounced than at the distal ends of the Bay where the changes tend to be smaller. This distinction between the large changes in the middle of the bay with modest change at each end of the bay was also noted in 2010, 2011, 2012 and 2013. The long term difference plot indicates that there is an overall trend of sediment supply from the actively eroding cliffs at Upgang Beach which is gradually transferred towards the distal ends of the bay.
- At Robin Hoods Bay the topographic change plots show that the Bay as a whole appears to have been subject to slight accretion. Erosion has taken place of failed material at the toe of the cliffs at Dungeon Hole and these will be more exposed to wave action over the winter. The long term difference plot shows very little change. No discernible change is has been registered by the cliff top markers and only one cliff recession marker shows substantial change in the long term record, and the majority of this change occurred in 2011.

- For Scarborough North Bay the plot of short term change between topographic surveys shows erosion in the foreshore and accretion in the upper beach in the. Changes in the south of the bay are of smaller magnitude but show a trend for accretion. The longer term plot indicates a movement of material away from the centre of the bay to the distal ends, but with a preference for northwards drift to occur.
- At Scarborough South Bay the beach profiles showed relatively little movement over the summer. The plot of short term change based on the topographic survey showed variable accretion and erosion, but there was a notable strip of erosion in front of the Spa, which had been nourished in May 2014. The longer term difference plot shows that sediment has been moved away from the area between the Spa and Foreshore Road and is moved primarily northwards. There is an anomalous area of erosion at the back of the beach in the north of the survey area in the longer term plot, but it was from here that sand was mined for the nourishment exercise and surveyors noted beach grooming here. Two cliff recession points showed real erosion. These are situated at the headscarp of a periodically active mudslide system. However, inspection of surveyor's photos indicates that this recession is caused by minor, localised collapse of the oversteepened headscarp rather than a more widespread reactivation. There is no need for concern.
- The Cayton Bay beach profiles show modest seasonal variation within the range of previous surveys and this is supported by evidence in the short term difference plots for seasonal to inter-annual bar migration. However, there has been a lowering of the beach elevation at the toe of the undefended glacial till cliffs which may leave them more open to wave attack over the winter and further failure of the lower and mid-cliff is likely. The longer term plot indicates that sediment moves into the centre of the bay from the distal ends, but with a preference for northwards drift. Overall the bay form is considered stable. The cliff top survey results show little to no erosion over the short term.
- Changes in the beach profiles at Filey Bay have over the summer of 2014 have been mixed. All the profiles are generally within the range of beach levels seen in the past, but the more northerly profiles are relatively high in the upper beach and the most southern profile is low in the lower foreshore. The short-term difference plot is dominated by shore parallel strips of erosion and accretion indicating seasonal to inter-annual bar migration. The short term difference plot for Filey Town shows seasonal changes of low magnitude. The longer term change plot indicates erosion of Speeton Sands and accretion at Reighton, Hunmanby and Muston Sands. Filey Sands and the beach northwards to the Brigg show change dominated by seasonal bar migration. In the long term cliff erosion is greatest at location 5, to the south of the Filey Town sea wall. However, there has been no further change here since September 2013, nor has there been any short term change at any of the other cliff top monitoring locations over the summer of 2014.

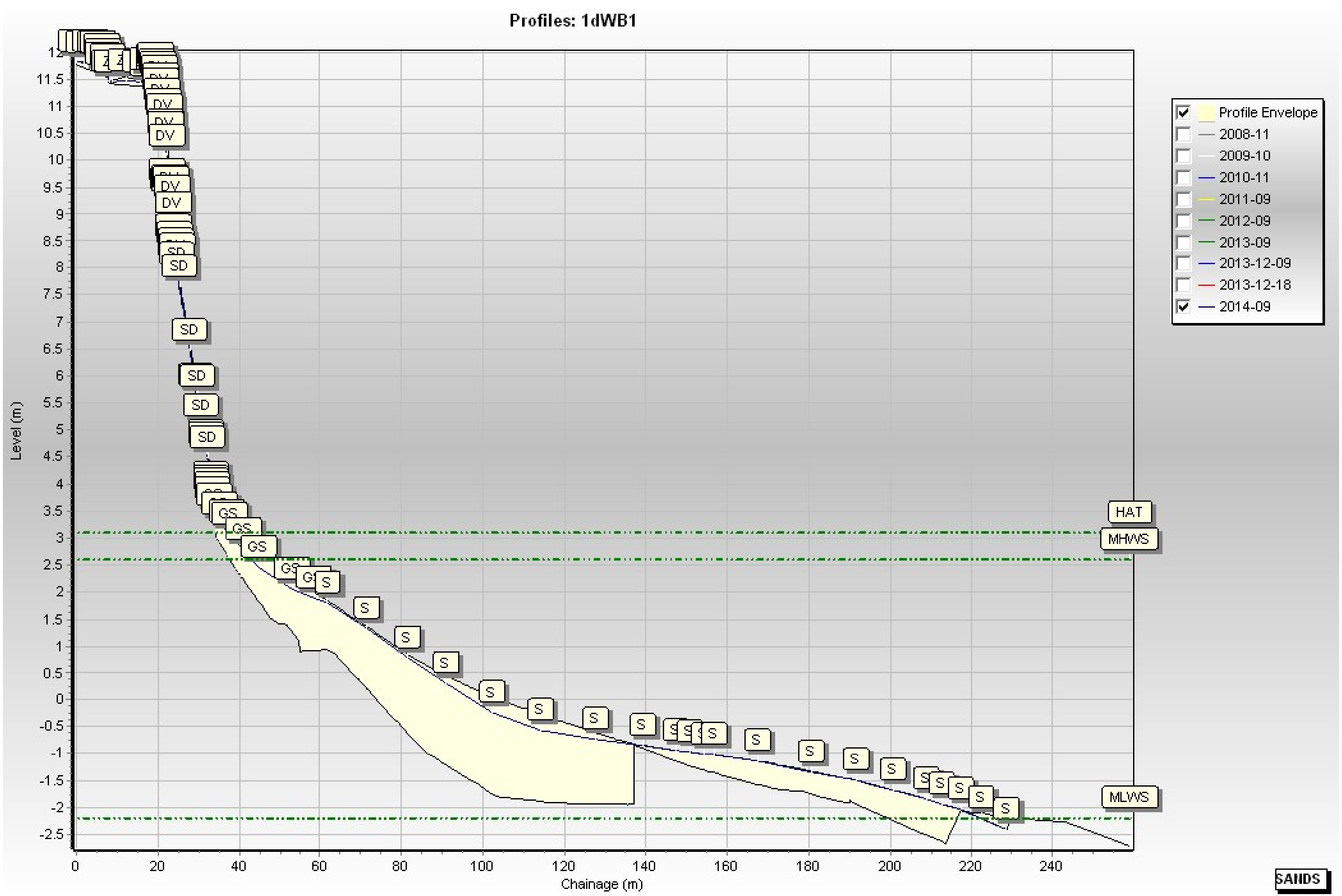
Appendices

Appendix A

Beach Profiles

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

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



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2010-11
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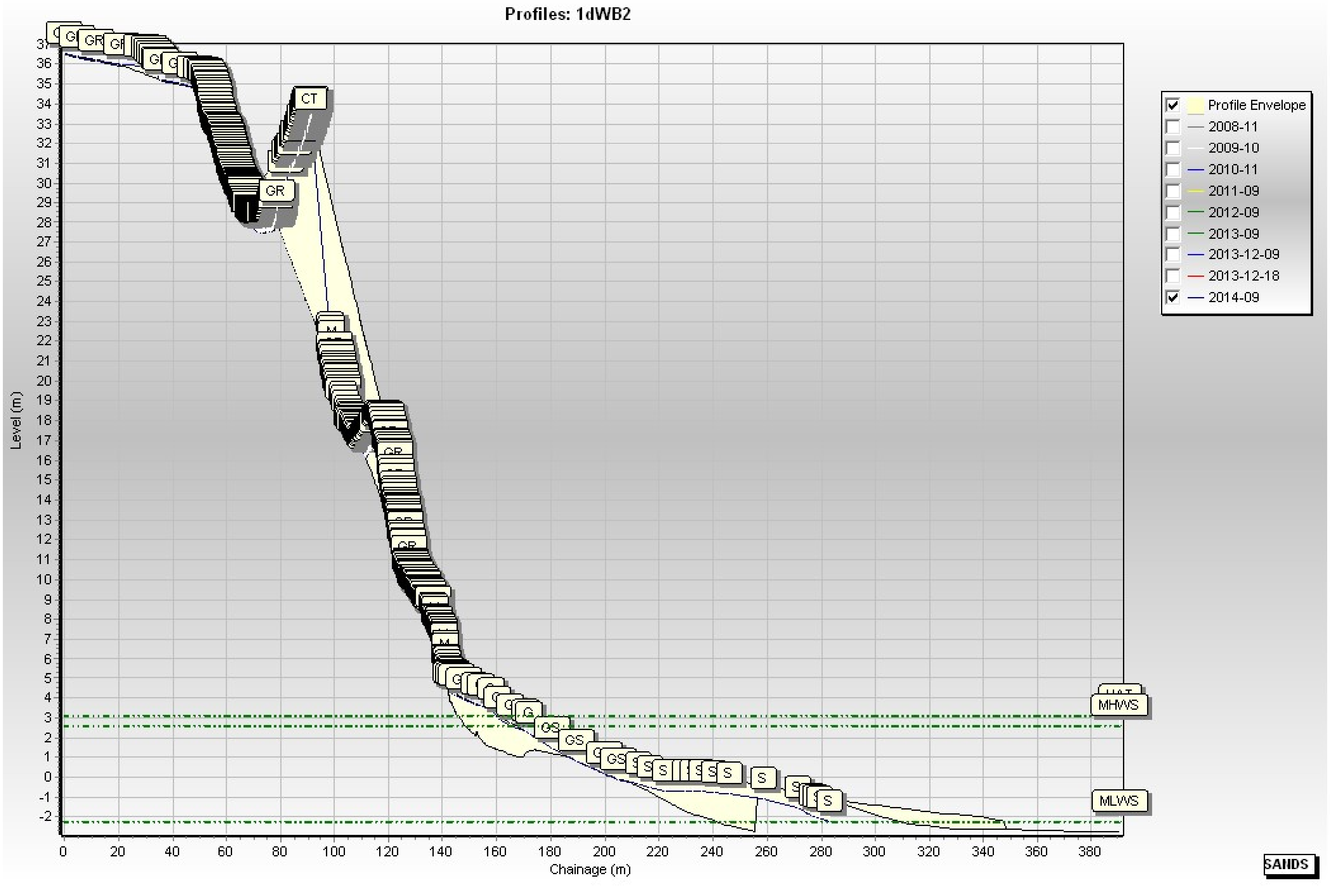
DV
SD
GS
S
SANDS



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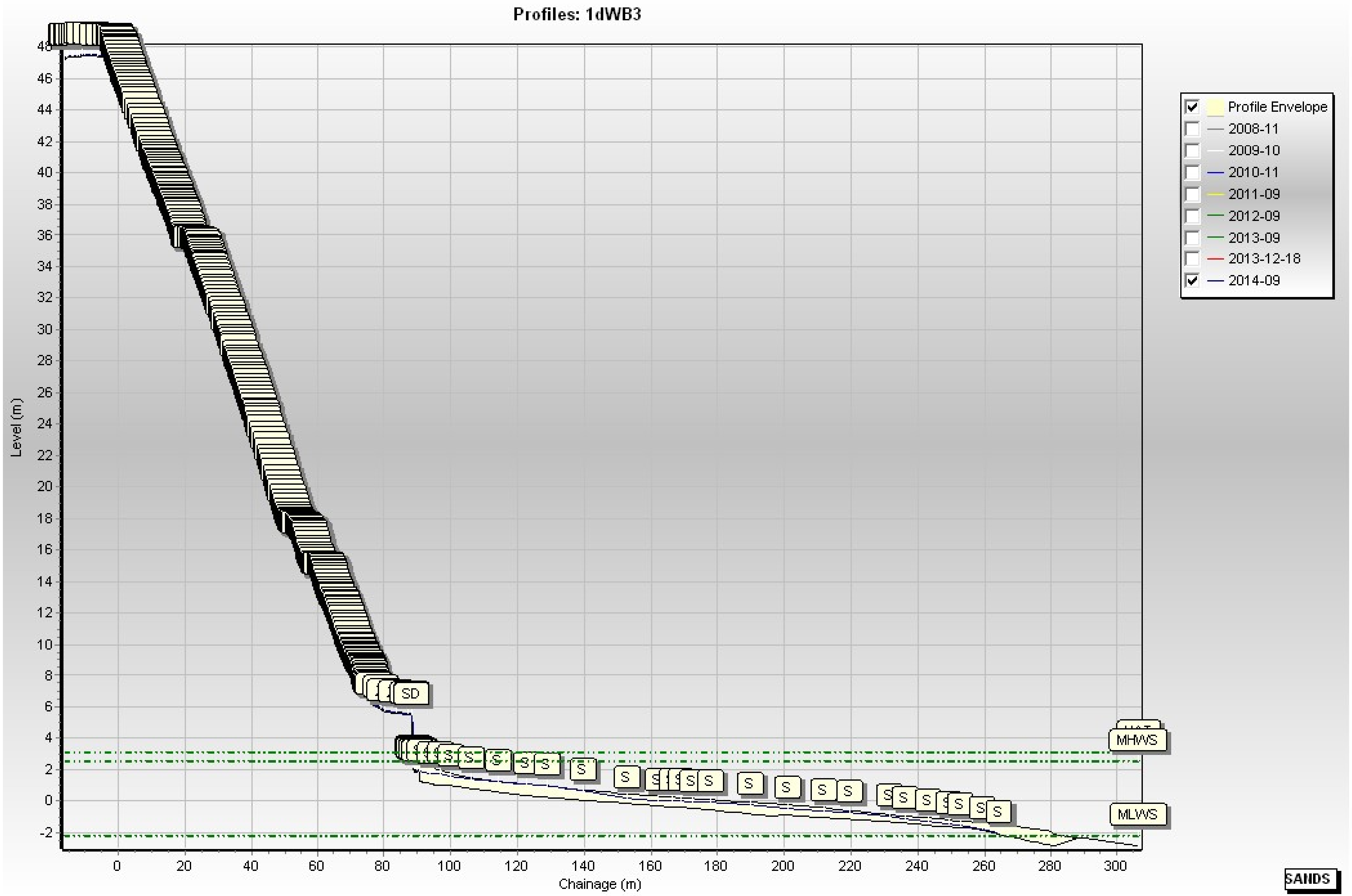
MLWS
GS
S
SANDS



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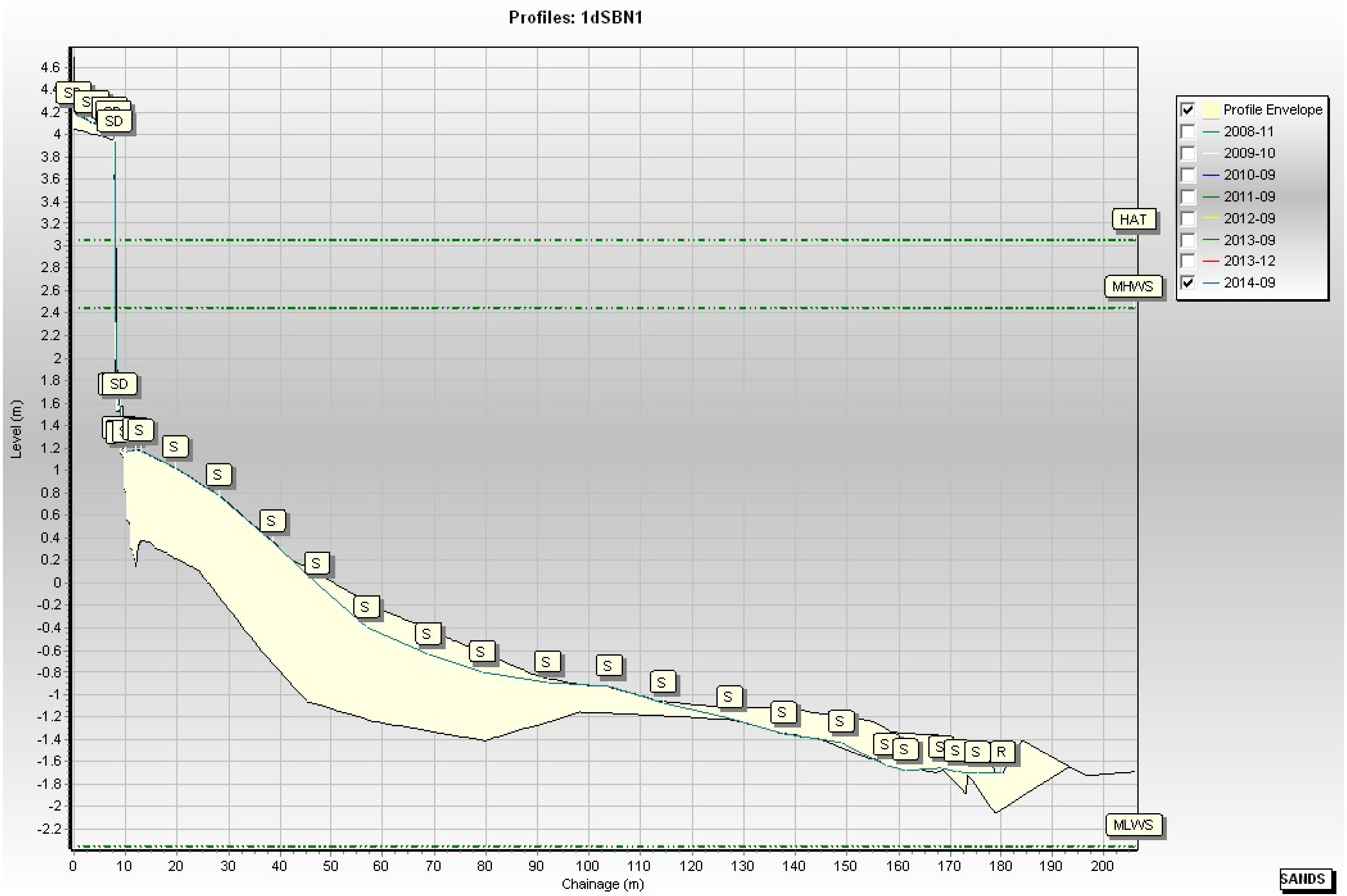
MLWS
SANDS



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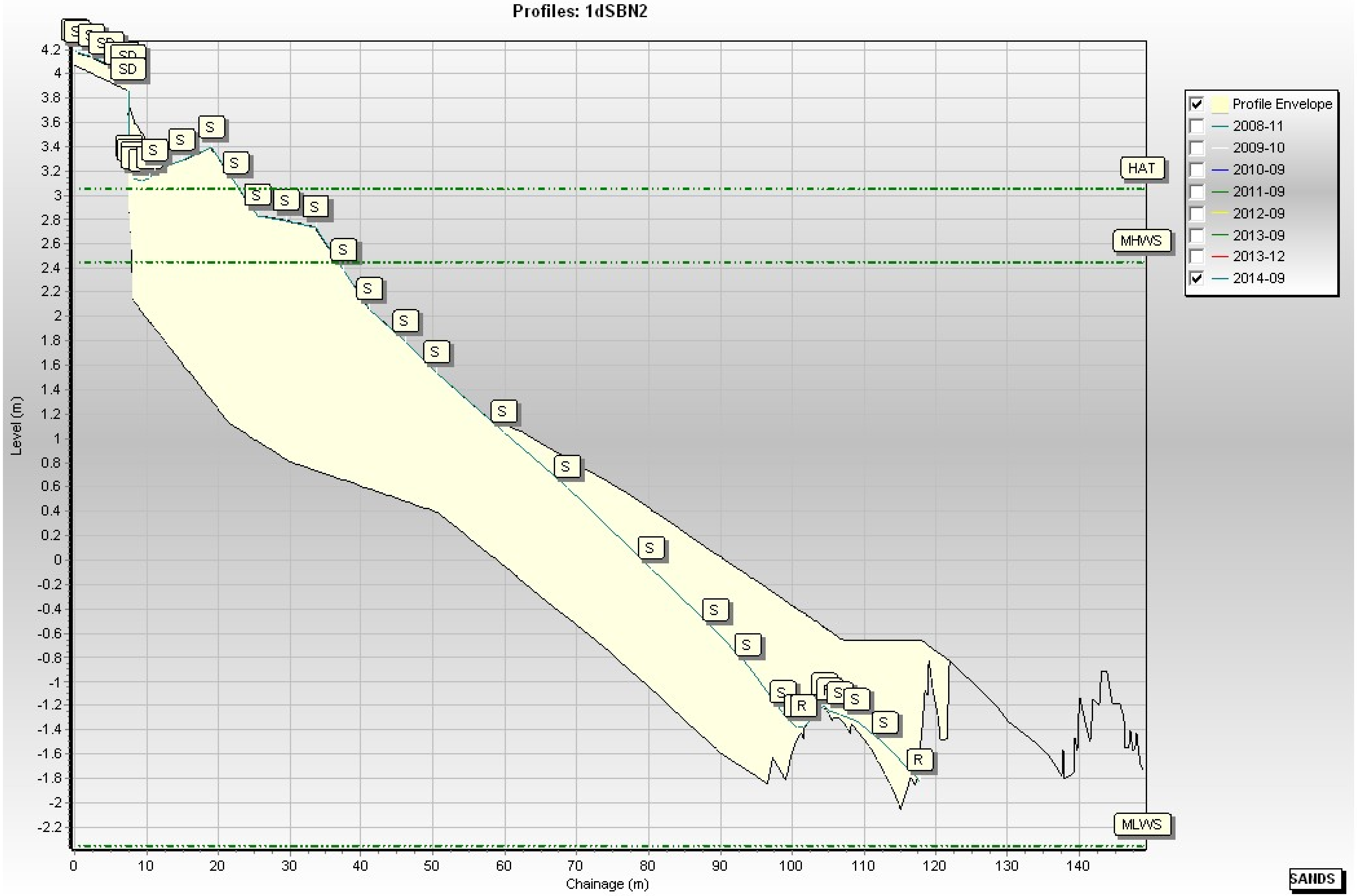
S
R
SANDS



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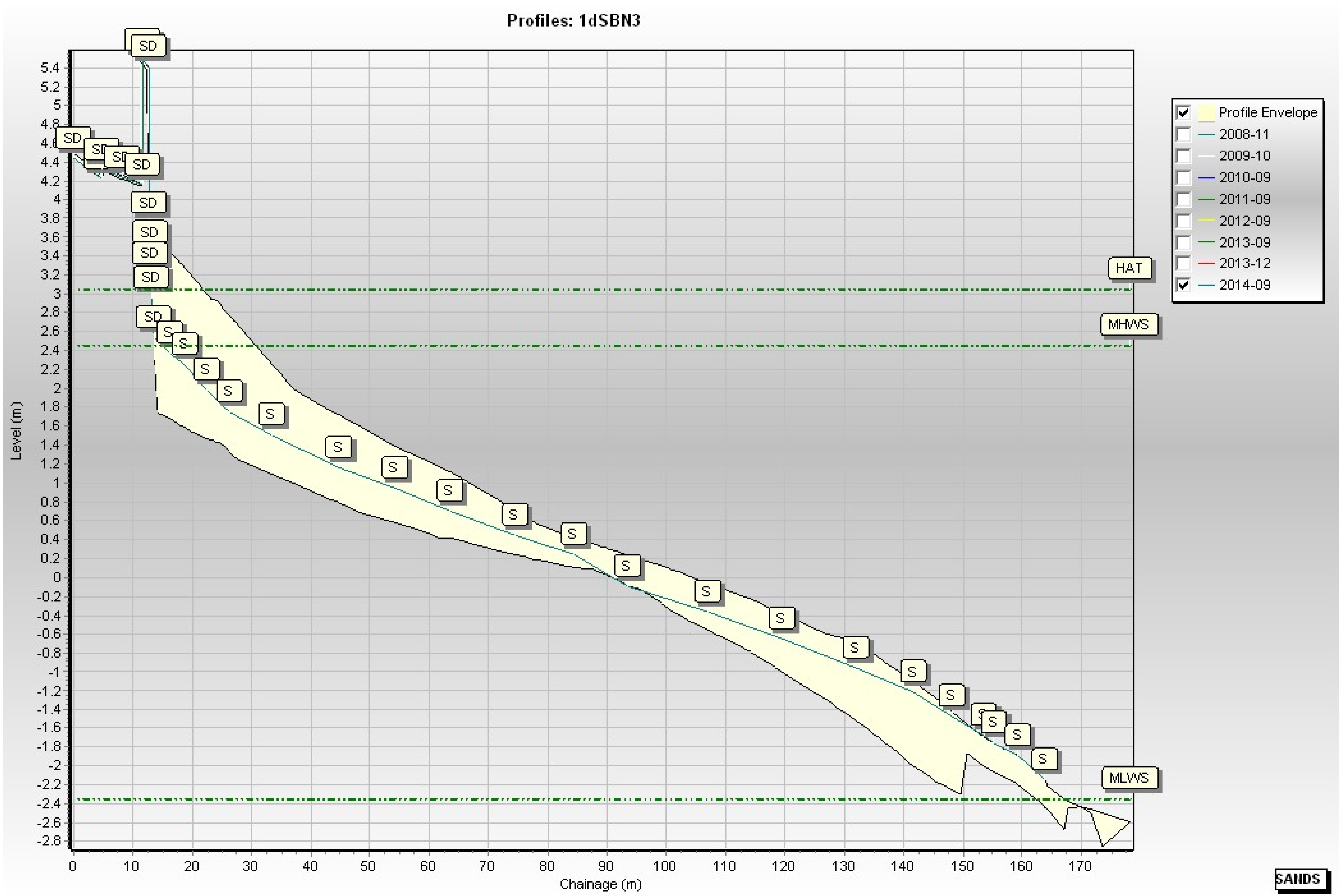

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S
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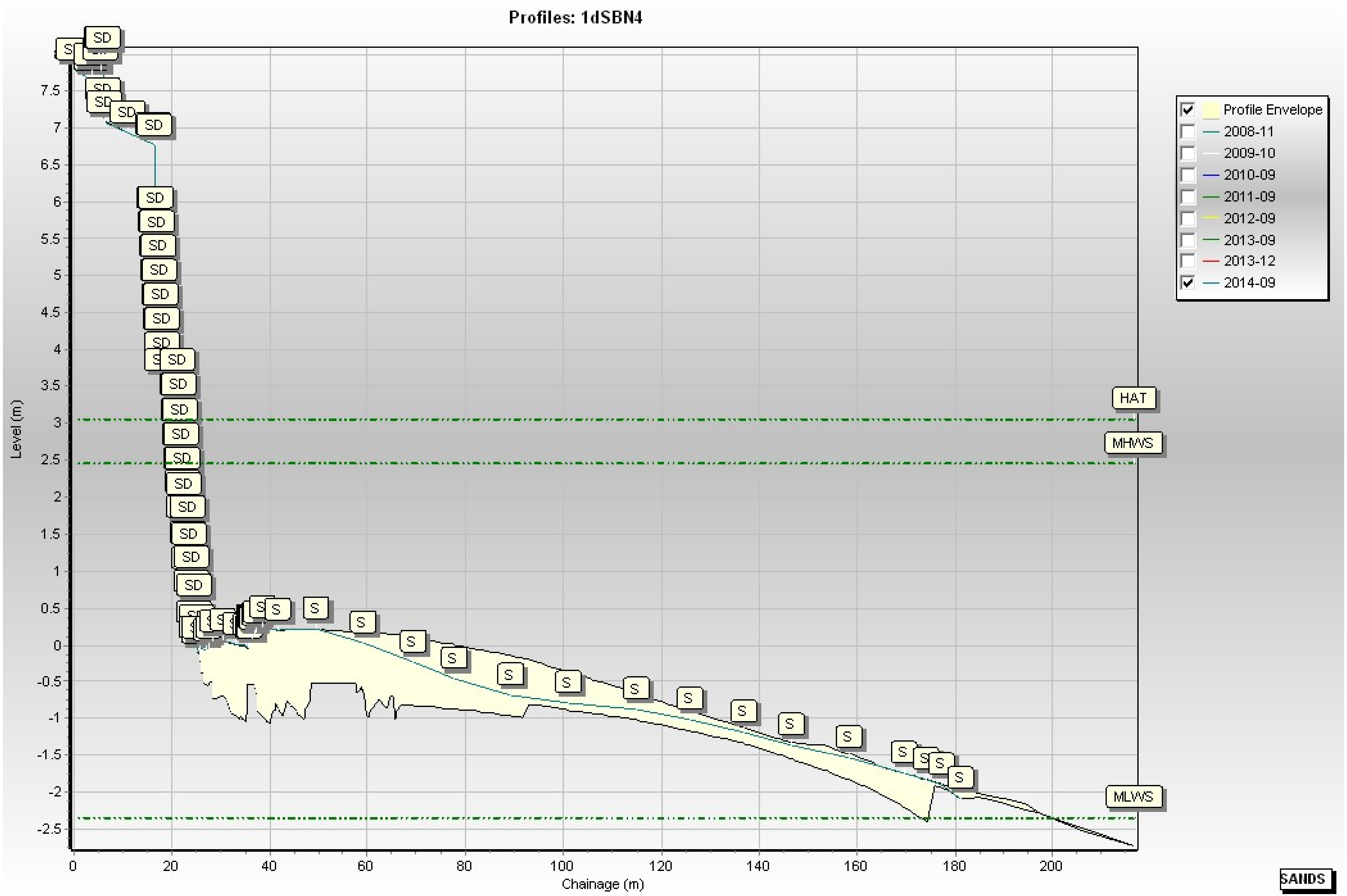

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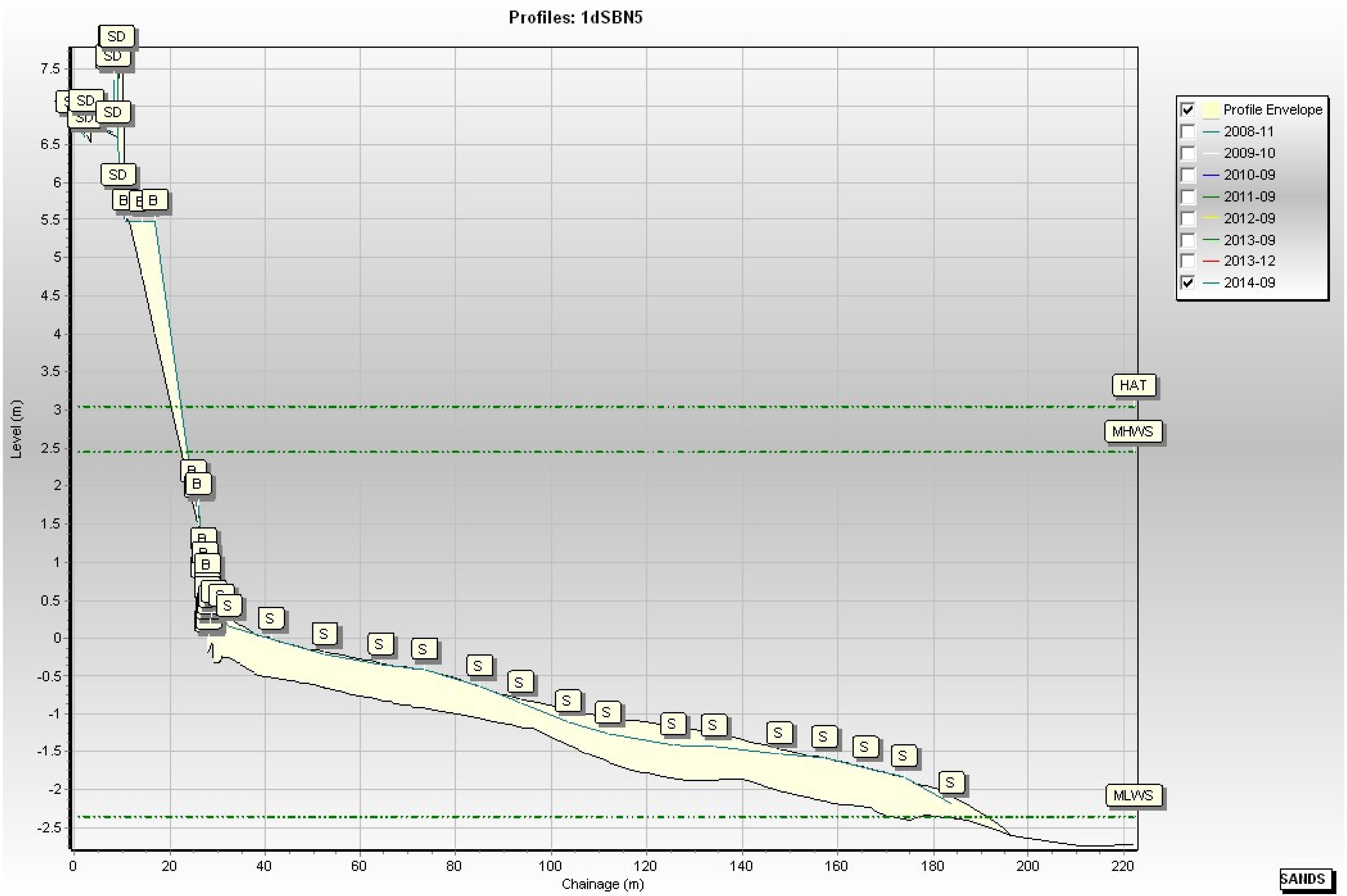

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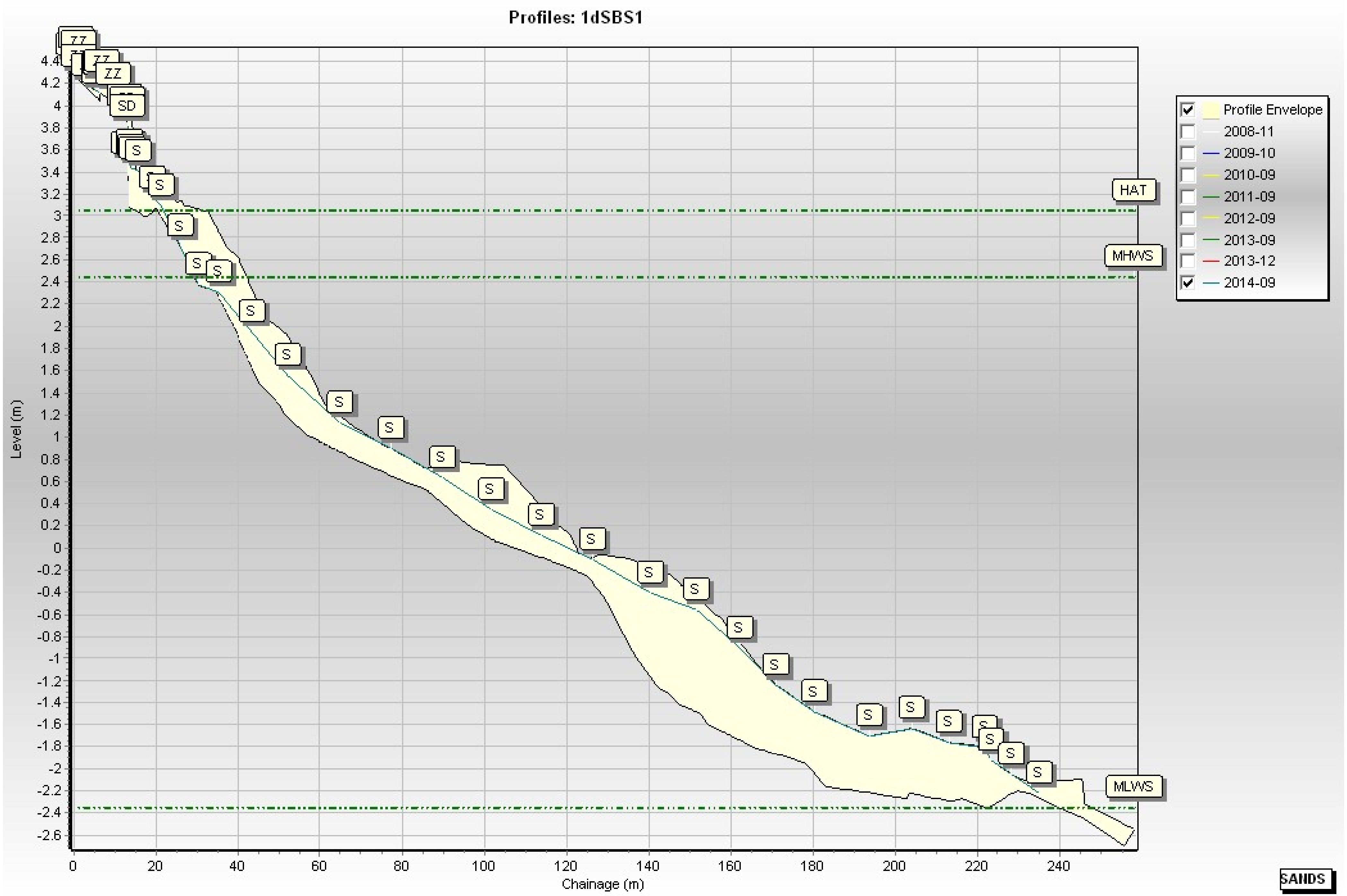

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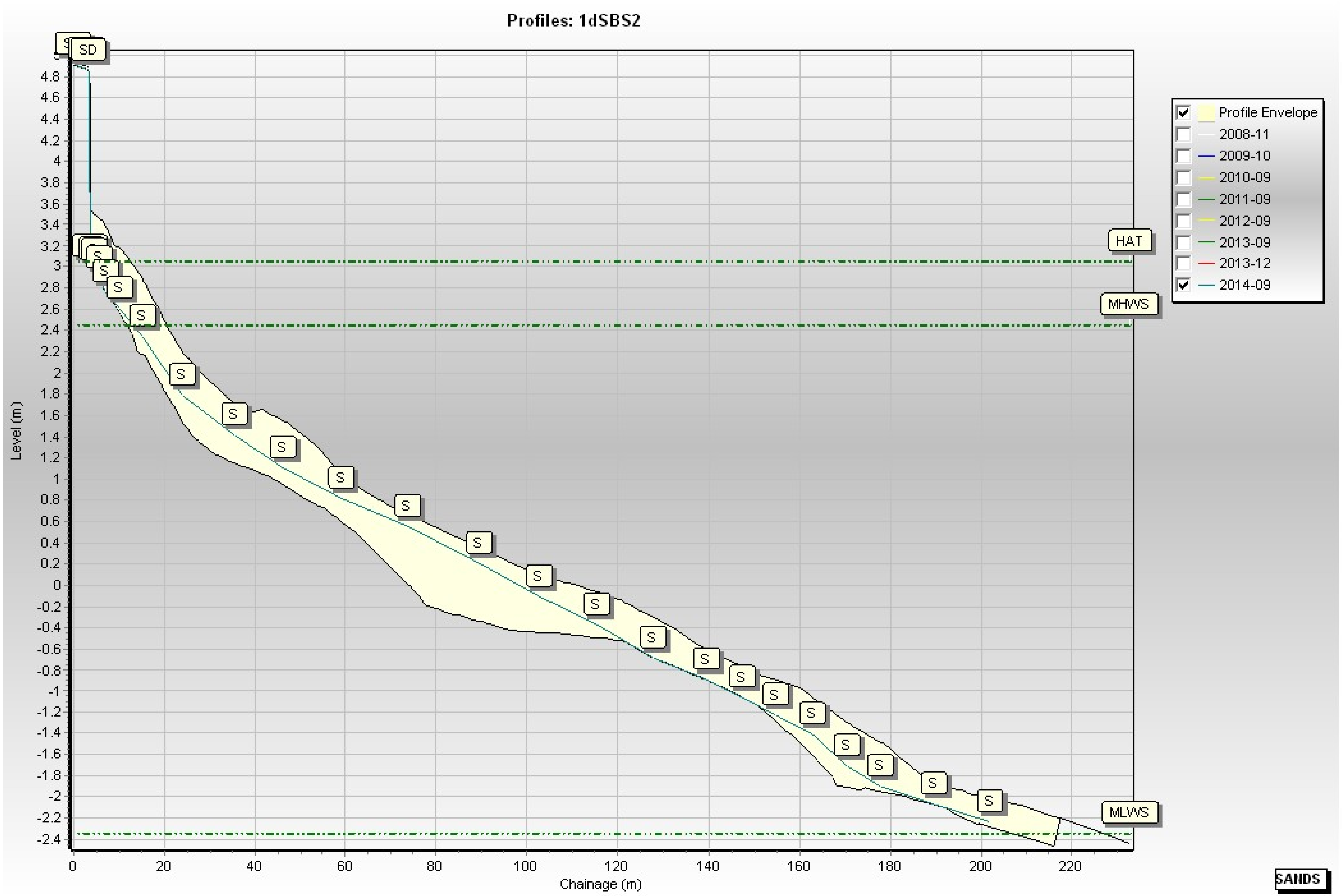

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SD
S
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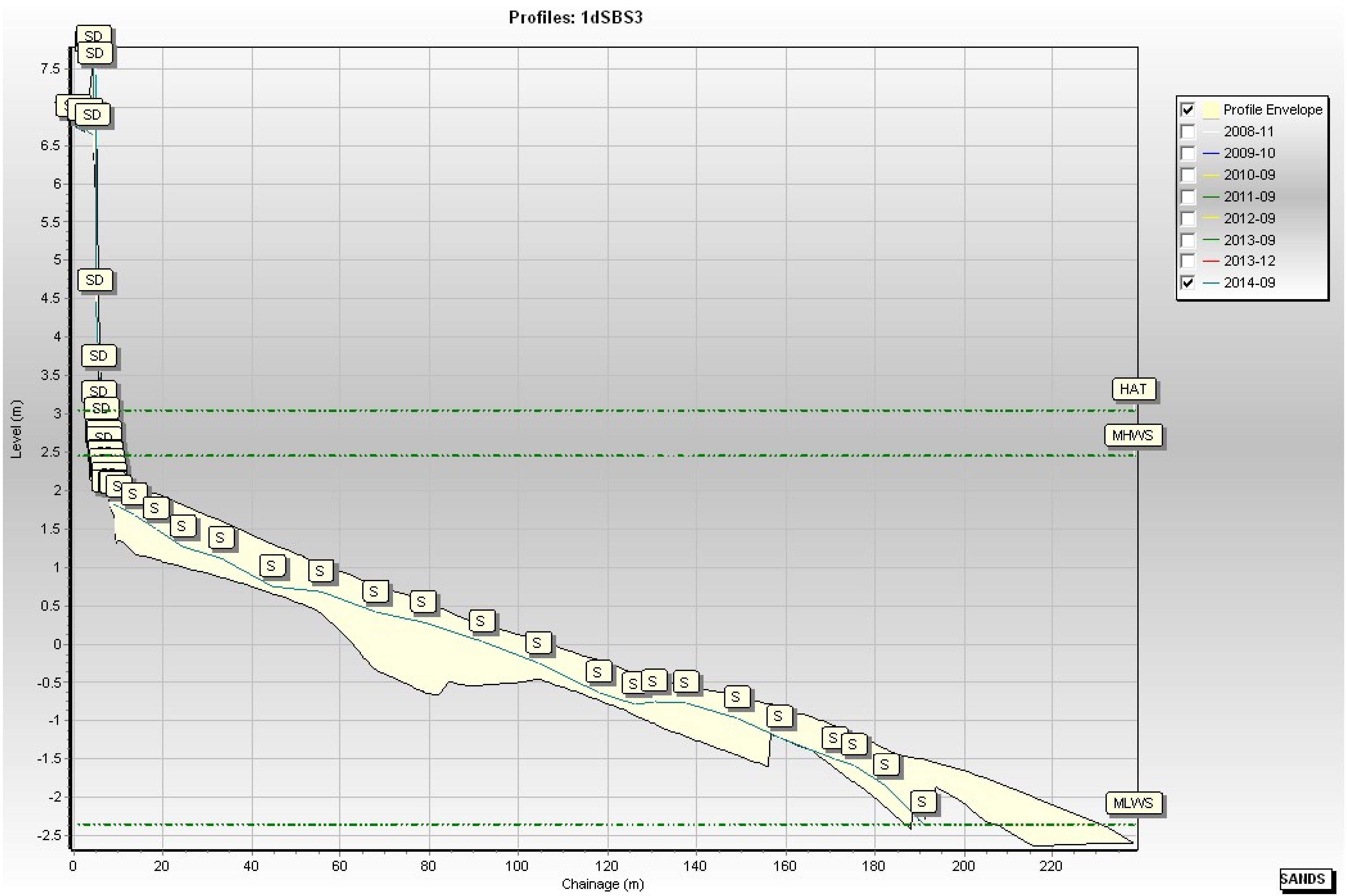

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S
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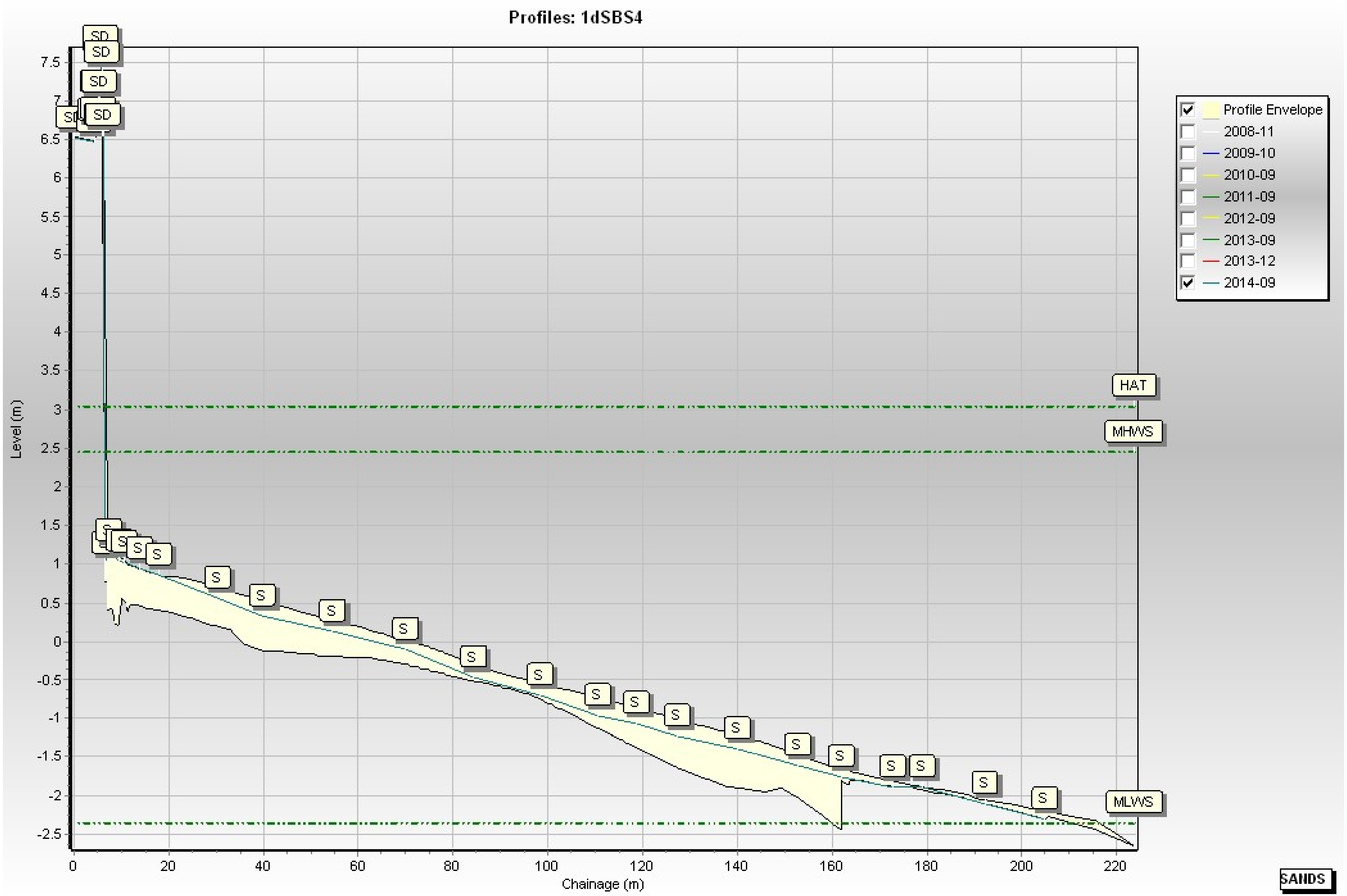
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SD
S
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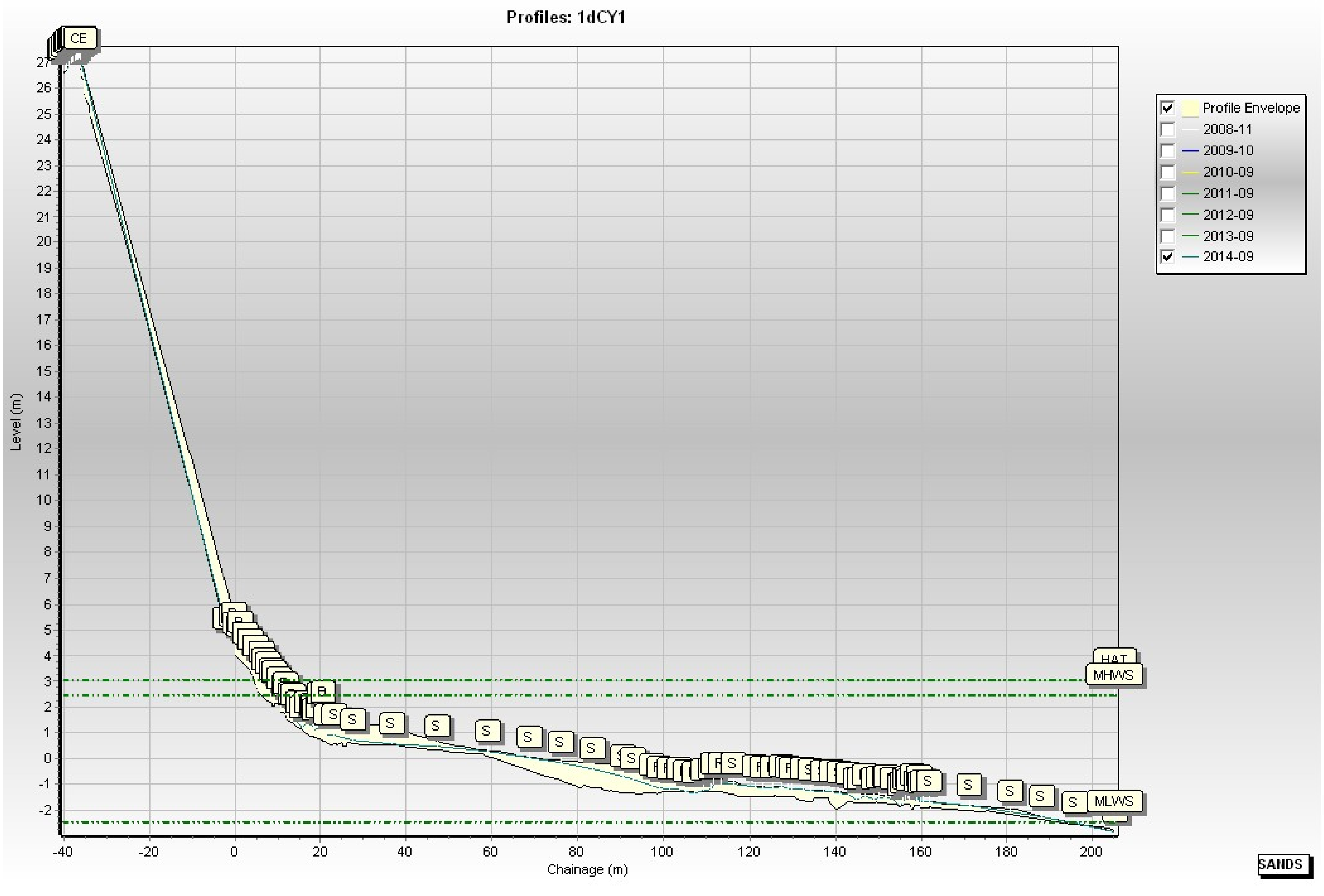
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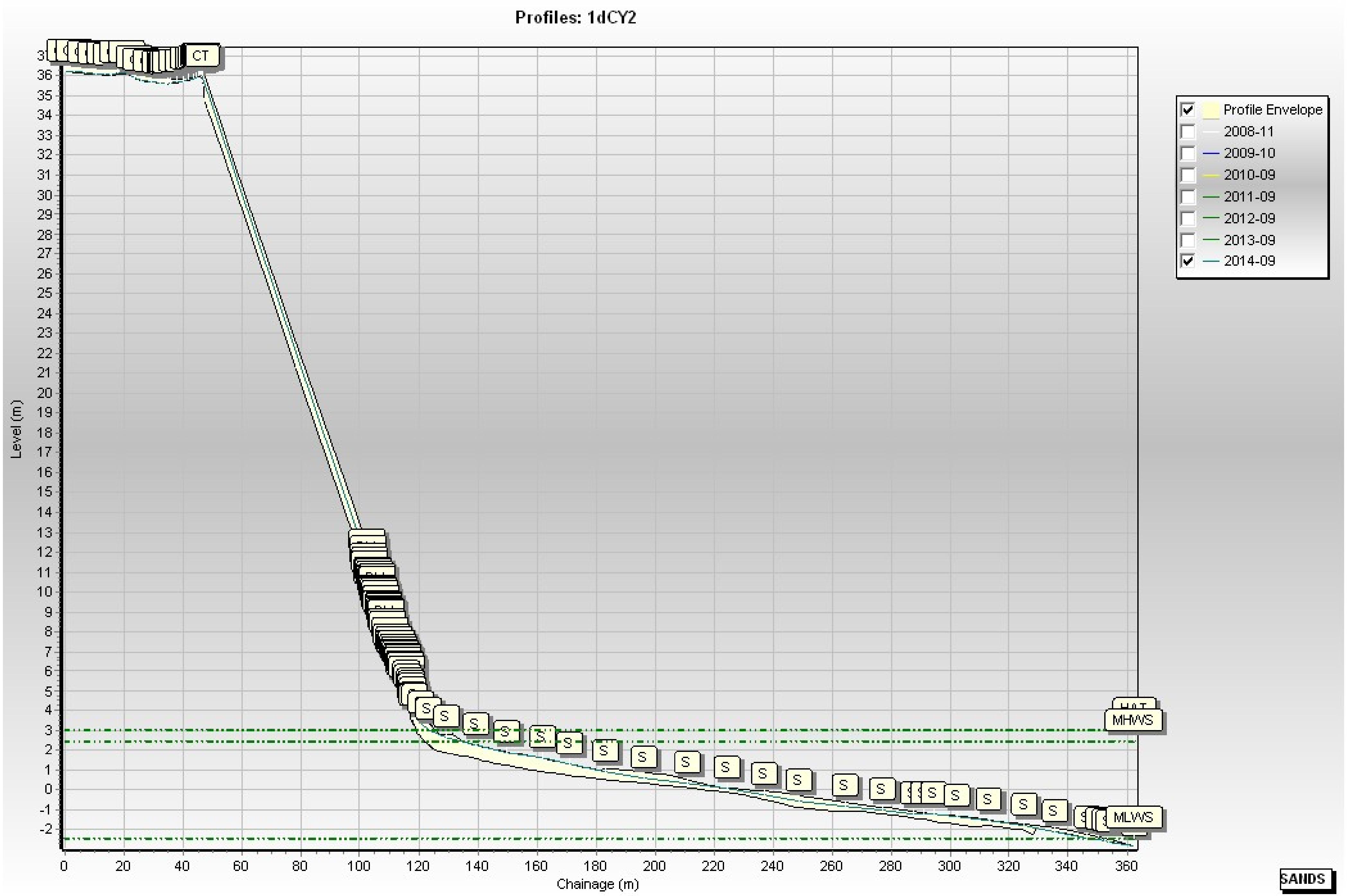

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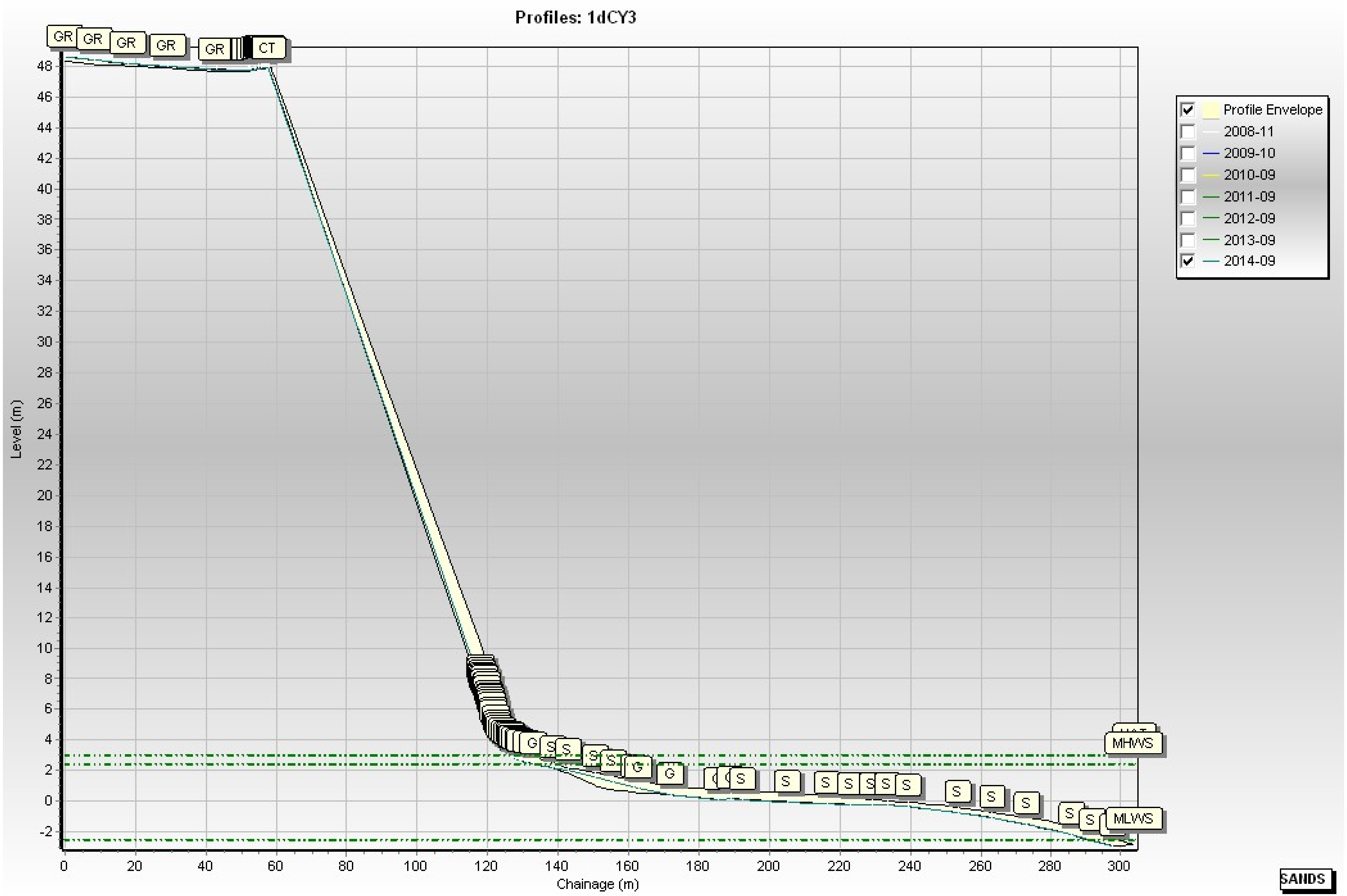

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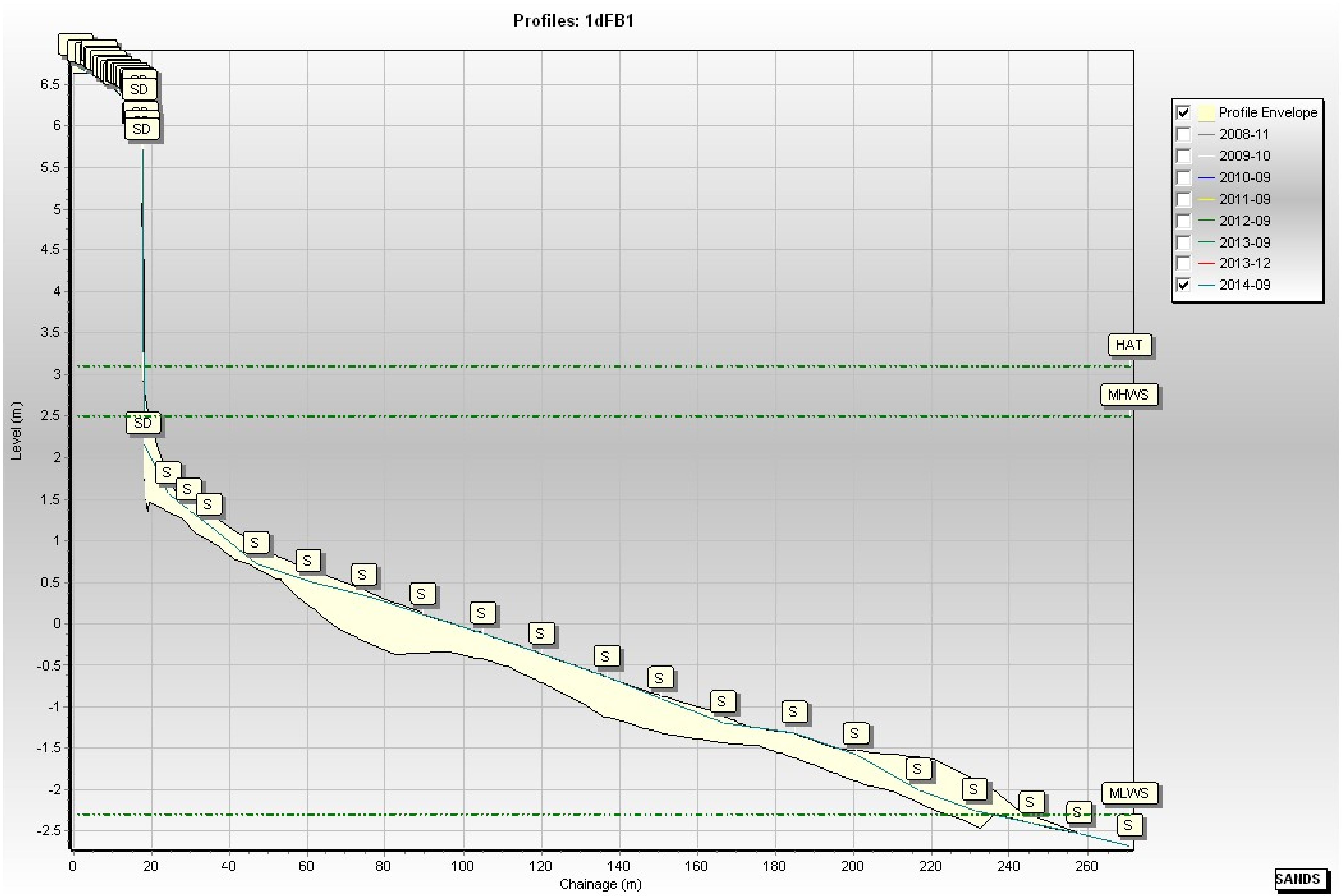
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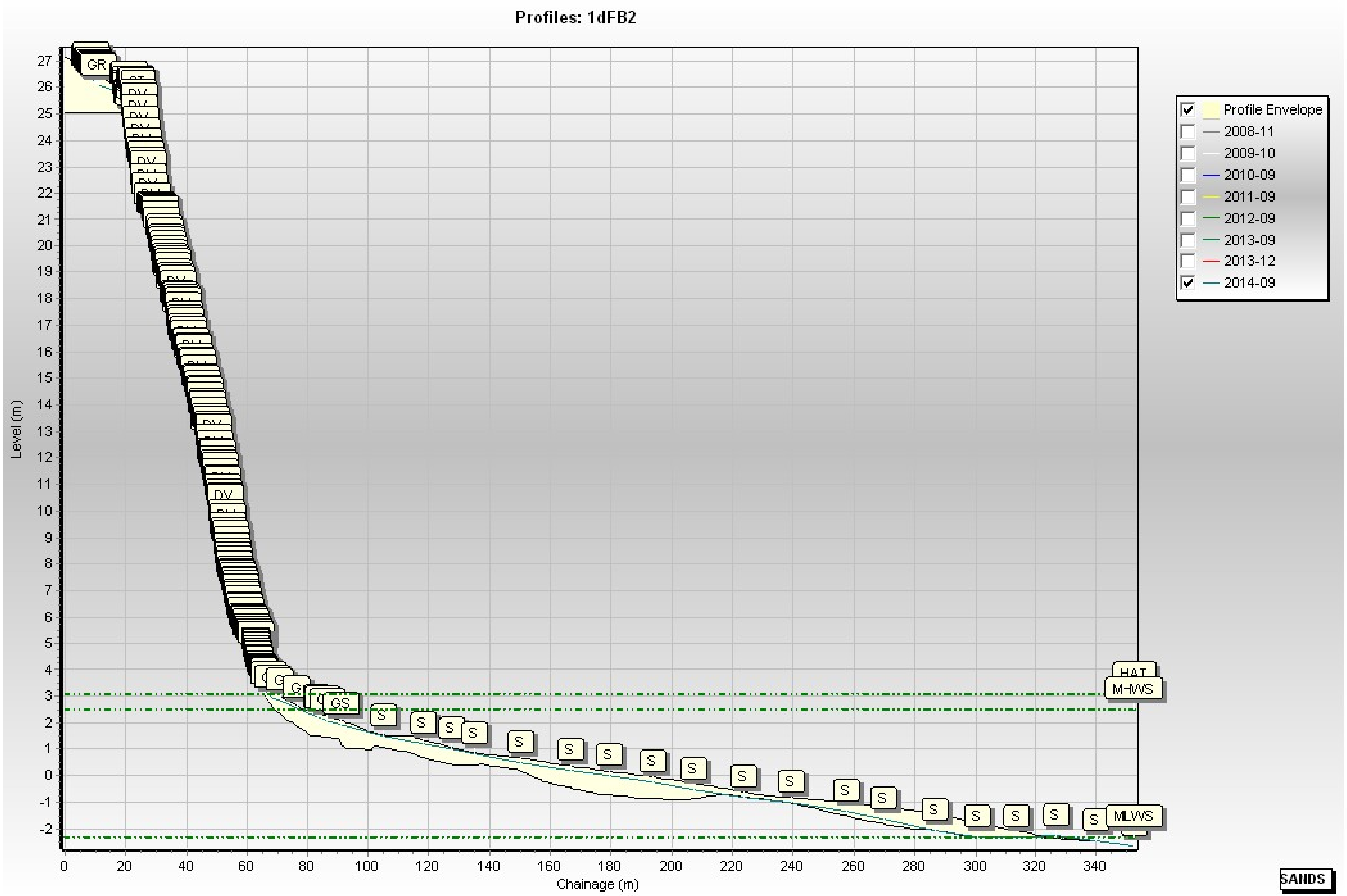

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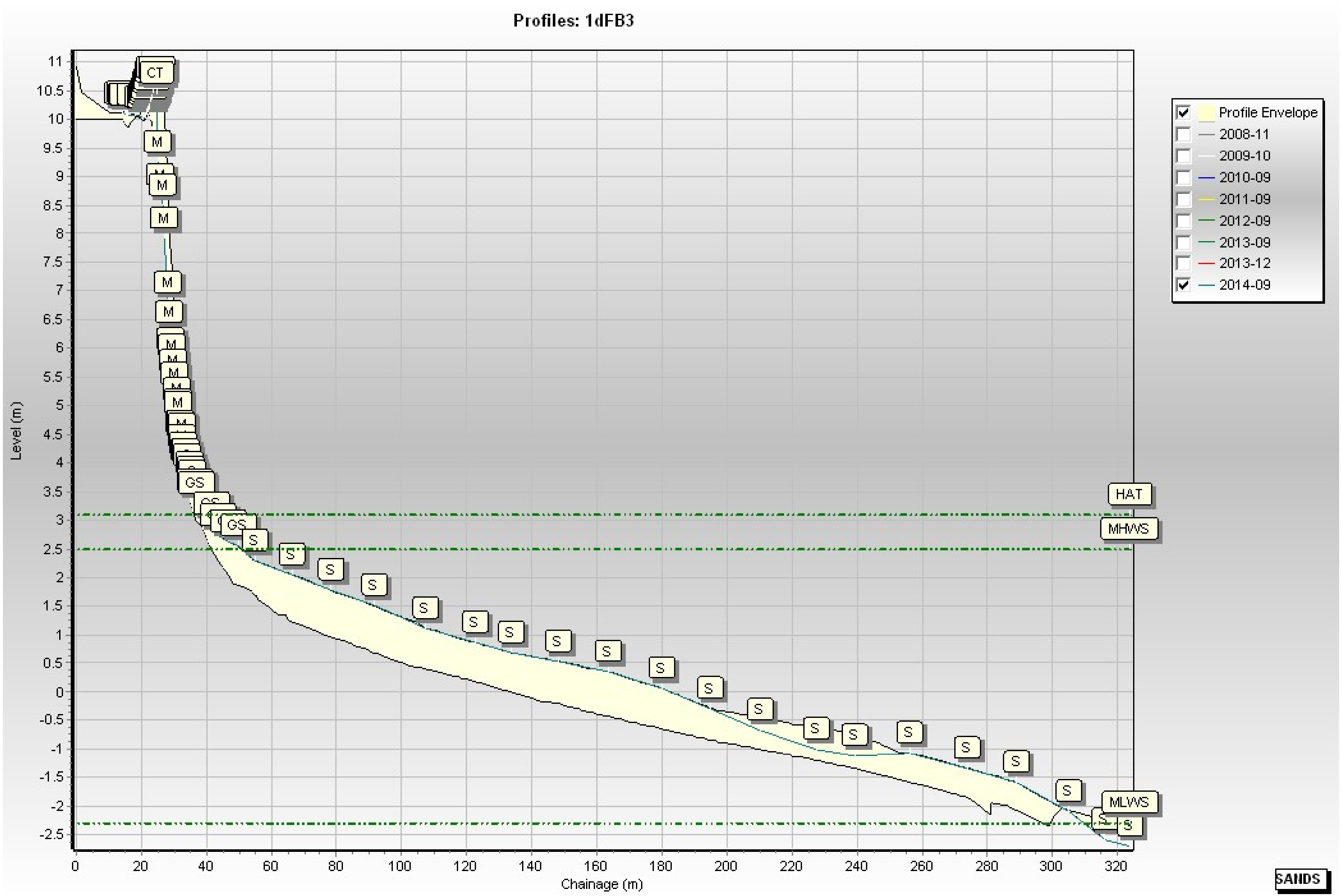
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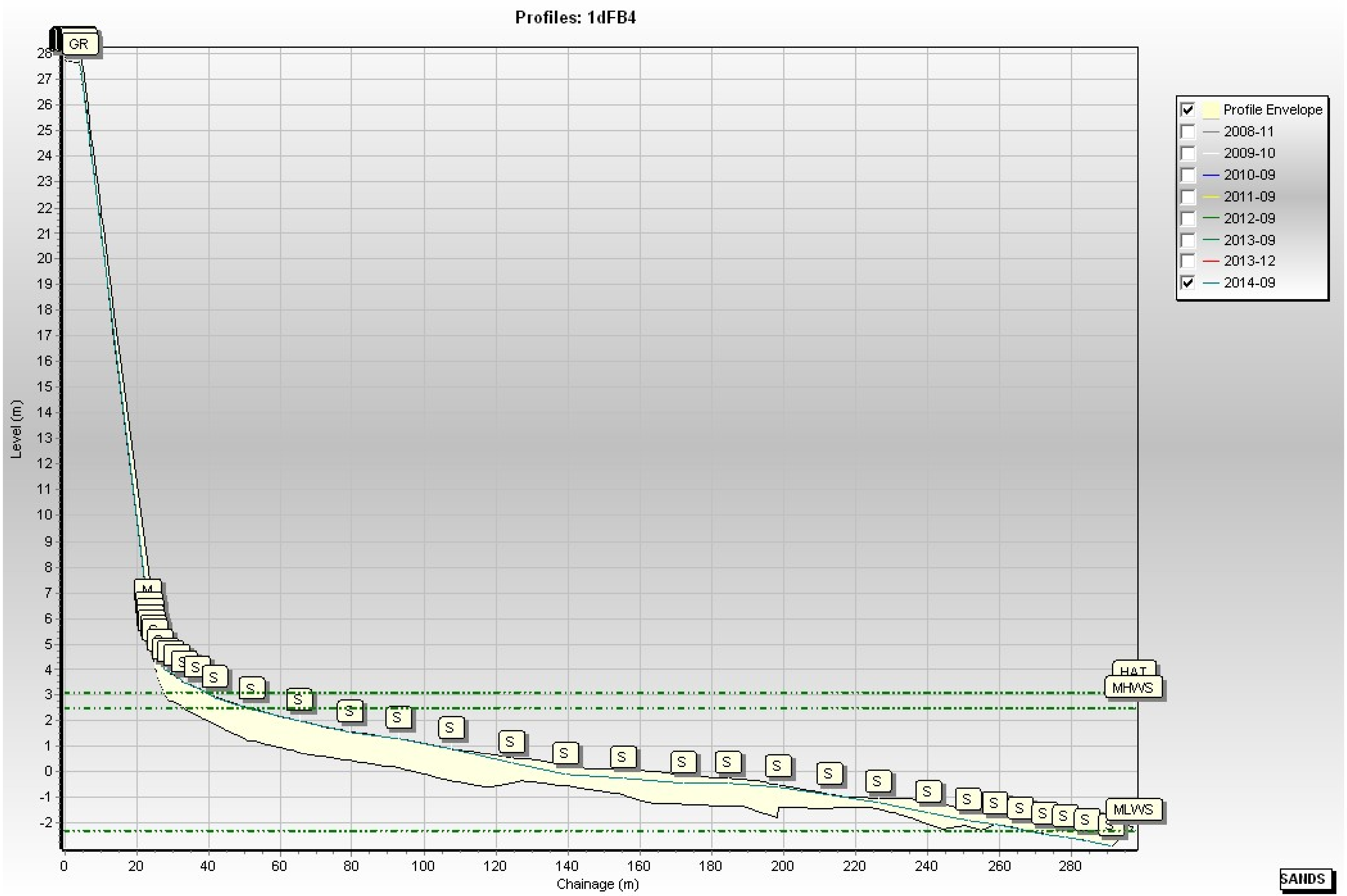
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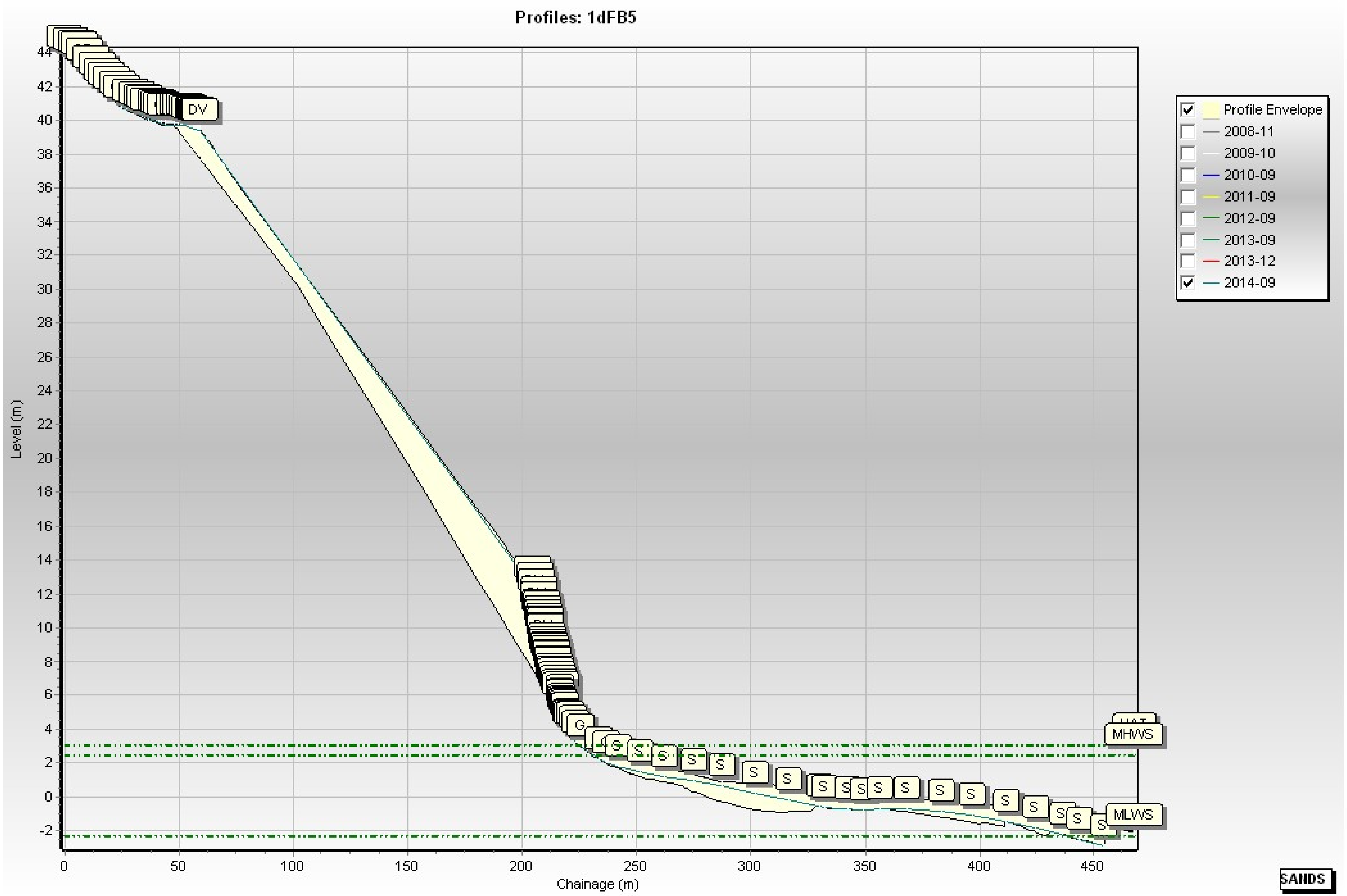

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S
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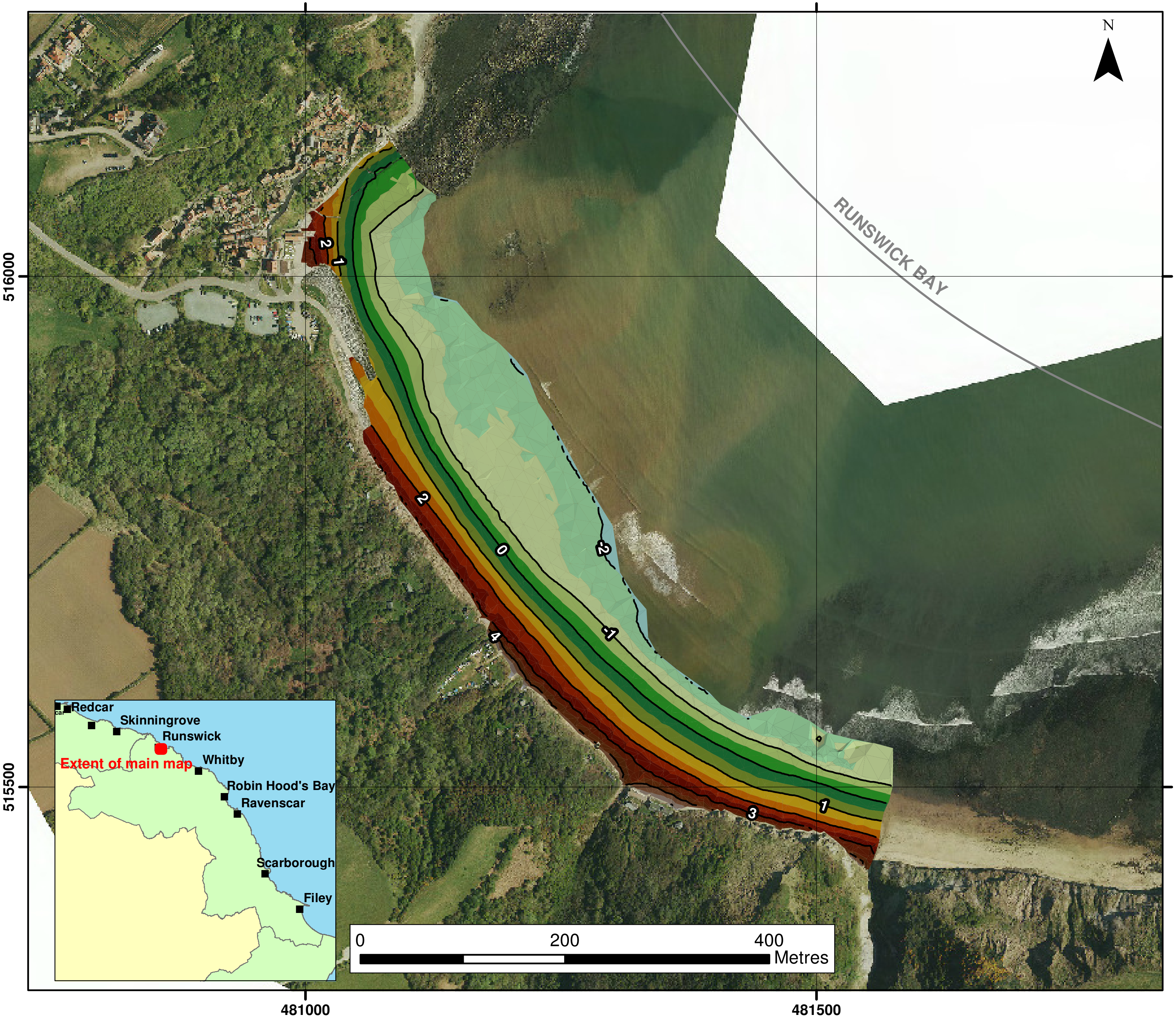
MLWS
SANDS

Appendix B

Topographic Survey



KEY

Elevation (m OD)

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

Client: North East Coastal Group

Project: Cell 1 Regional Coastal Monitoring Programme 2011 to 2016

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

Analytical Report 7
Full Measures Survey
Autumn 2014

CH2MHILL.
Halcrow

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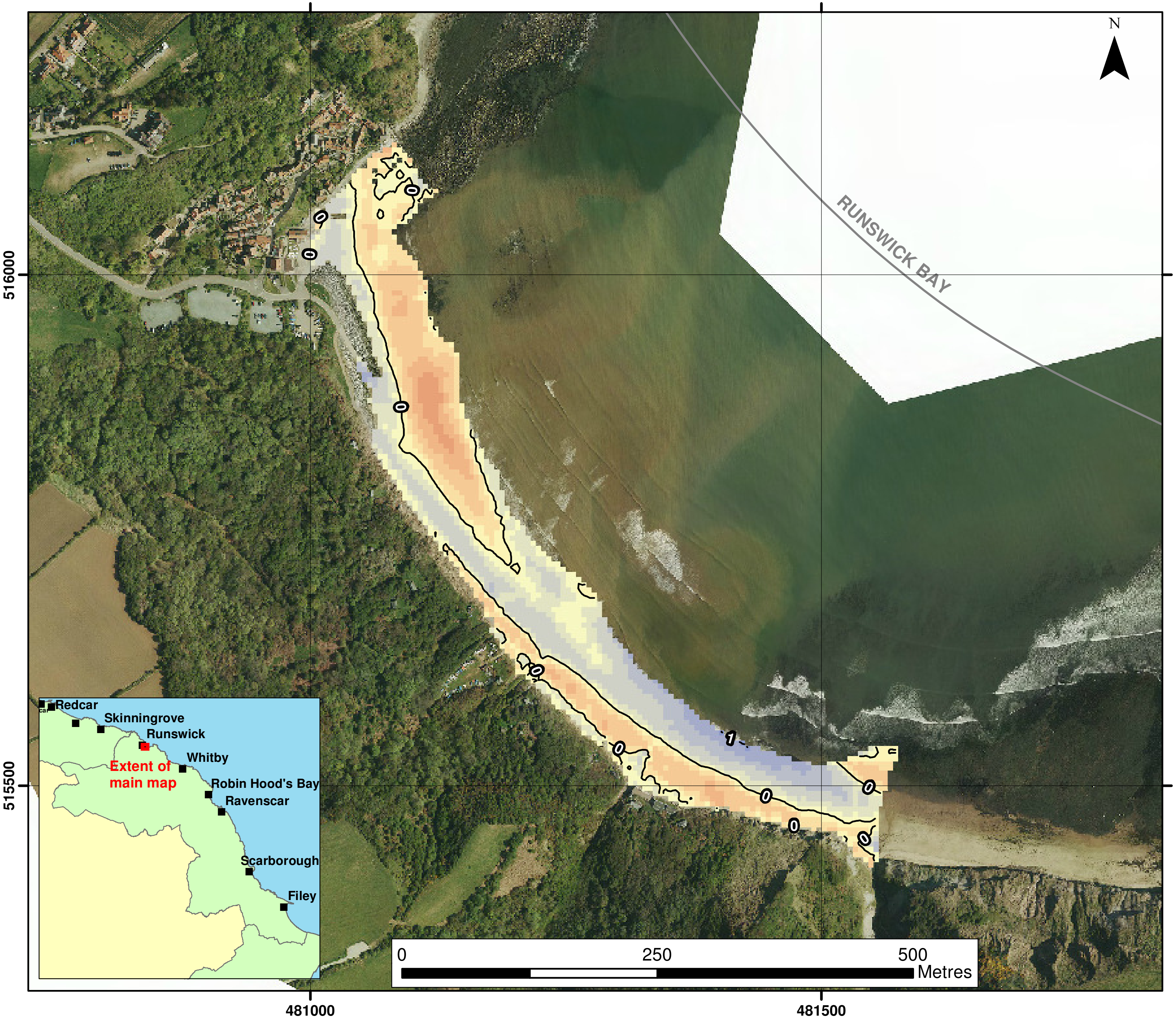
Fax: +44(0)121 456 1569
www.halcrow.com

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



KEY Spring 2014 and Autumn 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 1b
Short-term Elevation Change
Runswick
Scarborough Borough Council

Analytical Report 7
Full Measures Survey
Autumn 2014

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www.halcrow.com

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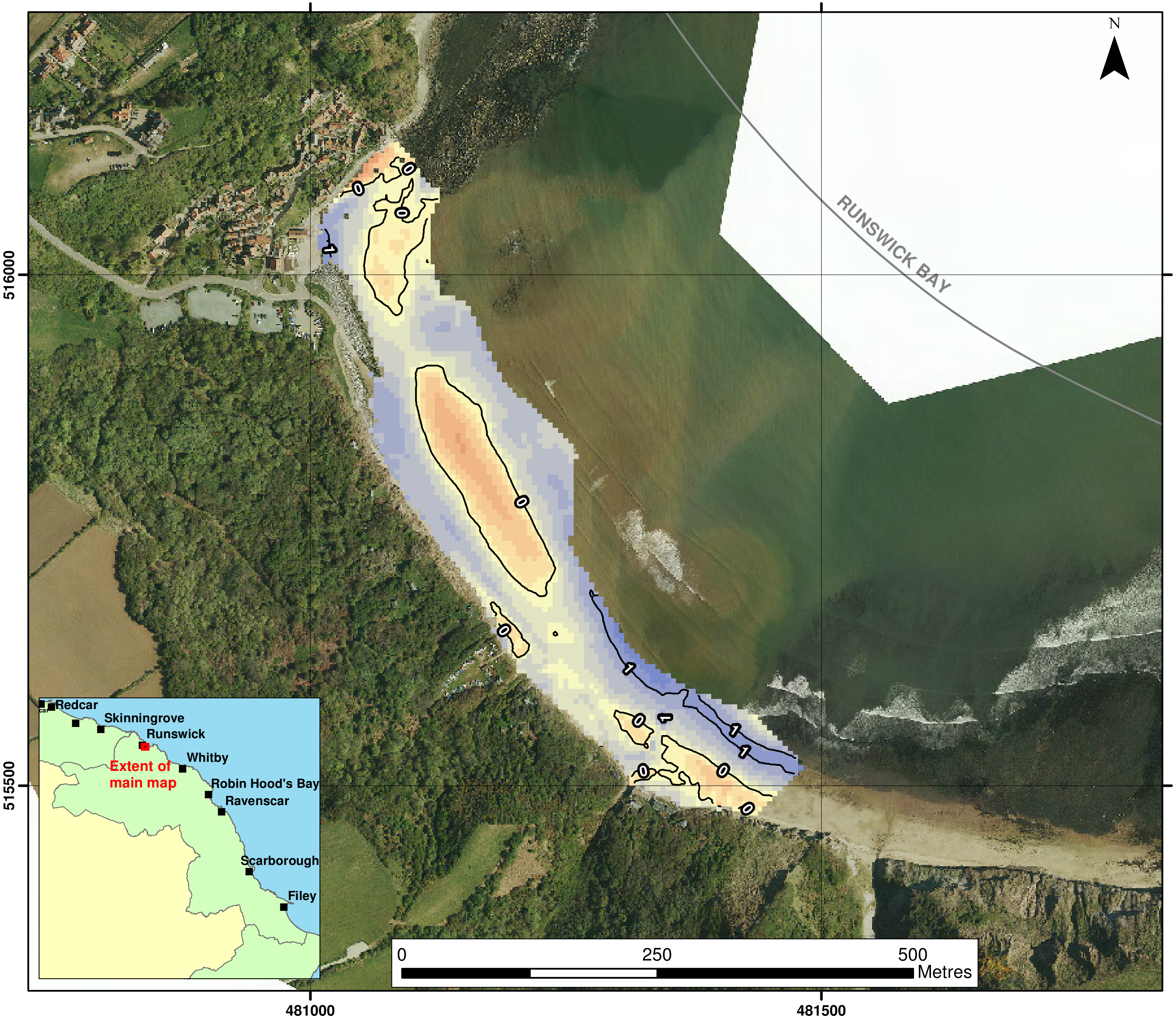
www.northeastcoastalobservatory.org.uk



KEY Autumn 2008 Autumn 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 1c
Long-term Elevation Change
Runswick
Scarborough Borough Council

Analytical Report 7
Full Measures Survey
Autumn 2014

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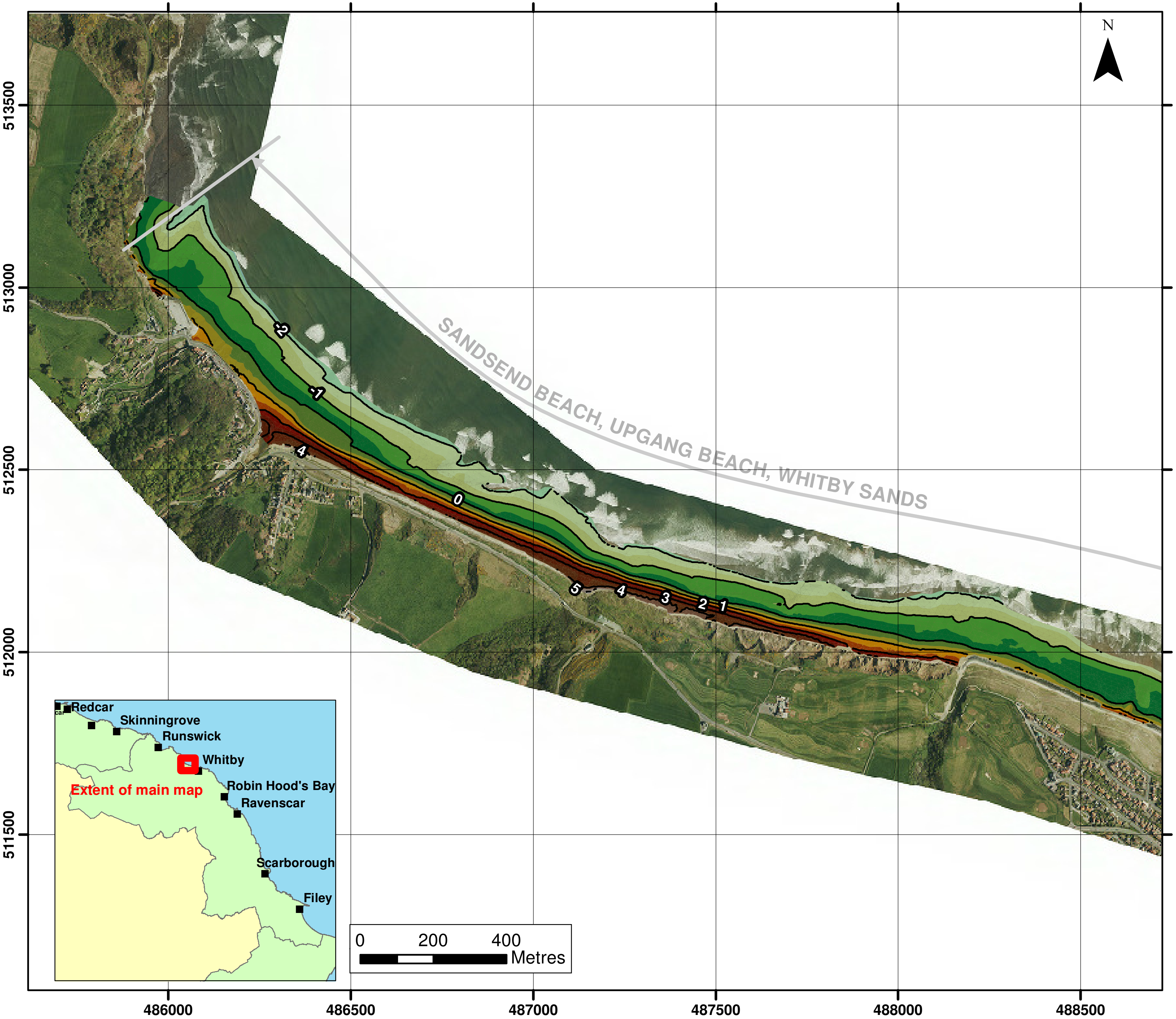

KEY

Elevation (m OD)

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

Client: North East Coastal Group

Project: Cell 1 Regional Coastal Monitoring Programme 2011 to 2016

Appendix B- Map 2a
Topographic Survey
Whitby
Scarborough
Borough Council

Analytical Report 7
Full Measures Survey
Autumn 2014

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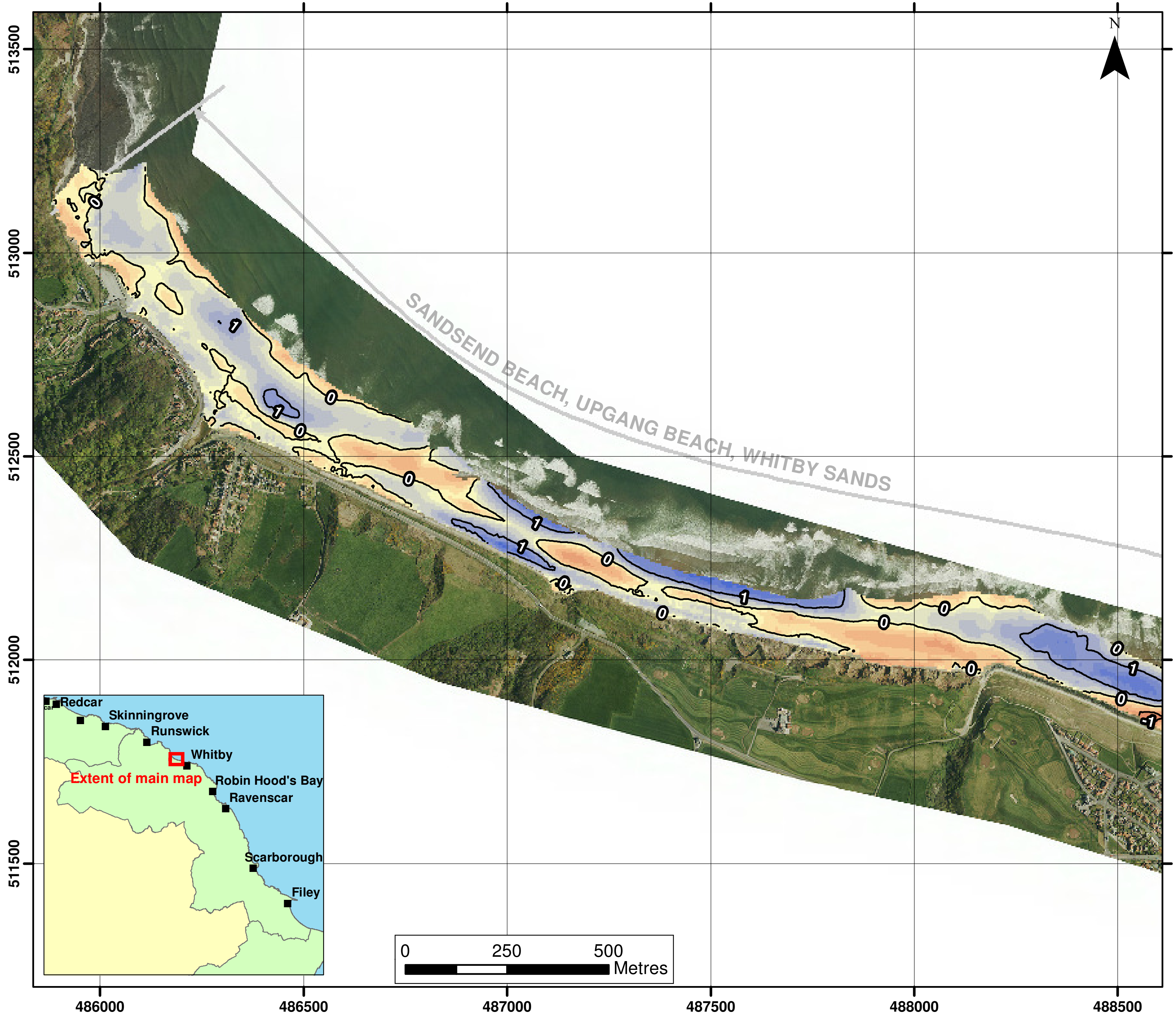
Fax: +44(0)121 456 1569
www.halcrow.com

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



KEY Autumn 2013 and Autumn 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 2b
Short-term Elevation Change Whitby Scarborough Borough Council

Analytical Report 7
Full Measures Survey
Autumn 2014

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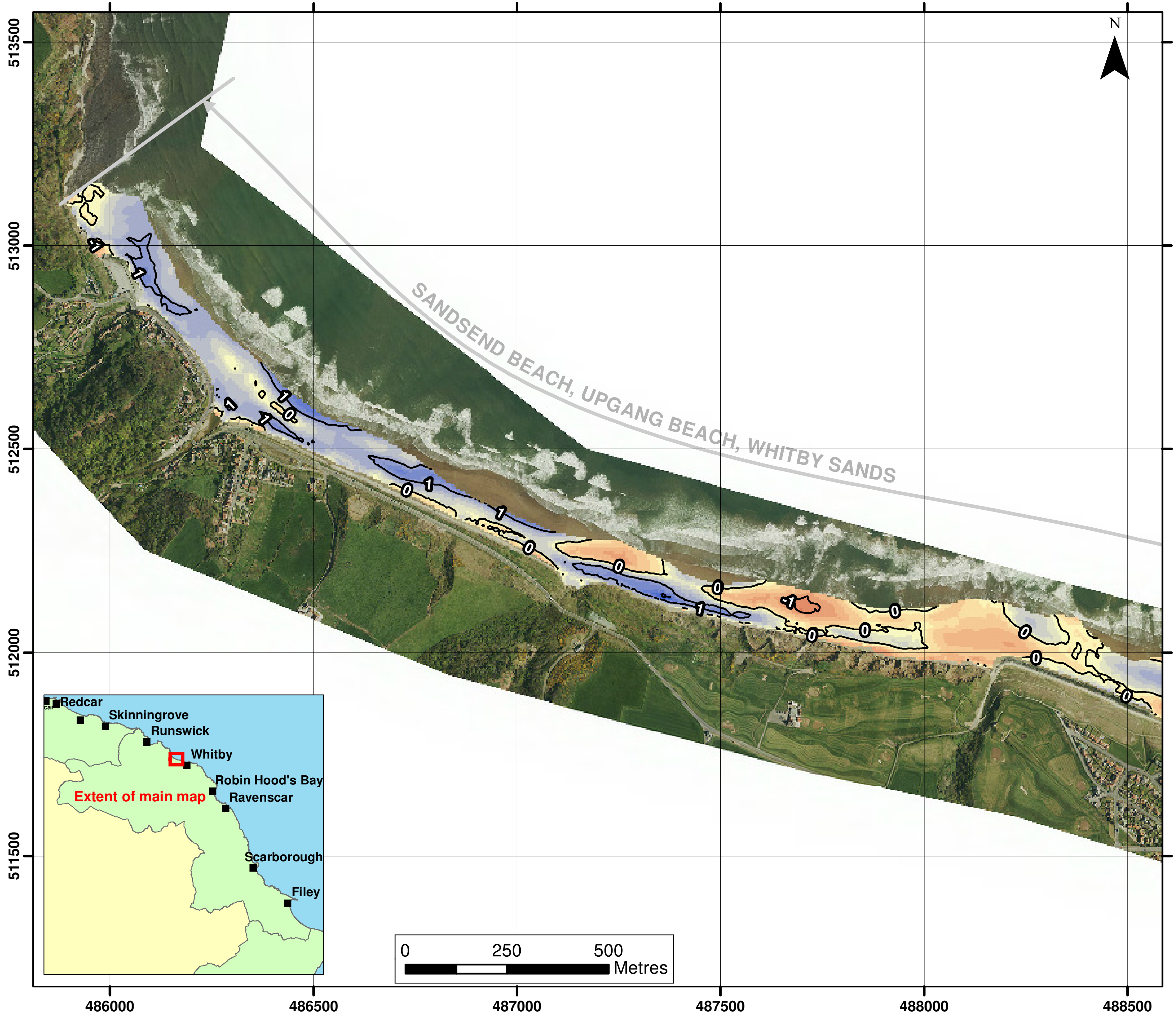

KEY Autumn 2008 and Autumn 2014
Change in elevation (m)

- <-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 2c
Long-term Elevation Change Whitby Scarborough Borough Council

Analytical Report 7
Full Measures Survey
Autumn 2014

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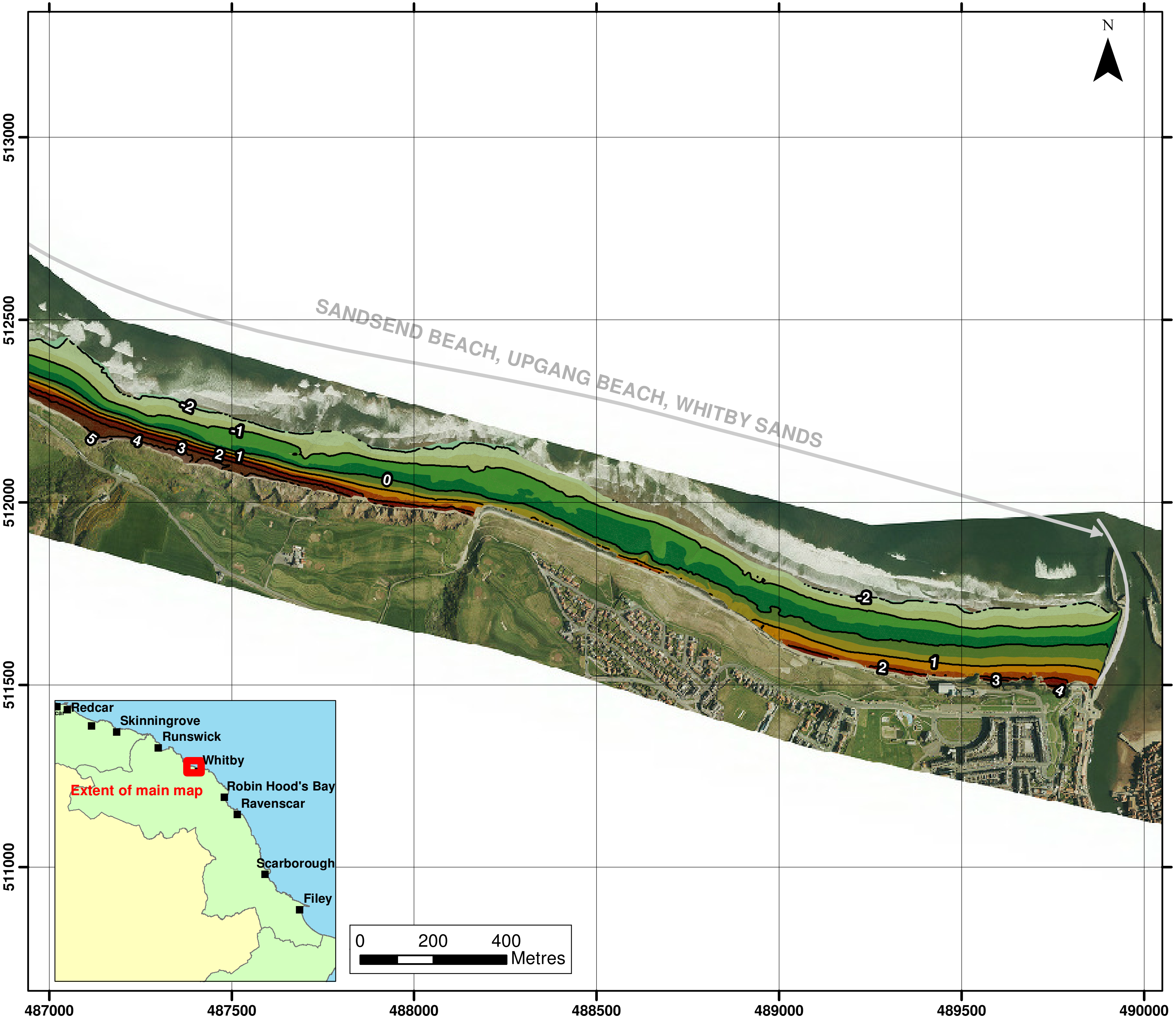

KEY

Elevation (m OD)

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

Client: North East Coastal Group

Project: Cell 1 Regional Coastal Monitoring Programme 2011 to 2016

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

Analytical Report 7
Full Measures Survey
Autumn 2014

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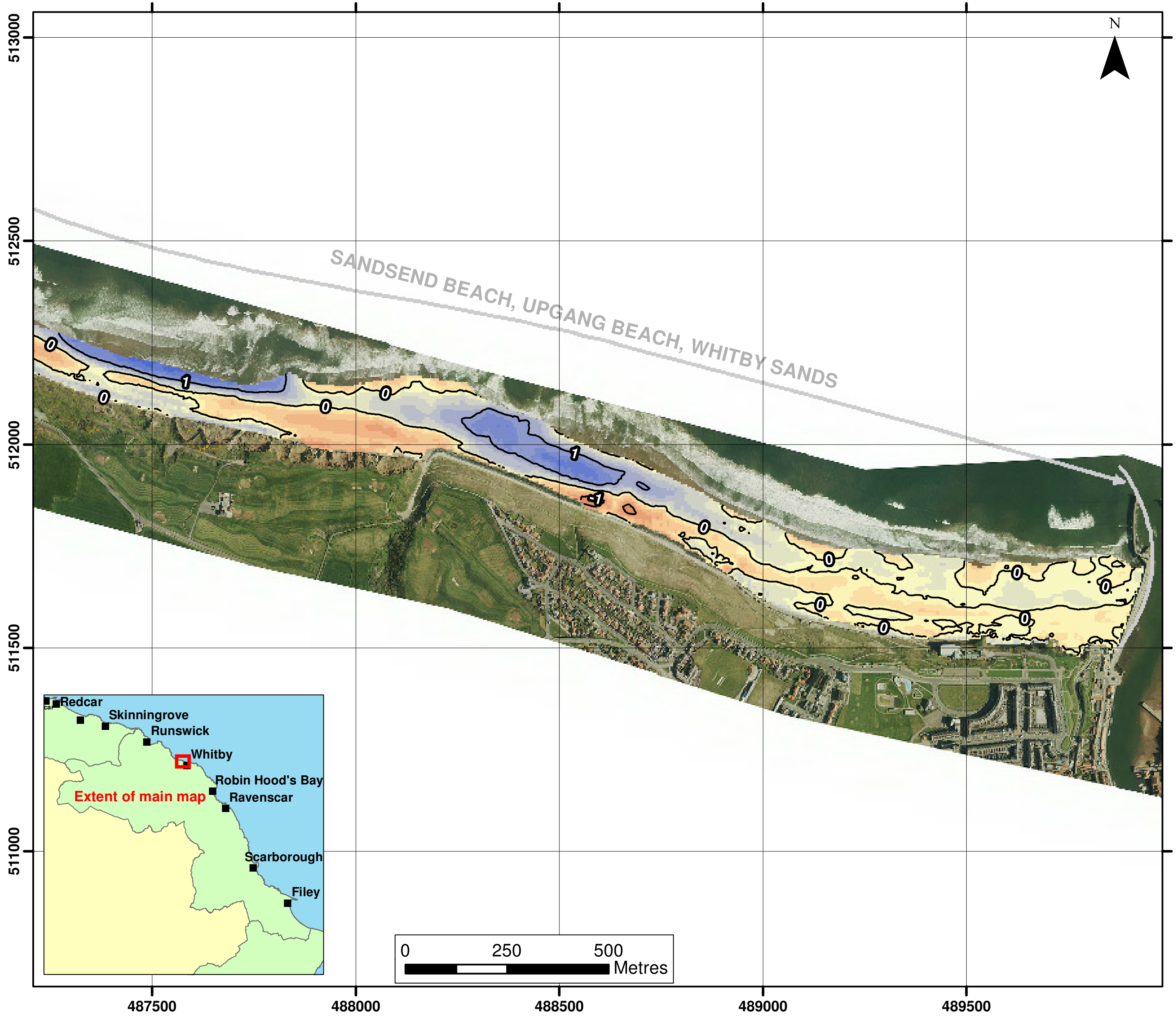

KEY

Autumn 2013 and Autumn 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 Whitby Scarborough Borough Council

Analytical Report 7
Full Measures Survey
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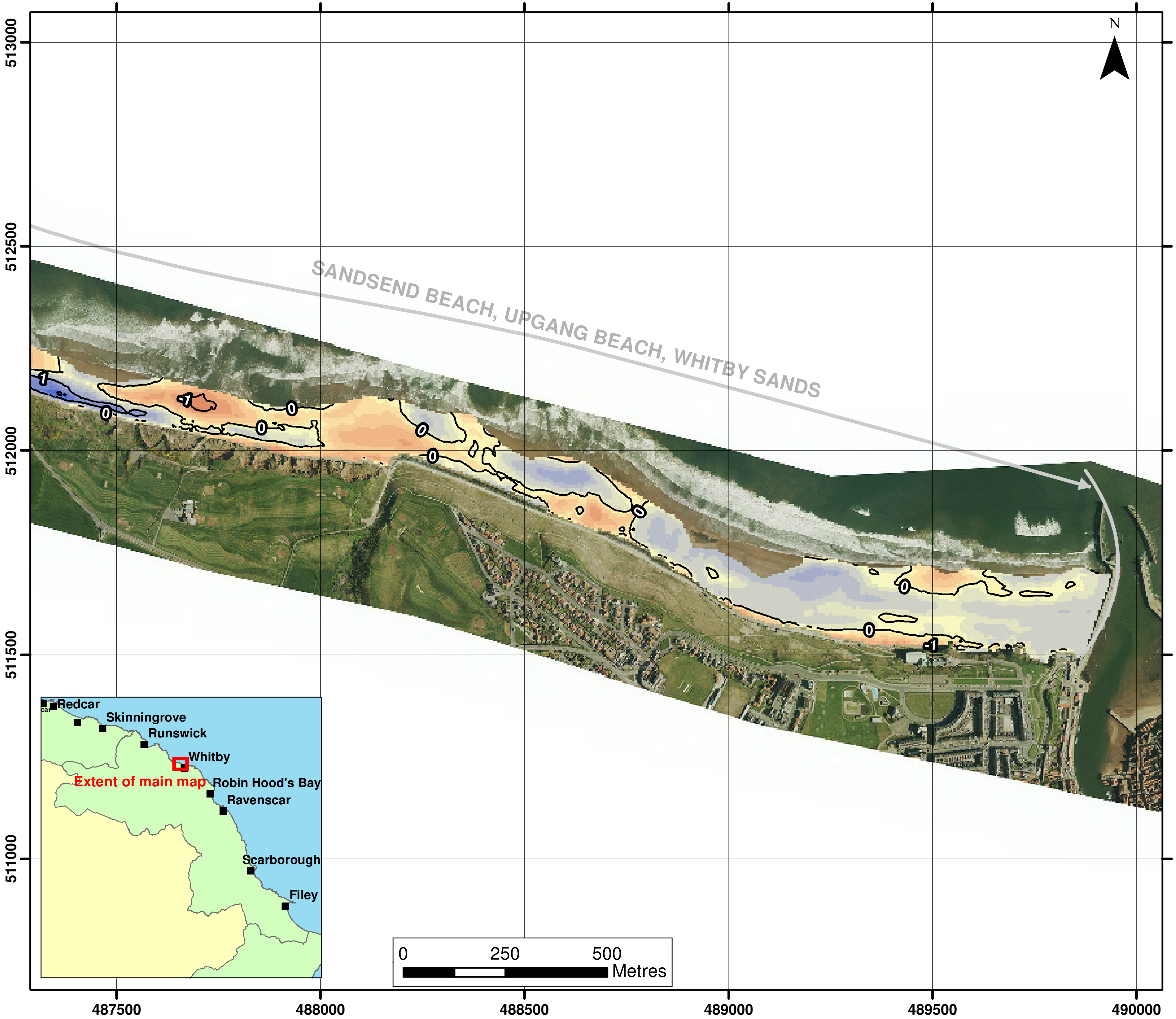

KEY Autumn 2008 and Autumn 2014
Change in elevation (m)

- <-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 3c
Long-term Elevation Change Whitby Scarborough Borough Council

Analytical Report 7
Full Measures Survey
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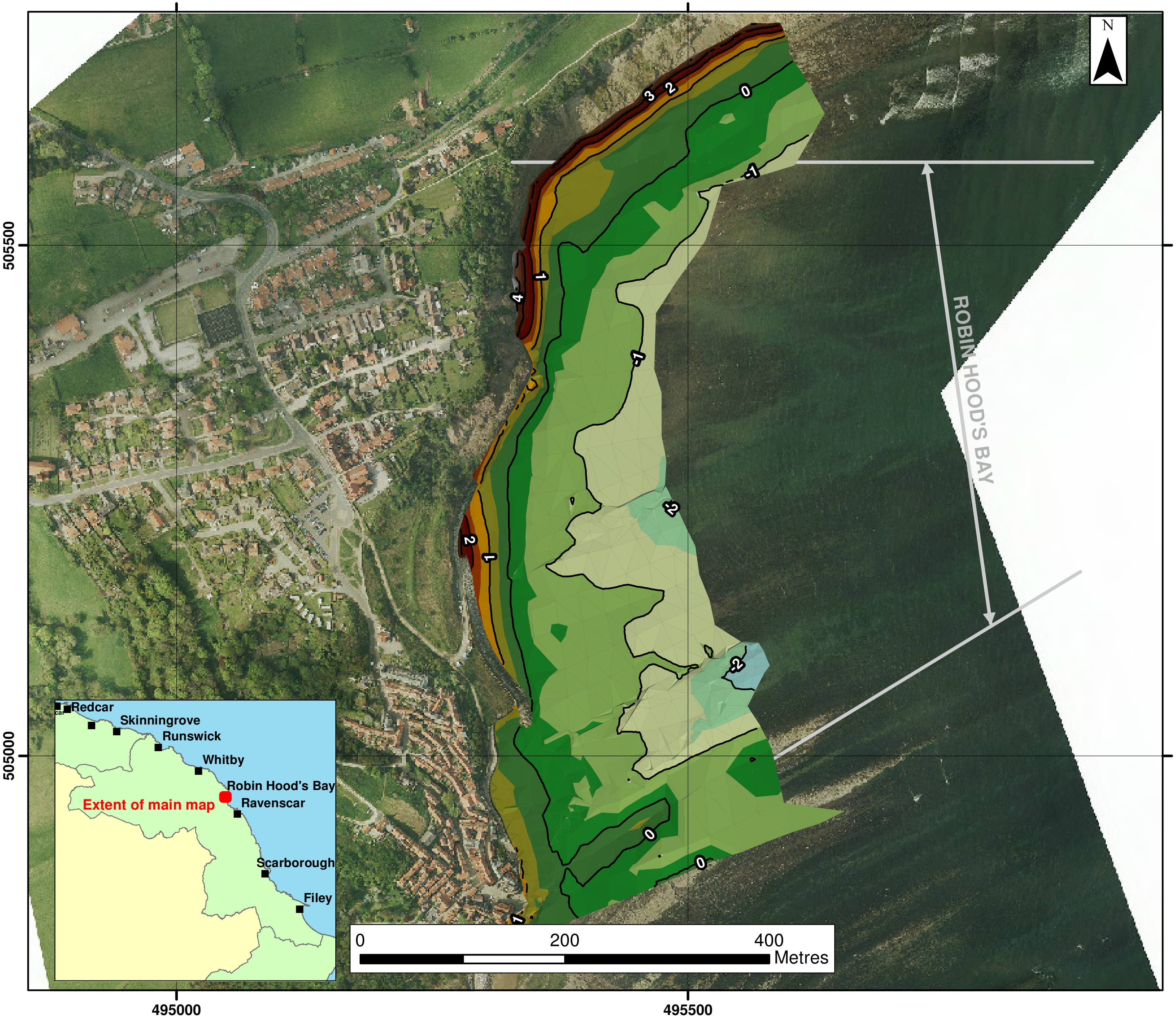

KEY

Elevation (m OD)

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

Client: North East Coastal Group

Project: Cell 1 Regional Coastal Monitoring Programme 2011 to 2016

Appendix B- Map 4a
Topographic Survey
Robin Hood's Bay
Scarborough Borough Council

Analytical Report 7
Full Measures Survey
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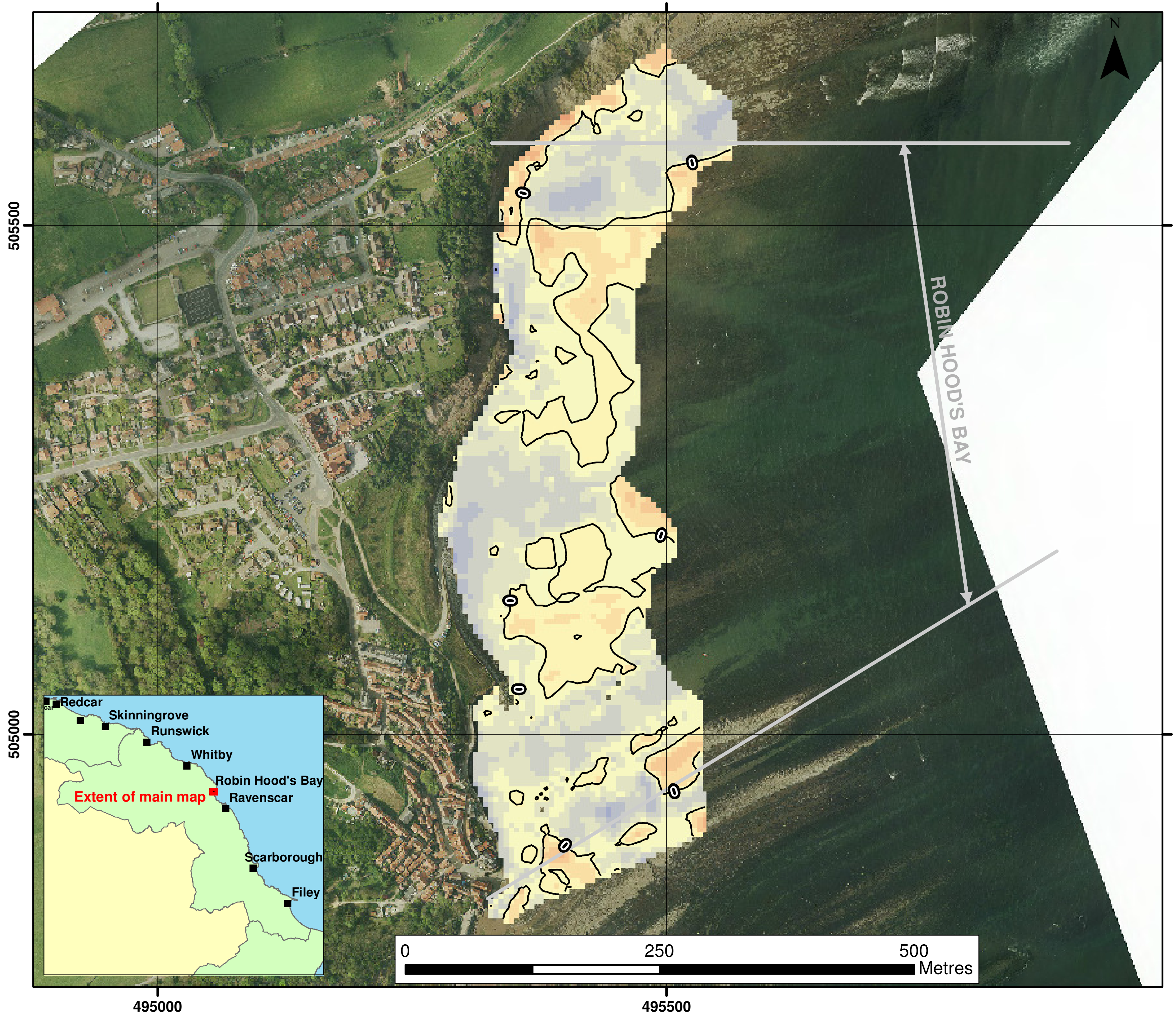

KEY Spring 2014 and Autumn 2014
Change in elevation (m)

- <-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 4b
Short-term Elevation Change
Robin Hood's Bay
Scarborough Borough Council

Analytical Report 7
Full Measures Survey
Autumn 2014

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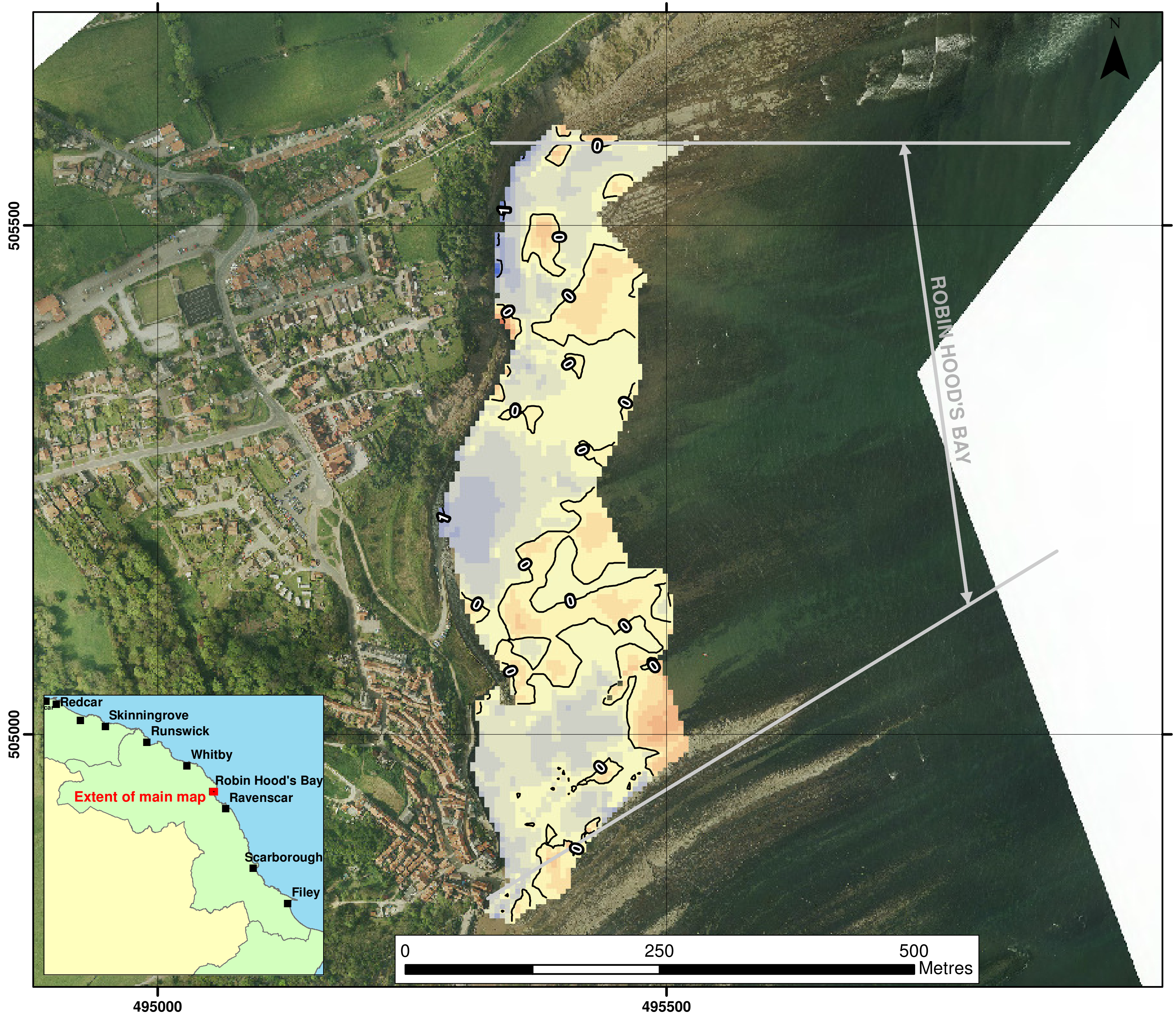

KEY Autumn 2008 and Autumn 2014
Change in elevation (m)

- <-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 4c
Long-term Elevation Change Robin Hood's Bay Scarborough Borough Council

Analytical Report 7
Full Measures Survey
Autumn 2014

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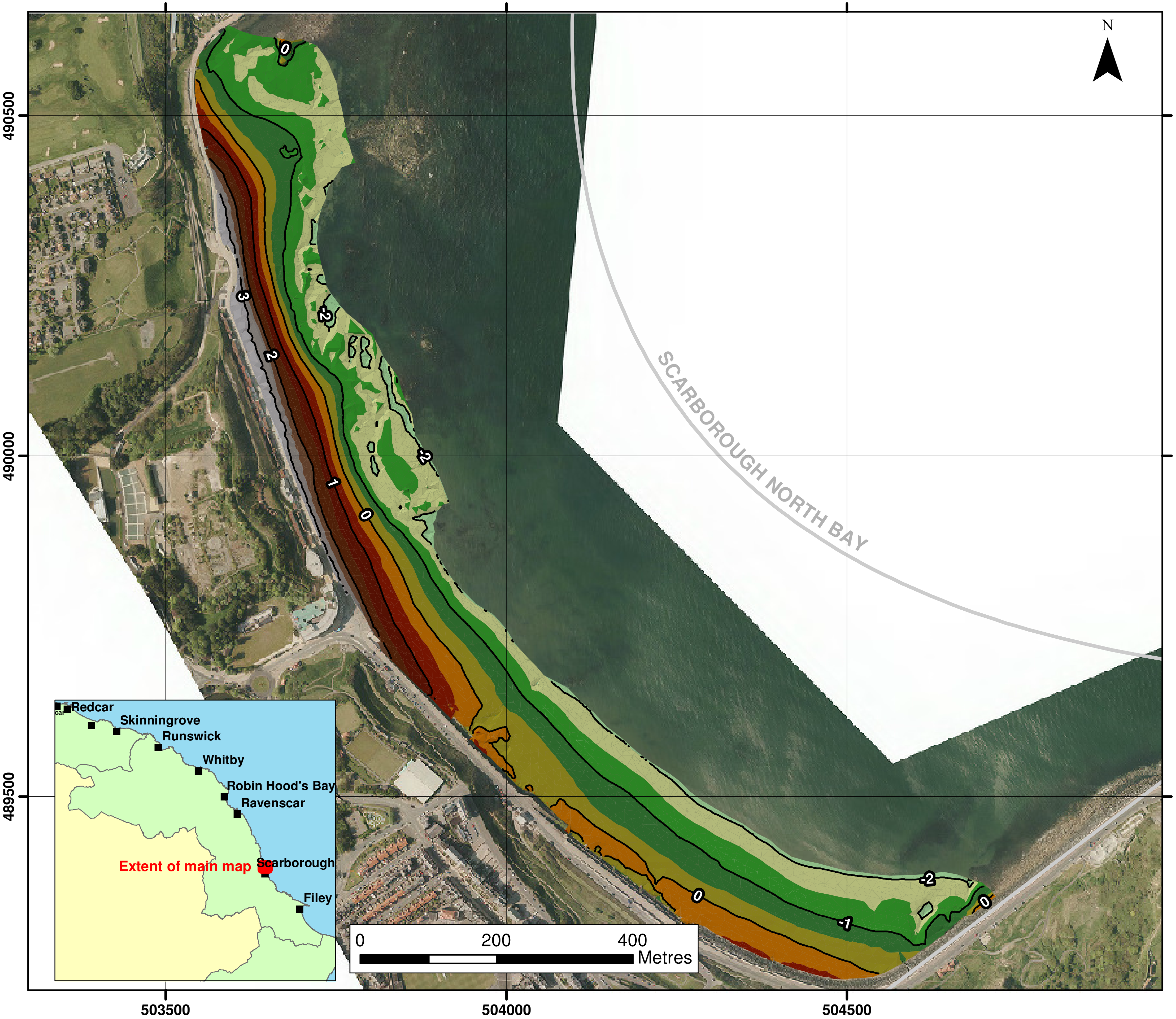

KEY

Elevation (m OD)

- 3.5 - 4
- 3 - 3.5
- 2.5 - 3
- 2 - 2.5
- 1.5 - 2
- 1 - 1.5
- 0.5 - 1
- 0 - 0.5
- -0.5 - 0
- -1 - -0.5
- -1.5 - -1
- -2 - -1.5
- -2.5 - -2
- -3 - -2.5
- Contour 1m

Client: North East Coastal Group

Project: Cell 1 Regional Coastal Monitoring Programme 2011 to 2016

Appendix B- Map 5a(i)
Topographic Survey
Scarborough North
Scarborough
Borough Council

Analytical Report 7
Full Measures Survey
Autumn 2014

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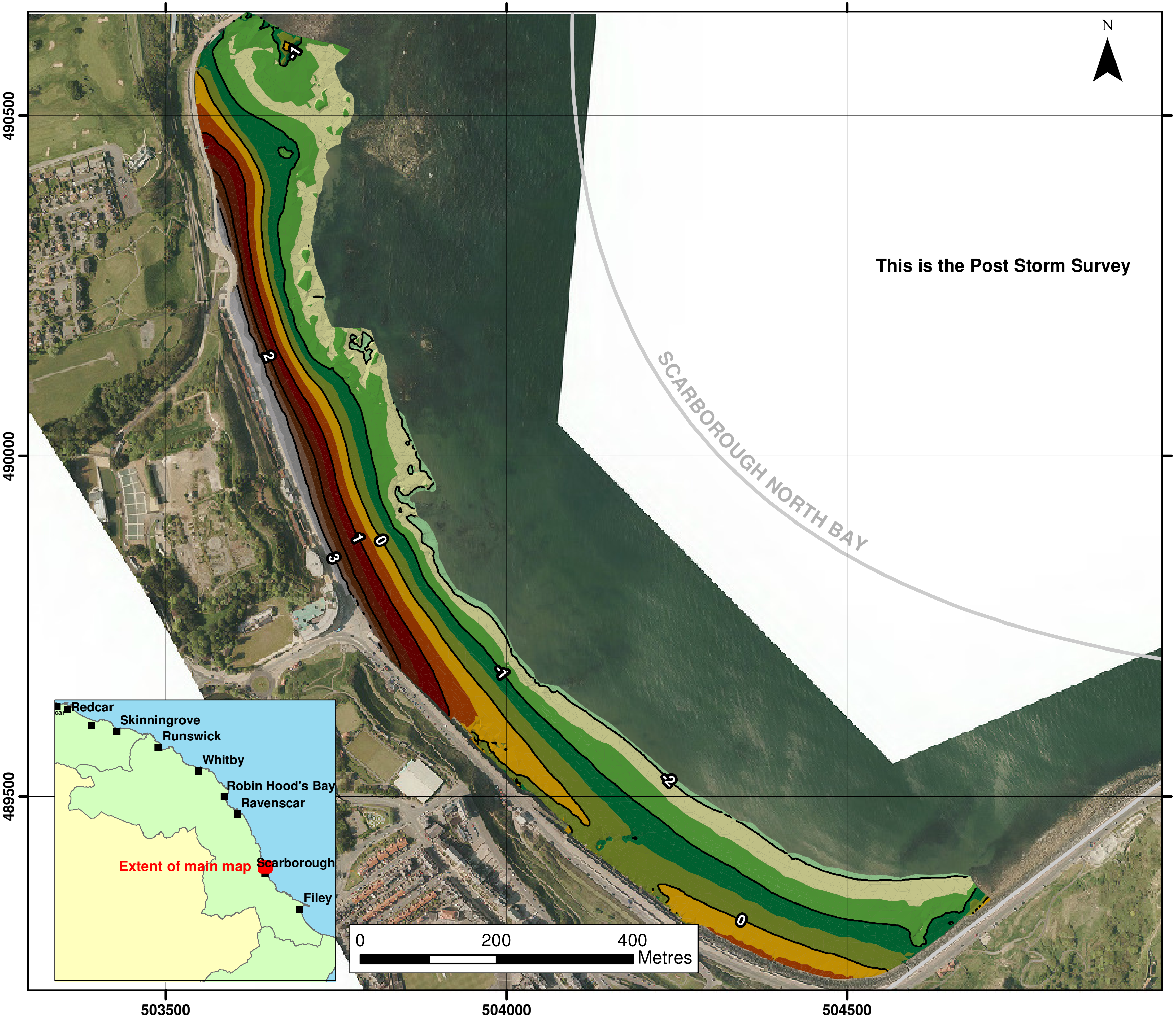

KEY

Elevation

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

Client: North East Coastal Group

Project: Cell 1 Regional Coastal Monitoring Programme 2011 to 2016

Appendix B- Map 5a(ii)
Topographic Survey
Scarborough North
Scarborough
Borough Council

Analytical Report 7
Full Measures Survey
Autumn 2014

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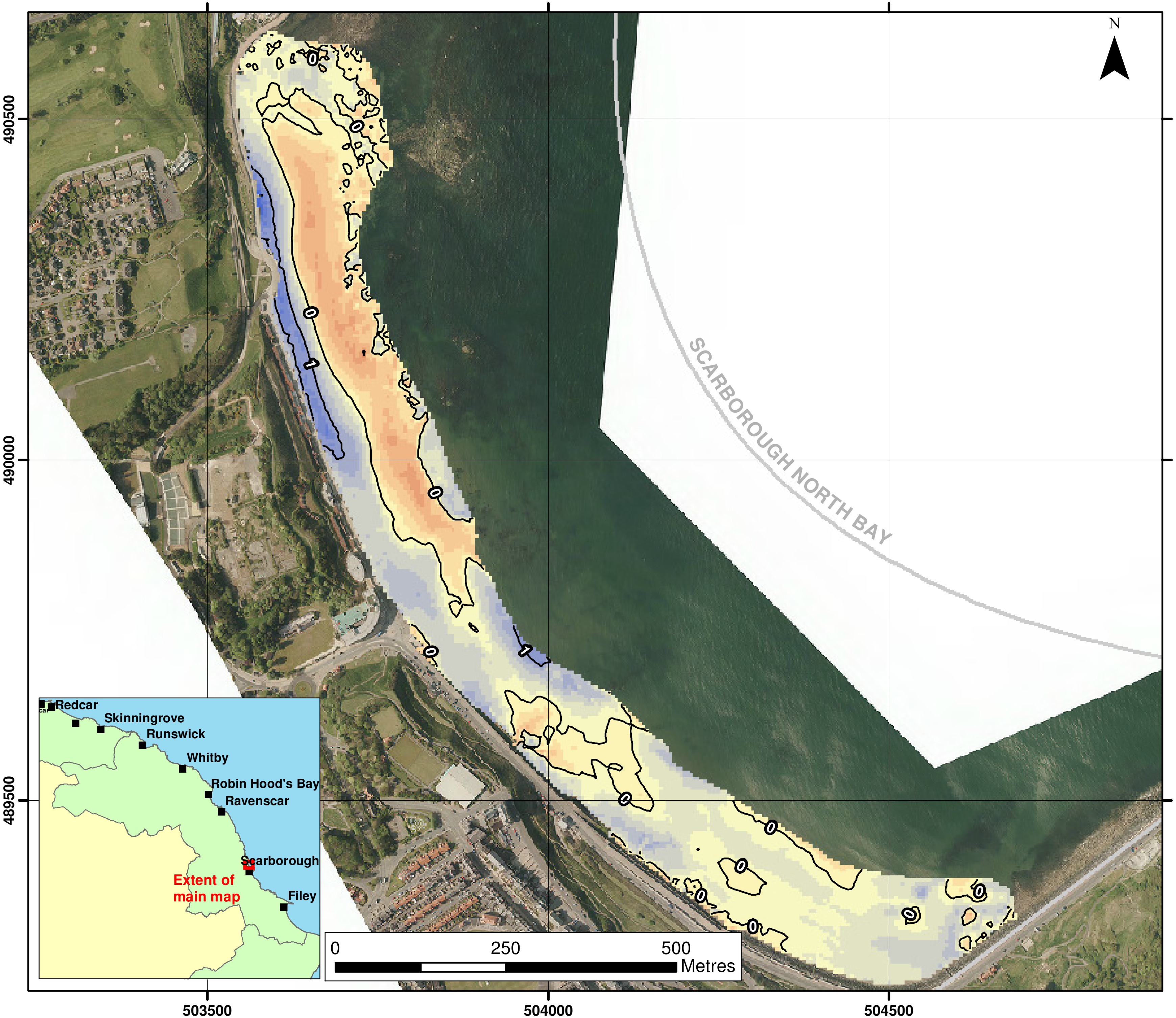

KEY Autumn 2013 and Autumn 2014
Change in elevation (m)

- <-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 5b(i) Short-term Elevation Change Scarborough North Scarborough Borough Council

Analytical Report 7
Full Measures Survey
Autumn 2014

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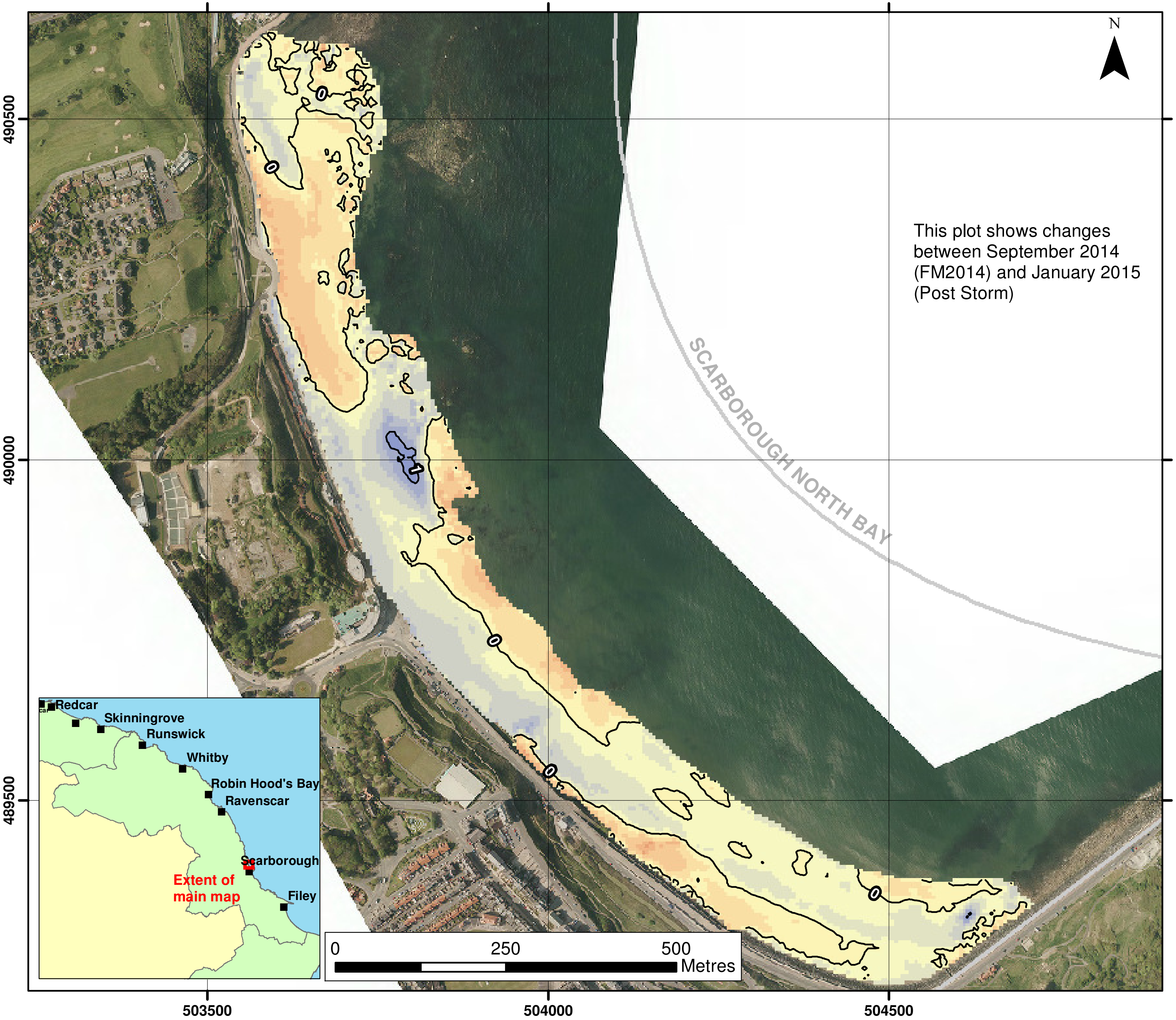

KEY Autumn 2014 and January 2015 Change in elevation (m)

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

Contours of change

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

Appendix B- Map 5b(ii)
Short-term Elevation Change Scarborough North Scarborough Borough Council

Analytical Report 7
Full Measures Survey
Autumn 2014

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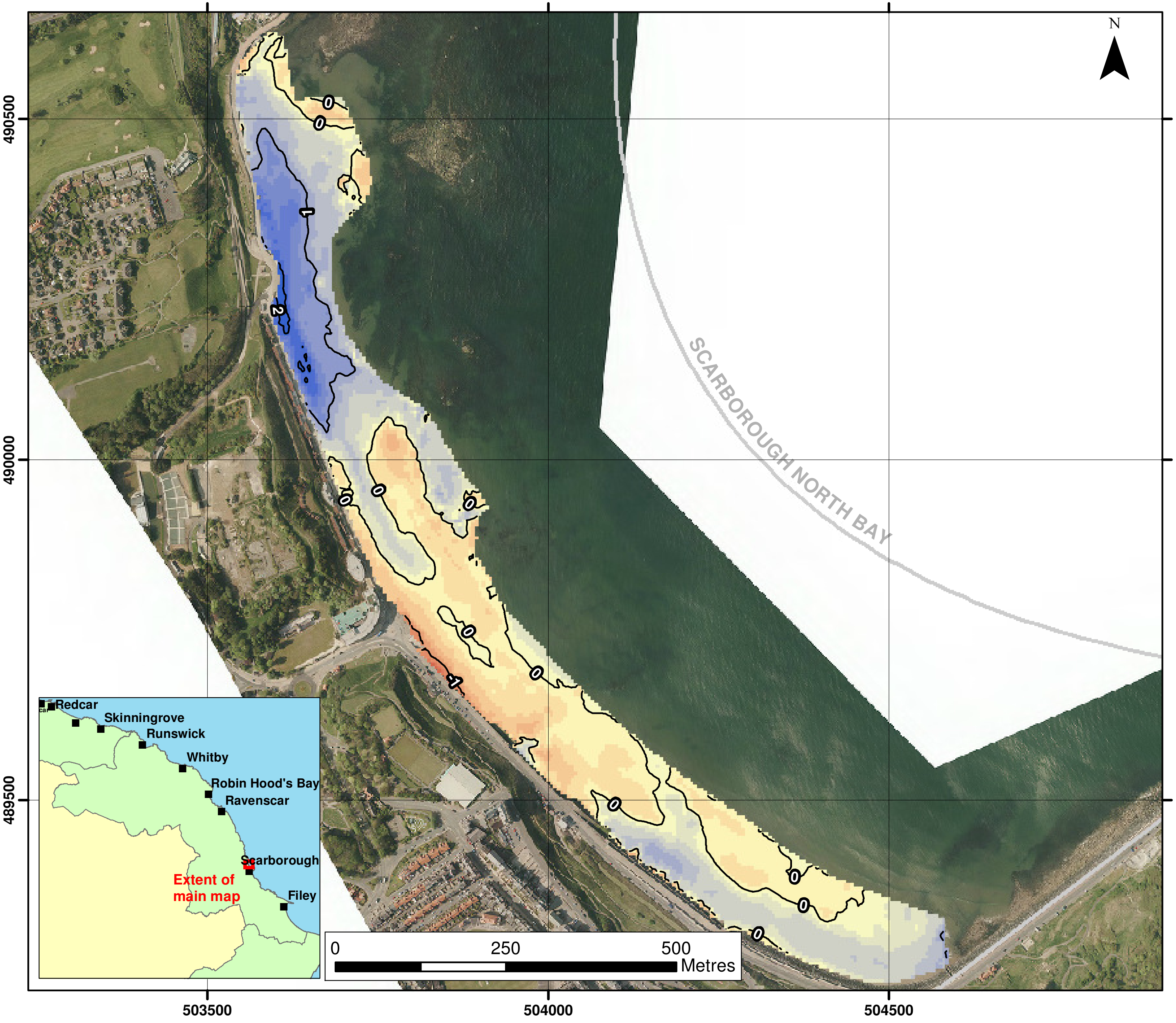

KEY Autumn 2008 and Autumn 2014
Change in elevation (m)

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

Contours of change

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

Appendix B- Map 5c
Long-term Elevation Change
Scarborough North
Scarborough Borough Council

Analytical Report 7
Full Measures Survey
Autumn 2014

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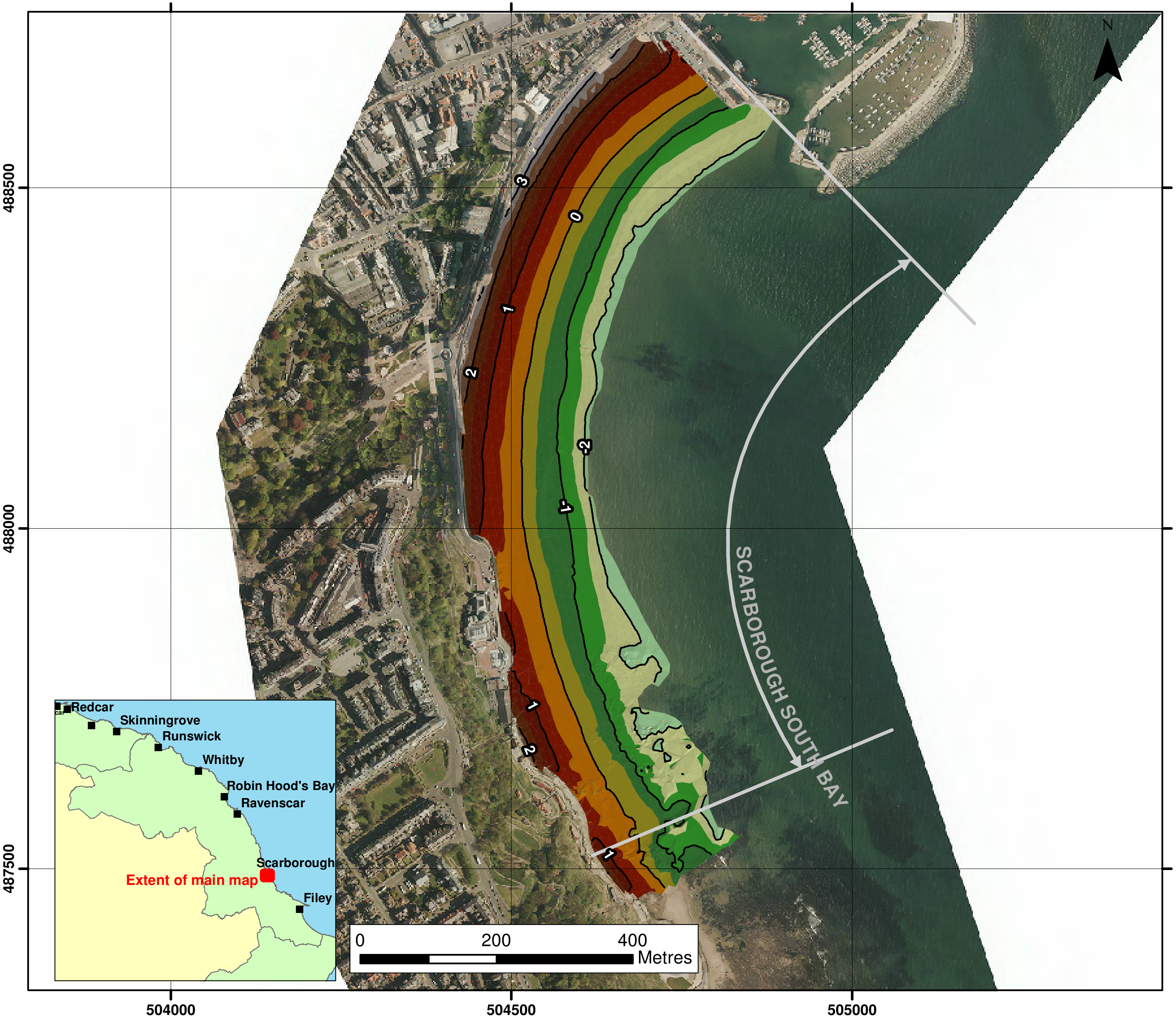

KEY

Elevation (m OD)

- 3.5 - 4
- 3 - 3.5
- 2.5 - 3
- 2 - 2.5
- 1.5 - 2
- 1 - 1.5
- 0.5 - 1
- 0 - 0.5
- -0.5 - 0
- -1 - -0.5
- -1.5 - -1
- -2 - -1.5
- -2.5 - -2
- -3 - -2.5
- Contour 1m

Client: North East Coastal Group

Project: Cell 1 Regional Coastal Monitoring Programme 2011 to 2016

Appendix B- Map 6a
Topographic Survey
Scarborough South
Scarborough
Borough Council

Analytical Report 7
Full Measures Survey
Autumn 2014

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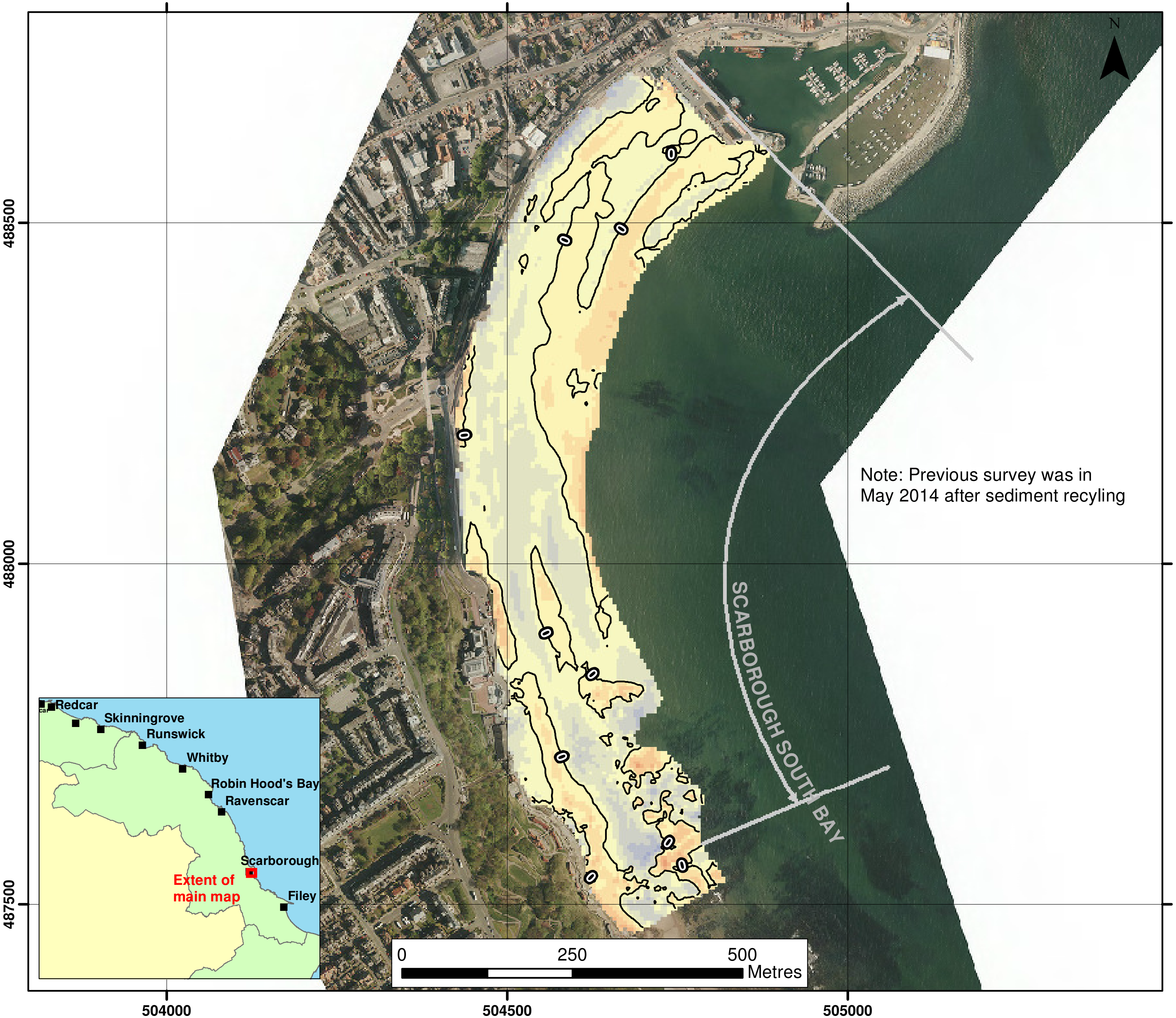

KEY Spring 2013 and Autumn 2014
Change in elevation (m)

- <-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 6b
Short-term Elevation Change
Scarborough South
Scarborough Borough Council

Analytical Report 7
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Autumn 2014

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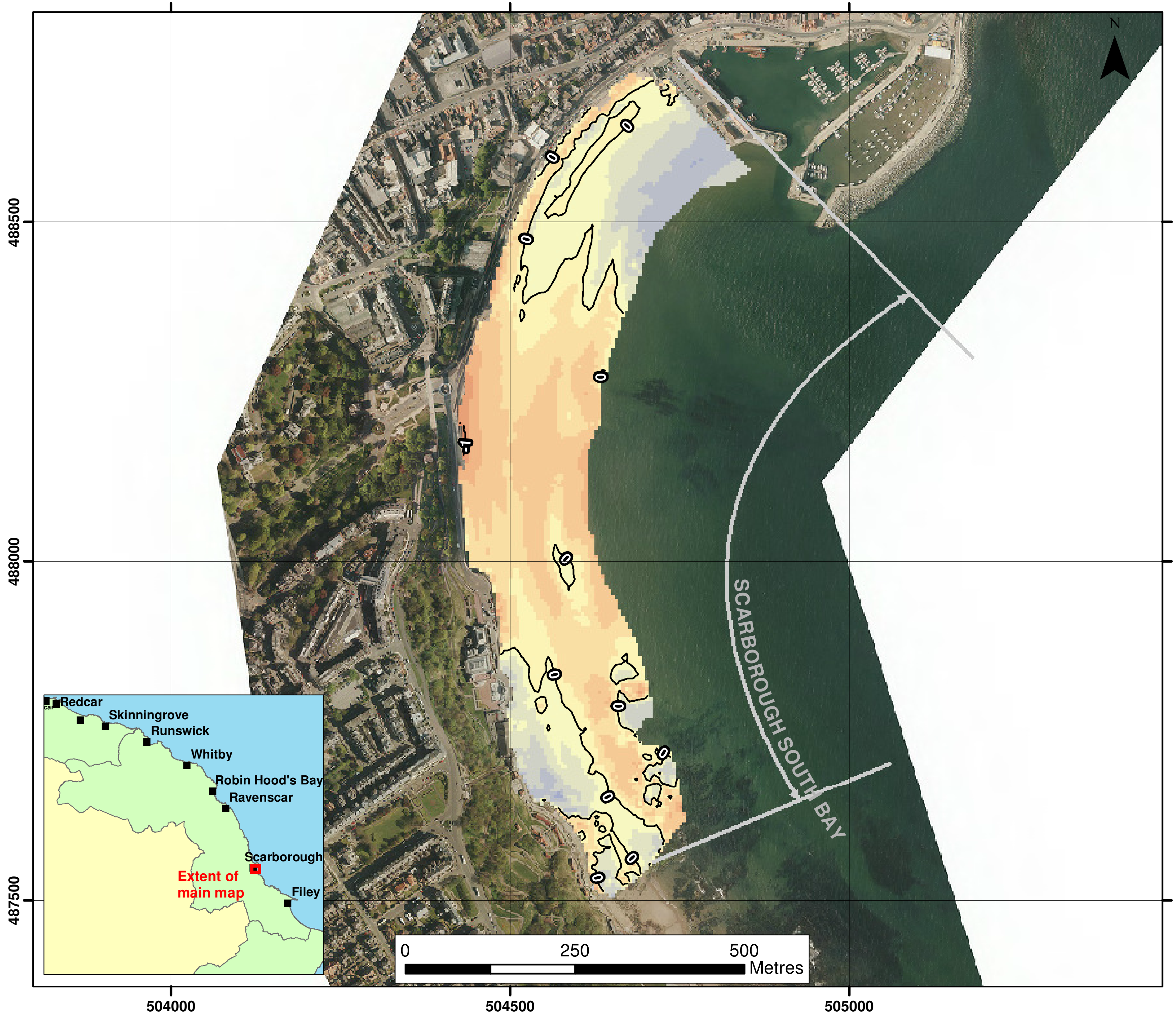

KEY Autumn 2008 and Autumn 2014
Change in elevation (m)

- <-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 6c
Long-term Elevation Change Scarborough South Scarborough Borough Council

Analytical Report 7
Full Measures Survey
Autumn 2014

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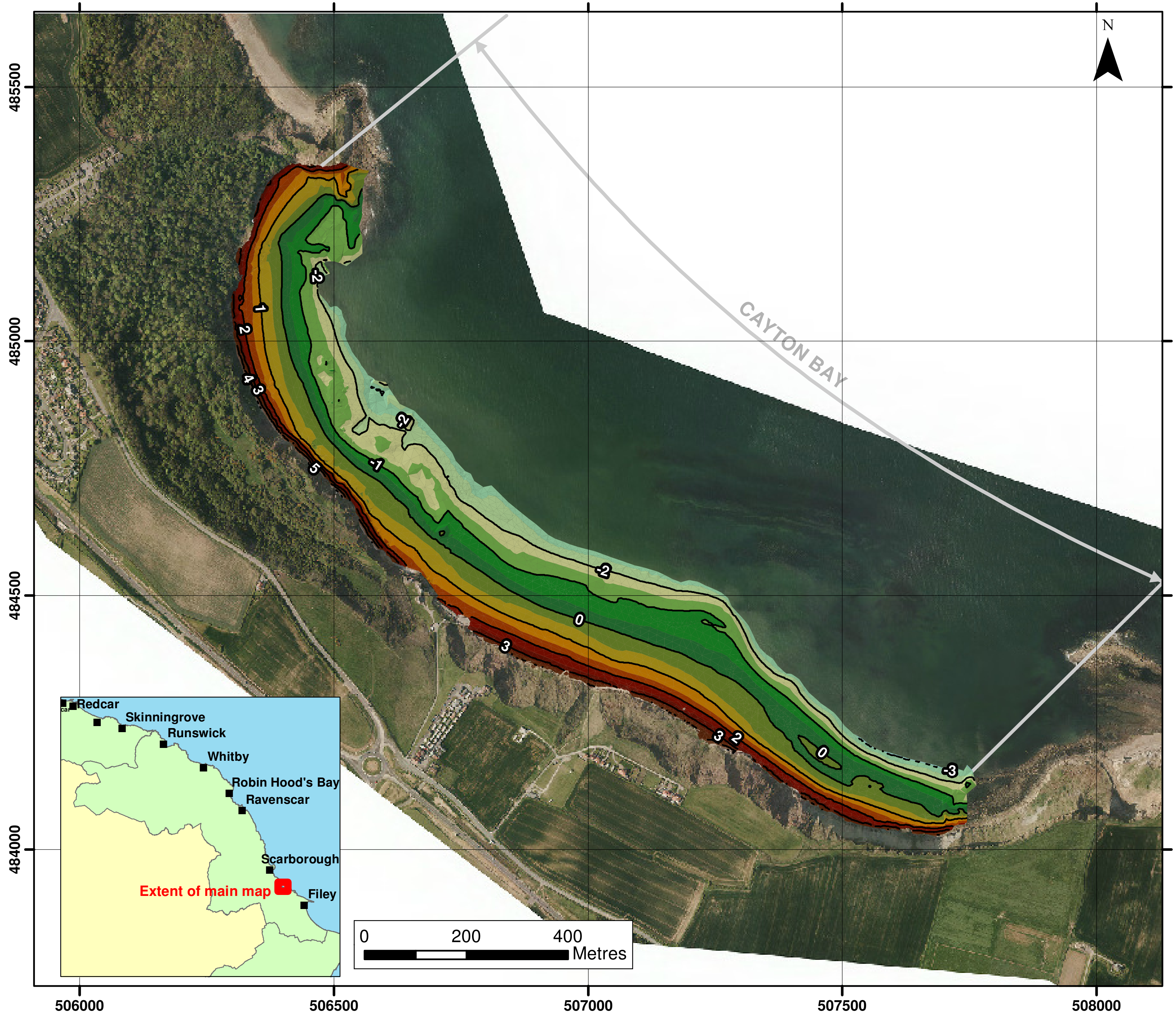

KEY

Elevation (m OD)

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

Client: North East Coastal Group

Project: Cell 1 Regional Coastal Monitoring Programme 2011 to 2016

Appendix B - Map 7a
Topographic Survey
Cayton Bay
Scarborough Borough Council

Analytical Report 7
Full Measures Survey
Autumn 2014

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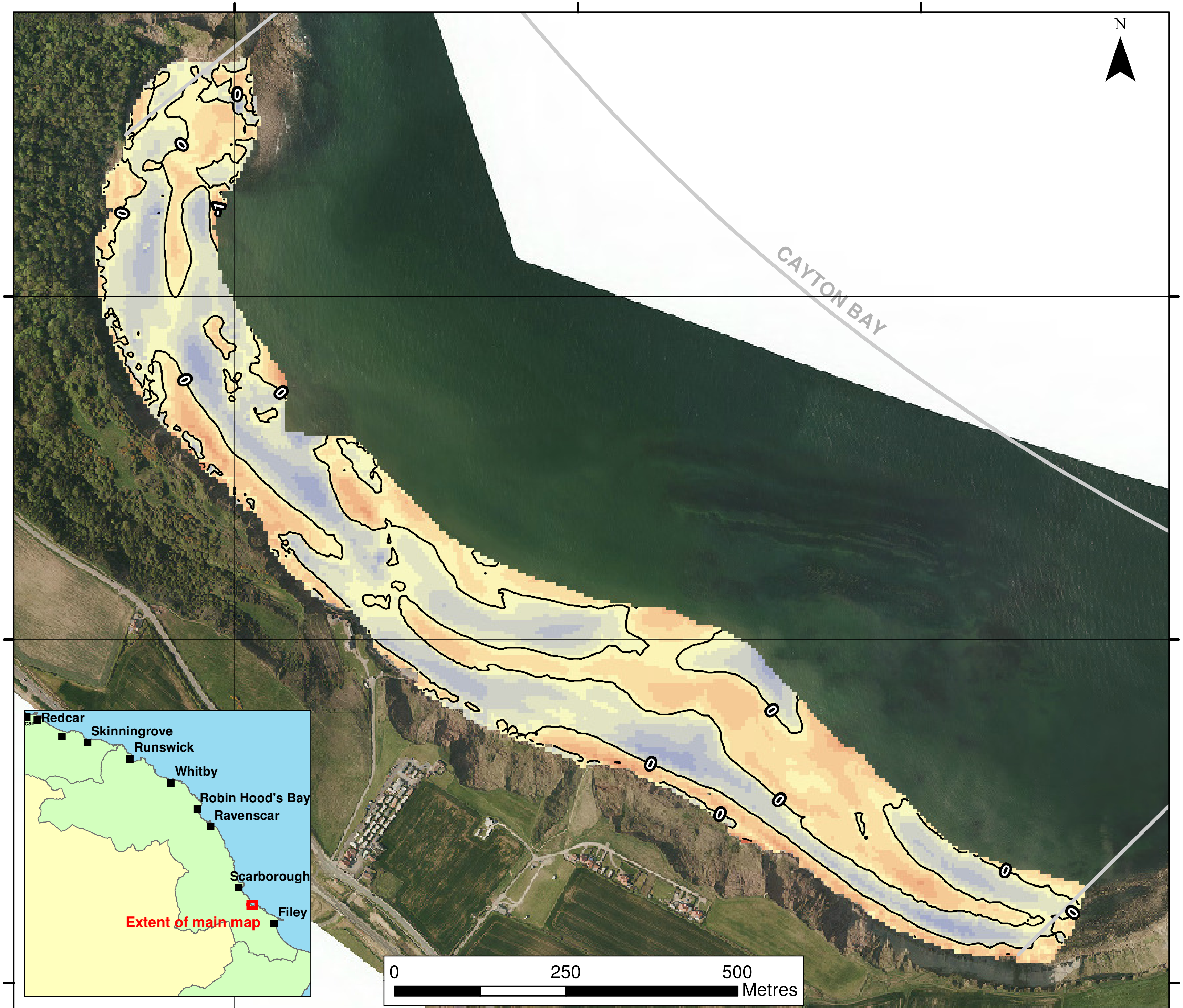

KEY Autumn 2013 and Autumn 2014
Change in elevation (m)

<-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 7b
Short-term Elevation Change
Cayton
Scarborough Borough Council

Analytical Report 7
Full Measures Surveys
Autumn 2014

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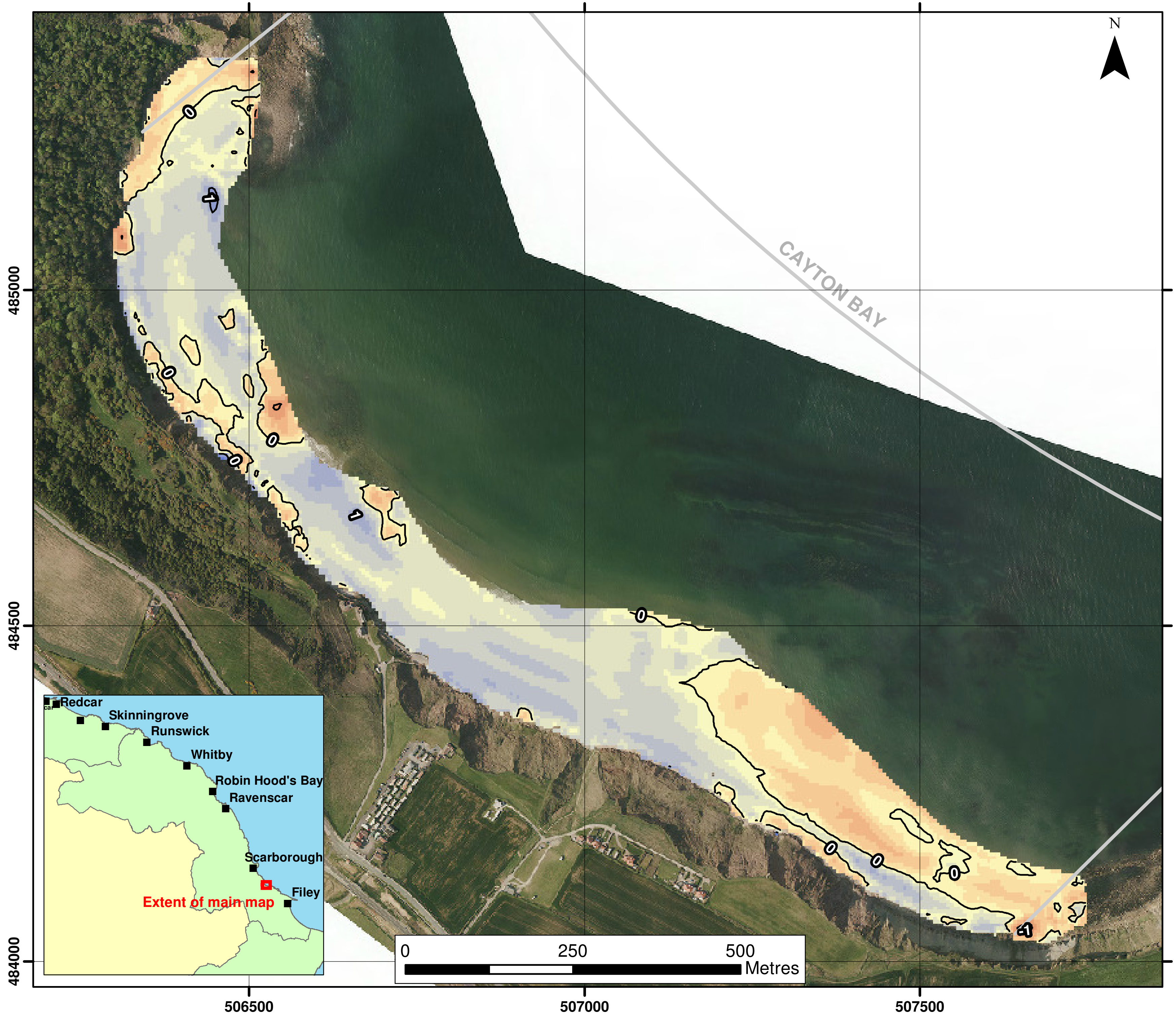

KEY Autumn 2008 and Autumn 2014
Change in elevation (m)

<-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 7c
Long-term Elevation Change
Cayton
Scarborough Borough Council

Analytical Report 7
Full Measures Survey
Autumn 2014

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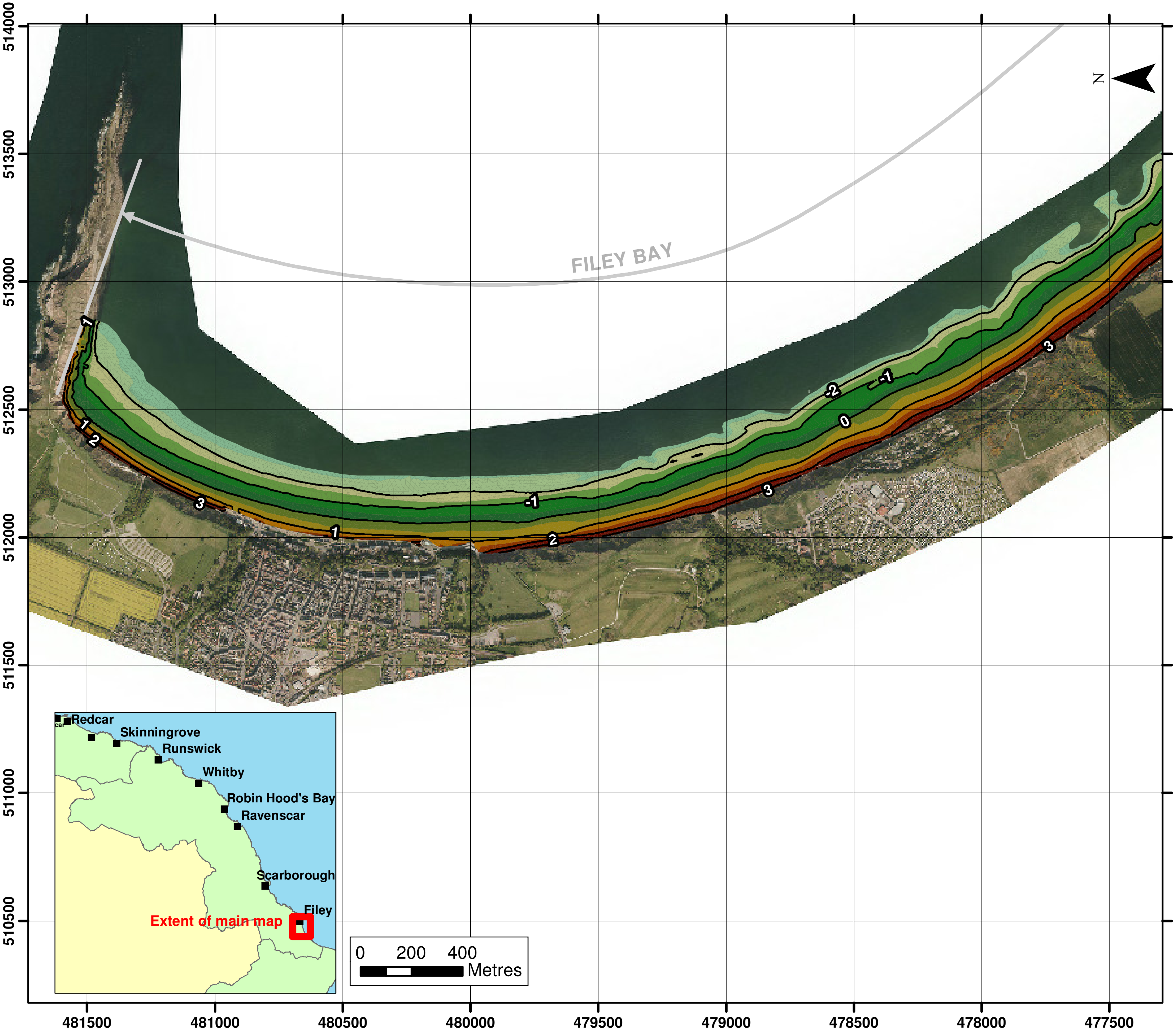

KEY

Elevation (m OD)

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

Client: North East Coastal Group

Project: Cell 1 Regional Coastal Monitoring Programme 2011 to 2016

Appendix B- Map 8a
Topographic Survey
Filey Bay a
Scarborough
Borough Council

Analytical Report 7
Full Measures Survey
Autumn 2014

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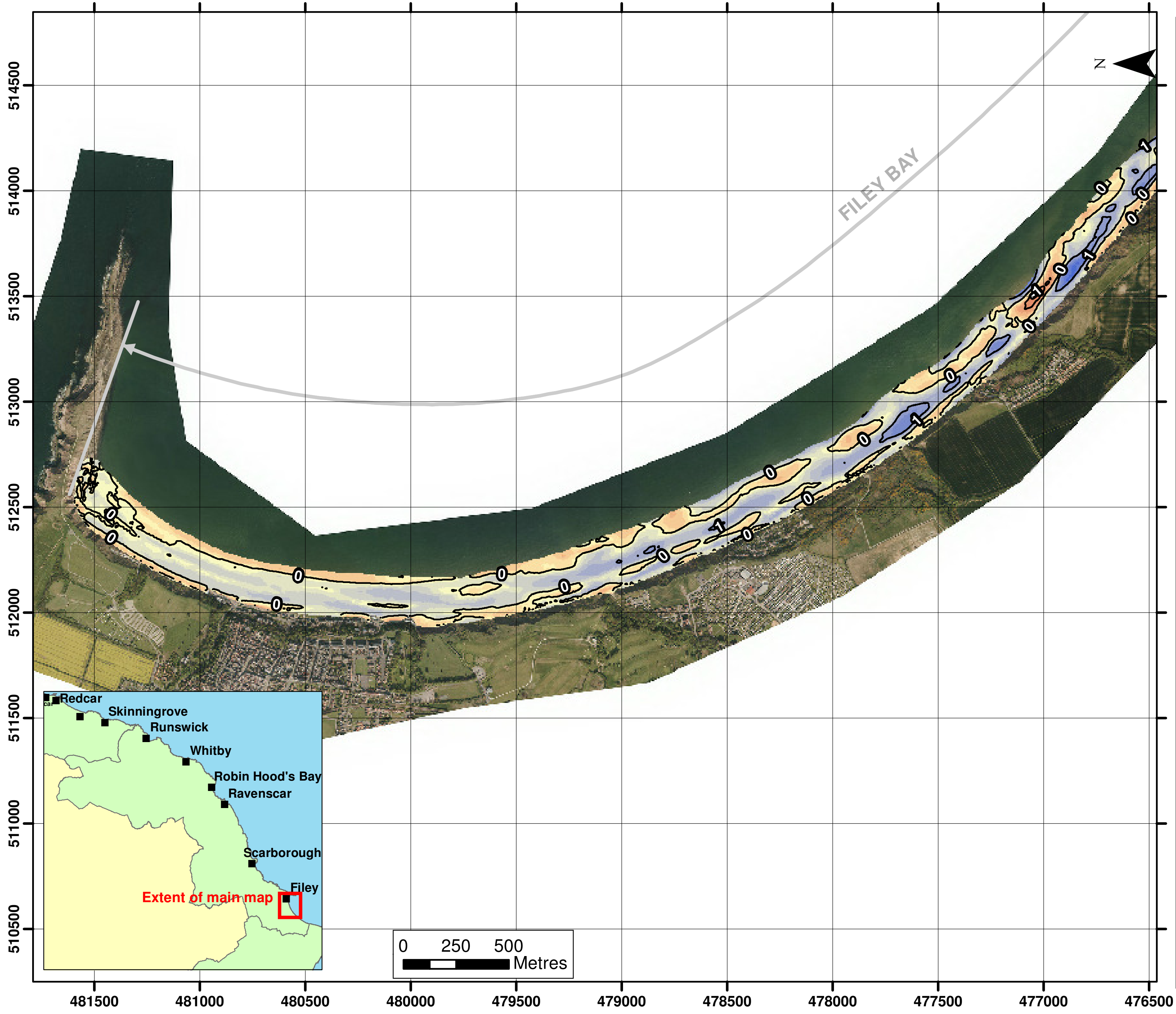

KEY **Autumn 2013 and Autumn 2014**
Change in elevation (m)

- <-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 8b
Short-term
Elevation Change
Filey a
Scarborough
Borough Council

Analytical Report 7
Full Measures Survey
Autumn 2014

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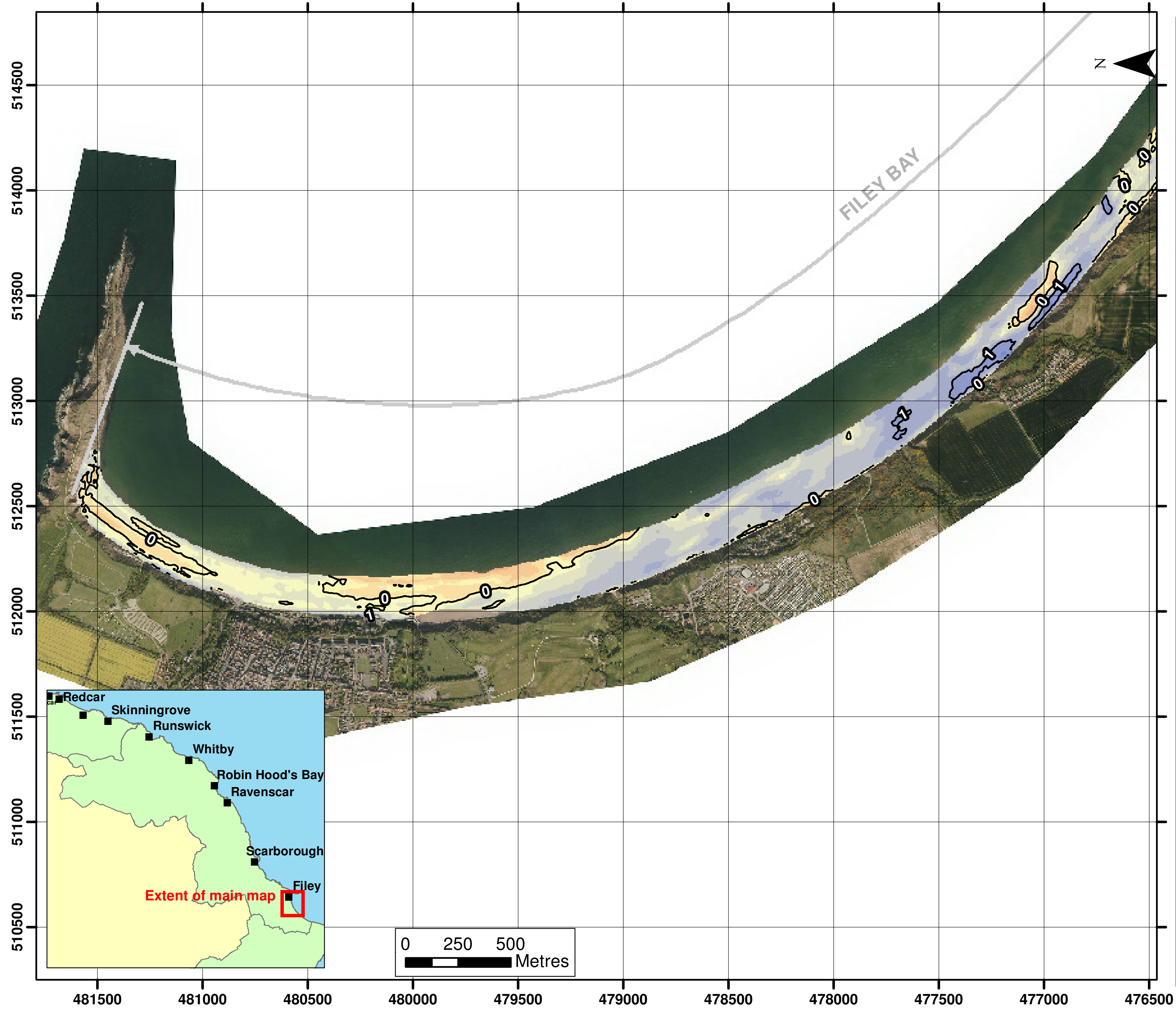

KEY **Autumn 2008 and Autumn 2014**
Change in elevation (m)

- <-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 8c Long-term Elevation Change Filey a Scarborough Borough Council

Analytical Report 7
Full Measures Survey
Autumn 2014

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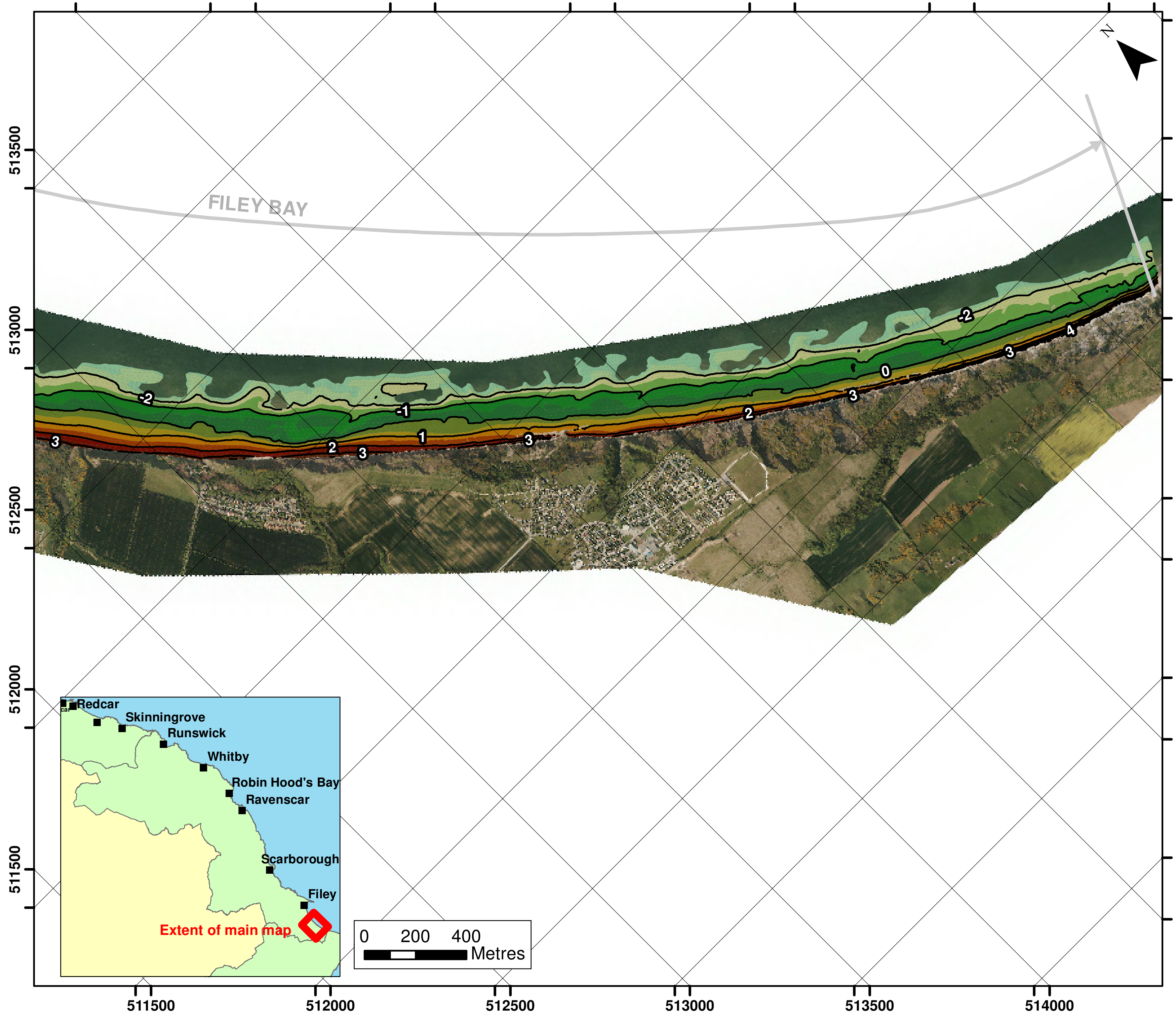

KEY

Elevation (m OD)

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

Client: North East Coastal Group

Project: Cell 1 Regional Coastal Monitoring Programme 2011 to 2016

Appendix B- Map 9a
Topographic Survey
Filey Bay b
Scarborough Borough Council

Analytical Report 7
Full Measures Survey
Autumn 2014

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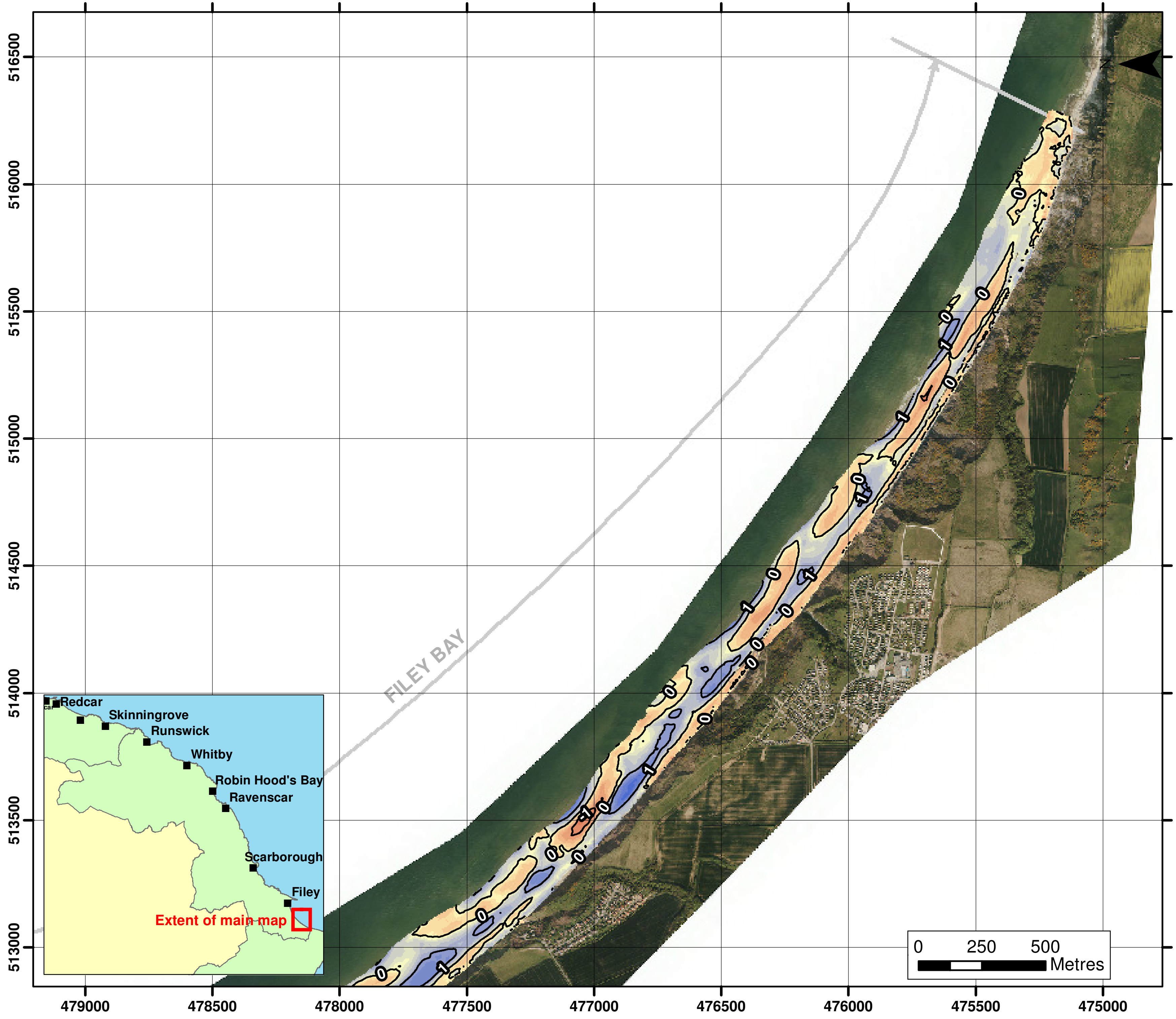

KEY Autumn 2013 and Autumn 2014
Change in elevation (m)

- <-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 9b Short-term Elevation Change Filey b Scarborough Borough Council

Analytical Report 7
Full Measures Survey
Autumn 2014

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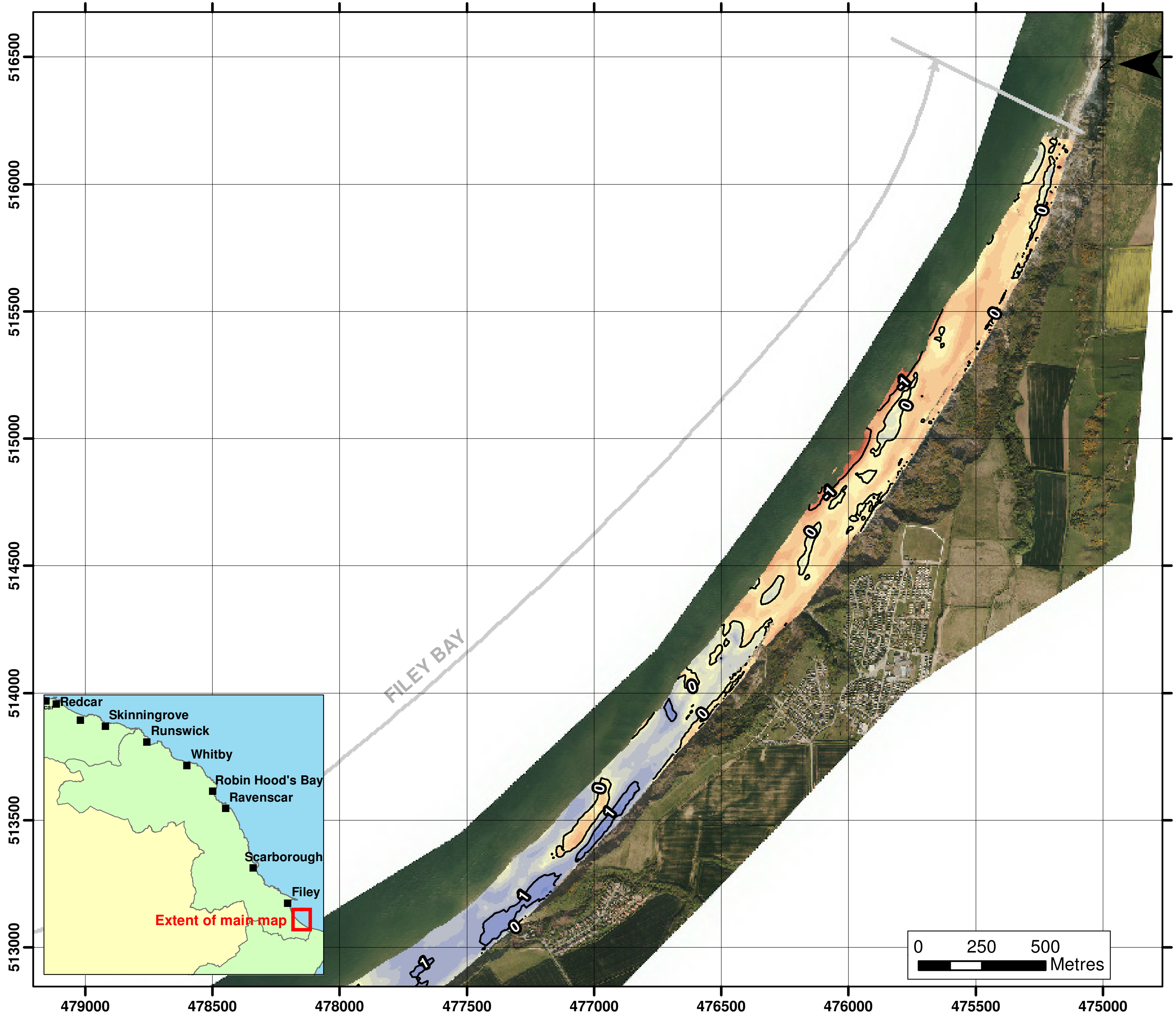

KEY Autumn 2008 and Autumn 2014
Change in elevation (m)

- <-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 9c
Long-term Elevation Change Filey b
Scarborough Borough Council

Analytical Report 7
Full Measures Survey
Autumn 2014

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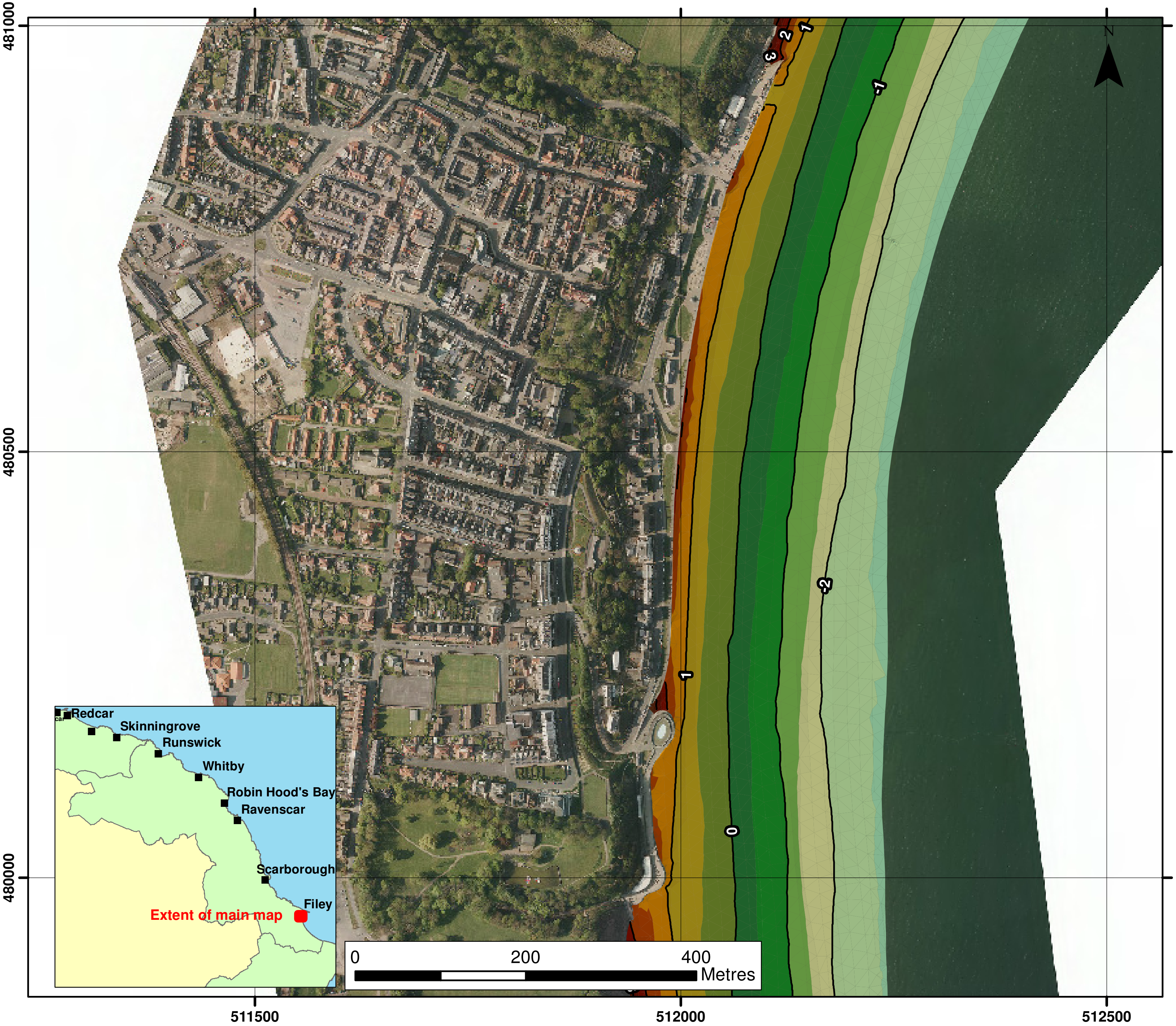

KEY

Elevation (m OD)

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

Client: North East Coastal Group

Project: Cell 1 Regional Coastal Monitoring Programme 2011 to 2016

Appendix B- Map 10a
Topographic Survey
Filey Bay
Scarborough
Borough Council

Analytical Report 7
Full Measures Survey
Autumn 2014

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KEY Spring 2014 and Autumn 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 10b
Short-term Elevation Change
Filey
Scarborough Borough Council

Analytical Report 7
Full Measures Survey
Autumn 2014

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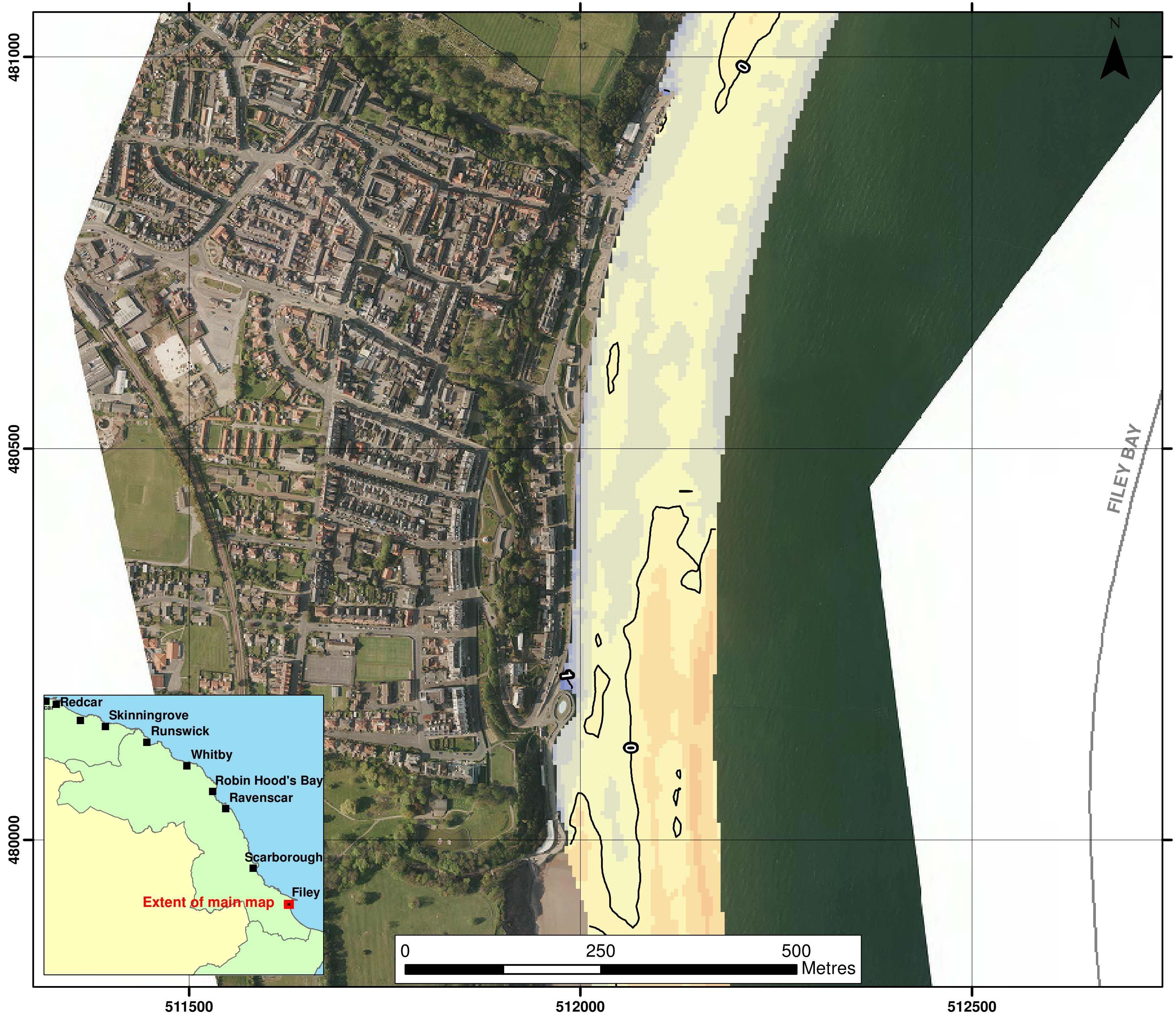

KEY Autumn 2008 and Autumn 2014

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 10c
Long-term Elevation Change
Filey
Scarborough Borough Council

Analytical Report 7
Full Measures Survey
Autumn 2014

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Appendix C

Cliff Top Survey

Cliff Top Survey

Staithes

Twenty ground control points have been established within 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 (April 2014)	Present Survey (Oct 2014)	Baseline (Nov 2008) to Present (Oct 2014)	Previous (April 2014) to Present (Oct 2014)	Baseline (Nov 2008) to Present (Oct 2014)
1	477228	518769	320	1.9	1.7	1.6	-0.3	-0.1	0.0
2	477334	518798	0	10.9	10.9	10.8	-0.1	-0.1	0.0
3	477487	518789	350	7.1	8.4	8.3	1.2	0.0	0.2
4	477594	518801	340	5.9	5.1	5.1	-0.8	0.0	-0.1
5	477683	518911	350	8.4	9.4	9.1	0.7	-0.3	0.1
6	477792	518867	30	8.6	8.6	8.5	-0.1	-0.1	0.0
7	477891	518828	60	7.7	7.5	7.3	-0.4	-0.2	-0.1
8	477959	518873	350	8.7	9.9	9.8	1.1	0.0	0.2
9	478088	518950	350	7.6	8.3	8.2	0.6	-0.1	0.1
10	478191	519023	340	8.4	8.8	8.8	0.4	0.0	0.1
11	478237	519007	60	6.9	6.8	6.8	-0.1	0.0	0.0
12	478213	518988	150	6.1	6.7	6.5	0.4	-0.2	0.1
13	478501	518809	15	11.4	9.2	9.2	-2.2	0.0	-0.4

14	478624	518807	20	7.5	7.5	7.5	0.0	-0.1	0.0
15	478737	518858	60	6.1	6.5	6.5	0.4	0.0	0.1
16	478823	518757	60	8	9.2	8.9	0.9	-0.4	0.1
17	478944	518671	30	9.3	9.4	9.2	-0.1	-0.3	0.0
18	479052	518630	20	9.2	9.4	9.5	0.3	0.1	0.0
19	479147	518610	0	14.2	14.4	14.4	0.2	0.0	0.0
20	479274	518618	20	11.4	11.4	11.1	-0.3	-0.3	0.0

Note: It is assumed that the accuracy of cliff top monitoring using this technique is ±0.1m. Therefore observed changes have been altered by this amount prior to calculation of an erosion rate. Erosion rates are not calculated where the cliff line shows advance. This is likely to be the product of differing survey interpretation, and far less likely to be a toppling cliff edge.

Robin Hoods Bay

Thirteen ground control points have been established within Robin Hoods Bay (Figure C1). The maximum separation between any two points is nominally 200m.

The cliff top surveys at Robin Hoods Bay are undertaken 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 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 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 (April 2014)	Present Survey (Sept 2014)	Baseline (March 2010) to Present (Sept 2014)	Previous (April 2014) to Present (Sept 2014)	Baseline (March 2010) to Present (Sept 2014)
1	495799.5	506002.2	130	11.6	7.9	8.0	-3.6	0.0	-0.8
2	495549.2	505807.3	135	9.3	9.2	9.2	-0.1	0.0	0.0
3	495456.3	505740	130	5	5.3	5.2	0.2	-0.1	0.0
4	495389.9	505683.7	140	6.3	6.2	6.2	-0.1	0.0	0.0
5	495259.4	505342.5	130	11.3	10.0	12.7	1.4	2.8	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	6.8	6.4	0.0	-0.4	0.0
8	495206.5	505153	75	5	5.1	5.2	0.2	0.1	0.0
9	495287.8	505060.5	80	4.3	4.9	4.5	0.2	-0.3	0.1
10	495187.8	504708.8	70	3.1	2.6	2.5	-0.6	0.0	-0.1
11	495226.2	504615.7	120	3.8	4.0	3.9	0.1	0.0	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	3.7	0.0	0.0	0.0

Note: It is assumed that the accuracy of cliff top monitoring using this technique is ±0.1m. Therefore observed changes have been altered by this amount prior to calculation of an erosion rate. Erosion rates are not calculated where the cliff line shows advance. This is likely to be the product of differing survey interpretation, and far less likely to be a toppling cliff edge.

Scarborough South Bay

Thirteen ground control points have been established between Scarborough South Bay and Cayton Bay (Figure C1). The maximum separation between any two points is nominally 300m.

The cliff top surveys at Scarborough South Bay are undertaken 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

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 (March 2014)	Present Survey (Sept 2014)	Baseline (March 2010) to Present (Sept 2014)	Previous (March 2014) to Present (Sept 2014)	Baseline (March 2010) to Present (Sept 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	8.7	8.8	0.0	0.1	0.0
6	505071.1	486652.1	75	3.8	3.8	3.5	-0.3	-0.3	-0.1
7	505284.3	486480	35	7.0	7.0	6.9	-0.1	-0.2	0.0
8	505597.9	486363.4	30	8.6	8.6	8.5	-0.1	-0.1	0.0
9	505758.6	486005.1	45	9.1	8.9	8.8	-0.3	-0.2	-0.1
10	505896	485889.6	15	14.8	14.8	14.8	0.0	-0.1	0.0
11	505990	485657.1	80	4.7	2.5	1.6	-3.1	-0.9	-0.7
12	506024.9	485421.8	55	6.1	4.2	4.1	-2.0	-0.1	-0.4

13	506036	485315.3	90	7.0	7.1	7.1	0.1	0.0	0.0

Note: It is assumed that the accuracy of cliff top monitoring using this technique is ±0.1m. Therefore observed changes have been altered by this amount prior to calculation of an erosion rate. Erosion rates are not calculated where the cliff line shows advance. This is likely to be the product of differing survey interpretation, and far less likely to be a toppling cliff edge.

Cayton Bay

Eight ground control points have been established within Cayton Bay (Figure C1). The maximum separation between any two points is nominally 300m.

The cliff top surveys at Cayton Bay are undertaken 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 (March 2014)	Present Survey (Sept 2014)	Baseline (Nov 2008) to Present (Sept 2014)	Previous (March 2014) to Present (Sept 2014)	Baseline (Nov 2008) to Present (Sept 2014)
1	506325.5	484849.7	50	4	3.7	3.4	-0.6	-0.3	-0.1
2	506459.4	484715.9	65	5	0.0	-0.1	-5.1	-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	6.1	-3.0	0.1	-0.5
5	507018.6	484221.6	342	7.7	8.1	8.1	0.4	0.0	0.1
6	507242.3	484121.7	2	7.4	6.5	6.5	-1.0	0.0	-0.2
7	507518.2	484008.2	25	7.5	7.8	7.8	0.3	0.0	0.1
8	507818.7	484006	1	5.5	6.2	6.2	0.7	0.0	0.1

Note: It is assumed that the accuracy of cliff top monitoring using this technique is ±0.1m. Therefore observed changes have been altered by this amount prior to calculation of an erosion rate. Erosion rates are not calculated where the cliff line shows advance. This is likely to be the product of differing survey interpretation, and far less likely to be a toppling cliff edge.

Filey Bay

Twenty-seven ground control points have been established within Filey Bay (Figure C1). The maximum separation between any two points is nominally 300m.

The cliff top surveys at Filey Bay are undertaken 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 at 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 (March 2014)	Present Survey (Sept 2014)	Baseline (Nov 2008) to Present (Sept 2014)	Previous (March 2014) to Present (Sept 2014)	Baseline (Nov 2008) to Present (Sept 2014)
1	512444.9	481630.9	130	8.7	8.8	8.8	0.1	0.0	0.0
2	512306.7	481490.3	144	7.6	7.9	7.9	0.3	-0.1	0.0
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	7.6	7.6	0.2	-0.1	0.0
5	511895.4	479888	89	7.1	0.8	0.7	-6.4	-0.1	-1.1
6	511908.5	479597.1	48	6.7	7.1	7.1	0.4	0.0	0.1
7	511991.4	479310.4	69	6.7	4.7	4.7	-2.0	0.0	-0.3
8	512083.4	478981.5	66	10.2	10.4	10.2	0.0	-0.2	0.0
9	512121.3	478786.3	76	8.3	8.5	8.4	0.1	-0.1	0.0
10	512226.2	478547.9	74	7.5	7.2	7.2	-0.3	0.0	0.0
11	512471.4	478153.5	53	6.6	7.7	7.8	1.2	0.1	0.2
12	512558.9	477901.9	66	7.7	7.8	7.7	0.0	-0.1	0.0
12A*	512655.8	477822.4	67	13.9	13.9	13.8	-0.1	-0.2	0.0

13**	512697.6	477719	34	4.2	No Data	No Data	No Data	No Data	No Data
13A*	512805.5	477572.1	32	13.42	0.0	13.4	0.0	N/A	N/A
14	512939.4	477400.9	66	8	7.1	7.0	-1.0	0.0	-0.2
15	513157	477192.7	51	5.2	4.6	4.6	-0.6	0.0	-0.1
16	513299.5	477024.6	30	7.7	7.1	7.1	-0.6	0.0	-0.1
17	513507.7	476821.1	34	10.7	10.7	10.6	-0.1	0.0	0.0
18	513721	476602.3	31	7.2	7.1	7.0	-0.2	-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	7.4	6.9	-0.2	-0.5	0.0
21	514471.5	475965.7	66	7.6	7.6	7.6	0.0	0.0	0.0
22	514656.2	475728.8	101	8.1	8.2	8.2	0.1	0.0	0.0
23	514889.5	475537.6	60	9.1	9.2	9.1	0.0	0.0	0.0
24*	512603.7	481665.9	14	19.9	19.8	19.8	-0.1	0.1	0.0
25*	512607.1	481648.9	184	17.2	17.1	17.0	-0.2	-0.1	0.0
26*	512301.9	481825.5	18	11	11.0	10.9	-0.1	0.0	0.0
27*	512475.8	481712.1	20	11.6	11.55	11.64	0.0	0.1	0.0

Note: It is assumed that the accuracy of cliff top monitoring using this technique is ±0.1m. Therefore observed changes have been altered by this amount prior to calculation of an erosion rate. Erosion rates are not calculated where the cliff line shows advance. This is likely to be the product of differing survey interpretation, and far less likely to be a toppling cliff edge.
*baseline for 12A and 24-27 is March 2011.

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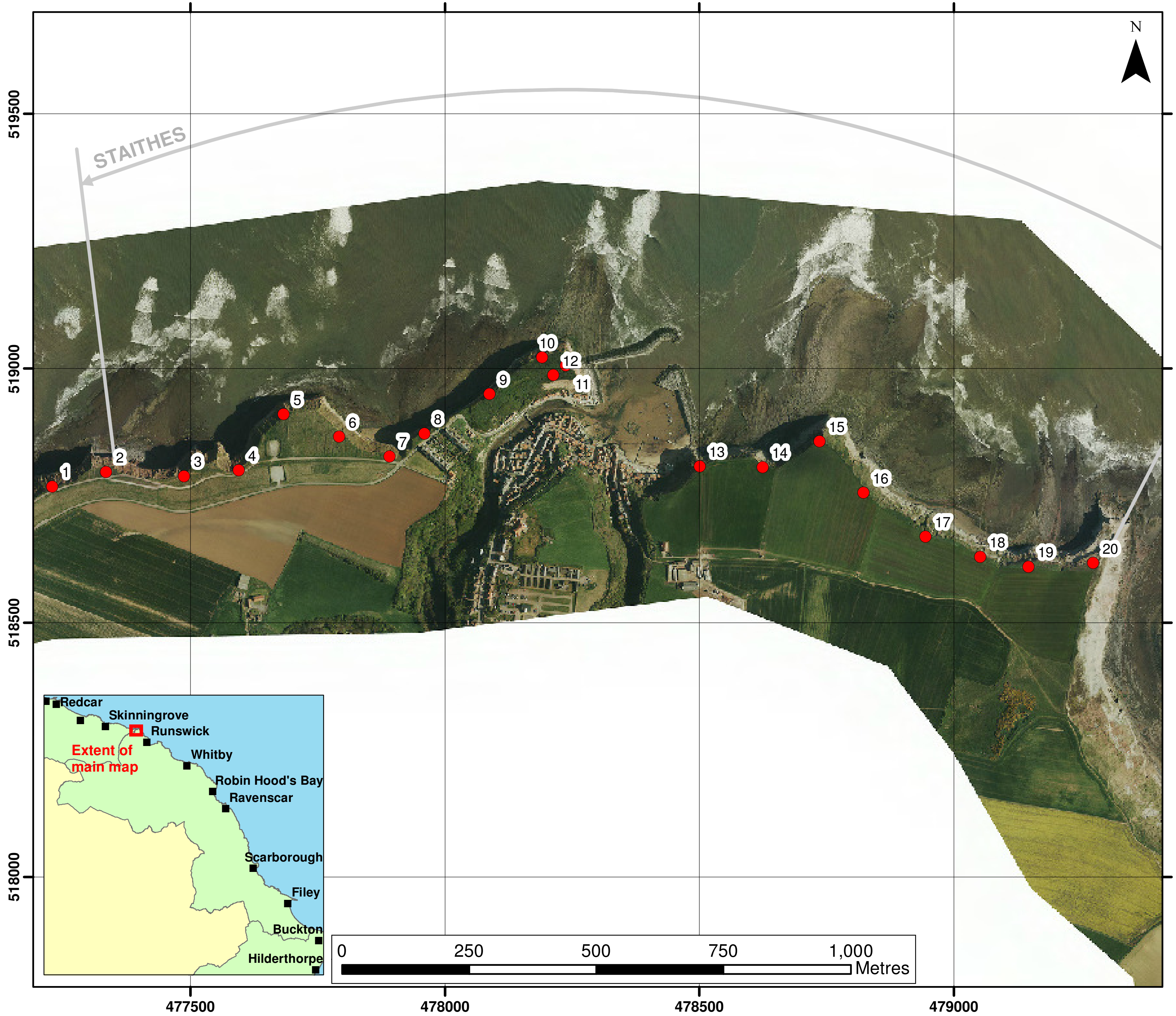

KEY

- 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

Analytical Report 7
Full Measures Survey
Autumn 2014

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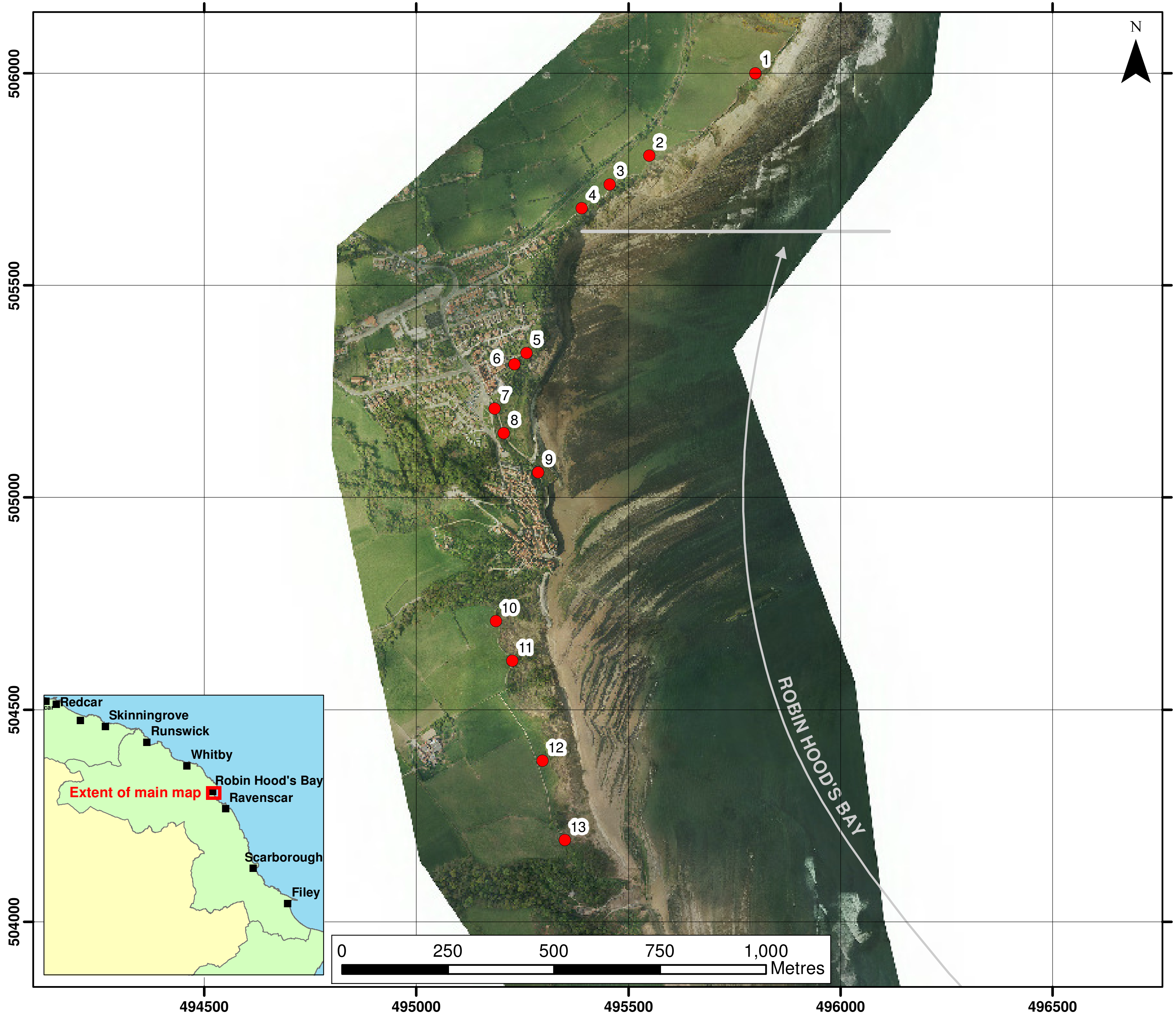
www.northeastcoastalobservatory.org.uk



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

Analytical Report 7
Full Measures Survey
Autumn 2014

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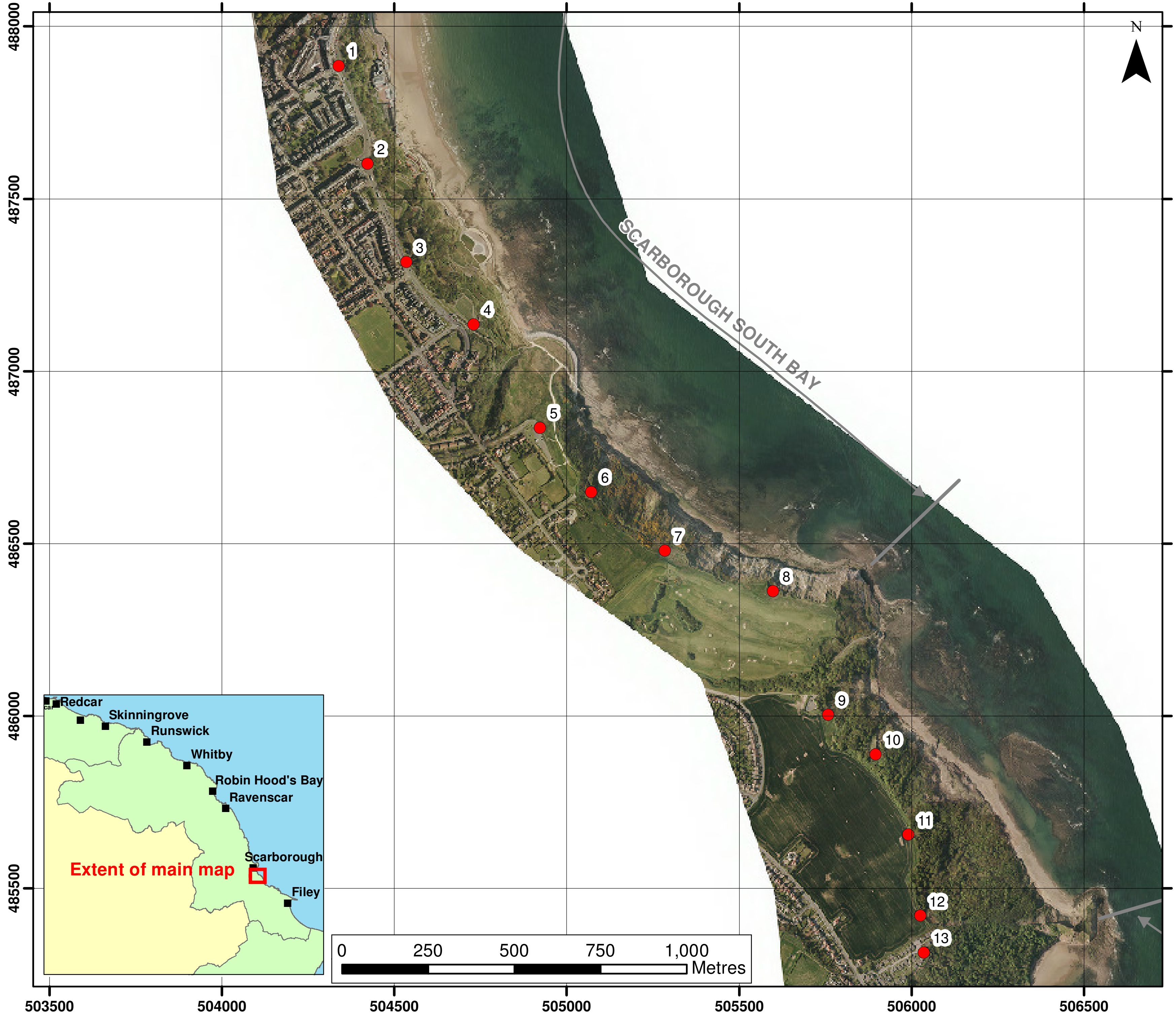

KEY

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

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