North East Coastal Observatory

Royal HaskoningDHV
Enhancing Society Together

Cell 1 Regional Coastal Monitoring Programme
Analytical Report 12 Full Measures Survey 2019

Whitby Scarborough Filey
Borough of Scarborough
A great place to live, work & play

Scarborough Council
January 2020

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Authors	
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Dr Nick Cooper – Review & Approval	Royal HaskoningDHV

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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.

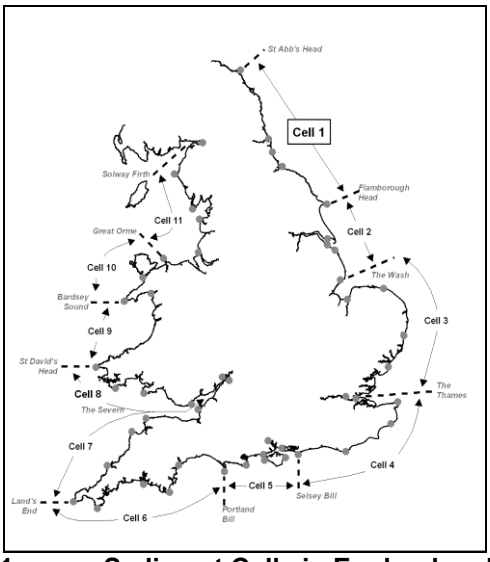


Figure 1 Sediment Cells in England and Wales

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:

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

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
- LiDAR Surveys
- walk-over cliff and coastal defence asset 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	Jul 10	-
3	2010/11	Aug-Nov 10	Feb 11	Feb-Apr 11	Aug 11	Sep 11
4	2011/12	Sep 11	Aug 12	Mar-May 12	Feb 13	
5	2012/13	Sep 12	Mar 13	Apr-May 13	May 13	
6	2013/14	Sep 13	Feb 14	Mar-Apr 14	Jul 14	
7	2014/15	Sep 14	Feb 15	Mar 15	Jul 15	
8	2015/16	Sep 15	Feb 16	Mar – Apr 16	Jul 16	Jun 16
9	2016/17	Sep–Nov16	Feb 17	Feb-Apr 17	Jul 17	
10	2017/18	Sep-Oct 16	Jan 17	Mar-May 18	Jun 18	
11	2018/19	Sep-Oct 18	Mar 19	Mar-Apr 19	July 19	
12	2019/20	Sep-Nov 19	Jan 20 (*)			

(*) The present report is **Analytical Report 12** and provides an analysis of the autumn/winter 2019 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 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
	Spittal B
	Goswick Sands
	Holy Island
	Bamburgh
	Beadnell Village
	Beadnell Bay
	Embelton Bay
	Boulmer
	Alnmouth Bay
	High Hauxley and Druridge Bay
	Lynemouth Bay
	Newbiggin Bay
	Cambois Bay
	Blyth South Beach
North Tyneside Council	Whitley Sands
	Cullercoats Bay
	Tynemouth Long Sands
	King Edward's Bay
South Tyneside Council	Littehaven Beach
	Herd Sands
	Trow Quarry (incl. Frenchman's Bay)
	Marsden Bay
Sunderland Council	Whitburn Bay
	Harbour and Docks
	Hendon to Ryhope (incl. Halliwell Banks)
Durham County Council	Featherbed Rocks
	Seaham
	Blast Beach
	Hawthorn Hive
	Blackhall Colliery
Hartlepool Borough Council	North Sands
	Headland
	Middleton
	Hartlepool Bay
Redcar & Cleveland Borough Council	Coatham Sands
	Redcar Sands
	Marske Sands
	Saltburn Sands
	Cattersty Sands (Skinningrove)
Scarborough Borough Council	Staithes
	Runswick Bay
	Sandsend Beach, Upgang Beach and Whitby Sands
	Robin Hood's Bay
	Scarborough North Bay
	Scarborough South Bay
	Cayton Bay
	Filey Bay

1. Introduction

1.1 Study Area

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 18th September 2019 and 29th November 2019. The weather and sea state varied greatly in that time, for details of the survey conditions refer to the Academy Geomatics survey reports for each location.

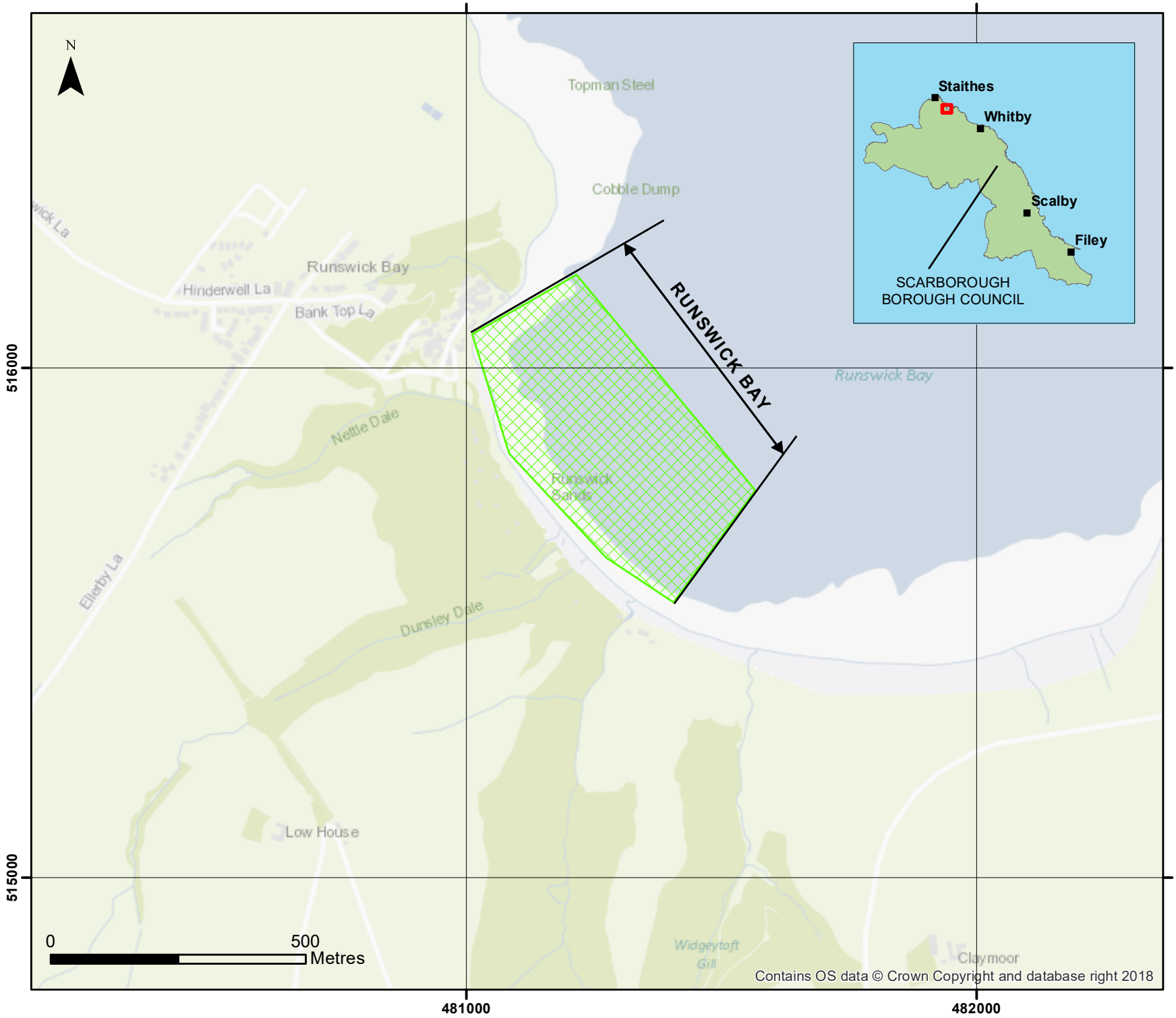
All data have been captured in a manner commensurate with the principles of the Environment Agency's *National Standard Contract and Specification for Surveying Services* and stored in a file format compatible with the software systems being used for the data analysis, namely SANDS and ArcGIS. This data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

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

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

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

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



Key

SURVEY LOCATIONS

Topographic Profiles

- Annual
- Bi-Annual

Topographic Surveys

- 6 monthly
- yearly
- 5 yearly

(Indicative Survey Extents shown)

Client: North East Coastal Group

Project: Cell 1 Regional Coastal Monitoring Programme

Figure 2 - Map 1

Scarborough Borough Council Frontage

Analytical Report
Topo Surveys

Drawing Scale at A4 1:10,000

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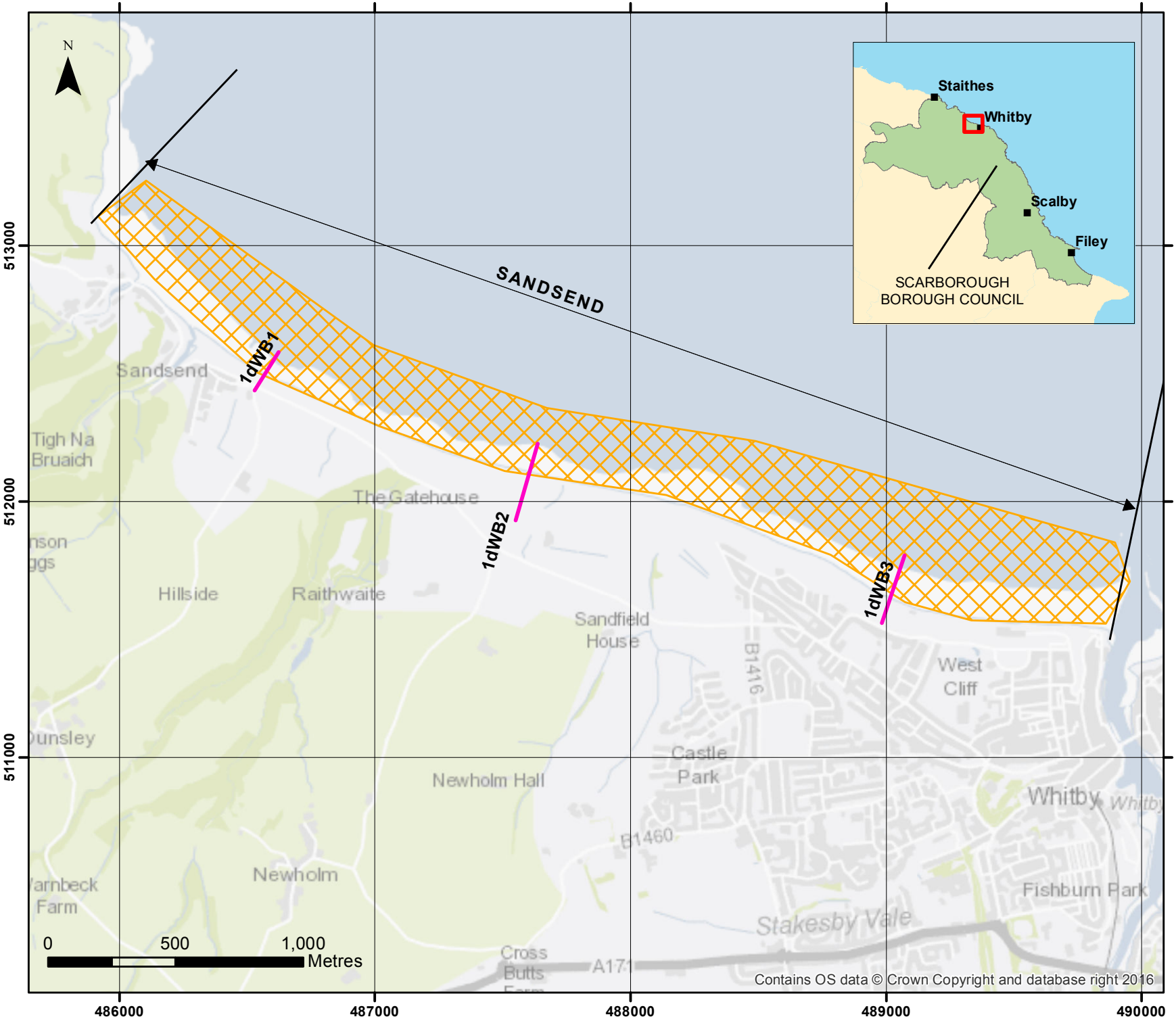

Key

SURVEY LOCATIONS

Topographic Profiles

- Annual
- Bi-Annual

Topographic Surveys

- 6 monthly
- yearly
- 5 yearly

(Indicative Survey Extents shown)

Client: North East Coastal Group

Project: Cell 1 Regional Coastal Monitoring Programme

Figure 2 - Map 2

Scarborough Borough Council Frontage

Analytical Report
Topo Surveys

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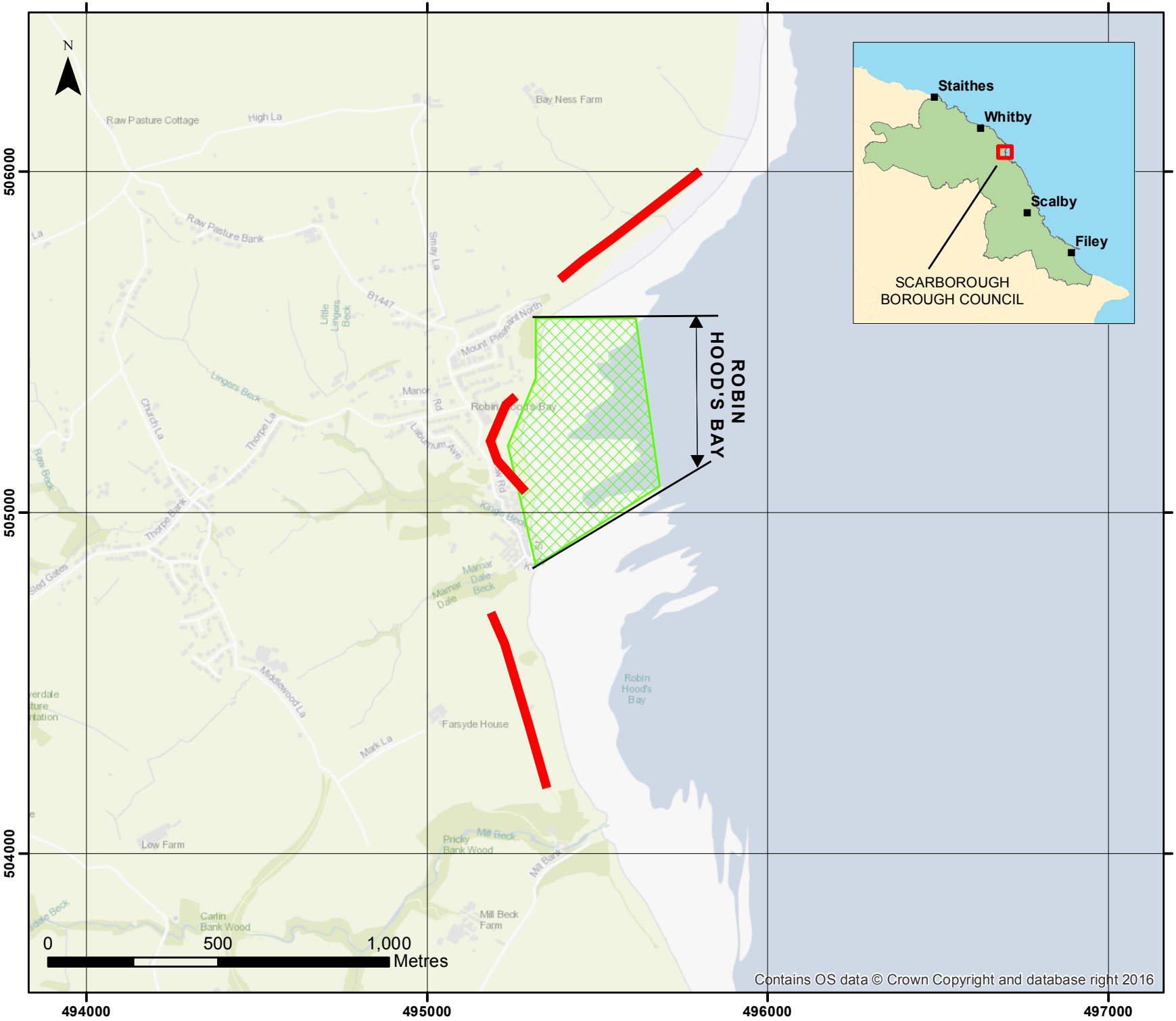

Key

SURVEY LOCATIONS

Topographic Profiles

Annual

Bi-Annual

Topographic Surveys

6 monthly

yearly

Cliff Top Monitoring Pegs

@ 300 centres

(Indicative Survey Extents shown)

Client: North East Coastal Group

Project: Cell 1 Regional Coastal Monitoring Programme

Figure 2 - Map 3

Scarborough Borough Council Frontage

Analytical Report
Topo Surveys

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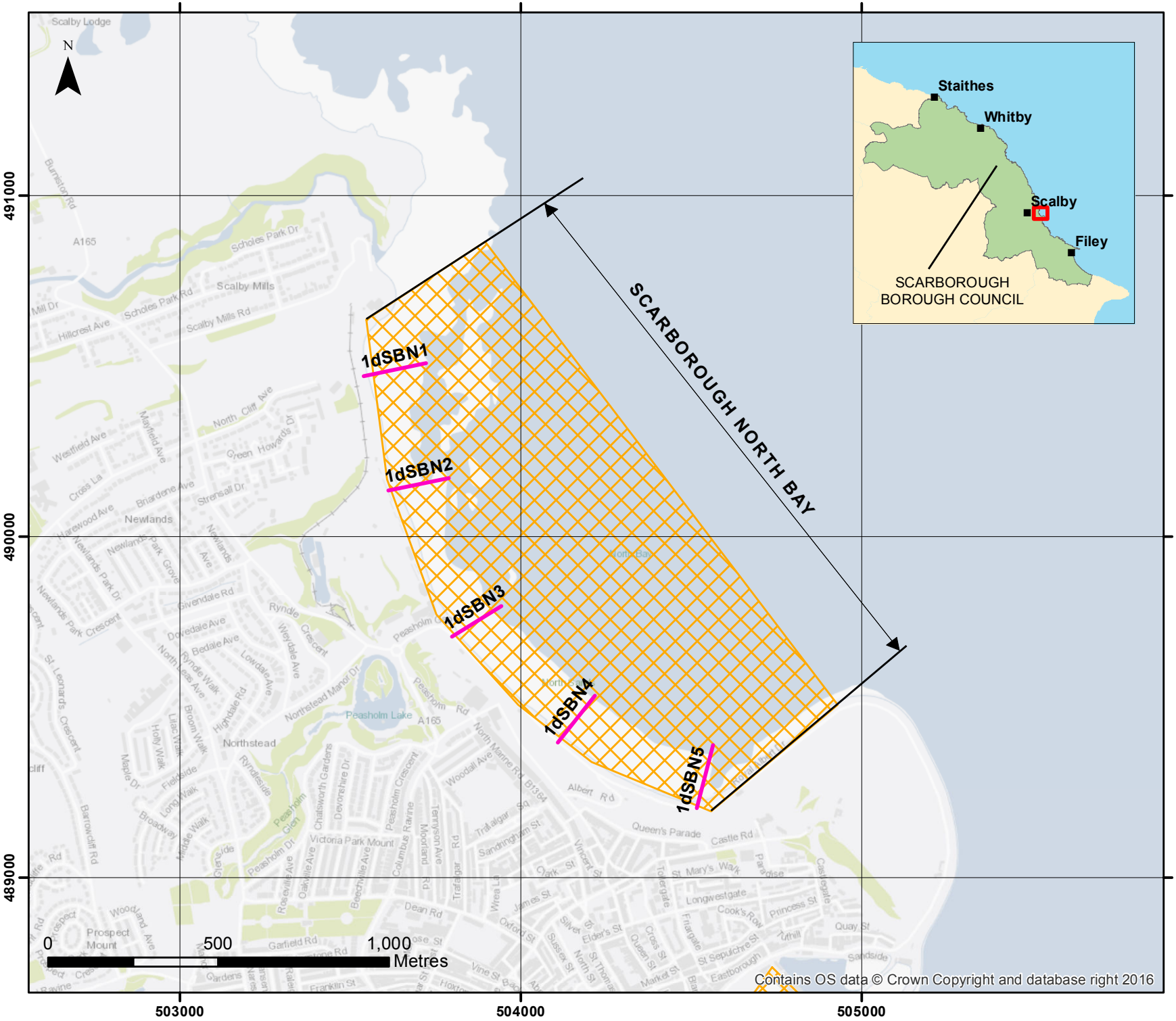

Key

SURVEY LOCATIONS

Topographic Profiles

- Annual
- Bi-Annual

Topographic Surveys

- 6 monthly
- yearly
- 5 yearly

(Indicative Survey Extents shown)

Client: North East Coastal Group

Project: Cell 1 Regional Coastal Monitoring Programme

Figure 2 - Map 4

Scarborough Borough Council Frontage

Analytical Report
Topo Surveys

Drawing Scale at A4 1:15,000

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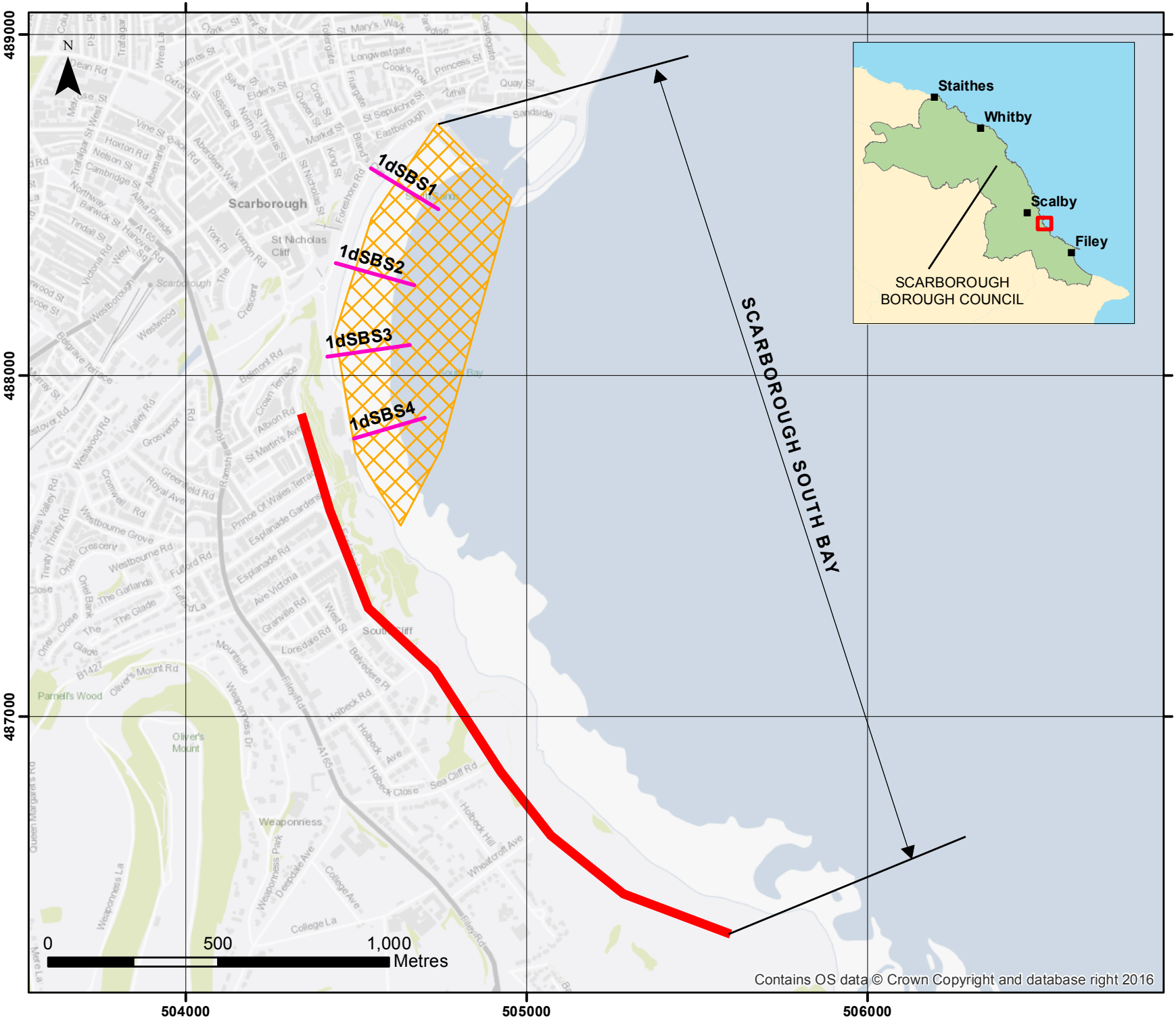

Key

SURVEY LOCATIONS

Topographic Profiles

- Annual
- Bi-Annual

Topographic Surveys

- 6 monthly
- yearly

Cliff Top Monitoring Pegs

- @ 300 centres

(Indicative Survey Extents shown)

Client: North East Coastal Group

Project: Cell 1 Regional Coastal Monitoring Programme

Figure 2 - Map 5

Scarborough Borough Council Frontage

Analytical Report
Topo Surveys

Drawing Scale at A4 1:15,000

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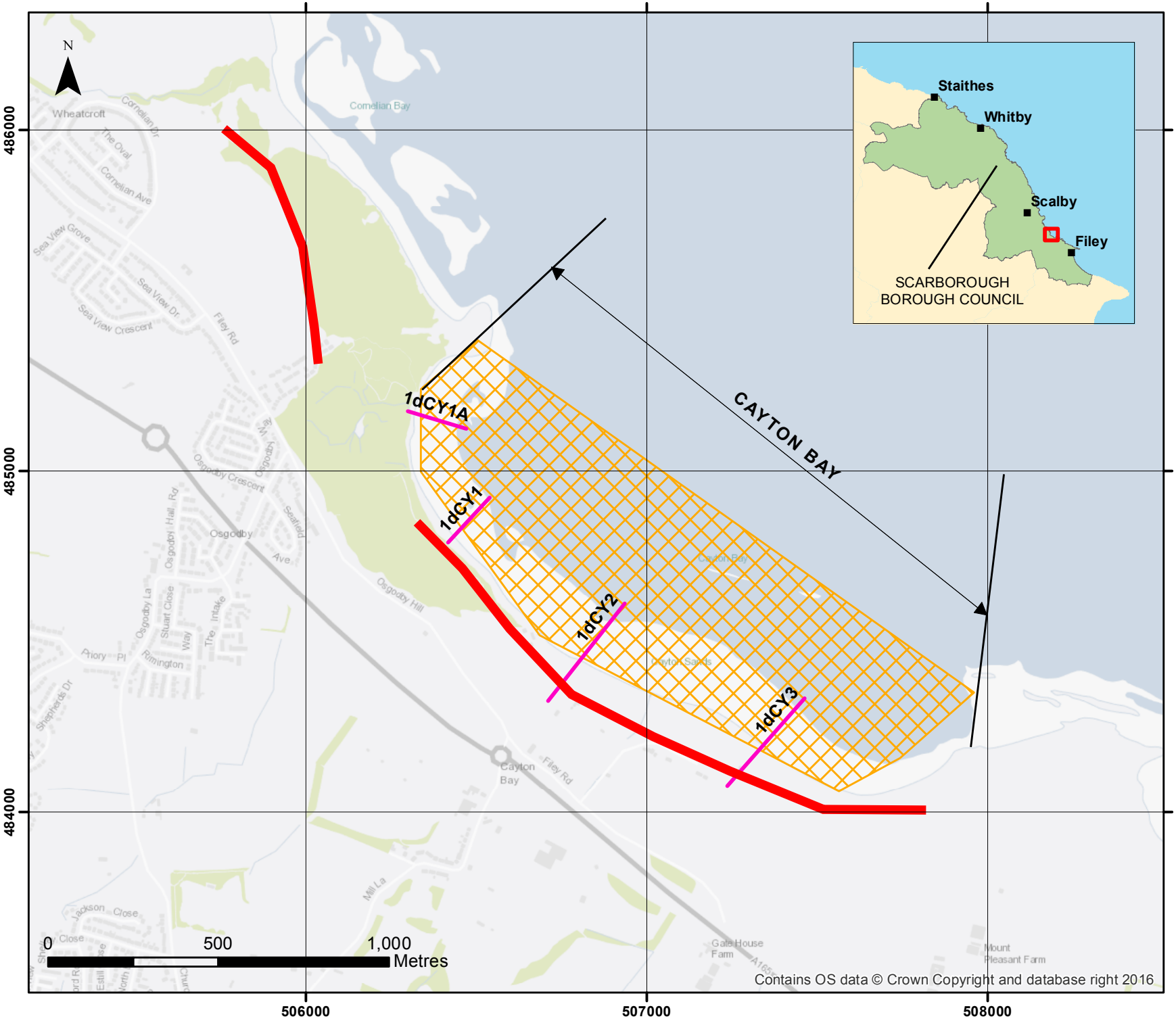

Key

SURVEY LOCATIONS

Cliff Top Monitoring Pegs

@ 300 centres

Topographic Profiles

Annual

Bi-Annual

Topographic Surveys

6 monthly

yearly

(Indicative Survey Extents shown)

Client: North East Coastal Group

Project: Cell 1 Regional Coastal Monitoring Programme

Figure 2 - Map 6

Scarborough Borough Council Frontage

Analytical Report
Topo Surveys

Drawing Scale at A4 1:15,000

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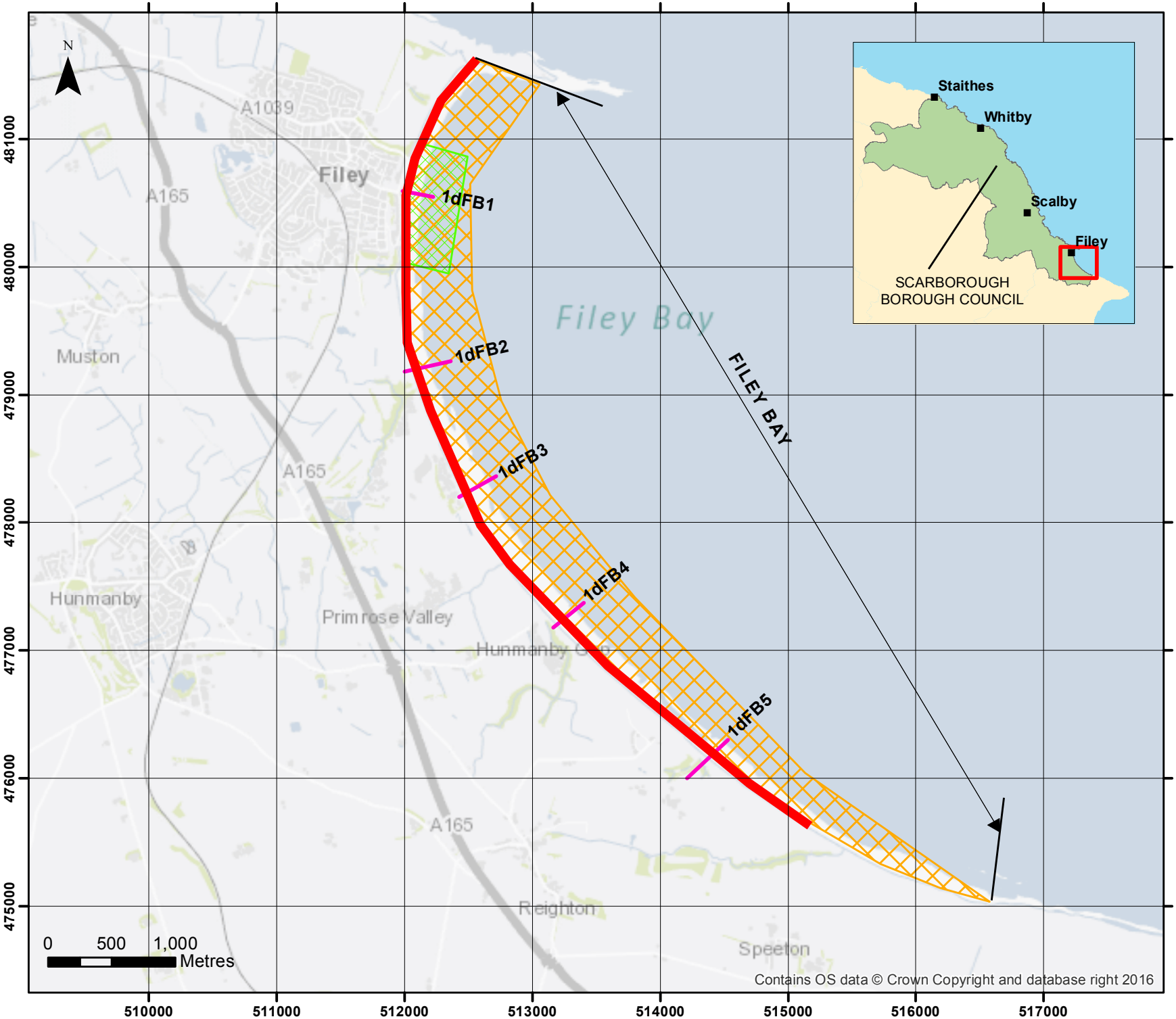

Key

SURVEY LOCATIONS

Topographic Profiles

- Annual
- Bi-Annual

Topographic Surveys

- 6 monthly
- yearly

Cliff Top Monitoring Pegs

- @ 300 centres

(Indicative Survey Extents shown)

Client: North East Coastal Group

Project: Cell 1 Regional Coastal Monitoring Programme

Figure 2 - Map 7

Scarborough Borough Council Frontage

Analytical Report
Topo Surveys

Drawing Scale at A4 1:40,000

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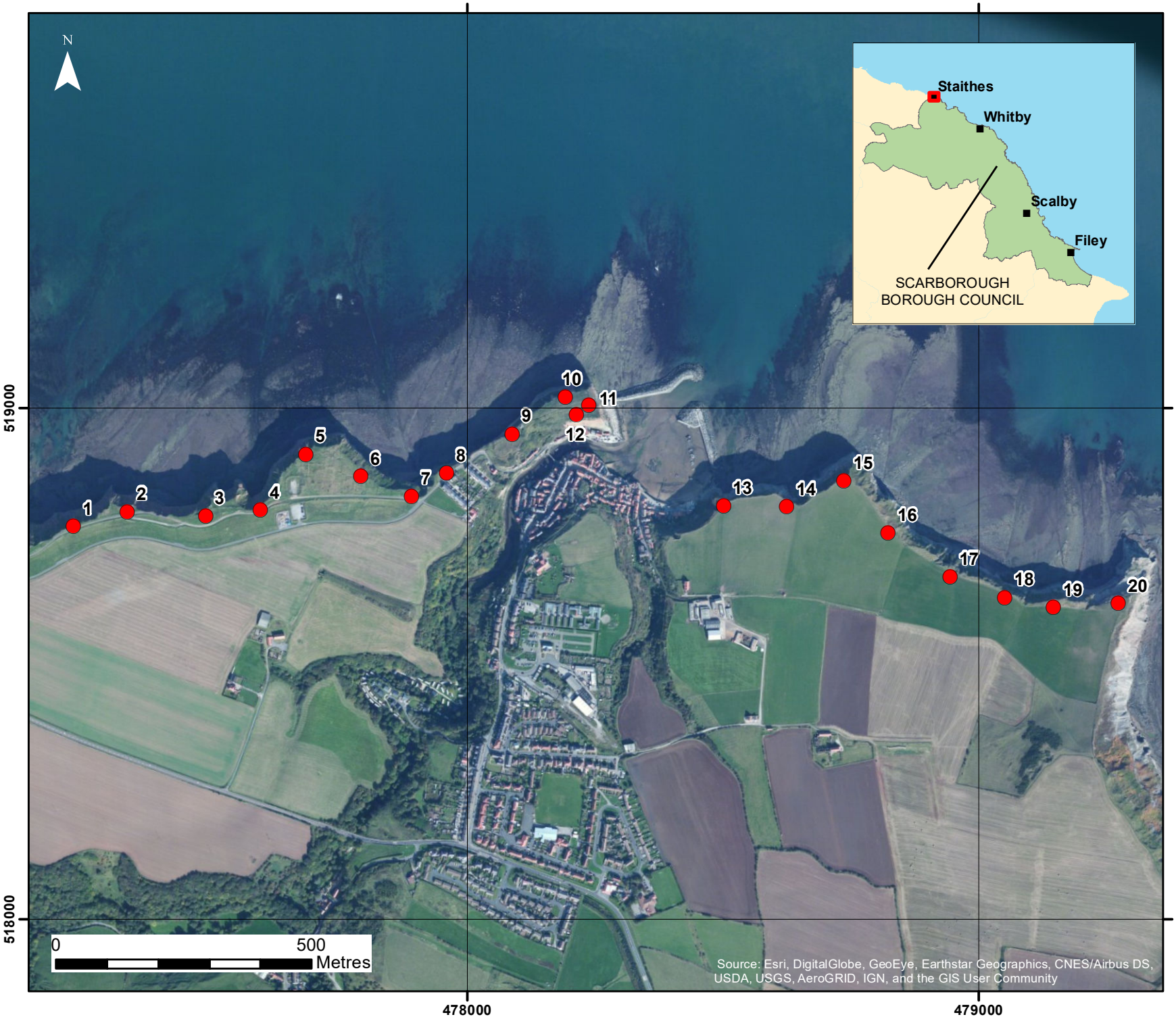

Key

- Cliff Top Survey Locations

Client: North East Coastal Group

Project: Cell 1 Regional Coastal Monitoring Programme

Figure 3 - Map 1

STAITHES

Scarborough Borough Council Council Frontage

Cliff Top Survey Locations

Drawing Scale at A4 1:10,000

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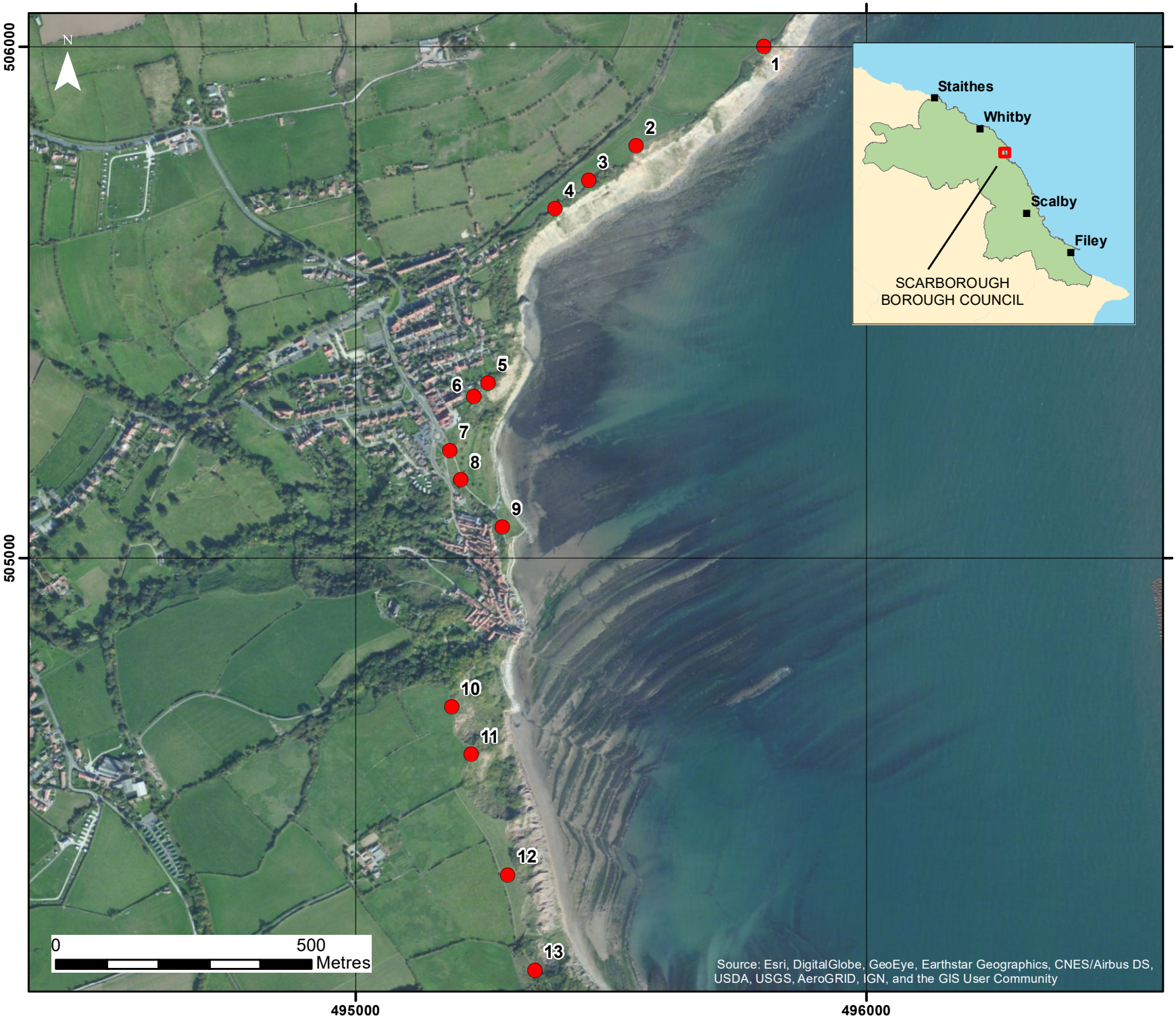

Key

- Cliff Top Survey Locations

Client: North East Coastal Group

Project: Cell 1 Regional Coastal Monitoring Programme

Figure 3 - Map 2

ROBIN HOOD'S BAY

Scarborough Borough Council Council Frontage

Cliff Top Survey Locations

Drawing Scale at A4 1:10,000

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Key

- Cliff Top Survey Locations

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Project: Cell 1 Regional Coastal Monitoring Programme

Figure 3 - Map 3

SCARBOROUGH SOUTH BAY

Scarborough Borough Council Council Frontage

Cliff Top Survey Locations

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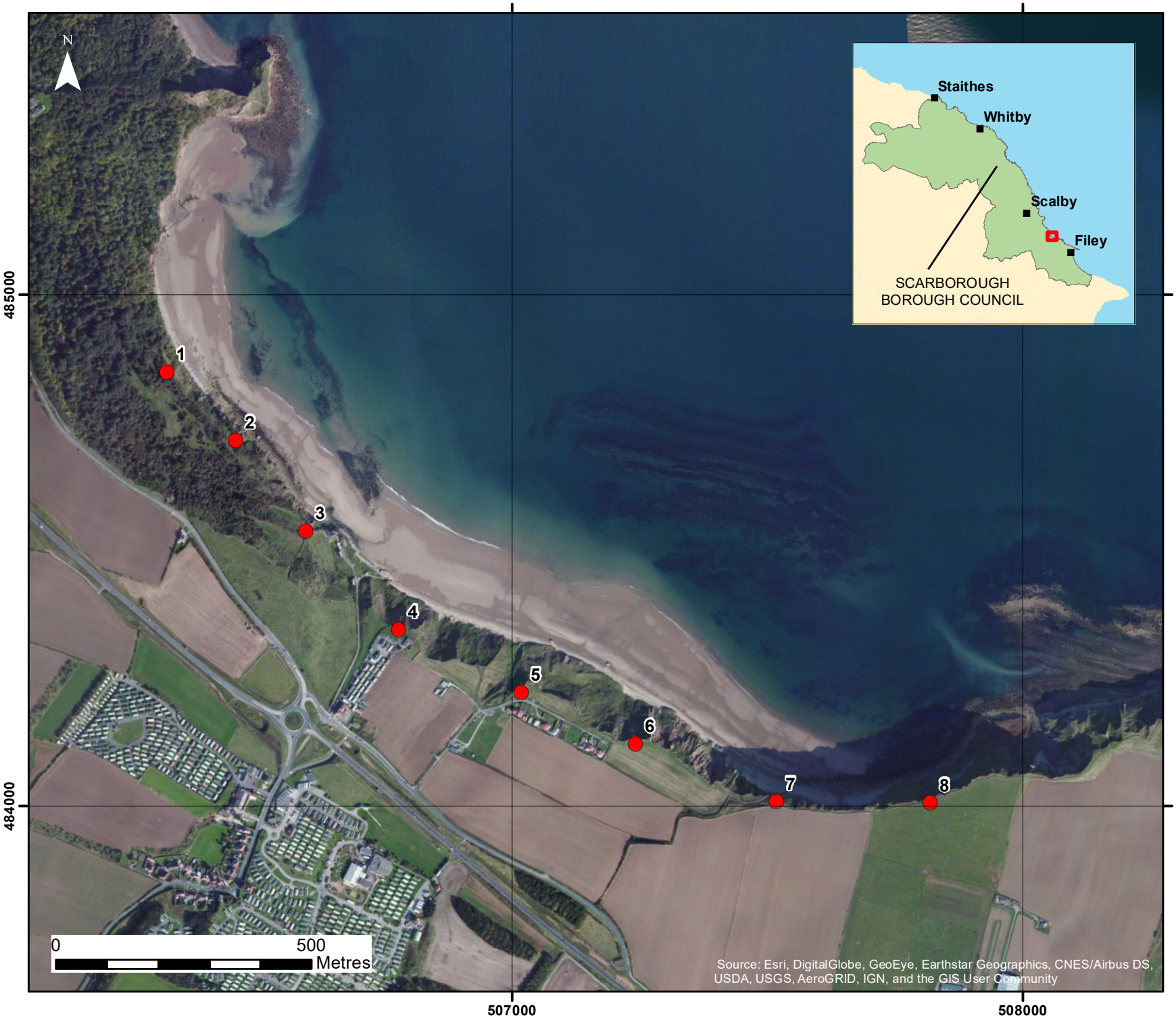

Key

- Cliff Top Survey Locations

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Project: Cell 1 Regional Coastal Monitoring Programme

Figure 3 - Map 4

CAYTON BAY

Scarborough Borough Council Council Frontage

Cliff Top Survey Locations

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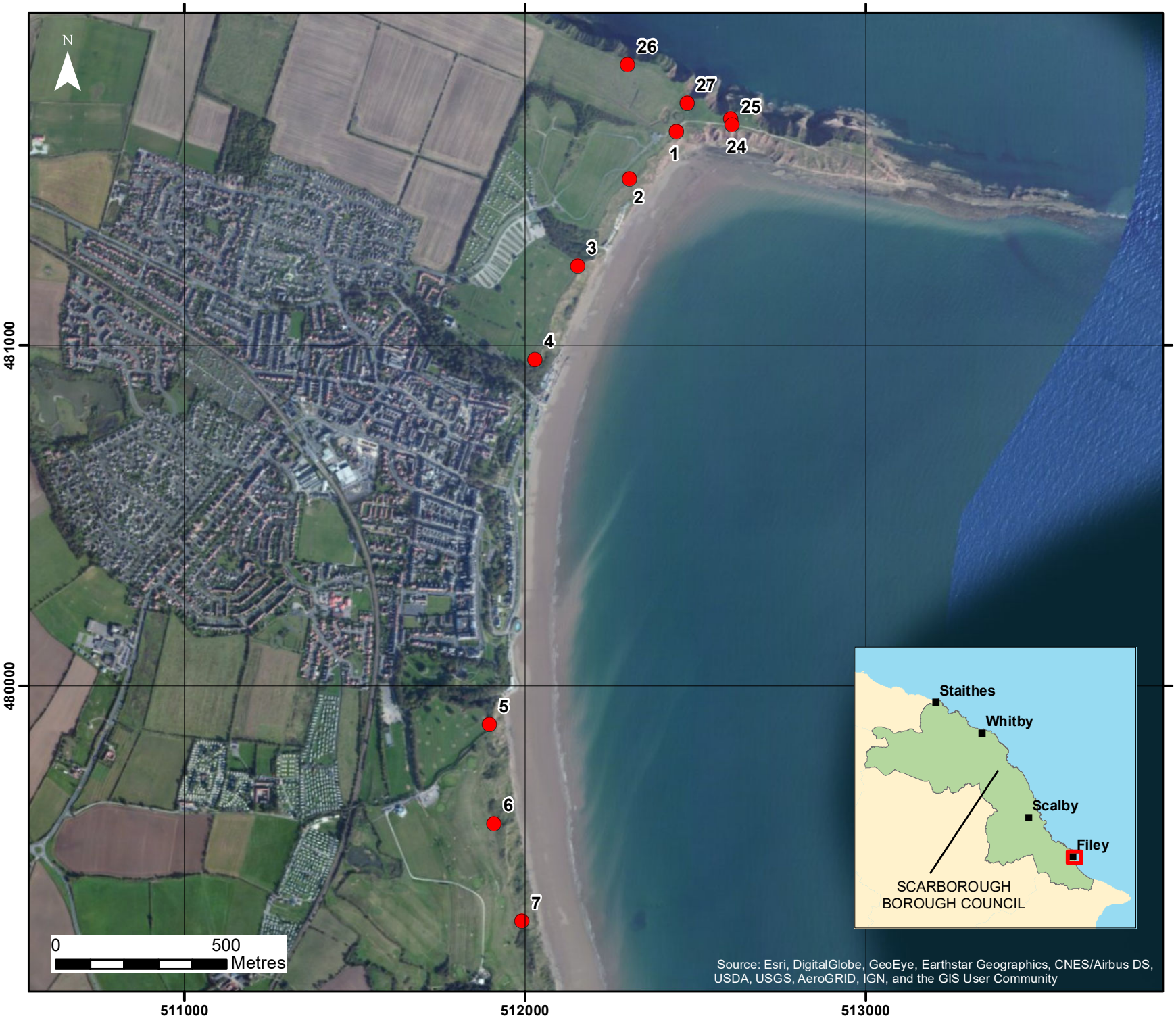

Key

- Cliff Top Survey Locations

Client: North East Coastal Group

Project: Cell 1 Regional Coastal Monitoring Programme

Figure 3 - Map 5

FILEY BAY NORTH

Scarborough Borough Council Council Frontage

Cliff Top Survey Locations

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Key

- Cliff Top Survey Locations

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Figure 3 - Map 6

FILEY BAY SOUTH

Scarborough Borough Council Council Frontage

Cliff Top Survey Locations

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2. Analysis of Survey Data

2.1 Staithes

Survey Date	Description of Changes Since Last Survey	Interpretation
4th October 2019	**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 100m. Data collection involves a distance offset measurement from the ground control point to the cliff edge along a fixed bearing. During the October 2019 survey, 4 of the posts were not measured due to access issues. Of the 16 remaining, 12 posts showed change within a range of ±0.1m, which is not considered significant given the error of the technique. Posts 1, 5 and 7 showed erosion of 0.18m, 0.45m and 0.12m respectively. At Post 8, the survey shows an accretion of 2.63m, this is likely due to the survey techniques and from photographs does not appear to be caused by movement in the upper cliff. Calculation of longer-term erosion rates based on the recorded change between 2008 and 2018 indicates that 13 posts on the frontage recorded a change rate within a range of ±0.1m/year, which is considered to be within the error of the measurement. Posts 1, 4, and 13 (near the eastern breakwater) show consistent erosion through the surveys at 0.14-0.62 m/yr. Posts 9 to 12 were inaccessible due to a landslip on the headland; the area was fenced off by the National Trust. Appendix C provides results from the October 2019 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.	Three stations showed erosion of between 0.1 and 0.5m over the summer of 2019. A further four stations continued to be inaccessible due to a landslip on the headland. **Longer term trends**: Table C1 shows that survey location 1 has shown the greatest total erosion with a loss of 6.77m (±0.3m) between the November 2008 baseline and October 2019, resulting in a long-term average recession rate of 0.62m/yr. Location 4 is has also showed progressive erosion with an average recession rate of 0.14m/year. Both of these stations are located adjacent the old Cowbar Lane which in places has now collapsed entirely. Location 13 has also experienced ongoing erosion of with an average recession rate of 0.24m/year. This area is above the eastern breakwater and is known to have experienced rock falls previously. The coastal path is now at risk of being undermined at this point.

2.2 Runswick Bay

Survey Date	Description of Changes Since Last Survey	Interpretation
25th November 2019	**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 1) and to calculate the differences between the current topographic survey (Autumn 2019) and the previous survey (Spring 2019) 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 8). Appendix B – Map 1 shows that the beach contours follow a broadly shore parallel pattern. The beach is shallower at its northern and south eastern extents, with a steeper section fronting the Runswick Bay Sailing Club and boathouse. A small sand bank protrudes into the bay from the centre of the survey extent. Appendix B - Map 8 shows a more active beach profile than following the previous survey in Spring 2019. In the north of the bay, accretion has dominated the profile, with the exception of some localised erosion around the lifeboat slipway and beach access point. Moving south; a wide band of erosion throughout the mid-beach separates two areas of accretion on the upper and lower beach. The central bay has experienced erosion across the upper, mid and lower beach. In the south of the bay erosion has dominated the upper beach, whilst accretion has dominated the mid and lower-beach. The magnitude of change is up to ±1.5m, with accretion being dominant in the north and south of the survey extent, and erosion concentrated in the central bay area, except for a small band of upper-beach erosion in the south of the bay. There is further evidence of accretion in the far north of the survey extent in front of the recently constructed rock armour revetment. It is unclear if this is due to the presence of the new defence or if the accretion can be attributed to the expected spring recovery. It is worth noting that the previous (Partial Measures 2019) survey noted erosion at the foot of this revetment following the Spring 2019 survey.	Between March and November 2019. Runswick Bay experienced a varied pattern of change, with the north and south of the bay showing more accretion. The central bay experienced more erosion. The exceptions to this trend are; a small area of erosion fronting the lifeboat station and beach access in the north of the bay, along with a band of erosion across the upper beach in the south of the bay. This indicates movement of material from the central bay to the its extremities and from the upper beach to the lower and mid-beach in the south of the bay. **Longer term trends**: The changes in the bay have been no more than ±1.5m. The data collected since 2008 indicate a general pattern of winter drawdown and spring recovery with no net change. The longer-term pattern of erosion in front of the village has paused since 2015.

2.3 Sandsend Beach, Upgang Beach and Whitby Sands

Survey Date	Description of Changes Since Last Survey	Interpretation
29th November 2019	**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). The beach level immediately in front of the new defences at Profile **1dWB1** (located around 400m south of Sandsend Village) has experienced accretion of up to 0.2m on the upper beach, from chainages 45m to 70m. The remainder of the profile is dominated with a mid to lower–beach berm from chainage 90m to the end of the survey at chainage 185m. The beach level over this extent is 0.4 to 0.5m higher than was recorded in the previous survey (April 2019). Elsewhere on the profile; between chainages 38m and 45m (at the toe of the defence), and between chainage 70m to 90m there has been little to no change. Overall the upper beach is at a medium level compared with the range recorded in previous surveys, whilst the mid and lower beach is at a high when compared to previous surveys, with the crest of the berm between chainages 105m and 125m being the highest on record. At **1dWB2** (located in centre of Upgang Beach) the profile to 140m chainage has experienced similar changes to **1dWB1**. There has been low level erosion of around 0.1m at the toe of the cliffs, between chainages 145m and 152m. Froom chainage 155m to 188m a shallow upper beach berm has formed from accumulated material up to 0.4m in height, whilst from chainage 188m to 217m there has been 0.3m of erosion. Seaward of this point, from chainage 217m to 261m, a mid to lower beach berm has formed, increasing the level of the beach by 0.4m at its crest. The toe of the beach has seen some erosion of up to 0.2m when compared against the April 2019 survey. Overall the beach is medium level; with the crest of the berm being slightly higher, and the trough on its landward side being slightly lower, when compared with the range of previously recorded surveys. At profile **1dWB3** fronting the stabilised face of Whitby West Cliff, no change has occurred as far as 90m chainage. At the toe of the seawall there has been 1m of erosion, which has effectively returned the beach level to that as last seen in May 2018. The profile has smoothed considerably from that seen in the previous survey (April 2019). From chainage 90m to 113m erosion has removed the upper beach accretion recorded here previously. Whilst the remainder of the profile is dominated by accretion of	The November 2019 profiles tended to be sat around the mid-point of the range recorded by previous surveys, with accretion being the predominant process. The topographic difference plots (calculated difference over the last 12 months) show a more complex spatial pattern. Erosion is the marginally predominant process; additionally, the depth of erosion appears to be of a higher magnitude. However, there remains clear areas of accretion, particularly on the mid beach fronting Sandsend and around the headland between Upgang Beach and Whitby Sands. Notably, the difference plot (calculated over 12 months) identifies erosion around the river outfall at Sandsend, and against the toe of the new defences, despite the 1dWB1 profile showing little change in these location over the preceding 6 months. 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 annual topographic difference plots show similar patterns of accretion and erosion in the all

Survey Date	Description of Changes Since Last Survey	Interpretation
	varying levels. From chainage 113m to 160m accretion has been as significant as 1m in depth. Seaward of this point until the end of the survey chainage 245m the level of accretion has varied between 0.1 and 0.3m in depth. Overall the full extent of the beach profile is at a medium level when compared with the range recorded from previous surveys, with the mid-beach recovering from the erosion recorded during the April 2019 survey.	surveys although the magnitude of change is generally modest.
	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 (Appendix B – Maps 2) using GIS. The GIS has also been used to calculate the differences between the current topographic survey DGM (Autumn 2019) and the earlier topographic survey DGM (Autumn 2018), with 5m resolution raster grids (as shown in Appendix B – Maps 9), to identify areas of erosion and accretion. Appendix B – Maps 9 show a varied picture of erosion and accretion. At the northern end of the frontage, erosion has dominated the upper beach, whilst accretion has dominated the mid and to a lesser extent the lower beach. The erosion is greatest around the outfall of East Row Beck. Fronting the new defences there has been a narrower band of erosion across the upper beach, whilst the mid-beach has been dominated with erosion. This is a trend which reverses moving eastwards. Fronting the undefended cliffs and onto Upgang Beach, accretion has tended to dominate the upper beach, with erosion being more dominant across the mid beach. At Upgang Beck there is a small patch of erosion against the toe of the cliffs, however the accretion is the dominant process over the beach in this location. Moving eastwards along Whitby Sands the distribution of change has been more sporadic. The west of Whitby Sands around the small 'headland' which marks the beginning of Whitby's defended frontage has experienced accretion, whilst the central section fronting West Cliff has seen more erosion. Changes at the eastern end of Whitby Sands have been slight, with change in levels recorded against the Pier being in the range of ±0.1m. Notably there has been some erosion on the upper beach in the location of 1dWB3, as discussed above, and at First Nab, although the changes here are less significant than elsewhere.	

2.4 Robin Hood's Bay

Survey Date	Description of Changes Since Last Survey	Interpretation
18th September 2019	**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 3) using GIS. The GIS has also been used to calculate the differences between the current topographic survey DGM (Autumn 2019) and the earlier topographic survey DGM (Spring 2019), with 5m resolution raster grids (as shown in Appendix B – Map 10), to identify areas of erosion and accretion. Appendix B - Map 10 shows a very patchy distribution of areas of accretion and erosion over the Summer of 2019. The majority of the bay has seen negligible change (±0.1m) associated with the rocky outcrops which run perpendicular to the shore. These are interspersed with some localised areas of erosion, and particularly in the north of the survey extent, some accretion. Although still localised, more notable areas of erosion are found; at the toe of the cliffs at Old Lance Cliff, Dungeon Hole, and directly north of the northern slipway beneath, the cliffs (an area of longstanding concern). Rock fall has been recorded from these cliffs in recent years and so erosional processes in these locations may simply be the seasonal redistribution of this this material across the beach. The topographic contour plot does not appear to show a net loss from the beach in these locations. Overall, erosion is slightly more dominant, however the magnitude of changes is small when compared with previous surveys. The range of erosion and accretion is typically between ±1.0m, however the vast majority of the beach has shown little or no significant change.	The topographic change plot shows that there has been very little change across the frontage over the summer of 2019. Cliff top monitoring shows little or no erosion since March 2019. **Longer term trends:** The limited change recorded in Robin Hoods Bay is due to the resistant rock platforms and thin, patchy cover of sand.

Survey Date	Description of Changes Since Last Survey	Interpretation
	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 only one location showed erosion between March and September 2019, Marker 11 which has recorded 0.1m of retreat. However, inspection of the survey photos indicates this could be due to difficulty locating the cliff edge precisely as the break in slope is covered by thick vegetation and brambles. Using data recorded between March 2010 and September 2019, calculated erosion rates show little change in all markers except Marker 1 which shows recession of 0.5m/yr. However, this marker has showed very little change since March 2012.	

2.5 Scarborough North Bay

Survey Date	Description of Changes Since Last Survey	Interpretation
30th September 2019	**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). The September 2019 survey shows that Profile **1dSBN1** remains stable at the defended, upper part of the profile. There has been accretion against the base of the seawall and the upper beach. From 10m to 17m accretion is as high as 1m, this decreases to 0.1m by chainage 40m. From 40m to 130m there is little change to beach levels with accretion being in the order of 0.1m. Seaward of this point, until the end of the survey at chainage 167m, there has been further accretion of approximately 0.2m. Beach levels remain lower than the spring and autumn 2018 levels throughout the entire profile, with the exception the upper beach at the toe of the sea wall where levels are high. The September 2019 profile is at a medium level when compared with the range of previously recorded results. At **1dSBN2** the beach is characterised by a shifting berm in the profile, which can form on the upper or lower beach. In September 2019, the beach level at the toe of the seawall had increased by 0.2m. The profile shows accretion in the upper beach to chainage 55m of up to 0.8m, with the berm crest moving up to the upper beach around chainage 22m, compared with chainage 80m in the March 2019 survey. From chainage 55m to 97m there has been erosion of up to 0.3m. The rock foreshore is exposed from chainage 100m until the end of the survey at chainage 158m, although it is noted that there has been some low levels of accretion between the two most landward rock outcrops. The September 2019 profile is; high on the upper beach, medium across much of the mid-beach and low at the toe of the beach when compared with the range recorded from previous surveys. The September 2019 survey shows that the beach at profile **1dSBN3** has experienced minor accretion of up between 0.1m and 0.3m from; chainage 15m at the base of the seawall until chainage 150m. The levels of accretion peak between chainage 40m and 90m where a wide shallow depression has been infilled. Accretion has been less significant in the lower beach and diminishes by chainage, where a small degree of erosion is recorded at the toe of the beach. The September 2019 profile is at a medium level when compared with the range recorded from previous surveys, with the upper section of beach	The beach profiles in September 2019 all show that accretion processes have dominated over the summer months. All the profiles experience some degree of accretion and are generally at medium levels compared to the range of previously recorded surveys. Despite this, there are some minor areas of erosion, particularly at the toe of the beach. All profiles show modest changes, with the exception of 1dSBN1 where there has been more significant accretion at the base of the seawall. The changes at 1bSBN2 are in line with the migration of the beach berm in this location. **Longer term trends:** The observed trends in the topographic plots and beach profiles point to overall stability with seasonal fluctuations.

Survey Date	Description of Changes Since Last Survey	Interpretation
	having a shallower gradient whilst the lower beach has a steeper gradient. There has been some low levels of accumulation of sand (up to 0.2m) over the rocks at the base of the seawall in the profile at **1dSBN4** however the rocks remain exposed between chainage 35m and 55m. Between chainage 60m and 110m there has been accretion of up to 0.4m, which then decreases in depth diminishing to an equilibrium around chainage 155m. Seawards of this point, at the toe of the beach, there has been some minor erosion, limited to around 0.1m. The September 2019 profile is at a medium level compared to the range recorded by previous surveys, although the rocks exposed on the upper beach indicate a low level in this location. On profile **1dSBN5** there has been accretion of 0.8m at the toe of the defences between the March 2019 and September 2019 surveys. Between chainage 35m and 105m there has been accretion of 0.3m. Seaward of this point, until the end of the survey at chainage 192m, there has been a diminishing level of accretion from 0.2m to 0m by chainage 174m. The September 2019 survey is high to medium when compared with the recorded range along most of its length.	
	Topographic Survey: Scarborough North Bay is covered by an annual topographic survey, which was carried out in September 2019. Data have been used to create a DGM (Appendix B - Map 4 and 16) with GIS for both surveys. The GIS has also been used to calculate the differences between the Full Measures topographic survey DGM (Autumn 2019) and the earlier topographic survey DGM (Autumn 2018), with 5m resolution raster grids (as shown in Appendix B – Map 11 and 17), to identify areas of erosion and accretion. Appendix B - Map 11 (October 2016 to September 2017) shows a more sporadic distribution of erosion and accretion than the previous survey. In the north of the bay, accretion has dominated the upper beach, whilst erosion has been more prevalent across the mid and lower beach. In the centre of the bay, around Peasholm Gap there has been accretion on the upper beach, with the mid and lower sections of beach remaining stable in level. In the south west of the survey extent, fronting Royal Albert Drive there has been a narrow band of erosion on the upper beach against the seawall. The upper mid-beach has been dominated by accretion, whilst the lower mid and lower beach have	

Survey Date	Description of Changes Since Last Survey	Interpretation
	experienced low levels of erosion. Overall, accretion has been the more dominant process across the full survey extent, however there are some more localised areas of erosion, notably against the seawall at Albert Gardens and fronting Royal Albert Drive .	

2.6 Scarborough South Bay

Survey Date	Description of Changes Since Last Survey	Interpretation
27th November 2019	**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). The comparisons of short-term change are between March and November 2019. At profile **1dSBS1** there has been erosion of 0.4m at the toe of the seawall, diminishing in magnitude until chainage 40m. From chainage 40m to chainage 150m there has been 0.3m of accretion, which has caused a smoothing of the profile across much of the upper and mid-beach. Seaward of chainage 150m, until chainage 195m, a shallow depression has been formed by around 0.3m of erosion. The remainder of the profile; chainage 195m to the end of the survey chainage 245m has experienced a low level of accretion (around 0.1m). The November 2019 profile is at a high level compared with the range recorded by previous surveys. Between chainage 68m and 90m, and chainage 205m and 245m the profile is at its highest recorded level. The beach at profile at **1dSBS2** has demonstrated a similar trend to 1dSBS2, with erosion on the upper beach and accretion on the mid beach. At the toe of the seawall; from chainage 5m to 17m there has been erosion of up 0.4m. There has been no change from chainage 17m to 25m, however from chainage 25m to chainage 130m there has been up to 0.3m of accretion throughout the mid-beach. Erosion has been more prevalent on the lower beach, from chainage 130m until the end of the survey at chainage 215m there has been up to 0.3m of erosion. The survey does not extend seaward enough to include the patch of rock which has been identified in previous surveys (most recently the Full Measures 2019 survey). The November 2019 profile is at a medium level compared to the range previously recorded. The slight exception to this is at the toe of the seawall where the beach profile is at its lowest recorded level. At profile **1dSBS3** there has been no change directly at the toe of the seawall. However, similar to the previous Full Measure Survey, two beach berms have formed along the profile. The upper beach berm has formed between the seawall and chainage 90m, and at its crest the berm has accumulated 0.4m of sand upon the March 2019 beach levels. The lower beach berm is shallower at around 0.2m height. Between the two berms is a narrow strip of erosion. Overall the November 2019 profile is at a medium	The level of the beach in the profiles is within the middle of the range recorded in previous years. All the profiles show accretion is the dominant process, however areas of erosion exist, primarily across the mid beach and in places the lower beach. The short-term change plot also shows variable erosion and accretion, matching the profiles. The accumulations in the mid-beach at the northern end is likely to be due to the action of constructive waves through the summer. The cliff top change markers have indicated negligible change at most locations' markers with, 0.3m loss recorded at location 11 and 0.1m loss recorded at location 13. **Longer term trends**: The beach is regularly re-profiled with sediment moved from near the harbour to the frontage of The Spa, but sediment naturally moves northwards towards the harbour. Table C3 shows that since March 2010 most of the cliff erosion profiles have shown negligible recession. Profiles 11 and 12 show erosion of 0.4 m/year and 0.3m/year respectively. These points are at the rear of a mudslide system which experiences periodic reactivation or head scarp collapse, however there has been little movement in the last two years.

Survey Date	Description of Changes Since Last Survey	Interpretation
	to low level compared with the range recorded by previous surveys. At chainage 100m, in the depression between the two berms the profile dips to its lowest recorded level. Profile **1dSBS4** shows erosion of up to 0.6m at the base of the seawall. A rocky outcrop located at chainage 10m, which was buried in the March 2019 survey was identified in the November 2019 survey. Seaward of this point, between chainage 20m and chainage 125m, there has been accretion of up to 0.5m, this has formed a wide berm with crest at chainage 80m. A smaller lower beach berm is also evident between chainage 155m and the end of the survey at chainage 187m. Between the two berms, there has been a narrow band of erosion, similar to that identified in 1dSBS3. Overall, the November 2019 profile is at a high level when compared with the range recorded by previous surveys. Notably, on the lower beach between chainage 165m and 187m the beach is at its highest recorded level.	
	Topographic Survey: Scarborough South Bay is covered by an annual topographic survey. Data have been used to create a DGM (Appendix B - Map 5) using GIS. The GIS has also been used to calculate the differences between the current topographic survey DGM (Autumn 2019) and the earlier topographic survey DGM (Autumn 2018), with 5m resolution raster grids (as shown in Appendix B – Map 12), to identify areas of erosion and accretion. Appendix B - Map 12 shows that in the north of the bay, alternating shore parallel bands of erosion and accretion have dominated. Against the seawall, a narrow band of erosion runs from the harbour in the north to the Spa complex in the centre of the survey extent. Adjacent to this, a wide band of accretion dominates the upper-mid beach, whilst a wide band of erosion dominates the lower-mid beach. In the north there is a 4th band (of accretion) at the seaward extremity of the survey area. The south of the bay is markedly different, with accretion dominating almost the full extent of the beach and only sporadic instance of erosion seen. Notably, three localised pockets of erosion exist on the upper beach along the Scarborough Spa seawall. The magnitude of change crosses the whole survey area is low, generally being less than ±0.5m.	

Survey Date	Description of Changes Since Last Survey	Interpretation
	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 November 2019 two of the thirteen locations showed change of more than ±0.1m, these were point 11 above Frank Cliff in Cornelian Bay which experienced 0.3m of retreat and point 13 at Knipe Point above Cayton Cliff which experienced 0.1m of retreat. Notably, at point 11 the survey photographs indicate that the footpath which runs along the upper cliff has been encroached upon and has begun to collapse. It would be advisable for the footpath to be diverted in this location to reduce the risk of injury to members of the public using the path. Control point 1 was inaccessible due to the ongoing Scarborough Spa Slope Stabilisation Project. The recession rates calculated for the period from March 2010 to November 2019 give a picture of the change over the longer term. Ten of the markers have a recession rate of less than 0.1m/yr. Markers 11 and 12 are the only markers showing a higher rate of 0.4m/yr and 0.3m/yr respectively. Appendix C provides results from the November 2019 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.	

2.7 Cayton Bay

Survey Date	Description of Changes Since Last Survey	Interpretation
26th November 2019	**Beach Profiles:** Cayton Bay is covered by four beach profile lines, distributed between Tenants' Cliff and the south of Cayton Sands (Appendix A). The survey report states that *'the cliff face could not be measure on Sections 1, 2 and 3 due to unsafe ground conditions'*. Profile **1dCY1A**, (Clayton Cliff) has been surveyed since November 2015. The latest survey (November 2019) reports that there has been little change on the upper beach from chainage 0m to chainage 65m. Between chainage 65m and 100m there has been accretion of 0.4m, with a shallow depression around chainage 100m. Seawards of the point until the end of the survey at chainage 175m there has been between 0 and 0.2m of accretion. The profile is at a high level compared with the range of previously recorded results, with the section between 85m and 95m being the highest on record. The cliff face at profile **1dCY1** (Tenant's Cliff) is heavily vegetated and the survey report states that *'the top of section 1 cannot be measured due to dense vegetation'*. There has been little change from the toe of the cliff until chainage 30m. From this point until chainage 120m a veneer beach has extended over the rocky foreshore. There has been 0.4m of accretion over much of this extent, however notably at the toe of the beach this increases to 0.7m. The sandy beach has extended seawards from chainage 100m (recorded in the March 2019 survey) to chainage 120m recorded in the current survey. Seaward of this point until the end of the survey at chainage 175m the rocky foreshore is exposed. Overall the November 2019 profile is at a medium level compared to the range recorded in previous surveys. At profile **1dCY2** (close to former pumping station) the surveyors were unable to measure the cliff face due to unsafe ground conditions. Furthermore, the survey report states that *'the vegetated area at the bottom of the cliff face on Section 2 could not be measured due to soft mud slides prohibiting access'*. From chainage 120m the profile has been dominated by accretion. The upper beach between chainage 120m and 170m has experienced between 0.2m and 0.3m of accretion, whilst the mid and lower-beach, between chainage 170m and chainage 310m has experienced between 0.3m and 0.4m of accretion. The November 2019 profile is at a medium level across the upper beach, and a high level across the mid and lower beach, when compared with the range recorded in previous surveys. Particularly	The beach profiles have been stable overall with accretion dominating in all the profiles. The plot of difference between Autumn 2018 to Autumn 2019 surveys shows variability in the erosion and accretion in the bay with little consistent pattern, although the changes are typically more extreme in the northern half of the bay. The cliff top survey data shows that only one marker (VMP4) showed recession of greater than or equal to 0.1m. No other significant recession has occurred at any of the marker points during the summer of 2019. **Longer term trends:** The pattern of migrating sand bars has remained consistent since 2010 indicating seasonal variation in beach level with no net change.

Survey Date	Description of Changes Since Last Survey	Interpretation
	between chainage 255m and 295m where the profile is at its highest recorded level. At profile **1dCY3** (600m southeast of the pumping station) the surveyors were unable to measure the cliff face due to unsafe ground conditions. The remainder of the profile has experienced a movement of material seawards down the beach. Material has been lost from the toe of the cliff between chainage 130m and 140m, although erosion here has been limited to 0.2m. From chainage 140m to 180m an upper beach berm has formed with 0.4m of accretion at the crest of the berm. A shallower lower beach berm has formed between chainage 220m and 250m, accretion here is limited to 0.2m. Between the upper and lower beach berm there is a shallow depression with up to 0.2m of erosion. Seaward of the lower beach berm the toe of the beach has eroded considerably, by 1m at its most seaward end. Overall the November 2019 profile is at a medium-low level compared to the range recorded from previous surveys, with the toe of the cliff (between chainage 130m and 140m) being the lowest recorded level in this location. Furthermore, the depression between the two berms is at a particularly low level.	
	Topographic Survey: Cayton Bay is covered by an annual topographic survey. Data have been used to create a DGM (Appendix B - Map 6) using GIS. The GIS has also been used to calculate the differences between the current topographic survey DGM (Autumn 2019) and the earlier topographic survey DGM (Autumn 2018), with 5m raster grids (as shown in Appendix B – Map 13), to identify areas of erosion and accretion. Appendix B - Map 13 shows that the observed changes are very patchy. During 2019 the northern and southern parts of the bay show a wide patchy band of accretion across the mid beach. This band of accretion has been split in the centre of the bay, fronting the former pumping station, by a wide patch of erosion. In the northern half of the bay the upper beach has experienced a sporadic mixture of accretion and erosion, whereas the upper beach in the south of the bay has experienced more erosion at the toe of the cliffs. Across the bay the lower beach has experienced a mixture of erosion and accretion. The section of beach fronting the Tenant's Cliff complex has experienced accretion, which may be caused by the redistribution of material lost from minor progressive cliff failures. The distribution of change is complex and patchy; however, on balance accretion appears to have been the dominant process.	

Survey Date	Description of Changes Since Last Survey	Interpretation
	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 November 2019 only one of the eight monitoring points (point 4) showed erosion of 0.1m, whilst one (point 5) showed an accretion of 0.22m. All other points experienced no change outside the ±0.1m accuracy of the survey. The survey report notes that there was no access to point 2 due to dense vegetation. Long-term erosion rates calculated using data collected since November 2008 show change either within the margin of error. Markers 4 and 6 show erosion rates of 0.3m/yr and 0.1m/yr respectively. Appendix C provides results from the September 2019 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.	

2.8 Filey Bay

Survey Date	Description of Changes Since Last Survey	Interpretation
1st - 3rd October 2019	**Beach Profiles:** Filey Bay is covered by five beach profiles between Filey Sands and Speeton Sands (Appendix A). At profile **1dFB1** fronting Filey seawall, there has been accretion of 0.1m on the upper beach between chainage 20m and 40m. From this point, across the mid beach to chainage 165m there has been further accretion of between 0.1m and 0.2m. The seaward toe of the beach from chainage 165m to end of the survey at chainage 185m has experienced erosion of up to 0.6m. The October 2019 profile is at a medium to high level compared to the range recorded from previous surveys, with chainage 120m to 155m being the highest recorded result in this location. At profile **1dFB2** (located to the north of Primrose Valley Holiday Village) there has been a small amount (~0.1m) erosion of material at the toe of the cliff. The survey report notes that *'an area of section 2 from approx chainage 11m to 20m is unable to be measures, due to undergrowth and bushes'*. From chainage 85m to chainage 205m there has been accretion of up to 0.4m, forming a wide shallow mid-beach berm. Seaward from chainage 205m to the end of the survey at 277m there has been 0.2m of accretion forming a shallow lower beach berm. The profile is a medium to high level compared to the range recorded from previous surveys. The upper beach between chainage 98m and chainage 108m is at its highest recorded level in this location. At profile **1dFB3**, near Flat Cliffs, there has been erosion of 0.5m at the toe of the cliff at chainage 40m. The remainder of the beach is dominated by two berms. The upper beach berm is formed from chainage 50m to 105m where there has been up to 0.5m of accretion. The lower beach berm is more pronounced and runs from chainage 140m to the toe of the beach at chainage 250m. Between chainage 140m and 200m there has been 0.6m of accretion. Between the two berms (chainage 105m to 140m) is a depression caused by 0.5m of erosion. The October 2019 profile is at a medium-high level compared to the range recorded from previous surveys. Notably, the lower beach berm crest is at a particularly high level, whilst between the berms the depression is particularly low. Profile **1dFB4** at Hunmanby Gap has experienced similar changes to those recorded at 1dFB3. There has been some minor erosion at the toe of the cliffs between chainage 30m and 40m, whilst the	The beach profiles are dominated by shifting bands of accretion and erosion, which has formed shore parallel berms. Each profile has experienced some erosion and some accretion, however the magnitude of change increases in the southern profiles. The beach levels are generally high-medium compared with the range recorded from the previous surveys. The topographic change map shows Filey Bay, particularly the south of the bay, has shore parallel bands of accretion and erosion in the associated with migrating berms with little change in the north. The cliff top survey data provided in Table C5 shows erosion at 7 monitoring points. The largest change was at marker 7 where 2.43m of erosion was recorded. At the remaining 6 points which experienced erosion outside of the ±0.1m survey tolerance, change was limited to 0.1m to 0.2m. The Flat Cliffs Slope Stabilisation Works undertaken in Summer 2018 aim to mitigate against any further recession in the location of monitoring point 10. **Longer term trends**: Past trends dominated by migrating sand bars continue to the present day.

Survey Date	Description of Changes Since Last Survey	Interpretation
	remainder of the profile is dominated by two berms. The upper beach berm has formed from 0.3m of accreted material between chainage 45m and 122m. Whilst the more prominent lower beach berm has formed from 0.4m of accreted material between the chainages of 175 and 245m. Between the two berms is an area of erosion (up to 0.2m) which has formed a shallow depression. The seaward end of the profile, between chainage 245m and the end of the survey at 267m has experienced accretion of 0.1m. The October 2019 profile is at a medium-high level compared to the range recorded from previous surveys. The crest of the lower beach berm, between the chainages of 195m and 235m, is the highest recorded level in this location. At profile **1dFB5** (located close to Reighton Gap) there has been a varied pattern of accretion and erosion across the profile. The survey report notes that the *'middle of section 5 is unable to be measures from chainage 39m to approx 210m, due to undergrowth and bushes'*. From chainage 220m to 265m there has been up to 0.8m of erosion. Seaward of this point until chainage 325m there has been accretion of up to 0.8m. From chainage 325m until the end of the survey at 395m there has been little change to the profile. With the exception of a small accretion of 0.2m of material between chainage 360m and 375m. Overall the October 2019 profile is at a medium to low level compared to the range recorded from previous surveys, with the upper-beach between chainage 232m and 240m being the lowest on record.	
	Topographic Survey (Filey Bay): Filey Bay is covered by an annual topographic survey. 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. Data have been used to create a DGM (Appendix B – Map 7) using GIS. The GIS has also been used to calculate the differences between the current topographic survey DGM (Autumn 2019) and the earlier topographic survey DGM (Autumn 2018), with 5m resolution raster grids (as shown in Appendix B – Map 15) to identify areas of erosion and accretion. Appendix B - Map 15 shows that in the north of the bay, accretion is the dominant process. With only some localised sporadic instances of the erosion, notably on the lower beach just south of Filey Brigg and on the upper beach at the southern end of the Filey Town seawall. The central and southern parts of the bay show alternating shore parallel bands of erosion and accretion. The magnitude of change is greater from Primrose Valley southwards. Notably, at the cliffs to the north	

Survey Date	Description of Changes Since Last Survey	Interpretation
	and south of Hunmanby Gap there has been a band of erosion against the toe of the cliffs which runs along to Reighton Sands and the southern extent of the survey area. The general pattern is for a band of accretion across the mid beach, which is sporadically broken with a central band of erosion. The upper beach has generally been for a narrow band of erosion on the upper beach. The lower beach has experienced less significant changes, though accretion has also tended to dominate these areas as well. The sixth month difference plot calculated between March 2019 and October 2019 shows negligible change over the summer of 2019. The upper beach has experienced change in the order of ±0.1m, whilst the mid-beach has been dominated by a wide band of low level accretion. There has been some minor erosion on the lower beach. Changes over the summer of 2019 are limited to ±0.5m. There are some small localised areas of erosion at the toe of the sea defence around the southern section of wall. Overall the difference plot calculate between September 2018 and October 2019 shows accretion to be the dominant process in the north of the bay. With roughly equal areas of accretion and erosion manifesting as alternating shore parallel bands in the south of the bay. The area of greatest change is between Hunmanby Gap and Reighton Gap. The short term difference plot calculated over the summer of 2019 shows that the magnitude of change on the beach fronting the Filey Town seawall is more marginal than when considering the long term (12 month) difference plot.	
	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 six months. Data collection involves a distance offset measurement from the ground control point to the cliff edge along a fixed bearing. Between March and September 2018 19 of the ground control points showed no discernible change (within the ±0.1m accuracy of the survey). Three of the markers (point 5, 12 and 13) were not surveyed due to access constraints. One marker (point 7) showed high recession of 2.43m. Marker 13A has	

Survey Date	Description of Changes Since Last Survey	Interpretation
	shown recession of 0.23m, whilst four markers (points 6, 8, 16 and 23) showed erosion of between 0.1m and 0.2m. Point 7 is located above Eller House Cliffs, north of Primrose Valley, survey photographs indicate that there has been a shallow slip from the headscarp of the cliff. Long term rates of change show only seven markers have erosion with rates between 0.1m/yr and 0.4m/yr (points 6, 7 10, 14, 16, 18 and 23). The largest erosion rate recorded is at point 7, in part due to the recession recorded in the autumn 2019 survey. Appendix C provides results from the September 2019 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.	

3. 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 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.

At Staithes the surveyors noted that VMP's 9 to 12 were still inaccessible due to a landslip on the headland; the area has been cordoned off by the National Trust.

At Robin Hoods Bay the surveyors noted there was continuous rock and gravel falls along the cliffs, and that VMP5 was located on a pile of deposited garden waste.

At Whitby the cliff top at Section 2 could not be measured due to dense gorse bushes prohibiting access. Also, the cliff face of Section 2 could not be measured due to unsafe ground conditions.

At Scalby in Scarborough North Bay the cliff edge was very overgrown resulting in areas that were unable to be surveyed.

At Scarborough South Bay, VMP1 was not measured due to the presence of the ongoing Scarborough Spa Slope Stabilisation Scheme.

At Cayton Bay the surveyors could not measure the top of profile 1dCY1 due to dense vegetation. Furthermore, cliff face of profiles 1dCY1, 1dCY2 and 1dCY3 could not be measured due unsafe ground conditions. Furthermore, the vegetated area at the bottom of the cliff face on Section 2 (1dCY2) could not be measured due to soft mud slides prohibiting access. There was no access to measure the VMP2 due to dense vegetation.

At Filey an area of section 1dFB2 from approximate chainage 11m to 20m was unable to be measured due to the undergrowth and dense vegetation. Additionally, the mid-section of 1dFB5 between chainage 39m and 210m was not surveyed due to the presence of undergrowth and bushes. VMP5 was inaccessible due to heavy vegetation and an unstable cliff edge. VMP12 an VMP13 were inaccessible due to heavy vegetation.

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.

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

No changes are recommended at the present time.

5. Conclusions and Areas of Concern

The following points have been observed:

- The measurements of the Cowbar and Staithes cliff top show erosion of between 0.1 and 0.5m over the summer of 2019 at two stations. The most westerly of the control points

(VMP1) has shown the greatest total recession between the November 2008 baseline and the October 2019, with an average recession rate of 0.62m/year. A further four stations continued to be inaccessible due to a landslip on the headland.

- Runswick Bay shows patchy longitudinal change with accretion in the north and south of the bay and some erosion in the central bay. Along with some minor shore parallel change, of accretion on the upper and mid-beach in the north of the bay and accretion on the mid and lower beach in the south. The survey records a narrow band of erosion on the upper beach in the south of the bay.
- At Sandsend Beach, Upgang Beach and Whitby Sands erosion has been the marginally more significant process over the summer of 2019 with beach levels at a medium level relative to the range recorded from previous surveys. There remains an area of accretion against the toe of the new coastal defence at Sandsend.
- At Robin Hoods Bay the beach and cliff have remained stable with very little change over the summer of 2019. No discernible change 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 September 2019 survey shows the beach profiles are generally at medium levels compared to the range of previously recorded surveys. All profiles experienced some degree of accretion, particularly in their upper and mid reaches. There has been some of beach material against the toe of the seawall, particularly in the north of the bay. Erosion has tended to be limited to the lower beach.
- At Scarborough South Bay all the beach profiles have experienced some degree of accretion over the summer of 2019 and are at medium level when compared to the previous profiles. The ongoing Scarborough Spa Slope Stabilisation Scheme meant that the surveyors were not able to access to VMP1.
- The Cayton Bay beach profiles show stability overall with evidence of the formation of beach berms. The pattern of migrating sand bars has remained consistent since 2010 indicating seasonal variation in beach level with no net change. The cliff monitoring showed recession of 0.1m at one of the marker points. At one of the markers an advancement of 0.2m was recorded, although this is thought to be due to survey error. Long-term erosion rates indicate that on average cliff activity is most prevalent at VMP5-7.
- The profiles at Filey Bay show accretion to be the predominant coastal process. The profiles have all seen accretion, with some erosion at the toe of the beach, and in places in the mid beach. The profiles are high to medium when compared with the range of previously recorded results. The topographic difference plot shows little change in the north but shore parallel bands of accretion and erosion in the centre and south of the bay associated with migrating berms. There has been significant recession recorded at various points through the centre and south of the bay. In particular at marker 7 where 2.43m of erosion was recorded. At the remaining 6 points which experienced erosion outside of the ±0.1m survey tolerance, change was limited to 0.1m to 0.2m. Marker 7 to the south of Filey Town has become the location with the highest erosion rate of 0.4m/yr despite having historically not experienced much activity.

Appendices

Appendix A

Beach Profiles

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

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

Beach Profile

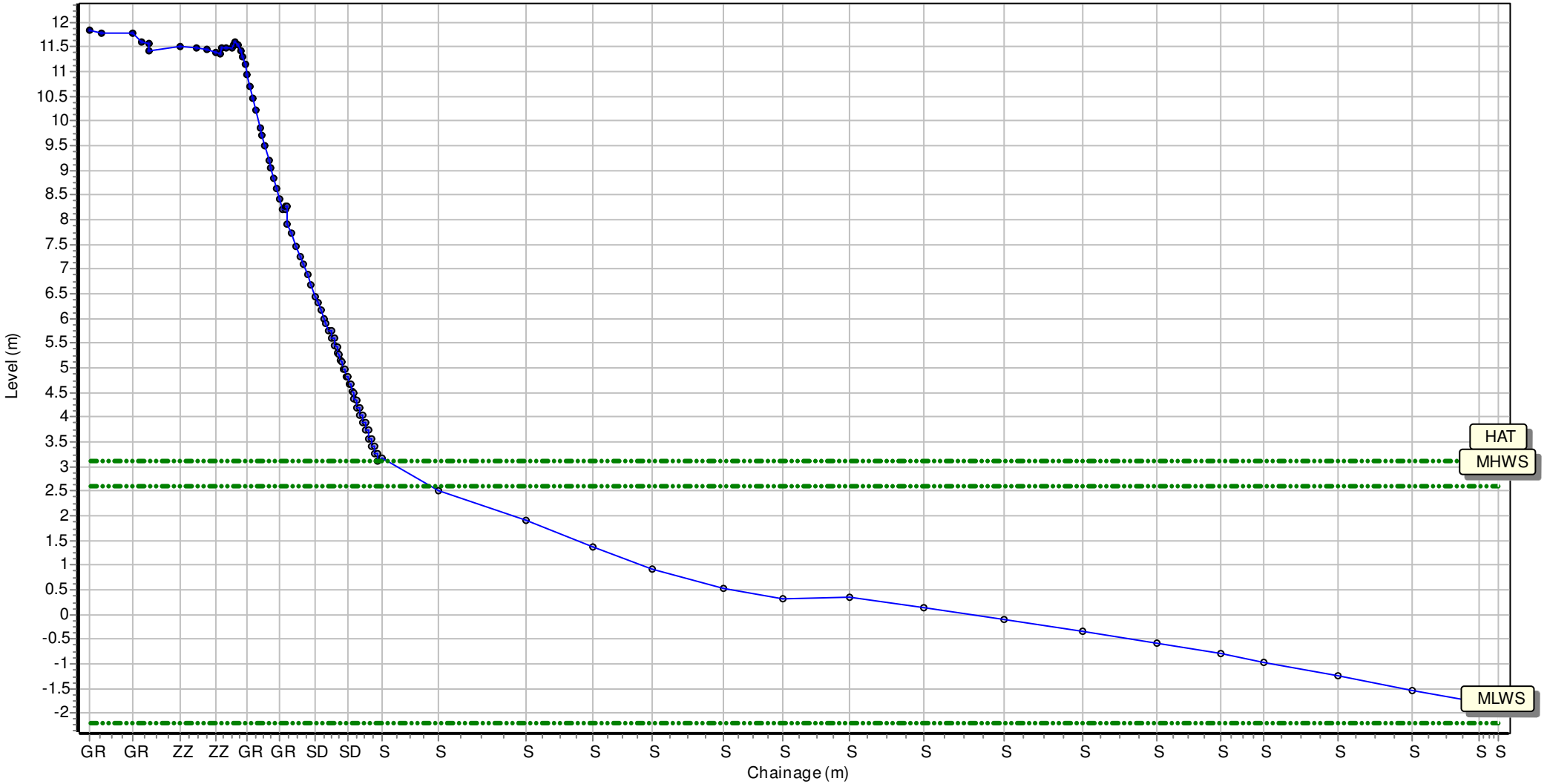
Location: **1dWB1**

Date: 29/11/2019 **Inspector:** AG **Low Tide:** **Low Tide Time:**

Wind **Sea State:** **Visibility:** **Rain:**

Summary: 2019 Full Measures Topo Survey

Easting: 486535.075 **Northing:** 512437.797 **Profile Bearing:** 32 ° from North



Beach Profile

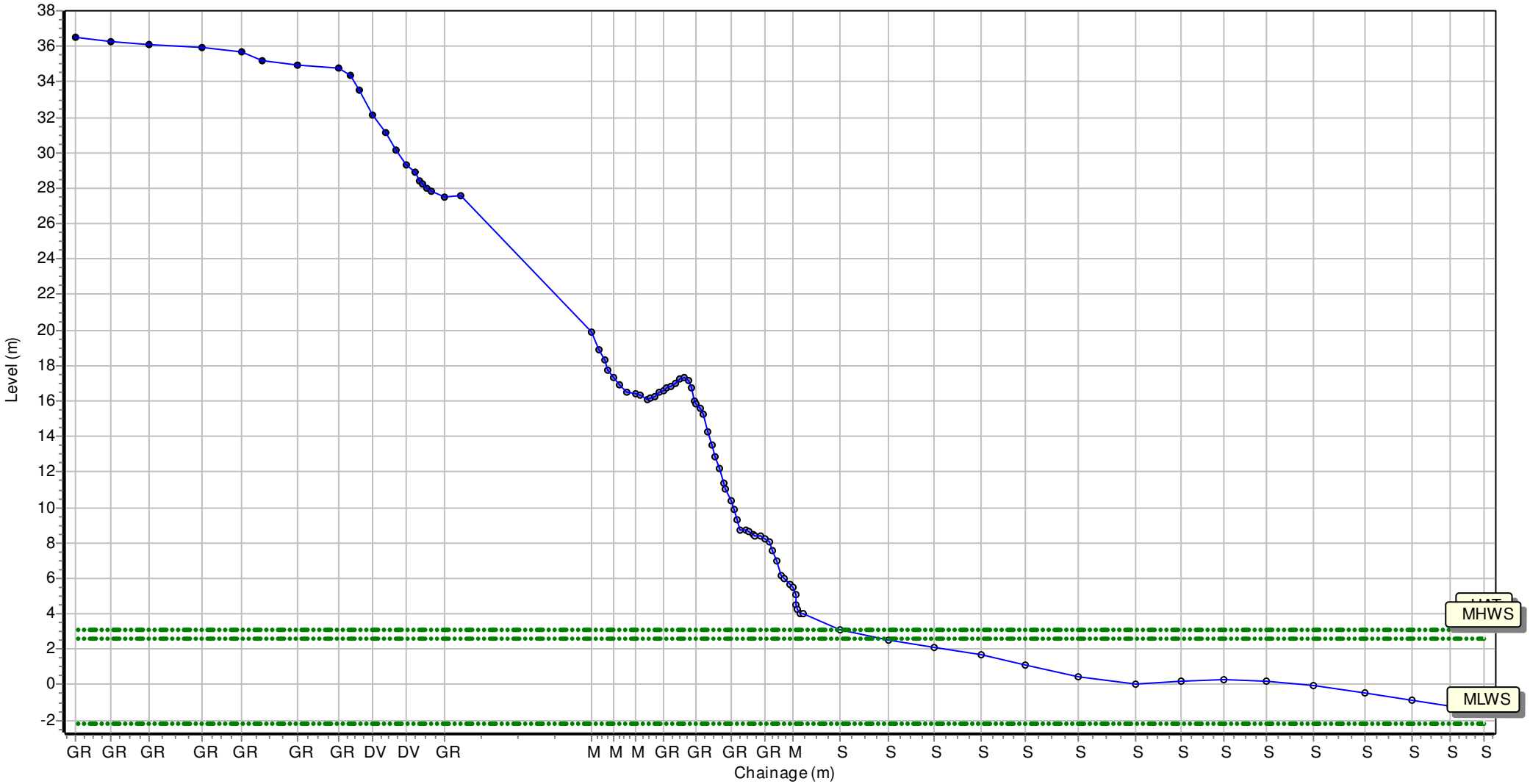
Location: **1dWB2**

Date: 29/11/2019 **Inspector:** AG **Low Tide:** **Low Tide Time:**

Wind **Sea State:** **Visibility:** **Rain:**

Summary: 2019 Full Measures Topo Survey

Easting: 487550.221 **Northing:** 511927.902 **Profile Bearing:** 16 ° from North



Beach Profile

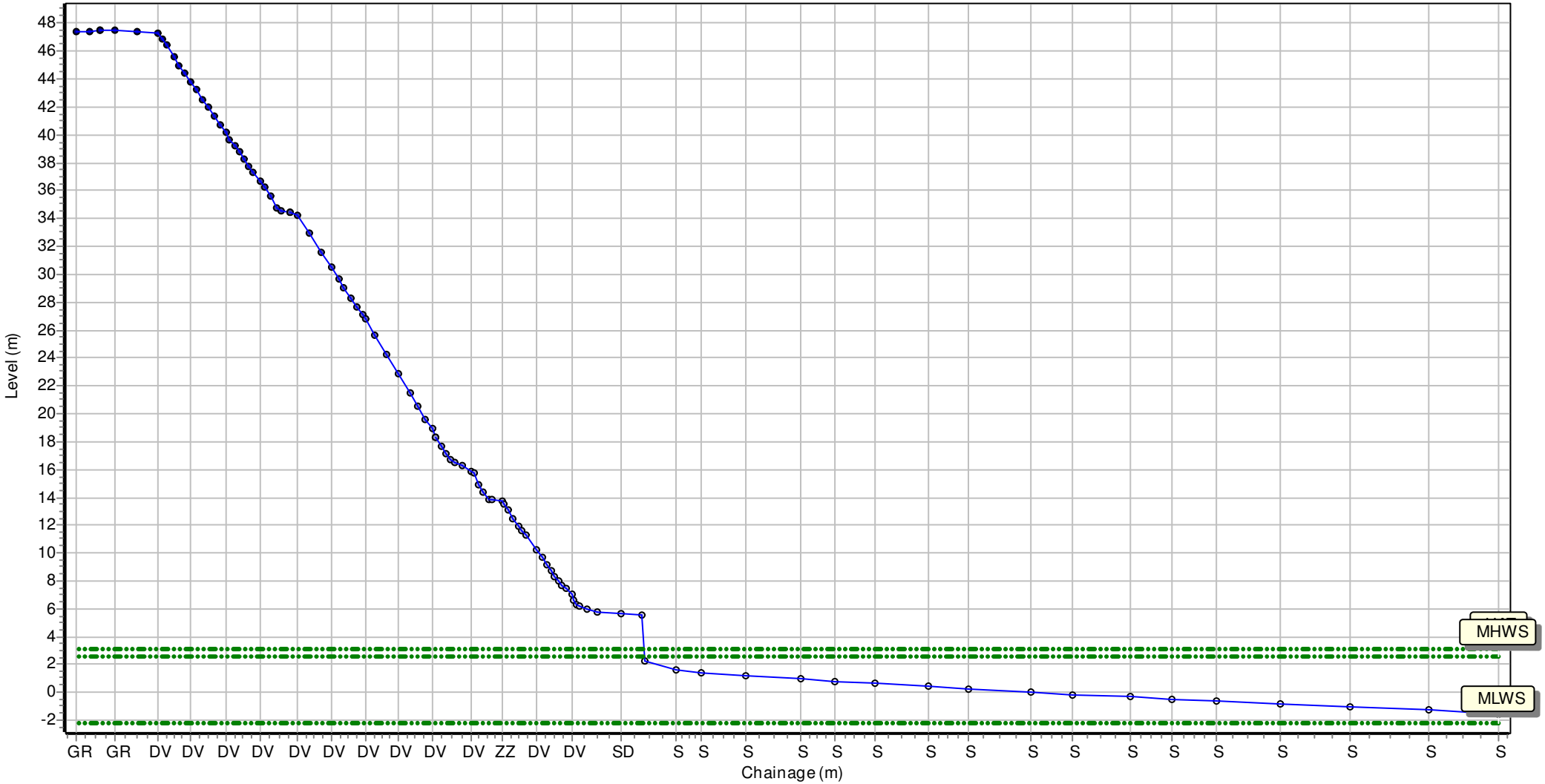
Location: **1dWB3**

Date: 29/11/2019 **Inspector:** AG **Low Tide:** **Low Tide Time:**

Wind **Sea State:** **Visibility:** **Rain:**

Summary: 2019 Full Measures Topo Survey

Easting: 488983.57 **Northing:** 511527.047 **Profile Bearing:** 19 ° from North



Beach Profile

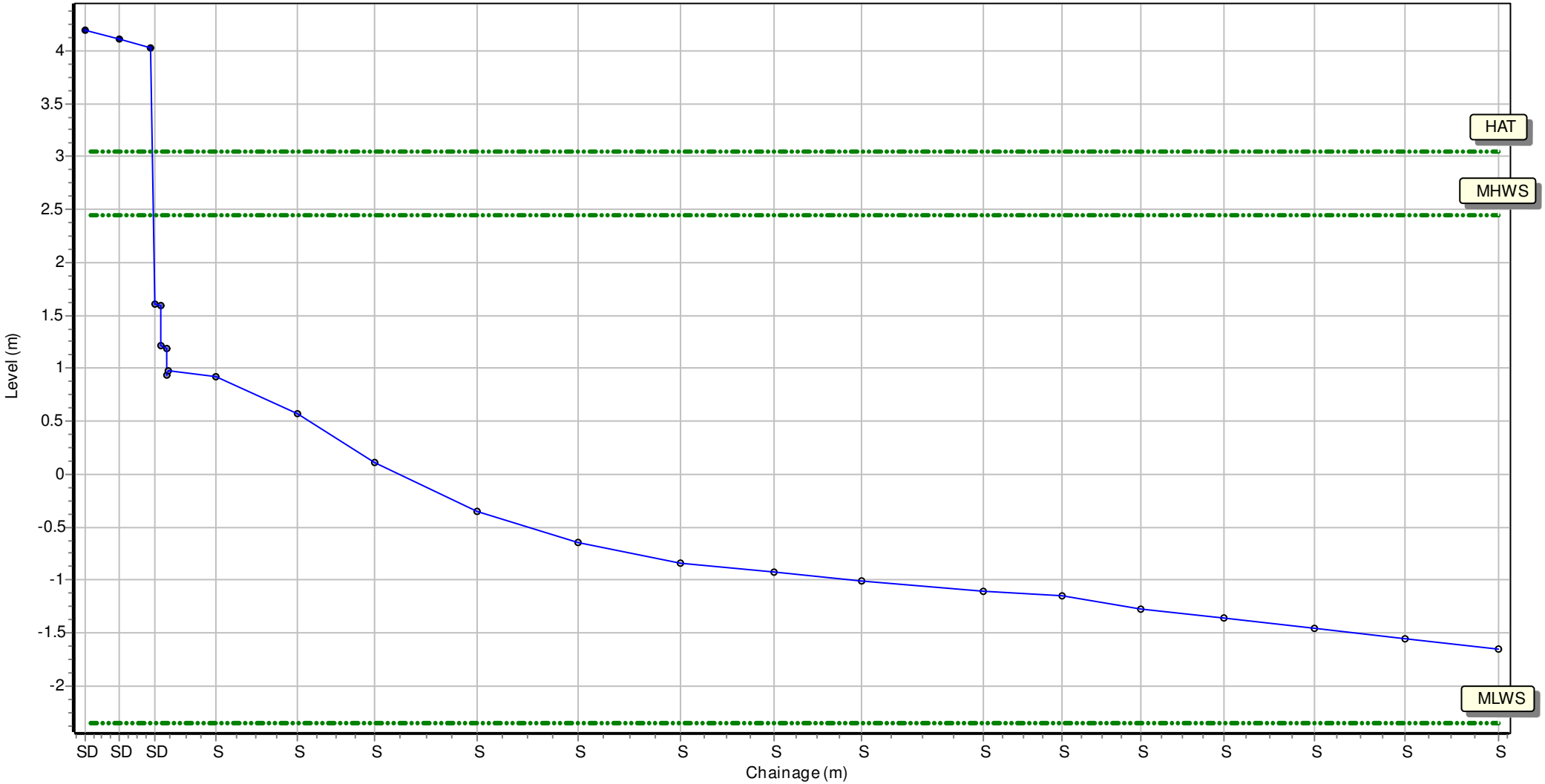
Location: **1dSBN1**

Date: 30/09/2019 **Inspector:** AG **Low Tide:** **Low Tide Time:**

Wind **Sea State:** **Visibility:** **Rain:**

Summary: 2019 Full Measures Topo Survey

Easting: 503543.363 **Northing:** 490470.74 **Profile Bearing:** 79 ° from North



Beach Profile

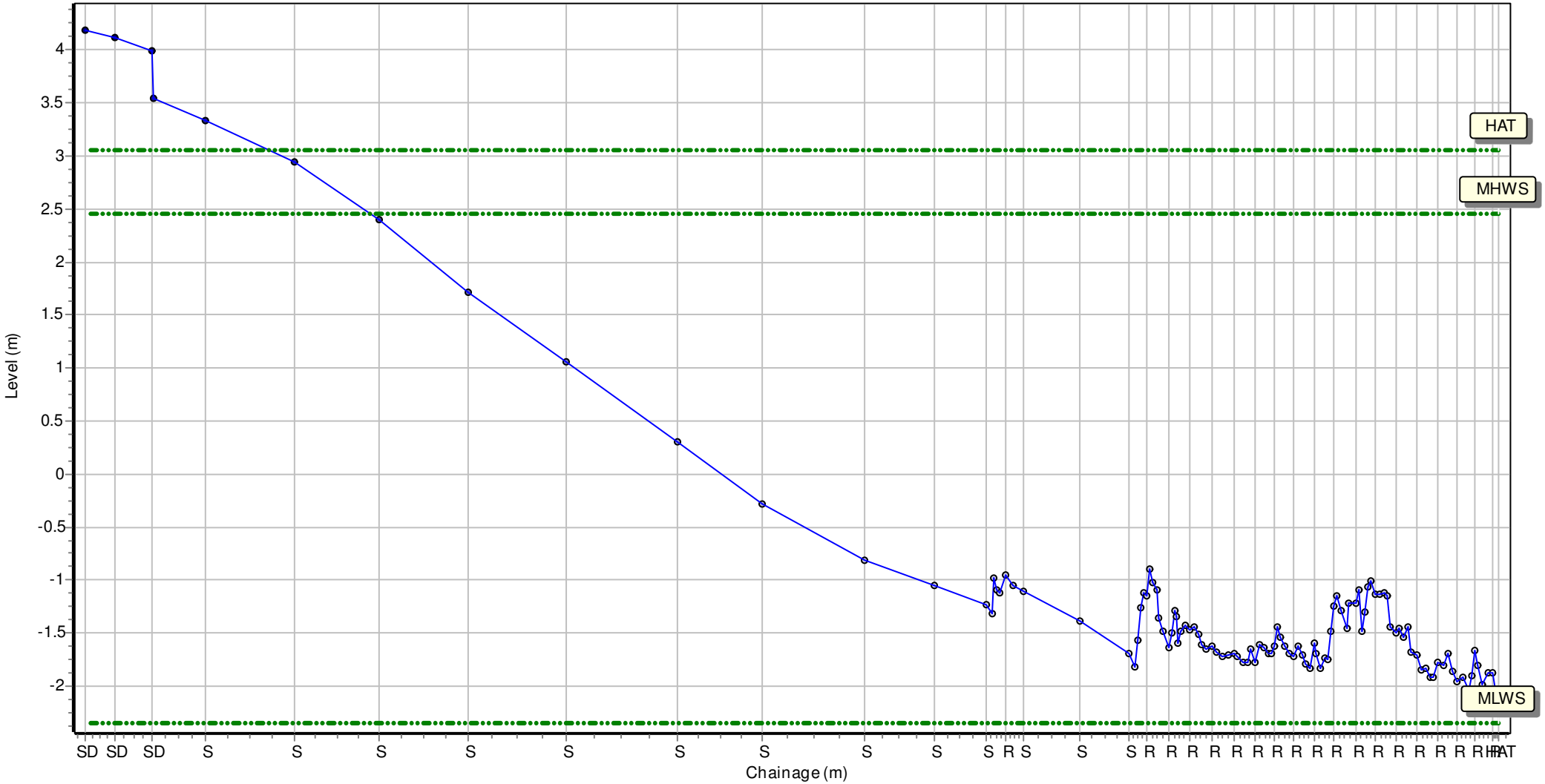
Location: **1dSBN2**

Date: 30/09/2019 **Inspector:** AG **Low Tide:** **Low Tide Time:**

Wind **Sea State:** **Visibility:** **Rain:**

Summary: 2019 Full Measures Topo Survey

Easting: 503616.346 **Northing:** 490135.674 **Profile Bearing:** 78 ° from North



Beach Profile

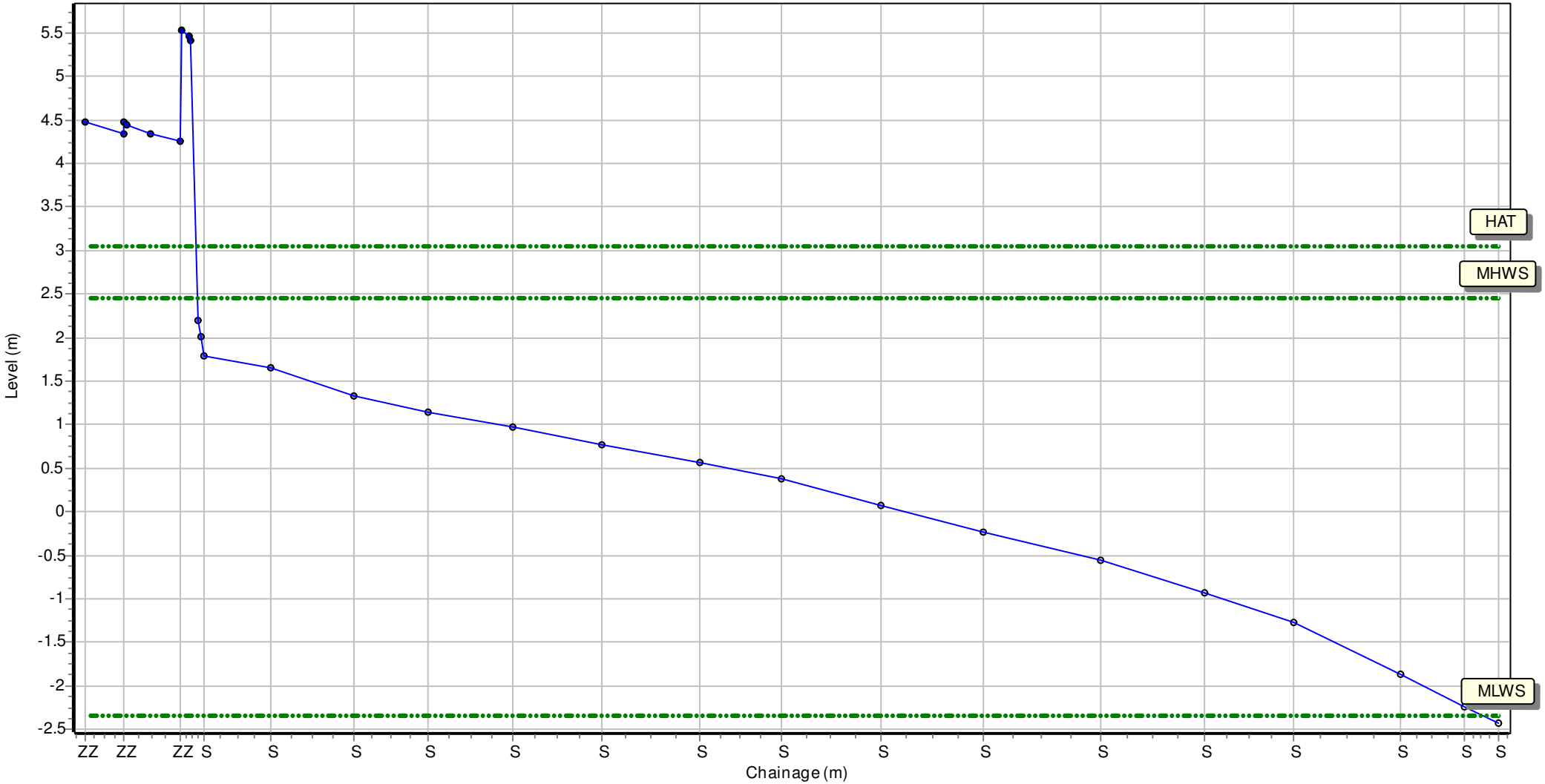
Location: **1dSBN3**

Date: 30/09/2019 **Inspector:** AG **Low Tide:** **Low Tide Time:**

Wind **Sea State:** **Visibility:** **Rain:**

Summary: 2019 Full Measures Topo Survey

Easting: 503803.958 **Northing:** 489708.315 **Profile Bearing:** 58 ° from North



Beach Profile

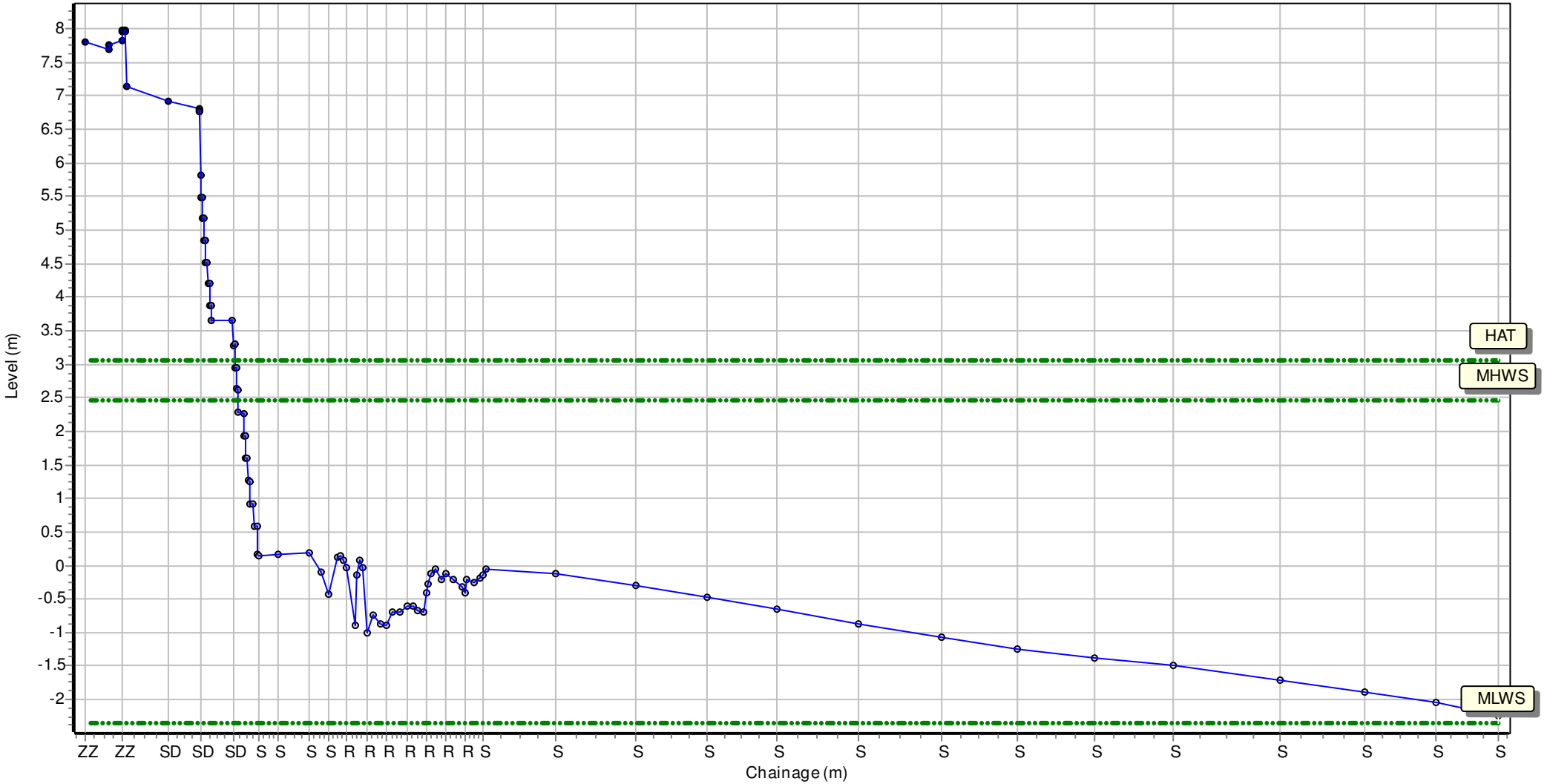
Location: **1dSBN4**

Date: 30/09/2019 **Inspector:** AG **Low Tide:** **Low Tide Time:**

Wind **Sea State:** **Visibility:** **Rain:**

Summary: 2019 Full Measures Topo Survey

Easting: 504111.79 **Northing:** 489397.699 **Profile Bearing:** 38 ° from North



Beach Profile

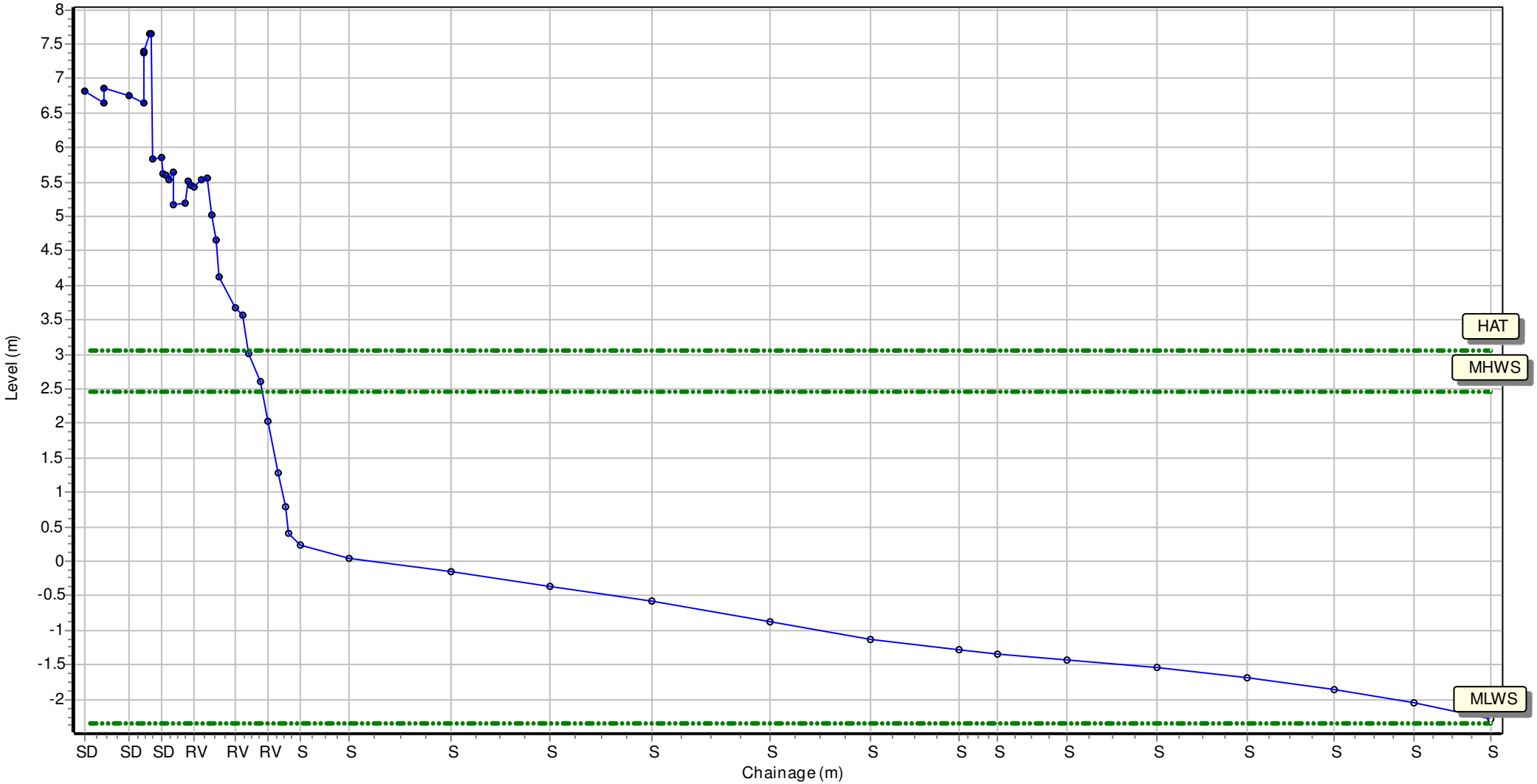
Location: **1dSBN5**

Date: 30/09/2019 **Inspector:** AG **Low Tide:** **Low Tide Time:**

Wind **Sea State:** **Visibility:** **Rain:**

Summary: 2019 Full Measures Topo Survey

Easting: 504515.599 **Northing:** 489205.724 **Profile Bearing:** 14 ° from North



Beach Profile

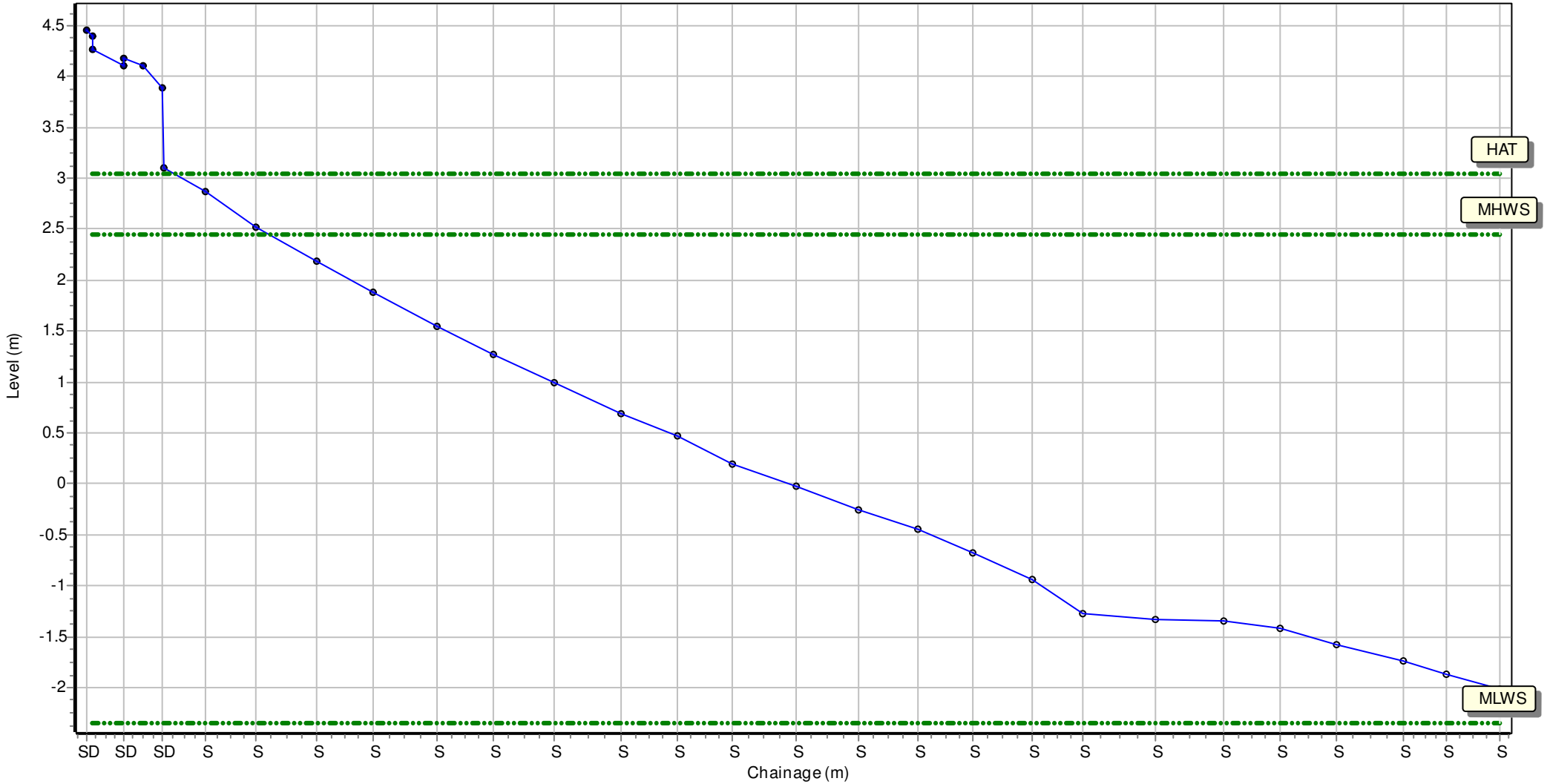
Location: **1dSBS1**

Date: 27/11/2019 **Inspector:** AG **Low Tide:** **Low Tide Time:**

Wind **Sea State:** **Visibility:** **Rain:**

Summary: 2019 Full Measures Topo Survey

Easting: 504544.727 **Northing:** 488604.814 **Profile Bearing:** 120 ° from North



Beach Profile

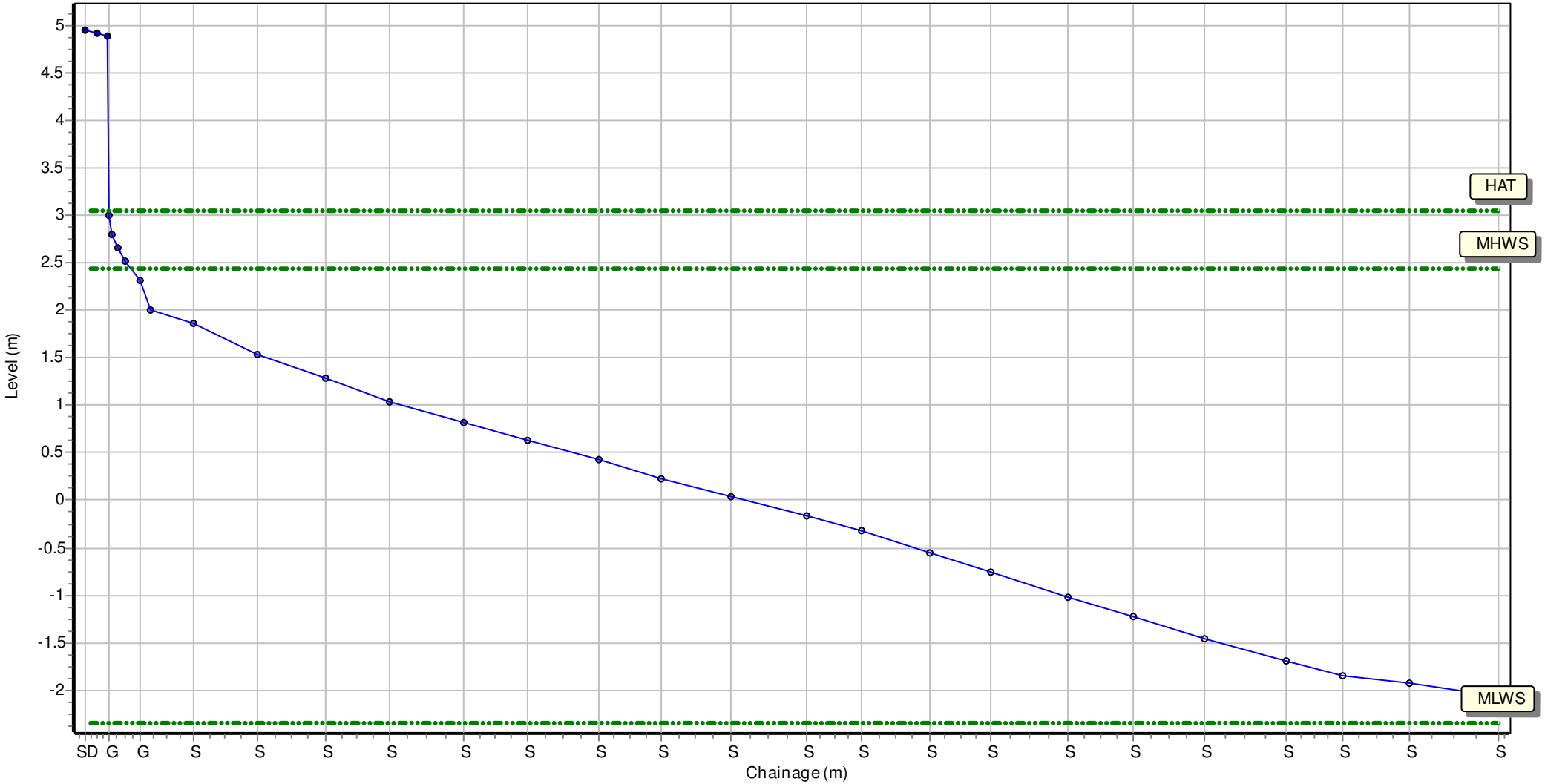
Location: **1dSBS2**

Date: 27/11/2019 **Inspector:** AG **Low Tide:** **Low Tide Time:**

Wind **Sea State:** **Visibility:** **Rain:**

Summary: 2019 Full Measures Topo Survey

Easting: 504443.218 **Northing:** 488326.371 **Profile Bearing:** 105 ° from North



Beach Profile

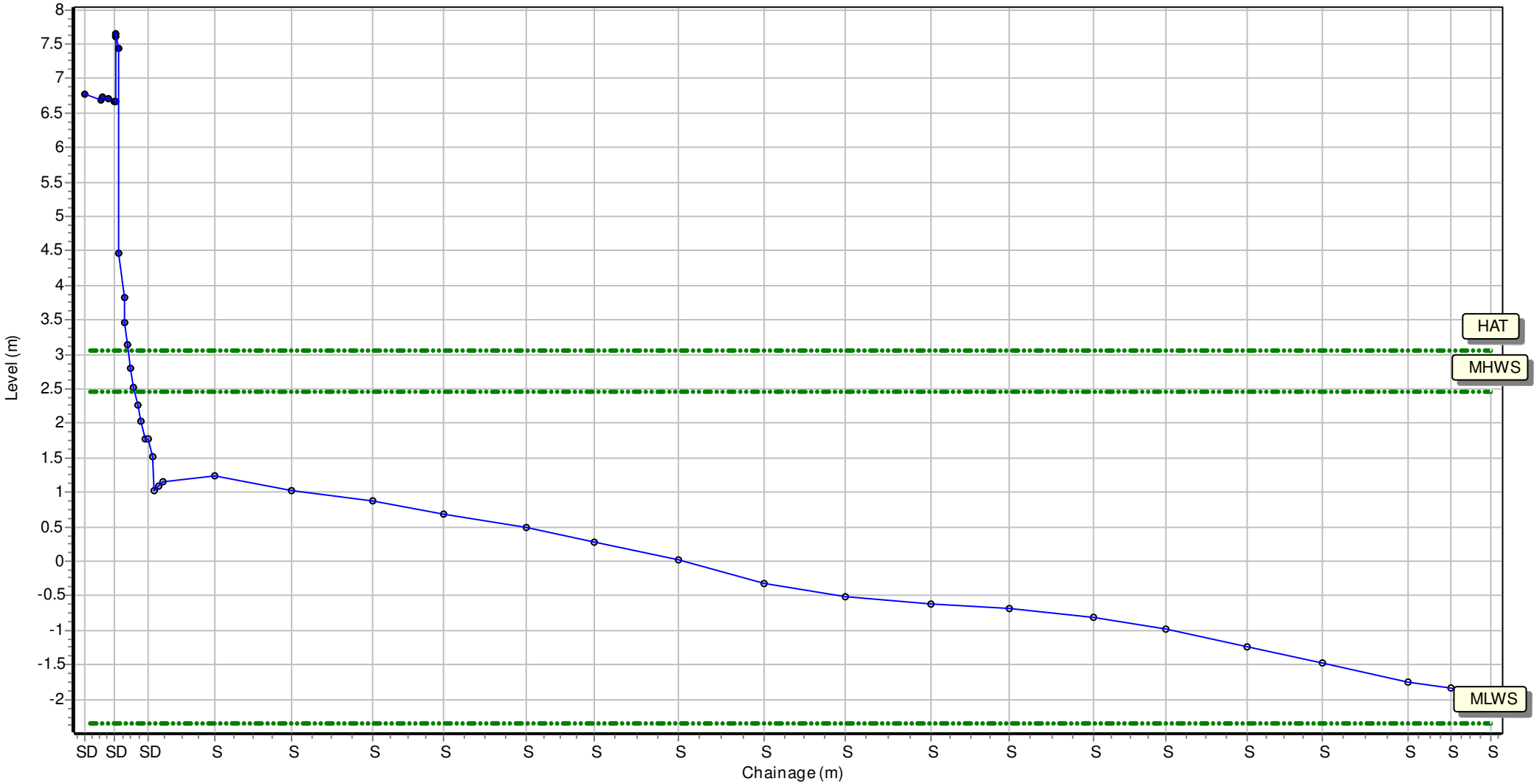
Location: **1dSBS3**

Date: 27/11/2019 **Inspector:** AG **Low Tide:** **Low Tide Time:**

Wind **Sea State:** **Visibility:** **Rain:**

Summary: 2019 Full Measures Topo Survey

Easting: 504423.086 **Northing:** 488057.66 **Profile Bearing:** 83 ° from North



Beach Profile

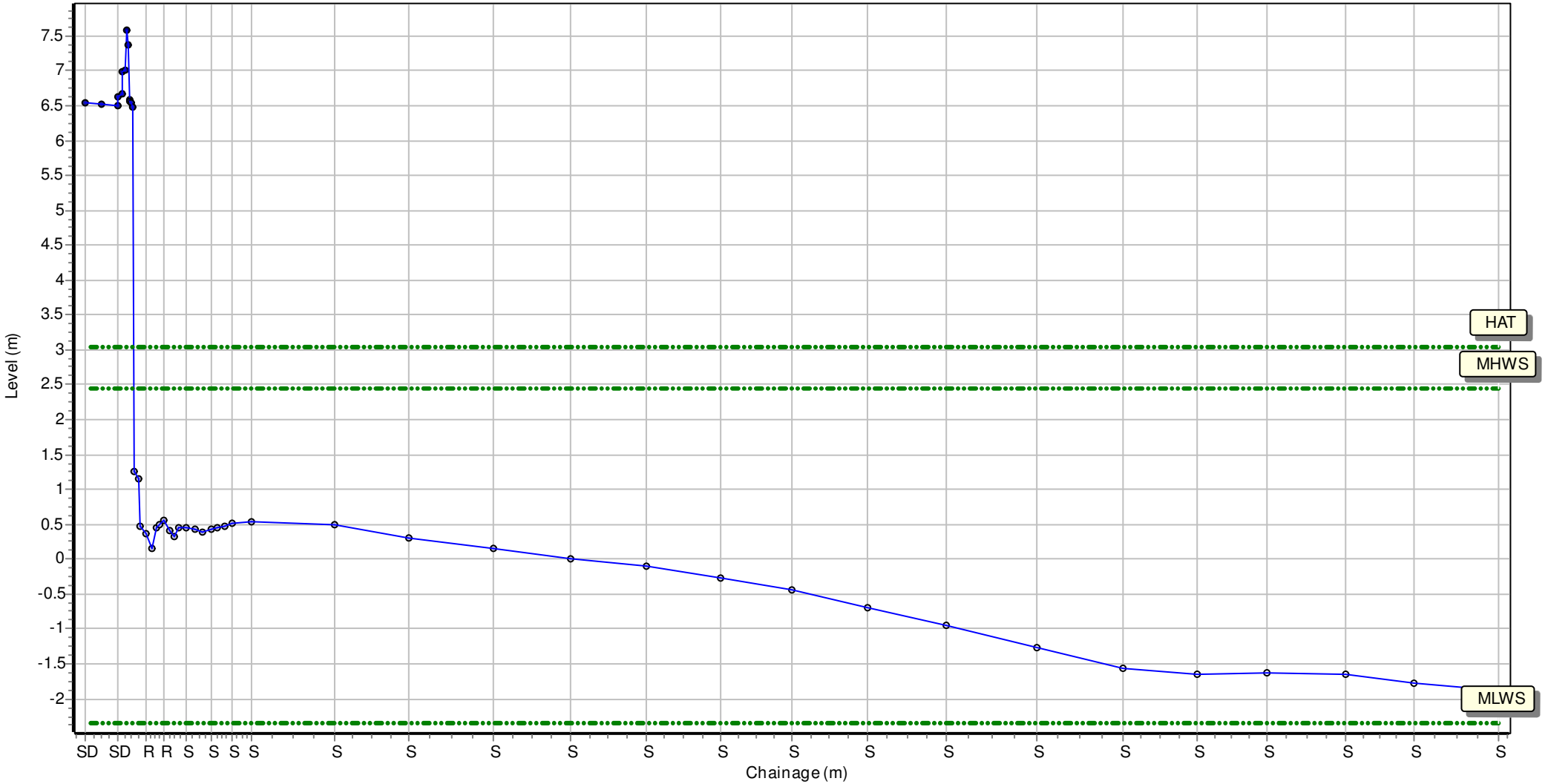
Location: **1dSBS4**

Date: 27/11/2019 **Inspector:** AG **Low Tide:** **Low Tide Time:**

Wind **Sea State:** **Visibility:** **Rain:**

Summary: 2019 Full Measures Topo Survey

Easting: 504494.785 **Northing:** 487816.983 **Profile Bearing:** 74 ° from North



Beach Profile

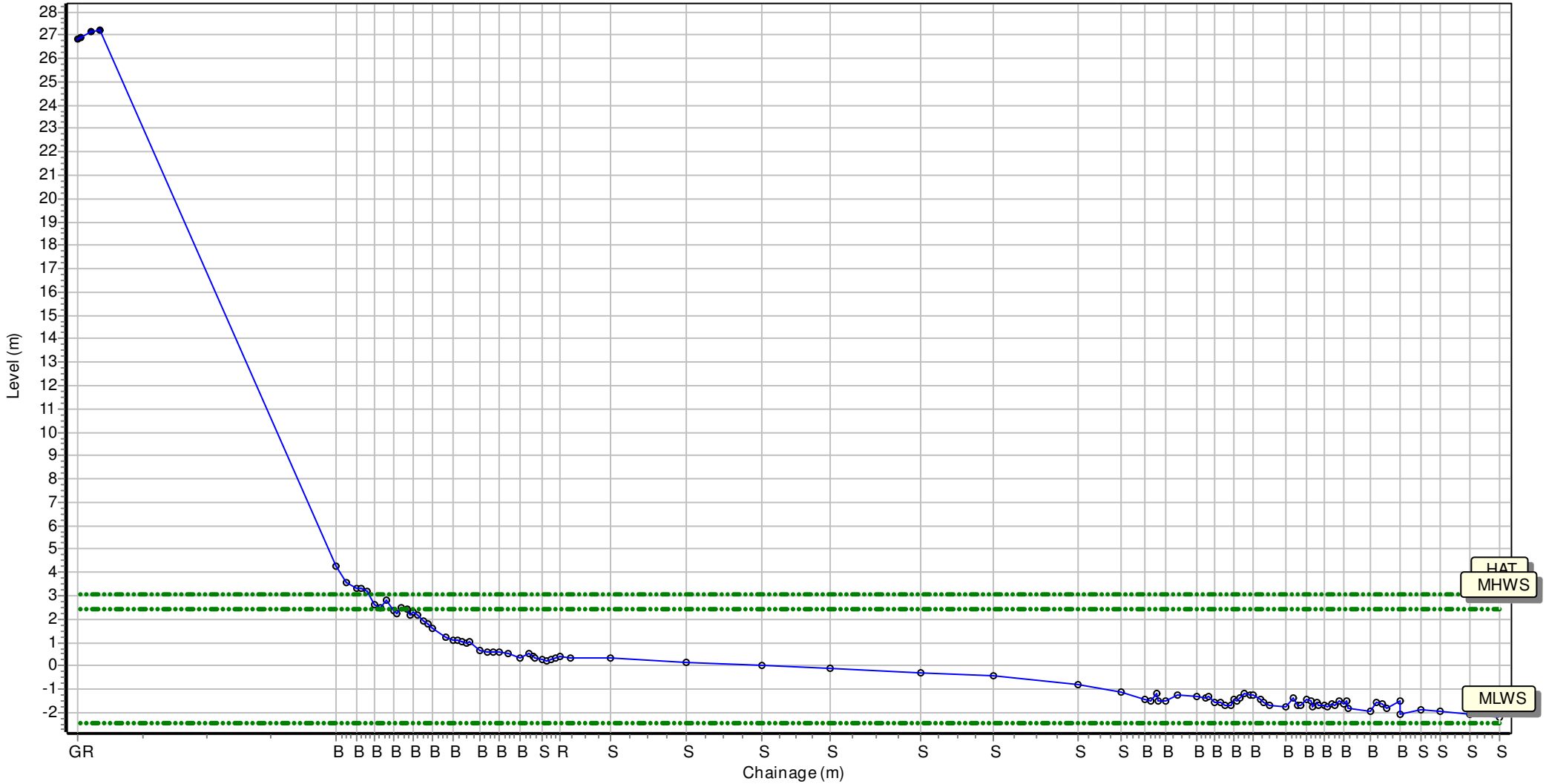
Location: **1dCY1**

Date: 26/11/2019 **Inspector:** AG **Low Tide:** **Low Tide Time:**

Wind **Sea State:** **Visibility:** **Rain:**

Summary: 2019 Full Measures Topo Survey

Easting: 506420.411 **Northing:** 484793.941 **Profile Bearing:** 43 ° from North



Beach Profile

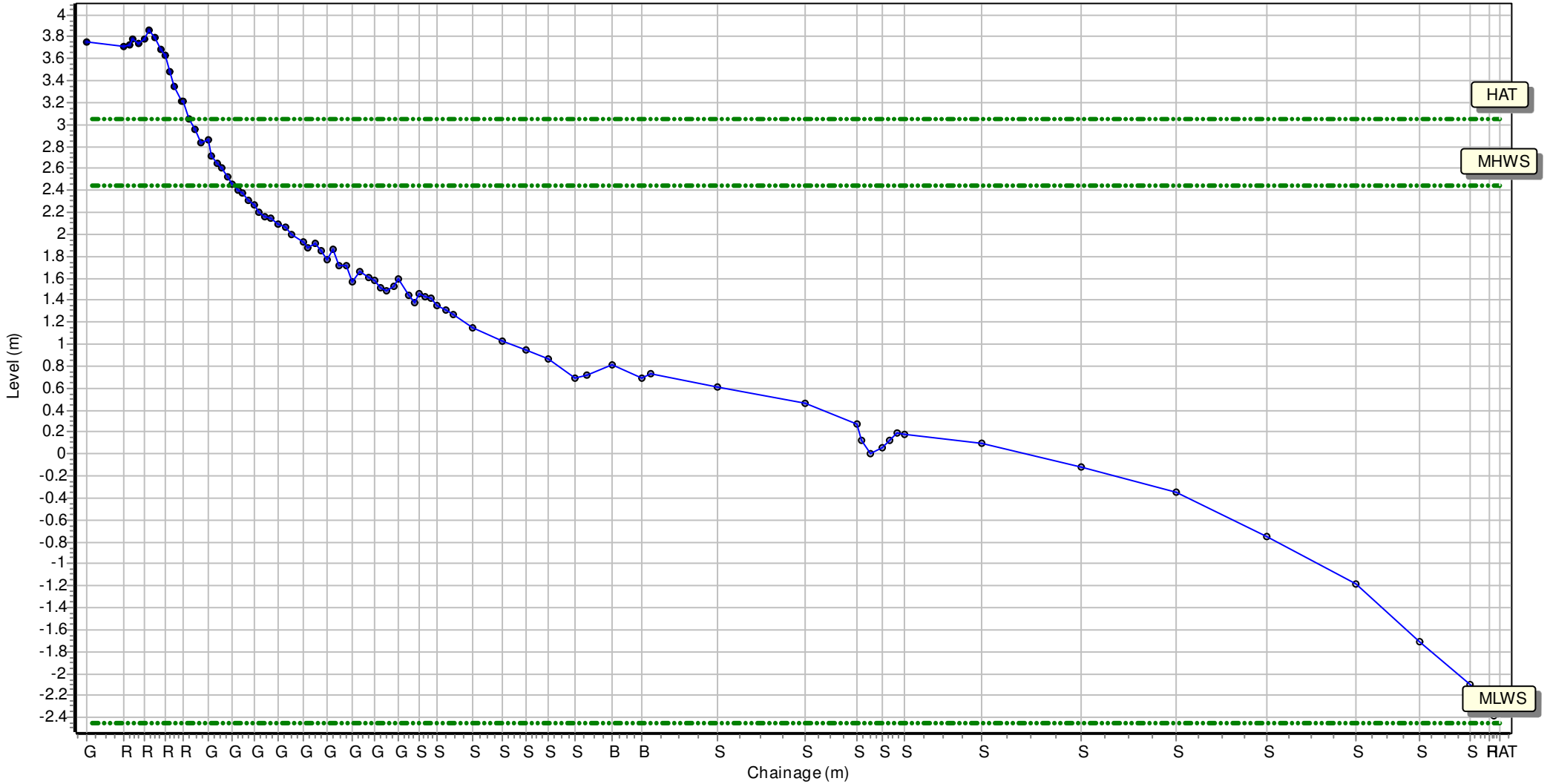
Location: **1dCY1A**

Date: 26/11/2019 **Inspector:** AG **Low Tide:** **Low Tide Time:**

Wind **Sea State:** **Visibility:** **Rain:**

Summary: 2019 Full Measures Topo Survey

Easting: 506298.519 **Northing:** 485175.932 **Profile Bearing:** 107 ° from North



Beach Profile

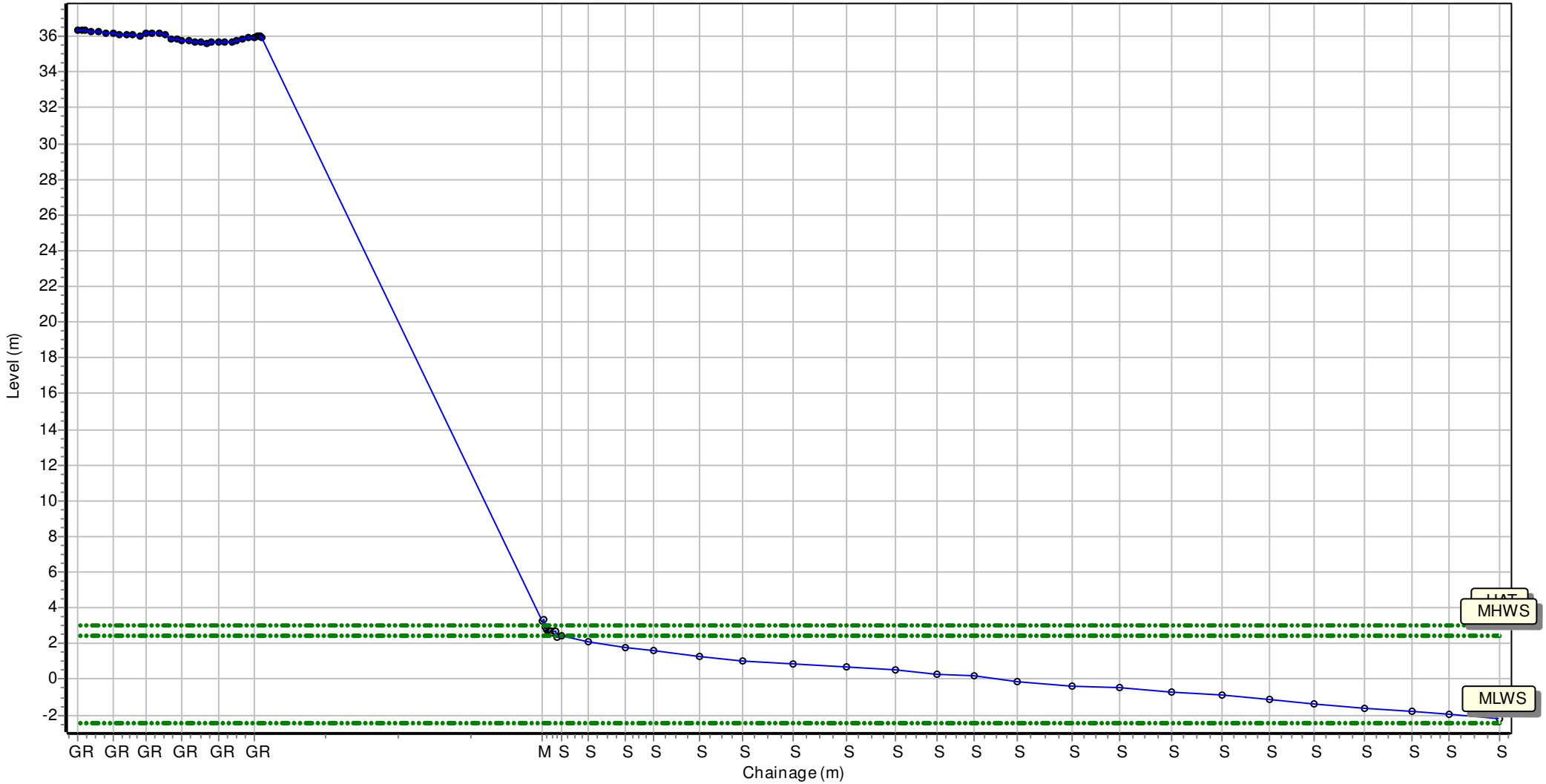
Location: **1dCY2**

Date: 26/11/2019 **Inspector:** AG **Low Tide:** **Low Tide Time:**

Wind **Sea State:** **Visibility:** **Rain:**

Summary: 2019 Full Measures Topo Survey

Easting: 506712.583 **Northing:** 484325.966 **Profile Bearing:** 38 ° from North



Beach Profile

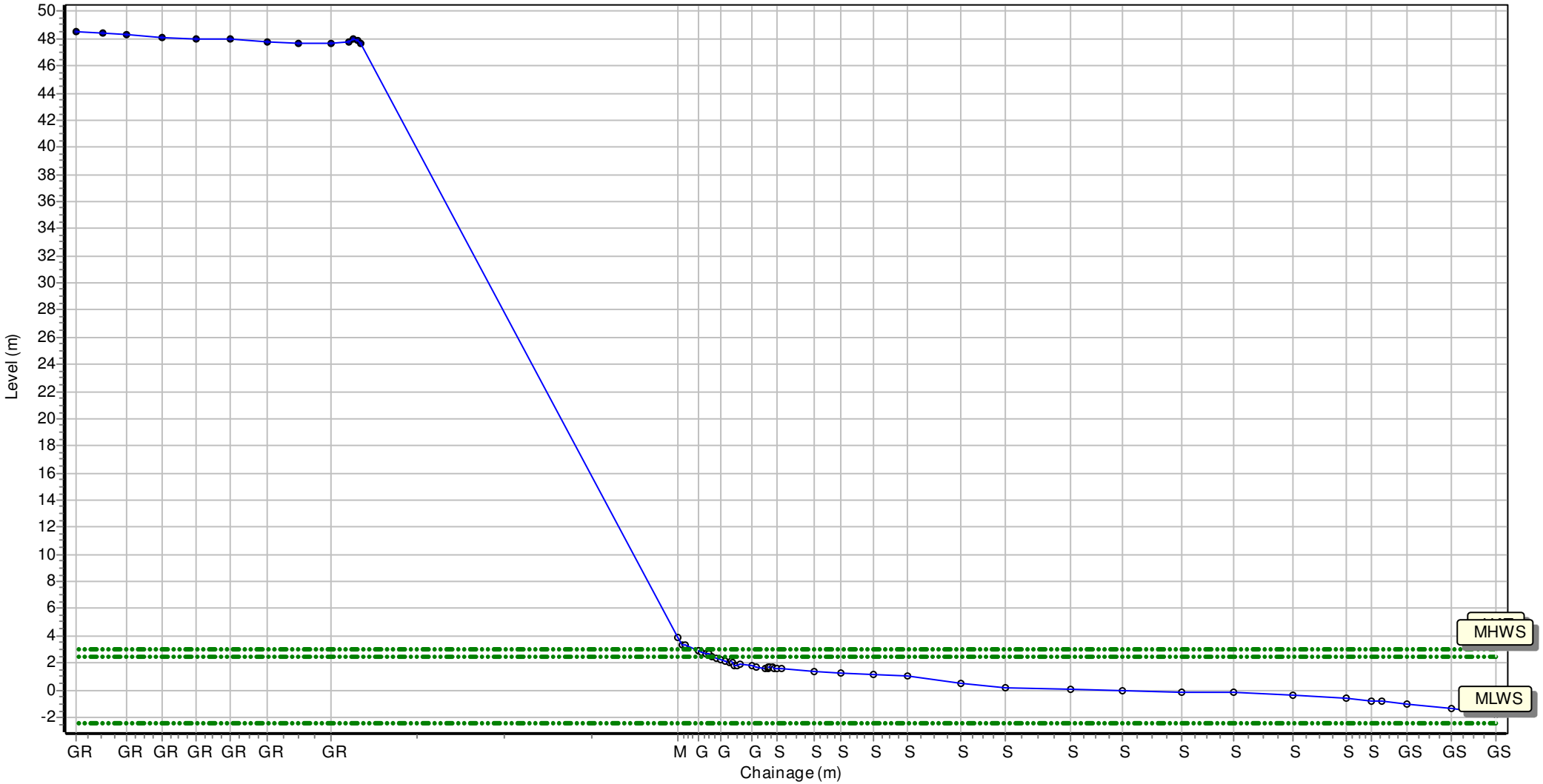
Location: **1dCY3**

Date: 26/11/2019 **Inspector:** AG **Low Tide:** **Low Tide Time:**

Wind **Sea State:** **Visibility:** **Rain:**

Summary: 2019 Full Measures Topo Survey

Easting: 507242.203 **Northing:** 484080.896 **Profile Bearing:** 42 ° from North



Beach Profile

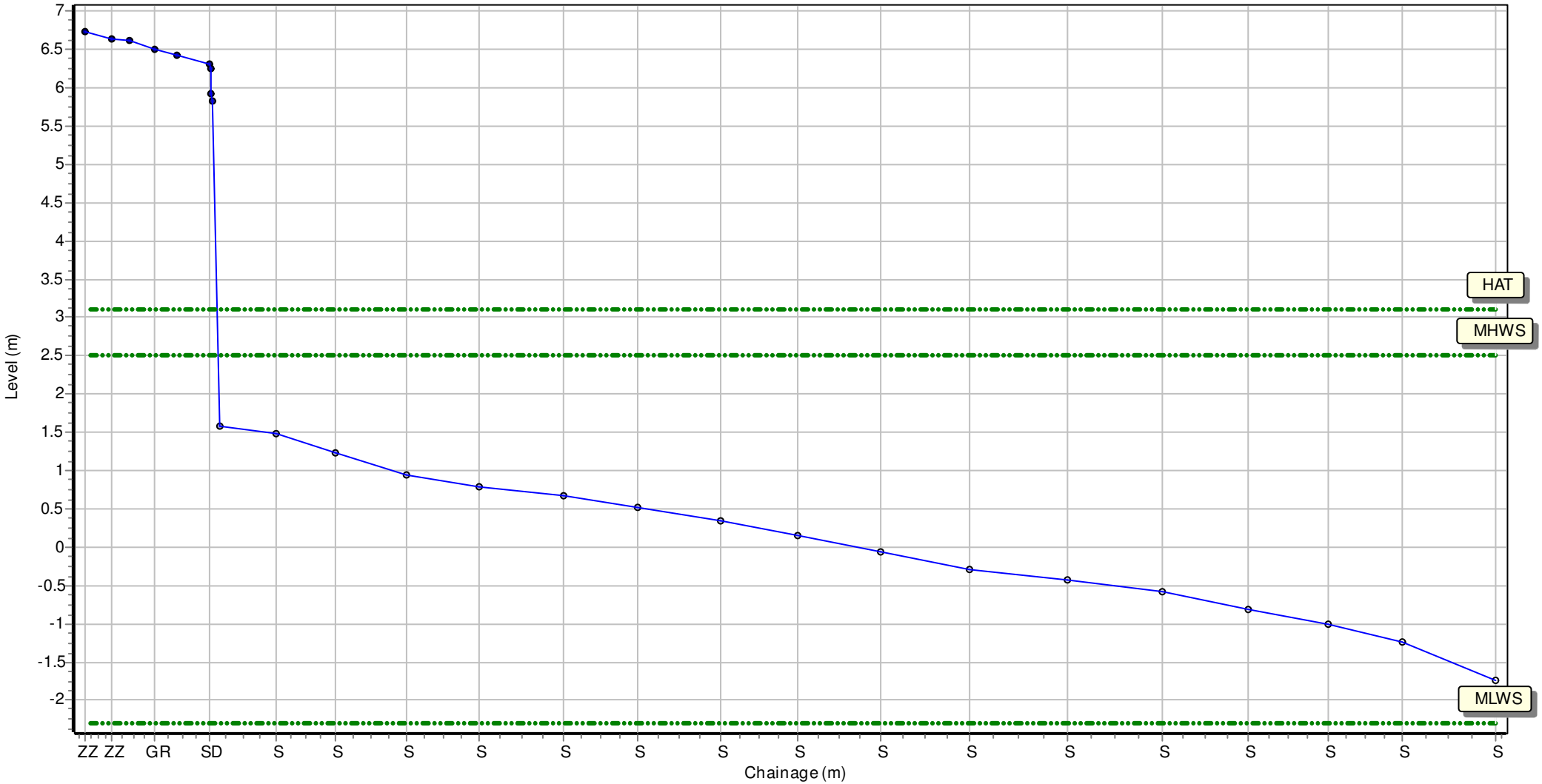
Location: **1dFB1**

Date: 03/10/2019 **Inspector:** AG **Low Tide:** **Low Tide Time:**

Wind **Sea State:** **Visibility:** **Rain:**

Summary: 2019 Full Measures Topo Survey

Easting: 511989.528 **Northing:** 480590.964 **Profile Bearing:** 100 ° from North



Beach Profile

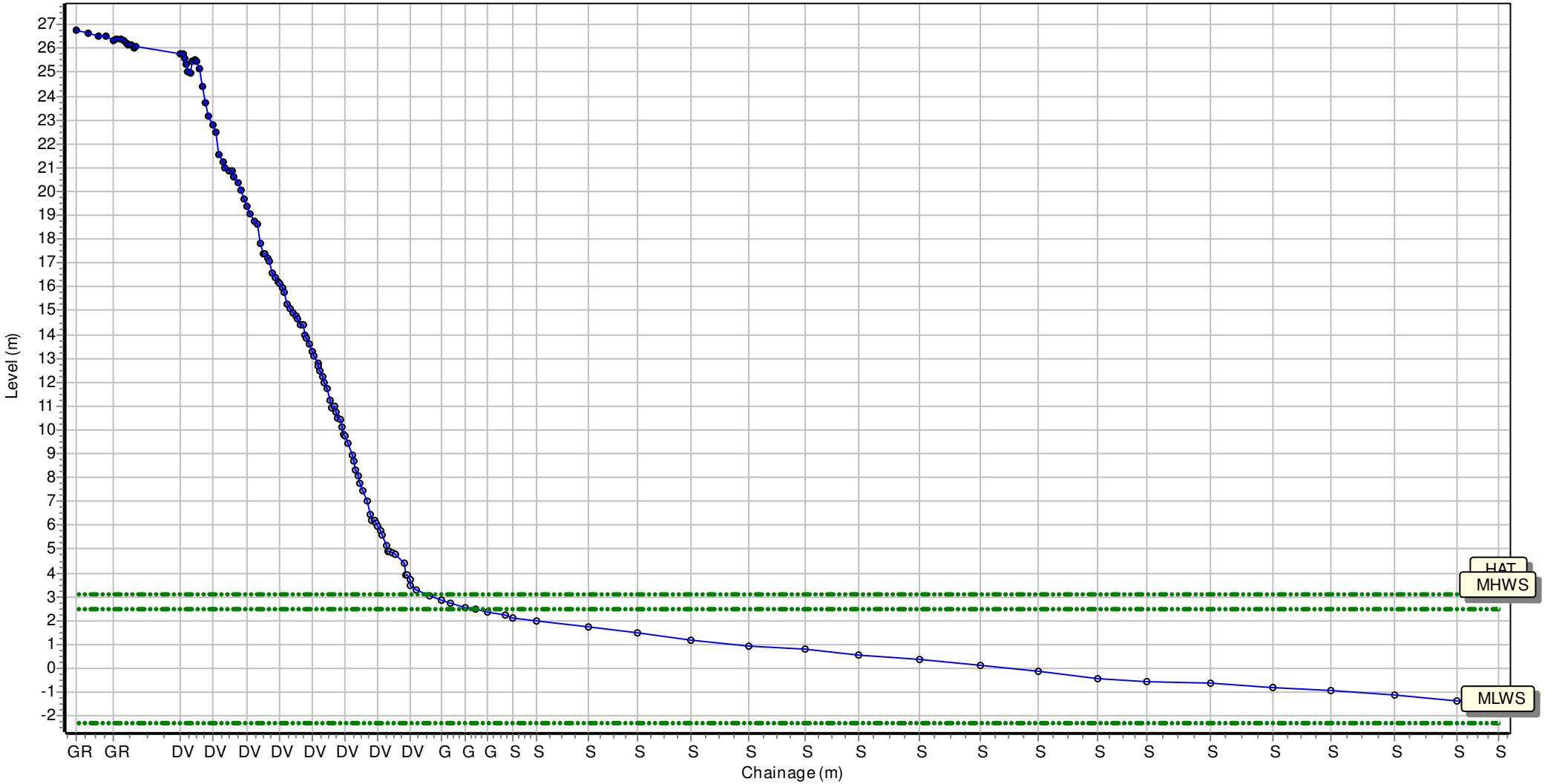
Location: **1dFB2**

Date: 03/10/2019 **Inspector:** AG **Low Tide:** **Low Tide Time:**

Wind **Sea State:** **Visibility:** **Rain:**

Summary: 2019 Full Measures Topo Survey

Easting: 512005.564 **Northing:** 479181.575 **Profile Bearing:** 77 ° from North



Beach Profile

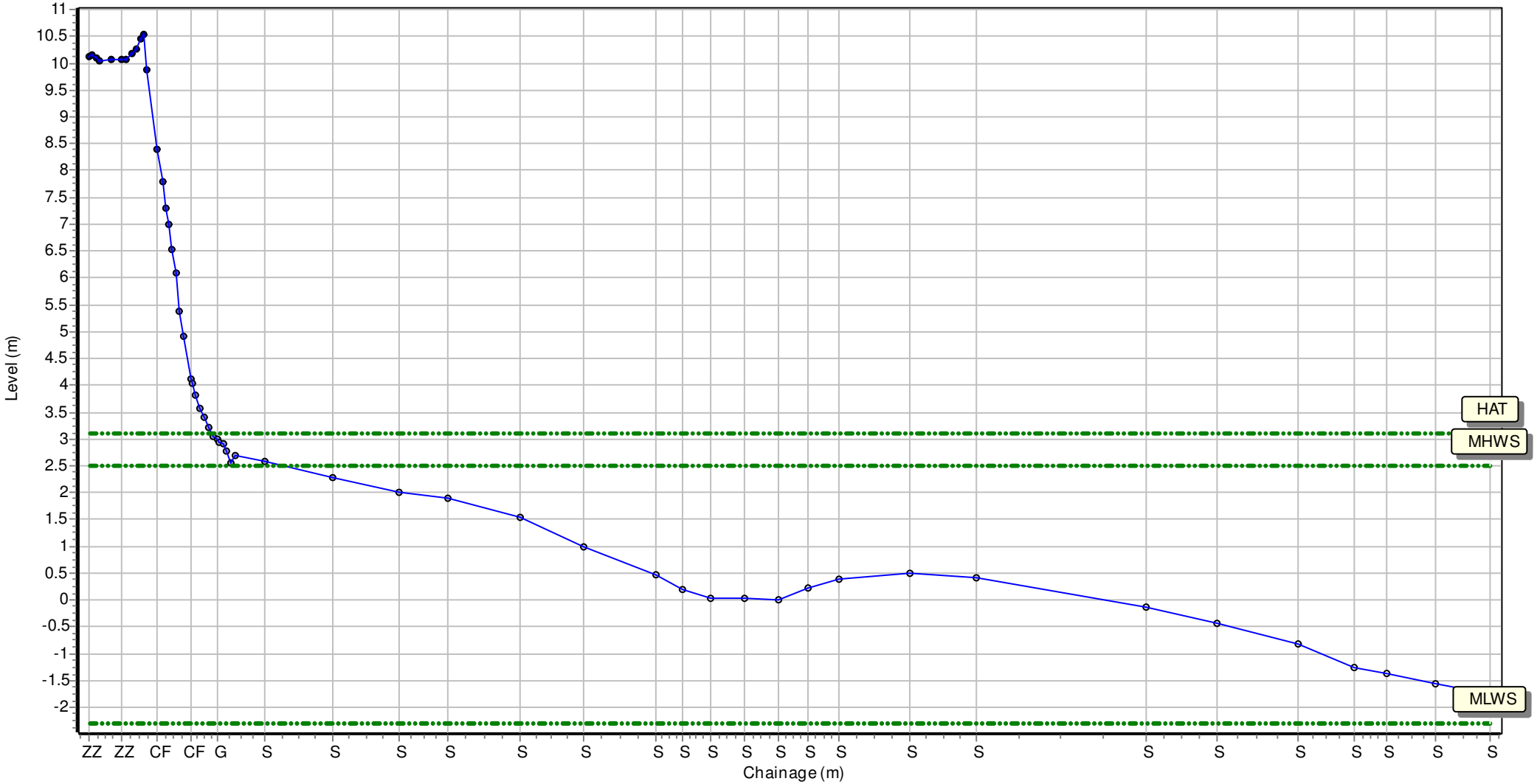
Location: **1dFB3**

Date: 03/10/2019 **Inspector:** AG **Low Tide:** **Low Tide Time:**

Wind **Sea State:** **Visibility:** **Rain:**

Summary: 2019 Full Measures Topo Survey

Easting: 512429.303 **Northing:** 478202.148 **Profile Bearing:** 61 ° from North



Beach Profile

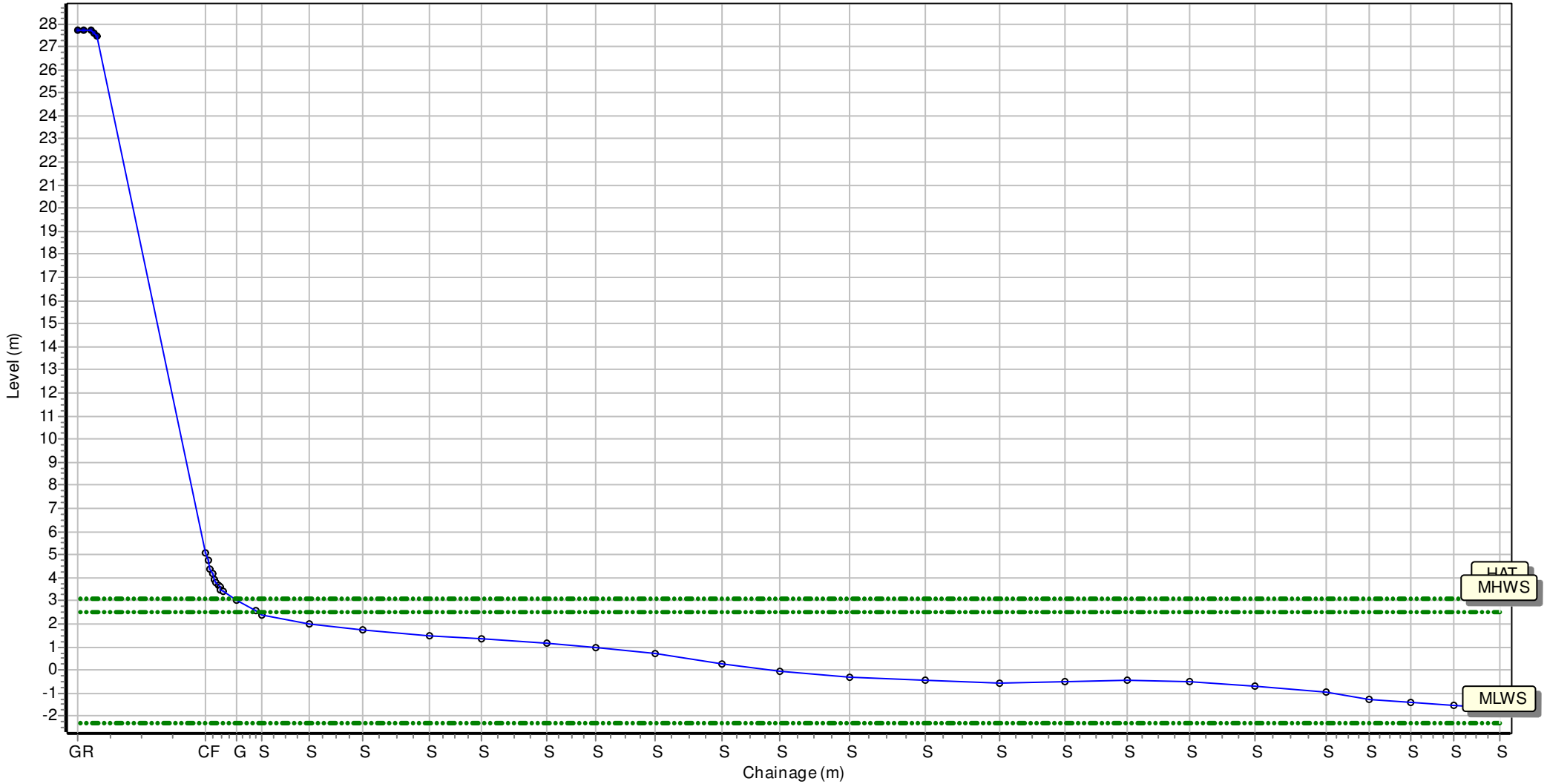
Location: **1dFB4**

Date: 03/10/2019 **Inspector:** AG **Low Tide:** **Low Tide Time:**

Wind **Sea State:** **Visibility:** **Rain:**

Summary: 2019 Full Measures Topo Survey

Easting: 513165.53 **Northing:** 477182.418 **Profile Bearing:** 51 ° from North



Beach Profile

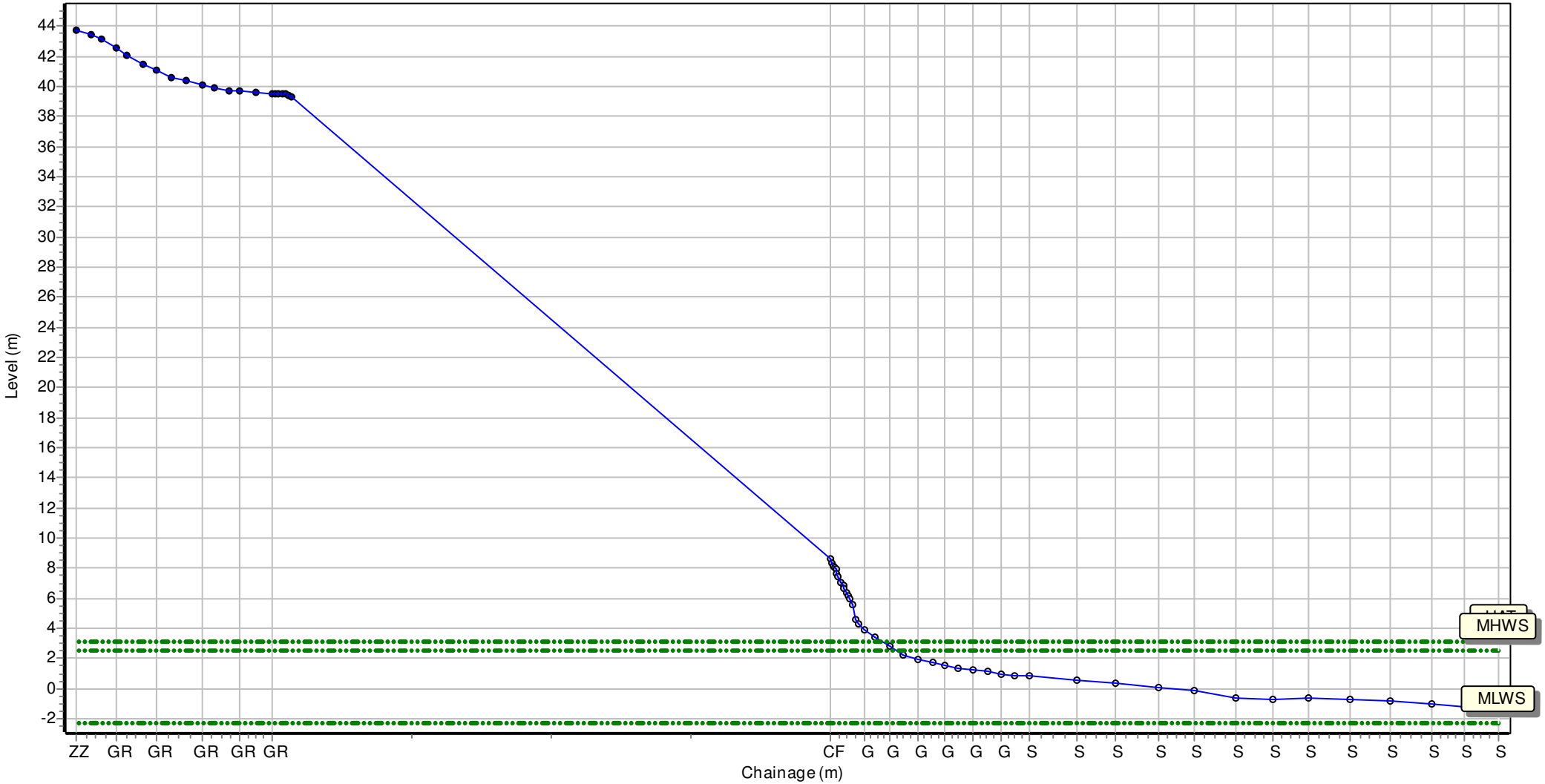
Location: **1dFB5**

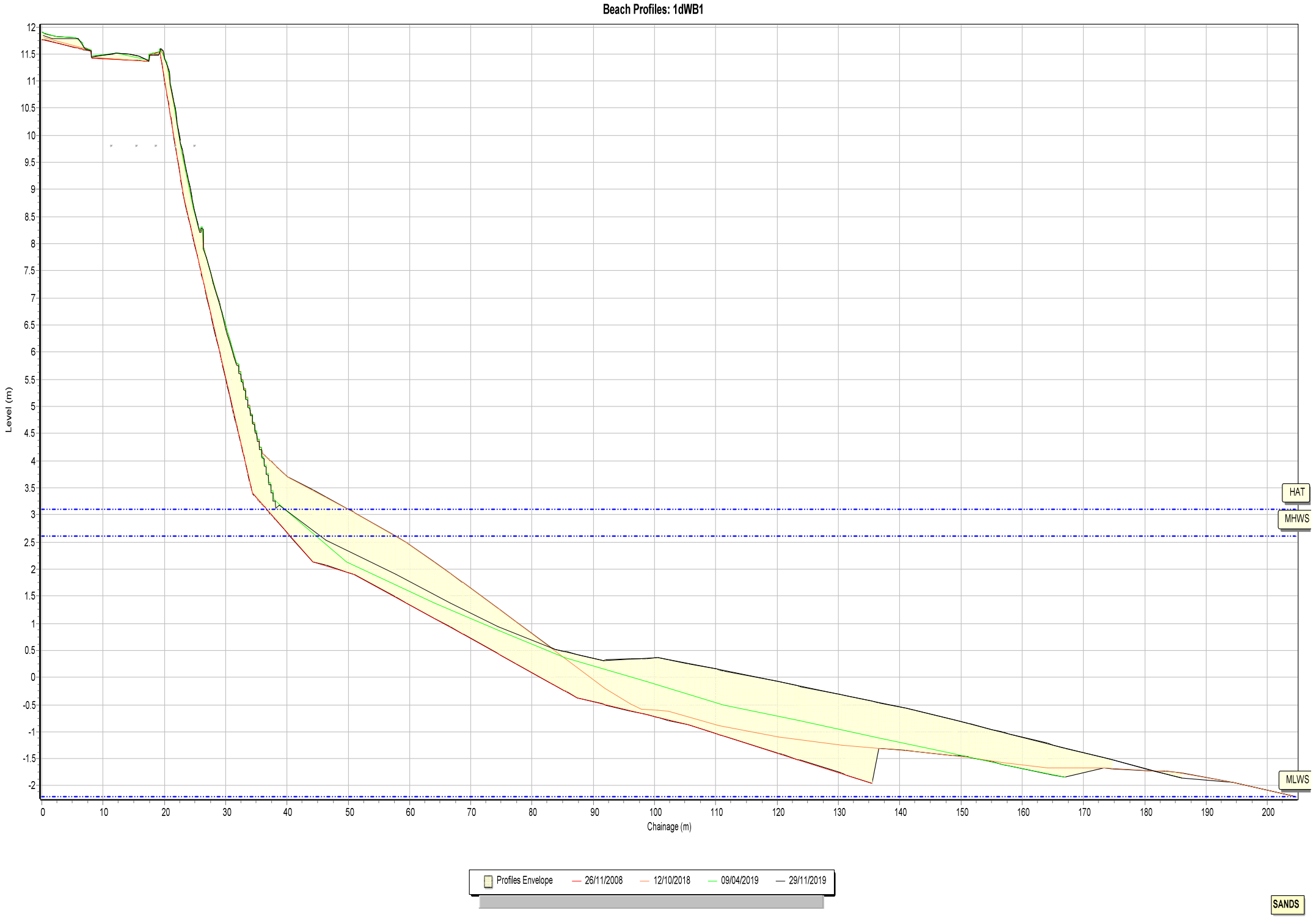
Date: 03/10/2019 **Inspector:** AG **Low Tide:** **Low Tide Time:**

Wind **Sea State:** **Visibility:** **Rain:**

Summary: 2019 Full Measures Topo Survey

Easting: 514207.792 **Northing:** 476001.334 **Profile Bearing:** 47 ° from North




Beach Profiles: 1dWB1
Level (m)
Chainage (m)
HAT
MHWS
MLWS
Profiles Envelope
26/11/2008
12/10/2018
09/04/2019
29/11/2019
SANDS


Beach Profiles: 1dWB2
Level (m)
Chainage (m)
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MLWS
Profiles Envelope
24/04/2009
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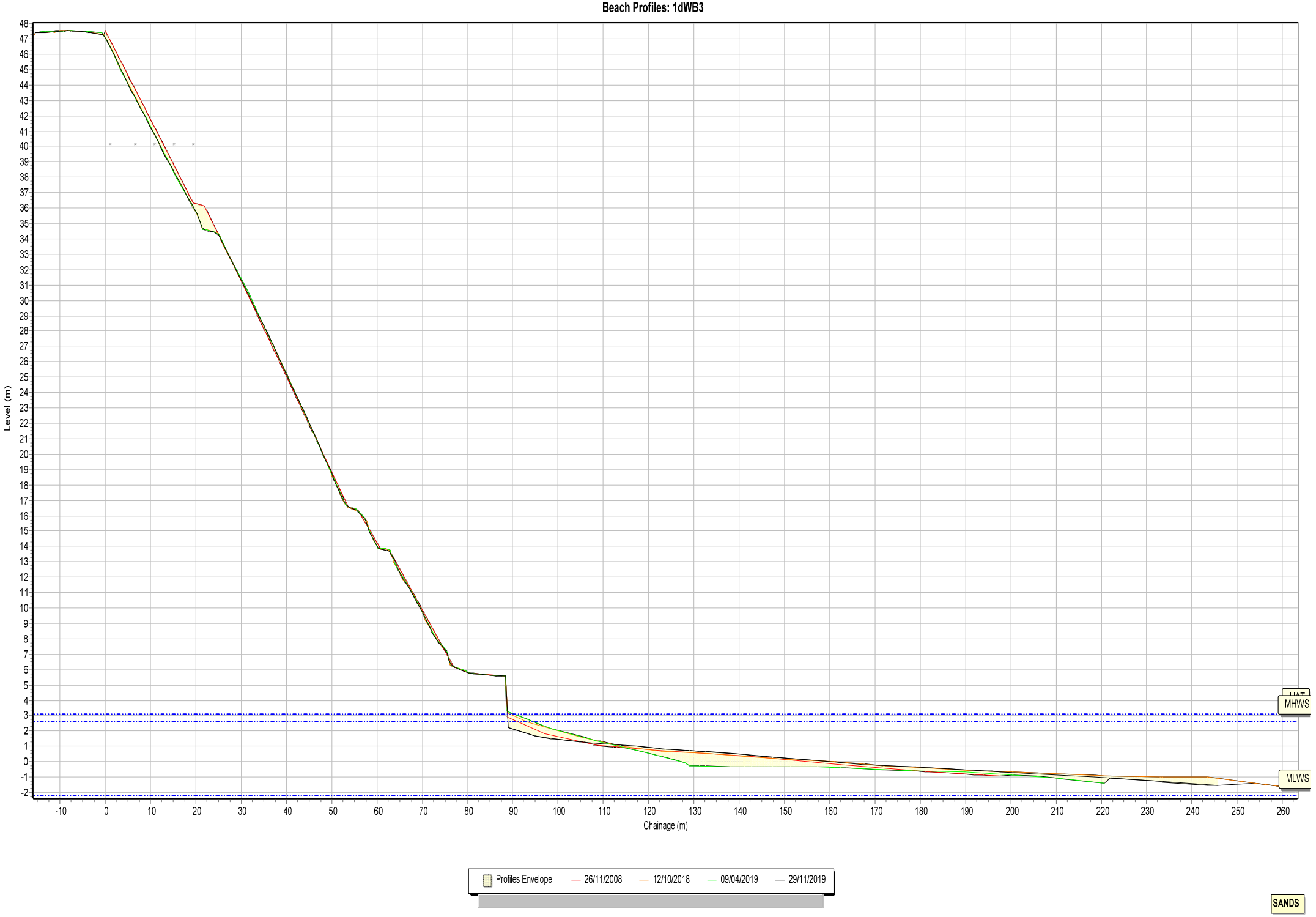
09/04/2019
29/11/2019
SANDS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Chainage (m)
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Profiles Envelope
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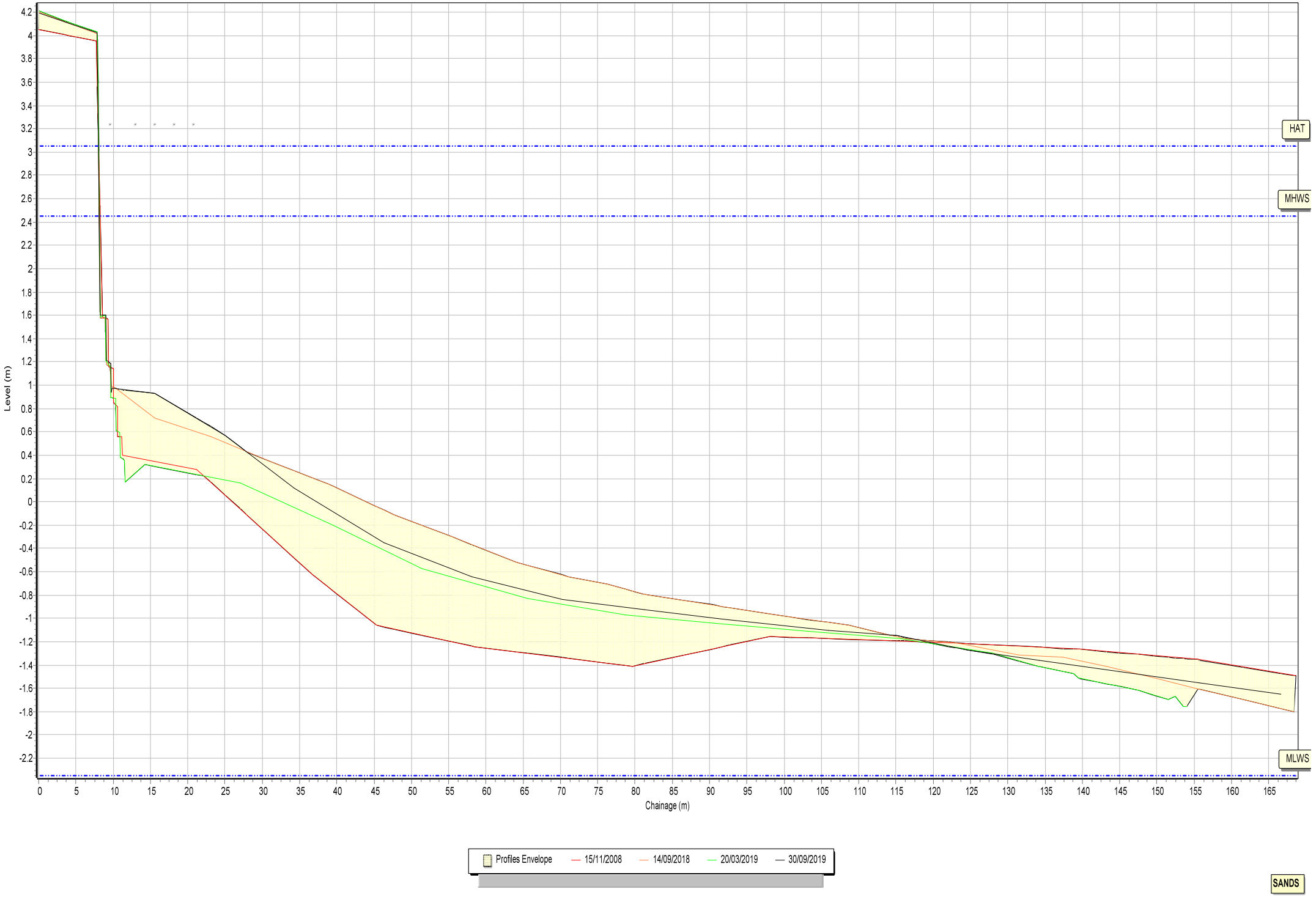
09/04/2019
29/11/2019
SANDS

Beach Profiles: 1dSBN1

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Chainage (m)
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SANDS
Profiles Envelope
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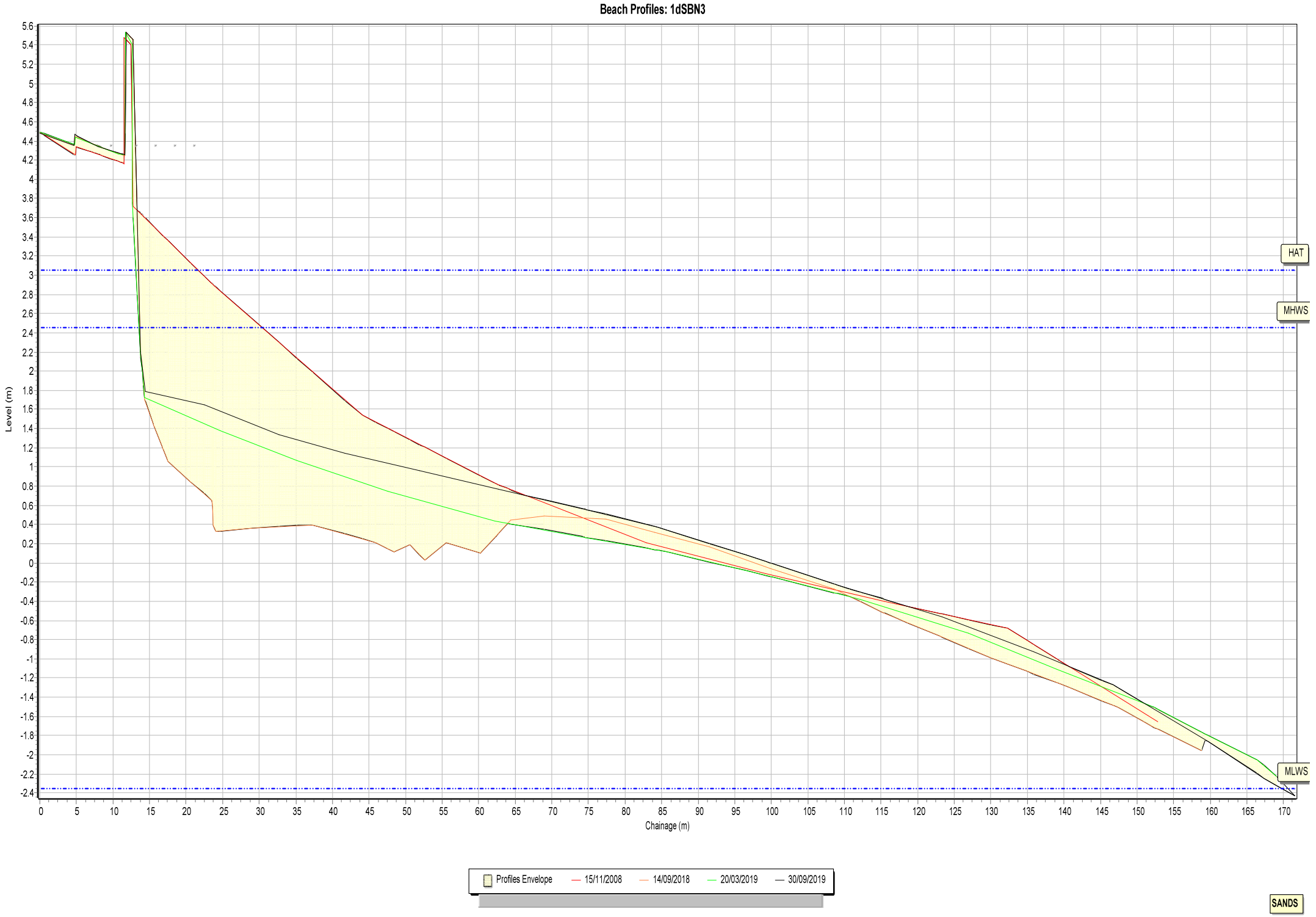
14/09/2018
20/03/2019
30/09/2019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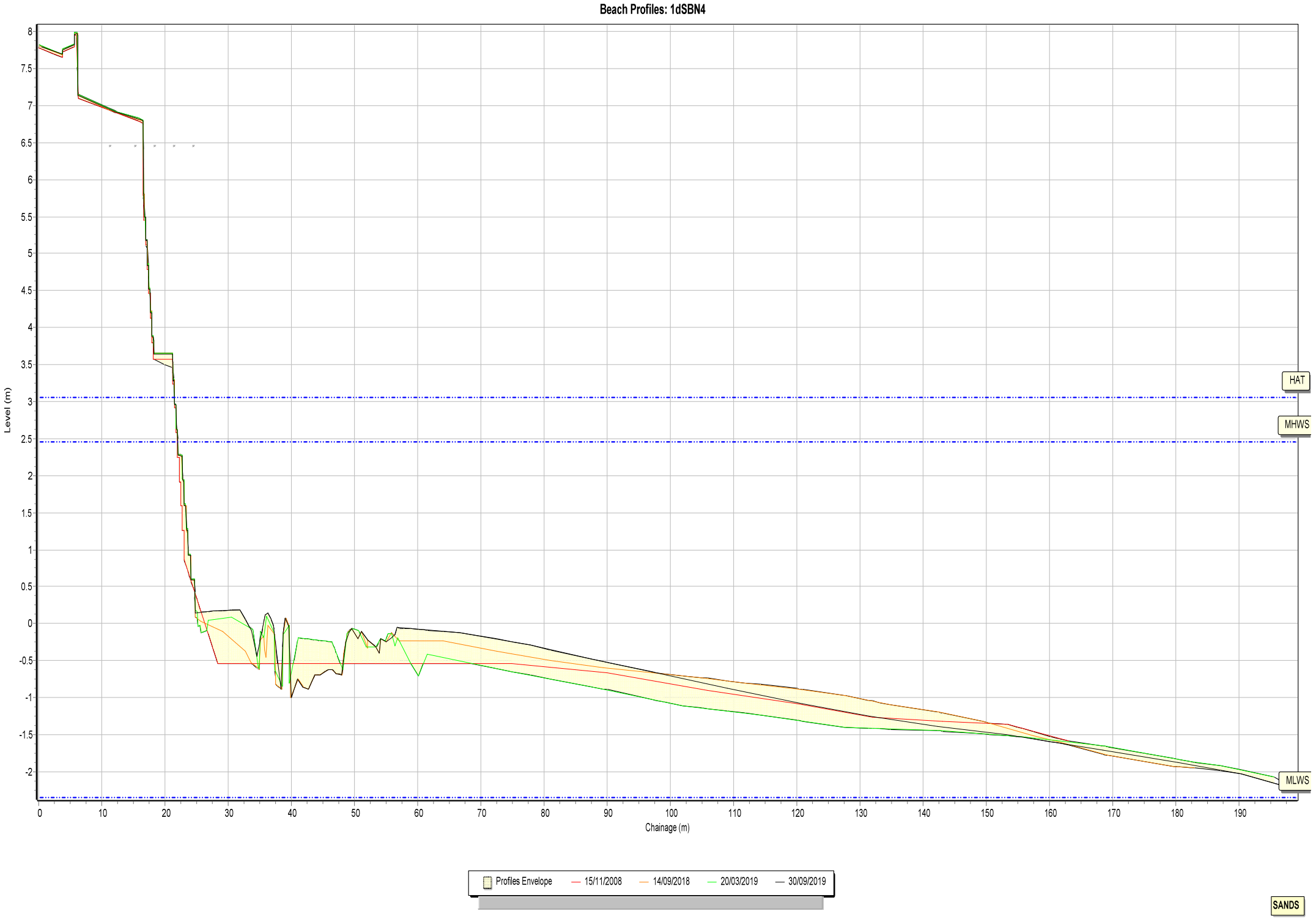
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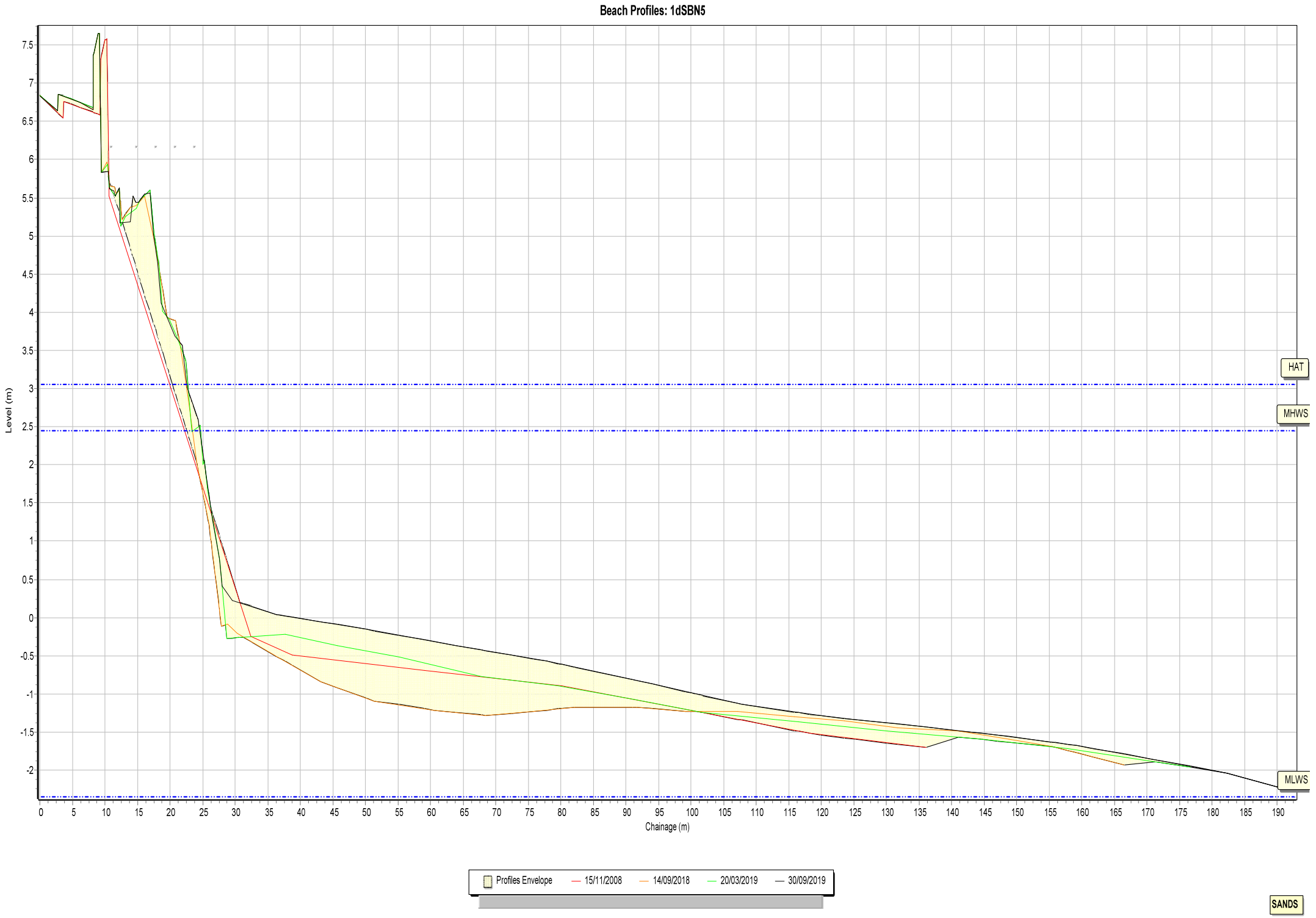
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30/09/2019
SANDS


Beach Profiles: 1dSBS1
Level (m)
Chainage (m)
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MLWS
Profiles Envelope
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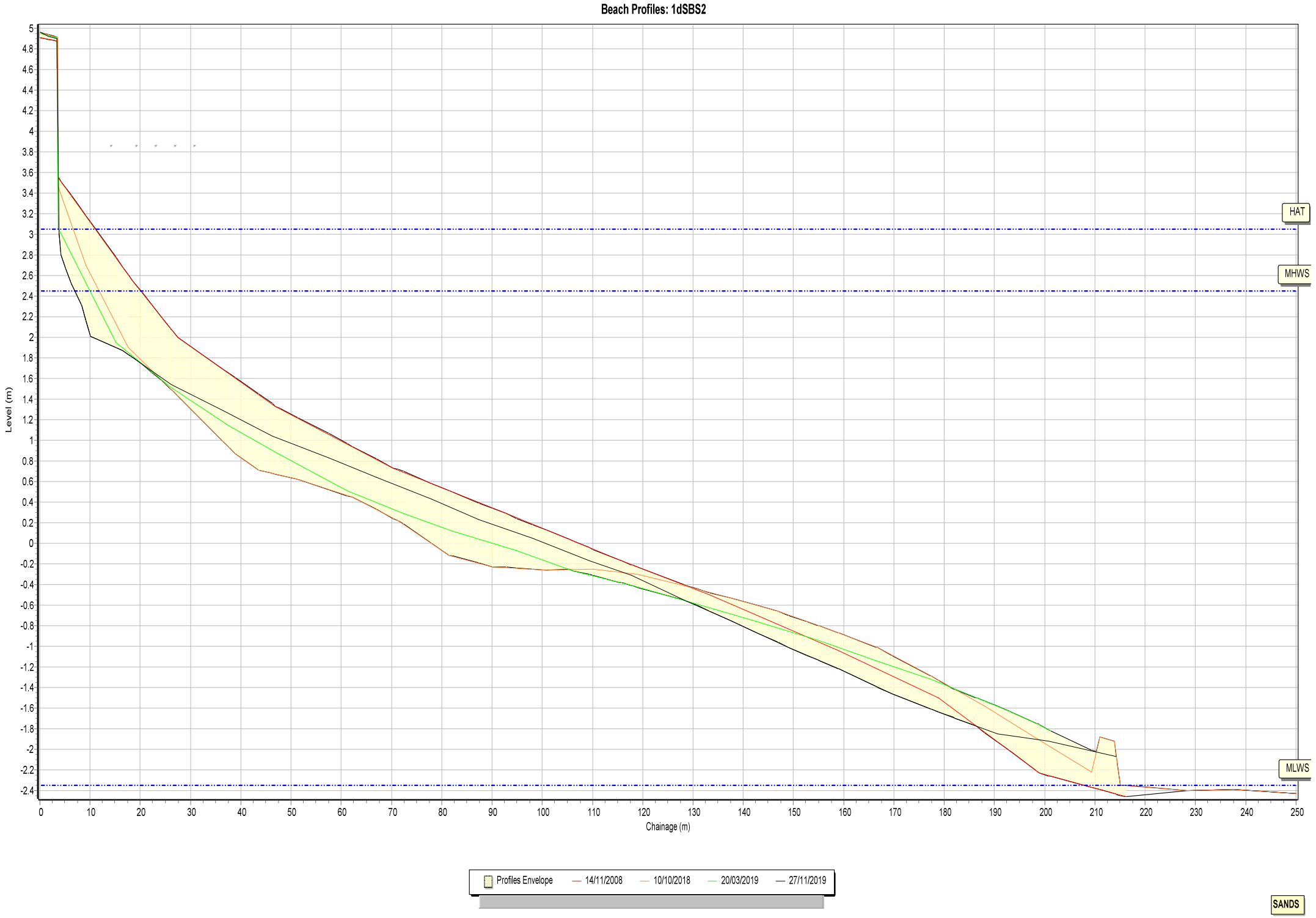
27/11/2019
SANDS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27/11/2019
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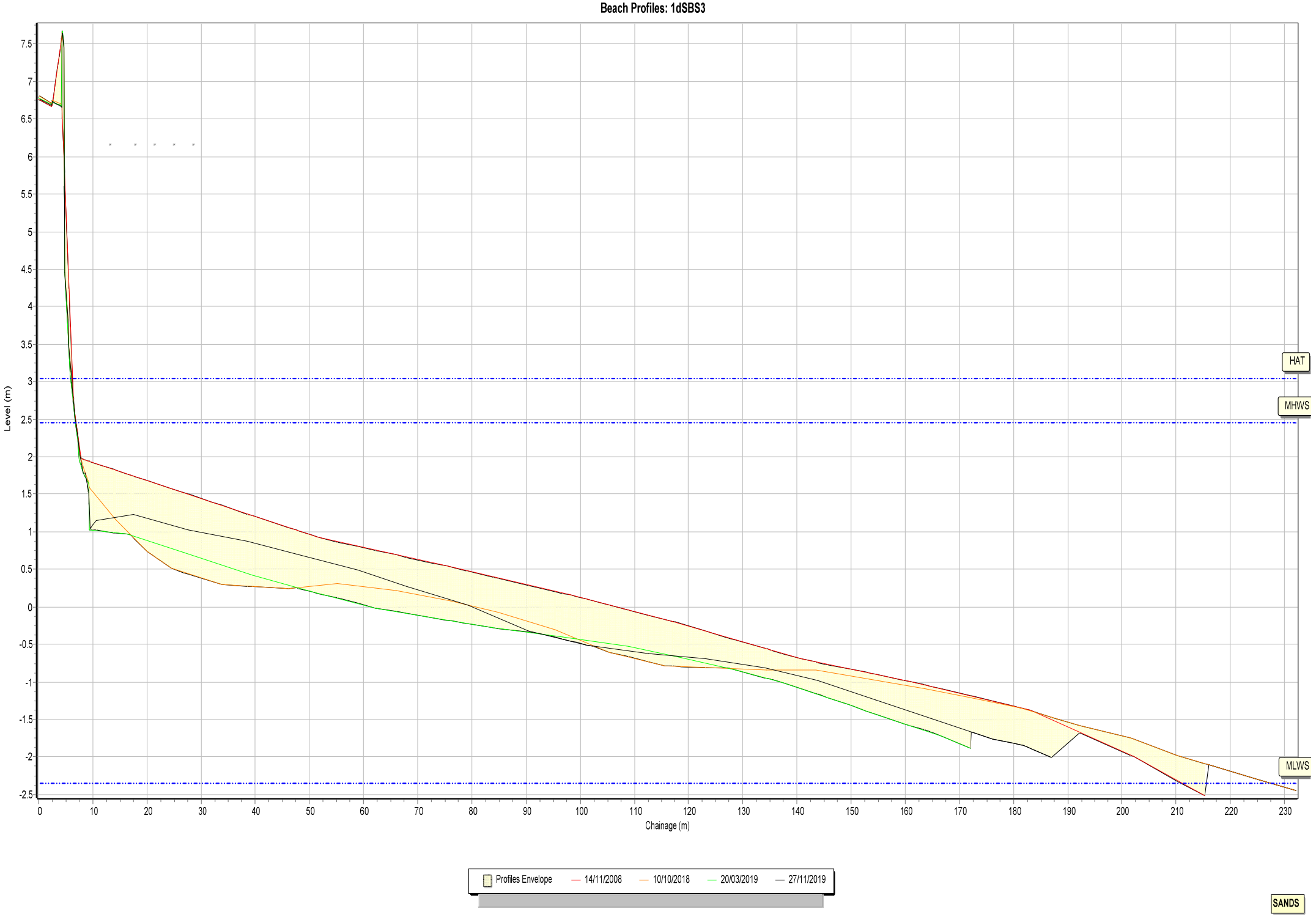
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Chainage (m)
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27/11/2019
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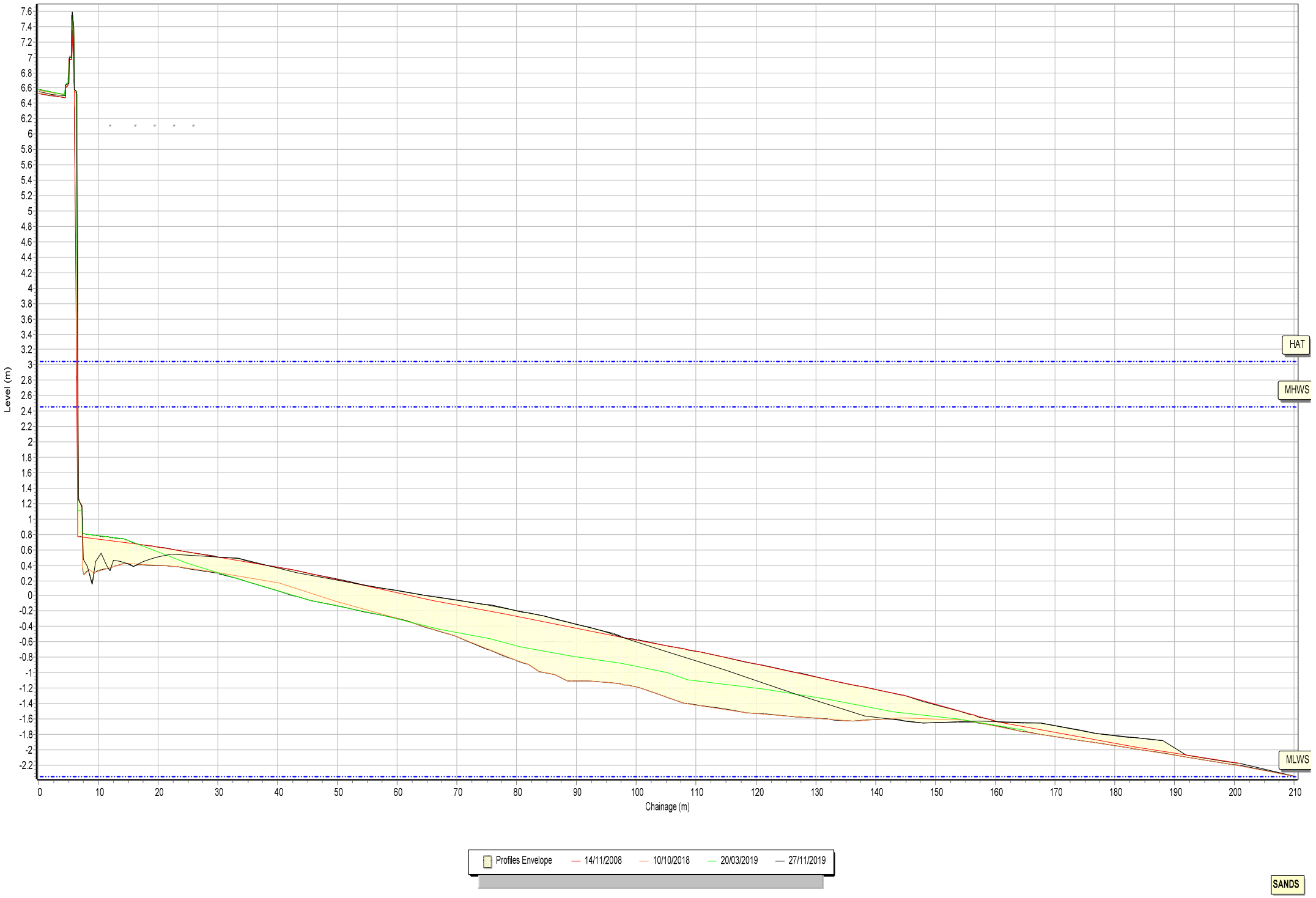
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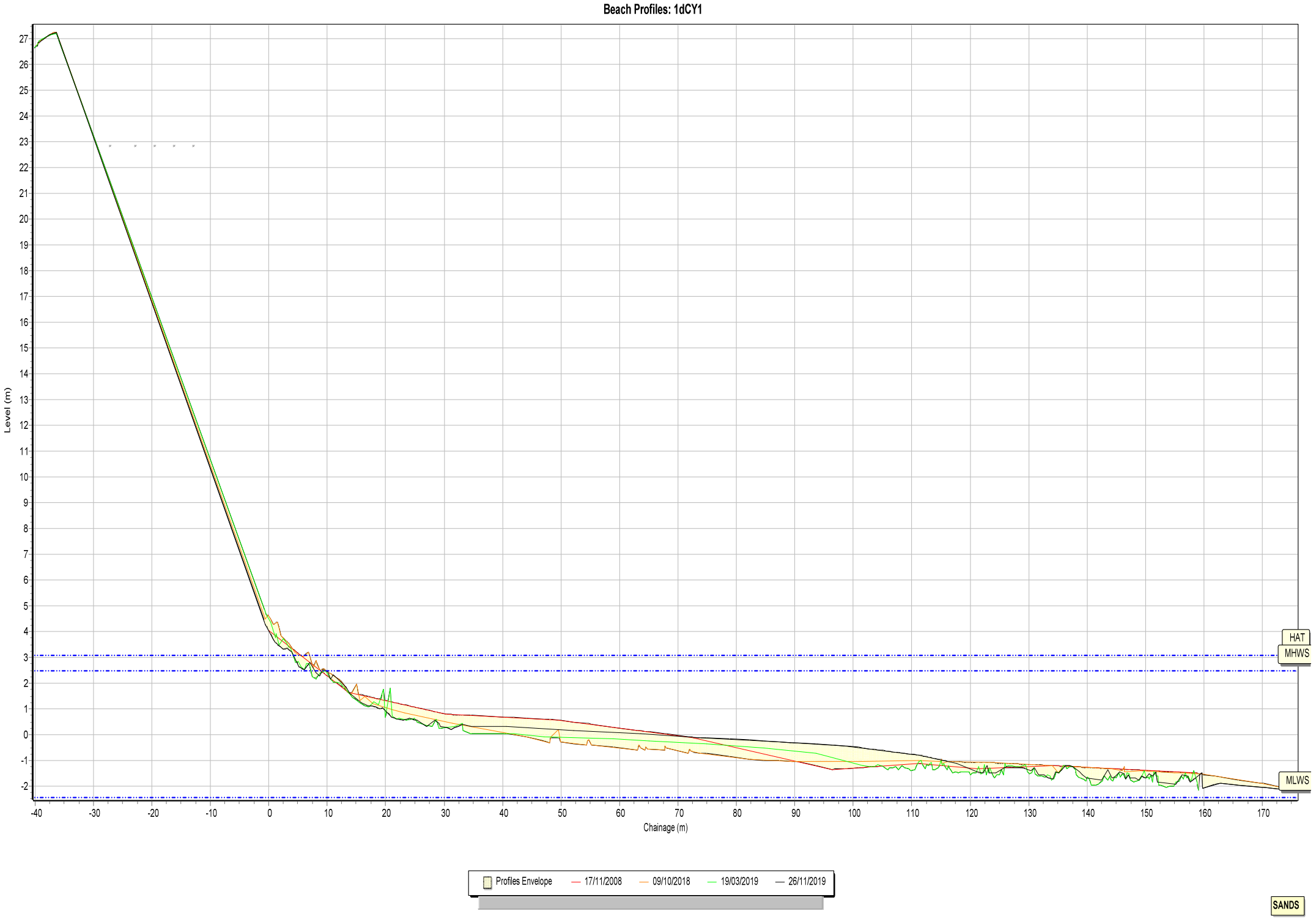
27/11/2019
SANDS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26/11/2019
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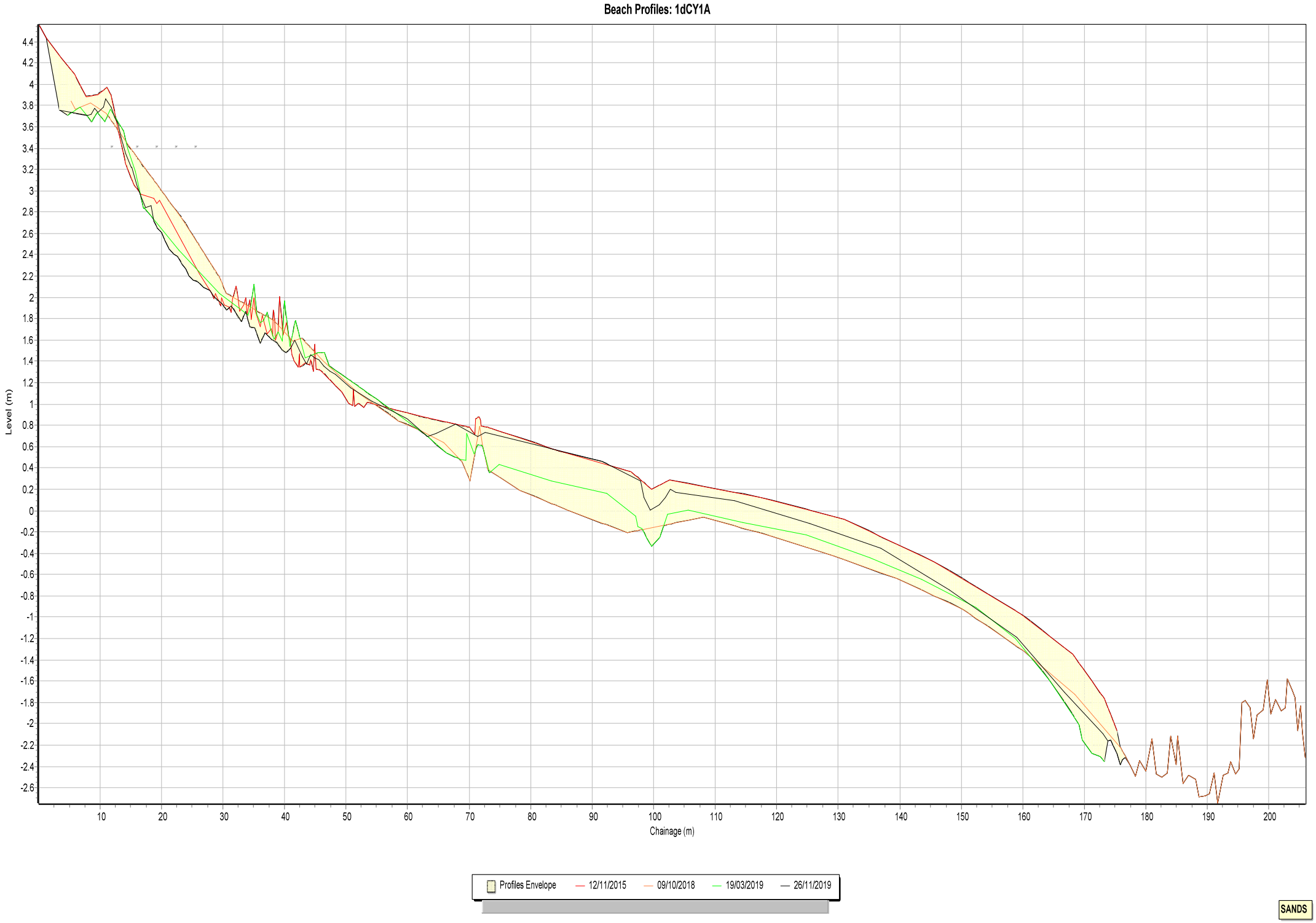
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3.6
3.4
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2.4
2.2
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1.8
1.6
1.4
1.2
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0.8
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
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-1.2
-1.4
-1.6
-1.8
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-2.2
-2.4
-2.6
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110
120
130
140
150
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200
Chainage (m)
Profiles Envelope
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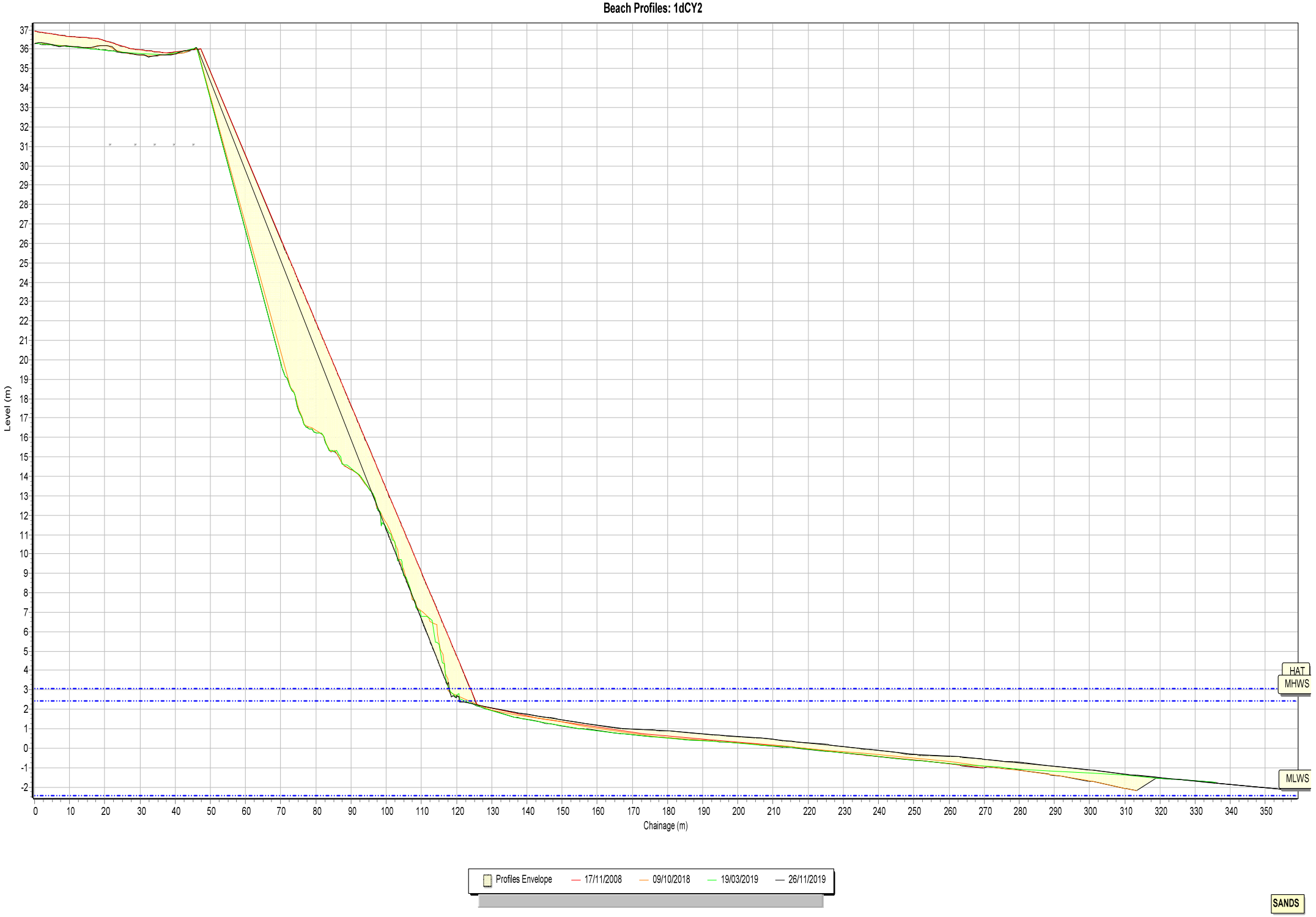
09/10/2018
19/03/2019
26/11/2019
SANDS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Level (m)
Chainage (m)
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MLWS
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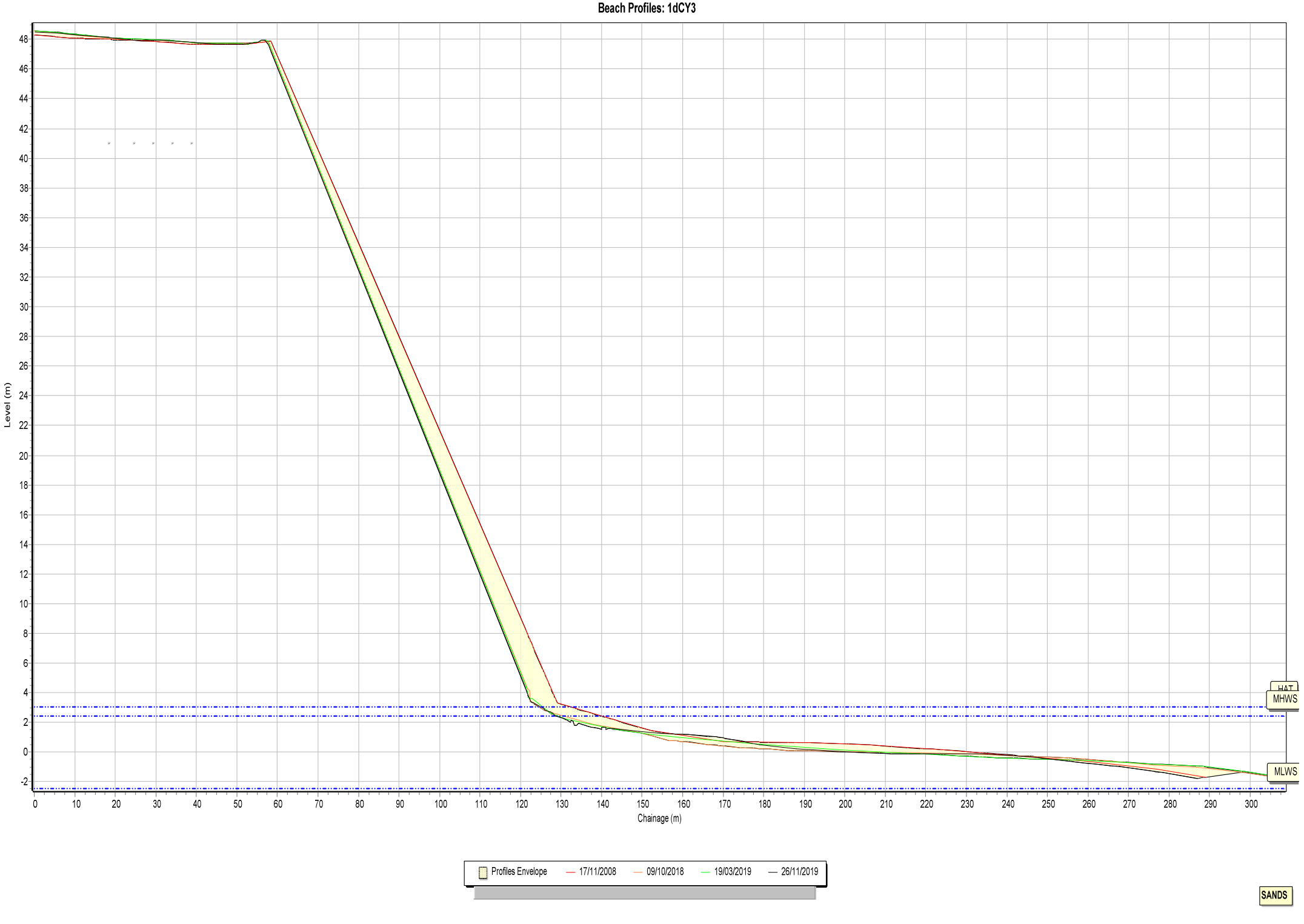
17/11/2008
09/10/2018
19/03/2019
26/11/2019
SANDS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17/11/2008
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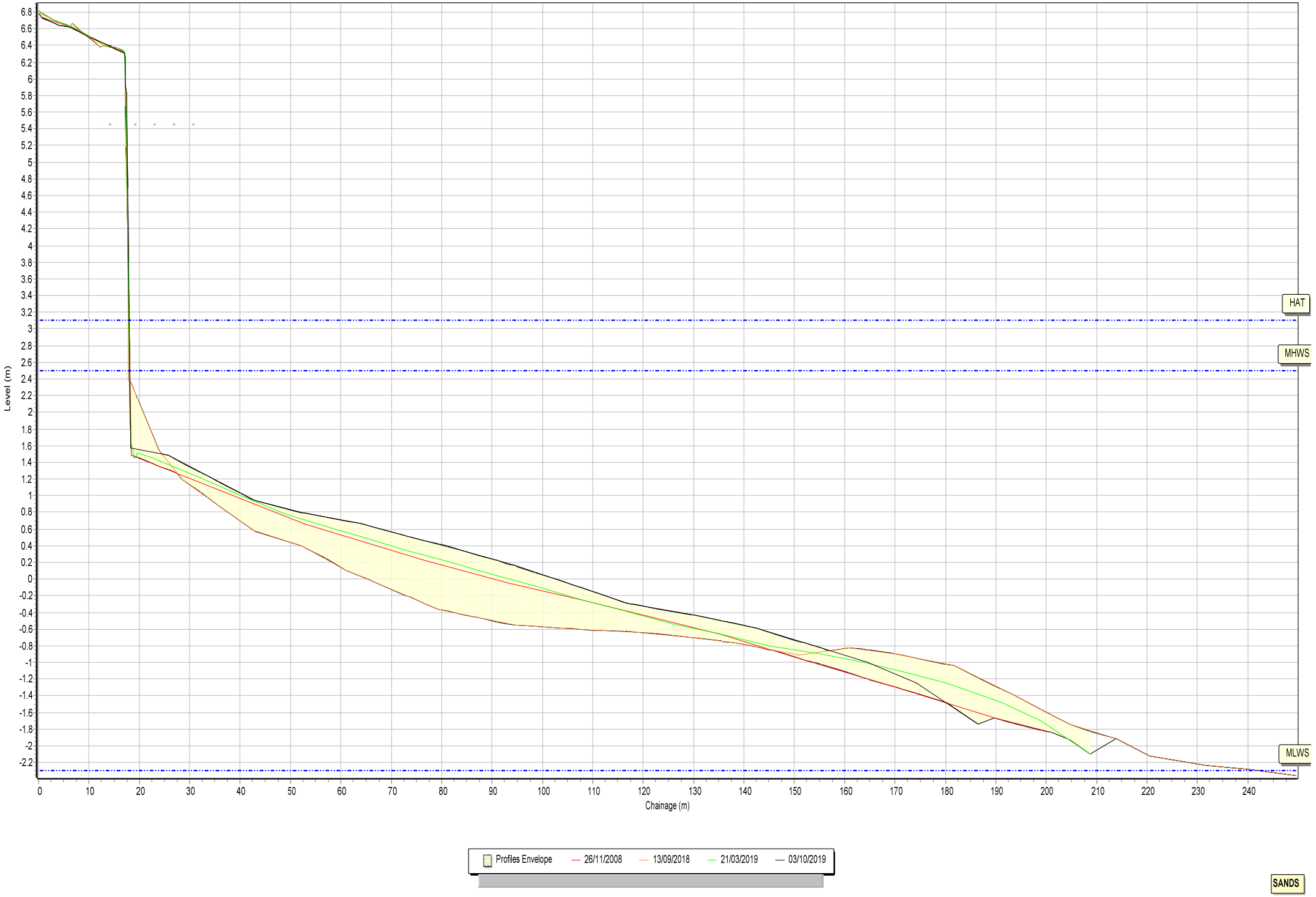
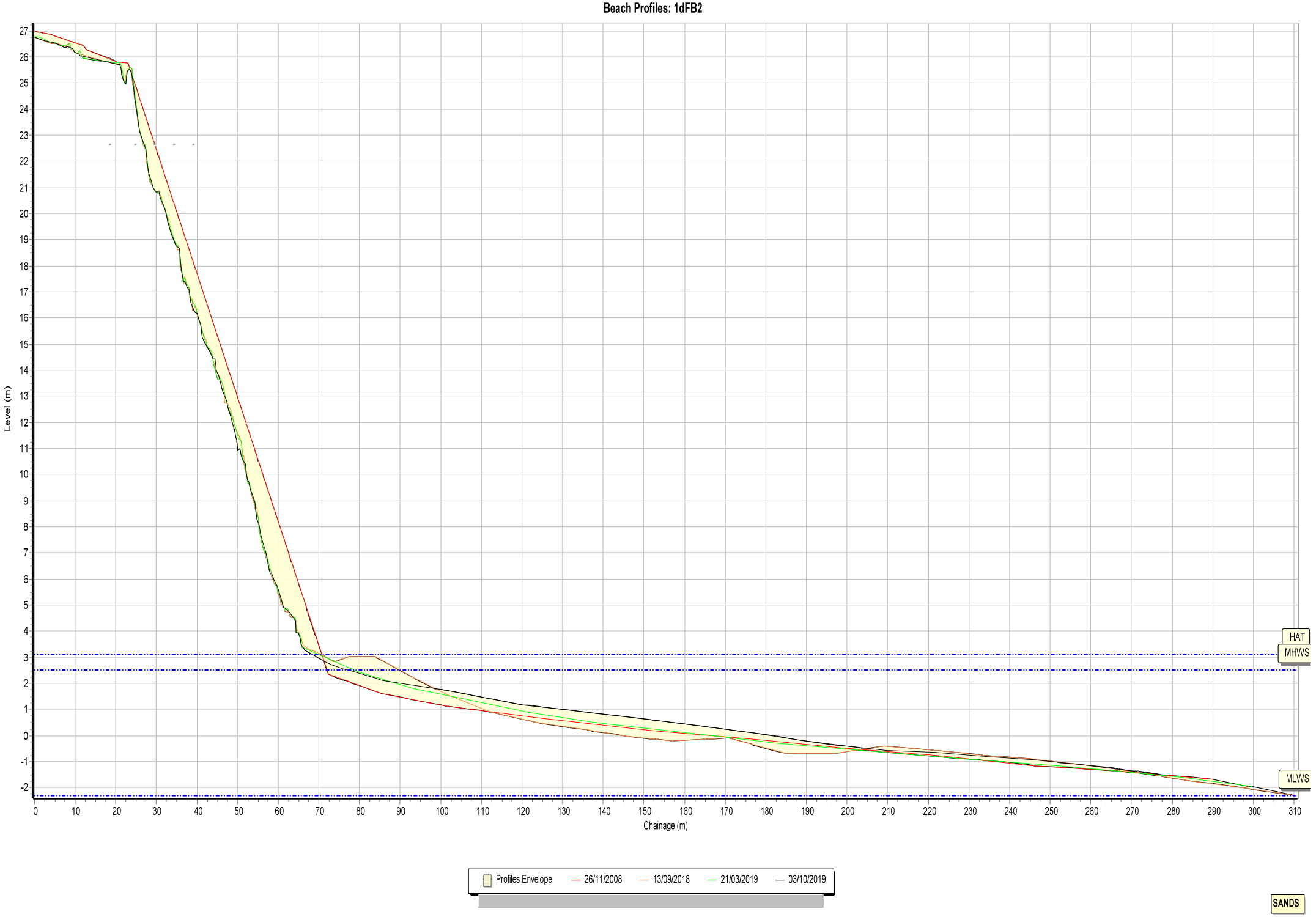
26/11/2019
SANDS

Beach Profiles: 1dFB1

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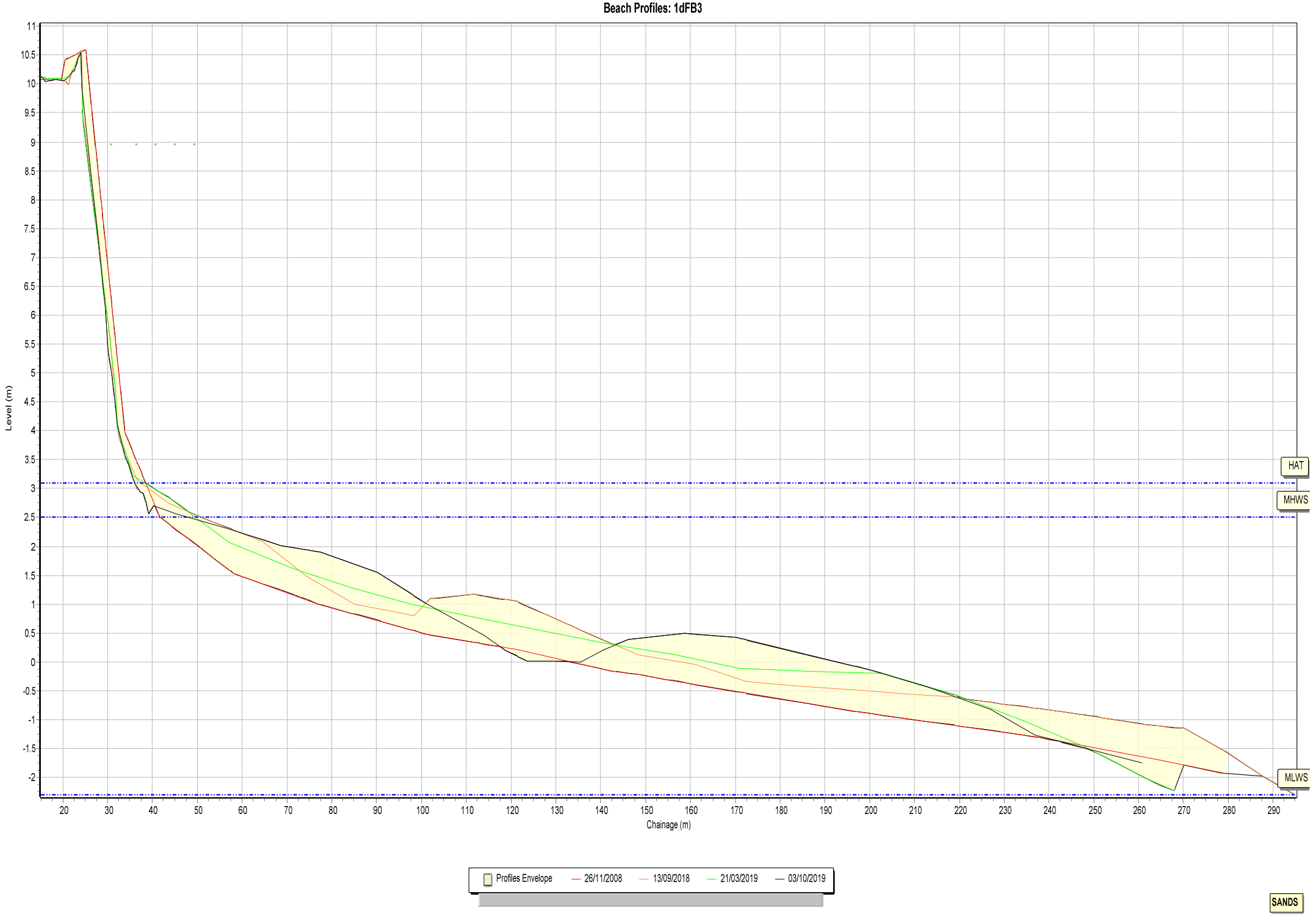
03/10/2019
SANDS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Chainage (m)
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Profiles Envelope
26/11/2008
13/09/2018
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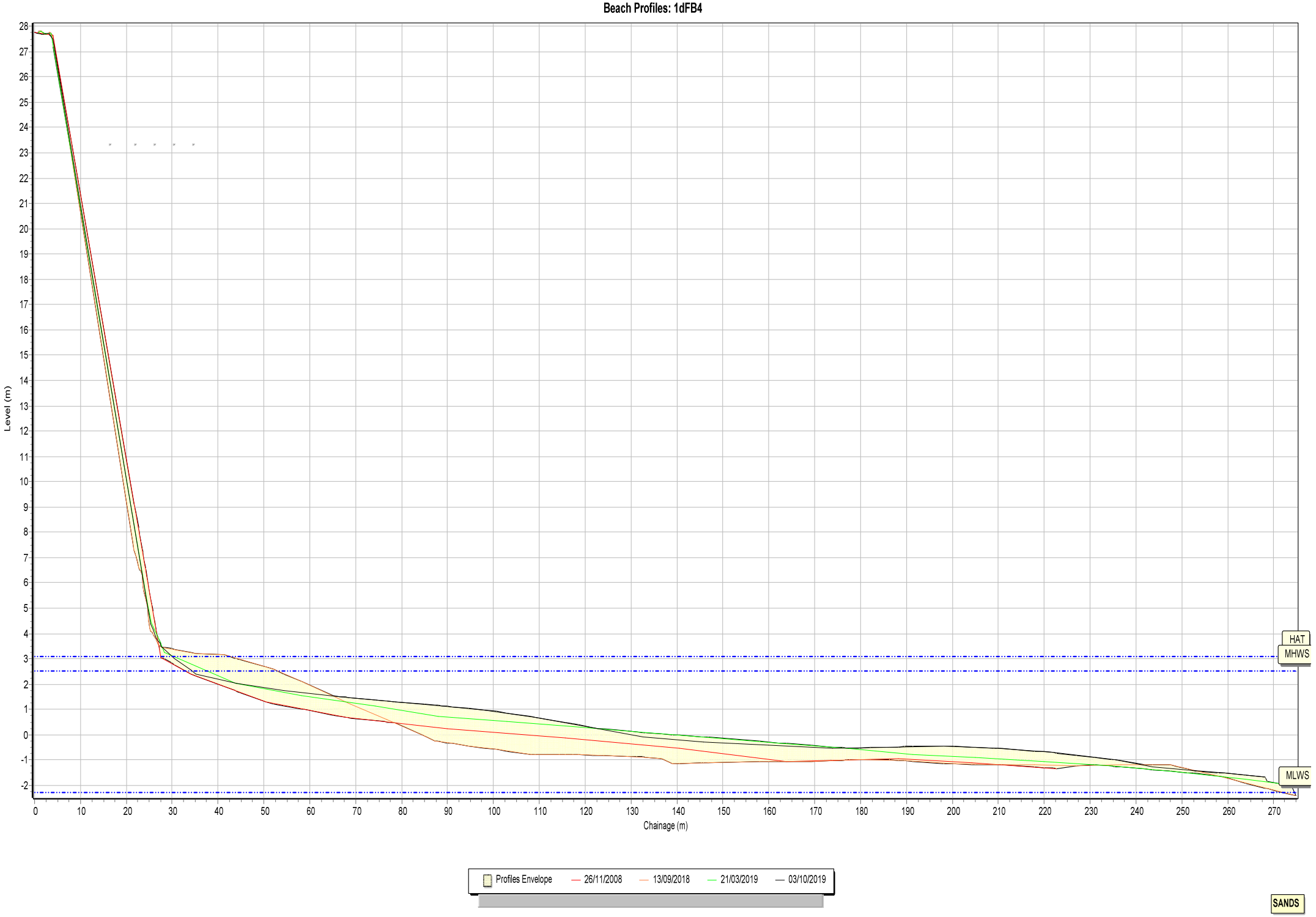
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Level (m)
Chainage (m)
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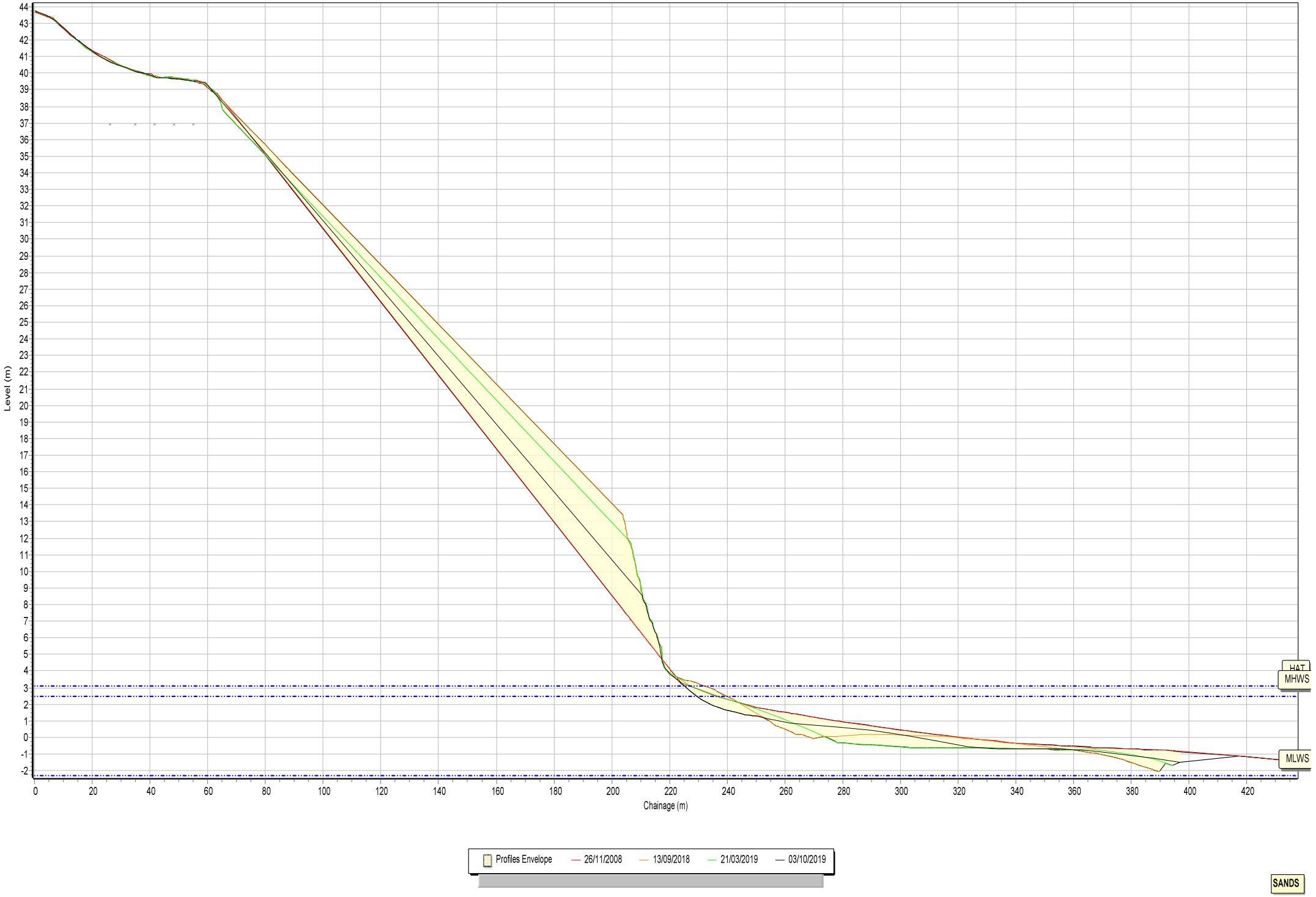
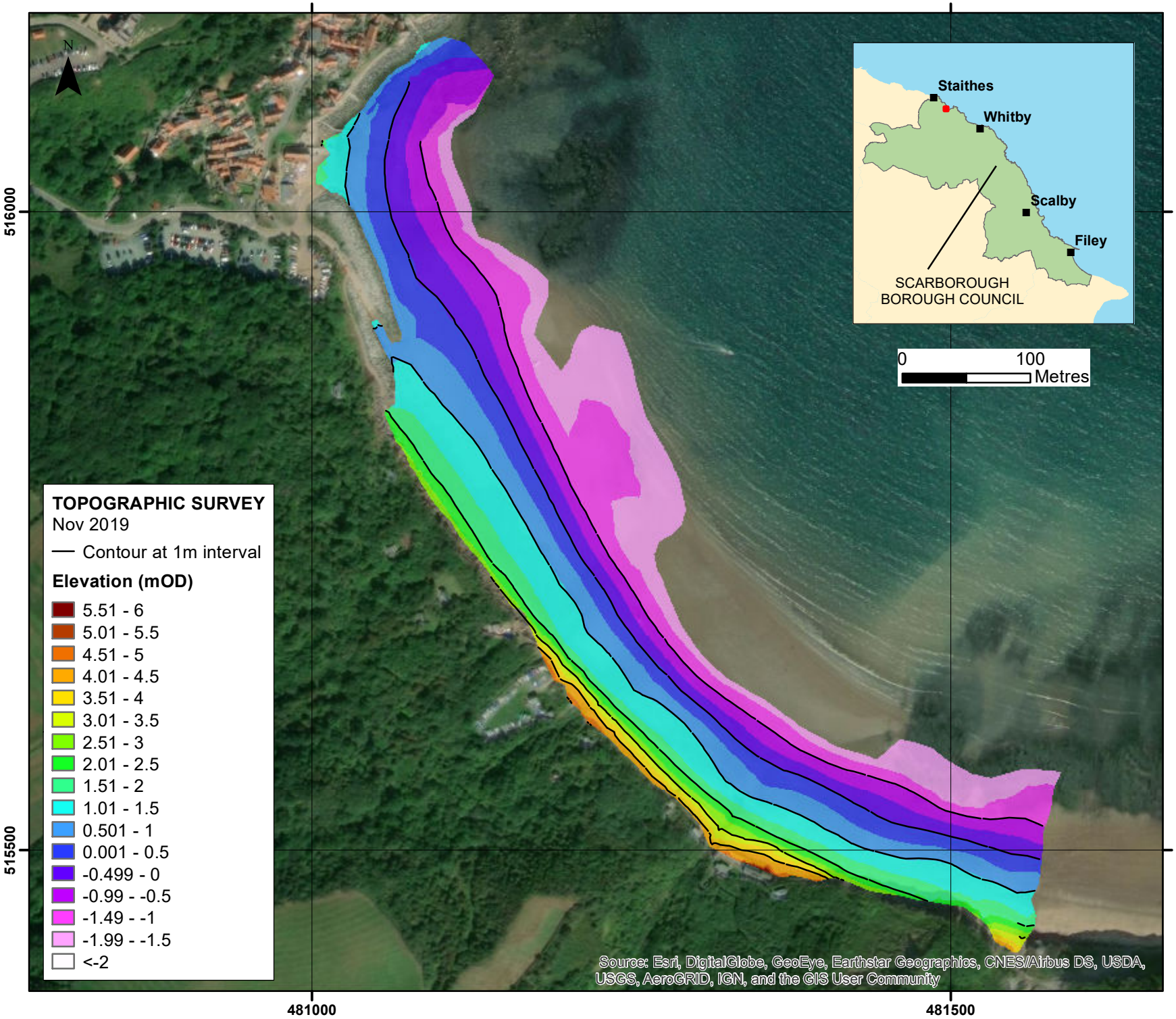
Profiles Envelope
26/11/2008
13/09/2018
21/03/2019
03/10/2019
SANDS

Beach Profiles: 1dFB5



Appendix B

Topographic Survey



Key

Client: North East Coastal Group

Project: Cell 1 Regional Coastal Monitoring Programme

Appendix B - Map 1

RUNSWICK BAY

Scarborough Borough Council Frontage

Analytical Report
'Full Measures' Survey 2019

Drawing Scale at A4 1:4,000

WATER
Royal HaskoningDHV
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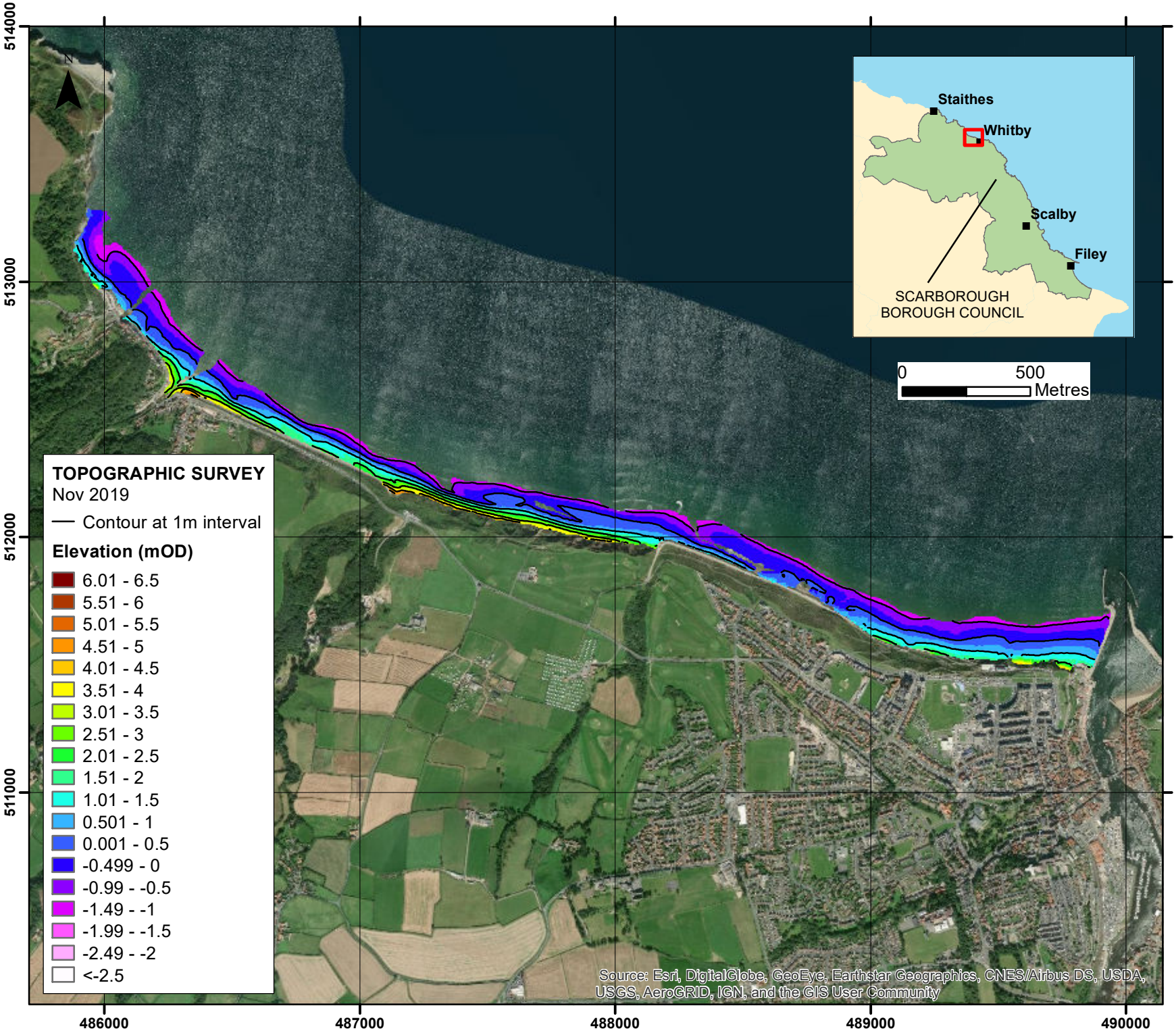

Key

Client: North East Coastal Group

Project: Cell 1 Regional Coastal Monitoring Programme

Appendix B - Map 2

SANDSEND

Scarborough Borough Council Frontage

Analytical Report
'Full Measures' Survey 2019

Drawing Scale at A4 1:20,000

WATER
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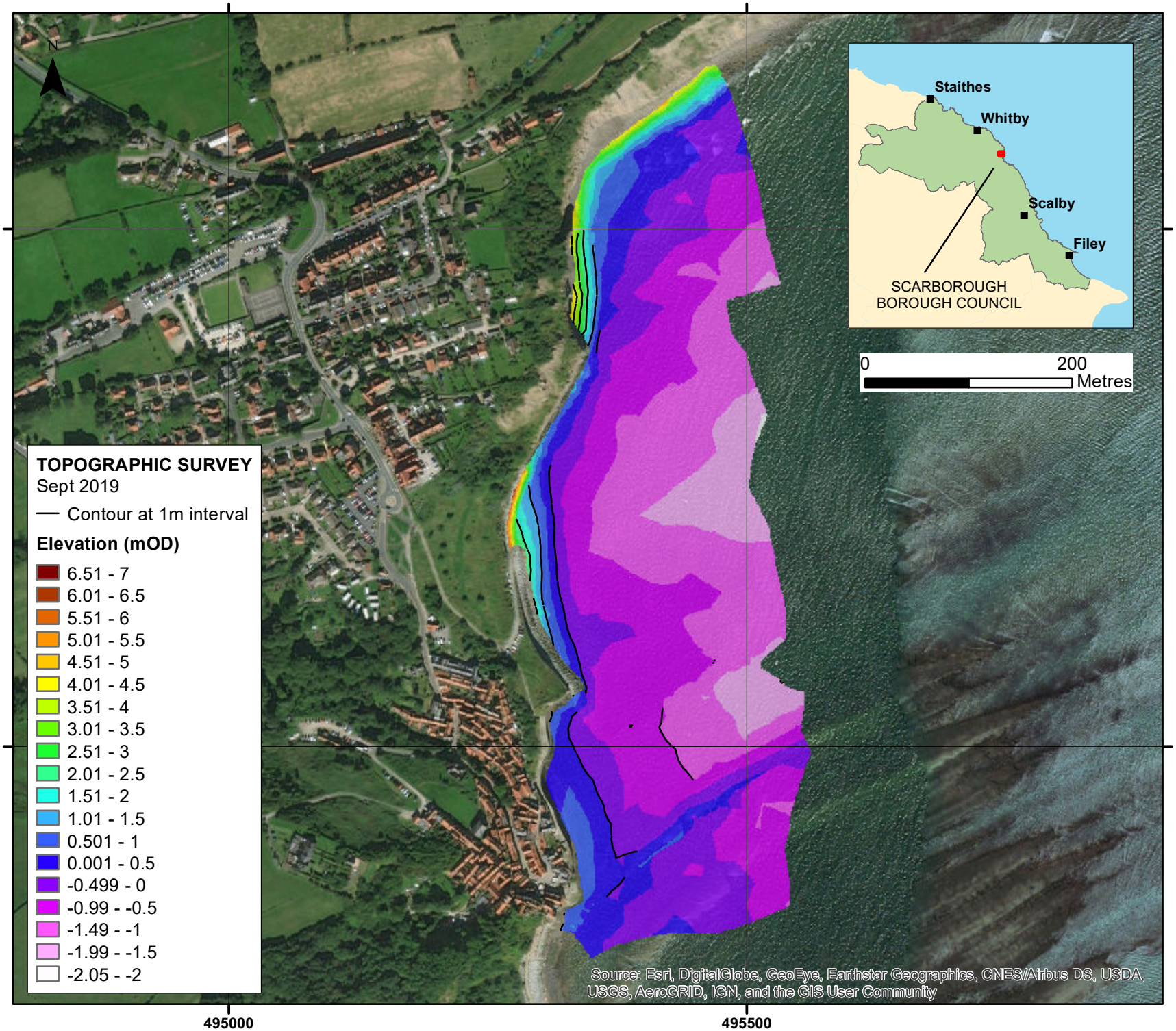

Key

Client: North East Coastal Group

Project: Cell 1 Regional Coastal Monitoring Programme

Appendix B - Map 3

ROBIN HOOD'S BAY

Scarborough Borough Council Frontage

Analytical Report
'Full Measures' Survey 2019

Drawing Scale at A4 1:5,000

WATER
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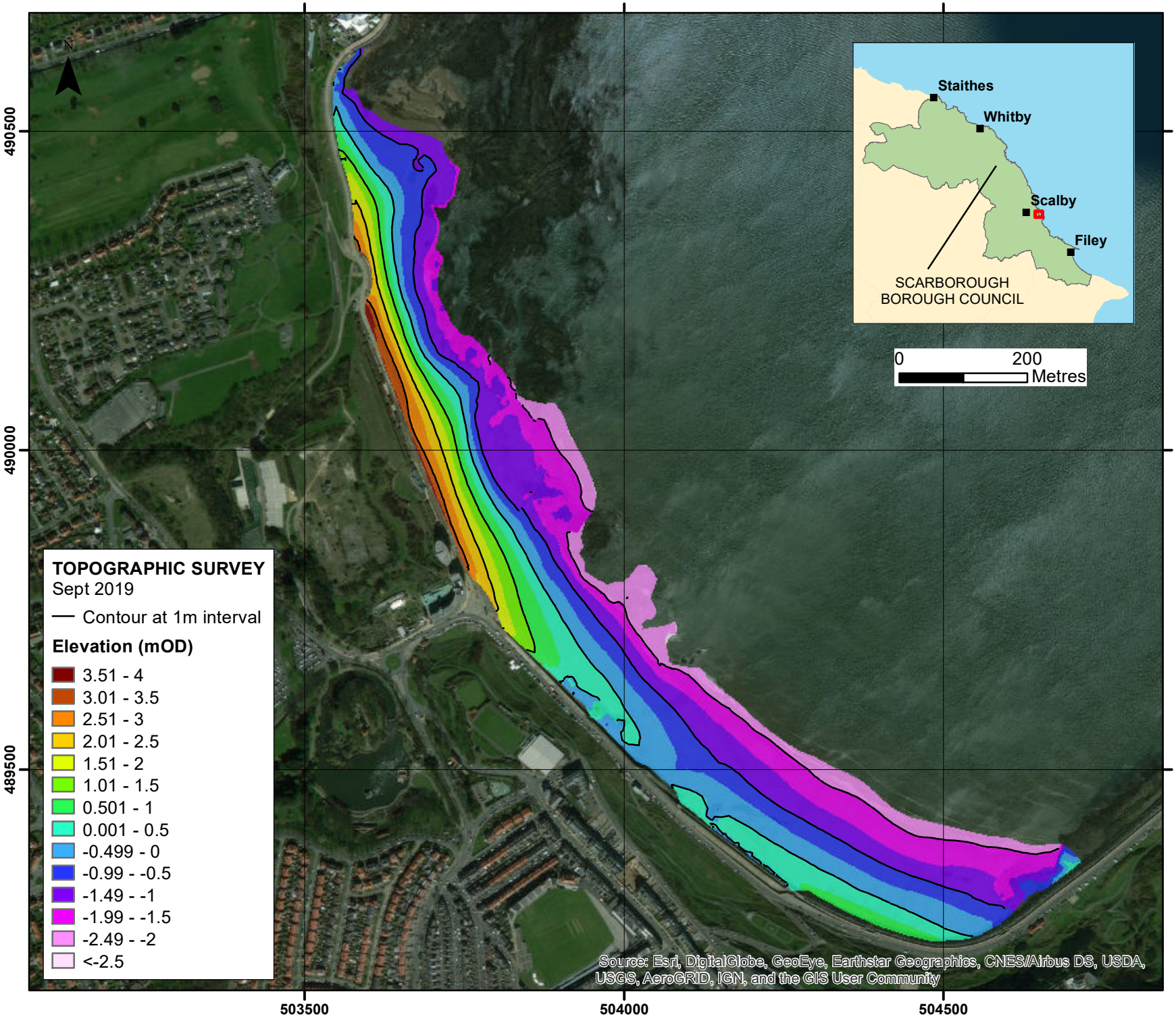

Key

Client: North East Coastal Group

Project: Cell 1 Regional Coastal Monitoring Programme

Appendix B - Map 4

SCARBOROUGH NORTH BAY

Scarborough Borough Council Frontage

Analytical Report
'Full Measures' Survey 2019

Drawing Scale at A4 1:8,000

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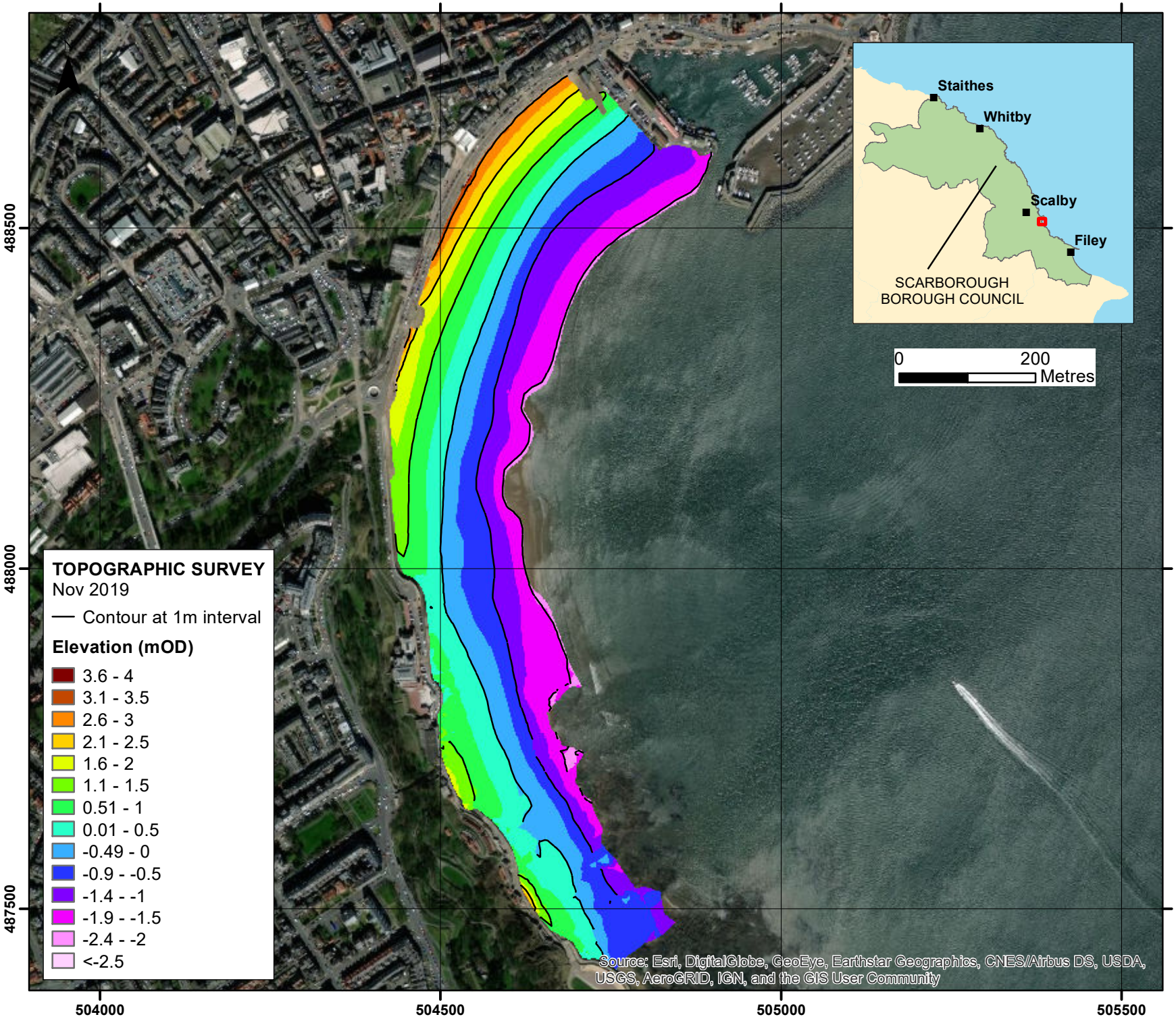

Key

Client: North East Coastal Group

Project: Cell 1 Regional Coastal Monitoring Programme

Appendix B - Map 5

SCARBOROUGH SOUTH BAY

Scarborough Borough Council Frontage

Analytical Report
'Full Measures' Survey 2019

Drawing Scale at A4 1:7,500

WATER
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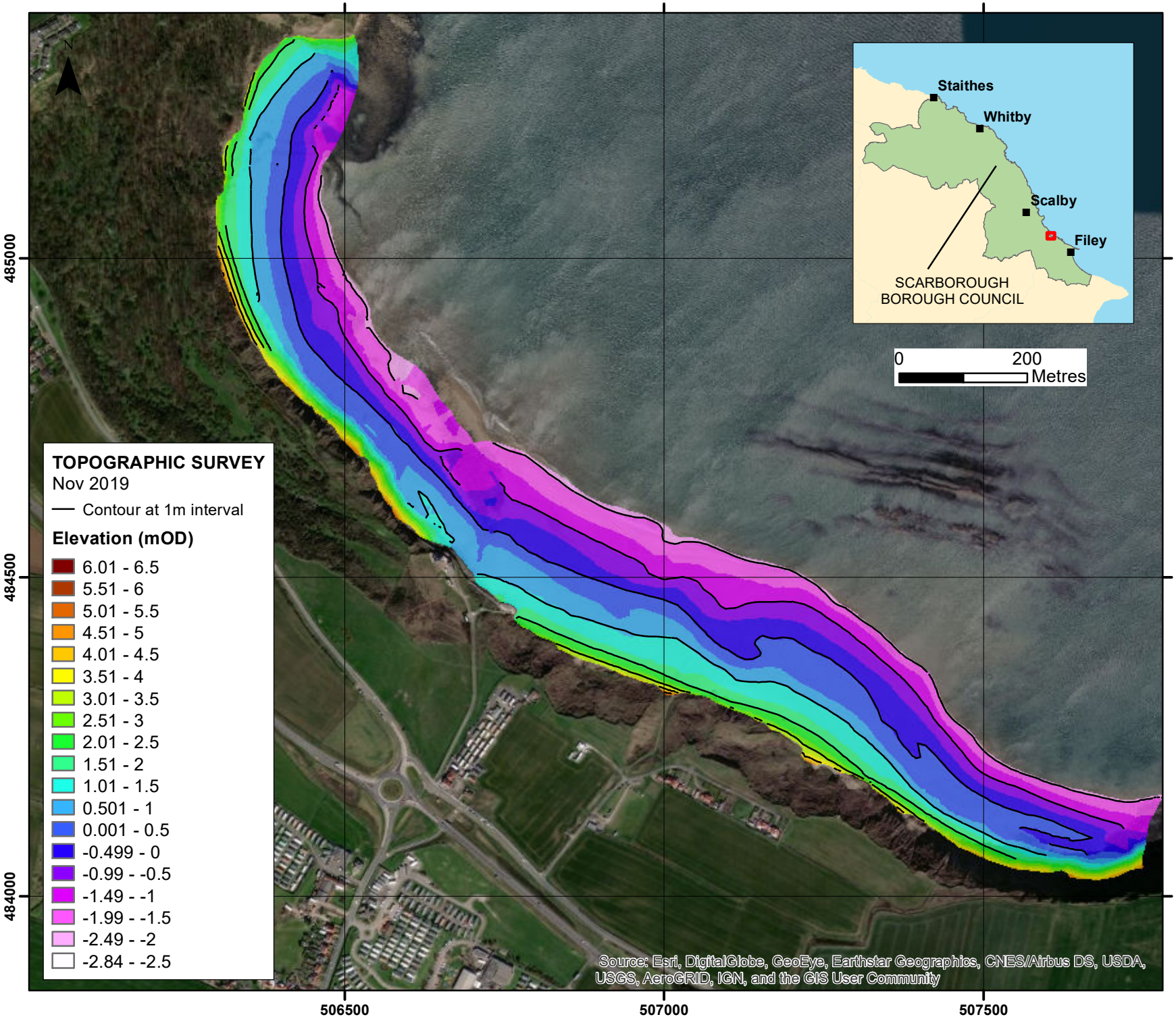

Key

Client: North East Coastal Group

Project: Cell 1 Regional Coastal Monitoring Programme

Appendix B - Map 6

CAYTON BAY

Scarborough Borough Council Frontage

Analytical Report
'Full Measures' Survey 2019

Drawing Scale at A4 1:8,000

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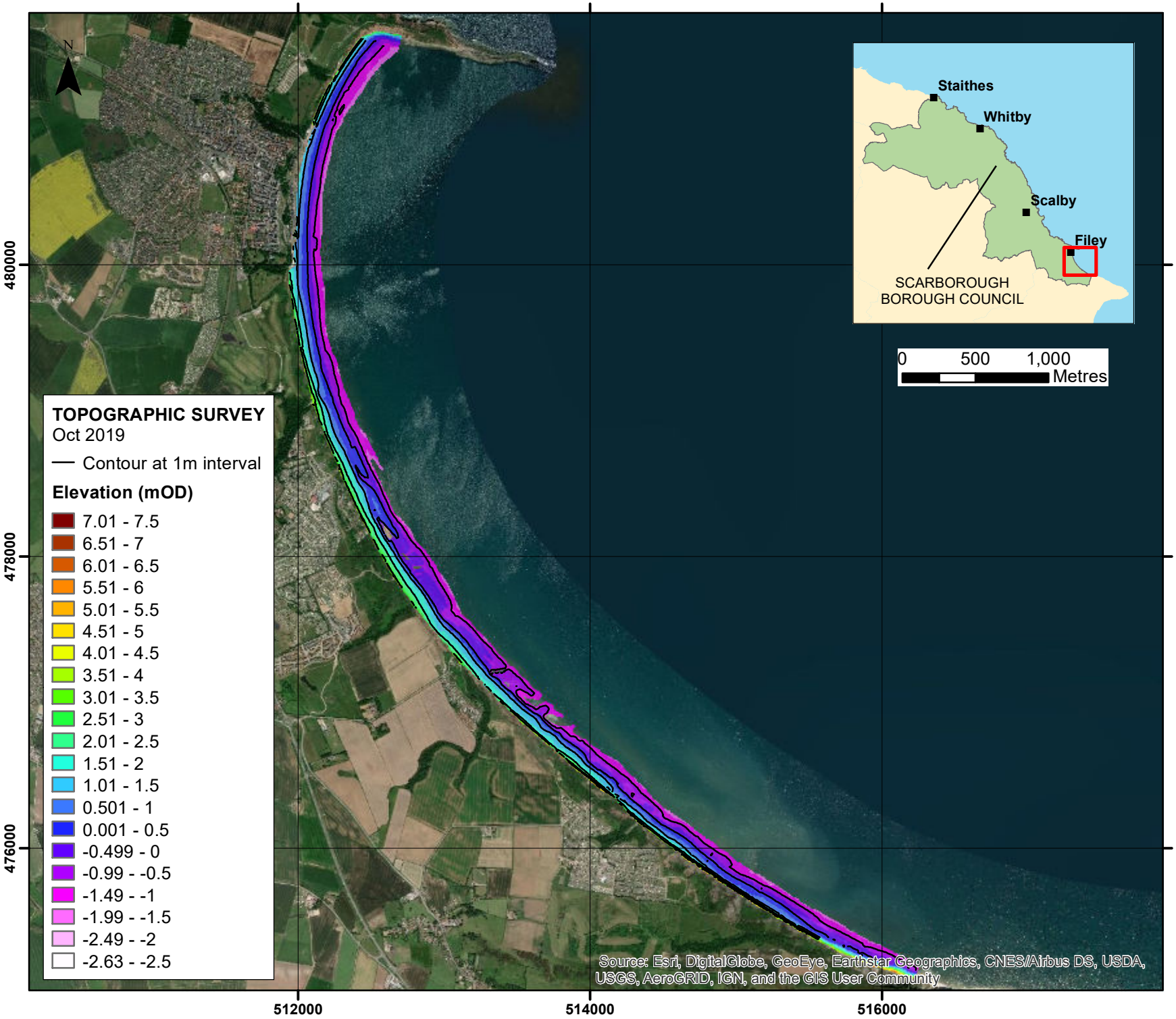

Key

Client: North East Coastal Group

Project: Cell 1 Regional Coastal Monitoring Programme

Appendix B - Map 7

FILEY BAY

Scarborough Borough Council Frontage

Analytical Report
'Full Measures' Survey 2019

Drawing Scale at A4 1:35,000

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Newcastle upon Tyne
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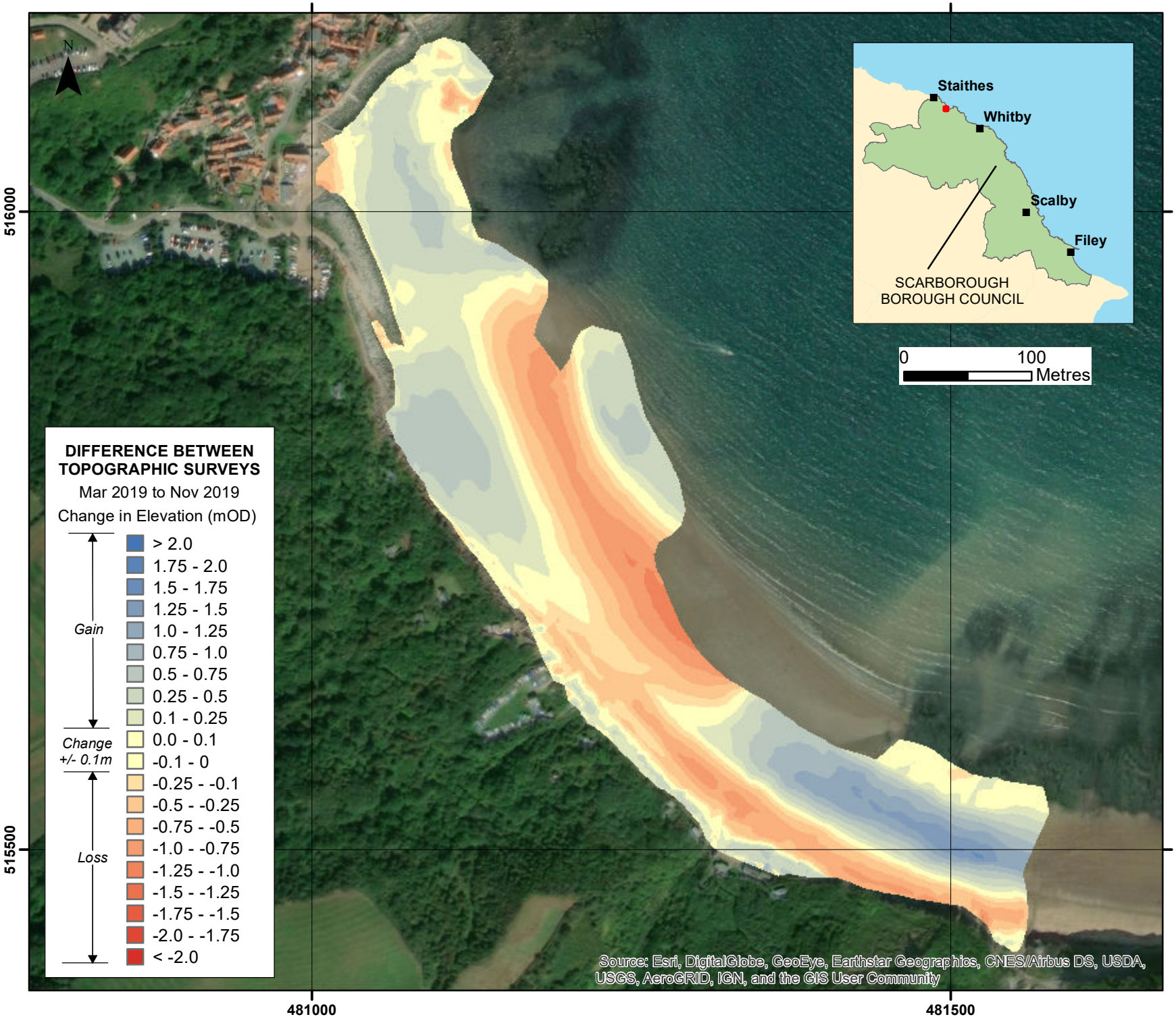

Key

Client: North East Coastal Group

Project: Cell 1 Regional Coastal Monitoring Programme

Appendix B - Map 8

RUNSWICK BAY

Scarborough Borough Council Frontage

Analytical Report
'Full Measures' Survey 2019

Drawing Scale at A4 1:4,000

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Newcastle upon Tyne
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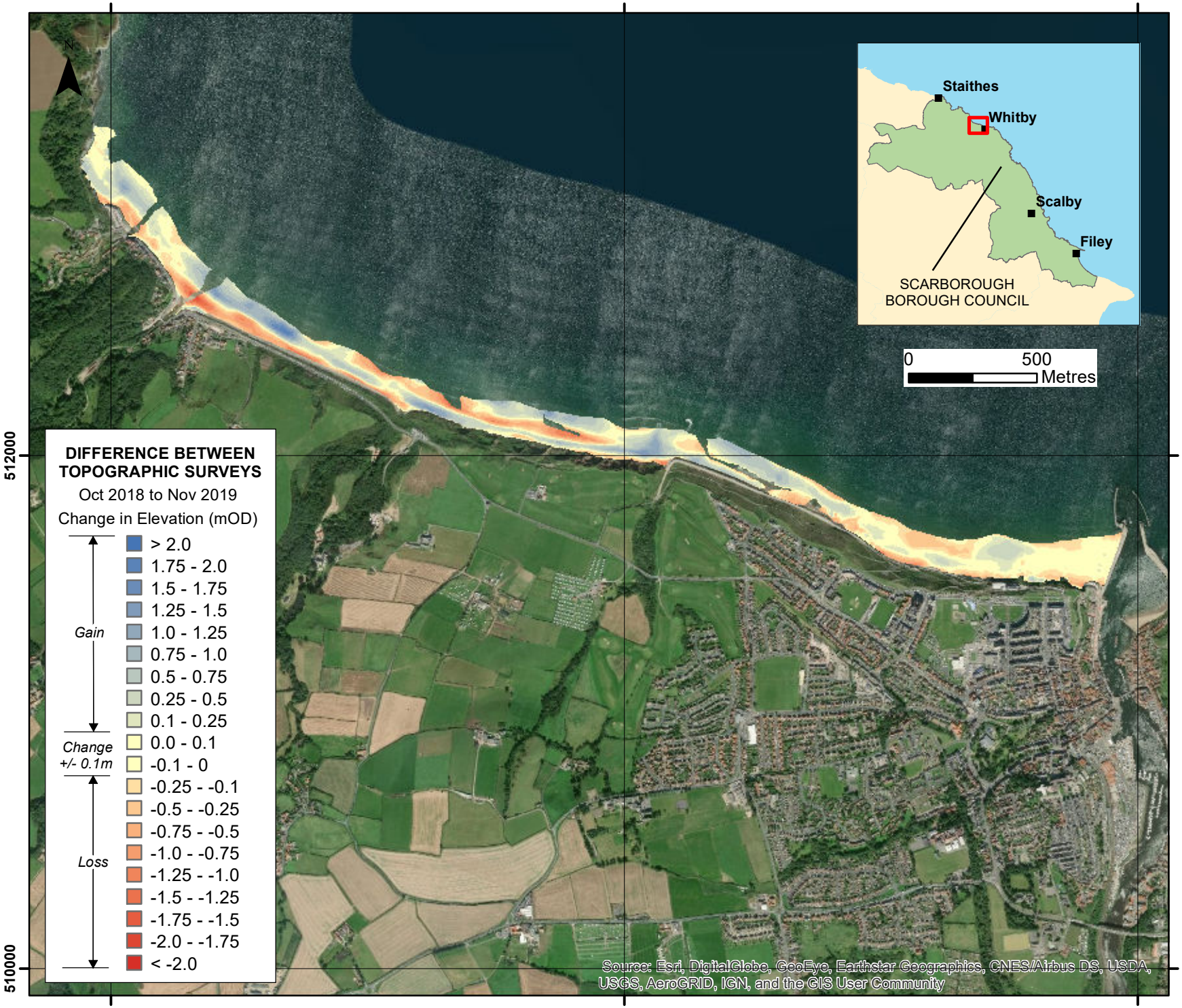

Key

Client: North East Coastal Group

Project: Cell 1 Regional Coastal Monitoring Programme

Appendix B - Map 9

SANDSEND

Scarborough Borough Council Frontage

Analytical Report
'Full Measures' Survey 2019

Drawing Scale at A4 1:20,000

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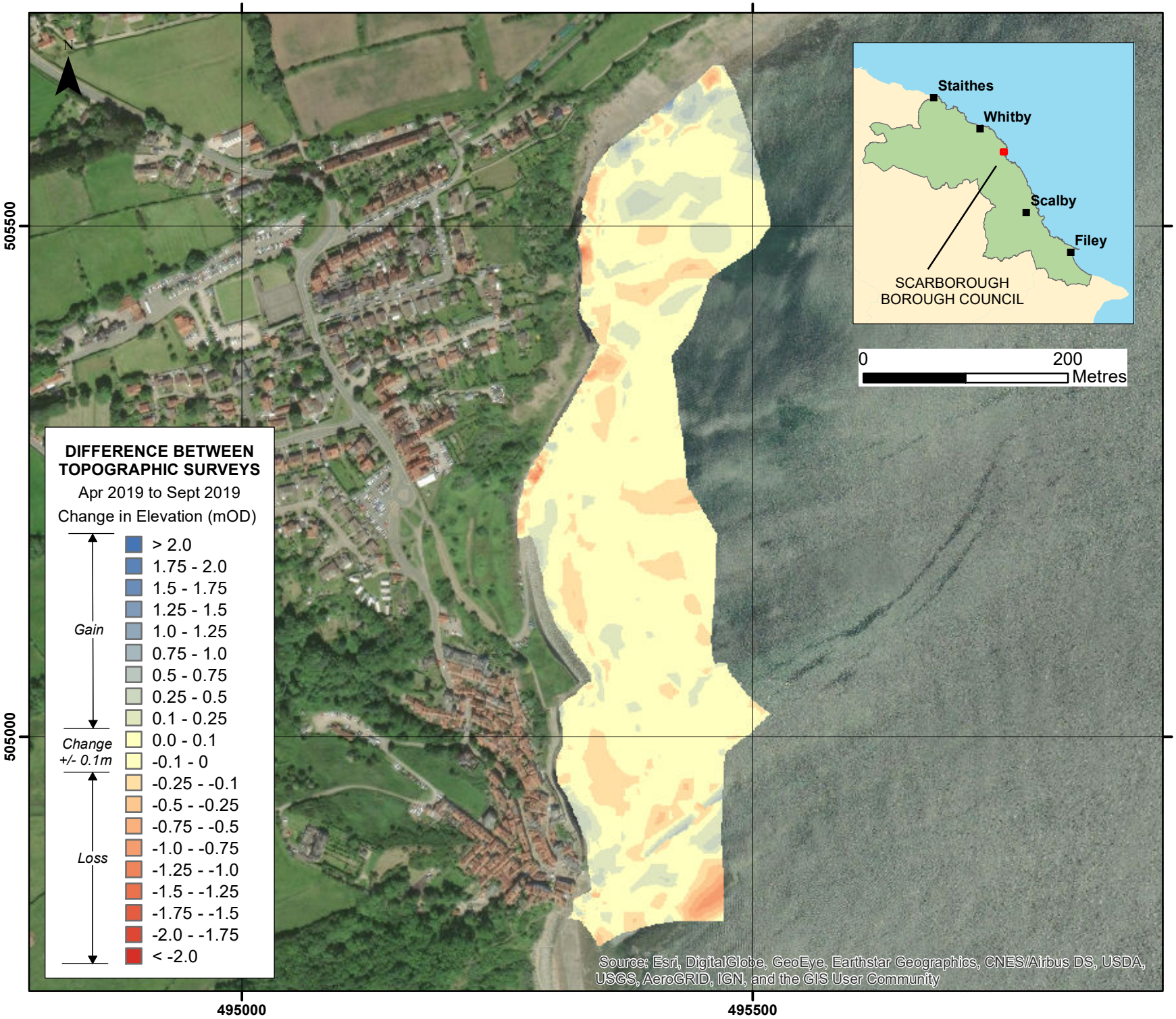

Key

Client: North East Coastal Group

Project: Cell 1 Regional Coastal Monitoring Programme

Appendix B - Map 10

ROBIN HOOD'S BAY

Scarborough Borough Council Frontage

Analytical Report
'Full Measures' Survey 2019

Drawing Scale at A4 1:5,000

WATER
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Fax: +44 (0)191 211 1313
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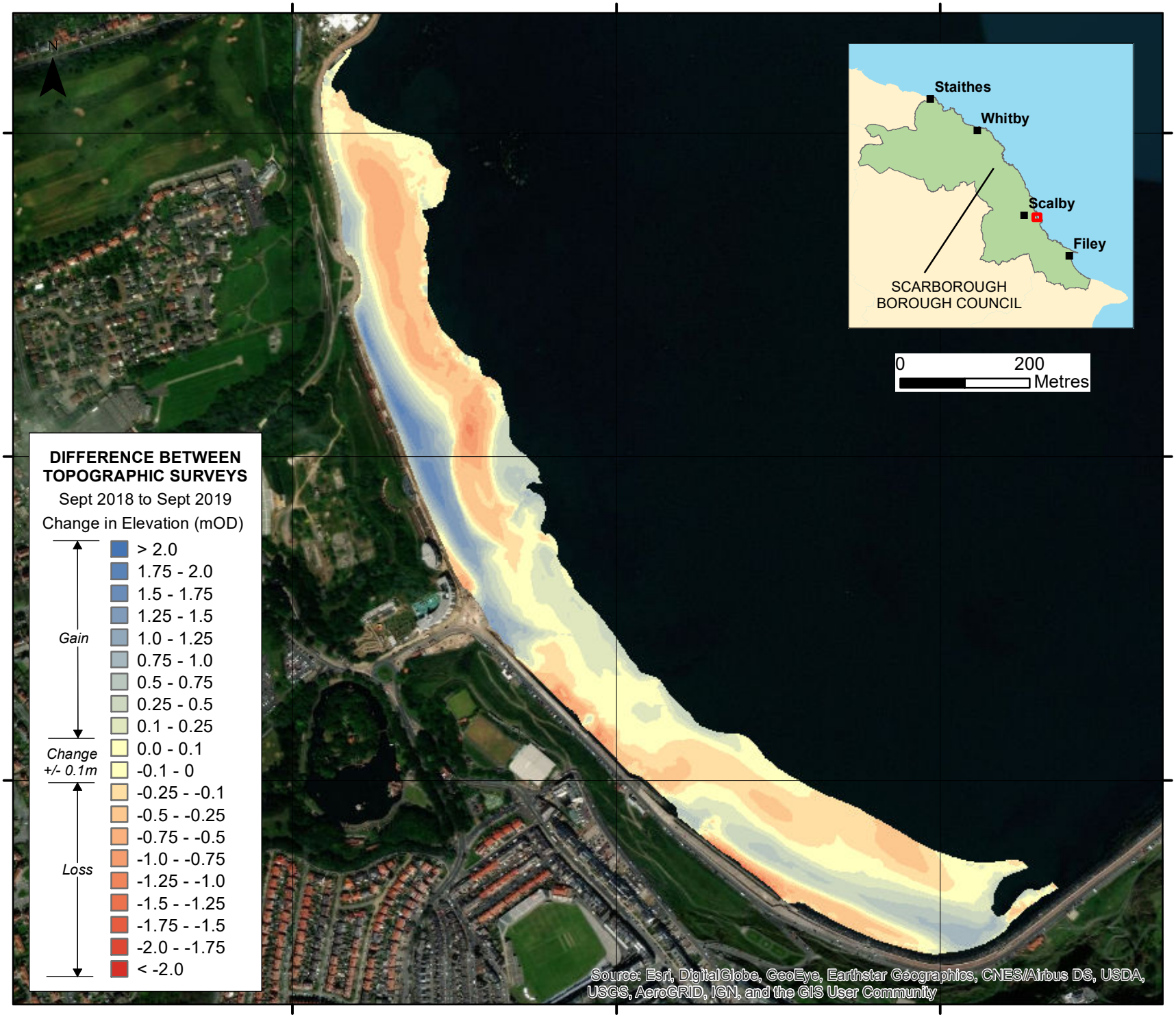

Key

Client: North East Coastal Group

Project: Cell 1 Regional Coastal Monitoring Programme

Appendix B - Map 11

SCARBOROUGH NORTH BAY

Scarborough Borough Council Frontage

Analytical Report
'Full Measures' Survey 2019

Drawing Scale at A4 1:8,000

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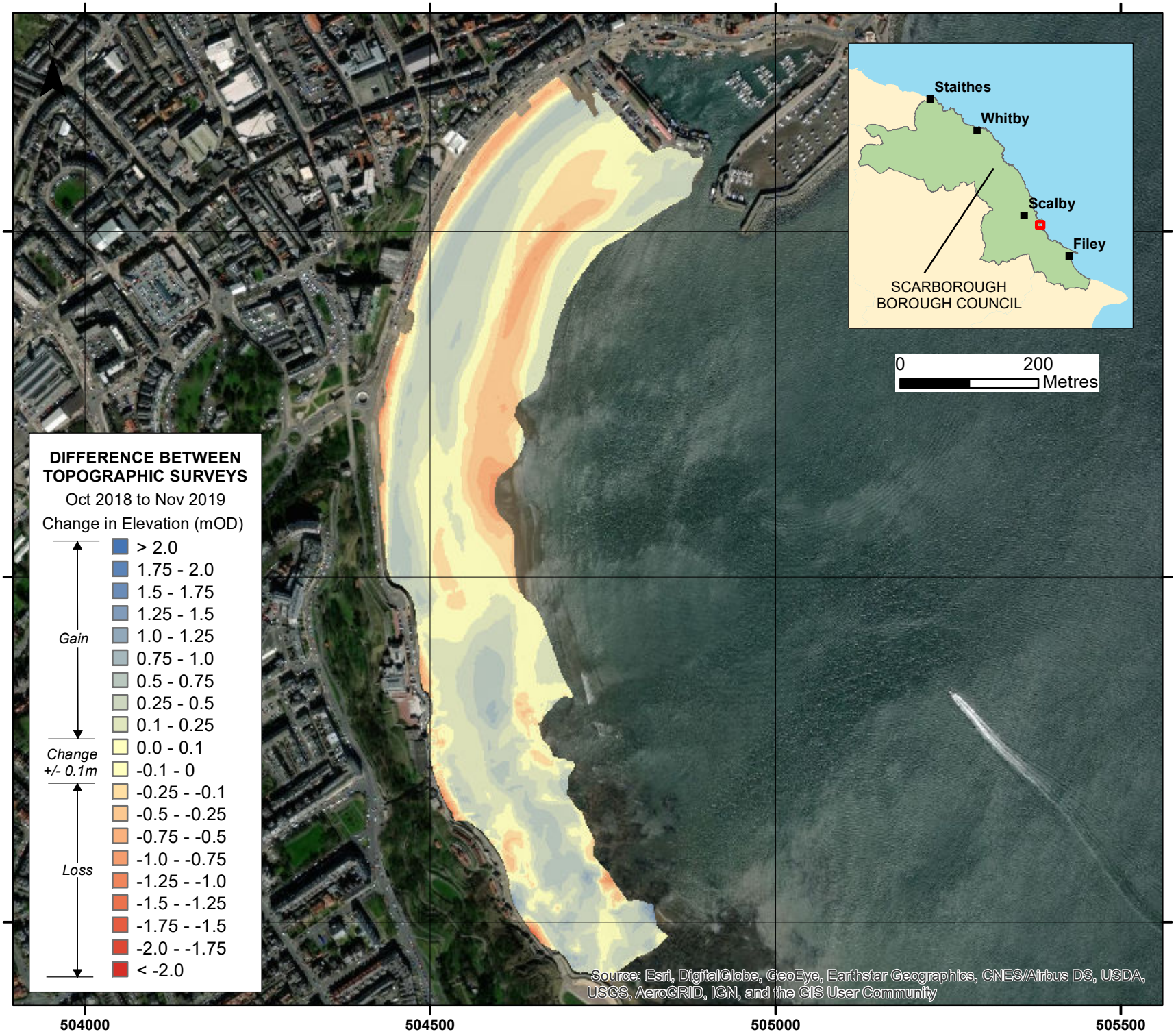

Key

Client: North East Coastal Group

Project: Cell 1 Regional Coastal Monitoring Programme

Appendix B - Map 12

SCARBOROUGH SOUTH BAY

Scarborough Borough Council Frontage

Analytical Report
'Full Measures' Survey 2019

Drawing Scale at A4 1:7,500

WATER
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Marlborough House
Marlborough Crescent
Newcastle upon Tyne
NE1 4EE

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Fax: +44 (0)191 211 1313
www.royalhaskoningdhv.com

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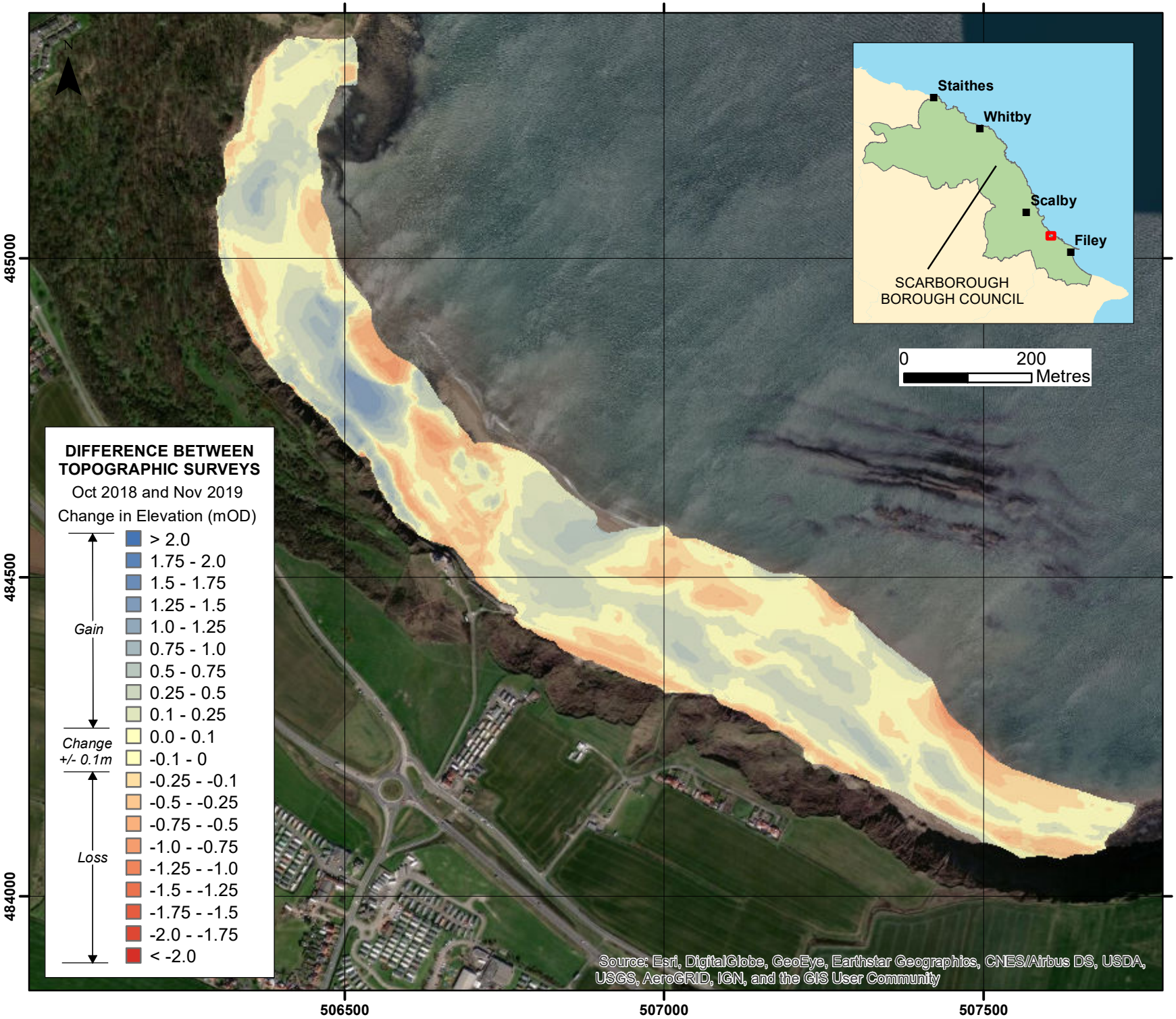

Key

Client: North East Coastal Group

Project: Cell 1 Regional Coastal Monitoring Programme

Appendix B - Map 13

CAYTON BAY

Scarborough Borough Council Frontage

Analytical Report
'Full Measures' Survey 2019

Drawing Scale at A4 1:8,000

WATER
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Newcastle upon Tyne
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Fax: +44 (0)191 211 1313
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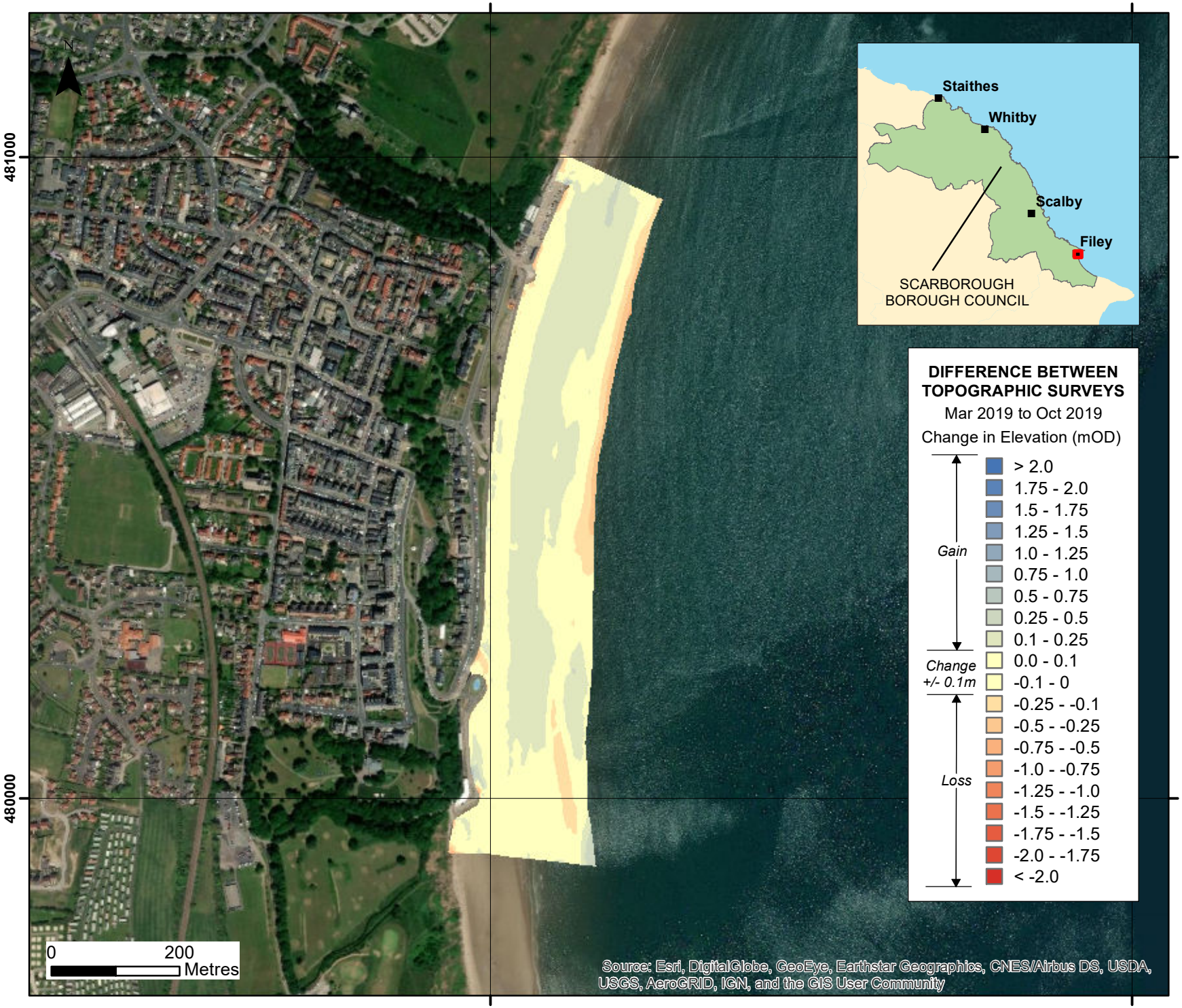

Key

Client: North East Coastal Group

Project: Cell 1 Regional Coastal Monitoring Programme

Appendix B - Map 14

FILEY BAY

Scarborough Borough Council Frontage

Analytical Report
'Full Measures' Survey 2019

Drawing Scale at A4 1:8,000

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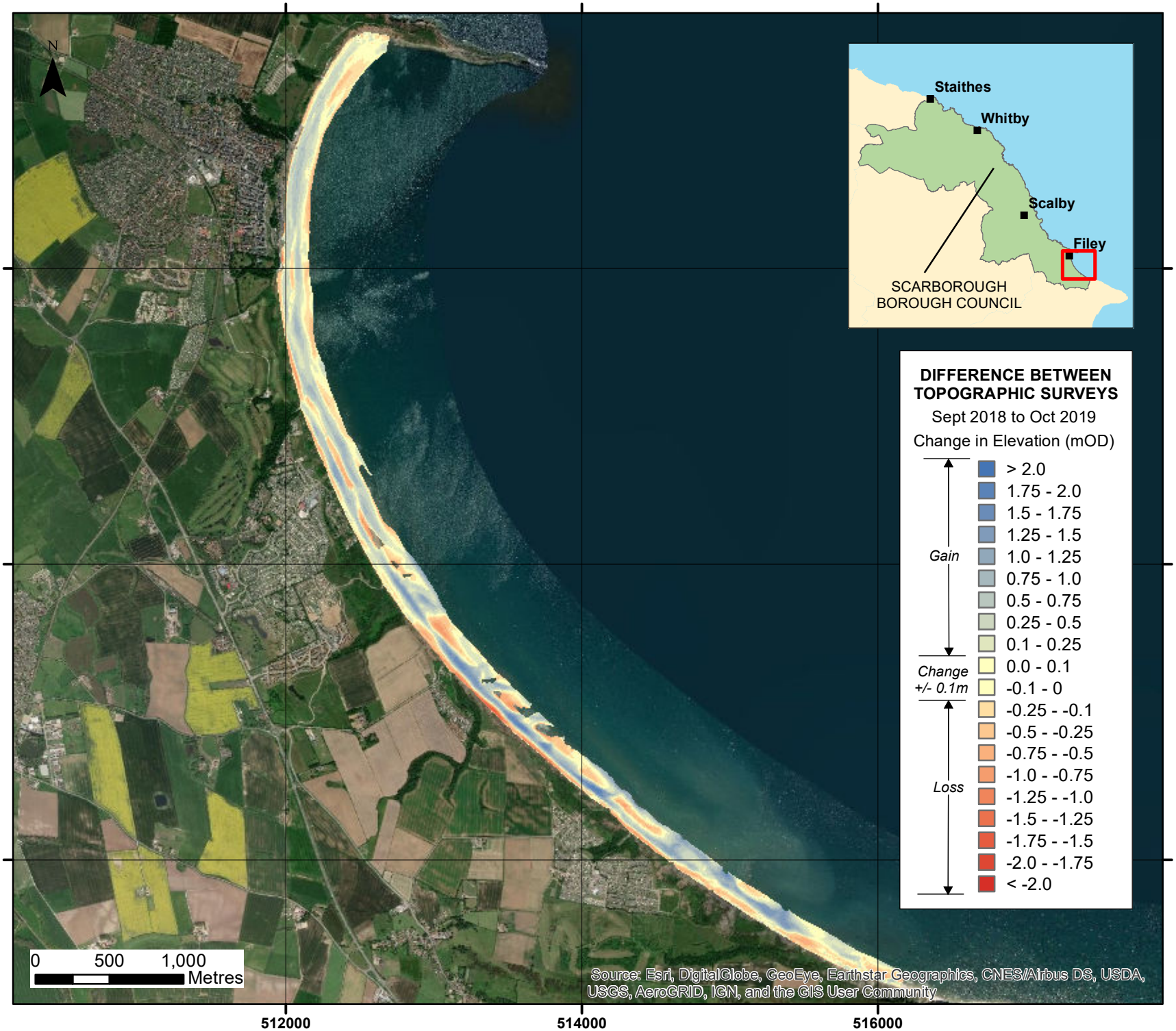

Key

Client: North East Coastal Group

Project: Cell 1 Regional Coastal Monitoring Programme

Appendix B - Map 15

FILEY BAY

Scarborough Borough Council Frontage

Analytical Report
'Full Measures' Survey 2019

Drawing Scale at A4 1:35,000

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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 Points				Distance to Cliff Top (m)			Total Erosion (m)		Erosion Rate (m/year)
Ref	Easting	Northing	Bearing (°)	Baseline Survey	Previous Survey	Present Survey	Baseline to Present	Previous to Present	Baseline to Present
STAITHES				Nov 2008	Mar 2019	Oct 2019	Nov 2008 - Oct 2019	March 2019 - Oct 2019	Nov 2008 - Oct 2019
1	477228	518769	320	1.90	-4.69	-4.87	6.77	0.18	0.62
2	477334	518798	0	10.90	10.71	10.78	0.12	-0.07	0.01
3	477487	518789	350	7.10	8.06	8.09	-0.99	-0.03	0.00
4	477594	518801	340	5.90	4.36	4.37	1.53	-0.01	0.14
5	477683	518911	350	8.40	8.80	8.35	0.05	0.45	0.00
6	477792	518867	30	8.60	8.54	8.55	0.05	-0.01	0.00
7	477891	518828	60	7.70	7.32	7.20	0.50	0.12	0.05
8	477959	518873	350	8.70	6.93	9.56	-0.86	-2.63	0.00
9	478088	518950	350	7.60	UTS	UTS	UTS	UTS	UTS
10	478191	519023	340	8.40	UTS	UTS	UTS	UTS	UTS
11	478237	519007	60	6.90	UTS	UTS	UTS	UTS	UTS
12	478213	518988	150	6.10	UTS	UTS	UTS	UTS	UTS
13	478501	518809	15	11.40	8.76	8.73	2.67	0.03	0.24
14	478624	518807	20	7.50	7.49	7.46	0.04	0.03	0.00
15	478737	518858	60	6.10	6.26	6.26	-0.16	0.00	0.00
16	478823	518757	60	8.00	8.54	8.50	-0.50	0.04	0.00
17	478944	518671	30	9.30	9.12	9.08	0.22	0.04	0.02

Ground Control Points				Distance to Cliff Top (m)			Total Erosion (m)		Erosion Rate (m/year)
Ref	Easting	Northing	Bearing (°)	Baseline Survey	Previous Survey	Present Survey	Baseline to Present	Previous to Present	Baseline to Present
STAITHES				Nov 2008	Mar 2019	Oct 2019	Nov 2008 - Oct 2019	March 2019 - Oct 2019	Nov 2008 - Oct 2019
18	479052	518630	20	9.20	9.26	9.18	0.02	0.08	0.00
19	479147	518610	0	14.20	14.36	14.36	-0.16	0.00	0.00
20	479274	518618	20	11.40	11.36	11.34	0.06	0.02	0.01

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.

Note: Shaded cells use the April 2016 Partial measures survey data for calculations as access was unavailable for the 2016 full measures survey.

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 Points				Distance to Cliff Top (m)			Total Erosion (m)		Erosion Rate (m/year)
Ref	Easting	Northing	Bearing (°)	Baseline Survey	Previous Survey	Present Survey	Baseline to Present	Previous to Present	Baseline to Present
ROBIN HOODS BAY				Mar 2010	Oct 2018	Sep 2019	Mar 2010 - Sep 2019	Apr 2019 - Sep 2019	Mar 2010 - Sep 2019
1	495799.5	506002.2	130	11.60	7.17	7.23	4.37	-0.06	0.49
2	495549.2	505807.3	135	9.30	9.04	9.02	0.28	0.02	0.03
3	495456.3	505740	130	5.00	5.44	5.35	-0.35	0.09	0.00
4	495389.9	505683.7	140	6.30	6.44	6.59	-0.29	-0.15	0.00
5	495259.4	505342.5	130	11.30	12.83	13.13	-1.83	-0.30	0.00
6	495231.2	505315.7	95	5.90	5.75	5.80	0.10	-0.05	0.01
7	495184.8	505210.7	85	6.40	7.25	7.32	-0.92	-0.07	0.00
8	495206.5	505153	75	5.00	5.25	5.34	-0.34	-0.09	0.00
9	495287.8	505060.5	80	4.30	4.54	4.69	-0.39	-0.15	0.00
10	495187.8	504708.8	70	3.10	2.38	2.45	0.65	-0.07	0.07
11	495226.2	504615.7	120	3.80	3.44	3.30	0.50	0.14	0.06
12	495297.5	504380.2	80	11.00	11.04	11.04	-0.04	0.00	0.00
13	495350.4	504193	55	3.70	3.80	3.80	-0.10	0.00	0.00

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 Points				Distance to Cliff Top (m)			Total Erosion (m)		Erosion Rate (m/year)
Ref	Easting	Northing	Bearing (°)	Baseline Survey	Previous Survey	Present Survey	Baseline to Present	Previous to Present	Baseline to Present
SCARBOROUGH SOUTH BAY				Mar 2010	Oct 2018	Nov 2019	Mar 2010-Nov 2019	Mar 2019 - Nov 2019	Mar 2010-Nov 2019
1	504339.5	487887.3	70	7.00	UTS	UTS	UTS	UTS	UTS
2	504422.3	487603.7	80	4.80	4.82	4.84	-0.04	-0.02	0.00
3	504534.8	487318.3	40	15.10	15.10	15.11	-0.01	-0.01	0.00
4	504730.2	487137.9	55	9.60	9.63	9.65	-0.05	-0.02	0.00
5	504922.9	486837.8	60	8.80	8.66	8.58	0.22	0.08	0.02
6	50571.1	486652.1	75	3.80	3.67	3.67	0.13	0.00	0.01
7	505284.3	486480	35	7.00	6.72	6.67	0.33	0.05	0.04
8	505597.9	486363.4	30	8.60	8.31	8.46	0.14	-0.15	0.02
9	505758.6	486005.1	45	9.10	8.49	8.48	0.62	0.01	0.07
10	505896	485889.6	15	14.80	14.72	14.70	0.10	0.02	0.01
11	505990	485657.1	80	4.70	1.37	1.08	3.62	0.29	0.40
12	506024.9	485421.8	55	6.10	3.15	3.16	2.94	-0.01	0.33
13	506036	485315.3	90	7.00	7.10	7.00	0.00	0.10	0.00

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 Points				Distance to Cliff Top (m)			Total Erosion (m)		Erosion Rate (m/year)
Ref	Easting	Northing	Bearing (°)	Baseline Survey	Previous Survey	Present Survey	Baseline to Present	Previous to Present	Baseline to Present
CAYTON BAY				Nov 2008	Oct 2018	Nov 2019	Nov 2008 - Nov 2019	Mar 2019 - Nov 2019	Nov 2008 - Nov 2019
1	506325.5	484849.7	50	4.00	3.60	3.57	0.43	0.03	0.04
2	506459.4	484715.9	65	5.00	UTS	UTS	UTS	UTS	UTS
3	506597.4	484538.6	65	5.00	6.26	6.28	-1.28	-0.02	0.00
4	506778.1	484345.5	21	9.00	5.97	5.87	3.13	0.10	0.28
5	507018.6	484221.6	342	7.70	7.81	8.03	-0.33	-0.22	0.00
6	507242.3	484121.7	2	7.40	5.91	5.88	1.52	0.03	0.14
7	507518.2	484008.2	25	7.50	7.64	7.58	-0.08	0.06	0.00
8	507818.7	484006	1	5.50	5.43	5.40	0.10	0.03	0.01

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 Points				Distance to Cliff Top (m)			Total Erosion (m)		Erosion Rate (m/year)
Ref	Easting	Northing	Bearing (°)	Baseline Survey	Previous Survey	Present Survey	Baseline to Present	Previous to Present	Baseline to Present
FILEY				Nov 2008	Sep 2018	Sept 2019	Nov 2008 - Sep 2019	Mar 2019 - Sep 2019	Nov 2008 - Sep 2019
1	512444.9	481630.9	130	8.70	8.44	8.40	0.30	0.04	0.03
2	512306.7	481490.3	144	7.60	7.88	7.83	-0.23	0.05	0.00
3	512153.6	481234.6	122	8.30	8.12	8.05	0.25	0.07	0.02
4	512029.2	480959.9	115	7.40	7.26	7.22	0.18	0.04	0.02
5	511895.4	479888	89	7.10	0.59	UTS	UTS	UTS	UTS
6	511908.5	479597.1	48	6.70	5.62	5.47	1.23	0.15	0.11
7	511991.4	479310.4	69	6.70	4.27	1.84	4.86	2.43	0.44
8	512083.4	478981.5	66	10.20	10.14	10.01	0.19	0.13	0.02
9	512121.3	478786.3	76	8.30	8.39	8.39	-0.09	0.00	0.00
10	512226.2	478547.9	74	7.50	5.96	5.85	1.65	0.11	0.15
11	512471.4	478153.5	53	6.60	6.67	6.65	-0.05	0.02	0.00
12*	512558.9	477901.9	66	7.70	UTS	UTS	UTS	UTS	UTS
12A*	512655.8	477822.4	67	13.90	13.13	13.12	0.78	0.01	0.07
13**	512697.6	477719	34	4.20	UTS	UTS	UTS	UTS	UTS
13A*	512805.5	477572.1	32	13.42	13.29	13.06	0.36	0.23	0.03
14	512939.4	477400.9	66	8.00	6.36	6.38	1.62	-0.02	0.15
15	513157	477192.7	51	5.20	4.60	4.59	0.61	0.01	0.06
16	513299.5	477024.6	30	7.70	6.55	6.38	1.32	0.17	0.12
17	513507.7	476821.1	34	10.70	10.36	10.33	0.37	0.03	0.03

Ground Control Points				Distance to Cliff Top (m)			Total Erosion (m)		Erosion Rate (m/year)
Ref	Easting	Northing	Bearing (°)	Baseline Survey	Previous Survey	Present Survey	Baseline to Present	Previous to Present	Baseline to Present
FILEY				Nov 2008	Sep 2018	Sept 2019	Nov 2008 - Sep 2019	Mar 2019 - Sep 2019	Nov 2008 - Sep 2019
18	513721	476602.3	31	7.20	6.12	6.08	1.12	0.04	0.10
19	513916.6	476354.1	51	6.60	6.30	6.37	0.23	-0.07	0.02
20	514174.8	476179.4	32	7.00	6.90	6.96	0.04	-0.06	0.00
21	514471.5	475965.7	66	7.60	7.44	7.46	0.14	-0.02	0.01
22	514656.2	475728.8	101	8.10	8.14	8.12	-0.02	0.02	0.00
23	514889.5	475537.6	60	9.10	8.05	7.95	1.15	0.10	0.10
24*	512603.7	481665.9	14	19.90	19.78	19.80	0.10	-0.02	0.01
25*	512607.1	481648.9	184	17.20	17.04	16.95	0.25	0.09	0.02
26*	512301.9	481825.5	18	11.00	10.88	10.88	0.12	0.00	0.01
27*	512475.8	481712.1	20	11.60	11.51	11.51	0.09	0.00	0.01

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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