Cell 1 Regional Coastal Monitoring Programme Analytical Report 11: 'Full Measures' Survey 2018

Redcar and Cleveland Borough Council

March 2019

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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
HAT	3.25	3.18	3.15	3.10
MHWS	2.65	2.68	2.65	2.60
MLWS	-1.95	-2.13	-2.15	-2.20
Water Level Parameter	**Water Level (m AOD) Saltwick Nab to Hundale Point**	**Hundale Point to White Nab**	**White Nab to Filey Brigg**	**Filey Brigg to Flamborough Head**
HAT	3.10	3.05	3.05	3.10
MHWS	2.60	2.45	2.45	2.50
MLWS	-2.20	-2.35	-2.35	-2.30

Source: *River Tyne to Flamborough Head Shoreline Management Plan 2*. Royal Haskoning, February 2007.

Glossary of Terms

Term	Definition
Beach nourishment	Artificial process of replenishing a beach with material from another source.
Berm crest	Ridge of sand or gravel deposited by wave action on the shore just above the normal high water mark.
Breaker zone	Area in the sea where the waves break.
Coastal squeeze	The reduction in habitat area which can arise if the natural landward migration of a habitat under sea level rise is prevented by the fixing of the high water mark, e.g. a sea wall.
Downdrift	Direction of alongshore movement of beach materials.
Ebb-tide	The falling tide, part of the tidal cycle between high water and the next low water.
Fetch	Length of water over which a given wind has blown that determines the size of the waves produced.
Flood-tide	Rising tide, part of the tidal cycle between low water and the next high water.
Foreshore	Zone between the high water and low water marks, also known as the intertidal zone.
Geomorphology	The branch of physical geography/geology which deals with the form of the Earth, the general configuration of its surface, the distribution of the land, water, etc.
Groyne	Shore protection structure built perpendicular to the shore; designed to trap sediment.
Mean High Water (MHW)	The average of all high waters observed over a sufficiently long period.
Mean Low Water (MLW)	The average of all low waters observed over a sufficiently long period.
Mean Sea Level (MSL)	Average height of the sea surface over a 19-year period.
Offshore zone	Extends from the low water mark to a water depth of about 15 m and is permanently covered with water.
Storm surge	A rise in the sea surface on an open coast, resulting from a storm.
Swell	Waves that have travelled out of the area in which they were generated.
Tidal prism	The volume of water within the estuary between the level of high and low tide, typically taken for mean spring tides.
Tide	Periodic rising and falling of large bodies of water resulting from the gravitational attraction of the moon and sun acting on the rotating earth.
Topography	Configuration of a surface including its relief and the position of its natural and man-made features.
Transgression	The landward movement of the shoreline in response to a rise in relative sea level.
Updrift	Direction opposite to the predominant movement of longshore transport.
Wave direction	Direction from which a wave approaches.
Wave refraction	Process by which the direction of approach of a wave changes as it moves into shallow water.

Preamble

The Cell 1 Regional Coastal Monitoring Programme covers approximately 300km of the north east coastline, from the Scottish Border (just south of St. Abb's Head) to Flamborough Head in East Yorkshire. This coastline is often referred to as 'Coastal Sediment Cell 1' in England and Wales (Figure 1). Within this frontage, the coastal landforms vary considerably, comprising low-lying tidal flats with fringing salt marshes, hard rock cliffs that are mantled with glacial sediment to varying thicknesses, softer rock cliffs and extensive landslide complexes.

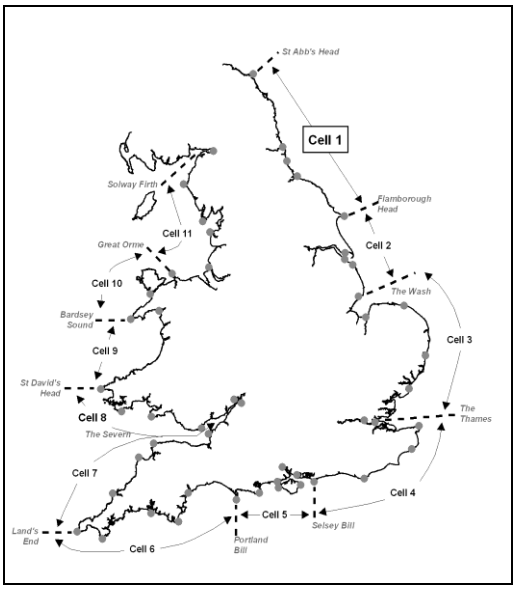


Figure 1 Sediment Cells in England and Wales

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

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

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

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

Each year, an Analytical Report is produced for each individual authority, providing a detailed analysis and interpretation of the 'Full Measures' surveys. This is followed by a brief Update Report for each individual authority, providing ongoing findings from the 'Partial Measures' surveys.

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

Table 1 Analytical, Update and Overview Reports Produced to Date

Year		Full Measures		Partial Measures		Cell 1 Overview Report
		Survey	Analytical Report	Survey	Update Report	
1	2008/09	Sep-Dec 08	May 09	Mar-May 09		-
2	2009/10	Sep-Dec 09	Mar 10	Feb-Mar 10	Jul 10	-
3	2010/11	Aug-Nov 10	Feb 11	Feb-Apr 11	Aug 11	Sep 11
4	2011/12	Sep-Oct 11	Oct 12	Mar-May 12	Feb 13	
5	2012/13	Sep 12	Mar 13	Feb- Mar 13	May 13	
6	2013/14	Oct-Nov 13	Feb 14	Mar-Apr 14	Jul 14	
7	2014/15	Sep-Oct 14	Feb 15	Mar-Apr	Jul 15	
8	2015/16	Sep-Oct 15	Feb 16	Mar 16	Jul 16	
9	2016/17	Sep-Nov 16	Feb 17	Mar 16	Jul 16	Jun 16
10	2017/18	Oct 17	Mar 18	Mar-May 18	Jun 18	
11	2018/19	Sep 18	Mar 19 (*)			

* The present report is **Analytical Report 11** and provides an analysis of the 2018 Full Measures survey for Redcar and Cleveland 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 sections listed in Table 2.

Table 2 Sub-divisions of the Cell 1 Coastline

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

1. Introduction

1.1 Study Area

Redcar & Cleveland Borough Council's frontage extends from the South Gare breakwater at the mouth of the River Tees to Cowbar Nab, Staithes. For the purposes of this report, report and for consistency with previous reporting, it has been sub-divided into six areas, namely:

- Coatham Sands
- Redcar Sands
- Marske Sands
- Saltburn Sands
- Cattersty Sands (Skinningrove)
- Staithes

The Staithes frontage straddles the boundary of jurisdiction of Redcar & Cleveland Council and Scarborough Borough Council and therefore reporting has been duplicated in both reports.

1.2 Methodology

Along Redcar & Cleveland Borough Council's frontage, the following surveying is undertaken:

- Full Measures survey annually (since 2008) each autumn/early winter comprising:
    - Beach profile surveys along nine transect lines
    - Topographic survey along Coatham Sands
    - Topographic survey along Redcar Sands
    - Topographic survey along Marske Sands
    - Topographic survey along Saltburn Sands
    - Topographic survey along Cattersty Sands
- Partial Measures survey annually each spring (since 2009) comprising:
    - Beach profile surveys along nine transect lines
    - Topographic survey along Redcar Sands
    - Topographic survey along Saltburn Sands
    - Topographic survey along Cattersty Sands
- Cliff top survey annually at:
    - Staithes

The Full Measures survey was undertaken along this frontage in September 2018. The weather and sea state varied considerably, for further details please refer to the Survey Report from Academy Geomatics.

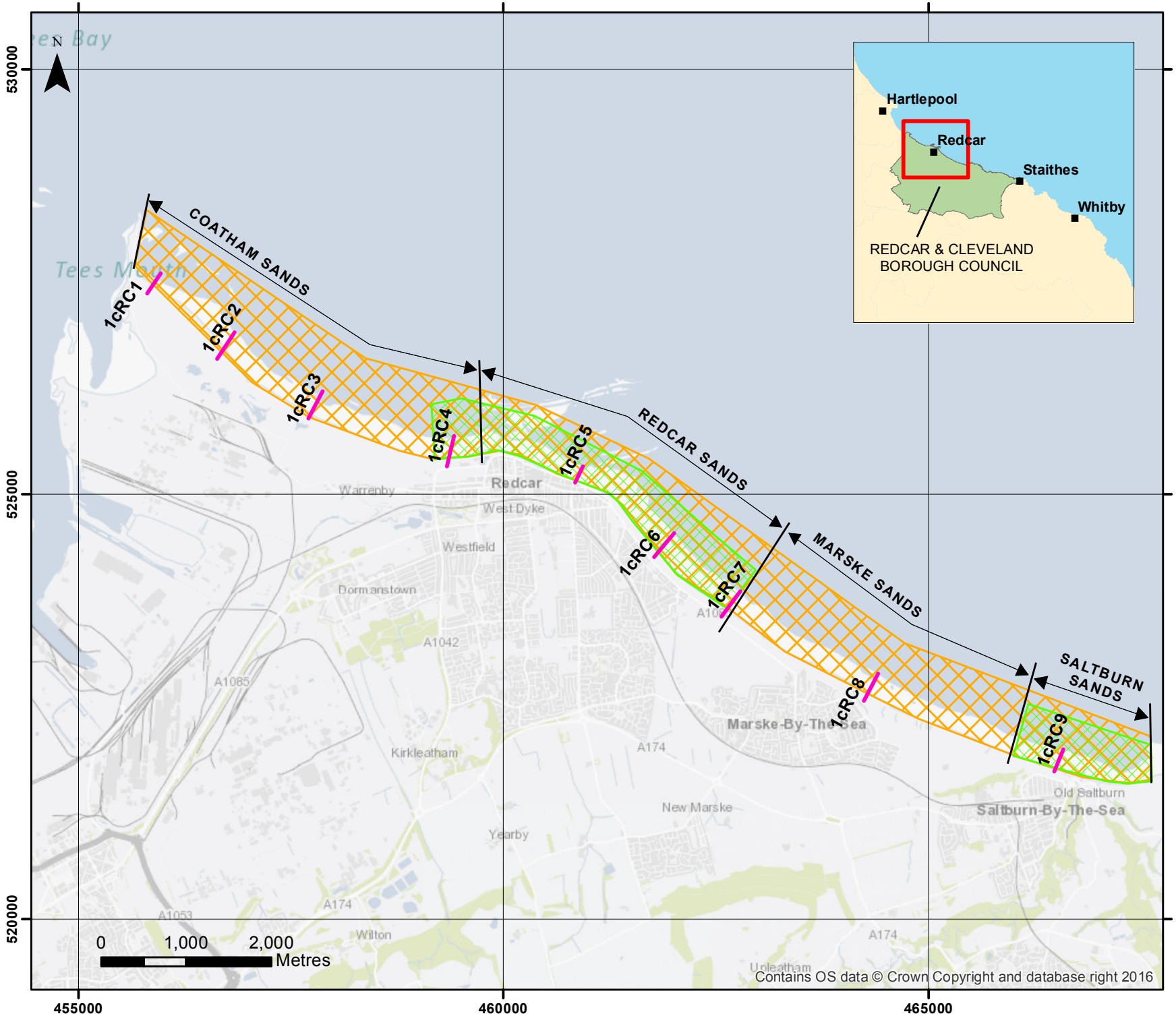
All data have been captured in a manner commensurate with the principles of the Environment Agency's *National Standard Contract and Specification for Surveying Services* and stored in a file format compatible with the software systems being used for the data analysis, namely SANDS and ArcGIS. This data 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

Redcar & Cleveland Borough Council Frontage

Analytical Report
Topo Surveys

Drawing Scale at A4 1:60,000

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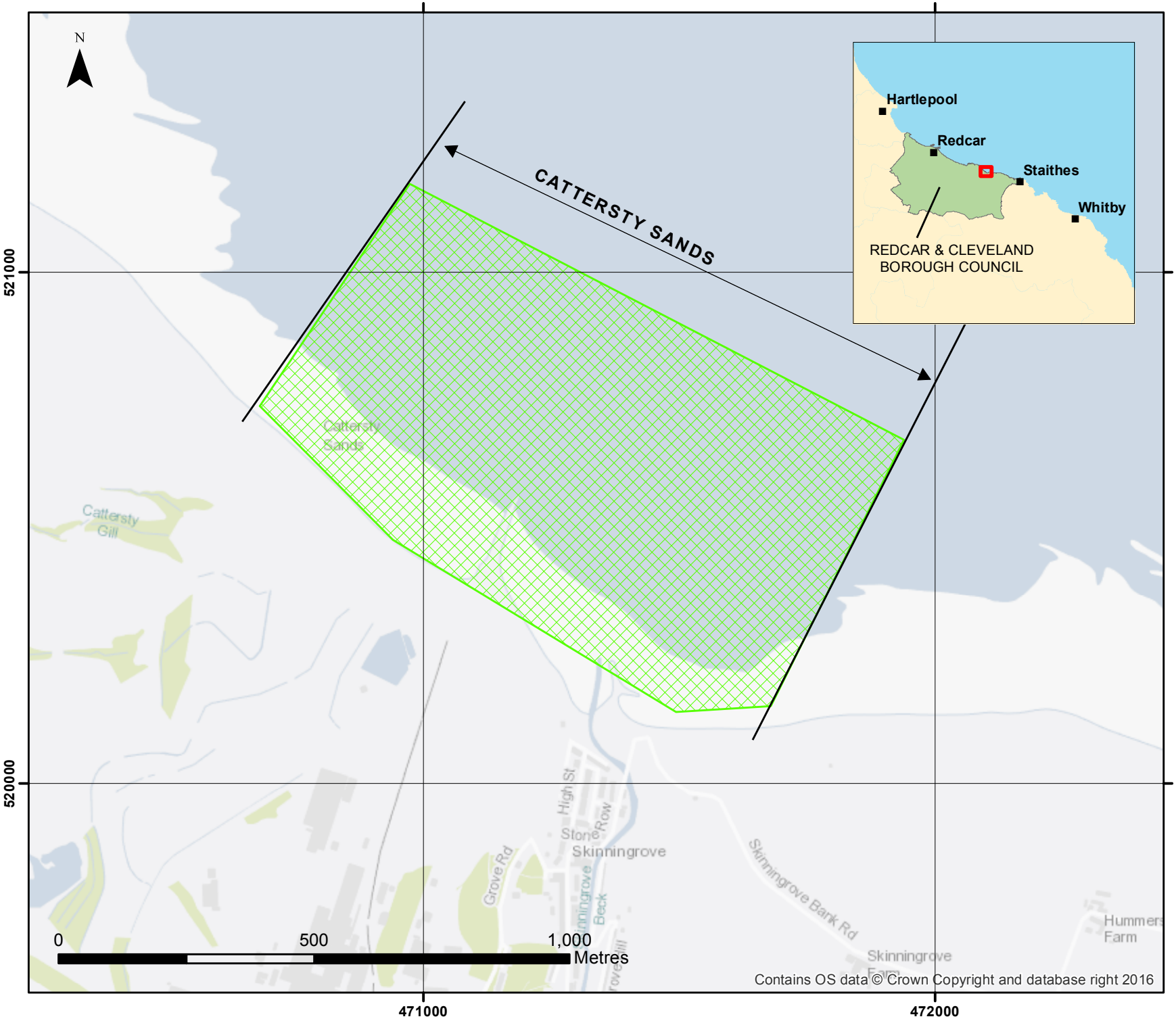

Key

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

Redcar & Cleveland Borough Council Frontage

Analytical Report
Topo Surveys

Drawing Scale at A4 1:10,000

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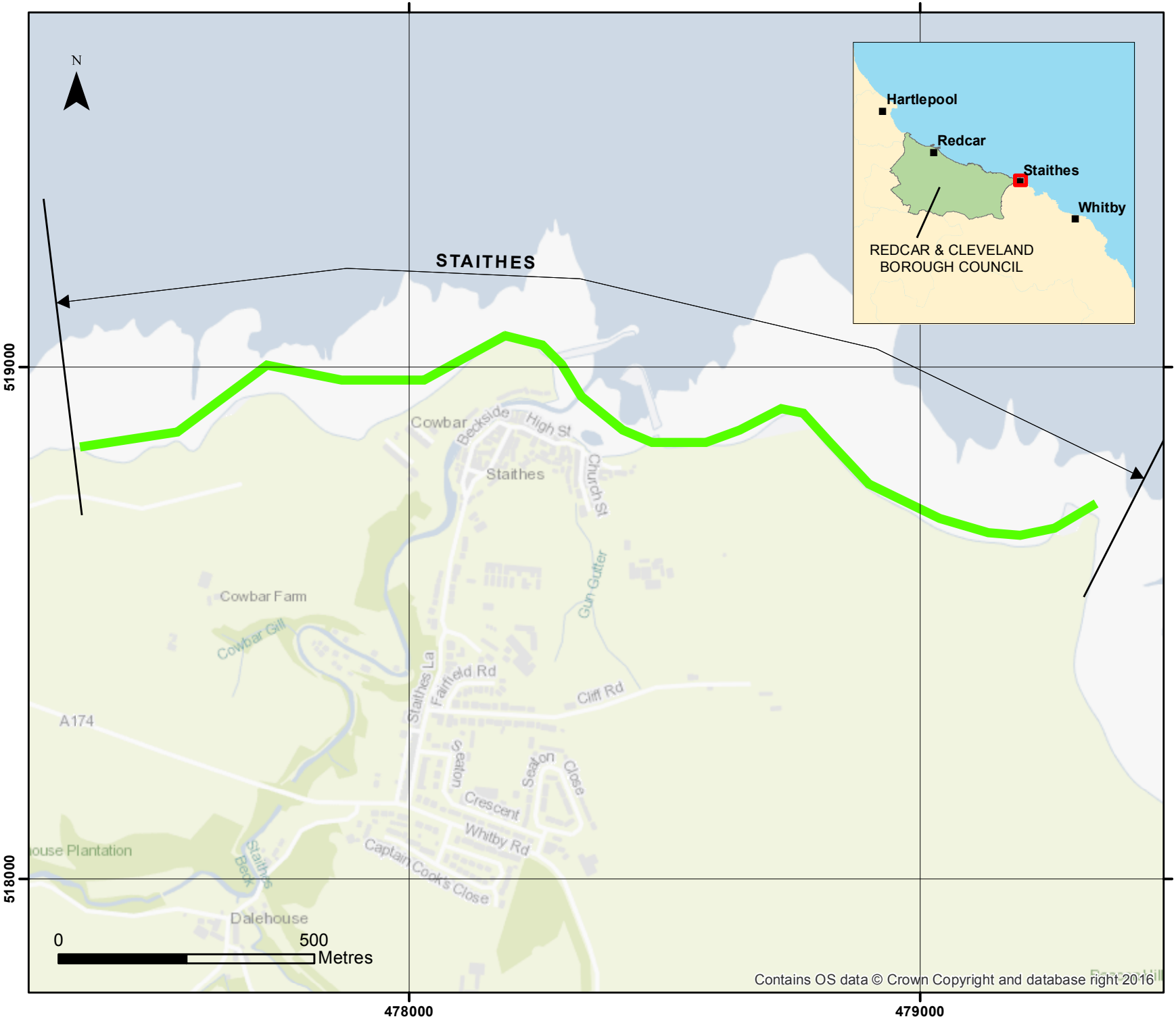

Key

SURVEY LOCATIONS

Frequency

@ 50

@ 100

@ 300

(Indicative Survey Extents shown)

Client: North East Coastal Group

Project: Cell 1 Regional Coastal Monitoring Programme

Figure 2 - Map 3

Redcar & Cleveland Borough Council Frontage

Analytical Report
Topo Surveys

Drawing Scale at A4 1:10,000

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2. Analysis of Survey Data

2.1 Coatham Sands

Survey Date	Description of Changes Since Last Survey	Interpretation
24th – 27th September 2018	**Beach Profiles:** Coatham Sands is covered by four beach profile lines during the Full Measures survey (RC1 to RC4; Appendix A). Profile **1cRC1** is located approximately 300m south of the South Gare breakwater, in the lee of the German Charlies slag banks. The upper profile is dominated by dune ridges, which have remained stable since the 2009 surveys. The foredune has undergone negligible accretion by <0.1m. There has been accretion from the toe of the dunes to chainage 212m of up to 1.2m. At the toe of the beach, between chainages 212m and 299m there has been erosion of up to 0.8m. Seawards of chainage 299m there has been slight accretion of <0.3m. The impact of these changes is to steepen the profile of the beach. Overall, the beach level remains high compared to the range recorded from previous surveys, reaching its highest level recorded seaward of chainage 299m. At Profile **1cRC2,** the dunes continue to remain stable. Over the summer of 2018, the foredunes between chainages 65m and 87m have eroded on the landward slope and accreted at the crest by up to 0.2m. There has been a small amount of accretion at the toe of the dunes of up to 0.3m to chainage 132m. The majority of the beach profile shows accretion of up to 0.3m. There is one small area of erosion between chainage 312m and 336m of up to 0.1m. The toe of the beach has accreted by up to 0.3m and extended seaward by 64m. The beach levels are medium compared to the range recorded from the previous surveys, however the foredunes are at their highest recorded level since records began in 2008. Profile **1cRC3** shows stable dunes and an accreting beach profile as far as 260m chainage, by up to 0.2m. Seaward of 260m, the toe of the beach has eroded by 0.25m and moved landward by 7m. Overall, the beach level is medium to low compared with the range recorded from the previous surveys, however the dunes are at a high level. Profile **1cRC4** is the beginning of the defended section at Redcar. The seaward face of the foredunes has moved landward by approximately 0.8m, with a small section of accretion at the toe of the dunes by	Overall, the dunes have remained stable at Coatham Sands since the previous partial measures survey, whilst beach levels have seen accretion over the intervening period, covering the summer of 2018. In contrast, the difference plot between the last full measures survey in Autumn 2017 and this present one in Autumn 2018 show predominantly low level erosion across the beach and low level accretion concentrated towards the northwest of the survey extent. **Longer term trends**: The magnitude of change in 2018 is more modest than that seen in the past. The upper beach in the southern part of the frontage has shown consistent erosion.

Survey Date	Description of Changes Since Last Survey	Interpretation
	up to 0.2m. On the upper beach there has been negligible erosion of up to 0.1m to chainage 48m. Overall, the beach level has accreted across the middle beach since the previous survey, by up to 0.2m. Seaward of chainage 279m there has been erosion of up to 0.3m, moving the toe of the beach landward by 16m. Overall, the beach level is at a medium to high level compared to the range recorded from previous surveys.	
Sept 2018	**Topographic Survey:** Coatham Sands is covered by an annual topographic survey extending from the South Gare Breakwater, although the survey is contiguous with the 6-monthly Redcar Sands survey. Data have been used to create a DGM (Appendix B – Map 1) using GIS. This shows that the beach contours recorded in Autumn 2018 were relatively shore parallel along the frontage, with a gently shelving beach slope. The beach is narrower and steeper to the north west of the subtle promontory around 1km SE of the breakwater and of shallower gradient further south-east. The GIS has also been used to calculate the differences between the current topographic (Autumn 2018) survey and the earlier topographic survey (Autumn 2017), as shown in Appendix B – Map 5, to identify areas of erosion and accretion. The topographic difference plot shows the beach is dominated by low level erosion across the survey area, with the greatest losses concentrated towards the easternmost part of the survey area. Accretion is concentrated on the middle and lower beach in the north-western survey area, the lower beach of the central area and east of Coatham Rocks. Overall change is limited to ±0.1m.	

2.2 Redcar Sands

Survey Date	Description of Changes Since Last Survey	Interpretation
24th – 27th September 2018	**Beach Profiles:** Redcar Sands is covered by three beach profile lines during the Full Measures survey (RC5 to RC7; Appendix A), with RC7 being approximately on the boundary with the Marske Sands area. At profile **1cRC5,** there has been accretion of 1.0m at the toe of the sea defence, continuing to chainage 112m with accretion more commonly up to 0.3m, covering a previously exposed rock platform. Seaward of chainage 112m the beach has dropped by up to 0.2m, exposing rocks at chainage 140m to 170m. The level of the beach is high on the upper beach (particularly at the toe of the sea defence which is at its highest level recorded), medium on the middle beach until the rock platform, where the lower beach is once again at a high level. At profile **1cRC6,** there has been a small section of erosion of up to 0.2m between chainages 58m and 73m. Across the rest of the beach profile, there has been accretion of up to 0.4m on the upper beach and 0.25m on the lower beach, with negligible change on the middle beach. As a result, the September 2018 profile is at a medium level compared to the range recorded from previous surveys. Profile **1cRC7** has experienced very little change on the dune frontage since April 2018. The upper and lower beach show accretion of up to 0.8m, whereas there has been erosion between chainage 182m to 255m of up to 0.9m forming a depression. Overall, the beach is at a medium-low level compared to the range recorded by the previous surveys, particularly at the depression which is at its lowest level between chainages 202m and 244m.	All three of the profiles show varying beach levels in autumn 2018, ranging from higher levels in the west, to lower levels in the east, however accretion is dominant across all three profiles. The topographic change plot between April 2018 and September 2018 reflects this pattern with accretion dominating since the Spring survey, and erosion generally restricted to isolated patches in the middle to lower beach. The pattern of change between Autumn 2017 and Autumn 2018 shows a more dominant trend of erosion across the beach with small patches of accretion on the upper beach. **Longer term trends**: The beach levels are generally at a medium to high level compared to previous years, suggesting recovery since the storms and surge of winter 2013/14. The exception is the depression formed at profile 1cRC7 which is at the lowest level recorded since surveys began. The most substantial accretion in front of the new defences may relate to the defence improvements introducing a less reflective seawall.
Sept 2018	**Topographic Survey:** Redcar Sands is covered by a six-monthly topographic survey. Data have been used to create a DGM (Appendix B – Map 2) using GIS. The plot shows shore-parallel contours for most of the frontage with the exception of the beach in front of Redcar, where there is a bay between the Redcar Rocks and West Scar. The most landward part of this embayment is close to Redcar Esplanade, where the beach is steeper than on any of the surrounding coast. The coastal defence scheme here was constructed	

Survey Date	Description of Changes Since Last Survey	Interpretation
	between the October 2012 and March 2013 surveys. The GIS has also been used to calculate the differences between the current topographic survey (Autumn 2018) and the previous full measures survey (Autumn 2017) and the most recent (Spring 2018) topographic survey, as shown in Appendix B – Maps 6 and 9, to identify areas of erosion and accretion. To the east of Redcar Rocks the changes are dominated by accretion between Spring 2018 and Autumn 2018. The pattern of change between Autumn 2017 and Autumn 2018 shows a more dominant trend of erosion across the beach with small patches of accretion on the upper beach. Between Coatham Rocks and Redcar Rocks there was accretion on the upper and middle beach and erosion on the lower beach between the April 2018 and September 2018 surveys, however when compared to the October 2017 survey there has been erosion across the beach to the east and west, with accretion confined to a small area in the centre To the west of Coatham Rocks there has been little change, with accretion being more typical between both surveys.	

2.3 Marske Sands

Survey Date	Description of Changes Since Last Survey	Interpretation
27th Sept 2018	**Beach Profiles:** Marske Sands is covered by two beach profile lines during the Full Measures survey (RC7 to RC8; Appendix A), with RC7 being approximately on the boundary with the Redcar Sands area. Profile **1cRC7** is located along The Stray and has been discussed in Section 2.2. At profile **1cRC8**, a berm has formed on the upper beach at chainage 93m with the accretion of 1.6m, reaching its highest level recorded. Between chainage 122m and 138m there has been a small section of erosion of up to 0.2m, followed by a section of accretion to chainage 193m of up to 0.8m, infilling a hollow formed in the Spring 2018 survey. Seaward of chainage 193m, the toe of the beach has eroded by up to 0.8m. Except for the berm at chainage 93m, the rest of the beach profile is at a relatively low level compared to the range recorded from previous surveys.	The impact of the December 2013 storm surge is still evident at the cliff toe in the profiles above HAT because the dune face is steep, however sand has now started to accrete at the toe. The general pattern is of stability. The difference plot for Autumn 2017 to Autumn 2018 shows accretion and erosion as shore parallel bands, with accretion more dominant across the upper and lower beach and erosion across the middle beach and beach toe. **Longer term trends:** Current beach profiles are relatively low, with the depression at profile 1cRC7 reaching its lowest level recorded. The berm at profile 1cRC8 has accreted to its highest level recorded. The change is due to the movement of bars on the beach, which is also shown on the topographic difference plots.
Sept 2018	**Topographic Survey:** Marske Sands is covered by an annual topographic survey. This survey is contiguous with the Redcar Sands and Saltburn Sands topographic surveys that are both surveyed six-monthly. Data have been used to create a DGM (Appendix B – Map 2) using GIS. The GIS has also been used to calculate the differences between the Autumn 2017 and Autumn 2018 topographic survey, as shown in Appendix B – Map 7. The topographic contours are generally shore parallel except where the outfalls of small, culverted streams issue in front of the Marske itself. Since the previous topographic survey in Autumn 2017, accretion and erosion has occurred in a shore parallel pattern, though generally accretion dominates on the upper and lower beach, with erosion concentrated in the middle. Magnitudes of change are modest at approximately ±1.5m.	

2.4 Saltburn Sands

Survey Date	Description of Changes Since Last Survey	Interpretation
24th – 27th September 2018	**Beach Profiles:** Saltburn Sands is covered by one beach profile during the Full Measures survey (RC9; Appendix A). At profile **1cRC9**, there has been erosion at the toe of the sea wall from chainage 21m to 29m by up to 0.25m. . From chainage 29m to 146m, the upper and middle beach has accreted by up to 0.4m. Seaward of chainage 146m, there is negligible change in beach level, except at the beach toe where erosion of 0.2m has occurred. Overall, the beach is at a medium level compared to the range recorded from previous surveys, although it is relatively low in the lower beach.	The beach showed an overall increase in level at profile 1cRC9. The difference plot between the last partial measures survey in Spring 2018 and the present full measures survey in Autumn 2018 shows accretion across much of the beach, although small in magnitude. There is limited erosion across much of the upper beach. The difference plot between the last full measures survey in Autumn 2017 and the present full measures survey in Autumn 2018 shows a slightly more erosive trend overall, although all changes are low in magnitude. **Longer term trends**: The April 2018 beach level was one of the lowest recorded profile since 2008, suggesting progressive erosion, however this survey shows recovery of beach levels. This is a similar pattern to 2017.
Sept 2018	**Topographic Survey:** Saltburn Sands is covered by a six-monthly topographic survey, although the survey is contiguous with the Marske Sands topographic survey that is surveyed annually. Data have been used to create a DGM (Appendix B – Map 3) using a GIS software package. This shows that the beach contours are shore parallel and gently shelving for the majority of the frontage. The contours are slightly indented opposite Skelton Beck, where the stream has eroded the foreshore. The GIS has also been used to calculate the differences over the six month period between Spring 2018 and Autumn 2018 topographic survey, as shown in Appendix B – Map 10, and the change since the last full measures survey in autumn 2017, to identify areas of net erosion and accretion (Appendix B – Map 7). For the plot showing changes since spring 2017 there are significantly more areas of accretion than erosion but the changes are generally of a small magnitude. There is however a narrow band of erosion at the uppermost beach along much of the survey length compared with the April 2018 survey. For the plot showing changes since October 2017, the beach is dominated by modest rates of erosion across the whole beach, lessening slightly to the east of the survey extent. The main area of accretion is confined to a narrow band along the upper beach in the central survey area, with some smaller patches on the middle and lower beach.	

2.5 Cattersty Sands

Survey Date	Description of Changes Since Last Survey	Interpretation
Sept 2018	**Topographic Survey:** Cattersty Sands is covered by a six-monthly topographic survey. Data have been used to create a DGM (Appendix B – Map 4) using a GIS package. The beach is steeper to the west of the breakwater than the east, but in both areas the gradient is relatively smooth. East of the breakwater, the beach is punctuated by Kilton Beck and the harbour so the gradient is shallower. Immediately east of the former fishtail groyne (which has since been modified to a rock breakwater arm), the stream has cut a channel, which is most deeply incised at its landward extent. The GIS has also been used to calculate the differences between Spring 2018 and Autumn 2018 topographic surveys and is presented as DGM (as shown in Appendix B – Map 8), to identify areas of net erosion and accretion. The difference plot shows a patchy distribution of accretion and erosion. To the west of the breakwater, shore parallel bands of accretion and erosion are evident, although changes are low in magnitude . To the east of the breakwater, accretion dominates, however change is not as shore-parallel as seen to the west of the breakwater. The main areas of accretion occur on the upper beach in the channel of the stream and to the east of the former fishtail groyne. There are some patches of erosion on the lower beach towards the breakwater, and on the lower beach to the east of the former fishtail groyne.	The topographic change data shows Cattersty Sands is very dynamic, influenced by both coastal and fluvial processes and the breakwater. Short term change, over the preceding six-monthly shows similar beach behaviour either side of the breakwater with accretion being dominant. **Longer term trends**: In contrast to the long term pattern, accretion occurred in the channel to the east of the survey. Accretion in the mid beach continued and the patch of erosion on the lower beach continued from the previous survey, although this is not a long term trend for the beach. The winter erosion dominates the overall behaviour of the beach but the calmer weather in the summer months should lead to some accretion. If the erosion of the upper beach continues, it is likely to drive cliff failures, which would add material to the upper beach for redistribution.

2.6 Staithes

Survey Date	Description of Changes Since Last Survey	Interpretation
Sept 2018	**Cliff-top Survey:** Twenty ground control points have been established at Cowbar and Staithes for biannual cliff top monitoring. Locations 12 to 20 are in the Scarborough Borough Council area. The separation between any two points is around 100 m. Data collection involves a distance offset measurement from the ground control point to the cliff edge along a fixed bearing. Between April 2018 and September 2018, 4 of the posts were not measured due to access issues. Of the 16 remaining, 8 posts showed change within a range of ±0.1m, which is not considered significant given the error of the technique. Posts 1, 13 and 16 showed erosion with 4.61m, 0.24m and 0.11m cliff recession recorded respectively. At Post 1, the surveyor notes that a significant cliff fall has occurred since the previous survey and the cliff top is now at risk of undermining the edge of the coastal path. Posts 3, 4, 15 and 18 showed accretion of 0.11m, 0.11m, 0.18m, 0.12m and 0.11m recorded respectively. This is likely to be the product of differing survey interpretation, and far less likely to be a toppling cliff edge and therefore are not analysed further. 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 0.14-0.59 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 September 2018 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 2018. 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 6.47m (±0.3m) between the November 2008 baseline and September 2018, resulting in a long-term average recession rate of 0.59m/yr. 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.

3. Problems Encountered and Uncertainty in Analysis

Cliff Top Surveys

The cliff top surveys at Staithes are assumed to have a limit of accuracy of ± 0.1m due to the techniques used. Posts 9 to 12 were still inaccessible due to a landslip on the headland; the area was fenced off by the National Trust. Additionally, there was a significant cliff fall at Post 1 and the cliff top is now at the edge of the track.

At Cattersty Sands, an area of cliff face had collapsed.

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

There are no current recommendations for 'fine-tuning' the monitoring programme.

5. Conclusions and Areas of Concern

- At Coatham Sands, there has been accretion across all profiles with beach levels being high compared to the range recorded from previous surveys.
- At Redcar Sands there has been some loss of material from the middle beach but accretion has dominated. Overall, profiles remain high in the west and lower in the east compared to the range recorded from previous surveys.
- At Marske Sands, the 2018 beach profiles show the beach is generally accreting, with two prominent areas of erosion at the middle beach at profile 1cRC7 and lower beach of 1cRC8. The short term topographic change plot reflects this with evidence of the migration of beach berms.
- The beach at Saltburn Sands has shown some recovery in levels between April and September 2018, which is a similar pattern to 2017.
- The Cattersty Sands difference model shows that the changes in the summer of 2018 were of similar magnitude either side of the breakwater, however changes have occurred in a shore parallel pattern to the west compared to the east. Overall, accretion occurred on the upper and middle beach, with erosion on the lower beach. In contrast to previous surveys, accretion has occurred in the stream channel in the lee of the former fishtail groyne.
- The measurements of the Cowbar and Staithes cliff top show erosion of between 0.1 and 4.6m over the summer of 2018 at three stations. The largest amount of erosion occurred at Post 1 (4.61m) as a result of cliff failure, which has now led to concerns that the coastal path could be undermined. This area should be monitored for further cliff failures and addressed in the next Partial Measures Survey Report. A further four stations continued to be inaccessible due to a landslip on the headland.

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

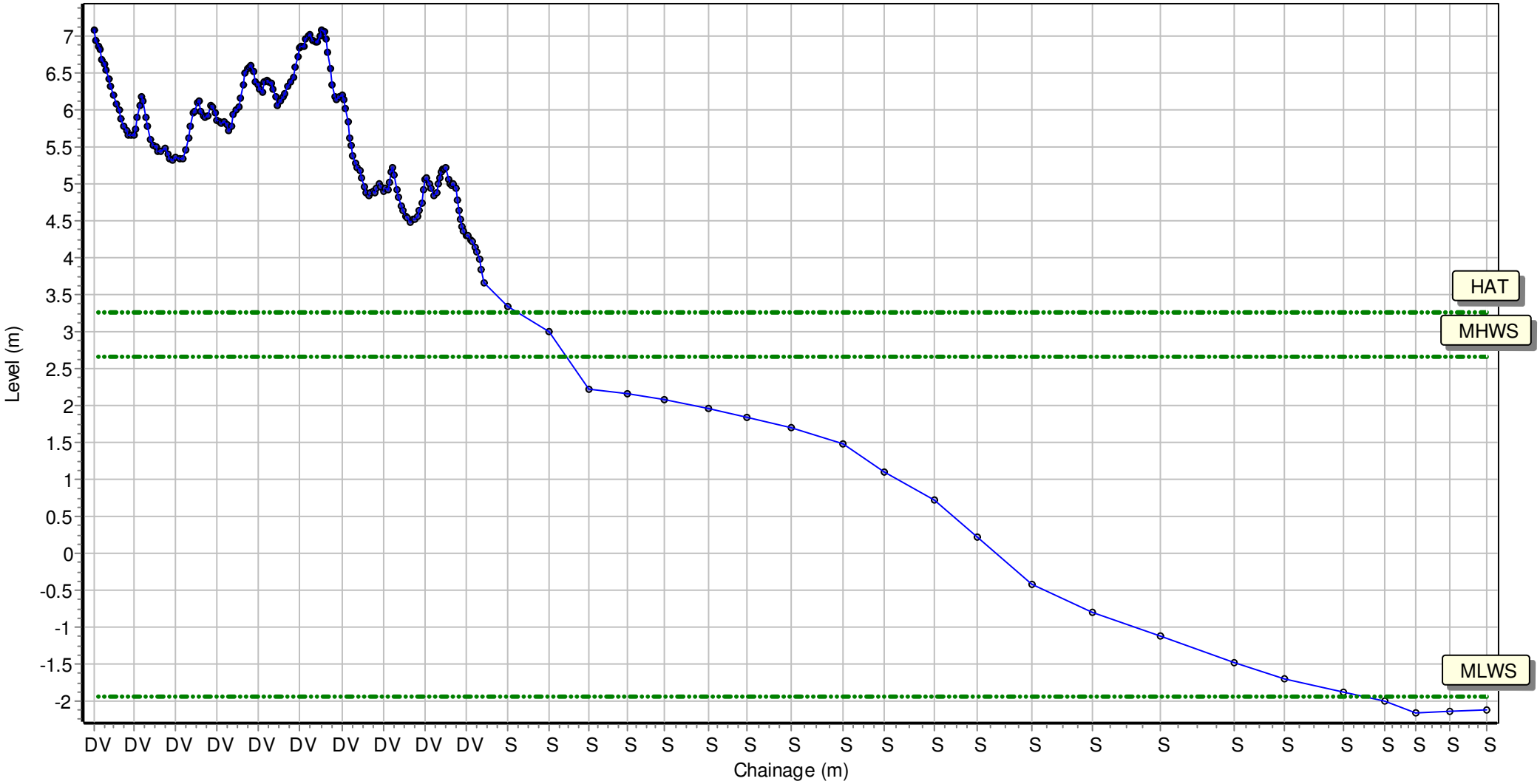
Location: 1cRC1

Date: 27/09/2018 **Inspector:** AG **Low Tide:** **Low Tide Time:**

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

Summary: 2018 Full Measures Topo Survey

Easting: 455811.436 **Northing:** 527373.402 **Profile Bearing:** 34 ° from North



Beach Profile

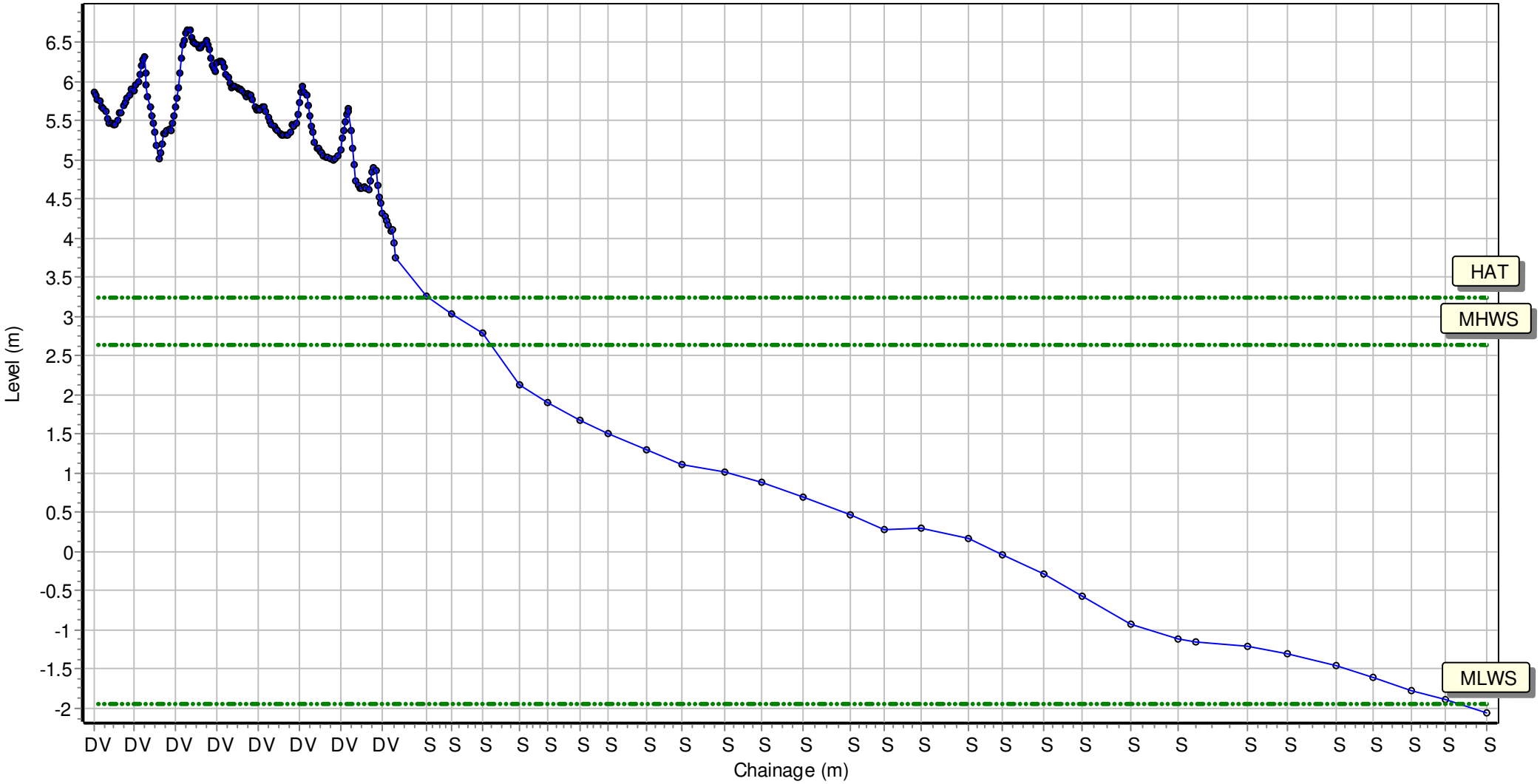
Location: 1cRC2

Date: 27/09/2018 **Inspector:** AG **Low Tide:** **Low Tide Time:**

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

Summary: 2018 Full Measures Topo Survey

Easting: 456633.253 **Northing:** 526599.577 **Profile Bearing:** 34 ° from North



Beach Profile

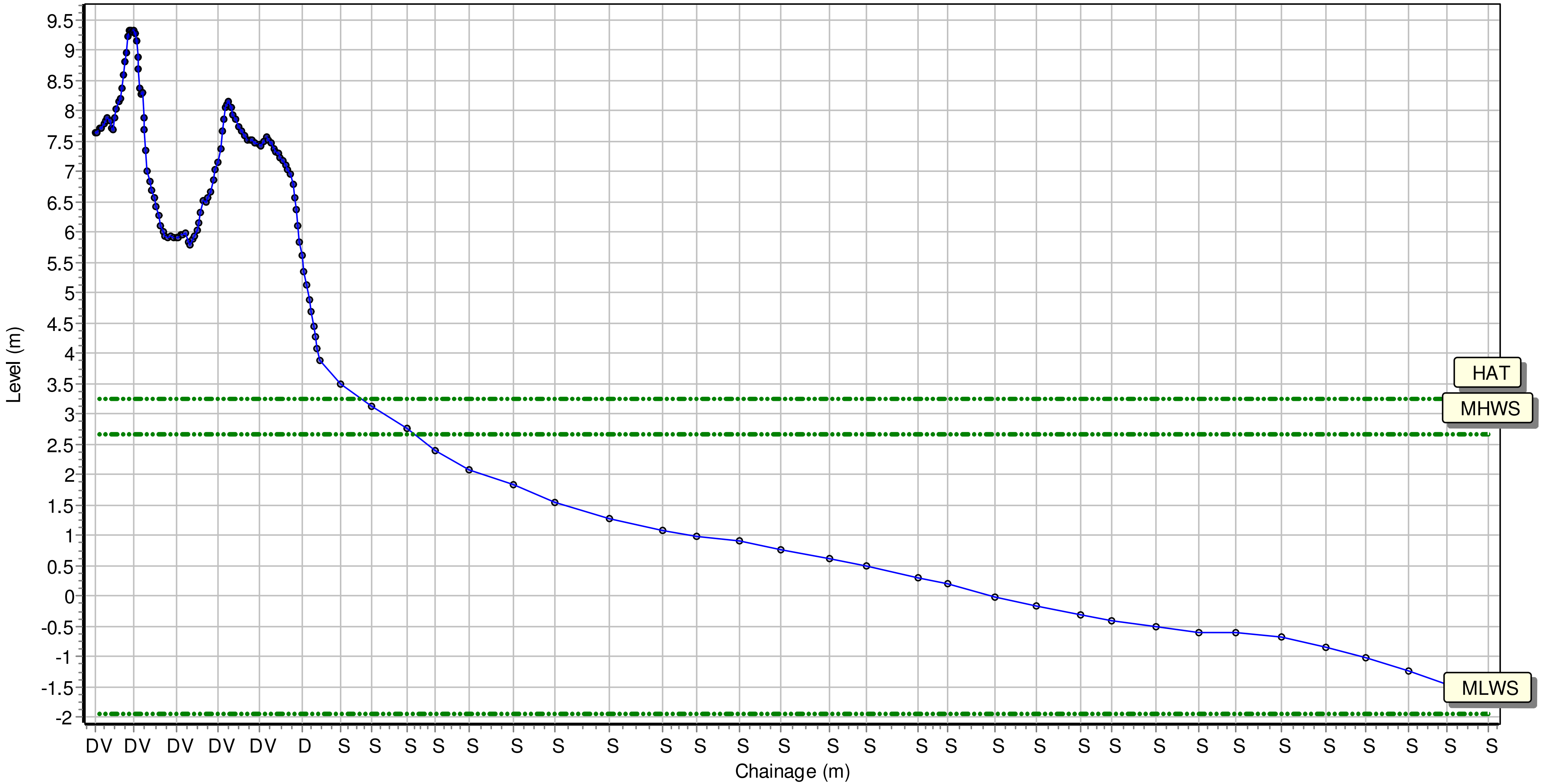
Location: **1cRC3**

Date: 27/09/2018 **Inspector:** AG **Low Tide:** **Low Tide Time:**

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

Summary: 2018 Full Measures Topo Survey

Easting: 457706.365 **Northing:** 525898.597 **Profile Bearing:** 28 ° from North



Beach Profile

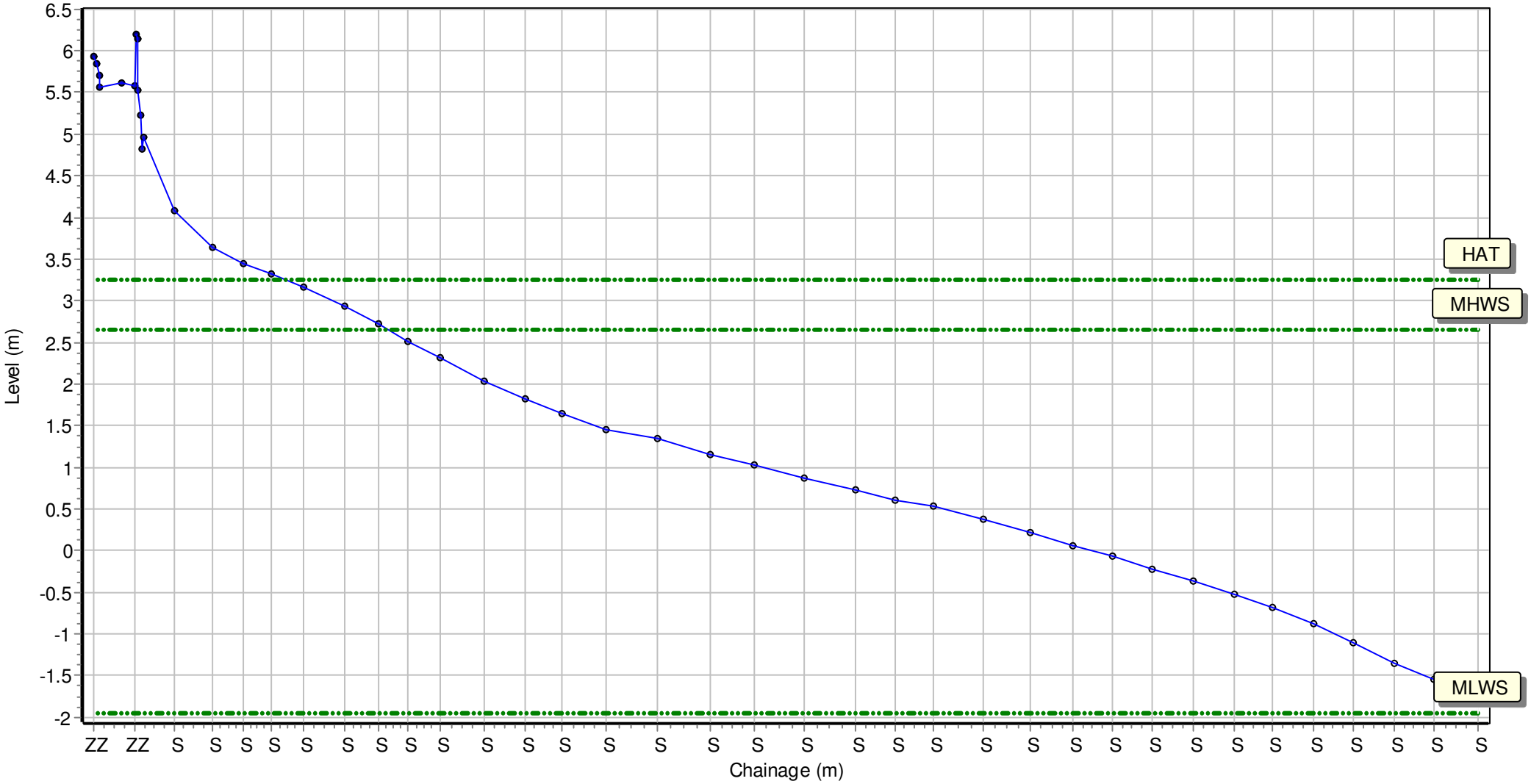
Location: **1cRC4**

Date: 27/09/2018 **Inspector:** AG **Low Tide:** **Low Tide Time:**

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

Summary: 2018 Full Measures Topo Survey

Easting: 459337.597 **Northing:** 525336.99 **Profile Bearing:** 13 ° from North



Beach Profile

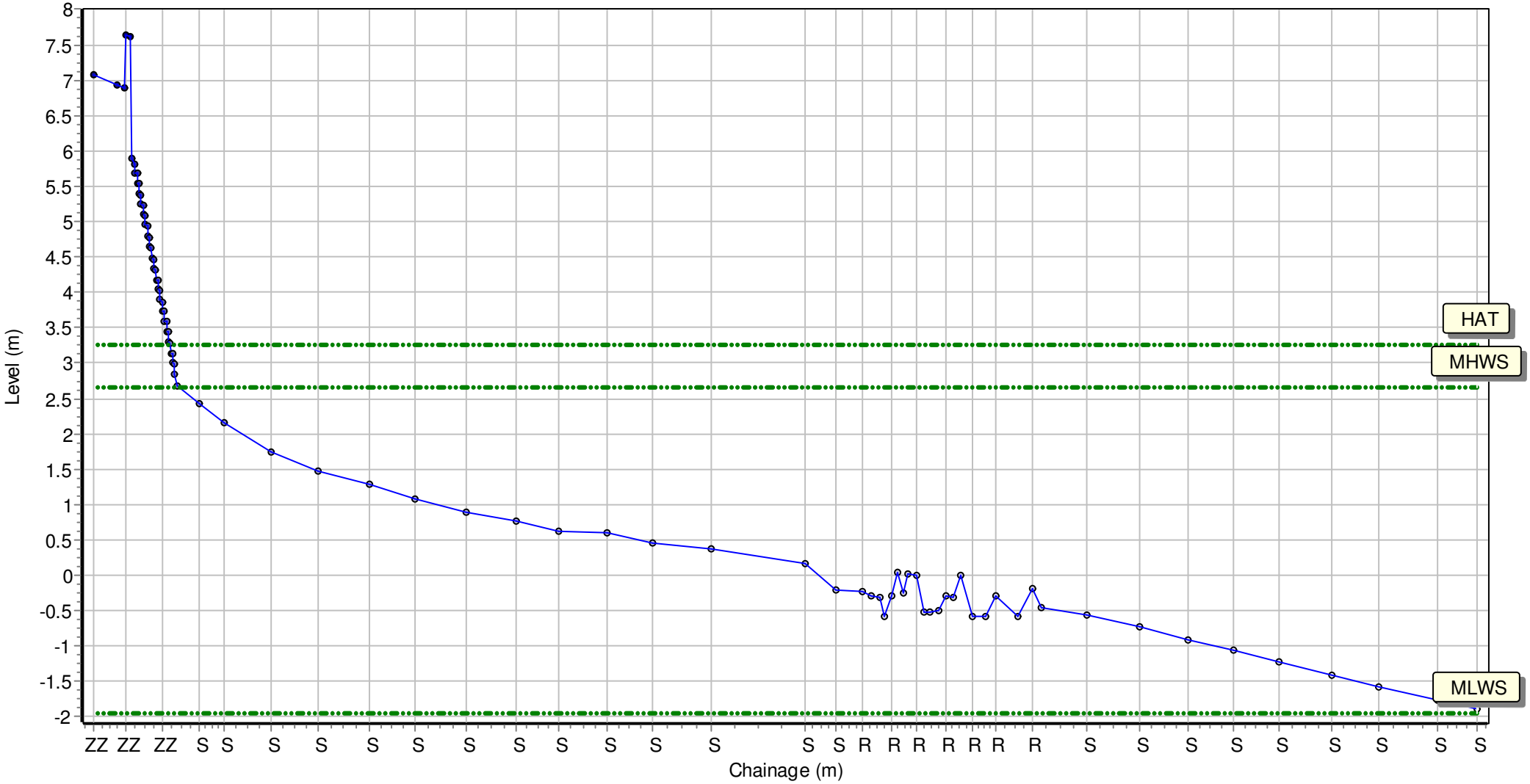
Location: **1cRC5**

Date: 27/09/2018 **Inspector:** AG **Low Tide:** **Low Tide Time:**

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

Summary: 2018 Full Measures Topo Survey

Easting: 460845.21 **Northing:** 525146.997 **Profile Bearing:** 26 ° from North



Beach Profile

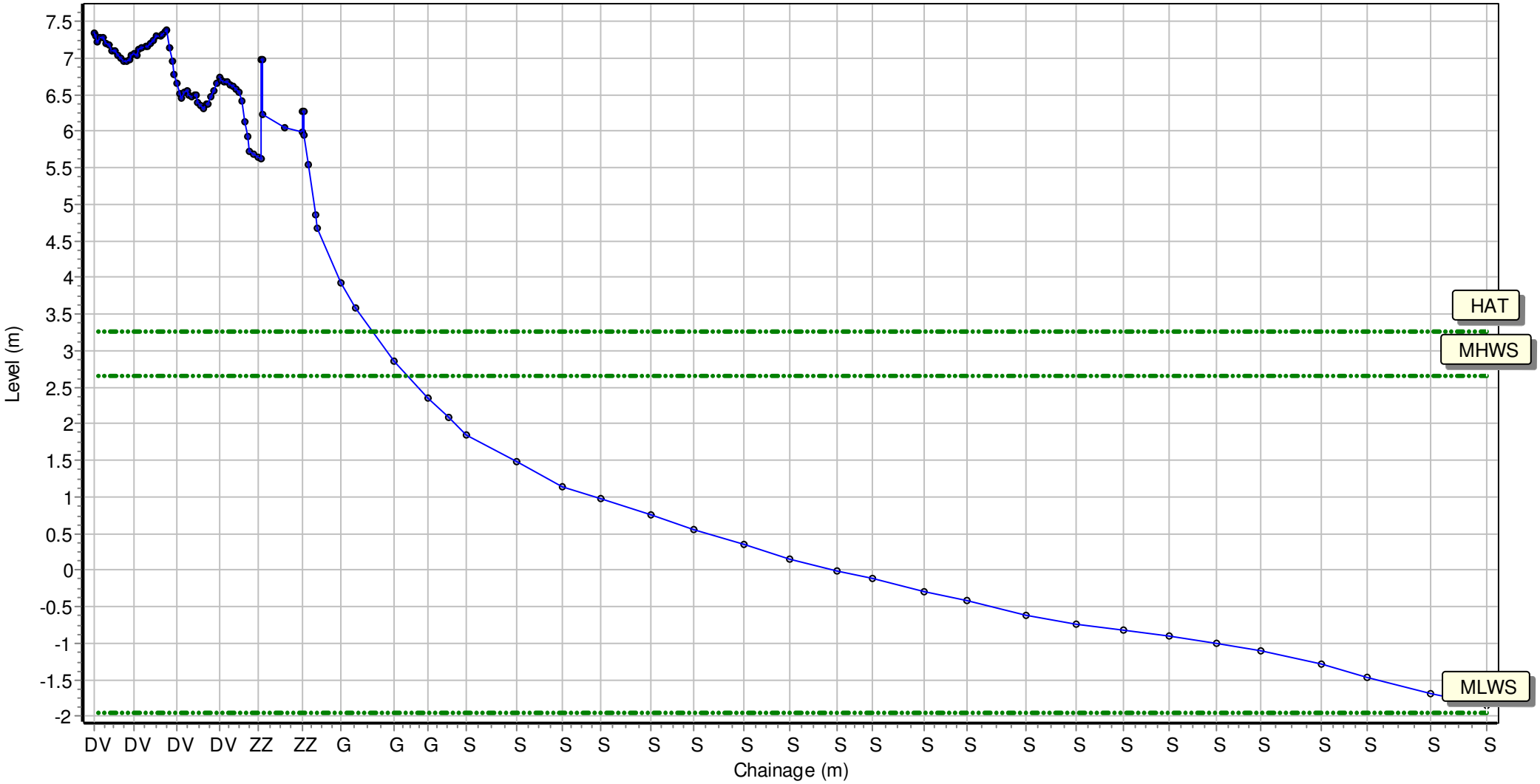
Location: 1cRC6

Date: 27/09/2018 **Inspector:** AG **Low Tide:** **Low Tide Time:**

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

Summary: 2018 Full Measures Topo Survey

Easting: 461776.835 **Northing:** 524269.592 **Profile Bearing:** 39 ° from North



Beach Profile

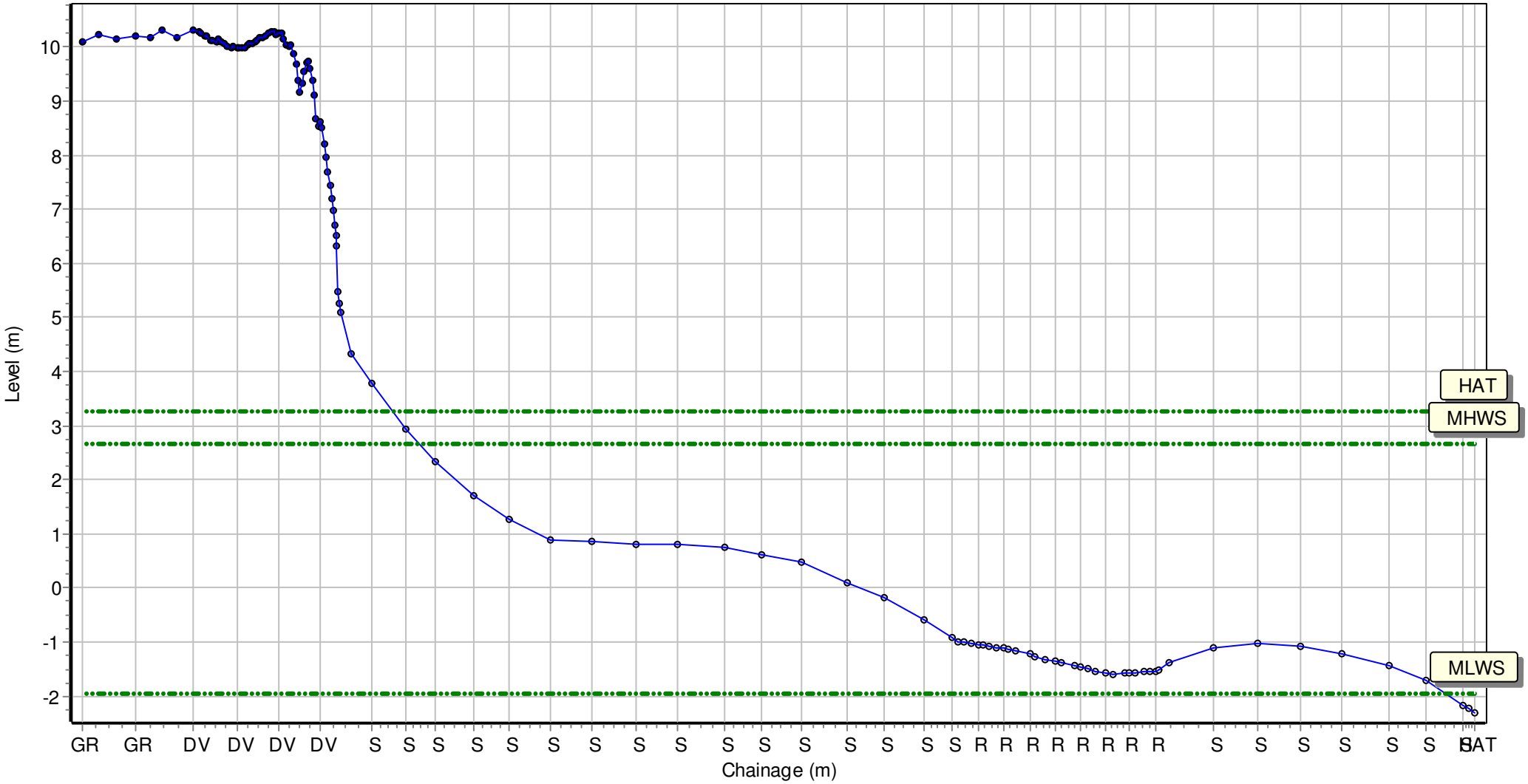
Location: 1cRC7

Date: 27/09/2018 **Inspector:** AG **Low Tide:** **Low Tide Time:**

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

Summary: 2018 Full Measures Topo Survey

Easting: 462568.453 **Northing:** 523568.436 **Profile Bearing:** 37 ° from North



Beach Profile

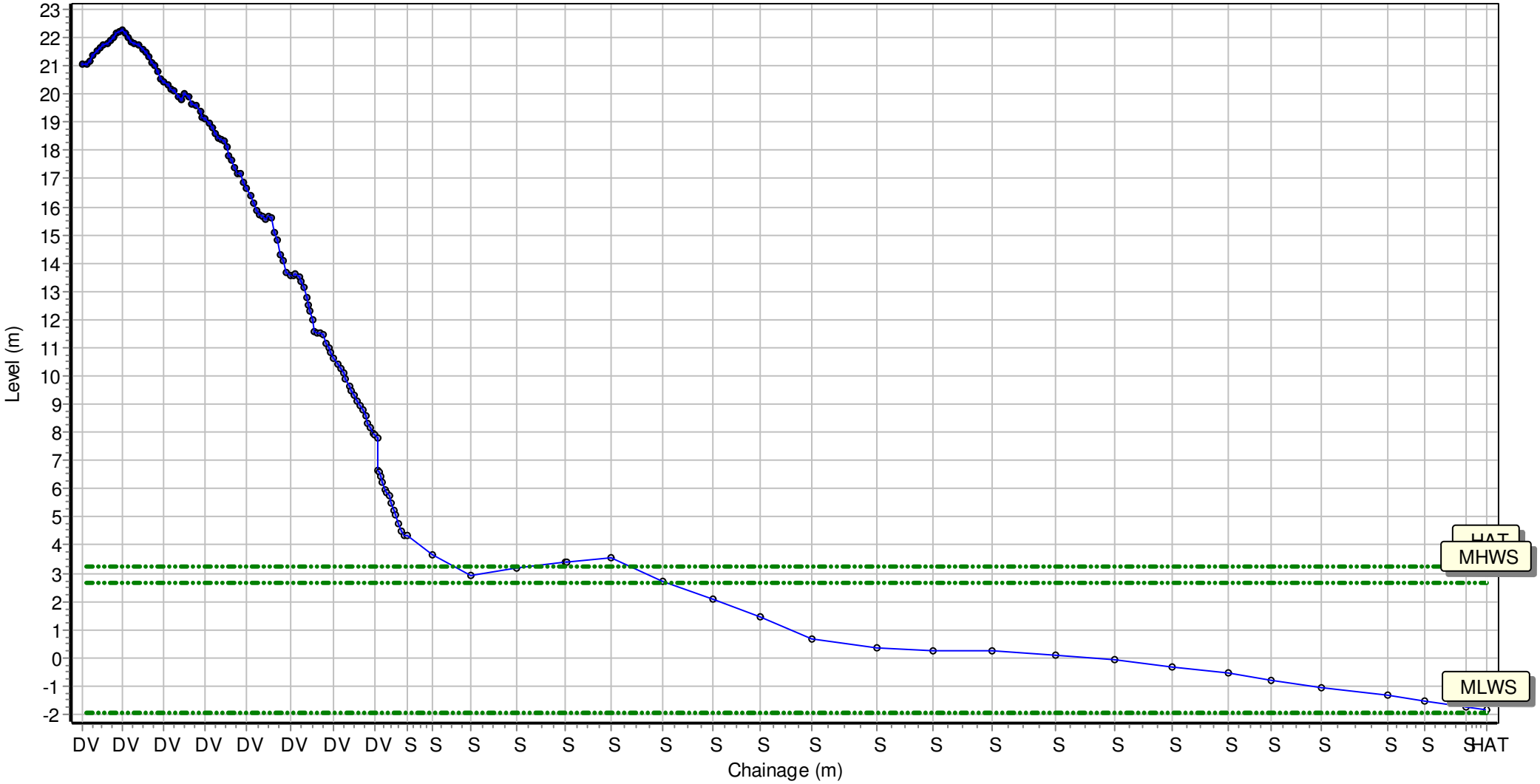
Location: 1cRC8

Date: 27/09/2018 **Inspector:** AG **Low Tide:** **Low Tide Time:**

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

Summary: 2018 Full Measures Topo Survey

Easting: 464245.579 **Northing:** 522578.097 **Profile Bearing:** 28 ° from North



Beach Profile

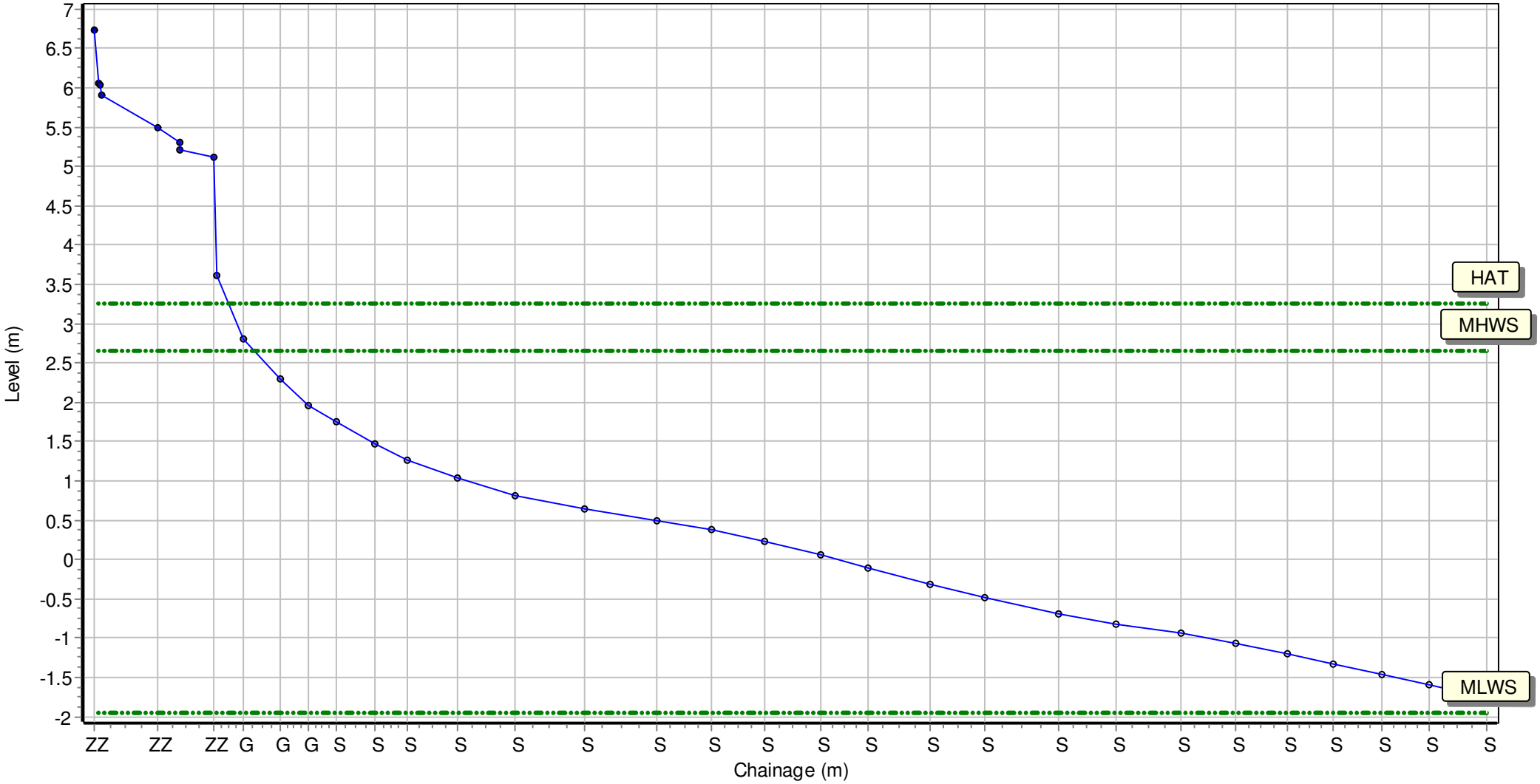
Location: **1cRC9**

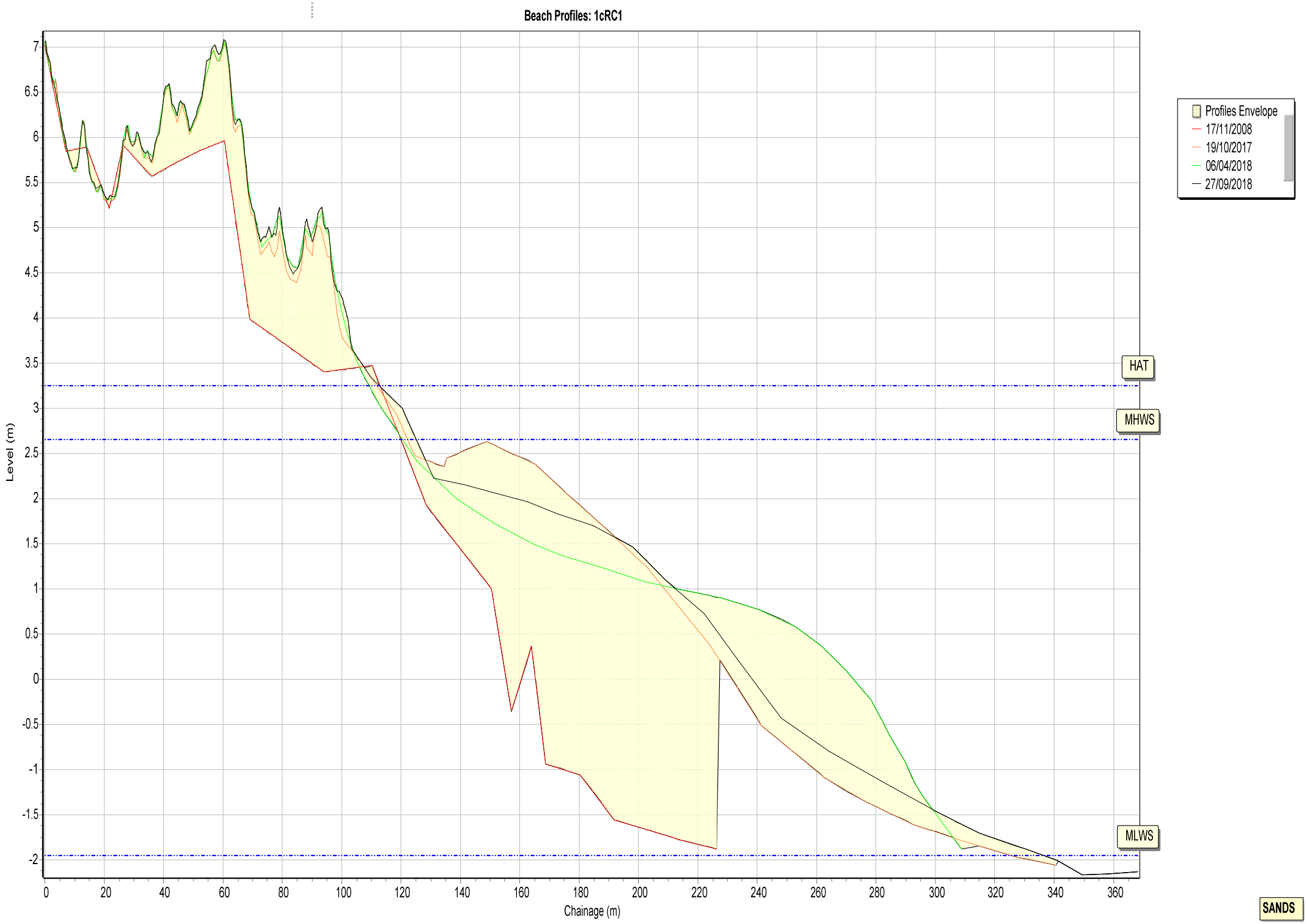
Date: 27/09/2018 **Inspector:** AG **Low Tide:** **Low Tide Time:**

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

Summary: 2018 Full Measures Topo Survey

Easting: 466477.532 **Northing:** 521748.87 **Profile Bearing:** 22 ° from North

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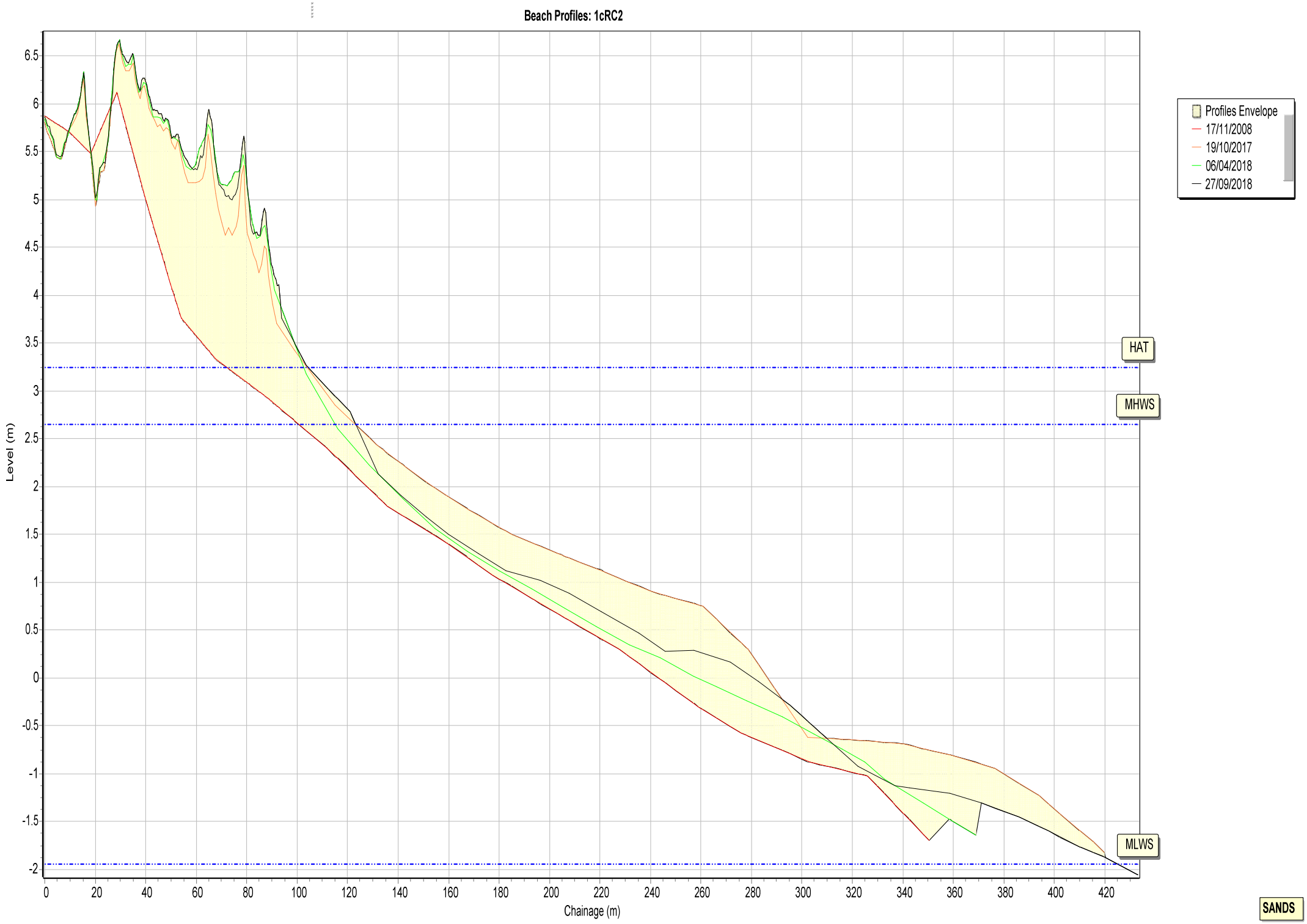
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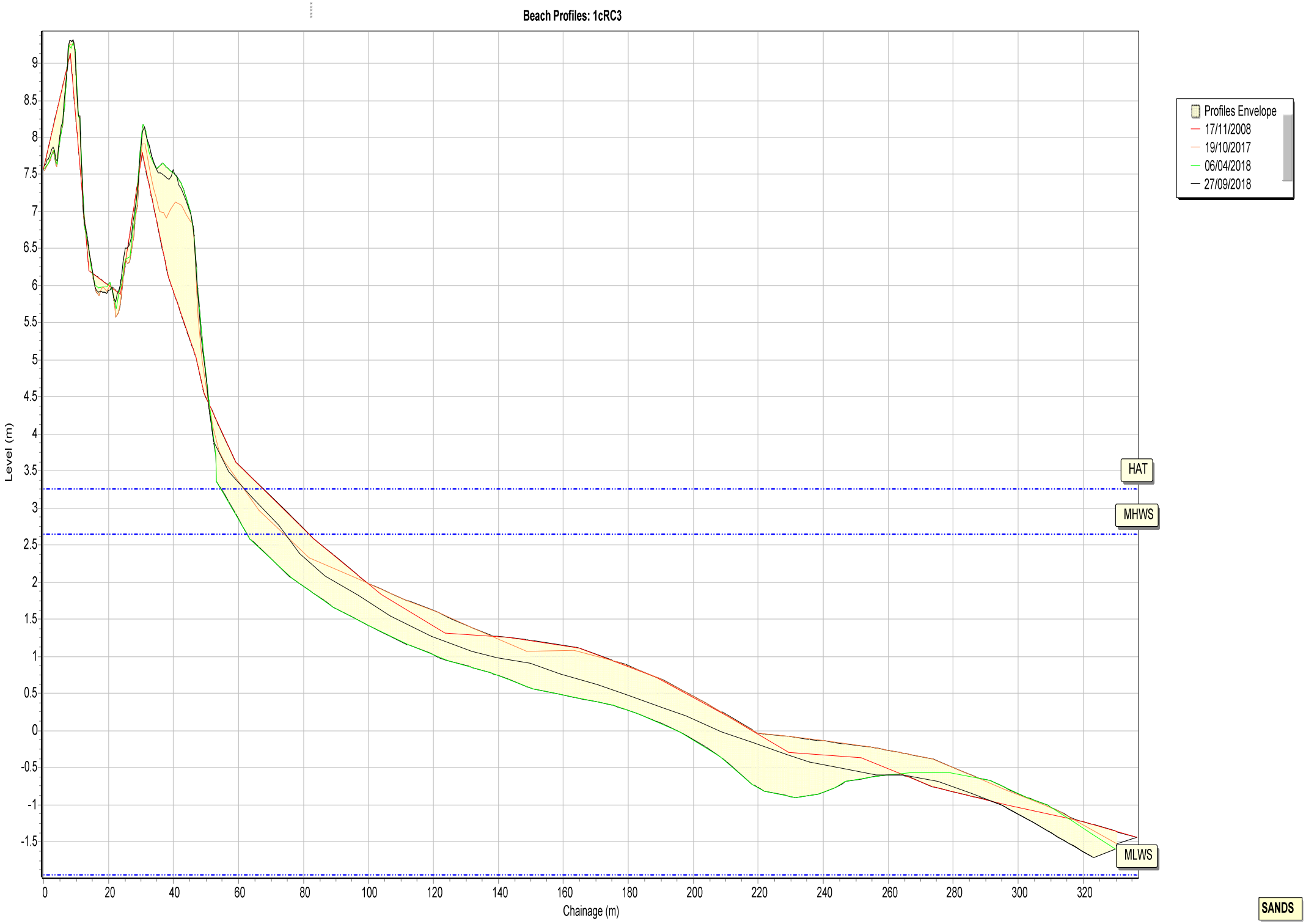
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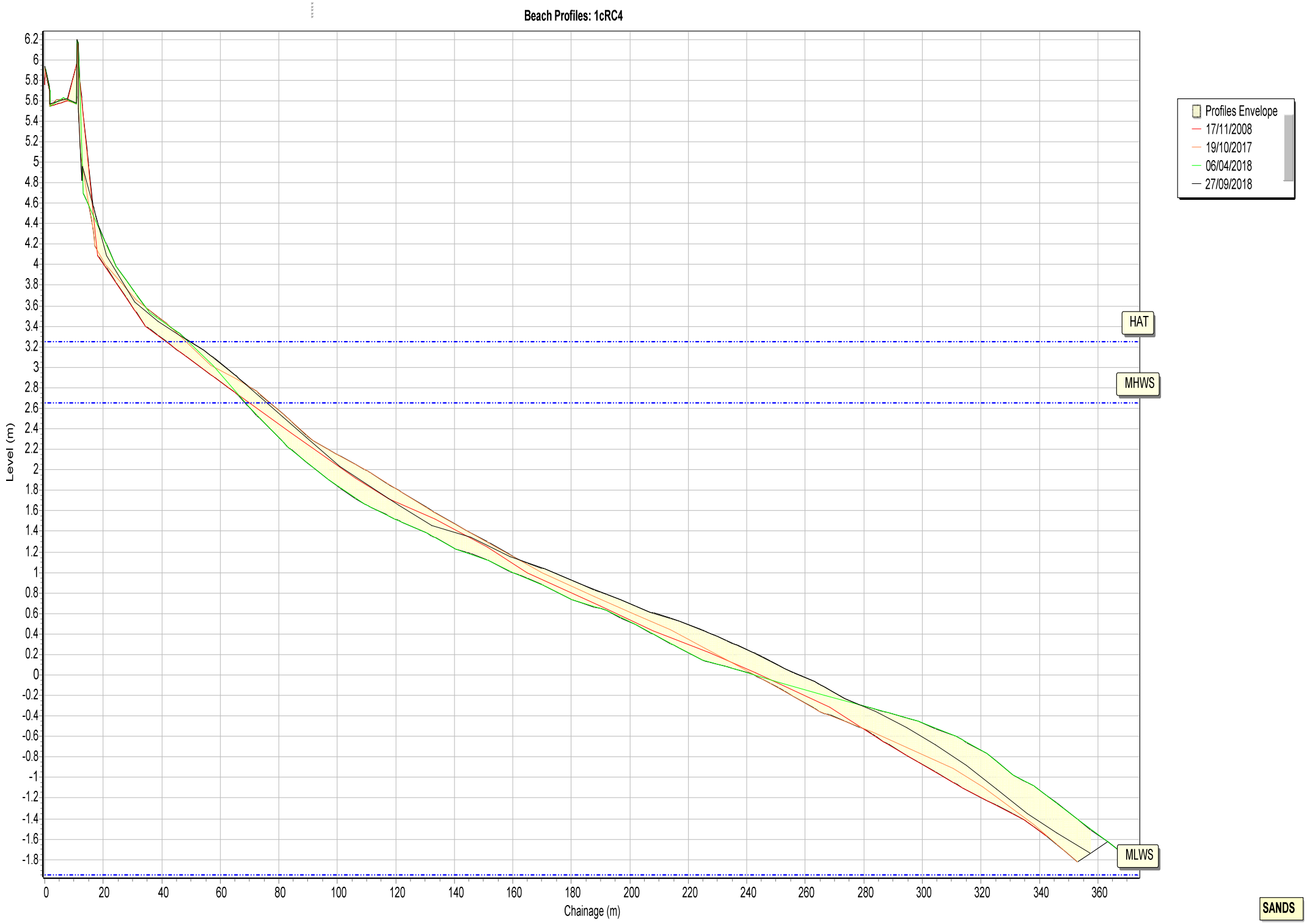
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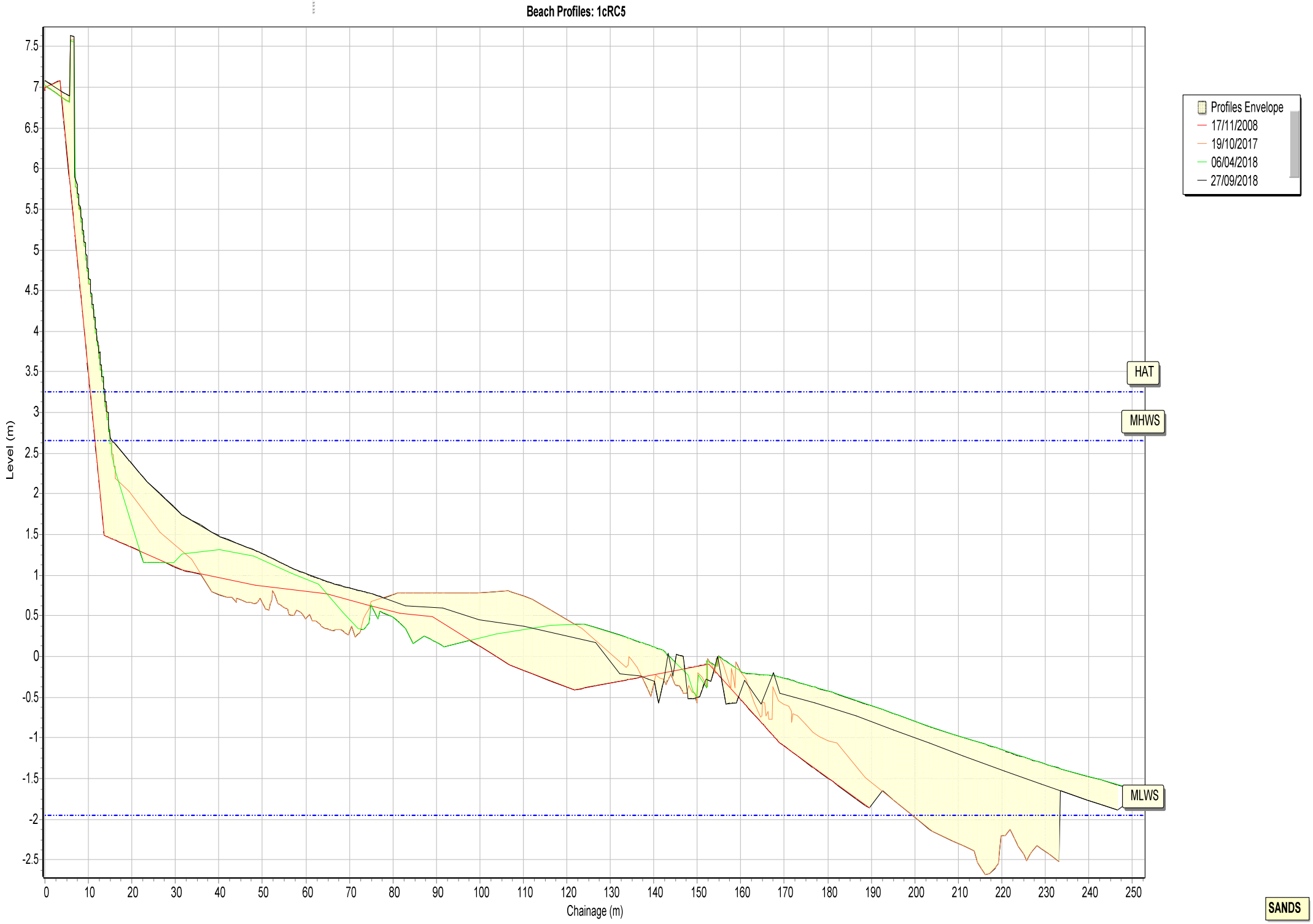
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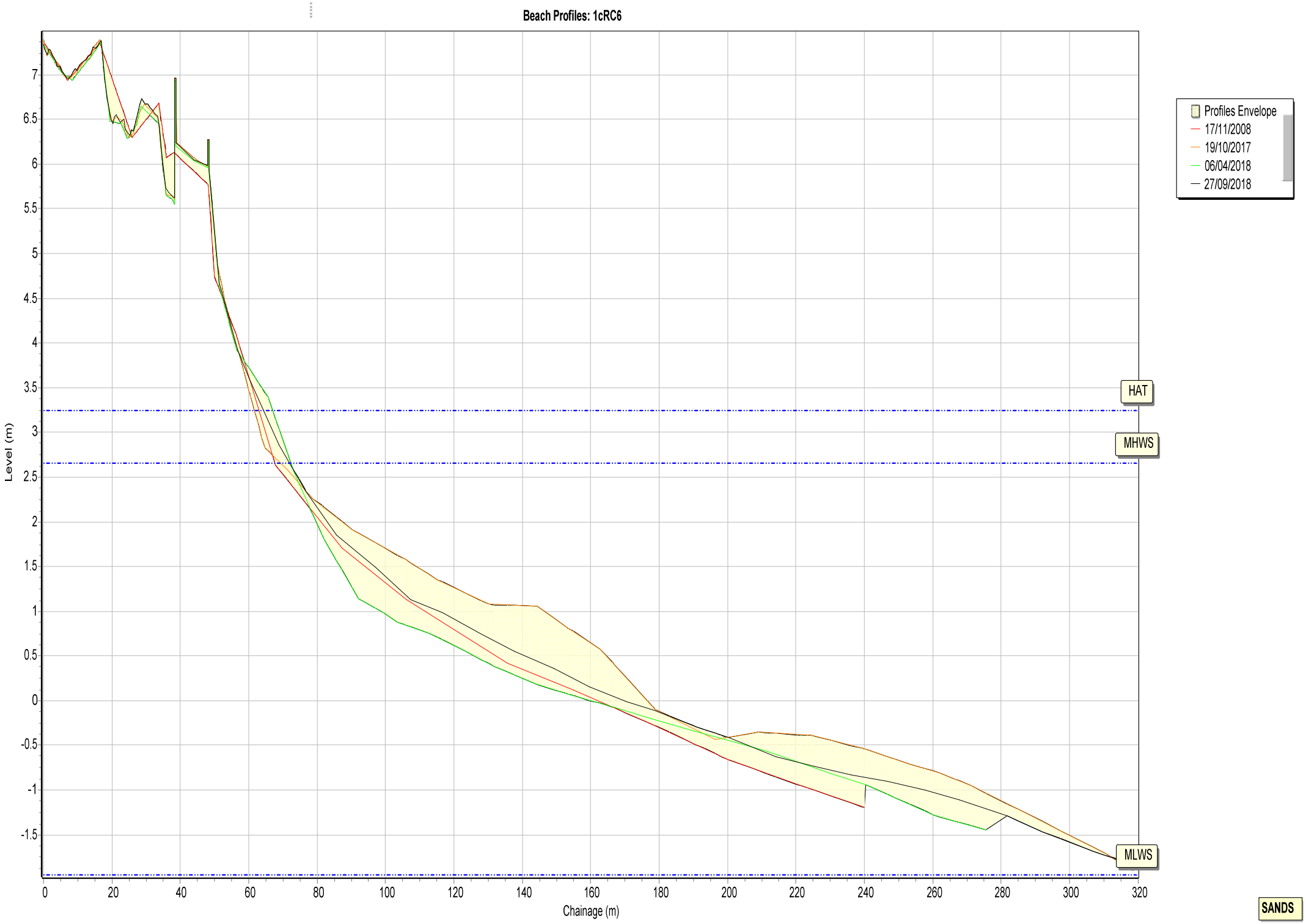
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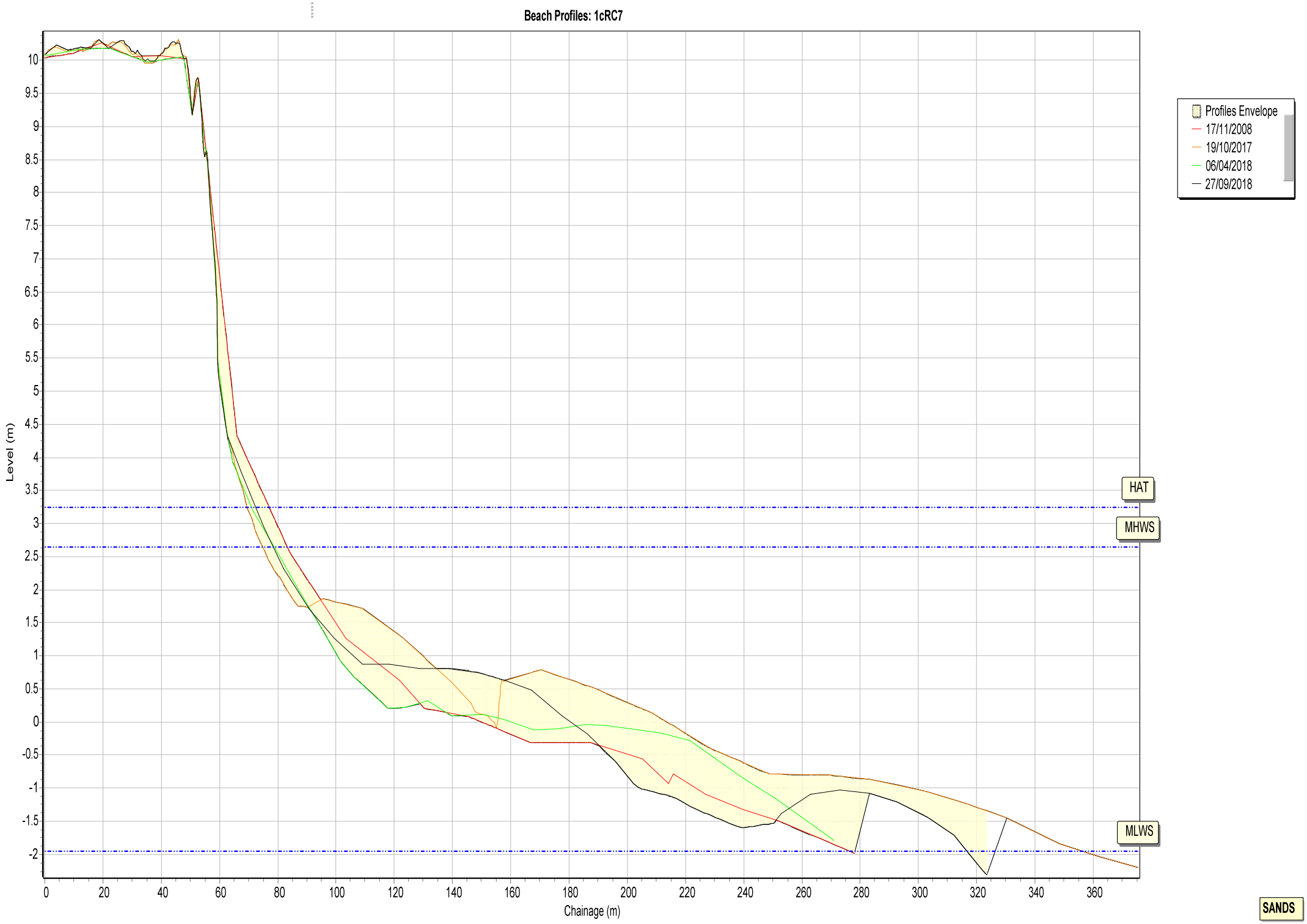
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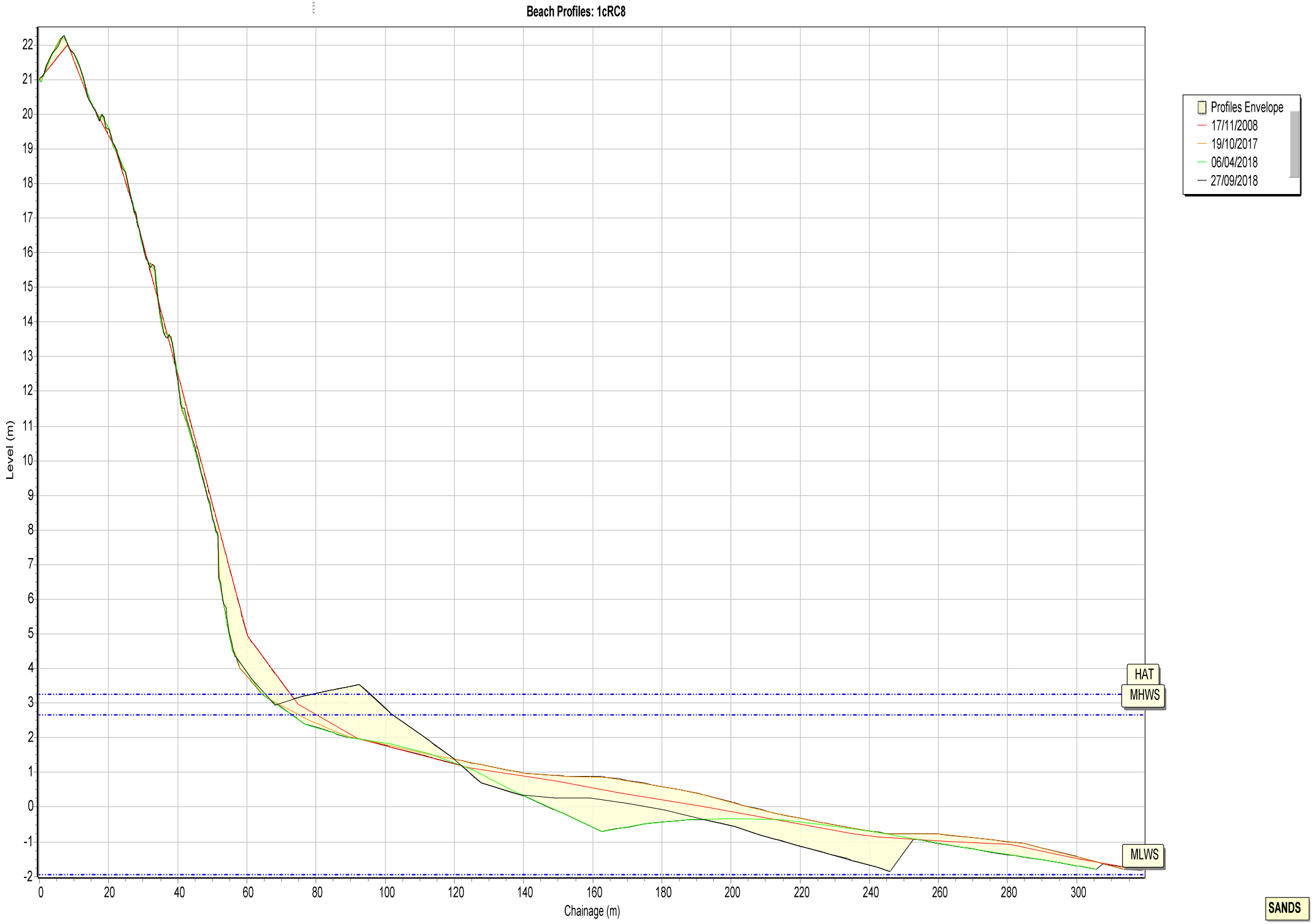
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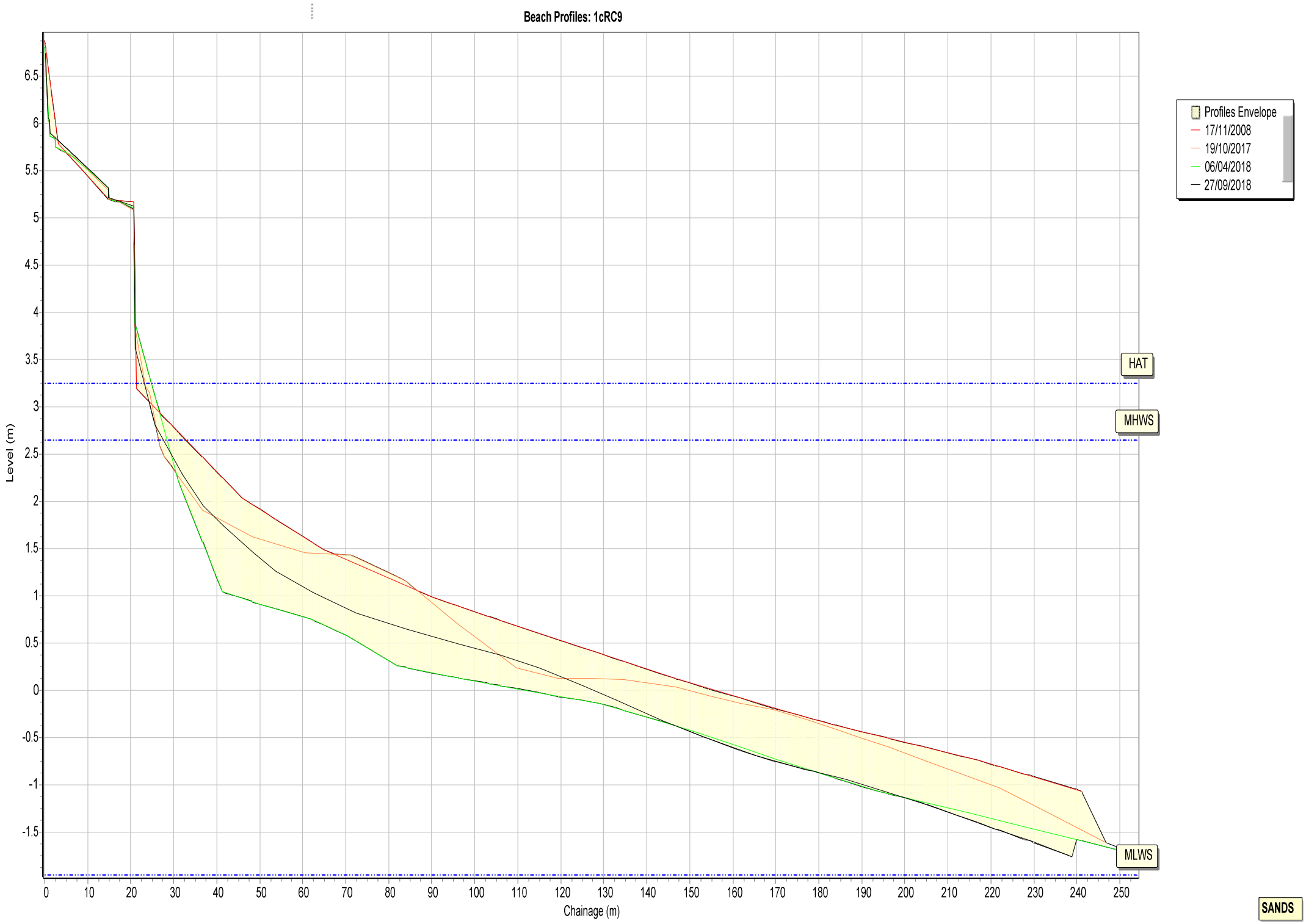
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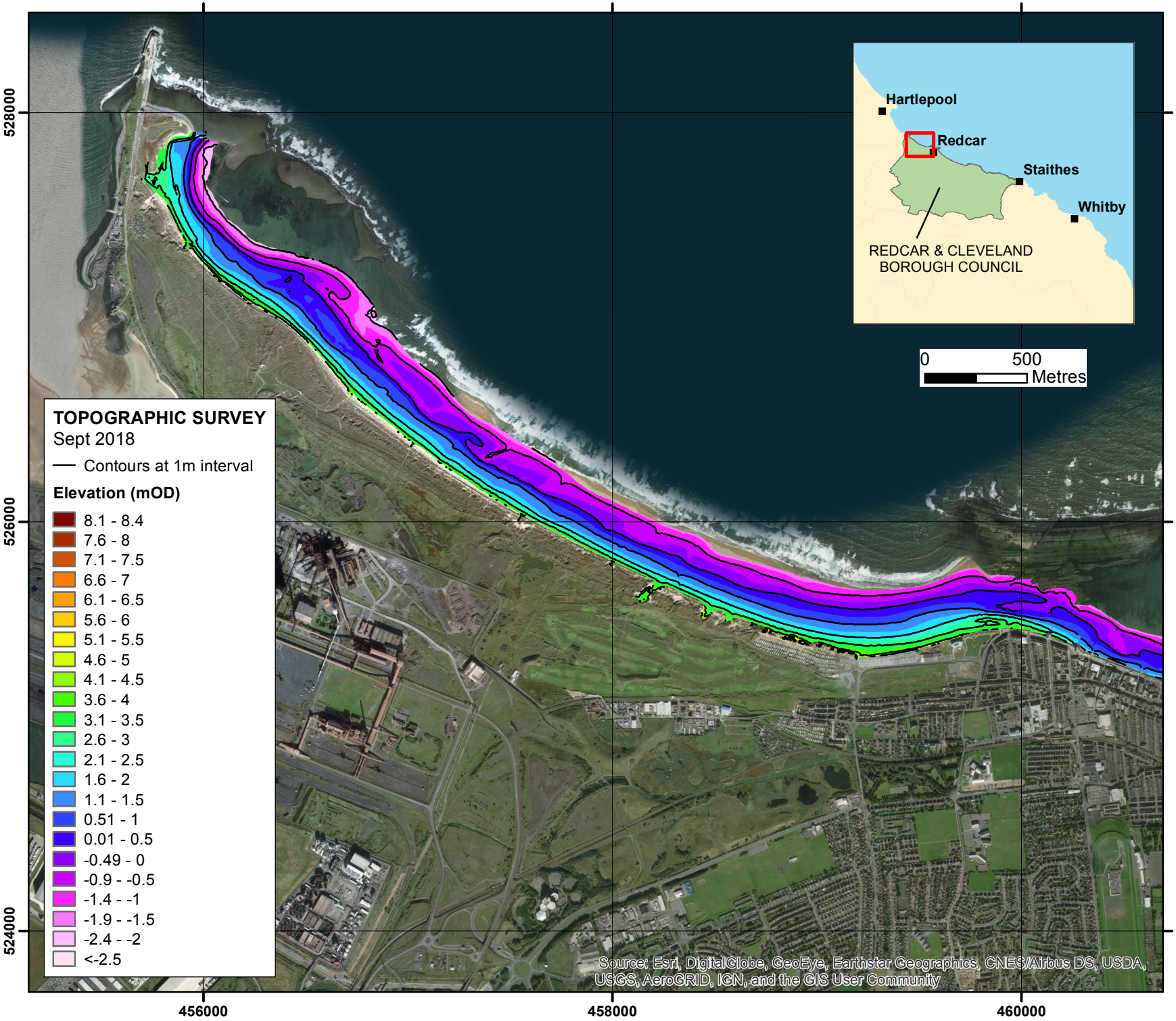
Appendix B

Topographic Survey



Key

Client: North East Coastal Group

Project: Cell 1 Regional Coastal Monitoring Programme

Appendix B - Map 1

COATHAM SANDS

Redcar and Cleveland Borough Council Frontage

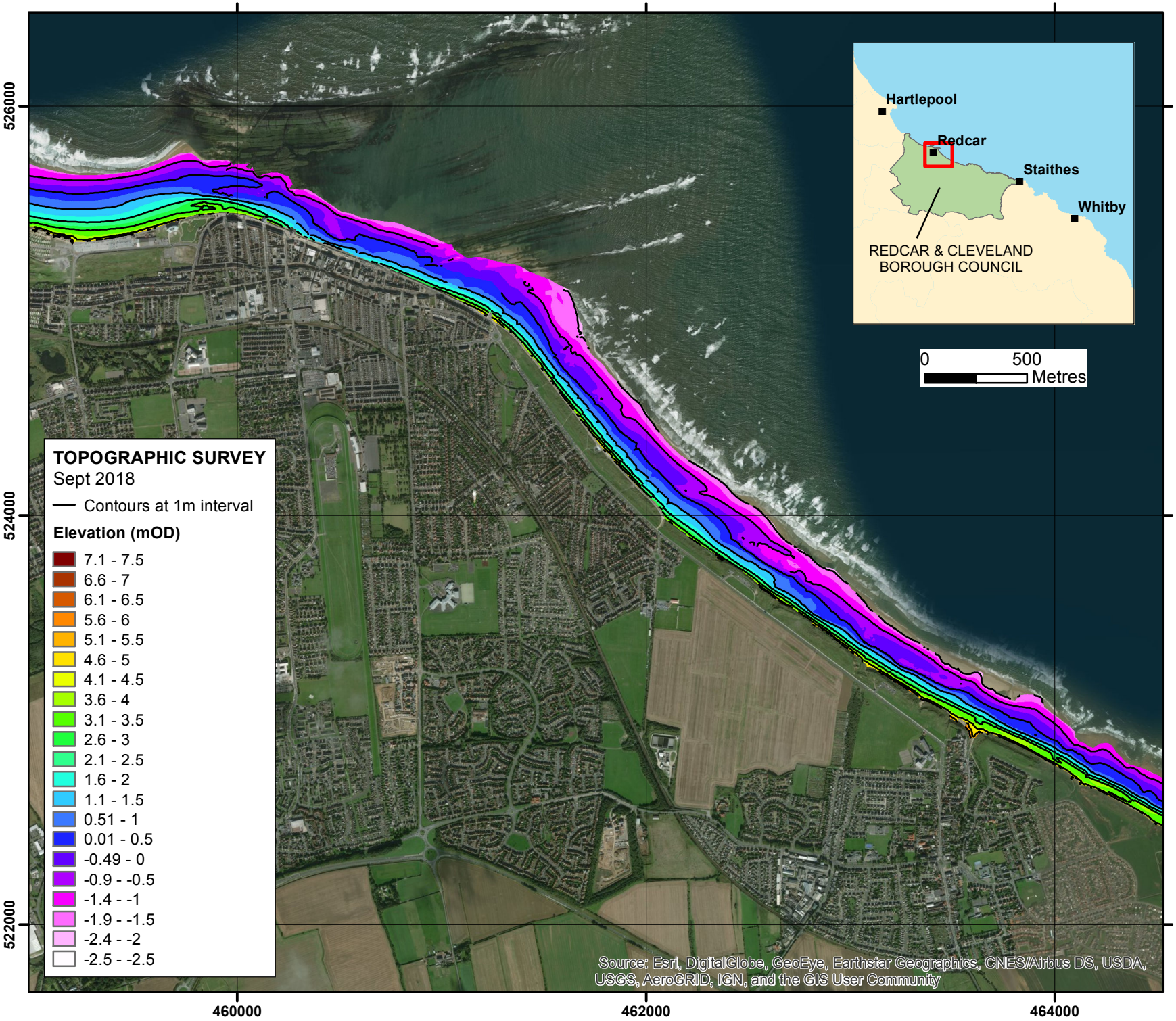
Analytical Report
'Full Measures' Survey 2018

Drawing Scale at A4 1:25,000

WATER
Royal HaskoningDHV
Marlborough House
Marlborough Crescent
Newcastle upon Tyne
NE1 4EE

Tel: +44 (0)191 211 1300
Fax: +44 (0)191 211 1313
www.royalhaskoningdhv.com

Royal HaskoningDHV
Enhancing Society Together



Key

Client: North East Coastal Group

Project: Cell 1 Regional Coastal Monitoring Programme

Appendix B - Map 2

REDCAR/MARSKE SANDS

Redcar and Cleveland Borough Council Frontage

Analytical Report
'Full Measures' Survey 2018

Drawing Scale at A4 1:25,000

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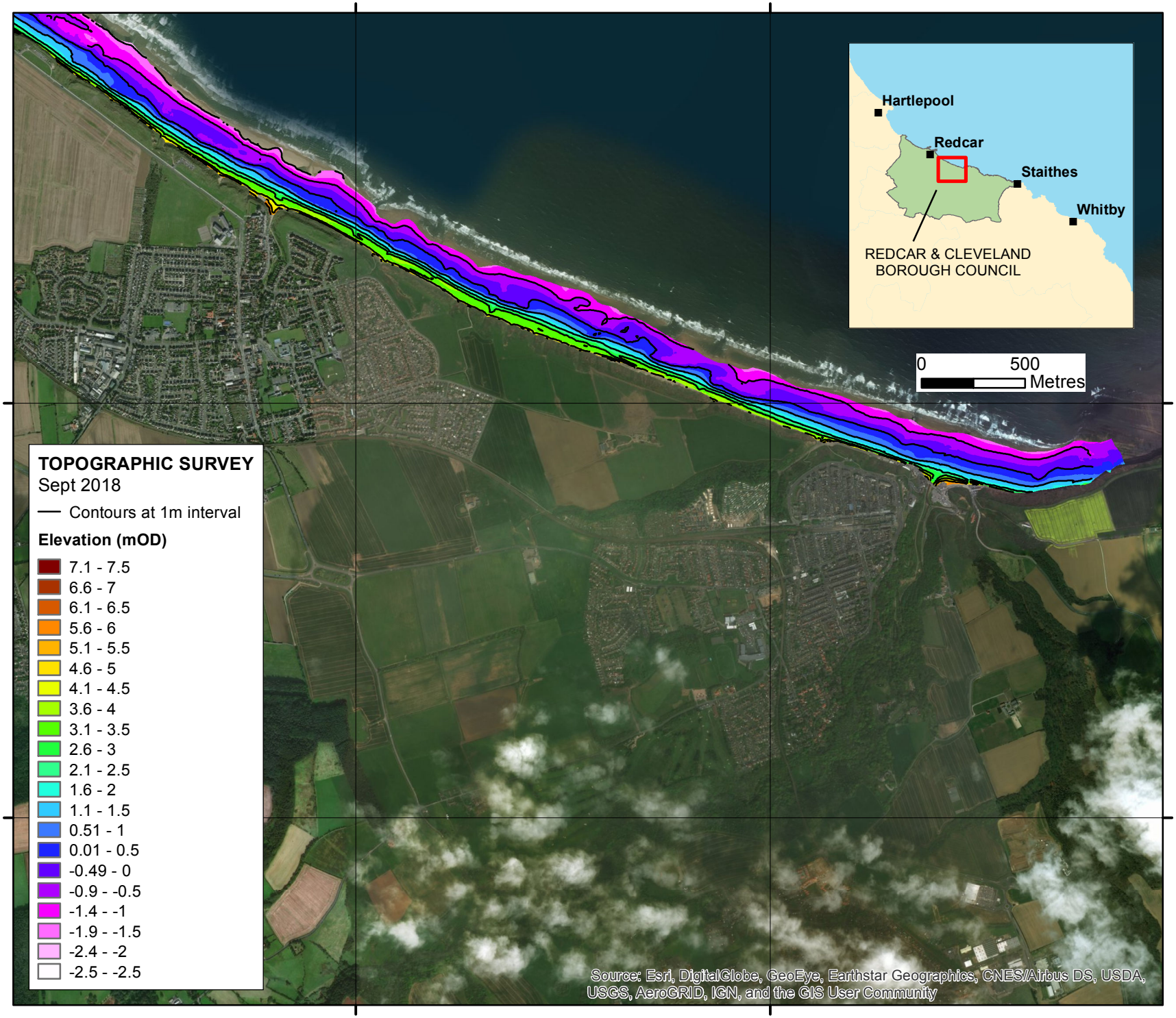
Fax: +44 (0)191 211 1313
www.royalhaskoningdhv.com

Royal HaskoningDHV
Enhancing Society Together



Key

Client: North East Coastal Group

Project: Cell 1 Regional Coastal Monitoring Programme

Appendix B - Map 3

MARSKE/ SALTBURN SANDS

Redcar and Cleveland Borough Council Frontage

Analytical Report
'Full Measures' Survey 2018

Drawing Scale at A4 1:25,000

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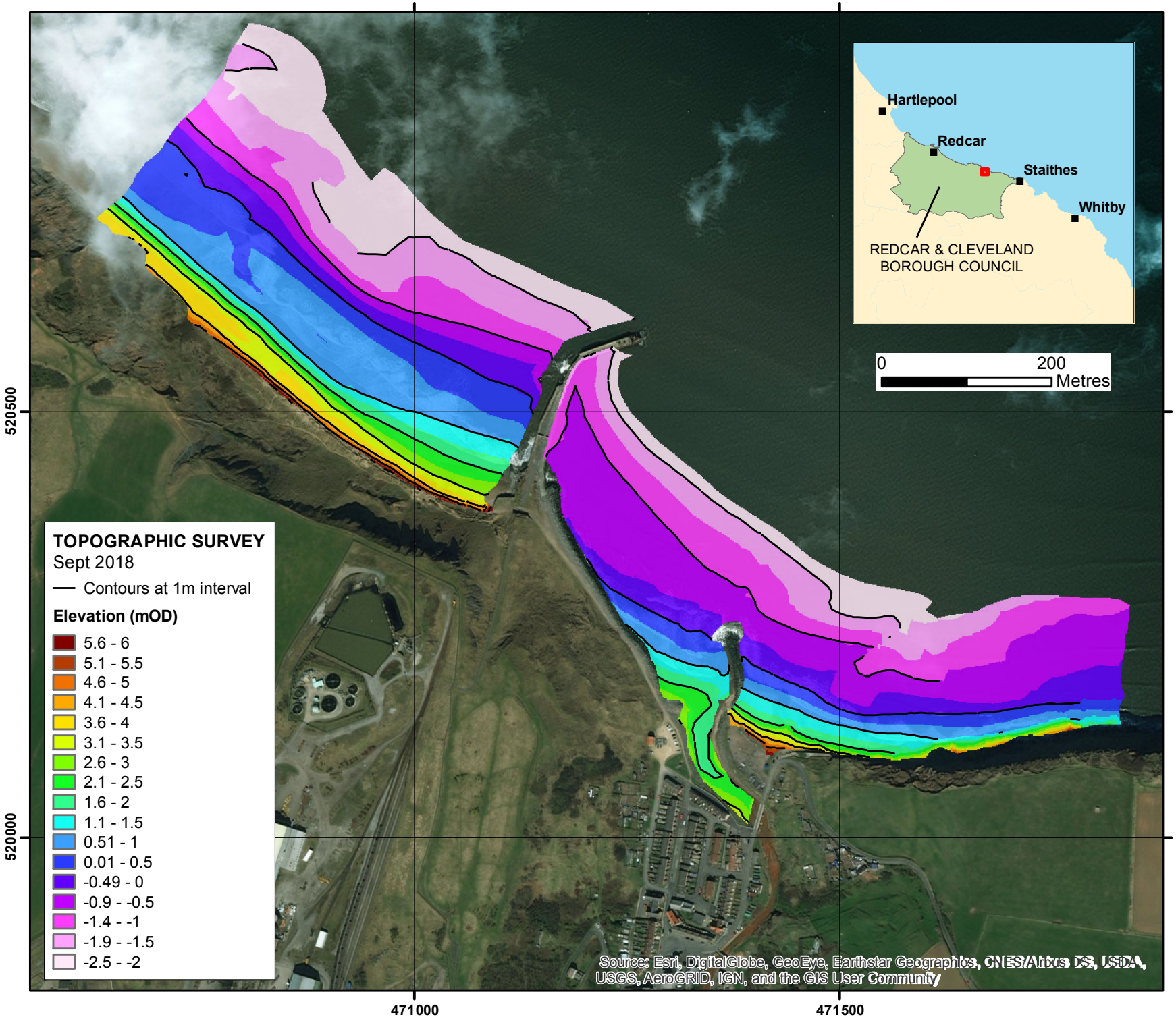

Key

Client: North East Coastal Group

Project: Cell 1 Regional Coastal Monitoring Programme

Appendix B - Map 4

CATTERSTY SANDS

Redcar and Cleveland Borough Council Frontage

Analytical Report
'Full Measures' Survey 2018

Drawing Scale at A4 1:6,000

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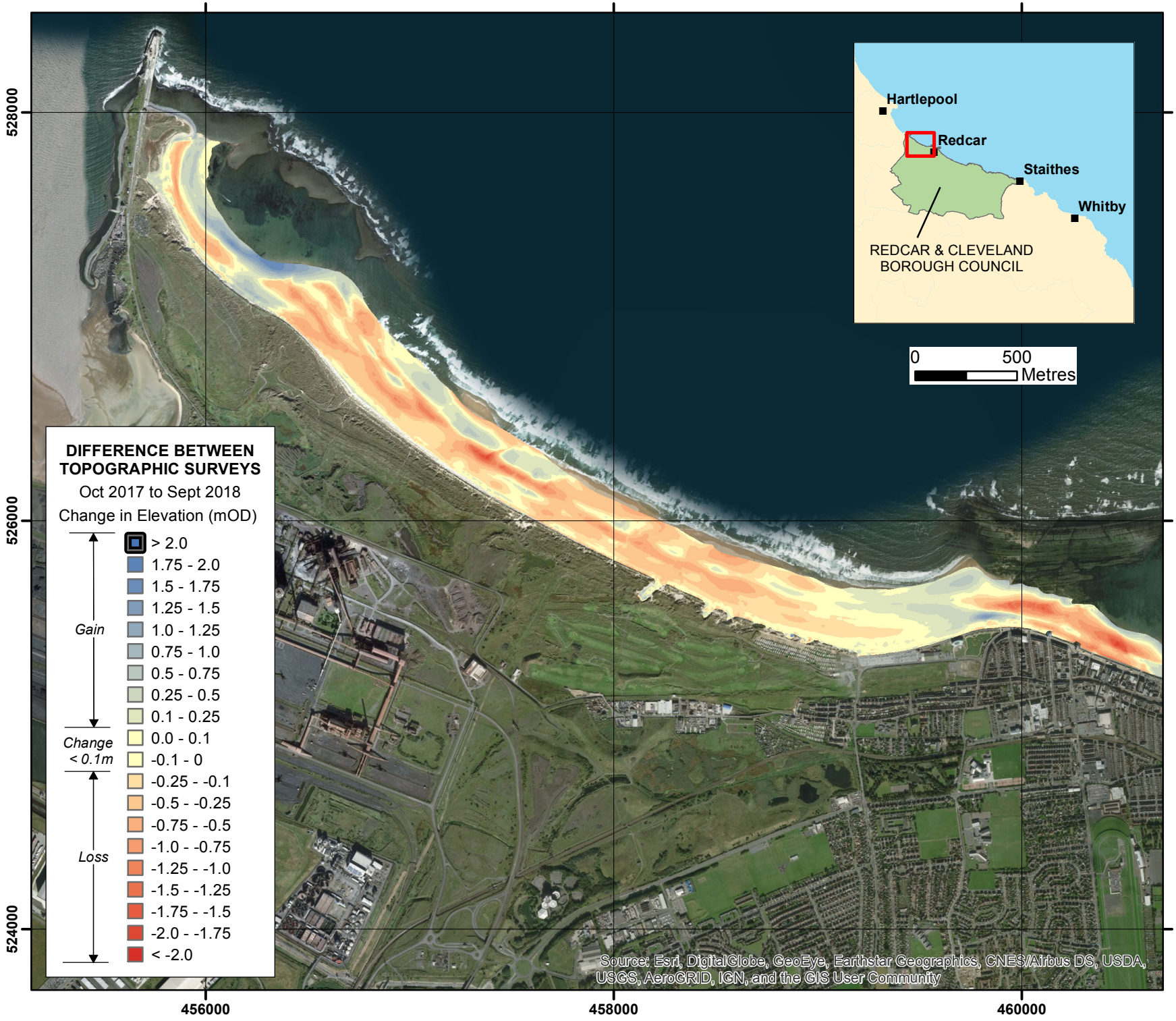

Key

Client: North East Coastal Group

Project: Cell 1 Regional Coastal Monitoring Programme

Appendix B - Map 5

COATHAM SANDS

Redcar and Cleveland Borough Council Frontage

Analytical Report
'Full Measures' Survey 2018

Drawing Scale at A4 1:25,000

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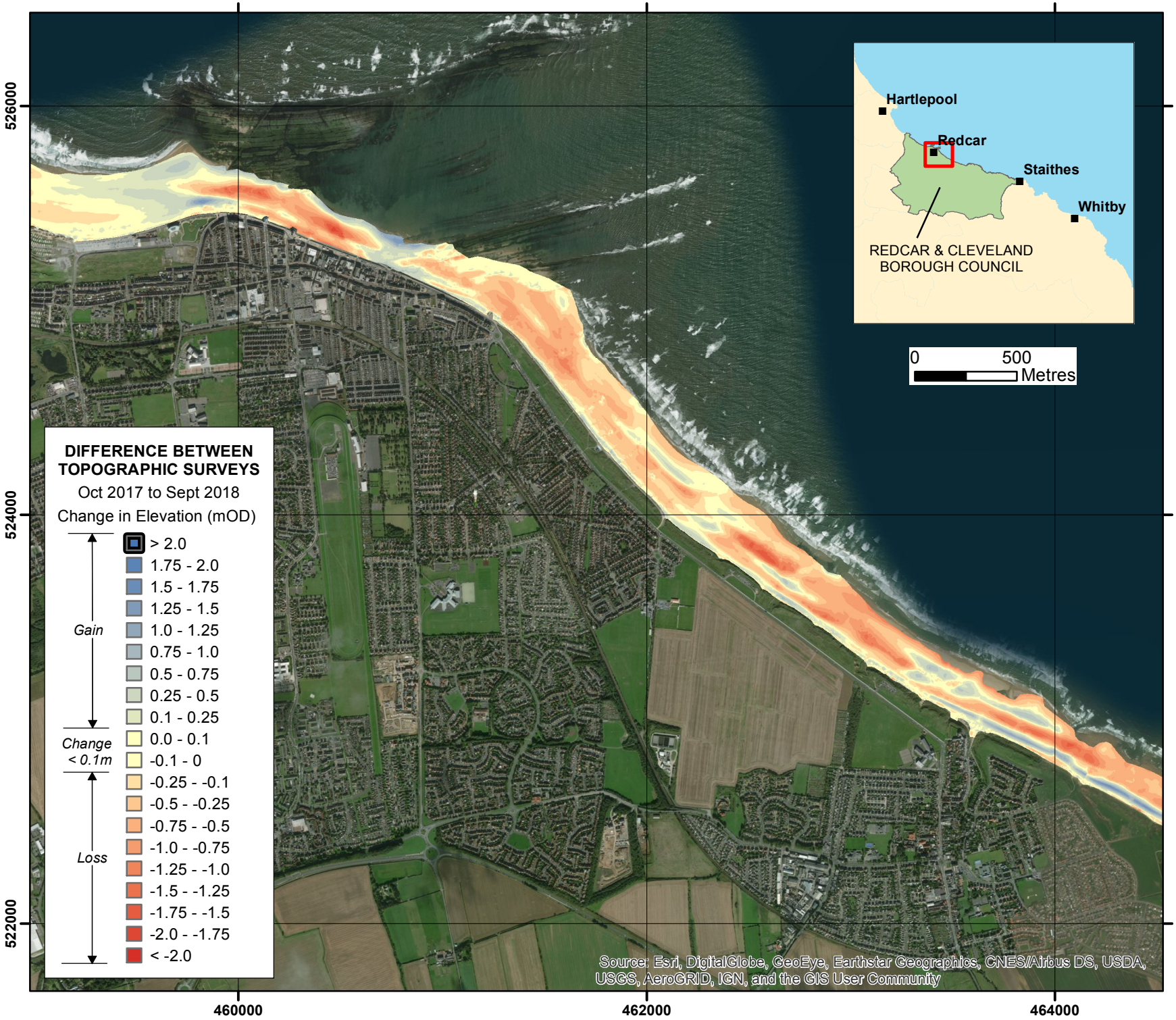

Key

Client: North East Coastal Group

Project: Cell 1 Regional Coastal Monitoring Programme

Appendix B - Map 6

REDCAR/MARSKE SANDS

Redcar and Cleveland Borough Council Frontage

Analytical Report
'Full Measures' Survey 2018

Drawing Scale at A4 1:25,000

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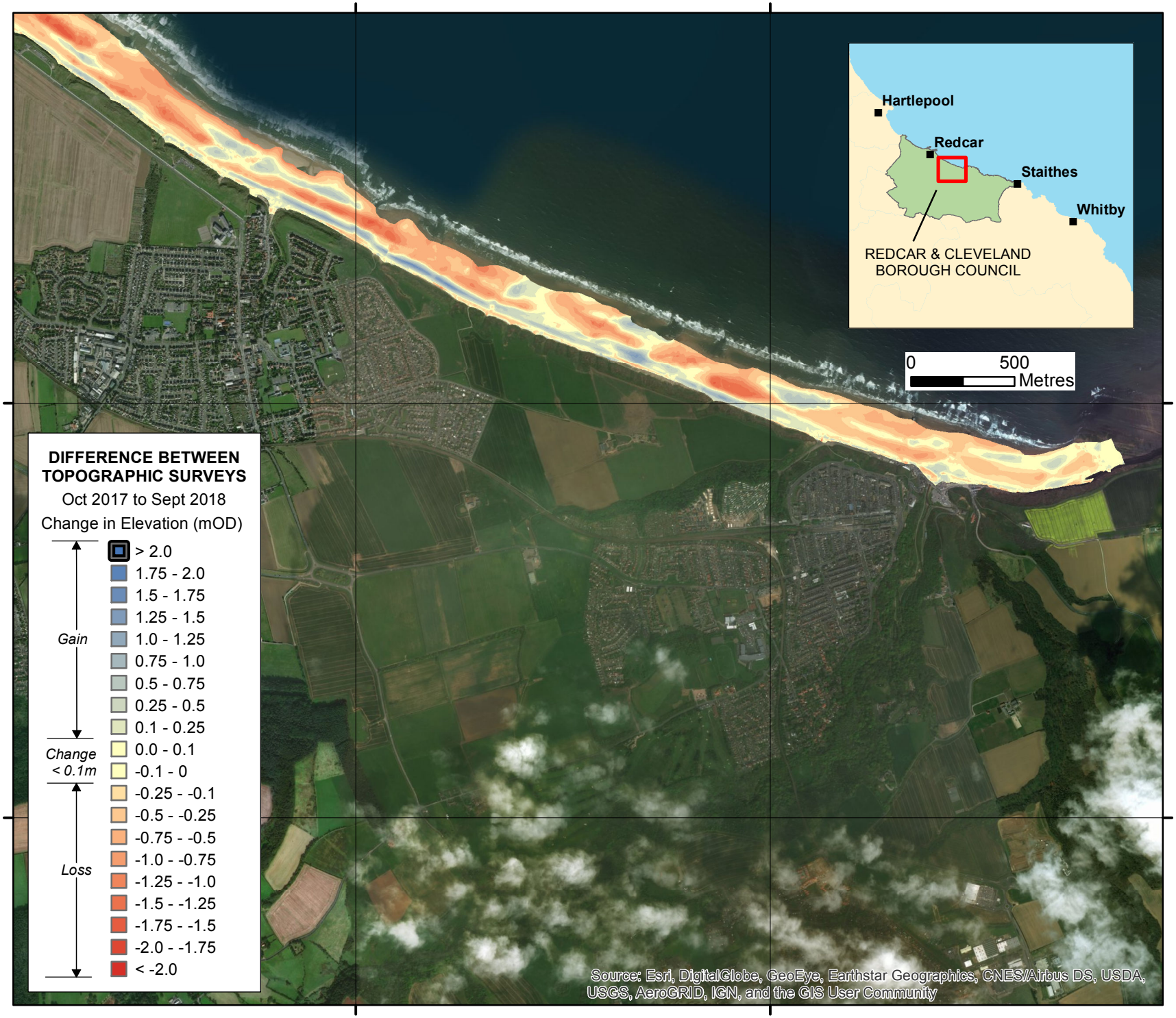

Key

Client: North East Coastal Group

Project: Cell 1 Regional Coastal Monitoring Programme

Appendix B - Map 7

MARSKE/ SALTBURN SANDS

Redcar and Cleveland Borough Council Frontage

Analytical Report
'Full Measures' Survey 2018

Drawing Scale at A4 1:25,000

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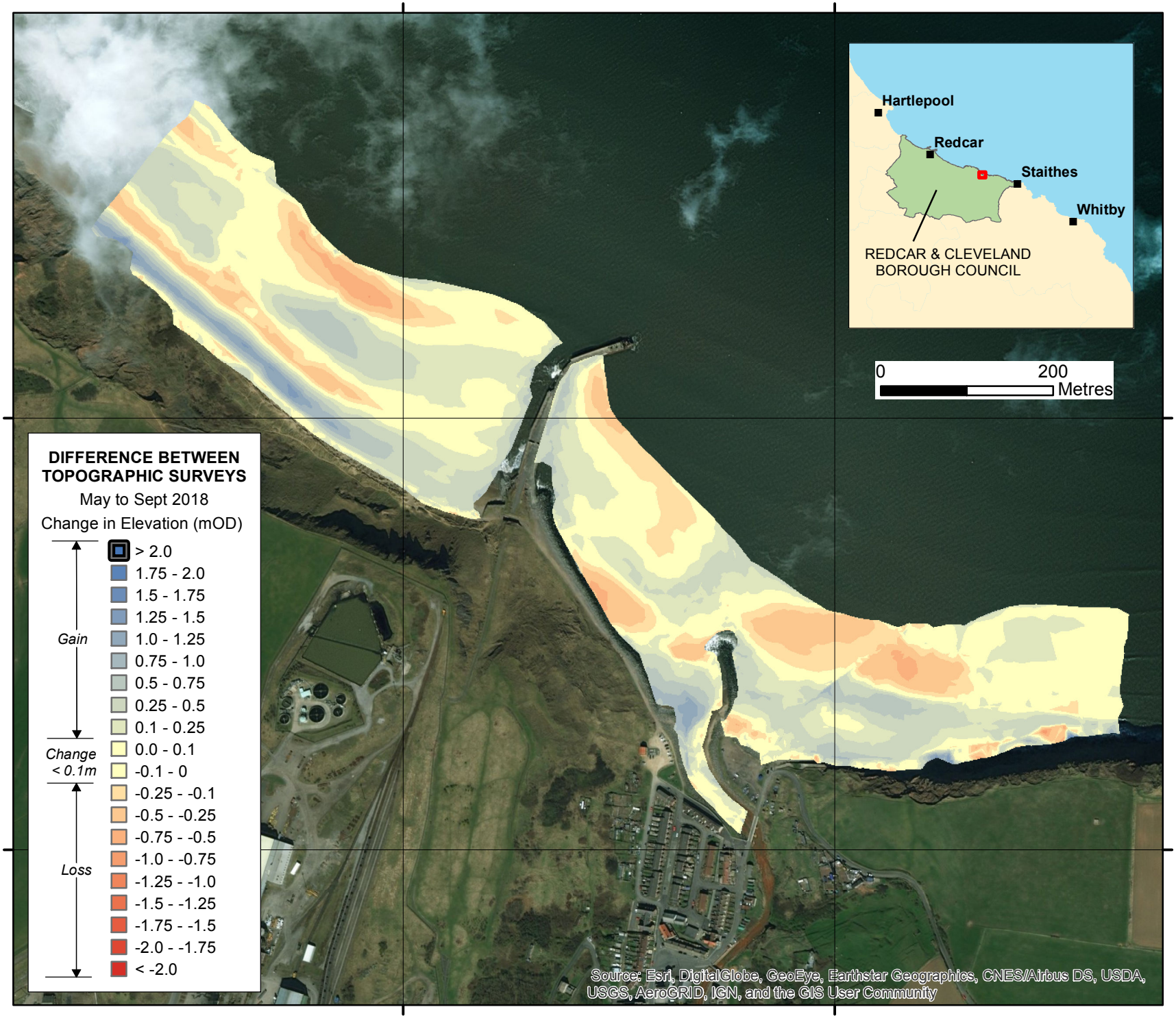

Key

Client: North East Coastal Group

Project: Cell 1 Regional Coastal Monitoring Programme

Appendix B - Map 8

CATTERSTY SANDS

Redcar and Cleveland Borough Council Frontage

Analytical Report
'Full Measures' Survey 2018

Drawing Scale at A4 1:6,000

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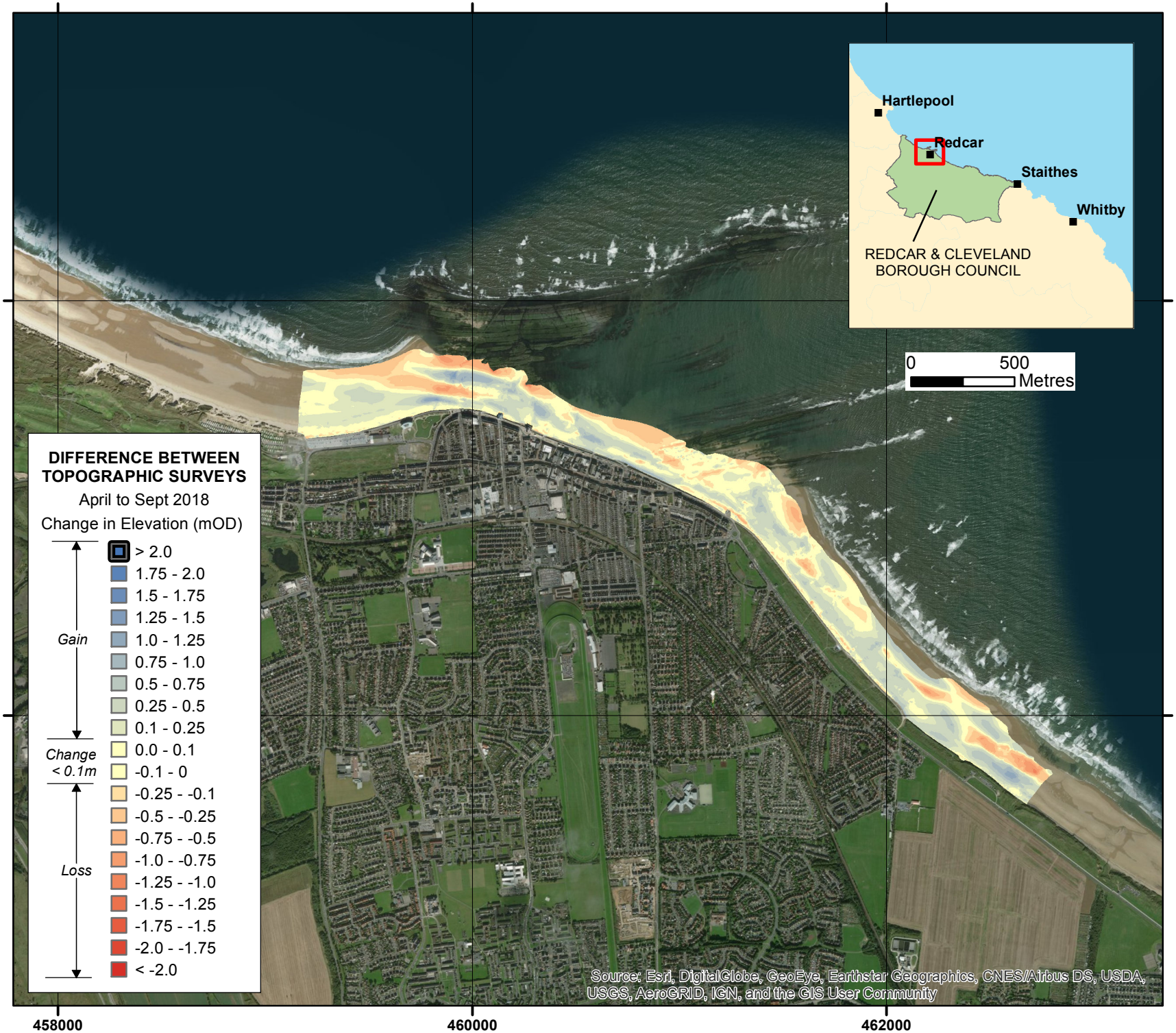

Key

Client: North East Coastal Group

Project: Cell 1 Regional Coastal Monitoring Programme

Appendix B - Map 9

REDCAR SANDS

Redcar and Cleveland Borough Council Frontage

Analytical Report
'Full Measures' Survey 2018

Drawing Scale at A4 1:25,000

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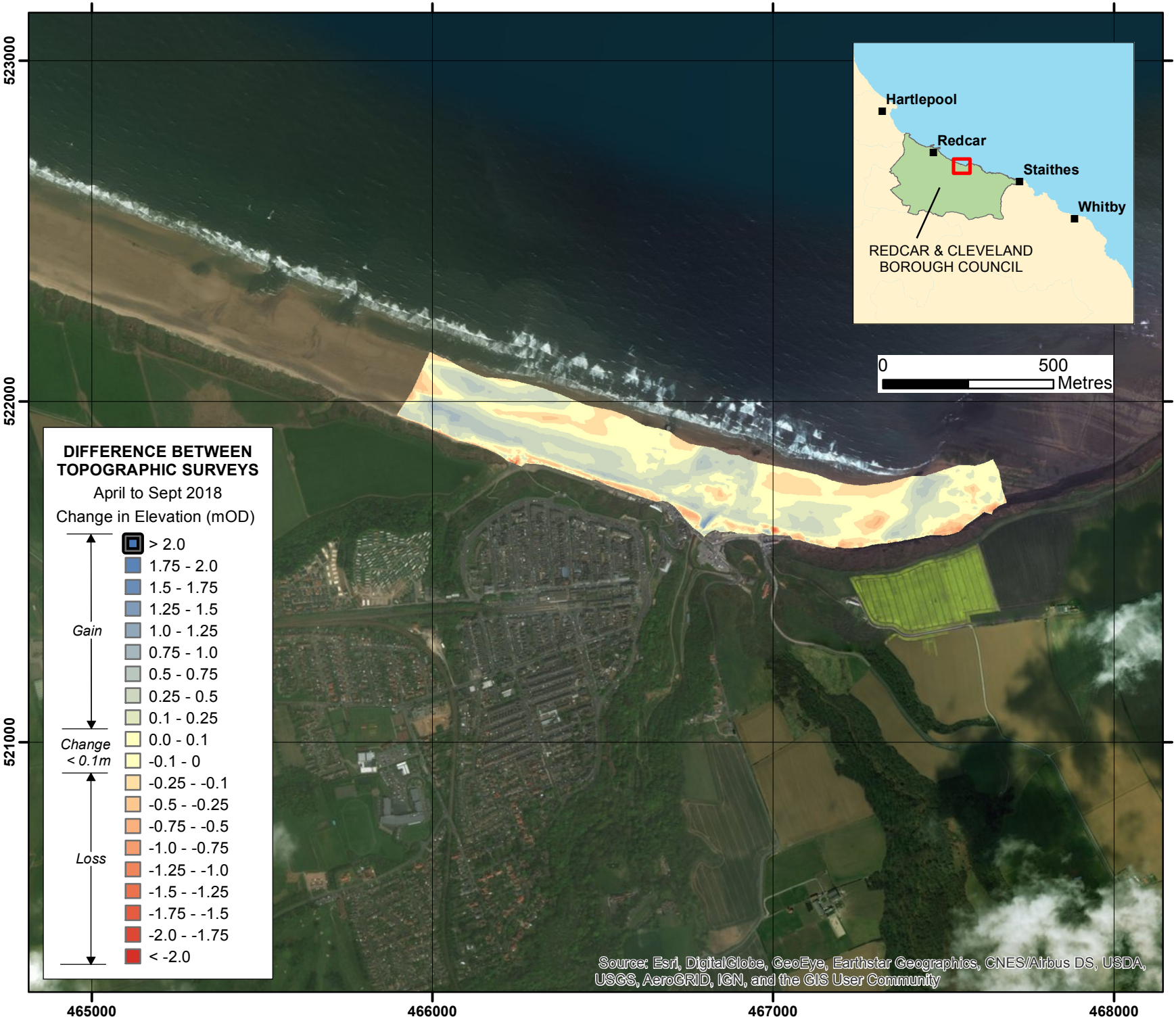

Key

Client: North East Coastal Group

Project: Cell 1 Regional Coastal Monitoring Programme

Appendix B - Map 10

SALTBURN SANDS

Redcar and Cleveland Borough Council Frontage

Analytical Report
'Full Measures' Survey 2018

Drawing Scale at A4 1:15,000

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Appendix C

Cliff Top Survey

Cliff Top Survey

Staithes

Twenty ground control points have been established within Staithes. 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	Apr 2018	Sep 2018	Nov 2008 - Sep 2018	Apr 2018 - Sep 2018	Nov 2008 - Sep 2018
1	477228	518769	320	1.9	0.04	-4.57	-6.47	-4.61	-0.59
2	477334	518798	0	10.9	10.78	10.73	-0.17	-0.05	-0.02
3	477487	518789	350	7.1	8.02	8.13	1.03	0.11	0.09
4	477594	518801	340	5.9	4.24	4.35	-1.55	0.11	-0.14
5	477683	518911	350	8.4	8.68	8.75	0.35	0.07	0.03
6	477792	518867	30	8.6	8.39	8.57	-0.03	0.18	0.00
7	477891	518828	60	7.7	7.31	7.32	-0.38	0.01	-0.03
8	477959	518873	350	8.7	9.64	9.61	0.91	-0.03	0.08
9	478088	518950	350	7.6	No Access	No Access	No Access	No Access	No Access
10	478191	519023	340	8.4	No Access	No Access	No Access	No Access	No Access
11	478237	519007	60	6.9	No Access	No Access	No Access	No Access	No Access
12	478213	518988	150	6.1	No Access	No Access	No Access	No Access	No Access
13	478501	518809	15	11.4	9.02	8.78	-2.62	-0.24	-0.24

14	478624	518807	20	7.5	7.5	7.49	-0.01	-0.01	0.00
15	478737	518858	60	6.1	6.17	6.29	0.19	0.12	0.02
16	478823	518757	60	8	8.67	8.56	0.56	-0.11	0.05
17	478944	518671	30	9.3	9.09	9.16	-0.14	0.07	-0.01
18	479052	518630	20	9.2	9.18	9.29	0.09	0.11	0.01
19	479147	518610	0	14.2	14.29	14.34	0.14	0.05	0.01
20	479274	518618	20	11.4	11.36	11.29	-0.11	-0.07	-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.