



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

**Redcar and Cleveland
Borough Council**



January 2020

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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 | Skinninggrove | 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.

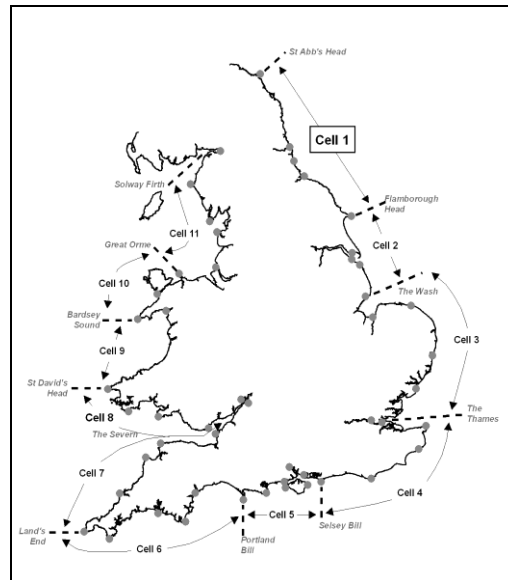


Figure 1 Sediment Cells in England and Wales

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
- 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.

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 | Jun 16 |
| 9 | 2016/17 | Sep-Nov 16 | Feb 17 | Mar 17 | Jul 17 | |
| 10 | 2017/18 | Oct 17 | Mar 18 | Mar-May 18 | Jun 18 | |
| 11 | 2018/19 | Sep 18 | Mar 19 | Mar-Apr 19 | May 19 | |
| 12 | 2019/20 | Oct & Nov 19 | Jan 20 (*) | | | |

* The present report is **Analytical Report 12** and provides an analysis of the 2019 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, Uppang 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 between October and November 2019. The weather and sea state varied, for further details please refer to the Survey Report from Academy Geomatics.

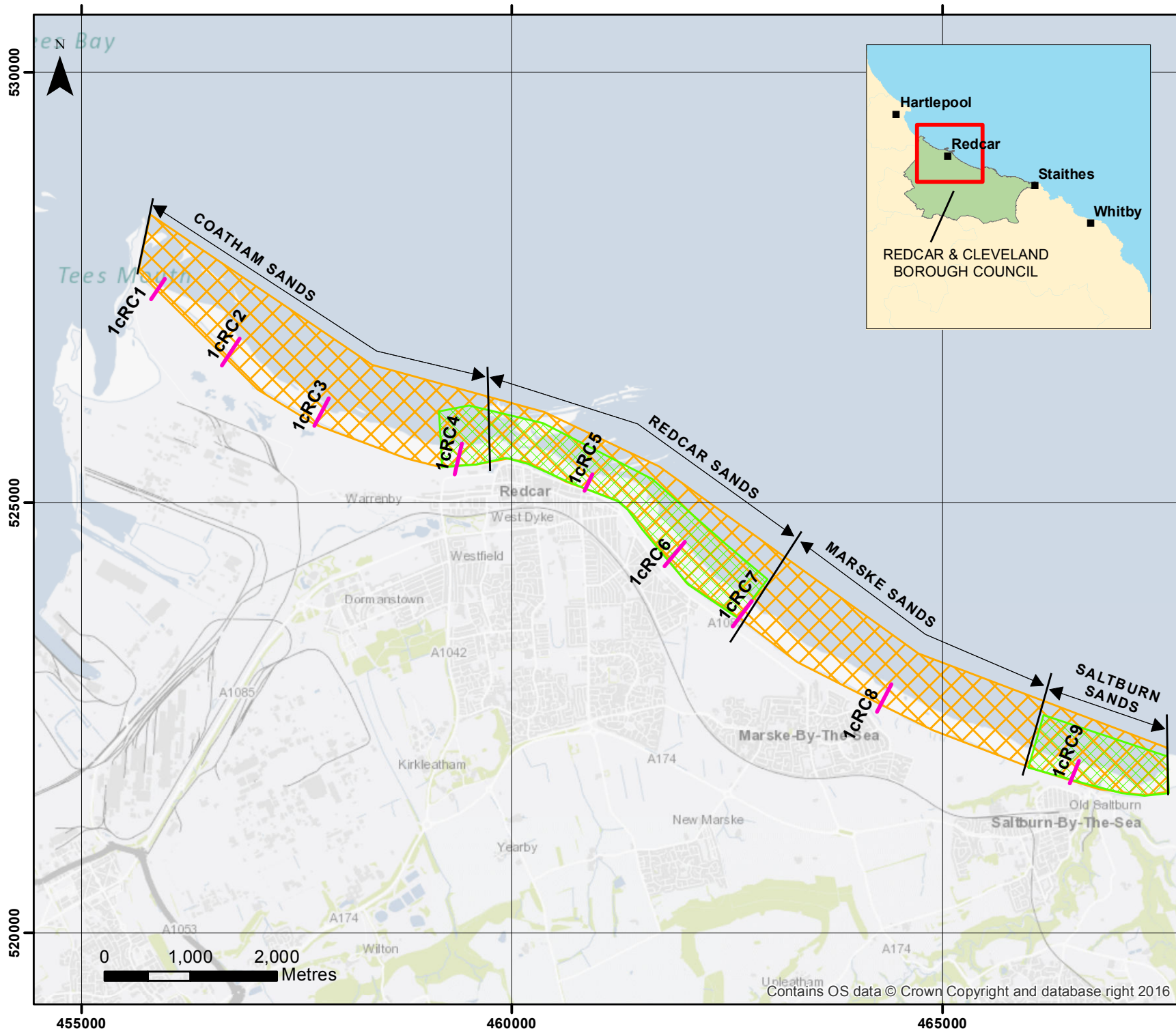
All data have been captured in a manner commensurate with the principles of the Environment Agency's *National Standard Contract and Specification for Surveying Services* and stored in a file format compatible with the software systems being used for the data analysis, namely SANDS and ArcGIS. This data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

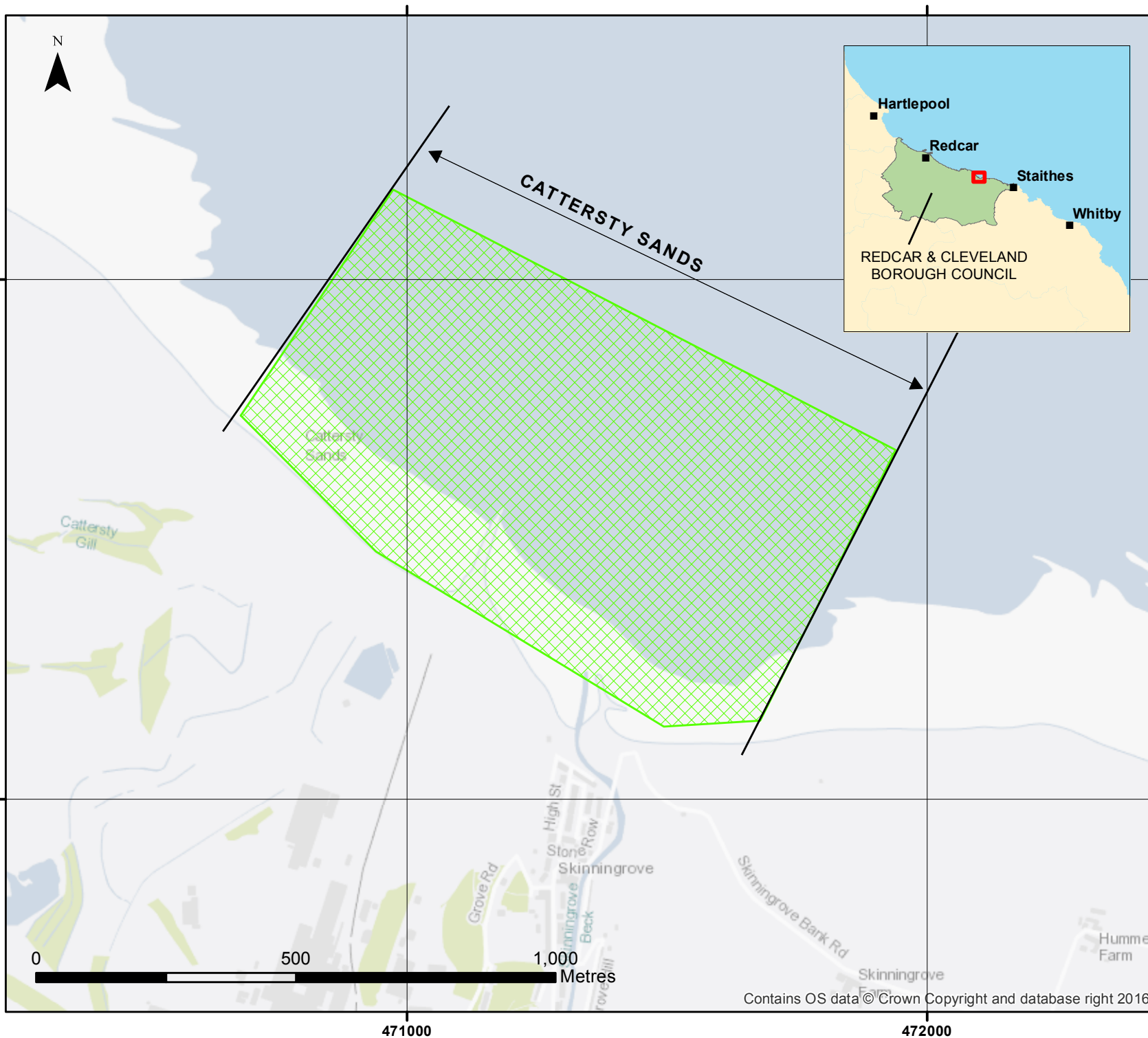
Drawing Scale at A4 1:60,000

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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

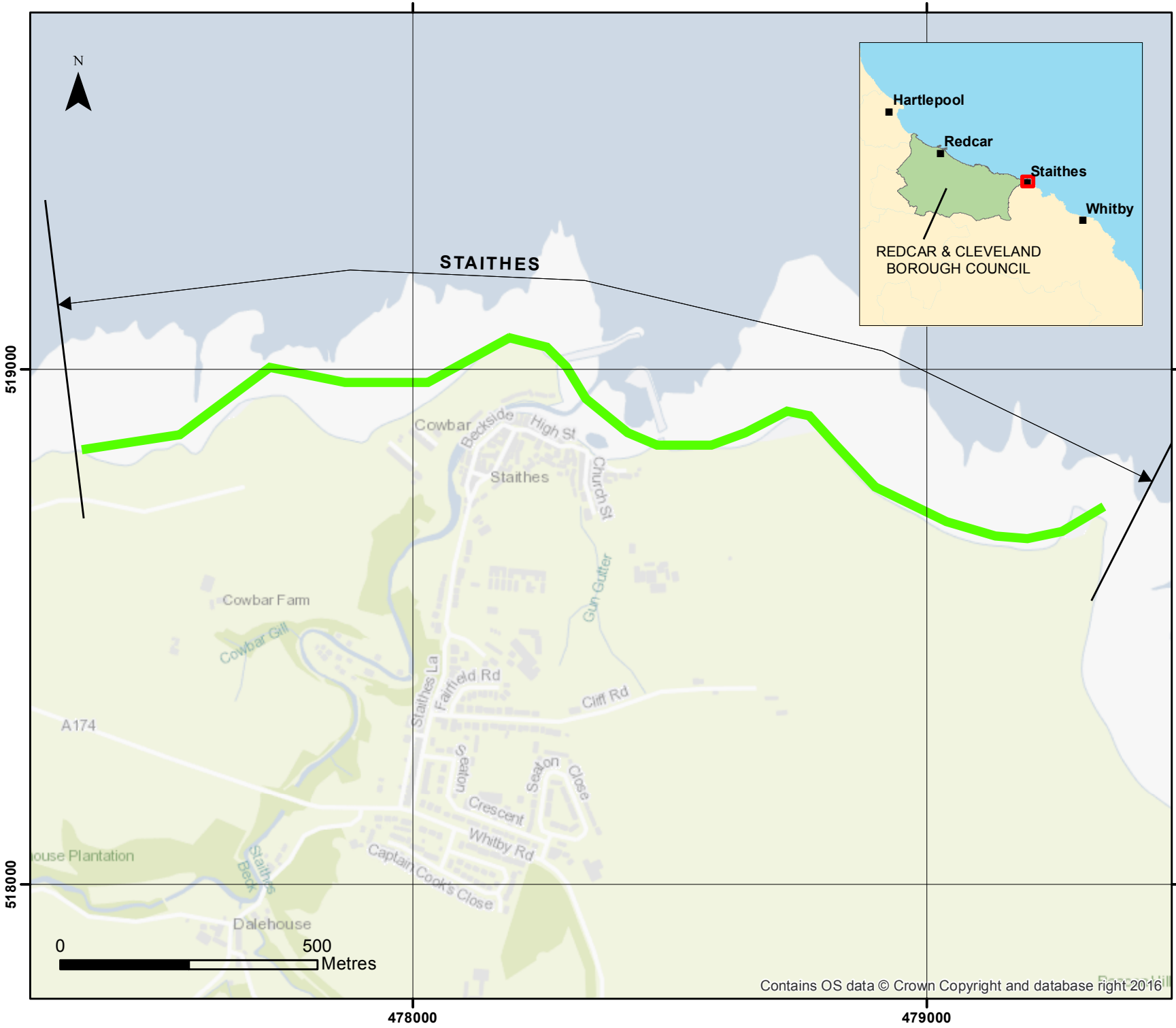
Analytical Report
Topo Surveys

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

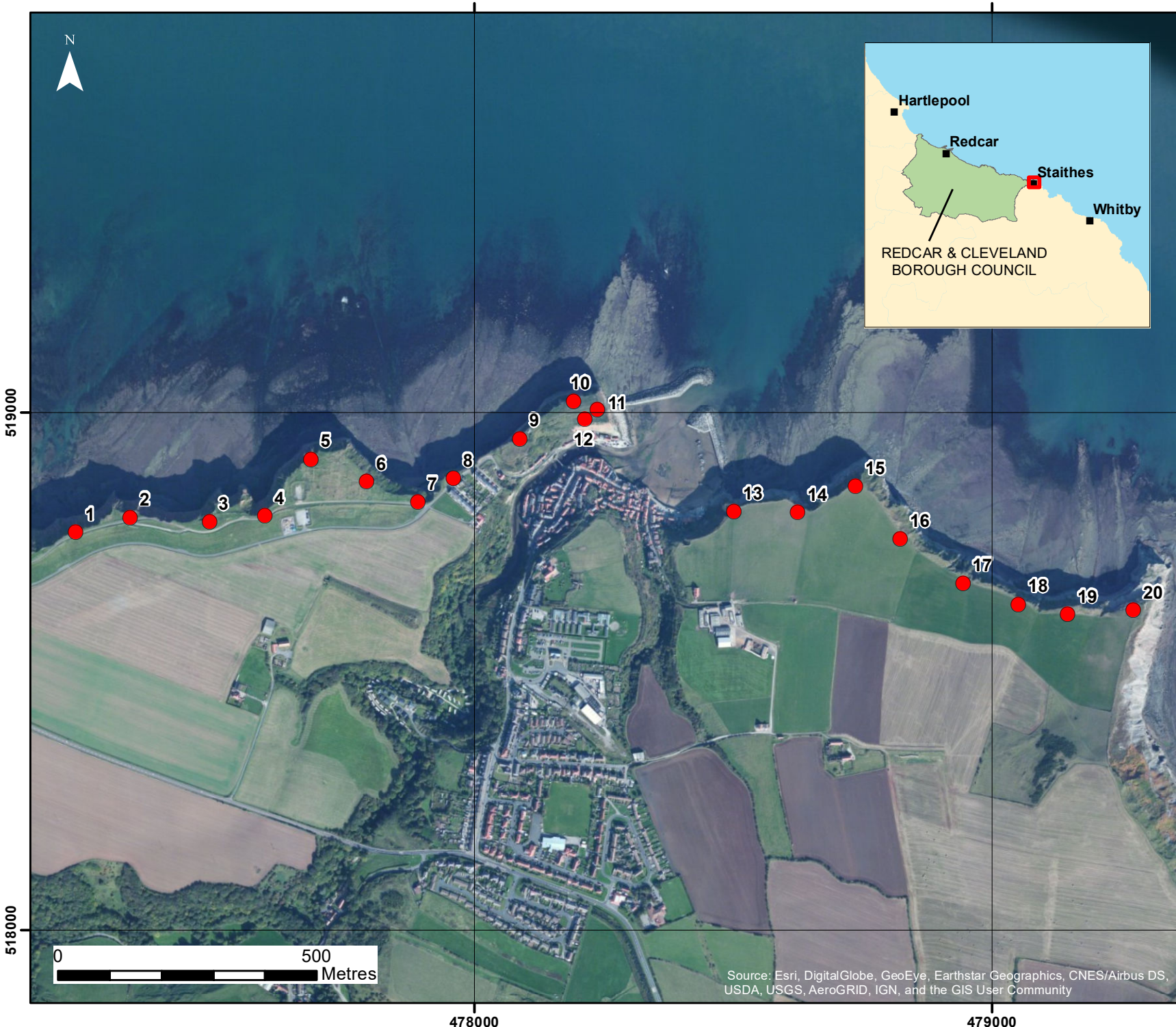
Drawing Scale at A4 1:10,000

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Key
 ● Cliff Top Survey Locations

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

Figure 3 - Map 1

STAITHES

Redcar and Cleveland Borough Council Council Frontage

Cliff Top Survey Locations

Drawing Scale at A4 1:10,000

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 Marlborough Crescent
 Newcastle upon Tyne
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Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

2. Analysis of Survey Data

2.1 Coatham Sands

| Survey Date | Description of Changes Since Last Survey | Interpretation |
|--|---|--|
| 28 th – 31 st October 2019 | <p>Beach Profiles:</p> <p>Coatham Sands is covered by four beach profile lines during the Full Measures survey (RC1 to RC4; Appendix A).</p> <p>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 accretion of 0.2m at its crest. There has been accretion from the toe of the dunes at 100m chainage to chainage 200m of up to 0.6m. This has caused a smoothing of the beach profile in its upper and mid reaches. From chainage 200m to chainage 240m there has been negligible accretion of <0.1m. From chainage 240m to the end of the survey at chainage 330m there has been some accretion of up to 0.2m. Overall these changes have reversed the steepening of the profile observed in the previous Full Measures survey. The beach level remains high compared to the range recorded from previous surveys. The sections of profile from chainage 90m to 135m and chainage 210m to 225m and chainage 310m to 330m are the highest on record.</p> <p>At Profile 1cRC2, the dunes continue to remain stable. Over the summer of 2019, the foredunes has remained stable with some accretion of up to 0.2m on their landward and seaward face. The foremost dune from chainage 80m to 90m records its highest crest level in 2019, with 0.3m of accretion having occurred since the Partial Measure survey in April 2019. There has been little change at the toe of the dunes and on the upper beach. From chainage 140m to 300m there has been accretion of up to 0.3m with the gradient of the beach remaining broadly similar to the previous survey. A shallow lower beach berm has formed between the chainages of 310m and 360m, Seaward of this point, until the end of the survey at chainage 390m there has been erosion of up to 0.4m. The beach levels are high when compared to the range recorded from the previous surveys, the foredunes are at their highest recorded level since records began in 2008. Additionally, from chainage 140m to 180m and chainage 330m to 342m the beach profile is at its highest recorded level.</p> <p>Profile 1cRC3 shows stable dunes with some erosion to the seaward face and toe of the foredune. From the toe of the dune at chainage 52m to 80m there has been erosion of up to 0.2m. From chainage 80m</p> | <p>Overall, the dunes have remained stable at Coatham Sands since the previous partial measures survey. Whilst the beach profiles show that accretion has been the dominant process over the intervening period, covering the summer of 2019, there has been some sporadic instances of erosion in the two southernmost profiles (1cRC3 and 1cRC4).</p> <p>The topographic survey difference plots show a similar trend, with accretion being the dominant process, particularly over the central swathe of the survey extent. There are however two areas of erosion, the southernmost area has been identified in beach profile 1cRC4. The northernmost area of erosion is located slightly to the south east of the location of 1cRC1 and as such was not identified in the beach profile surveys. Generally, erosion has been constrained to the lower beach.</p> <p>Longer term trends: The beach profile surveys indicate that the magnitude of change in 2019 is in line with the range of previously recorded results. The topographic survey difference plot has identified a more significant area of erosion in the north west of the survey area, however this is generally contained on the lower and mid-beach.</p> |

| Survey Date | Description of Changes Since Last Survey | Interpretation |
|------------------------|---|----------------|
| | <p>to 180m there has been a healthy accretion of up to 0.3m, restoring the beach from the low level recorded in April 2019. Between chainage 180m and 210m there has been no change. Seaward from chainage 210m to the end of the survey at chainage 320m accretion of up to 0.5m has infilled a depression recorded on the previous survey. The changes have had the effect of smoothing the profile of the beach. Overall, the upper beach level is at a low level, and the mid and lower beach is at a medium level, when compared with the range recorded from the previous surveys. It is worth noting that the toe of the foredune is at its most landward position (chainage 52m) when compared with the range of previously recorded results.</p> <p>Profile 1cRC4 is the beginning of the defended section at Redcar. There has been some minor erosion (<0.1m) at the toe of the defence from chainage 13m to chainage 35m. From chainage 35m to 55m there has been minor accretion, with further minor erosion from chainage 55m to 80m. There has been little net change on the upper beach. From chainage 80m to 210m the beach has shown some accretion of up to 0.2m. Seaward of this point until the end of the survey sat chainage 360m the beach has remained low but largely stable. Overall, the beach has experienced low levels of accretion across the mid-beach since the previous survey, by up to 0.2m. The lower beach has remained largely unchanged whilst the upper beach has experienced some alternating bands of accretion and erosion. Overall, the beach level is at a medium to low level compared to the range recorded from previous surveys, with the section seaward of chainage 300m being the lowest on record.</p> | |
| <p>Oct 2019</p> | <p>Topographic Survey:</p> <p>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 2019 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.</p> <p>The GIS has also been used to calculate the differences between the current topographic (Autumn 2019) survey and the earlier topographic survey (Autumn 2019), as shown in Appendix B – Map 5, to identify areas of erosion and accretion.</p> <p>The topographic difference plot shows that accretion has been the dominant process over much of the</p> | |

| Survey Date | Description of Changes Since Last Survey | Interpretation |
|-------------|--|----------------|
| | <p>survey area. The greatest areas of accretion are focused around the mid beach in the central swathe of the survey extent. There has been some erosion in the north west of the survey area however this has generally been constrained to the lower beach. In the south east of the survey area, in the section of beach fronting the Boating Lake and Bandstand there has been heightened levels of erosion of up to 1m. Overall change is limited to $\pm 1.5\text{m}$ across the survey area.</p> | |

2.2 Redcar Sands

| Survey Date | Description of Changes Since Last Survey | Interpretation |
|--|---|--|
| 28 th – 31 st October 2019 | <p>Beach Profiles:</p> <p>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.</p> <p>At profile 1cRC5, there has been some minor erosion of up to 0.3m at the toe of the sea defence, continuing to chainage 30m. From chainage 30m to 50m there has been a consistent accretion of 0.1m. Seaward of chainage 50m to 125m, accretion of up to 0.5m has restored beach levels across the mid-beach, covering the previously exposed rocks. From chainage 125m to the end of the survey at chainage 225m the rocks remain exposed as they were in the previous (Partial Measures) survey. The level of the beach is high on the upper and mid beach, on the lower beach the beach levels remain low. With the section of profile between chainage 190m to 220m being the lowest on record.</p> <p>At profile 1cRC6, there has been a small section of erosion of up to 0.2m between chainages 60m and 76m. Across the rest of the beach profile, there has been accretion of up to 0.2m on the upper beach and mid beach increasing to 0.4m at the toe of the beach. There was negligible change across the lower mid beach. As a result, the October 2019 profile is at a high level compared to the range recorded from previous surveys. In particular, from chainage 82m to 135m and chainage 155m to 290m the profile is at highest recorded level.</p> <p>Profile 1cRC7 has experienced very little change on the dune frontage since April 2019. At the toe of the dunes there has been negligible change from chainage 60m to 80m, however this has been limited to 0.1m. The upper beach from chainage 80m to 120m has experienced accretion of 0.5m, whilst from chainage 120m to 165m this trend has been reversed with 0.6m of erosion. The remainder of the profile has shown accretion of up to 0.5m. A lower beach berm recorded in the April 2019 survey has been buried and the profile appears to be at a shallower gradient than in many of the previous surveys. Overall, the beach is at a low level across the upper beach, and a medium level in the lower beach compared to the range recorded by the previous surveys.</p> | <p>All three of the profiles show varying beach levels in autumn 2019, ranging from higher levels in the east, to lower levels in the west, however accretion is dominant across all three profiles.</p> <p>The topographic change plot between April 2019 and October 2019 reflects this pattern with accretion dominating since the Spring survey, and erosion generally restricted to isolated patches. The pattern of change between Autumn 2018 and Autumn 2019 shows a more dominant trend of accretion with the exception of the area around Redcar Rocks.</p> <p>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.</p> <p>The new hard defences at Redcar have affected the patterns of accretion on the upper beach due to the introduction of a less reflective seawall.</p> |

| Survey Date | Description of Changes Since Last Survey | Interpretation |
|-------------|--|----------------|
| Oct 2019 | <p>Topographic Survey:</p> <p>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 between the October 2012 and March 2013 surveys.</p> <p>The GIS has also been used to calculate the differences between the current topographic survey (Autumn 2019) and the previous full measures survey (Autumn 2018) and the most recent (Spring 2019) 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 2019 and Autumn 2019. The pattern of change between Autumn 2018 and Autumn 2019 shows a more diverse mix of erosion and accretion across the frontage. Accretion has broadly dominated with some sporadic instances of significant erosion. Notably between Redcar Rocks and West Scar. Furthermore, in the south of the frontage shore parallel, alternating bands of accretion and erosion are present. 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.</p> | |

2.3 Marske Sands

| Survey Date | Description of Changes Since Last Survey | Interpretation |
|---------------------------|--|---|
| 31 st Oct 2019 | <p>Beach Profiles:</p> <p>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.</p> <p>Profile 1cRC7 is located along The Stray and has been discussed in Section 2.2.</p> <p>At profile 1cRC8, there is no change to the face of the cliff. The large upper beach berm recorded on the previous full measure survey eroded prior to the previous partial measures survey in April 2019. Although the change noted over the summer of 2019 is accretion on the upper beach from chainage 75m to 118m. A smaller mid-beach berm recorded in the previous survey has also been eroded between chainages 120m and 166m. Seaward of this point until the end of the survey at chainage 320m there has been accretion of up to 0.5m. The beach is at a medium level compared with the range of previously recorded survey.</p> | <p>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.</p> <p>The difference plot for Autumn 2018 to Autumn 2019 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.</p> <p>Longer term trends: Current beach profiles are medium compared with the range of previously recorded results. Recorded changes are due to the movement of bars on the beach, which is also shown on the topographic difference plots.</p> |
| Oct 2019 | <p>Topographic Survey:</p> <p>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 2019 and Autumn 2020 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 2018, accretion and erosion has occurred in broadly shore parallel patterns. There has been a narrow band of the accretion against the toe of the cliffs, whilst a narrow band of erosion dominates the upper beach. Across much of the mid beach low levels of accretion have dominated. There are sporadic bands of erosion on the lower beach. Magnitudes of change are modest at approximately $\pm 1.5\text{m}$.</p> | |

2.4 Saltburn Sands

| Survey Date | Description of Changes Since Last Survey | Interpretation |
|--|--|---|
| <p>31st October 2019</p> | <p>Beach Profiles:</p> <p>Saltburn Sands is covered by one beach profile during the Full Measures survey (RC9; Appendix A).</p> <p>At profile 1cRC9, there has been accretion of 0.5m at the toe of the seawall from chainage 21m to 26m. Whilst from chainage 26m to 43m erosion of 0.6m has occurred. Seaward of this point, from chainage 43m to the end of the survey at chainage 263m, the upper and middle beach has accreted by between 0.2 and 0.4m. On the lower beach a shallow berm has formed between chainage 200m and 260m.</p> <p>Overall, the beach is at a low to medium level compared to the range recorded from previous surveys, although the profile is at its lowest recorded level between chainages 27m to 37m .</p> | <p>The beach showed an overall increase in level at profile 1cRC9.</p> <p>The difference plot between the last partial measures survey in Spring 2019 and the present full measures survey in Autumn 2019 shows low levels of accretion across much of the beach. There is also some limited erosion much across the upper beach, notably fronting the promenade and sea wall to the west of Skelton Beck. The difference plot between the last full measures survey in Autumn 2019 and the present full measures survey in Autumn 2019 shows a slightly more erosive trend to the east of Skelton Beck with low levels of accretion dominating the beach to the west of the beck, although all changes are low in magnitude.</p> |
| <p>Oct 2019</p> | <p>Topographic Survey:</p> <p>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.</p> <p>The GIS has also been used to calculate the differences over the six month period between Spring 2019 and Autumn 2019 topographic survey, as shown in Appendix B – Map 10, and the change since the last full measures survey in autumn 2018, to identify areas of net erosion and accretion (Appendix B – Map 7).</p> <p>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. Accretion is more dominant to the west of Skelton Beck whilst to the east of the Beck, erosion is the dominant process. Since the previous Partial Measures survey changes have been of a small magnitude, with almost no changes experienced to the east of Skelton Beck.</p> <p>To the west of the Beck the mid and lower beach has been dominated by low levels of accretion. A narrow band of shore parallel erosion has occurred on the upper beach fronting the promenade and seawall which sit at the toe of the Saltburn cliffs. The most significant area of erosion has occurred</p> | <p>Longer term trends: The April 2019 beach level was one of the lowest recorded profile since 2008, suggesting ongoing progressive erosion, the October 2019 survey records some recovery over the summer of 2019. The trend of erosion through the winter months with some recovery over the summer is leading to the progressive erosion and drawdown of the beach. This pattern has been experienced for several years.</p> |

| Survey Date | Description of Changes Since Last Survey | Interpretation |
|--------------------|---|-----------------------|
| | around the outfall of Skelton Beck; however all changes have been restricted to $\pm 1.5\text{m}$. | |

2.5 Cattersty Sands

| Survey Date | Description of Changes Since Last Survey | Interpretation |
|--|---|--|
| <p style="text-align: center;">Nov 2019</p> | <p>Topographic Survey:</p> <p>Cattersty Sands is covered by a six-monthly topographic survey.</p> <p>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.</p> <p>The GIS has also been used to calculate the differences between Spring 2019 and Autumn 2019 topographic surveys and is presented as DGM (as shown in Appendix B – Map 8), to identify areas of net erosion and accretion.</p> <p>The difference plot shows a patchy distribution of accretion and erosion. To the west of the breakwater, changes have been limited. Much the mid-beach has experienced low levels of accretion, with the exception of the far north west of the survey extent which has experienced some minor erosion. There have been low levels of accretion directly to the west of the breakwater, however levels at the toe of the structure have remained broadly the same. To the east of the breakwater patchier erosion and accretion has been experienced. With the most significant changes being focused around the outfall of Kilton Beck. To the east of the Beck a fishtail groyne was modified some years ago, into a more conventional rock armour groyne. To the east of the short rock armour groyne erosion has dominated the upper beach whilst accretion has dominated the mid and lower beach.</p> | <p>The topographic change data shows Cattersty Sands is very dynamic, influenced by coastal and fluvial processes, along with the breakwater and the shorter rock armour groyne. Short term change, over the preceding six-monthly shows similar beach behaviour either side of the breakwater with accretion being the dominant process.</p> <p>Longer term trends: The magnitude of changes experienced over the summer of 2019 has been less than in previous years. There has been erosion to the channel and around the outfall of the Beck, although this appears to have only reversed the accretion experienced the previous year. The mid beach experienced further accretion, whilst the upper beach, particularly to the west of the breakwater experienced some minor erosion.</p> <p>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.</p> |

2.6 Staithes

| Survey Date | Description of Changes Since Last Survey | Interpretation |
|------------------------|---|---|
| <p>Oct 2019</p> | <p>Cliff-top Survey:</p> <p>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.</p> <p>Between March 2019 and October 2019, 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.</p> <p>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.</p> <p>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.</p> | <p>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.</p> <p>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.</p> <p>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.</p> |

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 $\pm 0.1\text{m}$ 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, ongoing successive cliff falls at Post 1 mean that the cliff top has now encroached into the track.

At Cattersty Sands, an area of cliff face which had collapsed prior to the 2018 Full Measures survey appears to have stabilised.

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 accretion has been the dominant process across the survey extent, with the exception of the area around Redcar Rocks which has experienced more erosion. Overall, profiles remain high in the west and lower in the east compared to the range recorded from previous surveys.
- At Marske Sands, the 2019 beach profiles show the beach is generally accreting, with the prominent area of erosion at the middle beach at profile 1cRC7 (recorded in the previous Full Measures survey) has recovered over the previous 12 months. At profile 1cRC8 there has been accretion in the upper and lower beach, with some erosion of the mid beach. 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 2019, which is a similar pattern to 2018 and 2017. However, the trend of winter erosion and summer recovery appears to be leading to a net loss from the beach as summer recovery is not compensating fully for the winter drawdown.
- The Cattersty Sands difference model shows that the changes in the summer of 2019 were of similar magnitude either side of the breakwater, however with a patchier distribution than in previous years. Overall, accretion occurred on middle beach, with erosion on the lower beach. To the west of the breakwater erosion occurred on the upper beach at the toe of the cliffs. To the east of the modified groyne, erosion has occurred on the upper beach and accretion on the mid beach. In contrast to 2018, but in keeping with the general trend from previous surveys, erosion 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 0.5m over the summer of 2019 at three stations. The largest amount of erosion occurred at Post 5 (0.45m) as a result of ongoing cliff failure. Stations 1 and 7 also showed erosion greater than 0.1m. Station 1 is an area of longstanding concern, and the erosion recorded in 2019 is in keeping with the general trend of retreat, whilst Station 7 has historically seen less erosion. 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. This frontage is the subject of the ongoing Staithes Strategic Appraisal Report (StAR) which seeks to address issues relating to coastal erosion.

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: 31/10/2019

Inspector: AG

Low Tide:

Low Tide Time:

Wind

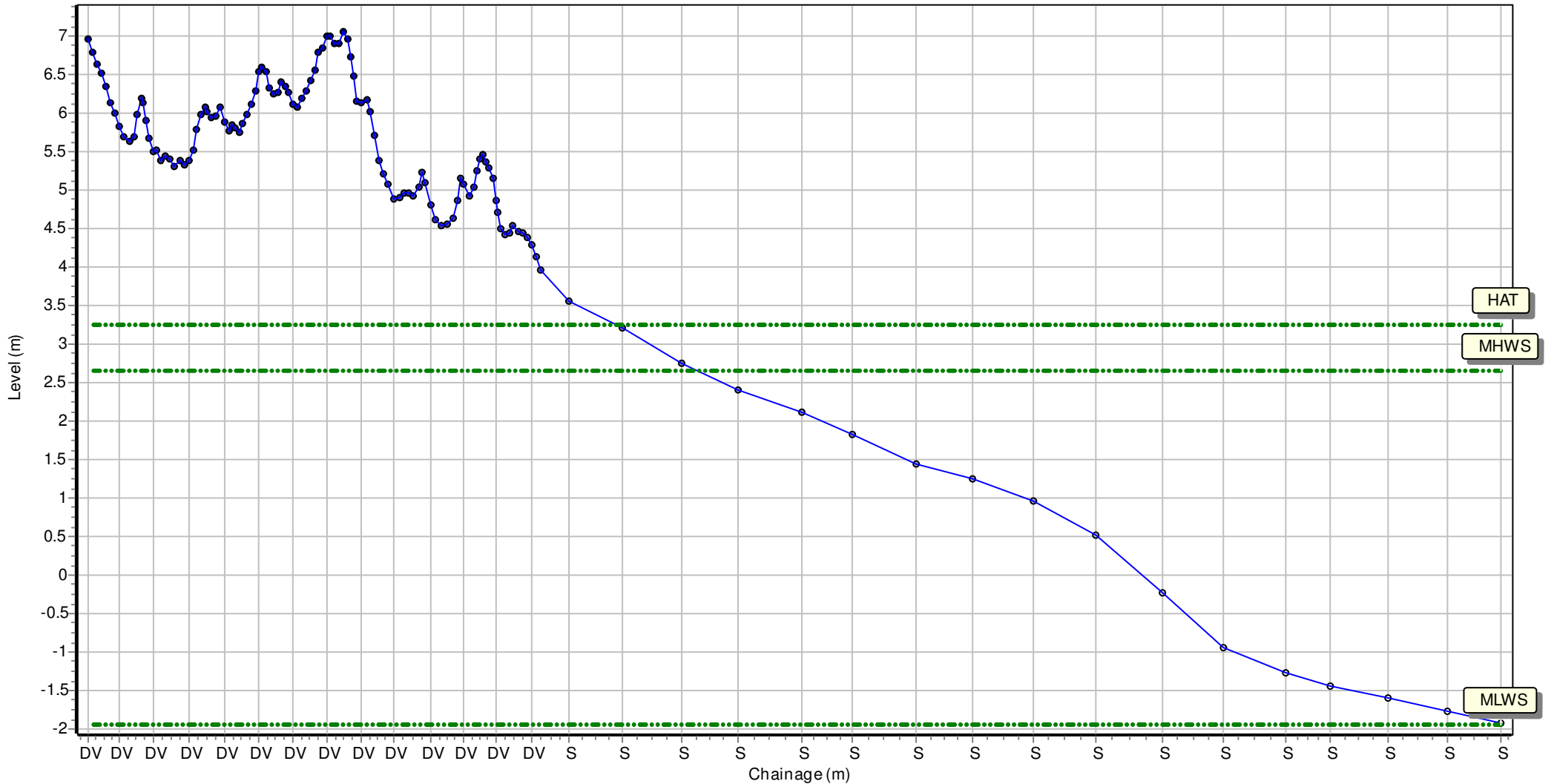
Sea State:

Visibility:

Rain:

Summary: 2019 Full Measures Topo Survey

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



Beach Profile

Location: 1cRC2

Date: 31/10/2019

Inspector: AG

Low Tide:

Low Tide Time:

Wind

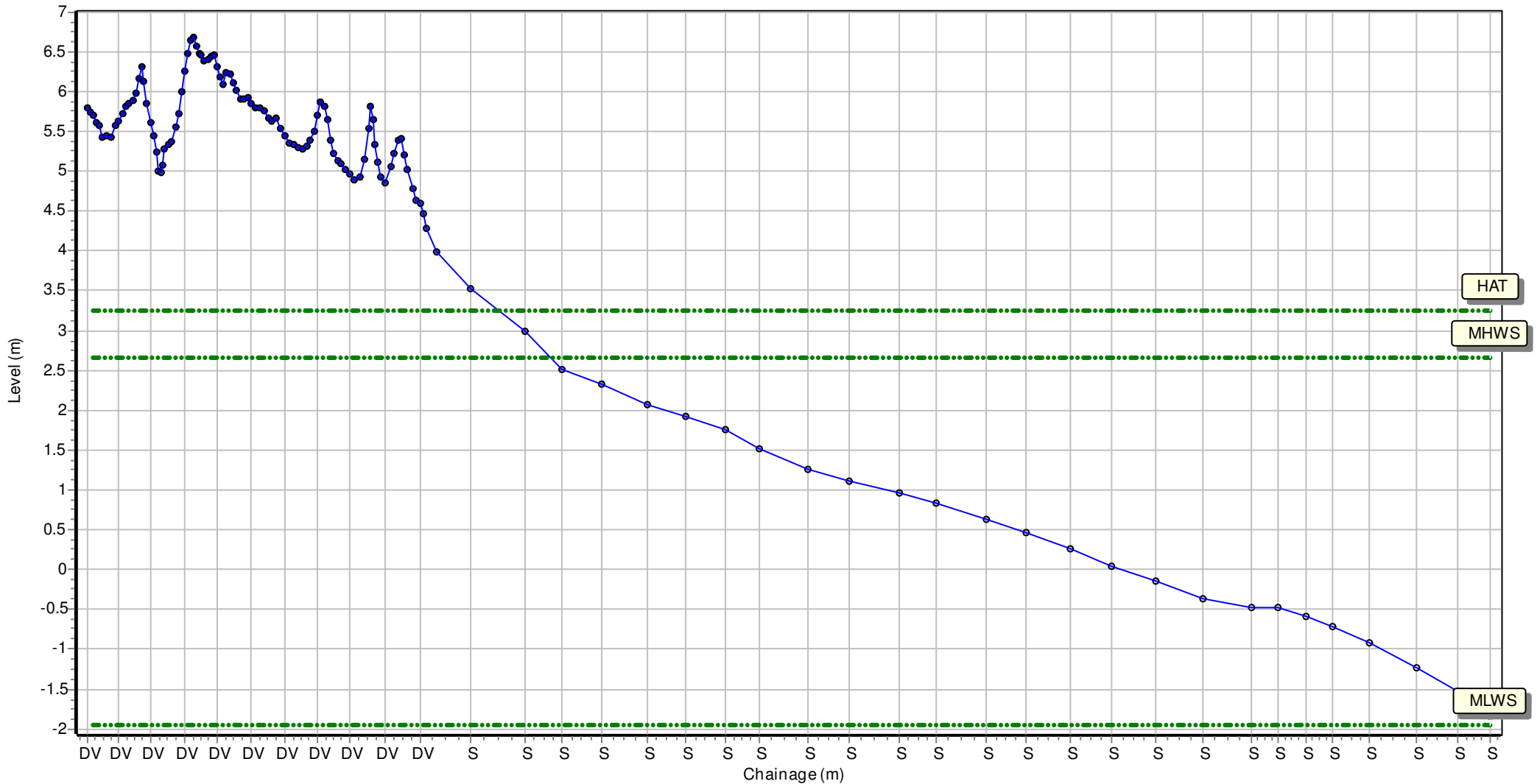
Sea State:

Visibility:

Rain:

Summary: 2019 Full Measures Topo Survey

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



Beach Profile

Location: 1cRC3

Date: 31/10/2019

Inspector: AG

Low Tide:

Low Tide Time:

Wind

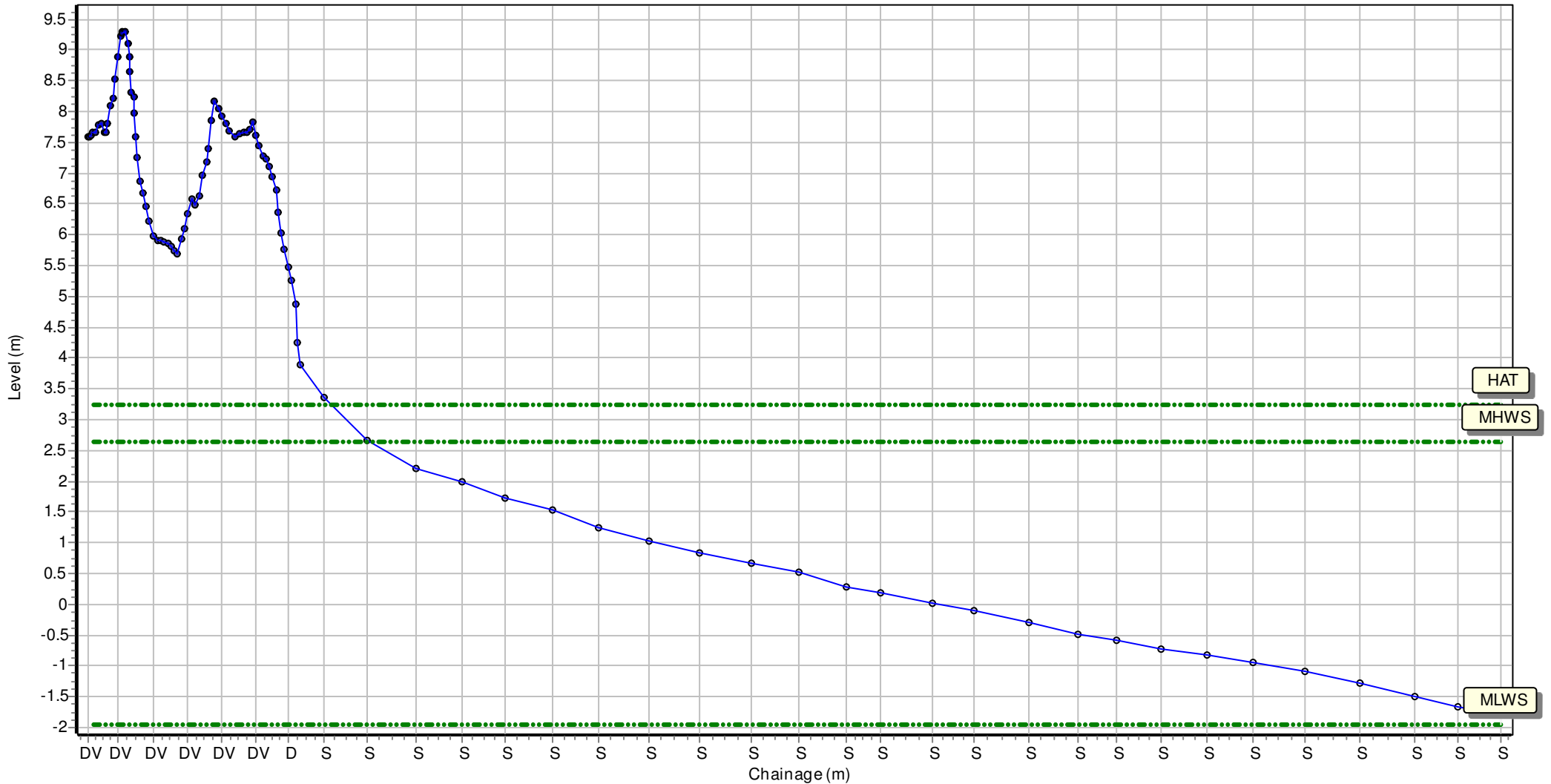
Sea State:

Visibility:

Rain:

Summary: 2019 Full Measures Topo Survey

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



Beach Profile

Location: 1cRC4

Date: 31/10/2019

Inspector: AG

Low Tide:

Low Tide Time:

Wind

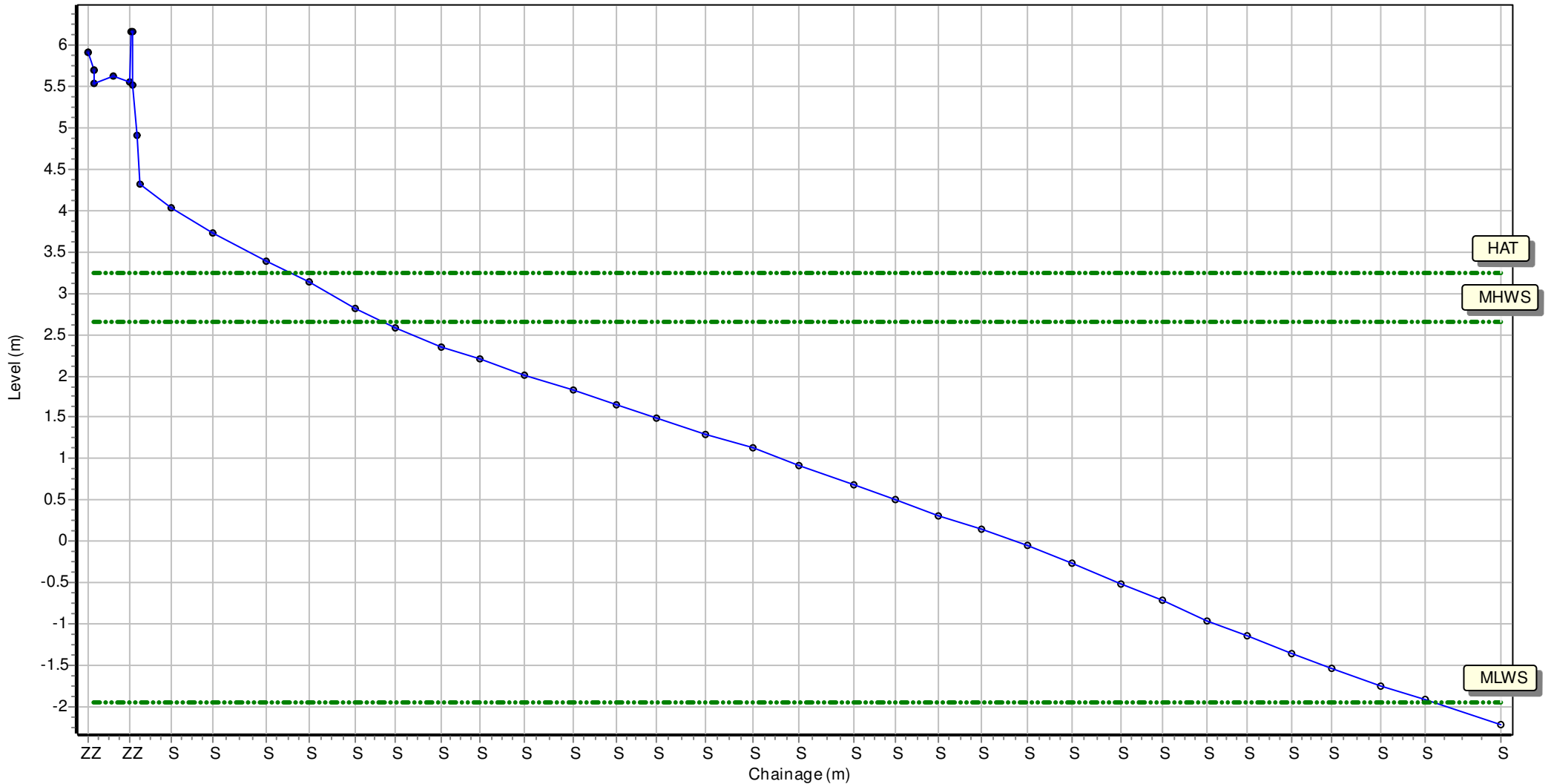
Sea State:

Visibility:

Rain:

Summary: 2019 Full Measures Topo Survey

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



Beach Profile

Location: 1cRC5

Date: 31/10/2019

Inspector: AG

Low Tide:

Low Tide Time:

Wind

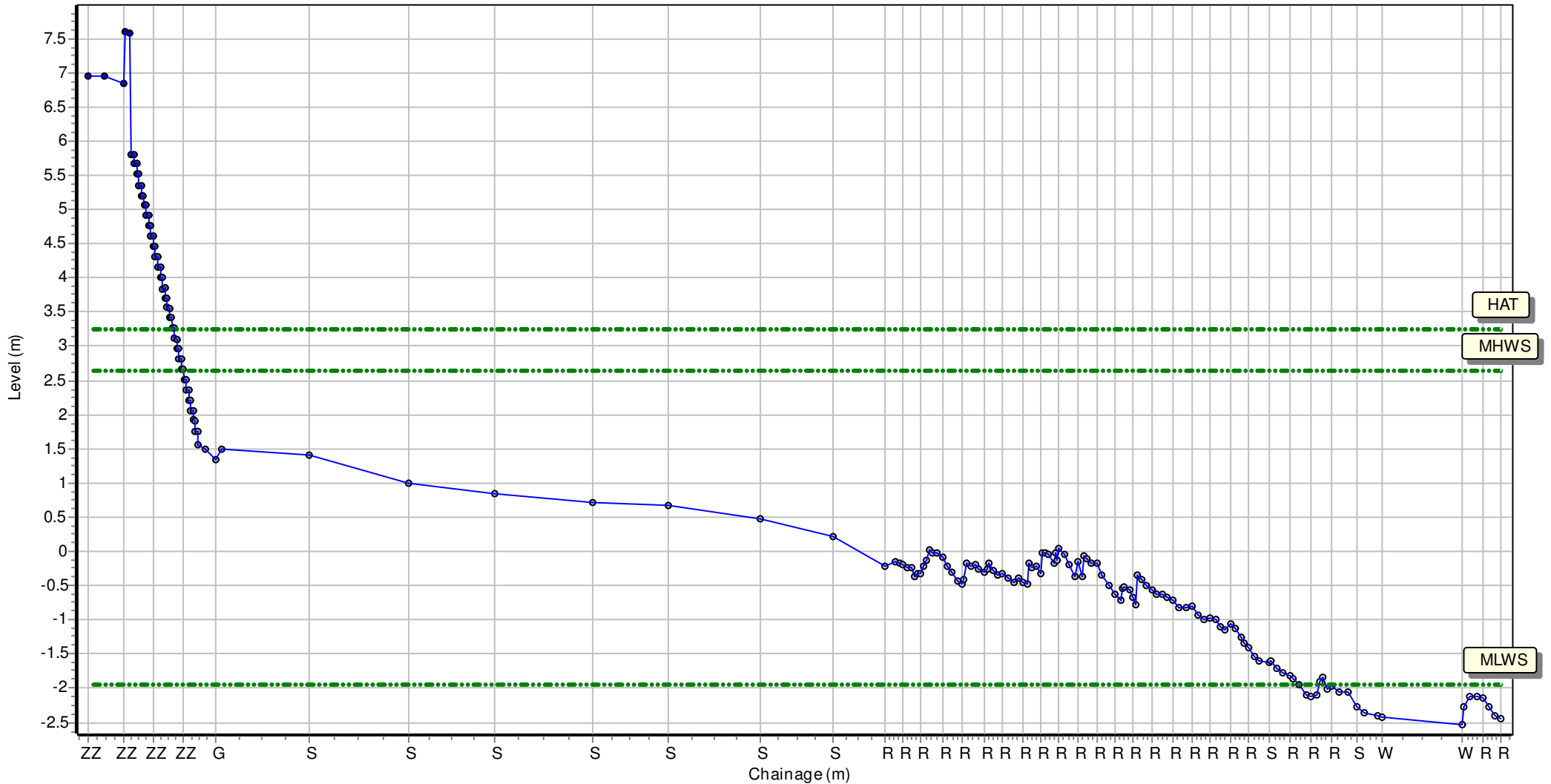
Sea State:

Visibility:

Rain:

Summary: 2019 Full Measures Topo Survey

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



Beach Profile

Location: 1cRC6

Date: 31/10/2019

Inspector: AG

Low Tide:

Low Tide Time:

Wind

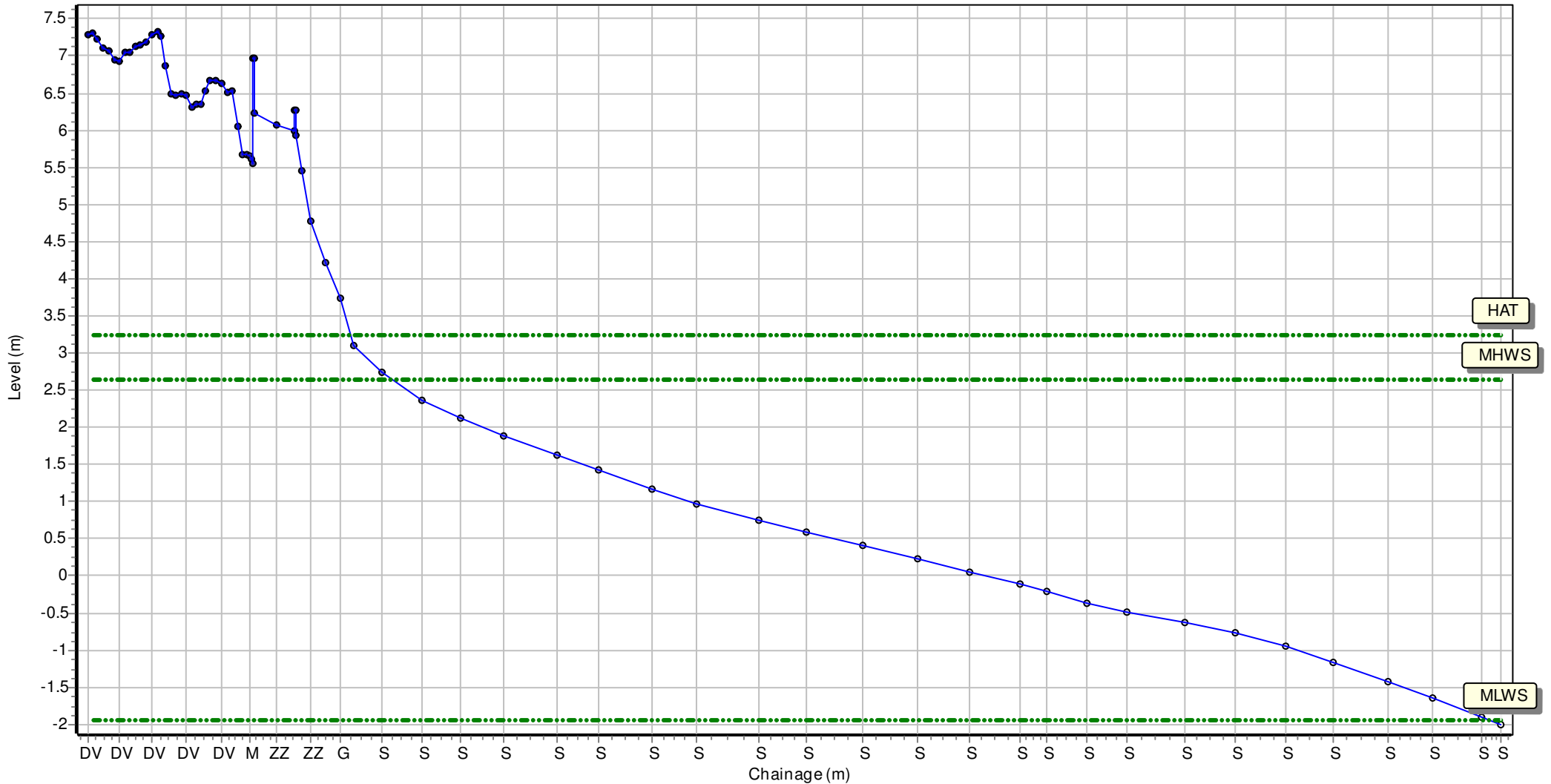
Sea State:

Visibility:

Rain:

Summary: 2019 Full Measures Topo Survey

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



Beach Profile

Location: 1cRC7

Date: 31/10/2019

Inspector: AG

Low Tide:

Low Tide Time:

Wind

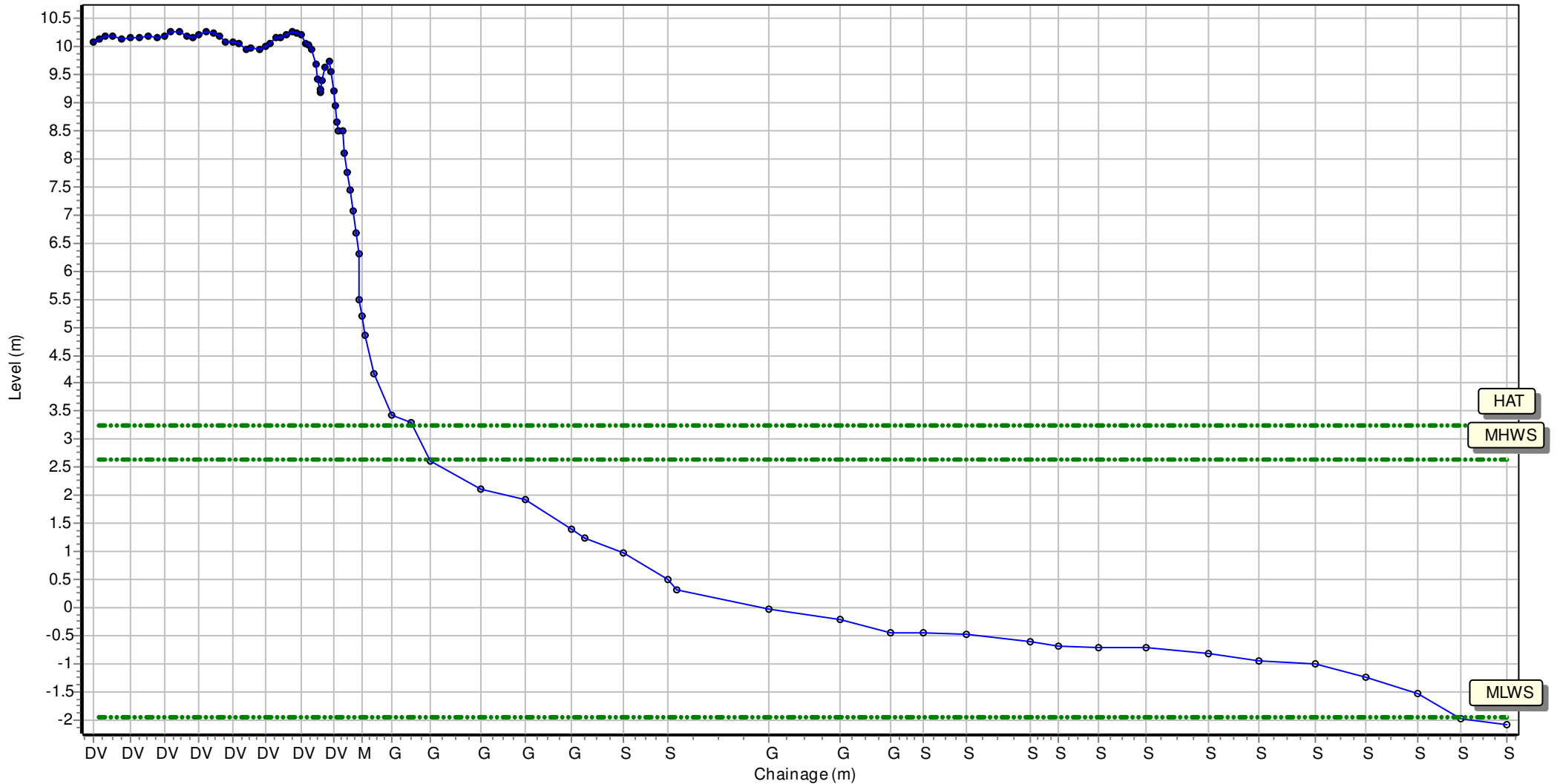
Sea State:

Visibility:

Rain:

Summary: 2019 Full Measures Topo Survey

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



Beach Profile

Location: 1cRC8

Date: 31/10/2019

Inspector: AG

Low Tide:

Low Tide Time:

Wind

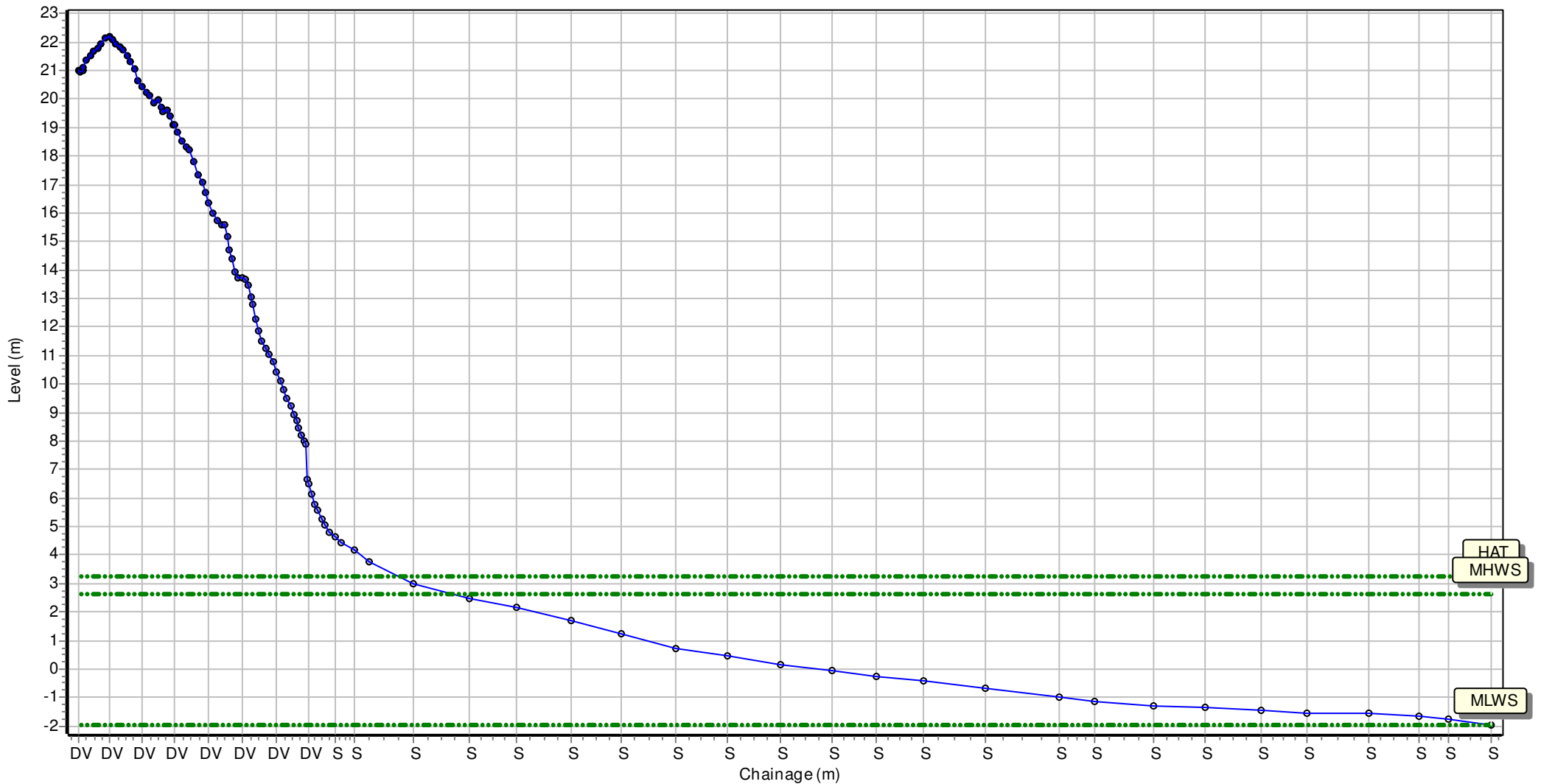
Sea State:

Visibility:

Rain:

Summary: 2019 Full Measures Topo Survey

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



Beach Profile

Location: 1cRC9

Date: 31/10/2019

Inspector: AG

Low Tide:

Low Tide Time:

Wind

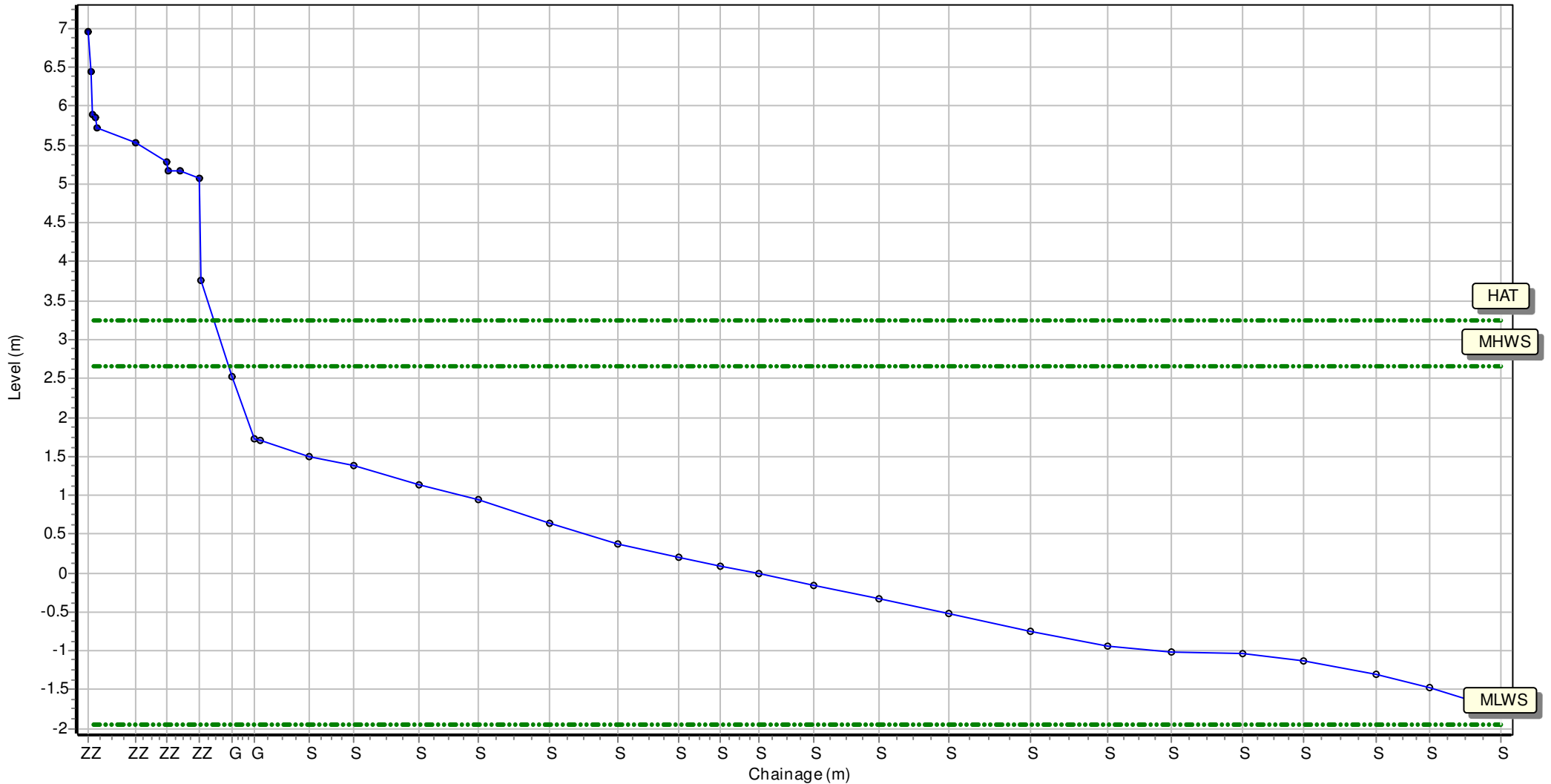
Sea State:

Visibility:

Rain:

Summary: 2019 Full Measures Topo Survey

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



Beach Profiles: 1cRC1



Profiles Envelope 17/11/2008 27/09/2018 05/04/2019 31/10/2019

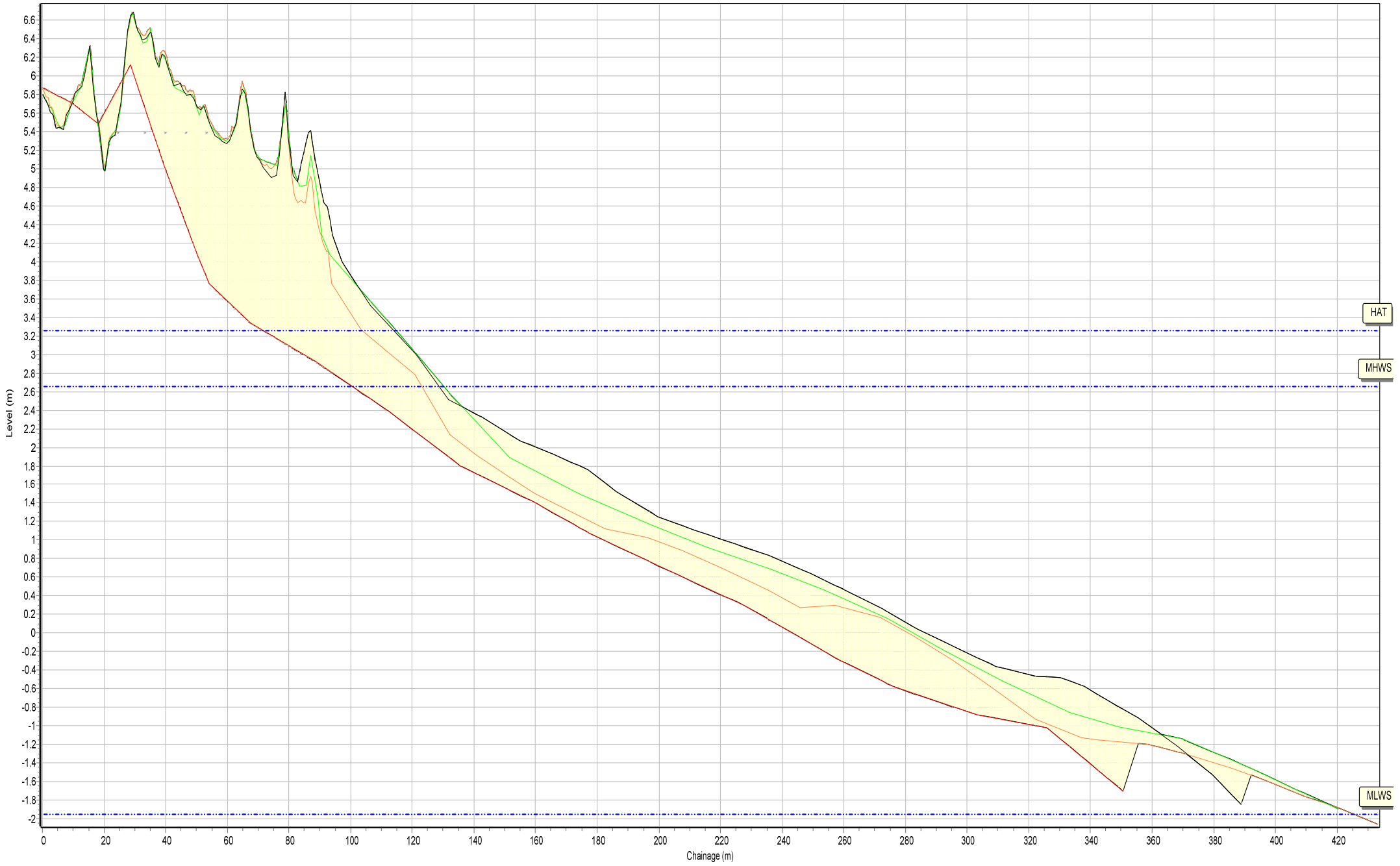
HAT

MHWS

MLWS

SANDS

Beach Profiles: 1cRC2



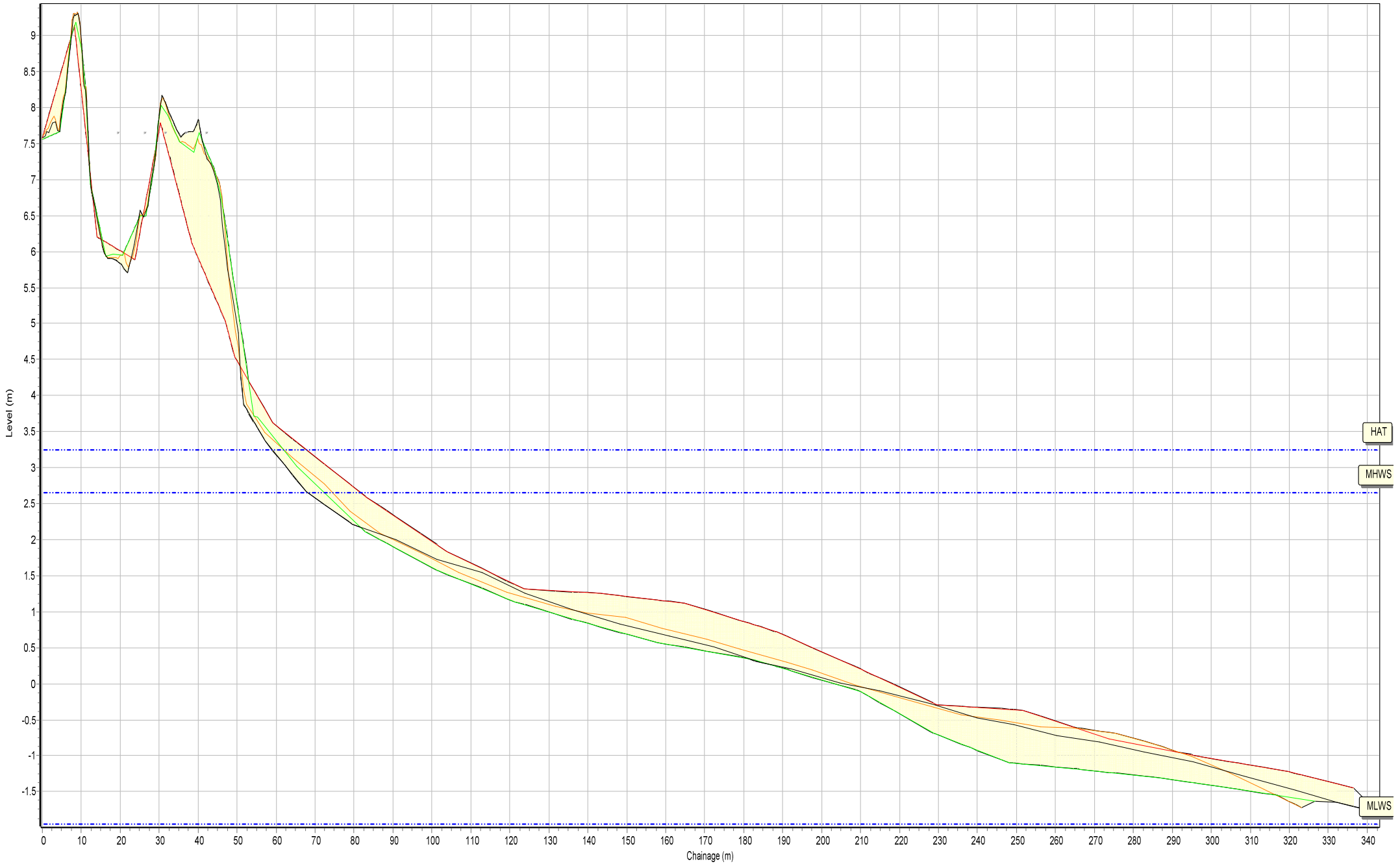
HAT

MHWS

MLWS

SANDS

Beach Profiles: 1cRC3



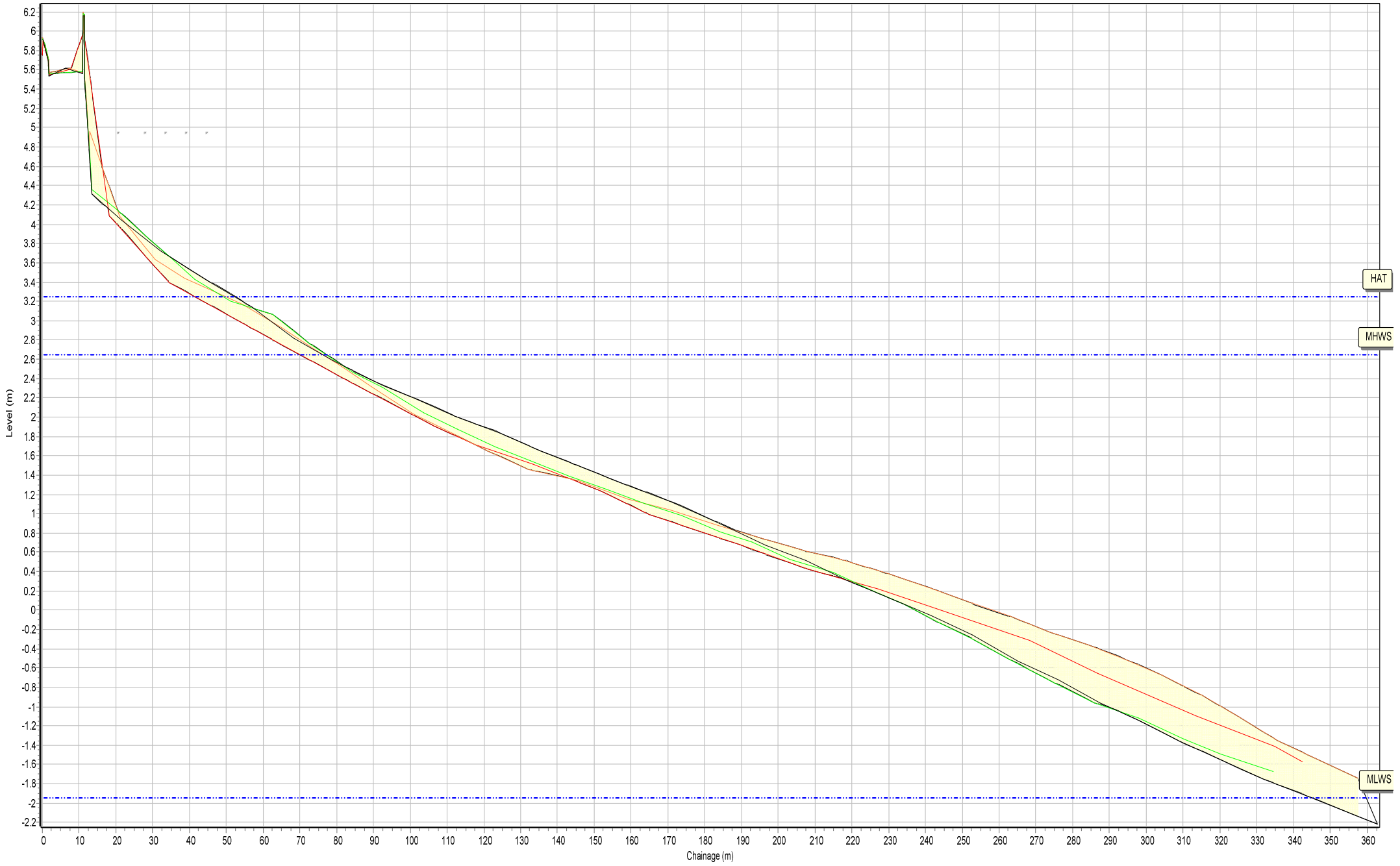
Profiles Envelope 17/11/2008 27/09/2018 05/04/2019 31/10/2019

HAT

MLWS

SANDS

Beach Profiles: 1cRC4



Beach Profiles: 1cRC5



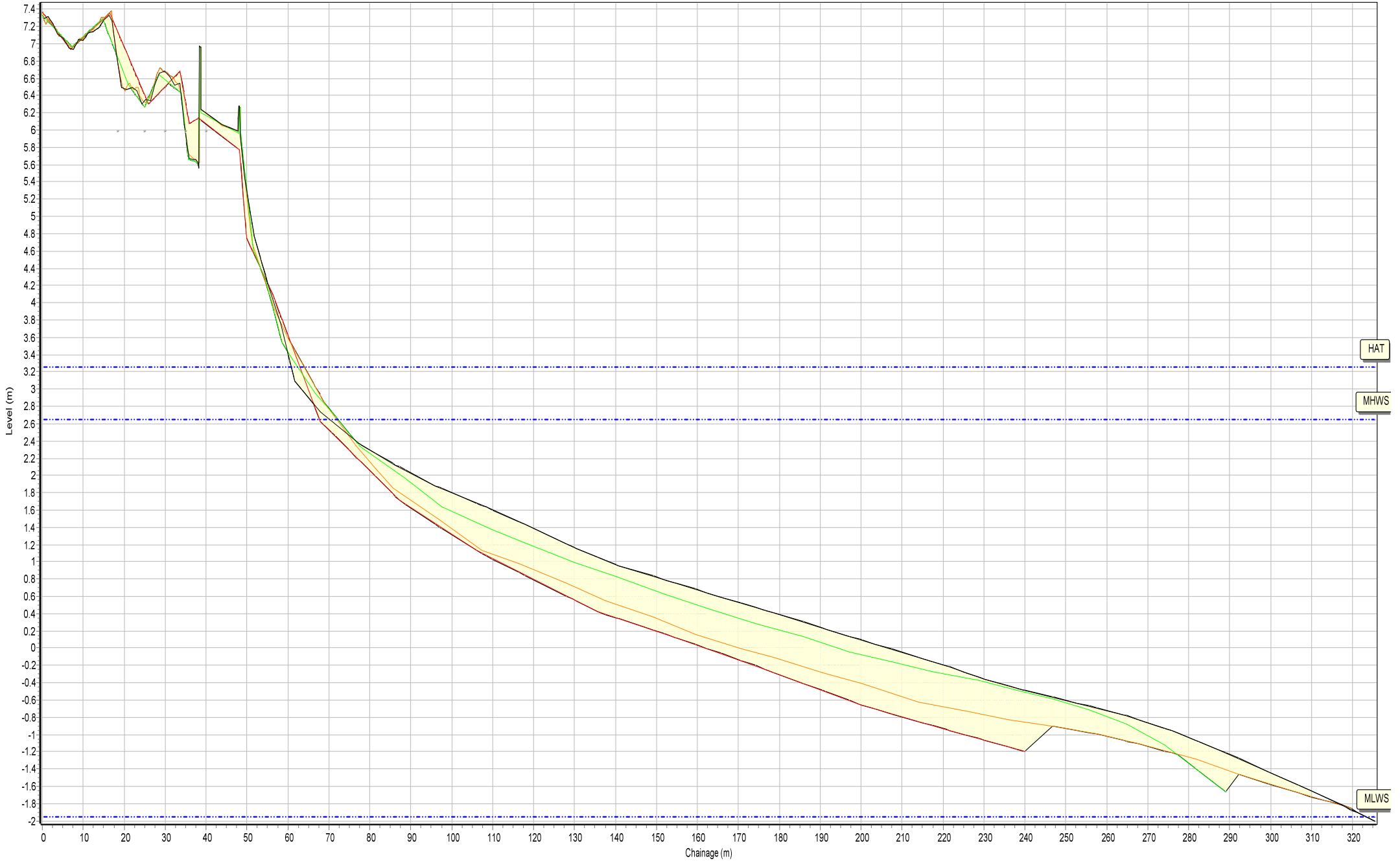
HAT

MHWS

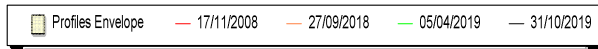
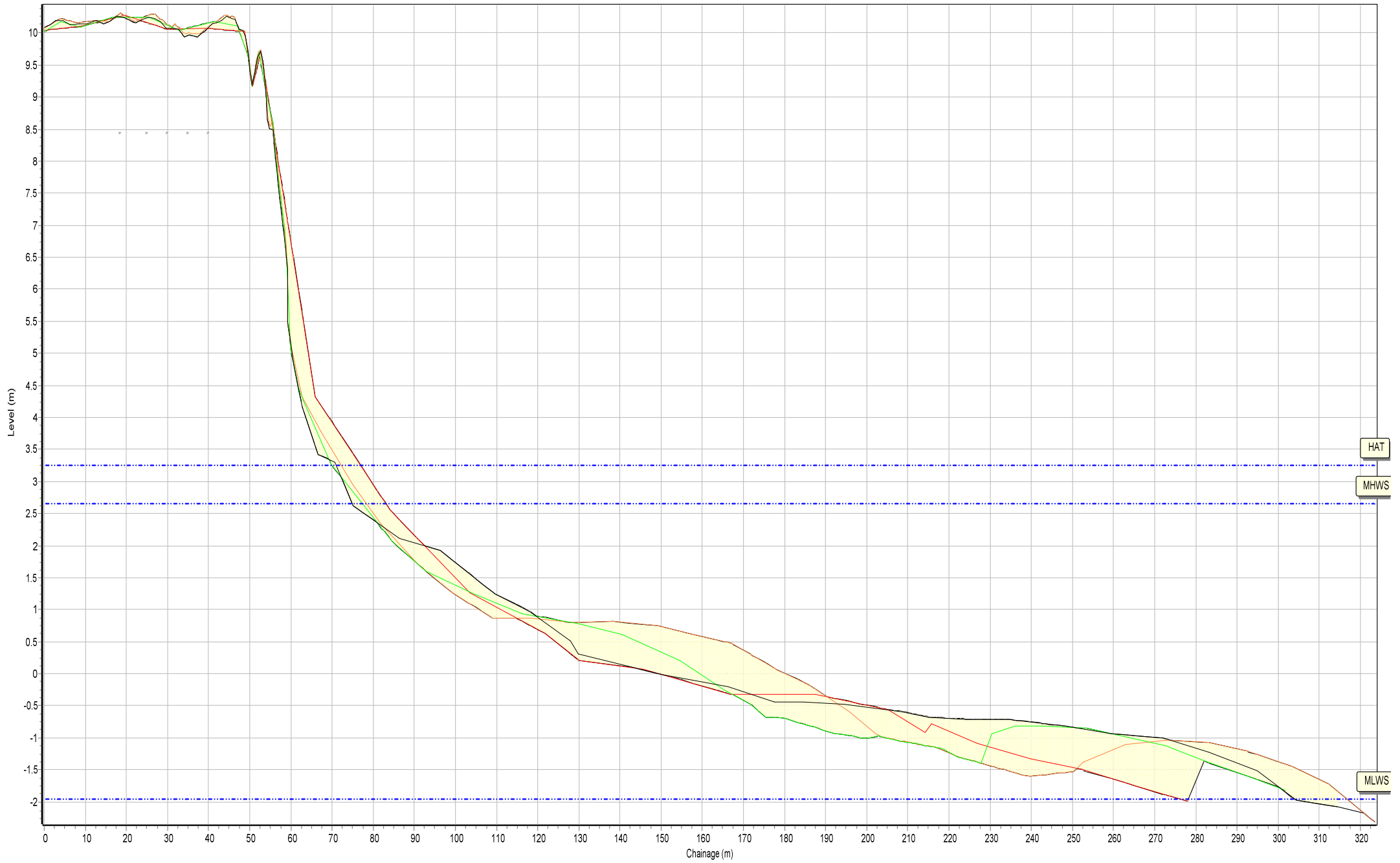
MLWS

SANDS

Beach Profiles: 1cRC6



Beach Profiles: 1cRC7



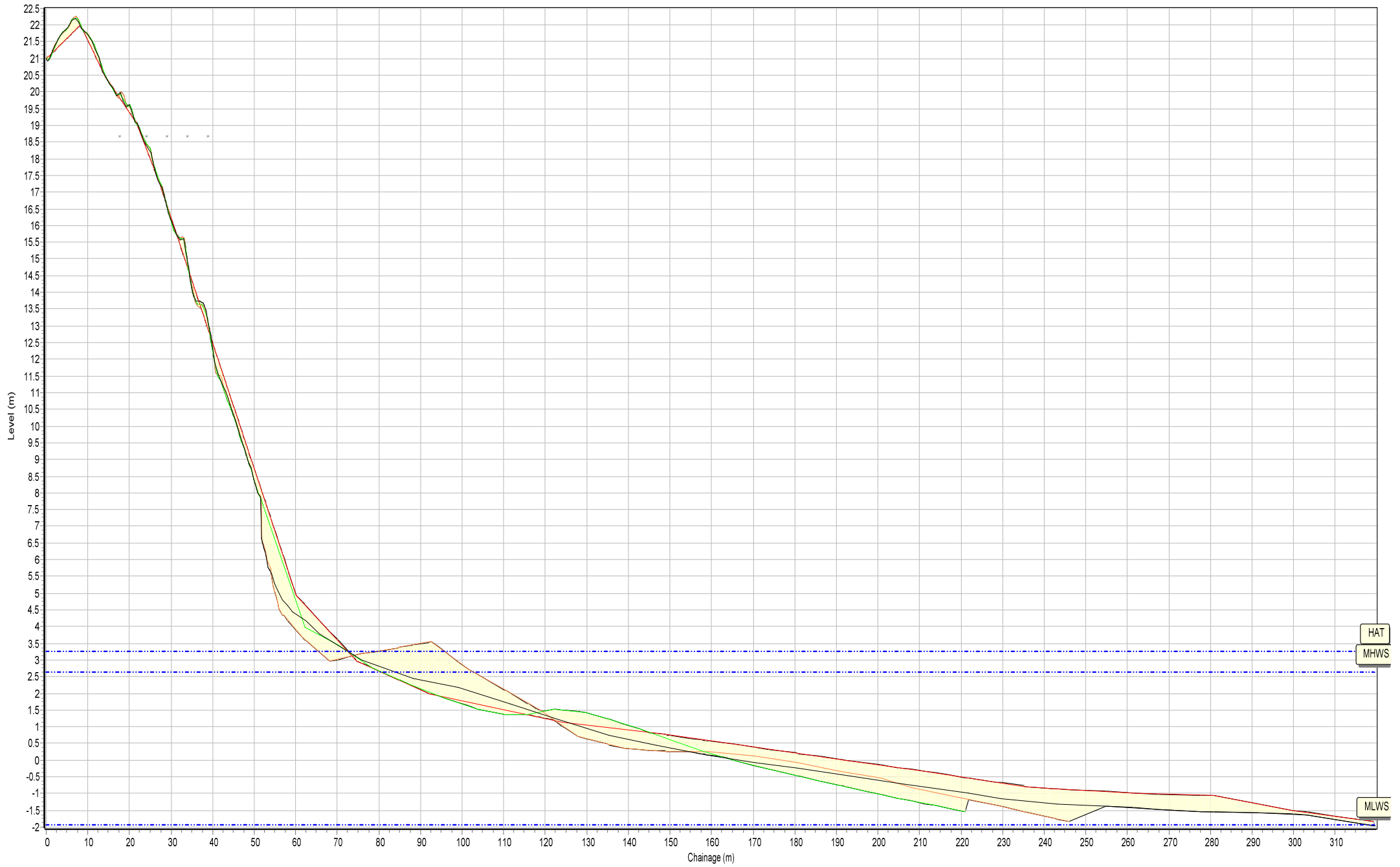
HAT

MHWS

MLWS

SANDS

Beach Profiles: 1cRC8



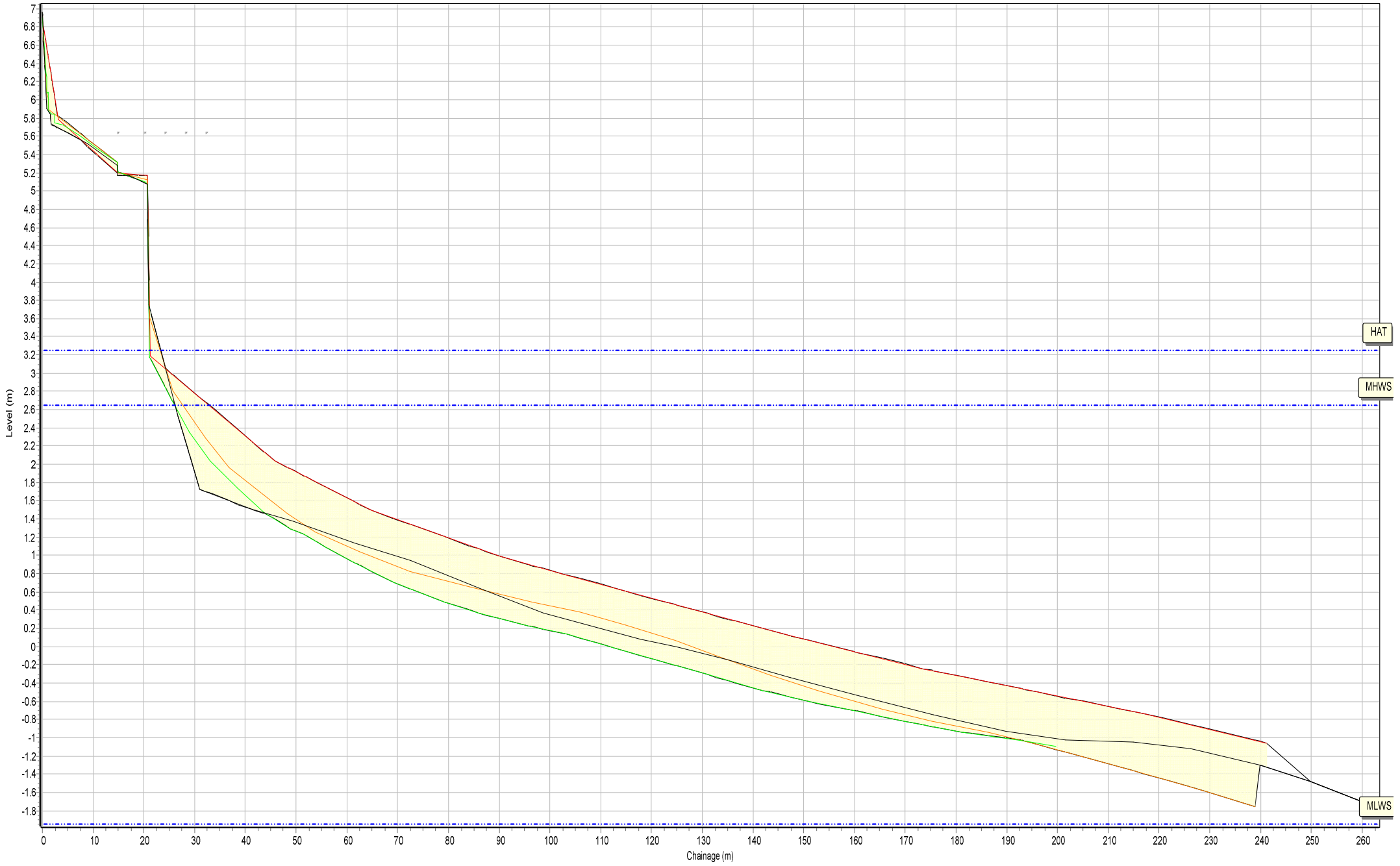
HAT

MHWS

MLWS

SANDS

Beach Profiles: 1cRC9



Profiles Envelope 17/11/2008 27/09/2018 05/04/2019 31/10/2019

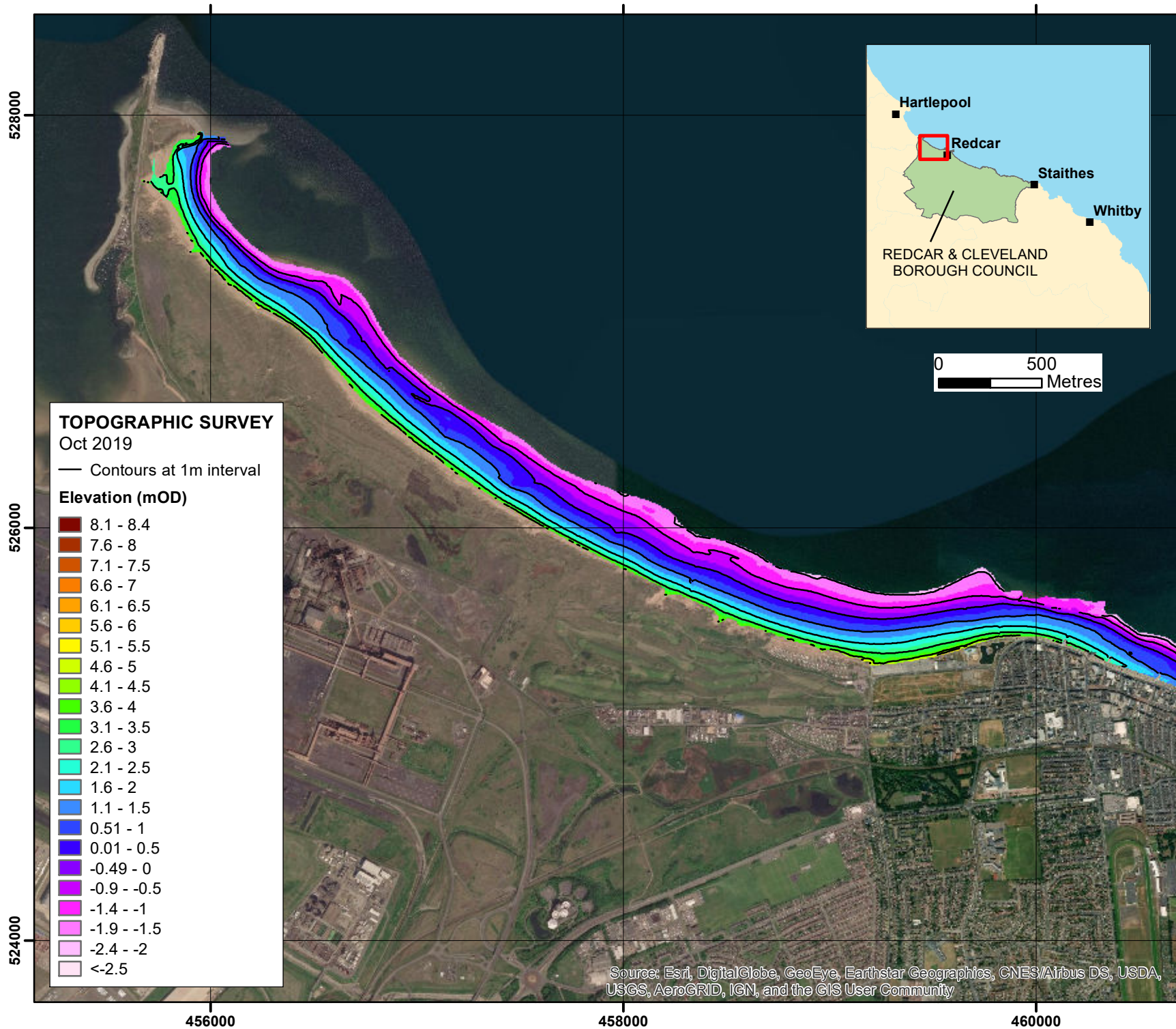
HAT

MHWS

MLWS

SANDS

Appendix B
Topographic Survey



Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Key

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

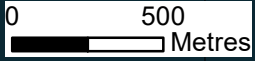
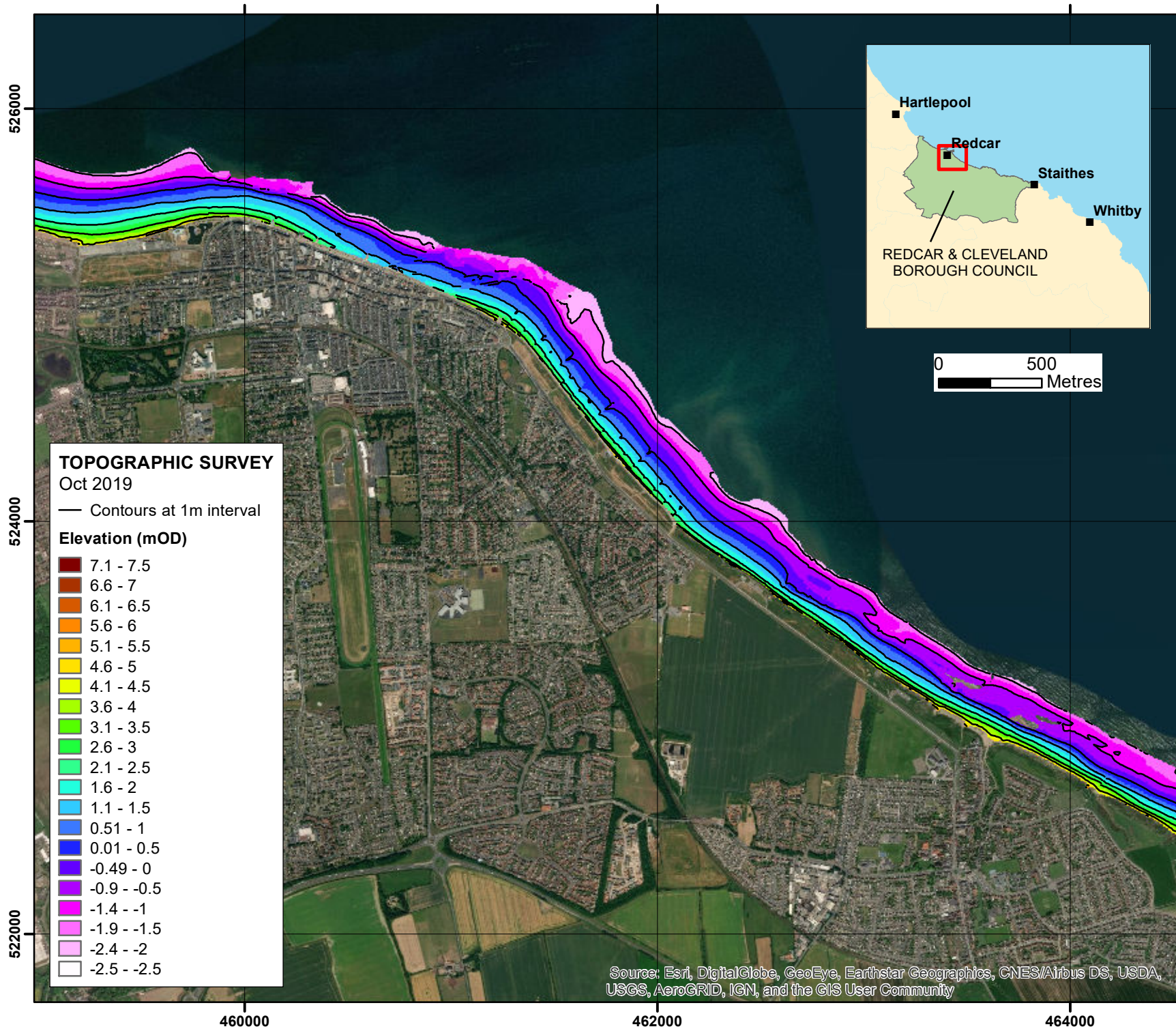
Appendix B - Map 1
COATHAM SANDS
Redcar and Cleveland Borough Council Frontage
Analytical Report
'Full Measures' Survey 2019

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





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

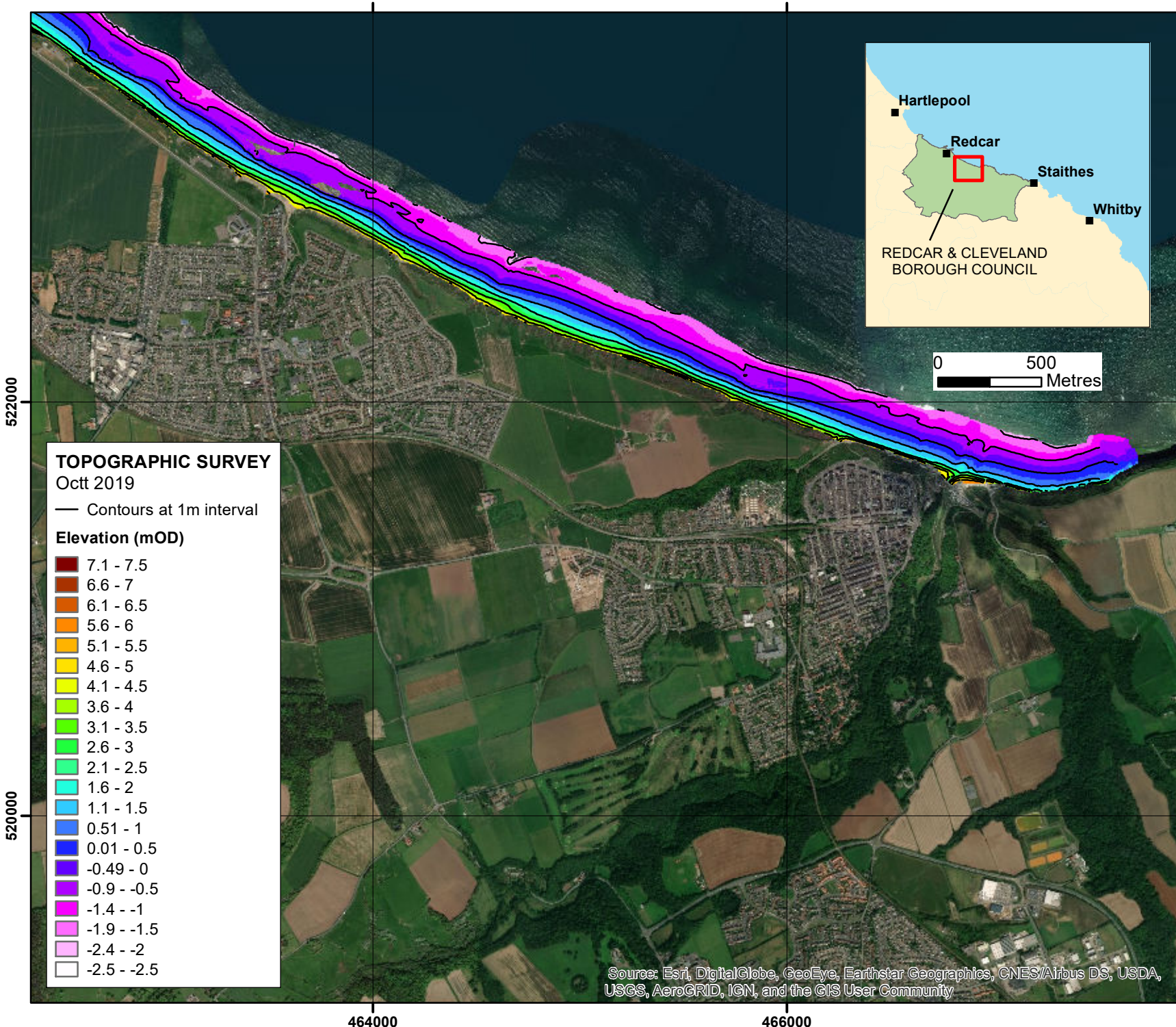
Analytical Report
'Full Measures' Survey 2019

Drawing Scale at A4 1:25,000

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

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





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 2019

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

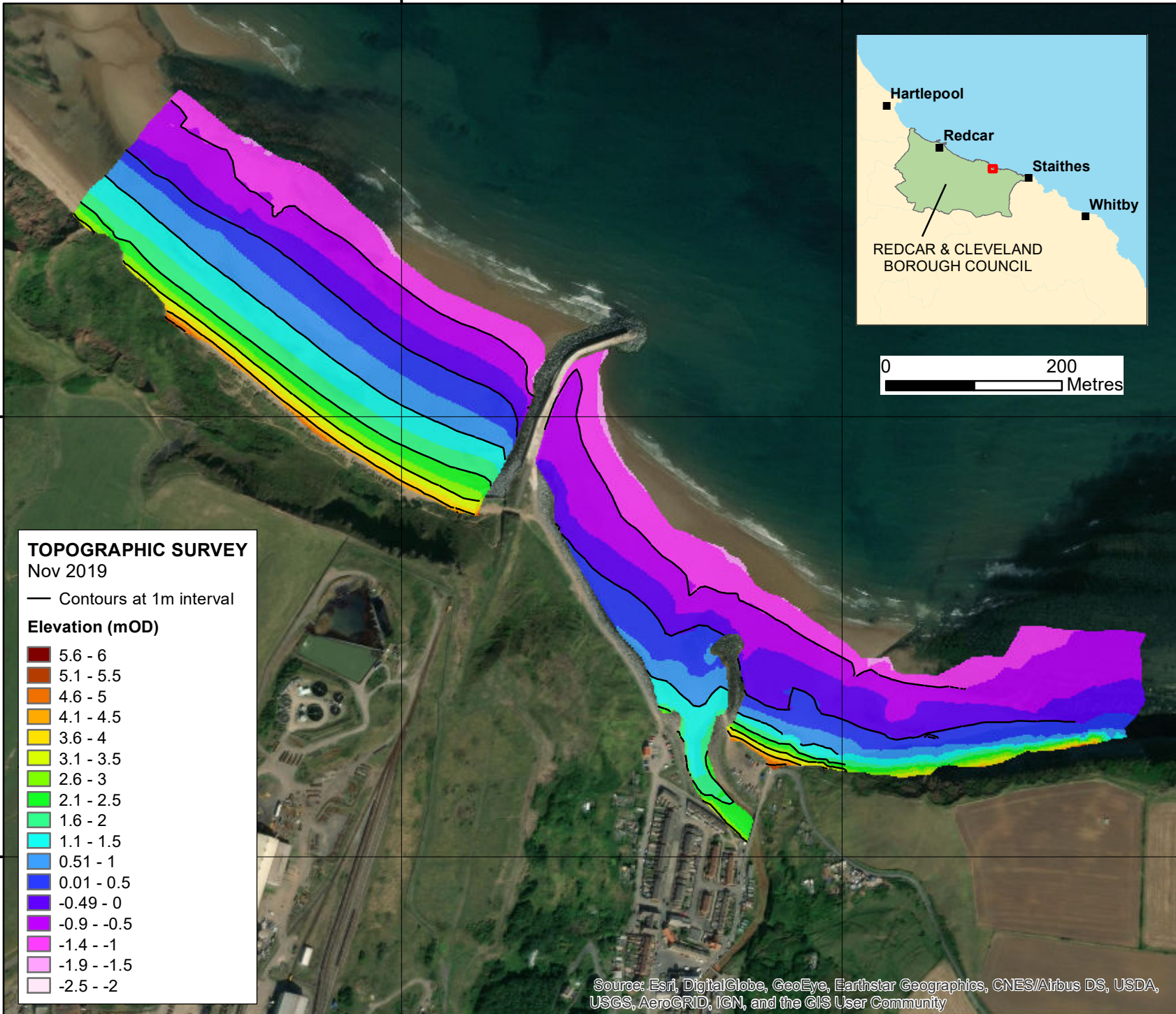


520500

520000

471000

471500



TOPOGRAPHIC SURVEY
Nov 2019

— Contours at 1m interval

Elevation (mOD)

| |
|-------------|
| 5.6 - 6 |
| 5.1 - 5.5 |
| 4.6 - 5 |
| 4.1 - 4.5 |
| 3.6 - 4 |
| 3.1 - 3.5 |
| 2.6 - 3 |
| 2.1 - 2.5 |
| 1.6 - 2 |
| 1.1 - 1.5 |
| 0.51 - 1 |
| 0.01 - 0.5 |
| -0.49 - 0 |
| -0.9 - -0.5 |
| -1.4 - -1 |
| -1.9 - -1.5 |
| -2.5 - -2 |



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 2019

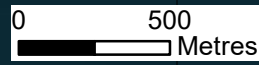
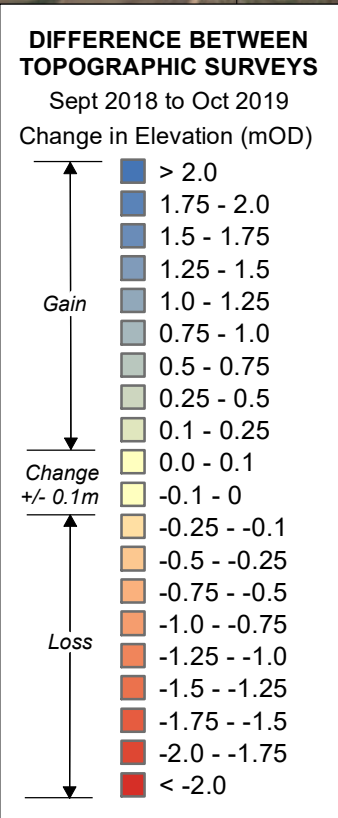
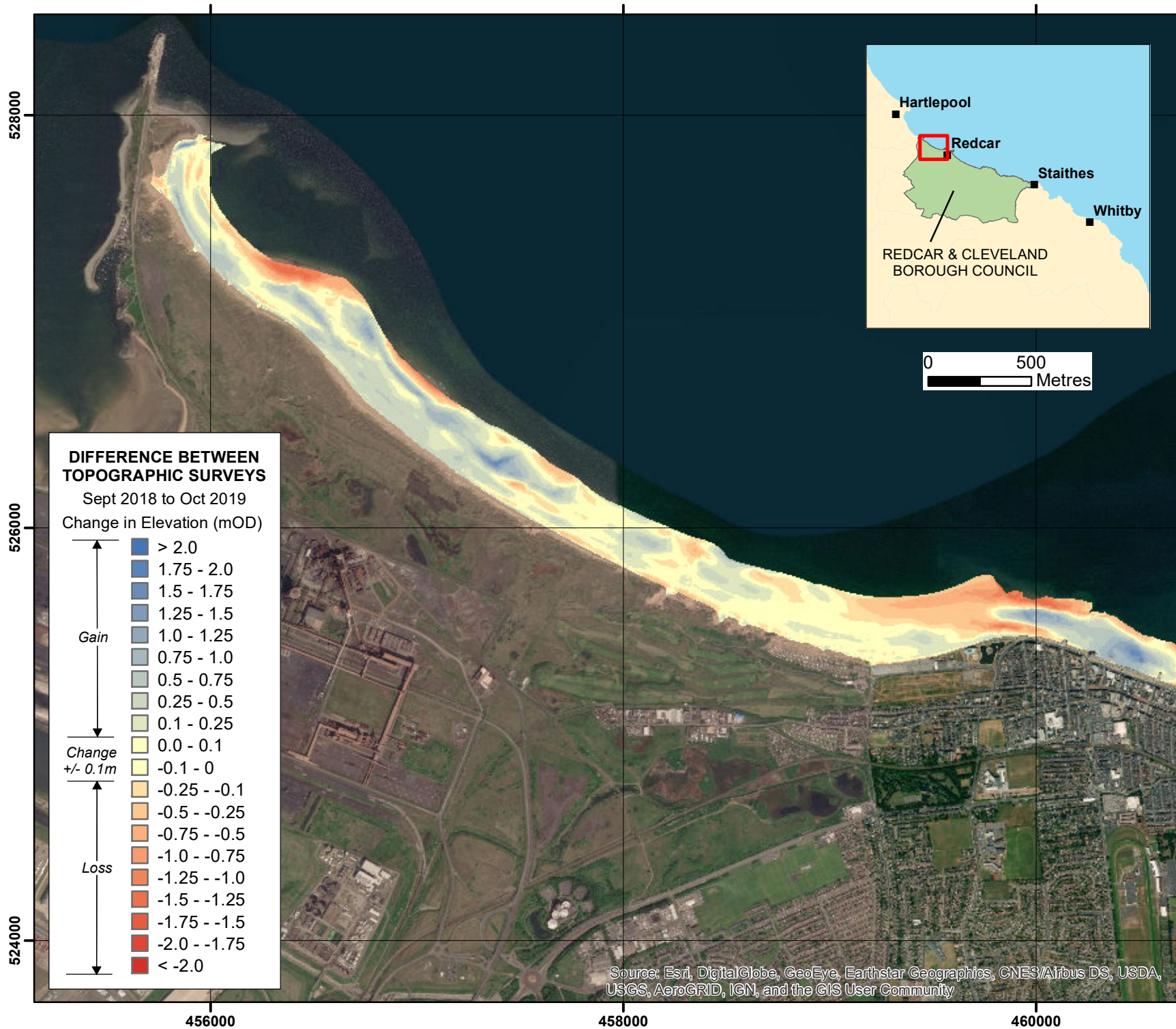
Drawing Scale at A4 1:6,000

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Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community



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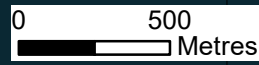
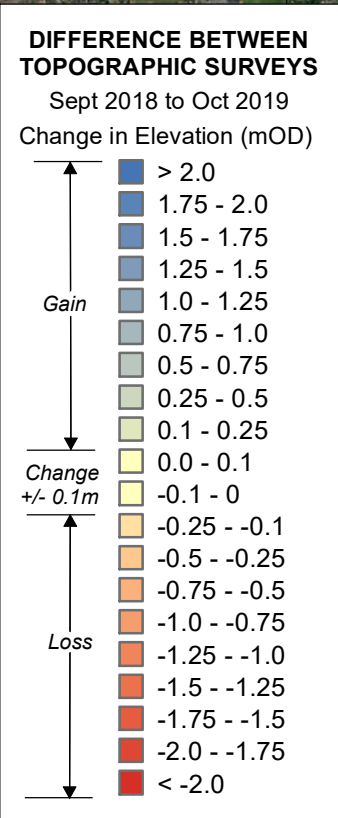
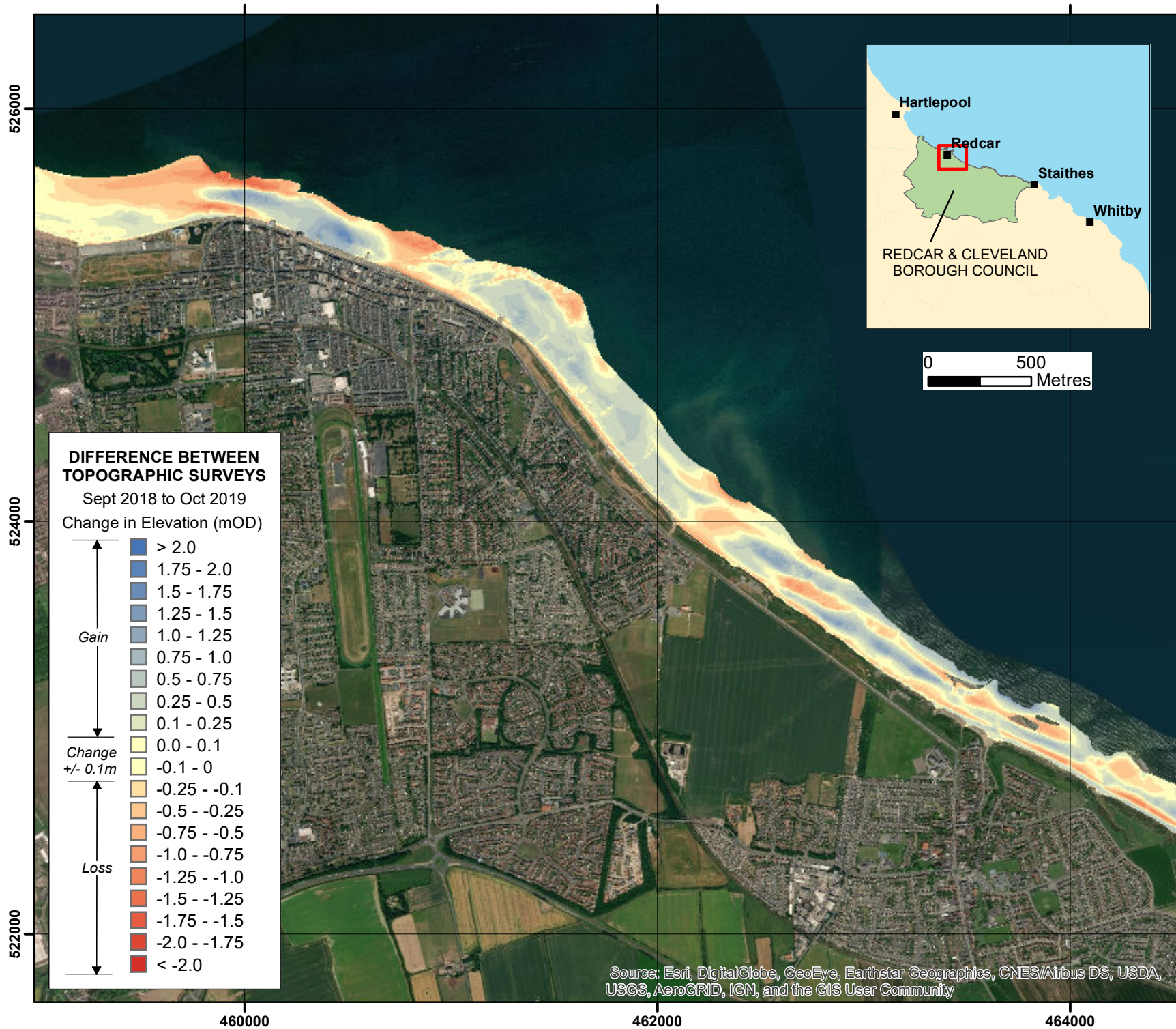
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 Project: Cell 1 Regional Coastal Monitoring Programme

Appendix B - Map 5
COATHAM SANDS
Redcar and Cleveland Borough Council Frontage
 Analytical Report
 'Full Measures' Survey 2019
 Drawing Scale at A4 1:25,000

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 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 2019

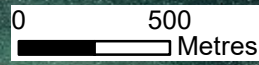
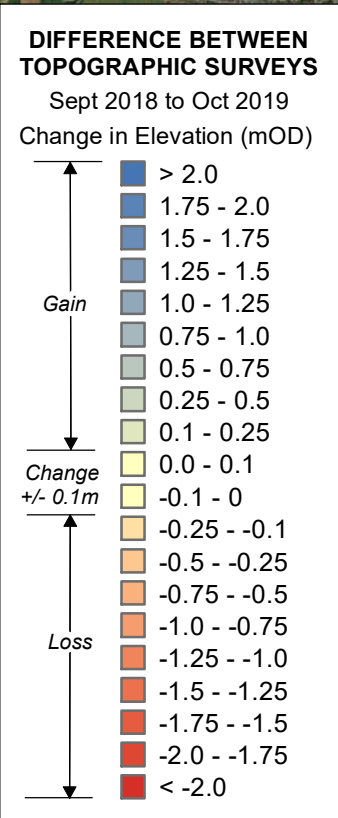
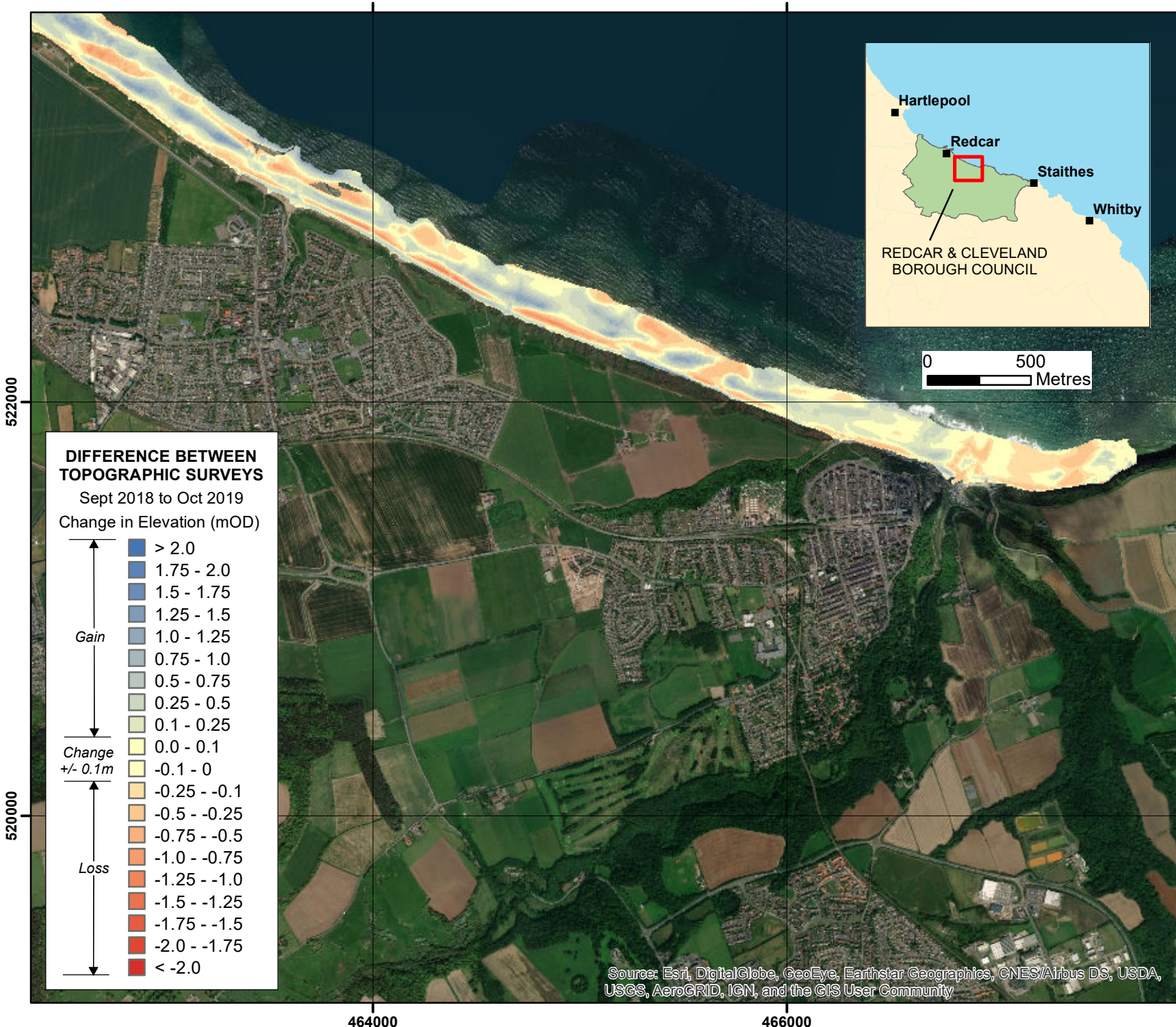
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Client: North East Coastal Group
 Project: Cell 1 Regional Coastal Monitoring Programme

Appendix B - Map 7
MARSKE/ SALT BURN SANDS
Redcar and Cleveland Borough Council Frontage
 Analytical Report
 'Full Measures' Survey 2019

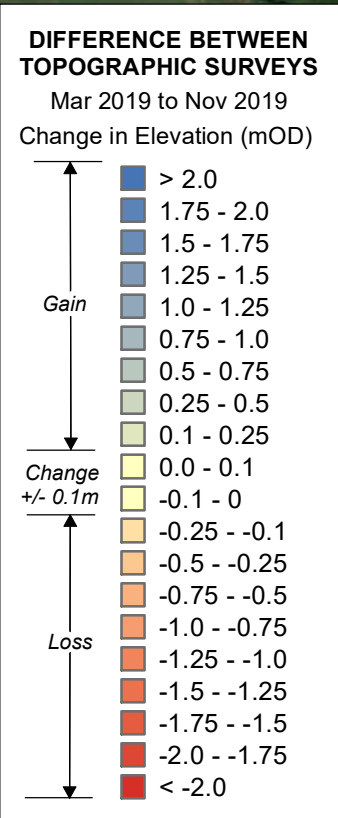
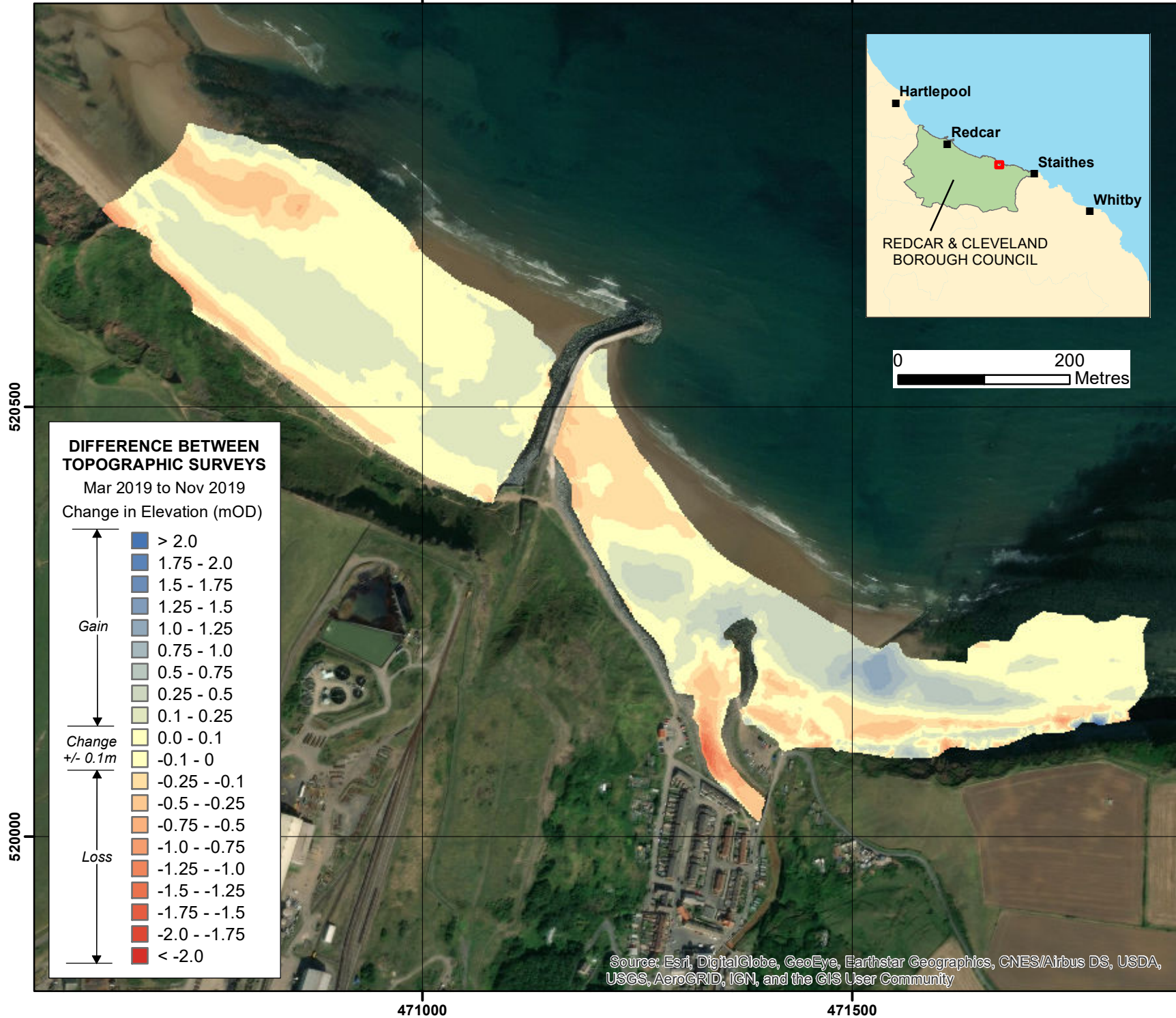
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 Project: Cell 1 Regional Coastal Monitoring Programme

Appendix B - Map 8
CATTERSTY SANDS
Redcar and Cleveland Borough Council Frontage
 Analytical Report
 'Full Measures' Survey 2019

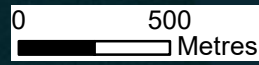
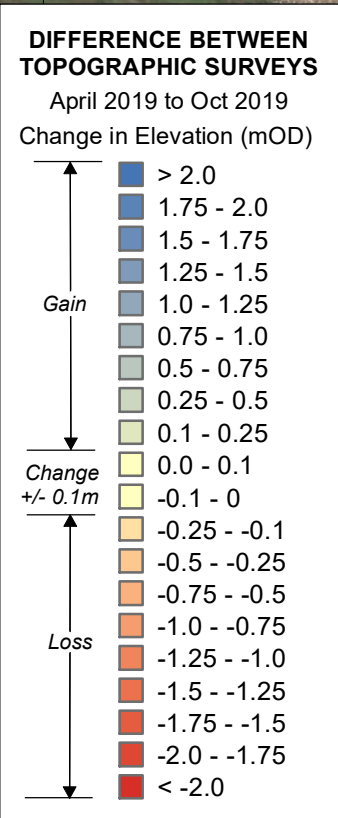
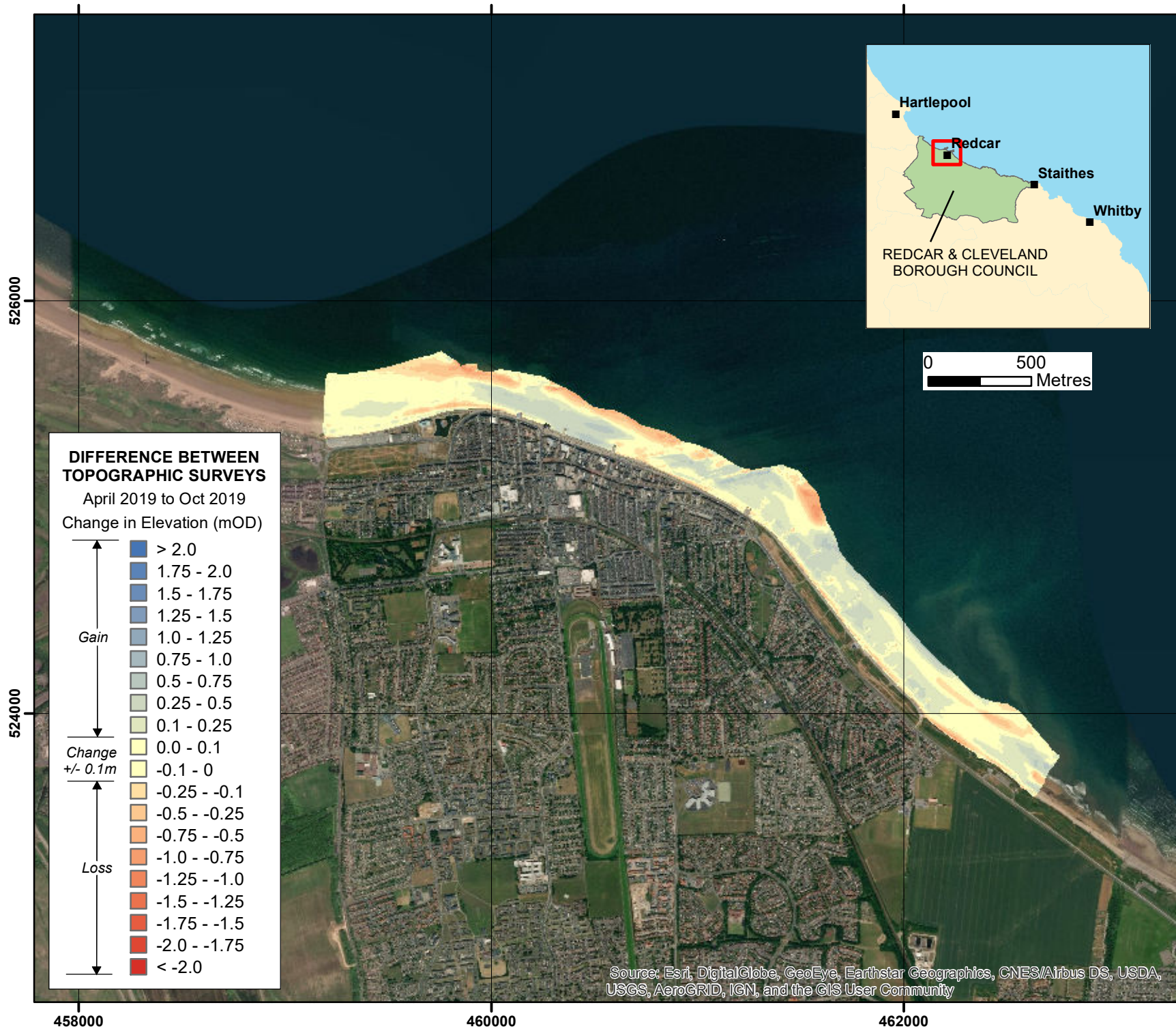
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Appendix B - Map 9
REDCAR SANDS
Redcar and Cleveland Borough Council Frontage

Analytical Report
 'Full Measures' Survey 2019

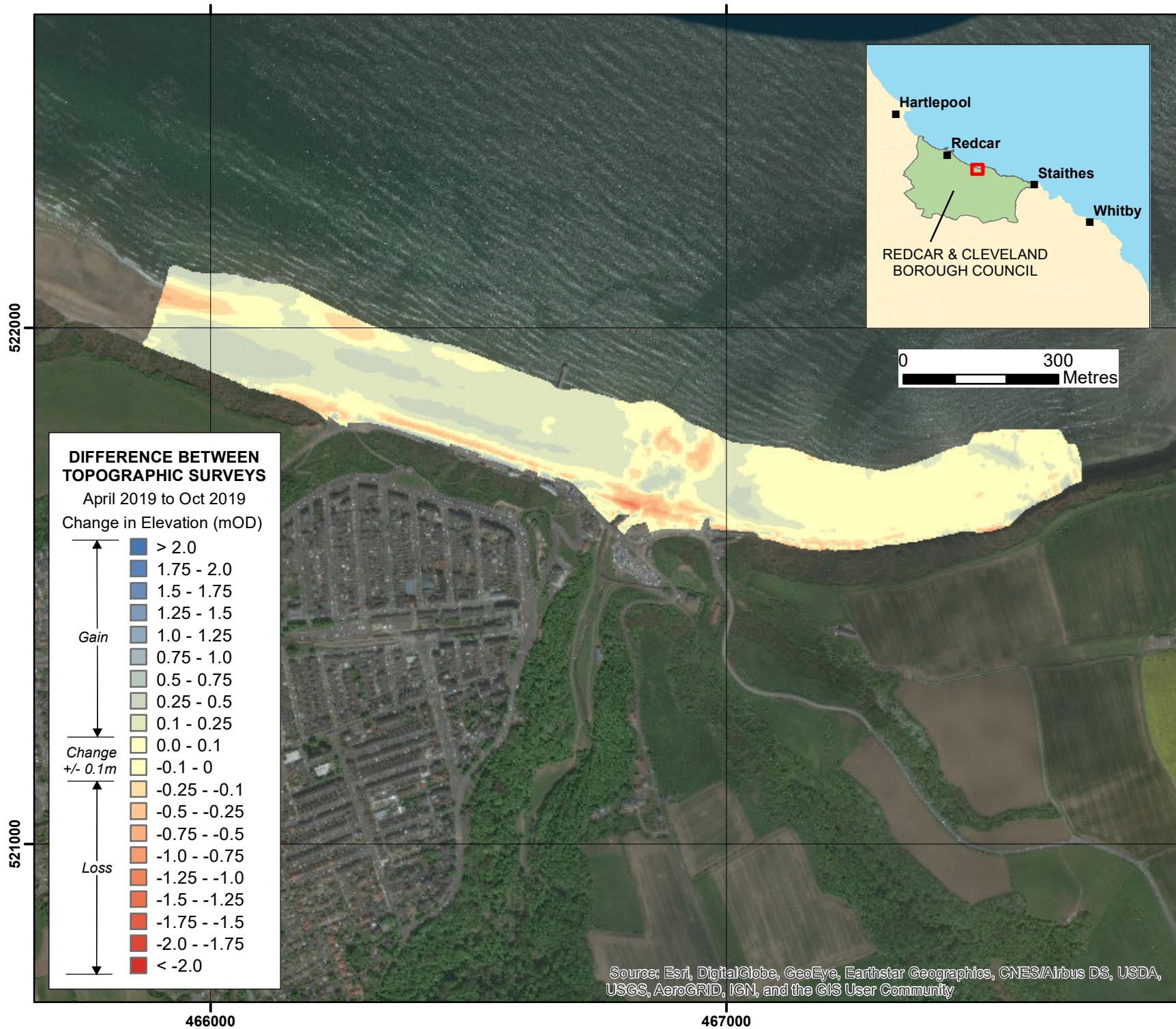
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Client: North East Coastal Group
 Project: Cell 1 Regional Coastal Monitoring Programme

Appendix B - Map 10
SALTBURN SANDS
Redcar and Cleveland Borough Council Frontage
 Analytical Report
 'Full Measures' Survey 2019

Drawing Scale at A4 1:10,000

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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 | 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 |

| 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 |
| 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 |
| 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 $\pm 0.1\text{m}$. 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.