



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



Hartlepool Borough Council

October 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)			
	River Tyne to Frenchman's Bay	Frenchman's Bay to Souter Point	Souter Point to Chourdon Point	Chourdon Point to Hartlepool Headland
1 in 200 year	3.41	3.44	3.66	3.91
HAT	2.85	2.88	3.18	3.30
MHWS	2.15	2.18	2.48	2.70
MLWS	-2.15	-2.12	-1.92	-1.90

Water Level Parameter	Water Level (m AOD)			
	Hartlepool Headland to Saltburn Scar	Skinningrove	Hummersea Scar to Sandsend Ness	Sandsend Ness to Saltwick Nab
1 in 200 year	3.87	3.86	4.1	3.88
HAT	3.25	3.18	3.15	3.10
MHWS	2.65	2.68	2.65	2.60
MLWS	-1.95	-2.13	-2.15	-2.20

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.

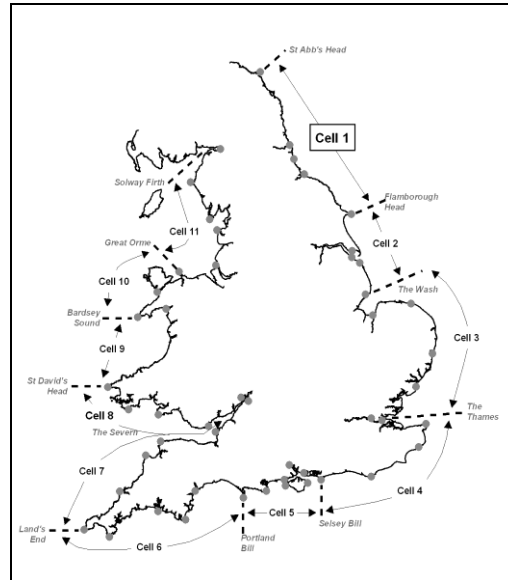


Figure 1 Sediment Cells in England and Wales

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	July 10	-
3	2010/11	Aug-Nov 10	Feb 11	Feb-April 11	August 11	Sept 11
4	2011/12	Sep-Oct 11	Oct 12	Mar-May 12	Feb 13	-
5	2012/13	Sep 2012	Feb 13	April 13	May 13	-
6	2013/14	Sep-Oct 13	Feb 14	March 14	July 14	
7	2014/15	Sep-Oct 14	Feb 15	April 15	June 15	
8	2015/16	August 2015	Feb 16	April 16	July 16	Jun 16
9	2016/17	Aug-Sep 2016	Feb 17	Apr 17	Jul 17	
10	2017/18	Sep-Nov 17	Feb 18	Mar 18	May 18	
11	2018/19	Aug-Oct 18	Feb 19	Feb 19	May 19	
12	2019/20	Sep-Oct 19	Nov 19 (*)			

(*) The present report is **Analytical Report 12** and provides an analysis of the 2019 Full Measures survey for Hartlepool 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

Hartlepool Borough Council's frontage extends from Crimdon Beck in the north, to the North Gare Breakwater in the south. For the purposes of this report, it has been sub-divided into four areas, namely:

- North Sands
- Hartlepool Headland
- Middleton
- Hartlepool Bay

1.2 Methodology

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

- Full Measures survey annually each autumn/early winter comprising:
 - Beach profile surveys along twelve transect lines
 - Topographic survey along part of North Sands (referred to as Hartlepool North or 'HN')
 - Topographic survey along Middleton (referred to as Hartlepool Central or 'HC')
 - Topographic survey along Hartlepool Bay (referred to as Hartlepool South or 'HS')
- Partial Measures survey annually each spring comprising:
 - Beach profile surveys along twelve transect lines
- Additionally, every five years (starting with 2008 as the baseline year), the Full Measures topographic survey at Hartlepool North is extended to fully cover the whole of North Sands and Hartlepool Headland with a topographic survey. This extends across the boundary of jurisdiction between Hartlepool Borough Council and County Durham Council.

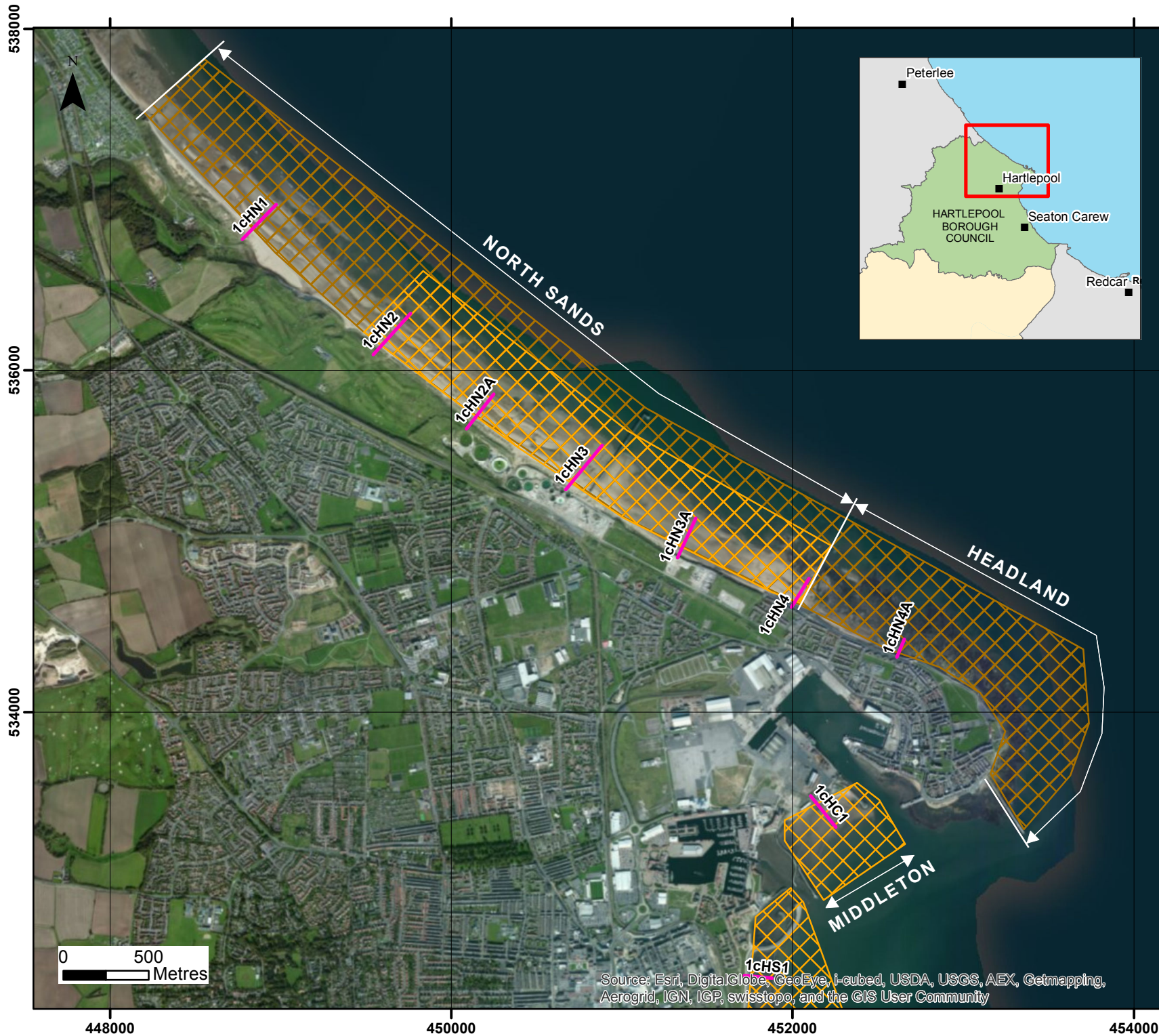
The location of these surveys is shown in Figure 2. The 2019 Full Measures survey was undertaken along this frontage on various dates between 2nd September and 13th October 2019. During this time, the weather was generally dry and sunny with force 2 to 4 breezes from variable directions. The sea state at all sites was either calm or moderate. The survey reports from Academy Geomatics document details of the weather conditions over this survey period.

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 (Blue line)
- Bi-Annual (Pink line)

Topographic Surveys

- 6 monthly (Green cross-hatch)
- yearly (Orange cross-hatch)
- 5 yearly (Yellow cross-hatch)

(Indicative Survey Extents shown)

Client: North East Coastal Group

Project: Cell 1 Regional Coastal Monitoring Programme

Figure 2 - Map 1
Hartlepool Borough Council Frontage

Analytical Report
 Topo Surveys

Drawing Scale at A4 1:30,000

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 Newcastle upon Tyne
 NE1 4EE

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Source: Esri, DigitalGlobe, GeoEye, I-cubed, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community



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

Hartlepool Borough Council Frontage

Analytical Report
Topo Surveys

Drawing Scale at A4 1:30,000

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Source: Esri, DigitalGlobe, GeoEye, i-cubed, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community



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 3
Hartlepool Borough
Council Frontage**

Analytical Report
Topo Surveys

Drawing Scale at A4 1:12,000

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Source: Esri, DigitalGlobe, GeoEye, i-cubed, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

2. Analysis of Survey Data

2.1 North Sands

Survey Date	Description of Changes Since Last Survey	Interpretation
<p>16th-17th Sep 2019</p>	<p>Beach Profiles:</p> <p>North Sands is covered by four beach profile lines during the Full Measures survey (Appendix A). They were last surveyed in February 2019.</p> <p>Profile 1cHN1 is located within Durham County Council's area of responsibility, about 400m north of the outfall of Crimdon Beck, but is reported here so changes can be interpreted in association with those observed elsewhere along North Sands at HN2, HN3 and HN4.</p> <p>The beginning of profile 1cHN1 between 0m and 70m change covers dunes and has small sections of accretion of up to 0.1m, whilst the seaward face of the dunes has prograded by up to 2.0m. A berm has formed at chainage 94m, with an accretion of up to 1.1m. The middle beach has eroded by 0.8m between chainages 119m and 162m. The berm present during the last survey has moved landward by 50m, whilst the beach toe has moved landward by 20m. The profile is generally at a high level across the dunes and upper beach compared to previous surveys, particularly the upper beach berm which is at its highest level recorded. The middle and lower beach is at a medium level compared to previous surveys.</p> <p>At Profile 1cHN2, the profile has not changed on the section with dunes. There has been accretion from the toe of the dunes to chainage 97m of up to 0.7m, forming a small berm at chainage 71m. Between chainage 97m and 135m, there has been erosion of 0.35m. Seaward of 135m chainage, there has been an accretion of up to 1.0m, extending the toe of the beach seaward by 80m. Overall the profile is at a medium level compared with previously recorded surveys.</p> <p>Profile 1cHN2A was established in October 2011 and runs through the dunes close to North Sands. The foredune which had started to re-accrete in the September 2015 has continued to accrete marginally. The toe of the dunes has accreted by up to 0.6m, forming a small berm at chainage 86m. There is a small section of erosion between chainages 86m and 123m by 0.4m. Seaward of chainage 123m there has been an accretion of up to 0.5m, with an extension of the beach toe by up to 33m. Overall, the profile shows low levels compared with previously recorded surveys.</p>	<p>The dunes at North Sands have remained stable since the previous survey, whilst beach levels have predominantly accreted on the upper beach and lower beach, and eroded across the middle beach, except towards the east of the survey area where there is relatively no change across the rock platform. Beach levels are at a medium to low level overall, however the upper beach berm at Profile 1cHN1 is at its highest level recorded.</p> <p>Longer term trends: The 2019 full measures survey is generally in line with the longer term trends which suggest accretion in the west and stability in the middle and east of the survey area.</p>

Survey Date	Description of Changes Since Last Survey	Interpretation
	<p>At Profile 1cHN3 there has been little change of the dunes. The toe of the dunes has accreted to chainage 83m by up to 1.0m, forming a small berm at 56m. The majority of the beach profile shows an accretion of up to 0.5m between 83m chainage and 219m. Seaward of chainage 219m there has been a minor amount of erosion of 0.1m. The dunes are at a high level, whilst the rest of the beach profile is at a low level compared to the range recorded from previous surveys.</p> <p>At Profile 1cHN3a there has been relative stability down to the dune face at 20m chainage, with minor sections of change limited to ± 0.1m. The drop in beach level at the toe of the dunes recorded in the March 2018 survey has continued to show signs of recovery, with levels accreting by 0.6m. There has been little change across the middle beach, limited to ± 0.15m. Seaward of 122m, there has been accretion of 0.8m. Overall the level is in the mid-to-low range of the previous profiles.</p> <p>At Profile 1cHN4 there has been little change from the toe of the rock protrusion to chainage 38m. Sediment covering the rock platform from the previous survey has been removed and is now exposed from chainage 38m seawards. There has been relatively no change across the exposed rock platform. Overall the profile is towards the low end of the range recorded from previous surveys.</p> <p>At Profile 1cHN4a, there has been little change across the beach profile compared to previous surveys, with minor sections of erosion / accretion limited to ± 0.1m. Overall the profile is at a medium-low level compared to the previous recorded surveys.</p>	
September 2019	<p>Topographic Survey:</p> <p>North Sands is covered by an annual topographic survey. Data from the 2019 Full Measures survey have been used to create a DGM (Appendix B – Map 1) using a GIS package. The majority of the frontage is characterised by shore-parallel contours, except in the vicinity of outfalls, groyne and the pier where contours change direction.</p> <p>The GIS has also been used to calculate the differences between the Autumn 2018 and Autumn 2019 topographic surveys, as shown in Appendix B – Map 4, to identify areas of net erosion and accretion. To the west of the pier, there are alternating bands of erosion and accretion, however accretion dominates with increases in sediment reaching over 1.5m in places. There are small bands of erosion concentrated on the upper-mid beach. To the east of the pier, the same pattern continues, however there is a band of high magnitude erosion on the upper-mid beach of over 1.75m. There is little to no change in beach level at the eastern-most end of the survey, with only minor patches of erosion and</p>	<p>The difference plot at North Sands shows alternating sections of erosion and accretion, with more modest erosion rates west of the pier compared to the east. The plot reflects the seasonal movement of sediment across the beach as sand bars. This is in contrast to the Autumn 2018 survey which was dominated by erosion across the survey area.</p>

Survey Date	Description of Changes Since Last Survey	Interpretation
	accretion limited to $\pm 0.1\text{m}$.	

2.2 Middleton

Survey Date	Description of Changes Since Last Survey	Interpretation
<p>18th September 2019</p>	<p>Beach Profiles:</p> <p>Middleton is covered by one beach profile line during the Full Measures 2019 survey (Appendix A). The survey report notes that there was no access to the upper section of the profile. The beach at Profile 1cHC1 between the toe of the seawall at chainage 48m and 67m shows accretion of up to 0.35m. Between chainage 67m and 151m, there has been accretion of up to 0.15m. Seawards of 151m there has been erosion of the beach toe of 0.35m. Overall the beach is at a medium level across the upper and lower beach compared to the range from previous surveys. The middle beach is at a high level compared to the range from previous surveys</p>	<p>The beach profile showed a gain in the upper and middle beach and a loss in the lower beach.</p> <p>Longer term trends: The upper and lower beach is in the medium range of the previously recorded levels, whilst the middle beach is at a high level.</p>
<p>September 2019</p>	<p>Topographic Survey:</p> <p>The frontage is covered by an annual topographic survey between Middleton Jetty and North Pier. Data from the 2019 Full Measures survey have been used to create a DGM (Appendix B – Map 1) using GIS software. Beach contours indicate a steeper beach in the east than the west, with the contours locally affected by pipelines and groynes. In the Autumn 2013 survey, differences between the eastern and western ends of the beach were less marked. Earlier years show a similar topography to 2014 and 2015.</p> <p>The GIS has also been used to calculate the differences between the Autumn 2018 and Autumn 2019 topographic surveys, as shown in Appendix B – Map 4, to identify areas of net erosion and accretion. There is generally shore parallel changes, with accretion dominating on the upper beach and in the middle beach towards the west of the study area, and a large band of erosion across the lower beach in the east of the study area. The beach near the Headland shows a patchy distribution of accretion and erosion, however erosion dominates across the beach. At Middleton accretion dominates in the west with erosion dominating in the east. The changes observed at Middleton beach over the year are modest at less than $\pm 0.75\text{m}$.</p>	<p>The difference plot for Middleton shows a zone of accretion across the upper beach, and across the middle beach in the west of the survey area. Erosion dominates in the east across the middle and lower beach. Changes are low in magnitude. In front of the headland the difference plots show a patchy distribution of change due to the thin but mobile cover of sand here.</p>

2.3 Hartlepool Bay

Survey Date	Description of Changes Since Last Survey	Interpretation
<p>2nd-3rd September 2019</p>	<p>Beach Profiles:</p> <p>Hartlepool Bay is covered by four beach profile lines during the Full Measures survey (Appendix A). The profiles were last surveyed in February 2019. Sea coalers had been banned from driving onto the beach in 2013 but on 28th March 2015 the gates were opened and they were allowed to remove coal from the beach again (Hartlepool Mail).</p> <p>Profile 1cHS1 is located approximately 150m south of the root of the South Pier. The profile starts at the wall to the rear of the promenade and extends across the promenade, over the fronting concrete splash wall and down the sloping face of the rock armour revetment before reaching the beach. Generally, there has been varying sections of erosion and accretion of up to 0.5m between the rock armour. Seaward of the rock armour, the beach has gained up to 0.3m and the toe has extended seaward by 42m. The beach level is at its highest level record across the majority of the profile compared to previous recorded surveys.</p> <p>There has been accretion of up to 0.5m at the toe of the rock revetment at Profile 1cHS2. There has been accretion across the upper beach of up to 0.3m. The middle beach shows negligible change limited to ± 0.1m. The lower beach shows an accretion of 0.2m, creating a flatter compared to February 2019. The profile is at a high level compared to previously recorded surveys.</p> <p>At profile 1cHS3 there has been accretion of up to 0.4m on the upper beach between chainage 30m and 90m, forming a small berm at chainage 60m. The lower beach berm has moved landward by 60m. The lower beach has accreted by 0.5m and the toe of the beach has extended seaward by 56m. The upper beach is at a medium level, whilst the middle and lower beach is at a high level compared to previous surveys.</p> <p>The profile 1cHS4 is located further south, around 1km north of the North Gare breakwater in an area of undefended dunes at Seaton Sands. The profile covers approximately 325m of dunes before the beach. The dune section is stable, with a foredune continuing to accrete at around 320m chainage with 0.2m of growth since March 2018. The berm present in the February 2019 survey at chainage 386m has accreted by 0.2m and migrated landward by 2m. The rest of the beach has accreted by up to 1.3m</p>	<p>The majority of the beach profile across Hartlepool Bay shows little change / accretion, with profiles HS1 and HS2 reaching their highest level recorded. The profiles are generally at a high level across the bay.</p> <p>Longer term trends: The profiles have shown relative stability over 2019. The accretion of the northern three profiles continues and beach levels are generally medium to high. The foredune continues to develop although footfall may be damaging it and leading to erosion.</p>

Survey Date	Description of Changes Since Last Survey	Interpretation
	<p>with a seaward extension of the toe of the beach by 121m, creating a flatter profile than the February 2019 survey. The foredune and upper beach berm are at their highest levels recorded, whilst the rest of the beach is at a medium level compared to the range recorded from previous surveys.</p> <p>Topographic Survey:</p> <p>Hartlepool Bay is covered by an annual topographic survey between the South Pier and the North Gare Breakwater. Data from the 2019 Full Measures survey have been used to create a DGM (Appendix B – Map 2) using a GIS software package. The plot shows the two smaller bays within the larger Hartlepool Bay frontage. These smaller bays are separated by a slight promontory at Carr House Sands between Hartlepool and Seaton Carew. The beach contours are generally shore parallel, except where linear features (e.g. outfalls) and rock outcrops are present, such as in the northern part of Seaton Sands. Elevations at the rear of the beach are lowest in the north of the survey area near South Pier and higher further south.</p> <p>The GIS has also been used to calculate the differences between the Autumn 2018 and Autumn 2019 topographic surveys, as shown in Appendix B – Map 5, to identify areas of erosion and accretion. The changes recorded over 2019 show the north of the bay has generally undergone very little change, whilst the central area has wide bands of accretion on the middle and lower beach, with a narrow band of erosion on the upper to middle beach. The southern area shows a dominance of erosion. The changes observed are modest in the north and centre of the bay at less than $\pm 0.75\text{m}$ and are slightly higher in magnitude towards the south of the bay, reaching $\pm 1.0\text{m}$. The plot generally shows shore-parallel changes, reflecting the seasonal movement of sediment across the beach in the form of sand bars.</p>	

2.4 North Gare

Survey Date	Description of Changes Since Last Survey	Interpretation
<p>October 2019</p>	<p>Topographic Survey:</p> <p>North Gare is covered by an annual topographic survey between the North Gare Breakwater and the Seaton on Tees Channel. The area is designated as the Teesmouth National Nature Reserve. Surveys have been carried out since Autumn 2011.</p> <p>Data from the 2019 Full Measures survey have been used to create a DGM (Appendix B – Map 3) using GIS software. The beach contours recorded in 2019 show the promontory and the contours run shore parallel to the beach in the north. In the south of the study area the contours diverge from the shore line and there is an extensive flat area between the shoreline and MHW. However, the lower beach and foreshore are much steeper in the south of the survey area than in the north.</p> <p>The GIS has also been used to calculate the differences between the Autumn 2018 and Autumn 2019 topographic surveys, as shown in Appendix B – Map 6, to identify areas of net erosion and accretion. The difference plot shows that there are alternating shore parallel bands of accretion and erosion in the north, with erosion dominating on the lower and upper beach. There is a band of accretion on the middle beach and in the most northern part of the study area. In the southern part of the survey area, to the north and landward of the promontory there is little change. There is generally little change seaward of the promontory, with accretion towards the MHWM and a band of erosion running north-east along the gravel bank from the end of the promontory. Overall there are more areas of little change / accretion across the survey area, however change across the survey area is limited in magnitude.</p>	<p>The changes seen in the 2018 Full Measures survey show a pronounced pattern of sand bar movement across the shore face in the north of the survey area and accretion on the seaward side of the promontory. Changes are low in magnitude.</p> <p>The pattern in 2019 generally mirrors that seen in 2018, however erosion is slightly more dominant on the lower foreshore than before.</p>

3. Problems Encountered and Uncertainty in Analysis

Beach profile HN1 is located within Durham County Council's area of responsibility but has been reported here so changes can be interpreted in association with those observed elsewhere along North Sands, along HN2, HN3 and HN4.

At Middleton, there was no access to the upper section of profile 1cHC1.

At North Gare, ground levels within the salt marsh area at the south east corner were taken on foot to avoid disturbing wildlife.

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

No further 'fine-tuning' is recommended at the present time.

5. Conclusions and Areas of Concern

- At North Sands, the beach profiles generally show accretion on the upper and lower beach across the bay, with erosion across the middle beach, except towards the east of the survey area where beach levels have remained stable. The beach is mostly at a medium-low level compared to previous surveys.
- At Middleton, the beach profile shows an increase in material at the toe of the sea wall and across the upper and middle beach, with a decrease in level of the beach toe since February 2019. The difference plot shows accretion dominating the upper and middle beach in the west of the survey area, whilst erosion dominates in the east across the middle and lower beach. The continuing erosion of the beach is expected because there are no sources of sediment to the Middleton frontage. The beach in front of the headland had a patchy distribution of change in 2019.
- The majority of changes through 2019 in Hartlepool Bay were modest. Profiles generally show accretion or little change across the survey area with berm formation in the south, reflecting the seasonal movement of sediment across the beach as sand bars. This pattern is also supported by the topographic survey difference plot.
- The topographic plot at North Gare shows a pronounced pattern of sand bar movement across the shore face in the north of the survey area and accretion on the seaward side of the promontory. Throughout 2019 there was erosion in the north and accretion in the south overall.
- There is no cause for concern at any of these areas.

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: 1cHN1

Date: 17/09/2019

Inspector: AG

Low Tide:

Low Tide Time:

Wind

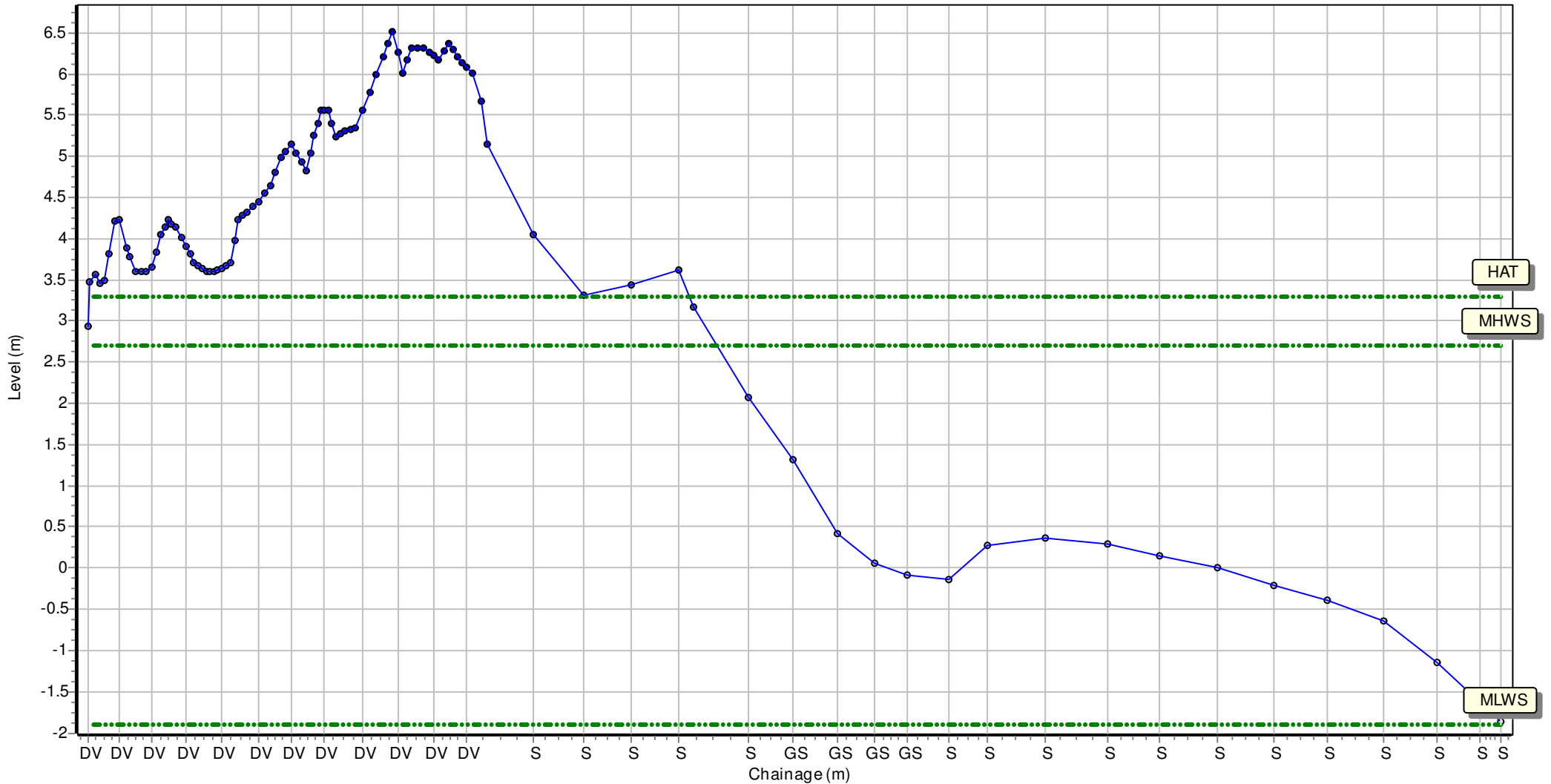
Sea State:

Visibility:

Rain:

Summary: 2019 Full Measures Topo Survey

Easting: 448779.624 Northing: 536767.42 Profile Bearing: 44 ° from North



Beach Profile

Location: 1cHN2

Date: 17/09/2019

Inspector: AG

Low Tide:

Low Tide Time:

Wind

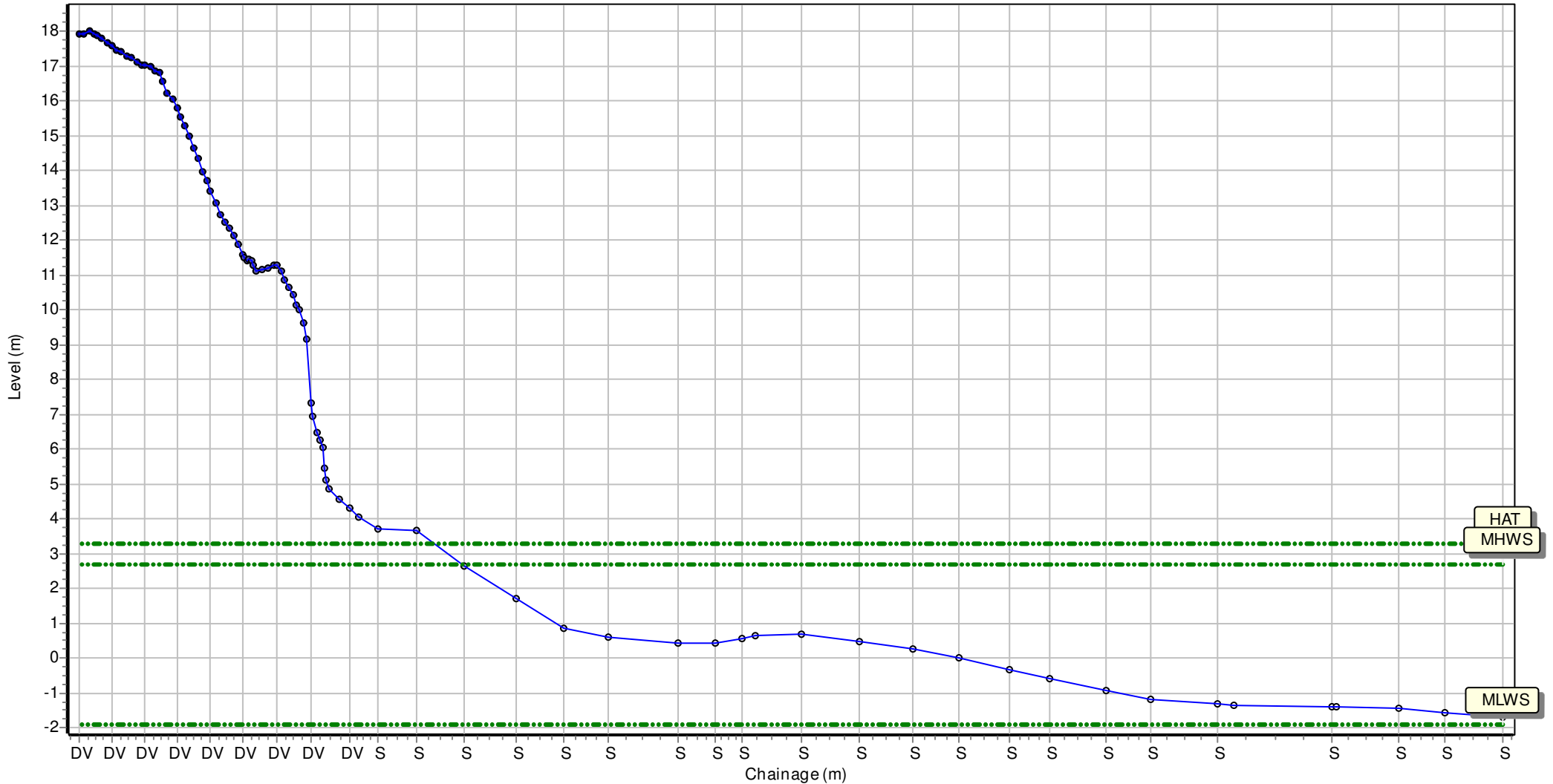
Sea State:

Visibility:

Rain:

Summary: 2019 Full Measures Topo Survey

Easting: 449547.217 Northing: 536095.458 Profile Bearing: 42 ° from North



Beach Profile

Location: 1cHN2A

Date: 17/09/2019

Inspector: AG

Low Tide:

Low Tide Time:

Wind

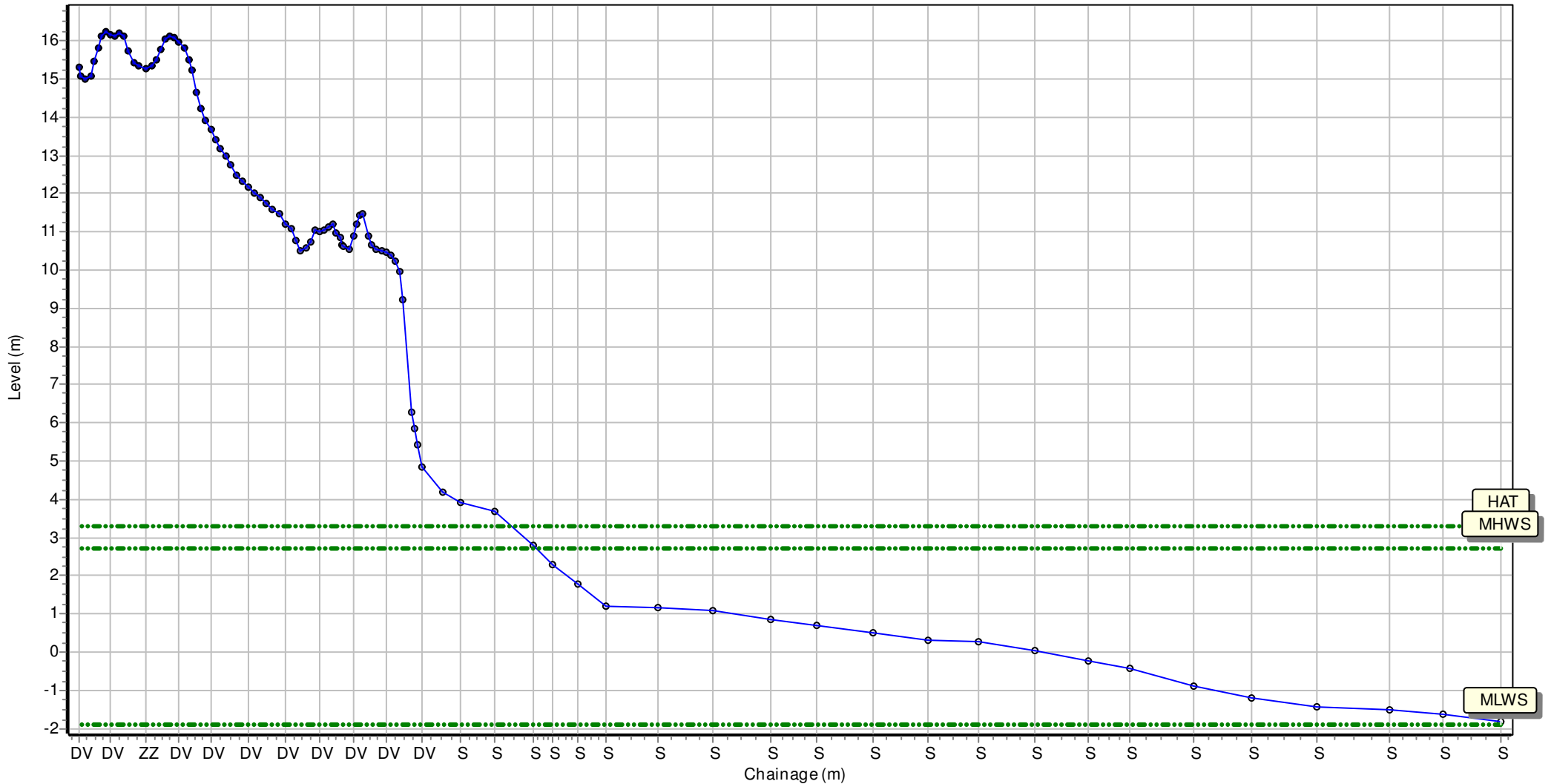
Sea State:

Visibility:

Rain:

Summary: 2019 Full Measures Topo Survey

Easting: 450088.047 Northing: 535658.212 Profile Bearing: 39 ° from North



Beach Profile

Location: 1cHN3

Date: 17/09/2019

Inspector: AG

Low Tide:

Low Tide Time:

Wind

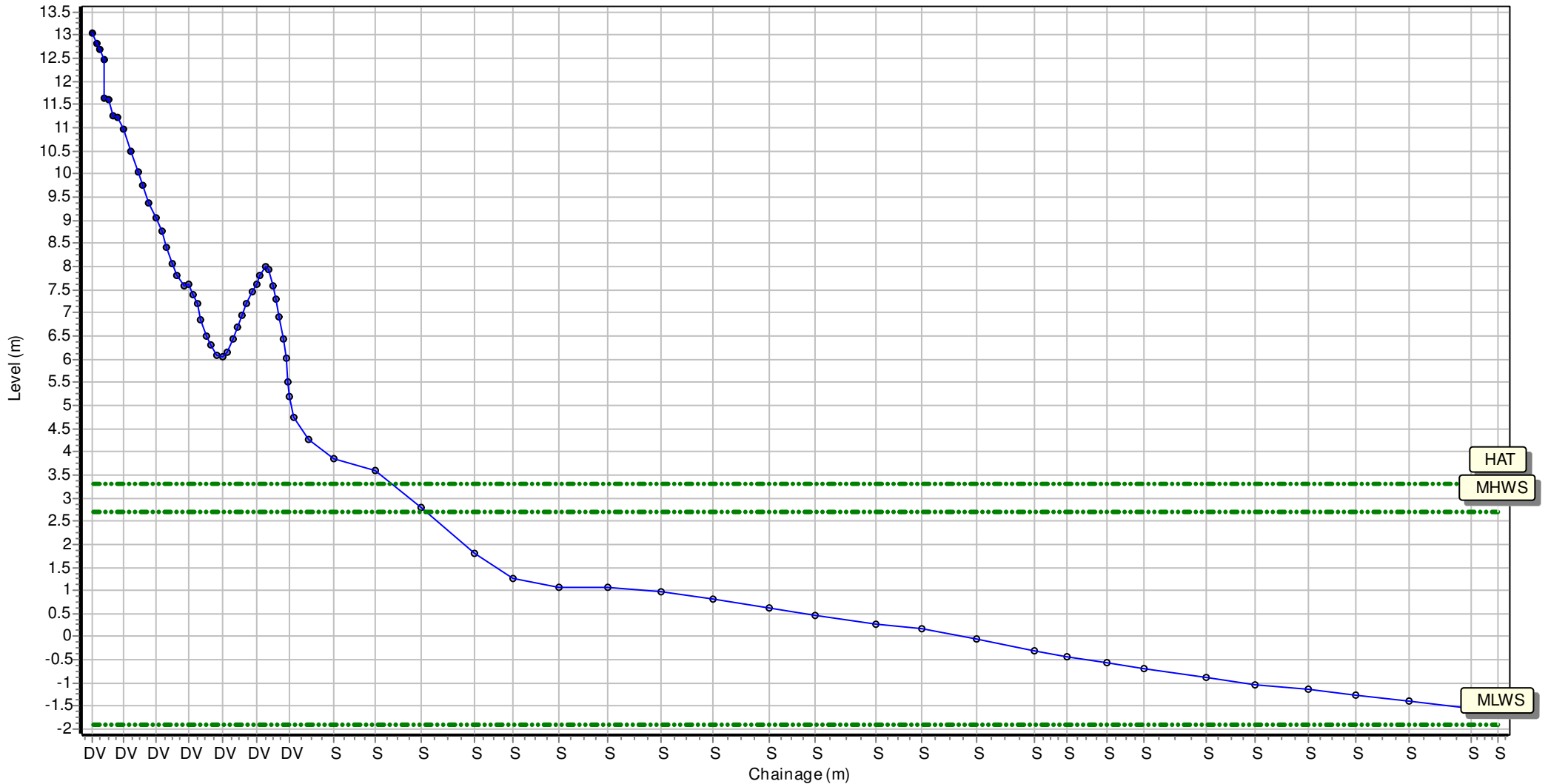
Sea State:

Visibility:

Rain:

Summary: 2019 Full Measures Topo Survey

Easting: 450674.424 Northing: 535305.141 Profile Bearing: 30 ° from North



Beach Profile

Location: 1cHN3A

Date: 17/09/2019

Inspector: AG

Low Tide:

Low Tide Time:

Wind

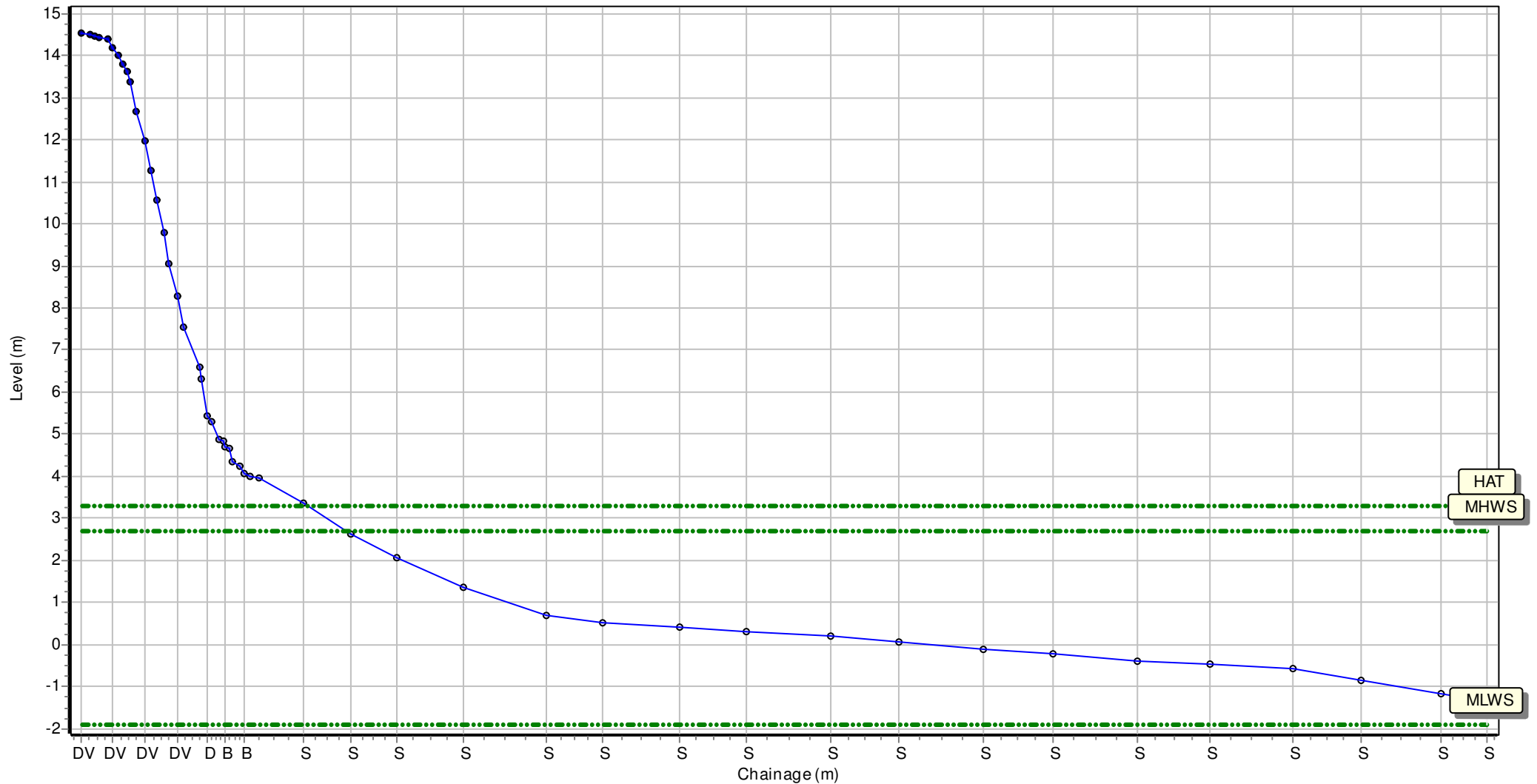
Sea State:

Visibility:

Rain:

Summary: 2019 Full Measures Topo Survey

Easting: 451324.71 Northing: 534903.35 Profile Bearing: 25 ° from North



Beach Profile

Location: 1cHC1

Date: 18/09/2019

Inspector: AG

Low Tide:

Low Tide Time:

Wind

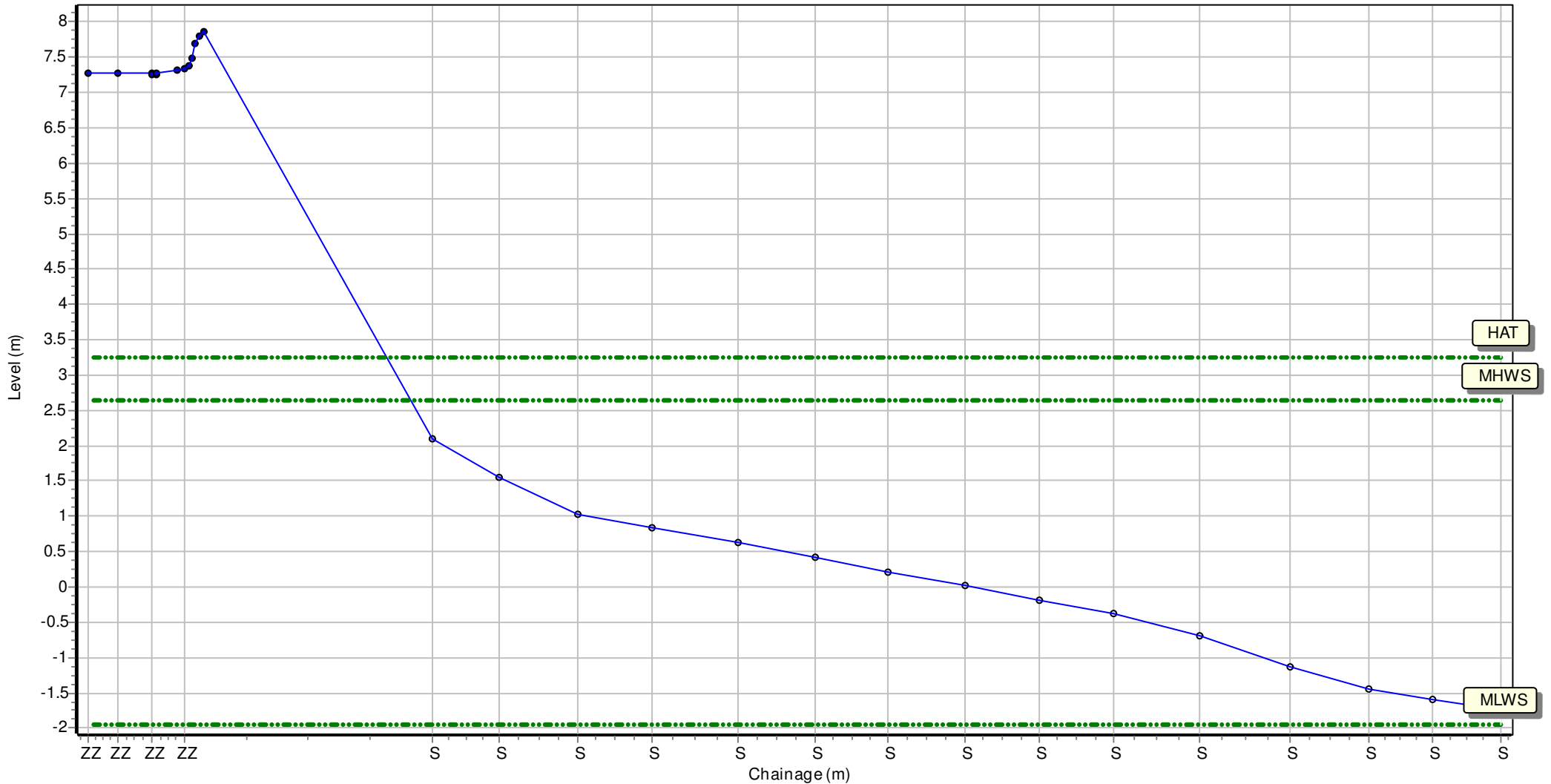
Sea State:

Visibility:

Rain:

Summary: 2019 Full Measures Topo Survey

Easting: 452108.075 Northing: 533506.119 Profile Bearing: 150 ° from North



Beach Profile

Location: 1cHS1

Date: 03/09/2019

Inspector: AG

Low Tide:

Low Tide Time:

Wind

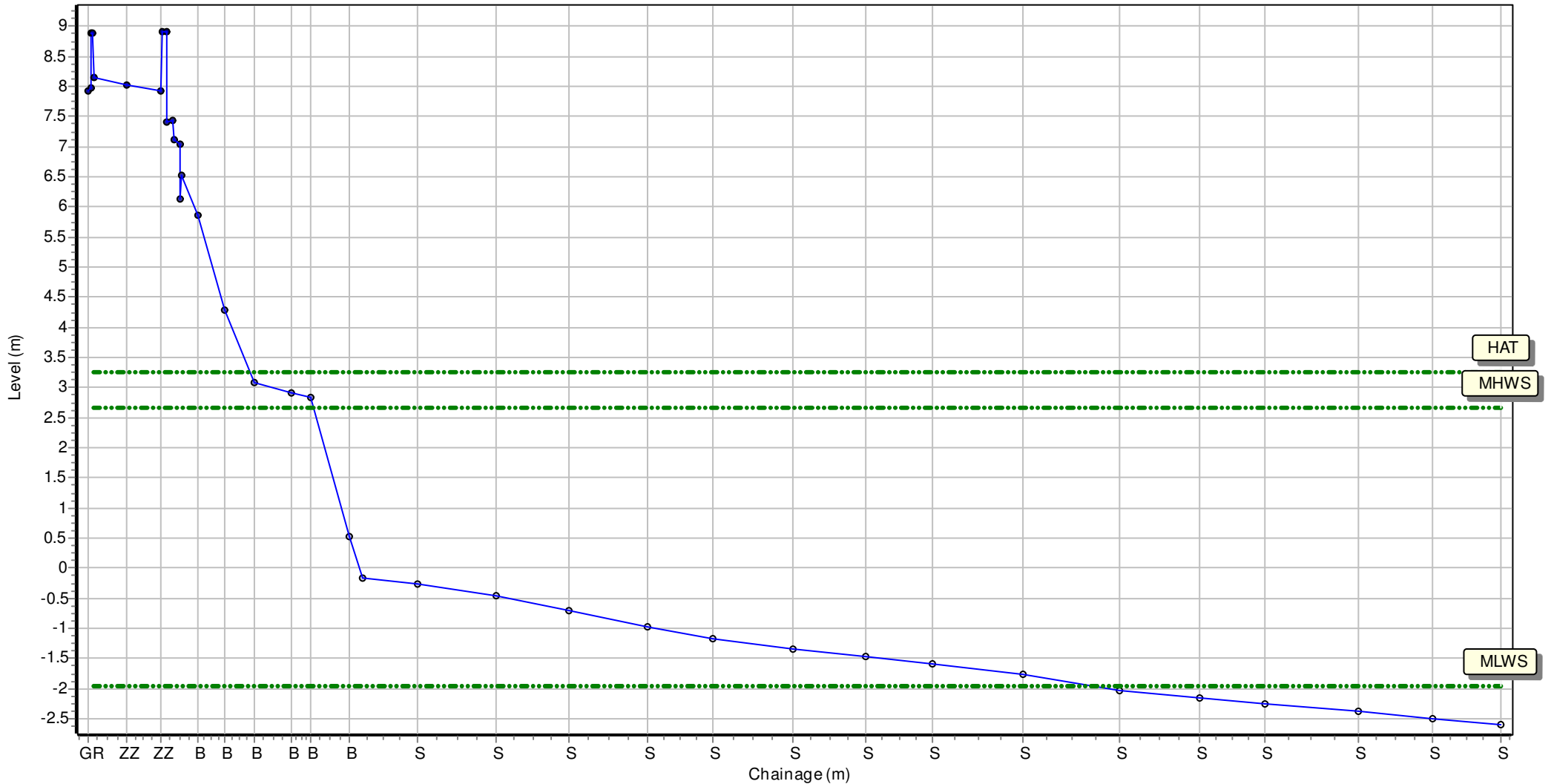
Sea State:

Visibility:

Rain:

Summary: 2019 Full Measures Topo Survey

Easting: 451718 Northing: 532455 Profile Bearing: 95 ° from North



Beach Profile

Location: 1cHS2

Date: 03/09/2019

Inspector: AG

Low Tide:

Low Tide Time:

Wind

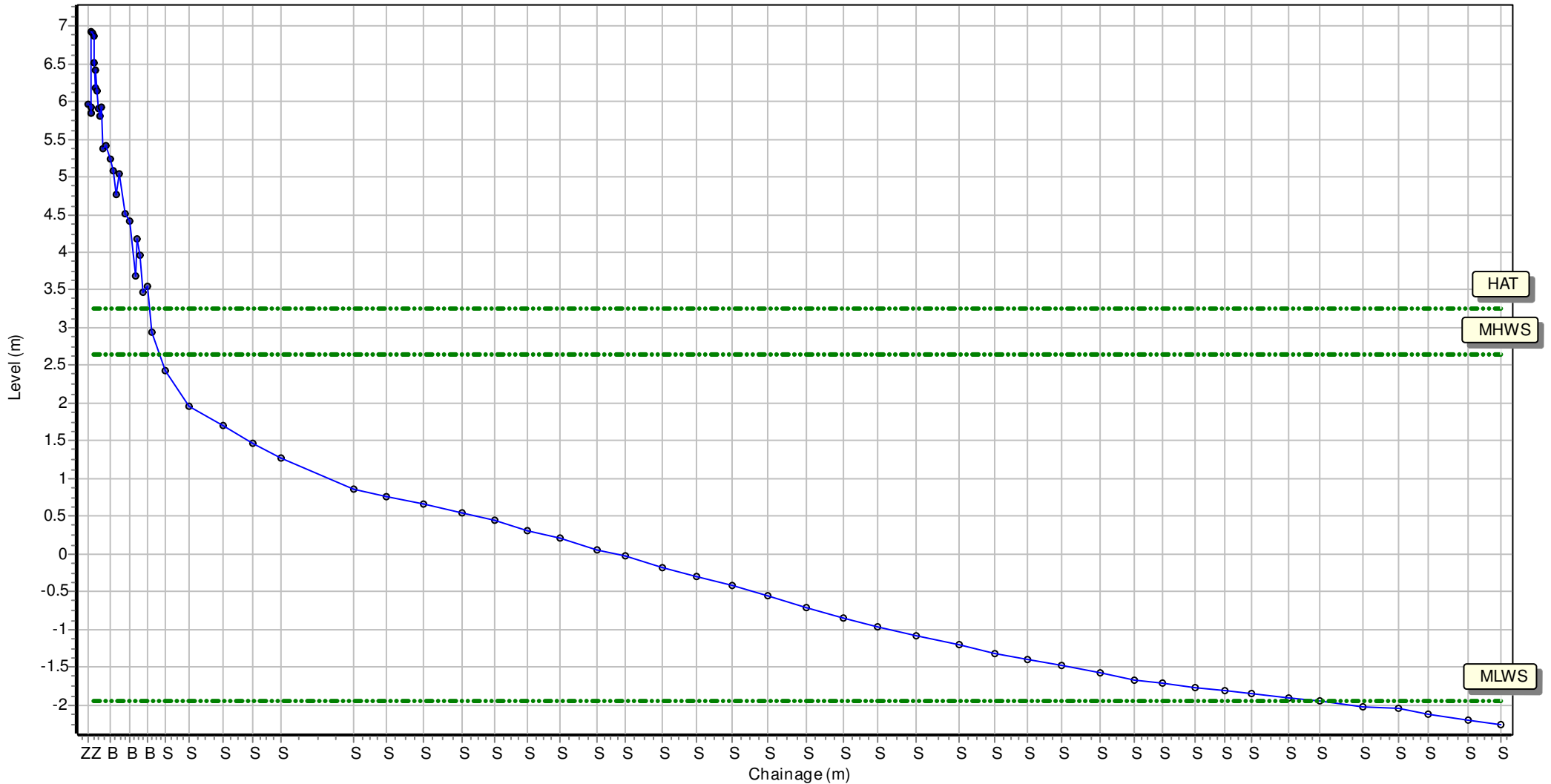
Sea State:

Visibility:

Rain:

Summary: 2019 Full Measures Topo Survey

Easting: 452160.59 Northing: 531071.39 Profile Bearing: 77 ° from North



Beach Profile

Location: 1cHS3

Date: 03/09/2019

Inspector: AG

Low Tide:

Low Tide Time:

Wind

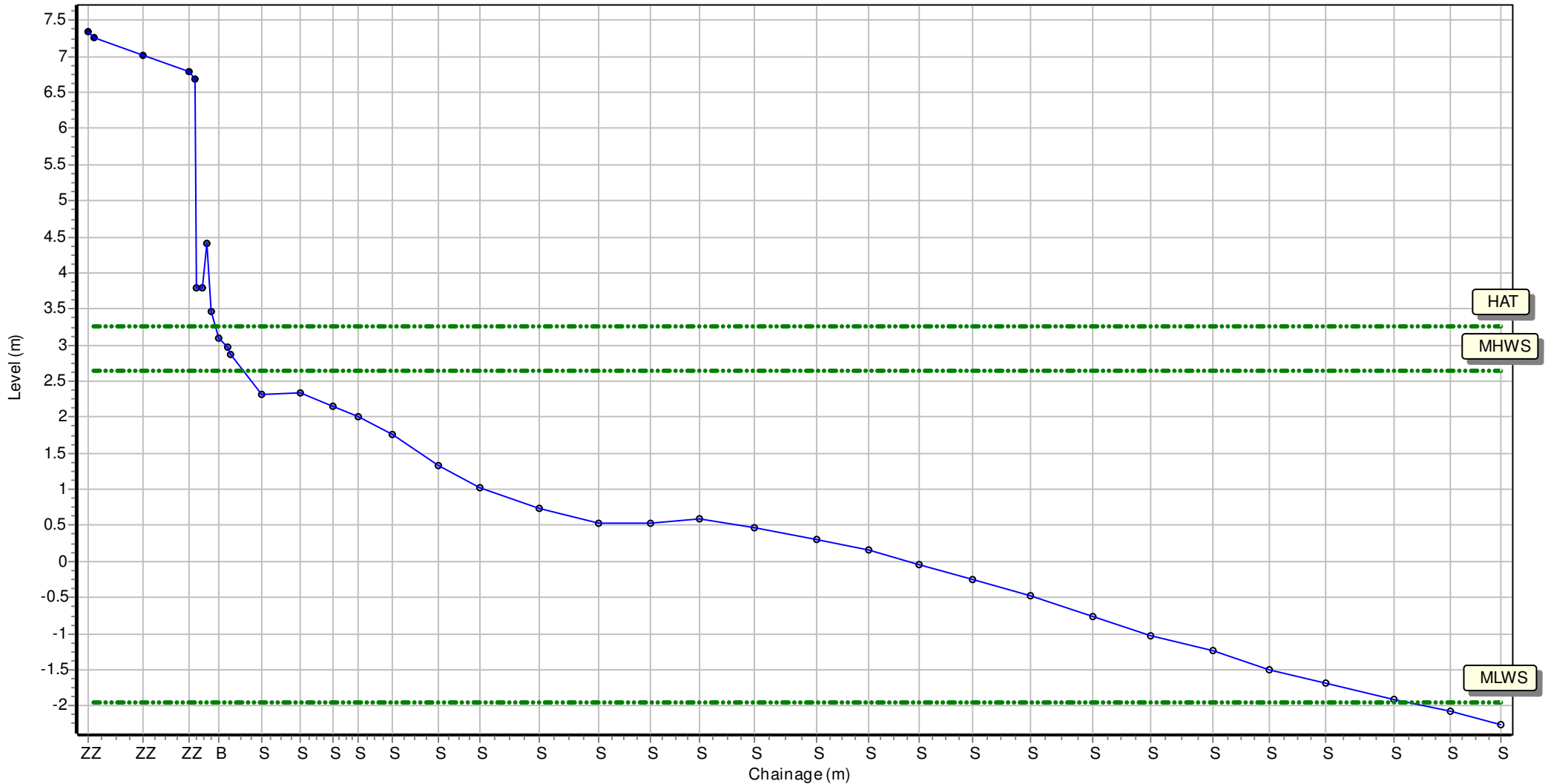
Sea State:

Visibility:

Rain:

Summary: 2019 Full Measures Topo Survey

Easting: 452517.25 Northing: 530064.57 Profile Bearing: 76 ° from North



Beach Profile

Location: 1cHS4

Date: 03/09/2019 Inspector: AG

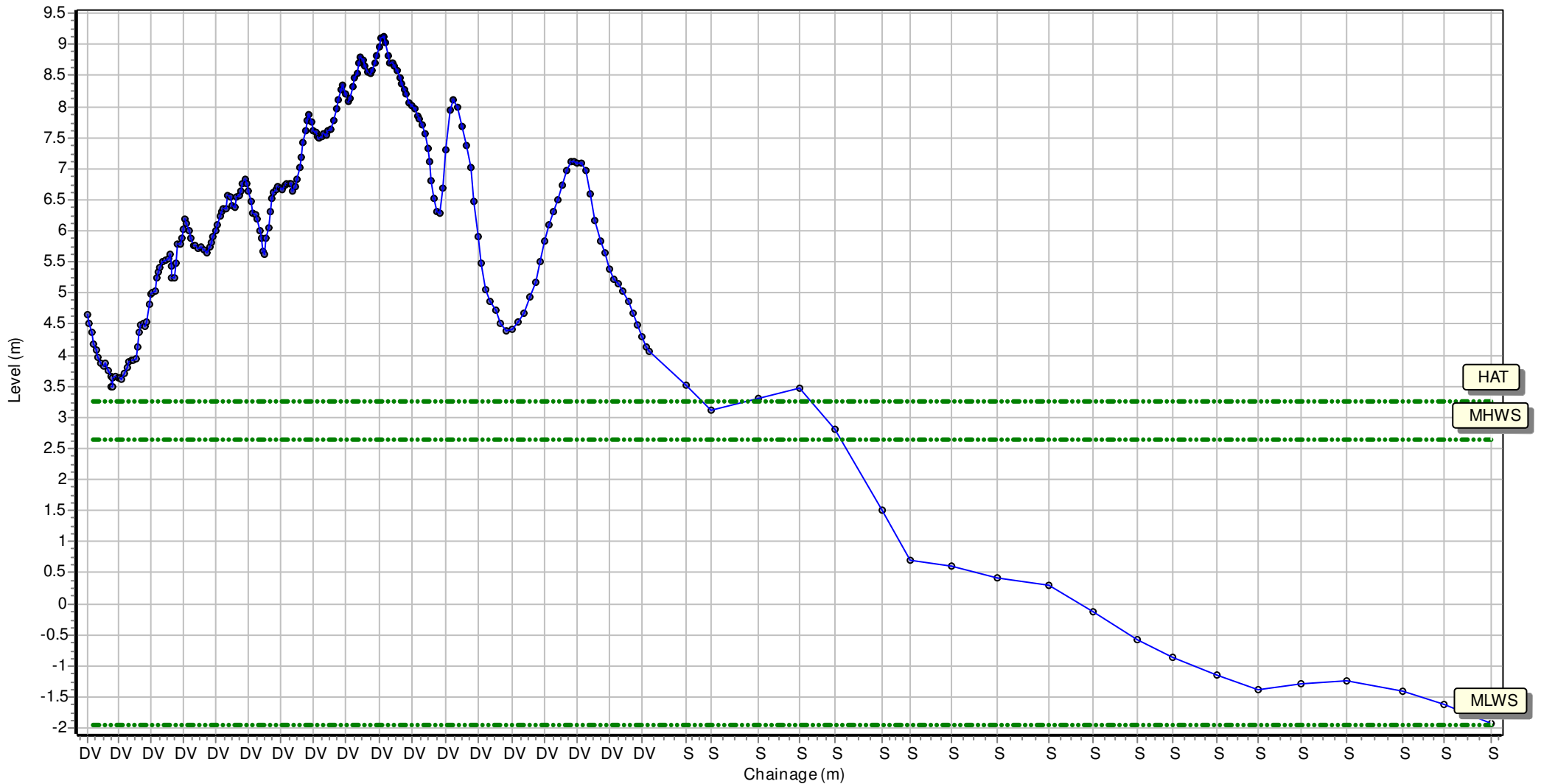
Low Tide: Low Tide Time:

Wind Sea State:

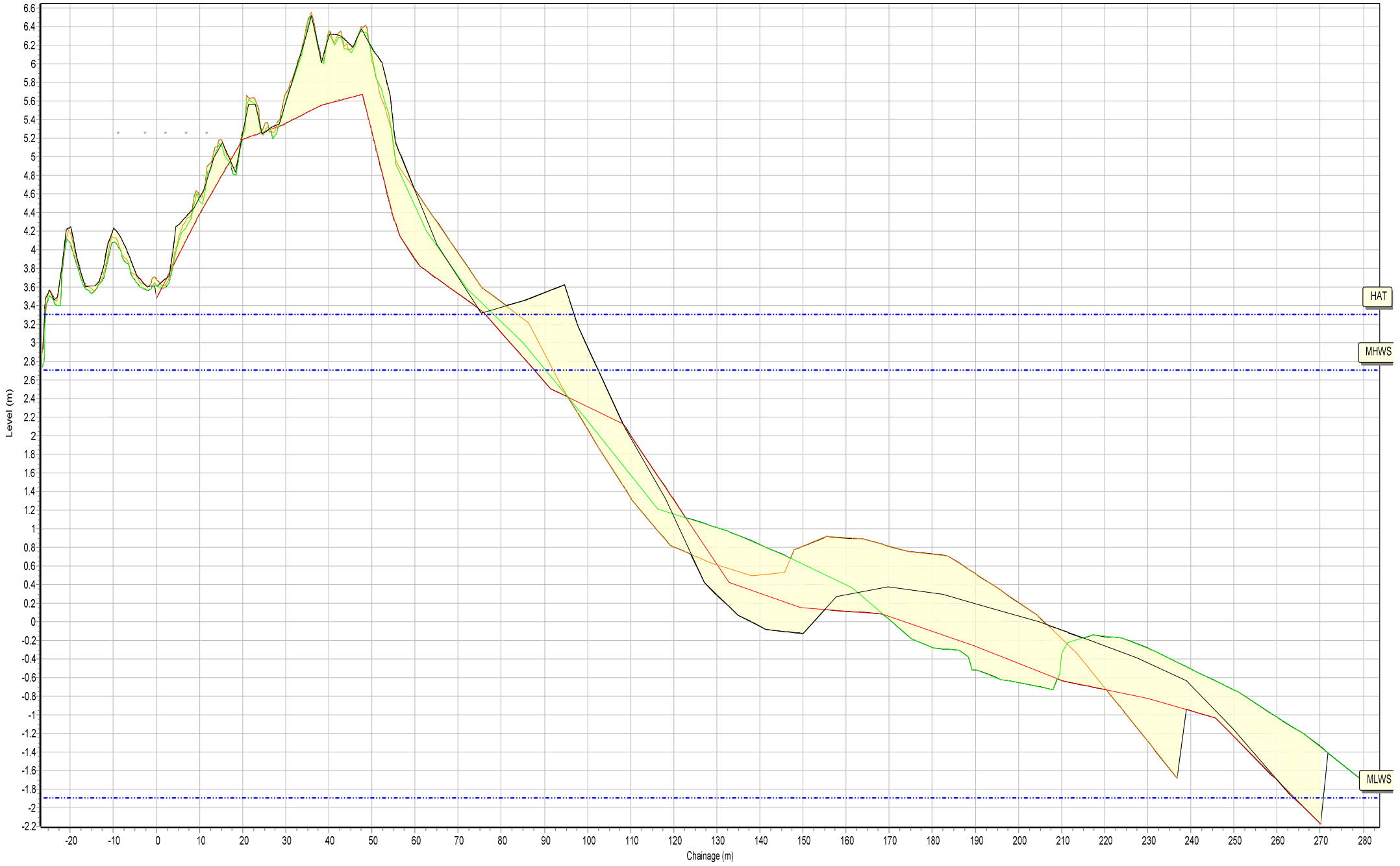
Visibility: Rain:

Summary: 2019 Full Measures Topo Survey

Easting: 452889 Northing: 528971 Profile Bearing: 76 ° from North



Beach Profiles: 1cHN1



HAT

MHWS

MLWS

SANDS

Beach Profiles: 1cHN2



Profiles Envelope 10/11/2008 31/08/2018 21/02/2019 17/09/2019

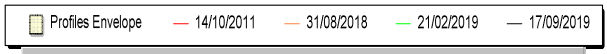
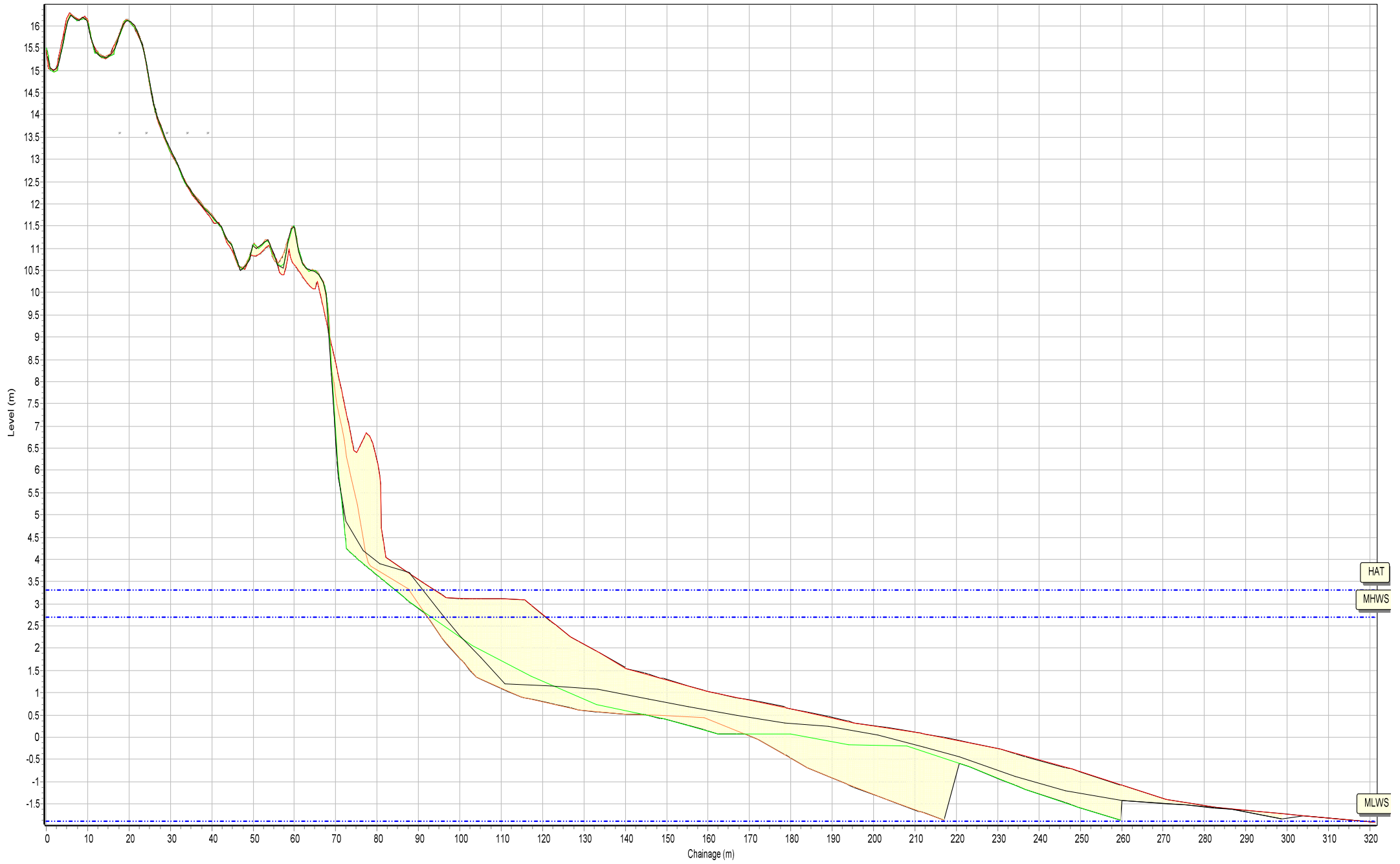
HAT

MHWS

MLWS

SANDS

Beach Profiles: 1cHN2A



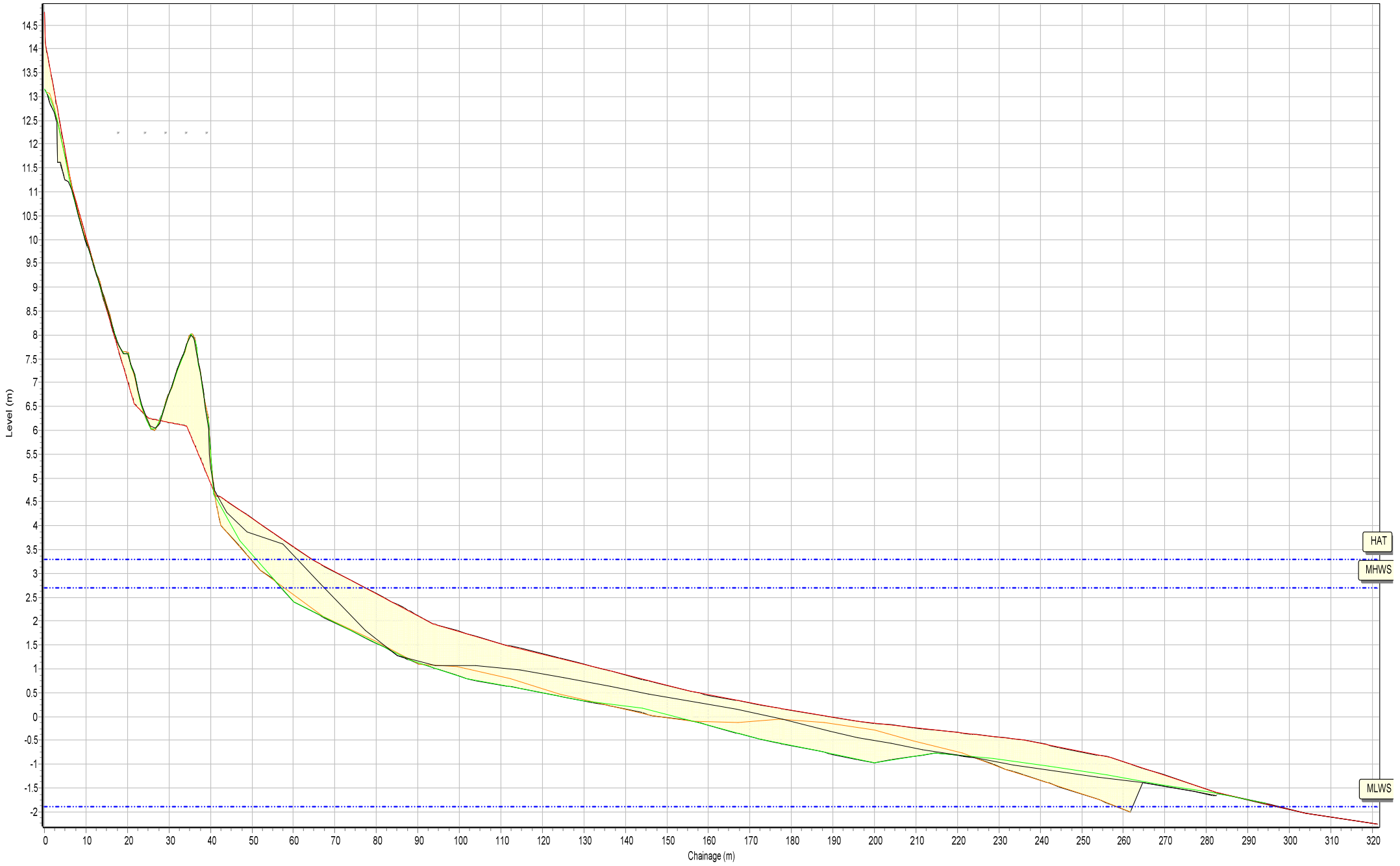
HAT

MHWS

MLWS

SANDS

Beach Profiles: 1cHN3



HAT

MHWS

MLWS

SANDS

Beach Profiles: 1cHN3A



Profiles Envelope 14/10/2011 31/08/2018 21/02/2019 17/09/2019

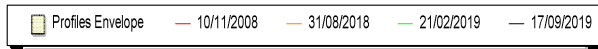
HAT

MHWS

MLWS

SANDS

Beach Profiles: 1cHN4



HAT

MHWS

MLWS

SANDS

Beach Profiles: 1cHN4A



Profiles Envelope 14/10/2011 31/08/2018 21/02/2019 17/09/2019

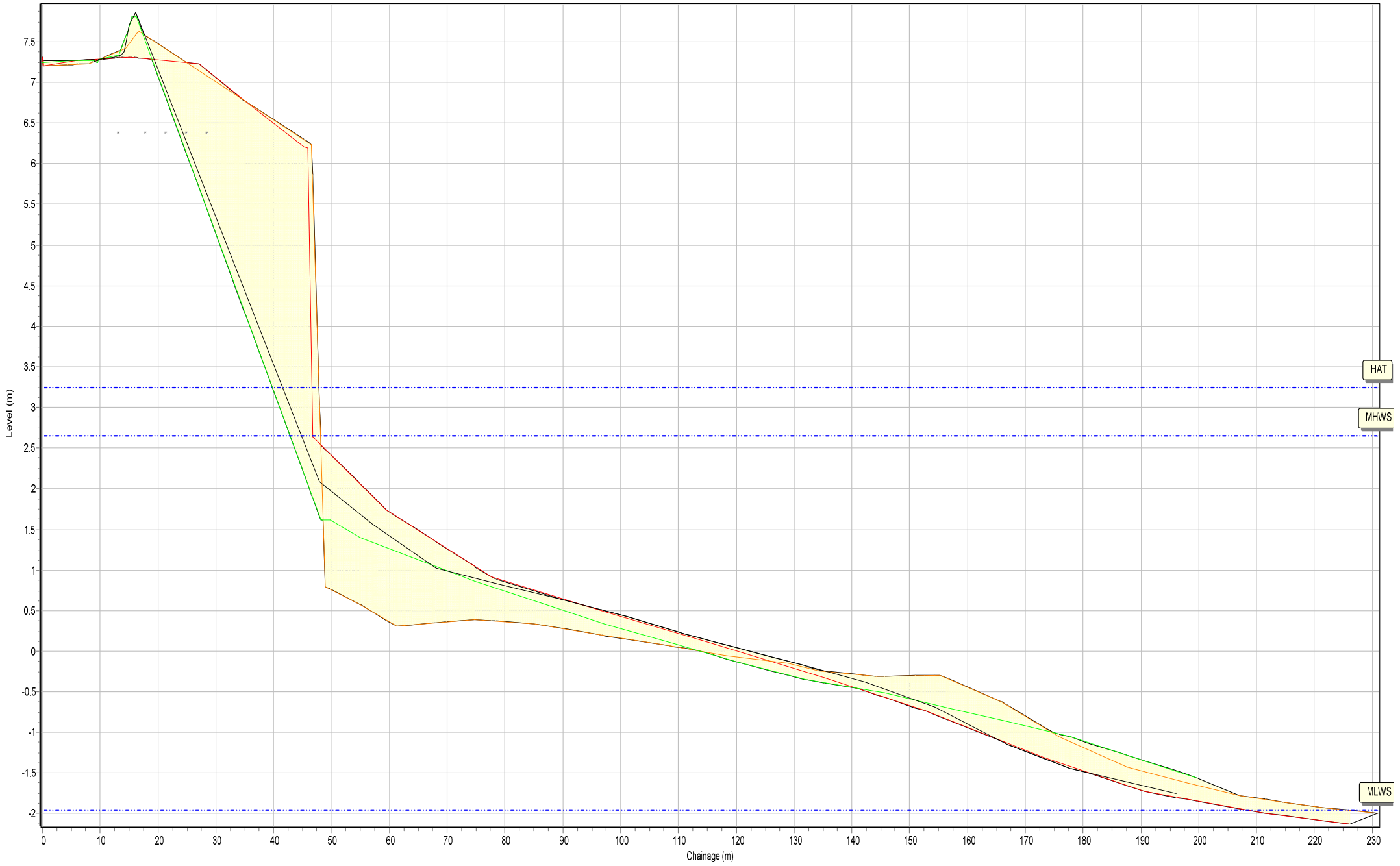
HAT

MHWS

MLWS

SANDS

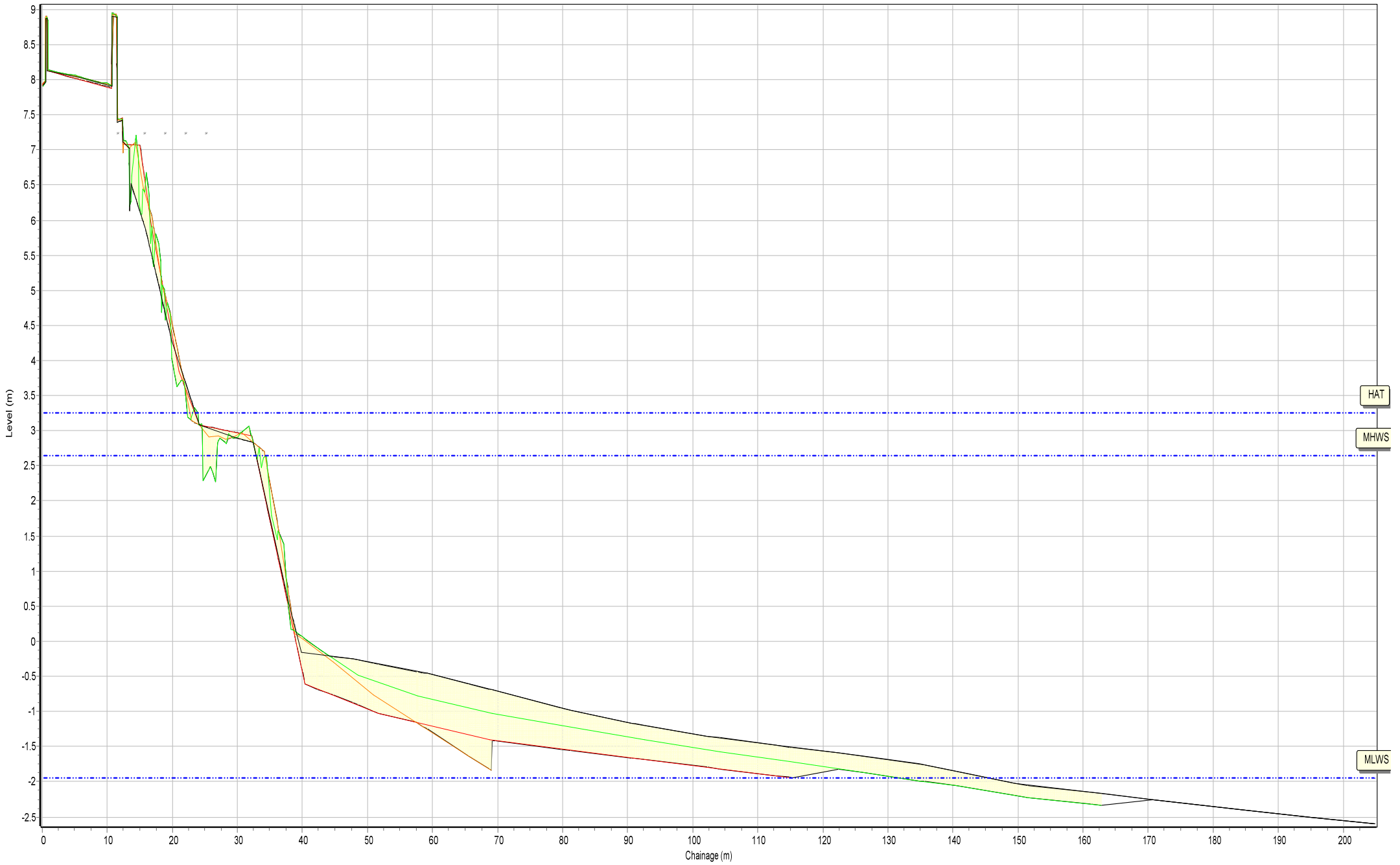
Beach Profiles: 1cHC1



Profiles Envelope 12/11/2008 08/10/2018 22/02/2019 18/09/2019

SANDS

Beach Profiles: 1cHS1



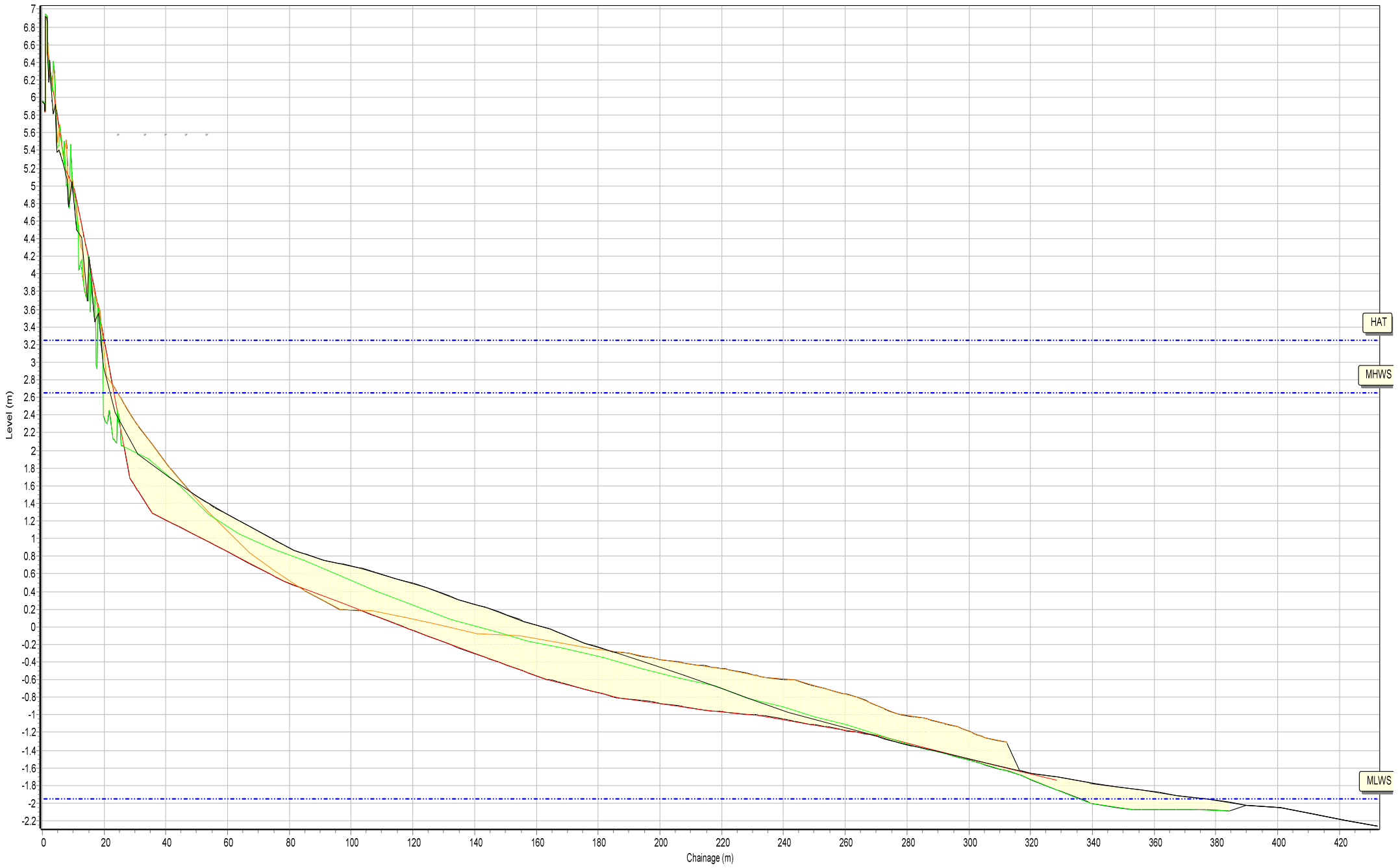
HAT

MHWS

MLWS

SANDS

Beach Profiles: 1cHS2



Beach Profiles: 1cHS3



Profiles Envelope 27/03/2009 24/10/2018 22/02/2019 03/09/2019

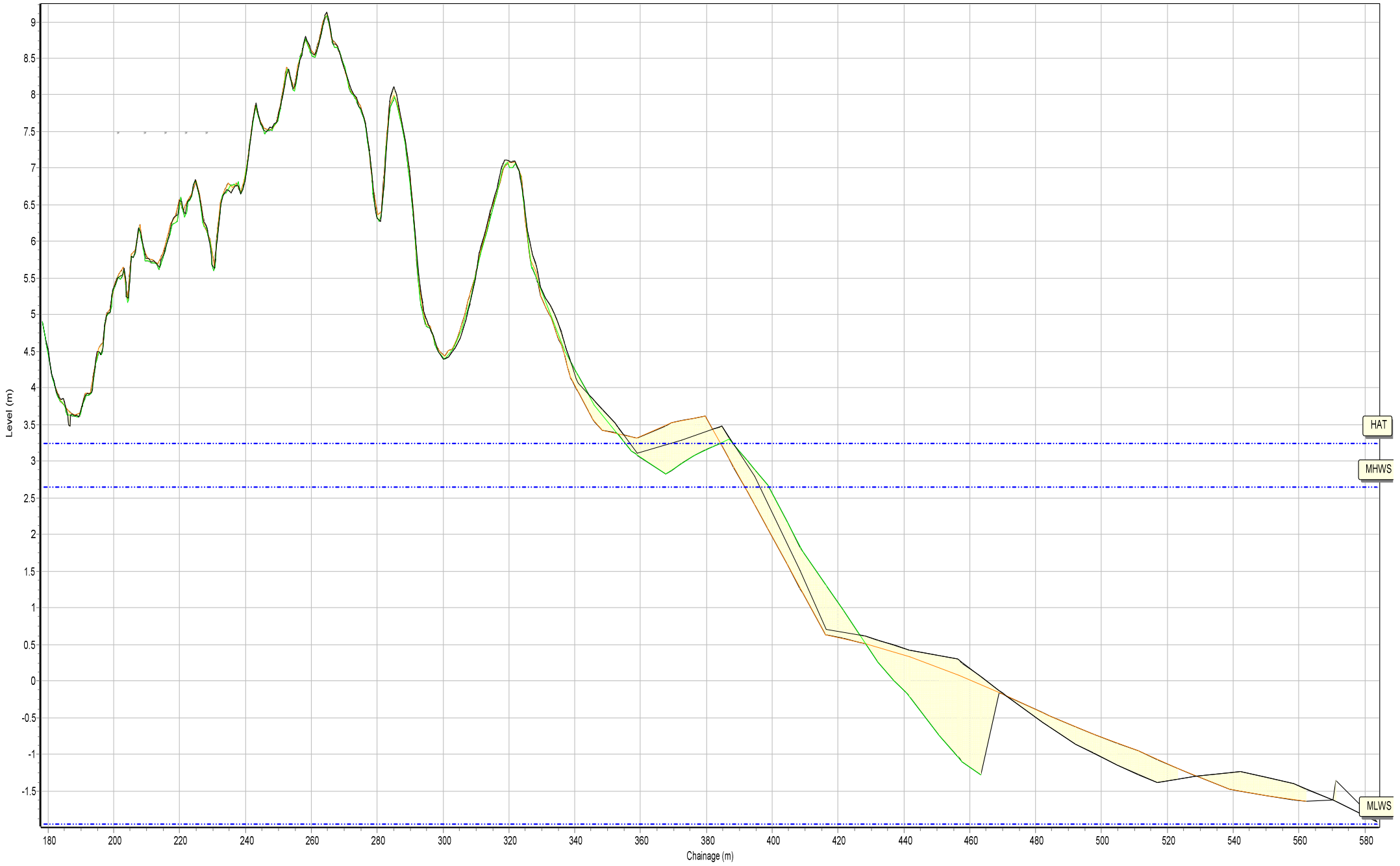
HAT

MHWS

MLWS

SANDS

Beach Profiles: 1cHS4



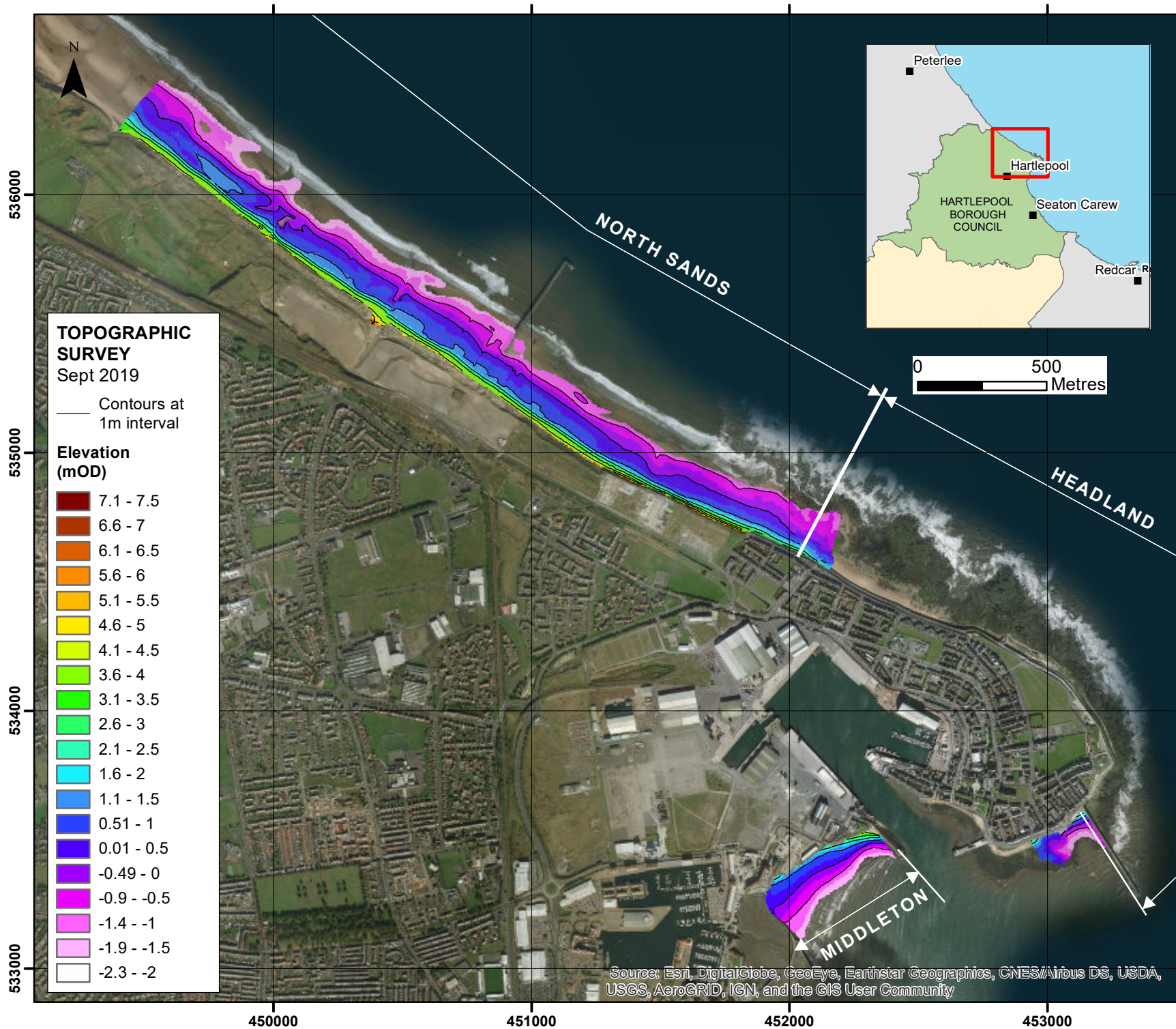
HAT

MLWS

MLWS

SANDS

Appendix B
Topographic Survey



Key

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

Appendix B - Map 1
HARTLEPOOL NORTH

Hartlepool Borough Council Frontage

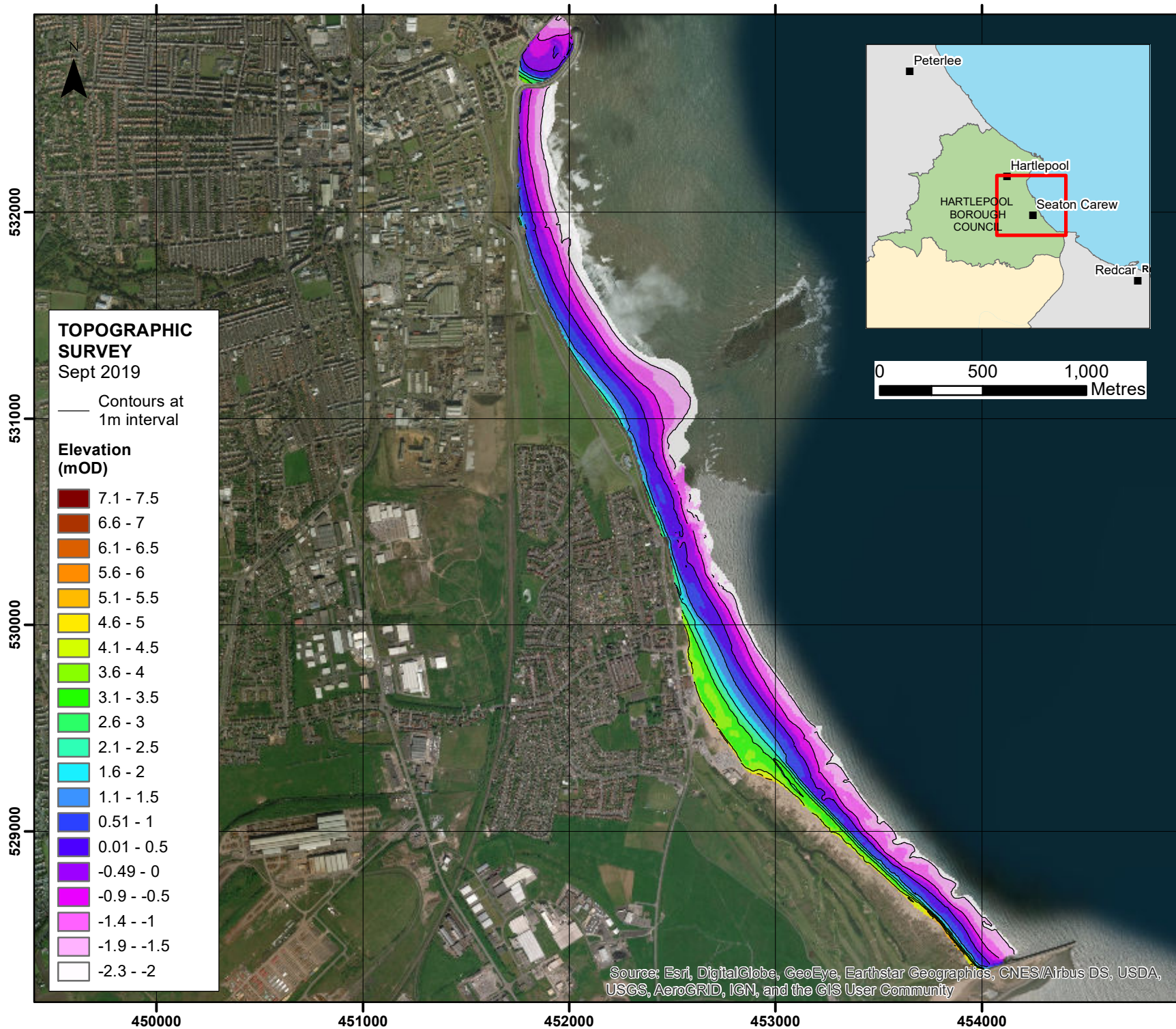
Analytical Report
'Full Measures' Survey 2019

Drawing Scale at A4 1:20,000

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Project: Cell 1 Regional Coastal Monitoring Programme

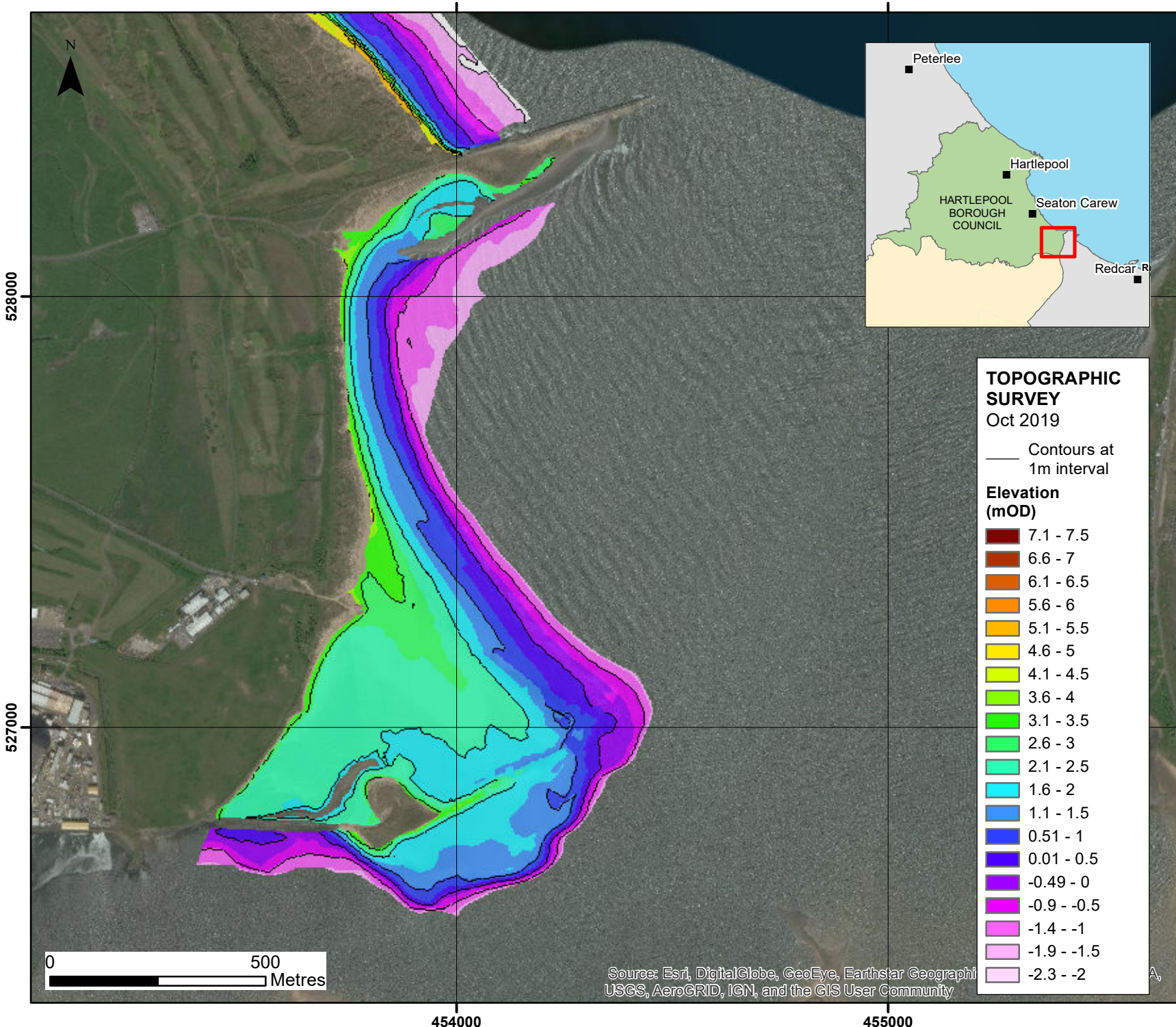
Appendix B - Map 2
HARTLEPOOL SOUTH
Hartlepool Borough Council Frontage
Analytical Report
'Full Measures' Survey 2019

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 3

HARTLEPOOL NORTH GARE

Hartlepool Borough Council Frontage

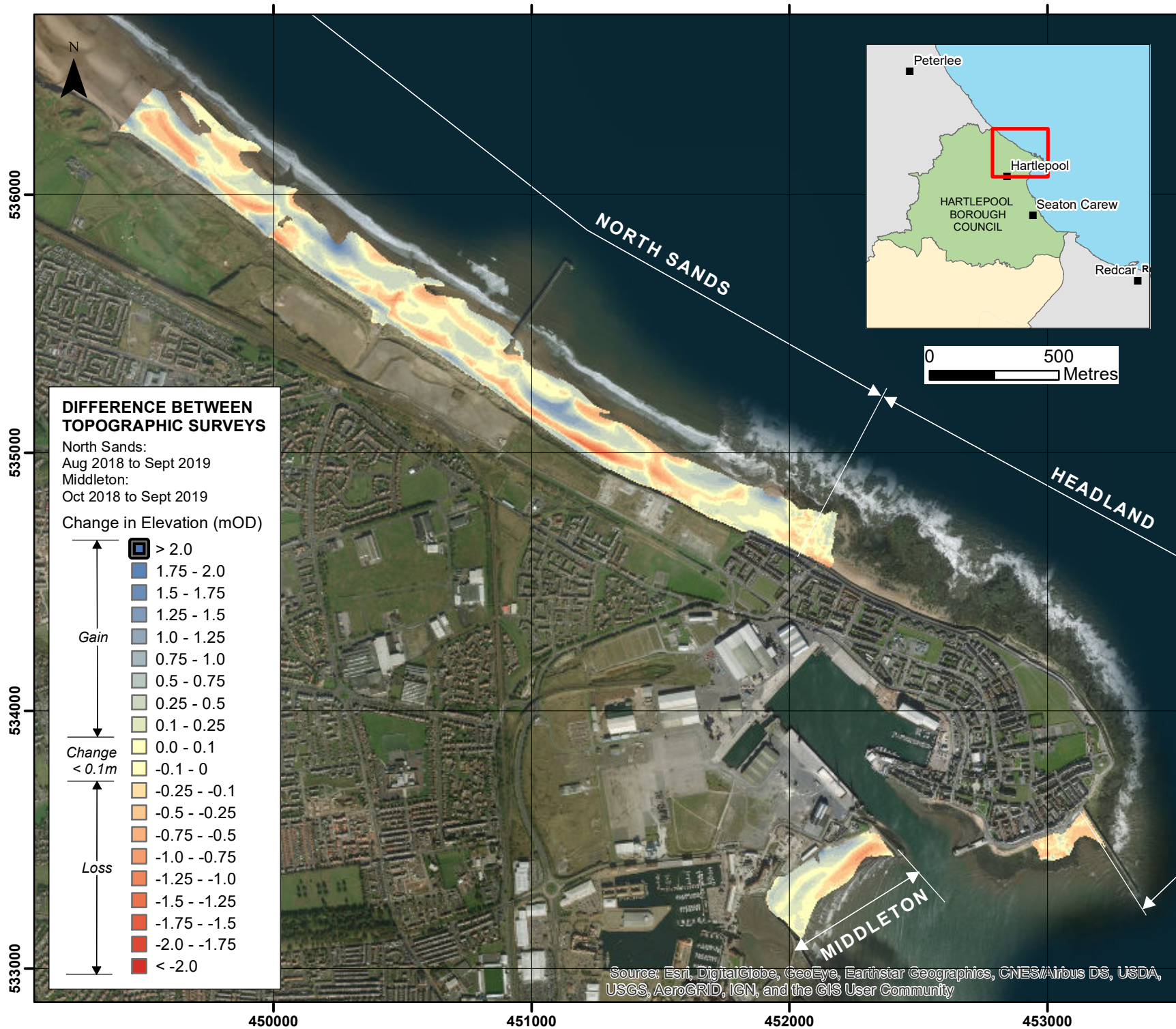
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DIFFERENCE BETWEEN TOPOGRAPHIC SURVEYS

North Sands:
Aug 2018 to Sept 2019
Middleton:
Oct 2018 to Sept 2019

Change in Elevation (mOD)

Gain	> 2.0
	1.75 - 2.0
	1.5 - 1.75
	1.25 - 1.5
	1.0 - 1.25
	0.75 - 1.0
	0.5 - 0.75
	0.25 - 0.5
	0.1 - 0.25
	0.0 - 0.1
Change < 0.1m	-0.1 - 0
	-0.25 - -0.1
	-0.5 - -0.25
	-0.75 - -0.5
Loss	-1.0 - -0.75
	-1.25 - -1.0
	-1.5 - -1.25
	-1.75 - -1.5
	-2.0 - -1.75
	< -2.0



Key

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

Appendix B - Map 4
HARTLEPOOL NORTH

Hartlepool Borough Council Frontage

Analytical Report
'Full Measures' Survey 2019

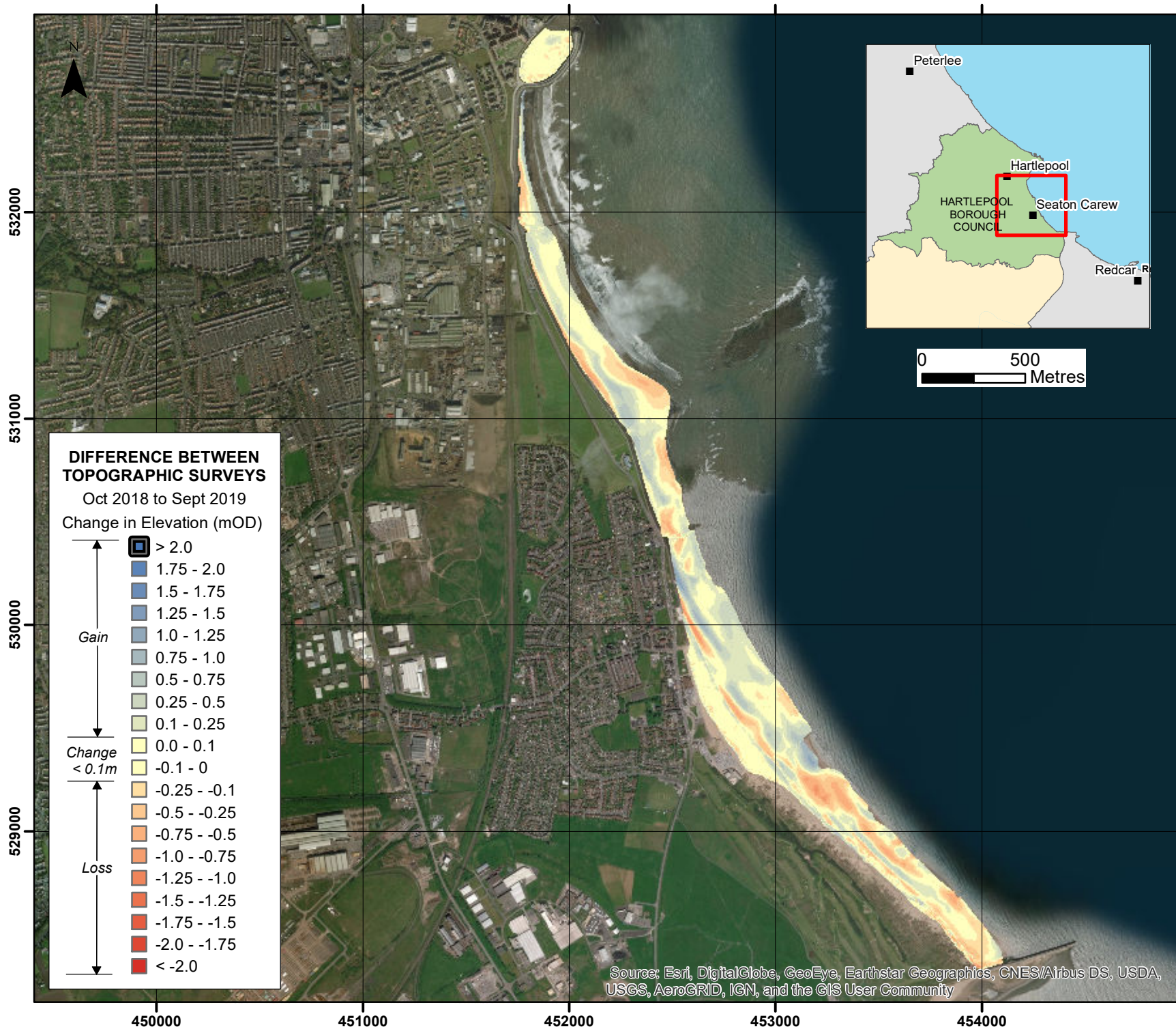
Drawing Scale at A4 1:20,000

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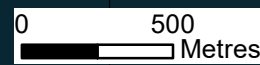


Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community



DIFFERENCE BETWEEN TOPOGRAPHIC SURVEYS
 Oct 2018 to Sept 2019
 Change in Elevation (mOD)

Gain	> 2.0
	1.75 - 2.0
	1.5 - 1.75
	1.25 - 1.5
	1.0 - 1.25
	0.75 - 1.0
	0.5 - 0.75
	0.25 - 0.5
	0.1 - 0.25
	0.0 - 0.1
Change < 0.1m	-0.1 - 0
	-0.25 - -0.1
	-0.5 - -0.25
	-0.75 - -0.5
	-1.0 - -0.75
	-1.25 - -1.0
	-1.5 - -1.25
	-1.75 - -1.5
	-2.0 - -1.75
	< -2.0
Loss	



Key

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

Appendix B - Map 5
HARTLEPOOL SOUTH

Hartlepool Borough Council Frontage

Analytical Report
 'Full Measures' Survey 2019

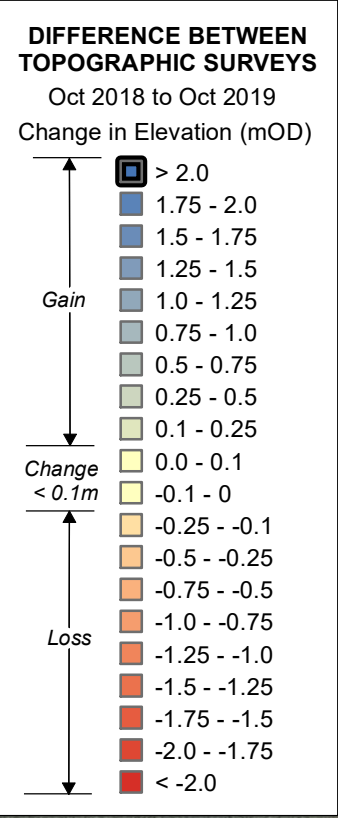
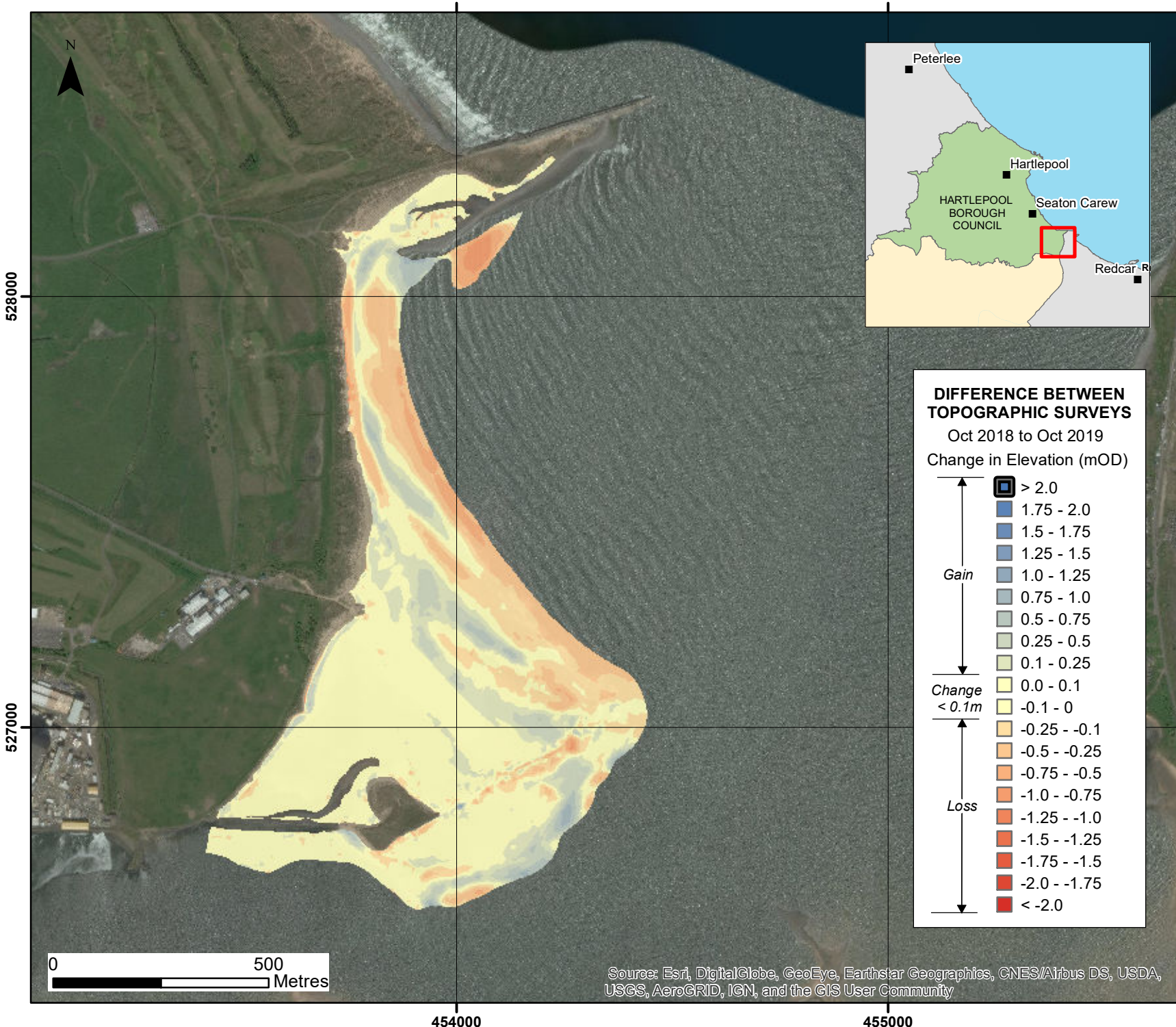
Drawing Scale at A4 1:25,000

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Key

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

Appendix B - Map 6
HARTLEPOOL
NORTH GARE
Hartlepool Borough
Council Frontage

Analytical Report
 'Full Measures' Survey 2019

Drawing Scale at A4 1:12,000

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