



Cell 1 Regional Coastal Monitoring Programme Analytical Report 14: 'Full Measures' Survey 2021



Hartlepool Borough Council

November 2021

Contents

Disclaimer	i
Abbreviations and Acronyms.....	ii
Water Levels Used in Interpretation of Changes	ii
Glossary of Terms.....	iii
Preamble	iv
1. Introduction.....	1
1.1 Study Area	1
1.2 Methodology.....	1
2.1 North Sands	2
2.2 Middleton.....	5
2.3 Hartlepool Bay.....	6
2.4 North Gare	8
3. Problems Encountered and Uncertainty in Analysis	9
4. Recommendations for 'Fine-tuning' the Monitoring Programme	9
5. Conclusions and Areas of Concern	9

Appendices

- Appendix A Beach Profiles
Appendix B Topographic Survey

List of Figures

- Figure 1 Sediment Cells in England and Wales
Figure 2 Survey Location Maps

List of Tables

- Table 1 Analytical, Update and Overview Reports Produced to Date
Table 2 Sub-division of the Cell 1 Coastline

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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)	Water Level (m AOD)
	North Sands to Middleton	Hartlepool Bay
HAT	3.30	3.25
MHWS	2.70	2.65
MHWN	1.50	1.45
MLWN	-0.90	-0.85
MLWS	-1.90	-1.95

Source: UKHO Admiralty Tide Tables, 2020

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.

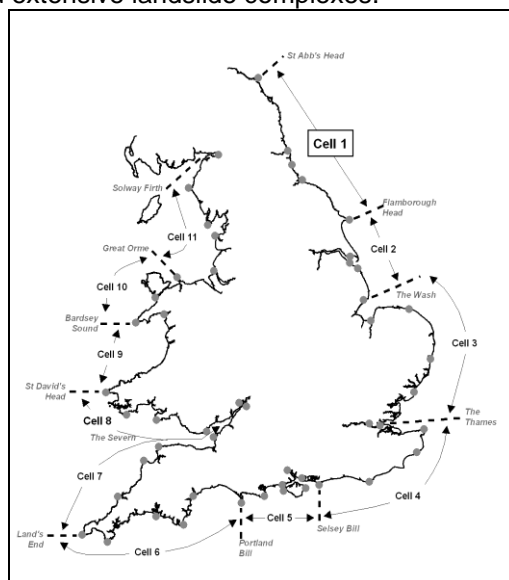


Figure 1 Sediment Cells in England and Wales

The programme commenced in its present guise in September 2008¹ and is managed by Scarborough Borough Council on behalf of the North East Coastal Observatory. It is funded by the Environment Agency, working in partnership with the following organisations:



¹ Prior to 2008, coastal monitoring was undertaken on a consistent basis across Northumberland and North Tyneside as part of the (then) Northumbrian Coastal Authorities Group's monitoring programme which commenced in 2002, whilst several authorities between the River Tyne and Flamborough Head undertook their own local monitoring programmes.

Royal HaskoningDHV has been appointed to provide Analytical Services in relation to the present phase of the Cell 1 Regional Coastal Monitoring Programme, between 2016 - 2027.

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	May 20	Jul 20	
13	2020/21	Sep-Oct 20	Feb 21	Apr 21	May 21	Aug 21
14	2021/22	Sep 21	Nov 21(*)			

(*) The present report is **Analytical Report 14** and provides an analysis of the 2021 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
	North Gare
Redcar & Cleveland Borough Council	Coatham Sands
	Redcar Sands
	Marske Sands
	Saltburn Sands
	Cattersty Sands (Skinningrove)
Scarborough Borough Council	Staithes
	Runswick Bay
	Sandsend Beach, Uppgang 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 2021 Full Measures survey was undertaken along this frontage between 19th September and 23rd September 2021. During this time, the weather was generally dry and sunny with force 2 to 5 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.



SURVEY LOCATIONS

Topographic Profile

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

Topographic Area

- 6 monthly (Light Green)
- yearly (Orange)
- 5 yearly (Purple)

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 World Imagery: Earthstar Geographics
 Hybrid Reference Layer: Esri UK, Esri, HERE, Garmin, INCREMENT P, METI/NASA, USGS
 GB Cartographic: Contains OS data © Crown Copyright and database right 2020
 Contains data from OS Zoomstack

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

Title:

Figure 2 - Map 1

NORTH SANDS, HEADLAND, MIDDLETON

Hartlepool Borough Council Frontage

Report:

Survey Report

Revision:	Date:	Drawn:	Checked:	Size:	Scale:
0	n/a	TC	NJC	A4	1:30,000

Co-ordinate system: British National Grid





SURVEY LOCATIONS

Topographic Profile

- Annual
- Bi-Annual

Topographic Area

- 6 monthly
- yearly
- 5 yearly

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 World Imagery: Maxar, Microsoft
 Hybrid Reference Layer: Esri UK, Esri, HERE, Garmin, INCREMENT P, METI/NASA, USGS
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Client:	Project:
North East Coastal Group	Cell 1 Regional Coastal Monitoring Programme

Title:

Figure 2 - Map 2

HARTLEPOOL BAY

Hartlepool Borough Council Frontage

Report:

Survey Report

Revision:	Date:	Drawn:	Checked:	Size:	Scale:
0	n/a	TC	NJC	A4	1:28,000

Co-ordinate system: British National Grid





SURVEY LOCATIONS

Topographic Profile

- Annual
- Bi-Annual

Topographic Area

- 6 monthly
- yearly
- 5 yearly

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 World Imagery: Maxar, Microsoft
 GB Cartographic: Contains OS data © Crown Copyright and database right 2020
 Contains data from OS Zoomstack
 Hybrid Reference Layer: Esri Community Maps Contributors, Esri UK, Esri, HERE, Garmin, INCREMENT P, METI/NASA, USGS

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

Title:

Figure 2 - Map 3

NORTH GARE

Hartlepool Borough Council Frontage

Report:

Survey Report

Revision:	Date:	Drawn:	Checked:	Size:	Scale:
0	n/a	TC	NJC	A4	1:15,000

Co-ordinate system: British National Grid



2. Analysis of Survey Data

2.1 North Sands

Survey Date	Description of Changes Since Last Survey	Interpretation
<p>20th-21th Sep 2021</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 April 2021</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 chainage, covers dunes and has remained largely unchanged. The crest of the foredune has accreted 0.1m in level and is at the highest level recorded. The seaward face of this dune remains unchanged. The upper beach has eroded by up to 0.2m in level between chainage 70m and 90m. Between chainage 100m and 260m the beach has accreted, with the most significant accretion occurring between chainage 180m and 200m where an increase by 1.0m in level is observed. This is the highest level recorded at this chainage. The profile is at a high level across the dunes compared to previous surveys, particularly at the foredune. The upper and middle beach are at a relatively medium level compared to previous surveys, whilst the lower beach is at a high level compared to the range recorded from previous surveys</p> <p>At profile 1cHN2, the dunes show very little change. Whilst the toe and crest of the foreshore dune are the same, the face of the dune has eroded by 1.0m resulting in the steepening of the upper face. Erosion, up to 0.5m, between chainage 90m and 120m has resulted in the steepening of the upper the beach and the plateauing of the middle beach. The lower beach, seaward of chainage 170m, has eroded by up to 0.5m in level.</p> <p>Profile 1cHN2A was established in October 2011 and runs through the dunes close to North Sands. The dunes, between chainage 0m and 70m have remained stable, experiencing minor accretion and erosion limited to 0.1m. The upper beach has accreted by up to 0.2m between chainage 90m and 120m. The middle and lower beach has alternated between accretion and erosion. Overall, the profile shows a medium level compared with previously recorded surveys, except the face of the foredune</p>	<p>The dunes at North Sands have generally remained stable since the previous survey, whilst beach levels have predominantly eroded on the upper beach and lower beach and accreted across the middle beach.</p> <p>Longer term trends: The 2021 Full Measures survey is roughly in line with the longer term trends with a general stability in the middle and east of the survey area. A larger magnitude of change is observed to the west.</p>

Survey Date	Description of Changes Since Last Survey	Interpretation
	<p>which remains at its most landward position.</p> <p>At profile 1cHN3 the foredune has accreted by 0.1m in level on the seaward face and by 0.2m on the landward face, making it the largest it has been on record. The toe of the rear dune has been eroded by 0.2m. From chainage 50m to 150m, the upper and middle beach has alternated between accretion and erosion by up to 0.4m. There has been significant accretion on the lower beach by up to 0.8m from chainage 150m to 245m. The dunes are at a high level, whilst the rest of the beach profile is at a medium level compared to the range recorded from previous surveys.</p> <p>At profile 1cHN3A the dune face at 20m chainage has remained unchanged, with the toe of the dune experiencing an accretion of 0.3m. The upper beach has accreted slightly by 0.1m. The beach profile from chainage 65m to 110m has experienced little change. From chainage 110m, the lower beach has accreted by up to 1.0m. Overall the level is in the medium range of the previous profiles.</p> <p>At profile 1cHN4 there has been an erosion of sediment across the majority of the beach, with the levels dropping between chainage 60m and 140m by up to 0.35m exposing the rocky foreshore in this location, for which is remains exposed until the end of the section at chainage 220m. There has been a slight accretion in sediment between chainage 30m and 60m by 0.2m. Overall, the profile is at a low level compared to the range recorded from previous surveys.</p> <p>At profile 1cHN4a, there has been an accumulation of up to 0.7m of sediment on the upper beach between chainages 10m and 48m, covering up previously exposed rocks. There has been a similar accretion on a section of the middle beach between chainages 56m and 68m. Seaward of this point, there has been little change across the beach profile compared to previous surveys, with apparent minor changes in positions of rocks, although these are likely to be due to the survey techniques. Overall, the profile is at a medium level on the upper beach, and a low level on the middle and lower beach compared to the previous recorded surveys.</p>	
<p>September 20st 2021</p>	<p>Topographic Survey:</p> <p>North Sands is covered by an annual topographic survey. Data from the 2021 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 difference plot at North Sands shows alternating bands of erosion and accretion running parallel to the shoreline. More intense colour can be seen to the west of the pier suggesting a greater change in comparison to the paler colours to the east. The plot reflects the seasonal movement of sediment across the beach as sand bars. This is similar to the Autumn</p>

Survey Date	Description of Changes Since Last Survey	Interpretation
	<p>The GIS has also been used to calculate the differences between the Autumn 2020 and Autumn 2021 topographic surveys, as shown in Appendix B – Map 4, to identify areas of net erosion and accretion. Across the frontage there are alternating bands of erosion and accretion that run parallel to the shoreline. Erosion is focused predominantly on the upper and lower beach, with accretion occurring in the middle beach. The area of most significant erosion occurs at the western extent of the survey at the lower beach where the erosion is almost 2m.</p>	<p>2020 survey which saw the same pattern of movement.</p>

2.2 Middleton

Survey Date	Description of Changes Since Last Survey	Interpretation
19 th September 2021	<p>Beach Profiles:</p> <p>Middleton is covered by one beach profile line, 1cHC1, during the Full Measures 2020 survey (Appendix A). The survey report again notes that there was no access to the upper section of the profile. At the toe of the seawall, chainage 48m, there has been accretion by 0.65m. This accretion gradually reduced until chainage 85m, where for the next 20m there has been slight erosion of up to 0.2m. Accretion of the middle beach, between chainage 115m and 155m, by 0.25m and erosion of the lower beach, between 155m and 210m, by similar amounts has resulted in the steepening of the lower sections of the beach profile. Overall, the beach is at a medium level, with the exception between chainage 120m and 140m where it is at the highest level on record.</p>	<p>The beach profile showed an accumulation of material at the toe of the sea wall and on the middle beach. The lower beach has eroded.</p> <p>Longer term trends: The beach level at this location tends to fluctuate through the year, with the most variable area being adjacent to the sea wall where wave energy is reflected. There is a pattern of seasonal variation, with lower levels typically recorded in the spring, following the period of winter storms. Recovery tends to occur by the autumn.</p>
September 2021	<p>Topographic Survey:</p> <p>The frontage is covered by an annual topographic survey between Middleton Jetty and North Pier. Data from the 2021 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 groyne.</p> <p>The GIS has also been used to calculate the differences between the Autumn 2020 and Autumn 2021 topographic surveys, as shown in Appendix B – Map 4, to identify areas of net erosion and accretion. The survey shows that the upper to middle beach to the West has been eroded and the middle lower beach to the East has been accreted. The changes observed at Middleton beach over the year are modest at $\pm 0.75\text{m}$ and reflect the change seen in profile 1cHC1.</p>	

2.3 Hartlepool Bay

Survey Date	Description of Changes Since Last Survey	Interpretation
22 nd – 23 rd September 2021	<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 April 2021.</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. No significant change has occurred until 40m chainage, which is the toe of the sea defences, since 2014. The level of the beach against the structure is unchanged. There has been accretion of the upper beach between chainage 40m and 78m by up to 0.2m and a similar of accretion to the lower beach from chainage 80m onwards. The beach level is at a high level across the majority of the profile compared to previous recorded surveys.</p> <p>At profile 1cHS2, there has been accretion of 0.3m at the toe of the revetment structure (chainage 26m). The beach profile from 26m to 300m has accreted by up to 0.5m The accretion over this upper to middle beach is focused between two areas; chainage 55m to 90m and 110m to 200m. The lower beach has been eroded by 0.3m from chainage 200m to 330m, this is lowest the beach has been recorder over this stretch. The upper beach profile is generally at a high level, where lower beach is at the lowest level is some place.</p> <p>Profile 1cHS3 shows no changes over the defended part of the profile up to 24m chainage. The beach profile seaward of chainage 24m has accreted by 0.7m on the upper beach and 1m in the middle beach. The areas of the largest accretion correlate with the areas of accretion noted in profile 1cHS2. The profile of the lower beach has steepened significantly, with an erosion of 1.2m recorded at chainage 115m The beach profile is at a high level (the highest at points) compared to the range recorded from previous surveys with the exception of the steepening lower beach.</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 survey report notes that dense thorn bushes restricted the start of the section. The profile covers approximately 325m of dunes before the beach. The dune</p>	<p>The northern beach profiles generally show accretion across the upper-lower beach, with erosion and steepening of the lower beach. The southern profile show alternating sections of erosion and accretion, representing sand bar movement across the foreshore. The foredune at 320m chainage at profile 1cHS4 has remained unchanged in this survey however, since March 2009 it has an overall accretion of 3.0m.</p> <p>Longer term trends: The profiles have shown relative stability over 2021, 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>section has generally remained stable since the previous survey including the large foredune at 320m chainage that has neither eroded or accreted since the last survey. The upper beach profile from chainage 350m to 420m has accreted by up to 1.35m, switching to erosion between chainage 440m and 475m of up to 0.6m. This has resulted in a steepened middle beach. Accretion of the lower beach by up to 0.7m has created a small berm at chainage 480m.</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 2021 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 2020 and Autumn 2021 topographic surveys, as shown in Appendix B – Map 5, to identify areas of erosion and accretion. The changes recorded over 2021 show the north of the bay has generally undergone little change, with low magnitude of erosion (<0.5m) dominating the lower beach towards the promontory. The changes to the south of the bay are more defined, with bands of alternating erosion and accretion obvious. The majority of the bay has experienced accretion at the upper and lower beach and erosion in the middle beach. The most intense change has occurred to the section of beach fronting the Seaton Carew golf club, just north of North Gare Pier, where a loss in the magnitude of 1.5m is seen in the middle beach and a similar gain at the upper beach. Overall, 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 style="text-align: center;">24th September 2021</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 2021 Full Measures survey have been used to create a DGM (Appendix B – Map 3) using GIS software. The beach contours recorded in 2021 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 shoreline 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 2020 and Autumn 2021 topographic surveys, as shown in Appendix B – Map 6, to identify areas of net erosion and accretion. The difference plot shows that there has been accretion (in the order of 1.0m) along the southern face of the North Gare breakwater. To the north of North Gare Sands, a band of erosion is observed along the upper and lower beach. The south of the bay is dominated by accretion, in the order of 0.75m, with three distinct shoreline parallel bands evident. An area of intense erosion is observed along the confluence between the Seaton on Tees Channel and the Teesmouth.</p>	<p>The pattern in 2021 generally differs to that seen in 2020. The area is largely dominated by accretion across the north and south bay, interrupted with local areas of erosion. The changes are low in magnitude in comparison to the previous survey highlighted by the lack of intensity in the colours.</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 Hartlepool Bay, dense thorn bushes restricted the start of profile 1cHS4

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 erosion on the upper and lower beach across the bay, with accretion across the middle beach.
- At Middleton, the beach profile shows an accretion at the toe of the sea wall and on the middle beach, with a decrease across the rest of the profile since 2021. The difference plot shows accretion dominating the middle lower beach to the east and erosion dominating the upper to middle beach to the west.
- Profiles in the north of Hartlepool Bay generally show little change, with low magnitude of erosion (<0.5m) dominating the lower beach towards the promontory. bay The changes to the south of the bay are more defined, with bands of alternating erosion and accretion obvious. The majority of the bay has experienced accretion at the upper and lower beach and erosion in the middle beach. The most intense change has occurred to the section of beach fronting the Seaton Carew golf club, just north of North Gare Pier, where a loss in the magnitude of 1.5m is seen in the middle beach and a similar gain at the upper beach.
- The topographic plot at North Gare shows the area has generally been dominated by accretion, although at a low magnitude. There are areas of erosion at the upper beach to the north and at the mouth of the Tees.
- 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: 21/09/2021 Inspector: AG

Wind Sea State:

Low Tide:

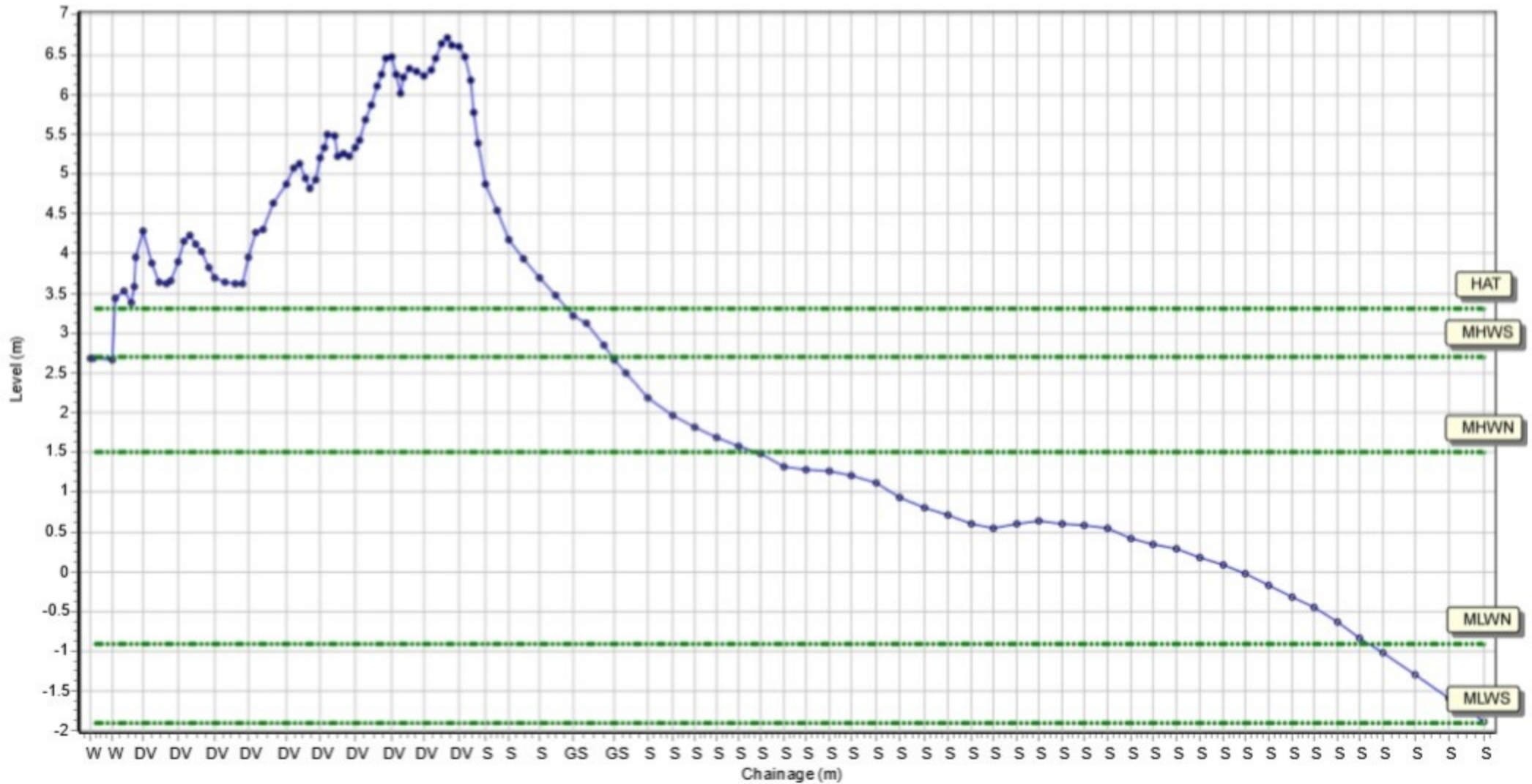
Low Tide Time:

Visibility:

Rain:

Summary: 2021 Full Measures Topo Survey

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



Beach Profile

Location: 1cHN2

Date: 21/09/2021

Inspector: AG

Low Tide:

Low Tide Time:

Wind

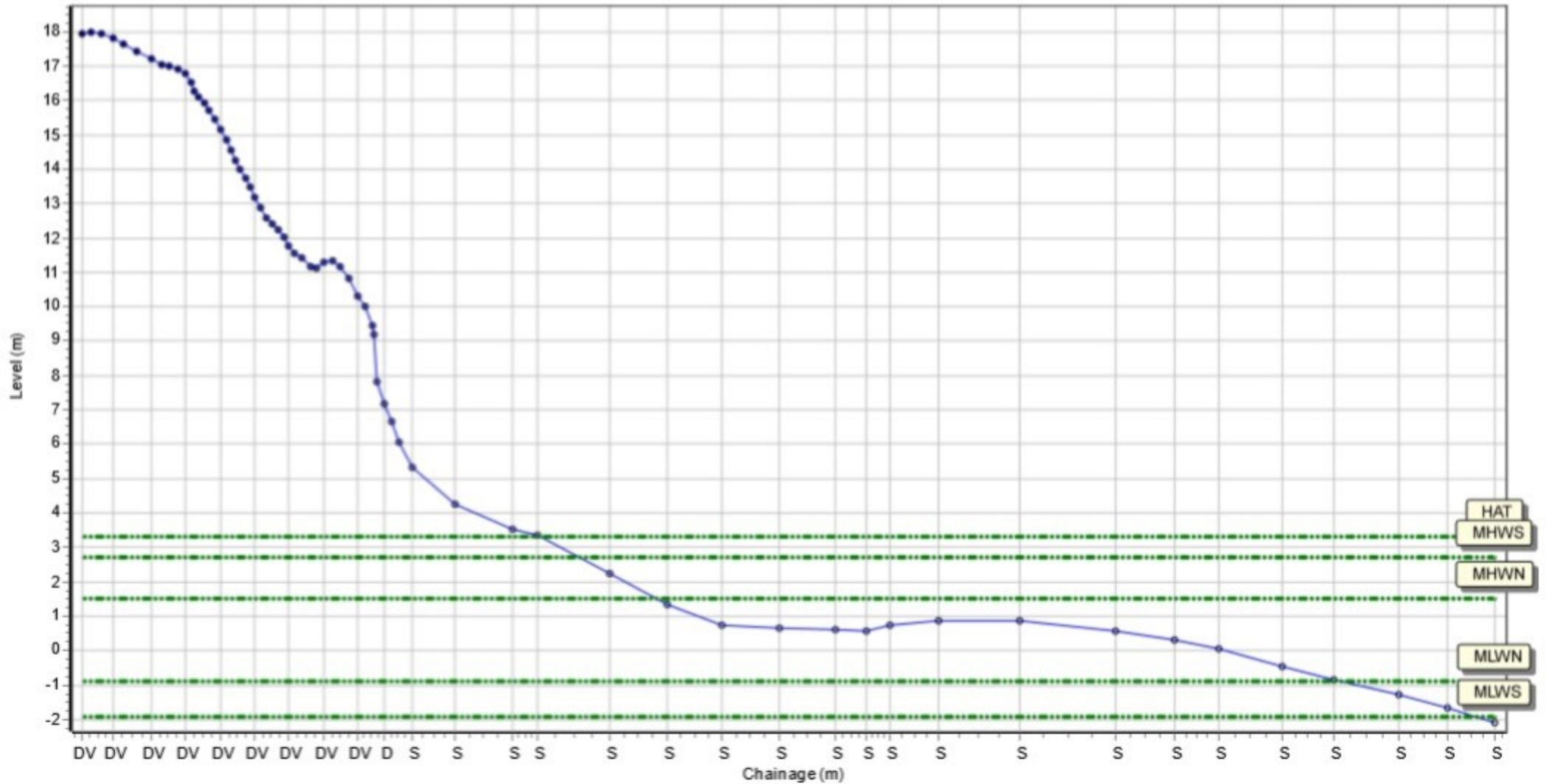
Sea State:

Visibility:

Rain:

Summary: 2021 Full Measures Topo Survey

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



Beach Profile

Location: 1cHN2A

Date: 21/09/2021

Inspector: AG

Low Tide:

Low Tide Time:

Wind

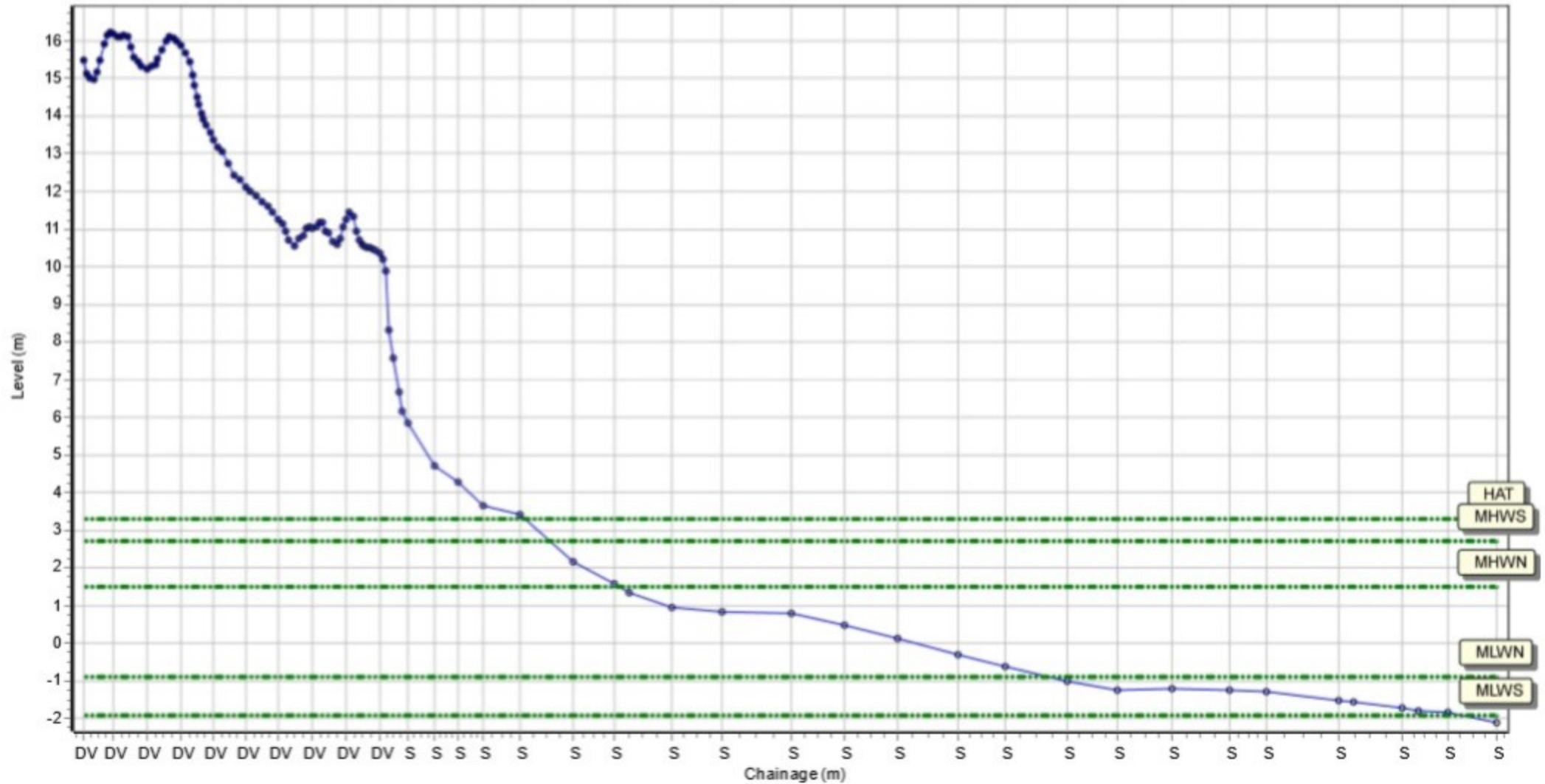
Sea State:

Visibility:

Rain:

Summary: 2021 Full Measures Topo Survey

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



Beach Profile

Location: 1cHN3

Date: 21/09/2021 Inspector: AG

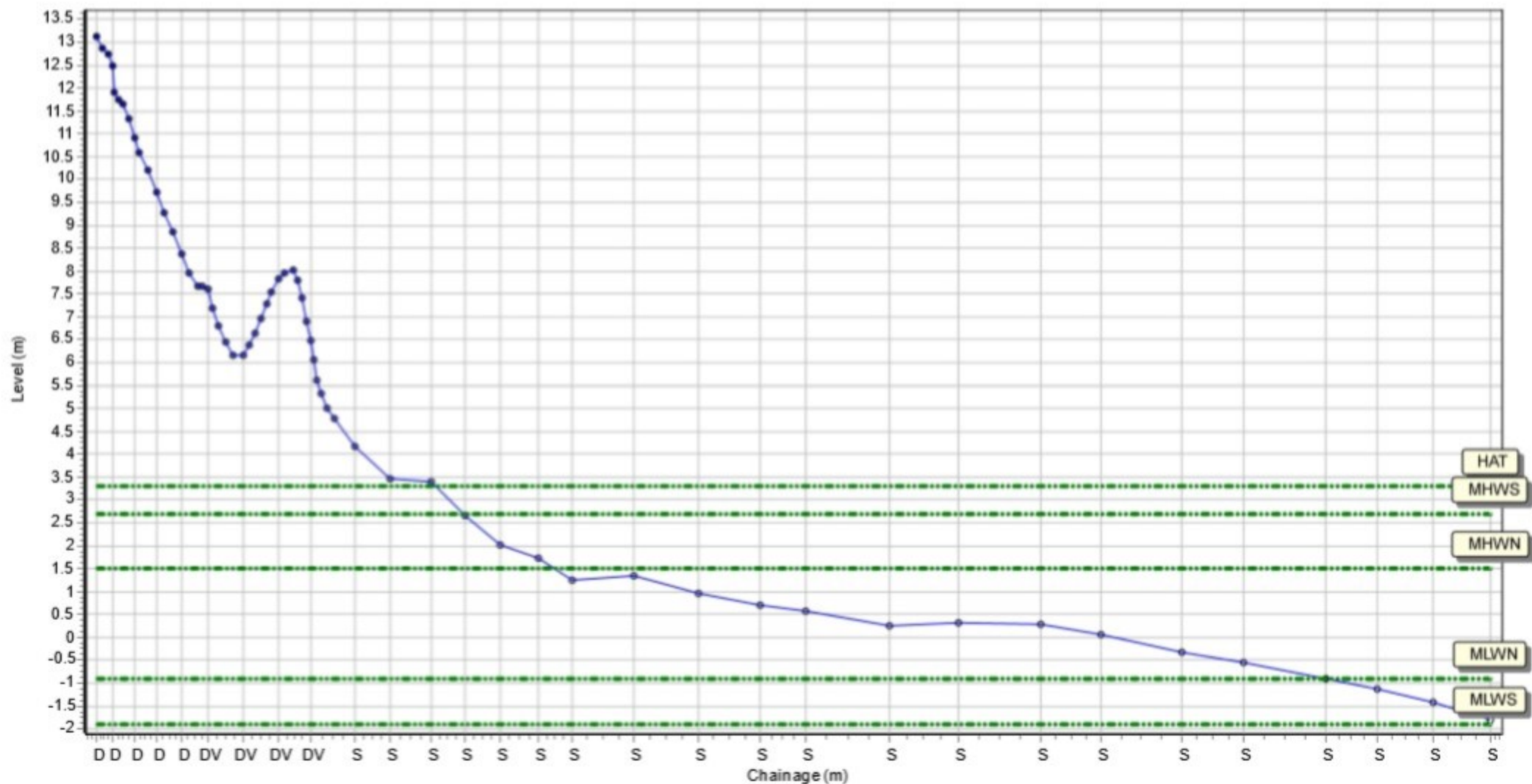
Low Tide: Low Tide Time:

Wind Sea State:

Visibility: Rain:

Summary: 2021 Full Measures Topo Survey

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



Beach Profile

Location: 1cHN3A

Date: 21/09/2021

Inspector: AG

Low Tide:

Low Tide Time:

Wind

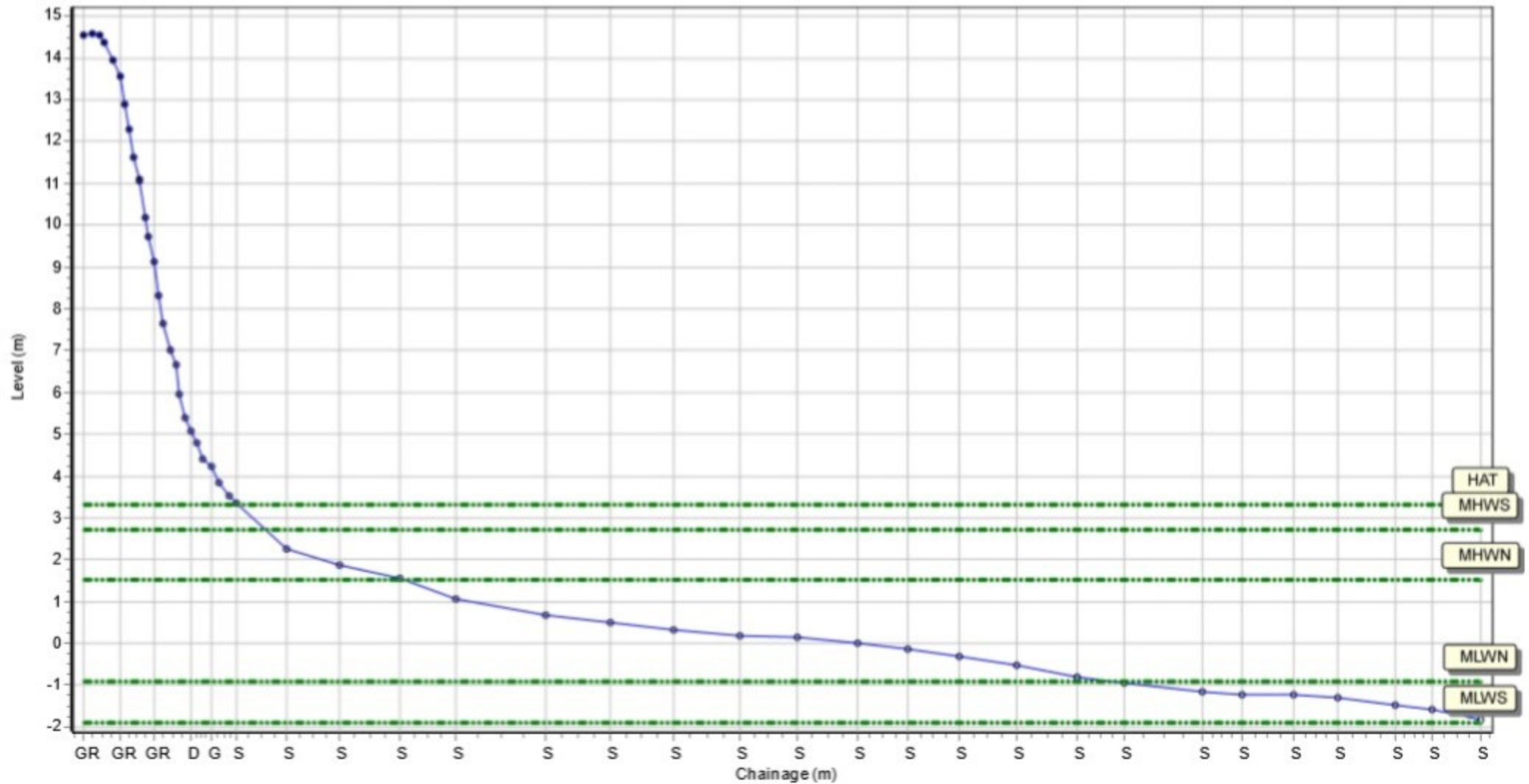
Sea State:

Visibility:

Rain:

Summary: 2021 Full Measures Topo Survey

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



Beach Profile

Location: 1cHN4

Date: 21/09/2021

Inspector: AG

Low Tide:

Low Tide Time:

Wind

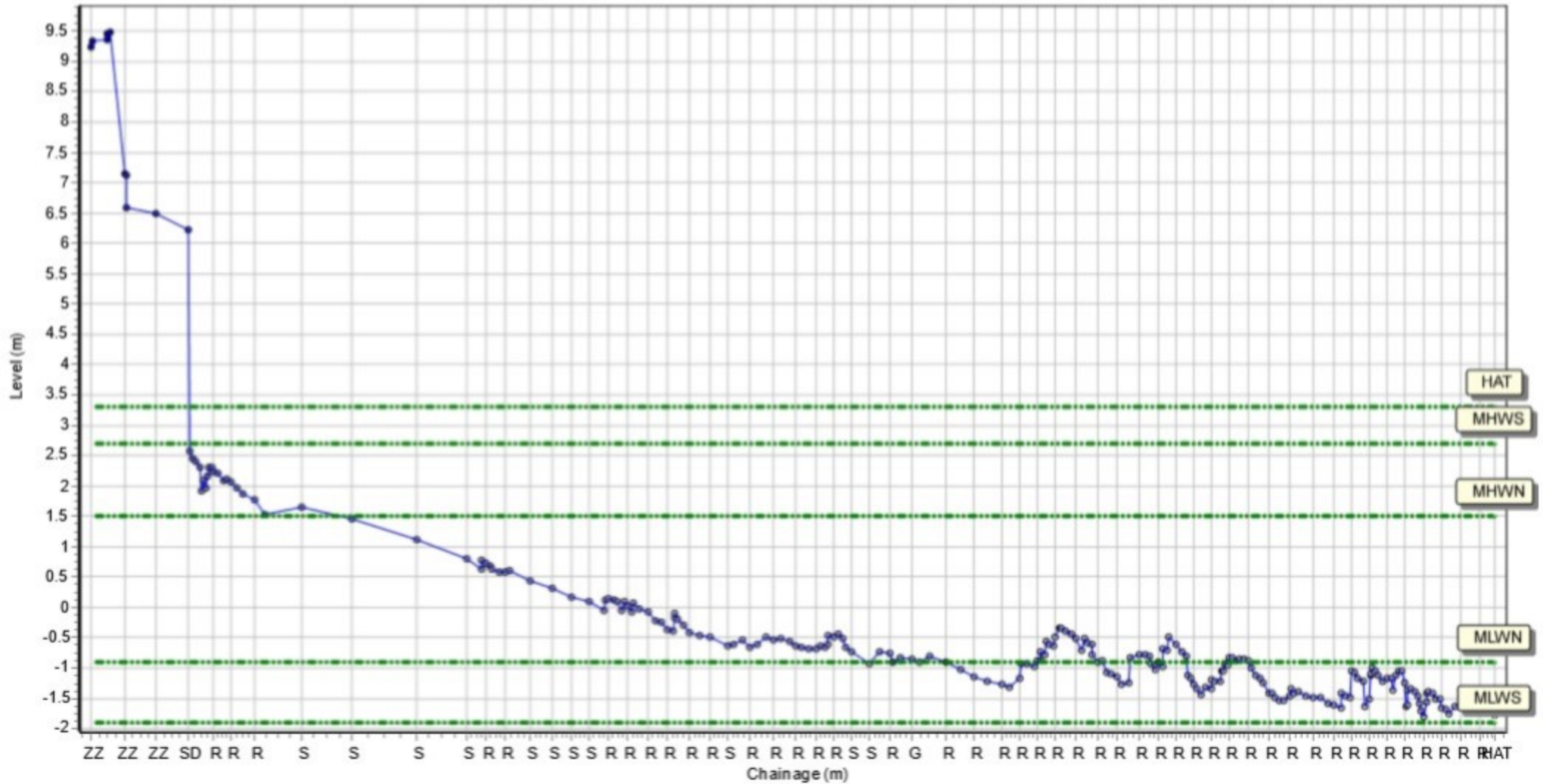
Sea State:

Visibility:

Rain:

Summary: 2021 Full Measures Topo Survey

Easting: 451997.114 Northing: 534616.627 Profile Bearing: 25 ° from North



Beach Profile

Location: 1cHN4A

Date: 21/09/2021

Inspector: AG

Low Tide:

Low Tide Time:

Wind

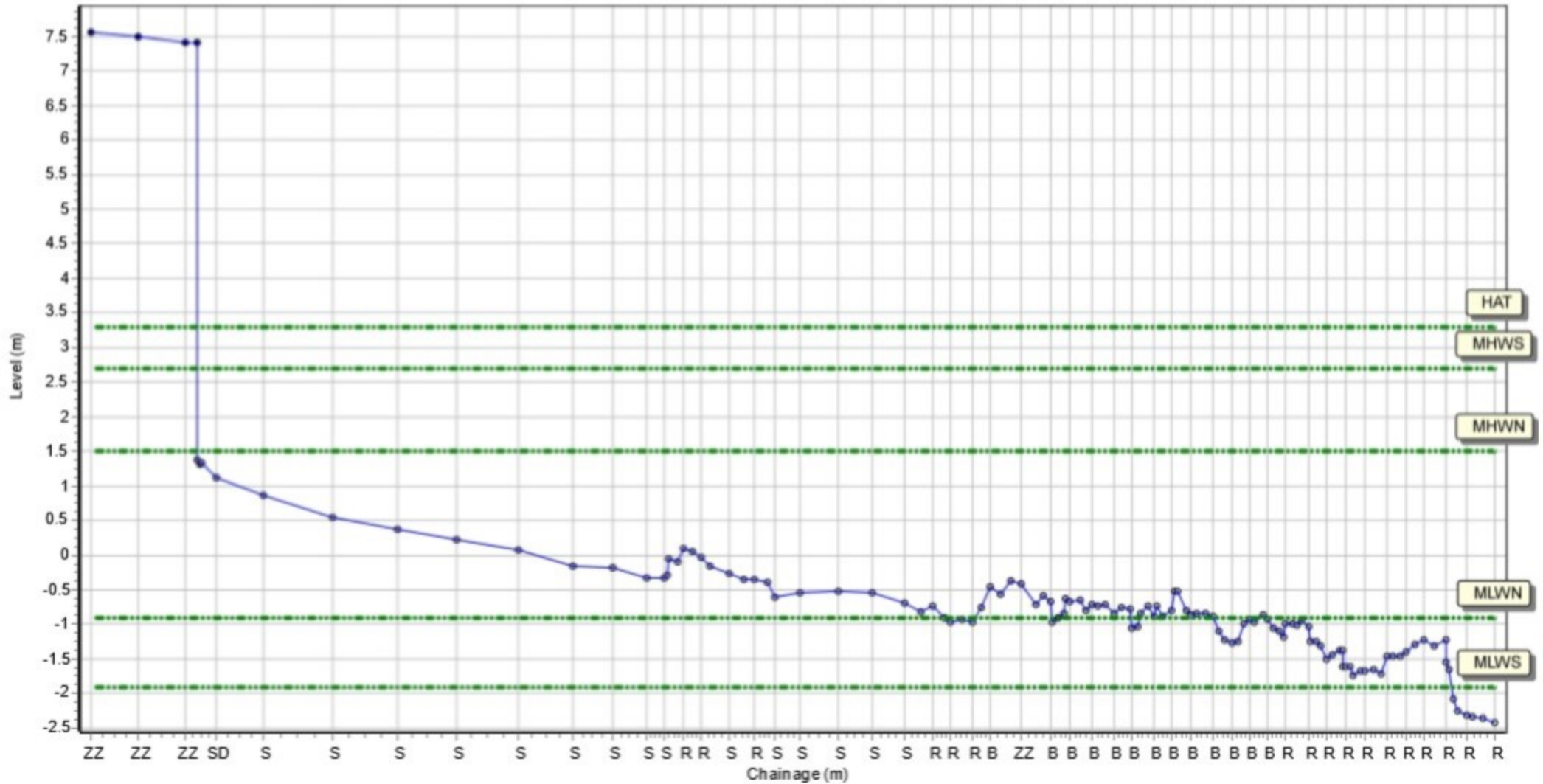
Sea State:

Visibility:

Rain:

Summary: 2021 Full Measures Topo Survey

Easting: 452610.565 Northing: 534321.038 Profile Bearing: 23 ° from North



Beach Profile

Location: 1cHC1

Date: 19/09/2021

Inspector: AG

Low Tide:

Low Tide Time:

Wind

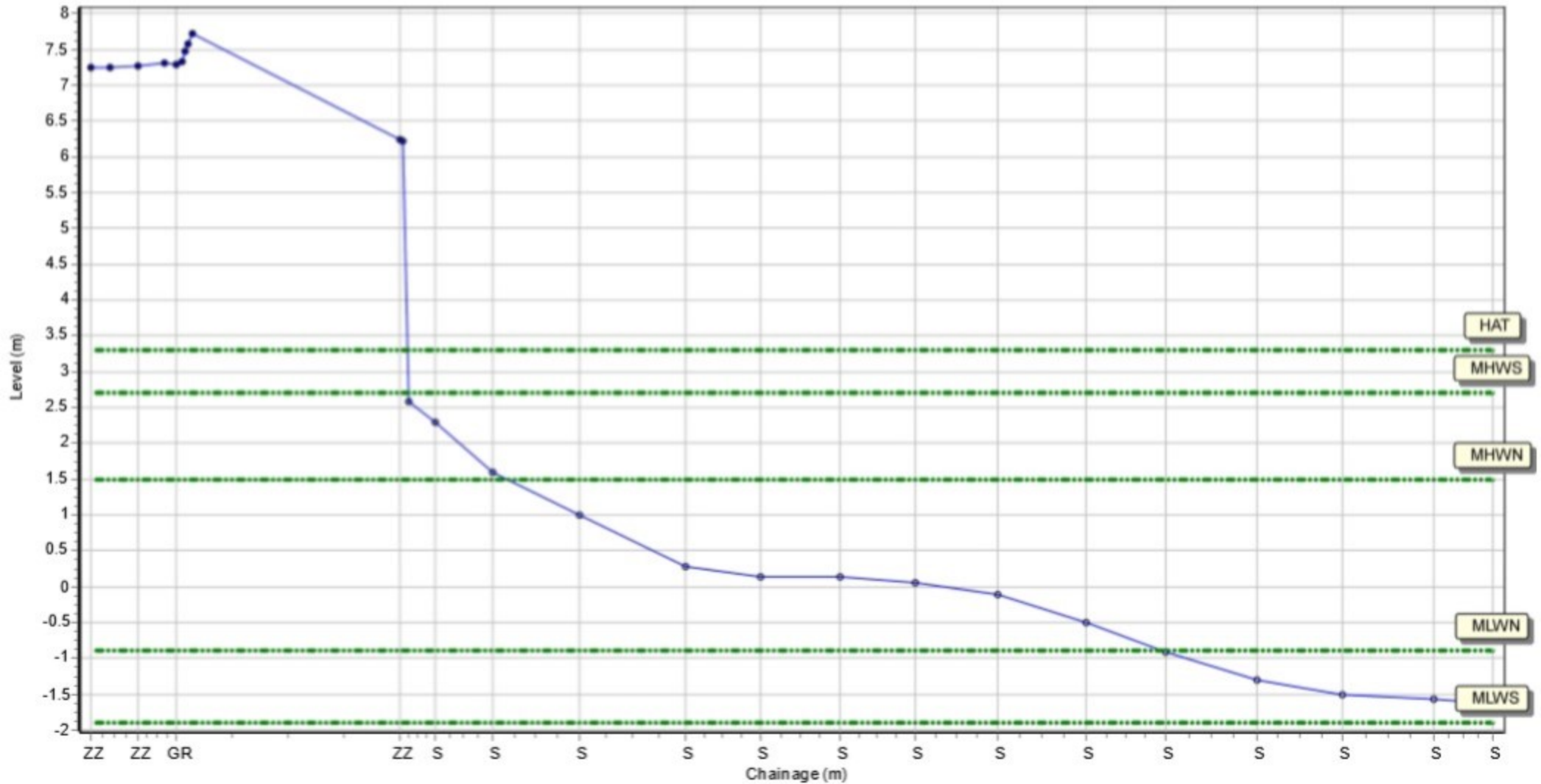
Sea State:

Visibility:

Rain:

Summary: 2021 Full Measures Topo Survey

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



Beach Profile

Location: 1cHS1

Date: 23/09/2021 Inspector: AG

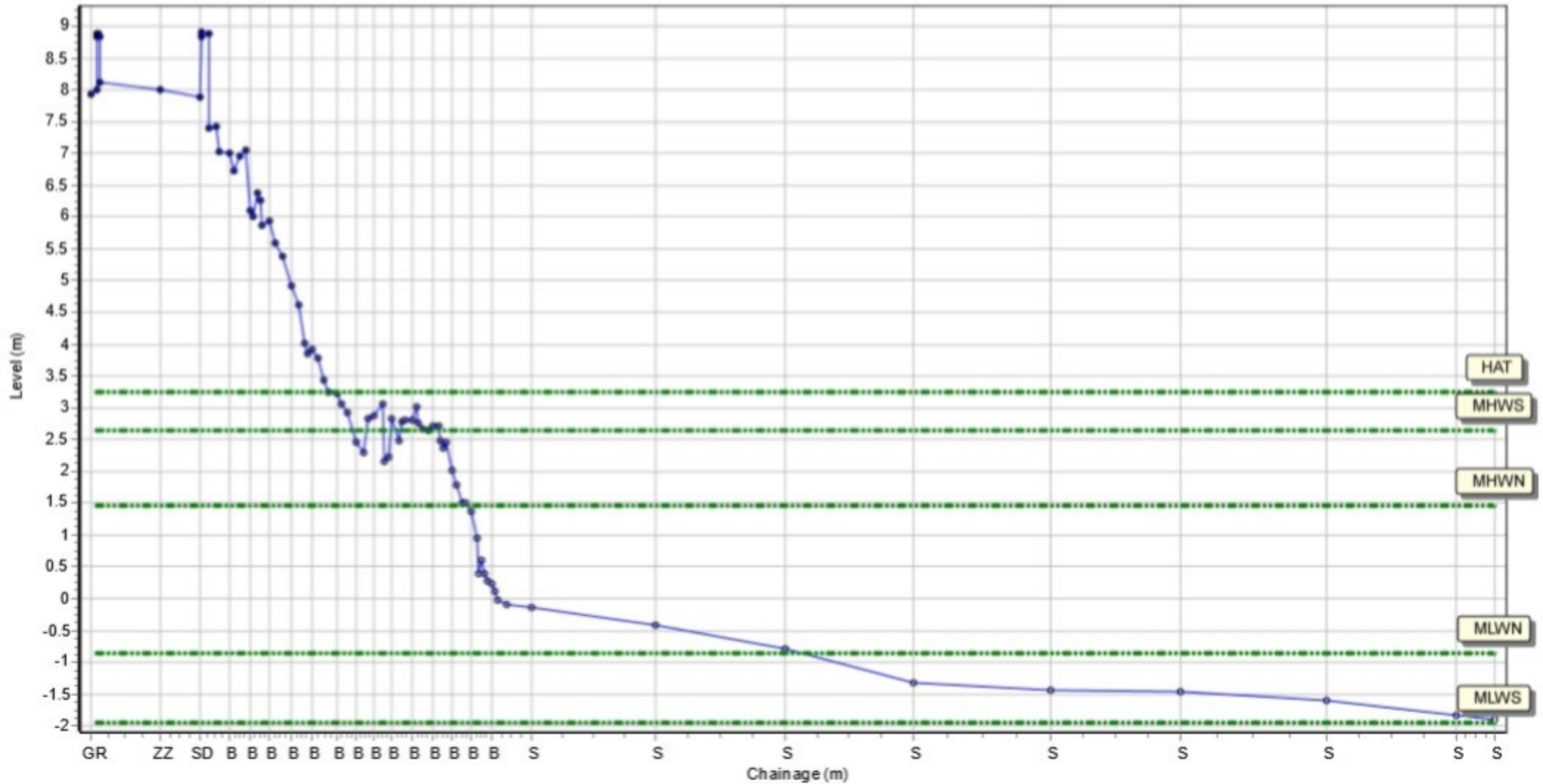
Low Tide: Low Tide Time:

Wind Sea State:

Visibility: Rain:

Summary: 2021 Full Measures Topo Survey

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



Beach Profile

Location: 1cHS2

Date: 23/09/2021 Inspector: AG

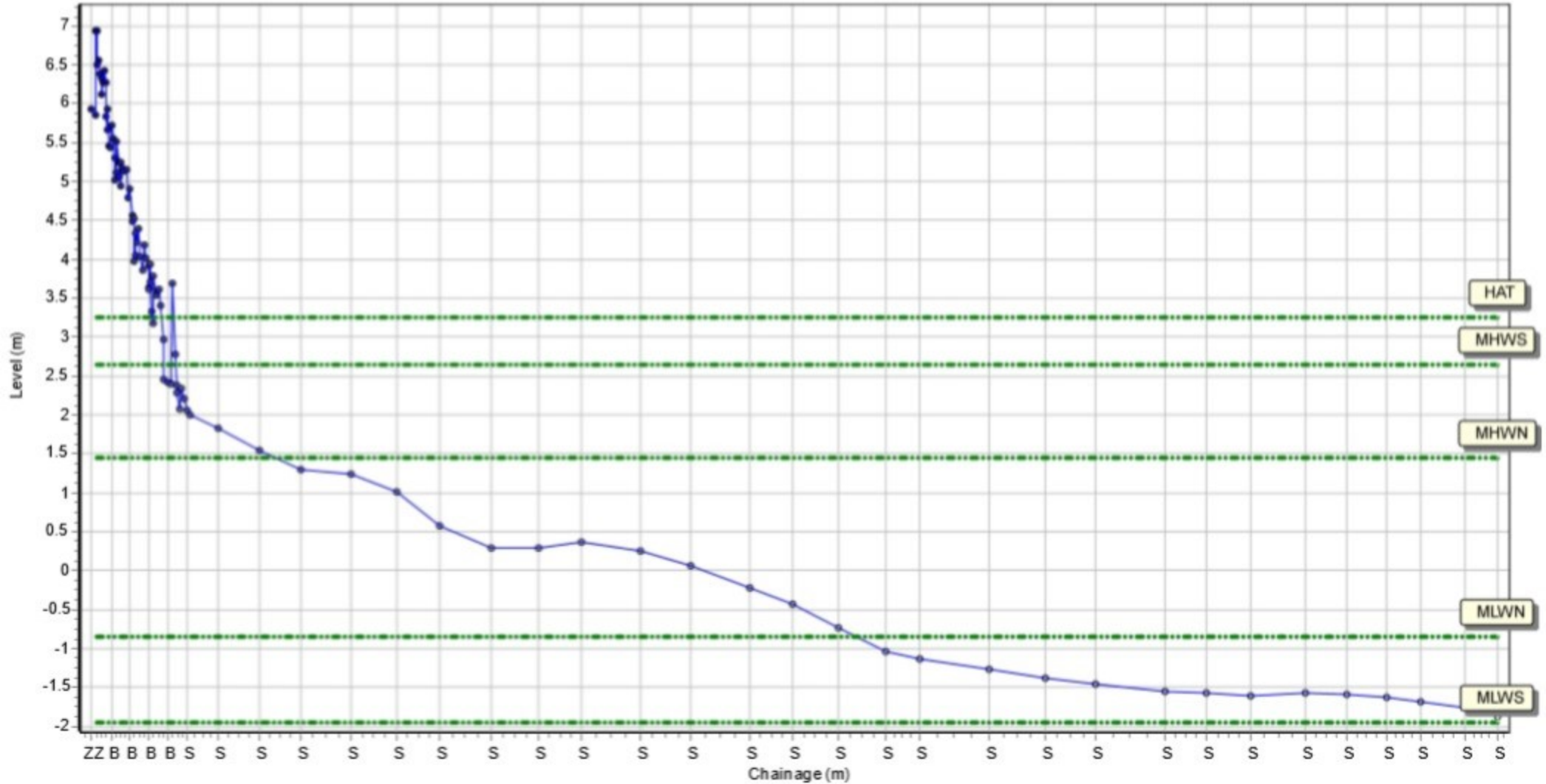
Low Tide: Low Tide Time:

Wind Sea State:

Visibility: Rain:

Summary: 2021 Full Measures Topo Survey

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



Beach Profile

Location: 1cHS3

Date: 23/09/2021

Inspector: AG

Low Tide:

Low Tide Time:

Wind

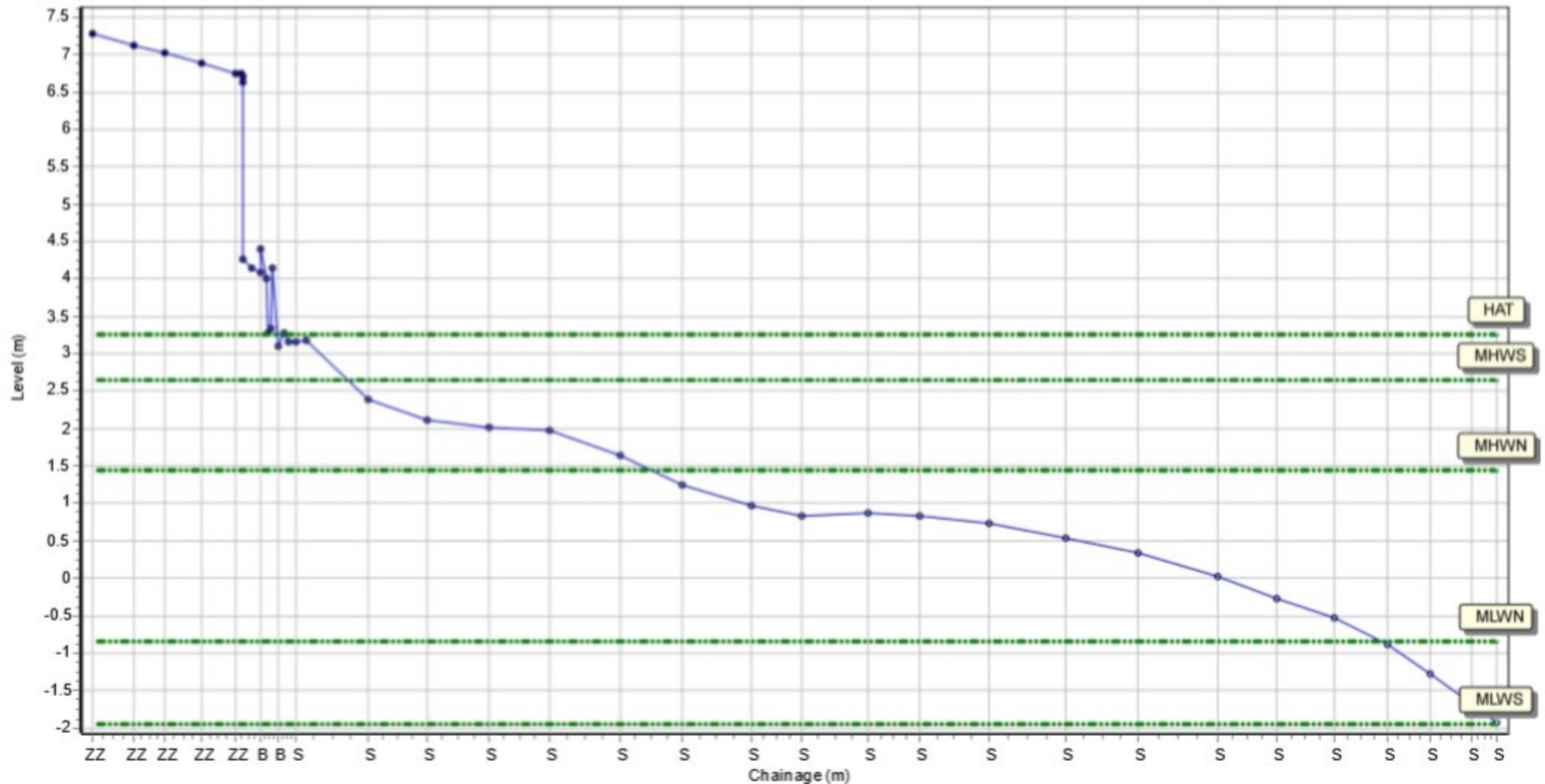
Sea State:

Visibility:

Rain:

Summary: 2021 Full Measures Topo Survey

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



Beach Profile

Location: 1cHS4

Date: 23/09/2021

Inspector: AG

Low Tide:

Low Tide Time:

Wind

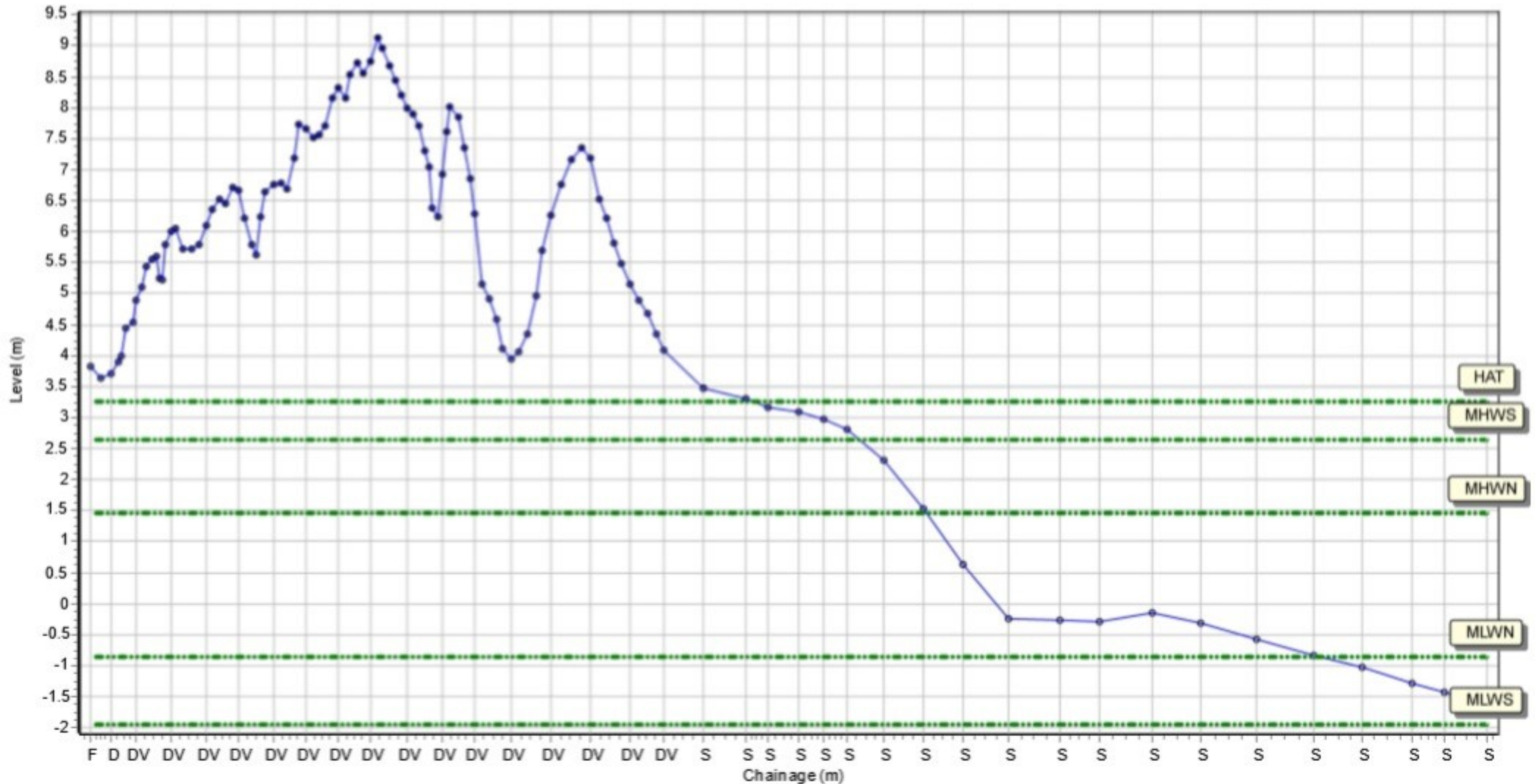
Sea State:

Visibility:

Rain:

Summary: 2021 Full Measures Topo Survey

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

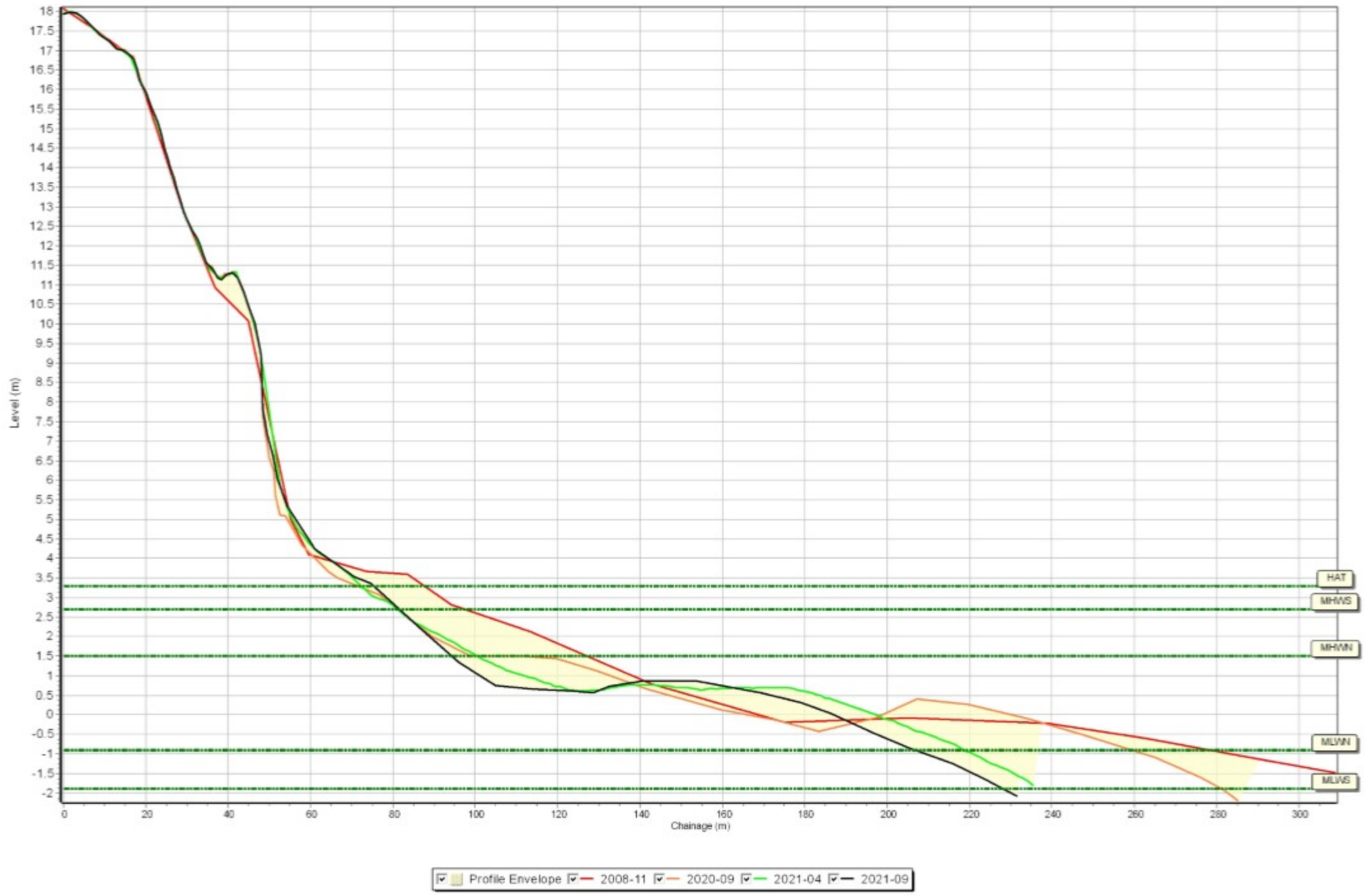


Profiles: 1cHN1



Profile Envelope 2008-11 2020-09 2021-04 2021-09

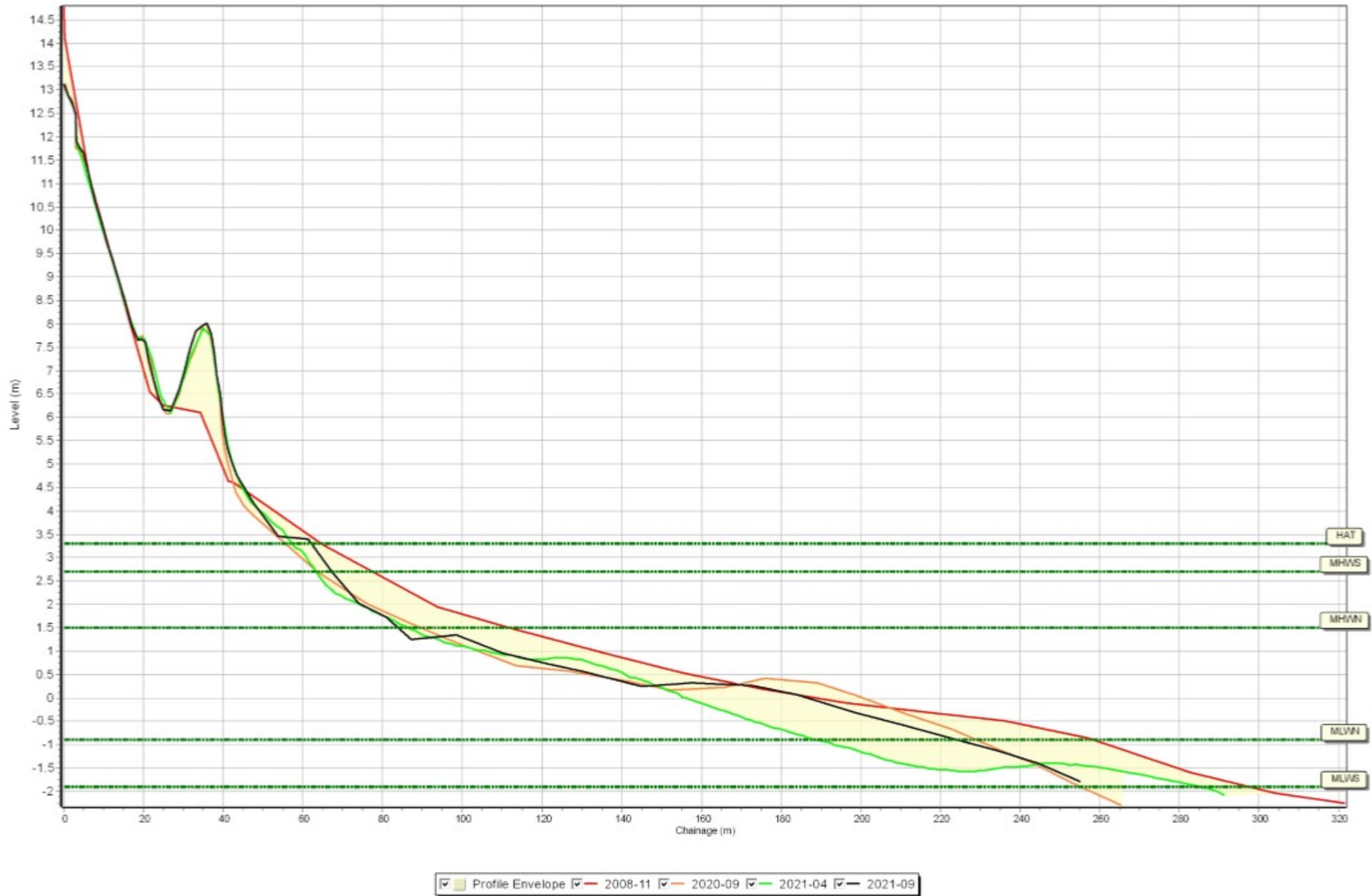
Profiles: 1cHN2



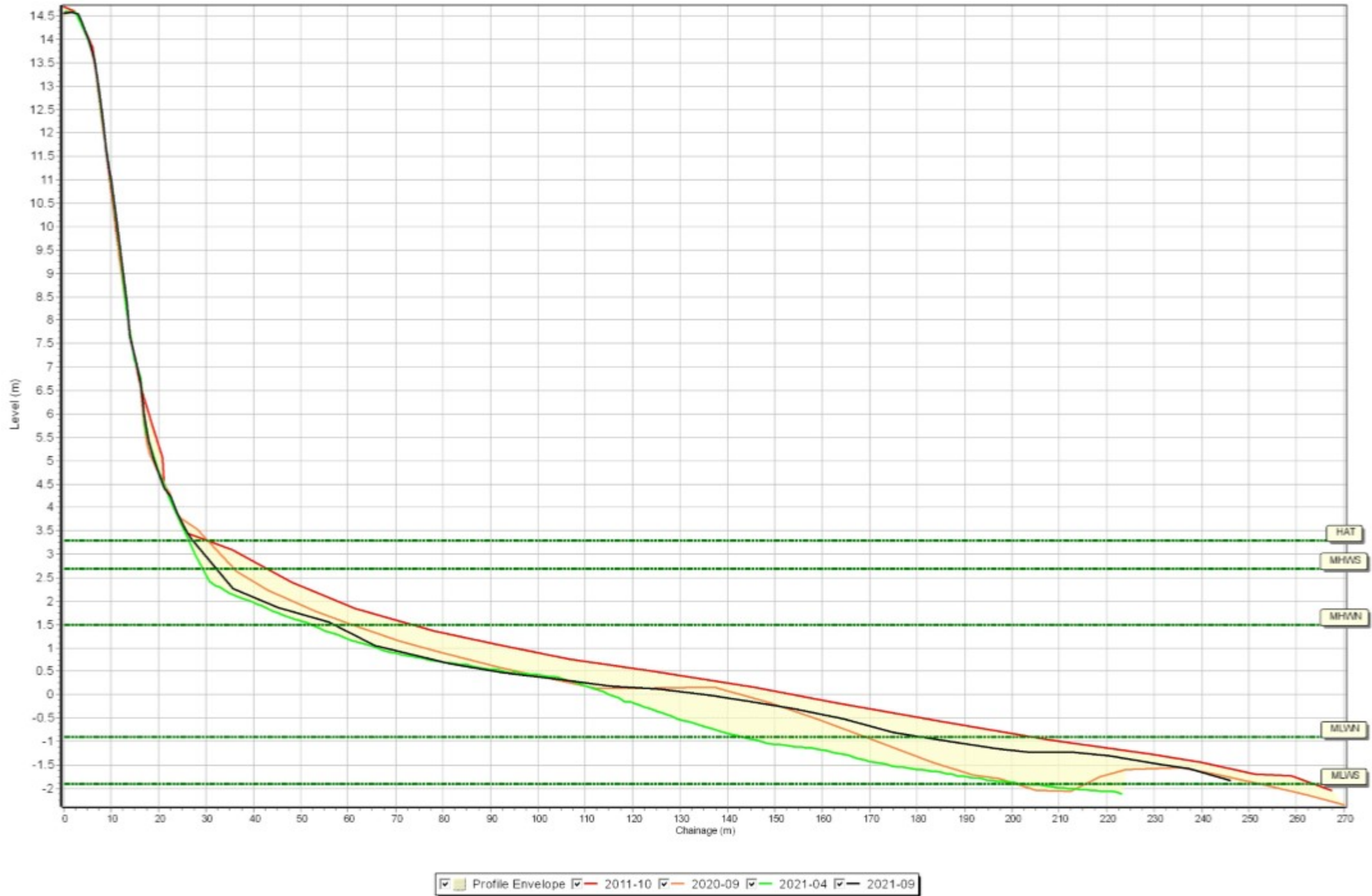
Profiles: 1cHN2A



Profiles: 1cHN3



Profiles: 1cHN3A



Profiles: 1cHN4

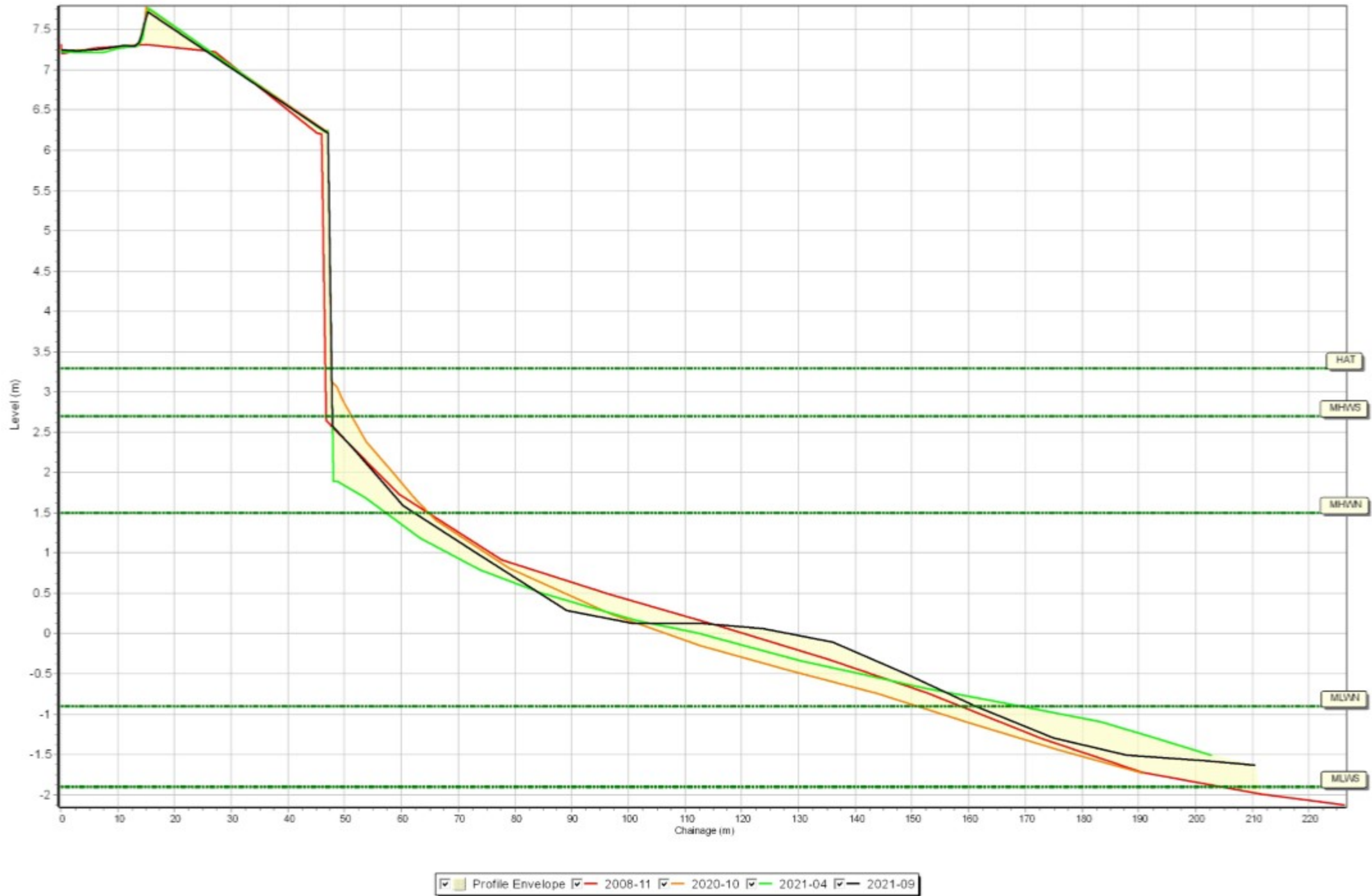


Profiles: 1cHN4A

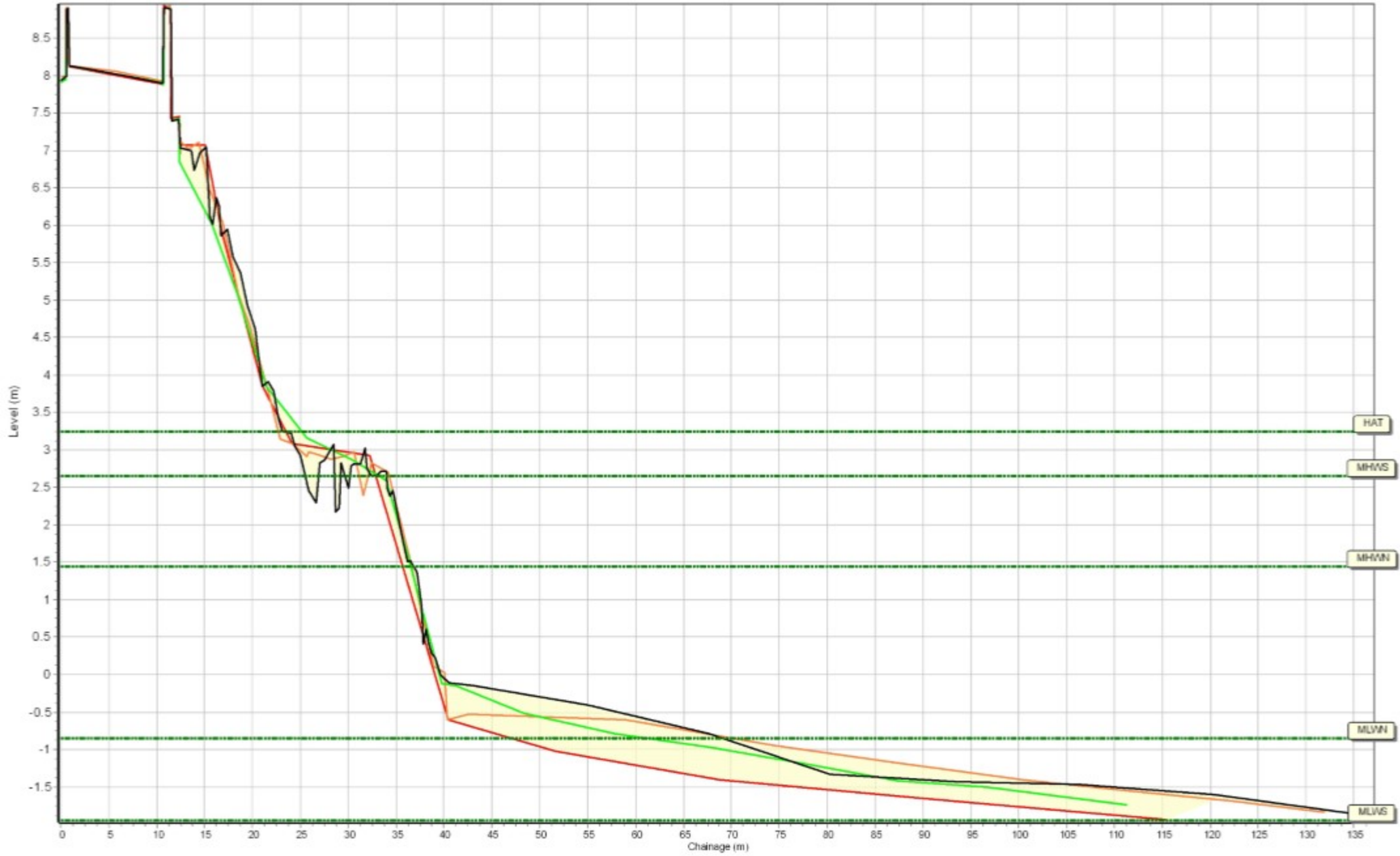


Profile Envelope 2011-10 2020-09 2021-04 2021-09

Profiles: 1cHC1

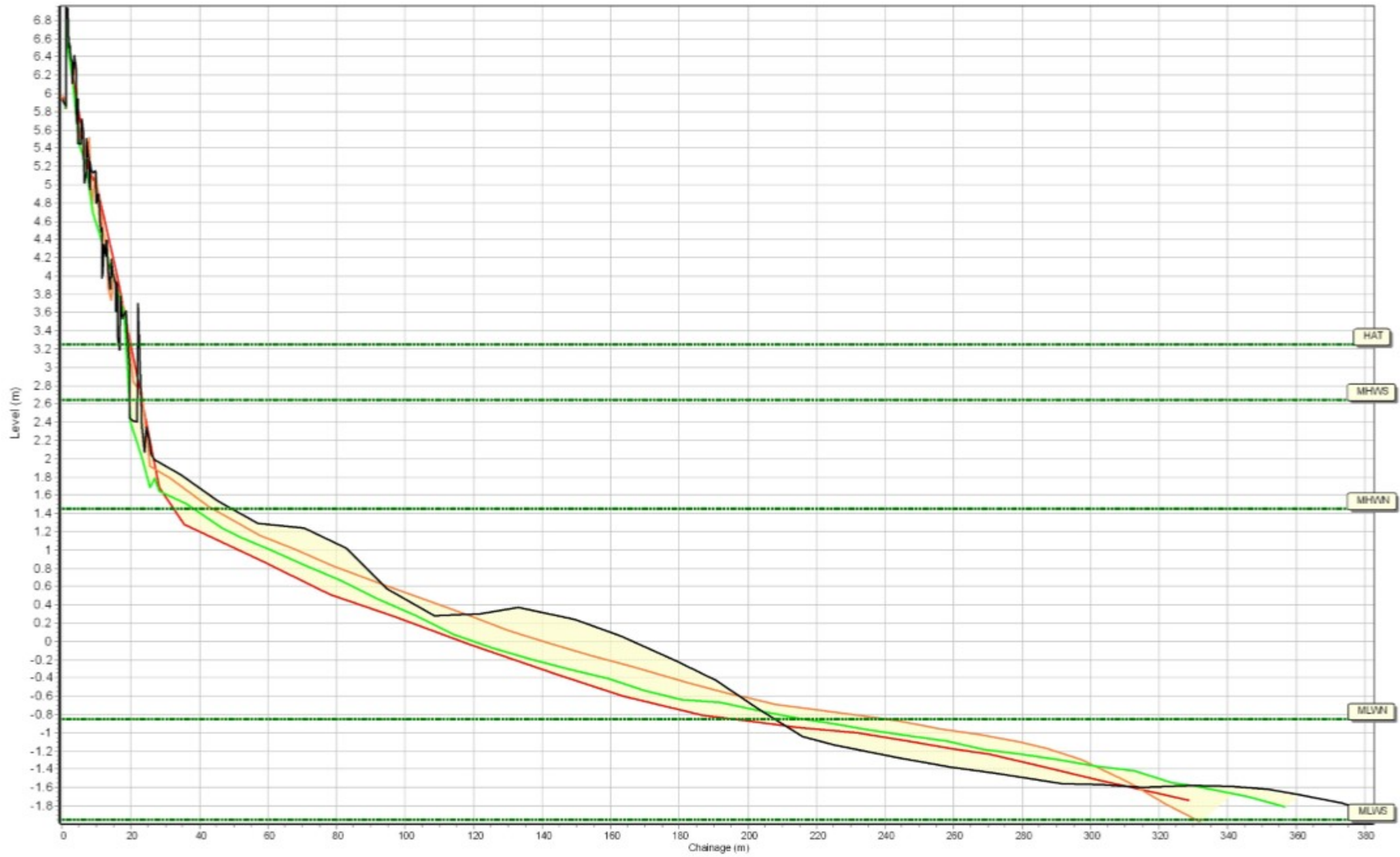


Profiles: 1cHS1



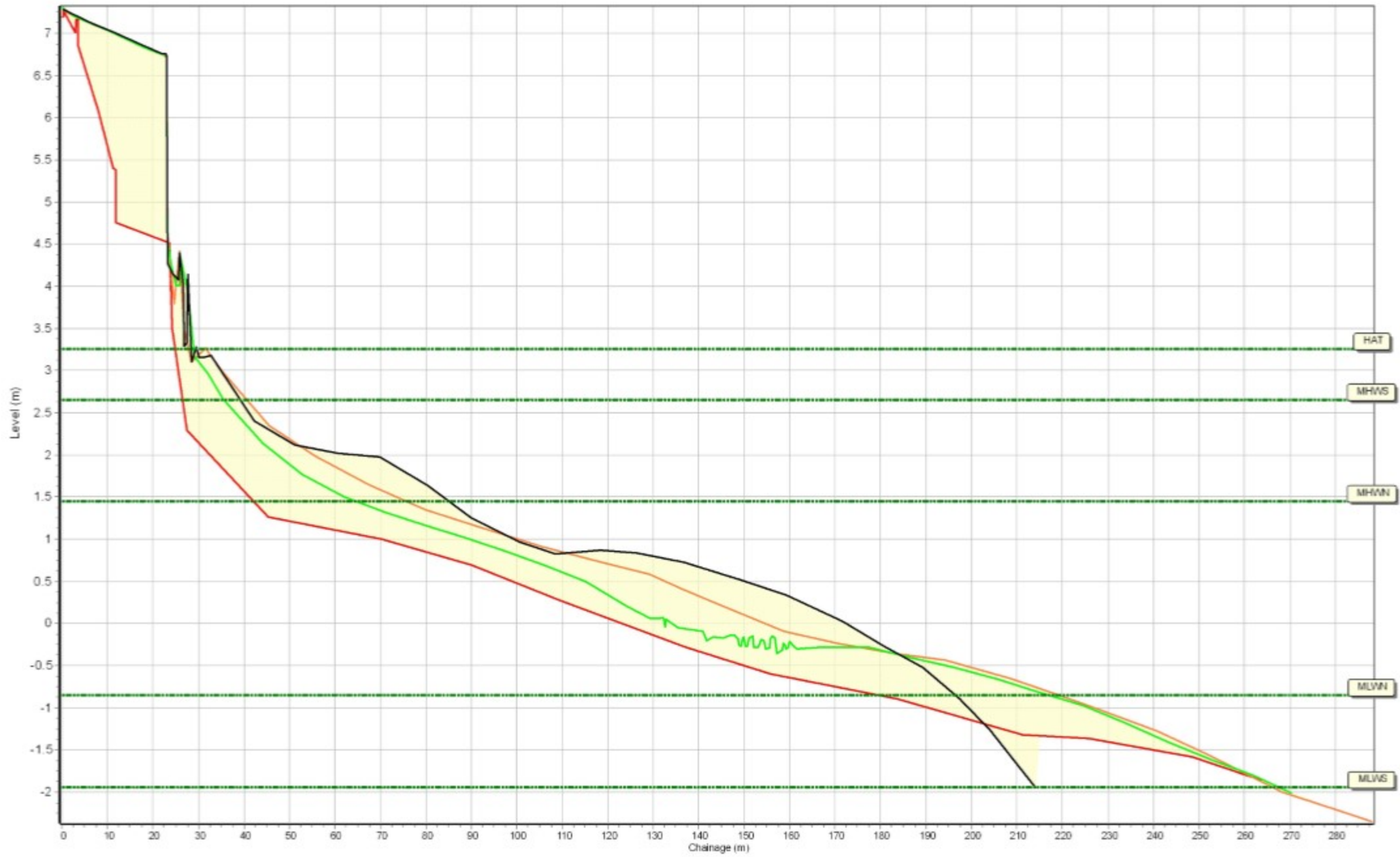
Profile Envelope 2009-03 2020-10 2021-04 2021-09

Profiles: 1cHS2



Profile Envelope 2009-03 2020-10 2021-04 2021-09

Profiles: 1cHS3



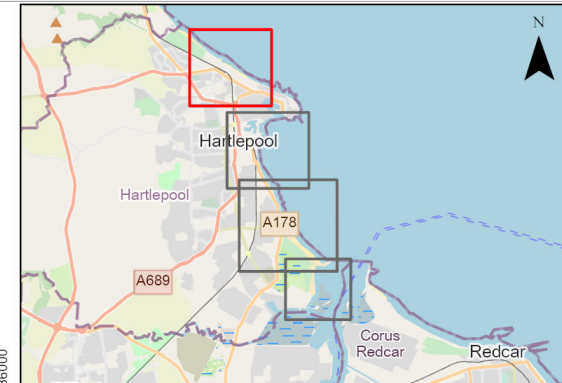
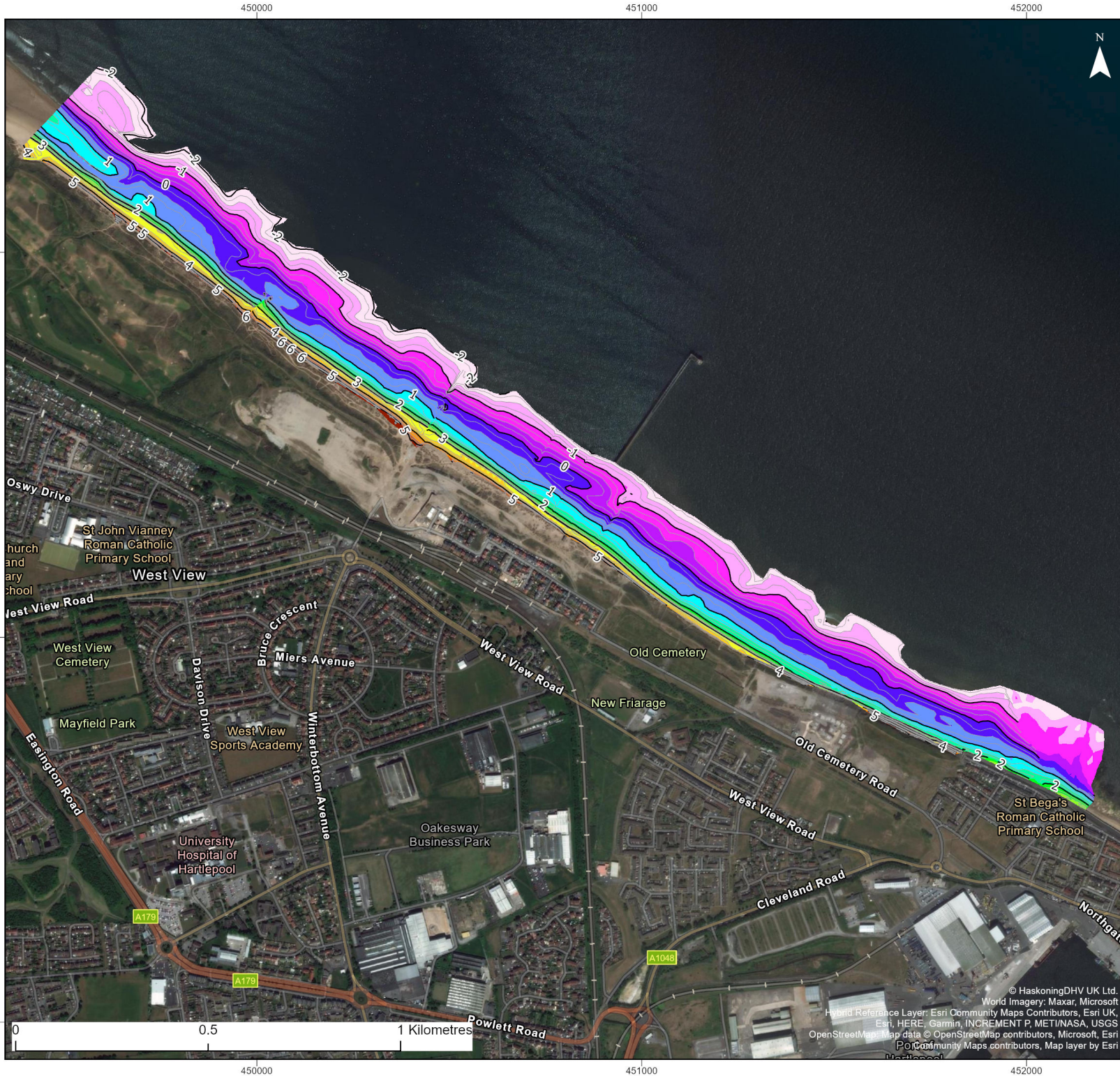
Profile Envelope 2009-03 2020-10 2021-04 2021-09

Profiles: 1cHS4

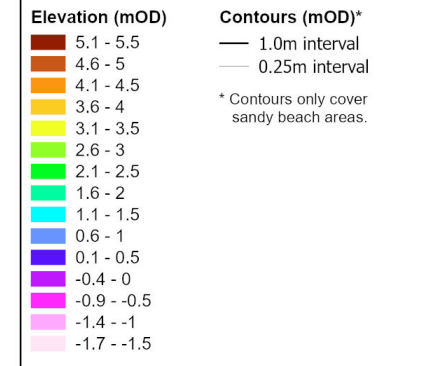


Profile Envelope 2009-03 2020-10 2021-04 2021-09

Appendix B
Topographic Survey



TOPOGRAPHIC SURVEY (September 2021)



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

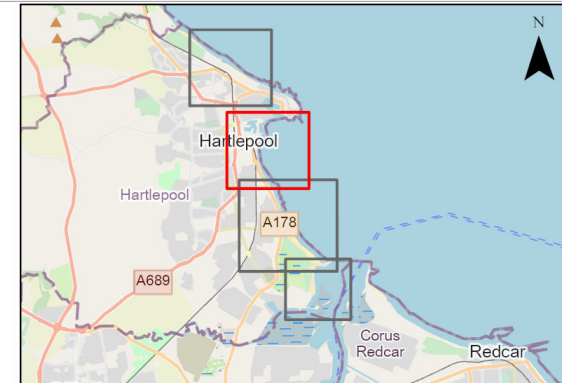
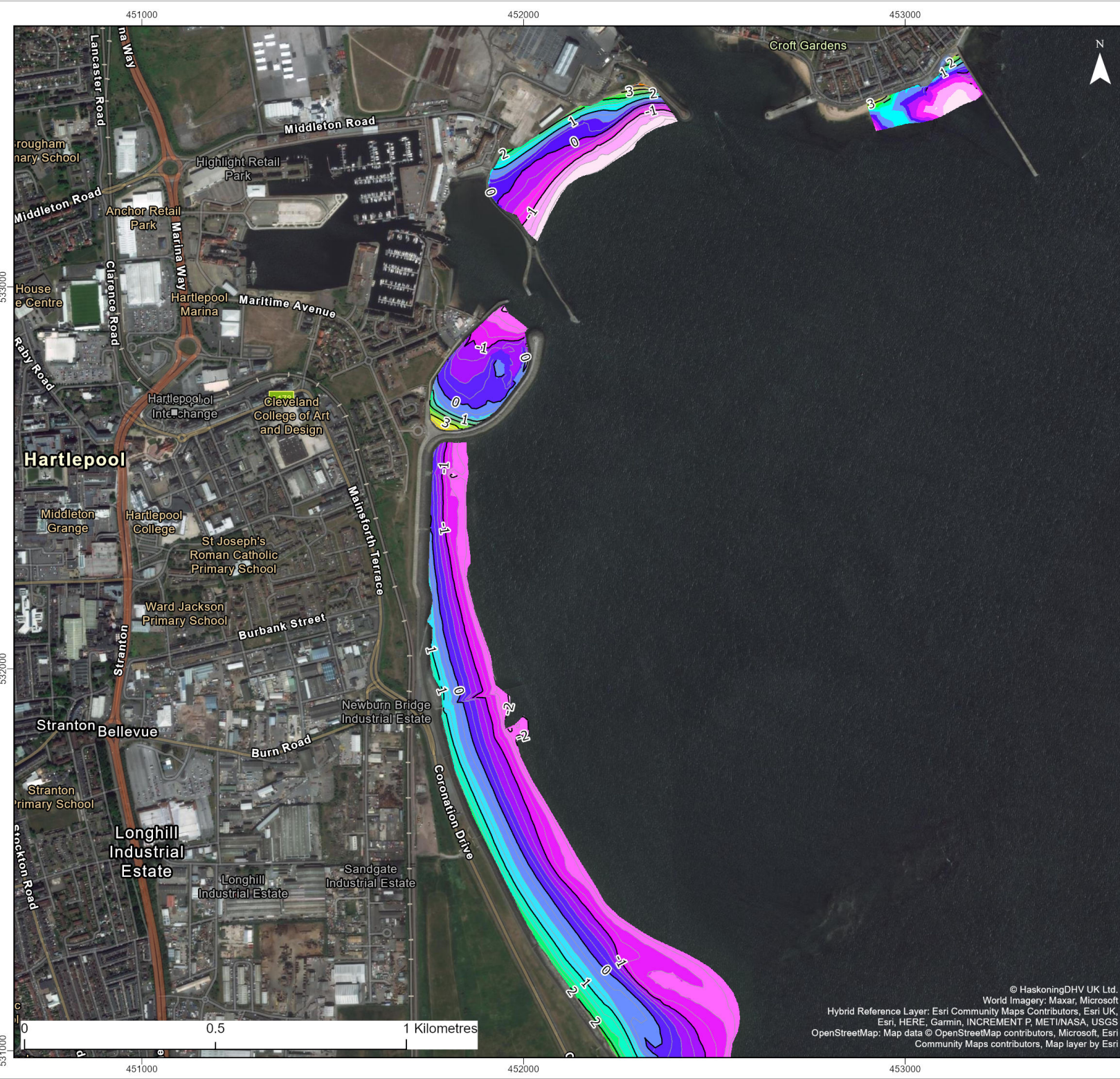
Appendix B - Map 1
NORTH SANDS
Hartlepool Borough Council Frontage

Report: Analytical Report
 'Full Measures' Survey 2021

Revision:	Date:	Drawn:	Checked:	Size:	Scale:
0	28/10/2021	TC	NJC	A3	1:10,000

Co-ordinate system: British National Grid

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 Hybrid Reference Layer: Esri Community Maps Contributors, Esri UK,
 Esri, HERE, Garmin, INCREMENT P, METI/NASA, USGS
 OpenStreetMap contributors, OpenStreetMap contributors, Microsoft, Esri
 PO Community Maps contributors, Map layer by Esri



TOPOGRAPHIC SURVEY (September 2021)

Elevation (mOD)	Contours (mOD)*
5.1 - 5.5	— 1.0m interval
4.6 - 5	— 0.25m interval
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	
0.6 - 1	
0.1 - 0.5	
-0.4 - 0	
-0.9 - -0.5	
-1.4 - -1	
-1.7 - -1.5	

* Contours only cover sandy beach areas.

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

Title:

Appendix B - Map 2

MIDDLETON AND HARTLEPOOL BAY (NORTH)

Hartlepool Borough Council Frontage

Report:

Analytical Report
'Full Measures' Survey 2021

Revision:	Date:	Drawn:	Checked:	Size:	Scale:
0	28/10/2021	TC	NJC	A3	1:10,000

Co-ordinate system: British National Grid

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Hybrid Reference Layer: Esri Community Maps Contributors, Esri UK,
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OpenStreetMap: Map data © OpenStreetMap contributors, Microsoft, Esri
Community Maps contributors, Map layer by Esri



452000

453000

454000



531000

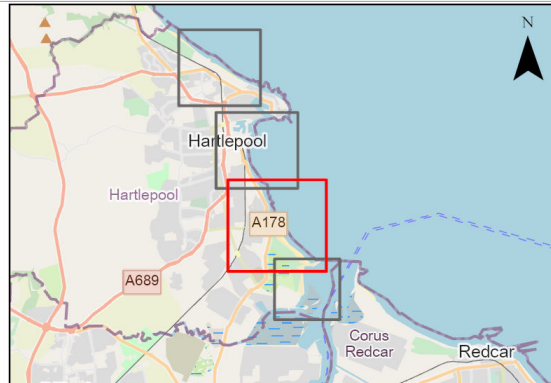
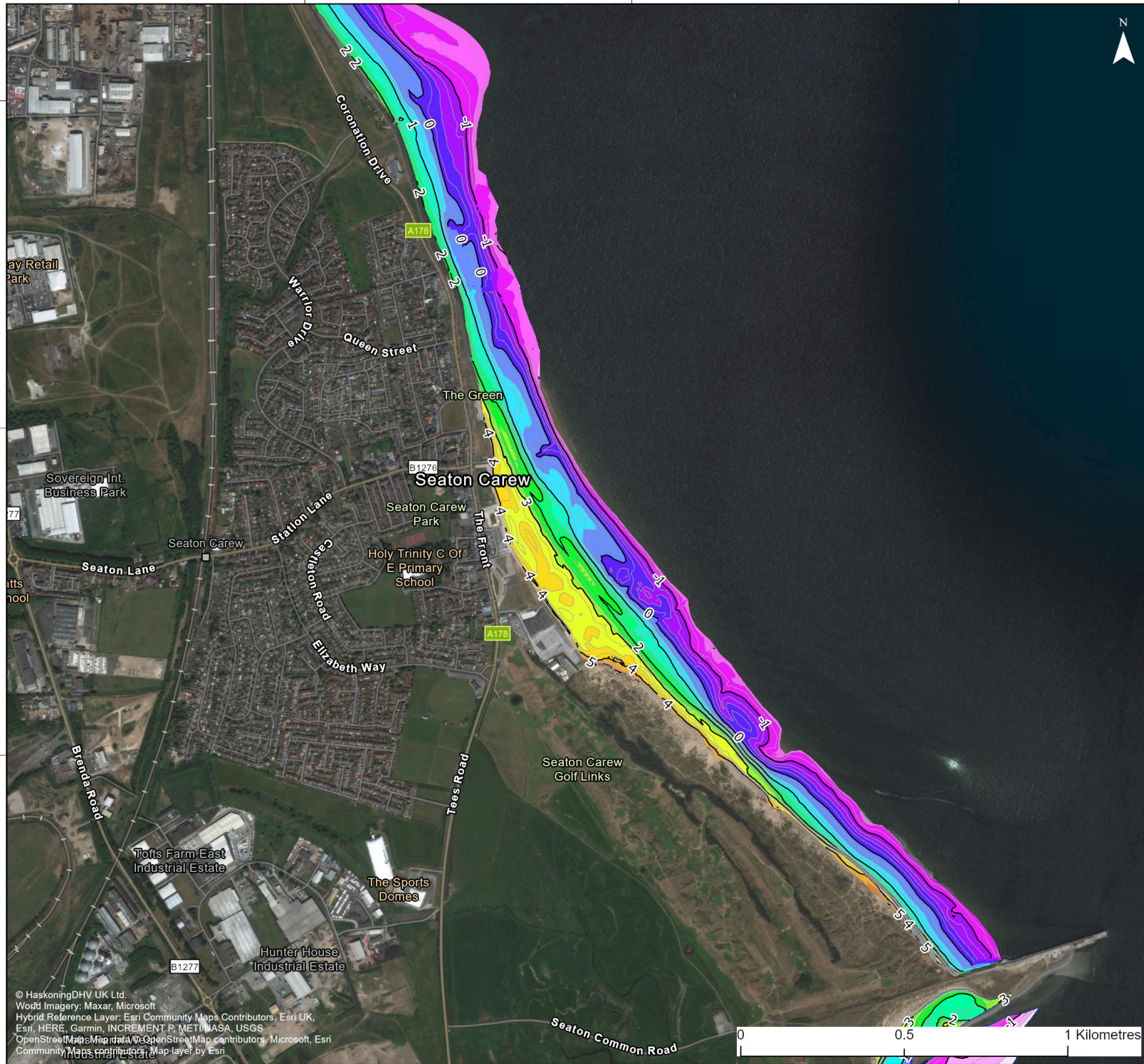
530000

529000

452000

453000

454000



TOPOGRAPHIC SURVEY (September 2021)

Elevation (mOD)	Contours (mOD)*
5.1 - 5.5	— 1.0m interval
4.6 - 5	— 0.25m interval
4.1 - 4.5	* Contours only cover sandy beach areas.
3.6 - 4	
3.1 - 3.5	
2.6 - 3	
2.1 - 2.5	
1.6 - 2	
1.1 - 1.5	
0.6 - 1	
0.1 - 0.5	
-0.4 - 0	
-0.9 - -0.5	
-1.4 - -1	
-1.7 - -1.5	

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

Title:

Appendix B - Map 3

HARTLEPOOL BAY (SOUTH)

Hartlepool Borough Council Frontage

Report:

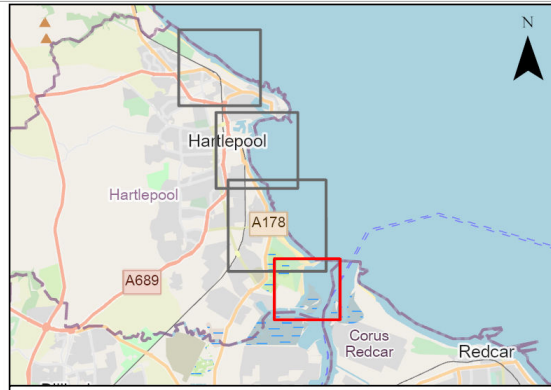
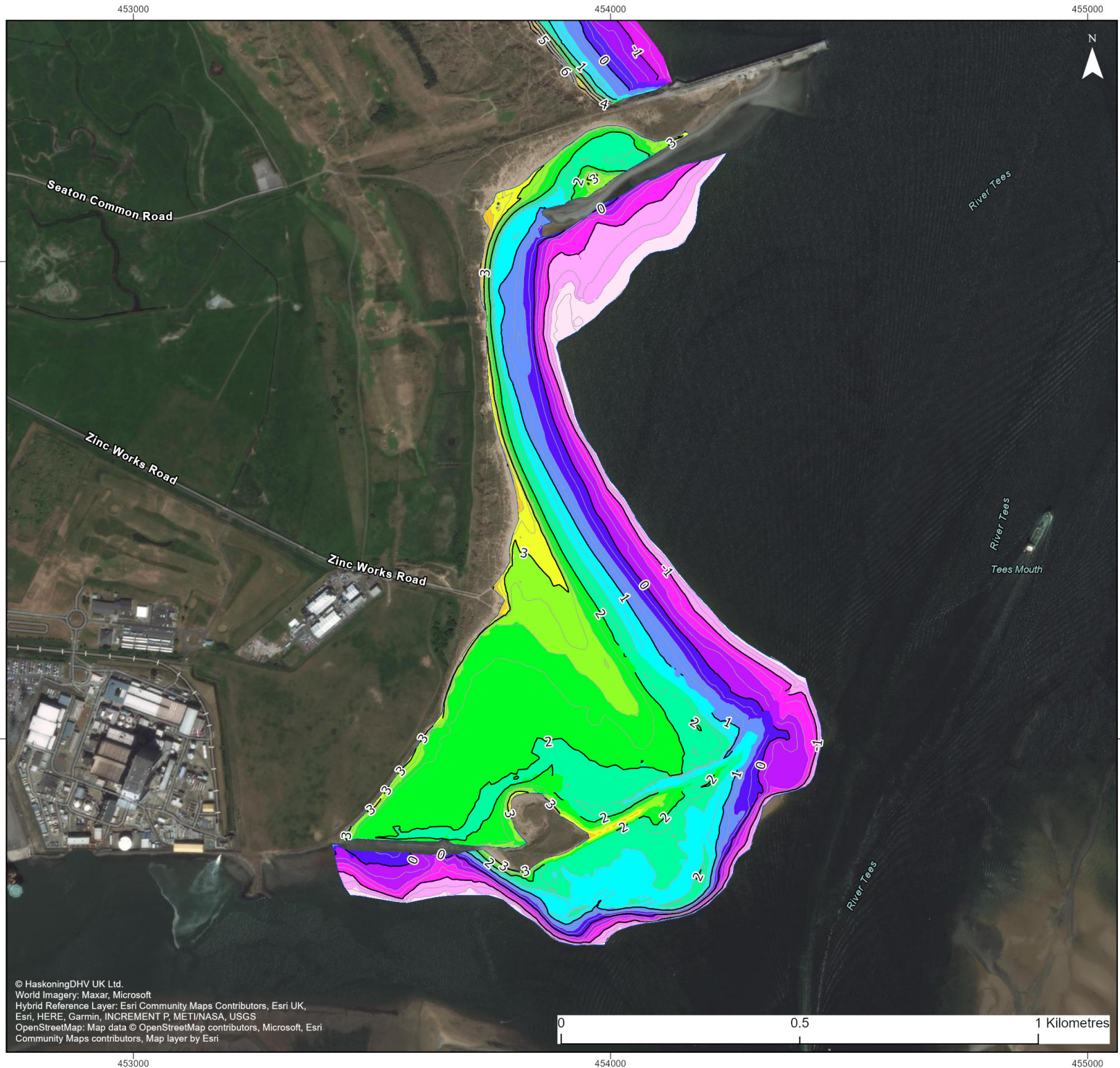
Analytical Report
'Full Measures' Survey 2021

Revision:	Date:	Drawn:	Checked:	Size:	Scale:
0	28/10/2021	TC	NJC	A3	1:12,000

Co-ordinate system: British National Grid

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World Imagery: Maxar, Microsoft
Hybrid Reference Layer: Esri Community Maps Contributors, Esri UK,
Esri, HERE, Garmin, INCREMENT P, META, NASA, USGS
OpenStreetMap contributors, Swatch, Mapbox, Mapbox contributors, Microsoft, Esri
Community Maps contributors, Map layer by Esri





TOPOGRAPHIC SURVEY (September 2021)

Elevation (mOD)	Contours (mOD)*
5.1 - 5.5	— 1.0m interval
4.6 - 5	— 0.25m interval
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	
0.6 - 1	
0.1 - 0.5	
-0.4 - 0	
-0.9 - -0.5	
-1.4 - -1	
-1.7 - -1.5	

* Contours only cover sandy beach areas.

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

Title:

Appendix B - Map 4

NORTH GARE

Hartlepool Borough Council Frontage

Report:

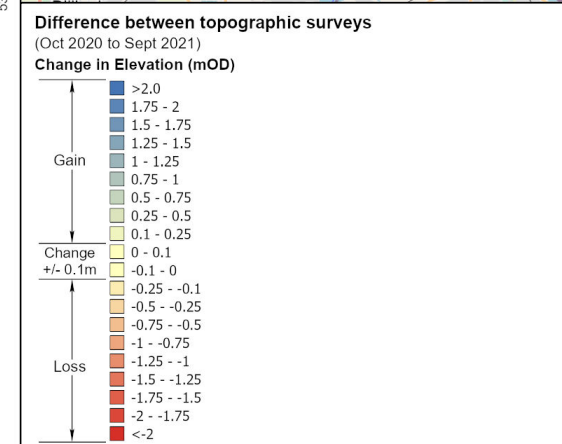
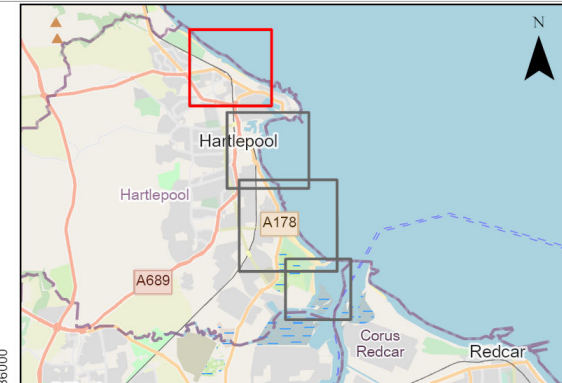
Analytical Report
'Full Measures' Survey 2021

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0	28/10/2021	TC	NJC	A3	1:8,000

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 OpenStreetMap: Map data © OpenStreetMap contributors, Microsoft, Esri
 Community Maps contributors, Map layer by Esri





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

Appendix B - Map 5

NORTH SANDS

Hartlepool Borough Council Frontage

Report:

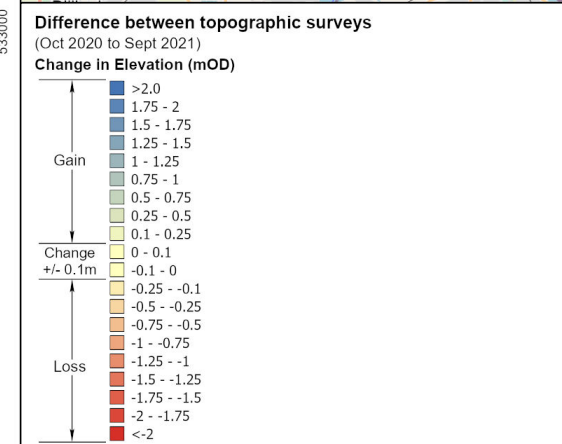
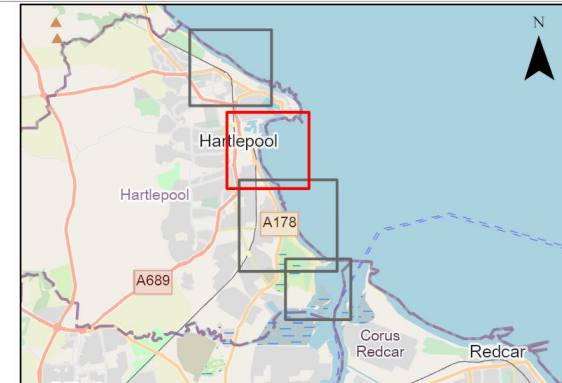
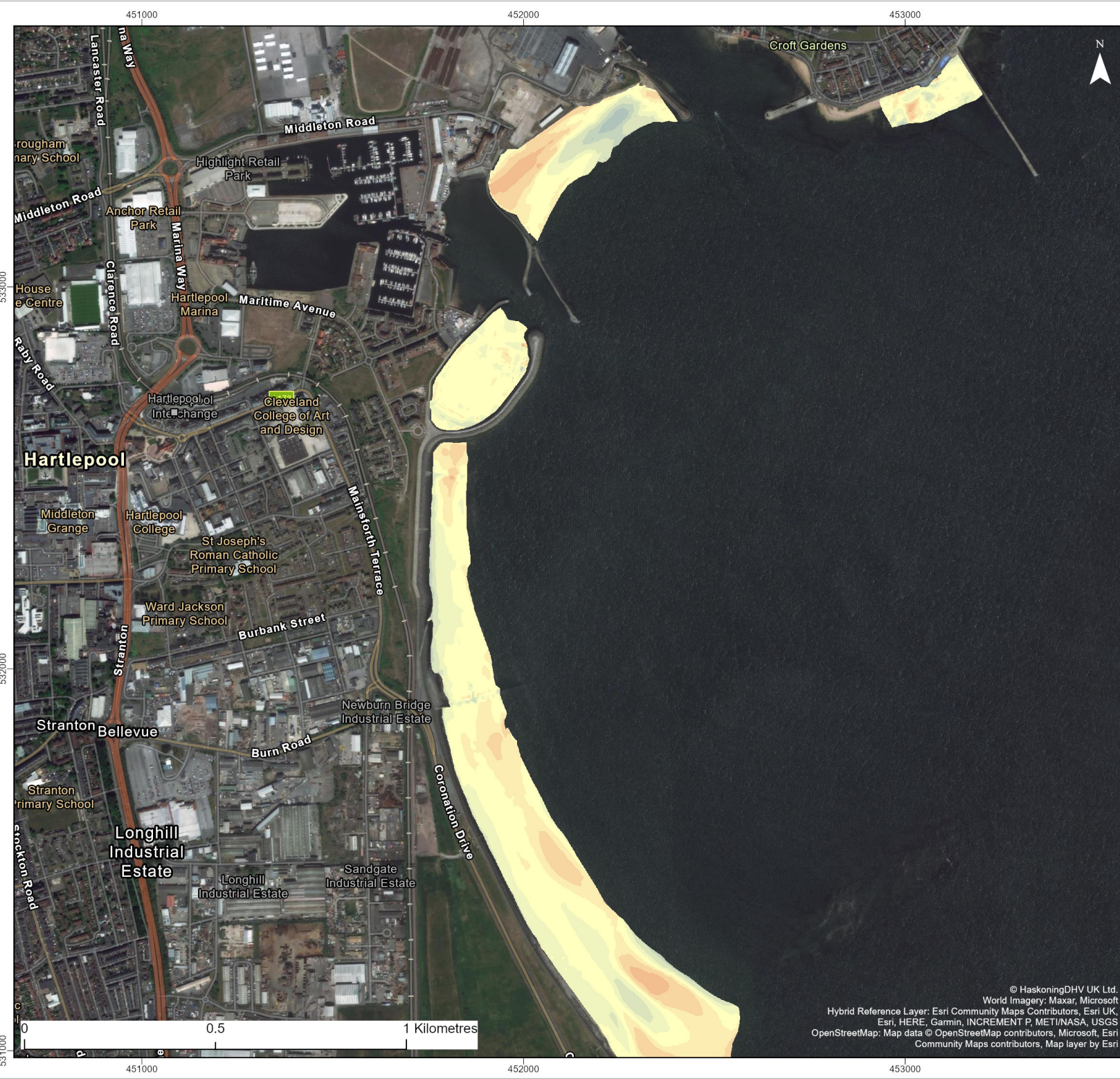
Analytical Report
'Full Measures' Survey 2021

Revision:	Date:	Drawn:	Checked:	Size:	Scale:
0	28/10/2021	TC	NJC	A3	1:10,000

Co-ordinate system: British National Grid




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

Title: **Appendix B - Map 6**
MIDDLETON AND HARTLEPOOL BAY (NORTH)
Hartlepool Borough Council Frontage

Report: Analytical Report
'Full Measures' Survey 2021

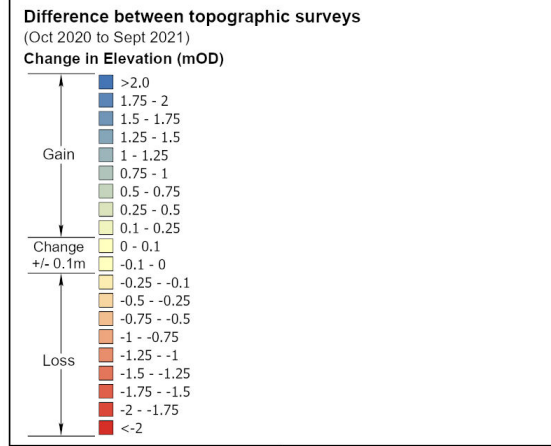
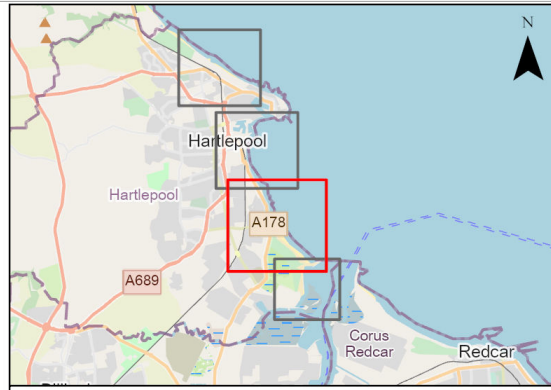
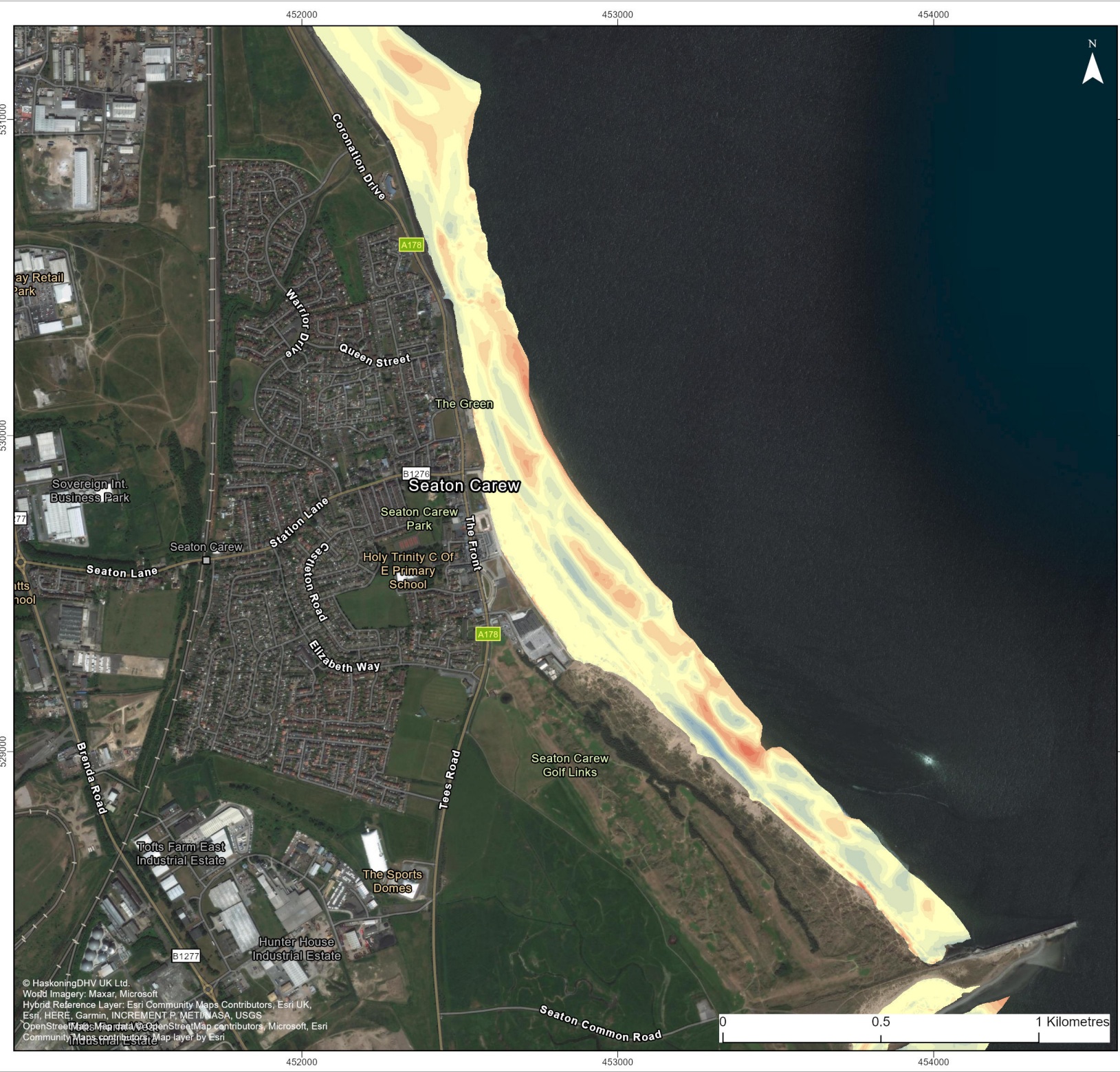
Revision:	Date:	Drawn:	Checked:	Size:	Scale:
0	28/10/2021	TC	NJC	A3	1:10,000

Co-ordinate system: British National Grid

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North East Coastal Observatory

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OpenStreetMap: Map data © OpenStreetMap contributors, Microsoft, Esri
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Client: North East Coastal Group
Project: Cell 1 Regional Coastal Monitoring Programme

Appendix B - Map 7
HARTLEPOOL BAY (SOUTH)
Hartlepool Borough Council Frontage

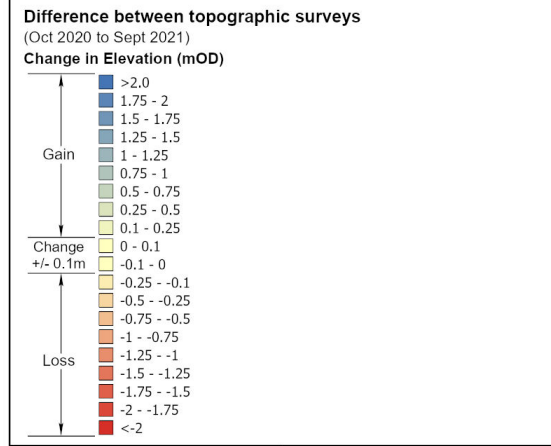
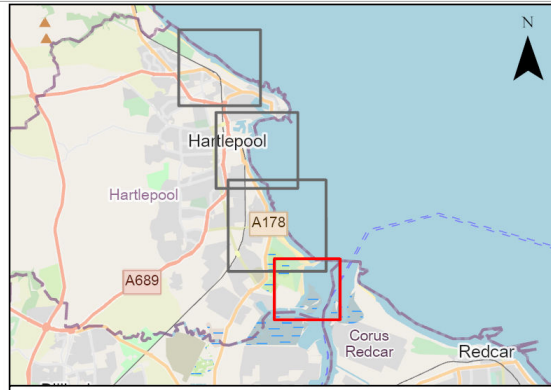
Report: Analytical Report
'Full Measures' Survey 2021

Revision:	Date:	Drawn:	Checked:	Size:	Scale:
0	28/10/2021	TC	NJC	A3	1:12,000

Co-ordinate system: British National Grid



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Community Maps contributors, Map layer by Esri



Client: North East Coastal Group

Project: Cell 1 Regional Coastal Monitoring Programme

Title: **Appendix B - Map 8**
NORTH GARE
Hartlepool Borough Council Frontage

Report: Analytical Report
'Full Measures' Survey 2021

Revision:	Date:	Drawn:	Checked:	Size:	Scale:
0	28/10/2021	TC	NJC	A3	1:8,000

Co-ordinate system: British National Grid

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Hybrid Reference Layer: Esri Community Maps Contributors, Esri UK,
Esri, HERE, Garmin, INCREMENT P, METI/NASA, USGS
OpenStreetMap: Map data © OpenStreetMap contributors, Microsoft, Esri
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