Cell 1 Regional Coastal Monitoring Programme Analytical Report 15: 'Full Measures' Survey 2022

Hartlepool Borough Council
January 2023

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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) North Sands to Middleton	Water Level (m AOD) 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.
Ebbtide	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.
Floodtide	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.

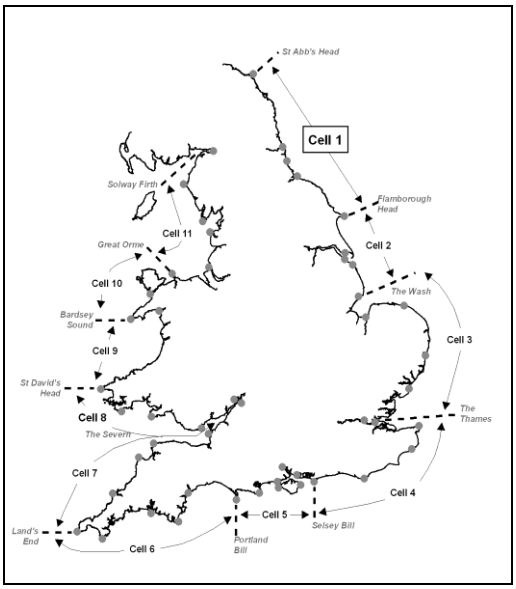


Figure 1 Sediment Cells in England and Wales

The programme commenced in its present guise in September 2008[1] 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	Apr 22	June 22	
15	2022/23	Sep-Oct 22	Jan 23 (*)			

(*) The present report is **Analytical Report 15** and provides an analysis of the 2022 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 seabed 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, 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.

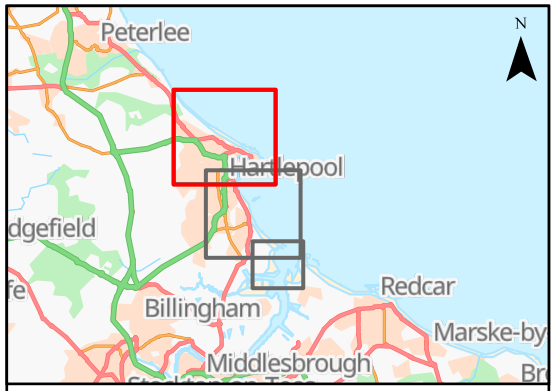
The location of these surveys is shown in Figure 2. The 2022 Full Measures survey was undertaken along this frontage between 29th September and 14th October 2022. The survey reports from Academy Geomatics document details of the weather conditions over this survey period.

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
- Bi-Annual

Topographic Area

- 6 monthly
- yearly
- 5 yearly

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

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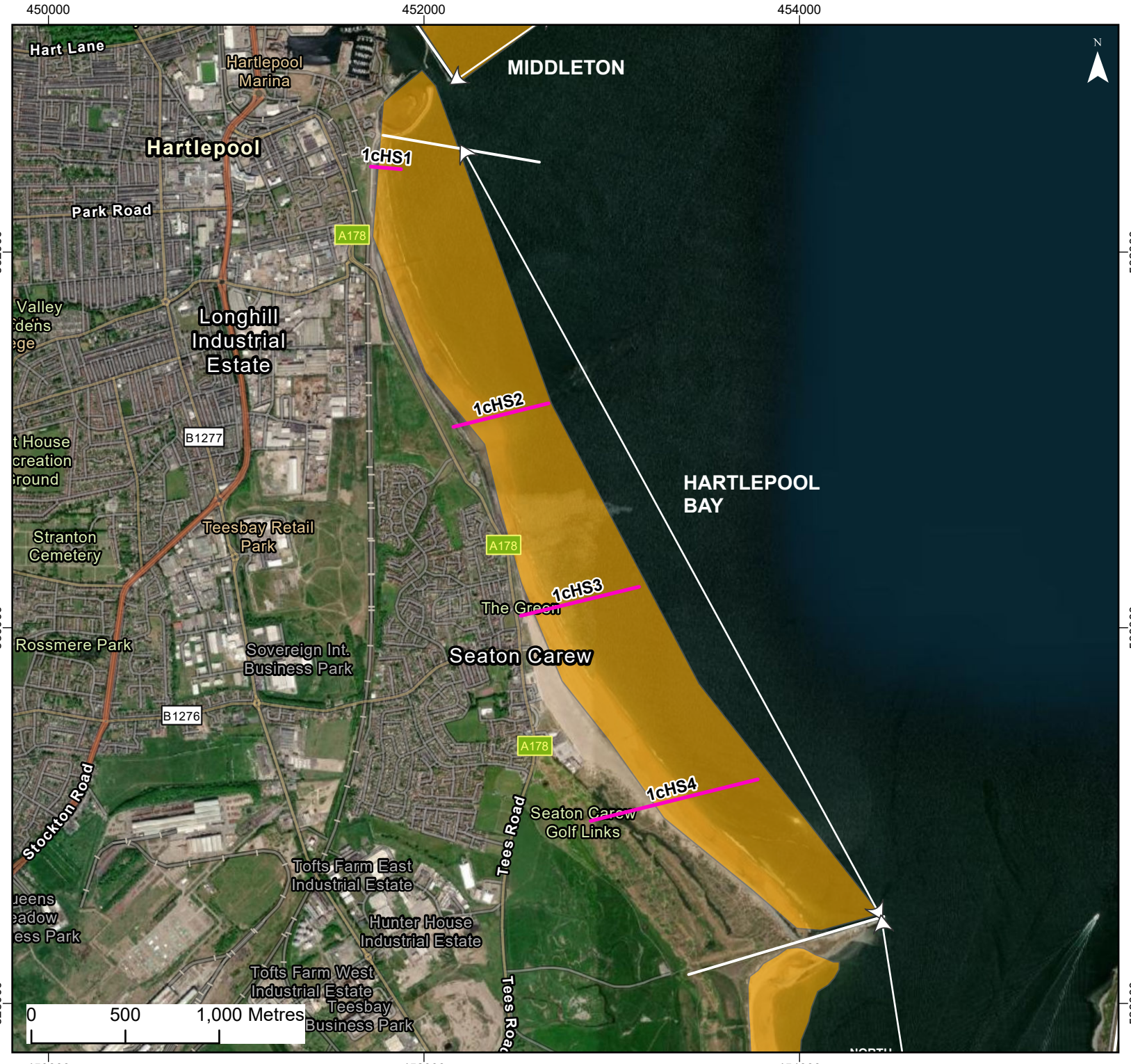

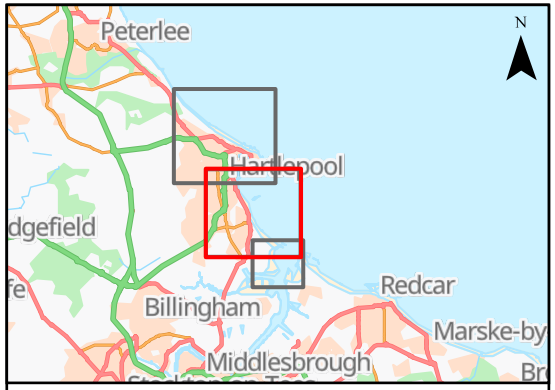

SURVEY LOCATIONS

Topographic Profile

- Annual
- Bi-Annual

Topographic Area

- 6 monthly
- yearly
- 5 yearly

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:
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Co-ordinate system: British National Grid

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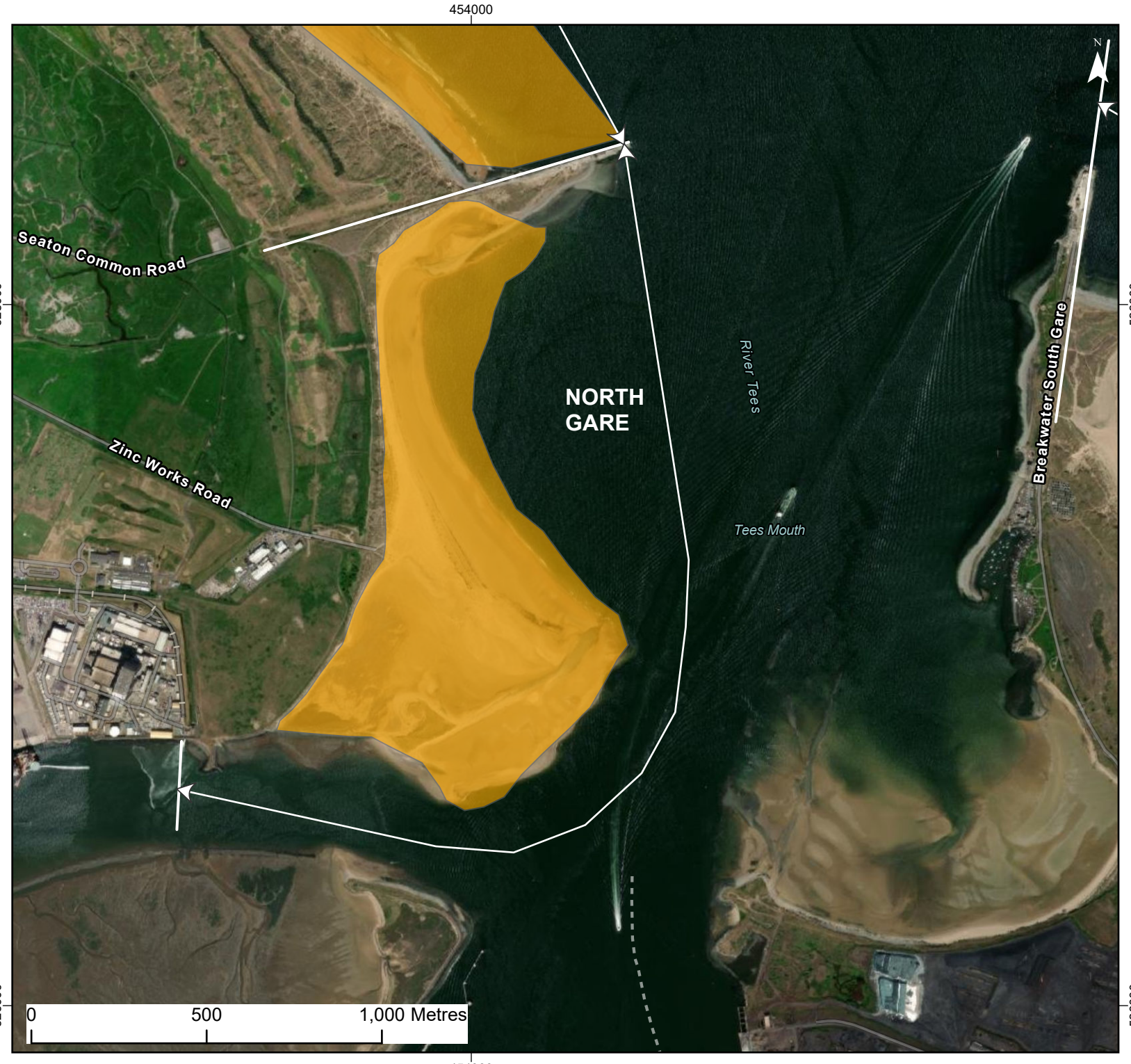

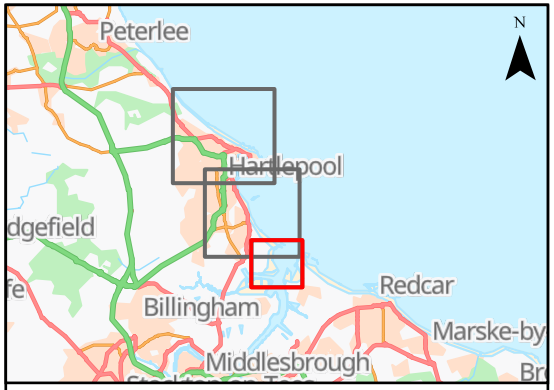

SURVEY LOCATIONS

Topographic Profile

- Annual
- Bi-Annual

Topographic Area

- 6 monthly
- yearly
- 5 yearly

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

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2. Analysis of Survey Data

2.1 North Sands

Survey Date	Description of Changes Since Last Survey	Interpretation
29th – 30th September 2022	**Beach Profiles:** North Sands and Hartlepool Headland is covered by six beach profile lines during the Full Measures survey (Appendix A). They were last surveyed in April 2021. In addition, profile **1cHN1** (which is located within Durham County Council's area of responsibility, about 400m north of the outfall of Crimdon Beck), is reported here so changes can be interpreted in association with those observed elsewhere along North Sands. The beginning of profile **1cHN1,** between 0m and 70m chainage, covers dunes that have overall, remained unchanged. The crest of the rear dunes at chainages -20m and -10m have both dropped in elevation by 0.4m. At the toe of the foredune, between chainage 78m and 115m, a berm has been eroded resulting in a drop of 0.6m in level in places. Seawards of chainages 115m, significant accretion has occurred up to chainage 237m, including infilling a channel that had previously incised through the foreshore between chainages 179m and 237m. The lower beach has steepened resulting in a drop in level of 0.8m at chainage 280m. The profile is at a medium level compared to the range from previous surveys. At profile **1cHN2,** there has been no change across the dune system and upper beach until chainage 55m. Seawards of this point, shifting sands have created alternating lengths of erosion and accretion, limited to ±0.2m until chainage 133m. At chainage 194m, erosion has caused a berm, 0.7m in height, to form with a small, incised channel at the toe of the landward slope. Accretion has dominated the lower extents of the beach with an increase in level of 0.6m observed at chainage 260m. Profile **1cHN2A** was established in October 2011 and runs through the dunes close to North Sands. The dunes, between chainage 0m and 76m have remained stable, experiencing minor accretion and erosion limited to ±0.1m. At the toe of the foredune, beach levels have accreted by 0.4m in level to chainage 92m. Accretion is also observed between chainage 110m and 178m of a magnitude up to 0.2m. The berm observed previously at chainage 175m has shifted seawards to chainage 182m. The seaward face of the berm has slackened resulting in an increase in level of 0.7m at chainage 250m. The profile remains within the range of the previous surveys. At profile **1cHN3,** the dunes up to chainage 42m have remained stable. The crest of the foredune has	The dunes along North Sands have generally remained stable since the previous survey. On the beach, the pattern of change across the profiles is more irregular due to the formation and erosion of shifting sandbars along the frontage, however beach levels remain within the range of the previous surveys. At The Headland, accretion has been the dominant process with sections of rocky foreshore that have previously been exposed, now covered with a thin layer of beach sediment,

Survey Date	Description of Changes Since Last Survey	Interpretation
	accreted by 0.1m in level. The upper beach between chainage 42m and 117m has accreted by 0.1m in level. Seaward of chainage 117m, the beach has eroded by 0.1m in level. The profile is at a medium level compared to the range from previous surveys. At profile **1cHN3A** the dune face has remained unchanged, with the toe of the dune experiencing a minor accretion of 0.2m in level between chainages 23m and 32m. Seaward of the dune, the beach profile highlights alternating lengths of erosion and accretion, on the whole limited to ±0.2m. The most significant change is between chainage 160m and 229m, which has recorded an accretion of up to 0.7m in level. When compared to the range of previous surveys, the October 2021 survey is at a medium level except the significant accretion on the lower beach which is at the highest level. At profile **1cHN4**, between the toe of the defence (chainage 16m) and chainage 43m, the beach has dropped by up to 1.0m in level, exposing the rocky foreshore over a 5m length adjacent to the seawall. Between chainage 43m and 80m the beach has remained stable with minor accretion (<0.1m) occurring. On the lower beach, between chainage 80m and 104m, accretion by 0.4m in level has concealed a portion of the previously exposed rocky foreshore. Seaward of chainage 104m the rocky foreshore remains exposed. At profile **1cHN4a** the defended part of the profile to 10m chainage has not changed since October 2011. The rocky shore platform remains exposed seaward of chainage 74m. However, wide-scale accretion (up to 0.5m in level) across the upper beach has concealed the foreshore in this location. Overall, the profile is at a high level compared to the previous recorded surveys, particular on the upper beach where it is the highest level on record.	
29th – 30th September 2022	**Topographic Survey:** North Sands is covered by an annual topographic survey. Data from the 2022 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, groynes, and the pier where contours change direction. The GIS has also been used to calculate the differences between the September 2021 and September 2022 topographic surveys to identify areas of net erosion and accretion (Appendix B – Map 5). The figure shows that across the frontage there are alternating, shoreline parallel bands of erosion and accretion associated with shifting sandbars. To the west of Streetley Pier, erosion typically dominates at	The difference plot at North Sands shows alternating bands of erosion and accretion running parallel to the shoreline associated with shifting sandbars. A pattern typical for this frontage.

Survey Date	Description of Changes Since Last Survey	Interpretation
	the toe of the cliff and the lower-middle beach, with accretion occurring on the upper-middle and lower beach. To the east of Streetley Pier, the change is slightly more unbalanced with accretion typically dominating the upper and lower beach, with a narrow band of accretion punctuating the two.	

2.2 Middleton

Survey Date	Description of Changes Since Last Survey	Interpretation
30th September 2022	**Beach Profiles:** Middleton is covered by one beach profile line (**1cHC1**) that is monitored on a bi-annual basis. (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 a very local drop in level of 0.15m. Seawards of this, the beach profile has generally steepened and become more linear, creating two distinct bands of change. On the upper beach, between chainage 52m and 121m, the beach has accreted by 0.3m in level. At chainage 121m, the accretion switches to erosion that continues to the end of the profile at chainage 205m. The magnitude of erosion is approximately 0.2m in level. Overall, the beach is at a medium to high level, with parts of the upper beach, where the accretion has occurred, being at the highest level on record.	The change observed is typical of seasonal fluctuations of sediment movements, moving from lower extents of the beach to the upper extents in the calmer summer months (compared to drawdown in the winter caused by more destructive waves). **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.
30th September 2022	**Topographic Survey:** The frontage is covered by an annual topographic survey between Middleton Jetty and North Pier. Data from the 2022 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 a build of sediment occurring on the upper beach in the lee of the breakwater. The contours are locally distorted by pipelines and groynes, particularly on the lower foreshore. The GIS has also been used to calculate the differences between the September 2021 and September 2022 topographic surveys, as shown in Appendix B – Map 4, to identify areas of net erosion and accretion. The survey shows overall the western half of the beach has been dominated by accretion and the eastern half dominated by erosion of a similar magnitude (±1.25m). A very narrow band of erosion can be observed along the toe of the defences and is likely associated with wave refraction caused by the hard structures.	Whilst large plan areas of erosion and accretion are observed, the areas appeared balanced suggesting that the volume of sediment on the beach has remained stable over 2022.

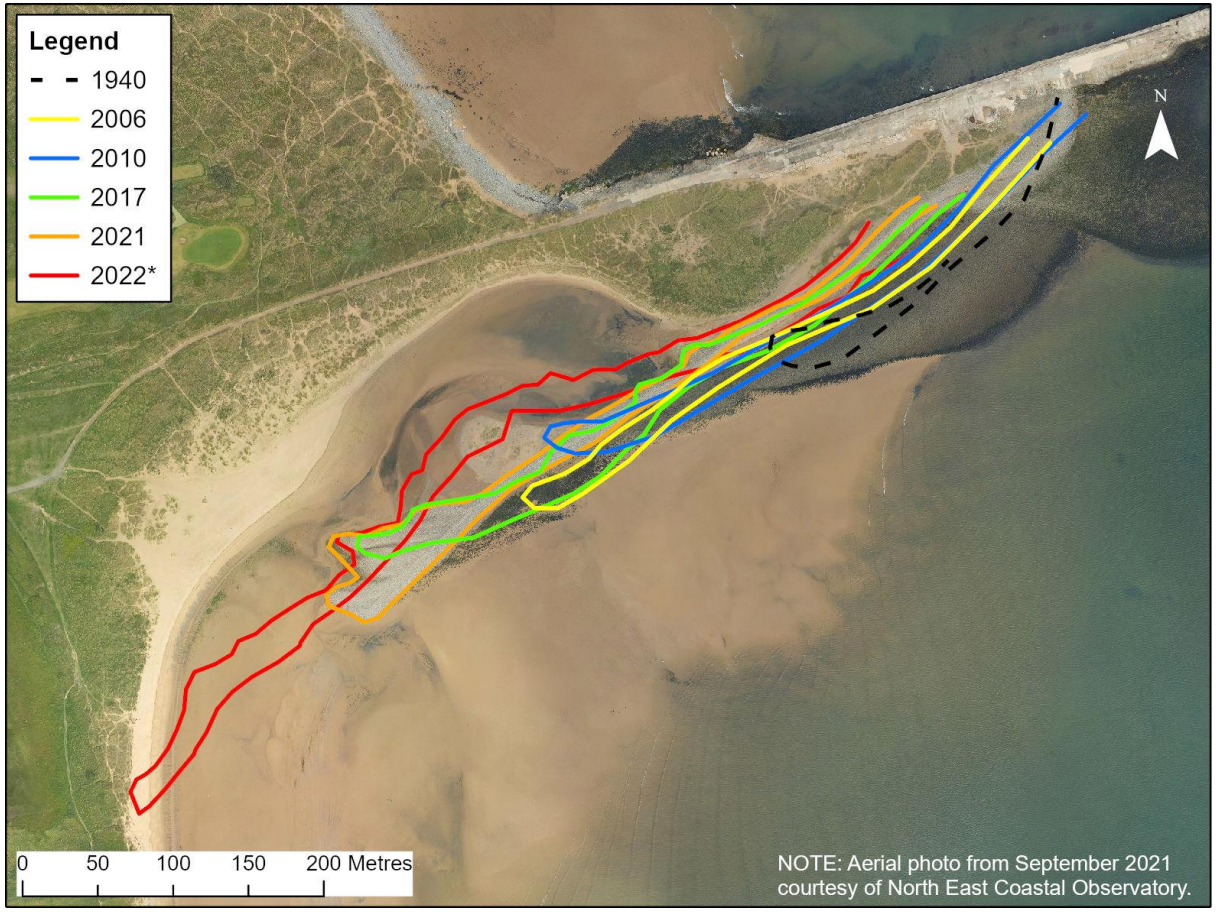
2.3 Hartlepool Bay

Survey Date	Description of Changes Since Last Survey	Interpretation
6th - 7th October 2022	**Beach Profiles:** Hartlepool Bay is covered by four beach profile lines during the Full Measures survey (Appendix A). The profiles were last surveyed in April 2022. The September 2022 survey report notes '*Heavy onshore winds restricted the depth of survey achievable at the South end of the job."* 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 beach against the structures has increase by 0.2m tapering to no change by chainage 58m. Seawards of this point the beach has remained largely stable with all change limited to ±0.1m. As a result, the beach remains at a high level in comparison to the range of the previous surveys. At Along profile **1cHS2**, the first 26m are covered by rock revetment and have experienced no change. At the toe of the structure beach levels have locally dropped by 0.4m, tapering to no change by chainage 38m. For the next 260m, until the end of the profile (at chainage 300m) all change is limited to <0.1m. Compared to the range of the previous surveys, the beach is at a medium level. Profile **1cHS3** shows no changes over the defended part of the profile up to 30m chainage. At the toe of the revetment, beach levels have locally dropped by 0.3m, tapering to no change by chainage 60m. On the middle section of beach, between chainages 60m and 160m, the levels have remained stable with any change limited ±0.1m. On the lower beach, a berm has formed with accretion of up to 0.45m in level observed up until the end of the profile at chainage 248m. 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 section has generally remained stable since the previous survey with the majority of change limited to ±0.1m. The crest of the foredune has shifted seaward by 1.5m but does not appear to have changed in elevation. Seawards of the dunes, the beach has also remained largely stable and displays a uniform	Since the previous surveys in April 2022, the four beach profiles along Hartlepool Bay indicate a period of stability has occurred. The four profiles all have large areas of little to no change (±0.1), particularly to the two northern profiles. The southern profiles show some evidence of sand bar movement with formation and removal of berms The difference between topographic surveys indicates wide scale change has occurred over the previous year. This is contrast to the 6-monthly profiles that indicates over the summer 2022 that the profiles have remained stables. This suggests that the winter months are the dominant months in driving change.

Survey Date	Description of Changes Since Last Survey	Interpretation
	gradient. Minor accretion is observed between chainage 390m and 425m at a magnitude of 0.1m. A berm previously observed at chainage 442m is no longer present and therefore beach levels have dropped locally in this location by 0.3m. Overall the beach is at medium level when compared to the range of the previous surveys.	
	Topographic Survey: Hartlepool Bay is covered by an annual topographic survey between the South Pier and the North Gare Breakwater. Data from the 2022 Full Measures survey have been used to create a DGM (Appendix B – Map 2 & Map 3) 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 at North Gare resulting much steeper upper beach, The GIS has also been used to calculate the differences between the September 2021 and September 2022 topographic surveys to identify areas of erosion and accretion, shown in Appendix B – Map 6 & Map 7, At Carr House Sands, generally the upper beach has been dominated erosion and the lower beach dominated by accretion. The change has typically occurred in shoreline parallel bands. It is clear the cross-shore structures, particular the outfall at Newburn Bridge, affect sediments movements, with accretion evident on the north side of the structure and erosion on the south. Along Seaton Sands, the change is more intense, particularly fronting the Seaton Carew golf club that experience and erosion on the upper beach up to 1.5m in level. Overall, the plot generally shows shore-parallel changes, reflecting the seasonal movement of sediment across the beach in the form of sand bars.	

2.4 North Gare

Survey Date	Description of Changes Since Last Survey	Interpretation
13th – 14th October 2022	**Topographic Survey:** 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. 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. The GIS has also been used to calculate the differences between the September 2021 and October 2022 topographic surveys, as shown in Appendix B – Map 8, to identify areas of net erosion and accretion. The plot shows that on the south aspect of the North Gare breakwater there has been a progressive redistribution of cobble berm from the tip of the North Gare towards the root. This has reached the point in 2022 where the corner of beach, in the lee of the breakwater, is now cut off from the rest of the bay. The difference plot shows that behind the now extended berm, there has been an increase in sediment levels of up to 1.25m. It is thought that if the berm remains that sediment will continue to build behind it and eventually dunes will begin to develop. An area of intense erosion can be seen where the cobble berm now connects to the beach and may be associated with scour around the end of the hard structure. Figure 3 below highlights the redistribution of this berm over time. The difference plot shows that on North Gare Sands there has been a general movement of sediment from the lower beach to the upper beach. The change is typically seen as narrow, shoreline parallel bands. On the south beach, at the confluence between the Seaton on Tees Channel and the River Tees, accretion has dominated the lower beach at a magnitude up to 1.5m. Pockets of erosion and accretion can be seen on the upper beach albeit at smaller magnitude.	The most significant change since the previous survey in September 2021 is the redistribution of the cobble berm form the tip of North Gare to the root, cutting off a section of beach. Accretion can be observed behind the berm which is likely to continue if the beach remains cut off. Elsewhere change has again occurred in shoreline parallel bands of change, generally moving from the lower beach to the upper beach.

Survey Date	Description of Changes Since Last Survey	Interpretation
	 **Figure 3 North Gare Berm Redistribution**	

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 and heavy onshore winds restricted the depth of survey achievable at the southern end.

At North Gare, ground levels within the salt marsh area at the southeast 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

- The dunes along North Sands have generally remained stable since the previous survey. On the beach, the pattern of change across the profiles is more irregular due to the formation and erosion of shifting sandbars along the frontage, however beach levels remain within the range of the previous surveys. At the Headland, accretion has been the dominant process with sections of rocky foreshore that have previously been exposed, now submerged with beach sediment,
- At Middleton, the change observed is typical of seasonal fluctuations of sediment movements, moving from lower extents of the beach to the upper extents in the calmer summer months (compared to drawdown in the winter caused by more destructive waves).
- At Hartlepool Bay, since the previous surveys in April 2022, the four beach profiles indicate a period of stability has occurred (although it is noted that some change over the preceding winter occurred). The four profiles all have large plan areas of little to no change (±0.1) since April 2022, particularly to the two northern profiles. The southern profiles show some evidence of sand bar movement with formation and removal of berms.
- At North Gare, the most significant change since the previous survey in September 2021 is the redistribution of the cobble berm form the tip of North Gare to the root, cutting off a section of beach. Accretion can be observed behind the berm which is likely to continue if the beach remains cut off. Elsewhere change has again occurred in shoreline parallel bands of change, generally moving from the lower beach to the upper beach. There is no cause for concern at any of these areas.

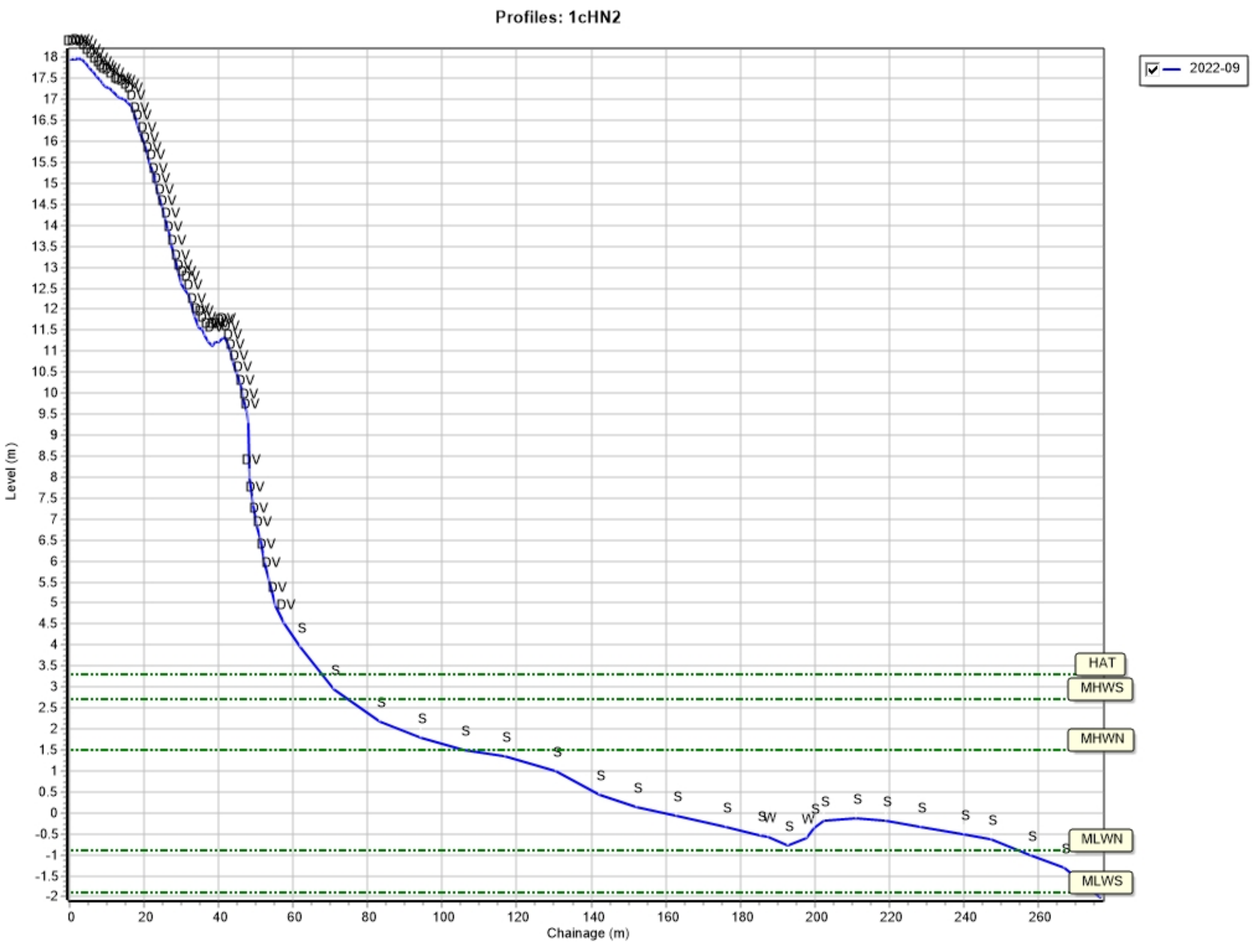
Appendices

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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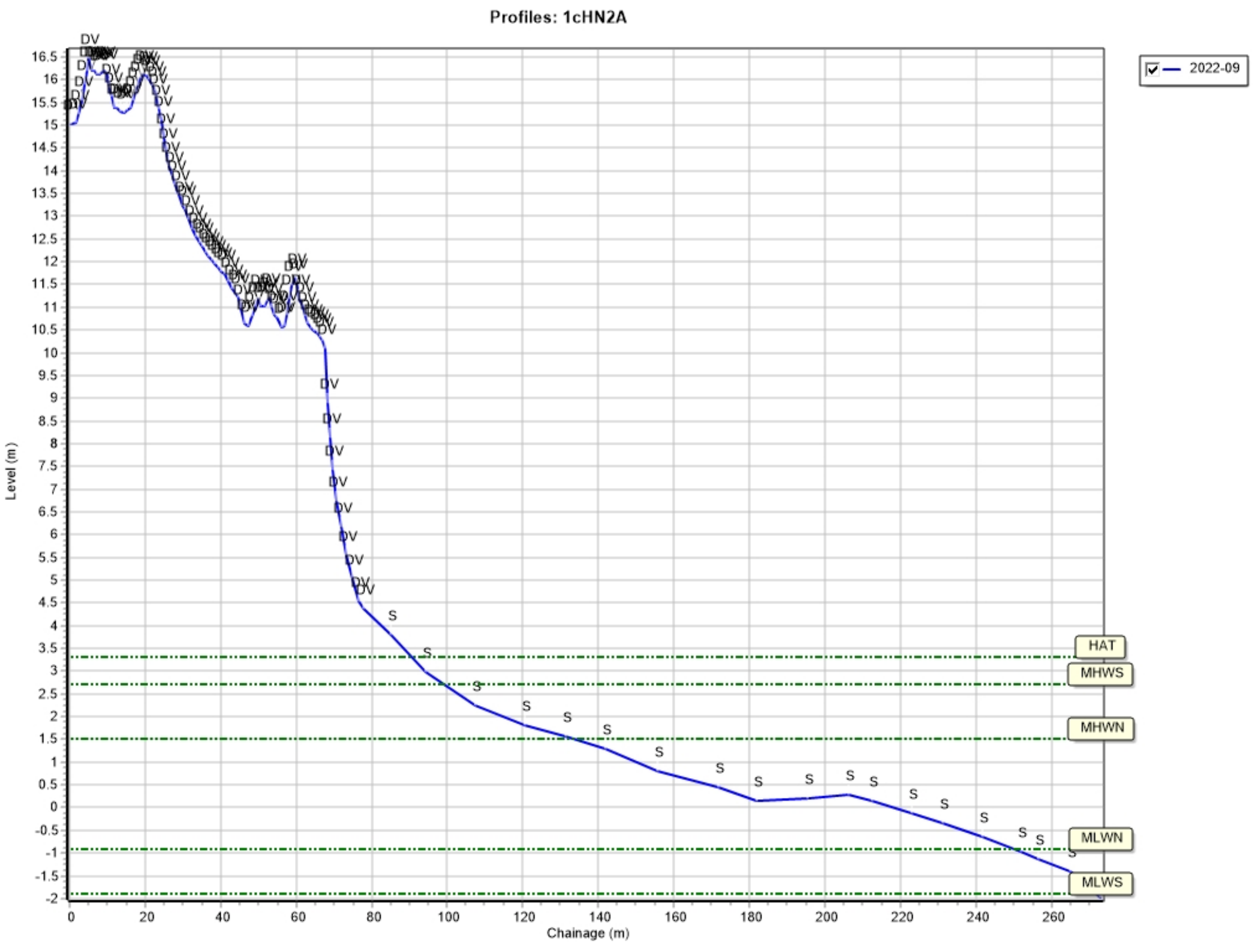
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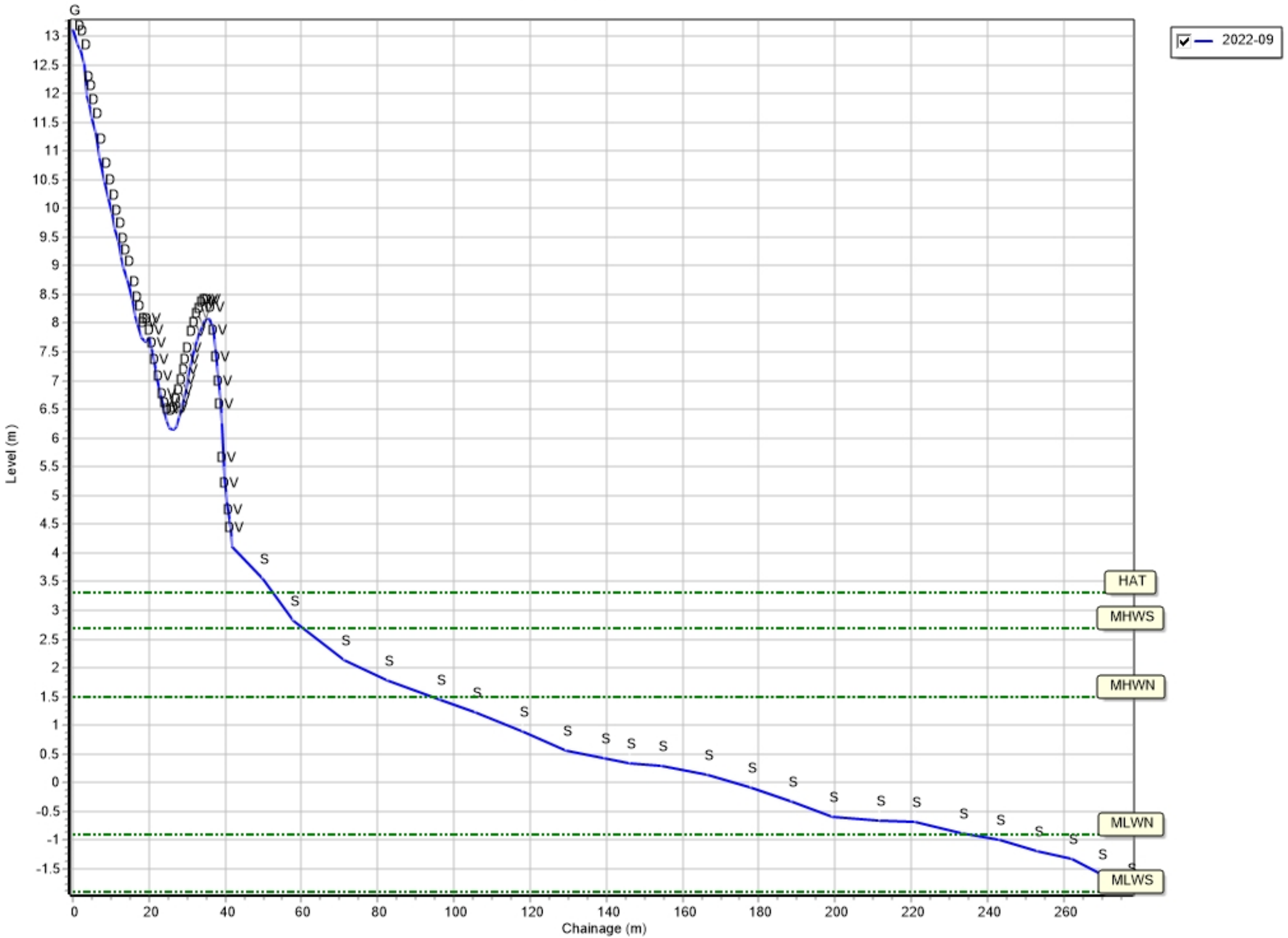
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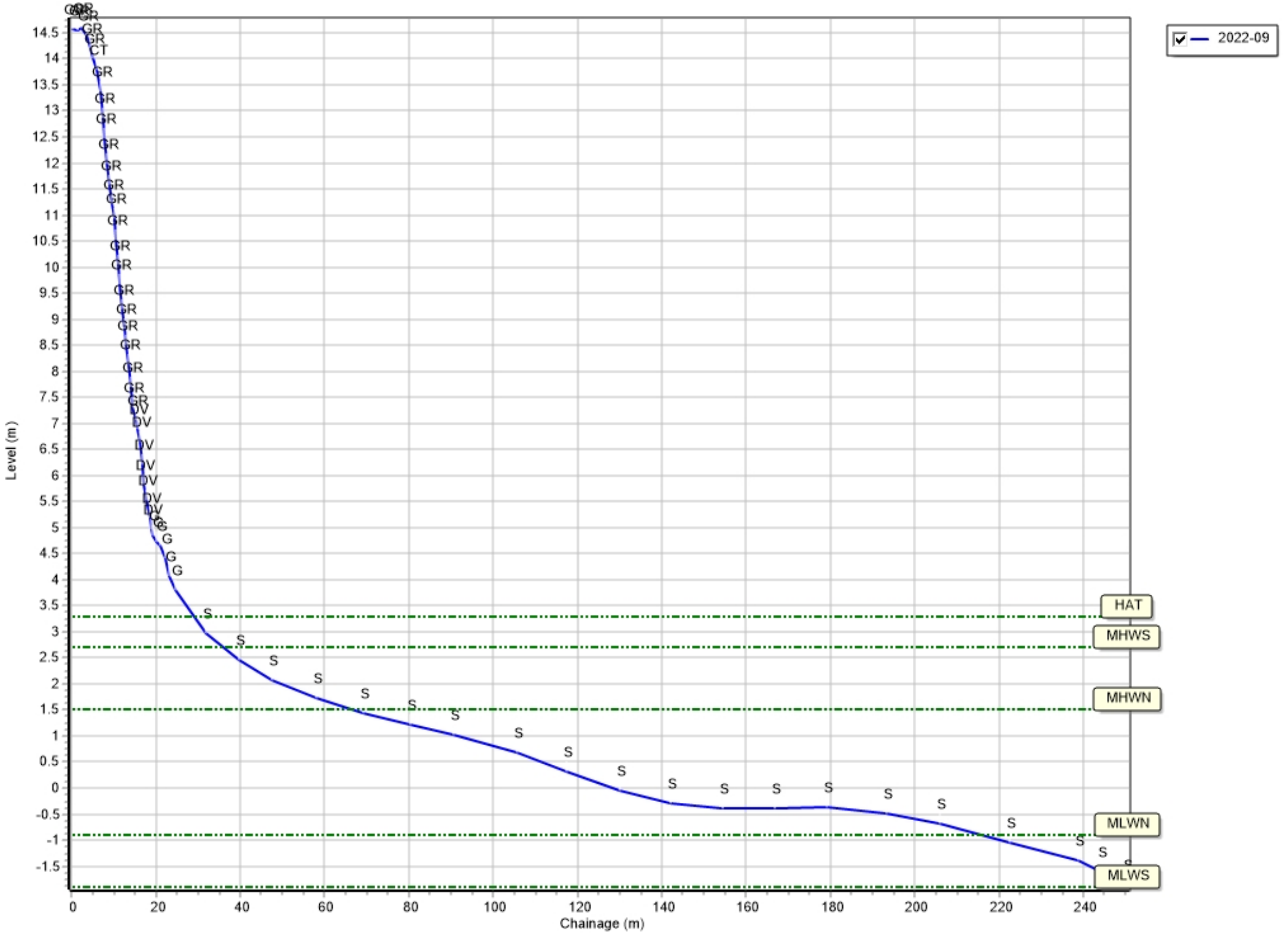
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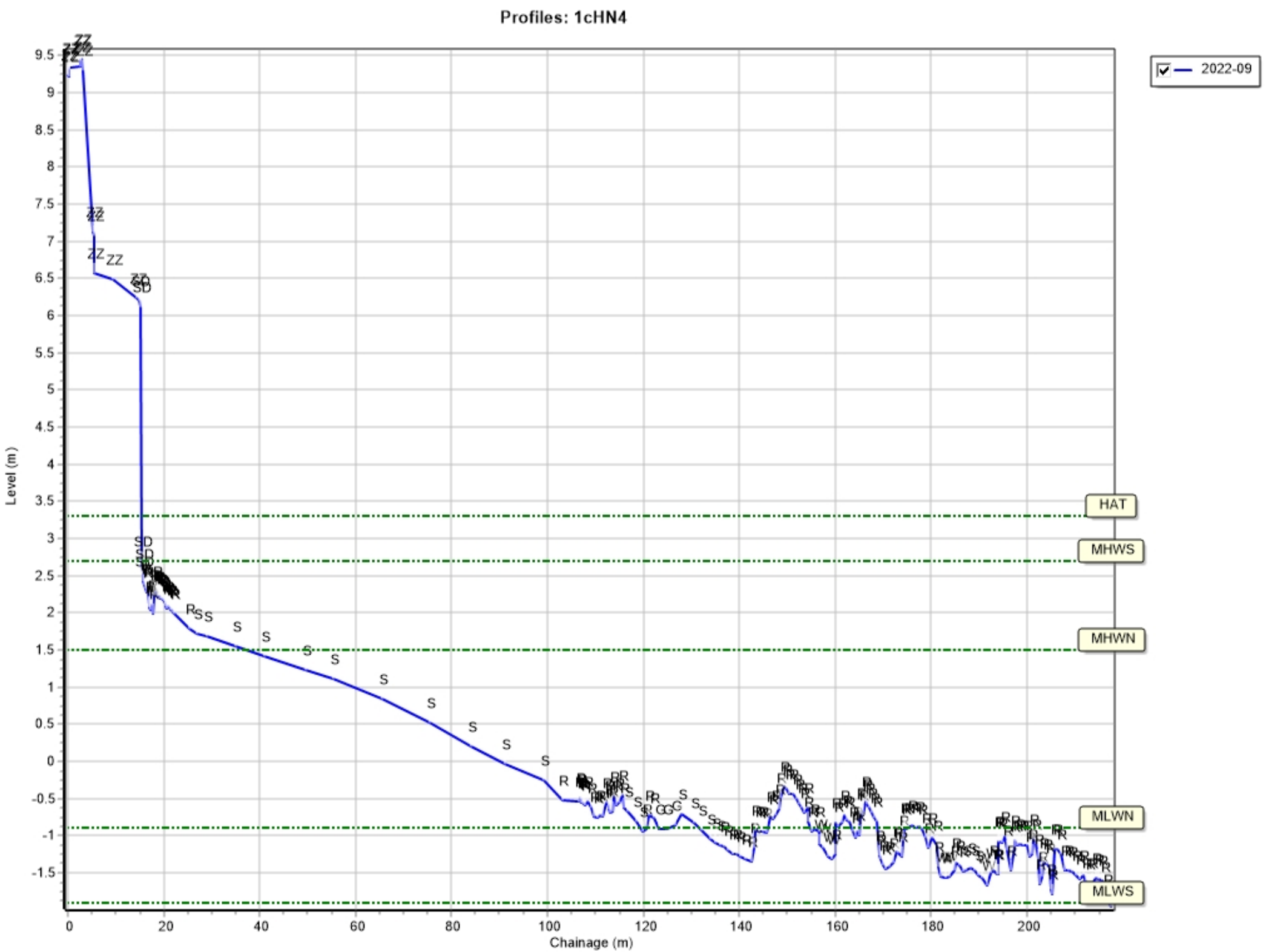
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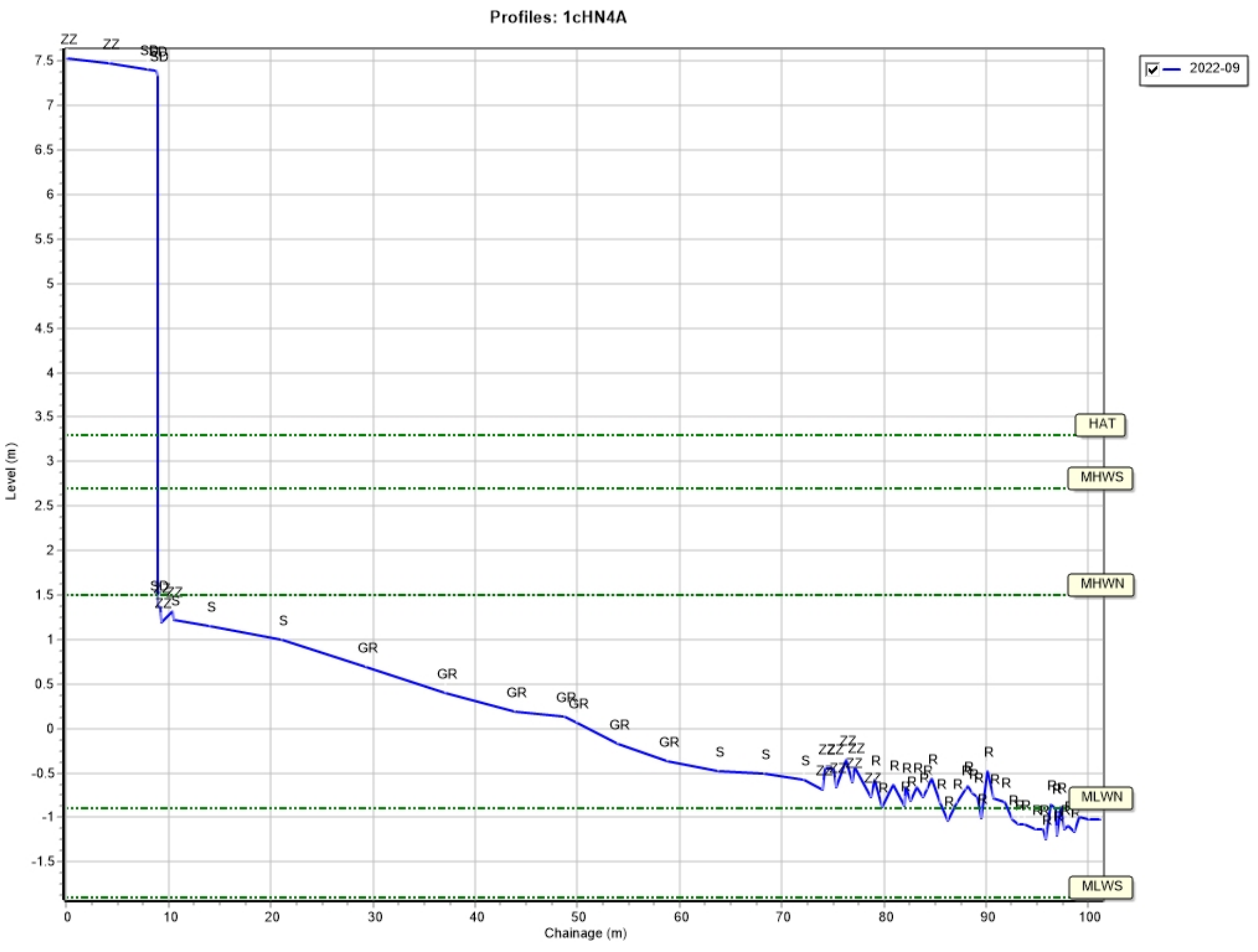
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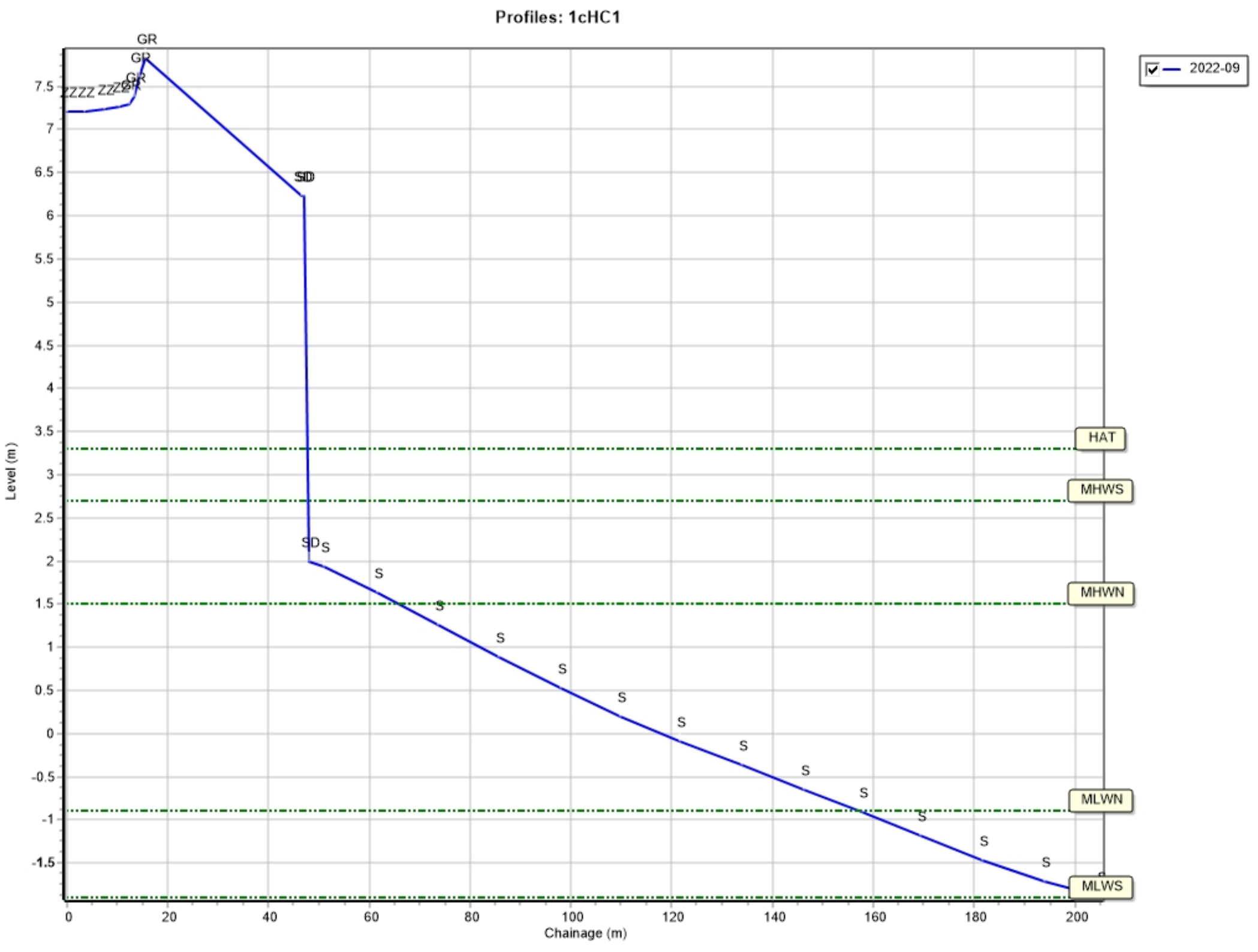
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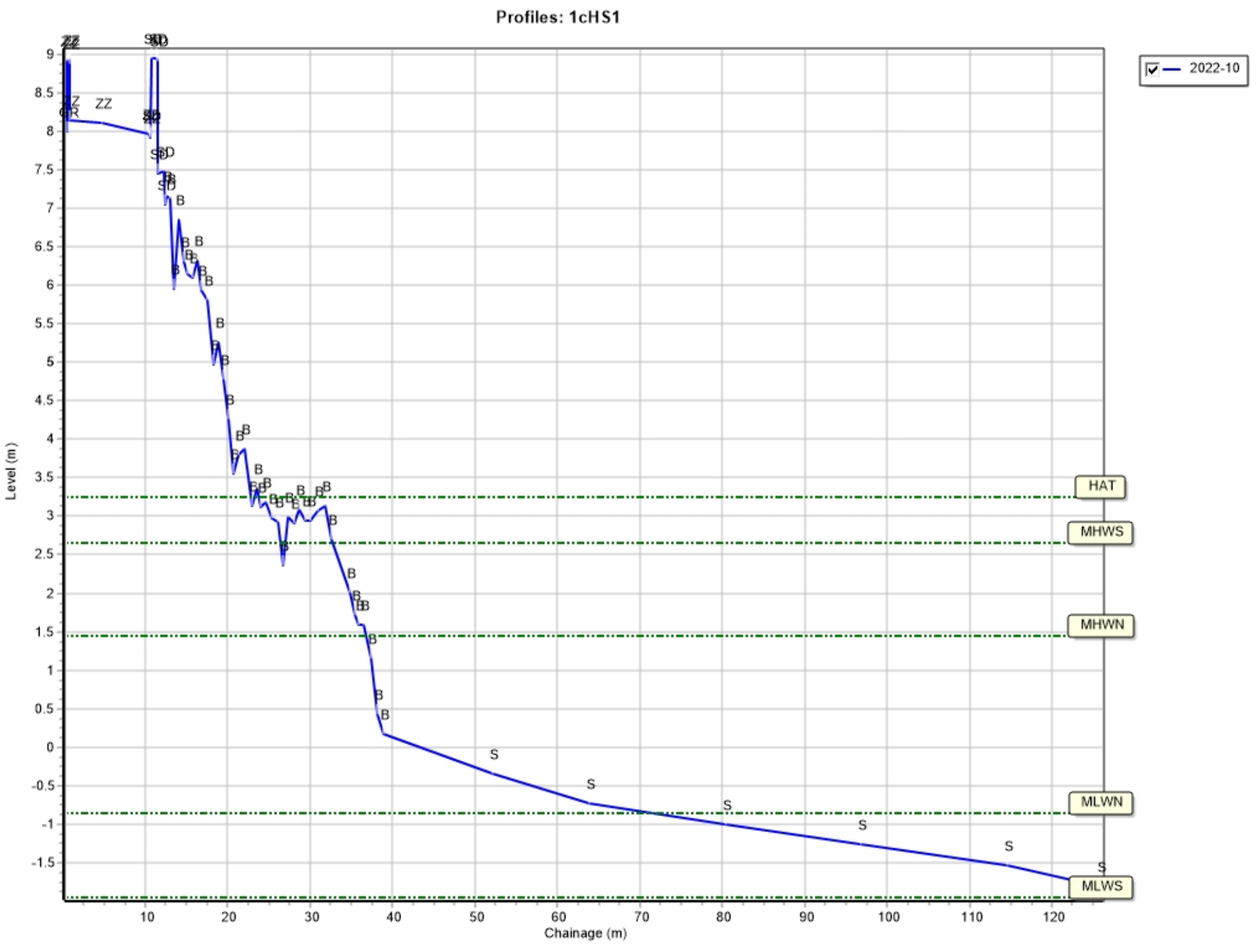
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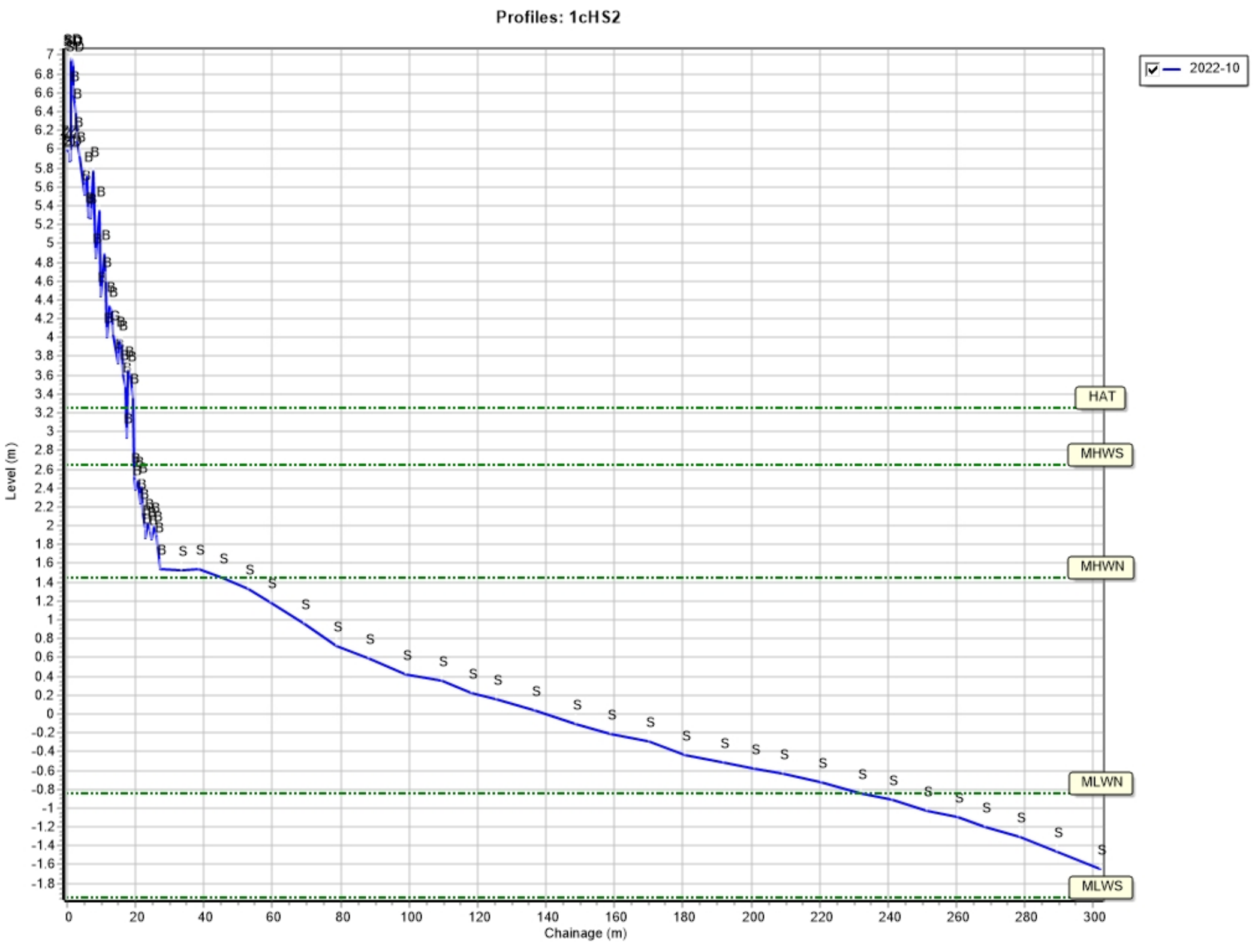
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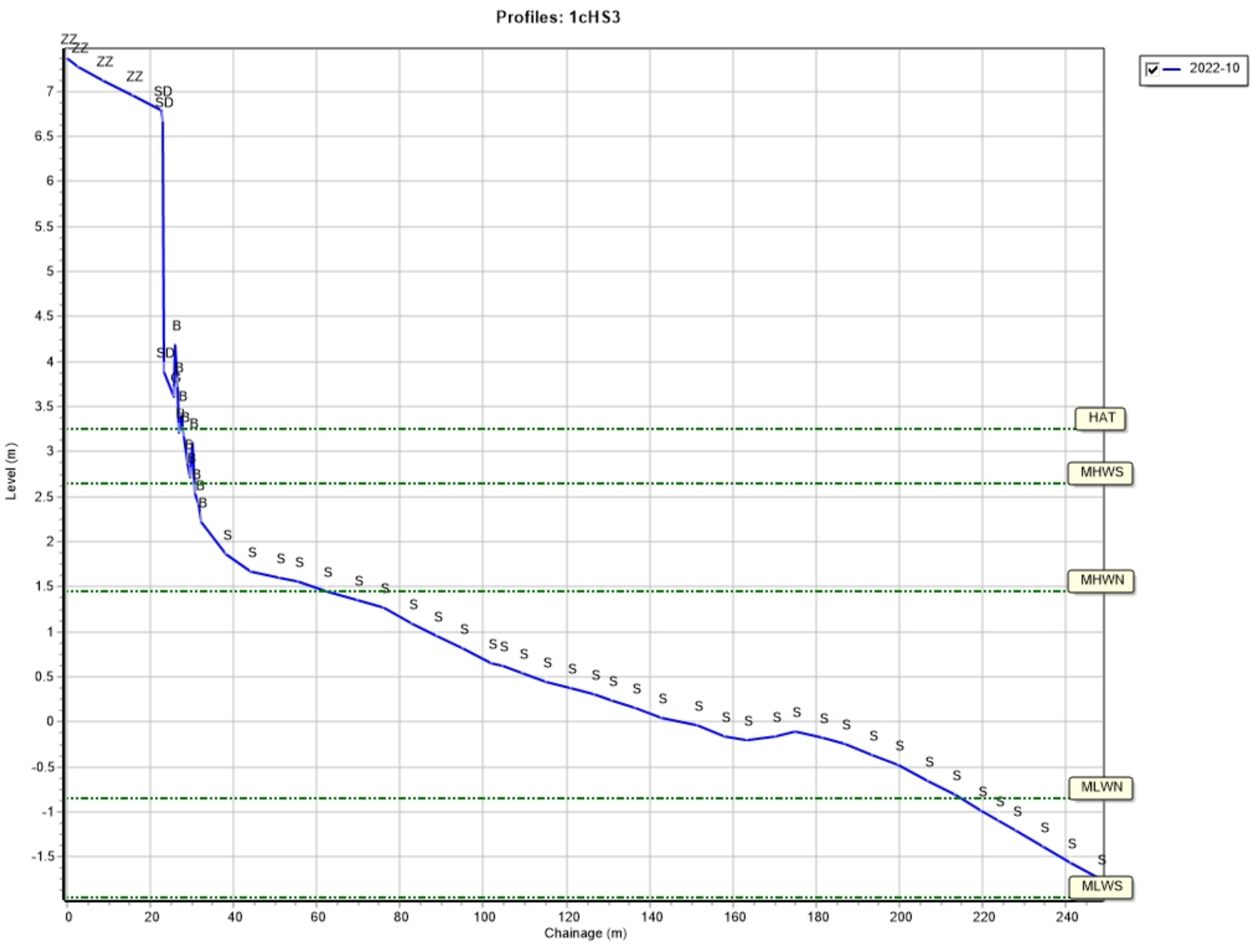
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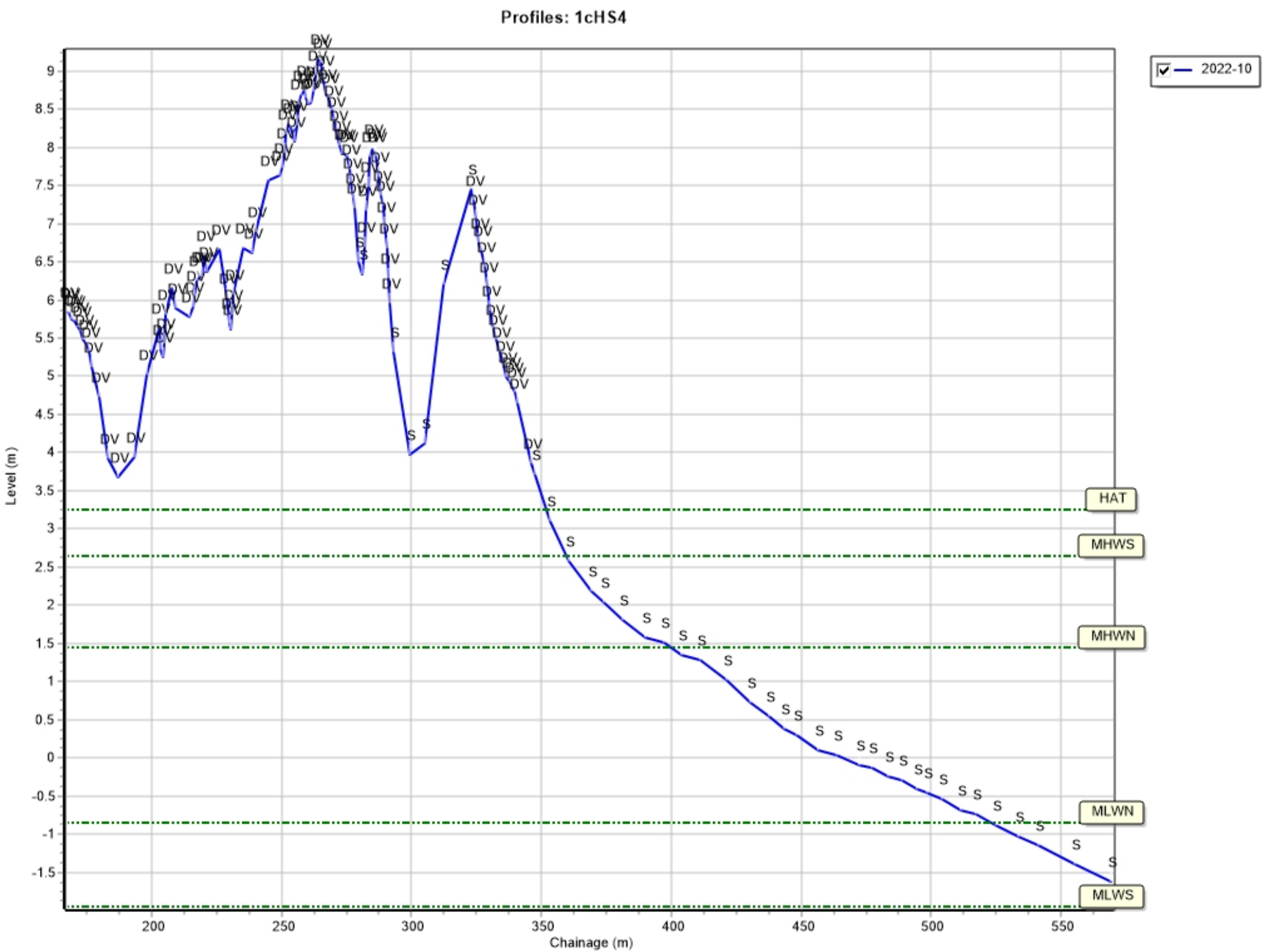
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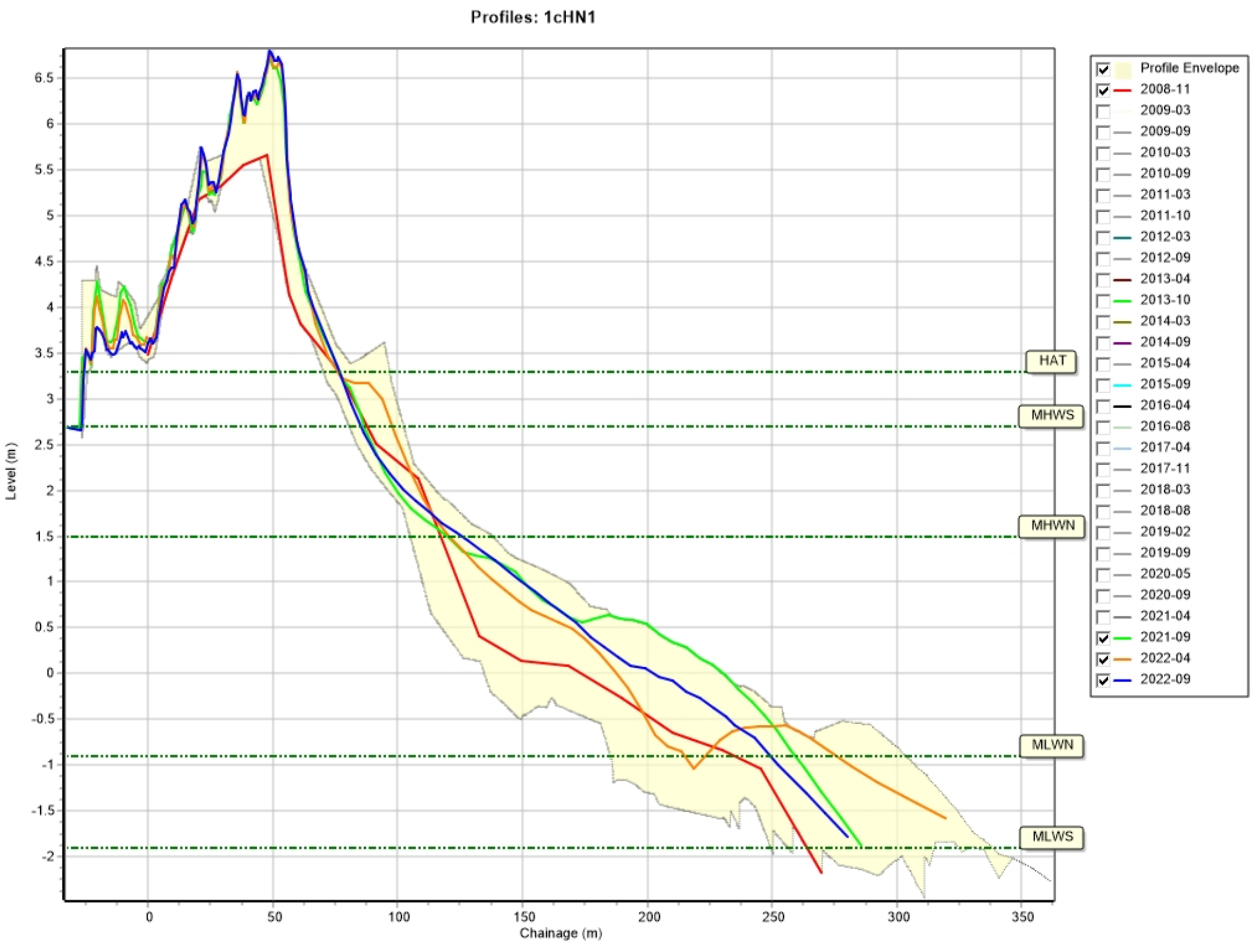
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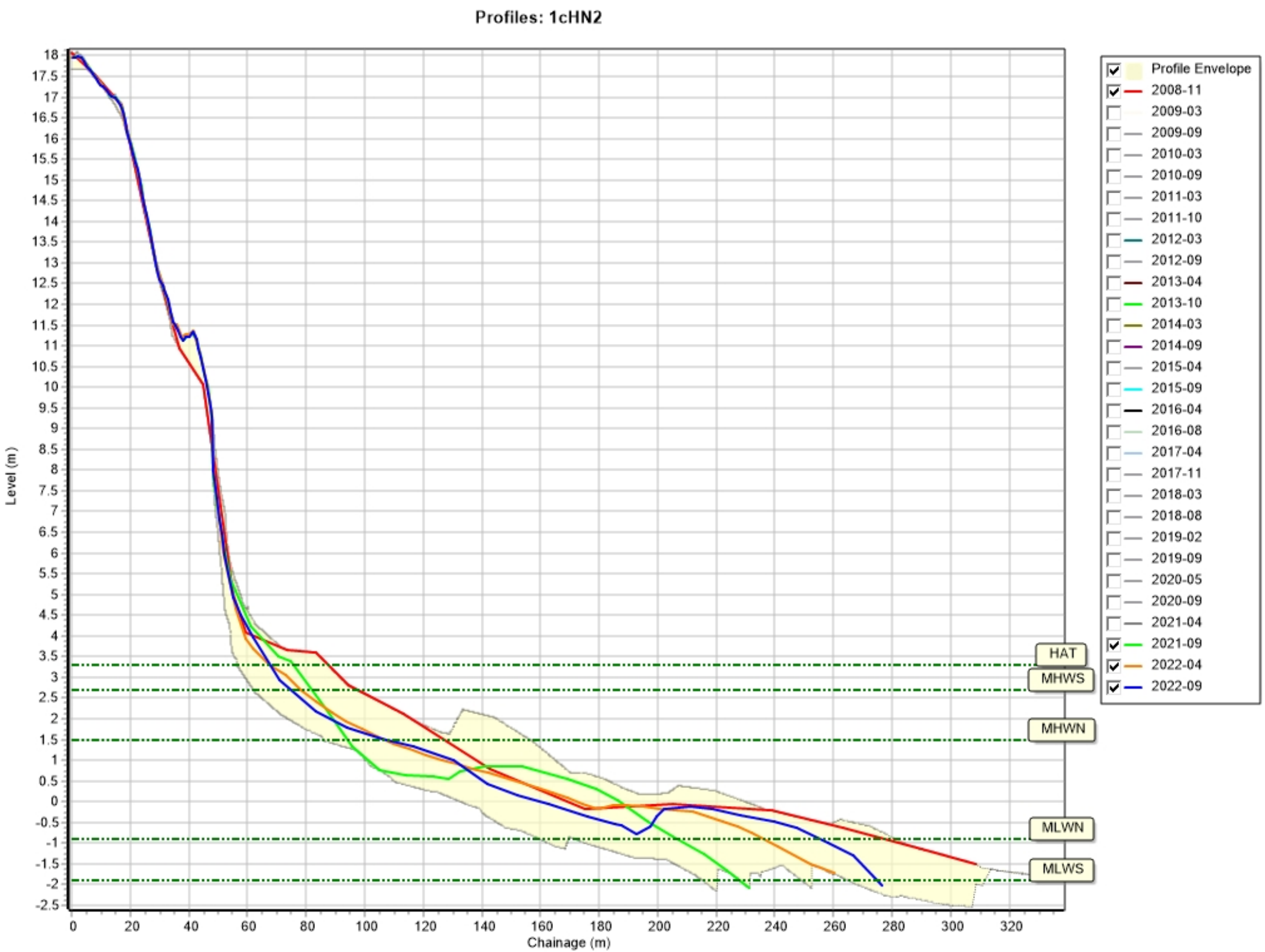
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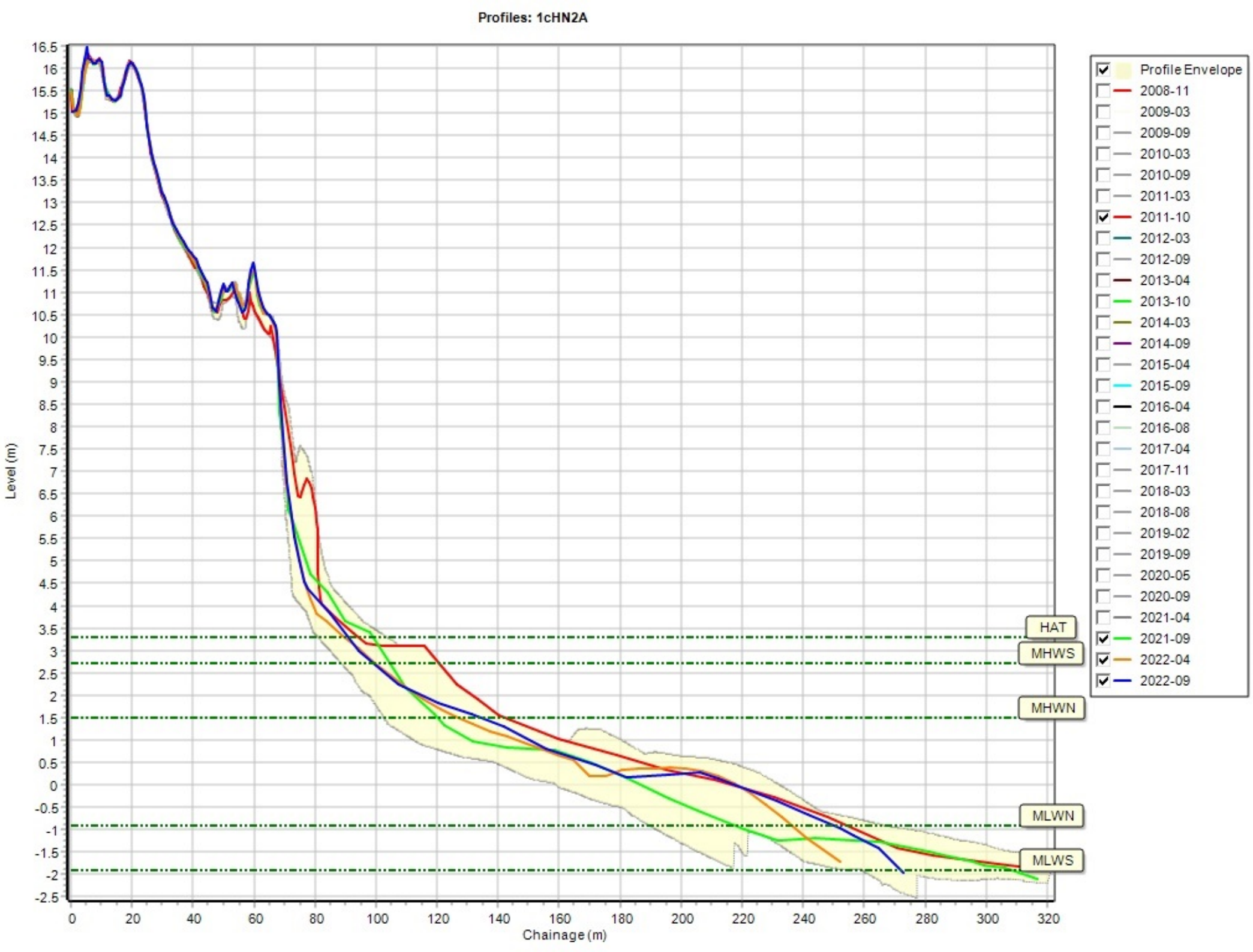
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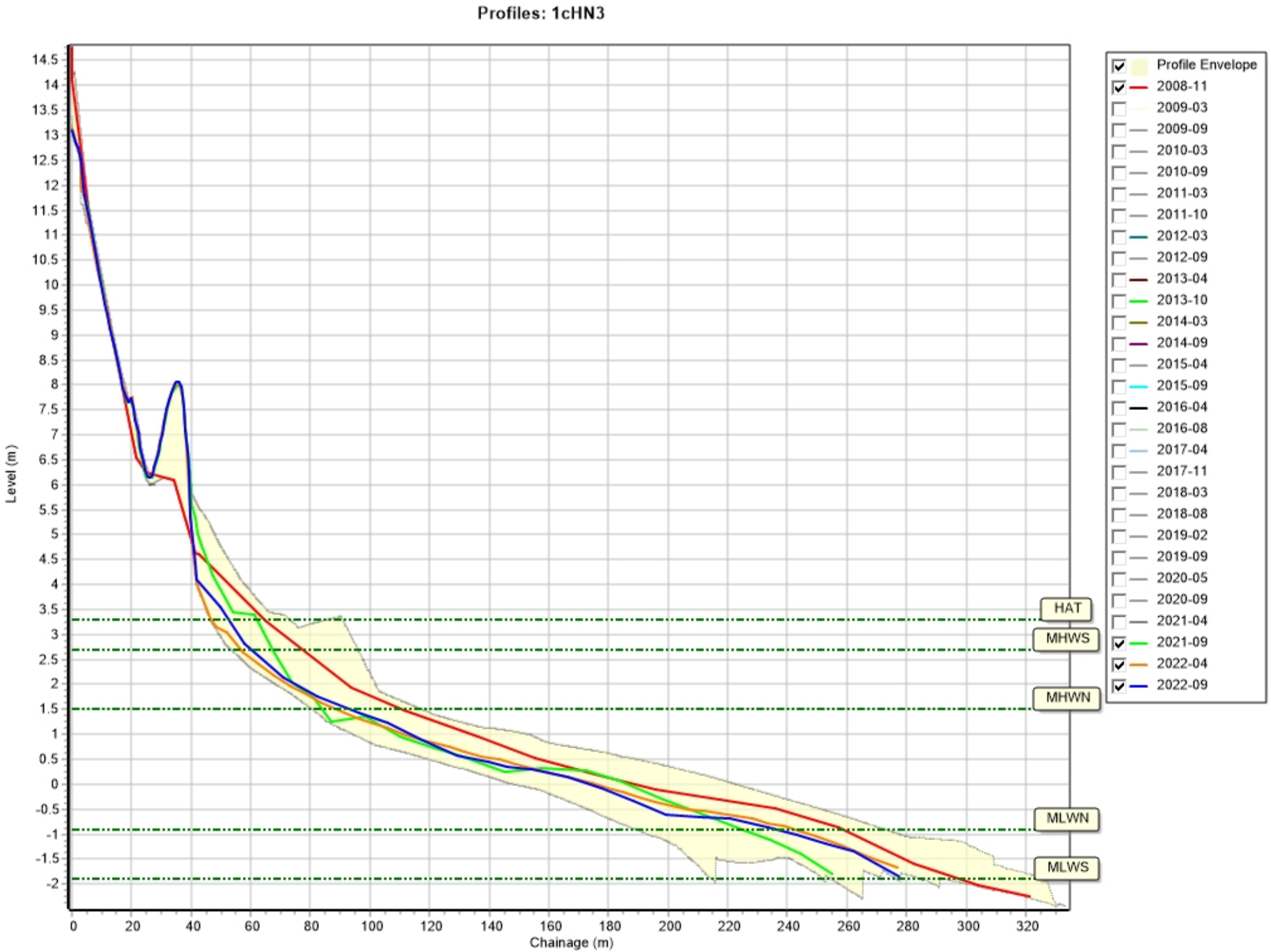
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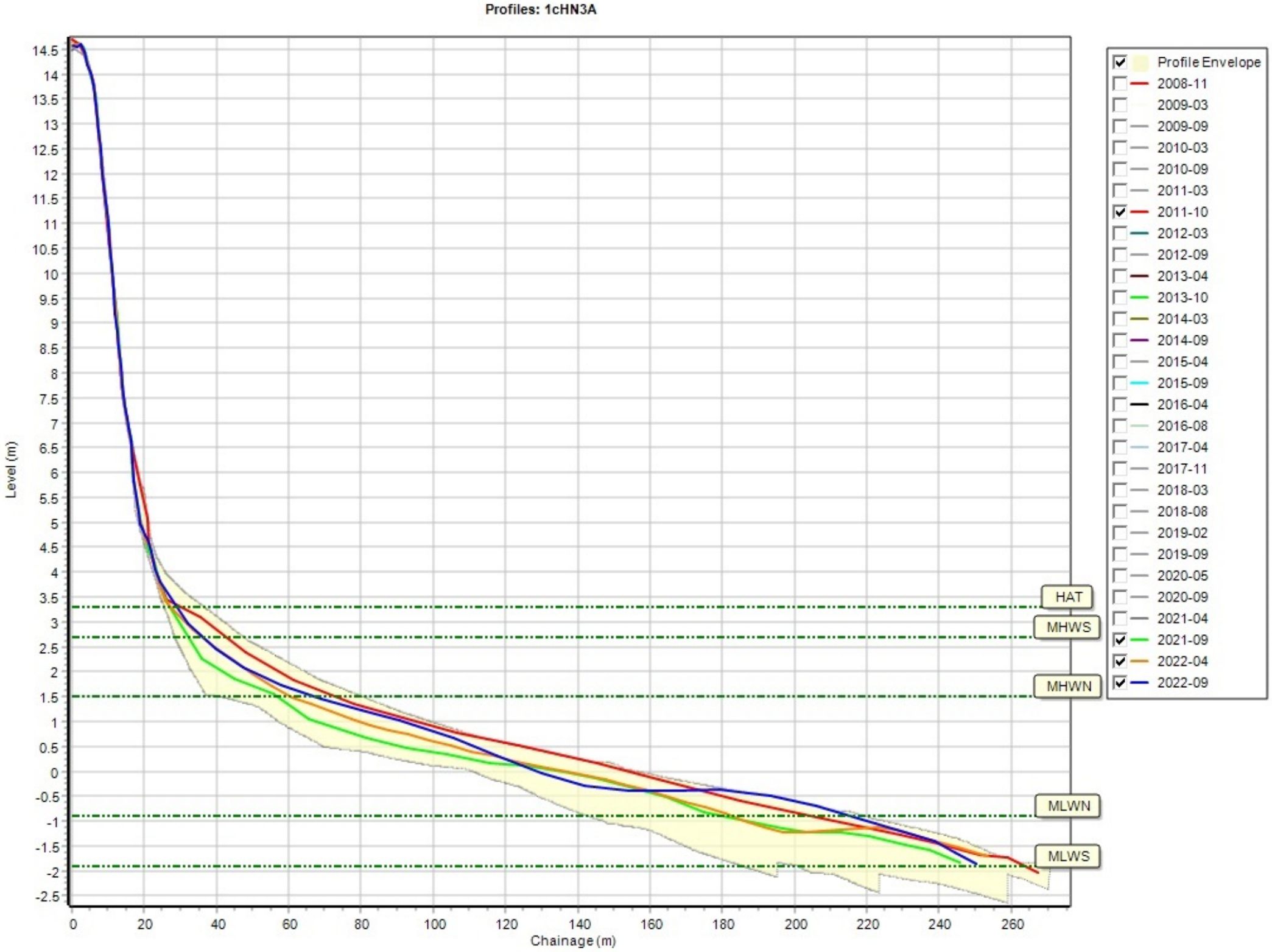
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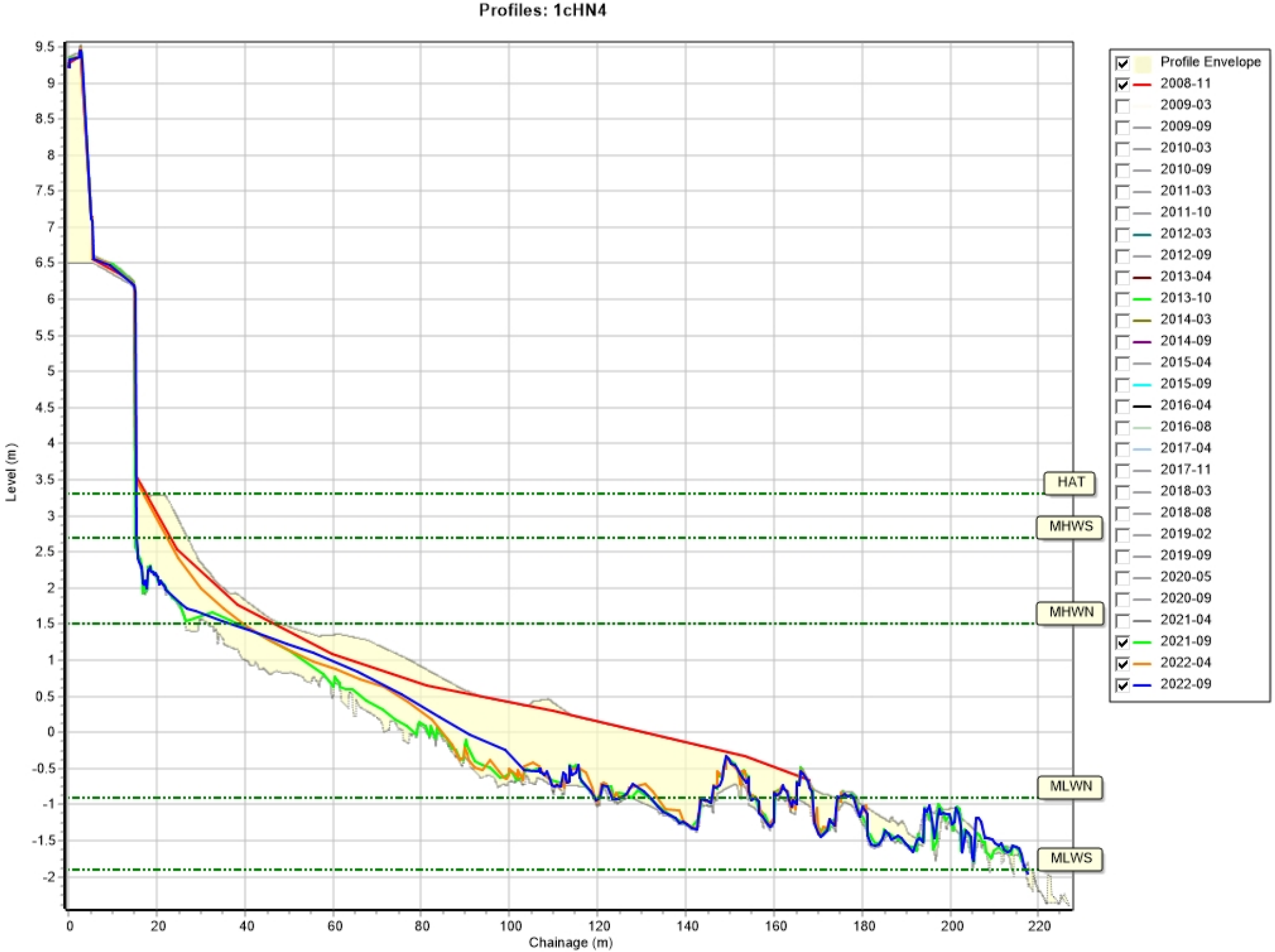
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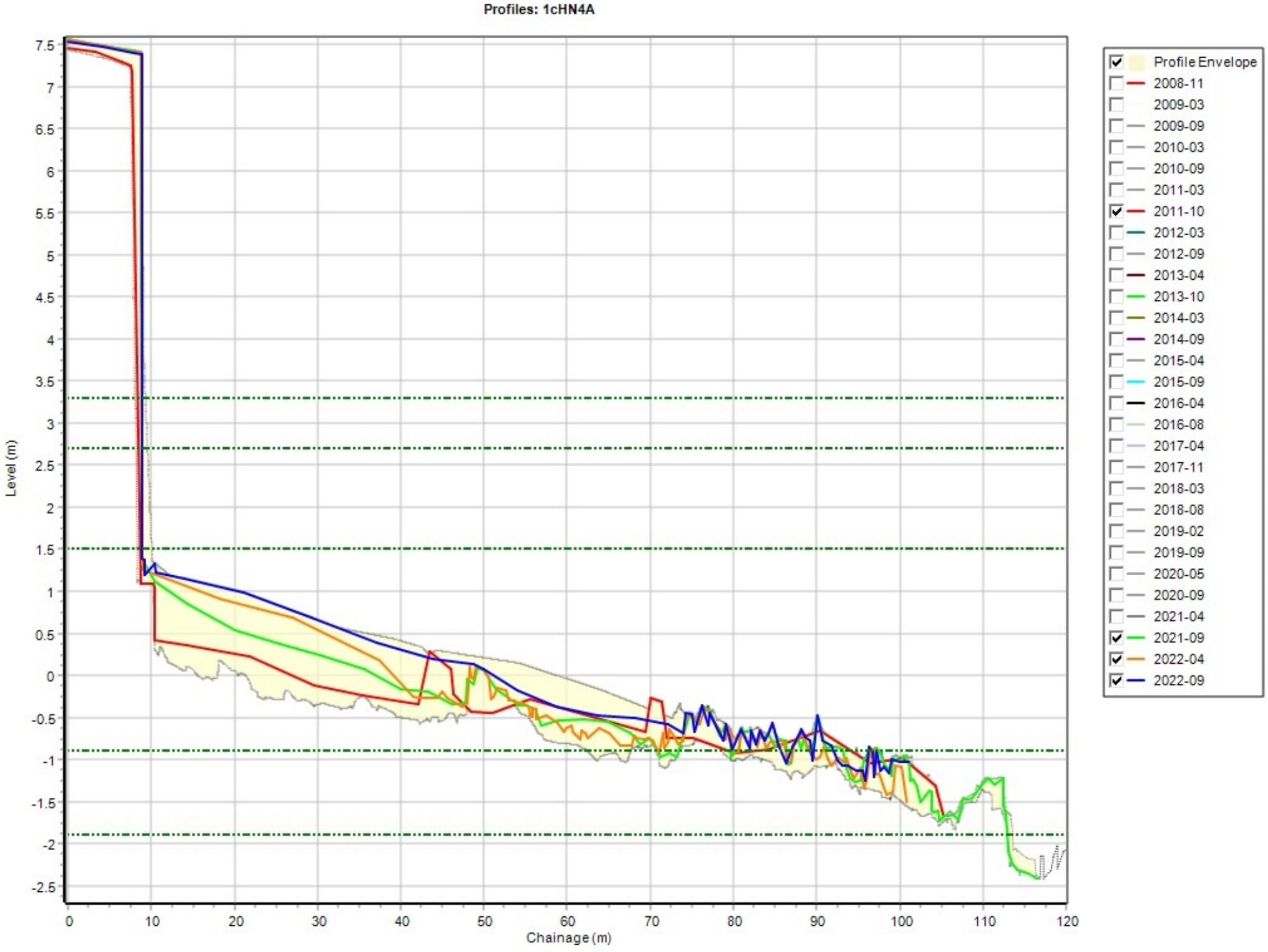
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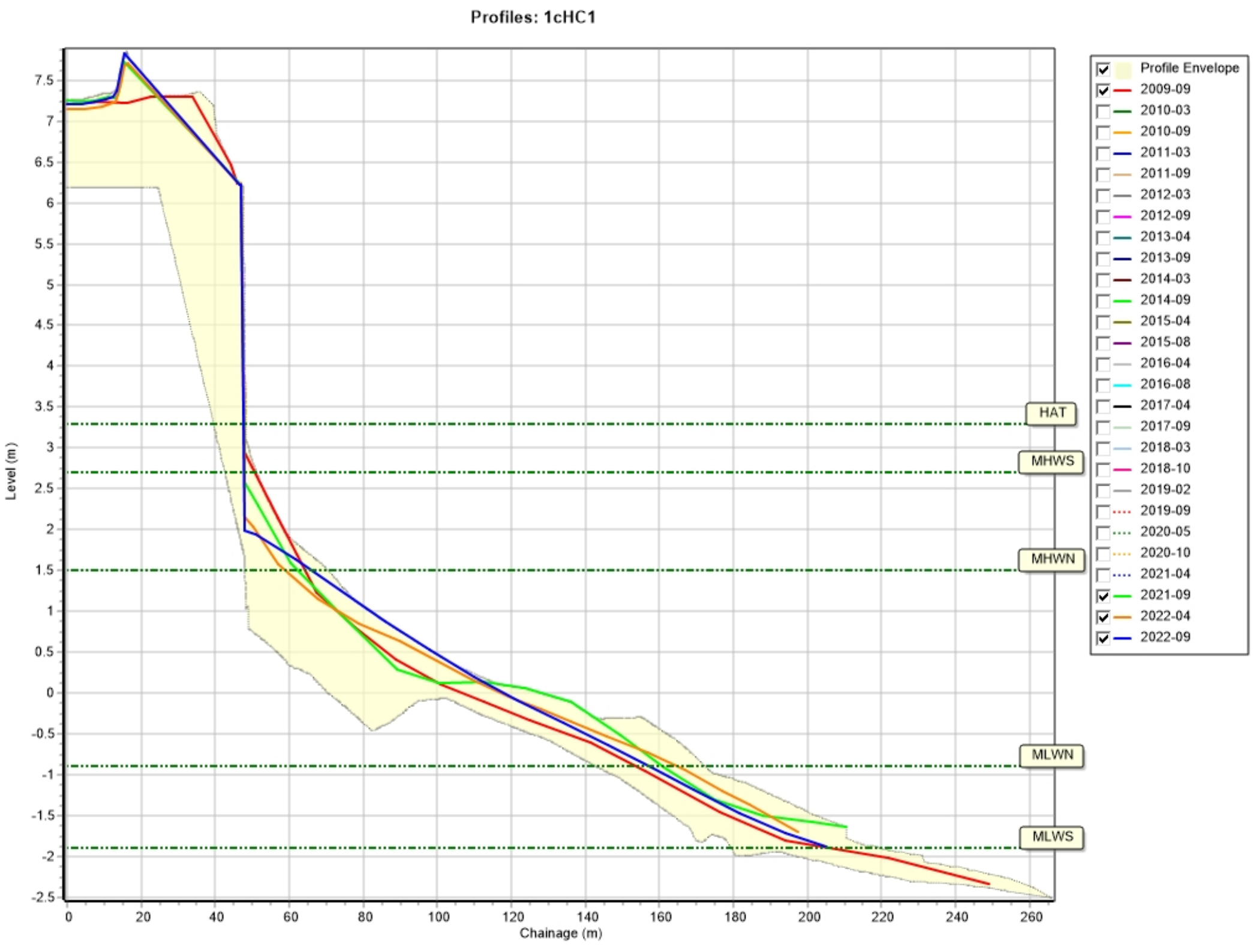
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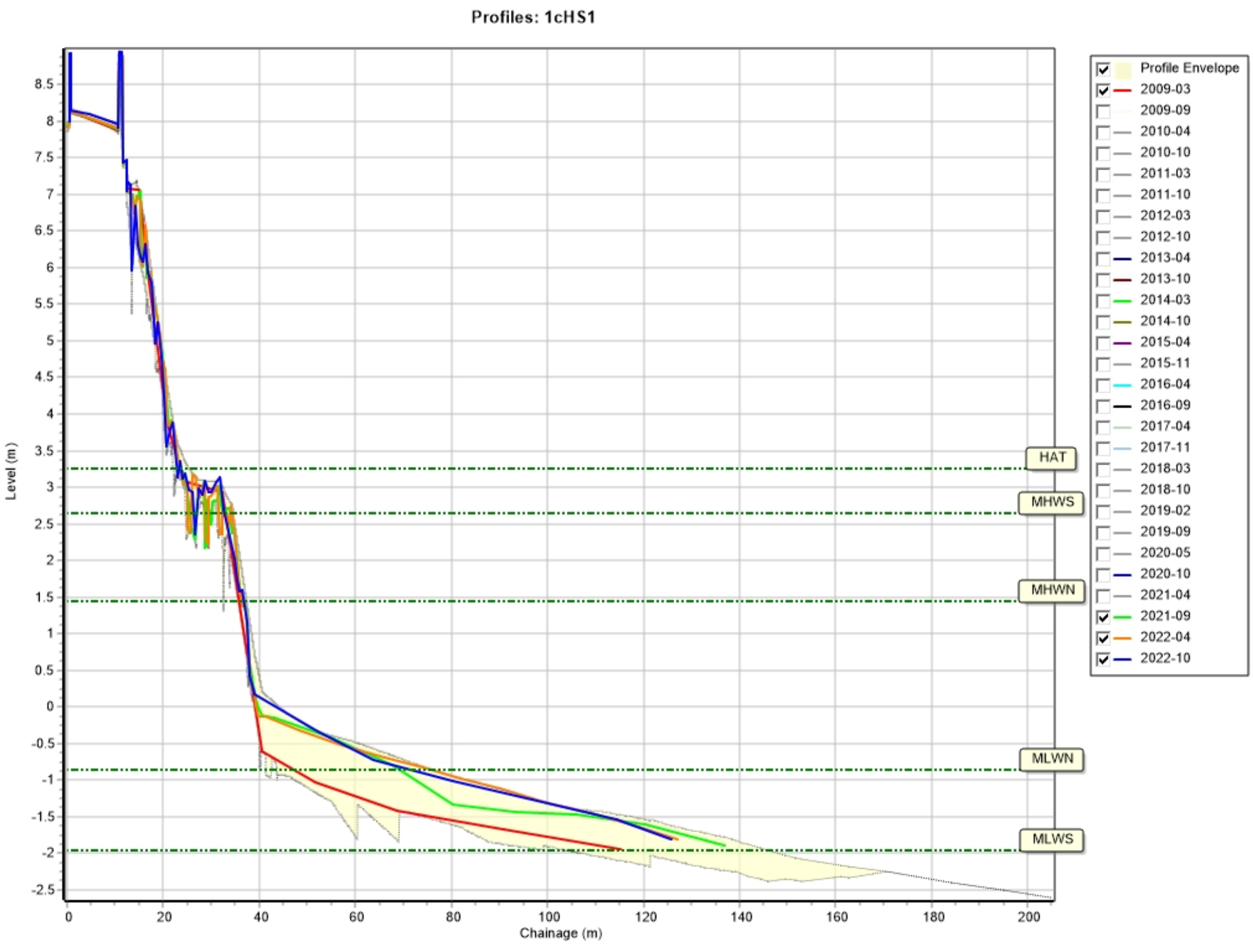
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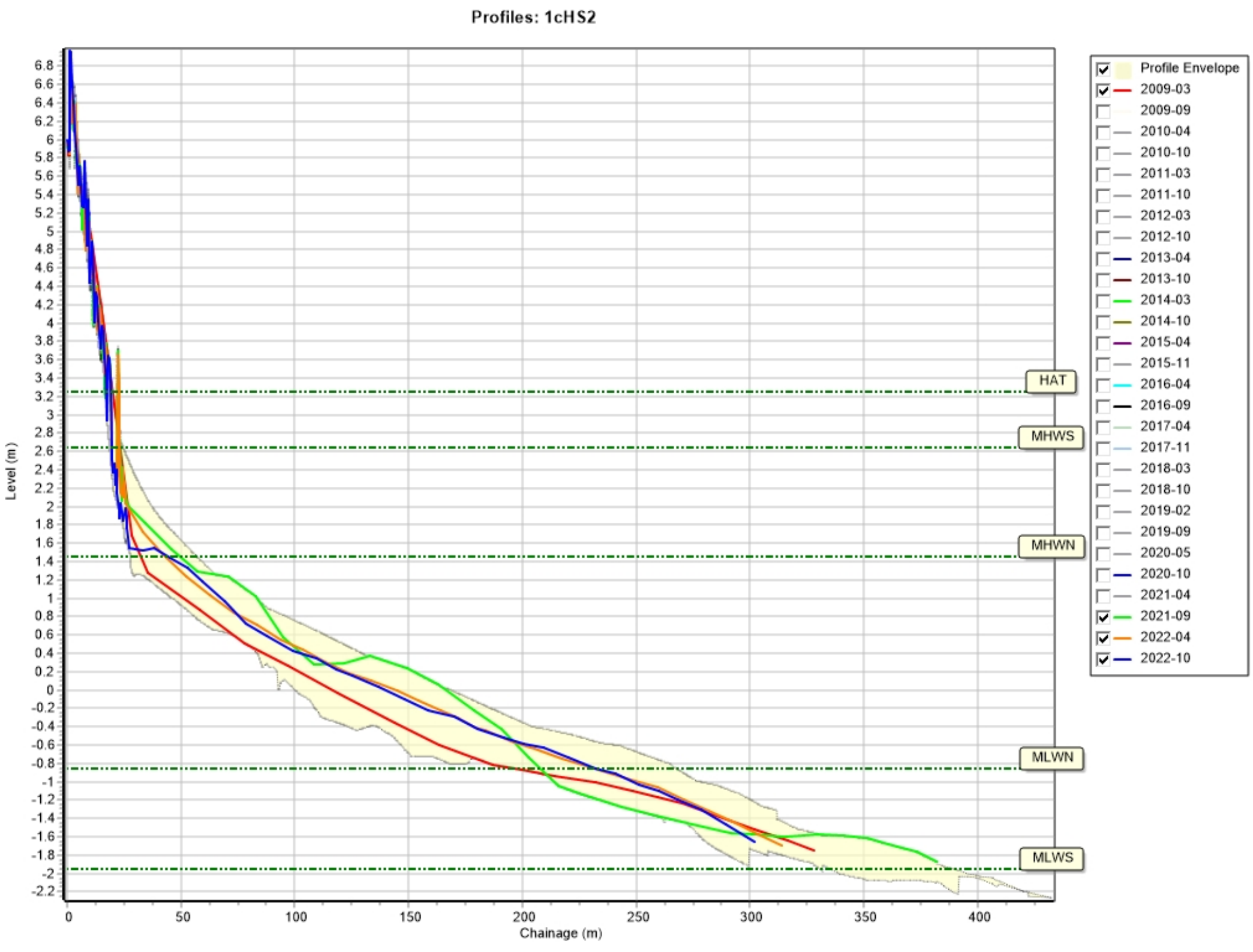
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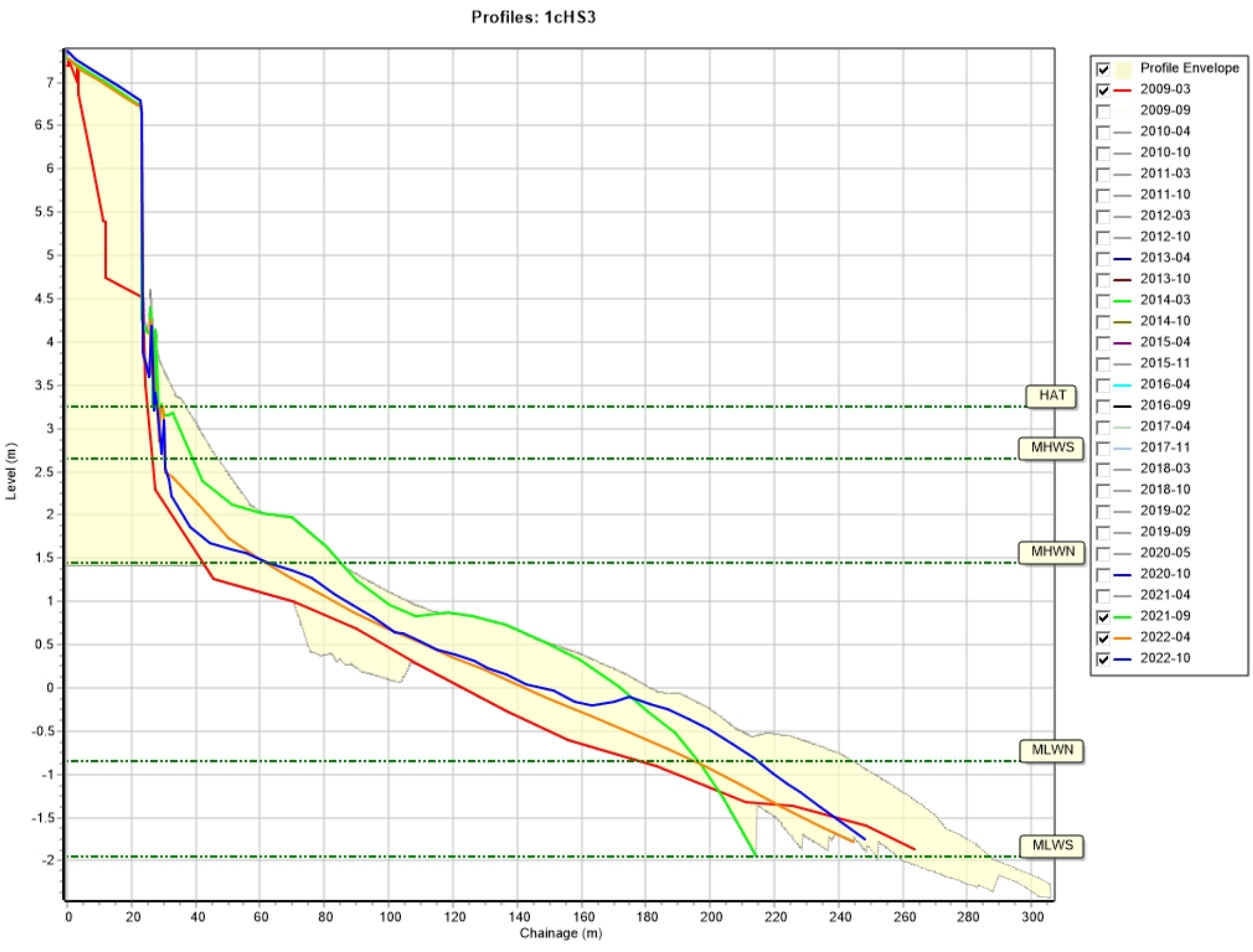
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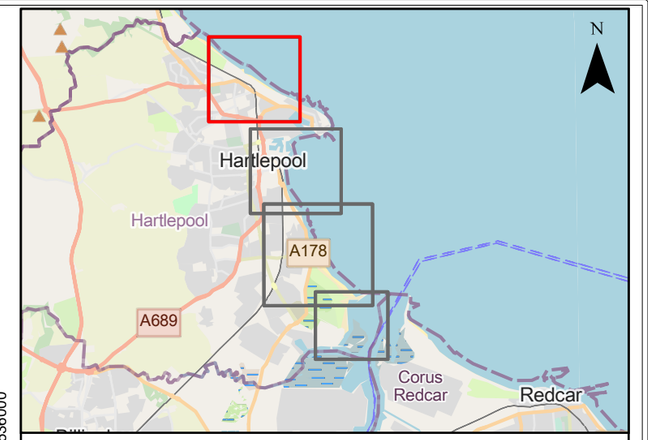
Appendix B

Topographic Survey



TOPOGRAPHIC SURVEY (September 2022)

Elevation (mOD)

- -2.7 - -2.5
- -2.4 - -2
- -1.9 - -1.5
- -1.4 - -1
- -0.9 - -0.5
- -0.4 - 0
- 0.1 - 0.5
- 0.6 - 1
- 1.1 - 1.5
- 1.6 - 2
- 2.1 - 2.5
- 2.6 - 3
- 3.1 - 3.5
- 3.6 - 4
- 4.1 - 4.5
- 4.6 - 5
- 5.1 - 5.5
- 5.6 - 6

Contours (mOD)*

- 1.0m interval
- 0.25m interval

* Contours only cover sandy beach areas.

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

Title:

Appendix B - Map 1

NORTH SANDS

Hartlepool Borough Council Frontage

Report:

Analytical Report
'Full Measures' Survey 2022

Revision:	Date:	Drawn:	Checked:	Size:	Scale:
0	14/12/2022	TC	TW	A3	1:10,000

Co-ordinate system: British National Grid

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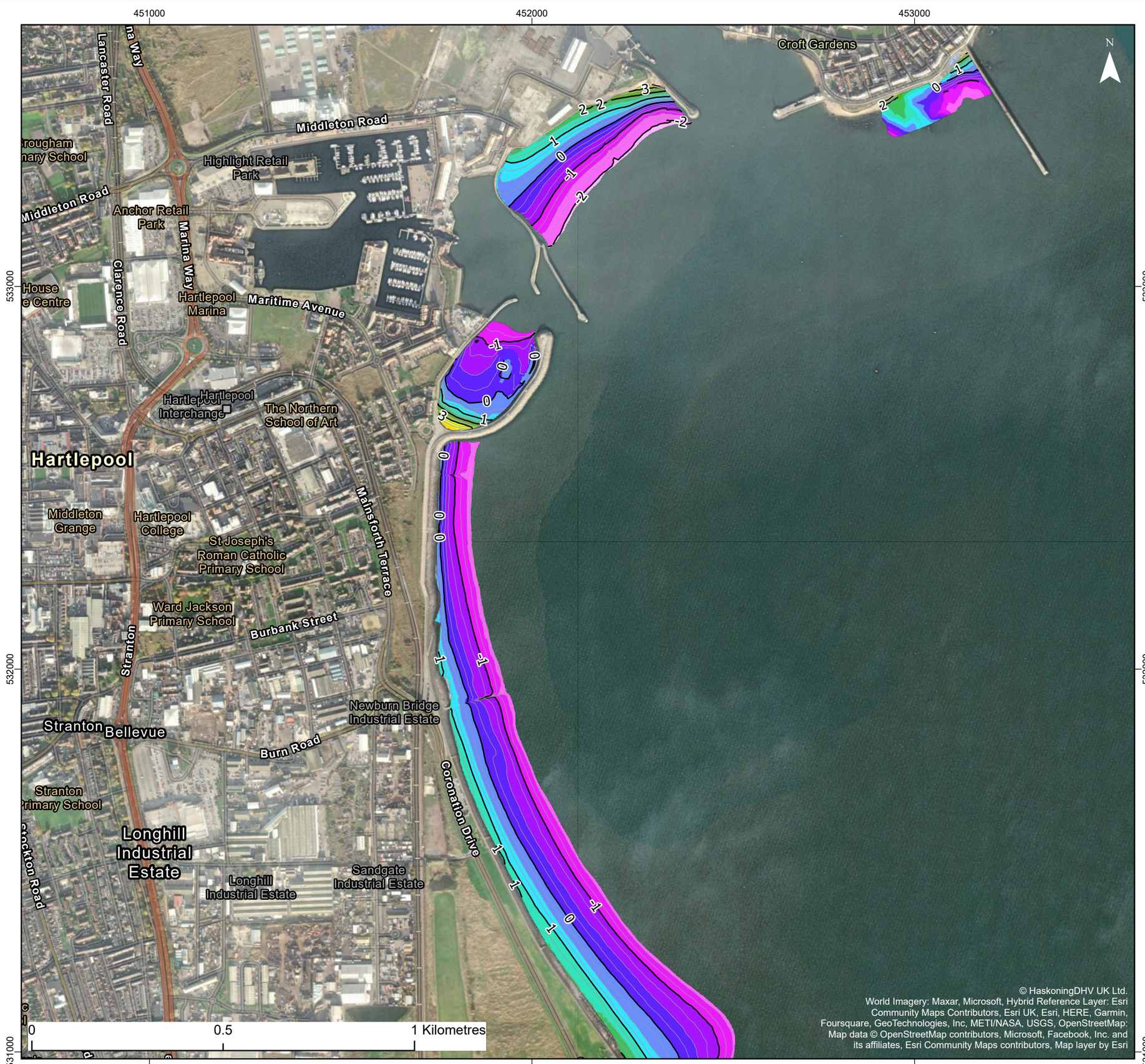

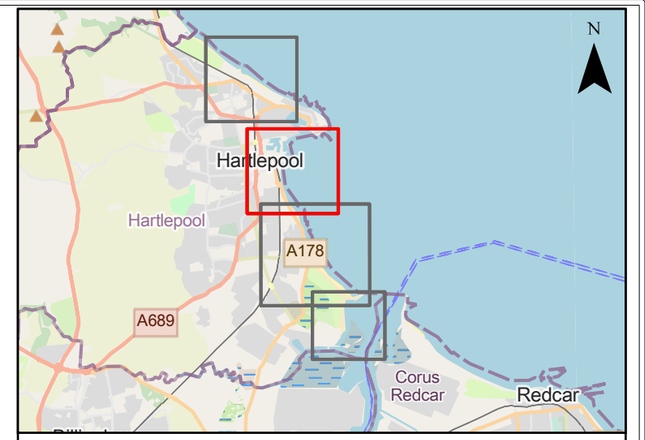

TOPOGRAPHIC SURVEY (September 2022)

Elevation (mOD)

- -2.7 - -2.5
- -2.4 - -2
- -1.9 - -1.5
- -1.4 - -1
- -0.9 - -0.5
- -0.4 - 0
- 0.1 - 0.5
- 0.6 - 1
- 1.1 - 1.5
- 1.6 - 2
- 2.1 - 2.5
- 2.6 - 3
- 3.1 - 3.5
- 3.6 - 4
- 4.1 - 4.5
- 4.6 - 5
- 5.1 - 5.5
- 5.6 - 6

Contours (mOD)*

- 1.0m interval
- 0.25m interval

* Contours only cover sandy beach areas.

Client: North East Coastal Group	Project: 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 2022

Revision:	Date:	Drawn:	Checked:	Size:	Scale:
0	14/12/2022	TC	TW	A3	1:10,000

Co-ordinate system: British National Grid

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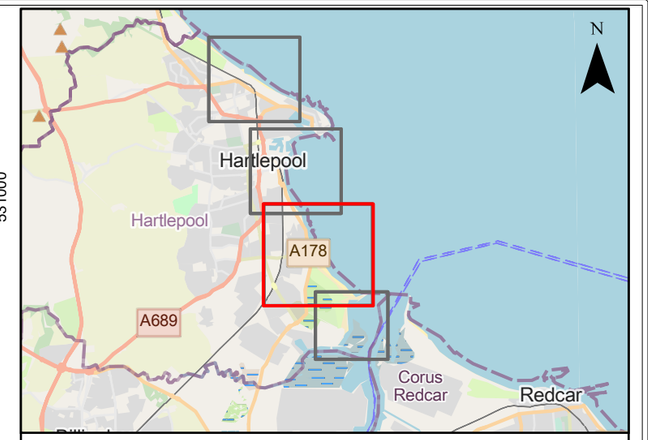
North East Coastal Observatory



TOPOGRAPHIC SURVEY (October 2022)

Elevation (mOD)

- -2.7 - -2.5
- -2.4 - -2
- -1.9 - -1.5
- -1.4 - -1
- -0.9 - -0.5
- -0.4 - 0
- 0.1 - 0.5
- 0.6 - 1
- 1.1 - 1.5
- 1.6 - 2
- 2.1 - 2.5
- 2.6 - 3
- 3.1 - 3.5
- 3.6 - 4
- 4.1 - 4.5
- 4.6 - 5
- 5.1 - 5.5
- 5.6 - 6

Contours (mOD)*

- 1.0m interval
- 0.25m interval

* Contours only cover sandy beach areas.

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

Title:

Appendix B - Map 3

HARTLEPOOL BAY (SOUTH)

Hartlepool Borough Council Frontage

Report: Analytical Report 'Full Measures' Survey 2022

Revision:	Date:	Drawn:	Checked:	Size:	Scale:
0	14/12/2022	TC	TW	A3	1:12,000

Co-ordinate system: British National Grid

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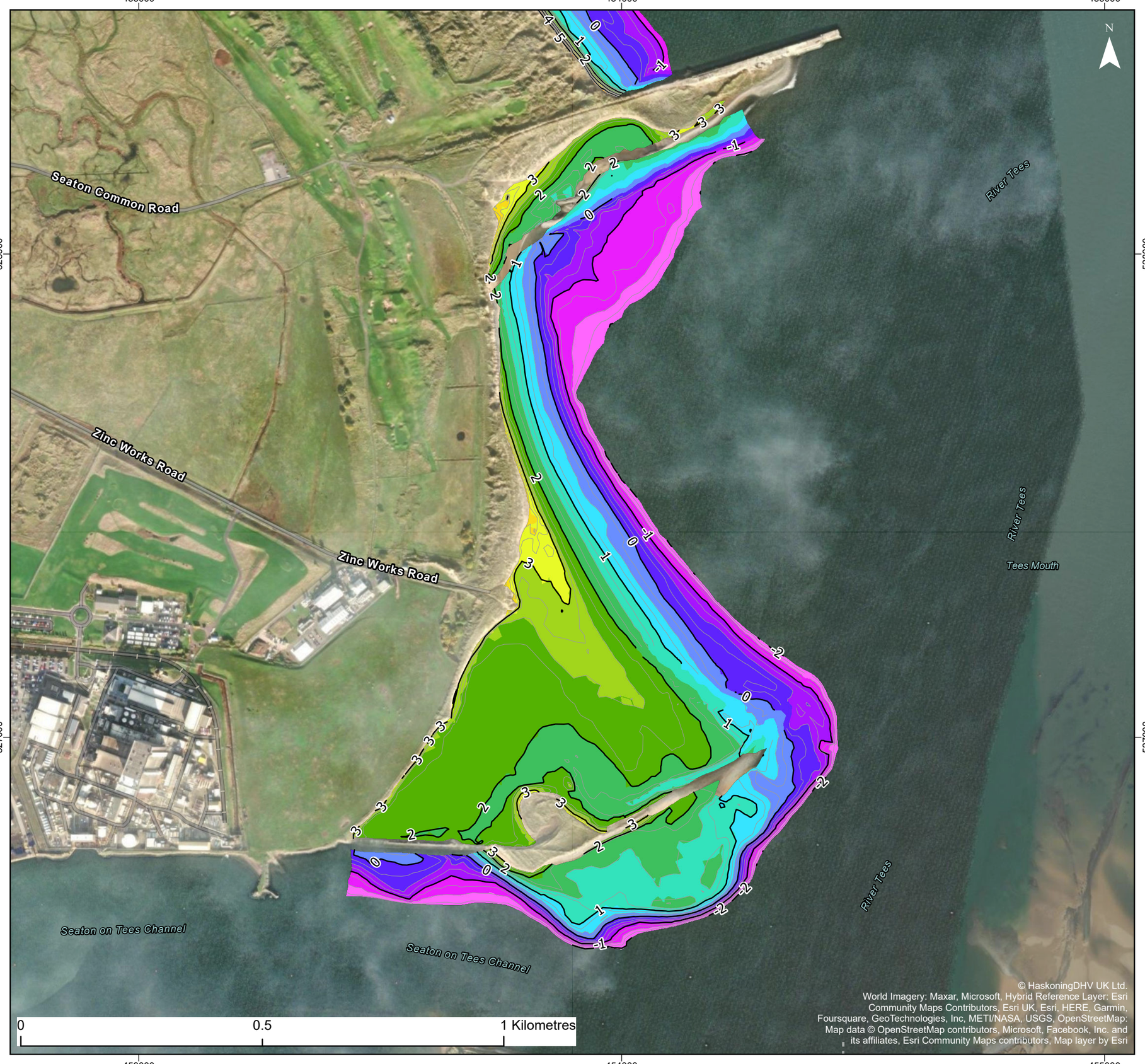
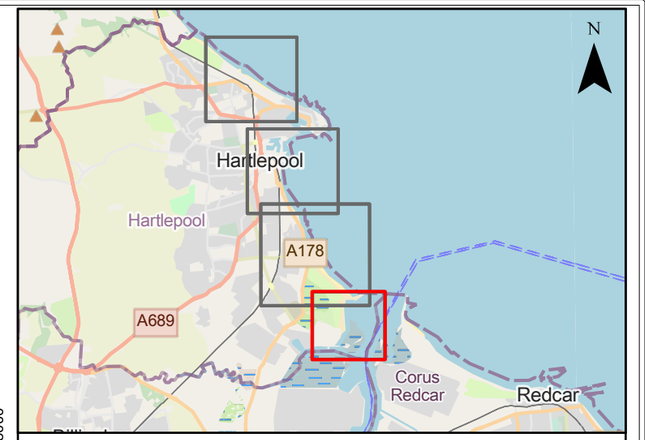
North East Coastal Observatory





TOPOGRAPHIC SURVEY (October 2022)

Elevation (mOD)

- -2.7 - -2.5
- -2.4 - -2
- -1.9 - -1.5
- -1.4 - -1
- -0.9 - -0.5
- -0.4 - 0
- 0.1 - 0.5
- 0.6 - 1
- 1.1 - 1.5
- 1.6 - 2
- 2.1 - 2.5
- 2.6 - 3
- 3.1 - 3.5
- 3.6 - 4
- 4.1 - 4.5
- 4.6 - 5
- 5.1 - 5.5
- 5.6 - 6

Contours (mOD)*

- 1.0m interval
- 0.25m interval

* 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 2022

Revision:	Date:	Drawn:	Checked:	Size:	Scale:
0	14/12/2022	TC	TW	A3	1:8,000

Co-ordinate system: British National Grid

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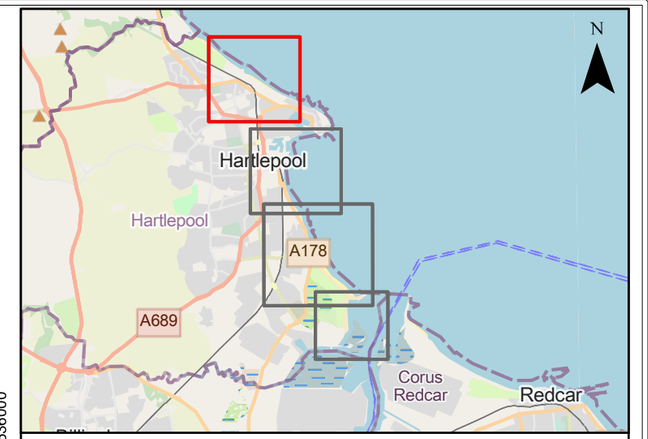
450000
451000
452000
536000
535000
534000
N
Oswy Drive
St John Vianney Roman Catholic Primary School
West View
West View Road
Bruce Crescent
Miers Avenue
West View Cemetery
Davison Drive
Winterbottom Avenue
Mayfield Park
West View Sports Academy
Old Cemetery
New Friarage
Old Cemetery Road
St Bega's Roman Catholic Primary School
Sheraton Court
University Hospital of Hartlepool
Alice House
Oakesway Business Park
ACE Northern Education Trust
Cleveland Road
The Slake
Northgate
A179
A1048
Powlett Road
0
0.5
1 Kilometres
© HaskoningDHV UK Ltd.
World Imagery: Maxar, Microsoft, Hybrid Reference Layer: Esri Community Maps Contributors, Esri UK, Esri, HERE, Garmin, Foursquare, GeoTechnologies, Inc, METI/NASA, USGS, OpenStreetMap: Map data © OpenStreetMap contributors, Microsoft, Facebook, Inc. and its affiliates, Esri Community Maps contributors, Map layer by Esri



Difference between topographic surveys
(Sept 2021 to Sept 2022)
Change in Elevation (mOD)

Gain	>2.0
	1.75 - 2
	1.5 - 1.75
	1.25 - 1.5
	1 - 1.25
	0.75 - 1
	0.5 - 0.75
	0.25 - 0.5
	0.1 - 0.25
Change +/- 0.1m	0 - 0.1
	-0.1 - 0
Loss	-0.25 - -0.1
	-0.5 - -0.25
	-0.75 - -0.5
	-1 - -0.75
	-1.25 - -1
	-1.5 - -1.25
	-1.75 - -1.5
	-2 - -1.75
	<-2

Client: North East Coastal Group

Project: Cell 1 Regional Coastal Monitoring Programme

Title:

Appendix B - Map 5

NORTH SANDS

Hartlepool Borough Council Frontage

Report: Analytical Report 'Full Measures' Survey 2022

Revision:	Date:	Drawn:	Checked:	Size:	Scale:
0	14/12/2022	TC	TW	A3	1:10,000

Co-ordinate system: British National Grid

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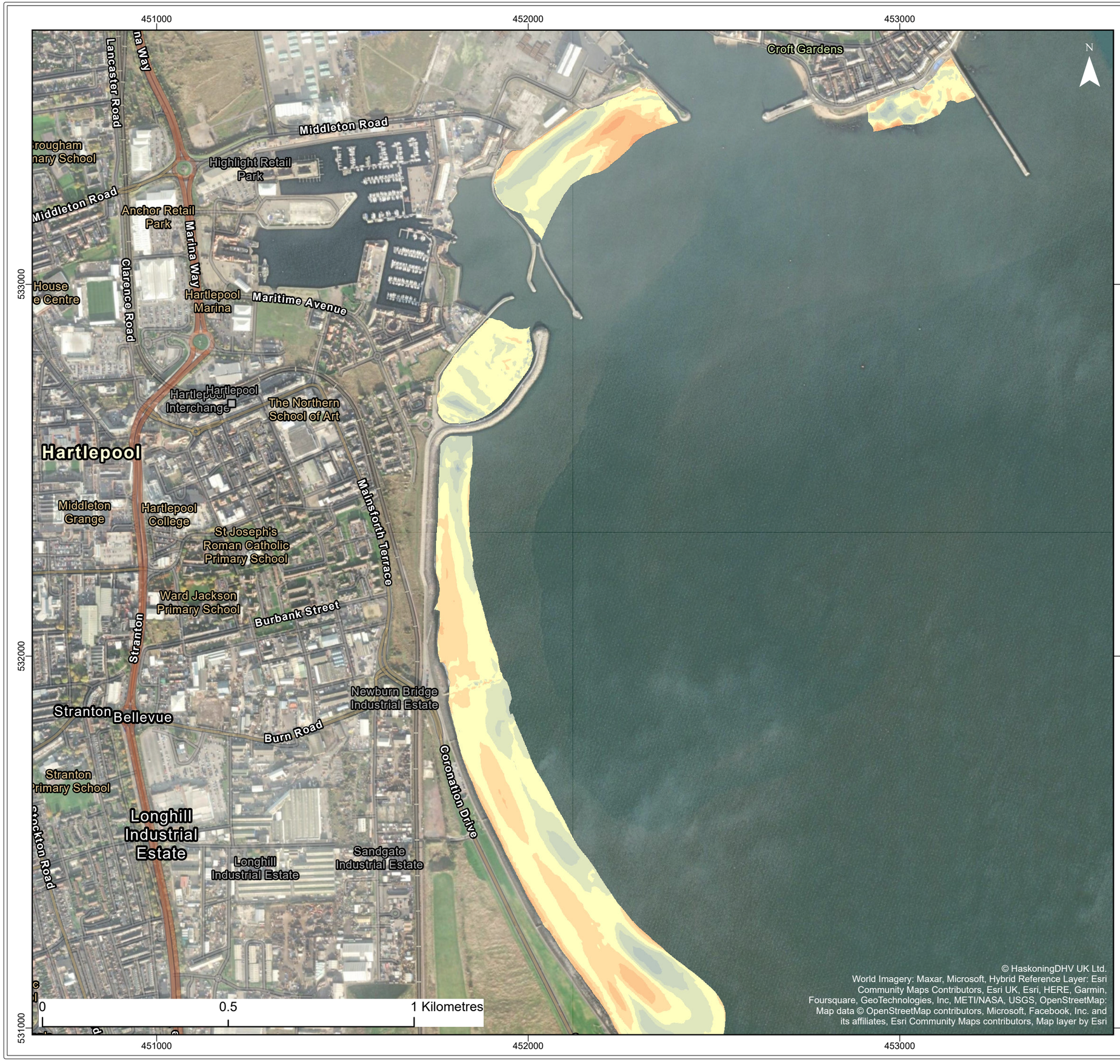

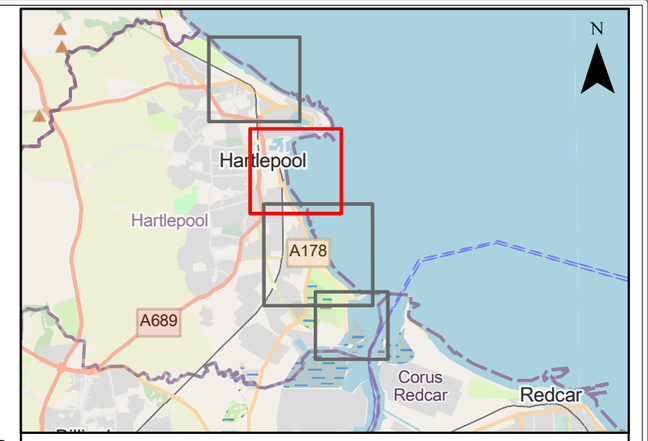

Difference between topographic surveys
(Sept 2021 to Sept 2022)
Change in Elevation (mOD)

Gain	>2.0
	1.75 - 2
	1.5 - 1.75
	1.25 - 1.5
	1 - 1.25
	0.75 - 1
	0.5 - 0.75
	0.25 - 0.5
	0.1 - 0.25
Change +/- 0.1m	0 - 0.1
	-0.1 - 0
Loss	-0.25 - -0.1
	-0.5 - -0.25
	-0.75 - -0.5
	-1 - -0.75
	-1.25 - -1
	-1.5 - -1.25
	-1.75 - -1.5
	-2 - -1.75
	<-2

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 2022

Revision:	Date:	Drawn:	Checked:	Size:	Scale:
0	14/12/2022	TC	TW	A3	1:10,000

Co-ordinate system: British National Grid

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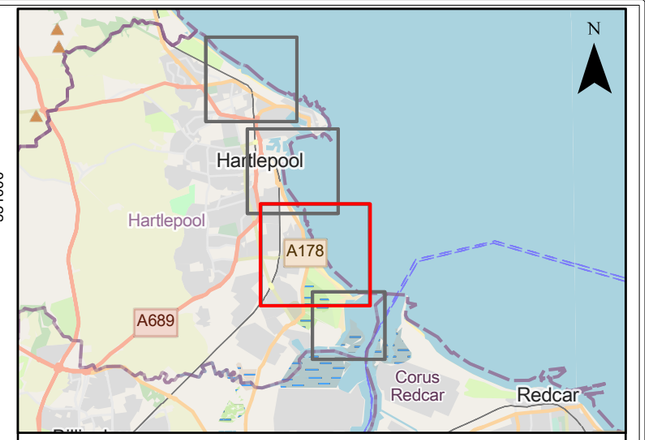

Difference between topographic surveys
(Sept 2021 to Oct 2022)
Change in Elevation (mOD)

Gain	>2.0
	1.75 - 2
	1.5 - 1.75
	1.25 - 1.5
	1 - 1.25
	0.75 - 1
	0.5 - 0.75
	0.25 - 0.5
	0.1 - 0.25
Change +/- 0.1m	0 - 0.1
	-0.1 - 0
Loss	-0.25 - -0.1
	-0.5 - -0.25
	-0.75 - -0.5
	-1 - -0.75
	-1.25 - -1
	-1.5 - -1.25
	-1.75 - -1.5
	-2 - -1.75
	<-2

Client: North East Coastal Group

Project: Cell 1 Regional Coastal Monitoring Programme

Title:

Appendix B - Map 7

HARTLEPOOL BAY (SOUTH)

Hartlepool Borough Council Frontage

Report: Analytical Report 'Full Measures' Survey 2022

Revision:	Date:	Drawn:	Checked:	Size:	Scale:
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Co-ordinate system: British National Grid

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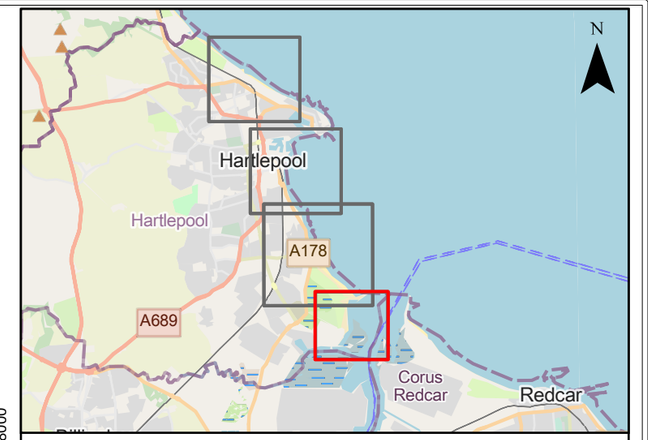

Difference between topographic surveys
(Sept 2021 to Oct 2022)

Change in Elevation (mOD)

- Gain
  - >2.0
  - 1.75 - 2
  - 1.5 - 1.75
  - 1.25 - 1.5
  - 1 - 1.25
  - 0.75 - 1
  - 0.5 - 0.75
  - 0.25 - 0.5
  - 0.1 - 0.25
- Change +/- 0.1m
  - 0 - 0.1
  - -0.1 - 0
- Loss
  - -0.25 - -0.1
  - -0.5 - -0.25
  - -0.75 - -0.5
  - -1 - -0.75
  - -1.25 - -1
  - -1.5 - -1.25
  - -1.75 - -1.5
  - -2 - -1.75
  - <-2

Shingle Ridge Alignment

- October 2022
- September 2021

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

Title:

Appendix B - Map 8

NORTH GARE

Hartlepool Borough Council Frontage

Report:

Analytical Report
'Full Measures' Survey 2022

Revision:	Date:	Drawn:	Checked:	Size:	Scale:
0	14/12/2022	TC	TW	A3	1:8,000

Co-ordinate system: British National Grid

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