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COUNCIL



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Cell 1 Regional Coastal Monitoring Programme Analytical Report 16: Full Measures Survey 2023



**North Yorkshire Council
February 2024**

Contents

Disclaimer	ii
Abbreviations and Acronyms.....	iii
Water Levels Used in Interpretation of Changes	iii
Glossary of Terms.....	iv
Preamble	v
1. Introduction	1
1.1 Study Area.....	1
1.2 Methodology	1
2. Analysis of Survey Data	3
2.1 Staithes.....	3
2.2 Runswick Bay	5
2.3 Sandsend Beach, Upgang Beach and Whitby Sands.....	6
2.4 Robin Hood's Bay	8
2.5 Scarborough North Bay	9
2.6 Scarborough South Bay.....	11
2.7 Cayton Bay.....	13
2.8 Filey Bay.....	15
3. Problems Encountered and Uncertainty in Analysis	18
4. Recommendations for 'Fine-tuning' the Monitoring Programme	18
5. Conclusions and Areas of Concern	18

Appendices

Appendix A	Beach Profiles
Appendix B	Topographic Survey
Appendix C	Cliff Top Survey

List of Figures

Figure 1	Sediment Cells in England and Wales
Figure 2	Survey Location Maps
Figure 3	Cliff Top Survey Locations

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)	Water Level (m AOD)
	Sandsend Beach to Whitby Sands	Scarborough North Bay to Cayton Bay	Filey Bay
HAT	3.2	3.25	3.35
MHWS	2.6	2.45	2.95
MHWN	1.4	1.35	2.05
MLWN	-0.8	-0.95	-0.45
MLWS	-2.0	-2.35	-1.85

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.

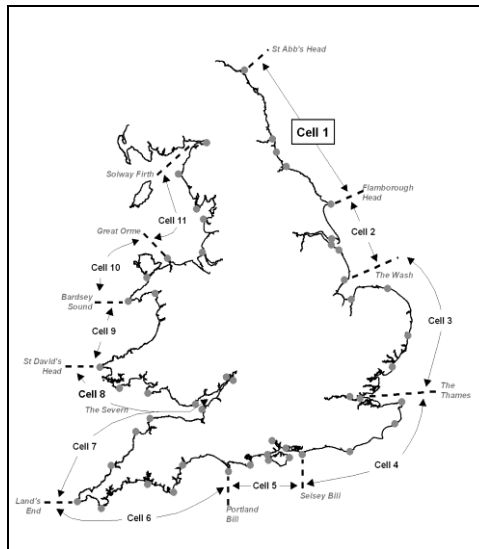


Figure 1 Sediment Cells in England and Wales

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	Jun 09	-
2	2009/10	Sep-Dec 09	Mar 10	Feb-Mar 10	Jul 10	-
3	2010/11	Aug-Nov 10	Feb 11	Feb-Apr 11	Aug 11	Sep 11
4	2011/12	Sep 11	Aug 12	Mar-May 12	Feb 13	-
5	2012/13	Sep 12	Mar 13	Apr-May 13	May 13	-
6	2013/14	Sep 13	Feb 14	Mar-Apr 14	Jul 14	-
7	2014/15	Sep 14	Feb 15	Mar 15	Jul 15	-
8	2015/16	Sep 15	Feb 16	Mar-Apr 16	Jul 16	Jun 16
9	2016/17	Sep-Nov 16	Feb 17	Feb-Apr 17	Jul 17	-
10	2017/18	Sep-Oct 16	Jan 17	Mar-May 18	Jun 18	-
11	2018/19	Sep-Oct 18	Mar 19	Mar-Apr 19	July 19	-
12	2019/20	Sep-Nov 19	Jan 20	Feb-Apr 20	June 20	-
13	2020/21	Nov-Dec 20	Mar 21	Mar-Apr 21	Jun 21	Aug 21
14	2021/22	Oct-Nov 21	Feb 22	Apr-May 22	Aug 22	-
15	2022/23	Sept-Oct 22	Jan 23	Mar 23	June 23	-
16	2023/24	Aug-Sep 23	Feb 23	-	-	-

(*) The present report is **Analytical Report 16** and provides an analysis of the 2023 Full Measures survey for Scarborough 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 sub-sections listed in Table 2. Areas covered in the current report are highlighted.

Table 2 Sub-divisions of the Cell 1 Coastline

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

Scarborough Borough Council's frontage extends from Staithes Harbour to Speeton, in Filey Bay. For the purposes of this report, the Scarborough frontage has been sub-divided into eight areas, namely:

- Staithes
- Runswick Bay
- Sandsend Beach, Upgang Beach and Whitby Sands
- Robin Hood's Bay
- Scarborough North Bay
- Scarborough South Bay
- Cayton Bay
- Filey Bay

1.2 Methodology

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

- Full Measures survey annually each autumn/early winter comprising:
 - Beach profile surveys along 20 transect lines
 - Topographic survey at Runswick Bay
 - Topographic survey along the Sandsend to Whitby frontage
 - Topographic survey at Robin Hood's Bay
 - Topographic survey at Scarborough North Bay
 - Topographic survey at Scarborough South Bay
 - Topographic survey at Cayton Bay
 - Topographic survey at Filey Bay
- Partial Measures survey annually each spring comprising:
 - Beach profile surveys along 20 transect lines
 - Topographic survey at Runswick Bay
 - Topographic survey at Robin Hood's Bay
 - Topographic survey at Filey Bay (Town coverage)
- Cliff top survey bi-annually at:
 - Staithes
 - Robin Hood's Bay (added Spring 2010)
 - Scarborough South Bay (added Spring 2010)
 - Cayton Bay
 - Filey

The location of these surveys is shown in Figure 2. Full Measures surveys were undertaken along this frontage between August and September 2023. The weather and sea state varied in that time, for details of the survey conditions refer to the Academy Geomatics survey reports for each location.

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

- Cliff Top Survey Points (refer to Figure 3 for details)

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

Title: **Figure 2 - Map 1**
RUNSWICK BAY
Scarborough Borough Council Frontage

Report: **Survey Report**

Revision:	Date:	Drawn:	Checked:	Size:	Scale:
0	n/a	TC	NJC	A4	1:10,000

Co-ordinate system: British National Grid

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SURVEY LOCATIONS

Topographic Profile

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

Topographic Area

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

- Cliff Top Survey Points (Red dot)

(refer to Figure 3 for details)

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

Title:

Figure 2 - Map 2

SANDSEND TO WHITBY

Scarborough Borough Council Frontage

Report:

Survey Report

Revision:	Date:	Drawn:	Checked:	Size:	Scale:
0	n/a	TC	NJC	A4	1:25,000

Co-ordinate system: British National Grid




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- SURVEY LOCATIONS**
- Topographic Profile**
- Annual
 - Bi-Annual
- Topographic Area**
- 6 monthly
 - yearly
 - 5 yearly
- Cliff Top Survey Points
(refer to Figure 3 for details)

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

Title: **Figure 2 - Map 3**
ROBIN HOOD'S BAY
Scarborough 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

- Cliff Top Survey Points
(refer to Figure 3 for details)

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

Title: **Figure 2 - Map 4**
SCARBOROUGH NORTH BAY
Scarborough 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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 UK, Sandstone, Garmin, INCREMENT P, METANASA, USGS



SURVEY LOCATIONS

Topographic Profile

- Annual
- Bi-Annual

Topographic Area

- 6 monthly
- yearly
- 5 yearly

- Cliff Top Survey Points (refer to Figure 3 for details)

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

Title:

Figure 2 - Map 5

SCARBOROUGH SOUTH BAY

Scarborough 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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SURVEY LOCATIONS

Topographic Profile

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

Topographic Area

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

● Cliff Top Survey Points (refer to Figure 3 for details)

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

Title: **Figure 2 - Map 6**
CAYTON BAY
Scarborough 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

- Cliff Top Survey Points (refer to Figure 3 for details)

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

Title: **Figure 2 - Map 7**
FILEY BAY
Scarborough Borough Council Frontage

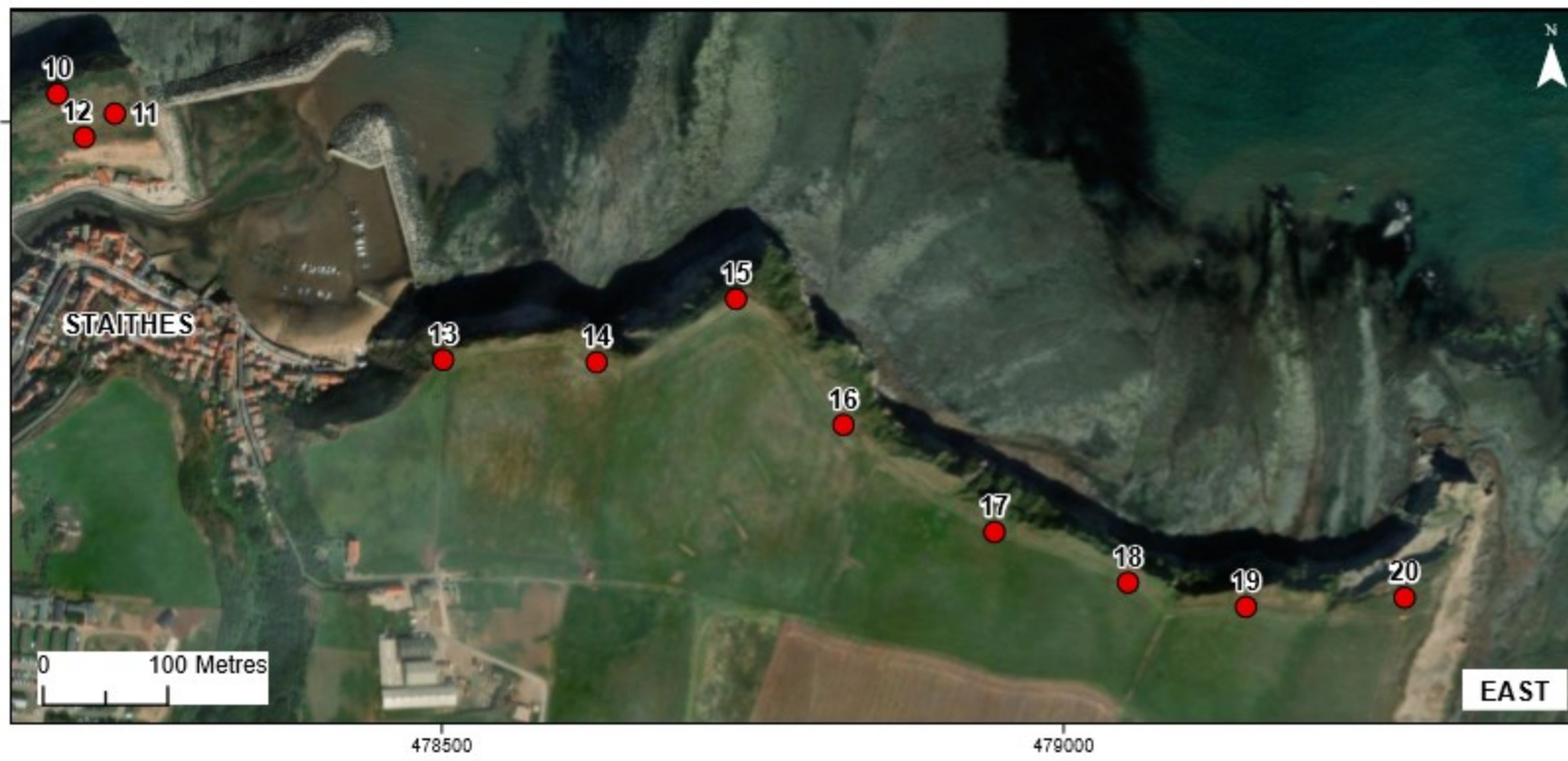
Report: **Survey Report**

Revision:	Date:	Drawn:	Checked:	Size:	Scale:
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SURVEY LOCATIONS

- Cliff Top Survey Points

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

Title:
Figure 3 - Map 1
STAITHES
Scarborough Borough Council Frontage

Report:
Survey Report

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





SURVEY LOCATIONS
 ● Cliff Top Survey Points

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

Title:
Figure 3 - Map 2
ROBIN HOOD'S BAY
Scarborough Borough Council Frontage

Report:
 Survey Report

Revision:	Date:	Drawn:	Checked:	Size:	Scale:
0	n/a	TC	NJC	A4	1:10,000

Co-ordinate system: British National Grid





SURVEY LOCATIONS

● Cliff Top Survey Points

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

Title:

Figure 3 - Map 3

SCARBOROUGH SOUTH BAY

Scarborough 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





SURVEY LOCATIONS

- Cliff Top Survey Points

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

Title: **Figure 3 - Map 4**
CAYTON BAY
Scarborough Borough Council Frontage

Report: **Survey Report**

Revision:	Date:	Drawn:	Checked:	Size:	Scale:
0	n/a	TC	NJC	A4	1:10,000

Co-ordinate system: British National Grid





SURVEY LOCATIONS
 ● Cliff Top Survey Points

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

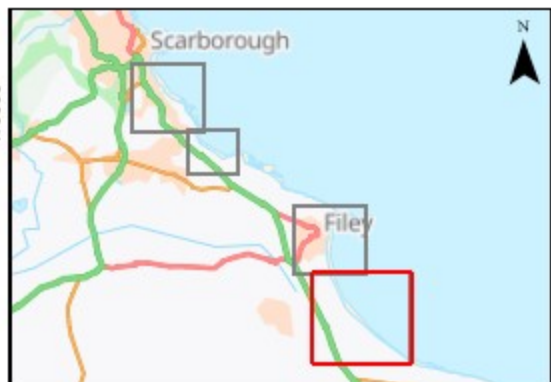
Title:
Figure 3 - Map 5
FILEY BAY (NORTH)
Scarborough Borough Council Frontage

Report:
 Survey Report

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

Co-ordinate system: British National Grid





SURVEY LOCATIONS

- Cliff Top Survey Points

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

Title:

Figure 3 - Map 6
FILEY BAY (SOUTH)
Scarborough Borough Council Frontage

Report:

Survey Report

Revision:	Date:	Drawn:	Checked:	Size:	Scale:
0	n/a	TC	NJC	A4	1:20,000

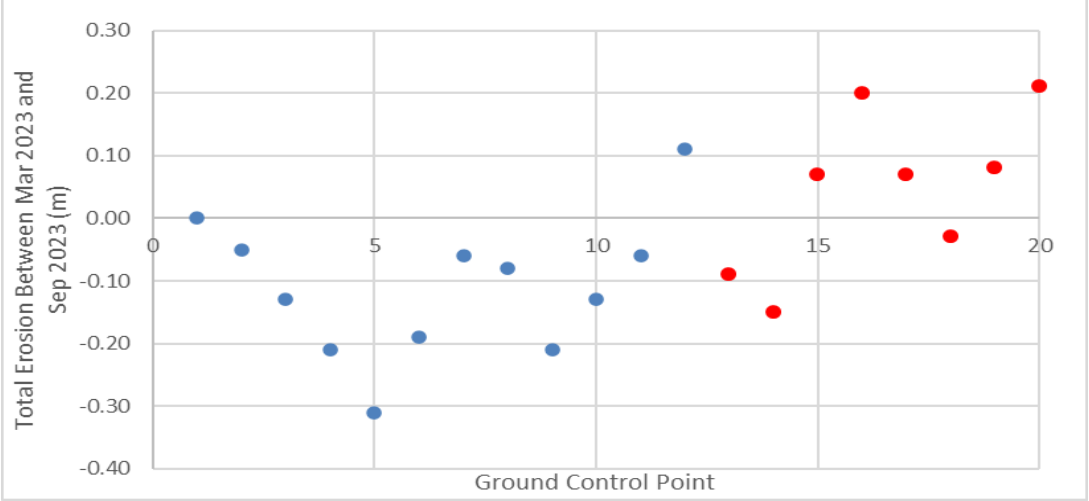
Co-ordinate system: British National Grid



2. Analysis of Survey Data

2.1 Staithes

Survey Date	Description of Changes Since Last Survey	Interpretation
<p style="text-align: center;">21st September 2023</p>	<p>Cliff-top Survey:</p> <p>Twenty ground control points have been established at Cowbar and Staithes for biannual cliff top monitoring. Points 13 to 20 are located on the cliffs to the south of Staithes Beck and therefore sit in the North Yorkshire Council area. Points 1 to 7 are north of the beck and therefore are within the Redcar and Cleveland unitary authority area. The separation between any two points is around 100m. Data collection involves a distance offset measurement from the ground control point to the cliff edge along a fixed bearing.</p> <p>Between March 2023 and September 2023, only 3 of the 20 ground control points experienced a retreat greater than +0.1m. These were Points 12, 16 and 20 experiencing 0.11m, 0.2m and 0.21m respectively, indicating a period of relative stability. The data also shows that between the survey dates 13 of the 20 points have advanced seawards, of which 7 were outside the assumed margin of error of the survey technique (± 0.1). It is unlikely this is true change and more likely a reflection in varying vegetation levels between surveys creating difficulty in identifying the cliff top.</p> <p>Intriguingly, the plot below highlights that the vast majority of these 'advancements' have occurred on the cliffs to north of Staithes Beck (blue dots), whilst the limited erosion has occurred south of Staithes (Red dots). This is not easily explained and could be a number of factors including varying vegetation levels or different surveying teams.</p>	<p>Only 3 of the 20 control points have experienced retreat greater than the margin of error (± 0.1m) indicating a period of stability.</p> <p>Longer term trends: Table C1 shows that survey Location 1 has shown the greatest total erosion with a loss of 7.60m between the November 2008 baseline and September 2023, resulting in a long-term average recession rate of 0.51m/yr.</p> <p>Location 4 has also showed progressive erosion with an average recession rate of 0.15m/year. Both stations are located adjacent the old Cowbar Lane which in places has now collapsed entirely.</p> <p>Location 13 has also experienced ongoing erosion of with an average recession rate of 0.21m/year.</p> <p>Despite these long-term recessions zero of these three points have retreated since the previous survey.</p>

Survey Date	Description of Changes Since Last Survey	Interpretation
	 <p>Plot 1</p> <p>Calculation of longer-term erosion rates based on the recorded change between 2008 and 2023 indicates that 17 of the 20 posts on the frontage recorded a change rate within a range of $\pm 0.1\text{m/year}$. Points 1, 4, and 13 show average erosion rate of above 0.1m/yr., experiencing 0.51m, 0.15m and 0.21m respectively.</p>	

2.2 Runswick Bay

Survey Date	Description of Changes Since Last Survey	Interpretation
<p style="text-align: center;">22nd August 2023</p>	<p>Topographic Survey:</p> <p>Runswick Bay is covered by a 6-monthly topographic survey. A consistently applied GIS processing routine has been used to create a digital ground model (DGM) (Appendix B - Map 1) and to calculate the differences between the current topographic survey (August 2023) and the previous survey (March 2023) to highlight areas and amounts of erosion and deposition. In all cases, a 5m resolution raster grid has been used to identify areas of erosion and accretion. (Appendix B – Map 8).</p> <p>Appendix B – Map 1 shows that the beach contours follow a broadly shore parallel pattern. The beach, from the end of the rock armour in the north through to the southern extents, is consistent in width and gradient. The upper beach fronting the sailing- club locally steepens, increasingly in elevation. In the North, the bay fronting the lifeboat station is steeper and narrower before transitioning to the exposed rocky foreshore. The parallel contours are locally distorted in several places where small watercourses outfall across the beach and also across the lower extents where the rocky foreshore is exposed.</p> <p>Appendix B – Map 8 shows that change over the Summer 2023 has generally occurred in shoreline parallel bands. The 250m stretch of upper beach from the end of the rock armour in the north, to the boat store in the centre, has been dominated by accretion. With the greatest magnitude (up to +1m) occurring at the transition between the rock armour and undefended cliffs. Accretion has also occurred in the small bay fronting the lifeboat station in the north (+0.5m) and across the rocky outcrops to the south. One large band of erosion has occurred across the mid beach in the centre of the bay of up to - 0.75m in magnitude.</p>	<p>Over Summer 2023 Runswick Bay appears to have been influenced predominantly by cross shore change highlighted by the shoreline parallel bands. The upper beach along the majority of the bay has accreted indicating the movement of material up the profile which is characteristic of calmer summer months.</p> <p>The erosion and accretion across the bay generally appear to balance suggesting there has not been a loss of material out of the system.</p> <p>Longer term trends: The data collected since 2008 indicate a general pattern of winter drawdown and spring recovery with no net long term change. This trend was noted to have suspended between 2015 and 2019, but has resumed since 2021.</p>

2.3 Sandsend Beach, Upgang Beach and Whitby Sands

Survey Date	Description of Changes Since Last Survey	Interpretation
<p>29th – 30th September 2023</p>	<p>Beach Profiles:</p> <p>The frontage spanning Sandsend Beach, Upgang Beach, and Whitby Sands is covered by three beach profile lines, spaced between Sandsend and Whitby West Cliff (Appendix A).</p> <p>The beach immediately in front of the replaced defences at Profile 1dWB1 (located around 400m south of Sandsend Village) has initially dropped 0.3m in level, revealing additional steps of the revetment (although has not revealed the toe beam as per the winter 2022 survey). This drop is very local occurring over the first 5m of the upper beach. Accretion has then occurred between chainage 44m and chainage 134m of up to 0.8m in level. Seawards of chainage 134m, the beach has dropped in level due to the removal of the berm observed previously (possibly pushed up the profile causing the accretion). Generally, beach levels are at a medium level when compared to the range of the previous surveys and appear to be recovering since the lows on Winter 2022.</p> <p>At 1dWB2, located in the centre of Upgang Beach, the cliff top and face could again not be measured due to dense Gorse bushes and unsafe conditions respectively. The toe of the cliff appears to have retreated 0.5m since the previous survey which is supported by the site photos that show evidence of recent activity. The profile has generally been dominated by accretion, although the formation of a berm on the upper beach (between chainages 157m and 191m) has caused alternating lengths of accretion and erosion (albeit at a low magnitude of ± 0.3m). Accretion has occurred across the lower beach slackening the profile. Overall, the beach is at a medium level, except the lower reaches where the accretion has caused the profile to be the highest on record.</p> <p>At profile 1dWB3, fronting the stabilised face of Whitby West Cliff, no significant change has occurred as far as the toe of the seawall at chainage 90m. The profile does show a drop in level of up to 0.1m on the promenade, which is thought to be the removal of beach deposits since previous survey. From the toe of the seawall to chainage 180m, the profile has largely remained stable with all change limited to ± 0.1m. Seawards of chainage 180m, the lower profile has accreted by up to 0.45m in level. The profile remains within the range envelope of the previous surveys.</p>	<p>Along Sandsend to Whitby, the beach generally appears to have experienced a net accretion over the Summer of 2023 indicating a period of recovery since the lows of Winter 2022.</p> <p>This accretion is not exclusive, and as indicated by the topography survey, there has been a movement of material from west to east which corresponds with seasonal prevailing wind (WNW).</p> <p>Longer term trends: the beach profiles show seasonal variation but no linear trend of accretion or erosion. The annual topographic difference plots show similar patterns of accretion and erosion in all surveys although the magnitude of change is generally modest.</p> <p>The cliffs of Upgang Beach in the central part of the study area are undefended and erosion provides an important source of material to the beach. It is likely that sediment released by erosion over the winter months is subsequently redistributed across the beach as migrating sand bars.</p>

Survey Date	Description of Changes Since Last Survey	Interpretation
	<p>Topographic Survey:</p> <p>The Sandsend to Whitby frontage is covered by an annual topographic survey, providing continuous data for Sandsend Beach, Uppang Beach, and Whitby Sands. Data have been used to create a DGM (Appendix B – Maps 2) using GIS. The figure shows that the beach contours broadly follow a shore parallel pattern, although the contours become less uniform on the lower beach as rocky out crops become exposed. The beach is shallower at its northern extents (fronting Sandsend) and steepest in the central section (fronting Whitby Golf Club).</p> <p>The GIS has also been used to calculate the differences between the current topographic survey DGM (August 2023) and the earlier topographic survey DGM (September 2022), with 5m resolution raster grids (as shown in Appendix B – Maps 9), to identify areas of erosion and accretion. It is recognised that these are just two snapshots in time along a vary active sediment cell and therefore change between the two dates must be interpreted carefully.</p> <p>Appendix B – Maps 9 show a varied picture of change across the approximately 4.5km stretch of coastline. The plot appears to show alternating, shoreline perpendicular, bands of erosion and accretion suggesting the transport of sediment along the coastline. To the east, the defended section fronting Whitby has largely been dominated by accretion with Sandsend to the west largely erosion. The most intense area of change has occurred to the undefended cliffs fronting Raithwaite, where the toe of cliffs dropped in level by 1.5m in level.</p>	

2.4 Robin Hood’s Bay

Survey Date	Description of Changes Since Last Survey	Interpretation
28 th Sept 2022	<p>Topographic Survey:</p> <p>Robin Hood’s Bay is covered by a six-monthly topographic survey. Data have been used to create a DGM (Appendix B – Map 3) using GIS. The map highlights the presence of the exposed rocky outcrop in this location with shoreline parallel contours, indicating sloping beach material, only very locally present in the indented bays.</p> <p>The GIS has also been used to calculate the differences between the current topographic survey DGM (August 2023) and the earlier topographic survey DGM (March 2023), with 5m resolution raster grids (as shown in Appendix B – Map 10), to identify areas of erosion and accretion.</p> <p>The map echo’s patterns previously observed with the vast majority of the bay experiencing negligible change ($\pm 0.1\text{m}$) due to the presence of already exposed rocky outcrops which run perpendicular to the shore. The little change there has been limited to sporadic pockets of low-level accretion and erosion, with a maximum magnitude limited to $\pm 0.75\text{m}$.</p>	<p>Longer term trends: The limited change recorded in Robin Hoods Bay is due to the resistant rock platforms and thin, patchy cover of sand.</p> <p>Changes on the upper beach, particularly in the north of the survey area, are associated with minor rockfall and slips from the cliffs fronting the northern part of the village. This process locally recharges beach levels on the upper beach before the material is redistributed by wave action across the remainder of the beach.</p>
	<p>Cliff-top Survey:</p> <p>Thirteen ground control points have been established at Robin Hood’s Bay since March 2010 to monitor cliff recession. The separation between any two points is around 200m. The survey report notes Points 7, 8 & 9 were unable to be surveyed during this inspection during ongoing construction works to the seawall.</p> <p>Off the remaining 9 control points, not one experienced change greater than the margin of error of the survey technique ($\pm 0.1\text{m}$) since the previous survey in March 2023.</p>	<p>Long term rates of change calculated between March 2010 and September 2023 show that only two markers have erosion with rates greater or equal to 0.1m/yr. These are Point’s 1 and 11 with 0.42m/yr and 0.15m/yr rates of recession respectively.</p>

2.5 Scarborough North Bay

Survey Date	Description of Changes Since Last Survey	Interpretation
12 th September 2022	<p>Beach Profiles:</p> <p>Scarborough North Bay is covered by five beach profile lines, distributed between the Sealife Centre at Scalby Mills and Clarence Gardens (Appendix A).</p> <p>Profile 1dSBN1 is located around 200m south of the Sea Life Centre. The profile is covered by promenade and seawall up to chainage 9m, over which length it has remained unchanged. At the toe of the seawall, the beach has accreted by up to 0.25m concealing more of the stepped toe of the structure. Seaward of this, the profile generally has remained stable with all change limited to ± 0.2m. The beach has initially dropped in level between chainages 32m and 95m, before accreting across the lower beach, although sections of rocky foreshore remain exposed. Overall, the beach remains at medium level when compared to the range of the previous surveys.</p> <p>Profile 1dSBN2 is located close to the former cliff lift. From the toe of the seawall at chainage 8m to chainage 46m, the upper beach has accreted by up to 0.65m in level. The lower beach has remained largely stable with some erosion occurring between chainages 67m and 98m, albeit at low magnitude (-0.15m). Seawards of chainage 98m, the rocky foreshore remains exposed.</p> <p>Profile 1dSBN3 is located near Royal Albert Drive. At the toe of the seawall (chainage 13m), the beach has dropped in level very locally by up 0.5m. Seawards of this, the beach appears to have remained stable with all change up to chainage 155m limited to ± 0.2m. Accretion has occurred across the lower beach slackening the profile. The profile remains at a high level when compared to the range of the previous surveys.</p> <p>At profile 1dSBN4, the beach levels between the toe of the defences (chainage 26m) and the beginning of the exposed rocky outcrop (chainage 34m) have increased by up to 0.65m in level. Between chainage 34m and 58m the rocky outcrops remain exposed. Seawards of this, the beach has again accreted by up to 0.45m reducing to no change by chainage 172m. The beach is generally at a medium level when compared to the range of the previous surveys with the exception of the lower beach which is at the top of the range envelope.</p> <p>Profile 1dSBN5 is located to the south of Clarence Gardens. The profile is covered by the promenade,</p>	<p>The five beach profiles along Scarborough North Bay highlight that change since March 2023 has been limited, with the vast majority constrained to ± 0.3m. The two most northern profiles indicate a slight movement of material up the profile, but the change remains within the range envelope of the previous surveys.</p> <p>Longer term trends: The observed trends in the topographic plots and beach profiles point to overall stability with seasonal fluctuations.</p>

Survey Date	Description of Changes Since Last Survey	Interpretation
	<p>upstand wall and rock revetment up to chainage 29m and has remained unchanged since the previous survey. Seawards of the revetment, the beach has also remained stable since the March 2023 survey with all change limited to $\pm 0.1\text{m}$. The beach therefore remains at medium to high level, particular on the lower beach where, in places, it is at the highest level on record.</p> <p>Topographic Survey:</p> <p>Scarborough North Bay is covered by an annual topographic survey, which was carried out in August 2023. Utilizing a GIS software, The data has been used to create a DGM, the plot of which is shown in Appendix B - Map 4. The plot shows that the beach contours broadly follow a shore parallel pattern before becoming distorted on the lower beach due to the presence of the exposed rocky foreshore. The beach in the south of the bay, fronting Royal Albert drive, drops in level against the defences and is shallower in gradient.</p> <p>The DGM has also been used to calculate the differences between the Full Measures topographic survey (August 2023) and the earlier topographic survey DGM (September 2022), with 5m resolution raster grids (as shown in Appendix B – Map 11), to identify areas of erosion and accretion.</p> <p>The plot shows that the change has occurred in shoreline parallel bands. Generally, the north of the bay has been dominated by erosion (up to -1.0m), particular on the upper beach. Patchy erosion on the lower beach reflects the exposed rocky foreshore. The south of the bay has bene dominated by accretion (up to $+1.0\text{m}$), particularly on the lower beach.</p>	

2.6 Scarborough South Bay

Survey Date	Description of Changes Since Last Survey	Interpretation
<p style="text-align: center;">1st September 2022</p>	<p>Beach Profiles:</p> <p>Scarborough South Bay is monitored by four beach profiles, between the harbour in the north and the Spa Complex in the south (Appendix A). The comparisons of short-term change are between March and September 2023</p> <p>At profile 1dSBS1, the beach has eroded by 0.1m at the toe of the seawall (chainage 13m). Across the upper beach, between chainages 15m and 93m, the beach has generally accreted by up to 0.25m. The lower beach has been dominated by the formation of two berms, at chainage 118m and chainage 208m, that have resulted alternating lengths of erosion and accretion limited to (± 0.5m). When compared to the range of the previous surveys, the profile varies between being at a high and low level corresponding with the formation of berms on the lower beach.</p> <p>Profile 1dSBS2 is located on the shore fronting St Nicholas Cliff. Since the previous survey, the beach has generally remained stable with all change limited to ± 0.1m. Minor erosion is observed between chainages 16m and 80m and again between 134m and 175m. Minor accretion is observed between 85m and 135m. The rocky foreshore is exposed seawards of chainage 184m. When compared to the range of the previous surveys, the upper beach is at a high level and the lower beach at a low level.</p> <p>Profile 1dSBS3 is located 250m north of the Scarborough Spa complex and is defended up until chainage 9m by the seawall. In general, the profile has remained stable since the previous survey with all change limited to ± 0.1m. The upper beach, between chainages 9m and 98m, has accreted, with the lower beach seawards of chainage 98m eroding by a similar magnitude. Overall the beach is at a medium to high level when compared to the range of the previous surveys.</p> <p>Profile 1dSBS4 is located on the beach in front of the Scarborough Spa Complex. All change across the profile is limited to ± 0.3m since the previous surveys. The upper beach, from the toe of the seawall at chainage 7m to chainage 94m, has accreted. The beach between chainages 95m and 125m has remained stable. Seawards of chainage 125m, the beach has dropped in level. Overall, the profile is at a high level when compared to the range of the previous surveys.</p>	<p>Despite comparing different time periods, the profiles (6 monthly change) and the topographic survey (annual change) both display similar patterns. The most significant change has occurred in the north of the bay, in the lee of the harbour, where the formation and erosion of berms is dominant. This may be because the natural movement of sediment is northwards and therefore material builds in the lee of the harbour over time.</p> <p>The centre and southern half of the bay generally have experienced less change.</p> <p>Longer term trends: The beach is regularly re-profiled with sediment moved from near the harbour to the frontage of The Spa, but sediment naturally moves northwards towards the harbour.</p> <p>Table C3 shows that since March 2010 most of the cliff erosion profiles have shown negligible recession. Profiles 11 and 12 show erosion of 0.29 m/year and 0.24m/year respectively. These points are at the rear of a mudslide system which experiences periodic reactivation or head scarp collapse, however, there has been little movement in the last two years and as a result the average rate of recession has been dropping.</p>

Survey Date	Description of Changes Since Last Survey	Interpretation
	<p>Topographic Survey:</p> <p>Scarborough South Bay is covered by an annual topographic survey. Data have been used to create a DGM (Appendix B - Map 5) using GIS. The GIS has also been used to calculate the differences between the current topographic survey DGM (September 2023) and the earlier topographic survey DGM (September 2022), with 5m resolution raster grids (as shown in Appendix B – Map 12), to identify areas of erosion and accretion.</p> <p>Appendix B - Map 12 shows that the most significant change has occurred in the north of the bay, in the lee of the harbour, where the formation and erosion of berms is dominant (limited to $\pm 1.0\text{m}$). In the centre of the bay there has been negligible change, before transition to patchy erosion and accretion reflecting the movement of sediment over the rocky platform in the south,</p>	
	<p>Cliff-top Survey:</p> <p>Thirteen ground control points have been established at Scarborough South Bay, extending from South Bay to Cayton Bay for the purposes of cliff top monitoring. The separation between any two points is around 300 m. The cliff top surveys at Scarborough South Bay are undertaken bi-annually. Data collection involves a distance offset measurement from the ground control point to the cliff edge along a fixed bearing.</p> <p>Between May and September 2023 only one of the thirteen control points experienced recession greater than or equal to 0.1m. This was point 13, the most southernly point in this group (located adjacent Beach View Holiday Home), which retreated 0.37m.</p> <p>The recession rates calculated for the period from March 2010 to September 2023 indicated that only two of the thirteen markers have experienced an average recession rate of greater than or equal to 0.1m/yr. These are control point 11 and point 12 that have a experienced a rate of recession of 0.29m/yr and 0.24m/yr respectively. It is noteworthy that following a period of stability since Mar 2023, the rates of recession have reduced.</p>	

2.7 Cayton Bay

Survey Date	Description of Changes Since Last Survey	Interpretation
<p style="text-align: center;">2nd September 2023</p>	<p>Beach Profiles:</p> <p>Cayton Bay is covered by four beach profile lines, distributed between Tenants' Cliff and the south of Cayton Sands (Appendix A).</p> <p>Profile 1dCY1A, (Clayton Cliff) has been surveyed since November 2015. The shallow berm on the upper beach has migrated landed 1m since the previous survey. The seaward face of the berm has slackened resulting in length of accretion between chainage 18m and 31m off up to 0.3m. The rocky outcrops remain exposed between chainages 34m to 44m and 69m and 72m although the exposed length have reduced to low level accretion. Seawards of the second outcrop, the beach has remained largely stable, an incised channel (+0.5m) at chainage 98m has been infilled and the lower beach seaward of chainage 160m, has accreted extending the profile seawards. On the whole, the beach is at a medium level when compared to the range of the previous surveys.</p> <p>At Profile 1dCY1 (Tenant's Cliff), the surveyor's report notes that the cliff top and cliff face could not be measured to dense vegetation and unsafe ground conditions respectively. The profile has been dominated by erosion since the previous inspection, between chainage 21m and 99m the beach has dropped in level by up to 0.9m. Seawards of chainage 99m, the rocky foreshore is exposed (an additional 37m from the previous inspection). Despite this, the beach is at a medium level when compared to the range of the previous surveys (was at a high level in the previous inspection).</p> <p>At profile 1dCY2 (close to the former pumping station) the surveyor's report notes that the cliff face and vegetated area to bottom of the cliff face could not be measured to unsafe ground conditions. From the toe of the cliff (at chainage 117m) to chainage 260m, the beach has accreted by up to 0.3m in level. Between chainage 260m and 315m a berm observed in the previous survey has been removed resulting in a drop in level of up to 0.3m. When compared to the range of the previous surveys, the profile is at high level.</p> <p>At profile 1dCY3 (600m southeast of the pumping station) the surveyors were unable to measure the cliff face due to unsafe ground conditions. Since the November 2021 survey, the remains of a pill box on the foreshore have been picked up between chainages 123m and 126m. Since the previous survey,</p>	<p>Three of the profiles at Cayton Bay show a general pattern of accretion, particularly across the upper beach, since the March 2023 survey. This is typical of seasonal fluctuations of movement of sediment up the profile during calmer summer months.</p> <p>In contrast, the annual topographic survey over the wider bay indicates the movement of sediment down the profile, with erosion observed along the toe of the cliffs. This suggests that despite some recovery during the summer months, the winter erosion was more dominant in the latter part of 2023.</p> <p>Longer term trends: The pattern of migrating sand bars has remained consistent since 2010 indicating seasonal variation in beach level with no net change.</p> <p>The longer-term recession rates from the cliff top monitoring points show that Points 4 and 6 have the highest rates of 0.29 and 0.11m/yr. Due to the presence of dense vegetation at Point 2 it has not been possible to survey since March 2018.</p>

Survey Date	Description of Changes Since Last Survey	Interpretation
	<p>the beach in between the cliff and the pillbox has eroded by 0.2m in level. Seawards of the pill box, the beach accreted by 0.3m up to a section of exposed rocky foreshore at chainage 152m. Seawards of the rocky outcrop all change is limited to 0.2m, accretion is observed between chainage 167m and 230m and erosion seawards of 262m, flattening a berm previously observed.</p> <p>Topographic Survey:</p> <p>Cayton Bay is covered by an annual topographic survey. Data have been used to create a DGM (Appendix B - Map 6) using GIS. The GIS has also been used to calculate the differences between the current topographic survey DGM (September 2023) and the earlier topographic survey DGM (September 2023), with 5m raster grids (as shown in Appendix B – Map 13), to identify areas of erosion and accretion.</p> <p>Appendix B – Map 13 shows that change across Cayton Bay has largely occurred in alternating, shoreline parallel bands of accretion and erosion, interspersed with swathes of no change. Generally, the upper beach, at the toe of the cliffs, has eroded by up to -1.0m in level with the lower beach accreting by a similar magnitude. The pattern of change is more varied to the south of the bay, at Red Cliff Hole, where sands shifting over the rocky foreshore is reflected in the plot.</p> <p>Cliff-top Survey:</p> <p>Eight ground control points have been established within Cayton Bay for the purposes of cliff top monitoring. The separation between any two points is typically around 200 m. The cliff top surveys at Cayton Bay are undertaken bi-annually. Data collection involves a distance offset measurement from the ground control point to the cliff edge along a fixed bearing. The survey report again notes that there was no access to point 2 due to dense vegetation. The results show between March and September 2023 two of the eight monitoring points (point 4 and 7) showed erosion of greater than 0.1m, experiencing 1.0m and 0.19m respectively. Point 4 is located within the centre of the bay. The 1.0m recession appears to be a result of a local rotational slip, which is typical of this frontage.</p> <p>Appendix C provides results from the September 2023 survey showing the distance from the ground control point to the edge of the cliff top along the defined bearing and changes in position since the November 2008 baseline survey.</p>	

2.8 Filey Bay

Survey Date	Description of Changes Since Last Survey	Interpretation
<p>3rd – 4th September 2023</p>	<p>Beach Profiles:</p> <p>Filey Bay is covered by five beach profiles between Filey Sands and Speeton Sands (Appendix A).</p> <p>Profile 1dFB1, fronting Filey seawall, has largely remained stable since the previous inspection in March 2023. The upper beach, from the toe of the seawall (chainage 18m) to chainage 67m, has accreted by up to 0.2m in level. Seawards of chainage 67m, there has been no change to the profile. When compared to the range of the previous surveys, the upper beach is at a high level and the lower beach a low level.</p> <p>At profile 1dFB2 (located to the north of Primrose Valley Holiday Village), the beach has again remained stable since the previous inspection with all change across the profile limited to ± 0.1m. The profile remains at a very high level compared to the range recorded from previous surveys.</p> <p>Profile 1dFB3 is located in front of Flat Cliffs hamlet. Then profile generally has remained a uniform gradient and has experienced limited change. There has been no change across the cliffs up to the toe at chainage 34m. At the toe, the beach has eroded up to chainage 48m by up to 0.15m in level. Seawards of chainage 48m the beach has accreted at low magnitude (+0.1m) across the whole profile. . Overall, the beach is at a medium level when compared to the range of the previous surveys.</p> <p>At profile 1dFB4, at Hunmanby Gap, there has been no change up to the toe of the cliff at chainage 26m. Seawards of the cliffs, the beach profile has accreted consistently by between +0.2m and +0.3m in level. The profile is at a medium level when compared to the range of the previous surveys.</p> <p>Profile 1dFB5 is located close to Reighton Gap. The survey report notes that the “<i>middle of section 5 is unable to be measured from approx. chainage 60m to 210m, due to undergrowth and bushes</i>”. The toe of the cliff at chainage 218m has eroded seaward by up to 0.5m. Between chainage 218m and 317m the beach has accreted by up to 0.3m in level. Between chainage 317m and 373m a observed in March 2023 has been eroded / shifted resulting in a drop in level of up to 0.4m in level. Seawards of 373m, the beach has again accreted. The beach remains at a very high level compared to the range of the previous surveys.</p>	<p>The profiles along Filey Bay show that the majority of the beach, particularly in the north, has experienced very little change since the previous survey indicating a period of stability. This is supported by the 6-monthly topographic survey fronting Filey Town which again shows negligible change. The central and southern sections show more change, with a pattern of shifting sand berms south. The increase in magnitude is likely due to being outside the influence of Filey Brigg.</p> <p>Longer term trends: Past trends dominated by migrating sand bars continue to the present day.</p>

Survey Date	Description of Changes Since Last Survey	Interpretation
	<p>Topographic Survey (Filey Bay):</p> <p>Filey Bay is covered by an annual topographic survey. In addition to the annual survey of Filey Bay, a smaller area fronting Filey Town is re-surveyed every six months to document seasonal patterns.</p> <p>Data have been used to create a DGM (Appendix B – Map 7) using GIS. The GIS has also been used to calculate the differences between the current topographic survey DGM (September 2023) and the earlier topographic surveys DGM with 5m resolution raster grids to identify areas of erosion and accretion. Map 14 shows the difference between the area fronting Filey town in the 6 months between March 2023 and September 2023. Map 15 shows the difference for the whole bay between September 2022 and September 2023.</p> <p>Appendix B – Map 15 shows that, as per previous years, in the north of the bay the magnitude of change is less significant than in the central and southern sections with large swathes of negligible change observed ($\pm 0.1\text{m}$). This is likely due to being in the lee of Filey Brigg. At the Central and southern sections, the change occurs in alternating bands of shoreline parallel accretion and erosion. The magnitude of change peaks between Hunmanby Gap and Reighton Gap where change up to $\pm 1.5\text{m}$ is observed. Generally, the central section is dominated by erosion and the southern section, accretion. This suggests the transport of sediment southwards within the bay.</p> <p>The short-term difference plot (Map 14) highlights a period of stability fronting Filey town with almost no change observed at all except for a very local, low magnitude, band of accretion observed at the toe of the seawall, although this is limited to $+0.25\text{m}$.</p> <p>Cliff-top Survey:</p> <p>Twenty-eight ground control points have been established within Filey Bay for the purposes of cliff top monitoring. This includes the installation of three additional locations in September 2010: points 12A (as a replacement for point 13 which can no longer be accessed due to vegetation growth), 24 & 25 (to the north of Filey Bay at Filey Brigg). A further replacement for monitoring point 13, 13A, has been added in 2014. In September 2023, points 5, 12, 12A and 13 were inaccessible due to heavy vegetation.</p>	

Survey Date	Description of Changes Since Last Survey	Interpretation
	<p>The maximum separation between any two points is nominally 300 m. The cliff top surveys at Filey Bay are undertaken every six months. Data collection involves a distance offset measurement from the ground control point to the cliff edge along a fixed bearing.</p> <p>Between March and September 2023 six of the remaining twenty-four ground control points showed erosion of greater than or equal to 0.1m. These were Point 13A (0.24m), Point 14 (0.11m), Point 20 (1.56m), Point 21 (0.25m), Point 22 (0.19m) and Point 23 (0.49m). It is unclear whether the significant change at point 20 is true change or a reflection of the overgrown vegetation that can be observed in the site photos. However the concentration of change from Point 20 to Point 23 does suggest that there has locally been an increase in erosion around the known active Reighton Gap.</p> <p>Long term rates of change calculated between November 2008 and September 2023 show that seven markers have erosion with rates greater or equal to 0.1m/yr. Control points 10, 14, 16 and 23 have all experienced average recession rates of <0.15m/yr. Control points 13A and 20 have recorded an average recession rate of <0.25m/yr (although Control Point 20 is significantly skewed by this survey's 1.56m 'loss'). Whilst at control point 7 an average rate of 0.40m/yr. has been recorded. Appendix C provides results from the September 2023 survey showing the distance from the ground control point to the edge of the cliff top along the defined bearing and changes in position since the baseline survey.</p>	

3. Problems Encountered and Uncertainty in Analysis

At Robin Hood's Bay the surveyors noted there was continuous rock and gravel falls along the cliffs, and that cliff top monitoring point 5 was located on a pile of deposited garden waste. They were also unable to survey VMPs 7, 8 and 9 due to construction activities.

At Whitby the cliff top at point 2 could not be measured due to dense gorse bushes preventing access. Also, the cliff face of Section 2 could not be measured due to unsafe ground conditions.

At Scalby in Scarborough North Bay the cliff edge was very overgrown resulting in areas that were unable to be surveyed.

At Cayton Bay the surveyors could not measure the top of profile 1dCY1 due to dense vegetation. Furthermore, cliff face of profiles 1dCY1, 1dCY2 and 1dCY3 could not be measured due unsafe ground conditions and the vegetated area at the bottom of the cliff face on profile 1dCY2 could not be measured due to soft mudslides restricting access. There was no access to measure the cliff top monitoring point 2 due to dense vegetation.

At Filey, several area were not inspectable due to heavy vegetation growth these included, an area of profile 1dFB2 from chainage 12m to 27m, profile 1dFB3 between chainage 21m to 28m, the mid-section of 1dFB5 between chainage 60m and 210m and the start of profile 1dFB4. Cliff top monitoring point 5, 12, 12A and 13 were also inaccessible due to heavy vegetation. The start of 1dFB3 was also inaccessible due to being within a locked compound.

The cliff top surveys are in general assumed to have a limit of accuracy of $\pm 0.1\text{m}$ due to the techniques used and problems have been experienced in precisely locating the cliff edge, due to vegetation growth and the convex profile. Most profiles have now been monitored for six years, and a more reliable picture of change is now emerging that indicates very low rates of erosion, with only occasional and localised examples of erosion exceeding 0.5m/yr .

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

No changes are recommended at the present time.

5. Conclusions and Areas of Concern

The following points have been observed:

- At Staithes, only 3 of the 20 control points have experienced retreat greater than the margin of error ($\pm 0.1\text{m}$) indicating a period of stability since the previous survey. 13 of the 20 points appeared to advanced seawards, 7 of which were outside the assumed margin of error of the survey technique (± 0.1). It is unlikely this is true change and more likely a reflection in varying vegetation levels between surveys creating difficulty in identifying the cliff top.
- At Runswick Bay the upper beach along the majority of the bay has accreted indicating the movement of material up the profile which is characteristic of calmer summer months. The erosion and accretion across the bay generally appear to balance suggesting there has not been a loss of material out of the system.
- Along Sandsend to Whitby, the beach generally appears to have experienced a net accretion over the Summer of 2023 indicating a period of recovery since the lows of Winter 2022. This accretion is not exclusive, and as indicated by the topography survey, there has been a movement of material from west to east which corresponds with seasonal prevailing wind (WNW).
- At Robin Hoods Bay, limited change has again been recorded due to the resistant rock platforms and thin, patchy cover of sand.
- The five beach profiles along Scarborough North Bay highlight that change since March 2023 has been limited.
- At Scarborough South Bay, the most significant change has occurred in the north of the bay, in the lee of the harbour, where the formation and erosion of berms is dominant. This may be because the

natural movement of sediment is northwards and therefore material builds in the lee of the harbour over time.

- At Cayton Bay 3 out of 4 of the profiles show a general pattern of accretion, particularly across the upper beach since the March 2023 survey. This is typical of seasonal fluctuations of movement of sediment up the profile during calmer summer months. On the contrary the annual topographic survey, indicates the movement of sediment down the profile, with erosion observed along the toe of the cliffs. This suggests that despite some recovery during the summer months, the winter erosion was more dominant in 2023.
- At Filey Bay, the profiles show that the majority of the beach, particularly in the north, has experienced very little change since the previous survey indicating a period of stability. This is supported by the 6 monthly topographic survey fronting Filey Town which again shows negligible change. The central and southern sections show more change, with a pattern of shifting sand berms south. The increase in magnitude is likely due to being outside the influence of Filey Brigg.

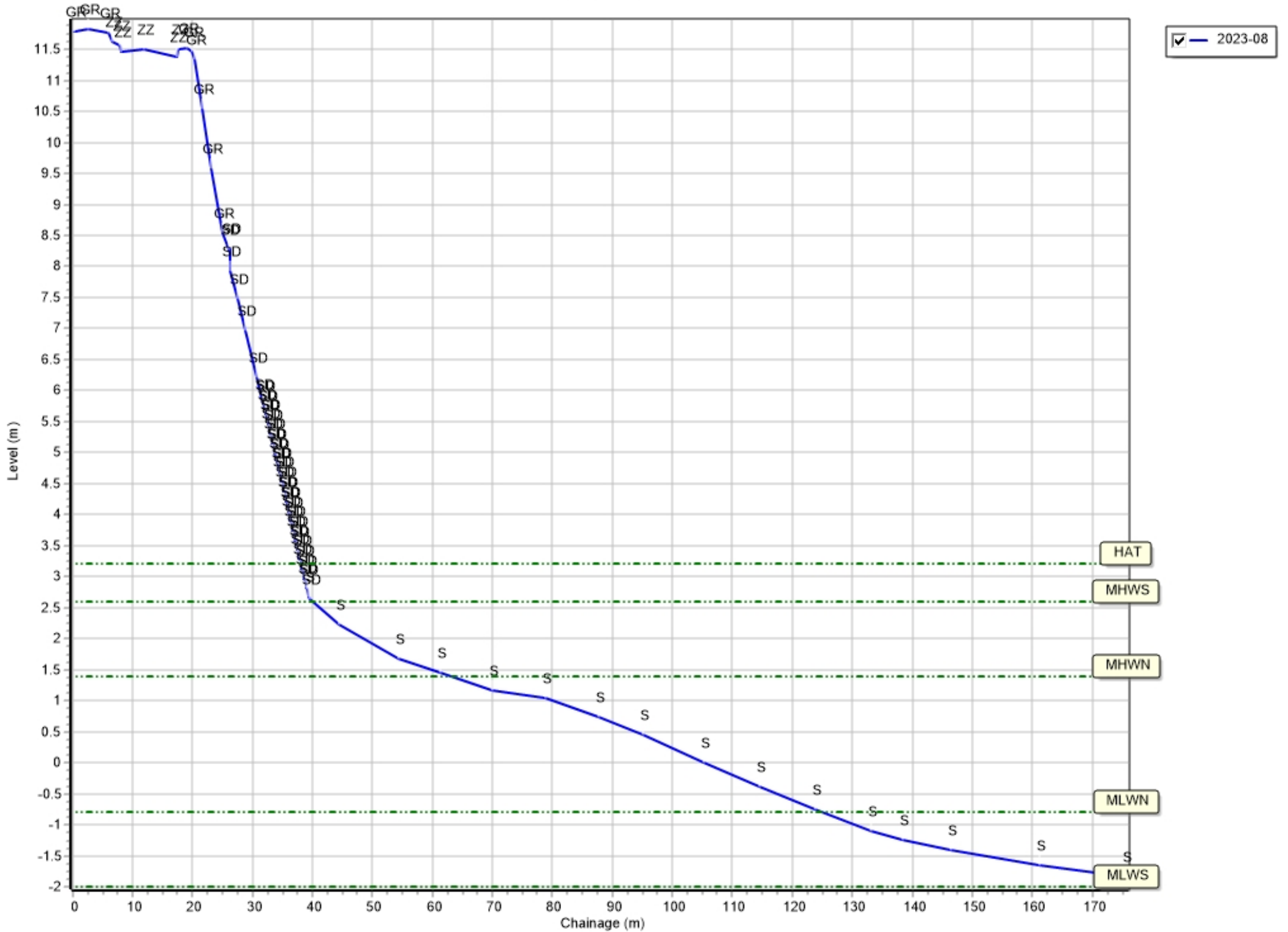
Appendices

Appendix A
Beach Profiles

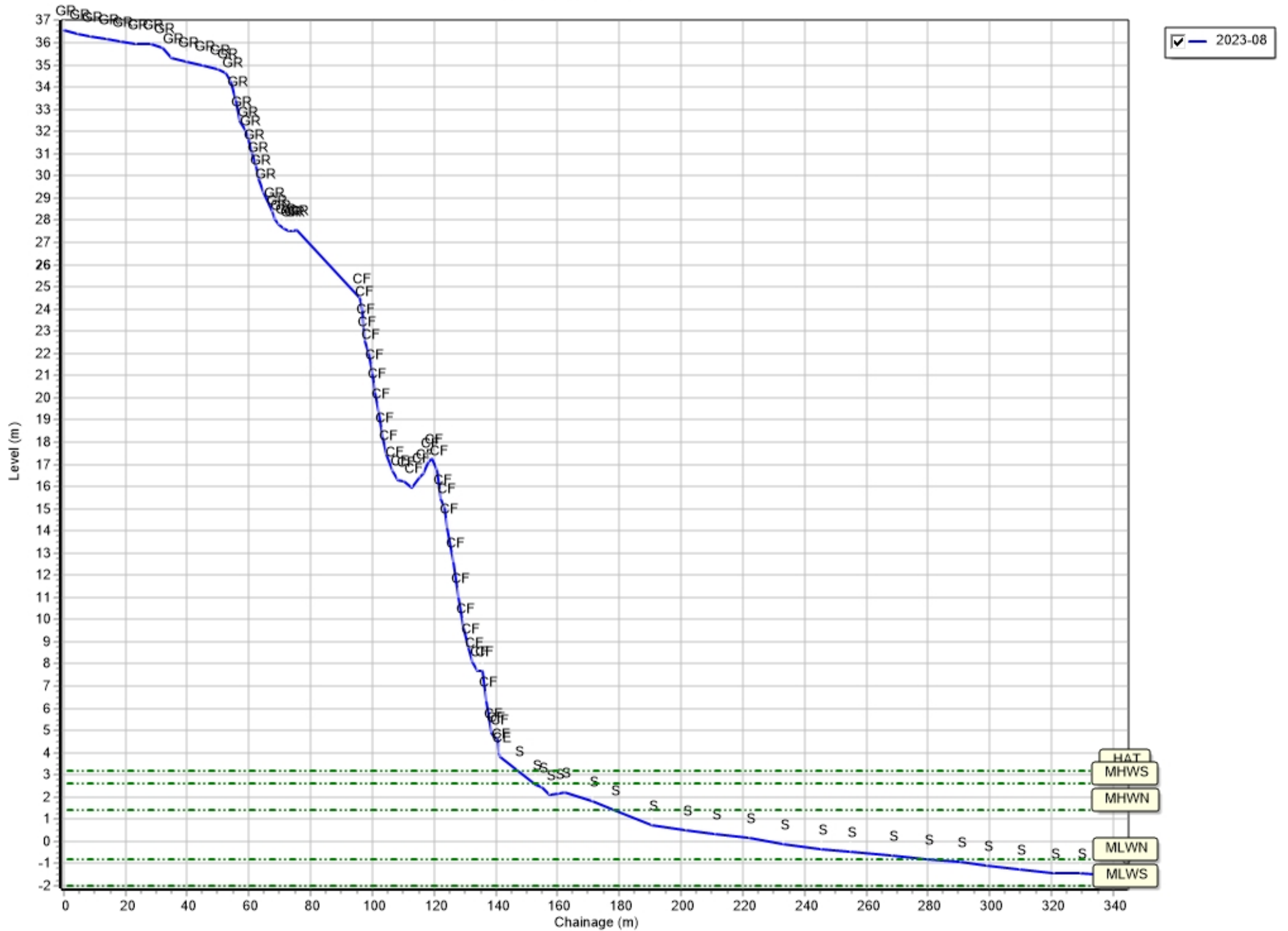
The following sediment feature codes are used on some profile plots:

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

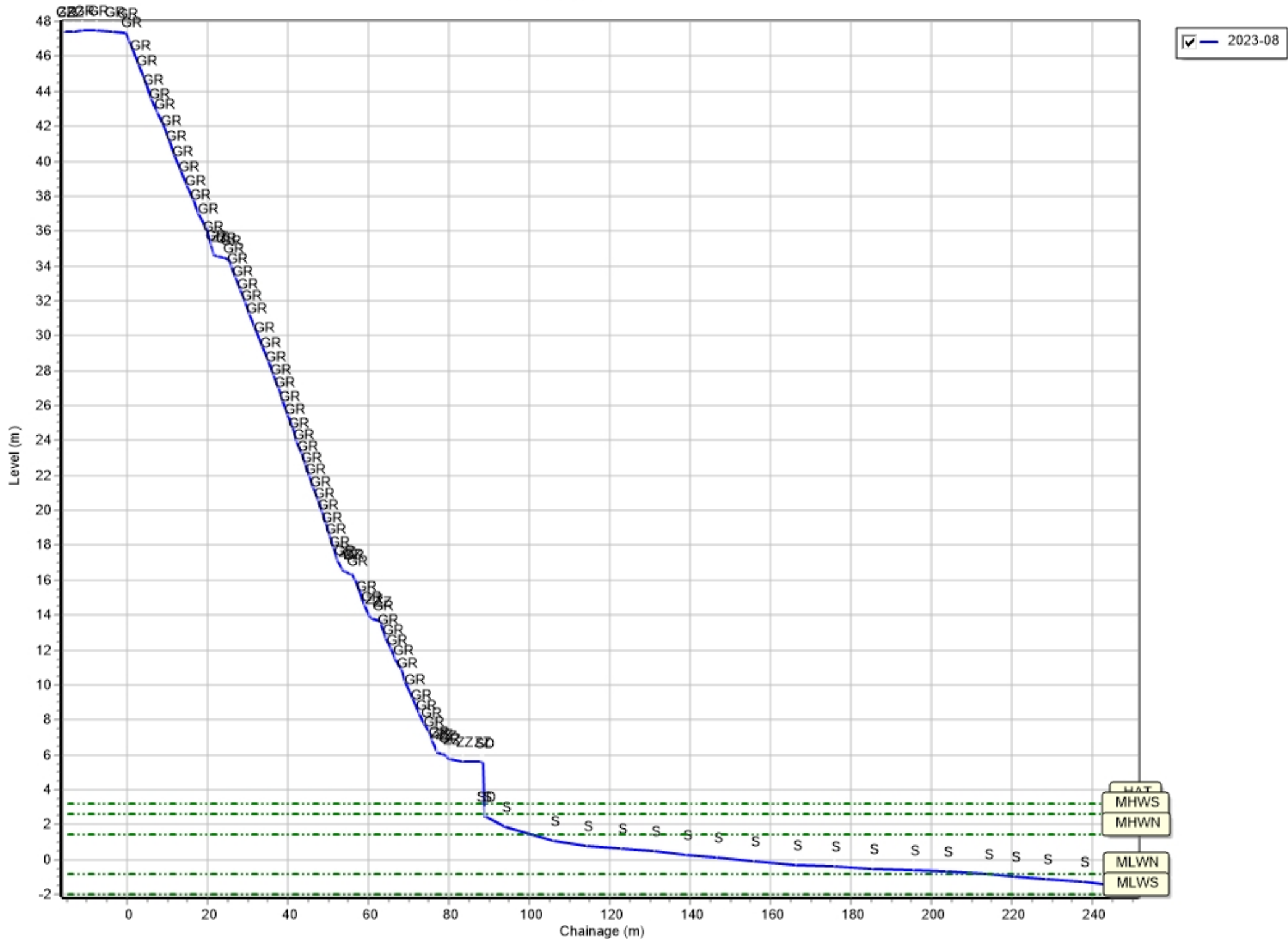
Profiles: 1dWB1



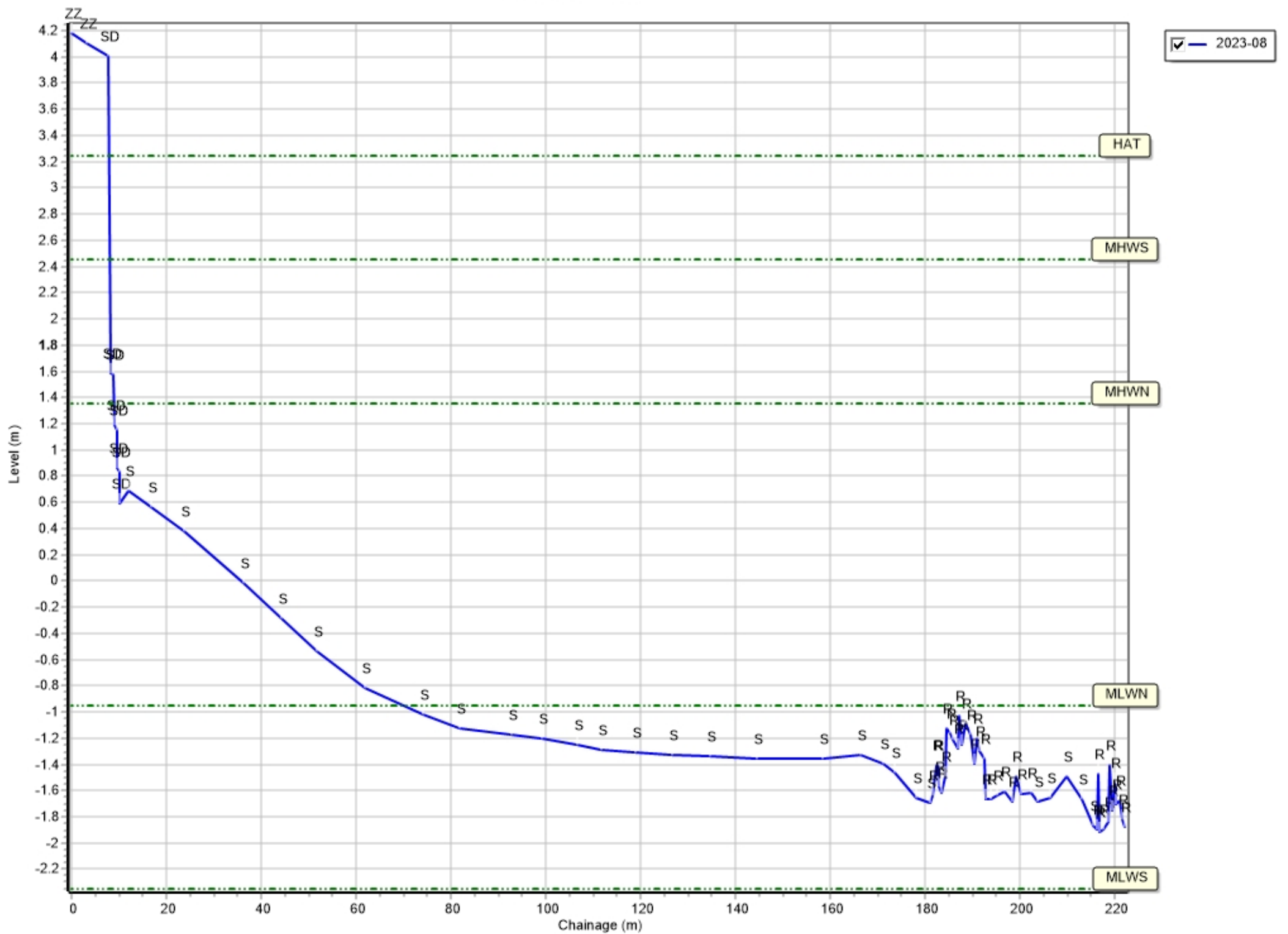
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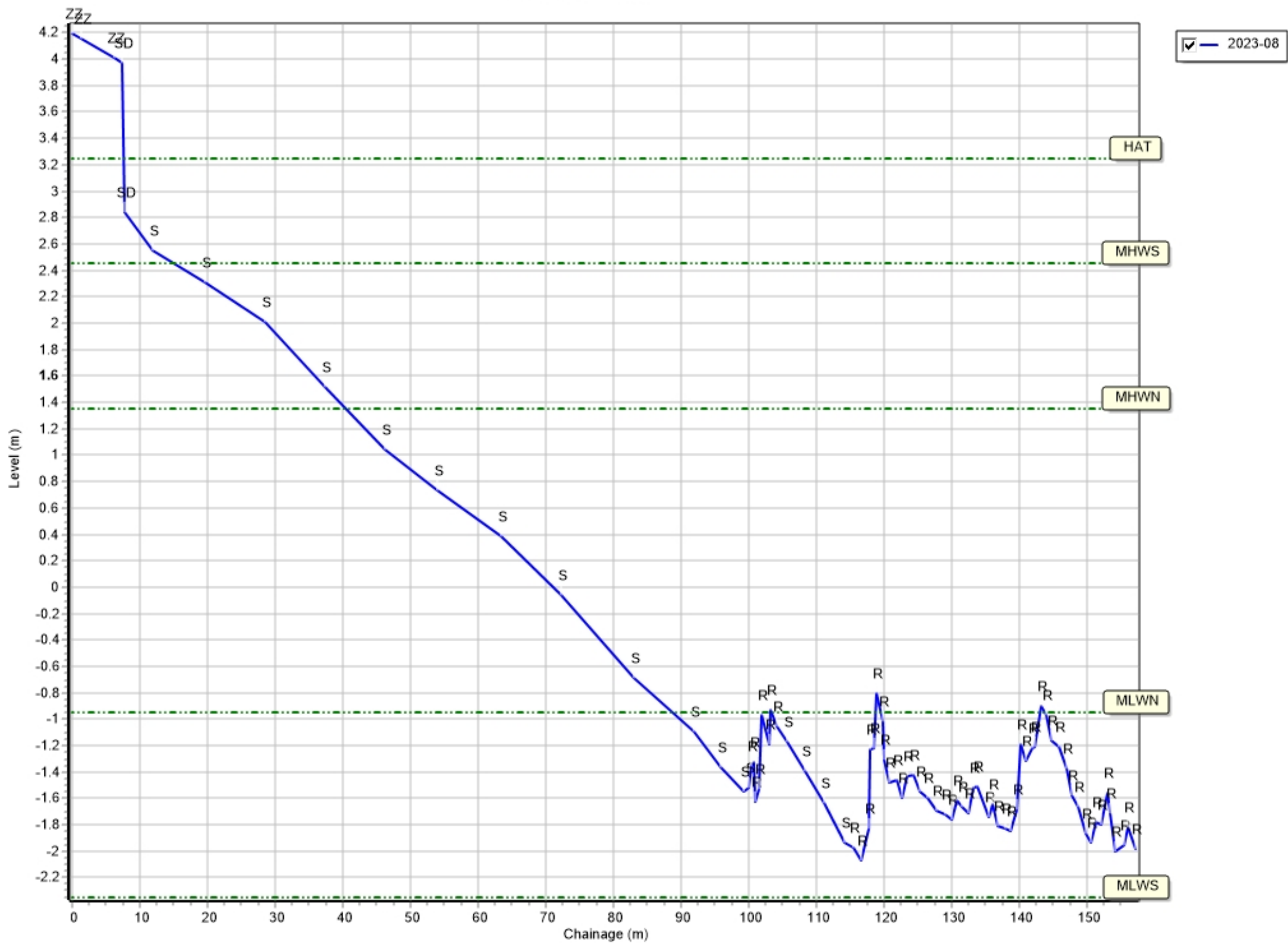
Profiles: 1dWB3



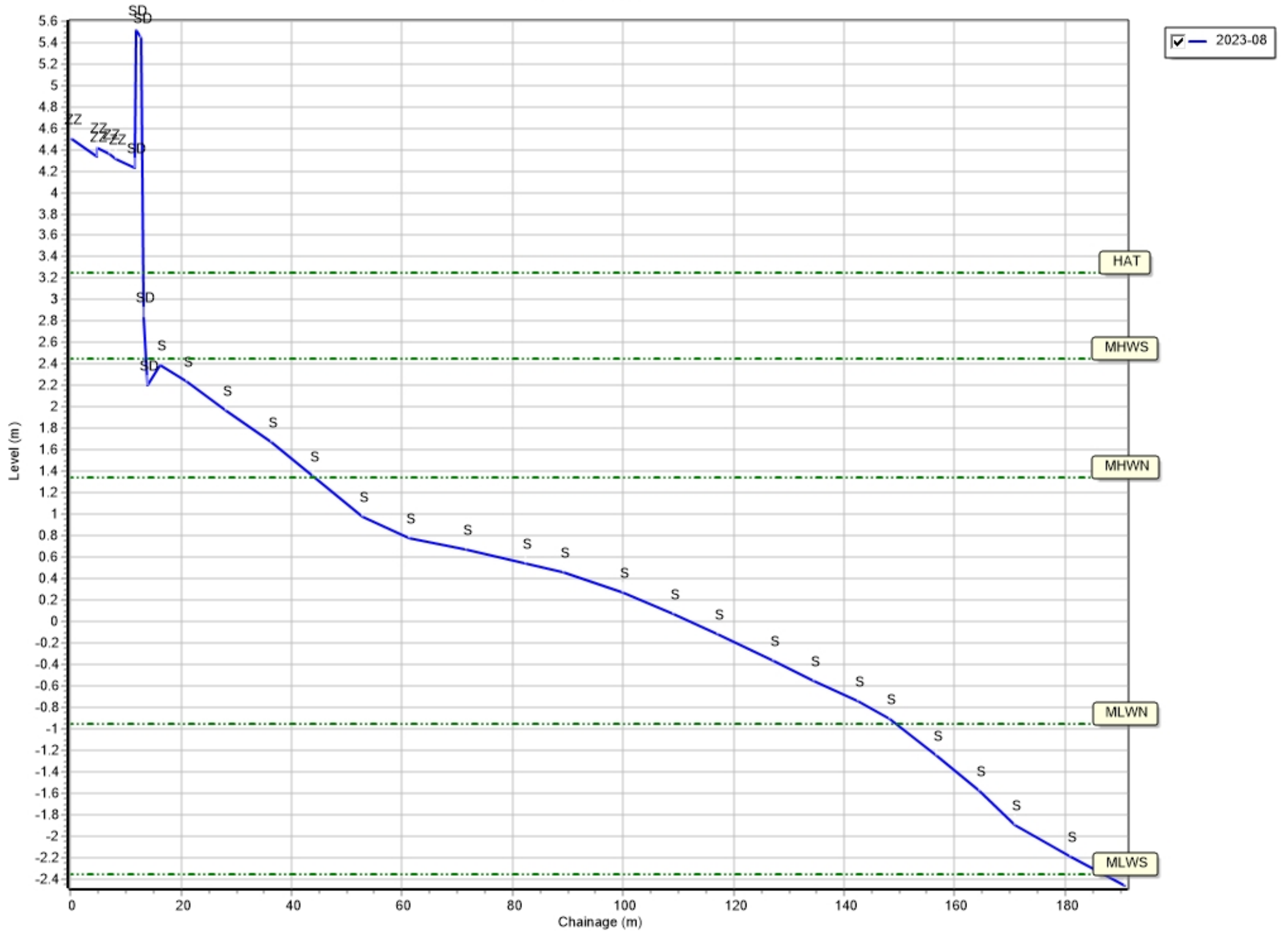
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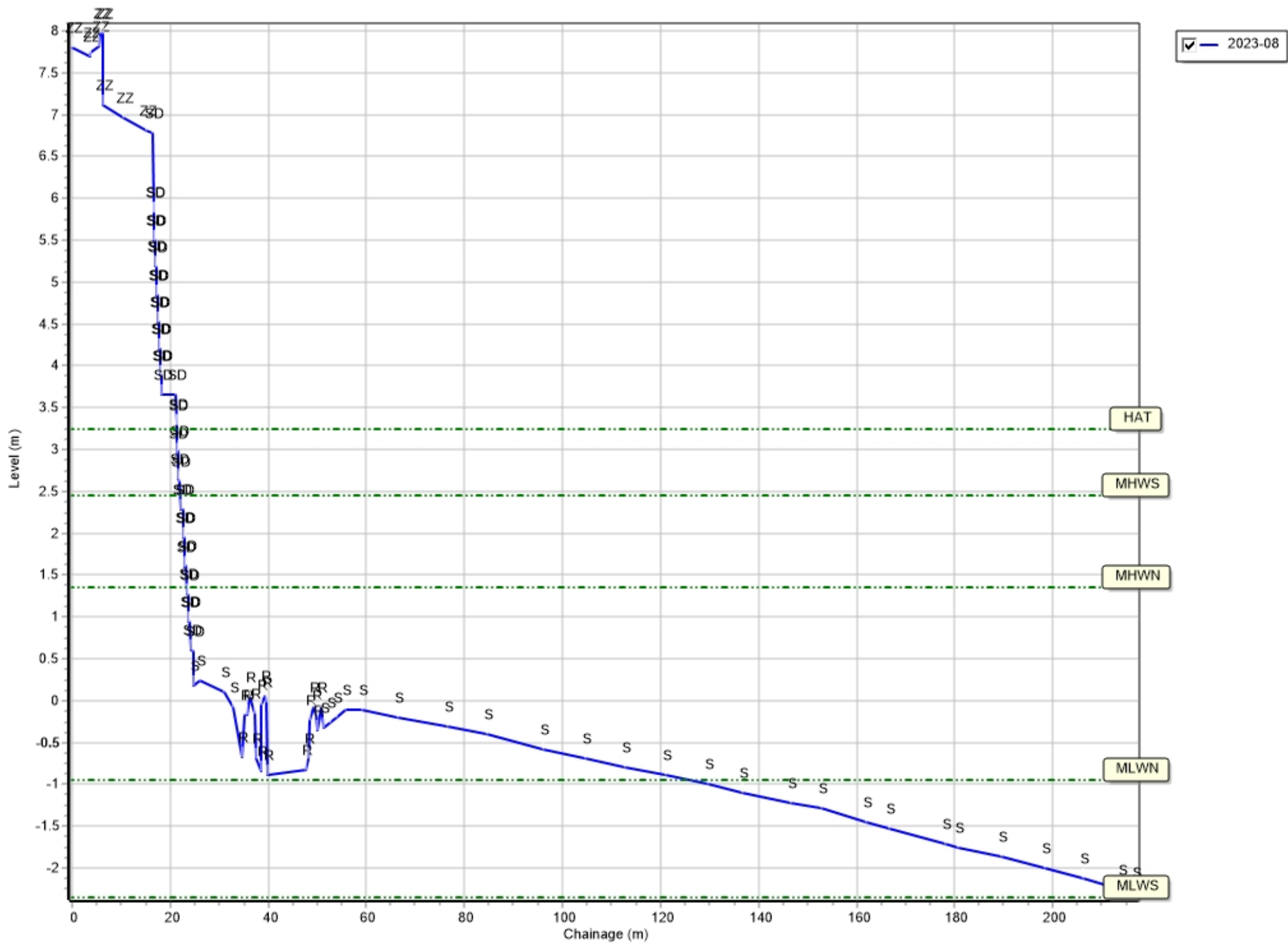
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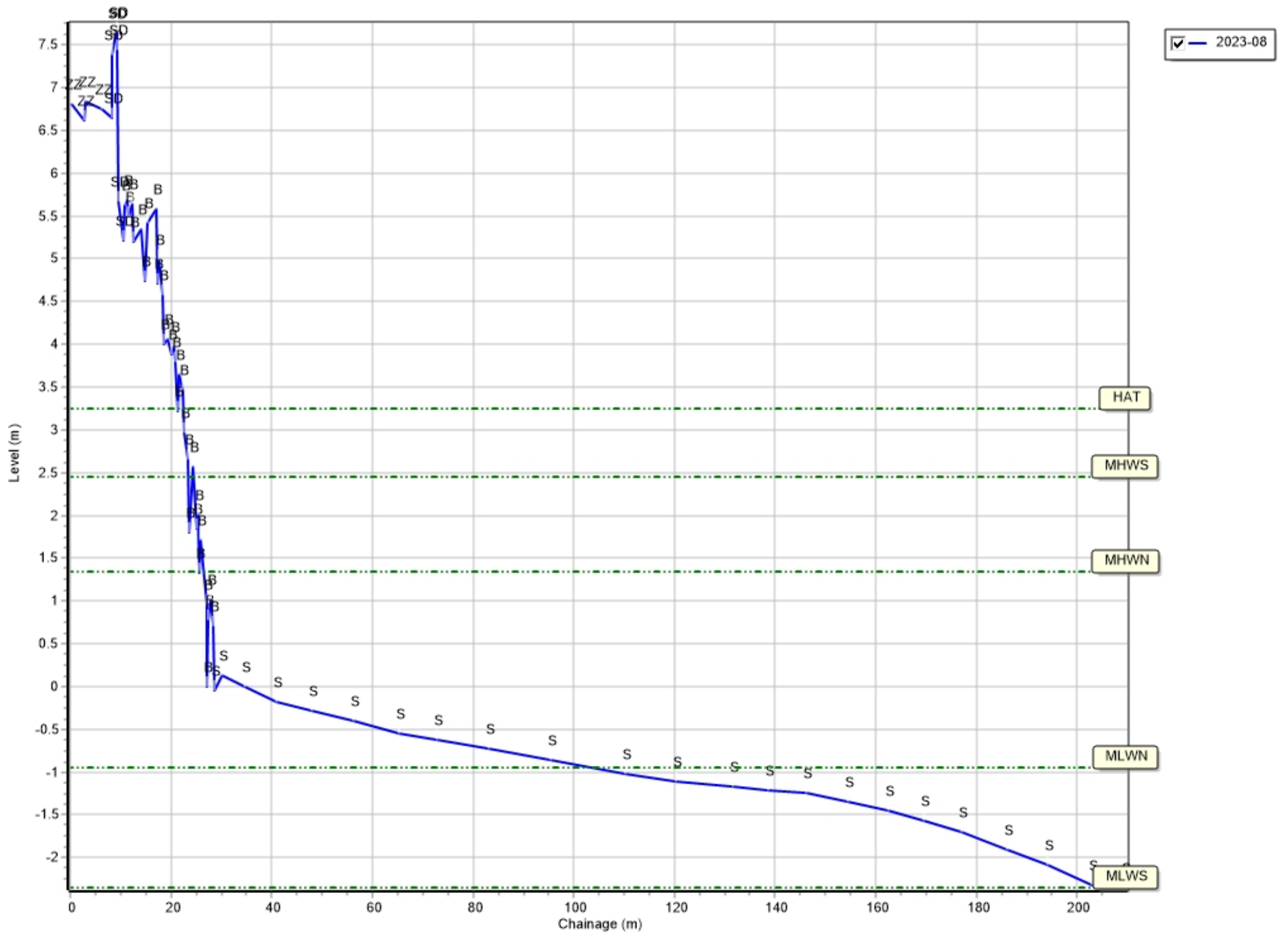
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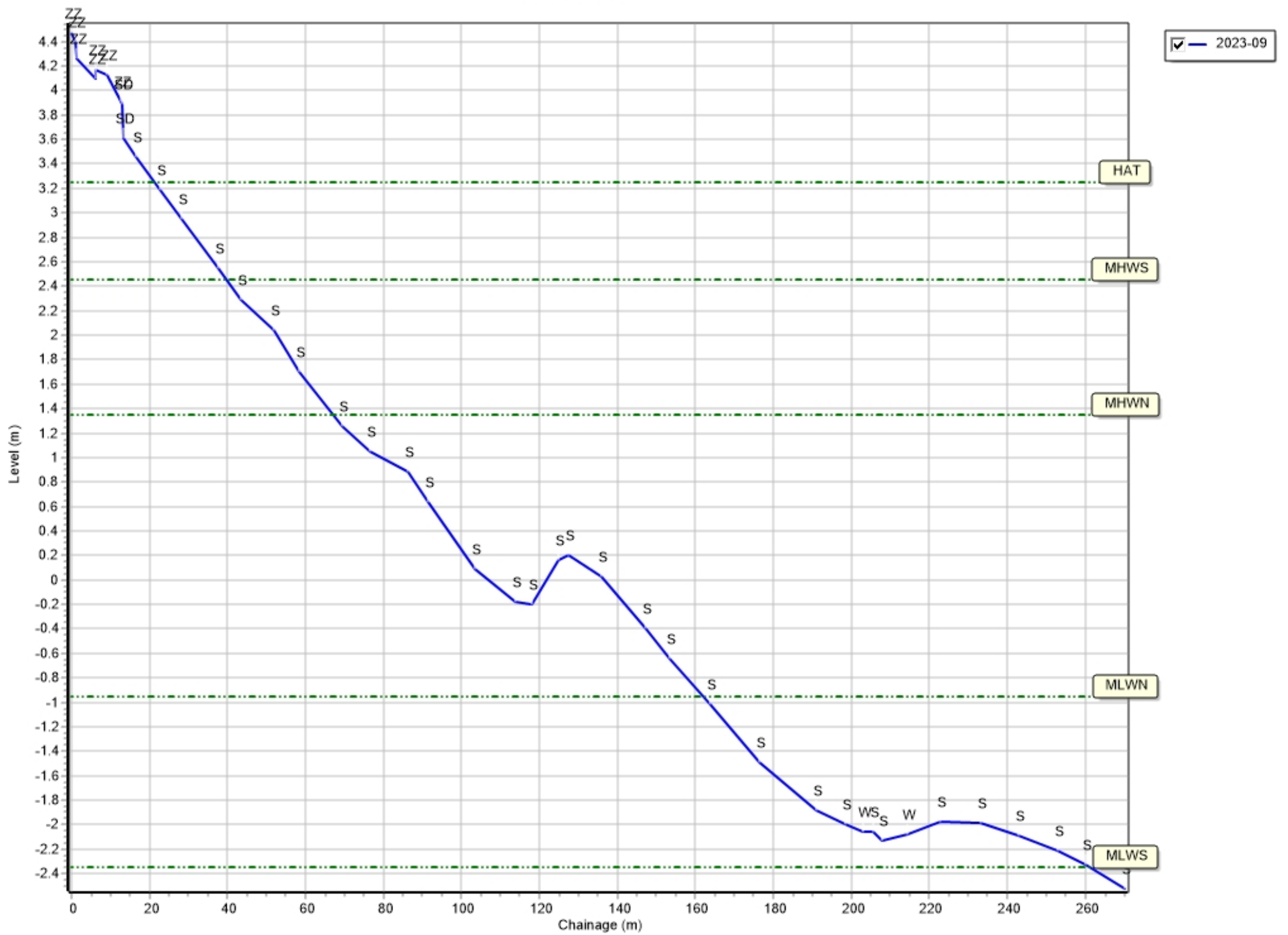
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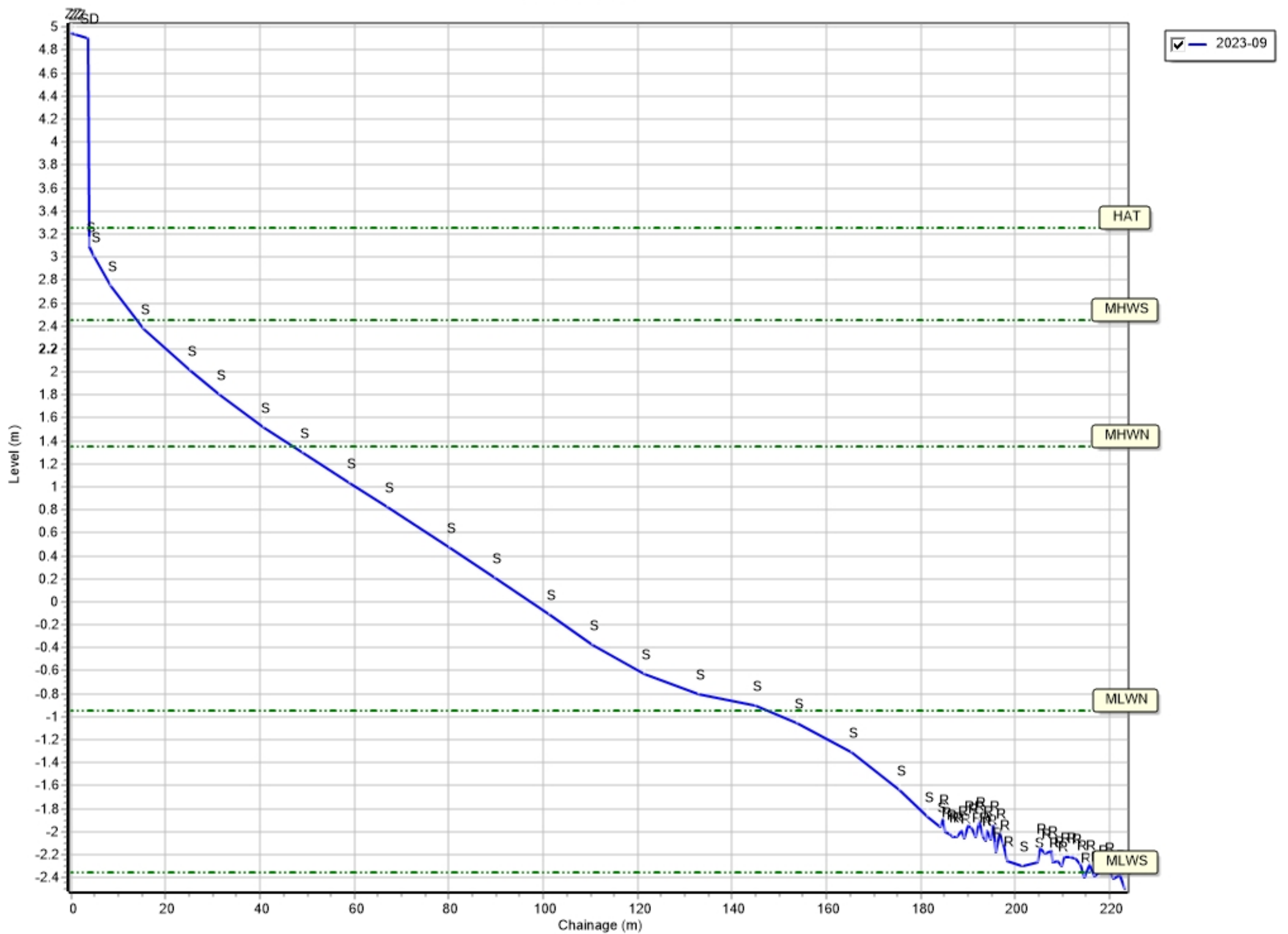
Profiles: 1dSBN5



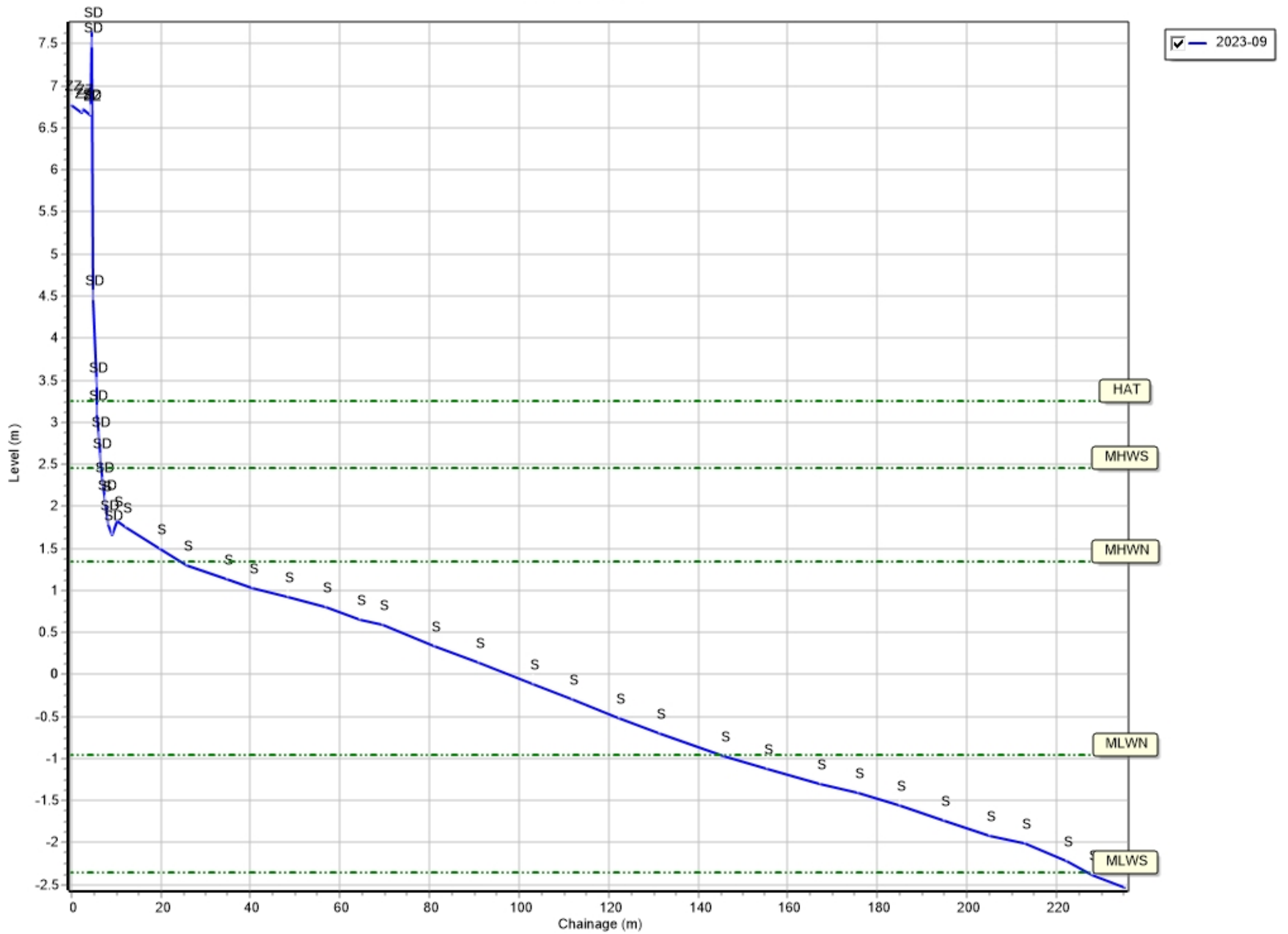
Profiles: 1dSBS1



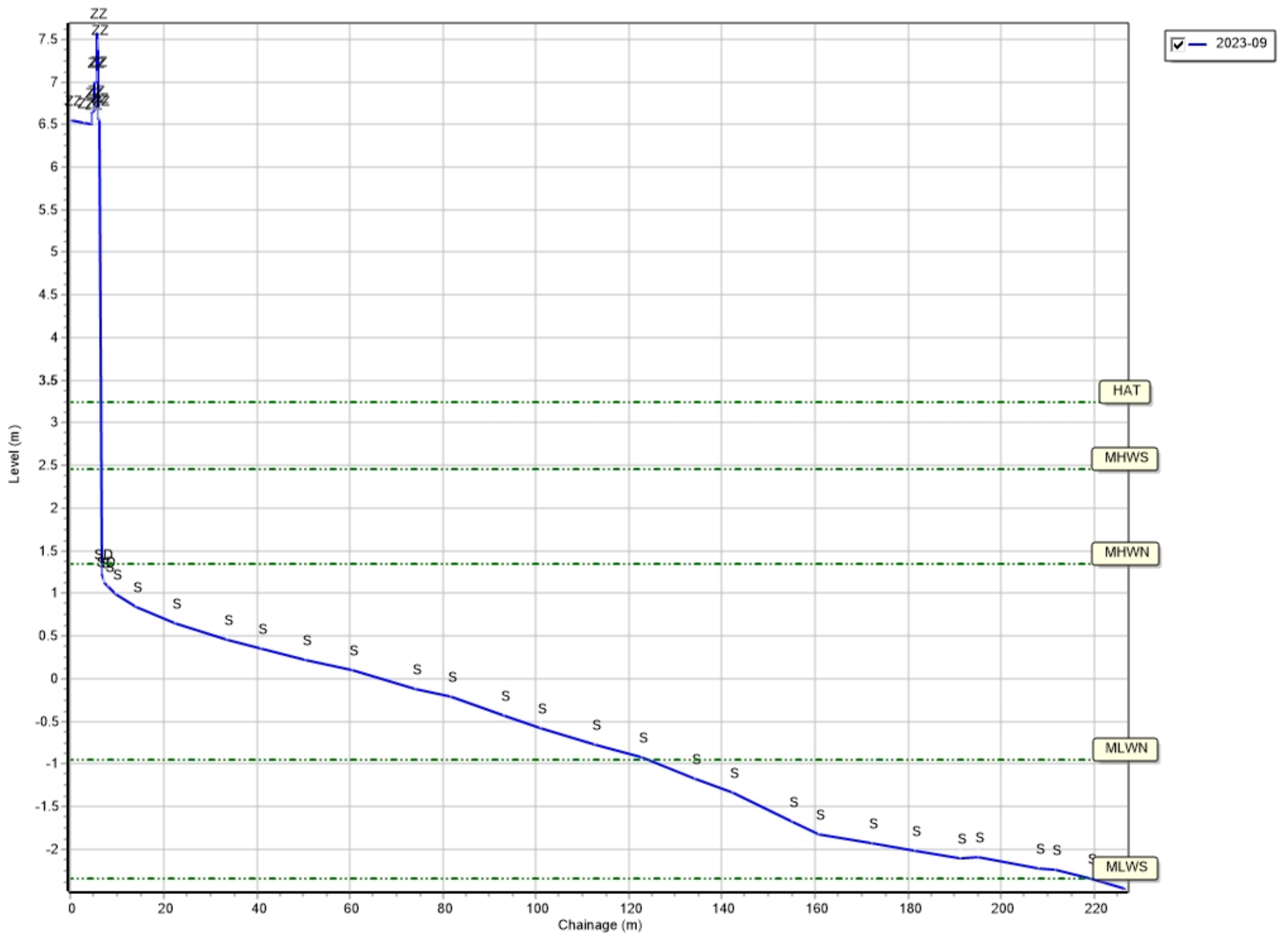
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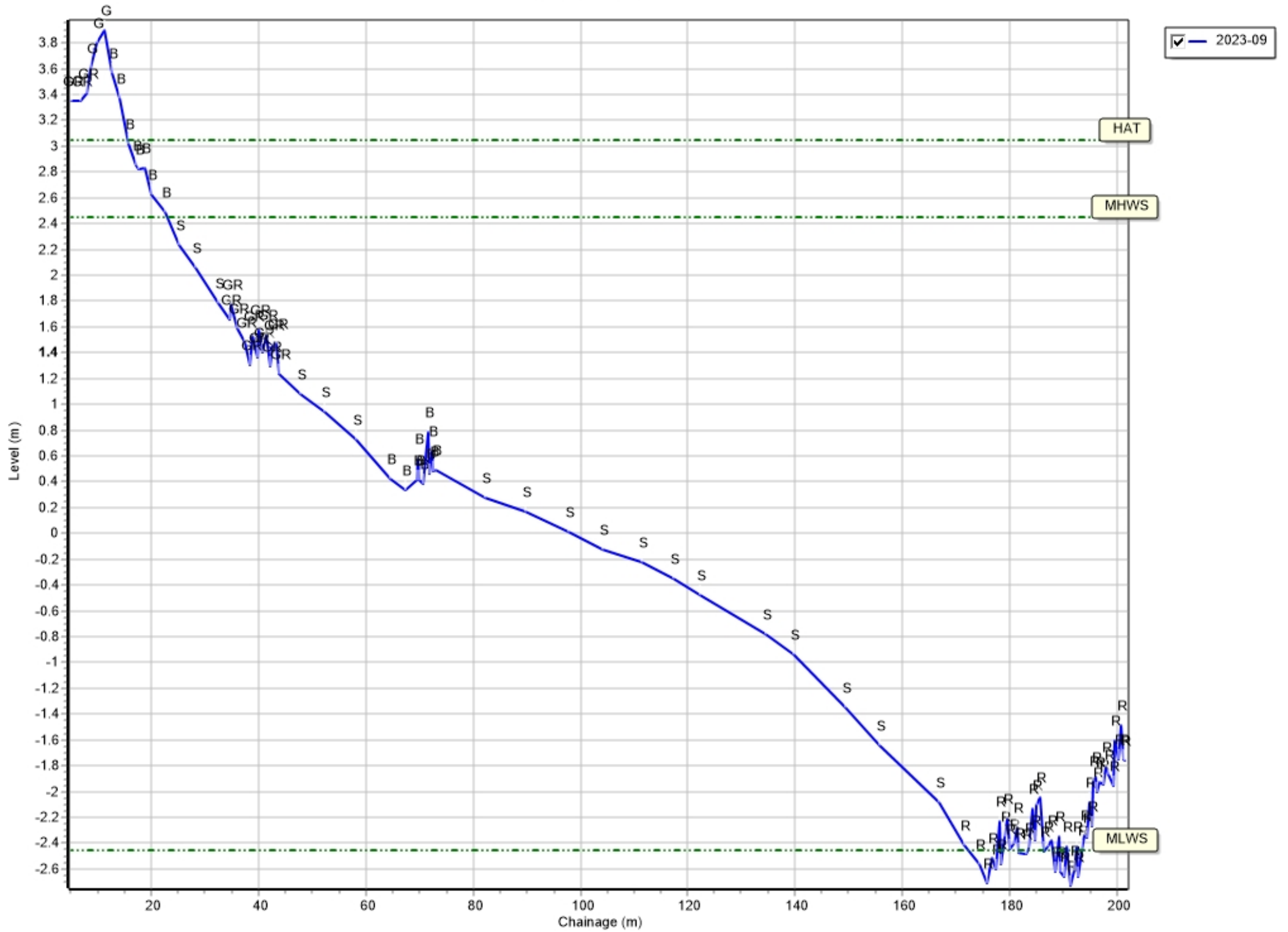
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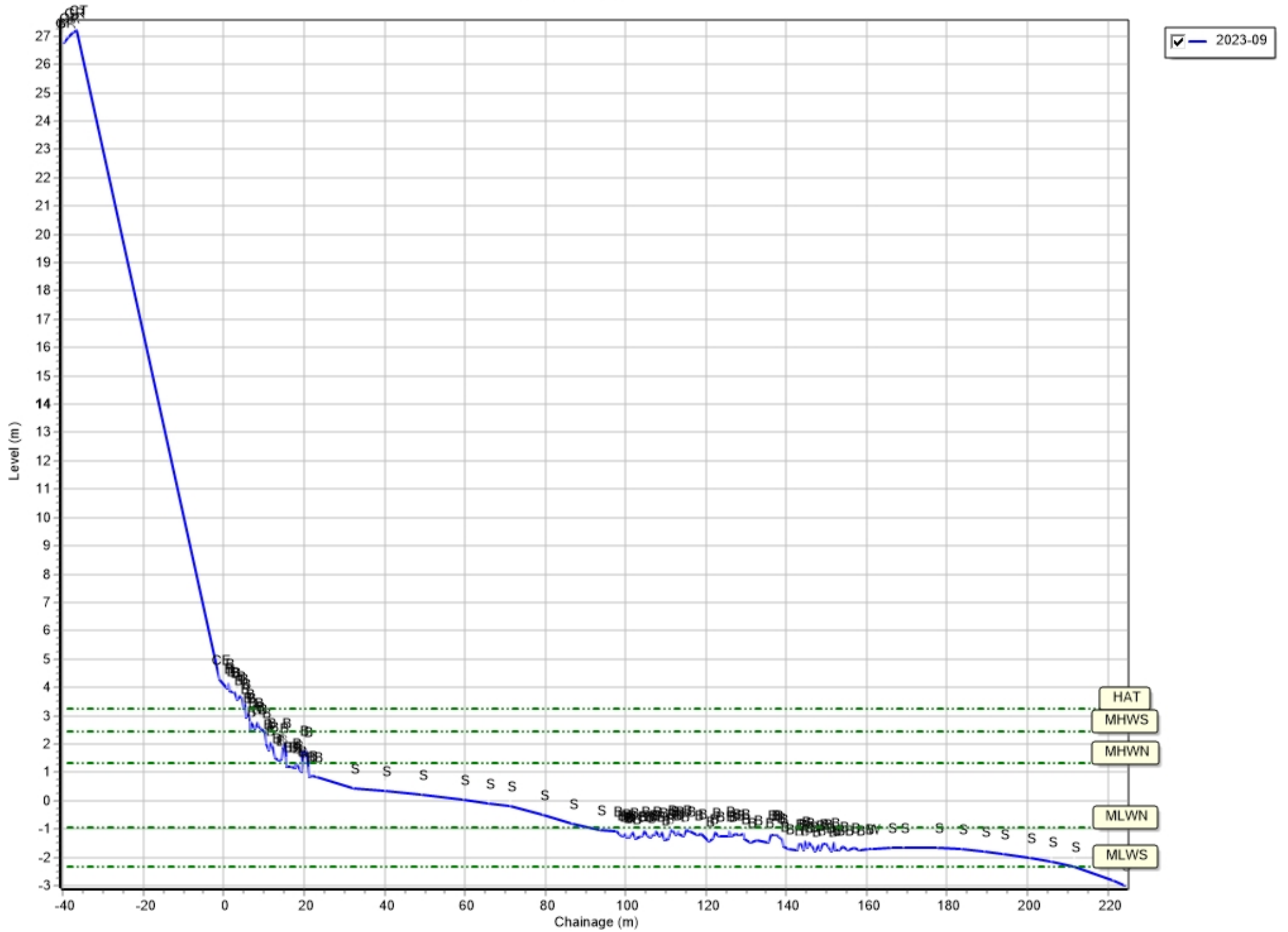
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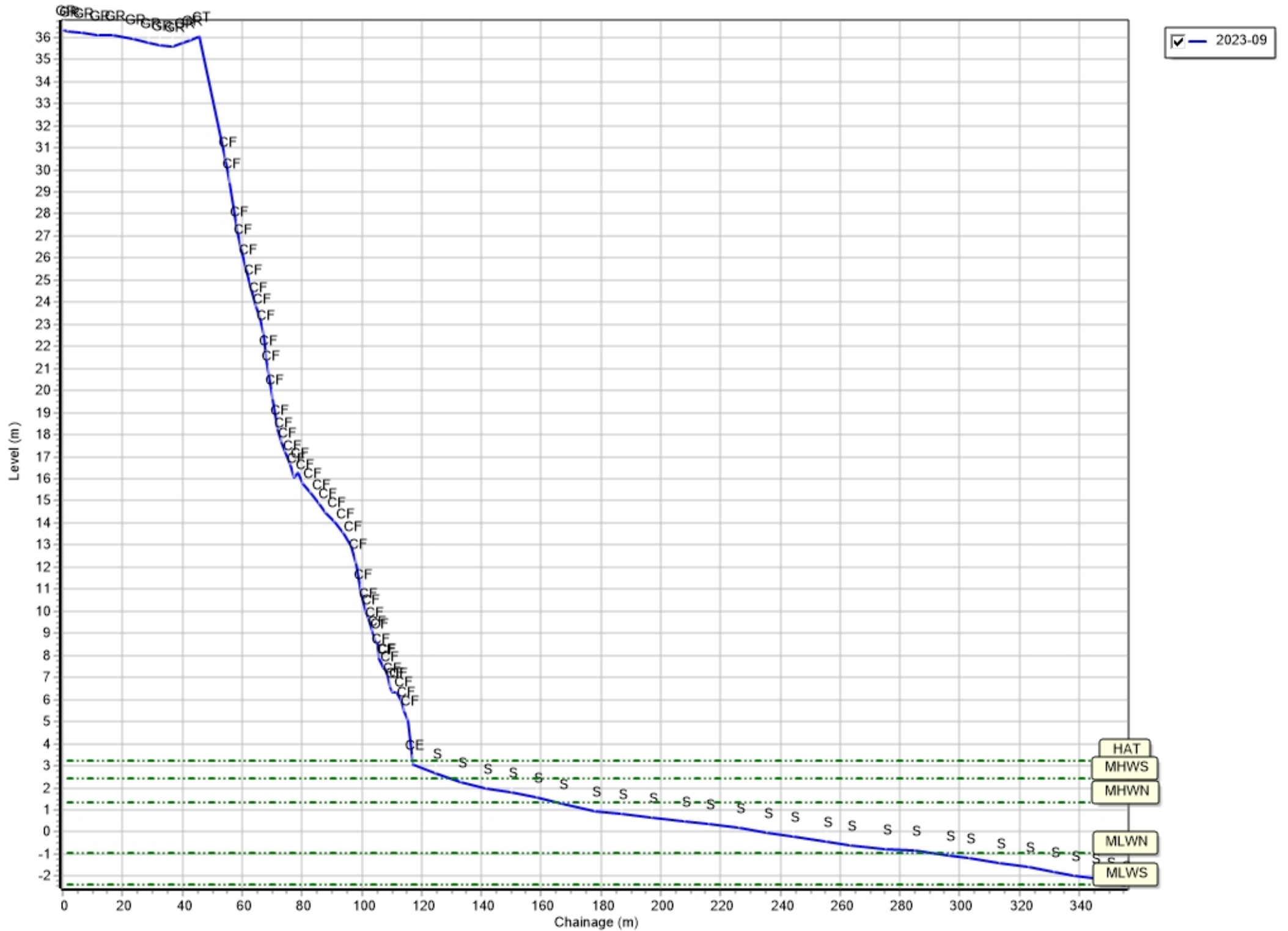
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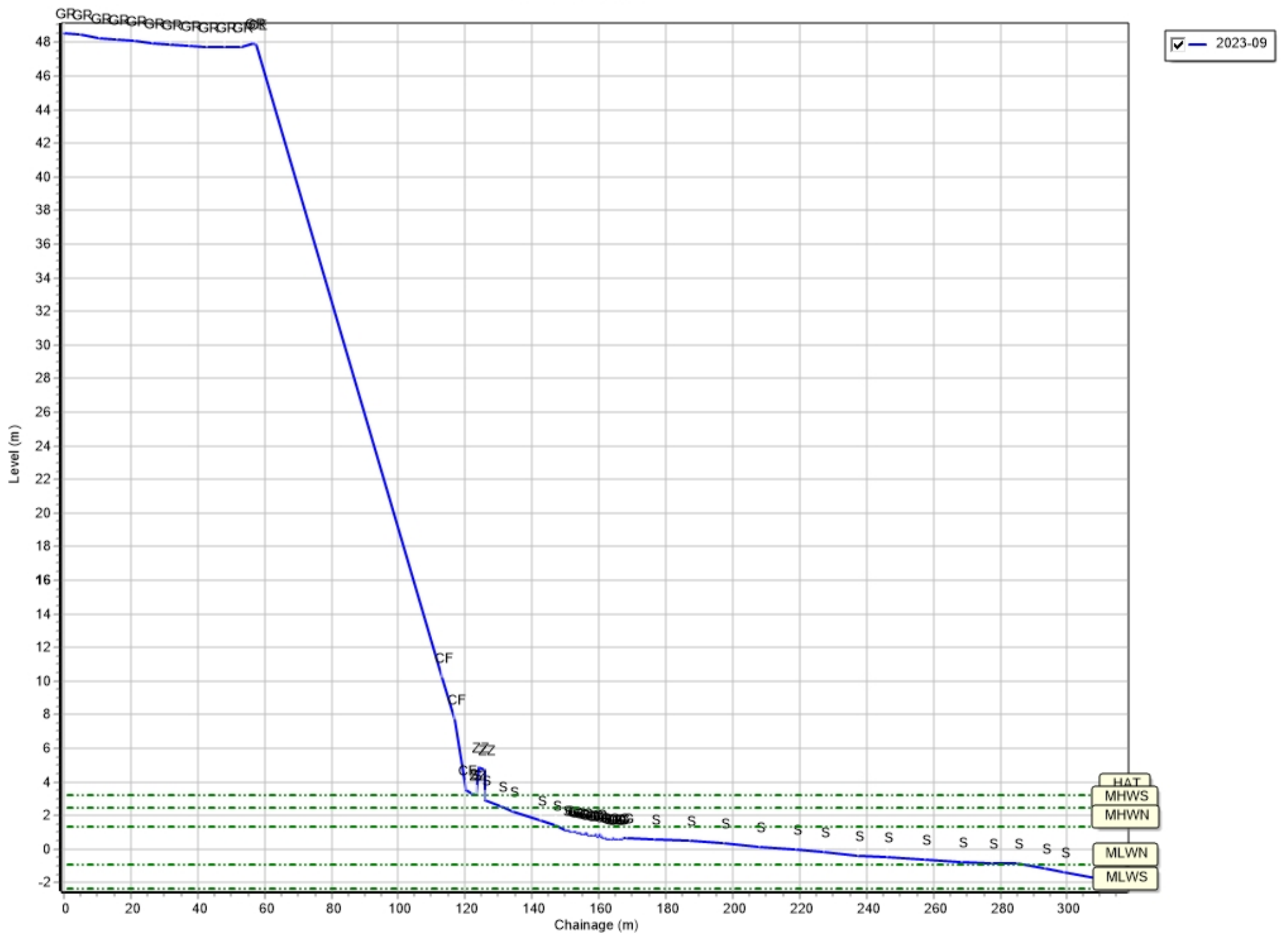
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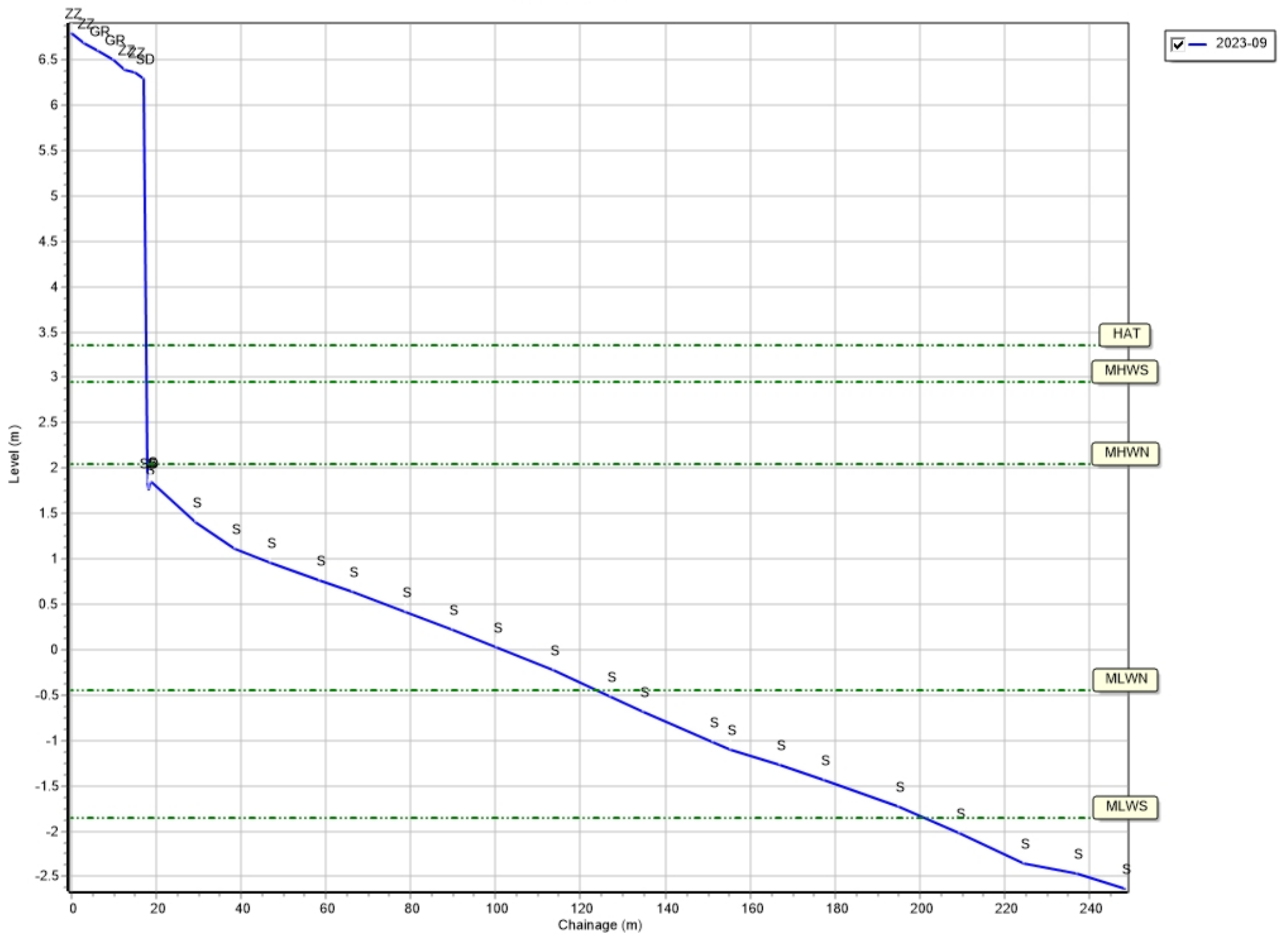
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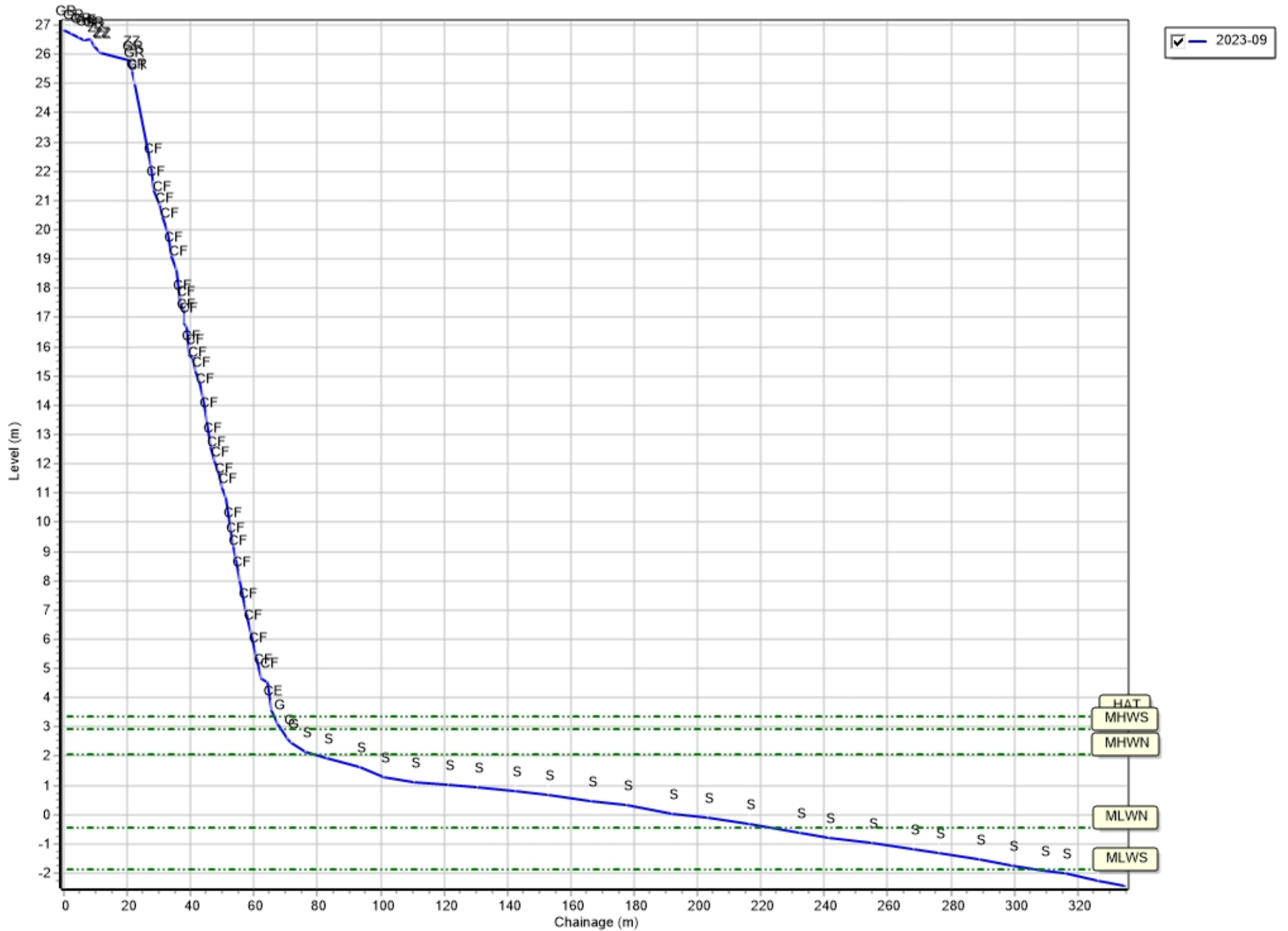
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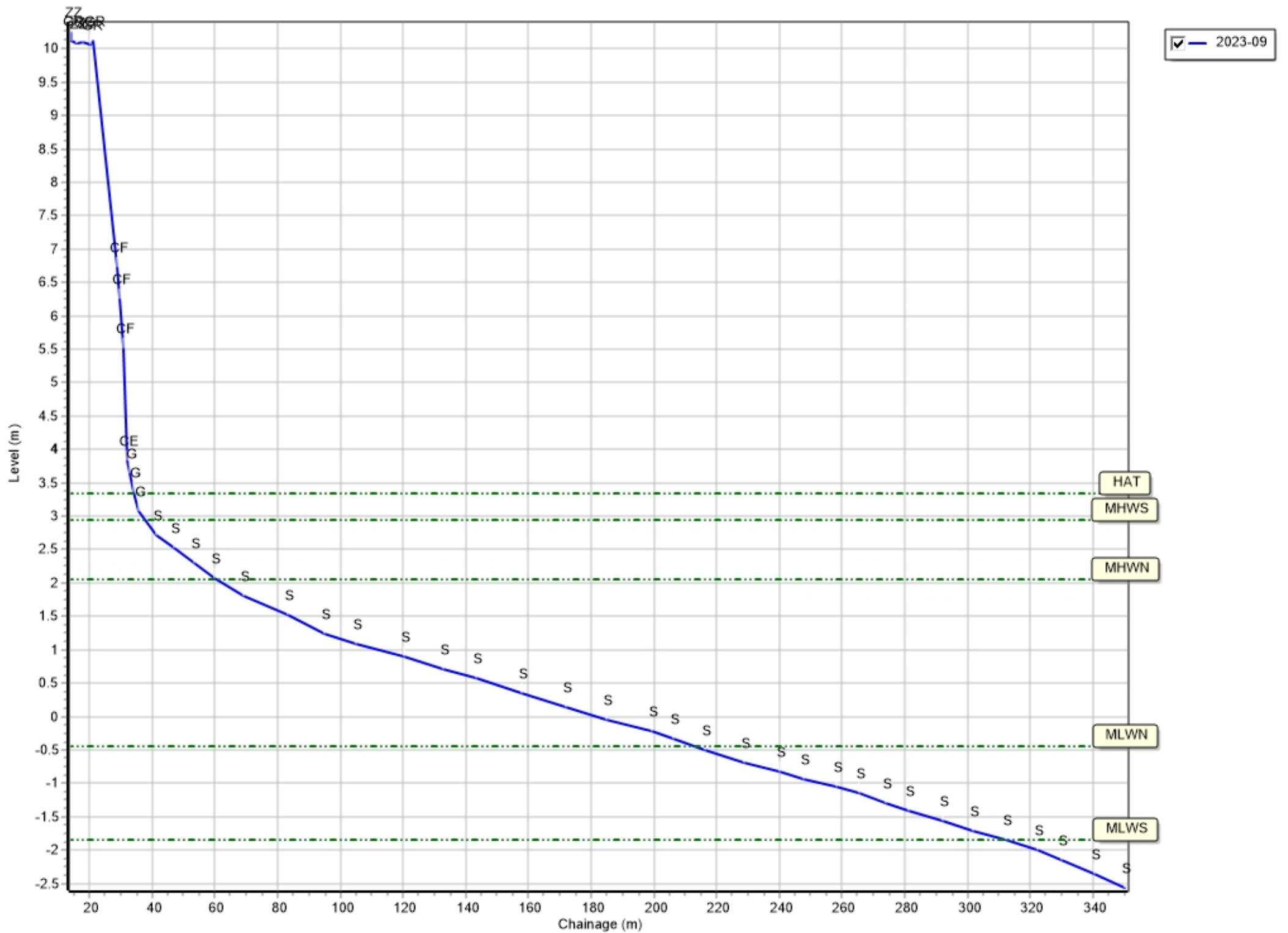
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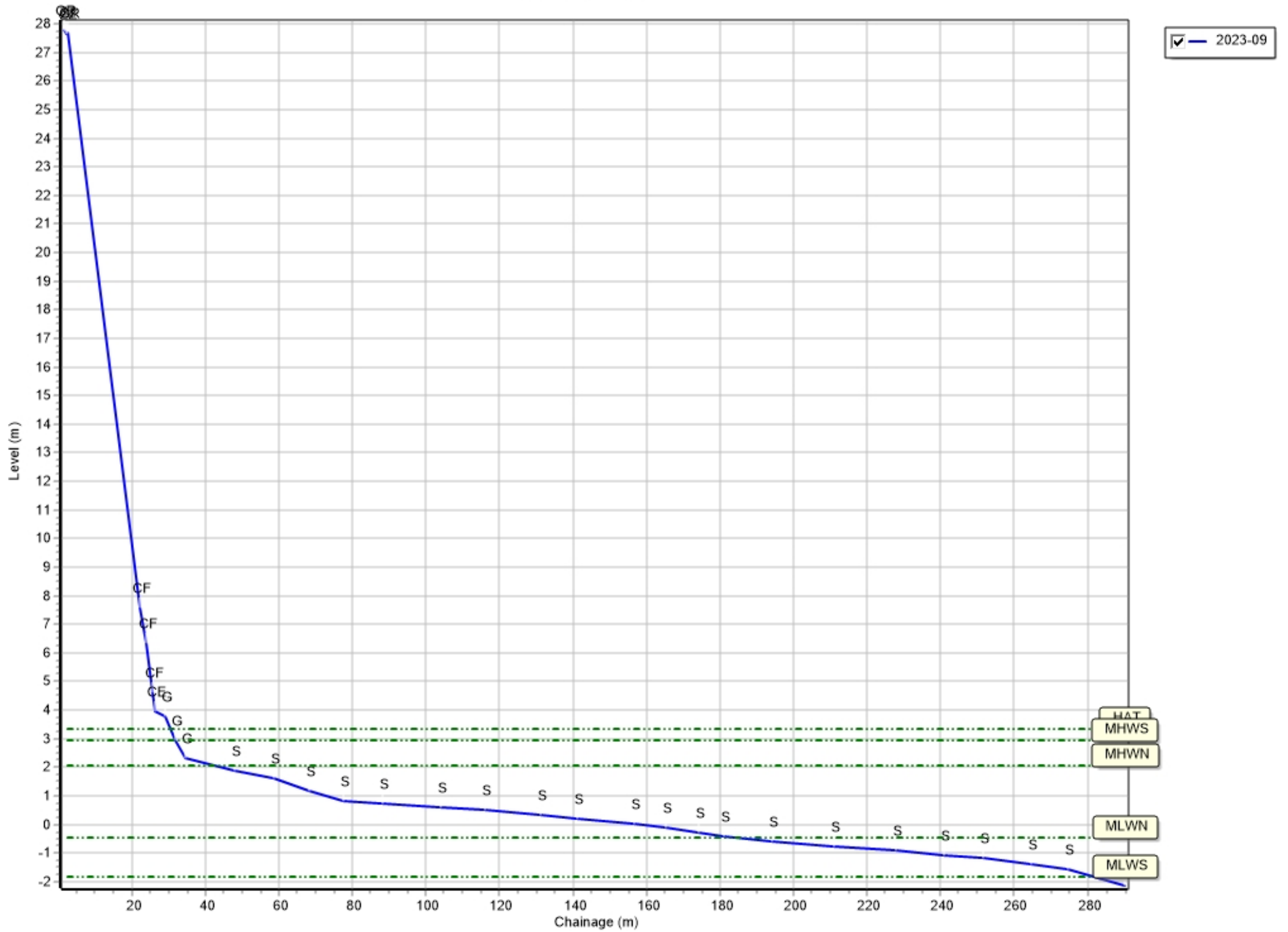
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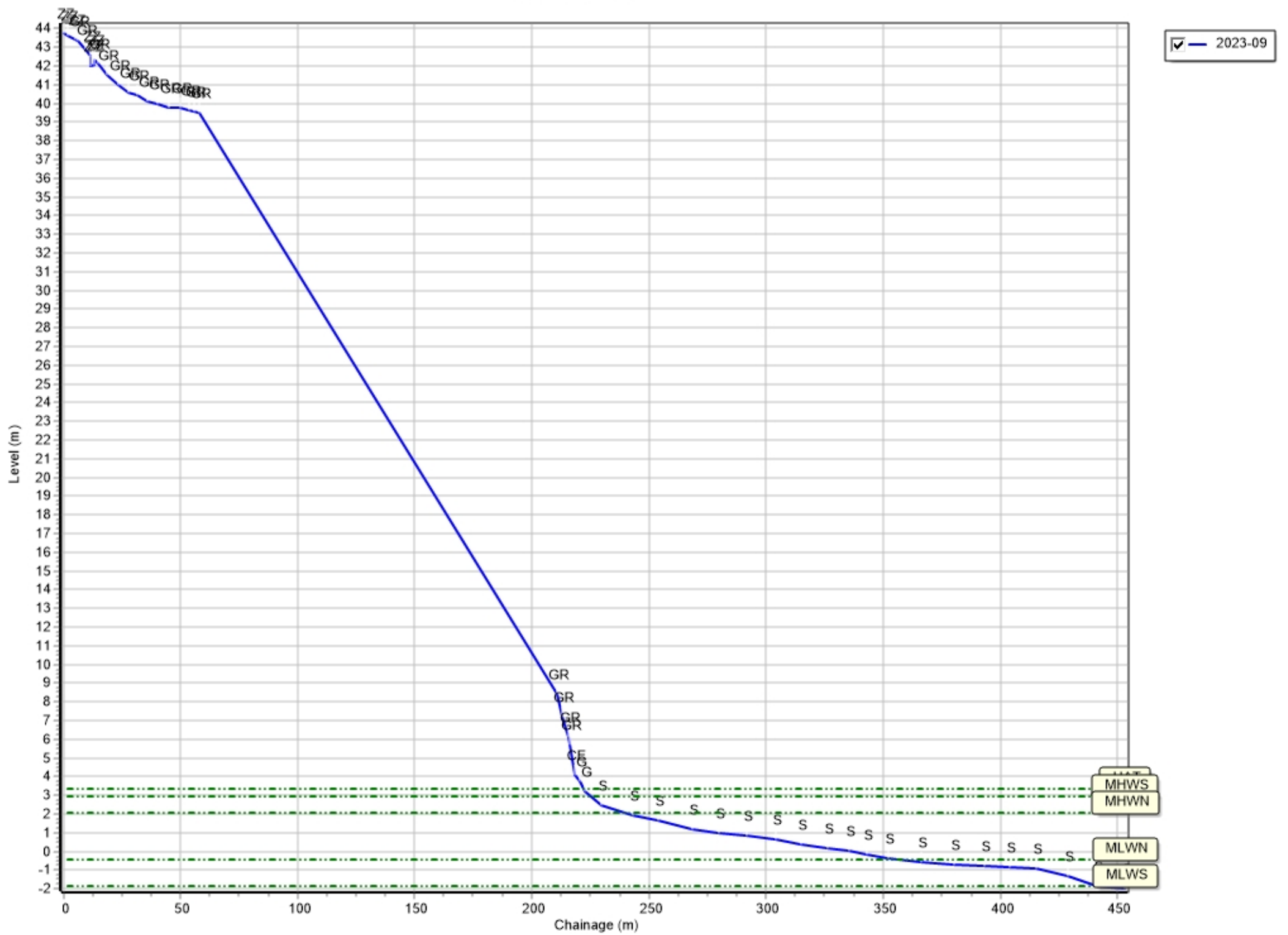
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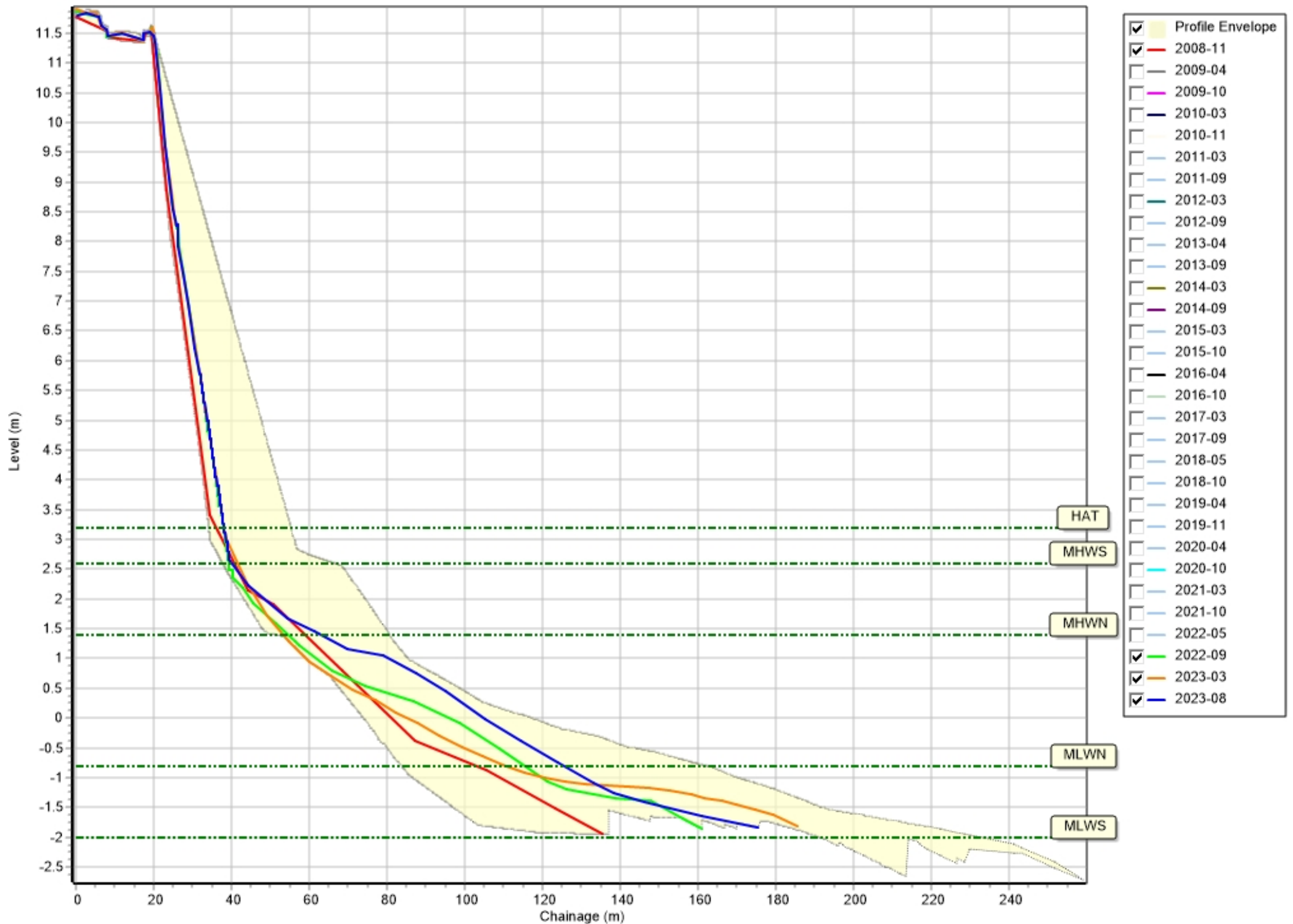
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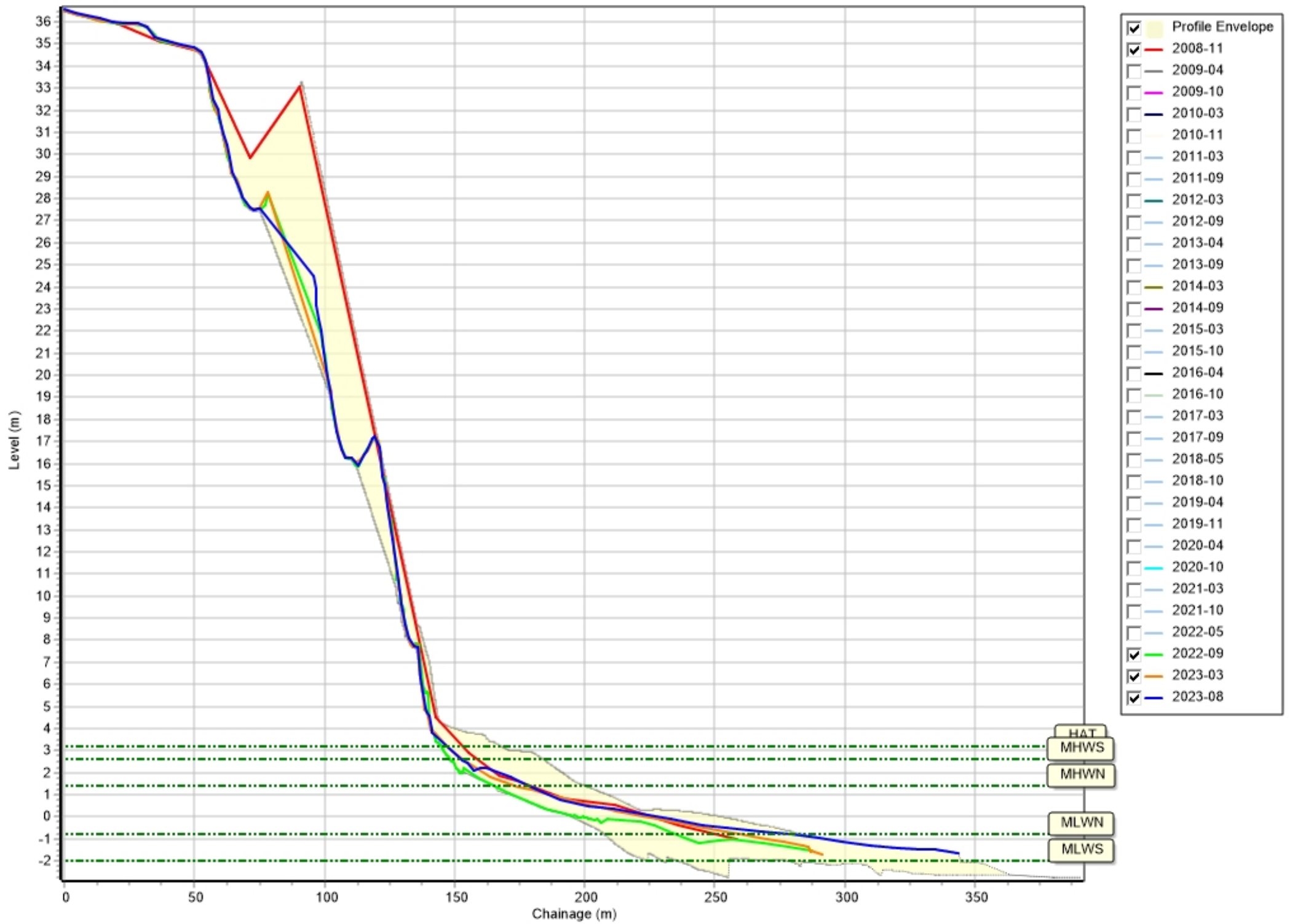
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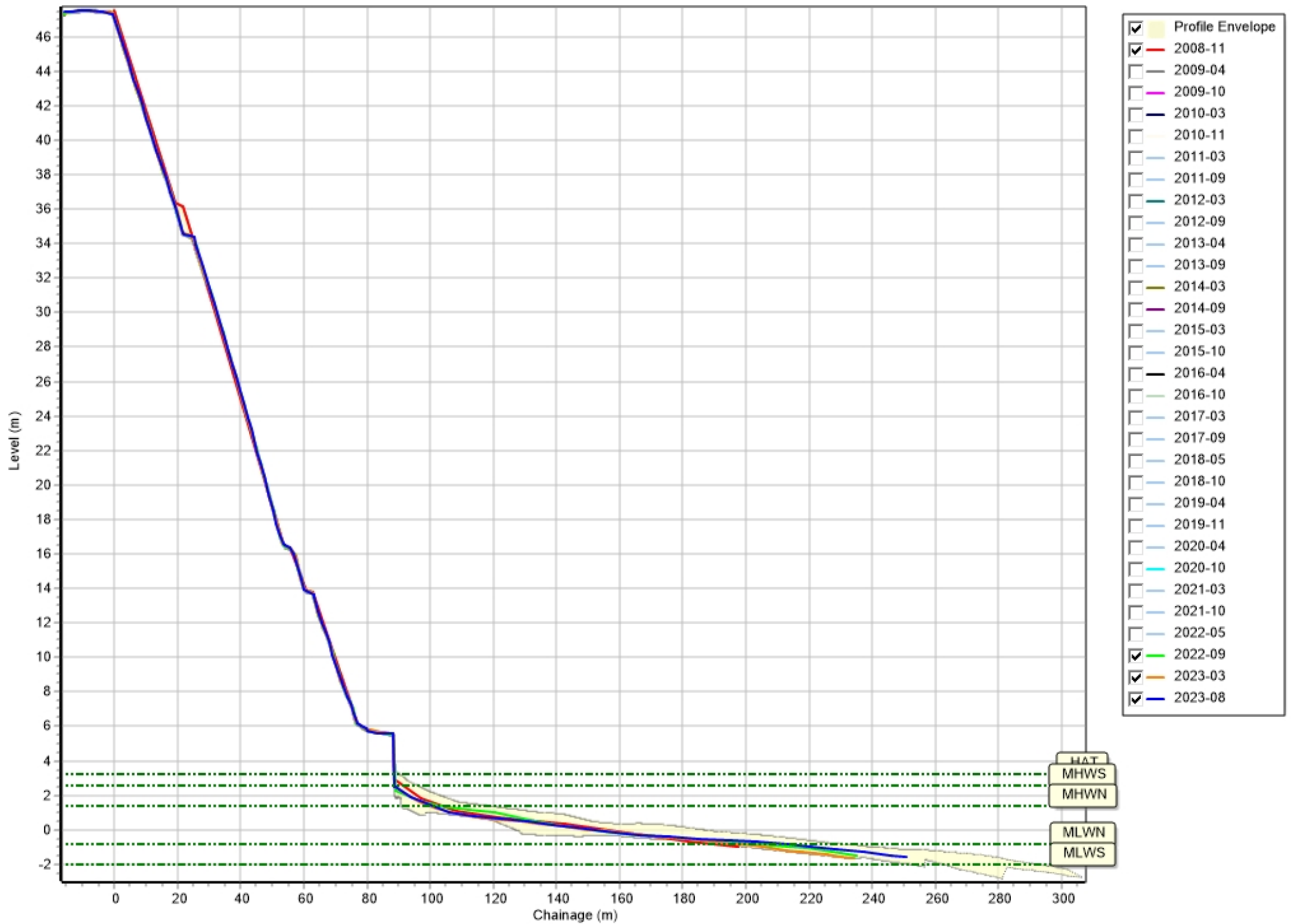
Profiles: 1dWB1



Profiles: 1dWB2



Profiles: 1dWB3



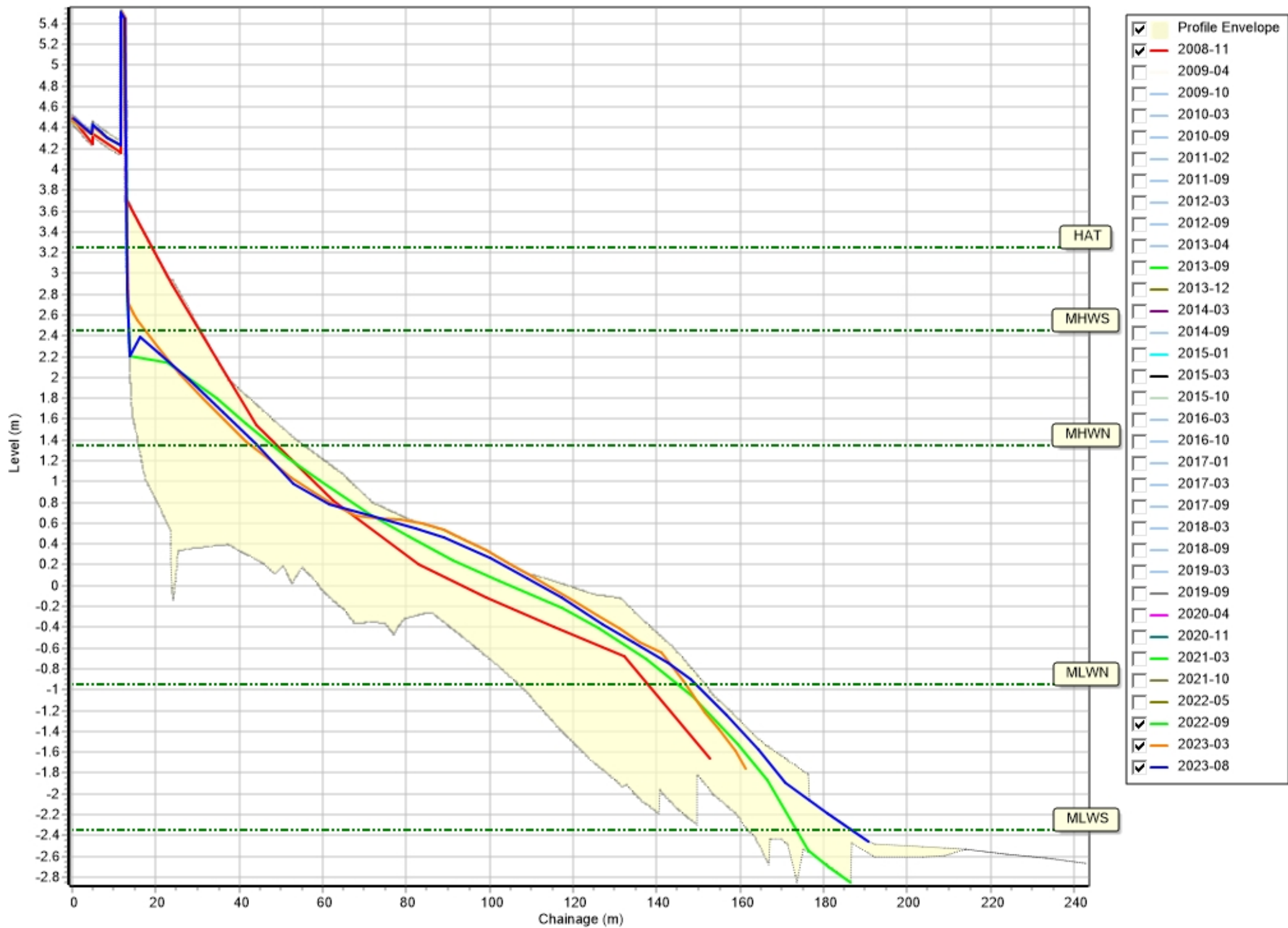
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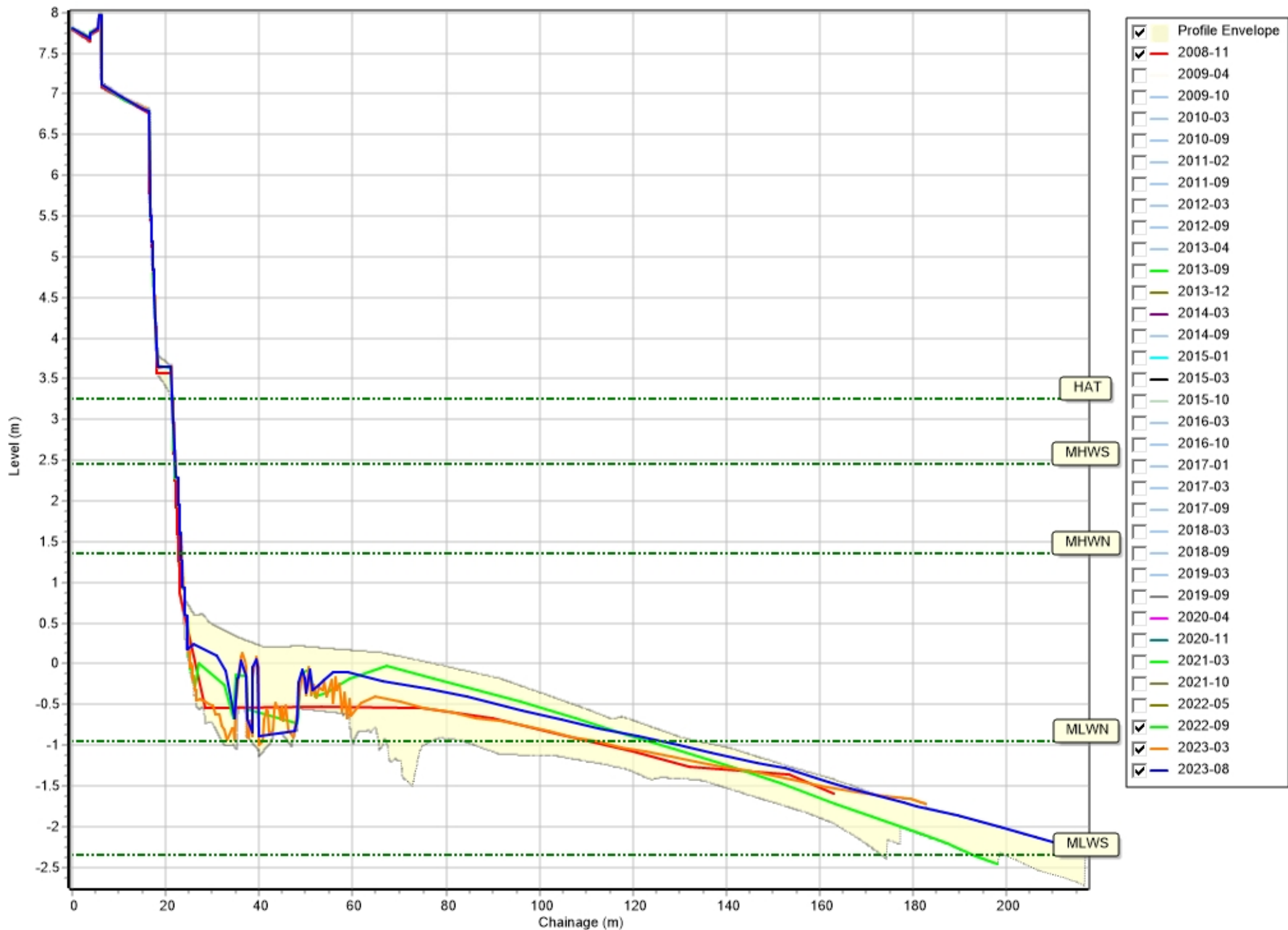
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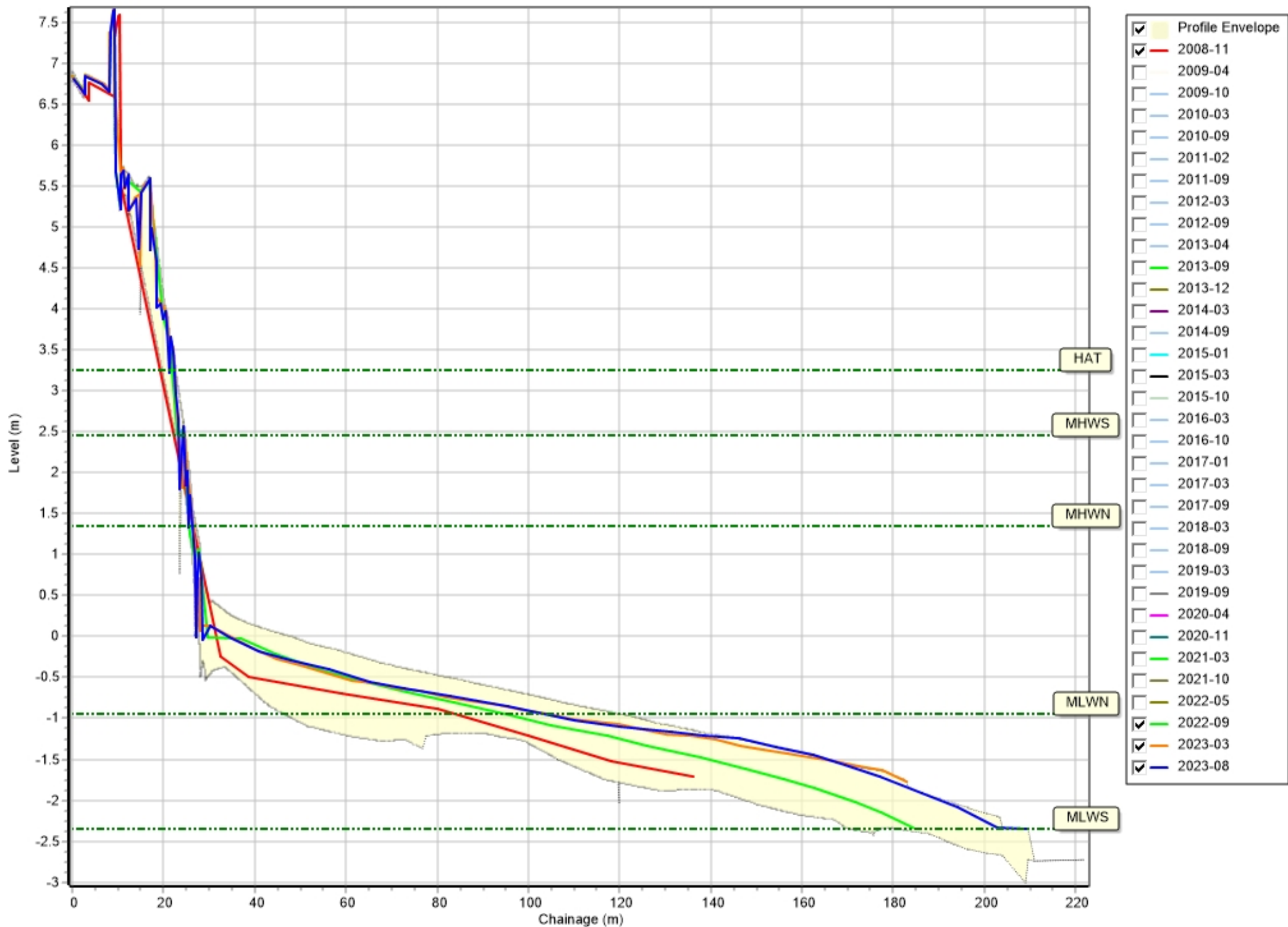
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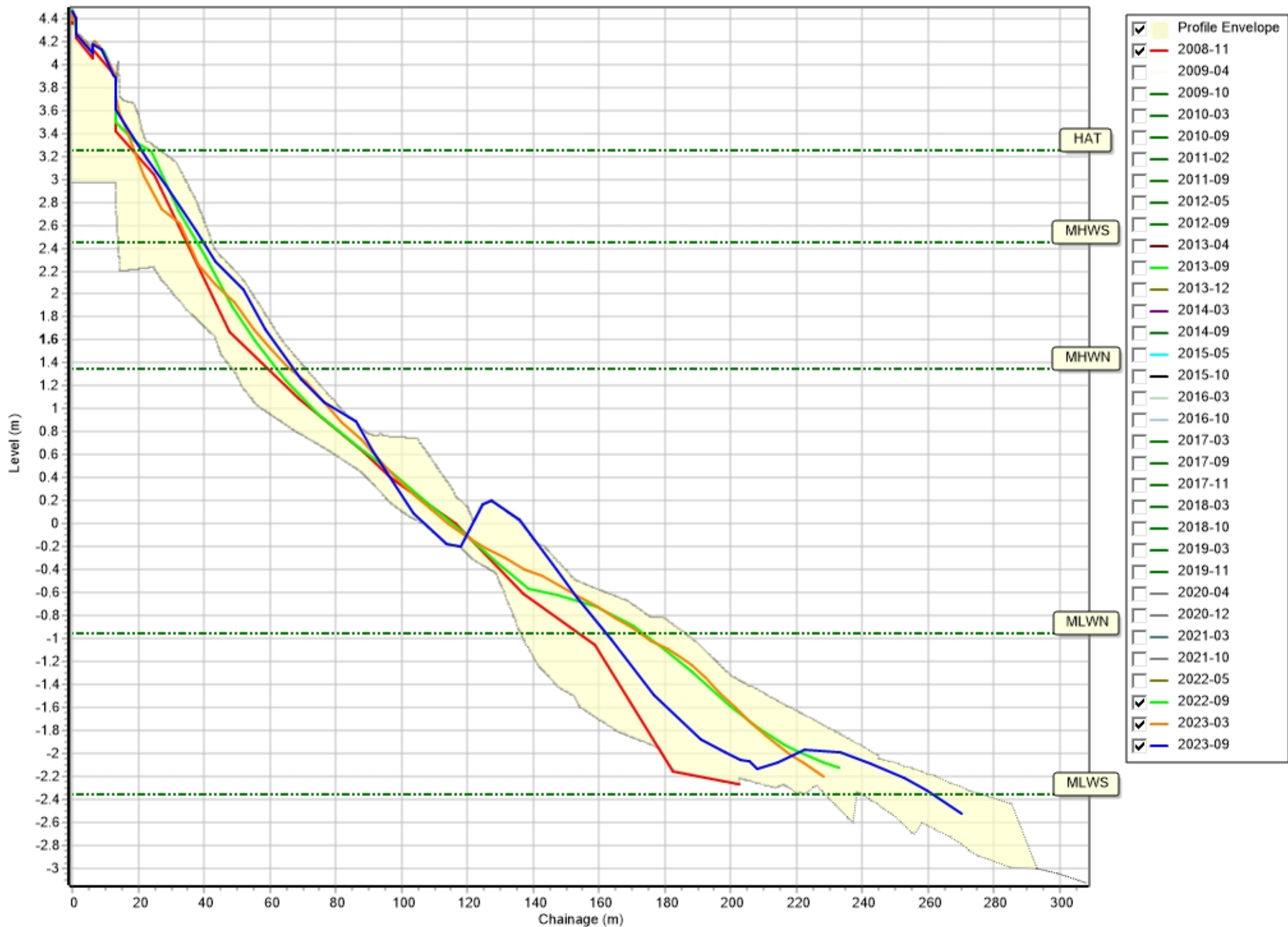
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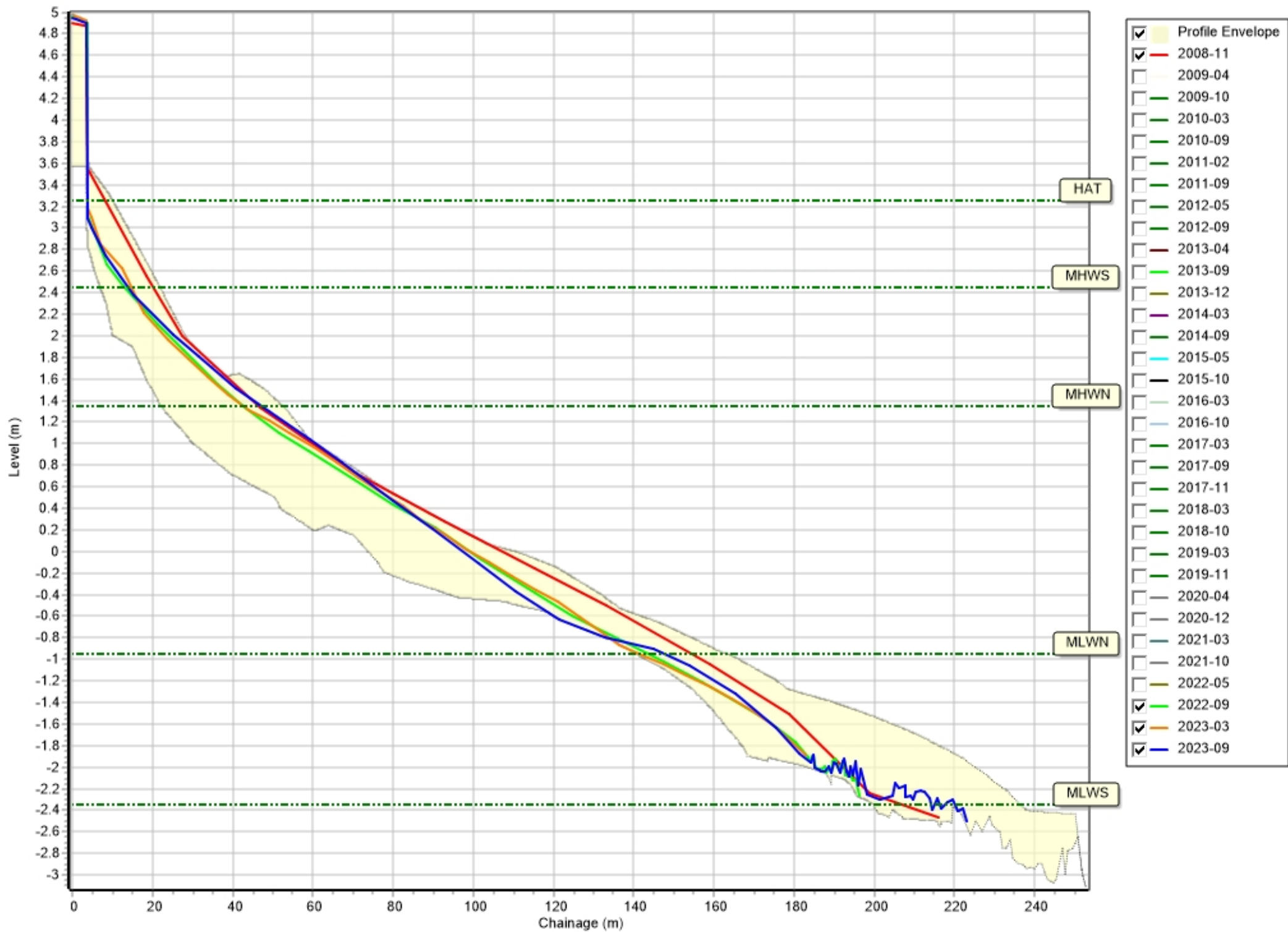
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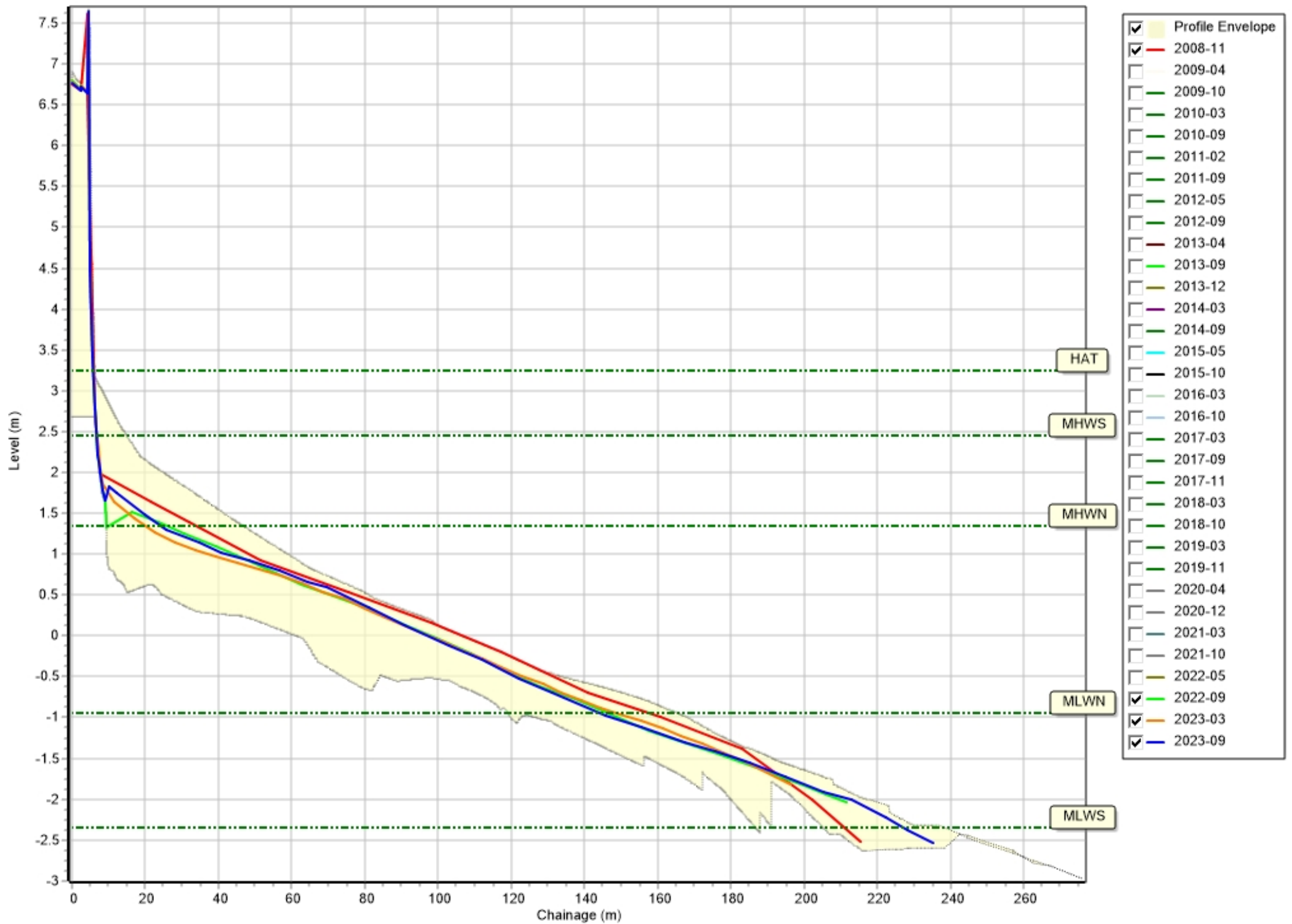
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Profiles: 1dSBS3



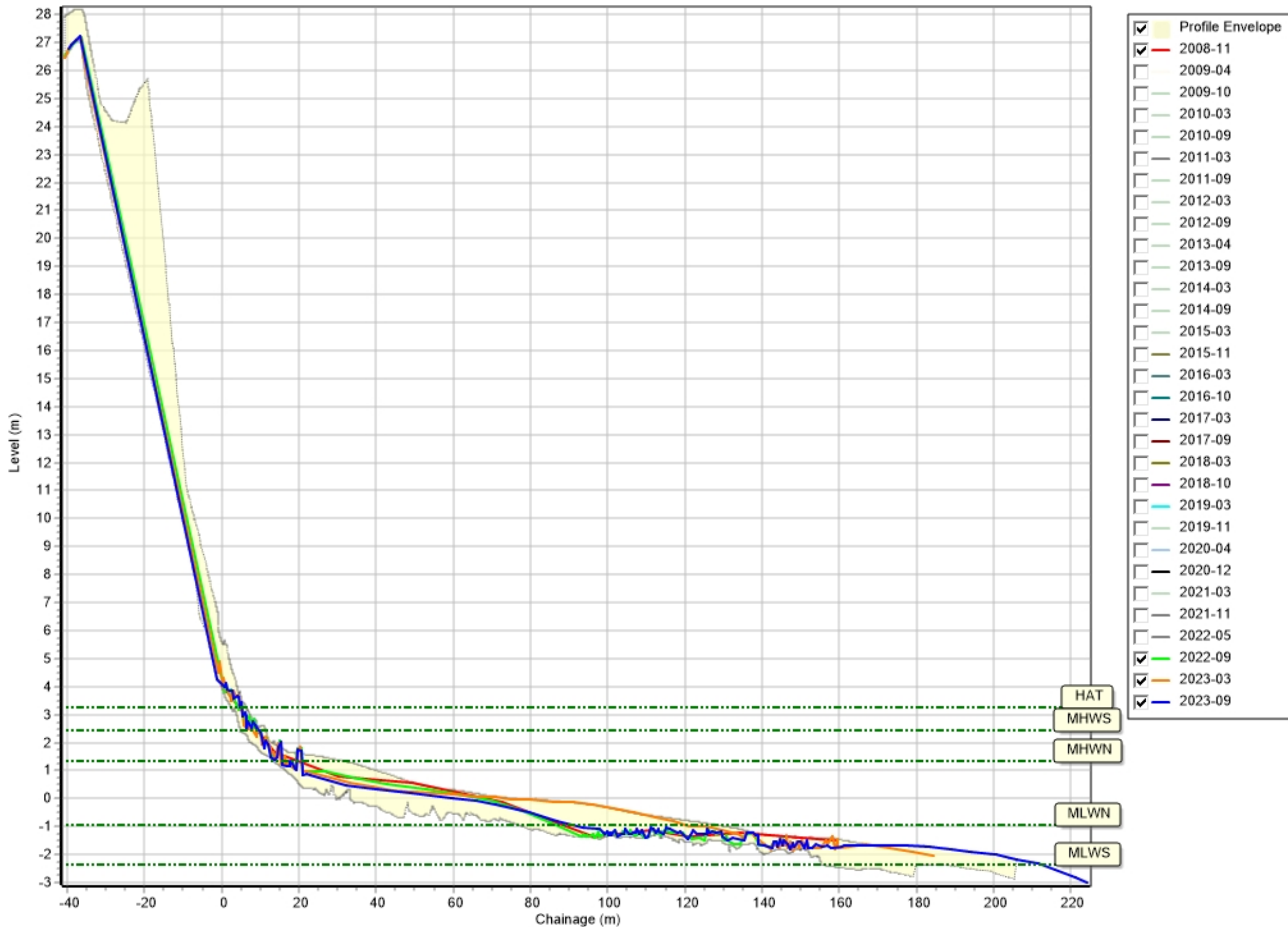
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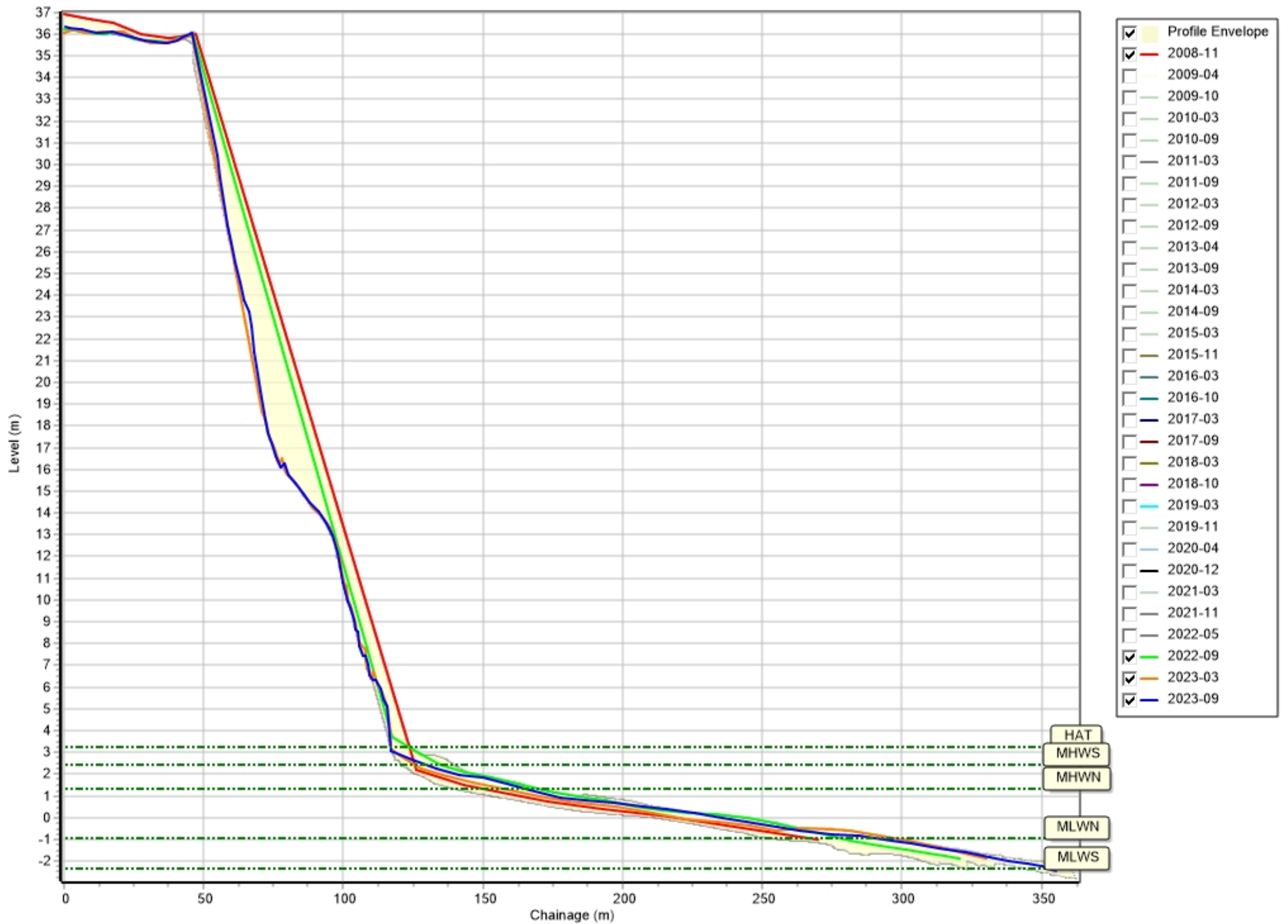
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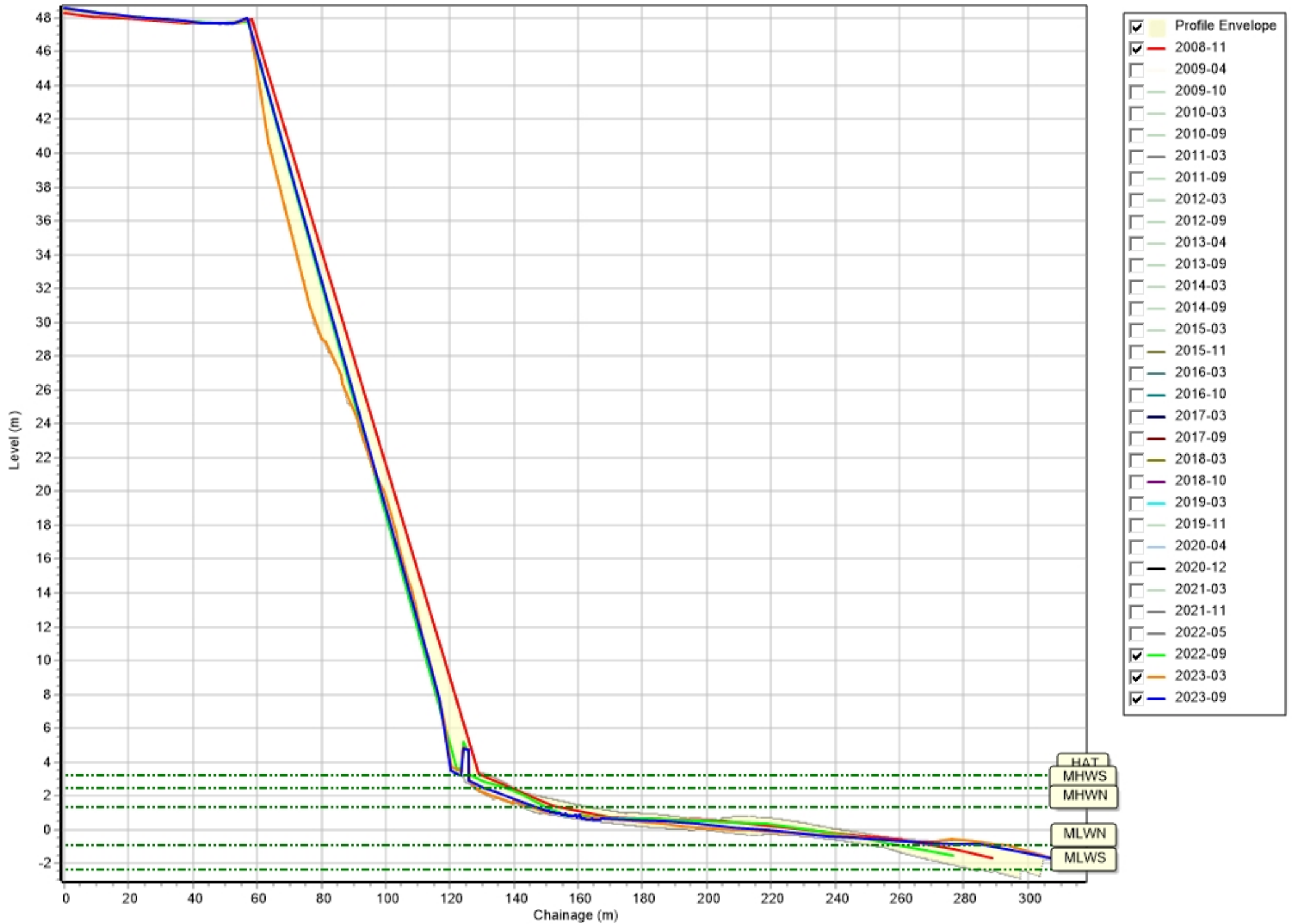
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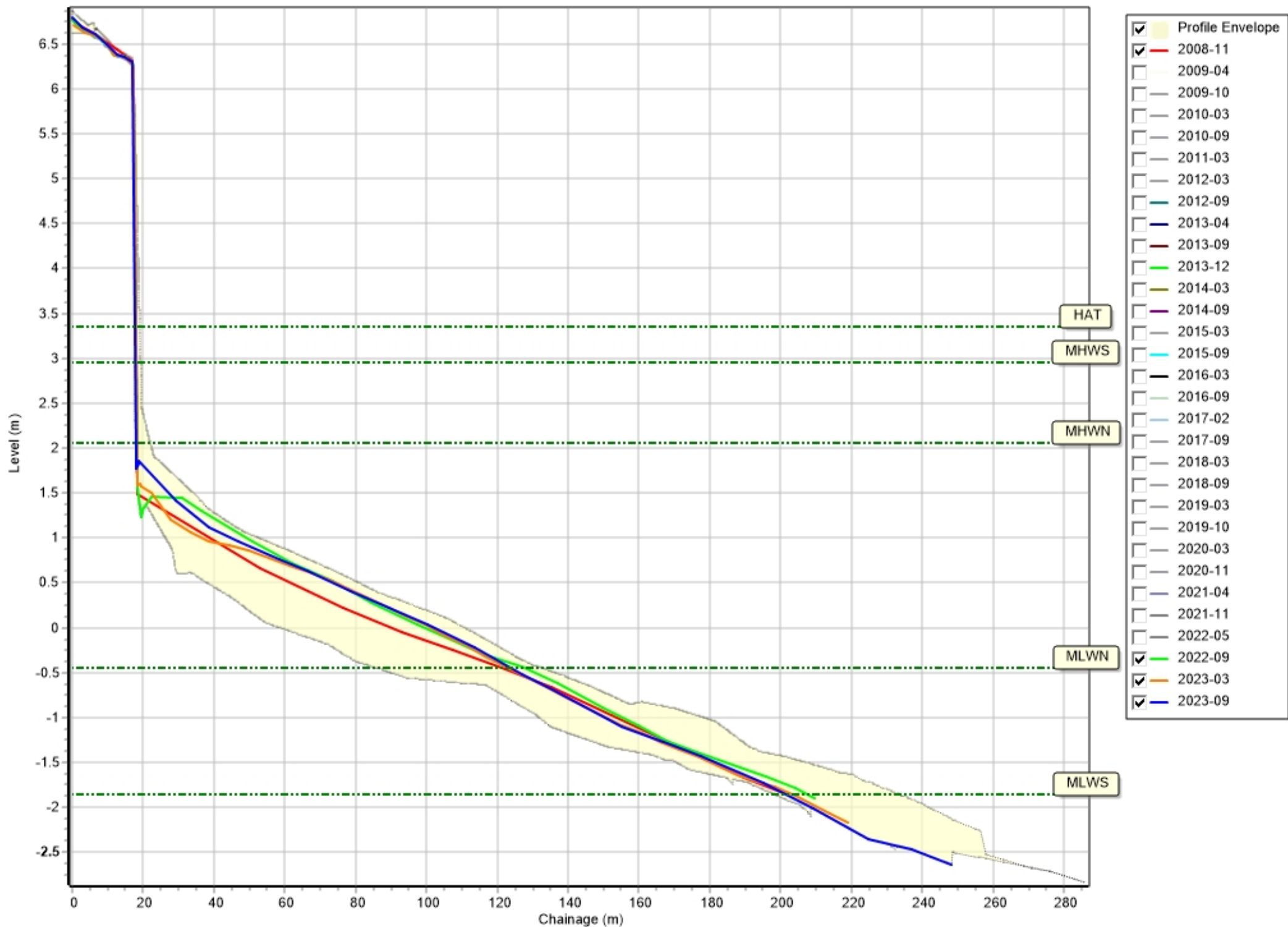
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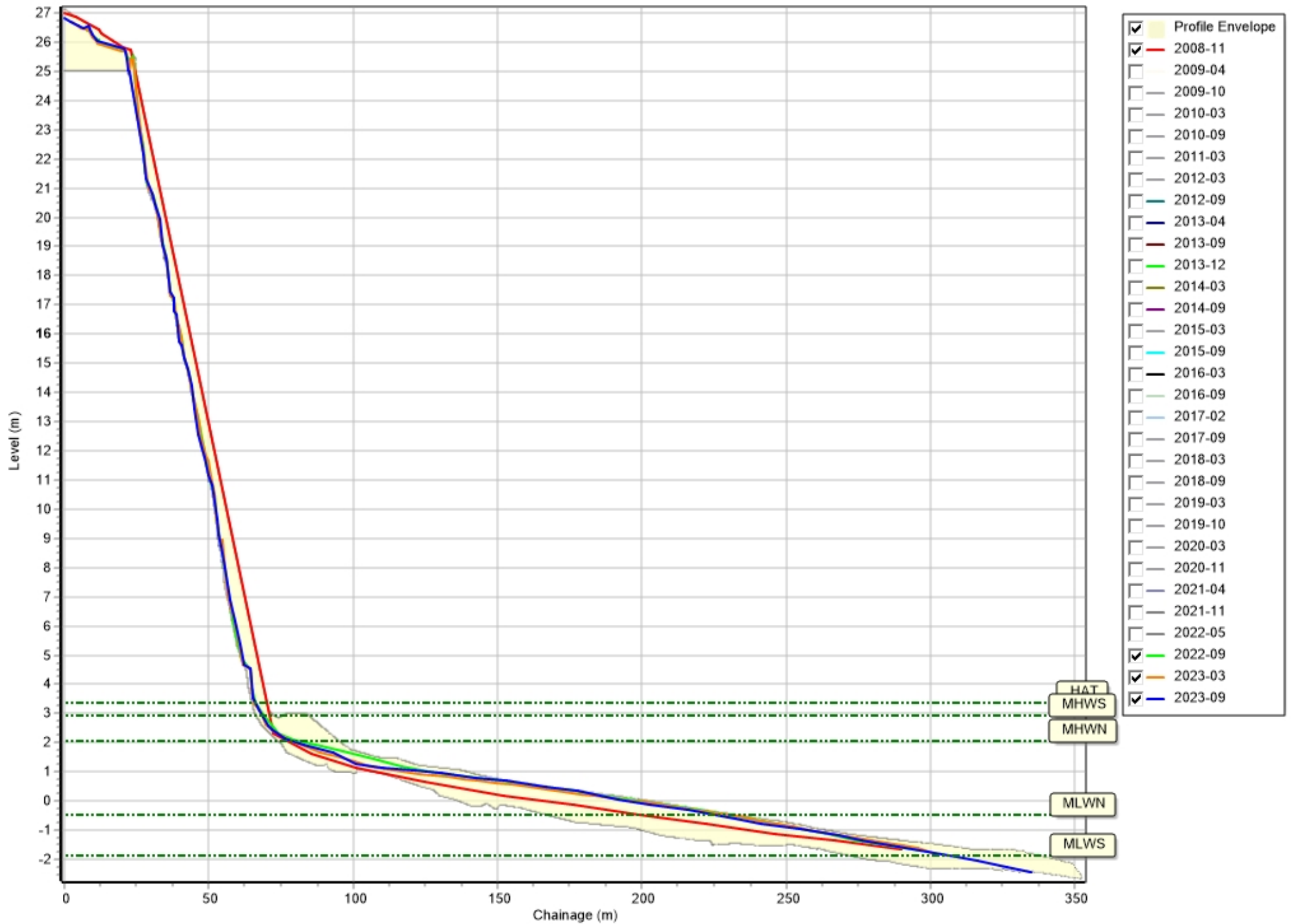
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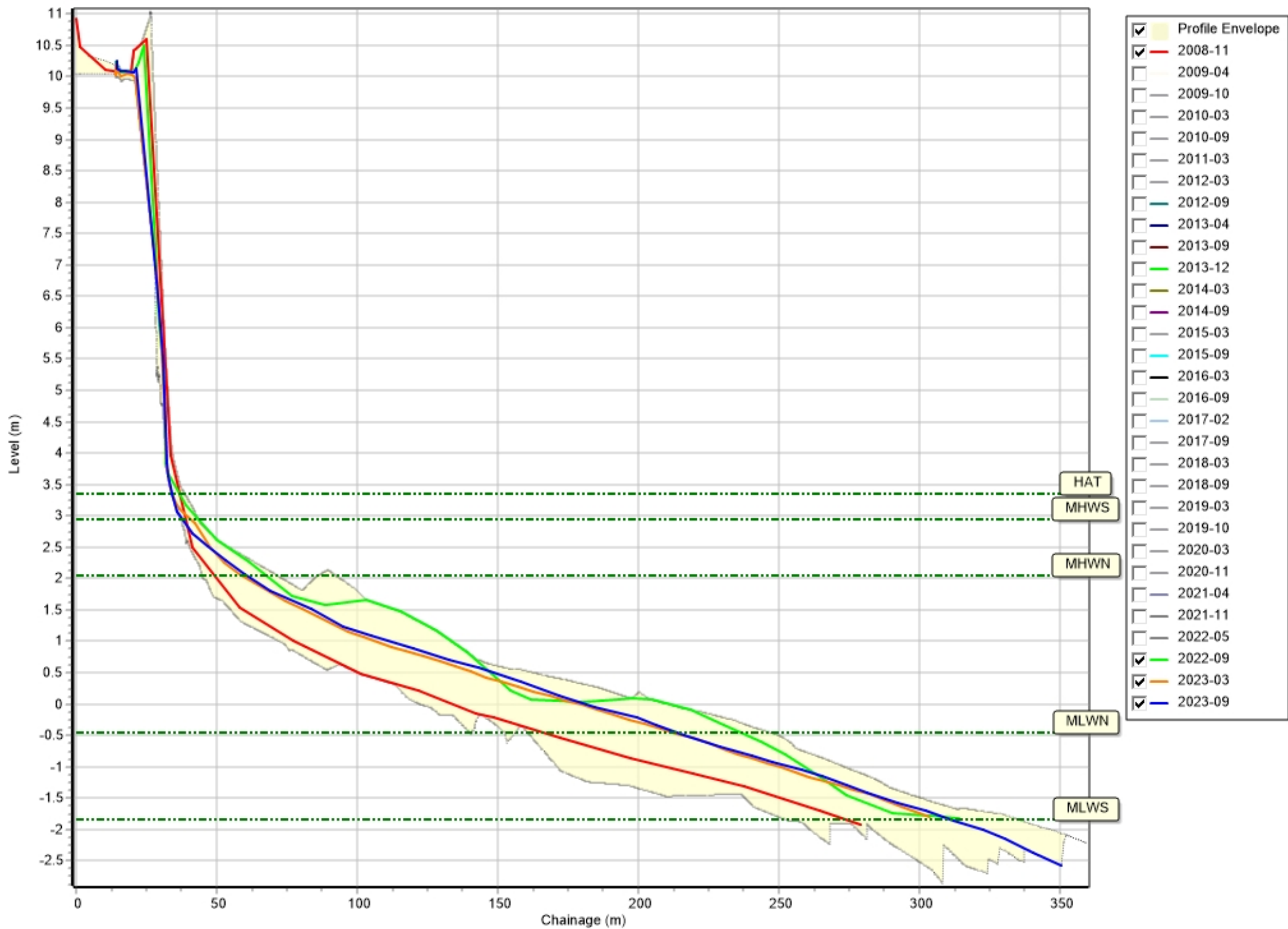
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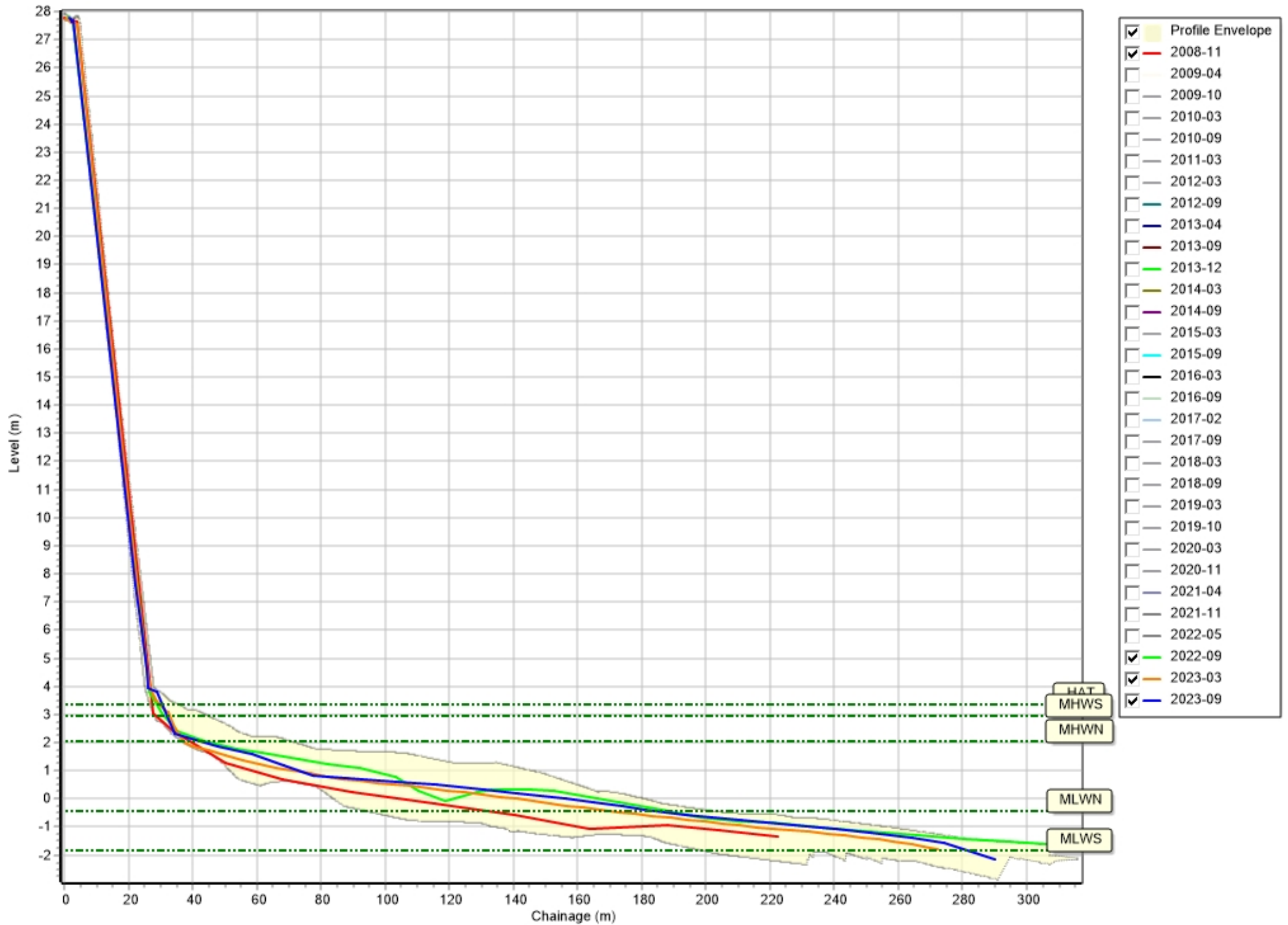
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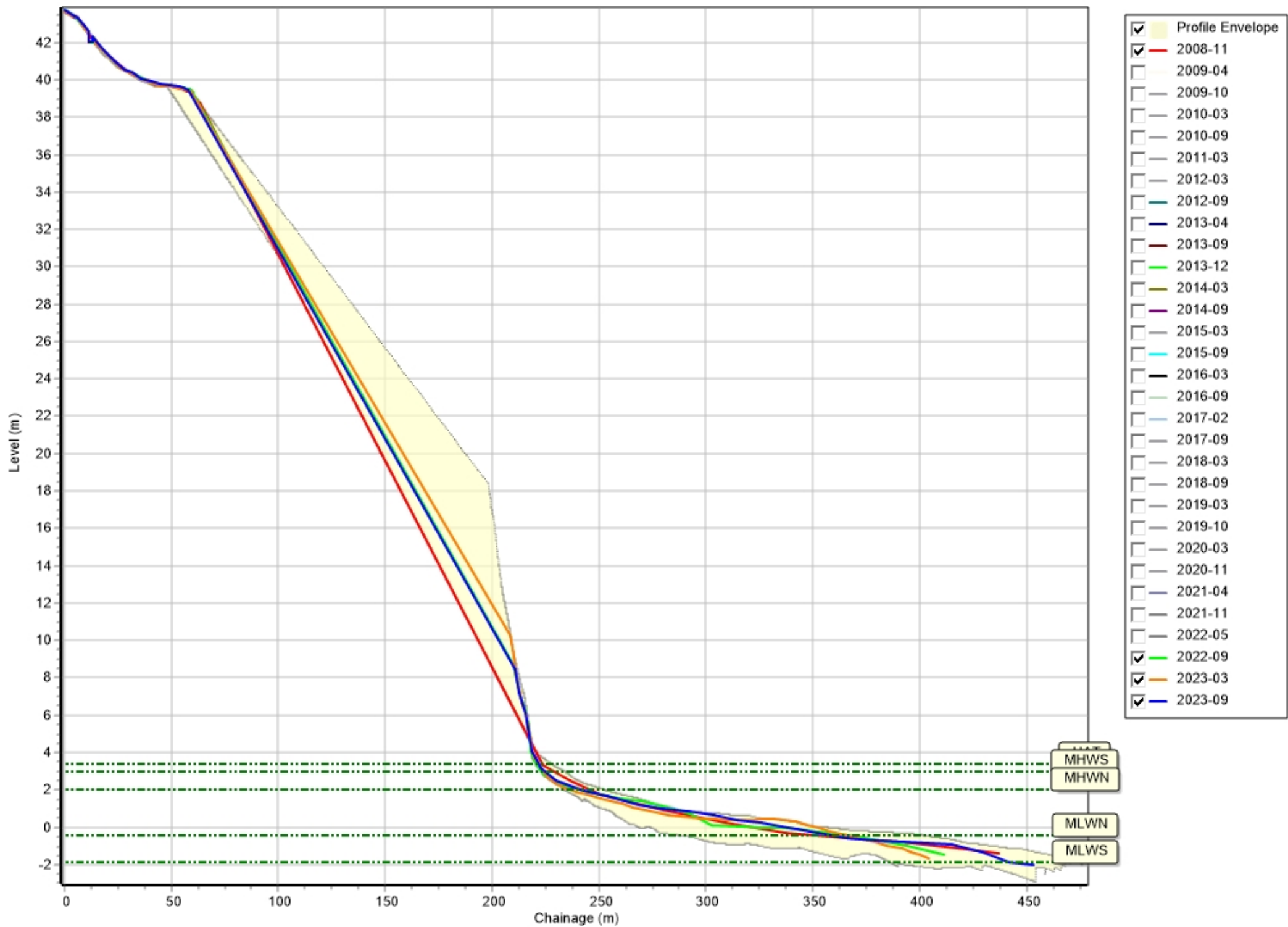
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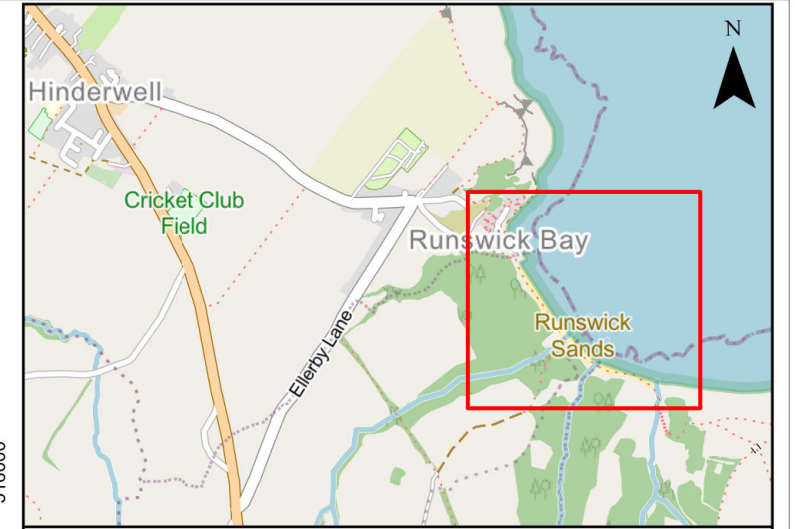
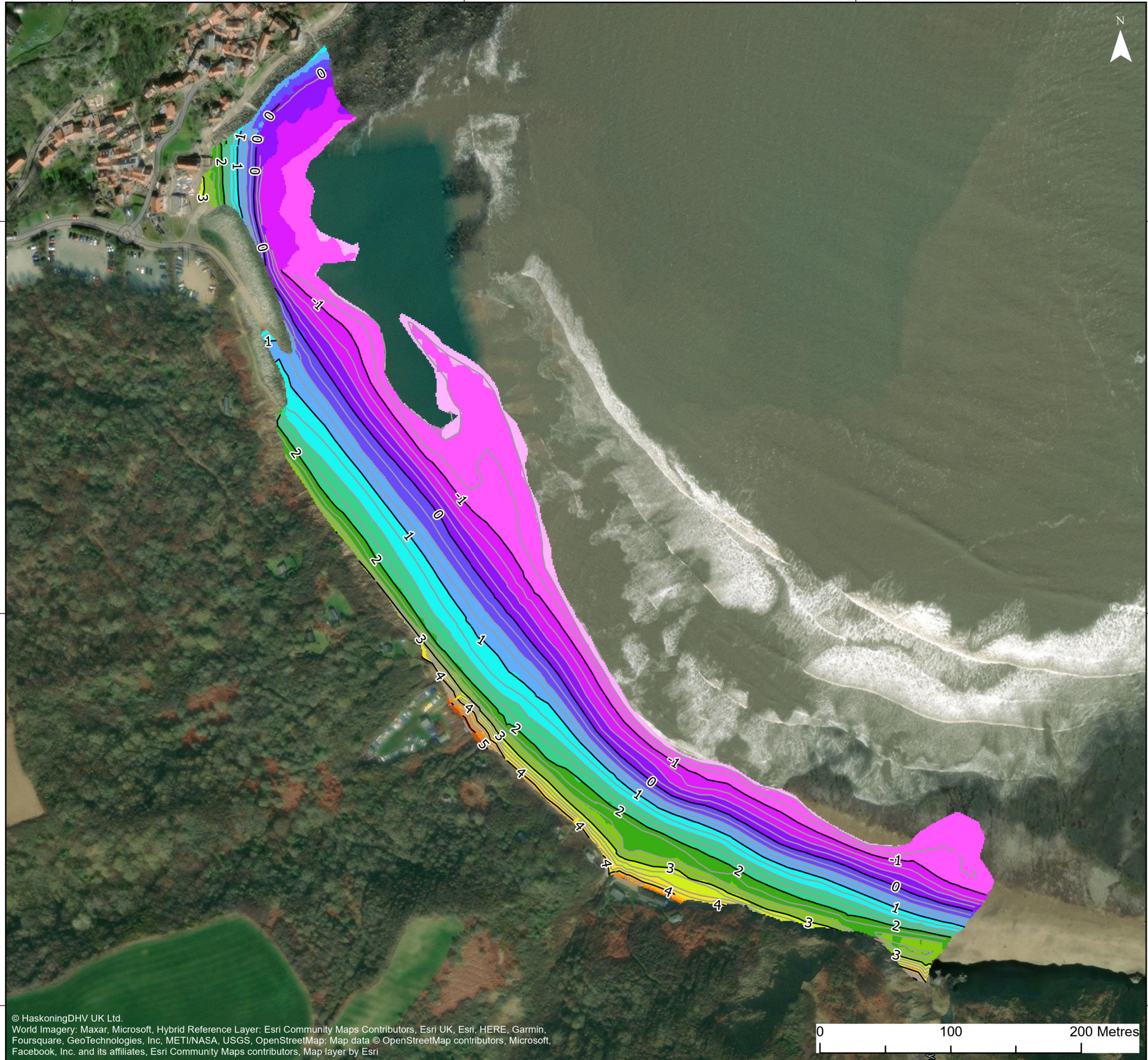
Profiles: 1dFB4



Profiles: 1dFB5



Appendix B
Topographic Survey



TOPOGRAPHIC SURVEY (August 2023)

Elevation (mOD)	Contours (mOD)*
<ul style="list-style-type: none"> -2.1 - -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 	<ul style="list-style-type: none"> — 1.0m interval — 0.25m interval <p>* Contours only cover sandy beach areas.</p>

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

Title:

Appendix B - Map 1

RUNSWICK BAY

North Yorkshire Council Frontage

Report:

Analytical Report
'Full Measures' Survey 2023

Revision:	Date:	Drawn:	Checked:	Size:	Scale:
0	08/11/2023	TC	NJC	A3	1:3,000

Co-ordinate system: British National Grid

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TOPOGRAPHIC SURVEY (August 2023)

Elevation (mOD)	Contours (mOD)*
-2.1 - -2	— 1.0m interval
-1.9 - -1.5	— 0.25m interval
-1.4 - -1	
-0.9 - -0.5	* Contours only cover sandy beach areas.
-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	

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

Title:

Appendix B - Map 2

SANDESEND

North Yorkshire Council Frontage

Report:

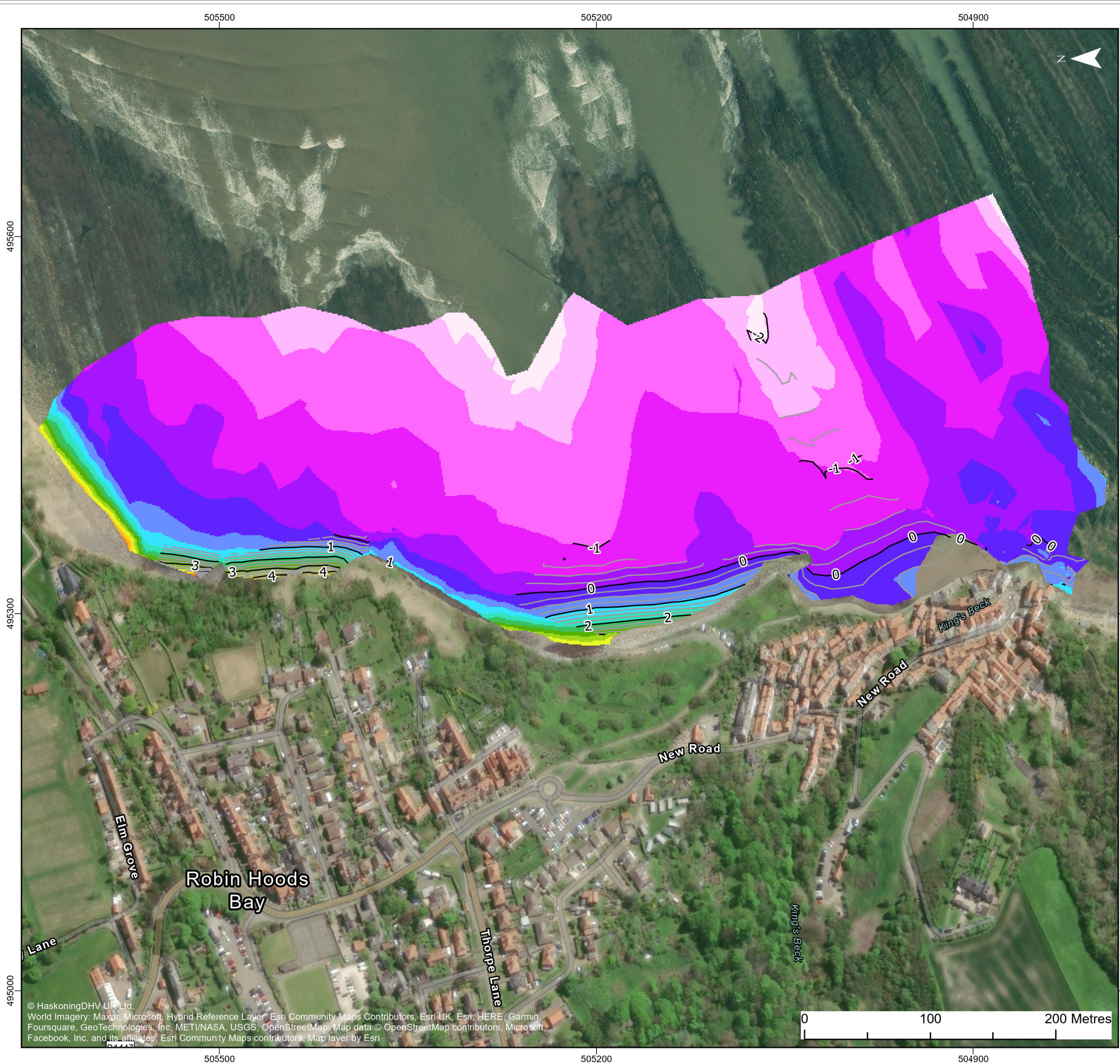
Analytical Report
'Full Measures' Survey 2023

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



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TOPOGRAPHIC SURVEY (August 2023)

Elevation (mOD)	Contours (mOD)*
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-1.9 - -1.5	— 0.25m interval
-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	
6.1 - 6.5	

* Contours only cover sandy beach areas.

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

Title:

Appendix B - Map 3

ROBIN HOOD'S BAY

North Yorkshire Council Frontage

Report:

Analytical Report
'Full Measures' Survey 2023

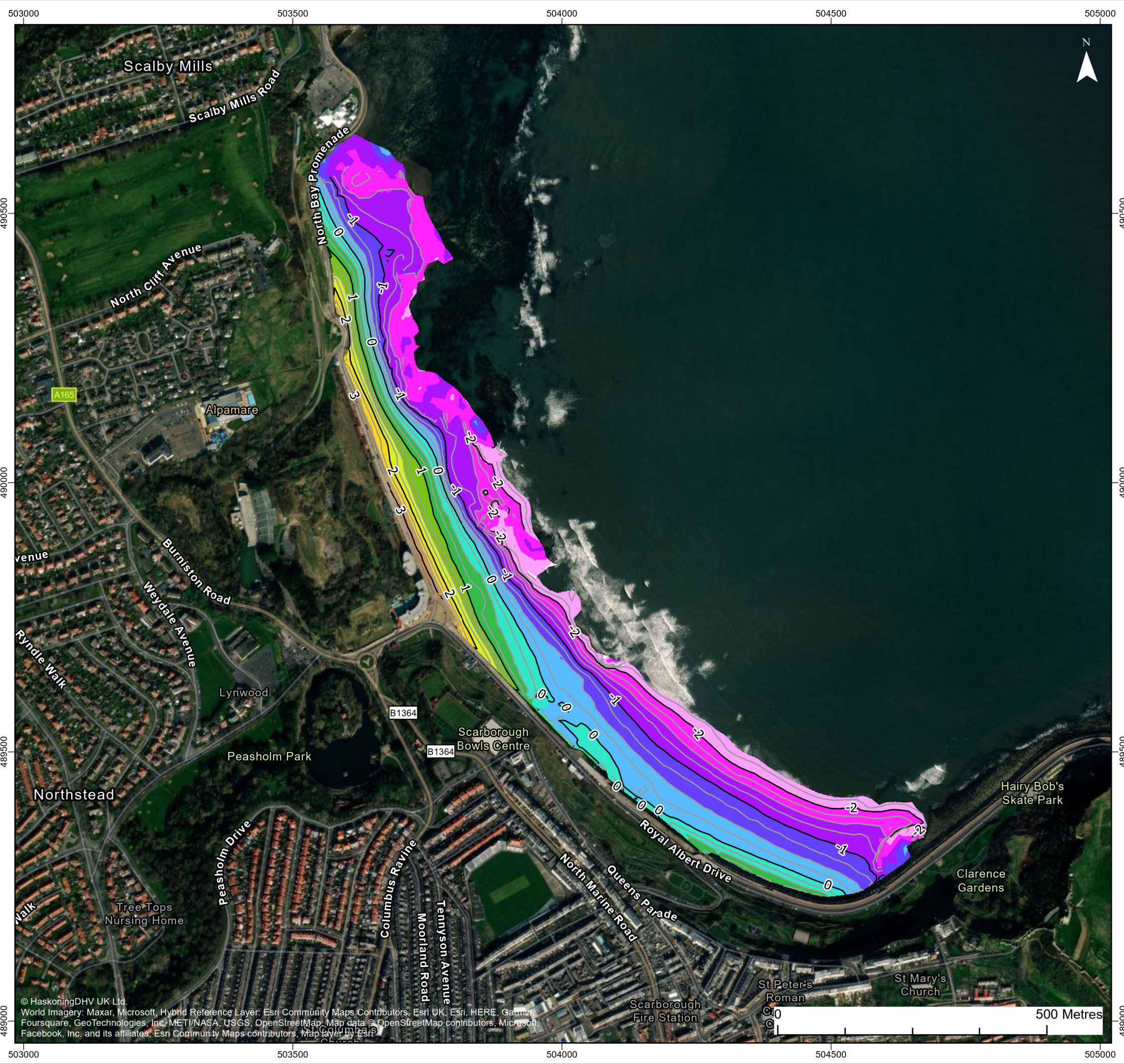
Revision:	Date:	Drawn:	Checked:	Size:	Scale:
0	08/11/2023	TC	NJC	A3	1:3,000

Co-ordinate system: British National Grid

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North East Coastal Observatory

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TOPOGRAPHIC SURVEY (August 2023)

Elevation (mOD)	Contours (mOD)*
<ul style="list-style-type: none"> -2.8 - -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 	<ul style="list-style-type: none"> 1.0m interval 0.25m interval <p>* Contours only cover sandy beach areas.</p>

Client: North East Coastal Group	Project: Cell 1 Regional Coastal Monitoring Programme
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Title:
Appendix B - Map 4
SCARBOROUGH NORTH BAY
North Yorkshire Council Frontage

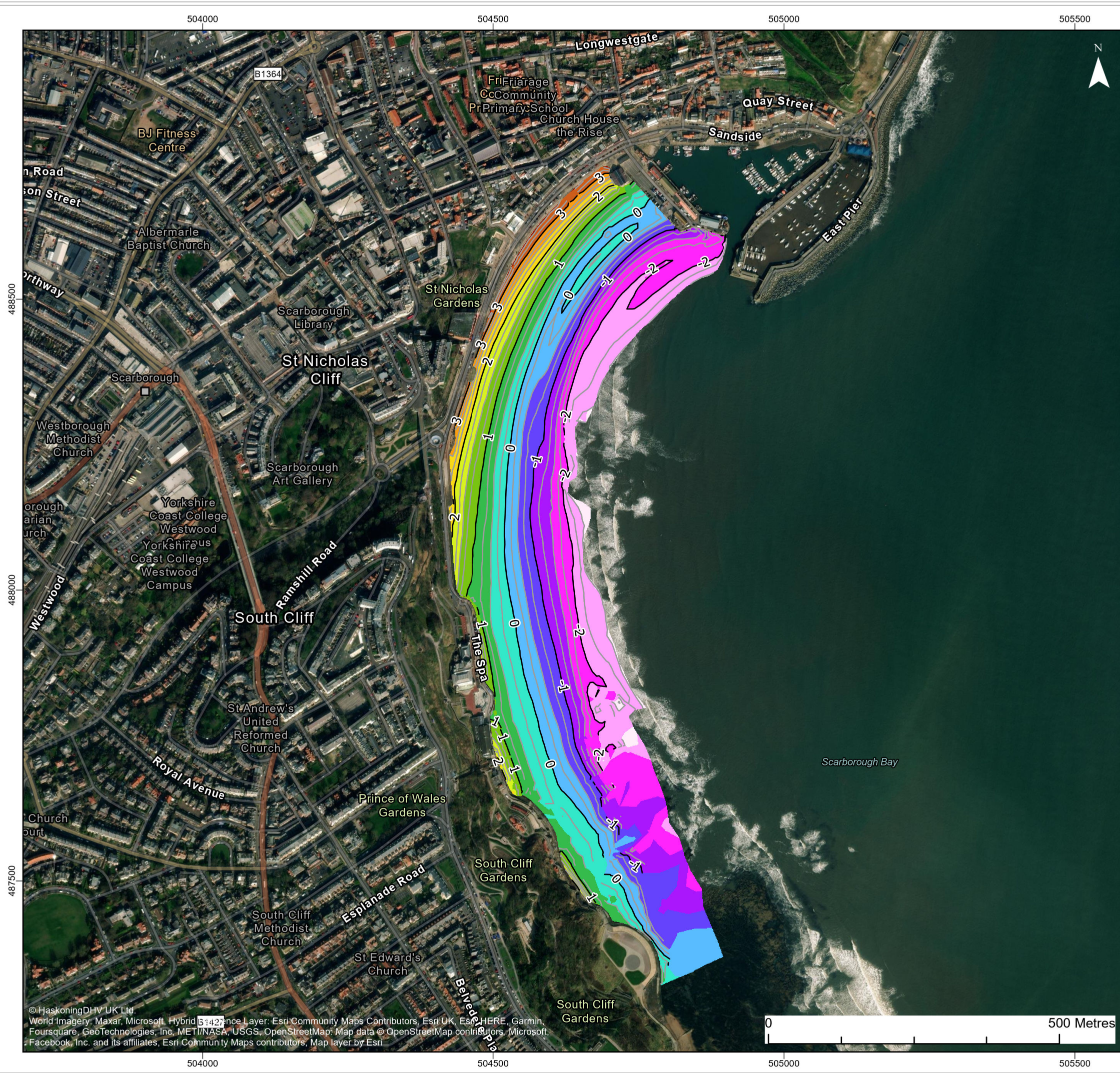
Report:
 Analytical Report
 'Full Measures' Survey 2023

Revision:	Date:	Drawn:	Checked:	Size:	Scale:
0	08/11/2023	TC	NJC	A3	1:7,000

Co-ordinate system: British National Grid



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TOPOGRAPHIC SURVEY (September 2023)

Elevation (mOD)	Contours (mOD)*
-2.7 - -2.5	— 1.0m interval
-2.4 - -2	— 0.25m interval
-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	

* Contours only cover sandy beach areas.

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

Title:

Appendix B - Map 5

SCARBOROUGH SOUTH BAY

North Yorkshire Council Frontage

Report:

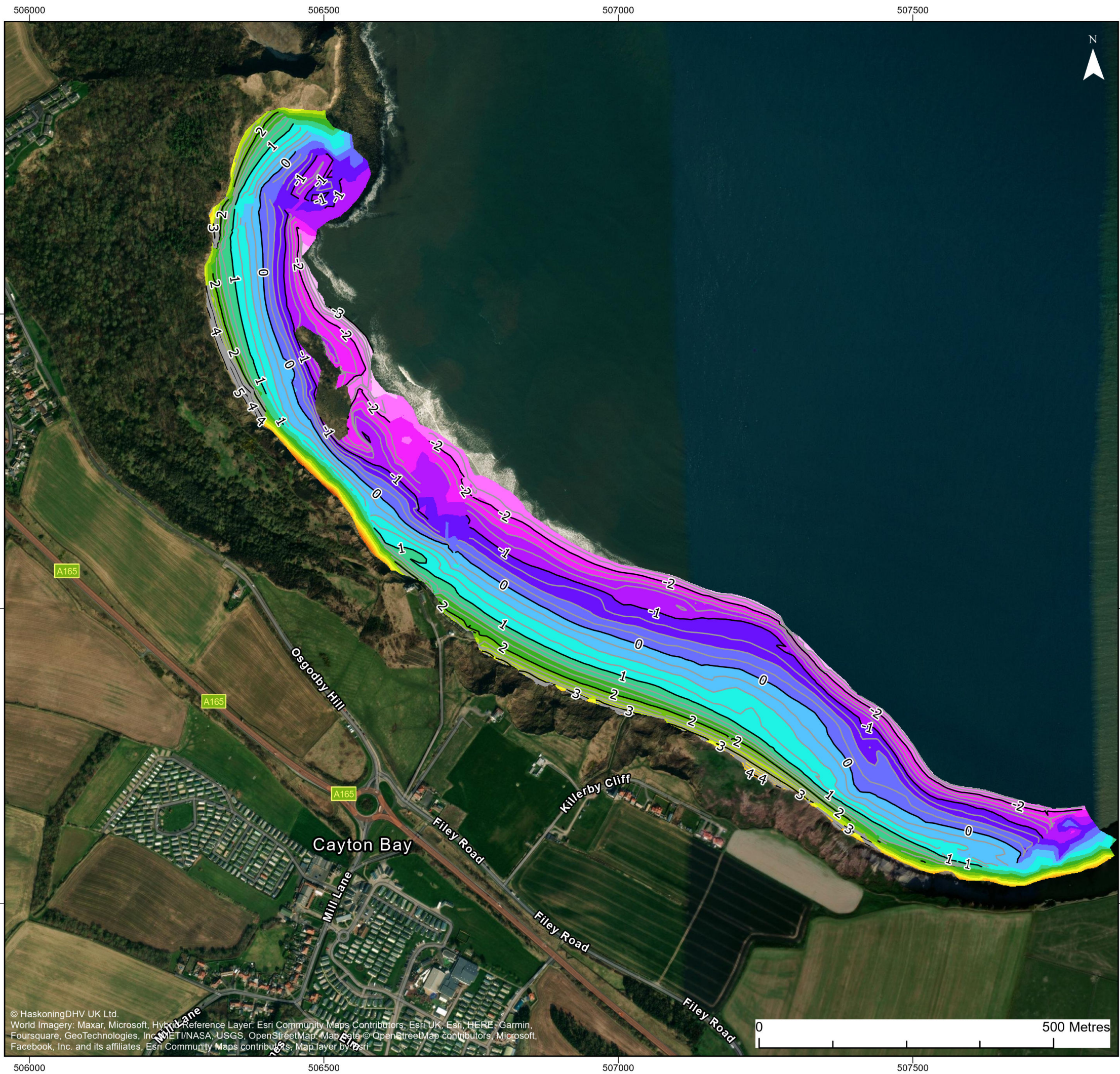
Analytical Report
'Full Measures' Survey 2023

Revision:	Date:	Drawn:	Checked:	Size:	Scale:
0	08/11/2023	TC	NJC	A3	1:6,500

Co-ordinate system: British National Grid

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TOPOGRAPHIC SURVEY (September 2023)

Elevation (mOD)	Contours (mOD)*
-3.035 - -3	— 1.0m interval
-2.999 - -2.5	— 0.25m interval
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-1.999 - -1.5	
-1.499 - -1	
-0.999 - -0.5	
-0.499 - 0	
0.001 - 0.5	
0.501 - 1	
1.001 - 1.5	
1.501 - 2	
2.001 - 2.5	
2.501 - 3	
3.001 - 3.5	
3.501 - 4	
4.001 - 4.5	
4.501 - 5	
5.001 - 5.5	
5.501 - 6	

* Contours only cover sandy beach areas.

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

Title:

Appendix B - Map 6

CAYTON BAY

North Yorkshire Council Frontage

Report:

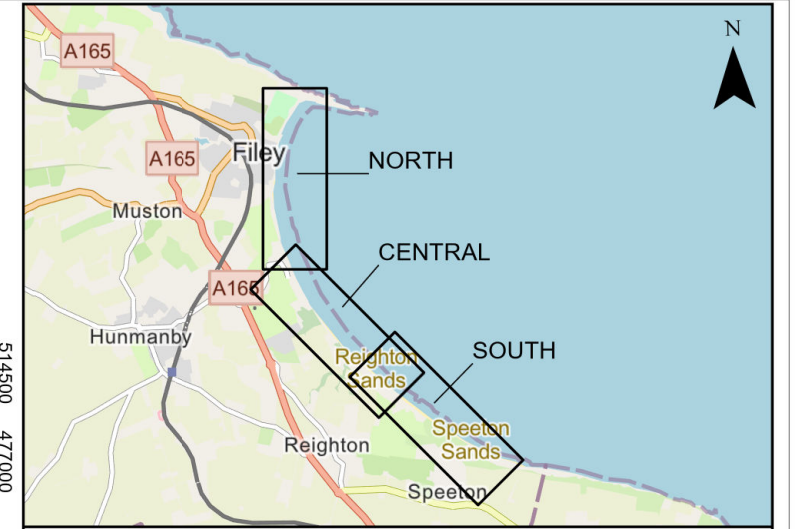
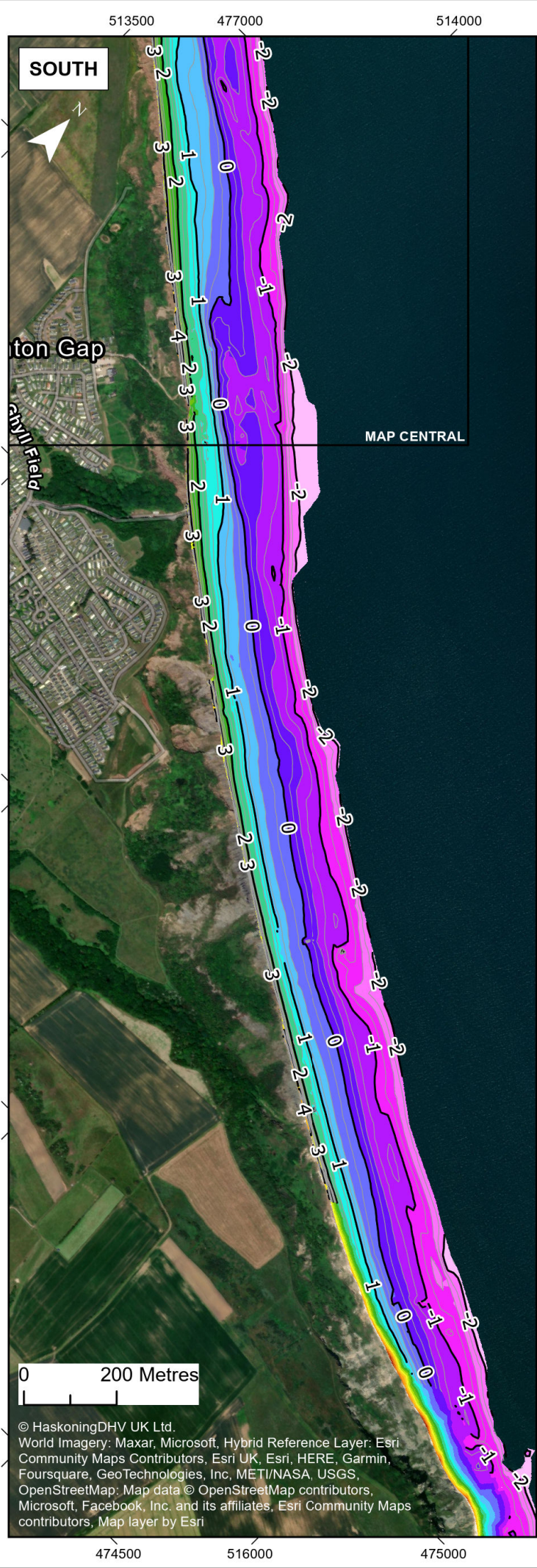
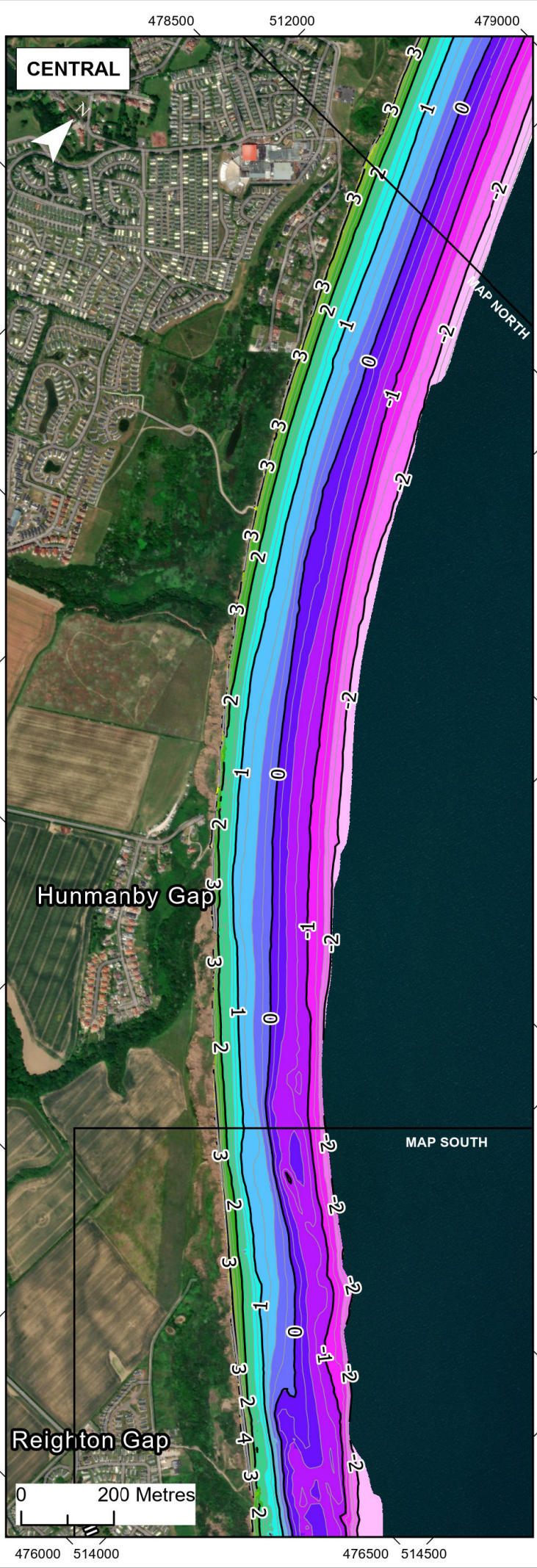
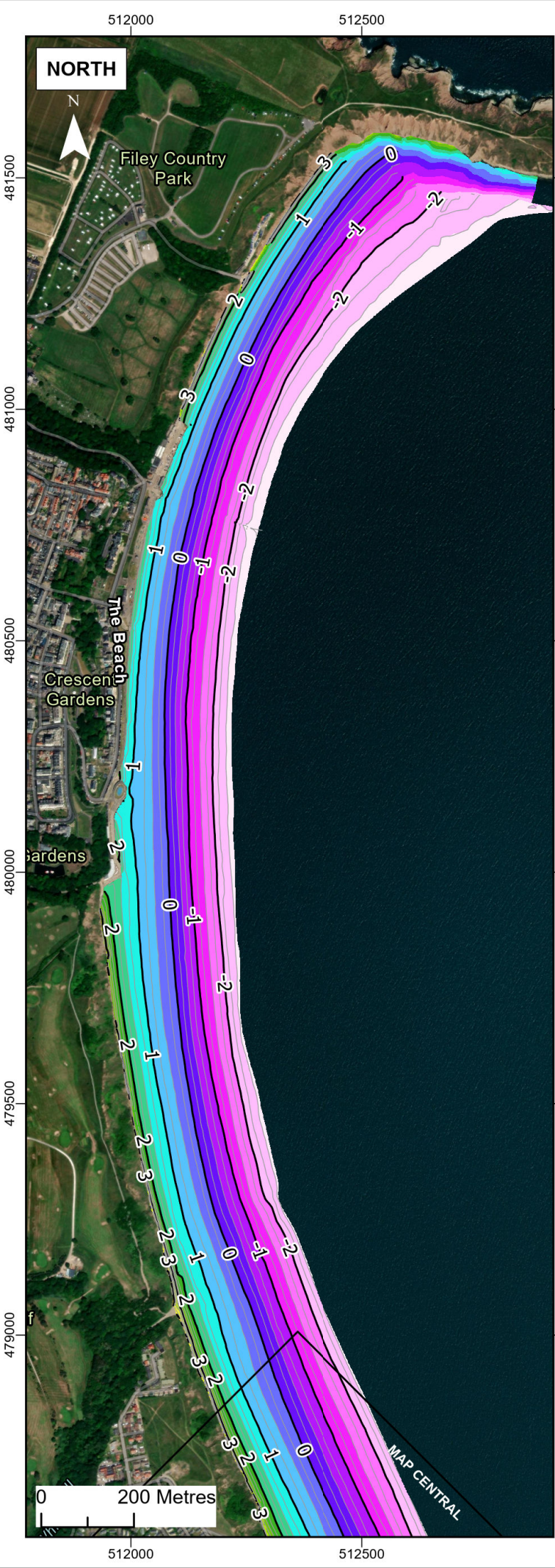
Analytical Report
'Full Measures' Survey 2023

Revision:	Date:	Drawn:	Checked:	Size:	Scale:
0	08/11/2023	TC	NJC	A3	1:6,500

Co-ordinate system: British National Grid



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TOPOGRAPHIC SURVEY (September 2023)

Elevation (mOD)	Contours (mOD)*
-2.8 - -2.5	— 1.0m interval
-2.4 - -2	— 0.25m interval
-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	
6.1 - 6.5	

* Contours only cover sandy beach areas.

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

Title:

Appendix B - Map 7

FILEY BAY

North Yorkshire Council Frontage

Report:

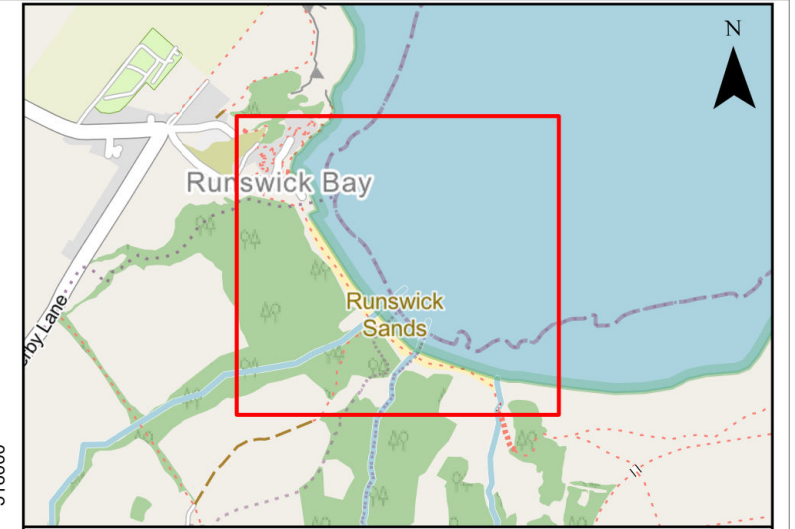
Analytical Report
'Full Measures' Survey 2023

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

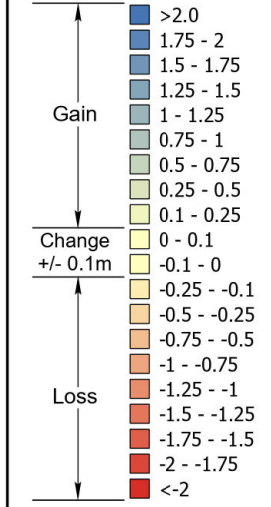


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Difference between topographic surveys
(Mar 2023 to Aug 2023)

Change in Elevation (mOD)



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

Title:

Appendix B - Map 8

RUNSWICK BAY

North Yorkshire Council Frontage

Report:

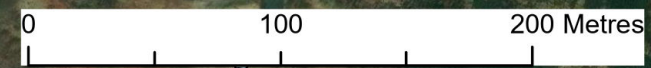
Analytical Report
'Full Measures' Survey 2023

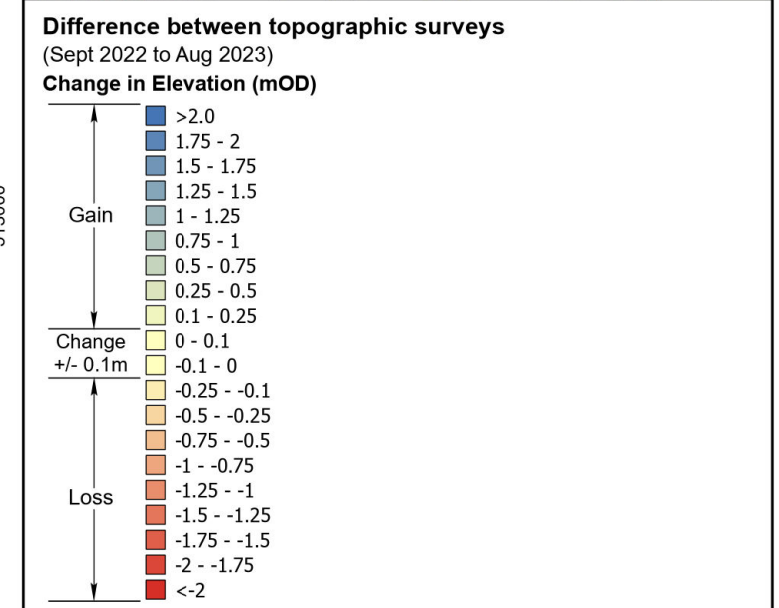
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Co-ordinate system: British National Grid



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

Title:

Appendix B - Map 9

SANDESEND

North Yorkshire Council Frontage

Report:

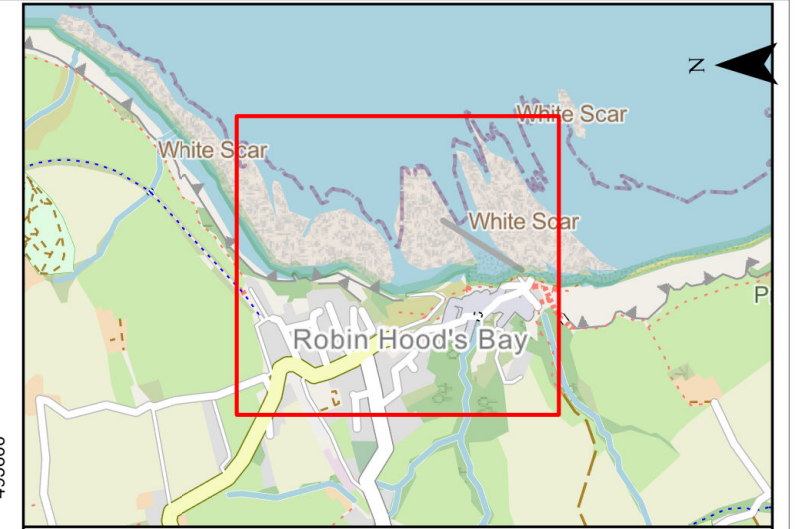
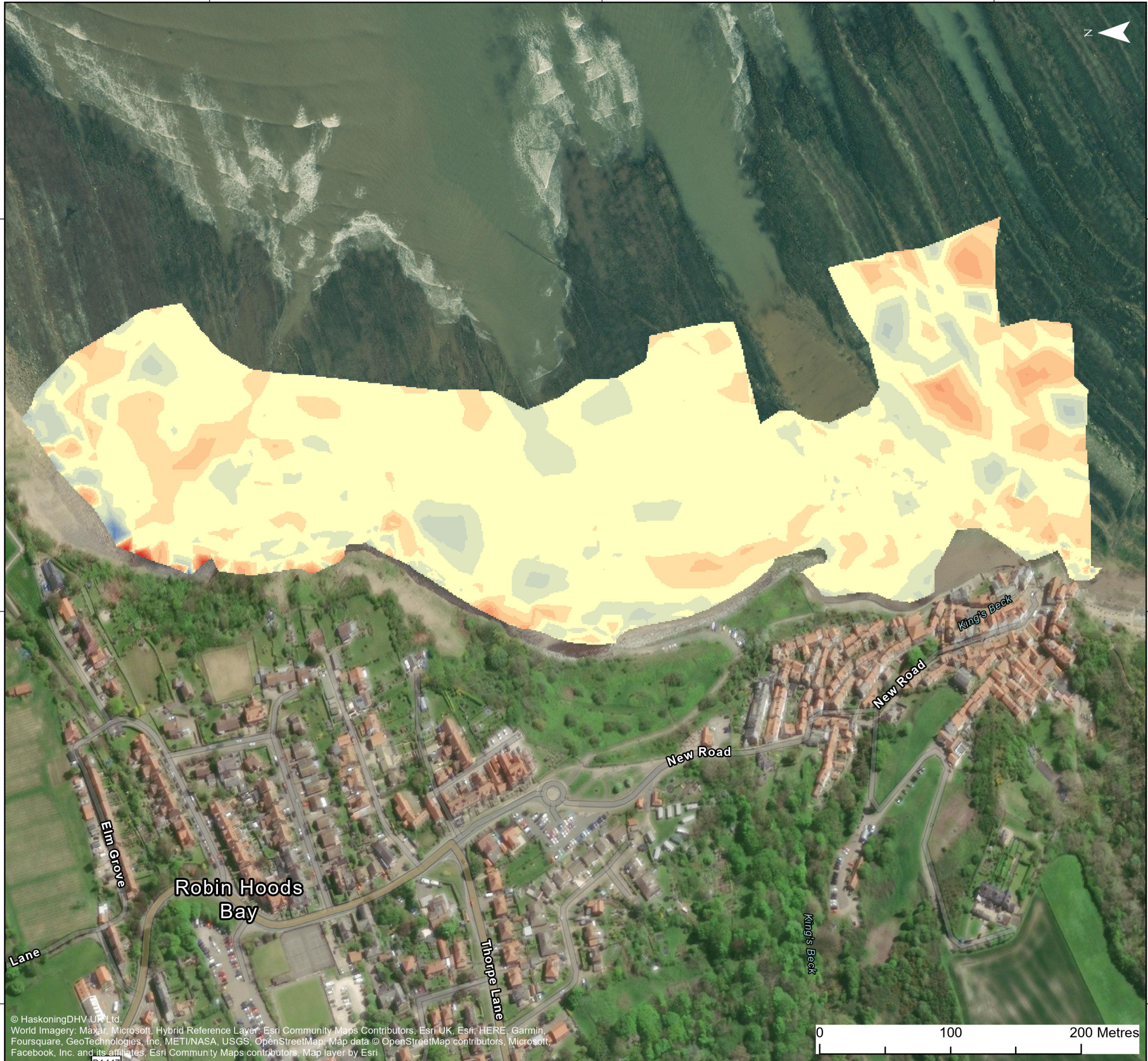
Analytical Report
'Full Measures' Survey 2023

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Co-ordinate system: British National Grid

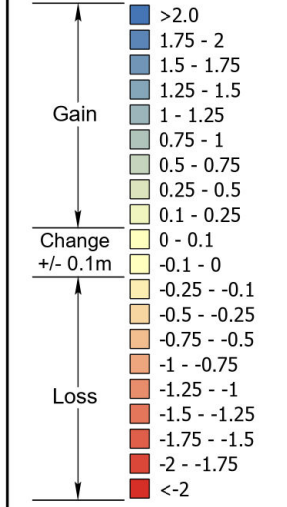


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Difference between topographic surveys
(Mar 2023 to Aug 2023)

Change in Elevation (mOD)



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

Title:

Appendix B - Map 10

ROBIN HOOD'S BAY

North Yorkshire Council Frontage

Report:

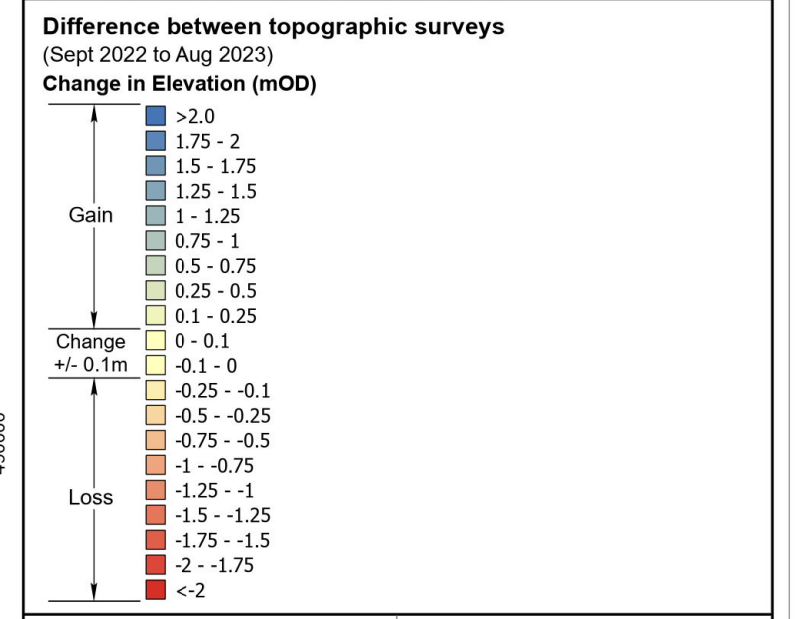
Analytical Report
'Full Measures' Survey 2023

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



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

Title:

Appendix B - Map 11

SCARBOROUGH NORTH BAY

North Yorkshire Council Frontage

Report:

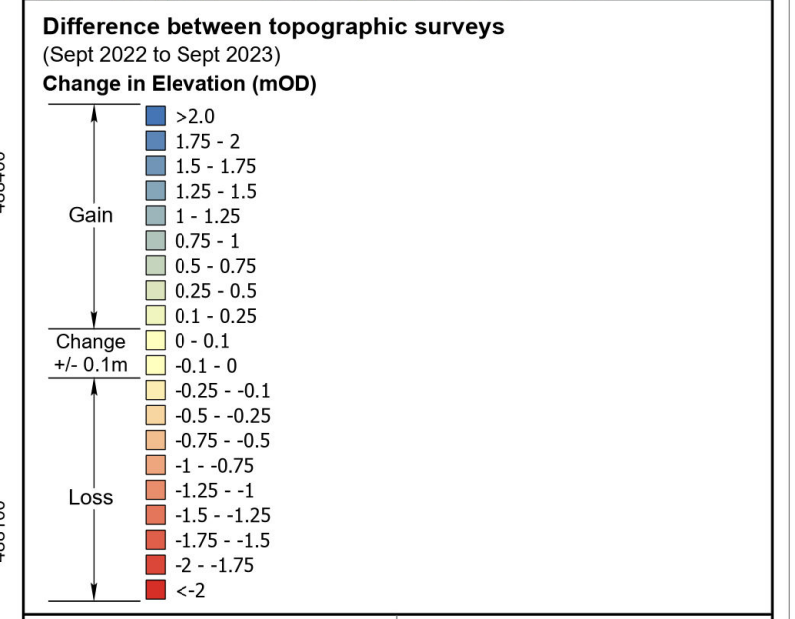
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Revision:	Date:	Drawn:	Checked:	Size:	Scale:
0	08/11/2023	TC	NJC	A3	1:7,000

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 12**
SCARBOROUGH SOUTH BAY
North Yorkshire Council Frontage

Report: Analytical Report
'Full Measures' Survey 2023

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

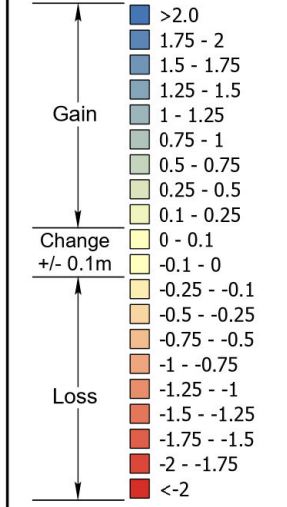


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Difference between topographic surveys
(Sept 2022 to Sept 2023)

Change in Elevation (mOD)



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

Title:

Appendix B - Map 13

CAYTON BAY

North Yorkshire Council Frontage

Report:

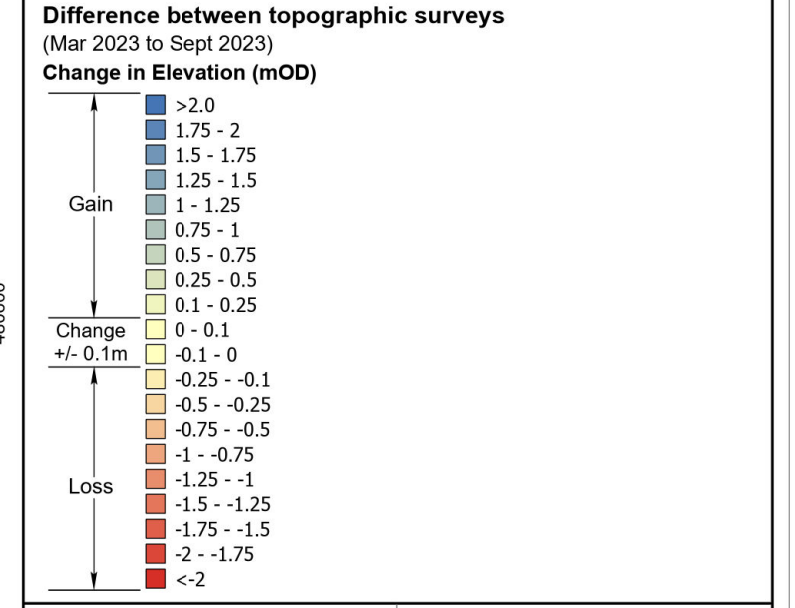
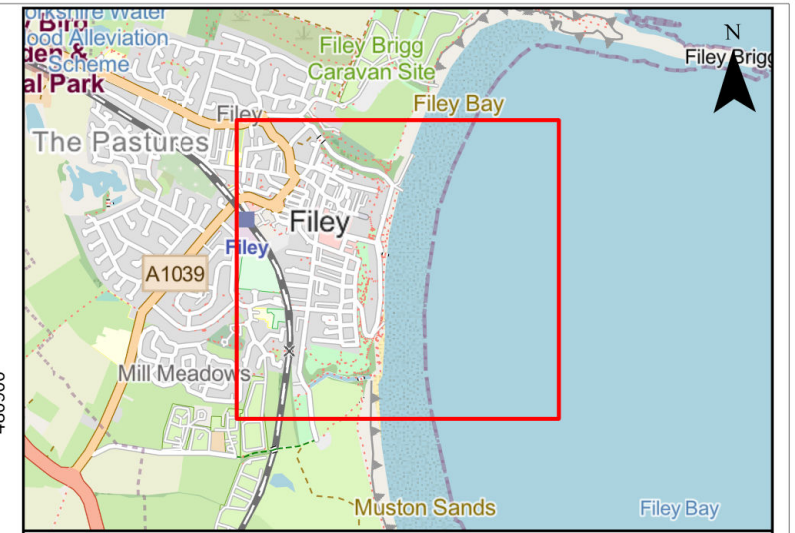
Analytical Report
'Full Measures' Survey 2023

Revision:	Date:	Drawn:	Checked:	Size:	Scale:
0	08/11/2023	TC	NJC	A3	1:6,500

Co-ordinate system: British National Grid



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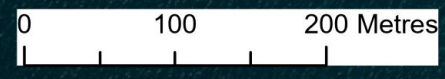
Client: North East Coastal Group	Project: Cell 1 Regional Coastal Monitoring Programme
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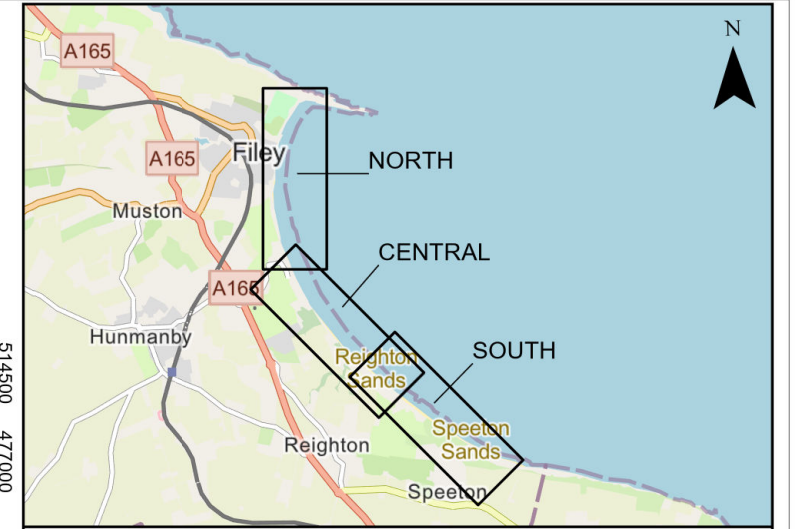
Title:
Appendix B - Map 14
FILEY
North Yorkshire Council Frontage

Report:
 Analytical Report
 'Full Measures' Survey 2023

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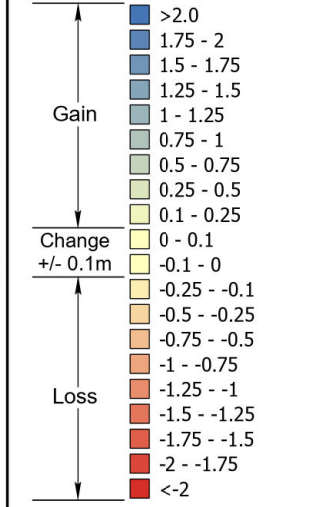
Co-ordinate system: British National Grid





Difference between topographic surveys
(Sept 2022 to Sept 2023)

Change in Elevation (mOD)



Client: North East Coastal Group

Project: Cell 1 Regional Coastal Monitoring Programme

Title: **Appendix B - Map 15**
FILEY BAY
North Yorkshire Council Frontage

Report: Analytical Report
'Full Measures' Survey 2023

Revision:	Date:	Drawn:	Checked:	Size:	Scale:
0	08/11/2023	TC	NJC	A3	1:12,000

Co-ordinate system: British National Grid



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Appendix C
Cliff Top Survey

Cliff Top Survey

Staithes

Twenty ground control points have been established within Staithes (Figure C1). The maximum separation between any two points is nominally 100m. The cliff top surveys at Staithes are undertaken bi-annually. Measurements are taken from a fixed ground control point along a fixed bearing to the edge of the cliff top. Table C1 provides baseline information about these ground control points and results from the 2008 (baseline) survey showing the position from the ground control point to the edge of the cliff top along the defined bearing. Future reports will show results from subsequent surveys and provide a means of assessing erosion since the baseline survey.

Table C1 – Cliff Top Surveys at Staithes

Ground Control Points				Distance to Cliff Top (m)			Total Erosion (m)		Erosion Rate (m/year)
Ref	Easting	Northing	Bearing (°)	Baseline Survey	Previous Survey	Present Survey	Baseline to Present	Previous to Present	Baseline to Present
STAITHES				Nov 2008	March 2023	Sep 2023	Nov 2008 - Sep 2023	Mar 2023 - Sep 2023	Nov 2008 - Sep 2023
1	477228	518769	320	1.90	-5.70	-5.70	7.60	0.00	0.51
2	477334	518798	0	10.90	10.61	10.66	0.24	-0.05	0.02
3	477487	518789	350	7.10	7.90	8.03	-0.93	-0.13	0.00
4	477594	518801	340	5.90	3.41	3.62	2.28	-0.21	0.15
5	477683	518911	350	8.40	8.21	8.52	-0.12	-0.31	0.00
6	477792	518867	30	8.60	8.44	8.63	-0.03	-0.19	0.00
7	477891	518828	60	7.70	7.17	7.23	0.47	-0.06	0.03
8	477959	518873	350	8.70	8.31	8.39	0.31	-0.08	0.02
9	478088	518950	350	7.60	7.84	8.05	-0.45	-0.21	0.00
10	478191	519023	340	8.40	8.53	8.66	-0.26	-0.13	0.00
11	478237	519007	60	6.90	6.50	6.56	0.34	-0.06	0.02
12	478213	518988	150	6.10	6.28	6.17	-0.07	0.11	0.00
13	478501	518809	15	11.40	8.15	8.24	3.16	-0.09	0.21
14	478624	518807	20	7.50	7.15	7.30	0.20	-0.15	0.01
15	478737	518858	60	6.10	6.19	6.12	-0.02	0.07	0.00
16	478823	518757	60	8.00	8.61	8.41	-0.41	0.20	0.00
17	478944	518671	30	9.30	8.62	8.55	0.75	0.07	0.05
18	479052	518630	20	9.20	9.02	9.05	0.15	-0.03	0.01

19	479147	518610	0	14.20	13.75	13.67	0.53	0.08	0.04
20	479274	518618	20	11.40	11.16	10.95	0.45	0.21	0.03

Note: It is assumed that the accuracy of cliff top monitoring using this technique is $\pm 0.1\text{m}$. Therefore, observed changes have been altered by this amount prior to calculation of an erosion rate. Erosion rates are not calculated where the cliff line shows advance. This is likely to be the product of differing survey interpretation, and far less likely to be a toppling cliff edge.

Robin Hoods Bay

Thirteen ground control points have been established within Robin Hoods Bay (Figure C1). The maximum separation between any two points is nominally 200m. The cliff top surveys at Robin Hoods Bay are undertaken annually. Measurements are taken from a fixed ground control point along a fixed bearing to the edge of the cliff top. Table C2 provides baseline information about these ground control points and results from the 2008 (baseline) survey showing the position from the ground control point to the edge of the cliff top along the defined bearing. Future reports will show results from subsequent surveys and provide a means of assessing erosion since the baseline survey.

Table C2 – Cliff Top Surveys at Robin Hoods Bay

Ground Control Points				Distance to Cliff Top (m)			Total Erosion (m)		Erosion Rate (m/year)
Ref	Easting	Northing	Bearing (°)	Baseline Survey	Previous Survey	Present Survey	Baseline to Present	Previous to Present	Baseline to Present
ROBIN HOODS BAY				Mar 2010	Mar 2023	Aug 2023	Mar 2010 - Aug 2023	Mar 2023 - Aug 2023	Mar 2010 - Aug 2023
1	495799.5	506002.2	130	11.60	6.26	6.17	5.43	0.09	0.42
2	495549.2	505807.3	135	9.30	8.96	8.97	0.33	-0.01	0.03
3	495456.3	505740	130	5.00	5.04	5.04	-0.04	0.00	0.00
4	495389.9	505683.7	140	6.30	6.02	6.07	0.23	-0.05	0.02
5	495259.4	505342.5	130	11.30	14.23	14.23	-2.93	0.00	0.00
6	495231.2	505315.7	95	5.90	5.68	5.71	0.19	-0.03	0.01
7	495184.8	505210.7	85	6.40	7.26	UTS	UTS	UTS	UTS
8	495206.5	505153	75	5.00	5.09	UTS	UTS	UTS	UTS
9	495287.8	505060.5	80	4.30	4.48	UTS	UTS	UTS	UTS
10	495187.8	504708.8	70	3.10	1.92	1.92	1.18	0.00	0.09
11	495226.2	504615.7	120	3.80	1.94	1.85	1.95	0.09	0.15
12	495297.5	504380.2	80	11.00	10.73	10.71	0.29	0.02	0.02
13	495350.4	504193	55	3.70	3.67	3.67	0.03	0.00	0.00

Note: It is assumed that the accuracy of cliff top monitoring using this technique is ± 0.1 m. Therefore, observed changes have been altered by this amount prior to calculation of an erosion rate. Erosion rates are not calculated where the cliff line shows advance. This is likely to be the product of differing survey interpretation, and far less likely to be a toppling cliff edge.

Scarborough South Bay

Thirteen ground control points have been established between Scarborough South Bay and Cayton Bay (Figure C1). The maximum separation between any two points is nominally 300m. The cliff top surveys at Scarborough South Bay are undertaken annually. Measurements are taken from a fixed ground control point along a fixed bearing to the edge of the cliff top. Table C3 provides baseline information about these ground control points and results from the 2010 (baseline) survey showing the position from the ground control point to the edge of the cliff top along the defined bearing. Future reports will show results from subsequent surveys and provide a means of assessing erosion since the baseline survey.

Table C3 – Cliff Top Surveys at Scarborough South

Ground Control Points				Distance to Cliff Top (m)			Total Erosion (m)		Erosion Rate (m/year)
Ref	Easting	Northing	Bearing (°)	Baseline Survey	Previous Survey	Present Survey	Baseline to Present	Previous to Present	Baseline to Present
SCARBOROUGH SOUTH BAY				Mar 2010	Mar 2023	Sept 2023	Mar 2010 - Sept 2023	Mar 2023 - Sep 2023	Mar 2010 - Sept 2023
1	504339.5	487887.3	70	7.00	6.96	6.96	0.04	0.00	0.00
2	504422.3	487603.7	80	4.80	4.82	4.81	-0.01	0.01	0.00
3	504534.8	487318.3	40	15.10	14.96	14.96	0.14	0.00	0.01
4	504730.2	487137.9	55	9.60	9.55	9.56	0.04	-0.01	0.00
5	504922.9	486837.8	60	8.80	8.48	8.48	0.32	0.00	0.02
6	50571.1	486652.1	75	3.80	3.63	3.64	0.16	-0.01	0.01
7	505284.3	486480	35	7.00	6.65	6.61	0.39	0.04	0.03
8	505597.9	486363.4	30	8.60	8.24	8.19	0.41	0.05	0.03
9	505758.6	486005.1	45	9.10	8.46	8.44	0.66	0.02	0.05
10	505896	485889.6	15	14.80	14.66	14.61	0.19	0.05	0.01
11	505990	485657.1	80	4.70	0.98	0.97	3.73	0.01	0.29
12	506024.9	485421.8	55	6.10	3.11	3.03	3.07	0.08	0.24
13	506036	485315.3	90	7.00	6.86	6.49	0.51	0.37	0.04

Note: It is assumed that the accuracy of cliff top monitoring using this technique is $\pm 0.1\text{m}$. Therefore, observed changes have been altered by this amount prior to calculation of an erosion rate. Erosion rates are not calculated where the cliff line shows advance. This is likely to be the product of differing survey interpretation, and far less likely to be a toppling cliff edge

Cayton Bay

Eight ground control points have been established within Cayton Bay (Figure C1). The maximum separation between any two points is nominally 300m. The cliff top surveys at Cayton Bay are undertaken annually. Measurements are taken from a fixed ground control point along a fixed bearing to the edge of the cliff top. Table C4 provides baseline information about these ground control points and results from the 2008 (baseline) survey showing the position from the ground control point to the edge of the cliff top along the defined bearing. Future reports will show results from subsequent surveys and provide a means of assessing erosion since the baseline survey.

Table C4 – Cliff Top Surveys at Cayton Bay

Ground Control Points				Distance to Cliff Top (m)			Total Erosion (m)		Erosion Rate (m/year)
Ref	Easting	Northing	Bearing (°)	Baseline Survey	Previous Survey	Present Survey	Baseline to Present	Previous to Present	Baseline to Present
CAYTON BAY				Nov 2008	Mar 2023	Sept 2023	Nov 2008 - Sep 2023	May 2023 - Sep 2023	Nov 2008 - Sep 2023
1	506325.5	484849.7	50	4.00	3.45	3.41	0.59	0.04	0.04
2	506459.4	484715.9	65	5.00	UTS	UTS	UTS	UTS	UTS
3	506597.4	484538.6	65	5.00	5.51	5.43	-0.43	0.08	0.00
4	506778.1	484345.5	21	9.00	5.60	4.60	4.40	1.00	0.29
5	507018.6	484221.6	342	7.70	7.93	7.92	-0.22	0.01	0.00
6	507242.3	484121.7	2	7.40	5.79	5.77	1.63	0.02	0.11
7	507518.2	484008.2	25	7.50	7.54	7.35	0.15	0.19	0.01
8	507818.7	484006	1	5.50	5.49	5.47	0.03	0.02	0.00

Note: It is assumed that the accuracy of cliff top monitoring using this technique is ± 0.1 m. Therefore, observed changes have been altered by this amount prior to calculation of an erosion rate. Erosion rates are not calculated where the cliff line shows advance. This is likely to be the product of differing survey interpretation, and far less likely to be a toppling cliff edge.

Filey Bay

Twenty-seven ground control points have been established within Filey Bay (Figure C1). The maximum separation between any two points is nominally 300m. The cliff top surveys at Filey Bay are undertaken annually. Measurements are taken from a fixed ground control point along a fixed bearing to the edge of the cliff top. Table C5 provides baseline information about these ground control points and results from the 2008 (baseline) survey showing the position from the ground control point to the edge of the cliff top along the defined bearing. Future reports will show results from subsequent surveys and provide a means of assessing erosion since the baseline survey.

Table C5 – Cliff Top Surveys at Filey Bay

Ground Control Points				Distance to Cliff Top (m)			Total Erosion (m)		Erosion Rate (m/year)
Ref	Easting	Northing	Bearing (°)	Baseline Survey	Previous Survey	Present Survey	Baseline to Present	Previous to Present	Baseline to Present
FILEY				Nov 2008	Mar 2023	Sept 2023	Nov 2008 - Sept 2023	March 2023 - Sept 2023	Nov 2008 - Sept 2023
1	512444.9	481630.9	130	8.70	8.29	8.28	0.42	0.01	0.03
2	512306.7	481490.3	144	7.60	7.72	7.71	-0.11	0.01	0.00
3	512153.6	481234.6	122	8.30	8.18	8.12	0.18	0.06	0.01
4	512029.2	480959.9	115	7.40	7.17	7.14	0.26	0.03	0.02
5	511895.4	479888	89	7.10	UTS	UTS	UTS	UTS	UTS
6	511908.5	479597.1	48	6.70	5.38	5.37	1.33	0.01	0.09
7	511991.4	479310.4	69	6.70	0.77	0.74	5.96	0.03	0.40
8	512083.4	478981.5	66	10.20	10.06	10.29	-0.09	-0.23	0.00
9	512121.3	478786.3	76	8.30	8.18	8.14	0.16	0.04	0.01
10	512226.2	478547.9	74	7.50	5.69	5.68	1.82	0.01	0.12
11	512471.4	478153.5	53	6.60	6.69	6.62	-0.02	0.07	0.00
12*	512558.9	477901.9	66	7.70	UTS	UTS	UTS	UTS	UTS
12A*	512655.8	477822.4	67	13.90	UTS	UTS	UTS	UTS	UTS
13**	512697.6	477719	34	4.20	UTS	UTS	UTS	UTS	UTS
13A*	512805.5	477572.1	32	13.42	9.86	9.62	3.80	0.24	0.25
14	512939.4	477400.9	66	8.00	6.23	6.12	1.88	0.11	0.13
15	513157	477192.7	51	5.20	4.52	4.51	0.69	0.01	0.05
16	513299.5	477024.6	30	7.70	5.68	5.69	2.01	-0.01	0.13
17	513507.7	476821.1	34	10.70	9.95	9.94	0.76	0.01	0.05
18	513721	476602.3	31	7.20	5.88	5.85	1.35	0.03	0.09

19	513916.6	476354.1	51	6.60	6.19	6.20	0.40	-0.01	0.03
20	514174.8	476179.4	32	7.00	6.07	4.51	2.49	1.56	0.17
21	514471.5	475965.7	66	7.60	7.40	7.15	0.45	0.25	0.03
22	514656.2	475728.8	101	8.10	6.93	6.74	1.36	0.19	0.09
23	514889.5	475537.6	60	9.10	7.66	7.17	1.93	0.49	0.13
24*	512603.7	481665.9	14	19.90	19.76	19.71	0.19	0.05	0.01
25*	512607.1	481648.9	184	17.20	16.93	16.88	0.32	0.05	0.02
26*	512301.9	481825.5	18	11.00	10.69	10.68	0.32	0.01	0.02
27*	512475.8	481712.1	20	11.60	11.22	11.20	0.40	0.02	0.03

Note: It is assumed that the accuracy of cliff top monitoring using this technique is $\pm 0.1\text{m}$. Therefore, observed changes have been altered by this amount prior to calculation of an erosion rate. Erosion rates are not calculated where the cliff line shows advance. This is likely to be the product of differing survey interpretation, and far less likely to be a toppling cliff edge.

*Baseline for 12A and 24-27 is March 2011.

**Surveyor's report states that 'VMPs 5,12,12A & 13 were inaccessible due to heavy vegetation'