Halcrow
A CH2M HILL COMPANY

Cell 1 Regional Coastal Monitoring Programme
Analytical Report 5: 'Full Measures' Survey 2012

Sunderland City Council

Sunderland City Council
Final Report

March 2013

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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 (m AOD)
Water Level Parameter	**Souter Point to Chourdon Point**
HAT	3.18
MHWS	2.48
MLWS	-1.92

Source: *River Tyne to Flamborough Head Shoreline Management Plan 2*. Royal Haskoning, February 2007.

Glossary of Terms

Term	Definition
Beach nourishment	Artificial process of replenishing a beach with material from another source.
Berm crest	Ridge of sand or gravel deposited by wave action on the shore just above the normal high water mark.
Breaker zone	Area in the sea where the waves break.
Coastal squeeze	The reduction in habitat area which can arise if the natural landward migration of a habitat under sea level rise is prevented by the fixing of the high water mark, e.g. a sea wall.
Downdrift	Direction of alongshore movement of beach materials.
Ebb-tide	The falling tide, part of the tidal cycle between high water and the next low water.
Fetch	Length of water over which a given wind has blown that determines the size of the waves produced.
Flood-tide	Rising tide, part of the tidal cycle between low water and the next high water.
Foreshore	Zone between the high water and low water marks, also known as the intertidal zone.
Geomorphology	The branch of physical geography/geology which deals with the form of the Earth, the general configuration of its surface, the distribution of the land, water, etc.
Groyne	Shore protection structure built perpendicular to the shore; designed to trap sediment.
Mean High Water (MHW)	The average of all high waters observed over a sufficiently long period.
Mean Low Water (MLW)	The average of all low waters observed over a sufficiently long period.
Mean Sea Level (MSL)	Average height of the sea surface over a 19-year period.
Offshore zone	Extends from the low water mark to a water depth of about 15 m and is permanently covered with water.
Storm surge	A rise in the sea surface on an open coast, resulting from a storm.
Swell	Waves that have travelled out of the area in which they were generated.
Tidal prism	The volume of water within the estuary between the level of high and low tide, typically taken for mean spring tides.
Tide	Periodic rising and falling of large bodies of water resulting from the gravitational attraction of the moon and sun acting on the rotating earth.
Topography	Configuration of a surface including its relief and the position of its natural and man-made features.
Transgression	The landward movement of the shoreline in response to a rise in relative sea level.
Updrift	Direction opposite to the predominant movement of longshore transport.
Wave direction	Direction from which a wave approaches.
Wave refraction	Process by which the direction of approach of a wave changes as it moves into shallow water.

Preamble

The Cell 1 Regional Coastal Monitoring Programme covers approximately 300km of the north east coastline, from the Scottish Border (just south of St. Abb's Head) to Flamborough Head in East Yorkshire. This coastline is often referred to as 'Coastal Sediment Cell 1' in England and Wales (Figure 1). Within this frontage the coastal landforms vary considerably, comprising low-lying tidal flats with fringing salt marshes, hard rock cliffs that are mantled with glacial sediment to varying thicknesses, softer rock cliffs and extensive landslide complexes.

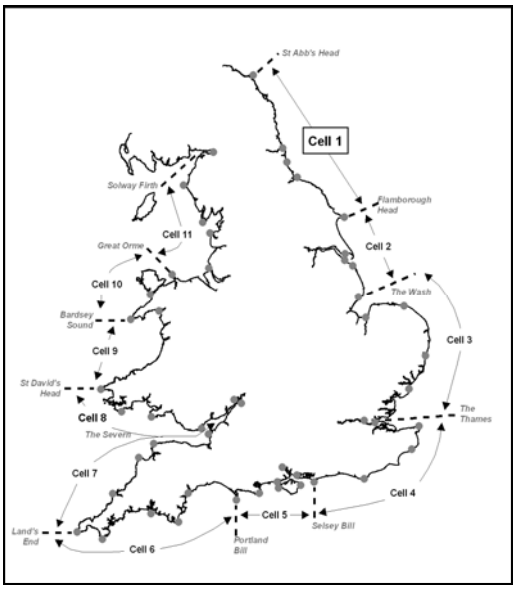


Figure 1 Sediment Cells in England and Wales

The work commenced with a three-year monitoring programme in September 2008 that was managed by Scarborough Borough Council on behalf of the North East Coastal Group. This initial phase has been followed by a five-year programme of work, which started in October 2011. The work is funded by the Environment Agency, working in partnership with the following organisations:

Northumberland County Council
Northumberland Coast AONB
North Tyneside Council
South Tyneside Council
Sunderland City Council
Durham County Council
Redcar & Cleveland Borough Council
Hartlepool Borough Council
Whitby Scarborough Filey Borough of Scarborough
A great place to live, work & play
East Riding of Yorkshire Council
Environment Agency
Natural England
The National Trust

The original three year programme of work was undertaken as a partnership between Royal Haskoning, Halcrow and Academy Geomatics. For the current five year programme of work the data collection associated with beach profiles, topographic surveys and cliff top surveys is being undertaken by Academy Geomatics. The analysis and reporting for the programme is being undertaken by Halcrow.

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
- walk-over surveys

The beach profile surveys, topographic surveys and cliff top recession surveys are undertaken as a 'Full Measures' survey in autumn (referred to as winter in previous reporting) 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	Sept-Dec 08	May 09	Mar-May 09		-
2	2009/10	Sept-Dec 09	Mar 10	Feb-Mar 10	Jul 10	-
3	2010/11	Aug-Nov 10	Feb 11	Feb-Apr 11	Aug 11	Sept 11
4	2011/12	Oct-Nov 11	Oct 12	Mar-May 12	Feb 13	-
5	2012/13	Sept-Oct 12	Mar 2013 (*)			

(*) The present report is **Analytical Report 5** and provides an analysis of the 2012 Full Measures survey for Sunderland City 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 the Table 2.

Table 2 Sub-divisions of the Cell 1 Coastline

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

1. Introduction

1.1 Study Area

Sunderland City Council's frontage extends from The Bents to Ryhope. For the purposes of this report and for consistency with previous reporting, it has been sub-divided into three areas, namely:

- Whitburn Bay
- Sunderland Harbour and Docks
- Hendon to Ryhope (including Halliwell Banks)

1.2 Methodology

Along Sunderland City Council's frontage, the following surveying is undertaken:

- Full Measures survey annually each autumn (previously referred to as winter) comprising:
    - Beach profile surveys along 58 transect lines (commenced 2009)
    - Topographic survey at Whitburn Bay (commenced 2009)
    - Topographic survey at Hendon to Ryhope (including Halliwell Banks) (commenced 2009)

- Partial Measures survey annually each spring comprising:
    - Beach profile surveys along 16 transect lines (commenced 2009)

- Cliff top survey bi-annually at:
    - Hendon to Ryhope (including Halliwell Banks) (commenced 2009)

The location of these surveys is shown in Figure 2. The Full Measures survey was undertaken along this frontage between 3rd and 7th September 2012, 18th September 2012, and 3rd and 4h October 2012. During this time weather conditions varied considerably; refer to the survey reports for details of the weather conditions over this survey period.

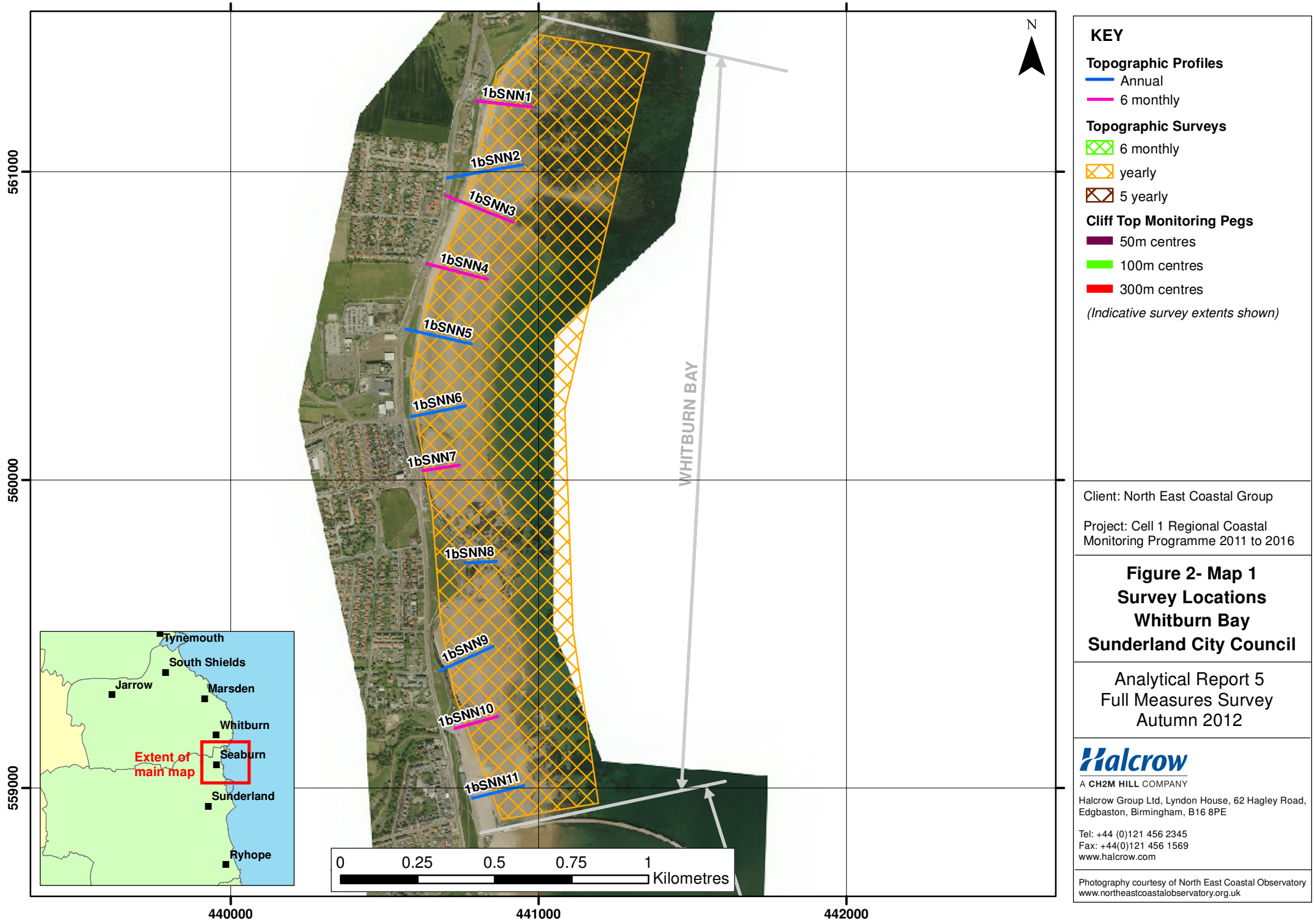
All data have been captured in a manner commensurate with the principles of the Environment Agency's *National Standard Contract and Specification for Surveying Services* and stored in a file format compatible with the software systems being used for the data analysis, namely SANDS and ArcGIS. This data collection approach and file format is comparable to that being used on other regional coastal monitoring programmes, such as in the South East and South West of England.

Upon receipt of the data from the survey team, they are quality assured and then uploaded onto the programme's website for storage and availability to others and also input to SANDS and GIS for subsequent analysis.

The Analytical Report is then produced following a standard structure for each authority. This involves:

- description of the changes observed since the previous survey and an interpretation of the drivers of these changes (Section 2);
- documentation of any problems encountered during surveying or uncertainties inherent in the analysis (Section 3);
- recommendations for 'fine-tuning' the programme to enhance its outputs (Section 4); and
- providing key conclusions and highlighting any areas of concern (Section 5).

Data from the present survey are presented in a processed form in the Appendices.



KEY

Topographic Profiles
- Annual
- 6 monthly

Topographic Surveys
- 6 monthly
- yearly
- 5 yearly

Cliff Top Monitoring Pegs
- 50m centres
- 100m centres
- 300m centres

(Indicative survey extents shown)

Client: North East Coastal Group

Project: Cell 1 Regional Coastal Monitoring Programme 2011 to 2016

Figure 2- Map 1
Survey Locations
Whitburn Bay
Sunderland City Council

Analytical Report 5
Full Measures Survey
Autumn 2012

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Cliff Top Monitoring Pegs
- 50m centres
- 100m centres
- 300m centres

(Indicative survey extents shown)

Client: North East Coastal Group

Project: Cell 1 Regional Coastal Monitoring Programme 2011 to 2016

Figure 2- Map 2
Survey Locations
Sunderland Harbour and Docks
Sunderland City Council

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Autumn 2012

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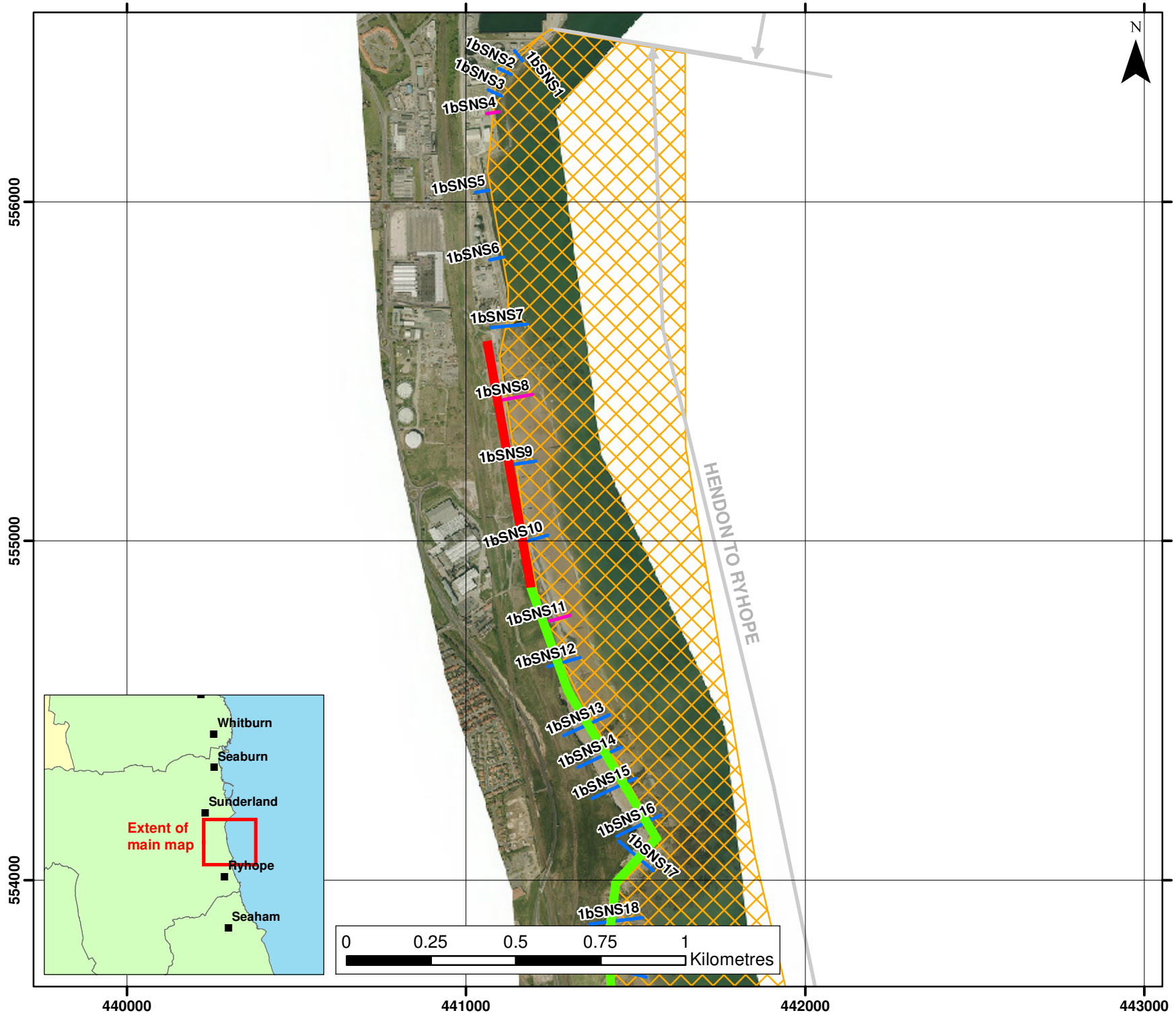

KEY

Topographic Profiles
- Annual
- 6 monthly

Topographic Surveys
- 6 monthly
- yearly
- 5 yearly

Cliff Top Monitoring Pegs
- 50m centres
- 100m centres
- 300m centres

(Indicative survey extents shown)

Client: North East Coastal Group

Project: Cell 1 Regional Coastal Monitoring Programme 2011 to 2016

Figure 2- Map 3
Survey Locations
Hendon to Ryhope North
Sunderland City Council

Analytical Report 5
Full Measures Survey
Autumn 2012

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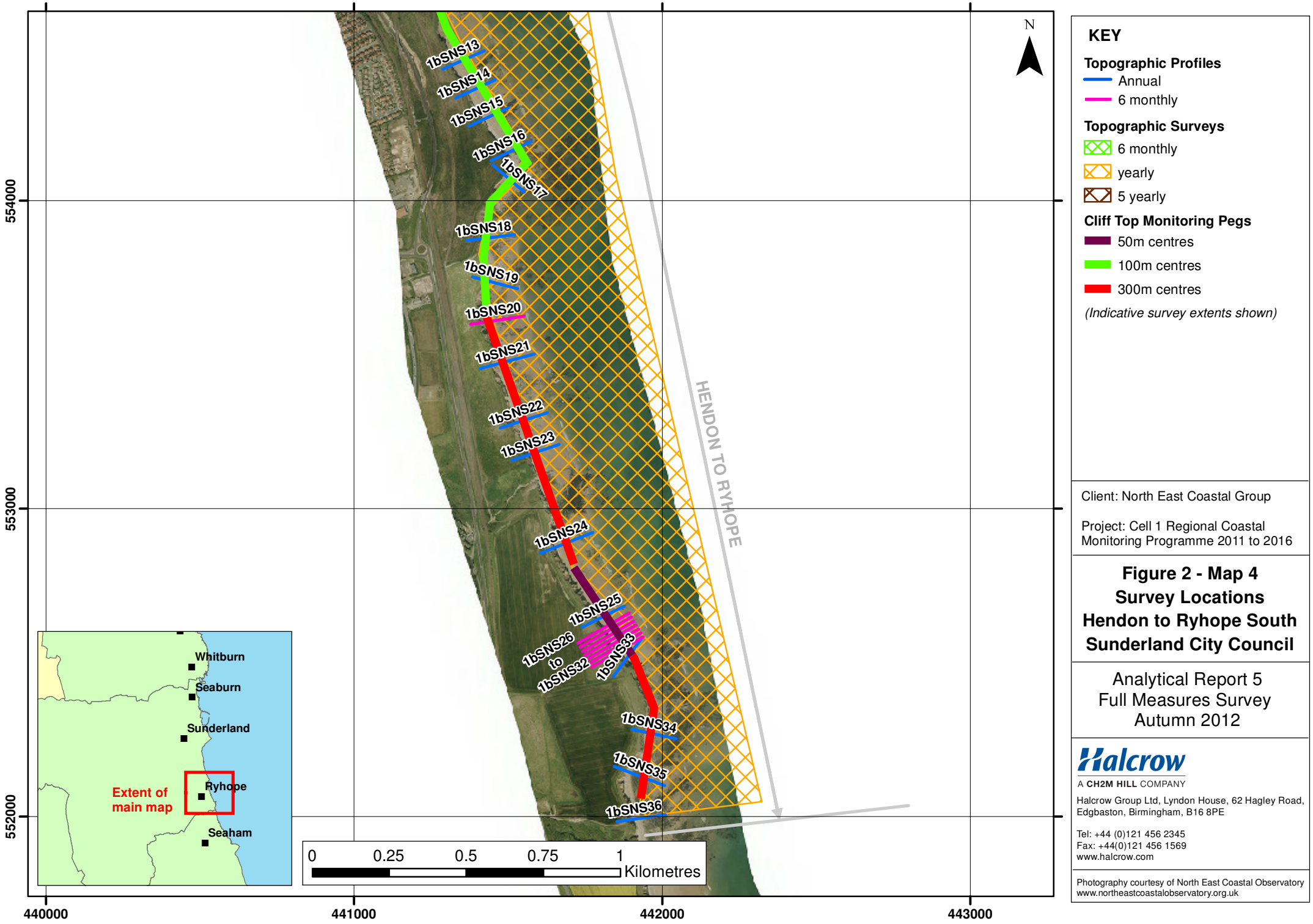

KEY

Topographic Profiles
- Annual
- 6 monthly

Topographic Surveys
- 6 monthly
- yearly
- 5 yearly

Cliff Top Monitoring Pegs
- 50m centres
- 100m centres
- 300m centres

(Indicative survey extents shown)

Client: North East Coastal Group

Project: Cell 1 Regional Coastal Monitoring Programme 2011 to 2016

Figure 2 - Map 4
Survey Locations
Hendon to Ryhope South
Sunderland City Council

Analytical Report 5
Full Measures Survey
Autumn 2012

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2. Analysis of Survey Data

2.1 Whitburn Bay

Survey Date	Description of Changes Since Last Survey	Interpretation
Oct 2012	**Beach Profiles:** Whitburn Bay is covered by eleven beach profile lines for the Full Measures survey (Appendix A). The previous survey was the full measures survey undertaken in autumn 2011 and the previous partial measures survey was undertaken in spring 2012. **1bSNN1** is just to the south of Sunderland City Council's northerly boundary of jurisdiction. Since the last survey (partial measures, spring 2012), between the sloping backshore and a chainage of 95m beach levels have fallen considerably, by up to 2m. Seaward of 95m, they have increased by 0.4m. The result is a steeper upper beach and a flatter middle and lower beach (as also shown by the survey photographs in Plates 1 and 2). The survey photograph for the present survey also shows the formation of runnels in the upper beach and large volumes of seaweed. This suggests cross-shore movement, possibly taking place as a result of storm activity. Profiles **1bSNN2** and **1bSNN3** are located towards the north of Whitburn Bay and extend across scrubland before reaching the upper gravel foreshore and then dropping across the lower sandy foreshore towards the rocky outcrop of Whitburn Steel. At profile **1bSSN2**, beach levels across the majority of the profile have decreased, including at the toe of the dunes seaward to MHWS where they have decreased by approximately 0.3m and seaward of a chainage of 130m. A small increase in beach levels has resulted in the formation of a small berm at MHWS. At **1bSNN3**, the changes observed at 1bSNN2 are repeated, the difference being that beach levels have fallen seaward of a chainage of 110m. Profiles **1bSNN4** to **1bSNN6** are between the southern edge of South Bents housing estate and just north of Parsons Rock. At profile **1bSNN4**, beach levels across the profile have decreased, particularly between MHWS and a chainage of 180m, where they have fallen by approximately 0.4m. Seaward of a chainage of 200m, beach levels have increased to form a small berm between 250m and 260m chainage, suggesting some cross shore movement and the possible draw-down of material due storms. At profile **1bSNN5**, beach levels have increased at the toe of the seawall to chainage of 90m by	Along the length of Whitburn Bay, generally beach levels have fallen. At discrete locations, beach levels at the toe of the defence have increased, including those to the north of the bay at 1bSNN2 and 1bSNN3, towards the centre of the bay at 1bSNN5 and 1bSNN7, and towards the south at 1bSNN10. The changes and the observations made from the survey photographs, for example the presence of large volumes of seaweed at 1bSNN11 and 1bSNN10 and the wet sand at the toe of the access ramp at 1bSNN10 suggest that the beaches have been subject to erosion via beach draw-down and lowering as result storm water levels and waves. **Longer term trends:** Along the length of the beach, beach levels have fallen (and in parts increased), however in general the changes observed in the present surveys are within the bounds of previous surveys. There are a few locations, where the level of the beach at the toe of the dunes / seawall is the highest observed to date, they are mainly located to the north and centre of the bay and include: 1bSNN2, 1bSNN3, 1bSNN5 and 1bSNN7.

Survey Date	Description of Changes Since Last Survey	Interpretation
	approximately 0.2m, and seaward of a chainage of 210. However, across the majority of the frontage, beach levels have fallen by approximately 0.2m. At profile **1bSNN6**, beach levels have fallen quite significantly across the centre profile; by up to 2m at the revetment steps and between 0.2-0.4m across the beach profile. The result is the exposure of 5 of the access steps (as shown by the survey photographs in Plates 3 and 4) and the presence of a channel (see Plates 5 and 6), carved by the outflow of water from the storm water outfall adjacent to the access steps. This is evidence of both storm conditions (resulting in beach lowering) and high surface water flows from heavy rainfall. **1bSNN7** is at Seaburn, just to the north of Parson's Rock. From the toe of the seawall to a chainage of 40m, beach levels have increased by approximately 0.3m since the last survey (partial measures, spring 2012). Seaward of there, they have decreased across the profile by up to 0.3m, however, the beach has retained the same form and slope. Profile **1bSNN8** extends across Parsons Rock. Beach levels at the toe of the seawall have decreased to expose the rocks below. This is a return to the beach levels observed in September 2010 (full measures, autumn 2010). Seaward of there, there is little discernible change. Profile **1bSNN9** drops from the cliff top to the foreshore at Roker. Beach levels have decreased across the majority of the profile by approximately 0.2m. **1bSNN10** is located approximately mid-way between Parson's Rock and Roker Pier. Since the last survey (partial measures, spring 2012), between a chainage of 35m and 70m, beach levels have fallen by approximately 0.2m. As observed from the survey photographs for this profile (see Plates 7 and 8), at the foot of the access ramp and between the seawall, the amount of sand accumulated there has decreased. The sand is wet and there is a large amount of seaweed. This suggests that higher water levels have reached the seawall in response to storm conditions, thus preventing the sane from drying out and being blown inshore as observed in the previous survey. **1bSNN11** is located to the south of Whitburn. Beach levels have decreased across the profile in the region of 0.5m to from a lower beach with a more concave profile.	

Survey Date	Description of Changes Since Last Survey	Interpretation
Oct 2012	**Topographic Survey:** Whitburn Bay, between the Bents and Roker Pier, is covered by an annual topographic survey which commenced in September 2009. Data from the most recent topographic survey (full measures, autumn 2012) have been used to create a digital ground model (DGM) (Appendix B – Map 1a) using a Geographical Information System (GIS). A difference plot has also been produced using the DGM (Appendix B – Map 1b) produced from the last produced topographic survey (full measures, autumn 2011) and the present survey. The difference plot showing changes occurring in beach elevation since the last survey, shows a mixture of beach elevation increase and decrease across the beach. Overall, there is reduction in beach levels generally across the middle of the beach along the length of this frontage, with beach elevation increase along the back of the beach and the lower shore. There is also a notable increase in beach elevation to the north, in the lee of Whitburn Steel Rocks. **Long Term Topographic Trends Autumn 2010 to Autumn 2012:** The long term difference plot (Appendix B – Map 1c) shows the net change in beach levels between autumn 2010 and autumn 2012. The plot shows an increase in beach levels along Whitburn Sands, from Whitburn Steel to Parsons Rock. Beach levels have fallen immediately to the north of Whitburn Steel and on the middle beach between Parsons Rocks and Roker Park. Between Roker park and Roker Pier, beach elevation has predominantly increased.	The topographic survey shows that since the last survey, there has been a mixture of beach elevation increase and decrease across the beach. Overall, there is reduction in beach levels generally across the middle of the beach along the length of this frontage, with beach elevation increase along the back of the beach and the lower shore. There is a notable increase in beach elevation to the north, in the lee of Whitburn Steel Rocks, where the protective function of the offshore rocks provides shelter from incoming waves encouraging accretion. **Longer term trends:** The longer term trends are covered by the long term topographic trends autumn 2009 to autumn 2012 (see below). **Long term topographic trends Autumn 2009 to Autumn 2012:** The plot shows an increase in beach levels along Whitburn Sands, from Whitburn Steel to Parsons Rock. As noted in the previous full measures report (autumn 2011), it is likely that material is being removed from the beach to the north and deposited in the lee of Whitburn Steel, where it is more sheltered. To the south, beach levels along Whitburn Sands, from Whitburn Steel to Parsons Rock have increased. Further south, between Parsons Rocks and Roker Park, there is a trend of beach elevation reduction, however, between Roker park and Roker Pier, beach levels have predominantly increased. This is due to the shelter provided by the pier.

Plate 1 – Survey photograph 1bSNN1_20121004_N4.jpg (FM 2012)

Plate 2 – Survey photograph 1bSNN1_20120320_N3.JPG (PM 2012)

Plate 3 – Survey photograph 1bSNN6_20121004_N1.jpg (FM 2012)

Plate 4 – Survey photograph 1bSNN6_20111013_N1.jpg (FM 2011)

Plate 5 – Survey photograph 1bSNN6_20121004_N2.jpg (FM 2012)

Plate 6 – Survey photograph 1bSNN6_20111013_N2.jpg (FM 2011)

Plate 7 – Survey photograph 1bSNN10_20121004_N1.JPG (FM 2012)

Plate 8 – Survey photograph 1bSNN10_20120320_N1.JPG (PM 2012)

2.2 Sunderland Harbour and Docks

Survey Date	Description of Changes Since Last Survey	Interpretation
Sept 2012	**Beach Profiles:** Sunderland Harbour and Docks is covered by eleven beach profile lines (Appendix A). The previous survey was the full measures survey undertaken in autumn 2011. **1bSNN12** and **1bSNN13** are both located within the shelter of Roker Pier. At profile **1bSNN12**, beach levels have fallen across the profile to a chainage of 125m, seaward of which they have increased. The beach crest at HAT has been eroded to form a more concave profile, and a small beach berm has formed just above HAT. The survey photograph (see Plates 9 and 10) shows a considerable amount of debris on the beach and a change in sediment from sand to sand/shingle. This reflects the occurrence of recent storm conditions. At **1bSNN13** beach levels at the toe of the revetment have dropped significantly, by as much as 1.5m, exposing a collection of cobbles/ boulders. Seaward of a chainage of 52m, beach levels have increased by 0.2m. It is likely that during storm conditions, beach material has been scoured from in front of the revetment and drawn-down the beach and deposited on the lower shore. **1bSNC1** and **1bSNC2** are located within the shelter of New South Pier. Profile **1bSNC1** starts at the seaward edge of the dock building and extends across an earth mound before reaching the stepped landward face of the dock wall. The profile then drops from the wall crest directly into deep water. For this reason, profile 1bSNC1 has not been analysed. Profile **1bSNC2** starts at the crest of New South Pier and drops several metres to foreshore level. Beach levels have increased across the profile to a chainage of 85m and the beach has retained the same from. Material deposited here is likely to be that transported by cross shore processes from the lower to the upper beach, but also that eroded from the beaches to the north. **1bSNC3** to **1bSNC6** are on the seaward face of the dock. Profile **1bSNC3** extends from the dock yard across a back flood wall, which has a crest level of around 7.2mODN, and promenade to the main seaward dock wall, which has a crest level of 7.55mODN. The profile then extends down the seaward face of the wall into deep water. For this reason, profile 1bSNC3 has not been analysed. Profiles **1bSNC4** and **1bSNC5** extend from the rock armoured revetment across the short width of foreshore down to low water. At profile **1bSNC4**, beach levels have decreased by approximately 2m across the lengthy of the profile and a change from a mainly sandy beach to one comprised of shingle. Review of	To the north of Sunderland Harbour and Docks, within the breakwaters to the north of the River Wear, beach levels have fallen quite considerably. The change in beach profile form and presence of debris on the beach shows that the beach has responded to particularly strong storm conditions. To the south of the River Wear, within the breakwaters, and in the lee of the harbour arm, the beach has accreted. Within the centre of this frontage, at profiles 1bSNC4 and 1bSNC5, beach levels have fallen. In the lee of the southern harbour arm, at profile 1bSNC4, beach levels have decreased significantly. The survey photographs also show the placement of new rock material. A review of the survey photograph for two years ago in 2010 (full measures, autumn 2010), shows the rock to be present. It was noted in the previous survey report (full measures, autumn 2011), '*the change in profile from 2010 to 2011 suggested that beach levels have increased by over 1.5m and it is possible that this is due to survey error.*' Therefore, the particularly high levels observed in autumn 2011 are likely to be associated with the removal of the rock and possibly beach management that occurred at that time. When the present profile and that from autumn 2010 are compared, they are very similar in form and level. To the south, at profiles 1bSNC6 and 1bSNC8, beach levels have increased, however, between these

Survey Date	Description of Changes Since Last Survey	Interpretation
	the survey photographs (see Plates 11 and 12) shows the placement of new rock adjacent to the seawall and on the backshore. A review of the survey photograph for two years ago in 2010 (full measures, autumn 2010), shows the rock to be present. It was noted in the previous survey report (full measures, autumn 2011), '*the change in profile from 2010 to 2011 suggested that beach levels have increased by over 1.5m and it is possible that this is due to survey error.*' Therefore, the particularly high levels observed in autumn 2011 are likely to be associated with the removal of the rock and possibly beach management that occurred at that time. At profile **1bSNC5**, beach levels have decreased by approximately 0.2m across the profile. **1bSNC6** extends across the revetment and seawall. A small veneer of sand covers the rock at the toe of the coastal defences. Beach levels have increased by over 1m along the length of this profile, covering the underlying boulders with a veneer of sand and shingle closer towards MLWS. **1bSNC7** to **1bSNC9** are within the shelter of North East Pier and South West Breakwater. **1bSNC7** is a section across North East Pier and shows the terraced nature of the landward face of the pier wall, extending across rock to the small sheltered bay between the two structures. For this reason, profile 1bSNC7 has not been analysed. Profile **1bSNC8** crosses the boulders and rubble, which reaches a level of around 6.2mODN, and then extends across the sandy but boulder strewn foreshore. Beach levels on the foreshore between a chainage of 30m and 70m have increased by up to 0.2m. Profile **1bSNC9** extends from the dock facilities and crosses a short length of concrete wall before extending across the sand foreshore to reach and cross a large boulder mound that is towards the seaward end of the south west breakwater. There is little discernible change in beach levels.	locations, they have decreased. This could potentially reflect the transfer of material from one profile to another. **Longer term trends:** The beaches within the breakwaters are showing signs of the most extreme change observed to date. The changes that have occurred since the last survey are particularly significant, and suggest that the beach has responded to particularly strong storm conditions. This is notable at: (i) profile 1bSNN13, where beach levels at the toe of the revetment are the lowest observed to date (by a margin of 0.8m, the second lowest observed in September 2009 (full measures survey, autumn 2009); and (ii) profile 1bSNC2, where beach levels at the toe of the pier are the highest observed to date and seaward of a chainage of 100m, the lowest observed to date. To the centre and south of Sunderland Harbour and Docks, although changes observed, the beaches are in generally of similar form and position to those profiles observed in the past. To note is 1bSNC4 (as described above).

Plate 9 – Survey photograph 1bSNN12_20121004_N6.JPG (FM 2012)

Plate 10 – Survey photograph 1bSNN12_20111013_N5.JPG (PM, 2011)

Plate 11 – Survey photograph 1bSNC4_20120918_N1.JPG (FM 2012)

Plate 12 – Survey photograph 1bSNC4_20111111_N2.JPG (FM 2011)

2.3 Hendon to Ryhope (incl. Halliwell Banks)

Survey Date	Description of Changes Since Last Survey	Interpretation
Sept 2012	**Beach Profiles:** Hendon to Ryhope is covered by thirty six beach profile lines (Appendix A). The previous survey was the full measures survey undertaken in autumn 2011 and the previous partial measures survey was undertaken in spring 2012. **1bSNS1** to **1bSNS6** are located along the sea wall protecting the Hendon Sewage Treatment Works. The profiles typically include a section along the concrete deck, wall crest (which varies in elevation between around 7.0mODN in the north and 7.6mODN in the south after the dog-leg in the wall position), near-vertical seaward face of the wall, and sloping rock armour revetment. The form of the profiles at **1bSNS1**, **1bSNS2**, and **1bSNS3** are defined by a seawall, a small section of fine rubble and rock revetment foreshore. The survey data is varied across the years, and is explained in the survey report for Sunderland South '*no access to bottoms of sections 1, 2, 3 and 4, requires crossing very slippery boulders'*. Therefore the beach profiles have not been analysed. Profile **1bSNS4** also extends into water and has not been analysed. Profiles **1bSNS5** and **1bSNS6** drop directly from the structure into deep water and have not been analysed. **1bSNS7** to **1bSNS10** are located along the defended coastal slopes along south Hendon, which rise in elevation to higher defended cliffs at 1bSNS11. Profile **1bSNS7** extends across a seawall and concrete revetment, which is fronted by a foreshore comprised of large pebbles and coarse shingle. From the toe of the revetment to a chainage of 34m, beach levels have decreased by 0.2m, and seaward of there, they have increased. It is likely that material has been moved from the upper to the lower beach by cross-shore transport during storm conditions. Profile **1bSNS8** extends across the seawall, rock revetment, a rocky upper beach and sandy middle and lower beach. An additional data point is showing on the full measures profile at a 25m chainage, which is likely to relate to survey technique rather than actual change. Beach levels have decreased across the length of the profile, particularly at the toe of the revetment where they have fallen by up to 0.5m. At profile **1bSNS9**, beach levels have decreased across the length of the profile by approximately 0.3m to 0.4m, exposing the underlying boulder platform.	The profiles to the north (immediately south of the South West Breakwater), between 1bSNS1 and 1bSNS6 have not been analysed as the data is of poor quality, as explained in the survey report for Sunderland South '*no access to bottoms of sections 1, 2, 3 and 4, requires crossing very slippery boulders'* & 'poor access to small beach between section 4 and 5, therefore not surveyed'. Profile 1bSNS4 extends into water and has therefore not been analysed. Profiles 1bSNS5 and 1bSNS6 drops directly from the structure into deep water and have therefore not been analysed. Along the length of south Hendon, between profiles 1bSNS7 and 1bSNS11, the backshore is defended and the beach is stabilised with groynes. Beach levels have fallen of this section of coastline, with some evidence of cross-shore movement indicating storm conditions. Along the length of Grangetown (south Hendon to Salterfen Rocks), between profiles 1bSSN12 and 1bSNS16, although there has been some discrete changes to the cliff position and beach levels, in general they have retained the same form and level. Along the length of coastline between Salterfen Rocks and the landfill at Halliwell banks (profiles 1bSNS17 to 1bSNS25), the cliffs have been differently along the length of the coastline, with some retaining the same form and position since the previous survey and

Survey Date	Description of Changes Since Last Survey	Interpretation
	At profile **1bSNS10**, beach levels have decreased across the majority of the profile by up to 0.2m, with a small increase at the toe of the revetment. Seaward of a chainage of 72m, beach levels have not changed since the last survey (full measures, 2011). At profile **1bSNS11** the cliffs have remained stable since the last survey (partial measures, spring 2012). Beach levels have decreased across the profile, from the toe to a chainage of 90m, by up to 0.5m. **1bSNS12** to **1bSNS36** are located along the undefended cliffs between Grangetown and Ryhope Dene. Profiles SNS12 to SNS16 are between the end of the Hendon sea wall and Salterfen Rocks. Cliff top levels are typically between 20m and 22mOD. They are highest along the profiles further north, dropping in the centre and then increasing again to the south. Profile **1bSNS12** extends from the cliff across the foreshore which is comprised of boulders. The cliff face is observed to have advanced by 1m, which is more likely to relate to survey interpretation rather than actual accretion. Profile levels at the toe of the cliff to a chainage of 50m have decreased (it is thought that this is rock rubble and not beach). Seaward of a chainage of 60m, there has been no discernible change in beach level. At profile **1bSNS13** the cliff face has not changed in form or position since the previous survey (full measures, 2011). Beach levels have increased marginally between a chainage of 44m and 55m, and deceased between a chainage of 65m and 115m to form a more concave beach profile. At profile **1bSNS14**, the cliff face has not changed in form or position since the previous survey (full measures, 2011). Beach levels have increased by approximately 0.2m between HAT and MHWS, and increased by 0.2m to 0.3m seaward o a chainage of 80m. At profile **1bSNS15**, the cliff face has retreated by 0.5m to 1m. Beach levels at the toe of the cliff have accreted marginally, by approximately 0.2m, otherwise there has been very little change to the beach levels since the last survey (full measures, autumn 2011). At profile **1bSNS16**, the cliff face is observed to have advanced by 1m, which is more likely to relate to survey interpretation rather than actual accretion. There have been no discernible changes to beach levels since the last survey (full measures, autumn 2011). Profiles **1bSNS17** to **1bSNS36** extend between Salterfen Rock and Ryhope Dean/Pincushion Rocks along Shirley Banks and Halliwell Banks. Profiles between SNS17 and SNS25 typically exhibit a	others either accreting or retreating. Survey interpretation. To the south of Salterfen Rocks, there have been small variations in beach level, which are likely to reflect the movement of pebbles and rocks across the foreshore rather than actual level changes. Beach levels at profiles 1bSNS21 and 1bSNS24 have changed most markedly with a fall in beach levels, otherwise elsewhere there are no discernible changes in beach levels. At the landfill site (profiles 1bSSN26 to 1bSSN32) the cliffs at 1bSNS26 and 1bSNS30 have retained the same form and position since the last survey (partial measures, 2011). At profiles 1bSNS27, 1bSNS28 and 1bSNS32 the cliff face has retreated. At profiles 1bSNS29 and 1bSNS31, the cliff face has advanced. Beach levels have increased across the beach at all profiles by up to 0.3m, however, the beaches have retailed the same form. To the south of Halliwell Banks, around Pincushion, the cliff face has retained the same form and position since the last surveys and there has been no discernible change to the beach levels. **Longer term trends:** Along the length of south Hendon, between profiles 1bSNS7 and 1bSNS11, the backshore is defended and the beach is stabilised with groynes. Although beach levels have fallen across this frontage, they have generally been observed to be lower in the past. Notably at 1bSNS8 and 1bSNS10, beach levels at the toe of the revetment are the lowest

Survey Date	Description of Changes Since Last Survey	Interpretation
	characteristic cliff height of between 23m and 29mOD, with beaches at the toe typically at levels between 3.1m and 4.6mOD. At **1bSNS17**, the profile shows the cliff face (from a height of 16m) to the cliff toe to have retreated (up to 2m at the toe). Across the foreshore there are small variations in beach level, which are likely to reflect the movement of pebbles and rocks across the foreshore rather than actual level changes. At **1bSNS18**, the profile shows the cliff face to have accreted. This could be related to retreat of the cliff face and the accumulation of the eroded material towards the bottom of the cliff. Beach levels have increased between MHWS to a chainage of 95m and decreased seaward of there. At **1bSNS19**, the cliff face has retained the same form and position since the last survey (full measures, 2011). Across the profile there are small variations in beach level, which is likely to reflect the movement of pebbles and rocks across the foreshore rather than actual level changes. At profile **1bSNS20**, the profile shows the cliff face to have accreted. This could be related to retreat of the cliff face and the accumulation of the eroded material towards the bottom of the cliff. Across the profile there are small variations in beach level, which is likely to reflect the movement of pebbles and rocks across the foreshore rather than actual level changes. At **1bSNS21**, the cliff face has retained the same form and position since the last survey (full measures, 2011). Since the last survey (full measures, autumn 2011), beach levels have decreased by up to 1m at the toe of the cliff. Across the foreshore there has been very little change to the beach levels since the last survey. At profile **1bSNS22**, the cliff face has retained the same form and position since the last survey (full measures, autumn 2011). Across the foreshore there has been no discernible change to beach levels since the last survey. At profile **1bSNS23**, the cliff face (from a height of 16m) to the cliff toe has retreated by up to 2m at the toe. Beach levels have decreased across the profile, particularly at the cliff toe (HAT/MHWS) where they have fallen by 0.1m to 0.2m. At **1bSNS24**, the cliff face (from a height of 18m) to the cliff toe to have retreated by up to 2m at the toe. Across the foreshore, from the cliff toe to a chainage of 85m, there has been no discernible change to beach levels since the last survey (full measures, autumn 20110. Between a chainage of 85m and	observed since 2009 and may be a result of particularly strong storm conditions as experienced at Northumberland, North and South Tyneside. Along the length of Grangetown (south Hendon to Saltfen Rocks), between profiles 1bSSN12 and 1bSNS16, the position of the cliff face has oscillated, which is not typical of cliff behaviour and it is therefore likely that the cliff position is related to survey interpretation and not actual change. Beach levels have in the main changed within the boundaries of previous surveys, however at (i) 1bSNS15, there has been a continued lowering of the beach at the cliff toe since September 2009; and (ii) at 1bSSN13 and 1bSNS14, seaward of a chainage of 70m and 80m respectively, beach levels are the highest beach levels observed to date. Along the length of coastline between Salterfen Rocks and the landfill at Halliwell banks (profiles 1bSNS17 to 1bSNS25), the position of the cliff face has oscillated, which is not typical of cliff behaviour and it is therefore likely that the cliff position is related to survey interpretation and not actual change. Although beach levels have fluctuated they are generally within the bounds of previous surveys. At the landfill site (profiles 1bSSN26 to 1bSSN32) the position of the cliff face has oscillated, which is not typical of cliff behaviour and it is therefore likely that the cliff position is related to survey interpretation and not actual change. The trend of beach level increase has continued since the last survey (full measures,

Survey Date	Description of Changes Since Last Survey	Interpretation
	135m, beach levels have increased by up to 1m. At profile **1bSNS25**, the cliff face has retreated with up to 3m of retreat at the cliff top. Beach levels have changed only marginally with approximately 0.1m increase at HAT/MHWS and seaward of a chainage of 110m and a decrease in beach levels in the order of 0.1m between. This suggests the redistribution of beach material across the beach. Profiles **1bSNS26** to **1bSNS32** are located at Halliwell Banks specifically to assess risks from erosion at a former land fill. Cliff height is characteristically around 26m and 27mODN, with beaches at the toe typically at levels between 3.3m and 3.9mODN. At profiles**1bSNS26** to **1bSNS32** the cliffs at **1bSNS26** and **1bSNS30** have retained the same form and position since the last survey (partial measures, 2011). At profiles **1bSNS27**, **1bSNS28** and **1bSNS32** the cliff face has retreated. At profiles **1bSNS29** and **1bSNS31**, the cliff face has advanced. Beach levels have increased across the beach at all profiles by up to 0.3m, however, the beaches have retailed the same form. The amount that beach levels have risen increases towards the south. Profiles **1bSNS33** to **1bSNS36** are all located around the Pincushion Headland. At all locations the cliff face has retained the same form and position since the last surveys. At profile**1bSNS33** beach levels have increased by approximately 0.1m to 0.2m across the profile. At **1bSNS34**, there are no discernible changes to the beach levels. At profile**1bSNS35**, beach levels have fallen marginally across the profile (by approximately 0.1m), with a small increase at the toe of the cliffs between HAT and MHWS and between a chainage of 95m and 100m. At profile**1bSNS36**, across the profile there are small variations in beach level so that the profile, which is likely to reflect the movement of pebbles and rocks across the foreshore and the movement of the veneer of sand between them.	autumn 2011), and beach levels are the highest observed to since September 2009. To the south of Halliwell Banks, at profiles 1bSNS33 and 1bSNS34, the position of the cliff face has oscillated, which is not typical of cliff behaviour and it is therefore likely that the cliff position is related to survey interpretation and not actual change. However, at 1bSNS35 and 1bSNS36, there is an ongoing trend of cliff face retreat. At profiles 1bSNS33 and 1bSNS36 beach levels at the toe are the lowest observed since 2009, otherwise beach levels are generally within the bounds of previous surveys. An additional assessment of cliff recession will be derived from analysis of time-series remote sensing data. A high quality baseline survey, comprising LiDAR and aerial photography, was collected in 2010, a repeat survey was completed in Sept/Oct 2012 and a second repeat survey is planned for 2014. These data will be analysed to give more accurate information on the behaviour of the cliffs in a separate report.

Survey Date	Description of Changes Since Last Survey	Interpretation
Oct 2012	**Topographic Survey:** Hendon to Ryhope is covered by an annual topographic survey between the Hendon Sea Wall and Ryhope Dene, which commenced in autumn 2009. Data from the most recent topographic survey (full measures, autumn 2011) have been used to create a DGM (Appendix B – Map 2a and Map 3a) using a Geographical Information System (GIS). A difference plot has also been produced using the DGM (Appendix B – Map 2b and Map 3b) produced from the last produced topographic survey (full measures, autumn 2012) and the present survey. Between Hendon and Salterfen Rocks, beach elevation along the back of the beach at the toe of the defences has fallen. Across the remainder, beach elevation has also reduced, with some interspersed areas of beach elevation increase. Around Salterfen Rocks areas of beach elevation and increase are interspersed and there is no discernible trend. Between Salterfen Rocks and Ryhope Dean/ Pincushion, to the north of the frontage, beach elevation is predominantly loss, however, to the south of at Halliwell Banks and Pincushion, beach elevation is predominantly gain. **Long Term Topographic Trends Autumn 2010 to Autumn 2012:** The long term difference plot (Appendix B – Map 2c and 3c) shows the net change in beach levels between autumn 2009 and autumn 2012. The plot shows a general trend of beach elevation loss towards the backshore and toe of the cliffs and beach elevation gain across the middle and lower beach. Areas to note where beach elevation loss is quite pronounced is around the works at Grangetown (to the north) and immediately to the north of Halliwell banks.	Between Hendon and Salterfen Rocks, beach elevation along the back of the beach at the toe of the defences has fallen. Across the remainder, beach elevation has also reduced, with some interspersed areas of beach elevation increase. Around Salterfen Rocks areas of beach elevation and increase are interspersed and there is no discernible trend. Between Salterfen Rocks and Ryhope Dean/ Pincushion, to the north of the frontage, beach elevation is predominantly loss, however, to the south of at Halliwell Banks and Pincushion, beach elevation is predominantly gain. **Longer term trends:** The longer term trends are covered by the long term topographic trends autumn 2009 to autumn 2012 (see below). **Long term topographic trends Autumn 2009 to Autumn 2012:** The plot shows a general trend of beach elevation loss towards the backshore and toe of the cliffs and beach elevation gain across the middle and lower beach. Areas to note where beach elevation loss is quite pronounced is around the works at Grangetown (to the north) and immediately to the north of Halliwell banks. This later location ties in with a stream and valley, and is likely that this is causing the erosion here.

Survey Date	Description of Changes Since Last Survey	Interpretation
Sept 2012	**Cliff Top Survey:** Cliff top survey data collected for baseline survey (spring, 2009), the partial measures survey (spring 2012) and the present full measures survey (autumn, 2012) is presented in this report. 32 ground control points (numbered 1-32) were established along the cliff top between Hendon and Ryhope in March 2009, with a further three (28A, 28B and 28C) added in September 2009. Note: the numbering of ground control points is not intended to correlate with that of the beach profile lines and reference should be made to Appendix B - Map 1 and Appendix B – Map 2 for the location of ground control points. Measurements are taken from each ground control point along a fixed bearing to the edge of the cliff top. These cliff top surveys are undertaken bi-annually and are intended to inform on erosion rates of the sea cliffs extending from the defended industrial areas at Hendon southwards along the undefended cliffs to Ryhope Dene. The results from the cliff top monitoring are anticipated to have an accuracy of ±0.2m due to the technique used. These cliff top surveys are undertaken bi-annually and are intended to inform on erosion rates of the sea cliffs extending from the defended industrial areas at Hendon southwards along the undefended cliffs to Ryhope Dene. Appendix B – Table B1 provides results from the cliff top survey, showing the position from the ground control point to the edge of the cliff top along a defined bearing. Results show that erosion or an amount of movement greater than the survey error has occurred at 18 ground control points since surveys began in March 2009 (or September 2009 for 28A and 28B). Other locations have change within the error band. Since the last survey, the cliff at only two locations is indicated to have eroded – point 2 (opposite the works) and point 32 (immediately to the south of Pincushion). The remaining points indicate erosion within the error band, advance or no change. This reflects survey error due to uncertainty over precise location of the cliff top. .	Since the last survey, the cliffs to the south of Sunderland Docks, at Hendon, opposite the works, and those immediately to the north of Halliwell Banks have eroded (by an amount greater than the survey error). The indicated cliff advance may result from survey of cliff fall debris, but is more likely to represent error in the survey, either due to misidentification of the cliff line, or error in the survey data. **Longer term trends:** The problems in identification of the cliff top due to growth of vegetation that make the short term change data unreliable diminish over the long-term, and three zones of erosion are indentified. Point 2 has a long term erosion rate of 0.2m, points 9 to 11 have long term erosion rates of between 0.4 and 1.1m/yr, points 19 to 21 have erosion of 0.7 to 1.2m/yr, point 25 has erosion of 1.6m/yr, points 27 to 28B have erosion of 0.3 to 1.3 m/yr and points 29 to 32 have erosion of 0.1 to 1.0m/yr. These erosion hotspots tend be on stretches of coast that face towards the northeast, which is the dominant wave direction. Other stretches of coast, which typically have an eastwards or south eastwards aspect that are marginally more protected from the dominant wave direction, have remained stable. An additional assessment of cliff recession will be derived from analysis of time-series remote sensing data. A high quality baseline survey, comprising LiDAR and aerial photography, was collected in 2010, a repeat survey was completed in Sept/Oct 2012 and

Survey Date	Description of Changes Since Last Survey	Interpretation
		a second repeat survey is planned for 2014. These data will be analysed to give more accurate information on the behaviour of the cliffs in a separate report.

3. Problems Encountered and Uncertainty in Analysis

Individual Profiles

At profile 1bSNN6, beach levels have fallen quite significantly across the centre profile; by up to 2m at the revetment steps and between 0.2-0.4m across the beach profile. The result is the exposure of five of the access steps and erosion of a channel by water flowing from the storm water outfall adjacent to the access steps. This is evidence of both storm conditions (resulting in beach lowering) and high surface water flows from heavy rainfall.

1bSNN10 is located approximately mid-way between Parson's Rock and Roker Pier. Since the last survey (partial measures, spring 2012), between a chainage of 35m and 70m, beach levels have fallen by approximately 0.2m. As observed from the survey photographs for this profile, at the foot of the access ramp and between the seawall, the amount of sand accumulated there has decreased. The sand is wet and there is a large amount of seaweed. This suggests that higher water levels have reached the seawall in response to storm conditions, thus preventing the sane from drying out and being blown inshore as observed in the previous survey.

At 1bSNN13 beach levels at the toe of the revetment have dropped significantly, by as much as 1.5m, exposing a collection of cobbles/ boulders. Seaward of a chainage of 52m, beach levels have increased by 0.2m. It is likely that during storm conditions, beach material has been scoured from in front of the revetment and drawn-down the beach and deposited on the lower shore.

At profile 1bSNC1, the profile drops from the wall crest directly into deep water and has therefore not been analysed.

Profile 1bSNC3 extends down the seaward face of the wall into deep water and has therefore not been analysed.

At profile 1bSNC4, beach levels have reduced by approximately 2m across the lengthy of the profile and a change from a mainly sandy beach to one comprised of shingle. Review of the survey photographs shows the placement of new rock adjacent to the seawall and on the backshore. A review of the survey photograph for two years ago in 2010 (full measures, autumn 2010), shows the rock to be present. It was noted in the previous survey report (full measures, autumn 2011), '*the change in profile from 2010 to 2011 suggested that beach levels have increased by over 1.5m and it is possible that this is due to survey error.*' Therefore, the particularly high levels observed in autumn 2011 are likely to be associated with the removal of the rock and possibly beach management that occurred at that time.

Profile 1bSNC7 is a section across North East Pier and shows the terraced nature of the landward face of the pier wall, extending across rock to the small sheltered bay between the two structures. No further analysis of this profile has been undertaken for this reason.

The profiles to the north (immediately south of the South West Breakwater), between 1bSNS1 and 1bSNS6 have not been analysed as the data is of various quality, as explained in the survey report for Sunderland South '*no access to bottoms of sections 1, 2, 3 and 4, requires crossing very slippery boulders*' & '*poor access to small beach between section 4 and 5, therefore not surveyed*'.

Profile 1bSNS4 extends into water and has therefore not been analysed.

Profiles 1bSNS5 and 1bSNS6 drops directly from the structure into deep water and have therefore not been analysed.

On profile 1bSNS8 an additional data point is showing on the full measures profile at a 25m chainage, which is likely to relate to survey technique rather than actual change.

At profiles 1bSNS12, 1bSNS16, 1bSNS18, 1bSNS20, 1bSNS29 and 1bSNS31, the profile shows the cliff face to have accreted. As suggested in previous reports (partial measures, 2012 and full measures, 2011), this could be related to retreat of the cliff face and the accumulation of material eroded at the toe of the cliff, debris from cliff falls at the toe, slumping of the toe of this cliff, or it could be due to the cliffs tendency to heave seawards prior to toppling or survey interpretation (as described below). Such cliff behaviour could bring about health and safety issues relating to the surveying of the cliff toe where the cliffs are unstable or overhanging, resulting in different interpretation of the survey locations.

Cliff Top Surveys

The survey report notes:

- '*There are a number of landslips that are evident*', although it is not certain as to where the report is referring to.
- '*No access to bottoms of sections 1, 2, 3 and 4, requires crossing very slippery boulders*'. Without further reference to the beach profile location or cliff top reference, it is uncertain where the report is referring to.
- '*Poor access to small beach between section 4 and 5, therefore not surveyed*'. It is assumed that this is referring to cliff top data points 4 and 5 rather than beach profiles.

Surveying any cliff top is difficult due to: (i) the Health and Safety risks posed to surveyors, especially during adverse weather; and (ii) the apparent changes that can arise due to problems in interpretation of the cliff edge on successive surveys. In particular, surveying the cliff top has been made challenging by growth of vegetation that makes identification of cliff edge in successive surveys difficult. For these reasons, it has been assumed that any changes of ±0.2m may be considered as being within the accuracy of the surveying technique.

In the short term, more reliable assessments of cliff recession will be derived from analysis of time-series remote sensing data. A high quality baseline survey, comprising LiDAR and aerial photography, was collected in 2010, a repeat survey was completed in late 2012 and a second repeat survey is planned for 2014. These data will be analysed to give more accurate information on the behaviour of the cliffs in a separate report.

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

No changes are recommended at the present time.

5. Conclusions and Areas of Concern

- At Whitburn Bay, the recorded profiles present no causes for concern.
- At Sunderland Harbour and Docks, the recorded profiles present no causes for concern.
- At Hendon to Ryhope (incl. Halliwell Banks), the recorded profiles present no causes for concern. Consideration should be given to the continuation of the cliff top survey.

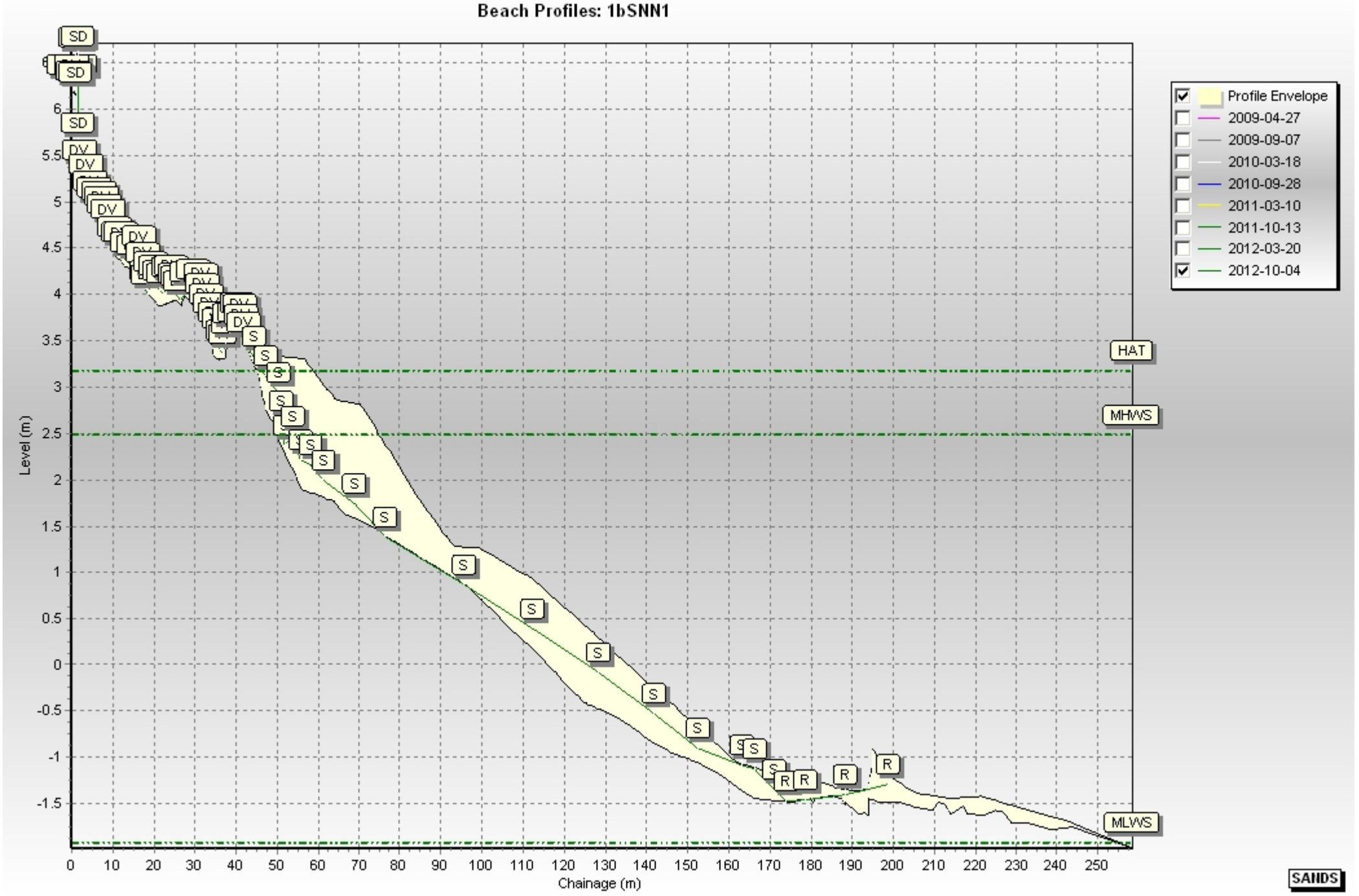
Appendices

Appendix A

Beach Profiles

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

Code	Description
S	Sand
M	Mud
G	Gravel
GS	Gravel & Sand
MS	Mud & Sand
B	Boulders
R	Rock
SD	Sea Defence
SM	Saltmarsh
W	Water Body
GM	Gravel & Mud
GR	Grass
D	Dune (non-vegetated)
DV	Dune (vegetated)
F	Forested
X	Mixture
FB	Obstruction
CT	Cliff Top
CE	Cliff Edge
CF	Cliff Face
SH	Shell
ZZ	Unknown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MLWS
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Chainage (m)
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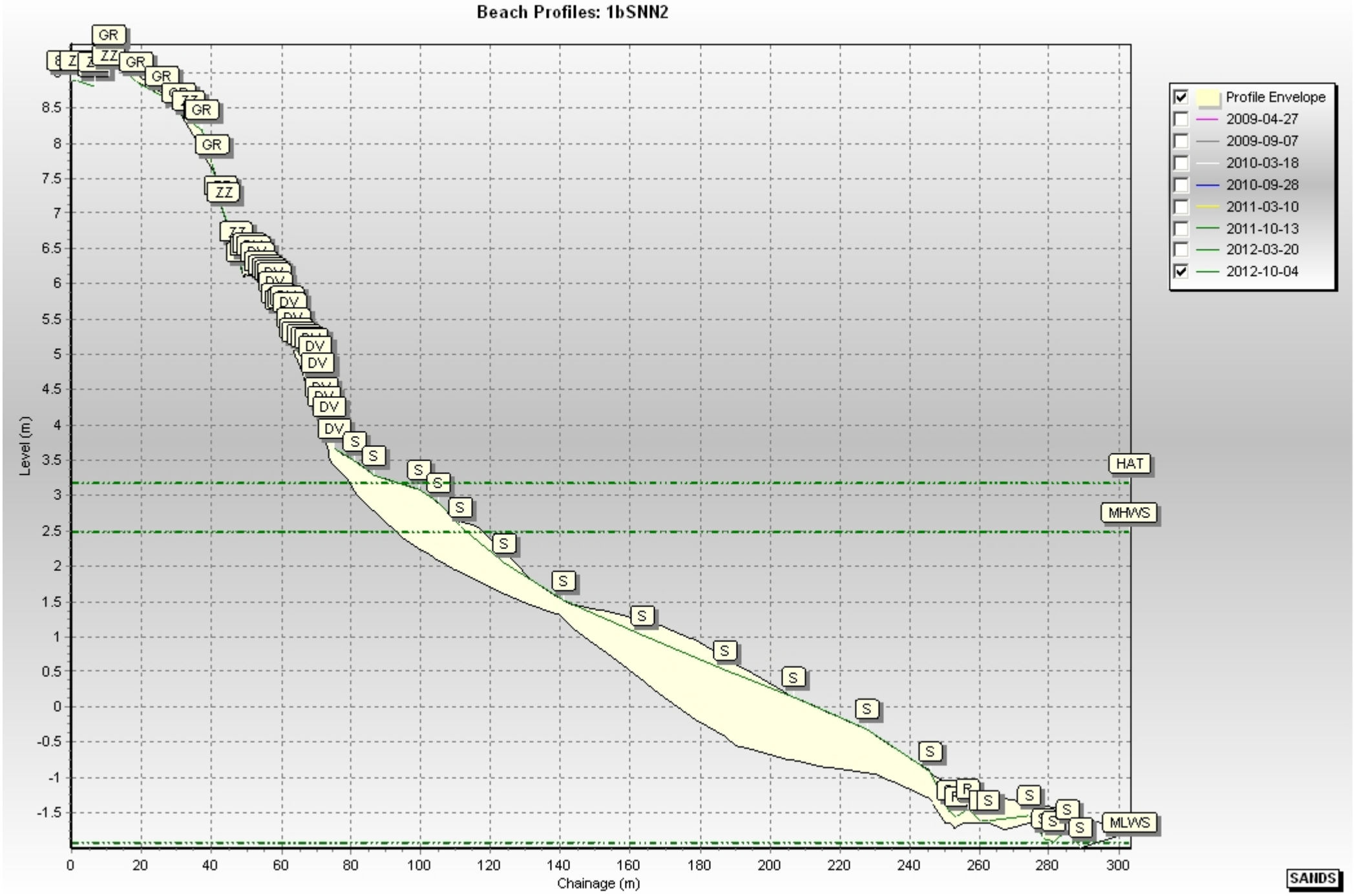
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Level (m)
Chainage (m)
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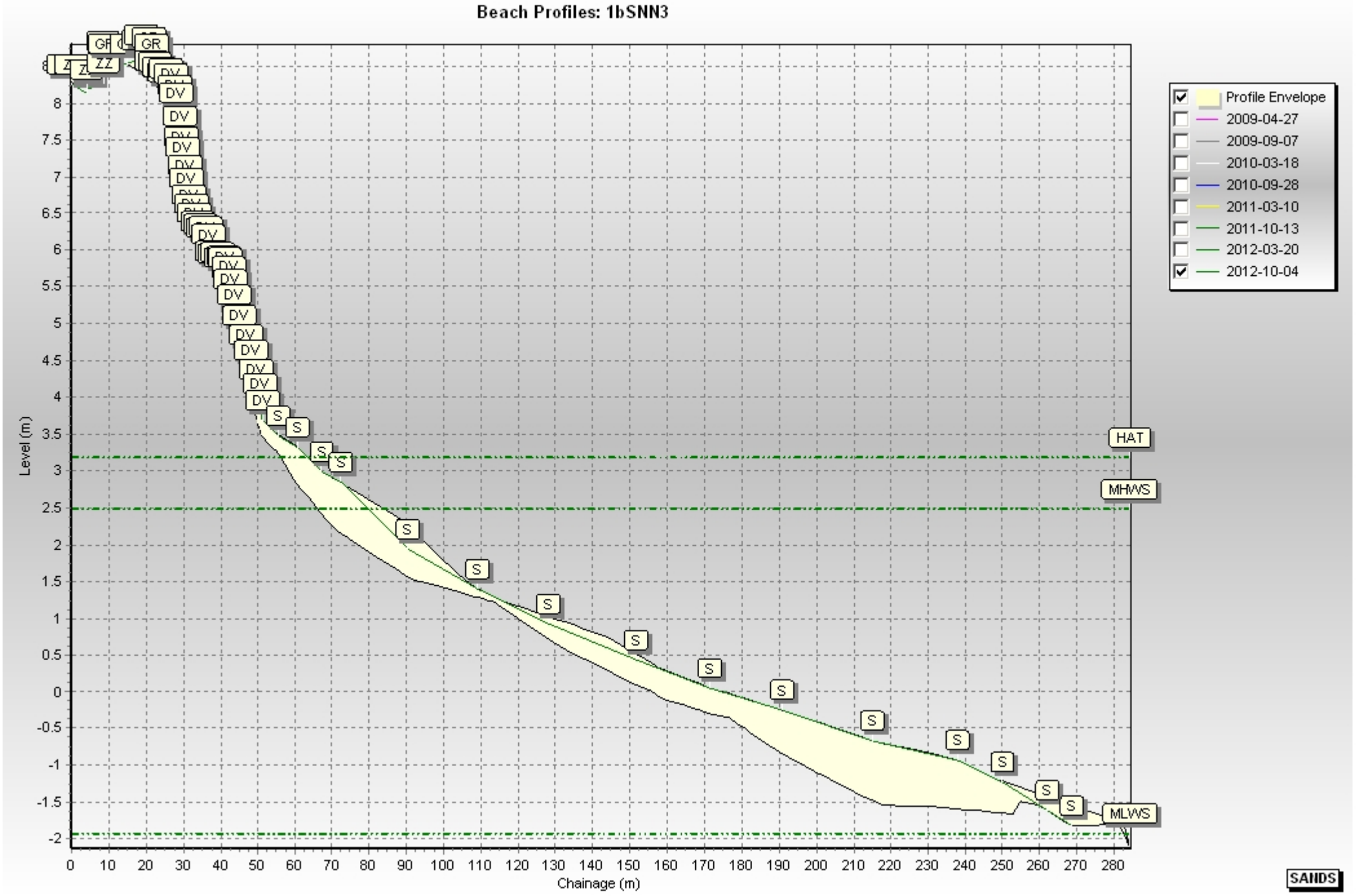
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Chainage (m)
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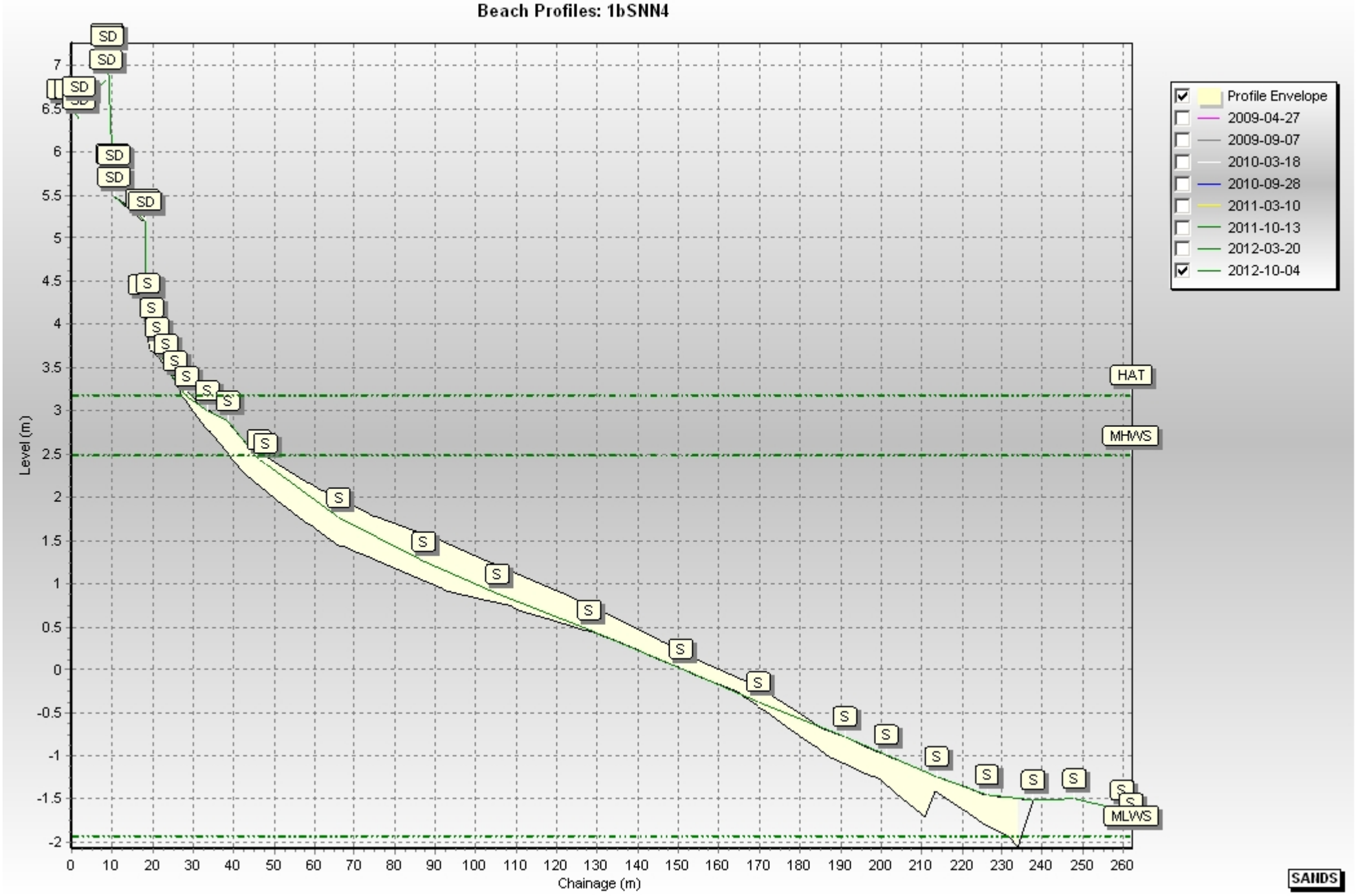
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Chainage (m)
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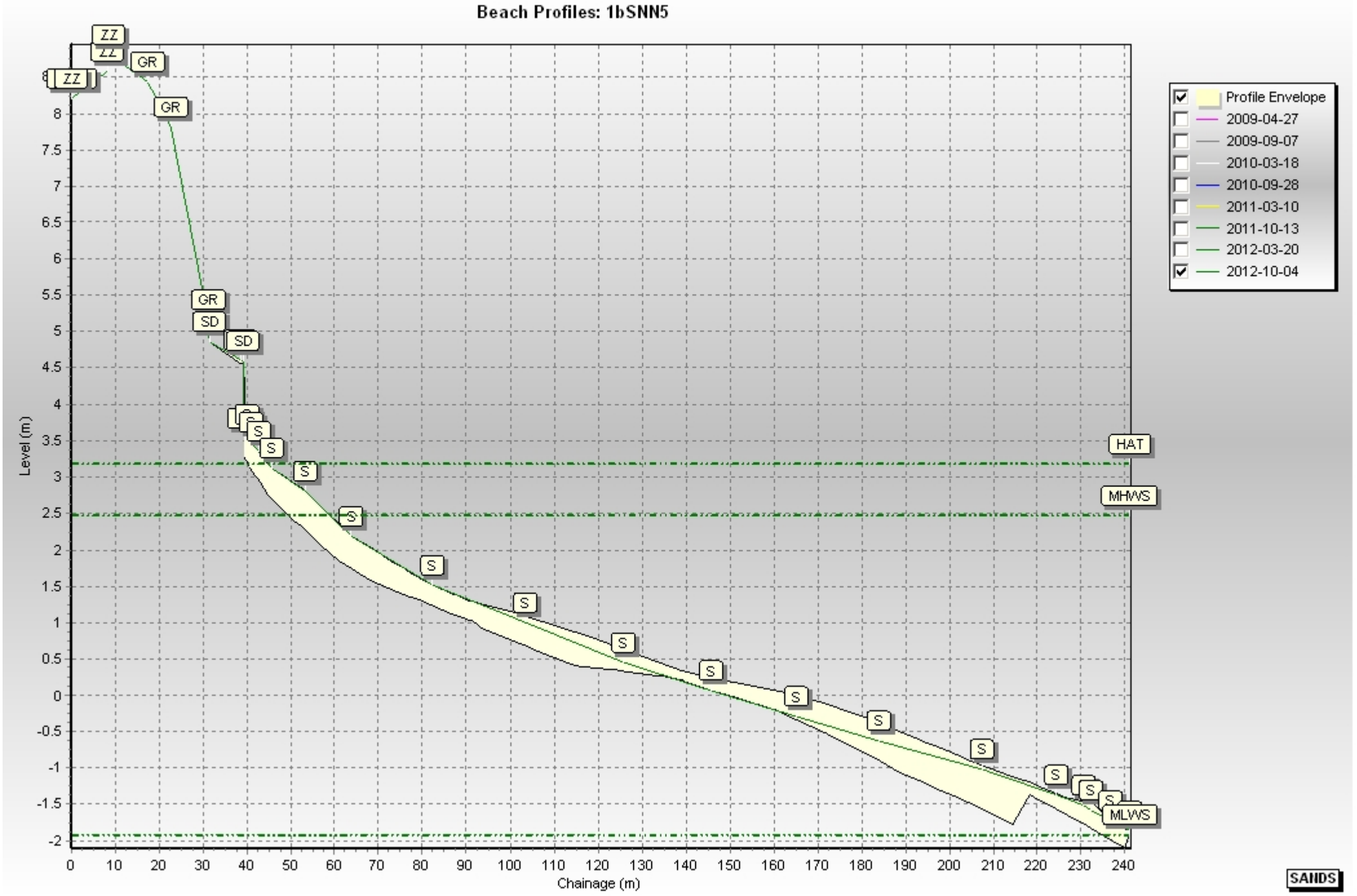
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Level (m)
Chainage (m)
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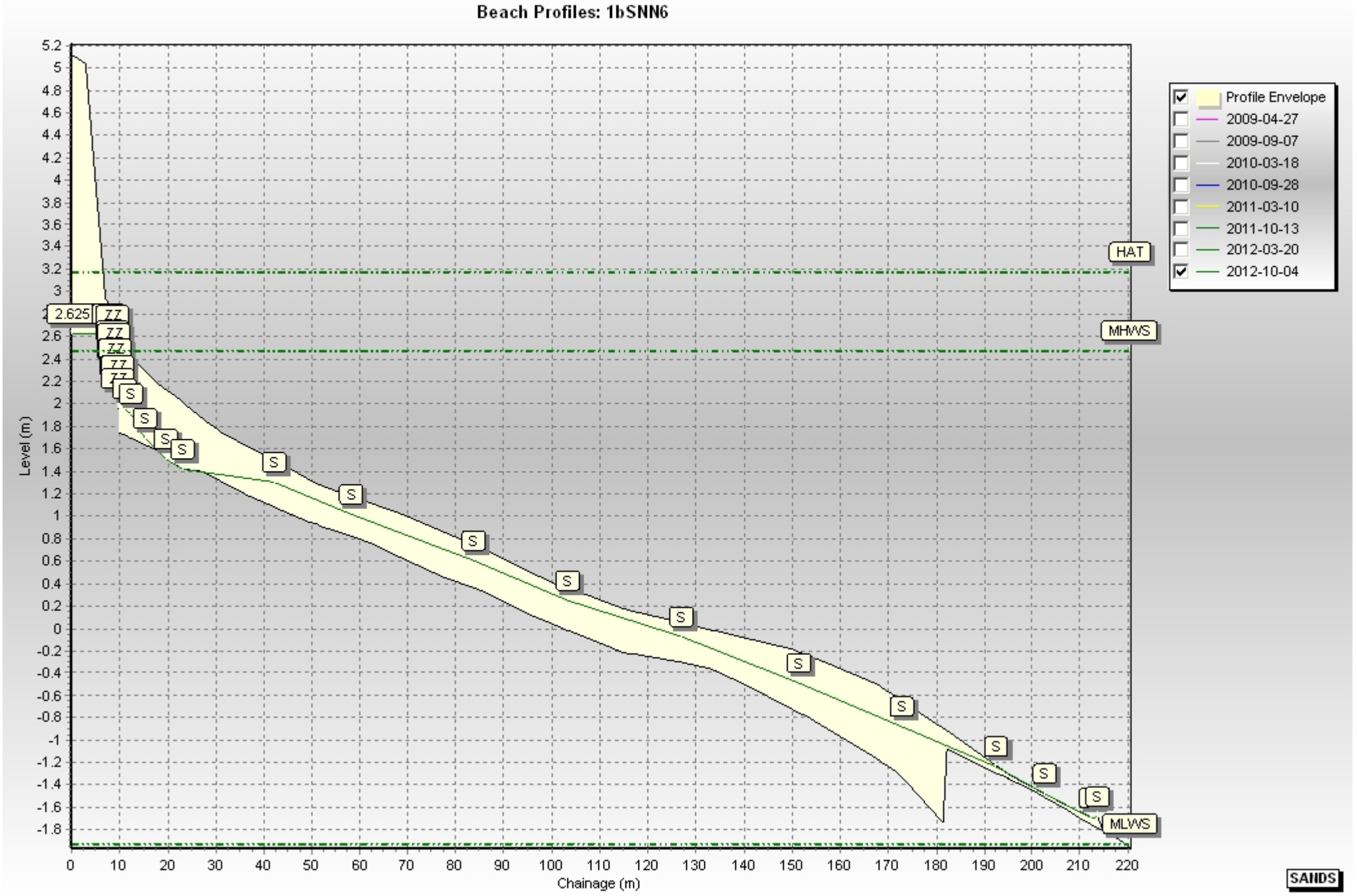
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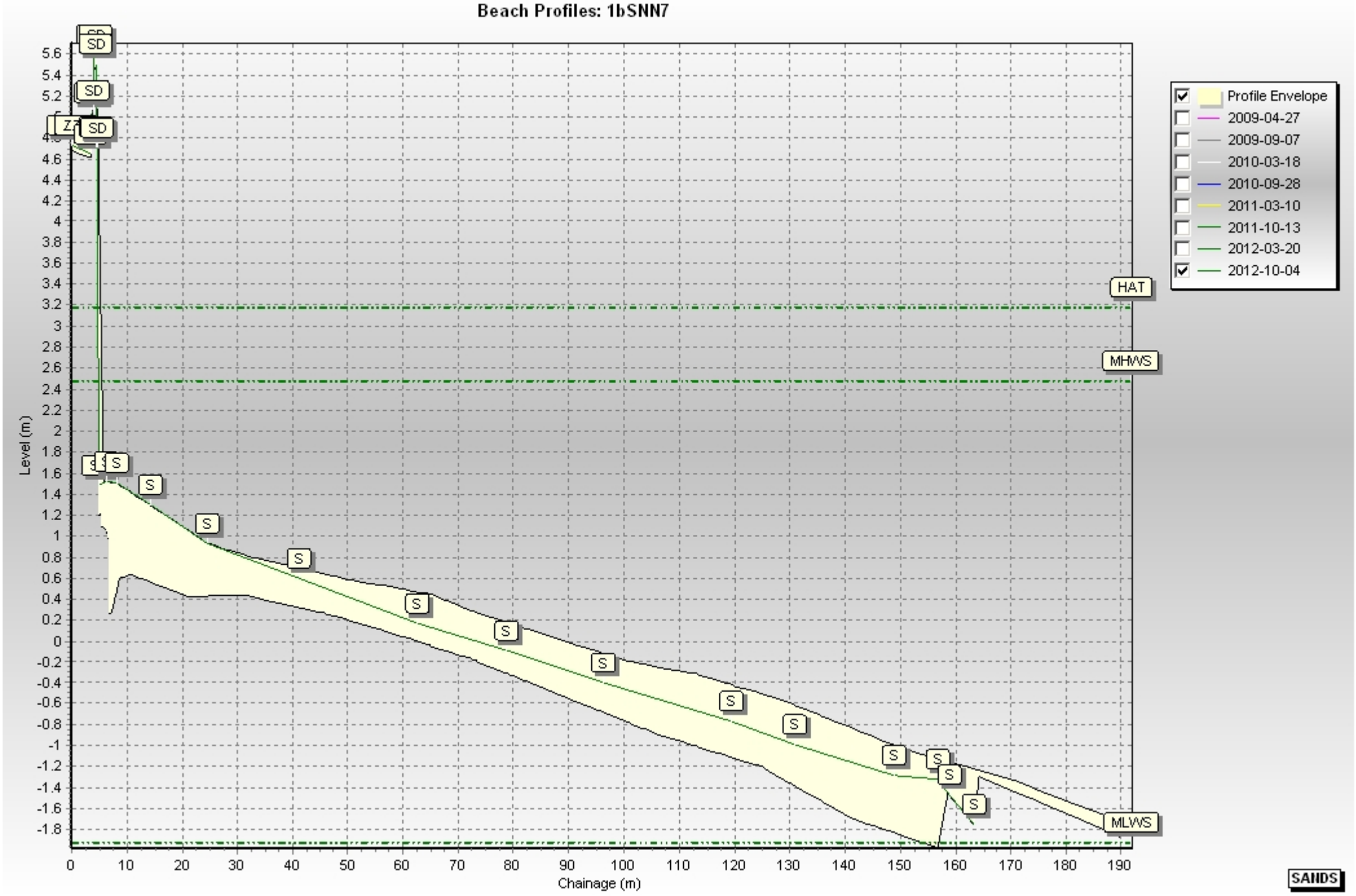
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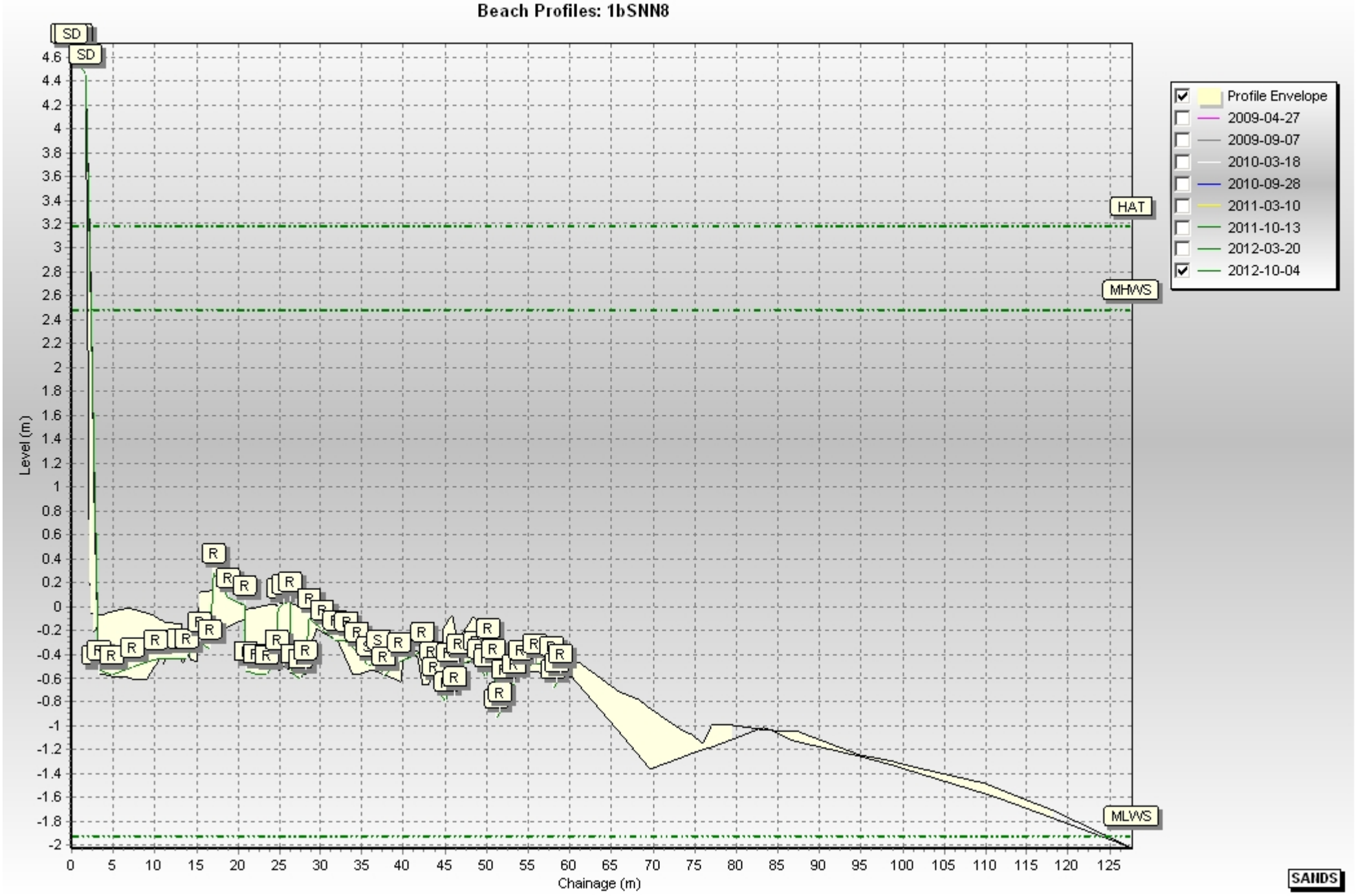
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Chainage (m)
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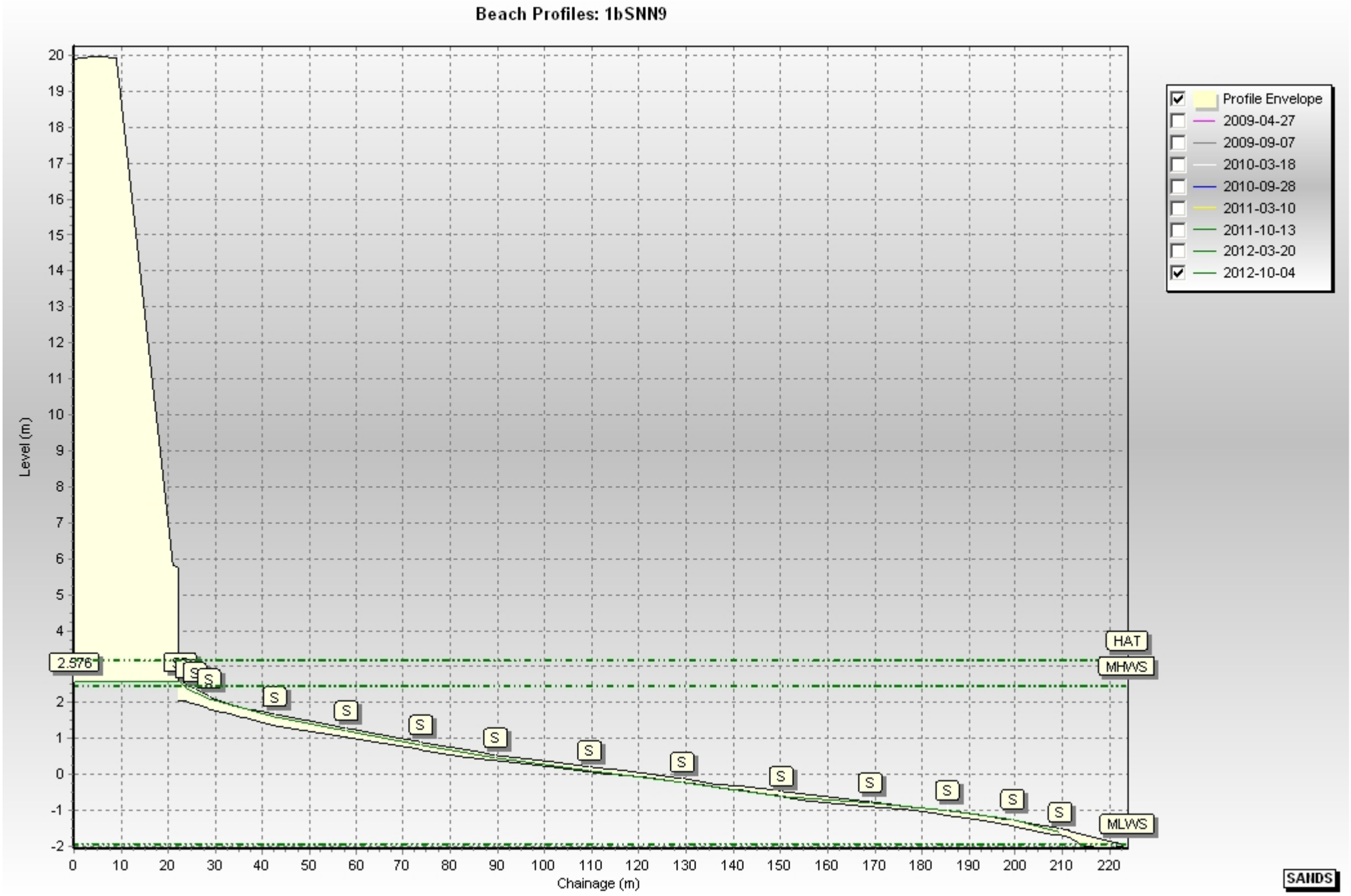
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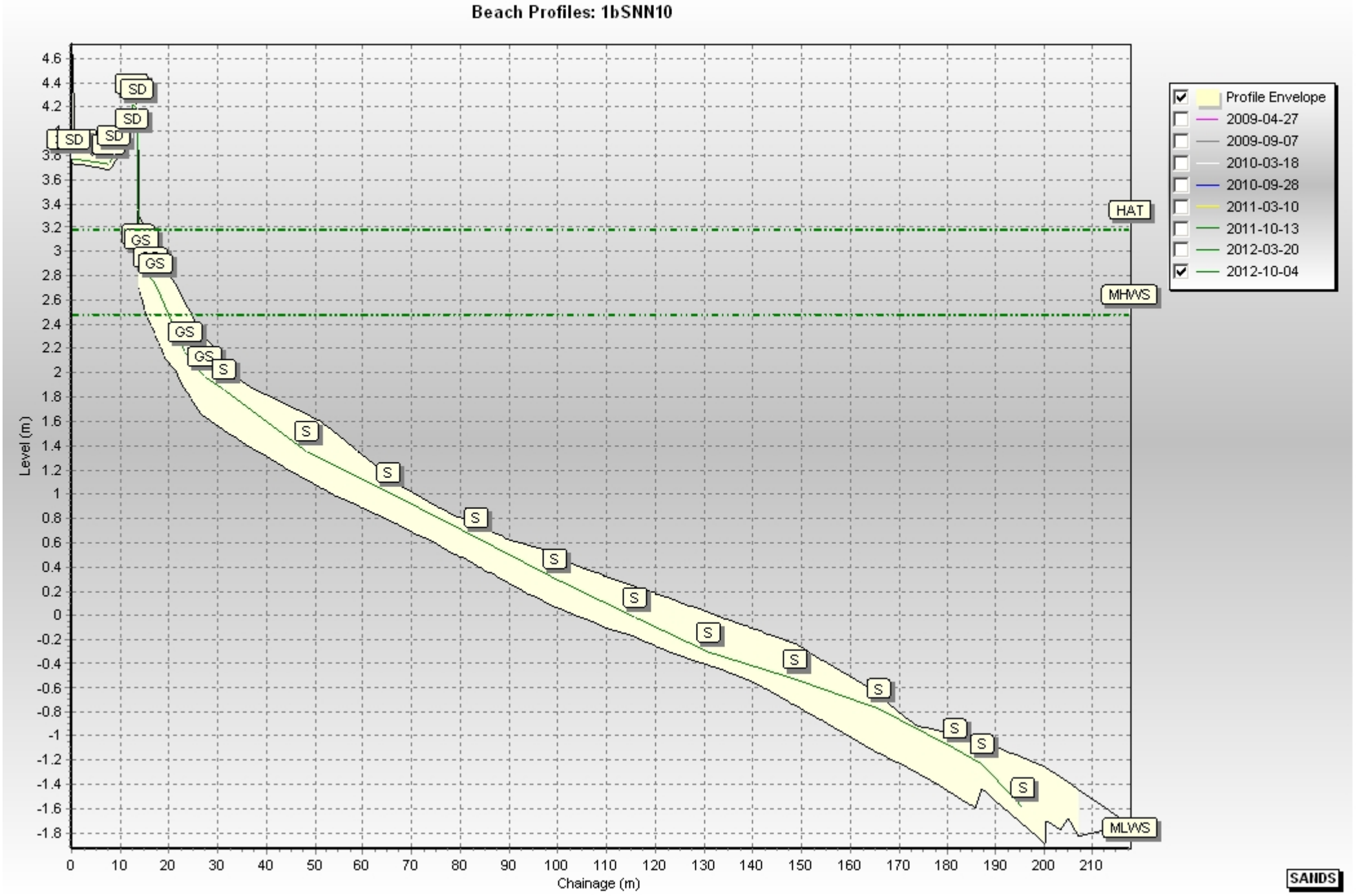
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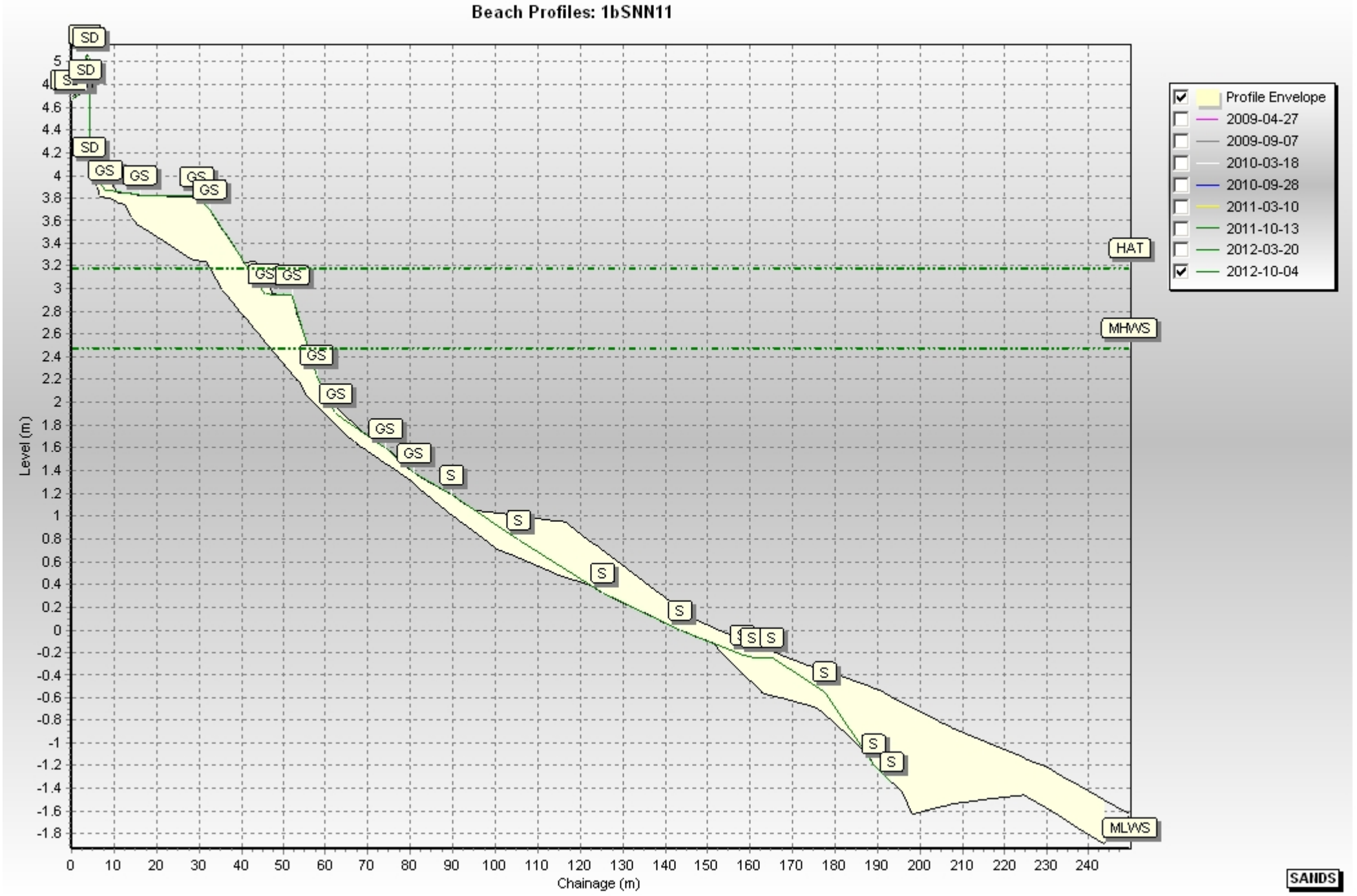
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Level (m)
Chainage (m)
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GS
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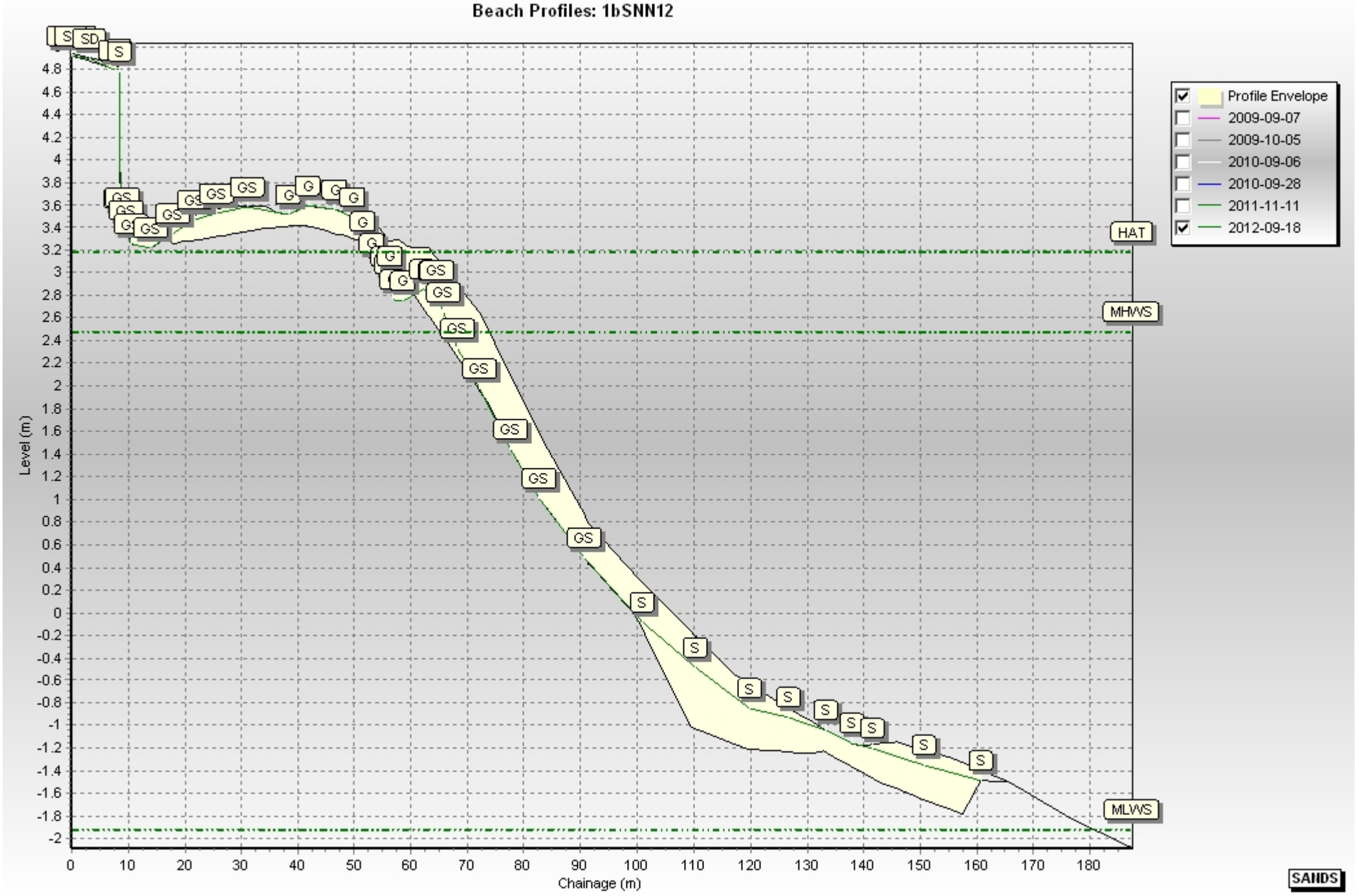
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Chainage (m)
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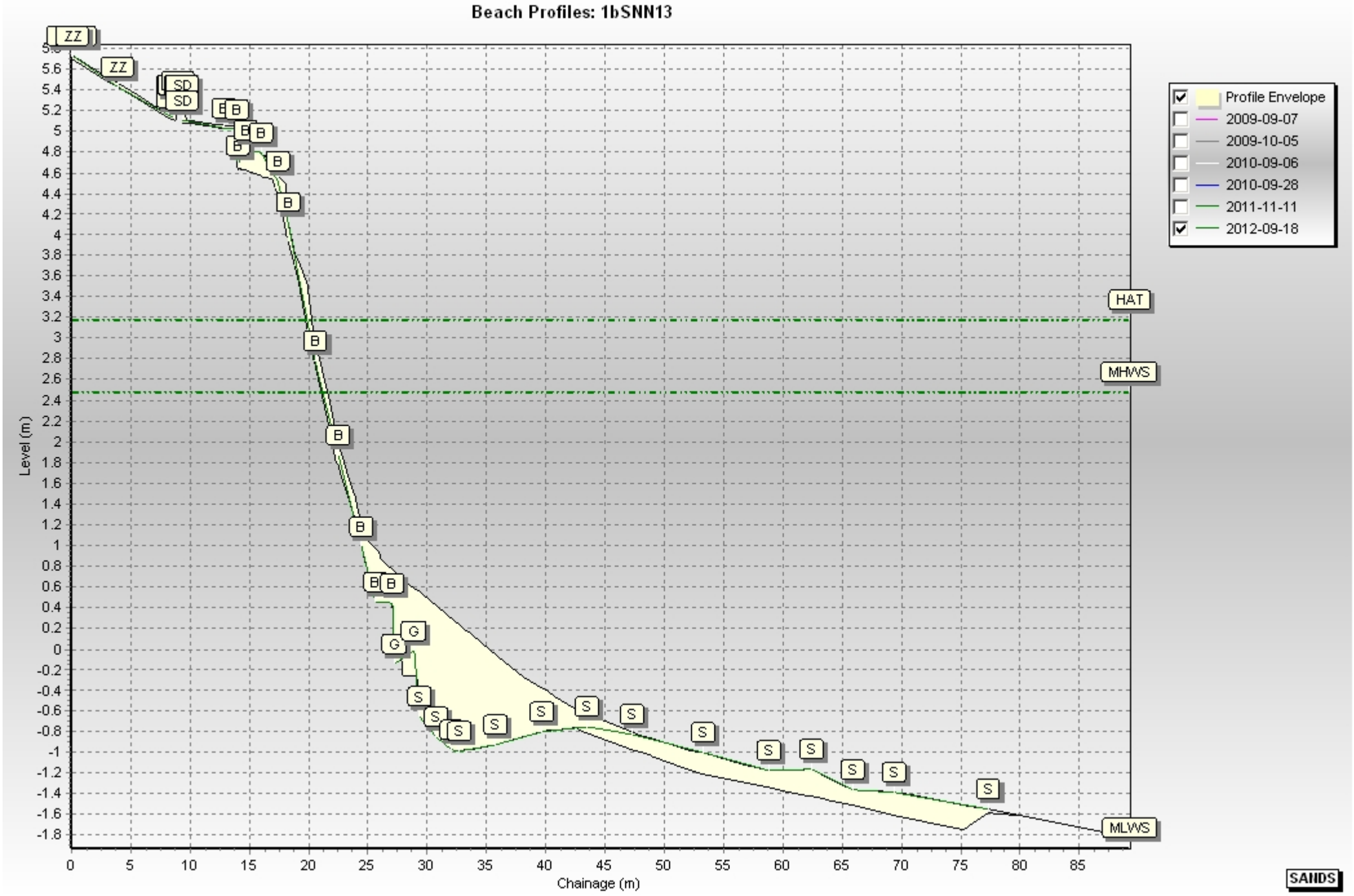
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Chainage (m)
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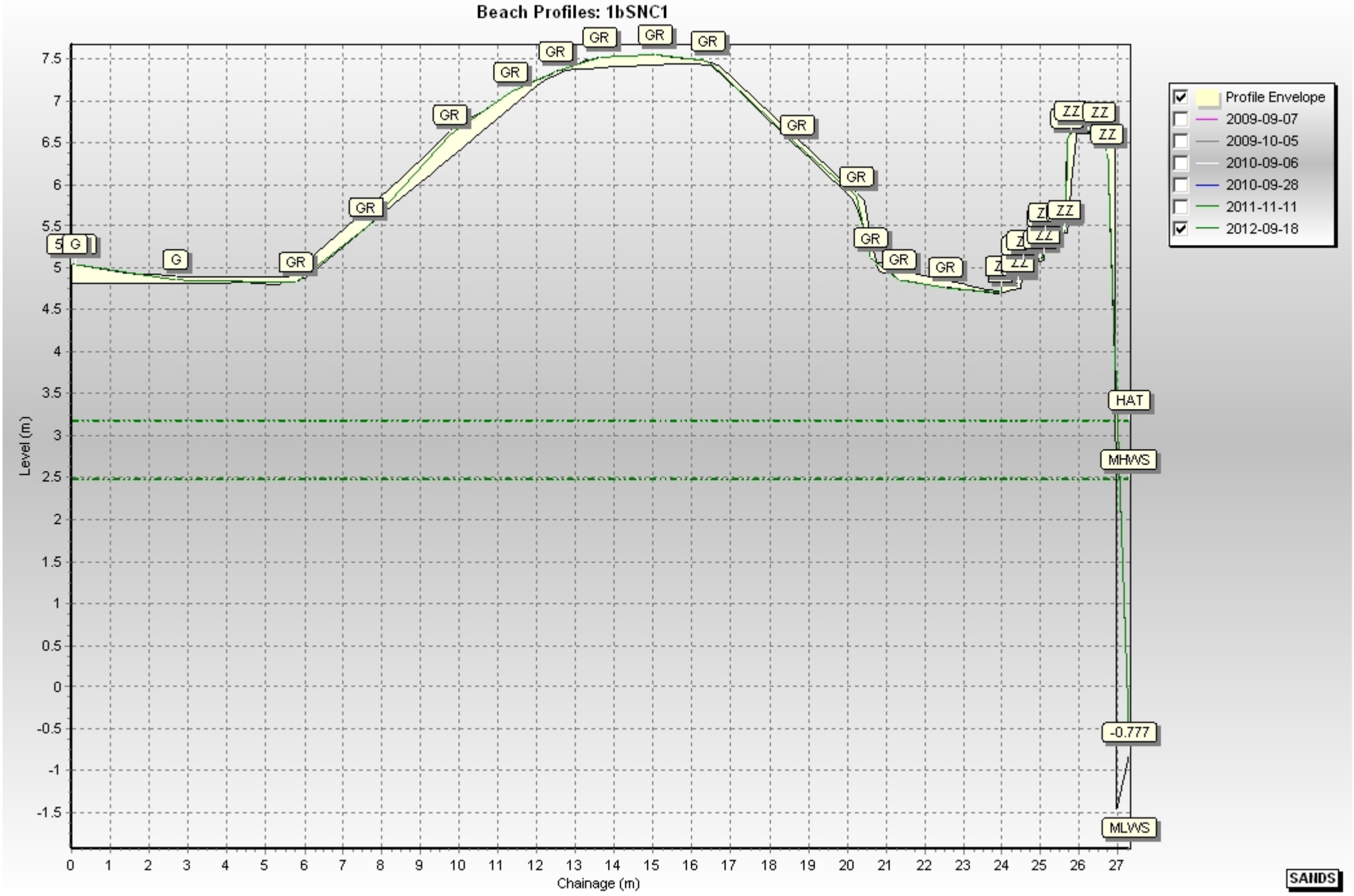
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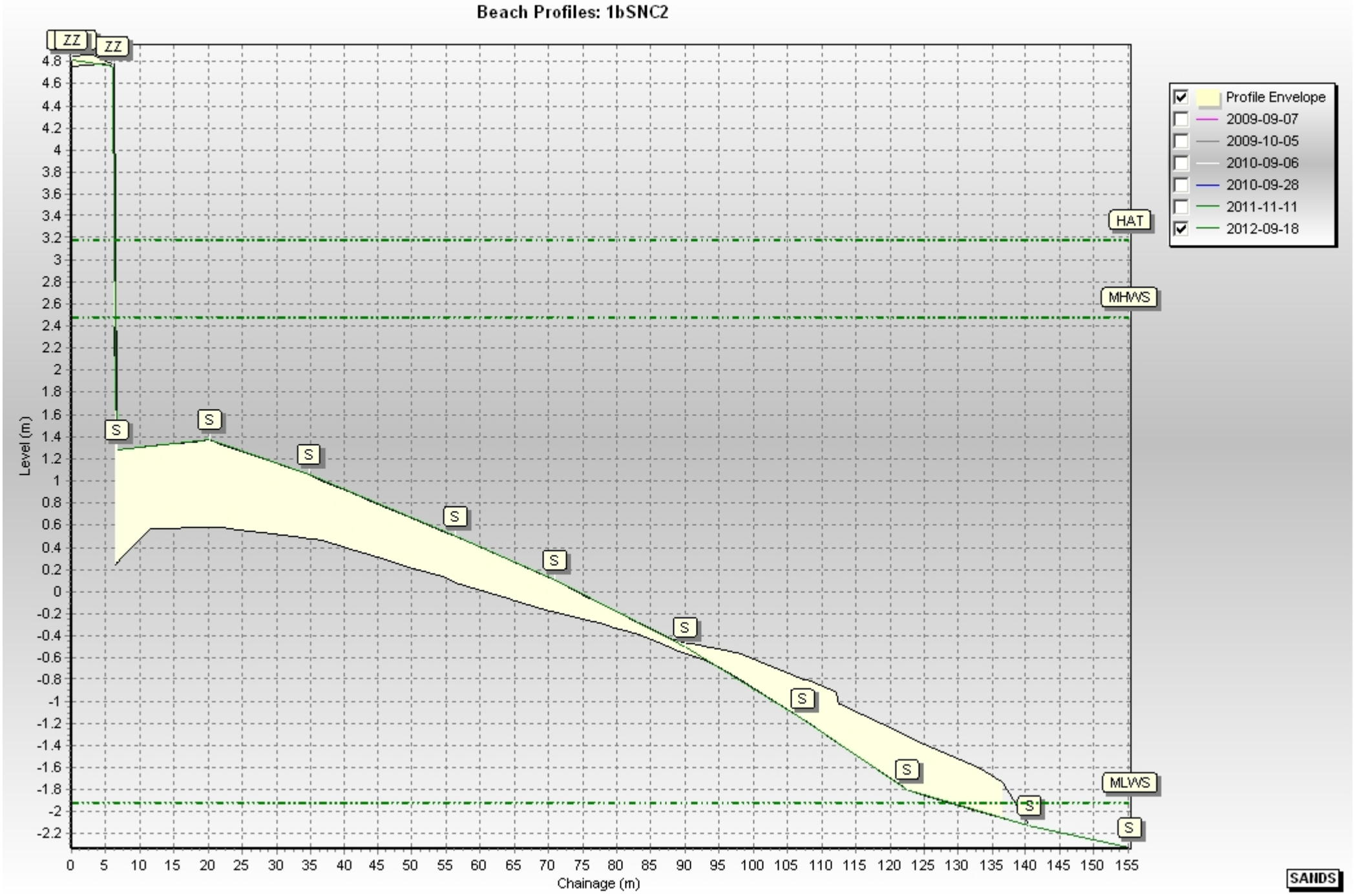
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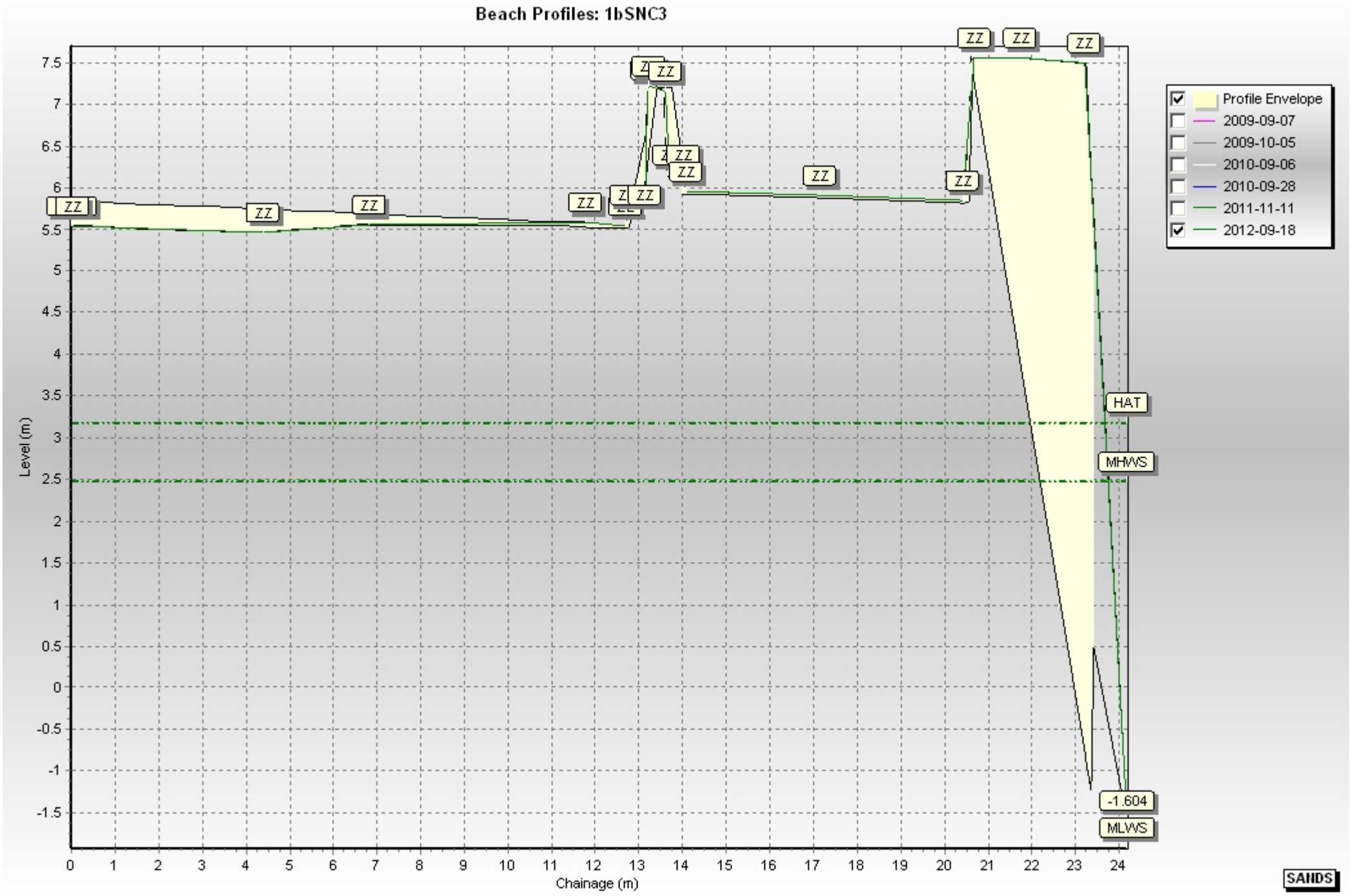
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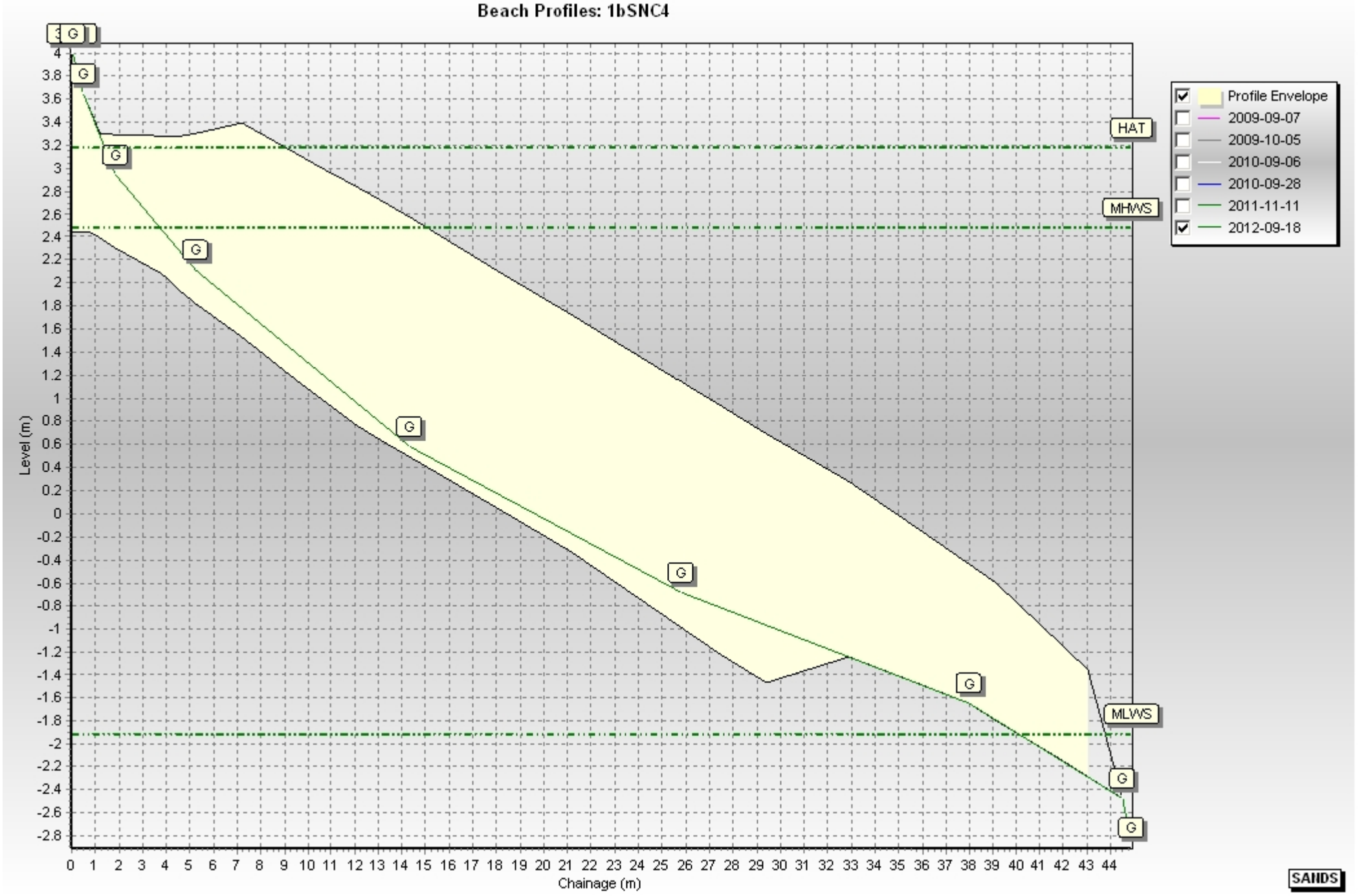
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Chainage (m)
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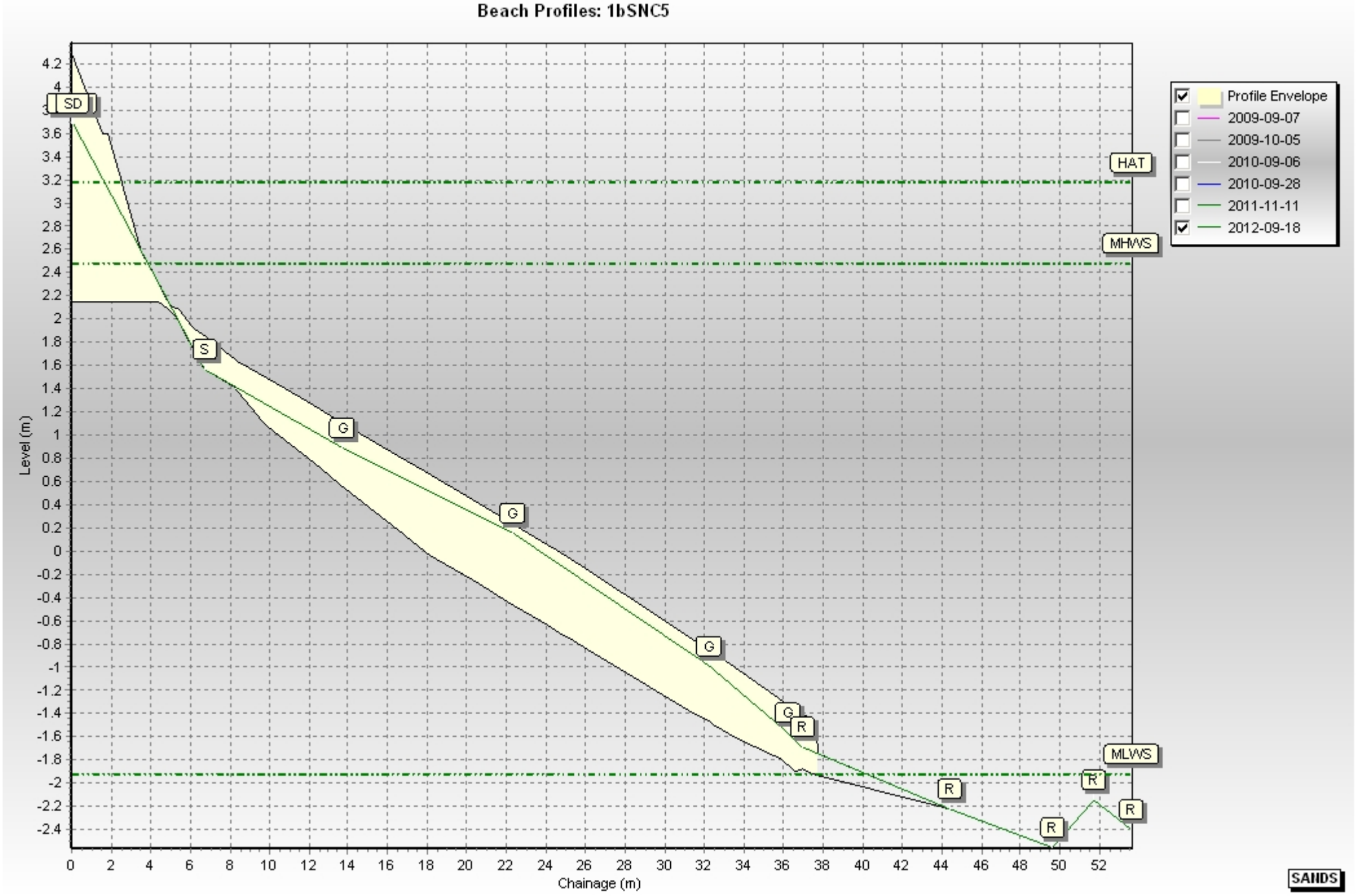
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G
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R
R
R
R'
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Chainage (m)
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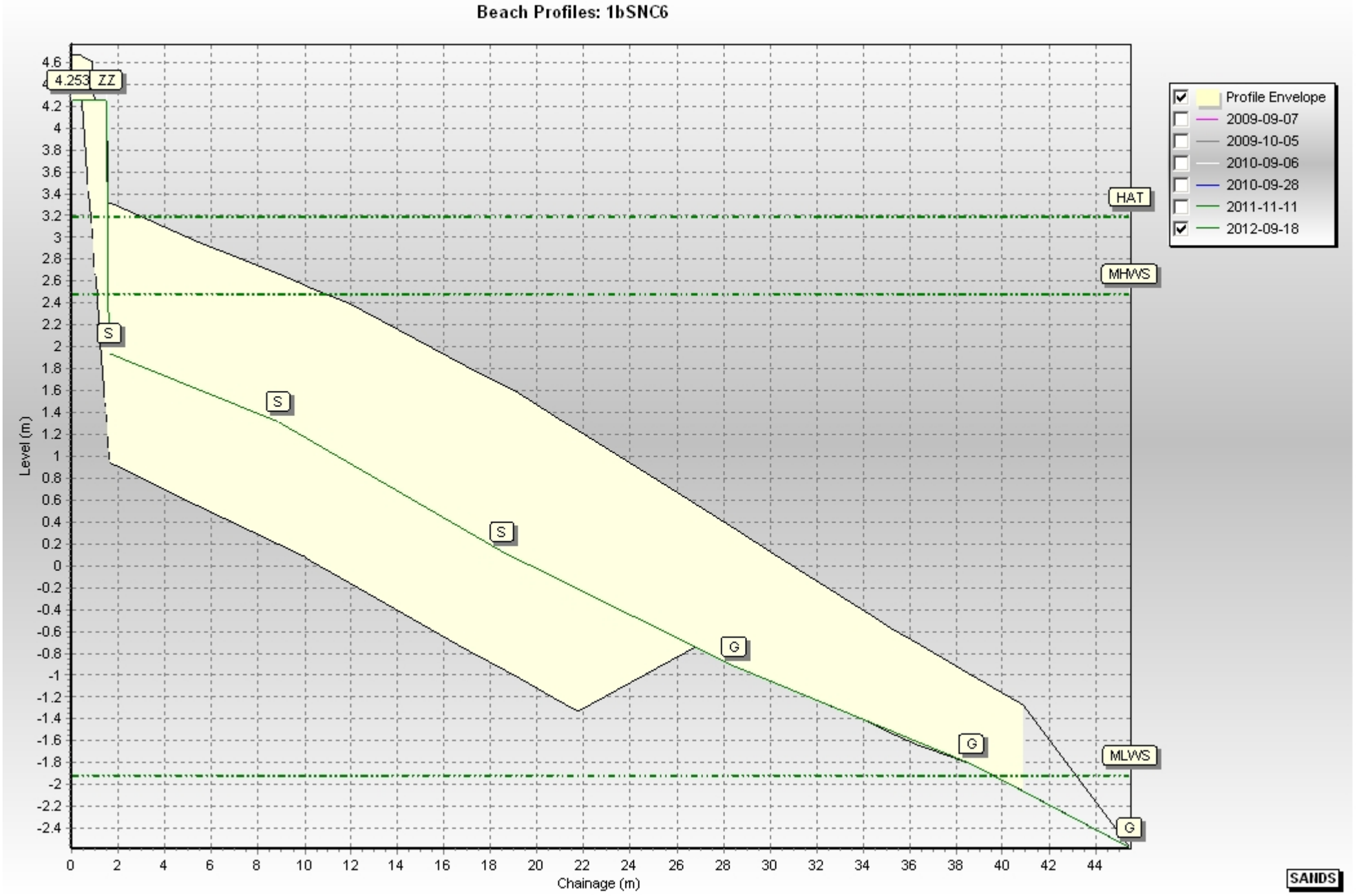
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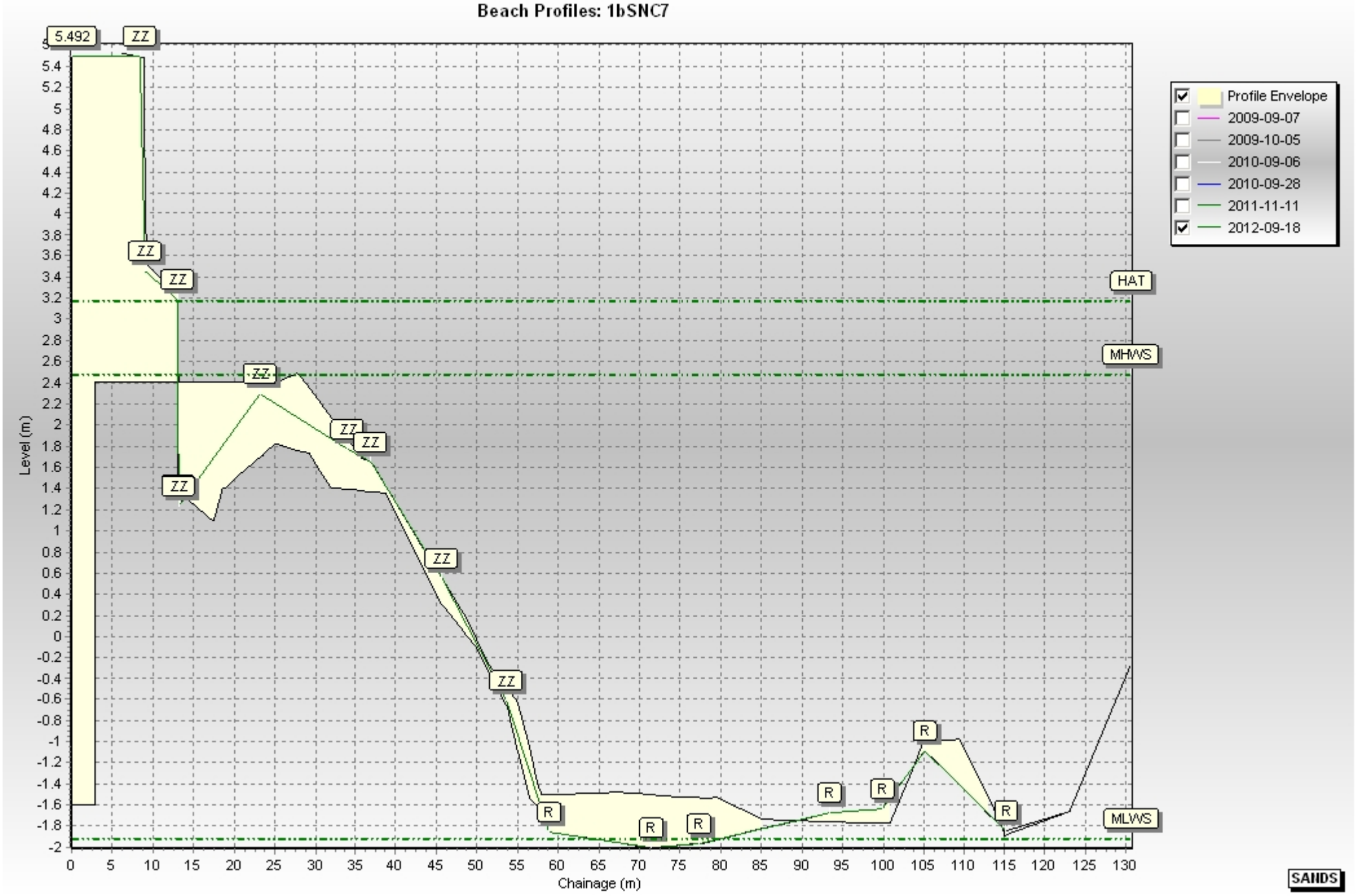
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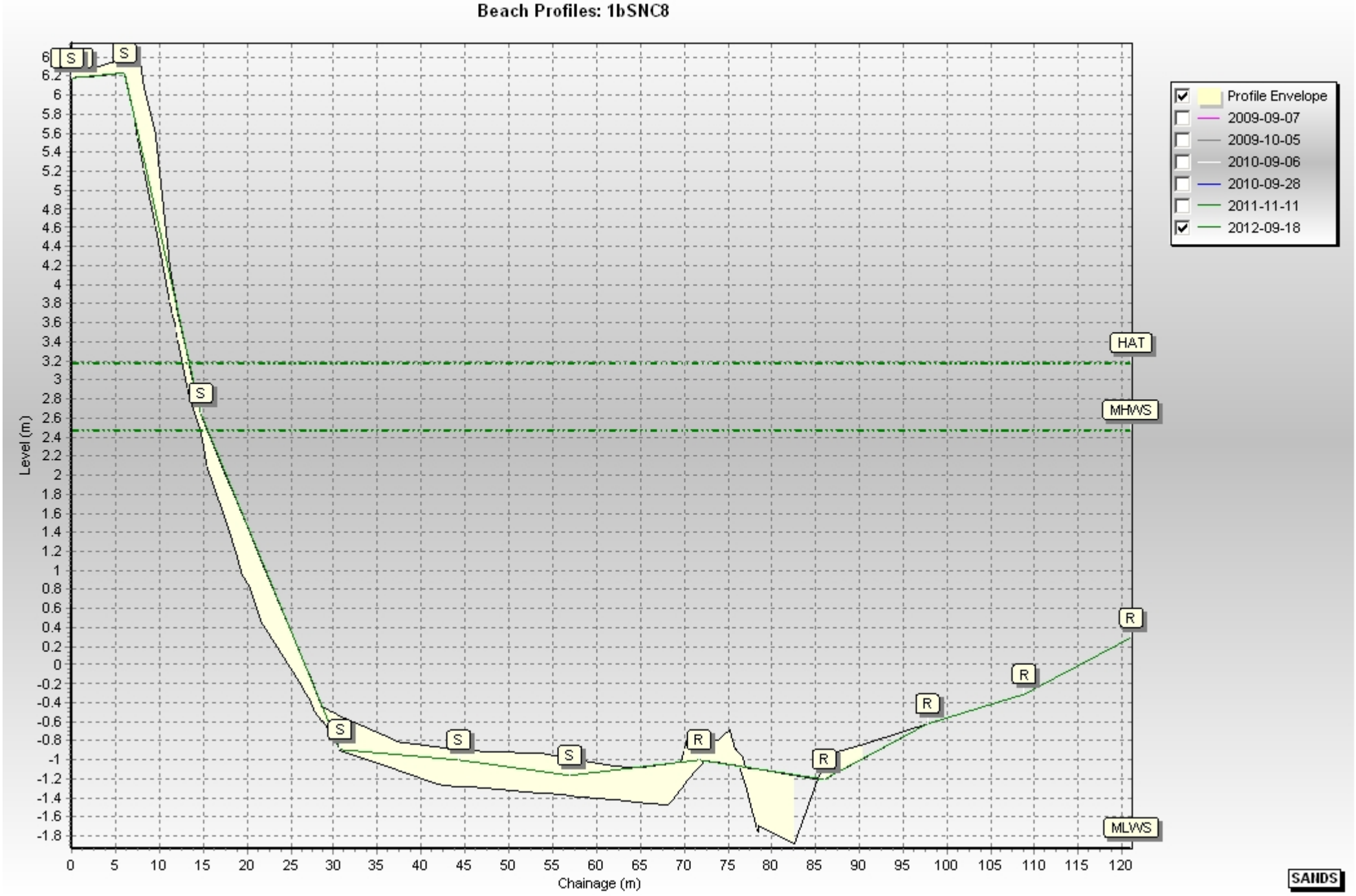
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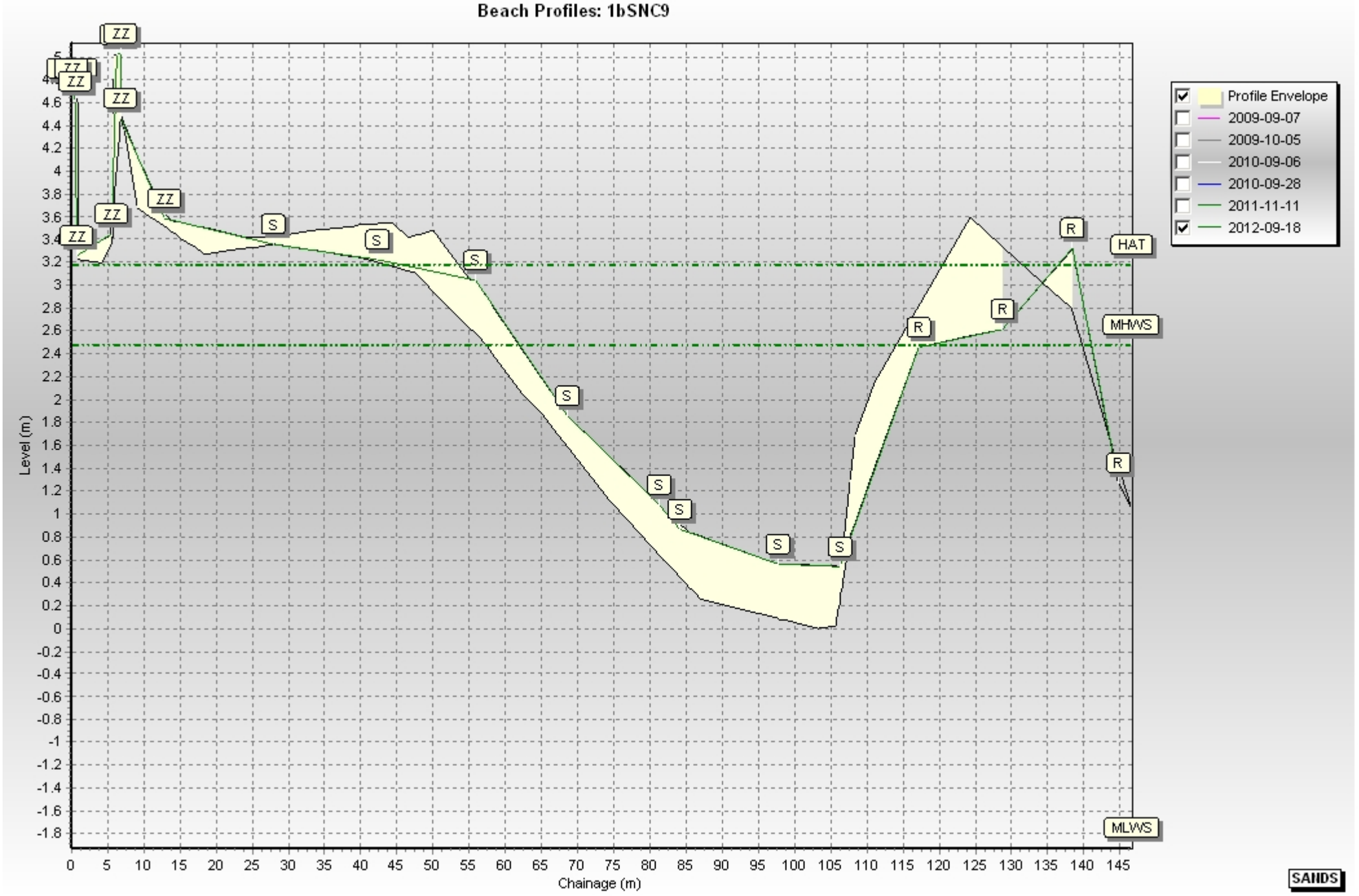
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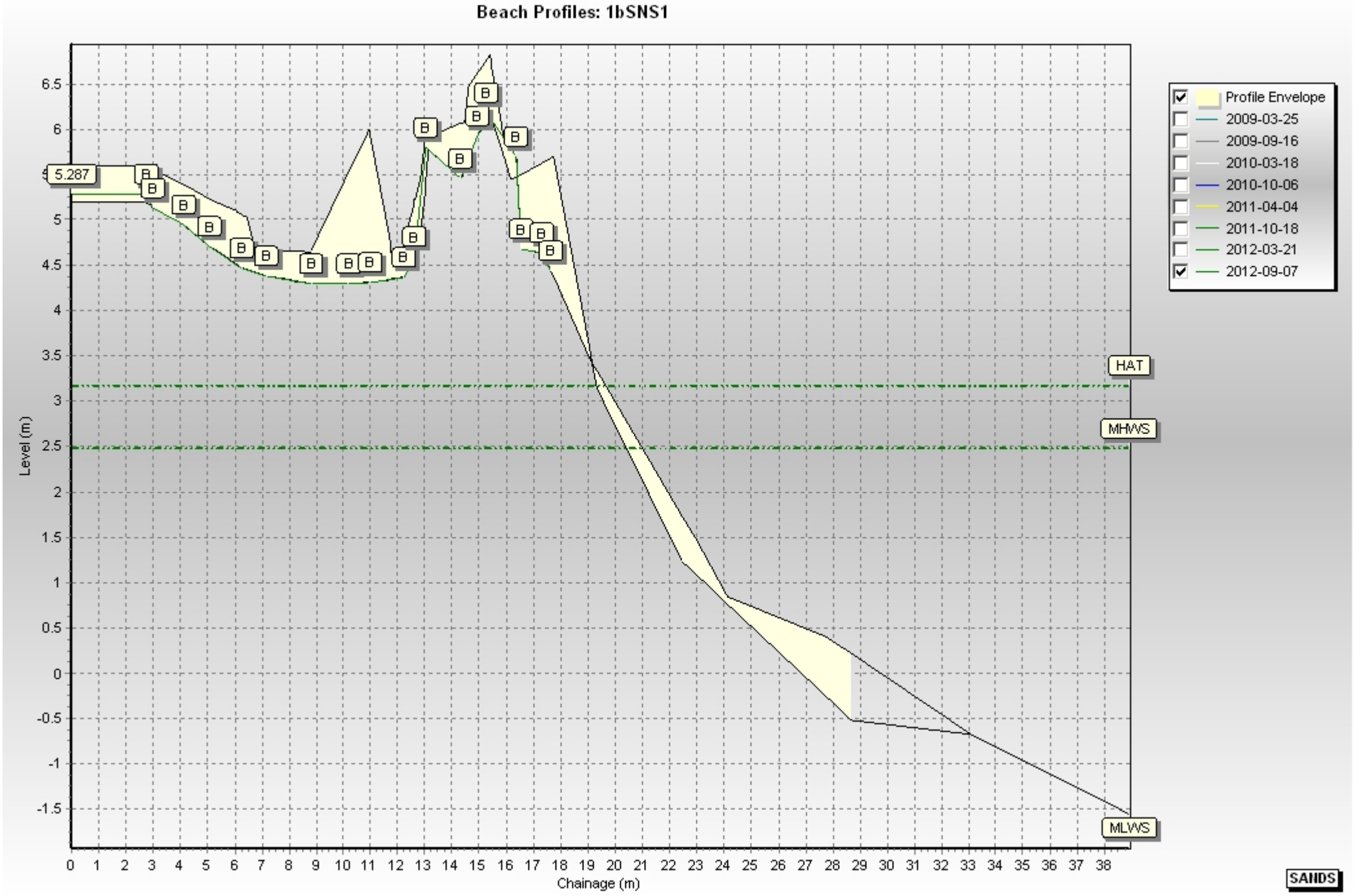
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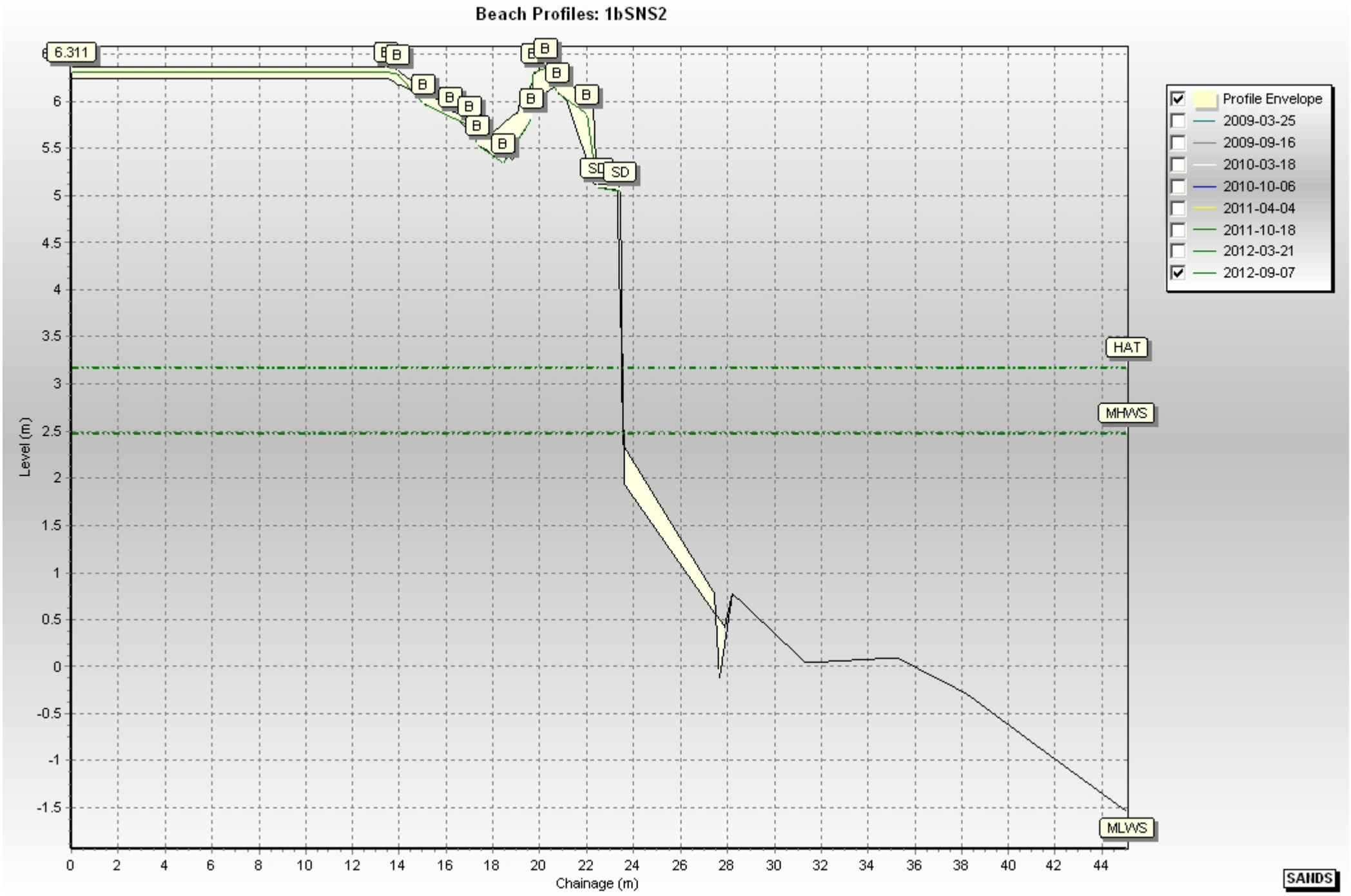
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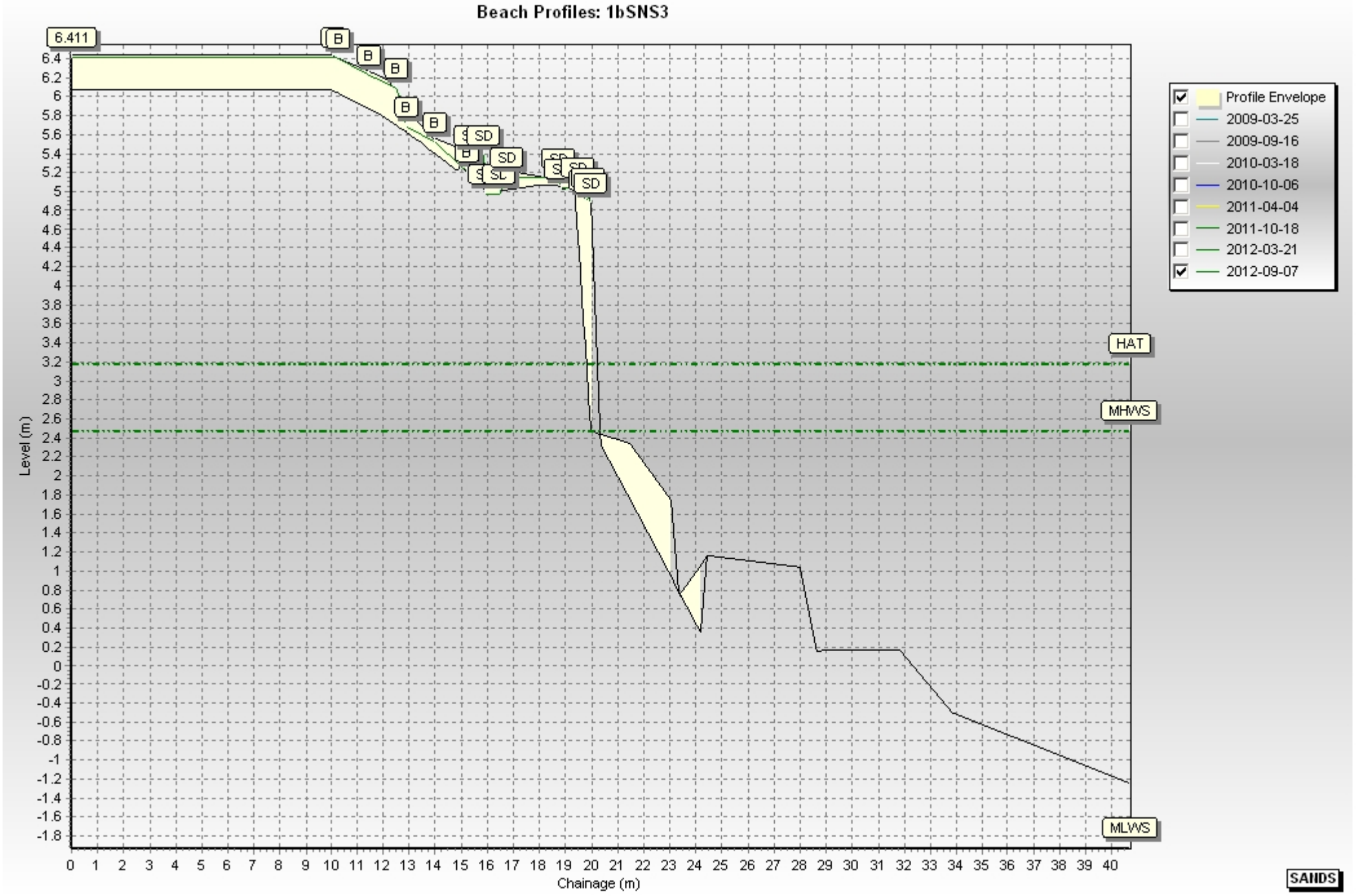
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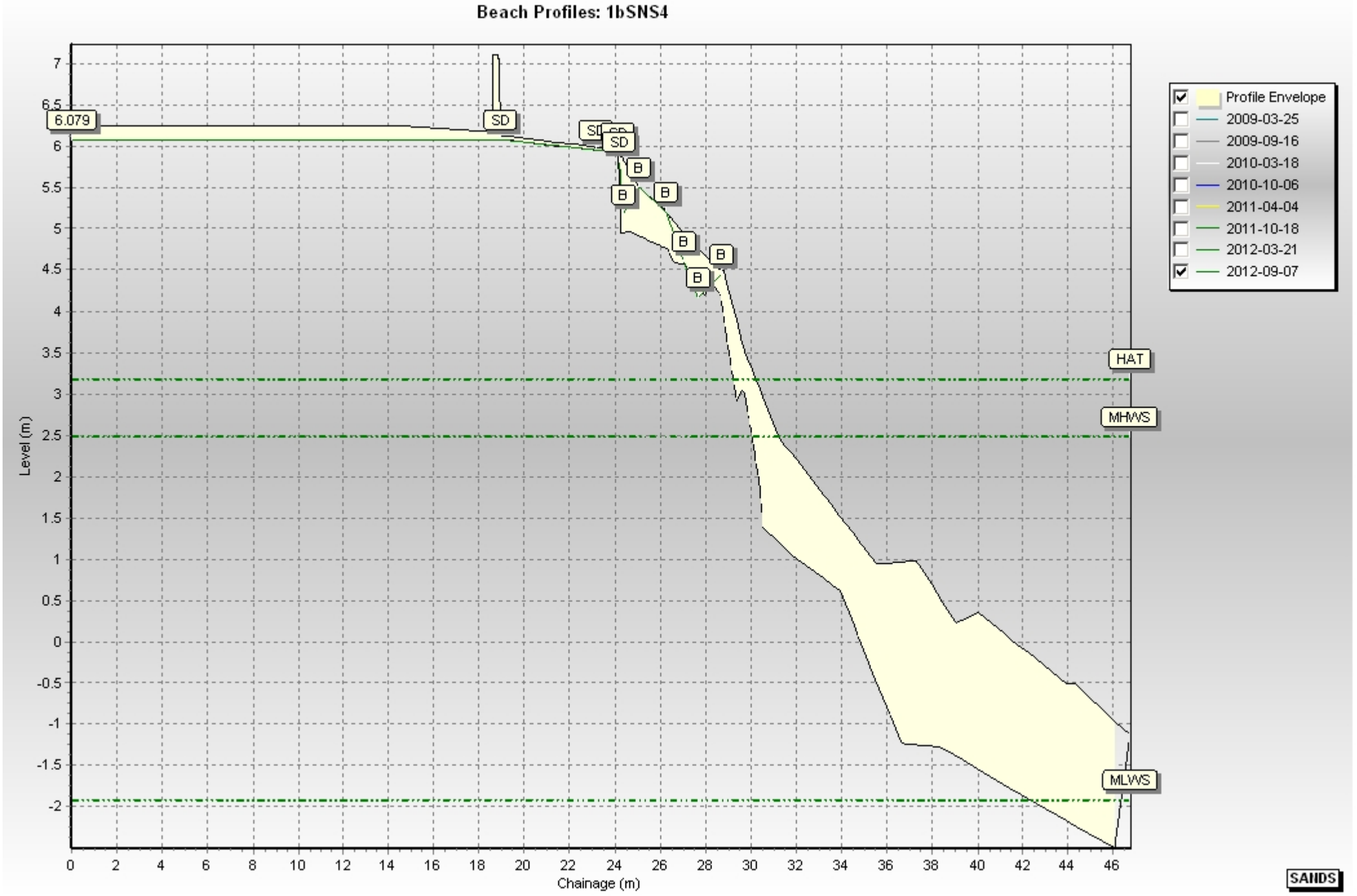
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Chainage (m)
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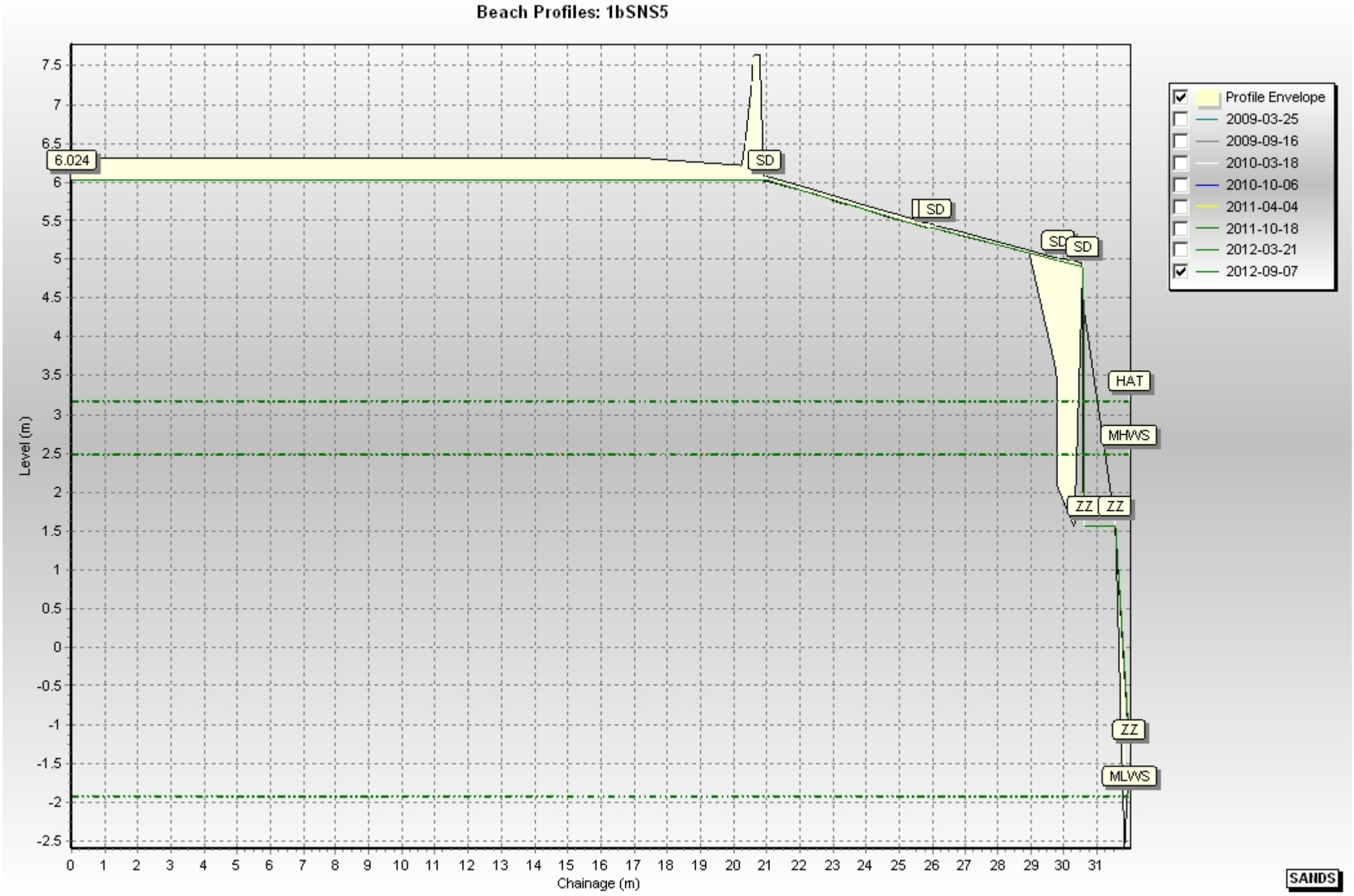
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Chainage (m)
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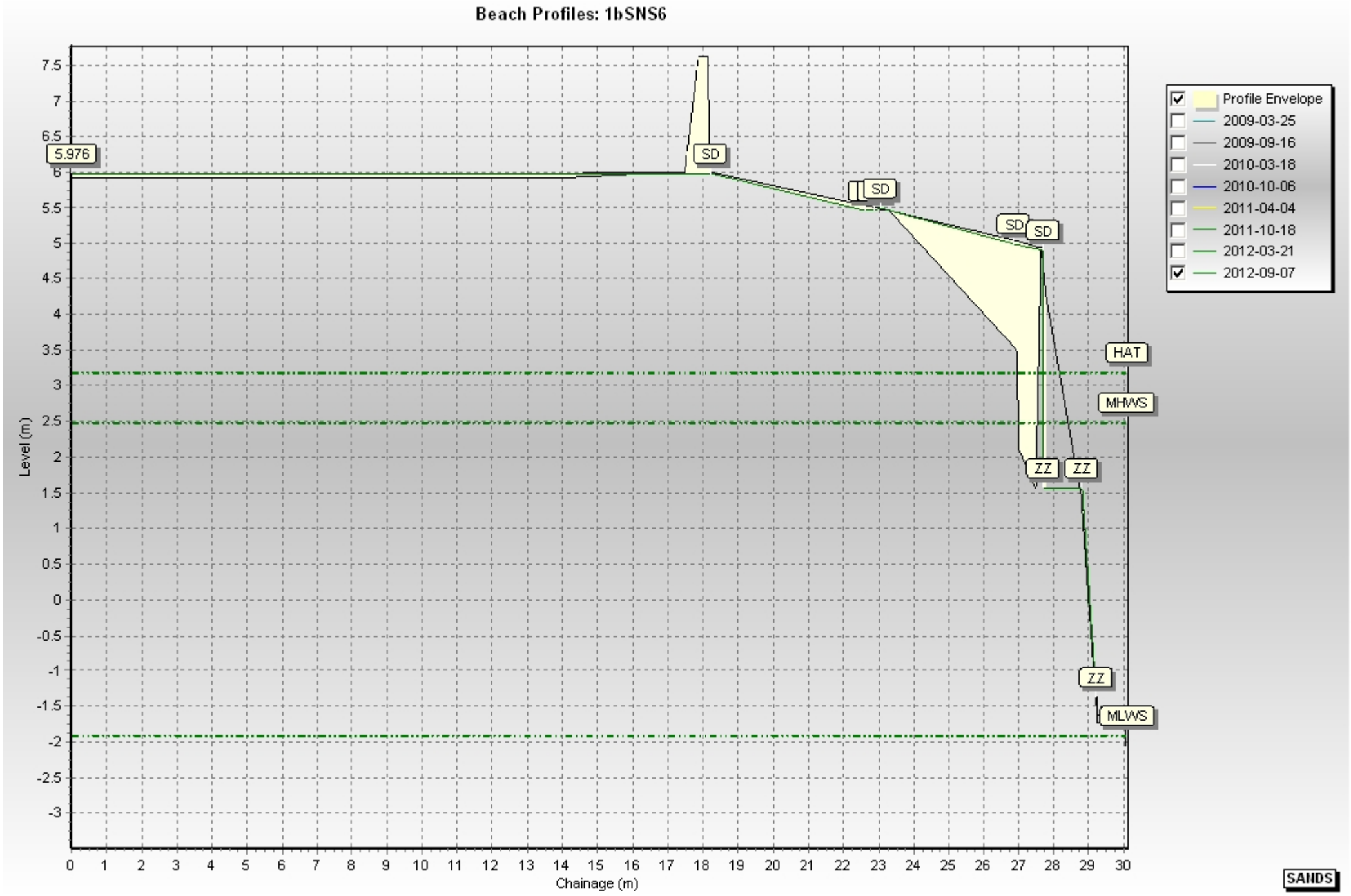
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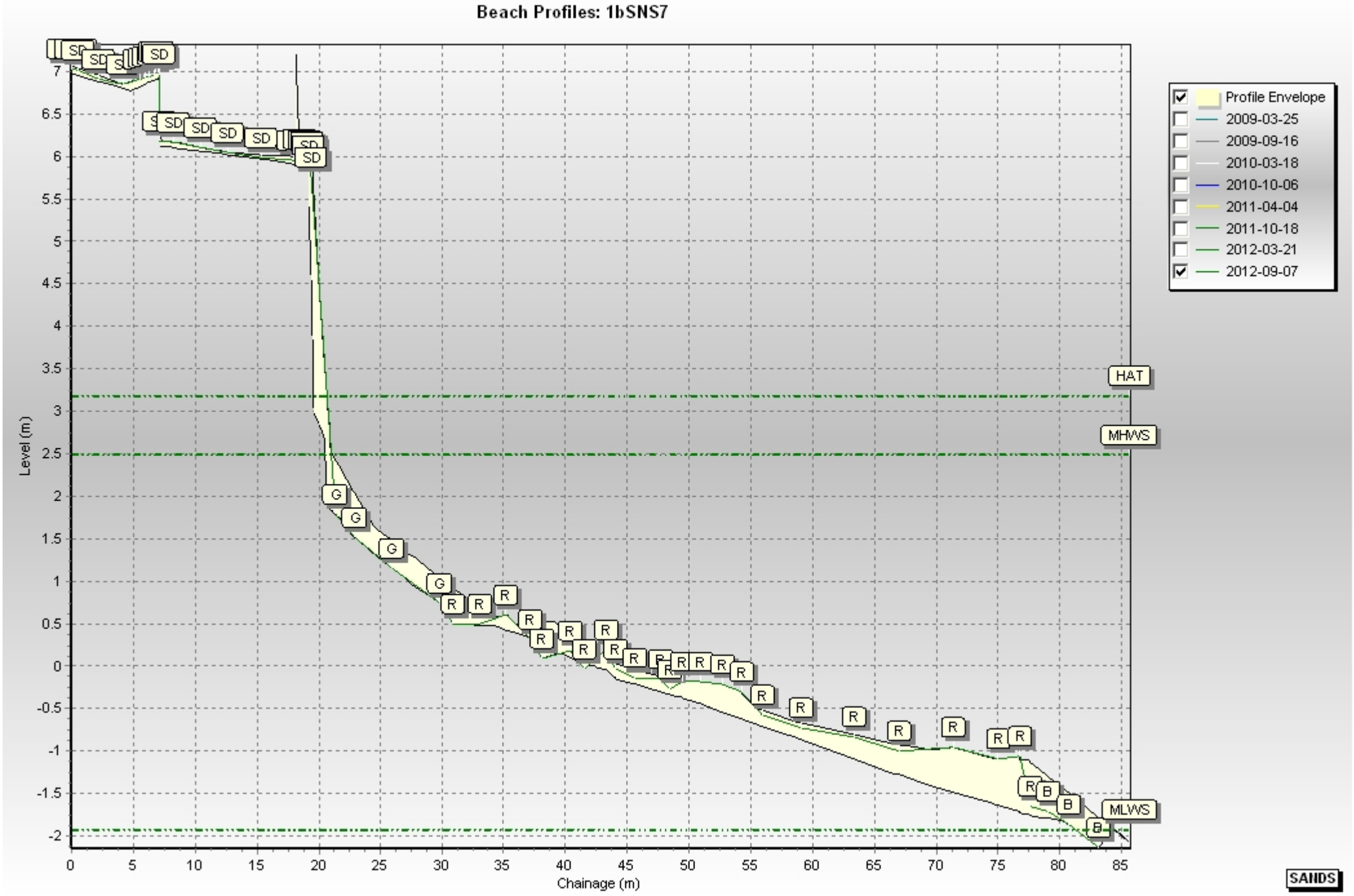
Chainage (m)
SANDS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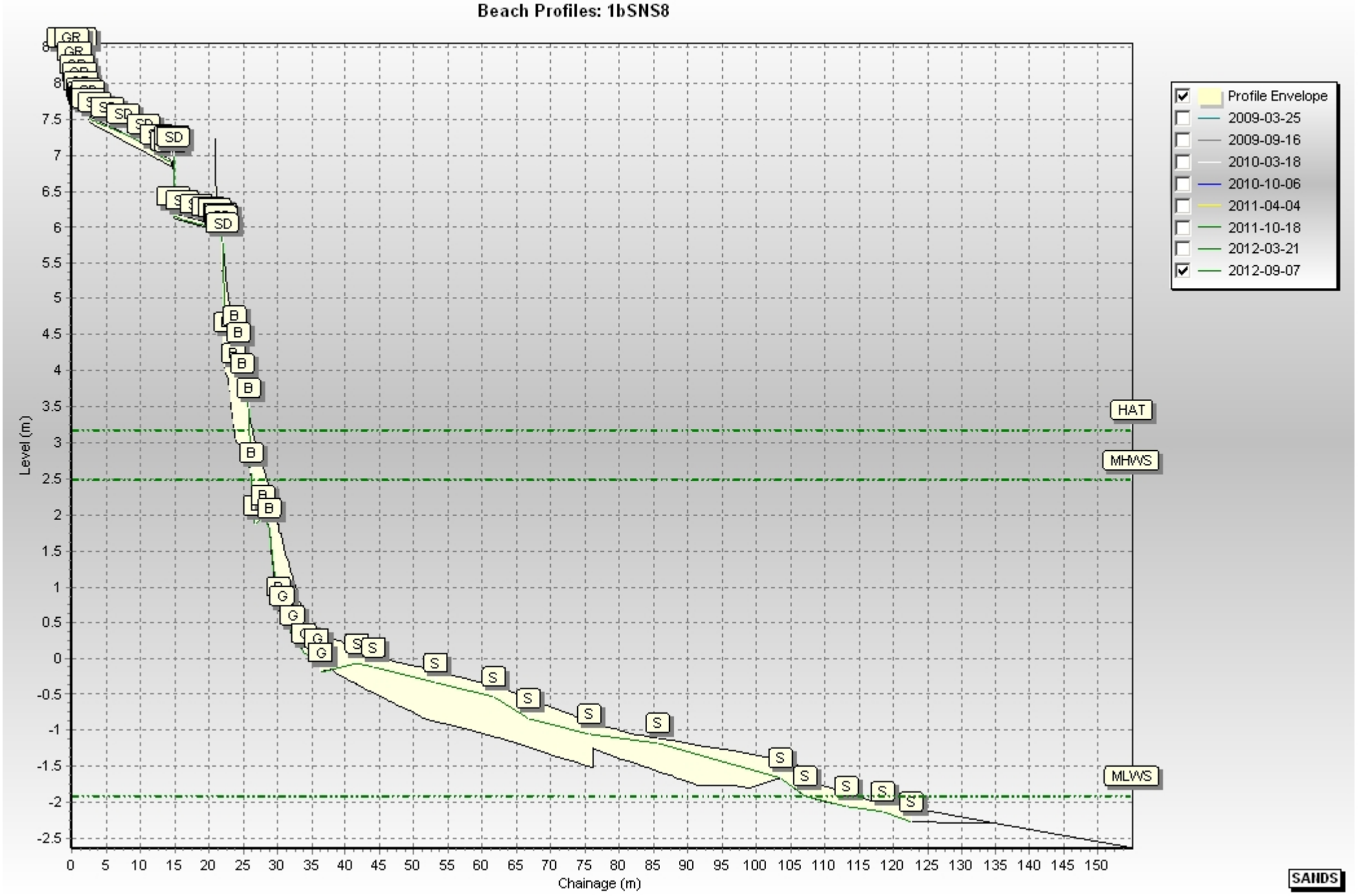
MHWS
MLWS
Level (m)
Chainage (m)
SANDS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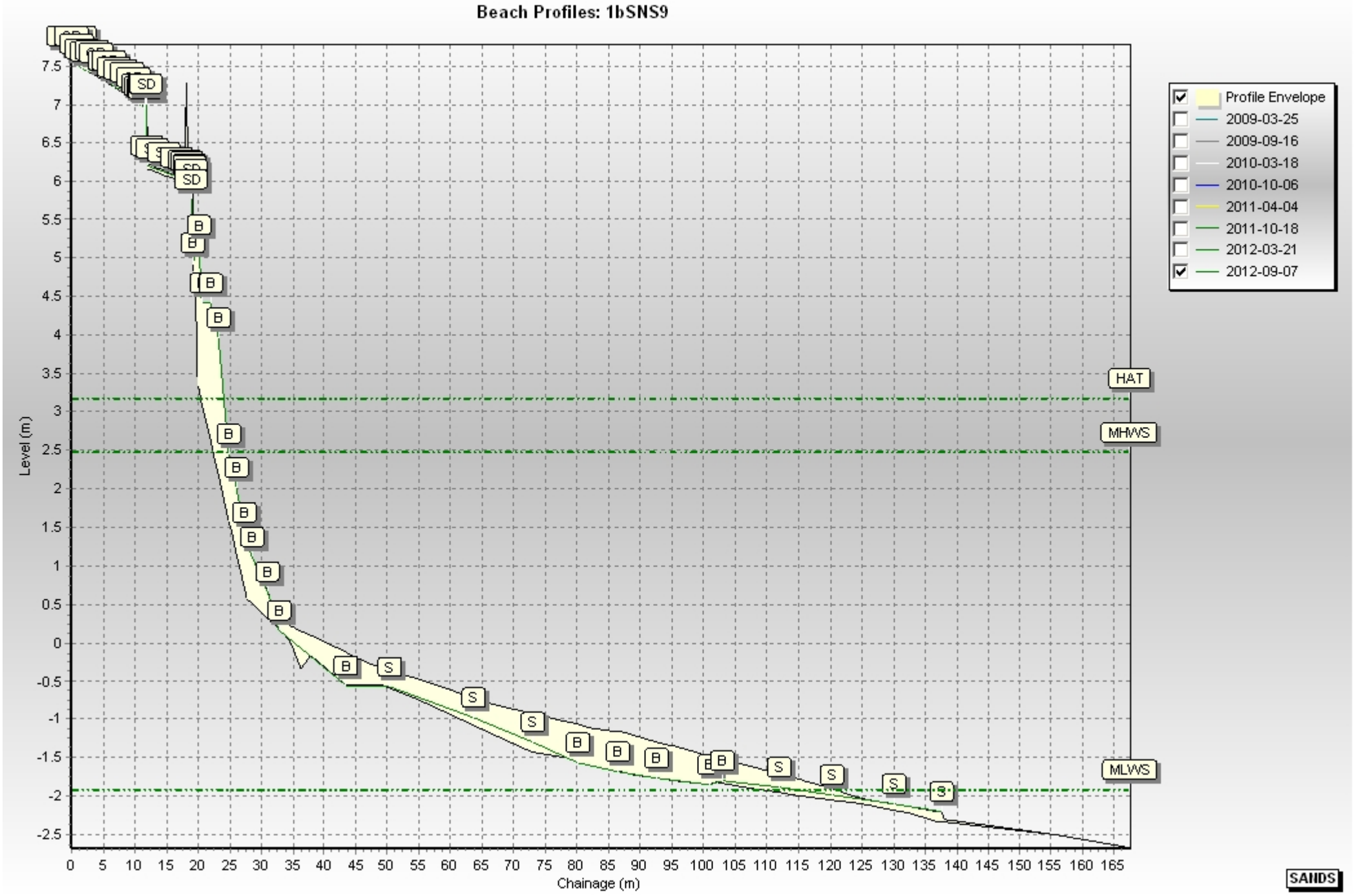
MHWS
MLWS
Level (m)
Chainage (m)
SANDS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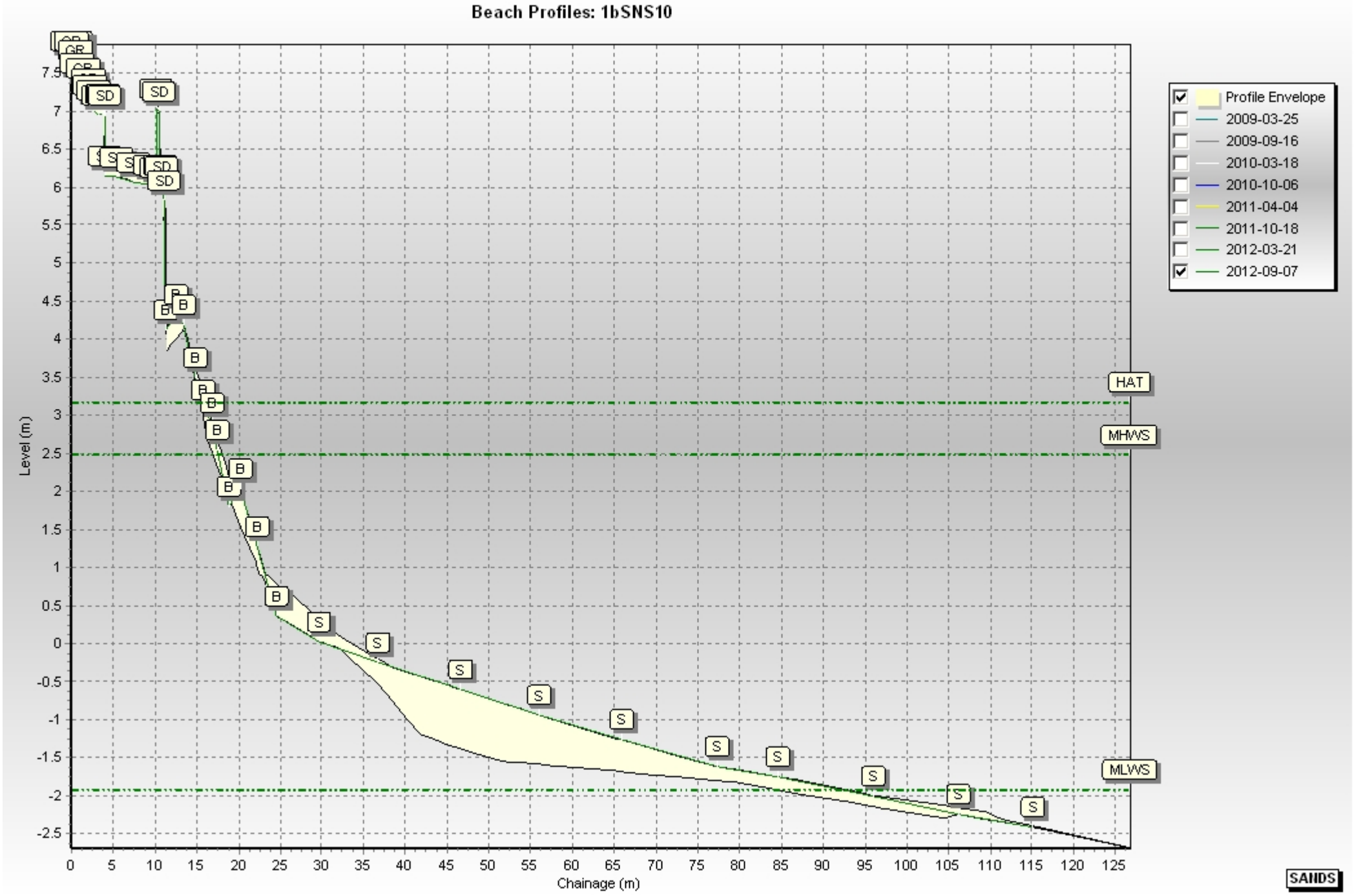
MLWS
SD
B
S
Level (m)
Chainage (m)
SANDS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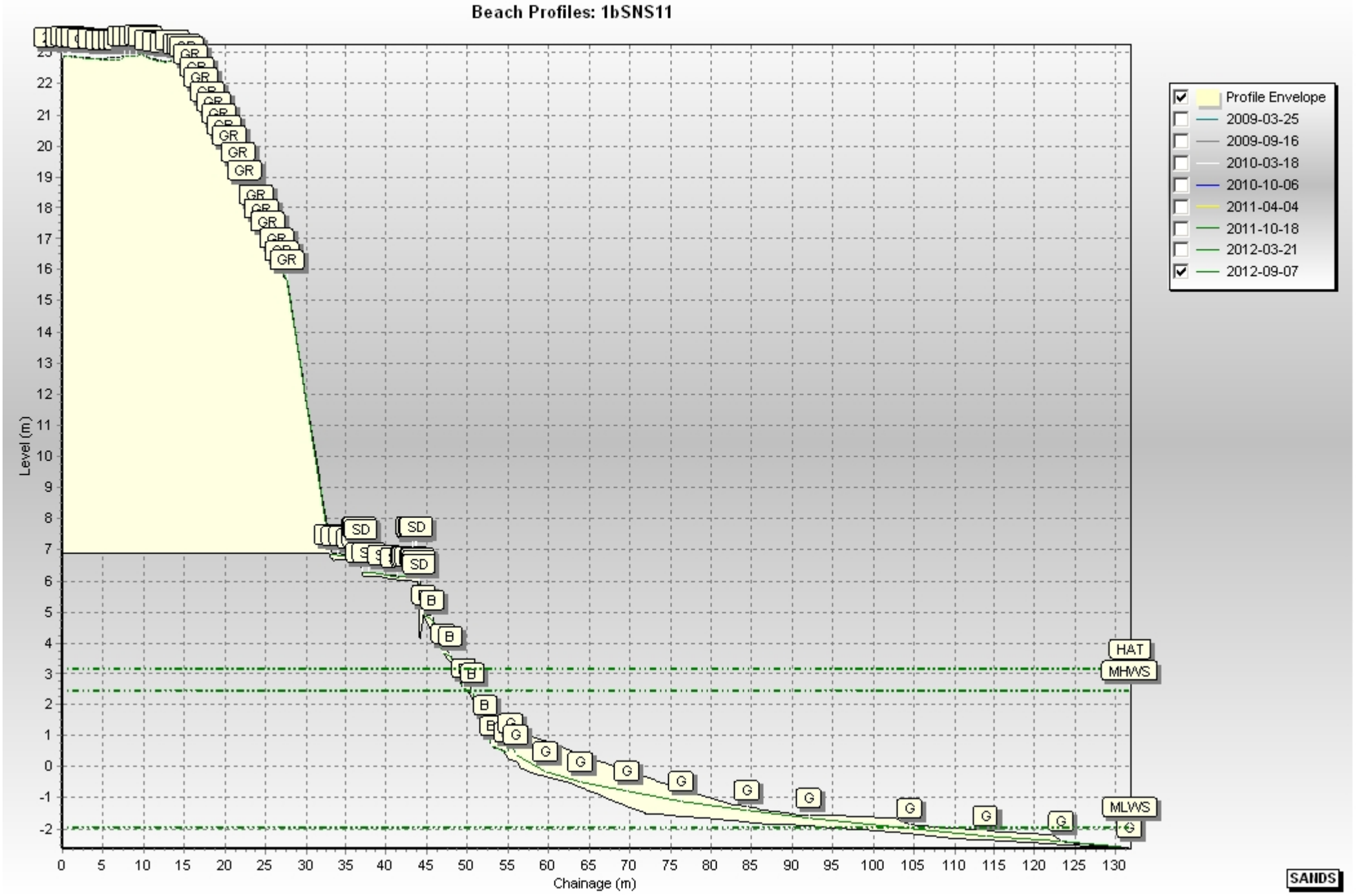
Level (m)
Chainage (m)
SANDS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Chainage (m)
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B
G
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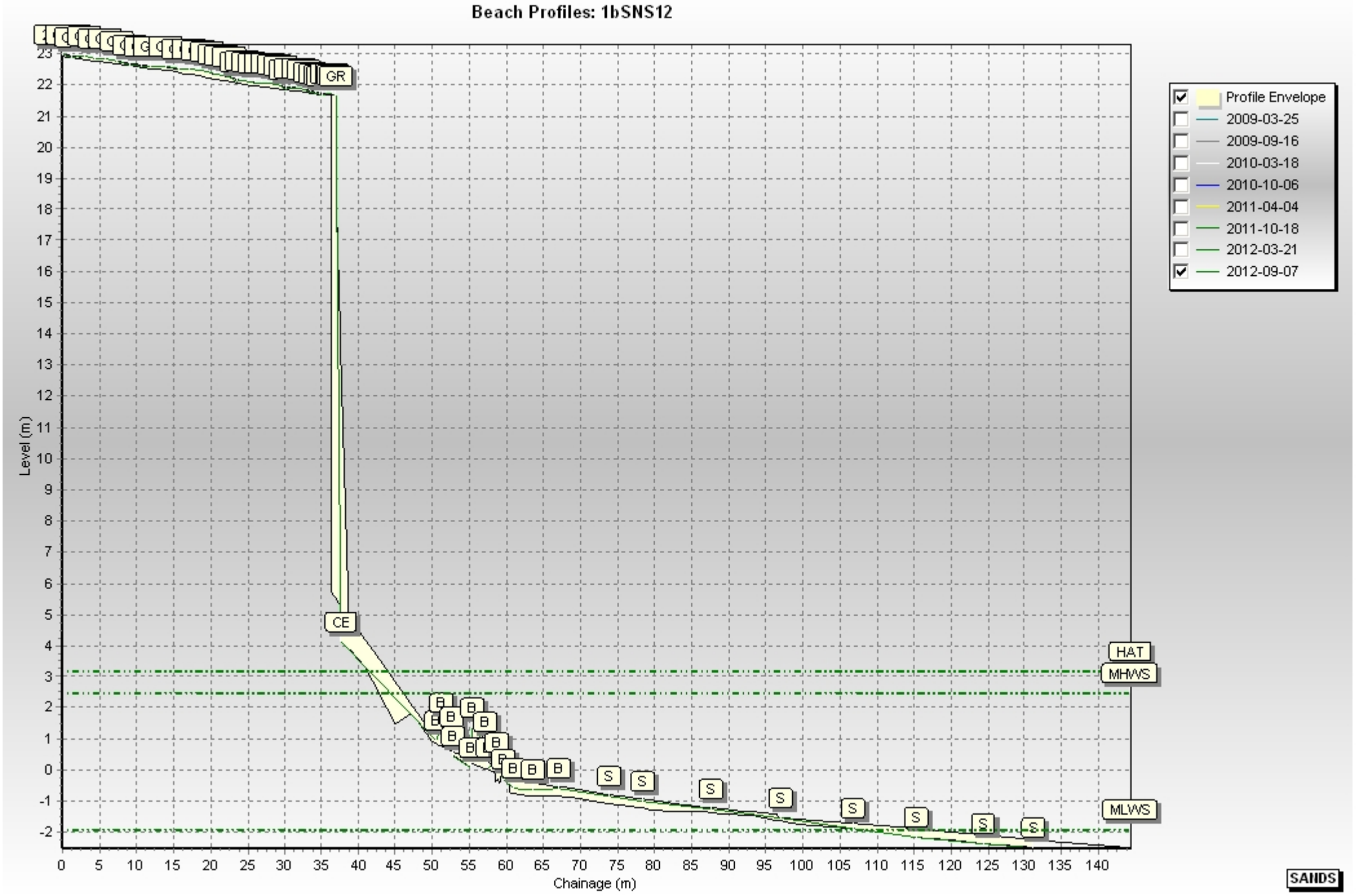
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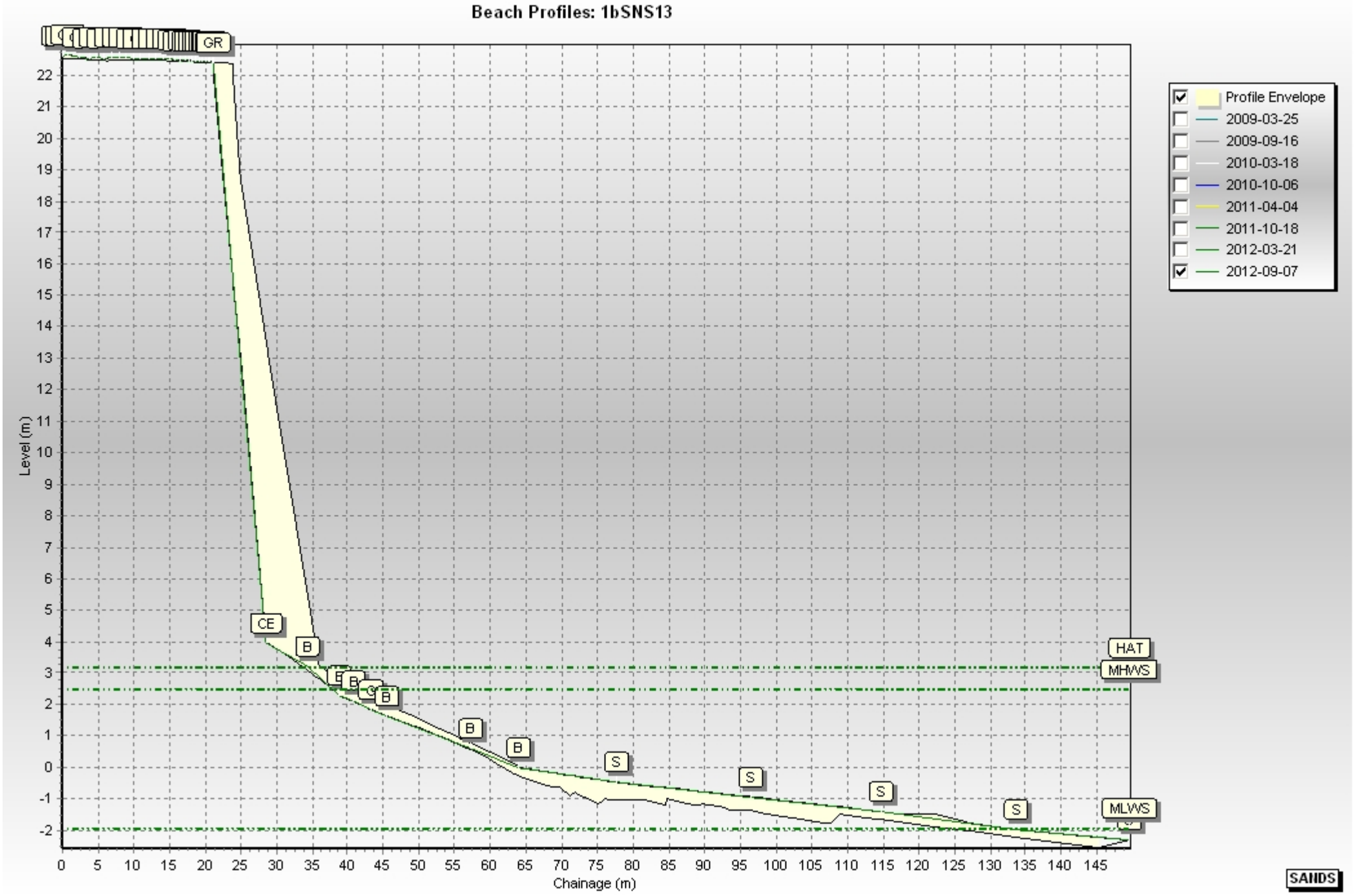
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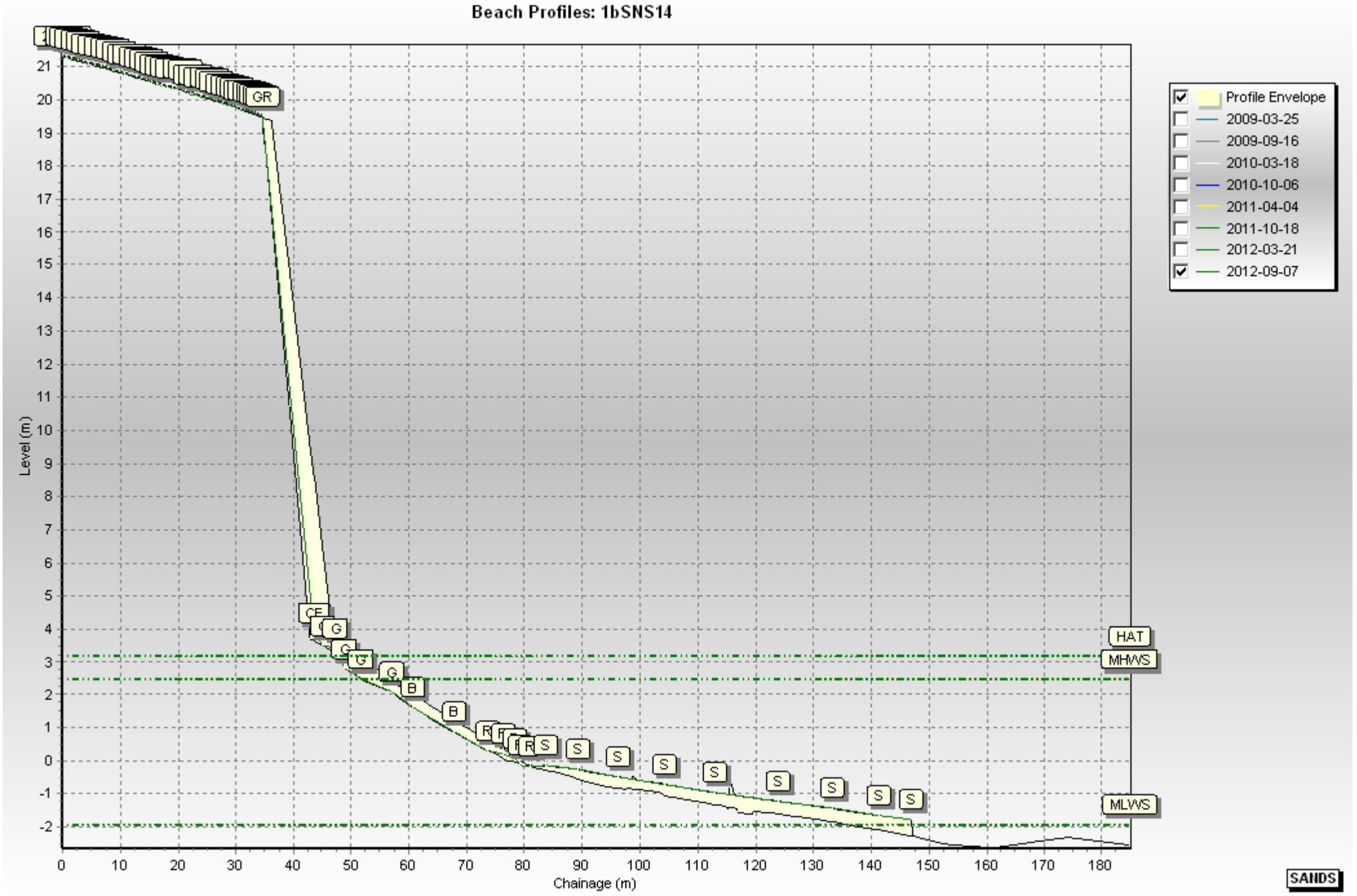
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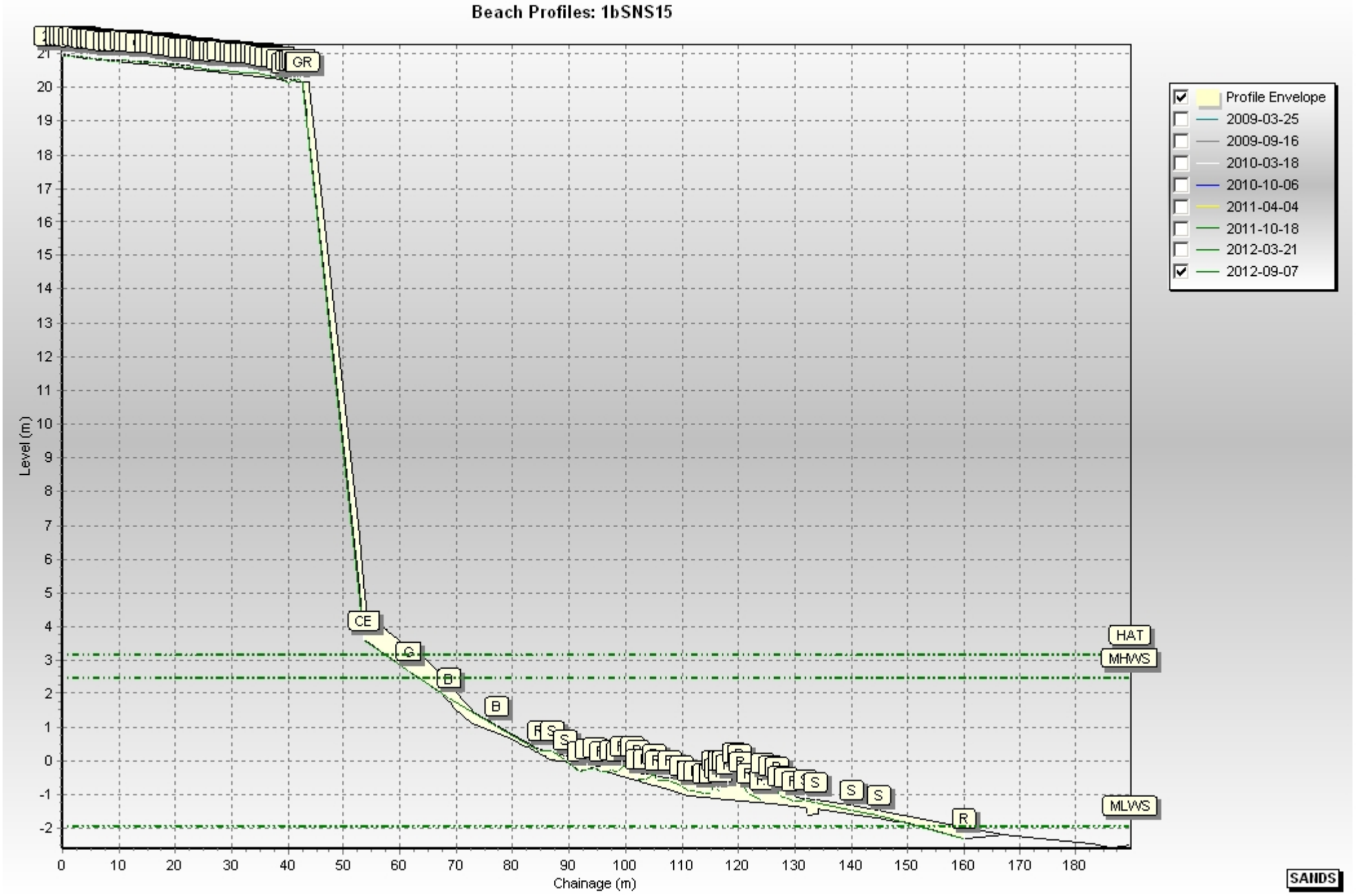
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MLWS
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Chainage (m)
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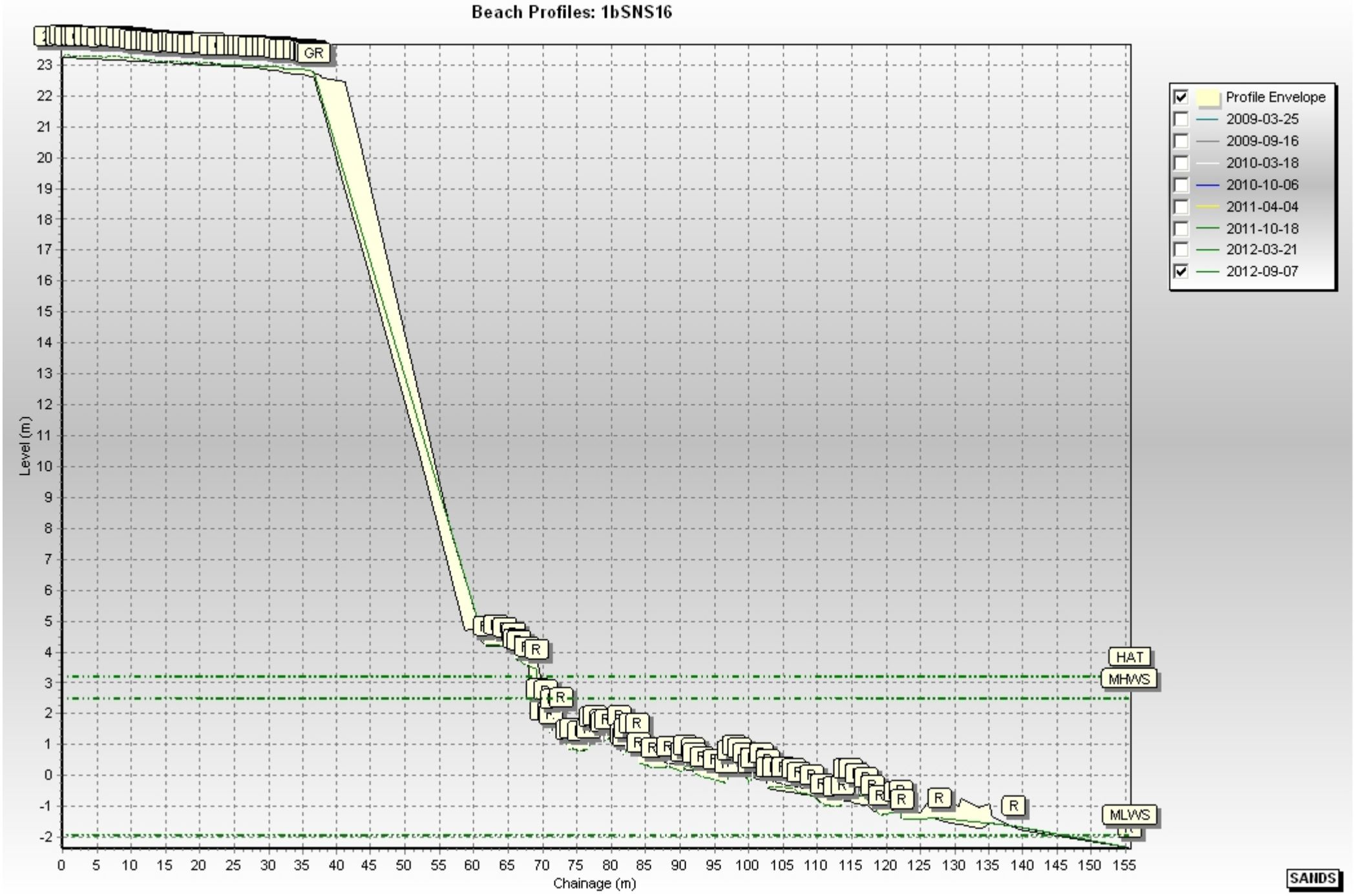
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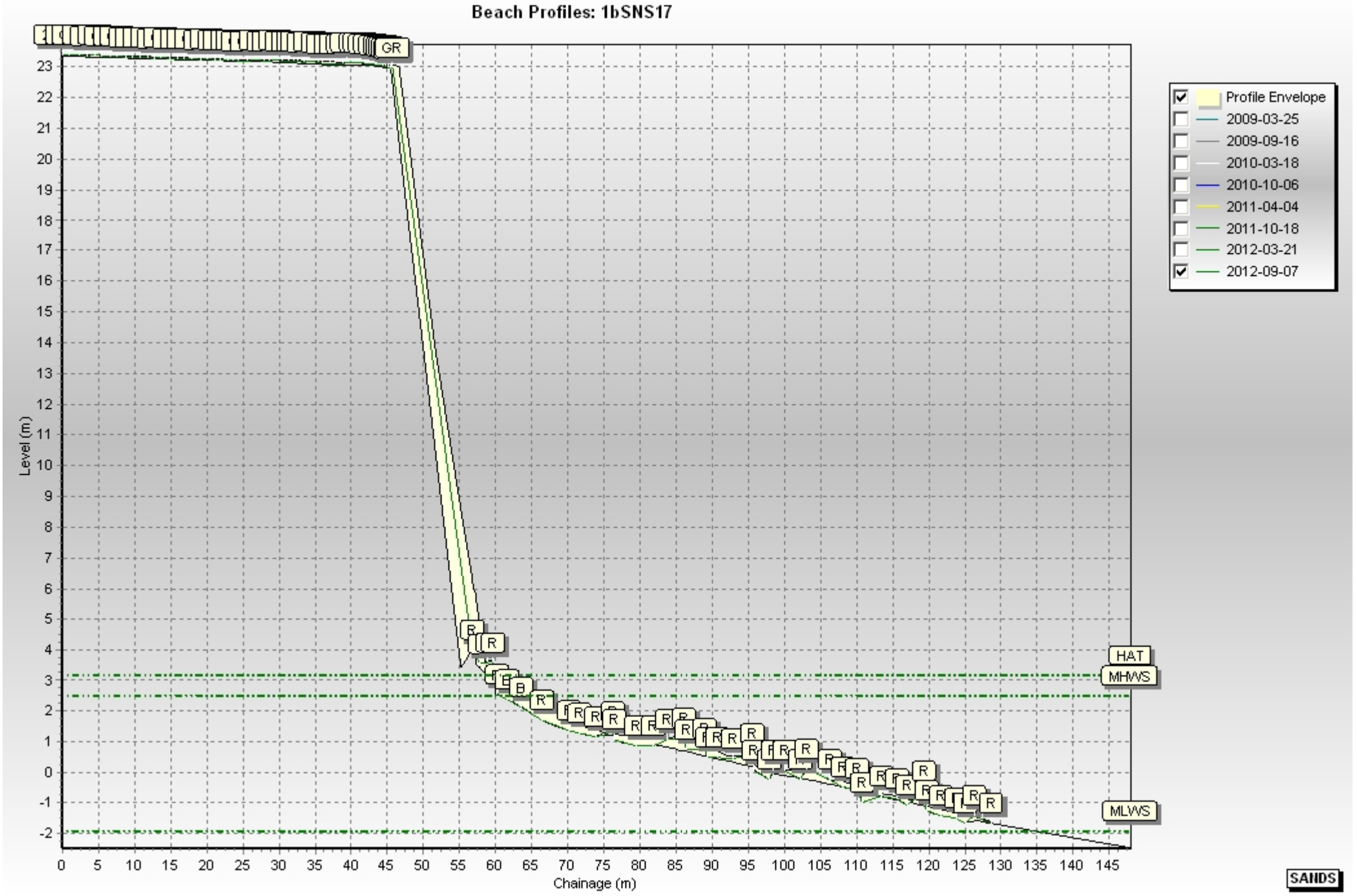
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Chainage (m)
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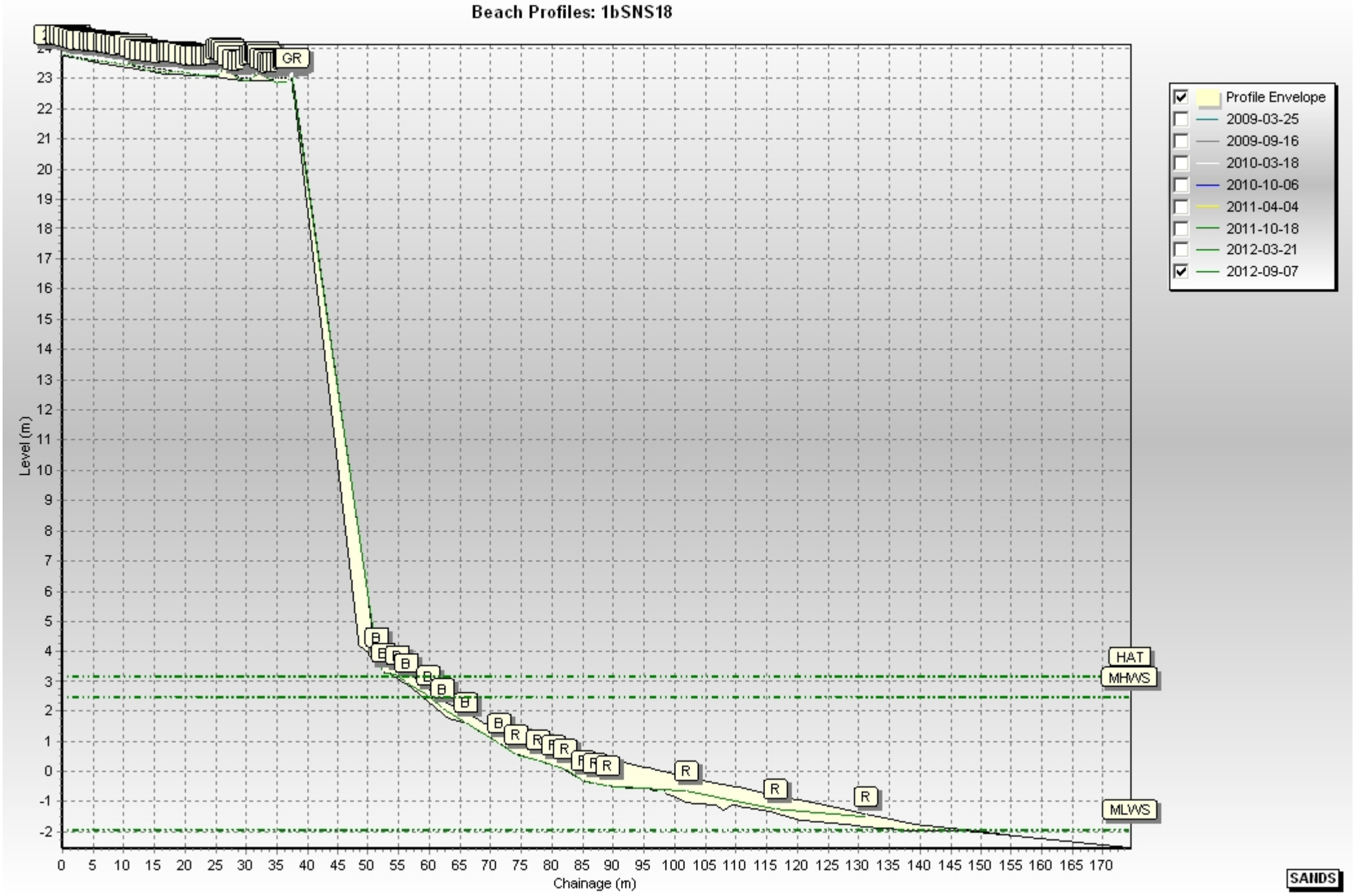
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Chainage (m)
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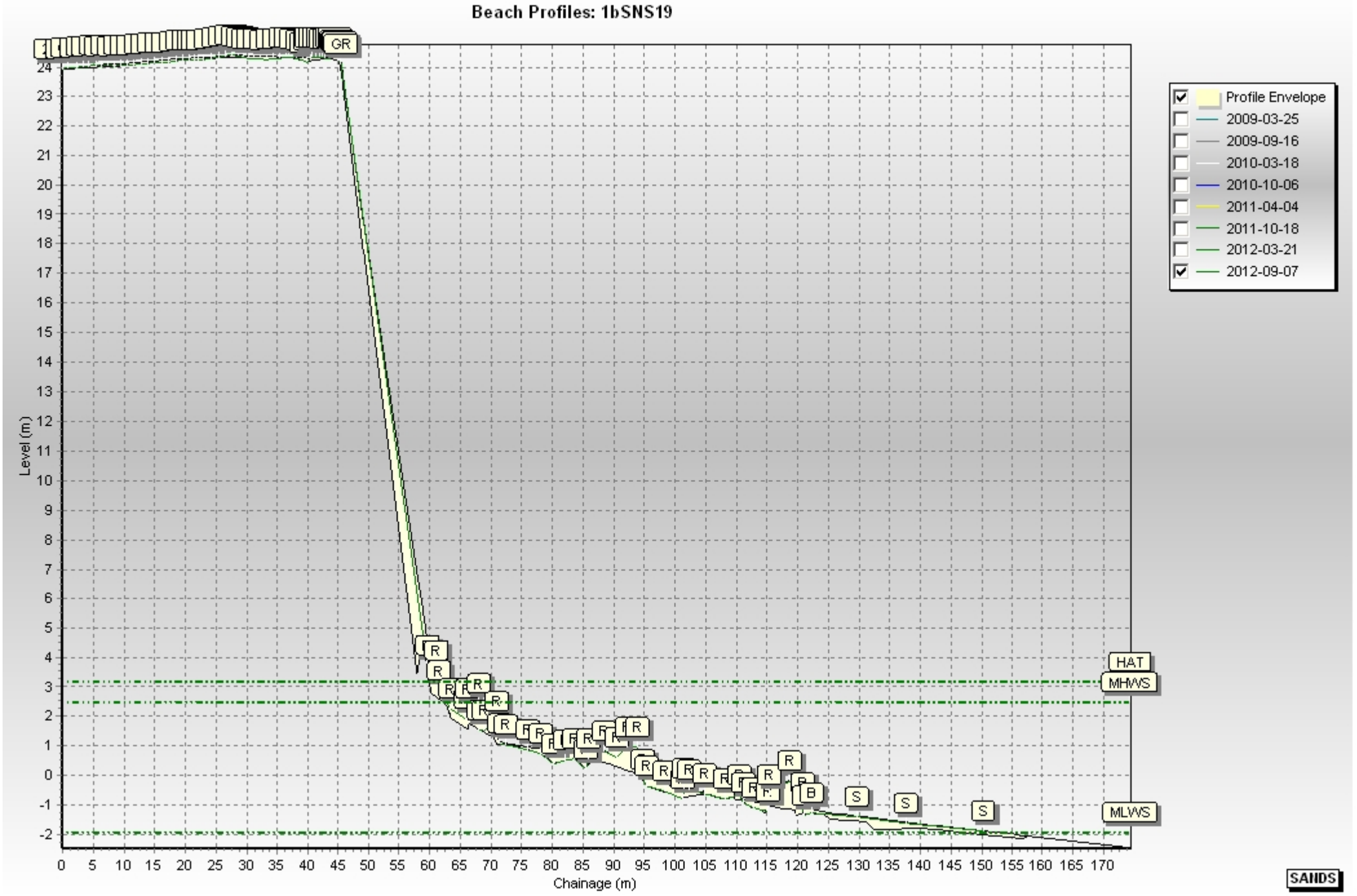
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Chainage (m)
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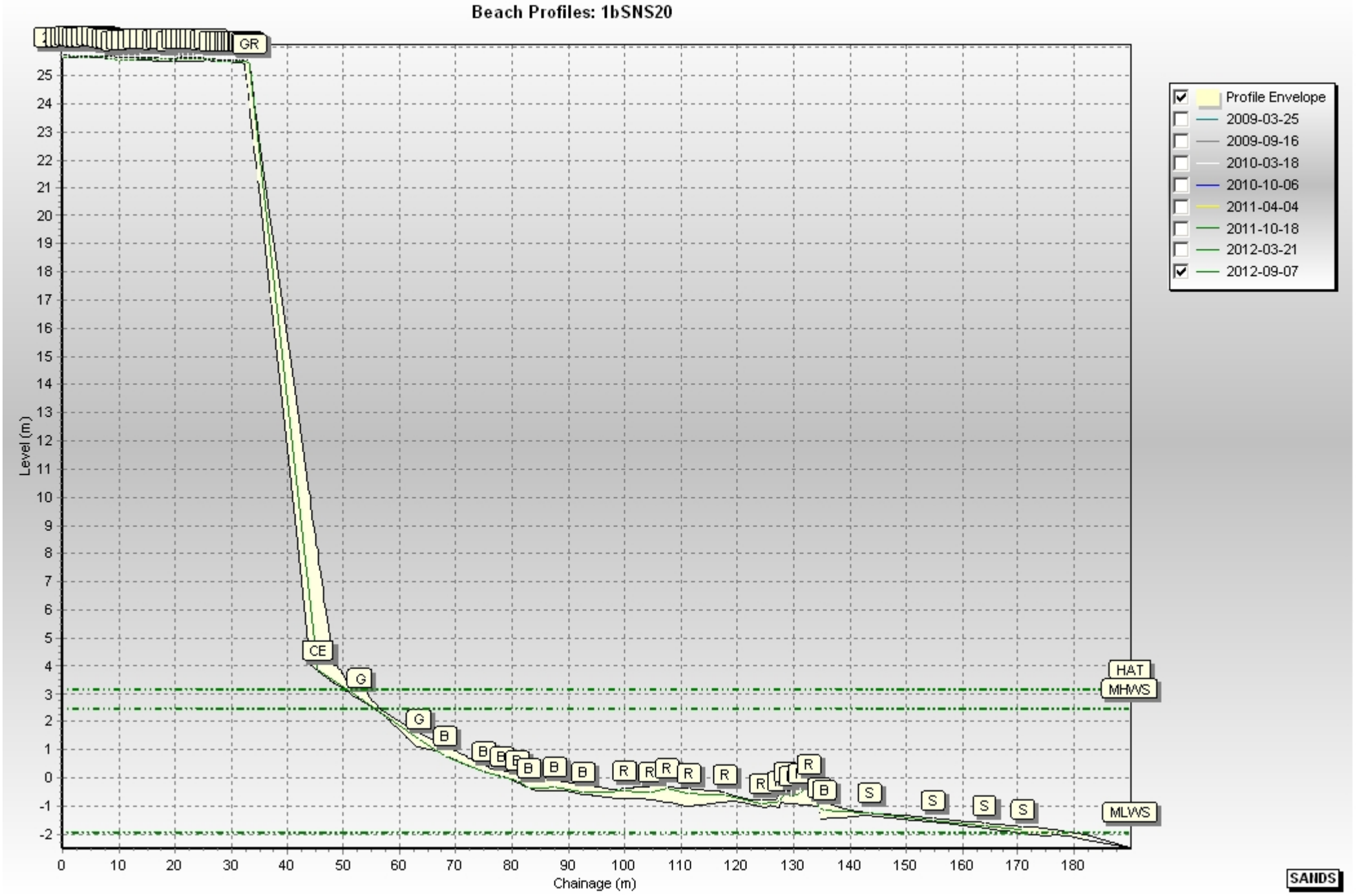
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Level (m)
Chainage (m)
GR
CE
G
G
B
B
B
B
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B
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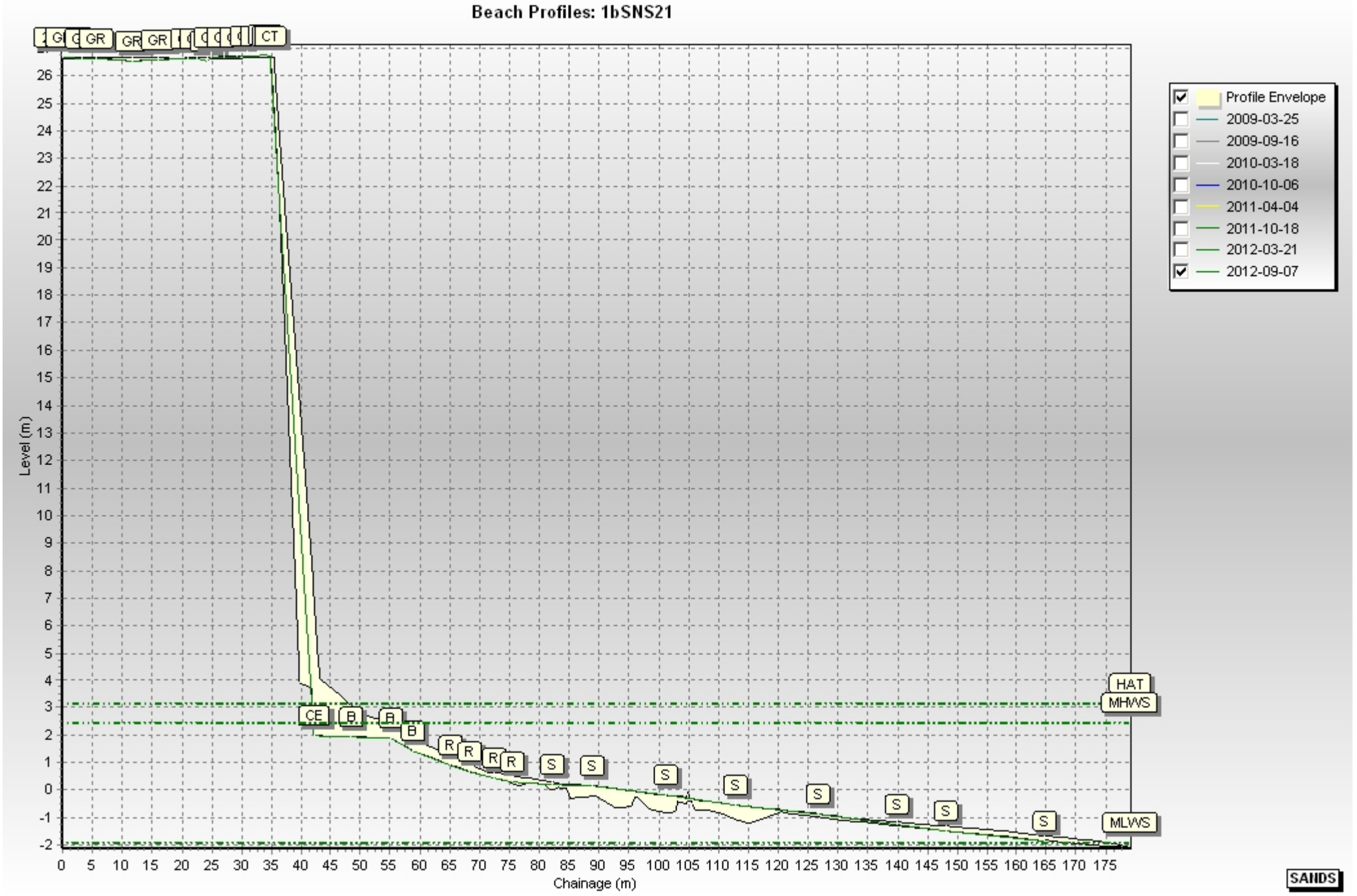
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Chainage (m)
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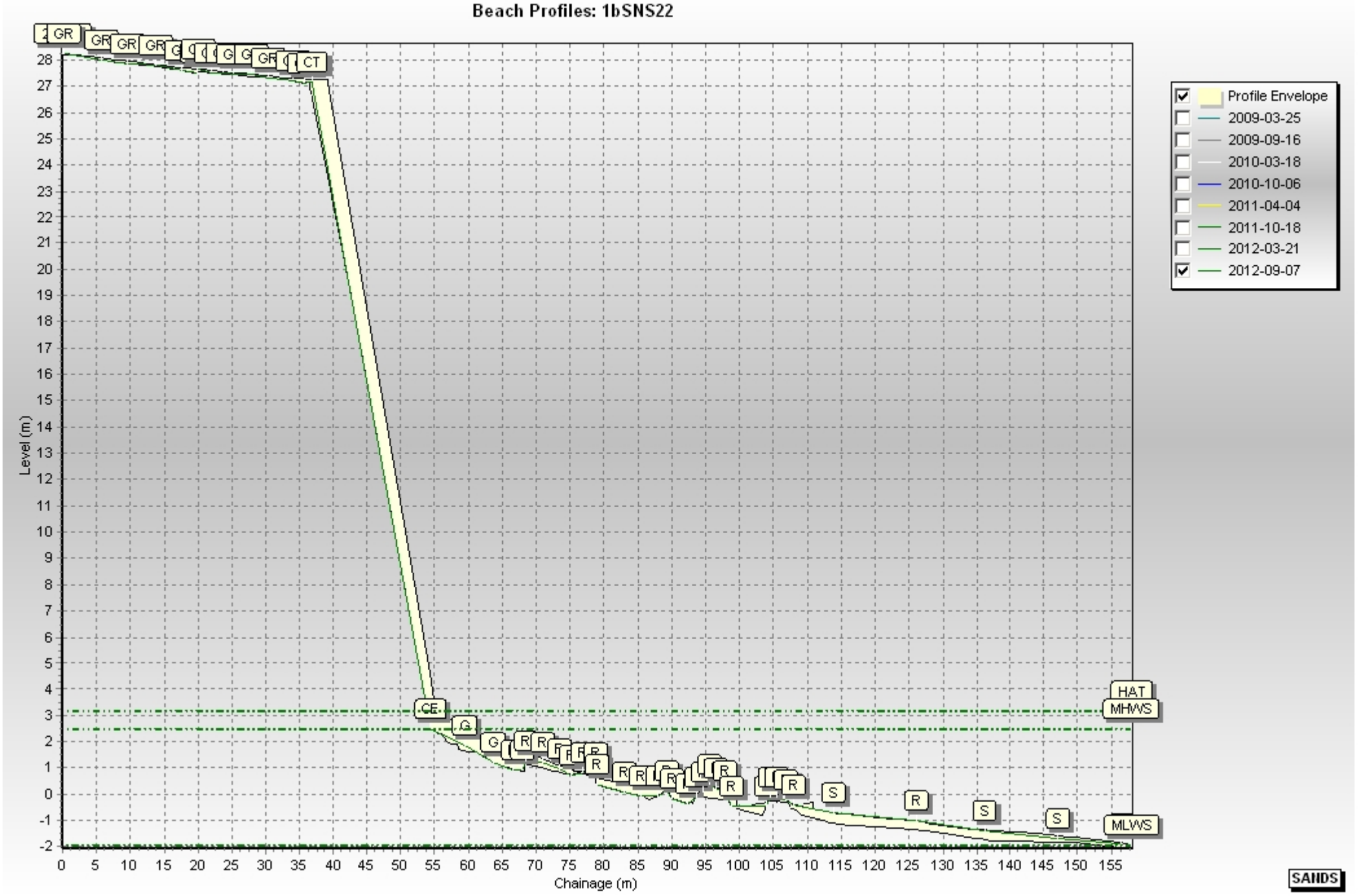
MLWS
CT
GR
CE
B
R
S
SANDS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Chainage (m)
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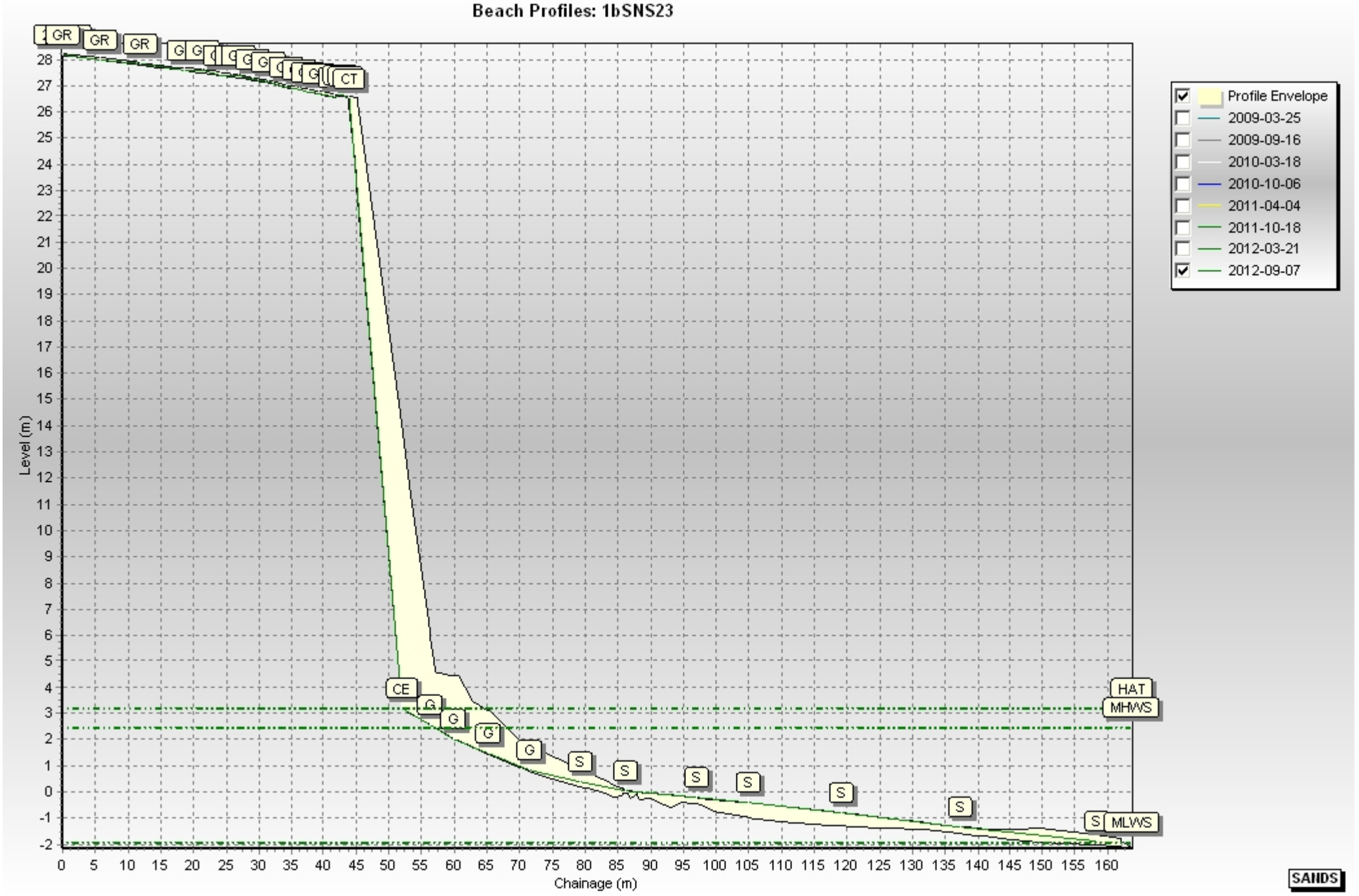
MHWS
MLWS
SANDS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Chainage (m)
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CT
CE
HAT
MHWS
MLWS
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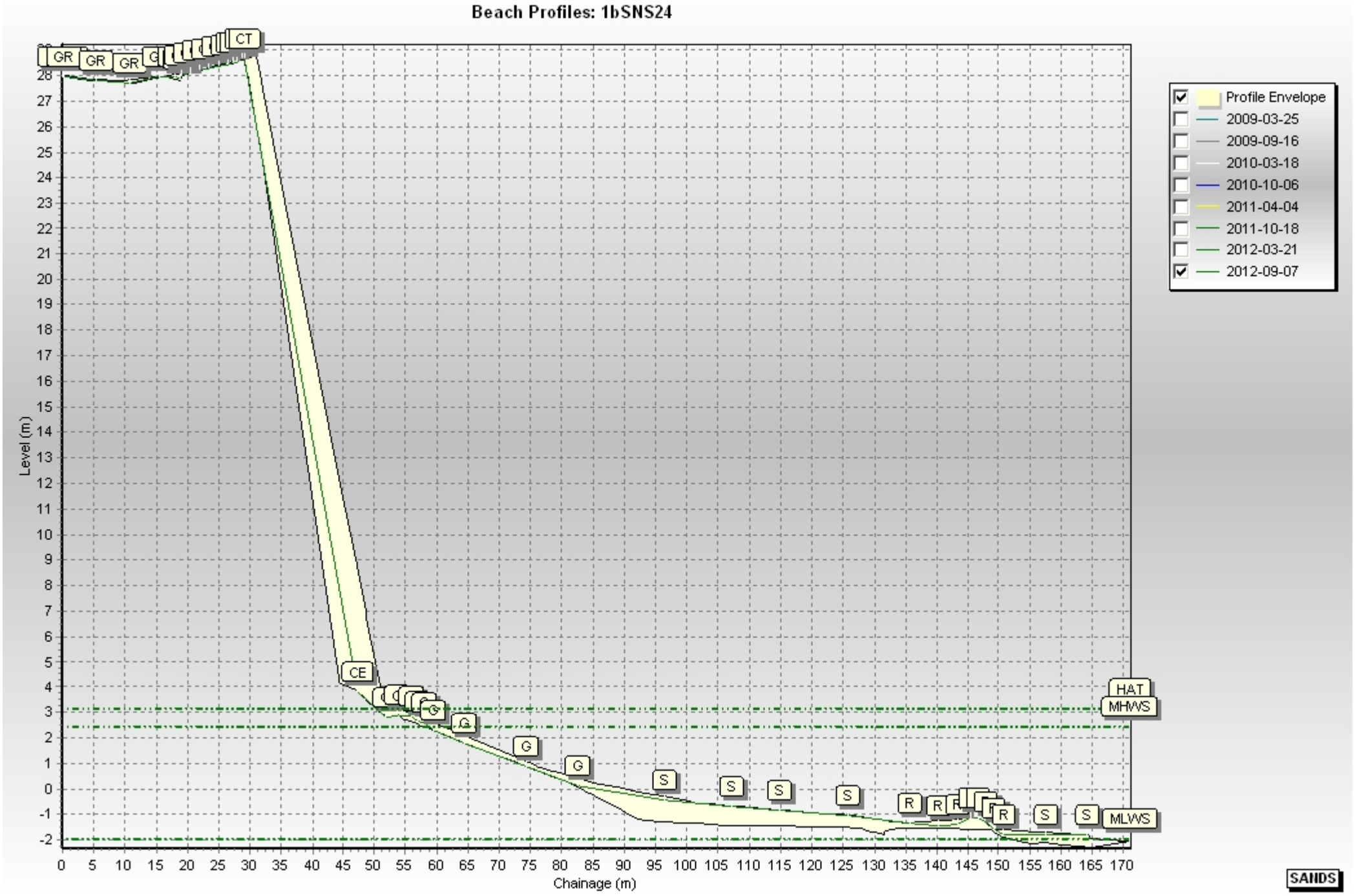
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CE
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G
G
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S
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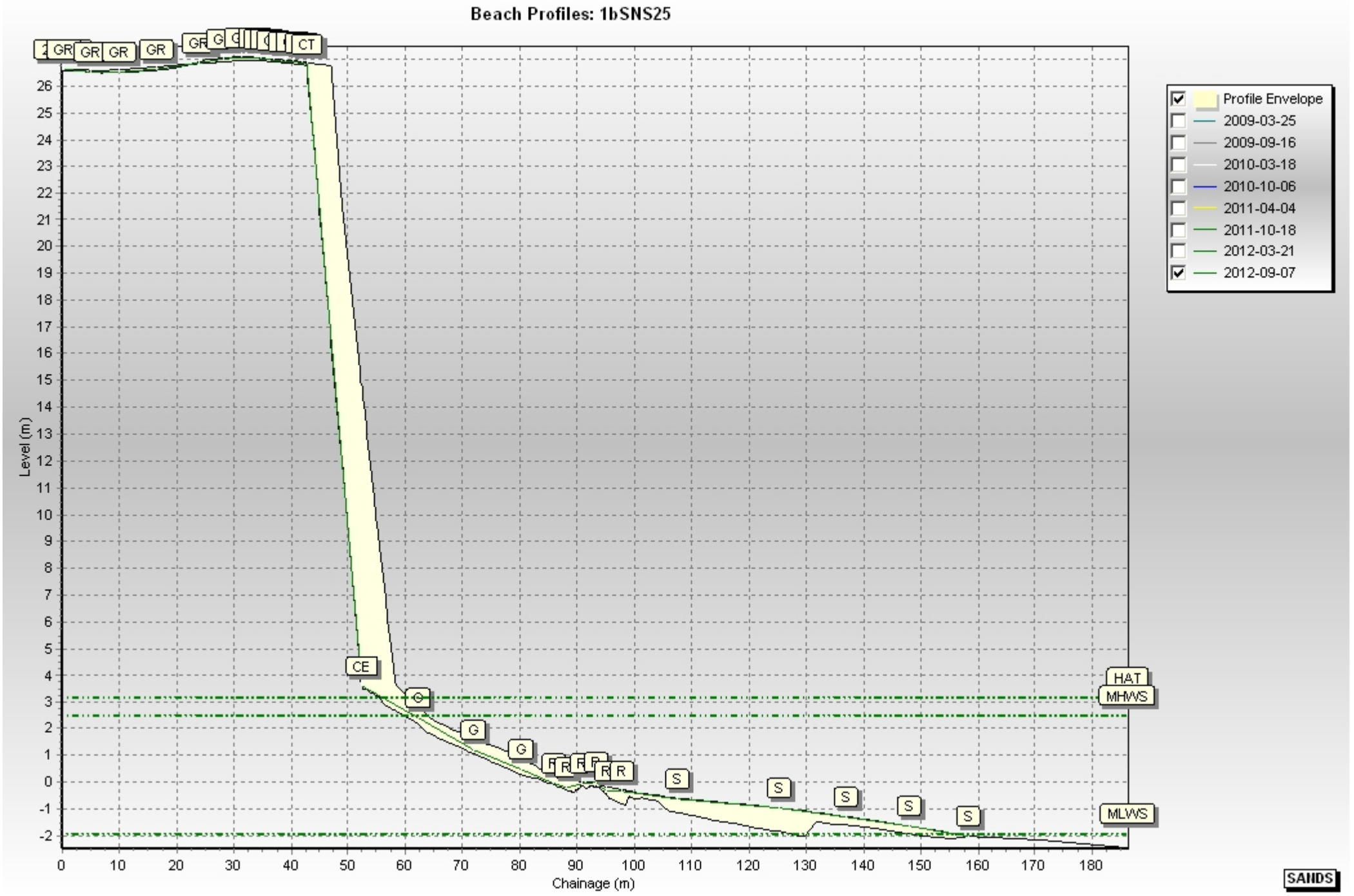
HAT
MHWS
MLWS
Level (m)
Chainage (m)
SANDS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CE
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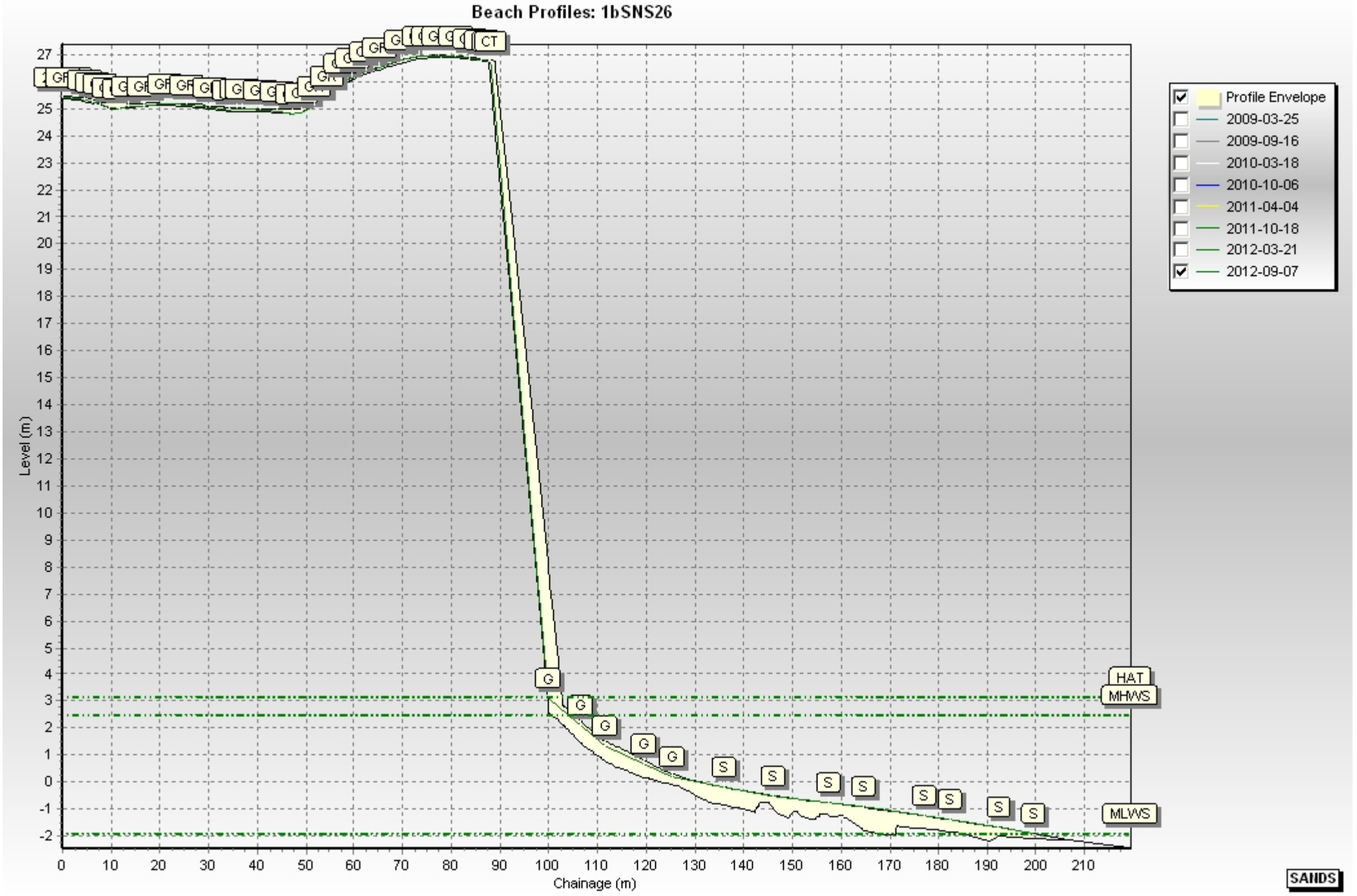
R
S
HAT
MHWS
MLWS
Level (m)
Chainage (m)
SANDS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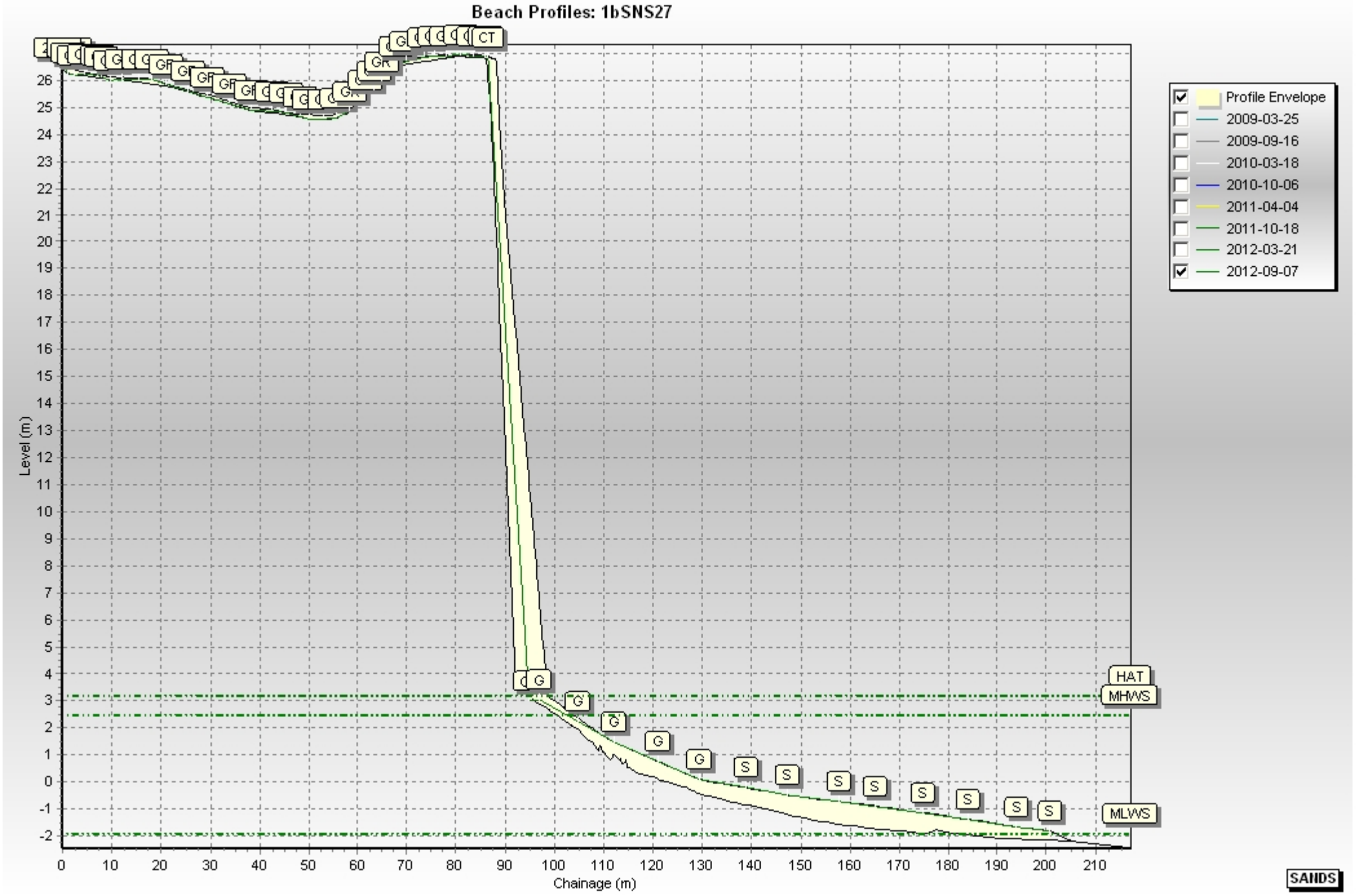
MHWS
MLWS
SANDS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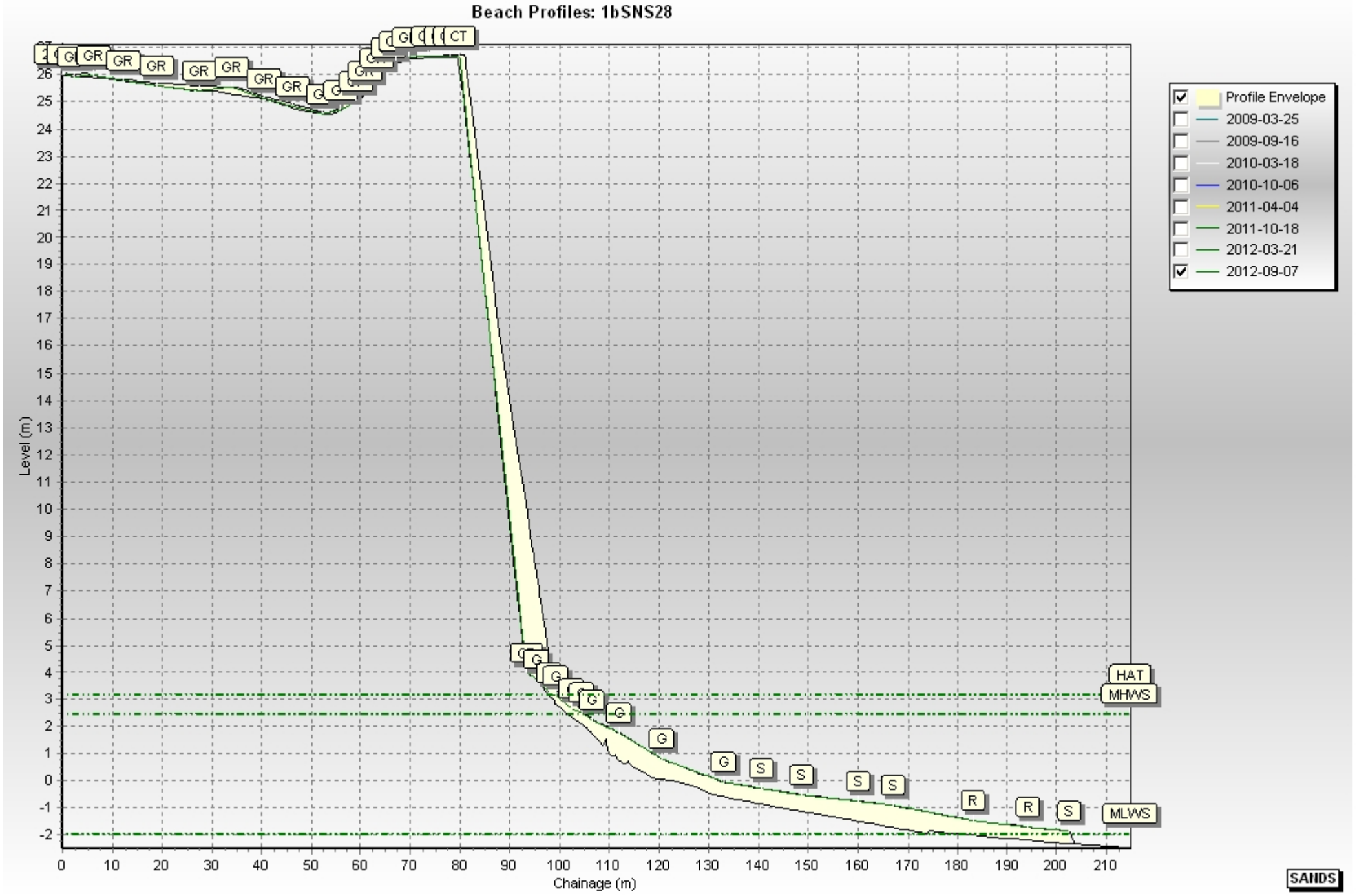
MLWS
Level (m)
Chainage (m)
SANDS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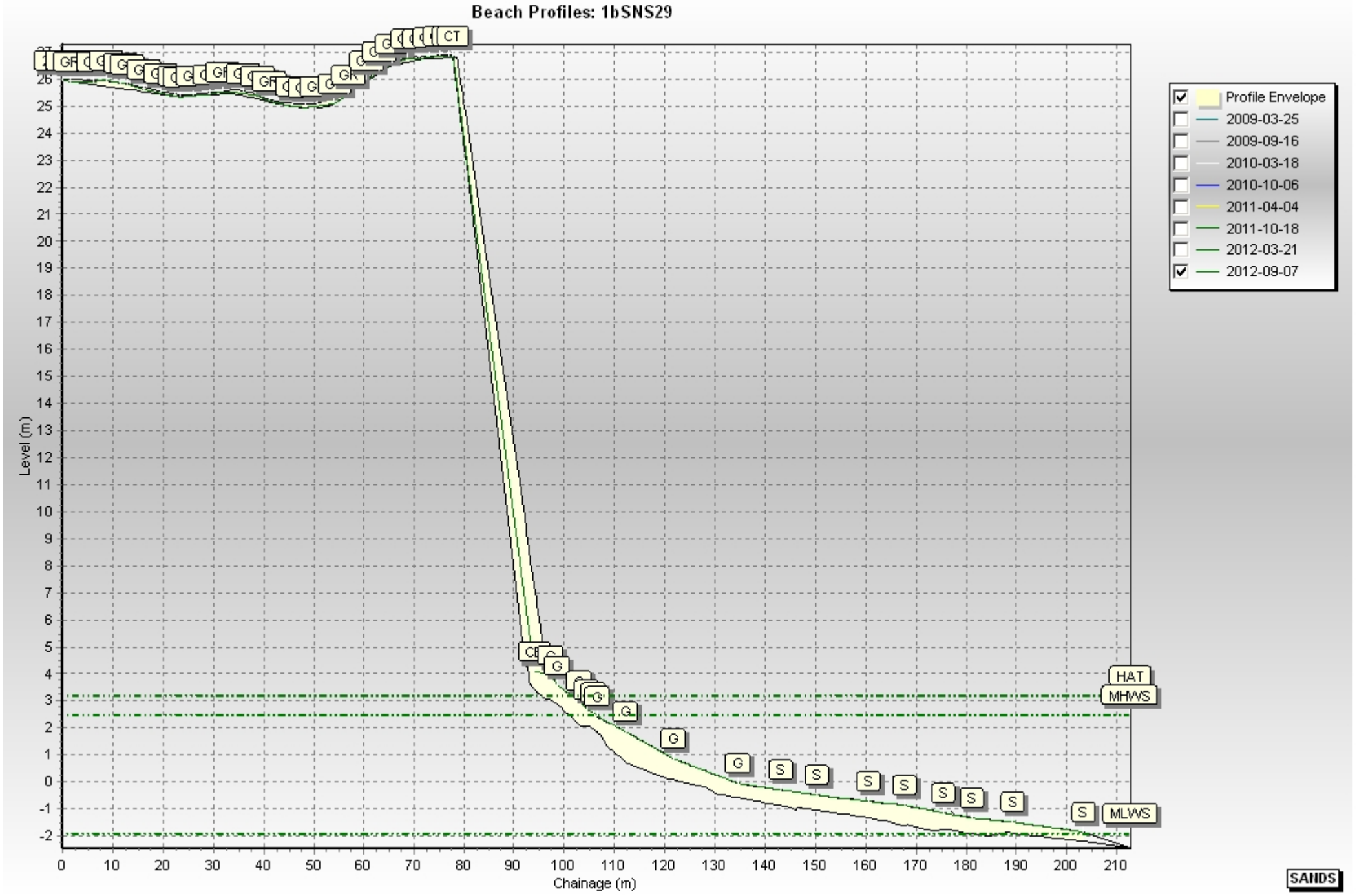
MLWS
Level (m)
Chainage (m)
SANDS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Chainage (m)
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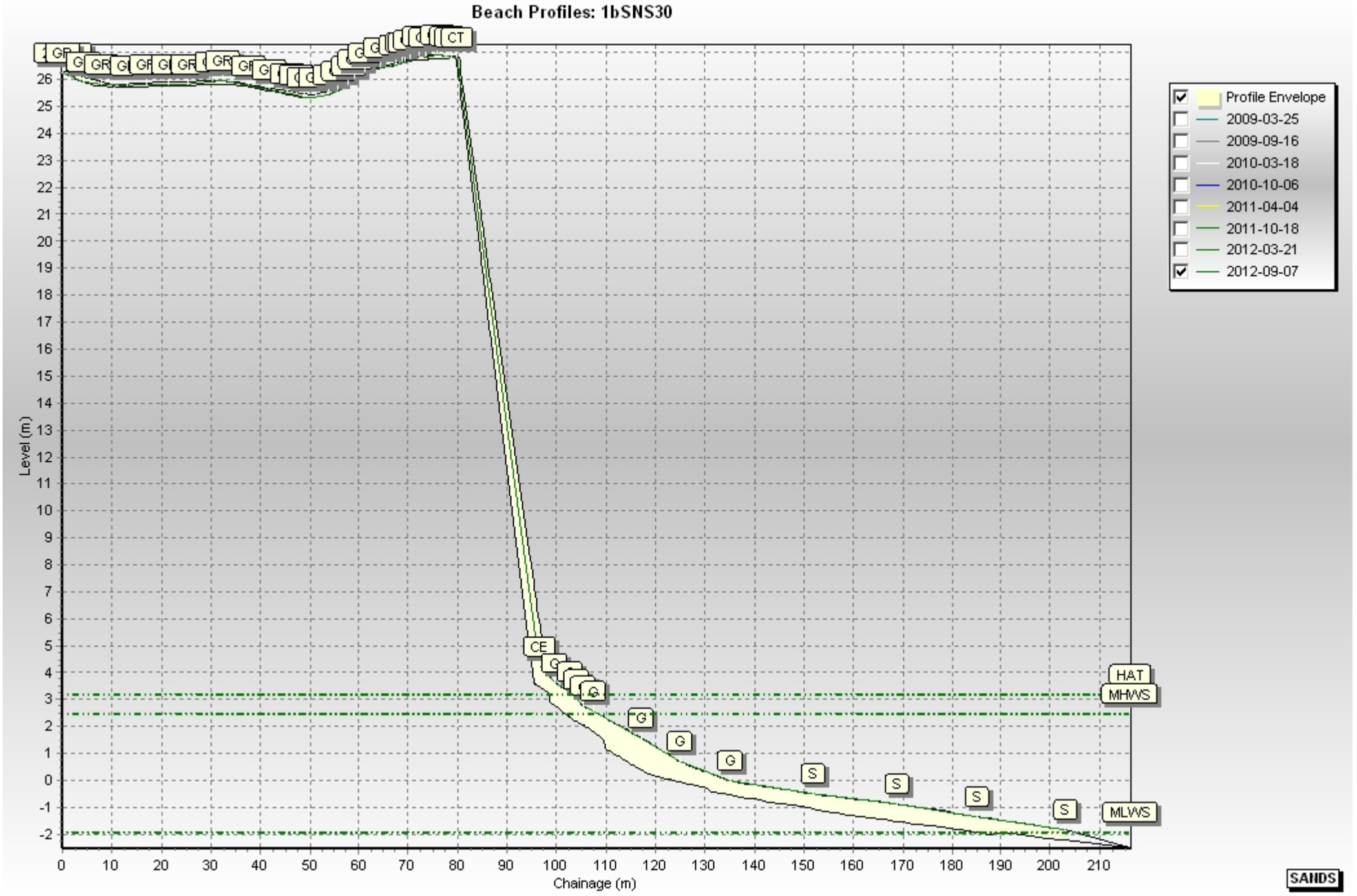
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Level (m)
Chainage (m)
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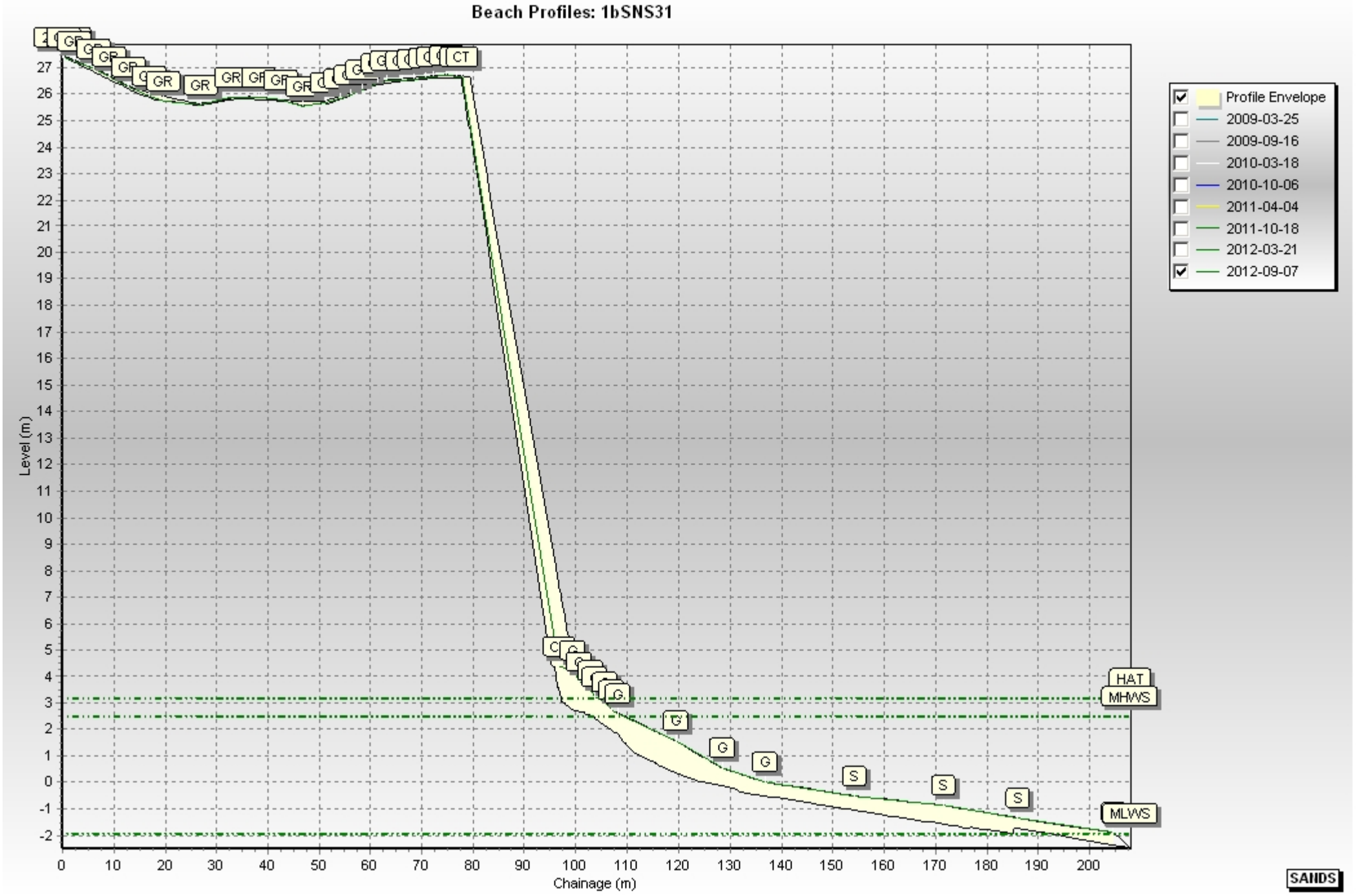
MHWS
MLWS
CT
CE
G
S
SANDS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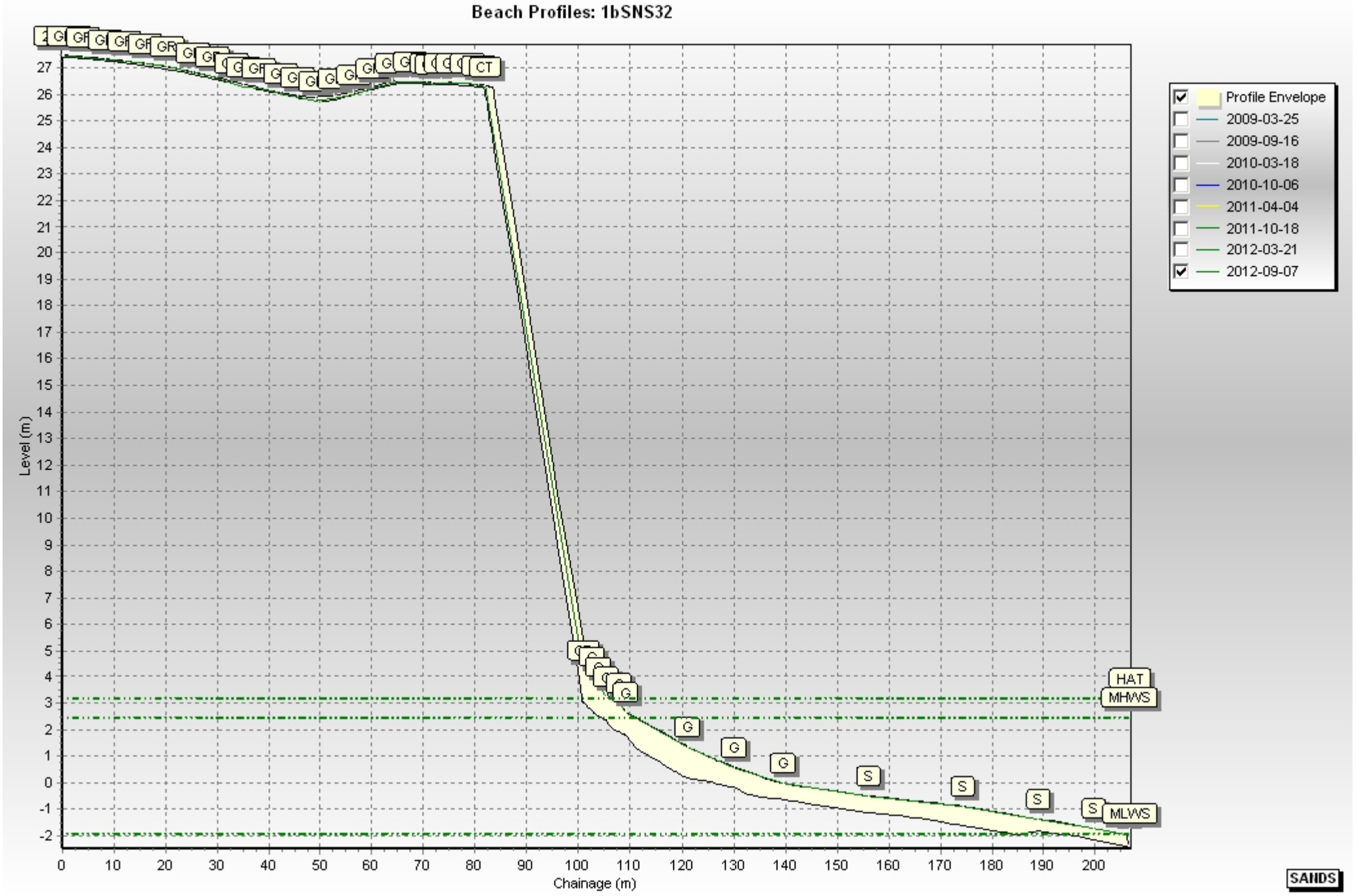
MHWS
MLWS
Level (m)
Chainage (m)
SANDS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Chainage (m)
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MLWS
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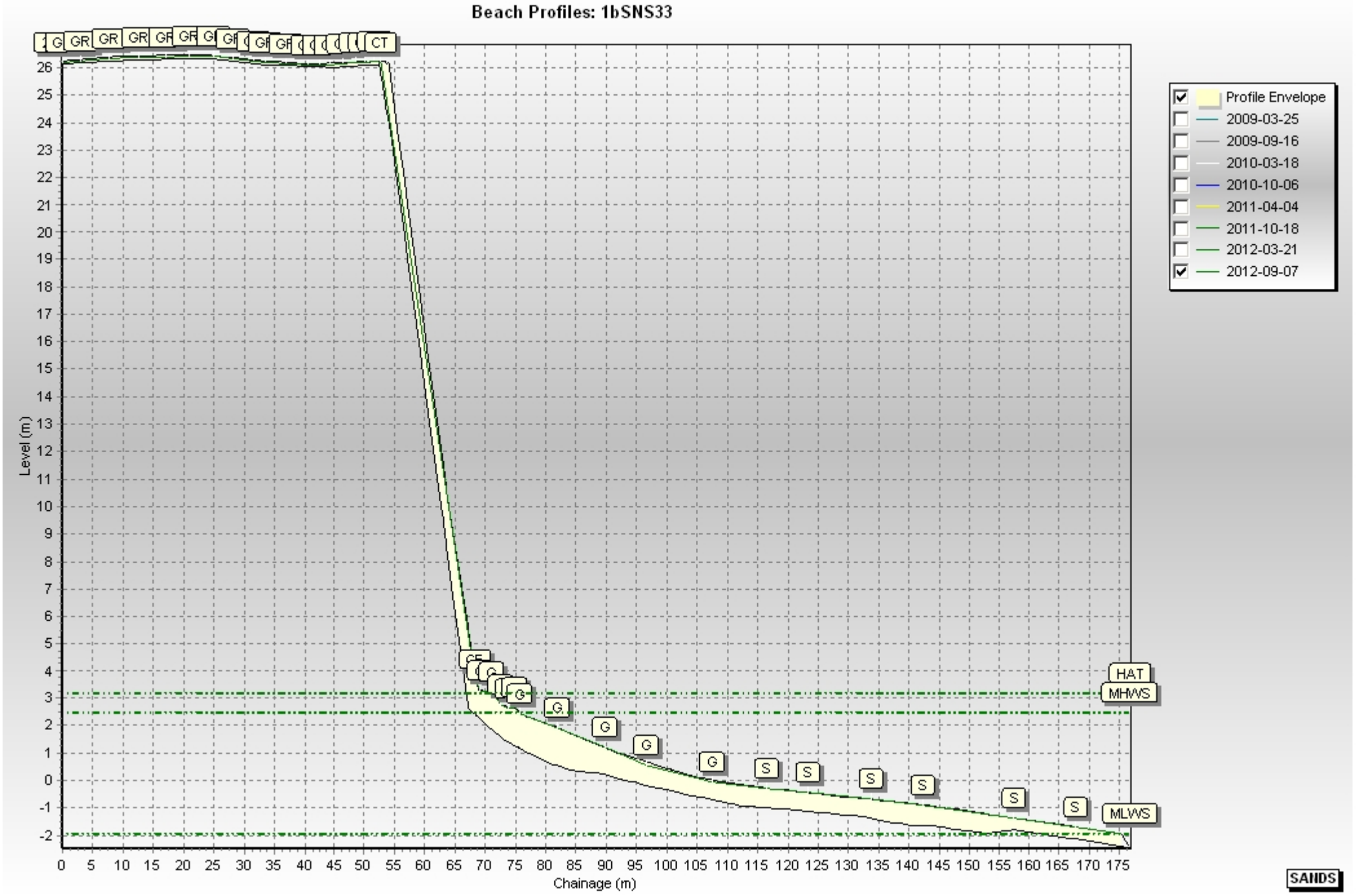
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Chainage (m)
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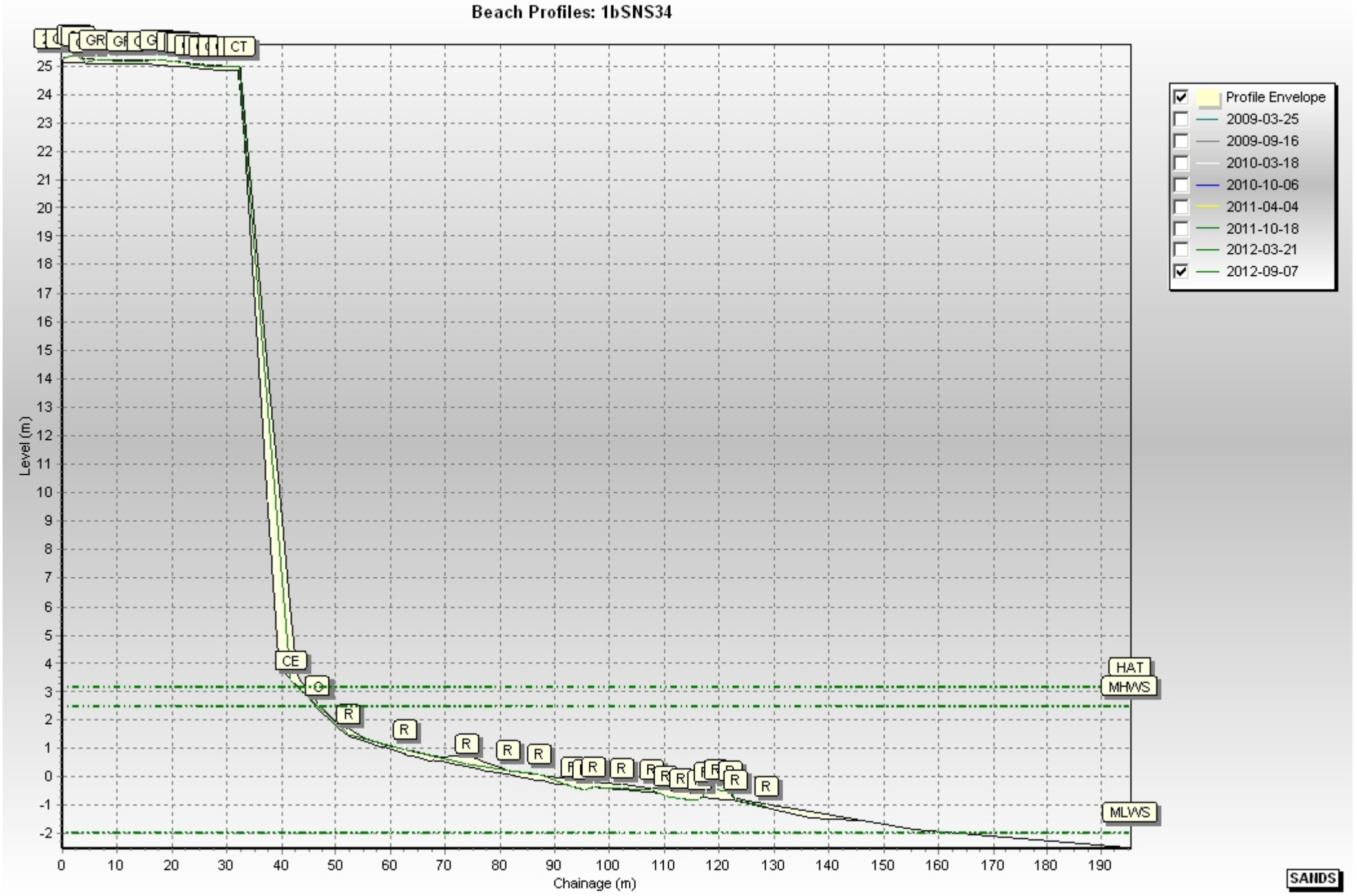
MHWS
MLWS
CT
GR
G
S
SANDS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HAT
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MLWS
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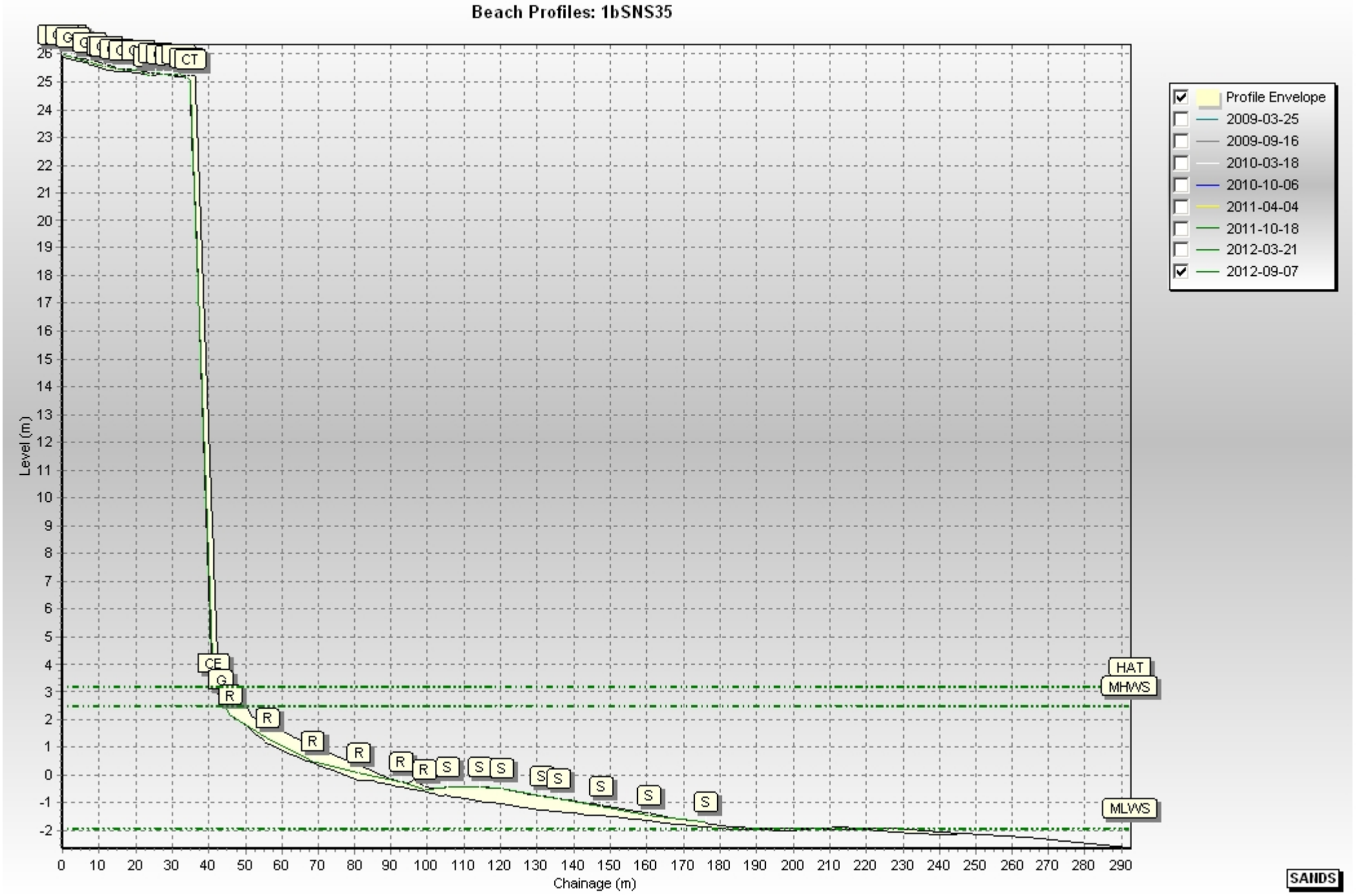
SANDS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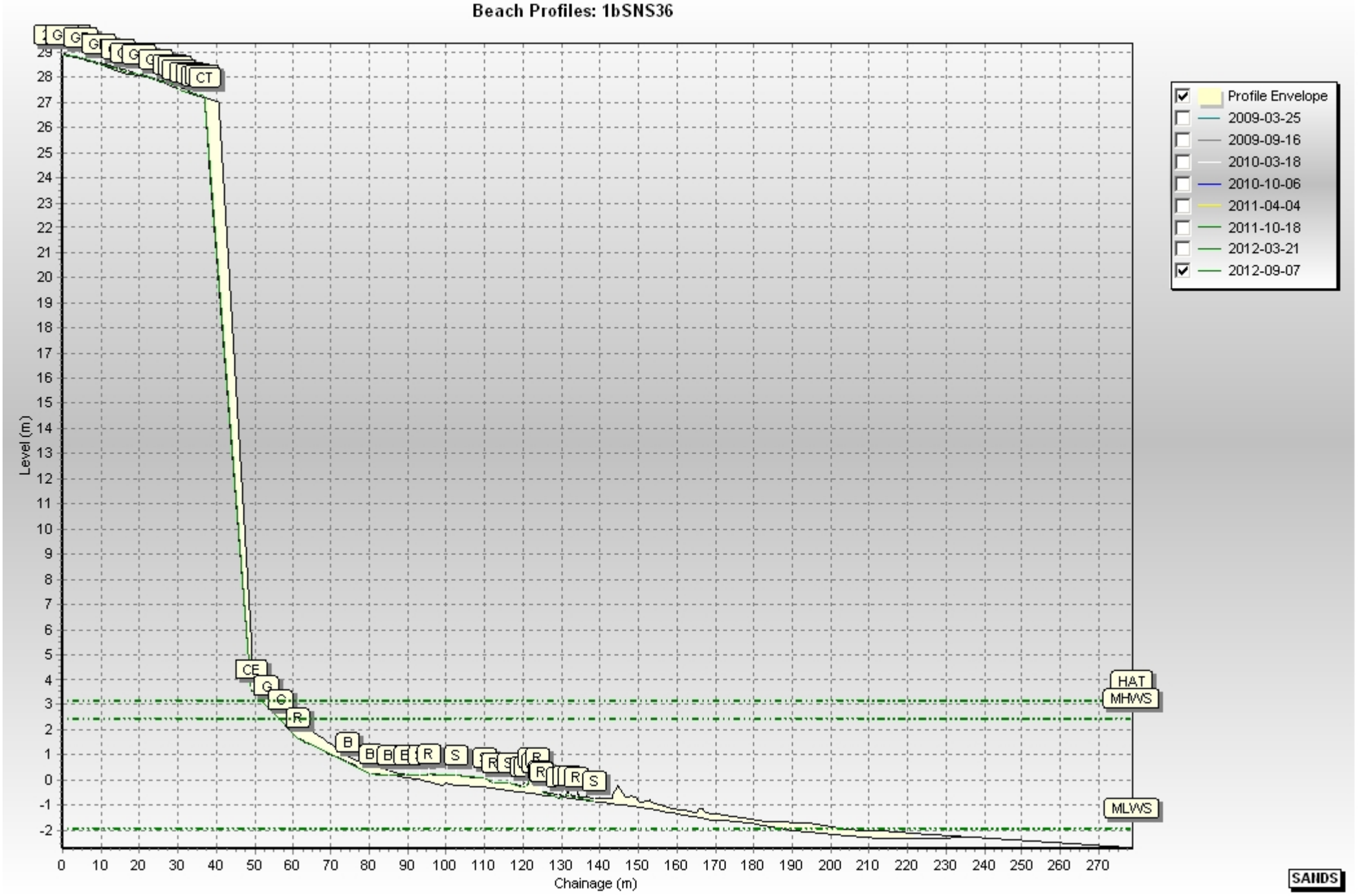
Chainage (m)
CT
CE
HAT
MHWS
MLWS
SANDS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2010-03-18
2010-10-06
2011-04-04
2011-10-18
2012-03-21
2012-09-07
HAT
MHWS
MLWS
SANDS

Appendix B

Topographic Survey

KEY

Elevation (m OD)

- 5 - 5.5
- 4.5 - 5
- 4 - 4.5
- 3.5 - 4
- 3 - 3.5
- 2.5 - 3
- 2 - 2.5
- 1.5 - 2
- 1 - 1.5
- 0.5 - 1
- 0 - 0.5
- -0.5 - 0
- -1 - -0.5
- -1.5 - -1
- -2 - -1.5
- -2 - -2
- Contour1m

Client: North East Coastal Group

Project: Cell 1 Regional Coastal Monitoring Programme 2011 to 2016

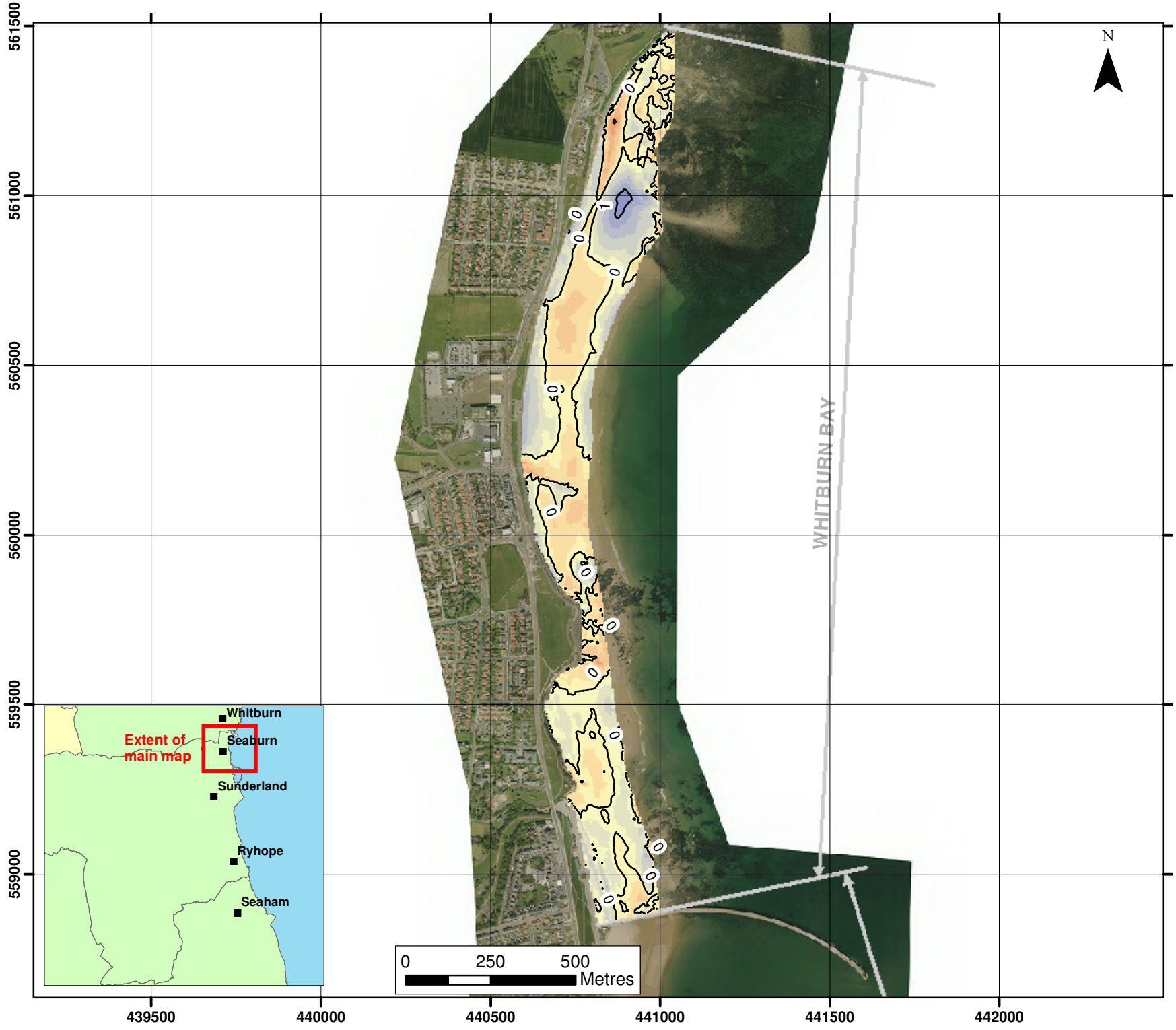
Appendix B - Map 1a
Topographic Survey
Whitburn Bay
Sunderland City Council

Analytical Report 5
Full Measures Survey
Autumn 2012

Halcrow
A CH2M HILL COMPANY

Halcrow Group Ltd, Lyndon House, 62 Hagley Road, Edgbaston, Birmingham, B16 8PE

Tel: +44 (0)121 456 2345
Fax: +44(0)121 456 1569
www.halcrow.com



KEY Autumn 2011 and Autumn 2012 Change in elevation (m)

- <-2
- -2 - -1.75
- -1.75 - -1.5
- -1.5- -1.25
- -1.25 - -1
- -1 - -0.75
- -0.75 - -0.5
- -0.5 - -0.25
- -0.25 - -0.1
- -0.1 - 0
- 0 - 0.1
- 0.1 - 0.25
- 0.25 - 0.5
- 0.5 - 0.75
- 0.75 - 1
- 1 - 1.25
- 1.25 - 1.5
- 1.5 - 1.75
- 1.75 - 2
- >2

Loss

Change < 0.1 m

Gain

Contours of change

Client: North East Coastal Group

Project: Cell 1 Regional Coastal Monitoring Programme 2011 to 2016

Appendix B- Map 1b Topographic Difference Whitburn Bay Sunderland City Council

Analytical Report 5
Full Measures Survey
Autumn 2012

Halcrow
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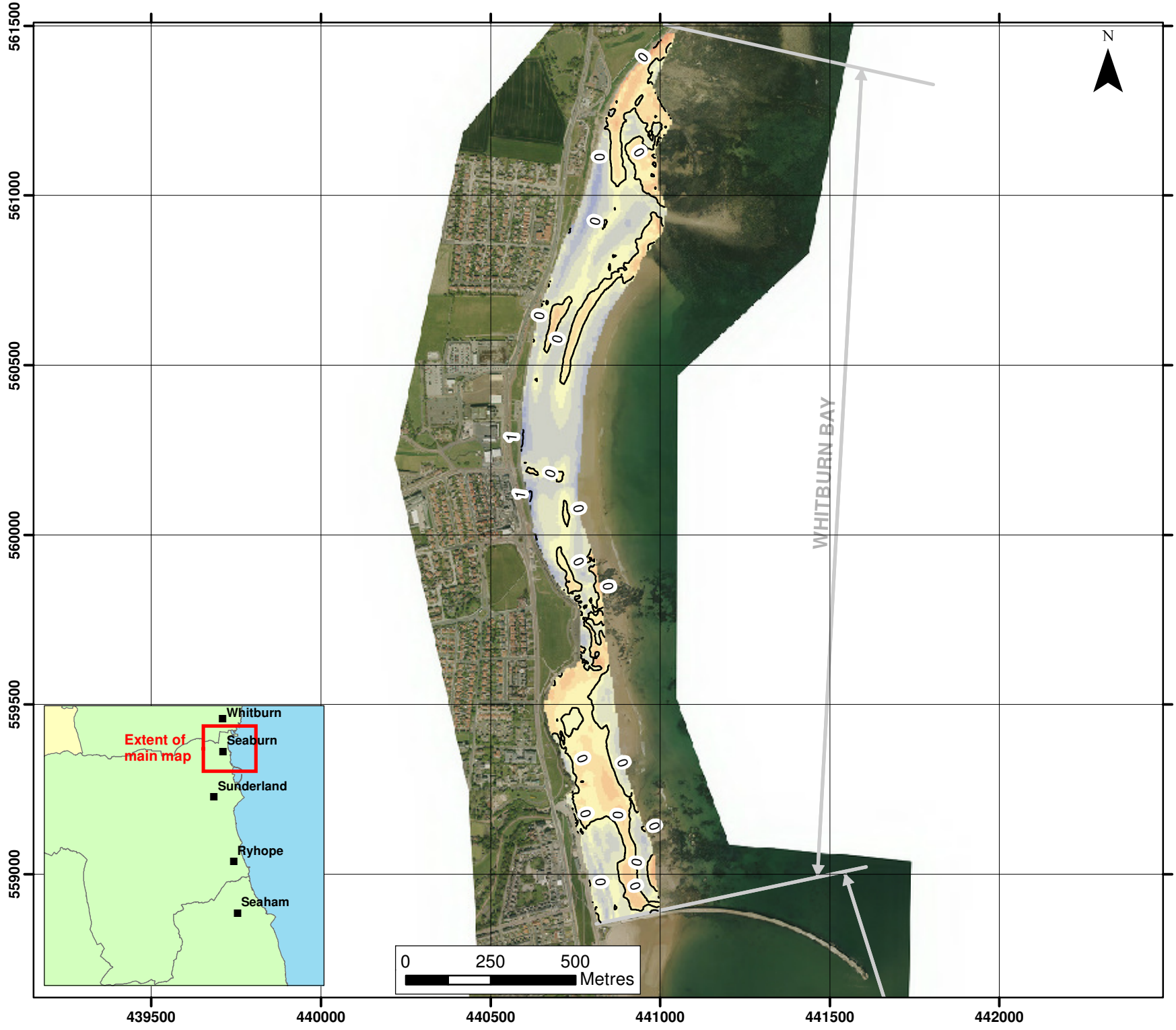
Fax: +44(0)121 456 1569
www.halcrow.com

Photography courtesy of North East Coastal Observatory
www.northeastcoastalobservatory.org.uk



KEY Autumn 2009 and Autumn 2012
Change in elevation (m)

- <-2
- -2 - -1.75
- -1.75 - -1.5
- -1.5- -1.25
- -1.25 - -1
- -1 - -0.75
- -0.75 - -0.5
- -0.5 - -0.25
- -0.25 - -0.1
- -0.1 - 0
- 0 - 0.1
- 0.1 - 0.25
- 0.25 - 0.5
- 0.5 - 0.75
- 0.75 - 1
- 1 - 1.25
- 1.25 - 1.5
- 1.5 - 1.75
- 1.75 - 2
- >2

Loss
Change < 0.1 m
Gain
Contours of change

Client: North East Coastal Group
Project: Cell 1 Regional Coastal Monitoring Programme 2011 to 2016

Appendix B- Map 1c
Long-term Elevation change
Whitburn Bay
Sunderland City Council

Analytical Report 5
Full Measures Survey
Autumn 2012

Halcrow
A CH2M HILL COMPANY
Halcrow Group Ltd, Lyndon House, 62 Hagley Road, Edgbaston, Birmingham, B16 8PE
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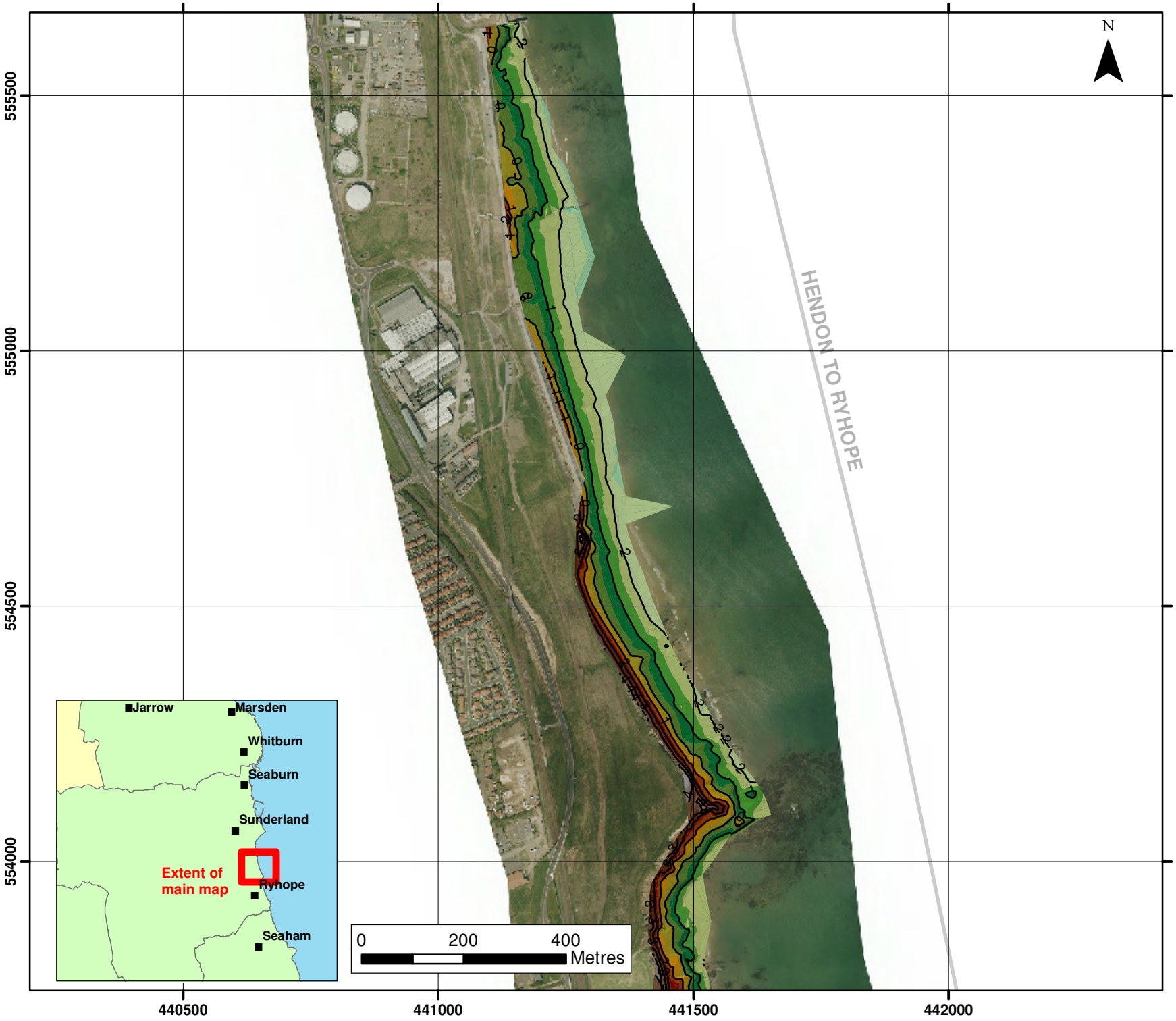
Fax: +44(0)121 456 1569
www.halcrow.com

Photography courtesy of North East Coastal Observatory
www.northeastcoastalobservatory.org.uk



KEY

Elevation (m OD)

- 5.5 - 6
- 5 - 5.5
- 4.5 - 5
- 4 - 4.5
- 3.5 - 4
- 3 - 3.5
- 2.5 - 3
- 2 - 2.5
- 1.5 - 2
- 1 - 1.5
- 0.5 - 1
- 0 - 0.5
- -0.5 - 0
- -1 - -0.5
- -1.5 - -1
- -2 - -1.5
- -2.5 - -2
- -3 - -2.5
- -3.5 - -3
- Contour 1m

Client: North East Coastal Group

Project: Cell 1 Regional Coastal Monitoring Programme 2011 to 2016

Appendix B - Map 2a Topographic Survey Hendon to Ryhope a Sunderland City Council

Analytical Report 5
Full Measures Survey
Autumn 2012

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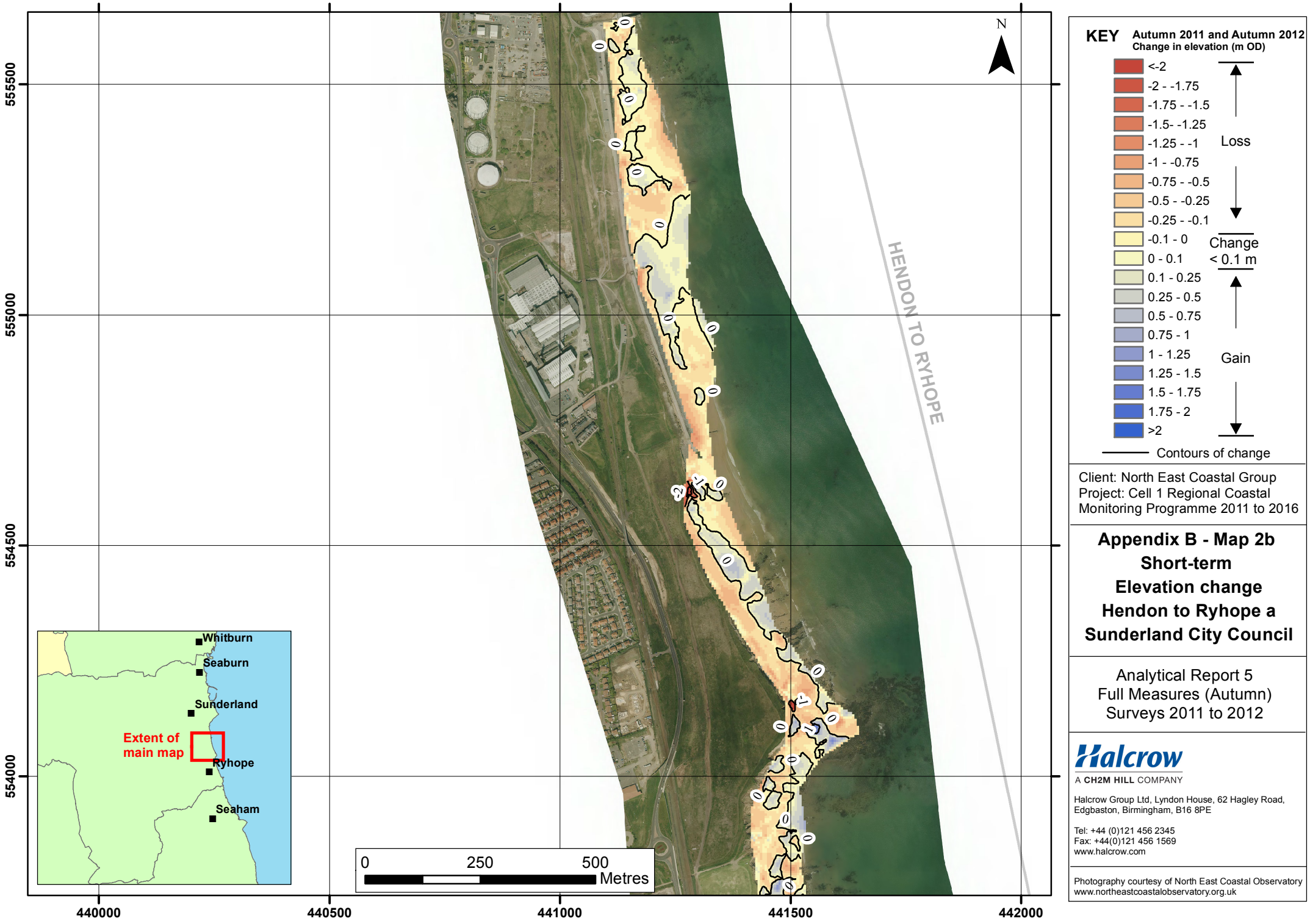
Fax: +44(0)121 456 1569
www.halcrow.com



Client: North East Coastal Group
Project: Cell 1 Regional Coastal Monitoring Programme 2011 to 2016

Appendix B - Map 2b
Short-term Elevation change
Hendon to Ryhope a Sunderland City Council

Analytical Report 5
Full Measures (Autumn) Surveys 2011 to 2012

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A CH2M HILL COMPANY

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Fax: +44(0)121 456 1569
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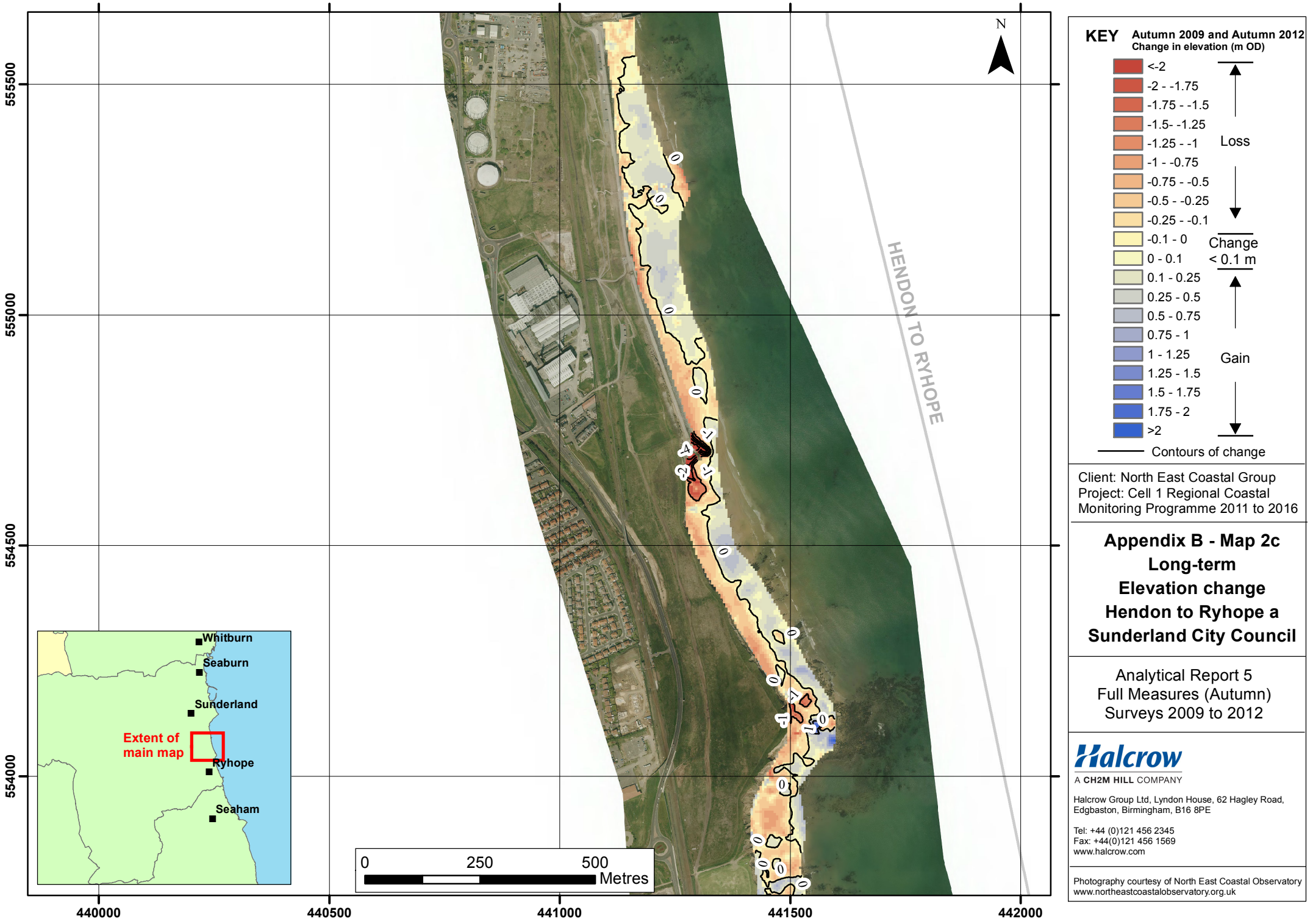
Photography courtesy of North East Coastal Observatory
www.northeastcoastalobservatory.org.uk



Client: North East Coastal Group
Project: Cell 1 Regional Coastal Monitoring Programme 2011 to 2016

Appendix B - Map 2c Long-term Elevation change Hendon to Ryhope a Sunderland City Council

Analytical Report 5
Full Measures (Autumn)
Surveys 2009 to 2012

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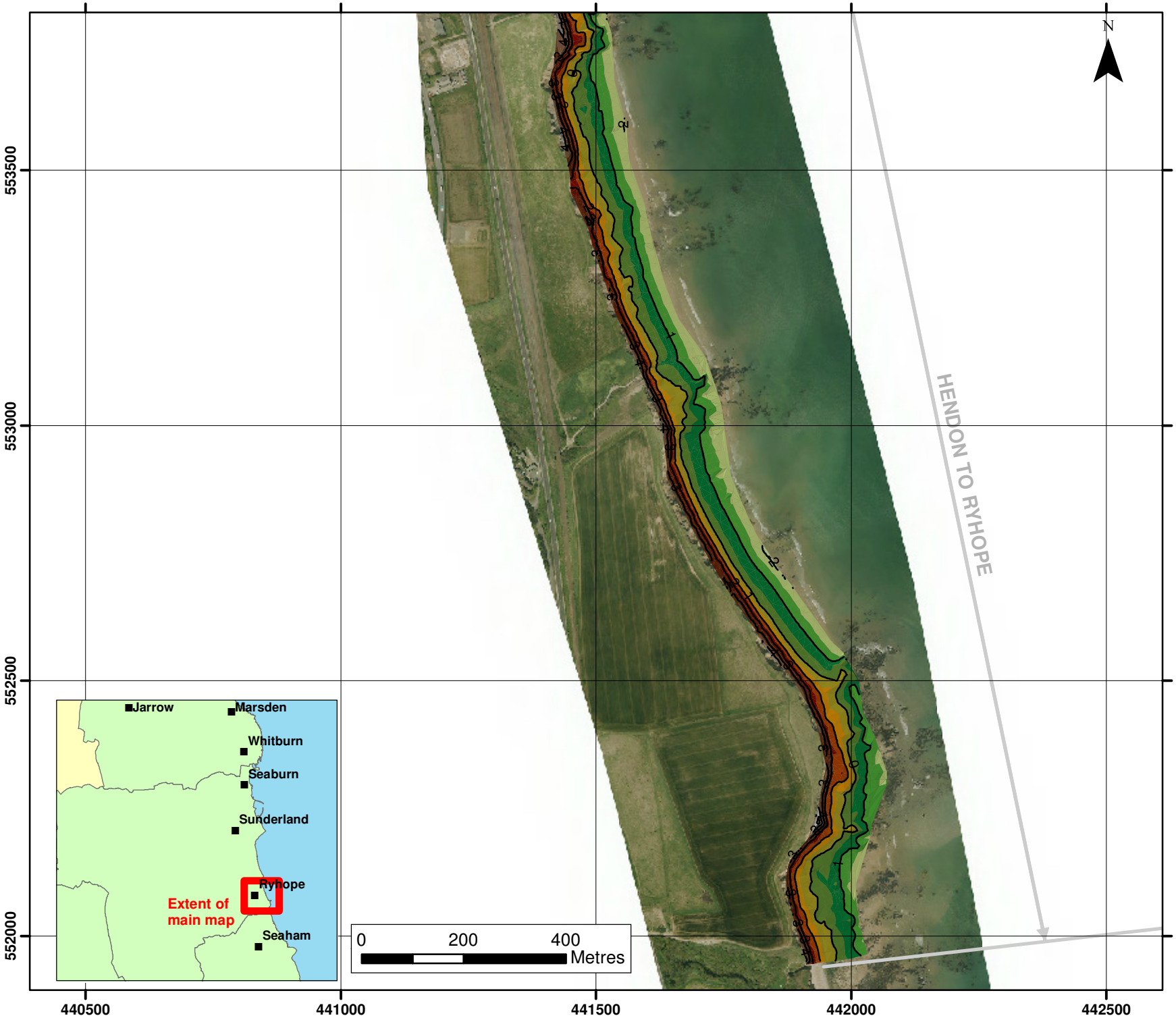

KEY

Elevation (m OD)

- 5.5 - 6
- 5 - 5.5
- 4.5 - 5
- 4 - 4.5
- 3.5 - 4
- 3 - 3.5
- 2.5 - 3
- 2 - 2.5
- 1.5 - 2
- 1 - 1.5
- 0.5 - 1
- 0 - 0.5
- -0.5 - 0
- -1 - -0.5
- -1.5 - -1
- -2 - -1.5
- -2.5 - -2
- -3 - -2.5
- -3.5 - -3
- Contour 1m

Client: North East Coastal Group

Project: Cell 1 Regional Coastal Monitoring Programme 2011 to 2016

Appendix B - Map 3a
Topographic Survey
Hendon to Ryhope
Sunderland City Council

Analytical Report 5
Full Measures Survey
Autumn 2012

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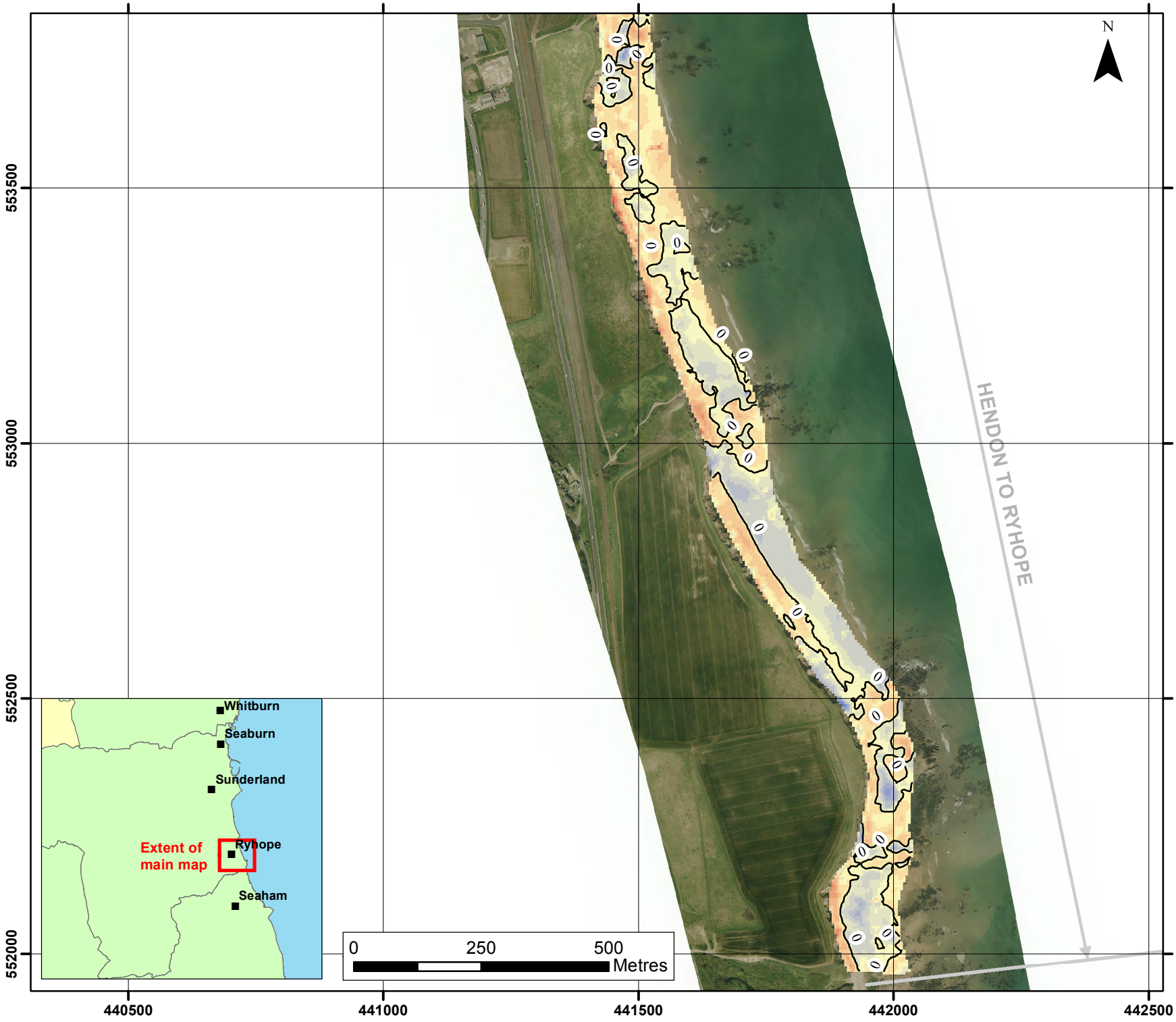

KEY Autumn 2011 and Autumn 2012
Change in elevation (m OD)

- <-2
- -2 - -1.75
- -1.75 - -1.5
- -1.5- -1.25
- -1.25 - -1
- -1 - -0.75
- -0.75 - -0.5
- -0.5 - -0.25
- -0.25 - -0.1
- -0.1 - 0
- 0 - 0.1
- 0.1 - 0.25
- 0.25 - 0.5
- 0.5 - 0.75
- 0.75 - 1
- 1 - 1.25
- 1.25 - 1.5
- 1.5 - 1.75
- 1.75 - 2
- >2

Loss
Change < 0.1 m
Gain
Contours of change

Client: North East Coastal Group
Project: Cell 1 Regional Coastal Monitoring Programme 2011 to 2016

Appendix B - Map 3b
Short-term Elevation change
Hendon to Ryhope b
Sunderland City Council

Analytical Report 5
Full Measures (Autumn)
Suverys 2011 to 2012

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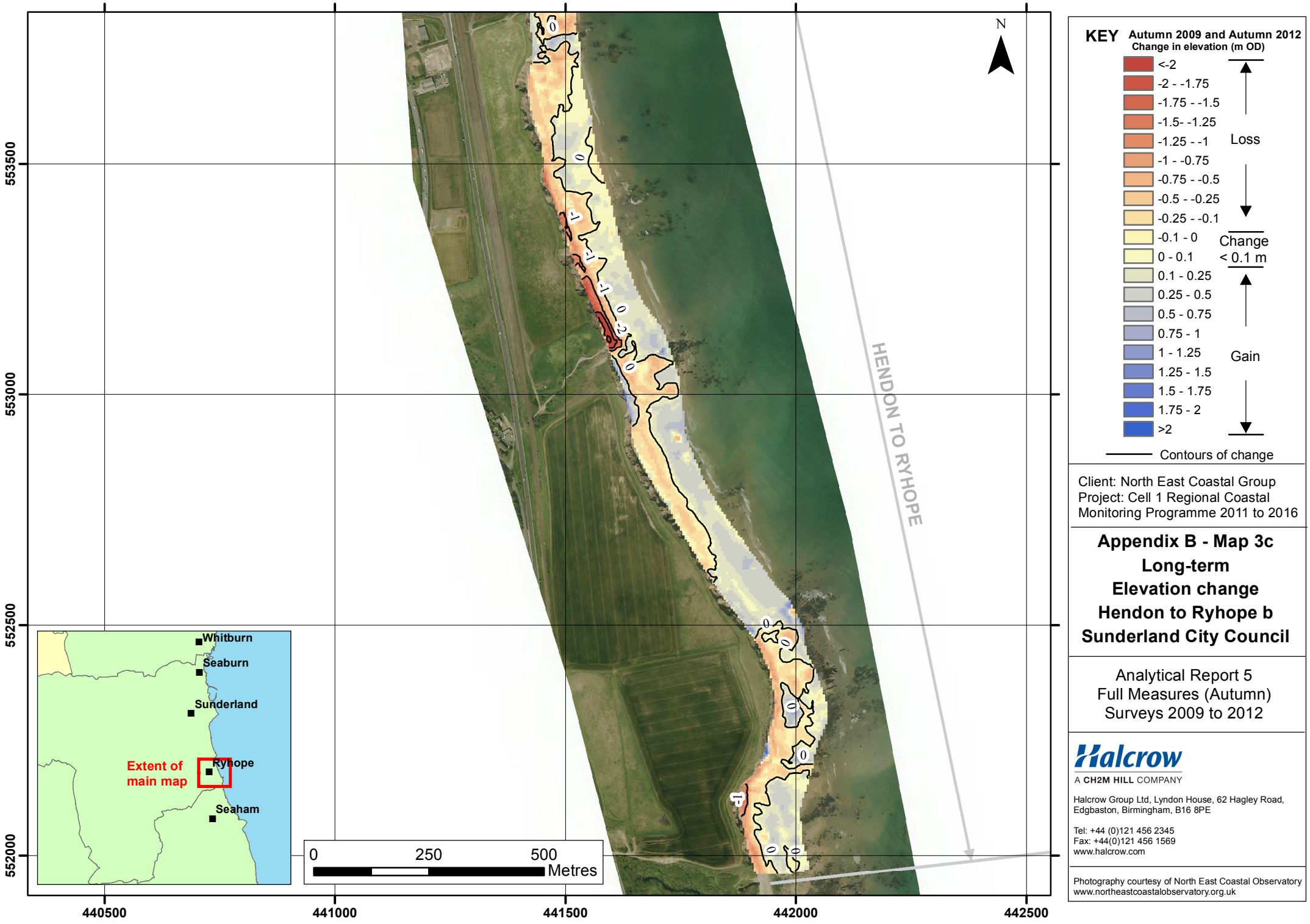

Client: North East Coastal Group
Project: Cell 1 Regional Coastal Monitoring Programme 2011 to 2016

Appendix B - Map 3c
Long-term Elevation change
Hendon to Ryhope b
Sunderland City Council

Analytical Report 5
Full Measures (Autumn)
Surveys 2009 to 2012

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Appendix C

Cliff Top Survey

Cliff Top Survey

Hendon and Ryhope

Thirty-two ground control points have been established between Hendon and Ryhope (Map 1 and Map 2). The maximum separation between any two points varies along the coast, reflecting the degree of risk from the erosion.

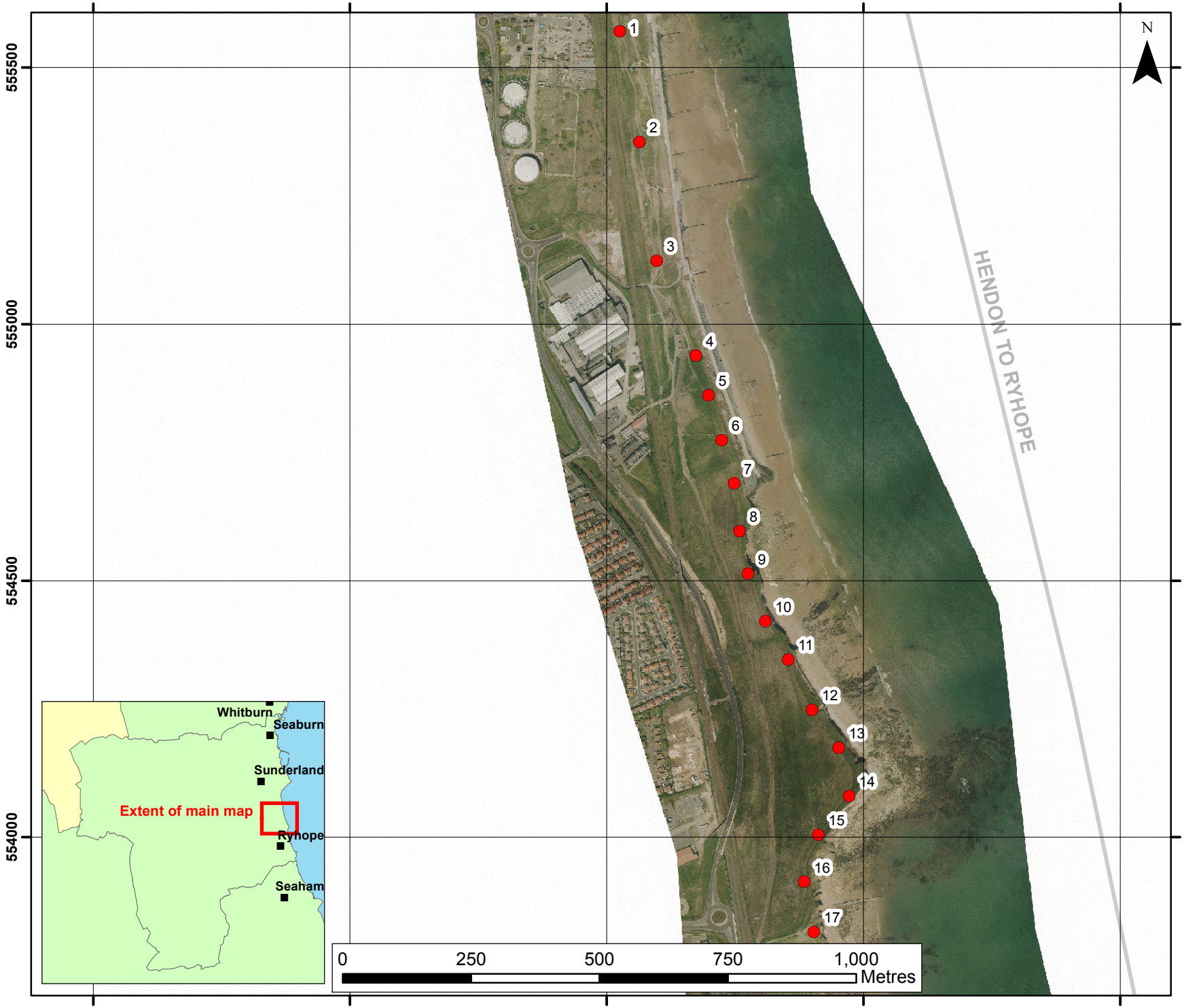
The cliff top surveys between Hendon and Ryhope are undertaken bi-annually. Measurements are taken from a fixed ground control point along a fixed bearing to the edge of the cliff top.

Table B1 provides baseline information about these ground control points and results from the 2009 (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 B1 – Cliff Top Surveys between Hendon and Ryhope

Ground Control Point Details				Distance to Cliff Top (m)			Total Erosion (m)		Erosion Rate (m/year)
Ref	Easting	Northing	Bearing (º)	Baseline Survey (Mar 09)	Previous Survey (Oct 2011)	Present Survey (Mar 2012)	Baseline (March 2009) to Present (Mar 2012)	Previous (Oct 2011) to Present (Mar 2012)	Baseline (March 2009) to Present (Mar 2012)
1	441025.7	555571.1	75	8.16	7.9	8.7	0.5	0.8	0.1
2	441064.4	555355.1	85	7.09	7.1	6.5	-0.6	-0.6	-0.2
3	441098	555124	82	10.01	10.4	10.4	0.4	0.0	0.1
4	441174	554938.7	65	10.3	10.4	10.5	0.2	0.2	0.1
5	441199.1	554861.1	65	7.71	7.6	7.8	0.1	0.2	0.0
6	441224.5	554774.2	71	10.83	10.8	11.0	0.1	0.1	0.0
7	441248.4	554690.3	74	10.18	10.4	10.3	0.2	-0.1	0.0
8	441259.3	554596.6	101	10.08	10.3	10.2	0.1	-0.1	0.0
9	441275.8	554513.4	66	10.52	6.7	6.6	-3.9	-0.1	-1.1
10	441309.4	554421.3	58	8.77	6.4	6.6	-2.2	0.1	-0.6
11	441354	554346.5	68	8.2	6.8	6.8	-1.4	0.0	-0.4

Ground Control Point Details				Distance to Cliff Top (m)			Total Erosion (m)		Erosion Rate (m/year)
Ref	Easting	Northing	Bearing (º)	Baseline Survey (Mar 09)	Previous Survey (Oct 2011)	Present Survey (Mar 2012)	Baseline (March 2009) to Present (Mar 2012)	Previous (Oct 2011) to Present (Mar 2012)	Baseline (March 2009) to Present (Mar 2012)
12	441400.2	554248.2	56	6.17	6.1	6.1	-0.1	0.0	0.0
13	441452.3	554174.7	63	11.61	11.9	11.8	0.2	-0.1	0.0
14	441472.3	554080.5	127	7.33	7.6	7.4	0.1	-0.1	0.0
15	441413	554005.1	122	7.84	8.0	8.0	0.1	0.0	0.0
16	441384.8	553913.3	90	9.89	9.9	10.0	0.1	0.1	0.0
17	441404.1	553815.5	93	6.32	6.5	6.5	0.1	0.0	0.0
18	441404.1	553723.6	119	8.1	8.2	8.1	0.0	-0.1	0.0
19	441398.5	553632.8	78	8.23	6.0	5.9	-2.4	-0.2	-0.7
20	441438.3	553452.9	71	10.09	7.0	6.9	-3.2	-0.1	-0.9
21	441506.1	553256.1	62	8.57	4.7	4.6	-4.0	-0.1	-1.2
22	441550.1	553158.7	103	6.57	6.7	6.7	0.1	0.0	0.0
23	441585.2	553076.5	64	8.11	8.0	8.0	-0.1	0.0	0.0
24	441624.4	552870.7	69	7.53	5.1	5.2	-2.3	0.1	-0.7
25	441689.1	552758	70	14.58	8.9	9.1	-5.5	0.3	-1.6
26	441715	552713.3	54	12.87	12.7	12.8	-0.1	0.1	0.0
27	441749.2	552674.4	62	14.56	10.5	10.7	-3.9	0.1	-1.1
28	441776.6	552629.9	57	8.62	4.6	4.6	-4.0	0.1	-1.2
28A	441798.6	552586.3	56	13.63	12.6	12.7	-0.9	0.1	-0.3
28B	441817.4	552542.4	64	12.30	11.17	11.3	-1.0	0.1	-0.3
28C	441852.2	552502.6	52	13.11	12.86	13.0	-0.1	0.1	0.0
29	441880.1	552471.6	83	15.46	15.1	15.2	-0.2	0.1	-0.1
30	441921.4	552269	97	8.55	8.0	7.9	-0.7	-0.1	-0.2
31	441853.1	552094	75	11.2	7.9	7.9	-3.4	0.0	-1.0
32	441883.3	551988.5	96	9.82	7.6	6.4	-3.4	-1.2	-1.0



KEY

- Ground Control Points

Client: North East Coastal Group

Project: Cell 1 Regional Coastal Monitoring Programme 2011 to 2016

Appendix B - Map 1
Ground Control Points
Hendon to Ryhope North
Sunderland City Council

Analytical Report 5
Full Measures Survey
Winter 2012

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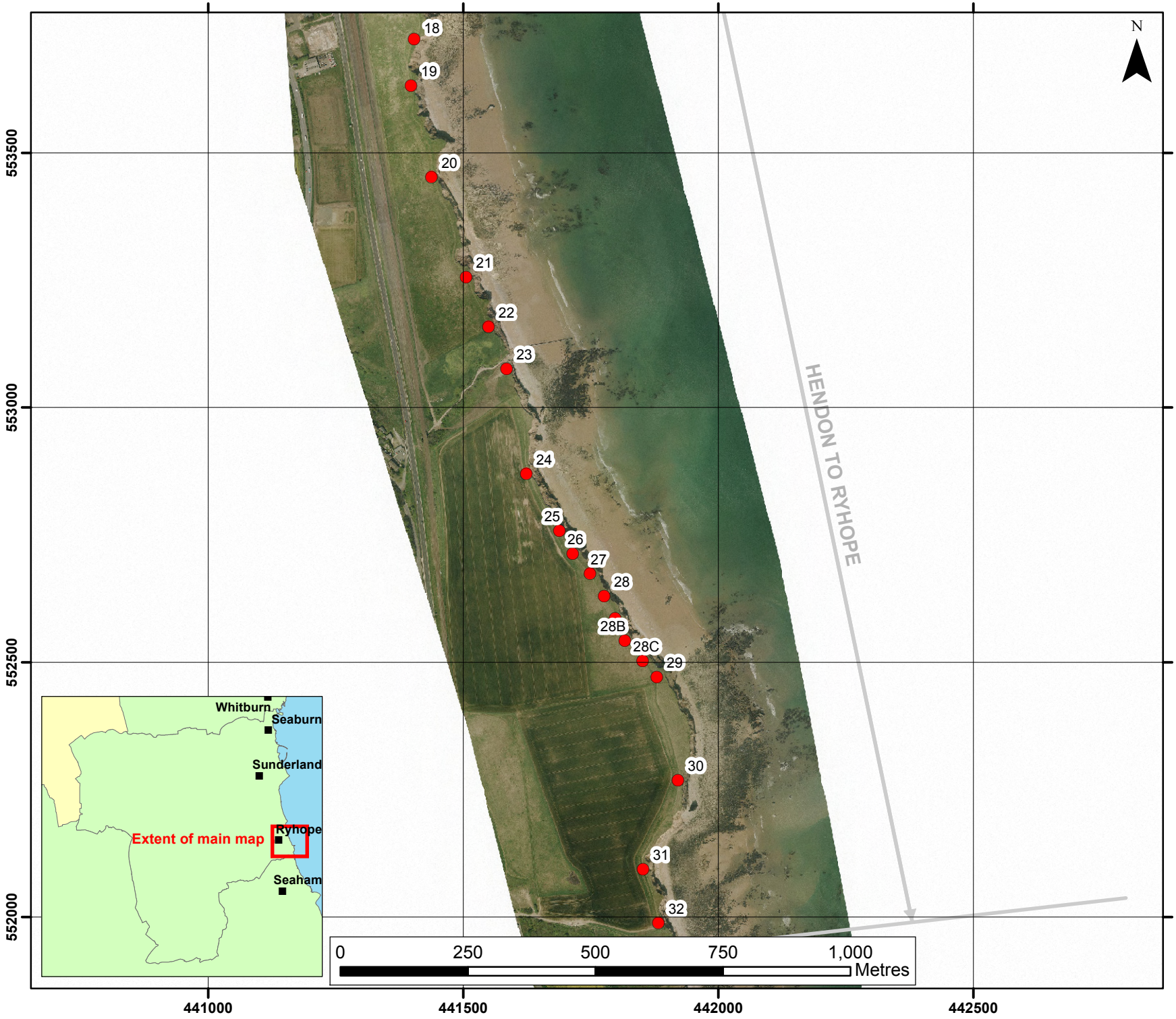

KEY

- Ground Control Points

Client: North East Coastal Group

Project: Cell 1 Regional Coastal Monitoring Programme 2011 to 2016

Appendix B - Map 2
Ground Control Points
Hendon to Ryhope South
Sunderland City Council

Analytical Report 5
Full Measures Survey
Winter 2012

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