CH2MHILL
Halcrow

Cell 1 Regional Coastal Monitoring Programme
Analytical Report 6: 'Full Measures' Survey 2013

Sunderland City Council

Sunderland City Council
Final Report

February 2014

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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.

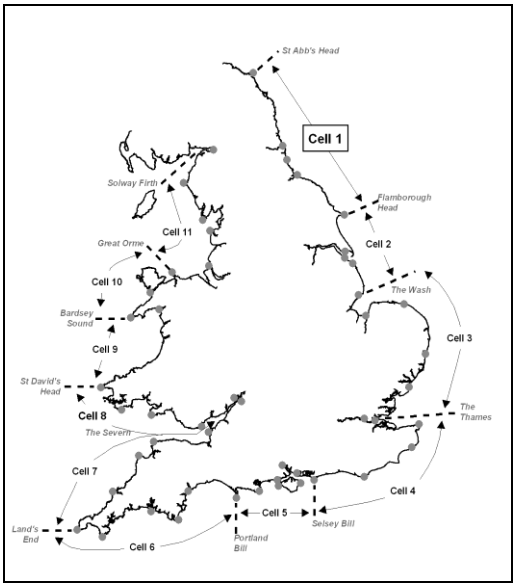


Figure 1 Sediment Cells in England and Wales

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
North Tyneside Council
South Tyneside Council
Northumberland Coast AONB
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 (rebranded as CH2M HILL since 2013).

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 13	Mar-May 13	Jun 13	-
6	2013/14	Sept-Oct 2013	Feb 14(*)			

(*) The present report is **Analytical Report 6** and provides an analysis of the 2013 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 2nd and 11th September 2013, and 3rd and 4h October 2013. 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.

1.3 Uncertainties in data and analysis

While uncertainty due to survey accuracy or systematic error is likely to be present in all datasets, the work is carefully managed to ensure data are as accurate as possible and results are not misleading. Error may arise from the limits of precision of survey techniques used, from low accuracy measurements being taken or from systematic failings of equipment.

For beach profiles and topographic surveys, all incoming data are checked allowing systematic errors to be identified, and removed from plots and subsequent analysis. The accuracy of these surveys is not known, but it is likely that all measurements are correct to ±0.1m. Therefore, changes less than ±0.1m are ignored and greyed out in the topographic change plots. For cliff top erosion surveys, there are commonly problems in precisely recognising the cliff edge due to vegetation growth and the convex shape of the feature. Errors can manifest themselves as results that suggest the cliff edge has advanced, which is very unlikely unless a toppling failure has been initiated, but the block has not yet fully detached. The accuracy of cliff top surveys are also unknown, but it is assumed that each measurement is accurate to ±0.1m.

These limits of accuracy mean that comparison of annual or biannual data can be of limited value if the measured change is less than or equal to the assumed error. However, all results become more significant over longer time periods when the errors in measurement in years 1 and *x* are averaged over the monitoring period:

$$\text{Error rate of change per year} = \frac{\text{Error in first measurement} + \text{Error in last measurement}}{\text{Years between measurements}}$$

The effect of averaging error over different monitoring periods is summarised in Table 3, which assumes that each annual survey is accurate to 0.1m.

Table 3 Error bands for long-term calculations of change.

Years between surveys	Error bands in inter-survey comparison (±m/yr)
1	0.200
2	0.100
3	0.067
4	0.050
5	0.040
5	0.033
7	0.029
8	0.025
9	0.022
10	0.020

While considering the uncertainty in comparing and analysing change between monitoring data sets it is also relevant to raise caution about drawing conclusions about short or longer term trends. Clearly the longer the data set the more confidence that can be given to likely ranges of beach changes and trends in change. Potential for seasonal, annual and longer term cycles need to be considered. Studies of long term monitoring data sets for other coastal and estuarial data have established that there are long period cyclical trends related to the 18.6 years lunar nodal cycle which need to be accounted for. Simply put this means that although the Cell 1 monitoring programme now has data in some locations up to 11 years, another 8 to 10 years of consistent data is needed before confidence can be given in trends from the analysis. In the context of this report “Longer Term Trends” are mentioned in each section and it should be noted that this is based on simple visual interpretation of the available data since the current programme began, and is generally based on only 5 to 10 years of data.

2. Wave Data and Interpretation.

2.1 Introduction

Wave monitoring data relevant to the Cell 1 Regional Coastal Monitoring Programme is available from one offshore regional wave buoy located at Tyne and Tees and three regional wave buoys, which are further inshore at Newbiggin, Whitby and Scarborough. The Tyne Tees buoy is managed by Cefas as part of the WaveNet system, while the three inshore buoys is managed by Scarborough BC as part of the Cell 1 monitoring programme.

An assessment of baseline wave data is presented in the 2011 Wave Data Analysis Report, which reviewed all readily available data in the region. In 2014 a wave data update report will update the baseline with analysis of the wave data collected under the programme for 2013, including the 5th and 6th December storm. In order to help put the beach and cliff changes discussed in this report into context analysed storm data for the wave buoys is presented in this section.

The longest consistent relevant wave data record in the Cell 1 region is from the WaveNet Tyne Tees buoy deployed under the national coastal monitoring programme by Cefas. Data has been downloaded from WaveNet and loaded into SANDS for analysis alongside the beach and cliff monitoring data. Results from analysis of the data to extract details of significant storms are presented in Table 3 below.

To aid interpretation of the results in Table 3 alternate years have been shaded and the storm with the largest peak wave height each year has been highlighted in bold. The annual storm with the highest wave energy at peak has also been highlighted in bold red text as this depends on wave period as well as wave height and so is not always the same as the largest wave height, e.g. in 2009 and 2010.

Table 4: SANDS Storm Analysis at Tyne/Tees WaveNet Buoy

General Storm Information					At Peak			
Start Time	**End Time**	**Duration (Hours)**	**Peak of Storm**	**Mean Direction Vector (Degrees)**	**Hs (m)**	**Tp (s)**	**Direction (Degrees)**	**Energy @ Peak (KJ/m/s)**
19/03/2007 10:30	21/03/2007 05:30	43	20/03/2007 14:30	79.0	6.2	12.4	22	11759.3
25/06/2007 20:00	26/06/2007 13:30	17.5	26/06/2007 10:00	81.6	4.4	8.6	22	2832.6
26/09/2007 03:00	27/09/2007 05:00	26	26/09/2007 19:00	80.4	4.6	11.6	6	5488.7
08/11/2007 20:00	**12/11/2007 15:00**	**91**	**09/11/2007 08:30**	**78.7**	**6.2**	**13.4**	**6**	**13698.9**
19/11/2007 03:30	25/11/2007 21:30	162	23/11/2007 05:00	78.8	4.9	10.7	17	5353.7
08/12/2007 03:00	10/12/2007 14:30	59.5	08/12/2007 03:30	85.1	4.1	10.8	17	3816.4
03/01/2008 10:30	04/01/2008 01:30	15	03/01/2008 23:30	14.8	4.2	9.1	62	2964.9
01/02/2008 15:00	02/02/2008 09:30	18.5	02/02/2008	80.9	6.0	13.8	17	13641.7
10/03/2008 08:30	10/03/2008 12:30	4	10/03/2008 11:00	307.6	4.6	8.0	141	2631.9
17/03/2008 15:00	**25/03/2008 03:00**	**180**	**22/03/2008 05:00**	**83.8**	**7.9**	**12.4**	**6**	**19123.9**
05/04/2008 22:00	07/04/2008 05:00	31	06/04/2008 19:00	83.8	4.6	11.6	6	5520.5
20/07/2008 16:00	21/07/2008 09:30	17.5	20/07/2008 23:30	75.9	4.2	9.9	11	3492.5
03/10/2008 03:00	03/10/2008 20:30	17.5	03/10/2008 16:30	82.4	4.7	11.4	22	5728.4
21/11/2008 04:00	25/11/2008 12:30	104.5	22/11/2008 11:30	75.8	6.0	13.1	11	12267.5

General Storm Information					At Peak			
Start Time	**End Time**	**Duration (Hours)**	**Peak of Storm**	**Mean Direction Vector (Degrees)**	**Hs (m)**	**Tp (s)**	**Direction (Degrees)**	**Energy @ Peak (KJ/m/s)**
10/12/2008 12:00	13/12/2008 18:00	78	13/12/2008 08:00	331.9	4.9	8.3	129	3286.2
31/01/2009 16:30	03/02/2009 09:00	64.5	02/02/2009 22:00	7.1	5.8	9.5	84	6078.5
23/03/2009 20:30	28/03/2009 20:30	120	28/03/2009 18:30	89.7	4.9	9.3	0	4053.0
10/07/2009 01:30	10/07/2009 02:30	1	10/07/2009 01:30	78.8	4.2	9.9	11	3504.3
29/11/2009 20:00	**30/11/2009 15:00**	**19**	**30/11/2009 00:30**	**73.4**	**6.0**	**9.4**	**11**	**6331.4**
17/12/2009 10:30	18/12/2009 05:00	18.5	17/12/2009 19:30	26.4	5.4	10.6	68	**6549.5**
30/12/2009 09:00	30/12/2009 23:00	14	30/12/2009 12:30	7.7	5.1	7.5	90	2866.0
06/01/2010 05:30	06/01/2010 11:00	5.5	06/01/2010 06:30	63.7	4.2	10.7	11	4044.1
29/01/2010 10:30	30/01/2010 00:30	14	29/01/2010 22:30	83.9	5.4	8.6	6	4258.2
26/02/2010 22:30	27/02/2010 02:30	4	27/02/2010 01:00	72.6	4.6	8.5	17	2925.7
19/06/2010 07:00	20/06/2010 08:30	25.5	19/06/2010 20:00	69.4	5.4	10.7	22	**6611.8**
29/08/2010 14:00	30/08/2010 06:30	16.5	29/08/2010 22:30	91.8	4.9	8.9	0	3715.5
06/09/2010 22:30	07/09/2010 16:00	17.5	07/09/2010 15:30	353.3	4.6	8.8	90	3192.5
17/09/2010 07:00	17/09/2010 18:30	11.5	17/09/2010 08:30	80.8	4.7	11.0	11	5323.3
24/09/2010 03:00	26/09/2010	45	24/09/2010 10:00	73.1	5.3	10.1	11	5564.7
20/10/2010 02:00	24/10/2010 16:30	110.5	20/10/2010 10:00	78.3	4.2	11.3	17	4514.5
08/11/2010 14:00	**09/11/2010 20:30**	**30.5**	**09/11/2010 10:00**	**3.1**	**5.6**	**8.8**	**73**	**4870.6**
17/11/2010 11:00	17/11/2010 18:30	7.5	17/11/2010 12:00	322.2	4.7	7.8	129	2646.0
29/11/2010 19:30	02/12/2010 08:30	61	29/11/2010 21:00	11.8	5.1	9.4	56	4474.2
16/12/2010 15:00	17/12/2010 06:30	15.5	17/12/2010 03:30	80.2	4.6	10.5	17	4504.6
23/07/2011 14:00	**24/07/2011 11:00**	**21**	**24/07/2011 03:00**	**67.5**	**4.7**	**10.8**	**17**	**5082.6**
24/10/2011 18:30	25/10/2011 09:30	15	25/10/2011 09:30	348.5	4.1	9.5	79	2986.1
09/12/2011 08:30	09/12/2011 10:00	1.5	09/12/2011 08:30	84.4	4.1	11.9	6	4669.0
05/01/2012 15:30	06/01/2012 05:00	13.5	06/01/2012 00:30	81.4	4.5	9.9	14	3896.6
03/04/2012 13:30	04/04/2012 10:30	21	04/04/2012 03:00	26.5	5.7	8.4	90	4510.0
24/09/2012 07:30	25/09/2012 11:00	27.5	24/09/2012 17:30	17.2	5.3	9.3	77	4786.2
26/10/2012 12:00	27/10/2012 15:00	27	26/10/2012 23:00	78.9	4.9	12.9	11	**7839.9**
05/12/2012 15:00	**15/12/2012 01:30**	**226.5**	**14/12/2012 18:30**	**39.6**	**6.1**	**8.4**	**107**	**5080.9**
20/12/2012 06:00	21/12/2012 14:30	32.5	20/12/2012 23:30	347.3	6.0	8.8	103	5436.3
18/01/2013 17:30	22/01/2013 07:30	86	21/01/2013 09:30	7.6	6.8	9.3	83	7978.4
06/02/2013 08:00	07/02/2013 08:30	24.5	06/02/2013 12:30	82.6	5.6	9.9	11	6039.7
07/03/2013 21:00	11/03/2013 04:00	79	08/03/2013 04:00	24.3	5.1	8.4	82	3667.4
18/03/2013 07:00	**25/03/2013 02:00**	**163**	**23/03/2013 10:30**	**4.5**	**7.3**	**9.3**	**89**	**9164.3**

General Storm Information					At Peak			
Start Time	**End Time**	**Duration (Hours)**	**Peak of Storm**	**Mean Direction Vector (Degrees)**	**Hs (m)**	**Tp (s)**	**Direction (Degrees)**	**Energy @ Peak (KJ/m/s)**
23/05/2013 18:00	24/05/2013 12:00	18	23/05/2013 22:30	77.5	6.7	10.5	17	**9678.4**
10/09/2013 13:00	10/09/2013 19:30	6.5	10/09/2013 14:00	79.3	4.4	9.2	11	3237.0
29/11/2013 22:30	30/11/2013 05:30	7	30/11/2013 00:30	82.8	5.6	10.7	11	7071.5
05/12/2013 14:00	07/12/2013 04:30	38.5	06/12/2013 20:00	80.4	4.7	14.3	6	8937.4
27/12/2013 09:30	27/12/2013 12:30	3	27/12/2013 10:00	249.3	4.1	6.1	202	1237.4

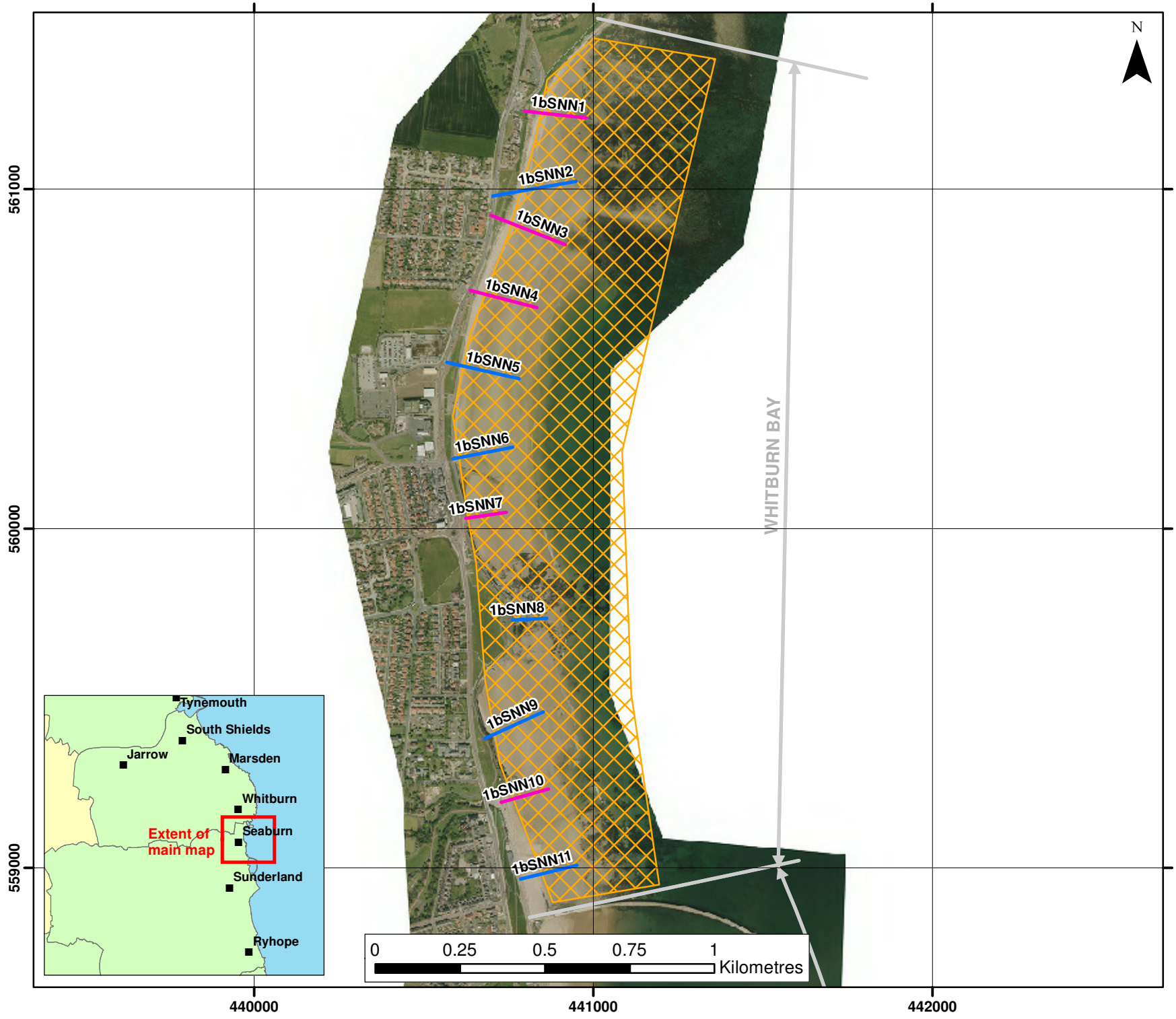
The storms mostly arrive from the north to northeast direction, 0 to 40 degrees, which has the longest fetch, but there are also a significant number of storms from other directions, particularly 80 to 140 degrees.

Comparing the annual storm records it can be seen that 2010 had the most storms (13). In 2010 the largest storm had an incident direction of 73 degrees which is unusual. We might therefore expect that the alongshore drift on the Cell 1 beaches in 2010 may have been atypical with unusual changes from the storm conditions. This was noted in several of the 2010 Full Measures reports.

The year with the fewest storms was 2011. This was reflected by accretion recorded in a number of the annual Full Measures reports.

The winter of 2012 to 2013 appears to have suffered with larger storms than usual, with the second largest peak wave height (7.3m) recorded on 23rd March 2013. The longest duration storm in the record was from 5th to 15th December 2012 (226.5 hours).

The storm on the 5th to 7th December, was particularly notable. Although this event did not have such large waves as the 23rd March 2013 storm, it had a high peak energy and exceptionally long wave period at 14.3 seconds. The 6th December storm was also accompanied by a significant storm surge with recorded water levels around 1.75m higher that predicted tides in some locations. The combined high water levels and large waves causing significant damage to many coastal defences and beaches in the north east. However, the Autumn 2013 full-measures survey data set which is assessed in this report was collected in September and October and as no post storm surveys were available the impacts will be seen until the Spring 2014 Partial Measures surveys.



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 6
Full Measures Survey
Autumn 2013

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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 2
Survey Locations
Sunderland Harbour and Docks
Sunderland City Council

Analytical Report 6
Fulll Measures Survey
Autumn 2013

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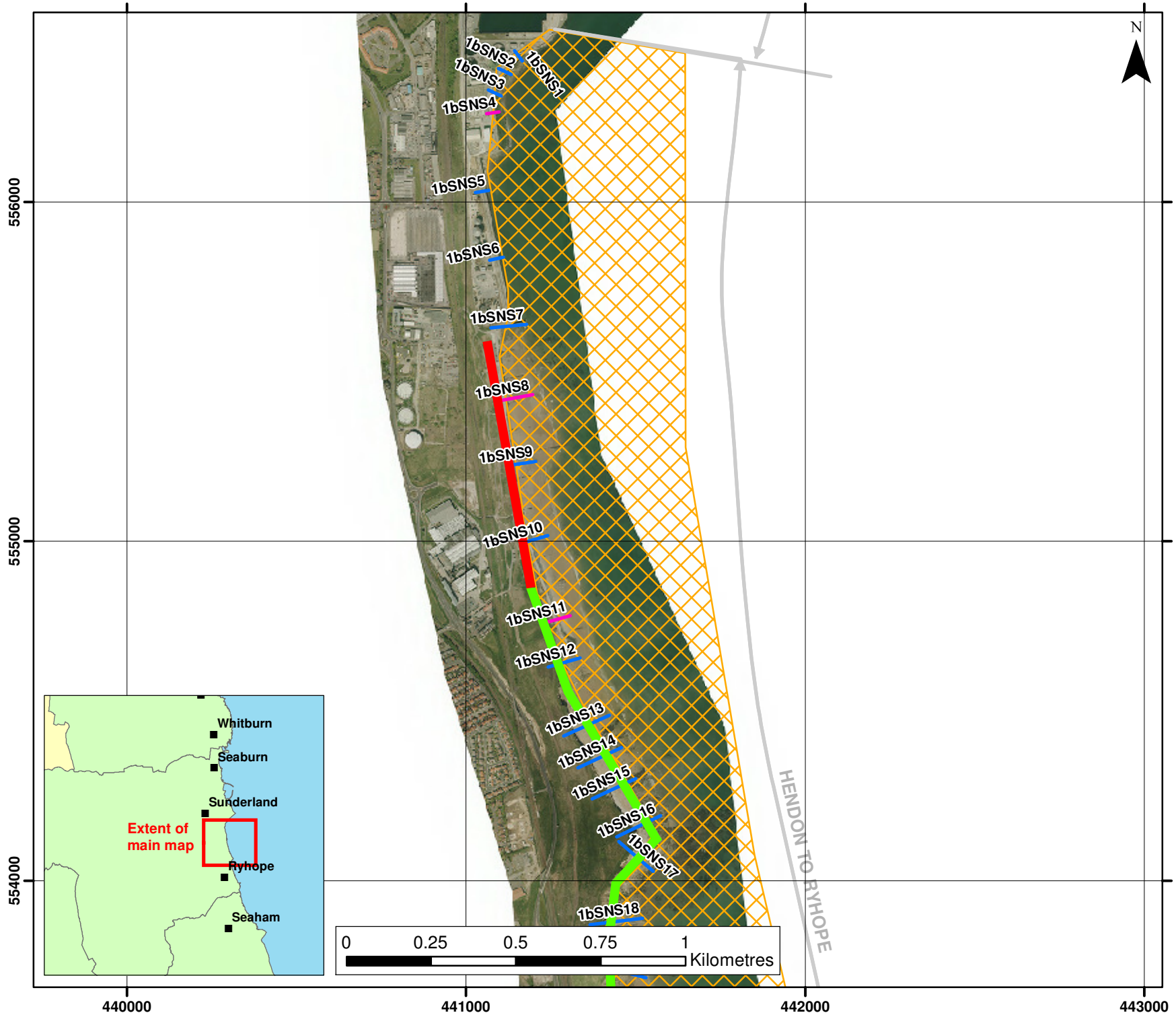

KEY

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 6
Full Measures Survey
Autumn 2013

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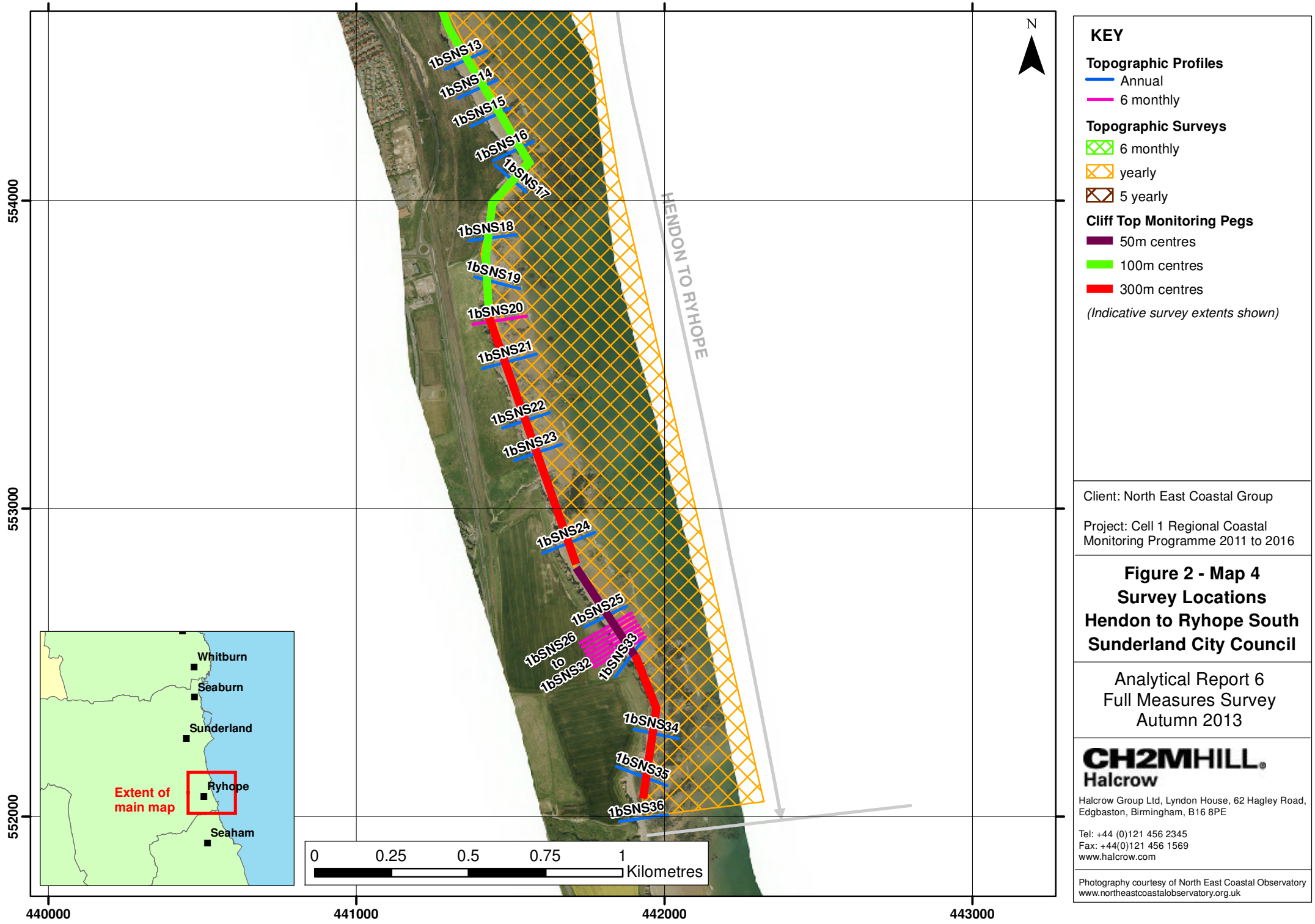

KEY

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 6
Full Measures Survey
Autumn 2013

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3. Analysis of Survey Data

3.1 Whitburn Bay

Survey Date	Description of Changes Since Last Survey	Interpretation
Oct 2013	**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 2012 and the previous partial measures survey was undertaken in spring 2013. **1bSNN1** is just to the south of Sunderland City Council's northerly boundary of jurisdiction. Since the last survey (partial measures, spring 2013) the dune profile and rocky sections of the profile have remained stable. The beach profile shows a trend of accretion and now forms a smoother slope with less distinct slope changes between the upper middle and lower beach. There is accretion of the upper beach of up to 0.6m and accretion of the toe by about 0.3m. The slope face between these two locations has cut back slightly. 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 have decreased across the profile. Beach levels have fallen by up to 0.7m on the upper/middle slope, by up to 0.9m at the toe and by approximately 0.1m between. The berm noted at HAT in the previous survey (autumn 2012) is now more distinct. At **1bSNN3** the profile has also become less smooth with greater changes in gradient along the slope. The beach levels have fluctuated around the previous survey with a slight decrease in level on the upper beach and increase in level along the middle part of the beach. There is a sharp dip in level at about 216m chainage where a trough has formed behind the berm which has developed at the toe of the toe beach. 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 fluctuated with the development of a berm towards the toe of the profile (167m chainage seawards) and a smaller berm at the toe of the sea wall (at around HAT). Water has collected in the trough landwards of the lower berm as can been seen in Plate 1. Overall there is no clear trend of erosion or accretion. At profile **1bSNN5**, a	Along the length of Whitburn Bay, beach levels have generally remained stable, however there has been a change in profile shape as material has been redistributed. Many profiles show an increase in elevation at the toe of the profile where berms have formed and a decrease in beach elevation at other points along the profile. Profile 1bSNN2 and 1bSNN6 show beach levels have decreased significantly. This trend was also seen in the previous survey and is reflected in the topographic survey here (see below). **Longer term trends:** Along the length of the beach, beach levels have fluctuated, however, the changes observed in the present surveys are largely within the bounds of previous surveys. Exceptions are: Profile 1bSNN6 which is at the lowest level recorded since the surveys started in 2009, Profiles 1bSNN10 and 1bSNN11 where the lower part of the profile are at the lowest recorded since monitoring began Profile1bSNN4 where the levels are within bounds of previous survey along much of profile but toe berm has increased to higher level than previously recorded and the trough landward of this is lower than

Survey Date	Description of Changes Since Last Survey	Interpretation
	similar trend is observed with the beach slope becoming less smooth and berms developing on the profile. Three berms have developed; one at approximately 140m to 230m chainage, a second at 230m chainage to the seaward end of the profile and as with the other profiles a small berm at HAT. There is no clear trend of erosion or accretion of the profile. At profile **1bSNN6**, beach levels have fallen quite significantly across the profile; by up to 0.4m at the toe of the revetment steps (Plates 3 and 4) and between 0.2m and 0.6m across the rest of the profile. The profile shows similar changes in slope to profiles **1bSNN4** and **1bSNN5**, with the development of a relatively large berm towards the beach toe (167m chainage seawards) and a small berm at about HAT. **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 fluctuated across the profile. The upper beach, from the toe of the sea wall to about 75m chainage, has steepened resulting in a small decrease in beach level. A berm has developed seawards of this steeper upper beach, resulting in increased beach levels between 95m and 135m chainage, and steepening of the profile toe. Profile **1bSNN8** extends across Parsons Rock. There are no discernable changes in this profile since the previous full measures survey (autumn 2012) 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. A trough has formed at the toe of the beach which results in erosion of about over 1m at approximately 180m chainage. **1bSNN10** is located approximately mid-way between Parson's Rock and Roker Pier. Since the last survey (partial measures, spring 2013) the material has been redistributed across the profile, with the beach profile becoming smoother and the berm at HAT becoming less distinct. The beach levels have increased slightly at the toe of the sea wall and across much of the upper beach, while they have fallen at the toe of the beach as the berm feature has moved landwards. **1bSNN11** is located to the south of Whitburn. Beach levels have decreased across this profile, with the exception of a small area of increase within 20m of the sea wall toe. The upper beach has cut back by about 0.25m but the lower beach has cut back by a larger amount (up to 1m), resulting in a steeper beach profile.	previously recorded.
Oct 2013	**Topographic Survey:** Whitburn Bay, between the Bents and Roker Pier, is covered by an annual topographic survey which	The topographic survey shows that since the last survey, there has been a mixture of beach elevation increase and decrease across the beach. Overall,

Survey Date	Description of Changes Since Last Survey	Interpretation
	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 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 2012) and the present survey. The difference plot shows that the majority of the beach has slightly decreased in level or remained stable. There are small areas of accretion, in particular to the north of the bay in the lee of Whitburn Steel Rocks and towards the middle of the bay, immediately south of Parsons Rock. There is also a pocket of significant erosion near MLW just north of Roker Pier, where over a metre has been lost. **Longer Term Topographic Trends Autumn 2010 to Autumn 2013:** The long term difference plot (Appendix B – Map 1c) shows the net change in beach levels between autumn 2010 and autumn 2013 and has a similar pattern to that seen over the past year. The plot shows a net increase in beach levels along the back of the beach, near MLW from Whitburn Steel to north of Parsons Rock, and along the back of the beach south of Parsons Rock. Beach levels have fallen in areas immediately to the north of Whitburn Steel and in the southern part of the bay on the lower foreshore just north of the pier. The dominant pattern of alternating bands of erosion and accretion in the central part of the bay is indicative of migrating sand bars.	there is reduction in beach levels across the frontage, with beach elevation increase in discrete areas. 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, and another south of Parsons Rock. **Longer term topographic trends Autumn 2009 to Autumn 2013:** The plot shows an increase in beach levels from Whitburn Steel to north of Parsons Rock along the back of the beach and along the toe. As noted in the previous full measures report (autumn 2012), 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 there is an area of increased elevation immediately north of the pier at the back of the beach. This is most likely due to the shelter provided by the pier. There is a pocket of erosion on the lower foreshore just north of Roker Pier. It is possible that material from here has been moved up the beach to the area of accretion north of the pier.

Plate 1 – Survey photograph 1bSNN4_20131003_N14.jpg (FM 2013)

Plate 2 – Survey photograph 1bSNN4_20120320_N5.JPG (FM 2012)

Plate 3 –Survey photograph 1bSNN6_20131003_Up.jpg (FM 2013

Plate 4 – Survey photograph 1bSNN6_20121004_up1.jpg (FM 2012)

3.2 Sunderland Harbour and Docks

Survey Date	Description of Changes Since Last Survey	Interpretation
Sept/ Oct 2013	**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 2012. **1bSNN12** and **1bSNN13** are both located within the shelter of Roker Pier. At profile **1bSNN12**, the beach has steepened, with an increase in elevation at the beach crest and along the beach slope of up to 0.3m but a decrease in beach elevation on the lower part of the profile (from chainage 95m seawards) of up to 0.7m. At **1bSNN13** beach levels at have decreased significantly. The beach crest has dropped by approximately 0.2m and the cobbles noted as being exposed on the previous survey report) remain exposed. There is no change to the slope of the beach face. The lower beach (chainage 35m and seawards) has lowered by approximately 0.8m, indicating a loss of material from this profile. **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 decreased by about 0.5m across the profile. From a 35m chainage this is the lowest recorded level for this profile, but the beach level at the toe of the wall was lower in 2010. **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. The foreshore level at this wall is low and undermining and damage to the wall toe has been noted in defence inspections. 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 increased by up to 1.2m across the length of the profile. In the previous survey (full measures, Autumn 2012) beach levels had dropped and there was a change from a mainly sandy beach to one comprised of shingle. Following the increase in level in this survey the beach composition now has a greater composition of sand. At profile **1bSNC5**, beach levels have decreased across the profile. The beach has steepened with the beach	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 beaches have steepened and beach levels have dropped. Within New South Pier, profile 1bSNC2 has also fallen significantly. The harbour was dredged in May 2013 to maintain a navigable channel and is not noted to have previously impacted on beach levels. This maintenance dredging is undertaken regularly. Within the centre of this frontage, at profile 1bSNC4 beach levels have increased and at 1bSNC5 beach levels have decreased. This could be a northwards alongshore transfer of material between profiles, that is against the southerly net longshore transport direction for the area described in the SMP2. To the south, at profiles 1bSNC6 and 1bSNC8 the beach profile has steepened. At profile 1bSNC6 the upper beach has increased notably in elevation while the lower beach has decreased (showing an overall increase) indicating cross shore movement of material over the calmer summer period. At profile 1bSNC8 the toe has steepened resulting in a much shorter measured profile. At profile 1bSNC9 there has been no notable change. **Longer term trends:** To the north of Sunderland Harbour and Docks, within the breakwaters to the north of the River Wear, the

Survey Date	Description of Changes Since Last Survey	Interpretation
	level decreasing more at the toe (by up to 0.7m) that at the top of the beach (approximately 0.2m). **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 0.5m at the toe of the sea wall along about a 6m stretch. The remainder of the beach profile has increased by a smaller amount (approximately 0.1m), but with a slight decrease in level at toe (24m chainage seawards). Survey photographs and feature coding of the profile data indicate that the beach composition has changed with a greater proportion of gravel present on the surface at the top of the beach (Plates 8 and 9). **1bSNC7** to **1bSNC9** are within the shelter of North East Pier and South West Breakwater in the former South Outlet, parts of which have been in-filled with tipped rubble. **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 have dropped steeply at the base of the boulder and rubble section, at approximately 30m chainage, dropping by nearly 0.9m by 36m. As such the measured profile for Autumn 2013 stops at 37m chainage, where as it previously extended across the foreshore up to 120m. 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. Although there seems to be an increase in level of the sand dunes and boulder mound, a closer investigation indicates that this is due to the location of survey measurement points and there is no significant difference in land elevation. Across the sand and gravel section (approximately 65m to 105m chainage), there is a slight increase in bed level of just 0.1m to 0.2m. The profile can be considered stable.	beach levels are some of the lowest recorded. Within New South Pier, profile 1bSNC2 shows the lowest recorded level at the seaward end of the profile as result of beach steepening. The profiles towards the middle and south of the area (1bSNC4 to 9) are within the bounds of previous surveys, apart from profile 1bSNC8, located within the shelter of North East Pier and South West Breakwater, which is shows beach levels lower than those previously recorded.

Plate 5 – Survey photograph 1bSNC4_20130911_N3.JPG (FM 2013)

Plate 6 – Survey photograph 1bSNC4_20120918_N1.JPG (FM 2012)

Plate 7 – Survey photograph 1bSNC4_20111111_N2.JPG (FM 2011)

Plate 8 – Survey photograph 1bSNC6_20130911_N4.JPG (FM 2013)

Plate 9 – Survey photograph 1bSNC6_20120918_N2.JPG (FM 2012)

3.3 Hendon to Ryhope (incl. Halliwell Banks)

Survey Date	Description of Changes Since Last Survey	Interpretation
Sept 2013	**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 it 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. There has been little discernible change across the profile apart from between 55m and 65m chainage, where a dip has occurred in the beach about 0.2m in depth. The profile feature code here indicates that rock has been removed (or moved) and sand exposed. Profile **1bSNS8** extends across the seawall, rock revetment, a rocky upper beach and sandy middle and lower beach. Beach levels have increased at the toe of the rocky upper beach by over 0.5m, filling the previous dip in the profile. Seawards of chainage 54m the beach levels have fallen slightly. These changes smooth the overall profile to a flatter slope, rather than the dome shape described in the previous survey report (partial measures, spring 2013). At profile **1bSNS9**, beach levels have varied across the length of the profile with erosion at the toe of the	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 drop directly from the structure into deep water and have therefore not been analysed. Along the length of south Hendon, between profiles 1bSNS7 and 1bSNS11, along-profile beach levels show areas of erosion and accretion, causing a change in profile shape. It is not possible to identify a clear trend of erosion or accretion, apart from at Profile 1bSNS11 which has accreted. At Grangetown (south Hendon to Salterfen Rocks), between profiles 1bSSN12 and 1bSNS16, cliff retreat can be observed in the southern profiles. This is supported by the survey report which notes landslips on the cliff face from Hendon to Rhyope. The northern three beach profiles have steepened, but there is no trend of erosion or accretion as a result of this, suggesting the beach has been reshaped by waves. Beach levels have however dropped on the upper

Survey Date	Description of Changes Since Last Survey	Interpretation
	boulder section and accretion seawards of 58m chainage. The boulder platform exposed at around 80m chainage in the previous survey is no longer exposed. At profile **1bSNS10**, beach levels have increased at the toe of the boulder section with the gravel and sand level being up to 0.6m higher, and decreased seawards of 32m chainage. This has resulted in a much steeper profile. At profile **1bSNS11** the cliffs have remained stable since the last survey. Beach levels have increased across the profile, from the sea defence toe to a 740m chainage, by between 0.1m and 1m. **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 at the toe, which is likely to relate to access problems at the toe of the cliff and not cliff advance. Beach levels have not changed on the upper beach, but on the lower beach (from about 65m chainage) levels have dropped by up to 0.6m. At profile **1bSNS13** the cliff face has not discernibly changed in form or position since the previous survey (full measures, 2012). Beach levels have increased marginally between a 34m and 52m chainage, and deceased between a 52mand 90m chainage to form a steeper beach profile. At profile **1bSNS14**, the cliff face has retreated by almost 1m. This may be due to survey interpretation but is most likely to be the result of cliff recession, as the survey report notes evidence of landslips and mudslides on these cliffs. Beach levels have increased by a small amount immediately at the toe of the cliff which could be material deposited from cliff falls. Across the middle of the profile beach levels remain the same as the previous survey (autumn 2012). At the seaward end of the profile the beach levels have dropped by about 0.3m and the sand cover has been removed exposing rock. At profile **1bSNS15**, the cliff top has retreated by approximately 0.75m. Beach levels at the sand and gravel section at the toe of the cliff have lowered, by approximately 0.6m. The lower, rocky portion of the profile has not changed. At profile **1bSNS16**, the cliff face is observed to have retreated by approximately 0.75m. There have	sand/ gravel section at profile 1bSNS15. Between Salterfen Rocks and the landfill at Halliwell banks (profiles 1bSNS17 to 1bSNS25), the cliff face has retreated in most locations, with cliff falls evident in survey photographs. The cliff material has generally accumulated on the upper beach at the toe of the cliff, increasing upper beach levels. In many locations the beach toe has eroded resulting in a steeper beach. Where the profile is rocky, and there was not previously loose material to be eroded, the profiles have remained stable. At the landfill site (profiles 1bSSN26 to 1bSSN32) the cliffs have retained the same form and position since the last survey (partial measures, 2013). Beach levels have decreased across the beach at all profiles and sand cover has reduced exposing more rock and gravel. To the south of Halliwell Banks, around Pincushion, the cliff face to the north of this section has retained the same form and position since the last surveys but to the south the cliffs have receded slightly. Beach levels to the north have remained stable while a minor decrease in level was noted on the southern most profiles. **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. Along most of the profiles the levels remain within the bounds of previous surveys. There are sections that are particularly low however, notably, (i)

Survey Date	Description of Changes Since Last Survey	Interpretation
	been no discernible changes to beach levels since the last survey (autumn 2012). 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 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 remained stable. 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 to have retreated by over 1m at the toe. Beach levels have increased between MHWS to a chainage of 75m but decreased seaward of this. At **1bSNS19**, the cliff face has retreated by approximately 0.5m since the last survey (full measures, 2012). 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 beach level changes. At profile **1bSNS20**, the profile shows the cliff toe to have accreted. This is likely to be related to survey interpretation or access problems at the cliff toe. Across the profile there are small variations in beach level, which is likely to reflect the movement of pebbles and rocks across the foreshore and a slight increase in sand levels between the pebbles and rocks, At **1bSNS21**, the cliff top has retreated by 2m since the last survey (full measures, 2012). Beach levels at the toe of the cliff have increased by up to 1.8m, which is likely to be an accumulation of eroded cliff material. On the lower beach the levels have decreased resulting in a slightly steeper beach profile. At profile **1bSNS22**, the cliff face has retreated by over 1m since the last survey (autumn 2012). Across the foreshore there has been no discernible change to beach levels since the last survey. At profile **1bSNS23**, the cliff is observed to have retreated by up to 8m.The profile photographs show a cliff fall in this area (Plate 10). This is however not observed in the cliff top survey. This may be due to the cliff survey measurement points falling either side of the cliff fall. Although the cliff is likely to have retreated here it is possible that a proportion the 8m retreat is a result of survey interpretation of the cliff edge and ability to safely walk up to the cliff edge, and the actual cliff retreat may be smaller than the 8m recorded. There is no additional material observed on the beach profile as a result of the cliff fall and	1bSNS7 where levels are the lowest recorded on the upper beach and at MLW (ii) 1bSNS9 where the levels are at the lowest recorded on the upper beach, and at MLW (iii) 1bSNS10 where the levels are at the lowest recorded to date At Grangetown (south Hendon to Saltfen Rocks), between profiles 1bSSN12 and 1bSNS16, the position of the cliff face has generally retreated slightly since the survey programme began. Beach levels along these profiles are generally at the lowest boundary of previous surveys or are lower than previous surveys, in particular along the lower beach as a result of beach steepening. 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 not been surveyed accurately and it unclear how much erosion has occurred. However, Profiles 1bSNS21, 22 and 23 confirm a general trend of cliff retreat. Beach levels here have fluctuated and remain on the lower edge of the previous survey envelope. At the landfill site (profiles 1bSSN26 to 1bSSN32) the position of the cliff face has not been surveyed accurately and the erosion rate is uncertain. The trend of beach level decrease has continued since the last survey (spring 2013), and beach levels are on the lower bound of surveys recorded to date, with some sections being the lowest to be recorded. To the south of Halliwell Banks, at profiles 1bSNS33 and 1bSNS34, the position of the cliff face has

Survey Date	Description of Changes Since Last Survey	Interpretation
	beach levels have decreased across the profile, particularly at the toe of the beach resulting in a steeper beach profile. At **1bSNS24**, the cliff top has remained stable, but there is evidence in the photographs of a cliff fall part way down the cliff face (Plate 11). This can be observed in the measured profile as the toe of the cliff has accreted as a result of material falling from the cliff face. Across the foreshore, the upper beach has increased in level since the previous survey (autumn 20112) while the middle to lower beach (90m to 140m chainage) has decreased in level resulting in a steeper beach profile. The sand previously present between 82m and 135m chainage is no longer present and rock has been exposed. This is a return to the levels recorded in 2011. At profile **1bSNS25**, the cliff top has remained stable but a cliff fall has occurred on the cliff face (Plate 12), depositing cliff material at the toe of the cliff. As a result beach levels have increased at the cliff toe down to 74m chainage. Seawards of 74m chainage the profile has remained the same as the previous survey (spring 2013). 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** fluctuations in the cliff face and toe since the previous survey (spring 2013) are small enough that they can be attributed to survey interpretation or access difficulties. Beach levels have generally fallen by a small amount on all profiles in this section, but with a greater decrease in level on the lower part of the profile. The feature coding and photographs indicate that there is less sand present on the beach and the survey report notes "*the beach seems lower than usual with very little sand in its usual places*" Profiles **1bSNS33** to **1bSNS36** are all located around the Pincushion Headland. At locations**1bSNS33** to **1bSNS35** the cliff face has retained the same form and position since the last surveys. At locations**1bSNS35** to **1bSNS36** the cliff top shows a small amount of retreat, in the region of 0.5m, which is an ongoing trend in this location. At profile**1bSNS33** and **1bSNS34** there are no discernible changes to the beach levels. At profile**1bSNS35**, beach levels have fallen marginally across the profile, with the fall in level increasing	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 cliff retreat. At profiles 1bSNS33 and 1bSNS36 beach levels are at the lower bound of previous surveys.

Survey Date	Description of Changes Since Last Survey	Interpretation
	seawards and reaching about 0.5m. The profile has steepened. At profile**1bSNS36**, there are small variations in the upper beach level, which are likely to reflect the movement of pebbles and rocks across the foreshore and the movement of the veneer of sand between them. The lower shore shows a small decrease in level of 0.3m from approximately 85m chainage seawards.	
Sept 2013	**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 2013) have been used to create a DGM (Appendix B – Map 2a and Map 3a) using a 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 increased slightly, with isolated pockets of large increase, which are likely to be cliff falls depositing material onto the beach. Across the remainder of the beach, elevation has generally reduced. Around Salterfen Rocks there is a general pattern of beach elevation increase across much of the upper beach, but with areas of no change or a small reduction in level interspersed. Between Salterfen Rocks and Ryhope Dean/ Pincushion, to the north of the frontage, beach levels have predominantly decreased, However there are areas of gain at some locations along the back of the beach, which are most likely attributable to cliff fall material. There is an area of notable loss covering the width of the beach just to the north of Pincushion. At Pincushion there is little change and no clear trend. Immediately south of Pincushion the plot shows accretion at the back of the beach but erosion lower on the profile. **Longer Term Topographic Trends Autumn 2010 to Autumn 2013:** The long term difference plot (Appendix B – Map 2c and 3c) shows the net change in beach levels between autumn 2009 and autumn 2013. The plot shows a general trend of beach elevation loss with interspersed areas with small amounts of gain, in particular at the back of the beach, towards the north of the whole frontage near Hendon and around Salterfen Rocks. Beach loss is most pronounced around	Between Hendon and Salterfen Rocks, beach elevation along the back of the beach at the toe of the defences has increased, possibly as a result of cliff falls depositing material at the cliff toe. Across the remainder of the beach, levels have generally reduced, with some interspersed areas of elevation increase. Around Salterfen Rocks there is no clear trend of erosion or accretion. Between Salterfen Rocks and Ryhope Dean/ Pincushion, to the north of the frontage, beach elevation changes predominantly show loss, however, there are areas of gain associated with cliff falls at the back of the beach. There is a notable area of loss just north of Pincushion which covers the width of the beach, **Longer term topographic trends Autumn 2009 to Autumn 2012:** The plot shows a general trend of beach elevation gain towards the backshore where cliff falls have added material to the beach but with beach elevation loss across much of the remainder of the beach. Beach loss is most pronounced around the works at Grangetown (to the north), immediately to the north of Halliwell banks and immediately north of Pincushion. The losses north of Halliwell Banks

Survey Date	Description of Changes Since Last Survey	Interpretation
	the works at Grangetown (to the north), immediately to the north of Halliwell banks and immediately north of Pincushion.	probably relates to stream erosion.
Sept 2013	**Cliff Top Survey:** Cliff top survey data collected for baseline survey (spring 2009), the partial measures survey (spring 2013) and the present full measures survey (autumn 2013) 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 ±0.1m 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 greater than the assumed error has only occurred at four locations, where losses of between 0.2 and 1.1m have occurred at Salterfen Rocks, north of Halliwell Banks, and along Halliwell Banks. Since surveys began in March 2009 (or September 2009 for 28A and 28B) erosion greater than the survey error has occurred at around a third of the ground control points, where total losses are as high as 7.7m (location 25), but are more typically 2 to 4m. The calculated long-term erosion rates are as high as 1.7m/yr (location 25), but more typically are between 0.5 and 1.0m/yr.	Since the last survey 3 areas of cliff erosion can be identified (i) points 11, 13 and 16 near Salterfen Rocks have eroded by 0.3 to 0.8 m (ii) points 21 and 22 north of Halliwell Bank have eroded by 2.7 to 2.9m (iii) points 28 and 28A at Halliwell Banks have eroded by 0.4 to 1.6m. The indicated cliff advance in some locations 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: As** longer-term data sets are collected measured change and calculated erosion rates will become increasingly accurate. However analysis is presently limited to only four years. Key areas of significant erosion to note are Grangetown (up to 0.6 m/yr), North of Halliwell Banks (up to 0.8 m/yr), Halliwell Banks (up 1.7m/yr) and either side of Pincushion (up to 0.9m/yr). An additional assessment of cliff recession was undertaken using aerial photography collected between 2008 and 2013. This analysis showed localised areas of very significant erosion since 2008, particularly north of Salterfern Rocks where an average erosion rate of 4.15m/yr was recorded between 2008 and 2013. This reflects the effect of episodic landslides/rock falls from the cliffs.

Plate 10 – Survey photograph 1bSNC23_20130913_N5.JPG (FM 2013)

Plate 11 – Survey photograph 1bSNC24_20130913_N5.JPG (FM 2013)

Plate 12 – Survey photograph 1bSNC25_20130913_N6.JPG (FM 2013)

4. Problems Encountered and Uncertainty in Analysis

Individual Profiles

During the profile survey a number of problems were encountered which may impact upon the data collected. These problems are noted in the survey report and are discussed in this section.

At Whitburn Bay the northern bay promenade and the promenade inside the sea wall was fenced off as contractors were carrying out improvement works. These sections of the profiles could therefore not be measured. The beach had been regraded in the southern bay to the north of the sea wall which would impact upon the beach profile change.

The start of section 4 was obscured by a vehicle so there is a gap in the survey data. The top of section 5 goes through the contractor's fenced area and hence could not be measured.

Cliff Top Surveys

The survey report notes:

- '*There are a number of landslips and mudflows that are evident on the cliffs*', 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 the Health and Safety risks posed to surveyors, especially during adverse weather; and 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. However, collection of longer-term data allows underlying trends to be shown and the data indicates erosion rates similar to those measured from analysis of aerial photographs, which is provided in a separate report

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

No changes are recommended at the present time.

6. Conclusions and Areas of Concern

- At Whitburn Bay, the recorded beach levels have generally fluctuated around the previous profiles, but show no clear trend of erosion and hence no causes for concern.
- At Sunderland Harbour and Docks the beach profiles to the north have steepened and beach levels have decreased. The beach levels here are some of the lowest recorded since the surveys began. Further monitoring will indicate whether beach levels will recover to previous levels.
- At Sunderland Harbour and Docks, to the south the profiles have steepened but the upper beach has accreted indicating crosshore sediment movement rather than sediment loss. Profile1bSNC8, located within the shelter of North East Pier and South West Breakwater, shows beach levels lower than those previously recorded. Further monitoring will indicate whether beach levels here will recover to previous levels.
- Along the remainder of Sunderland Harbour and Docks, the recorded profiles present no causes for concern.

- At Hendon to Ryhope (incl. Halliwell Banks), there were a number of landslips and mudslides evident on the cliff face noted in the survey report. The cliff survey and profile surveys showed recession of the cliff and deposition of cliff material at the back of the beach in a number of locations. The long term cliff recession data are beginning to become statistically reliable and erosion rates of over 0.5m/yr are reported at many locations, particularly towards Ryhope.
- At Hendon to Ryhope (incl. Halliwell Banks), the beach profiles show no causes for concern.

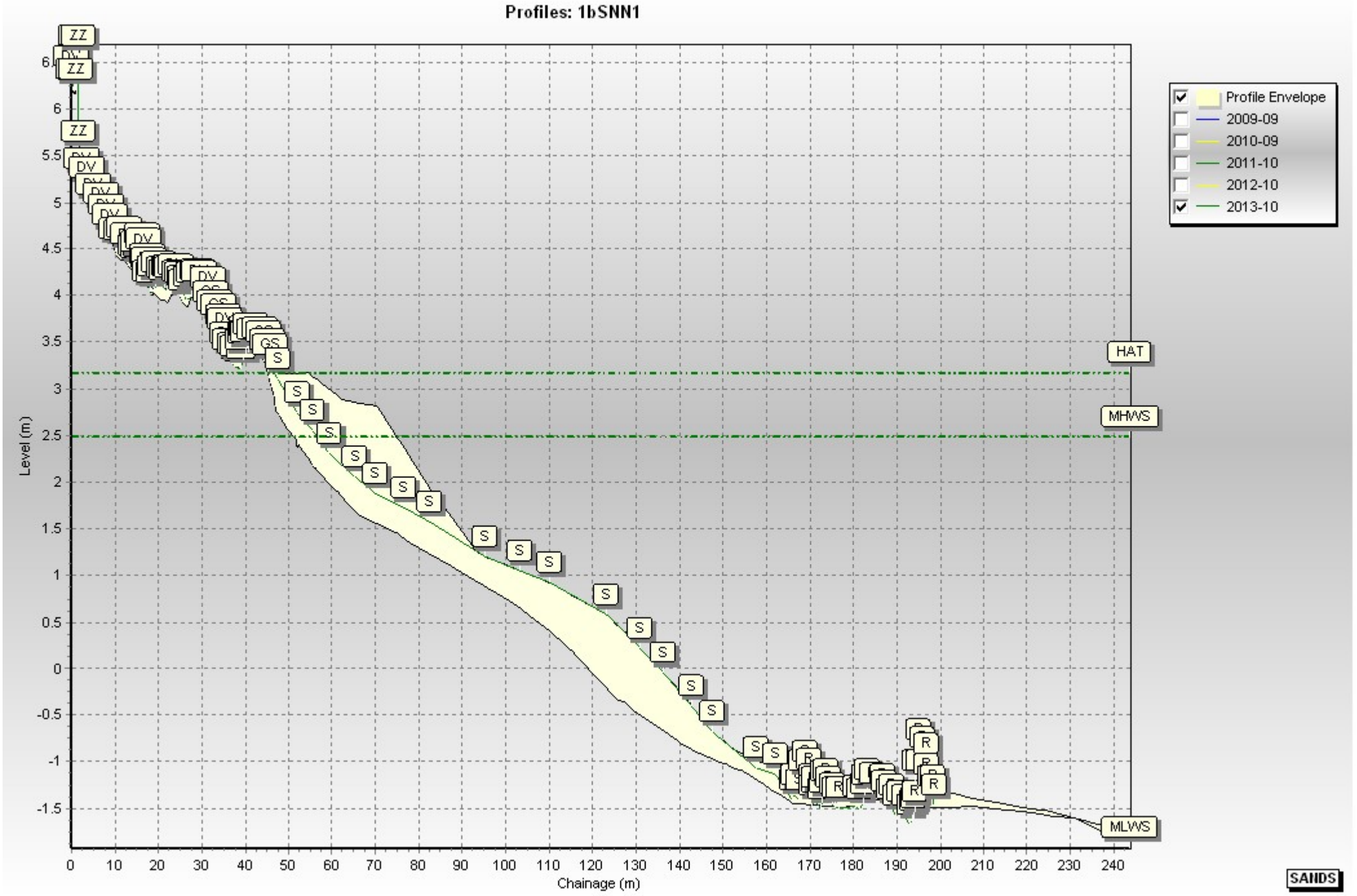
Appendices

Appendix A

Beach Profiles

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

Code	Description
S	Sand
M	Mud
G	Gravel
GS	Gravel & Sand
MS	Mud & Sand
B	Boulders
R	Rock
SD	Sea Defence
SM	Saltmarsh
W	Water Body
GM	Gravel & Mud
GR	Grass
D	Dune (non-vegetated)
DV	Dune (vegetated)
F	Forested
X	Mixture
FB	Obstruction
CT	Cliff Top
CE	Cliff Edge
CF	Cliff Face
SH	Shell
ZZ	Unknown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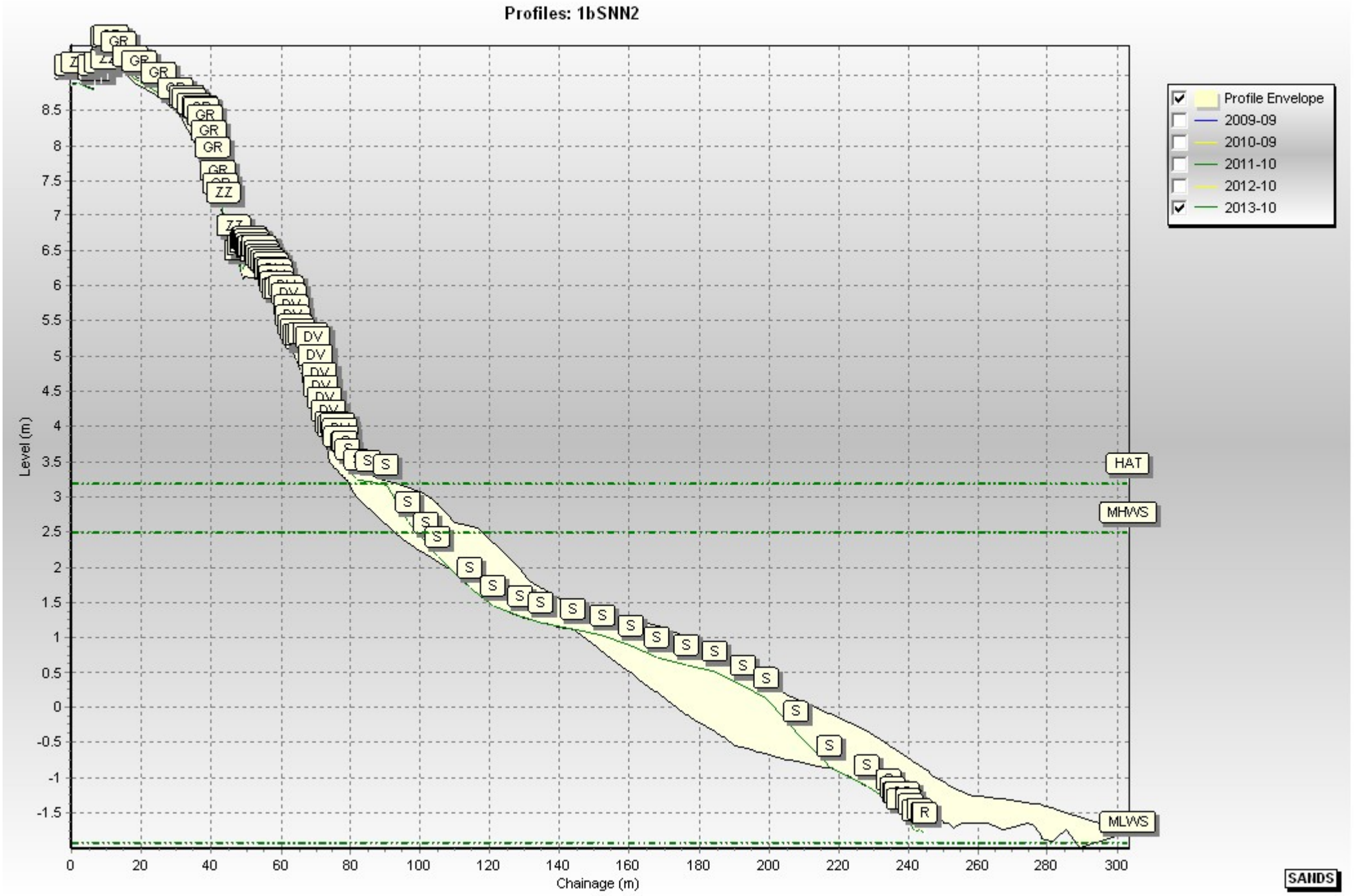
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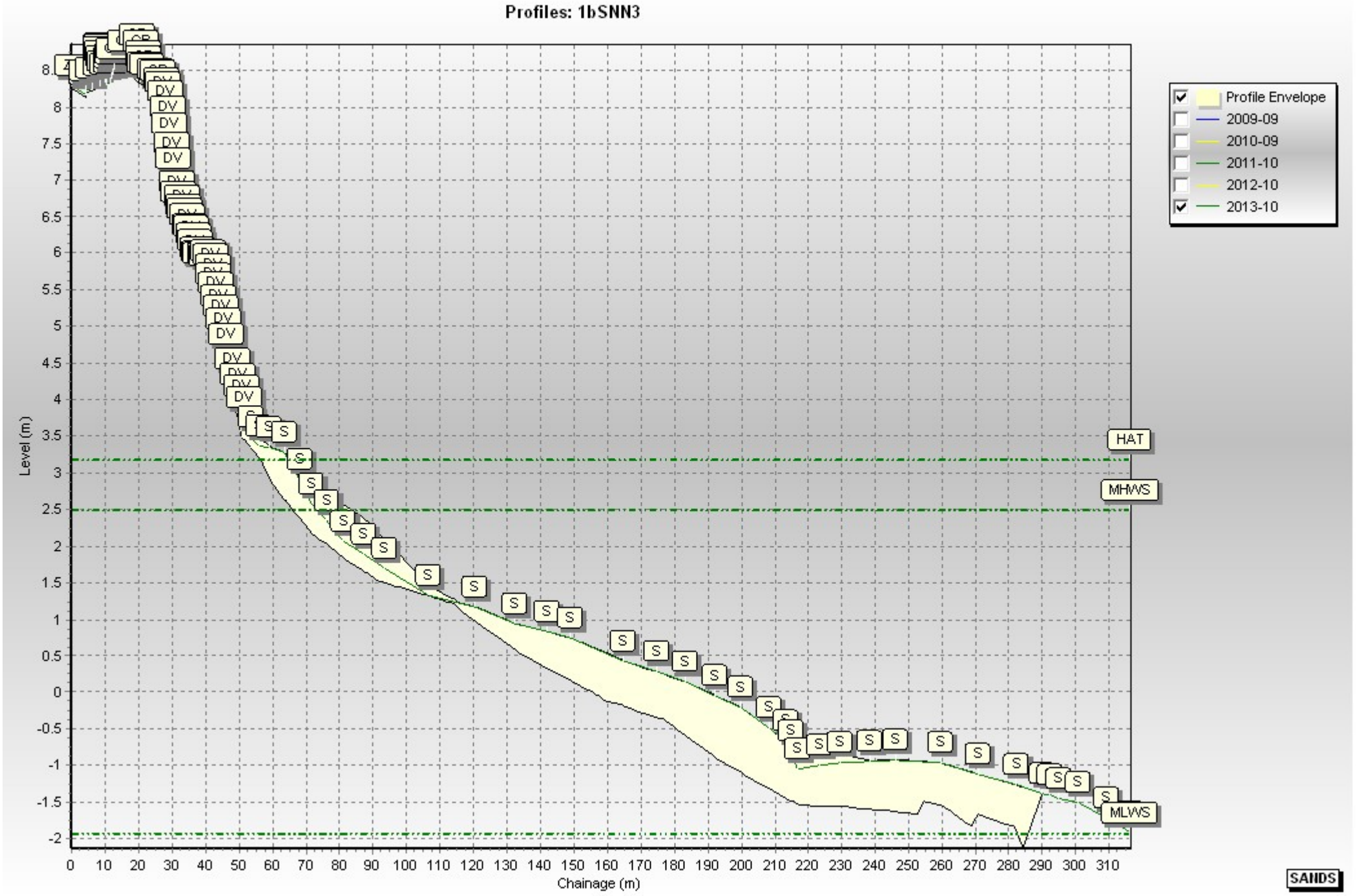
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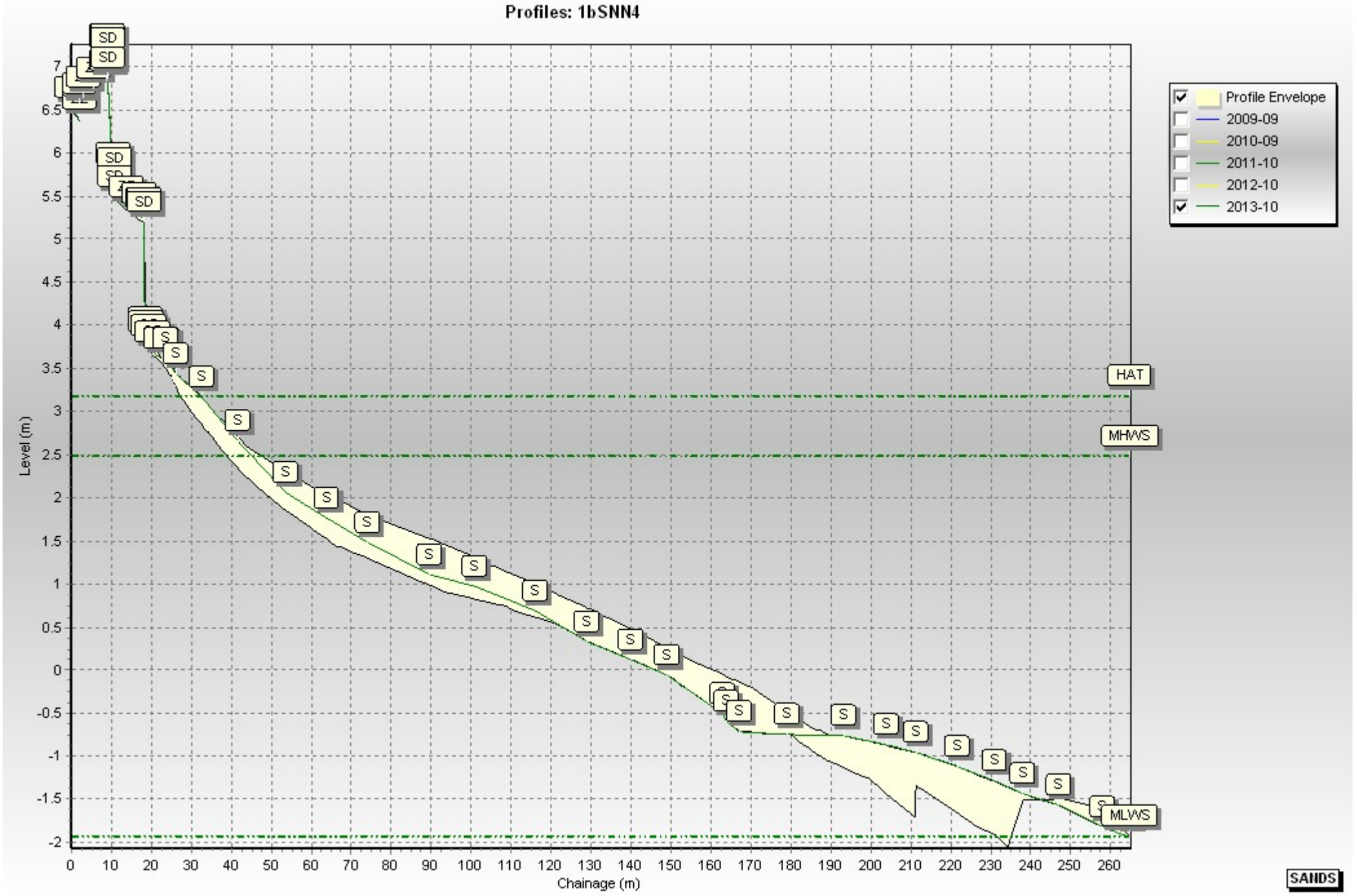
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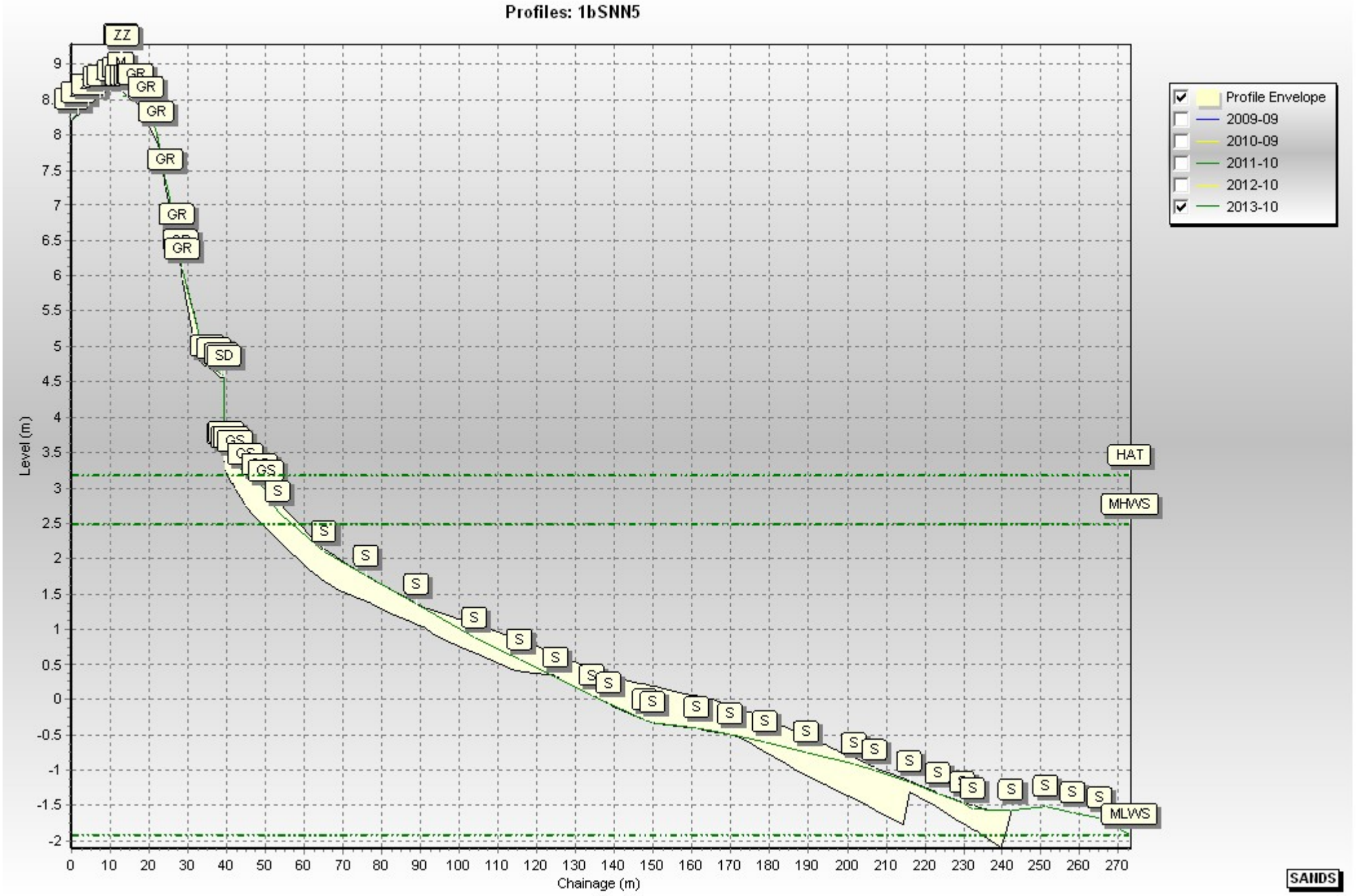
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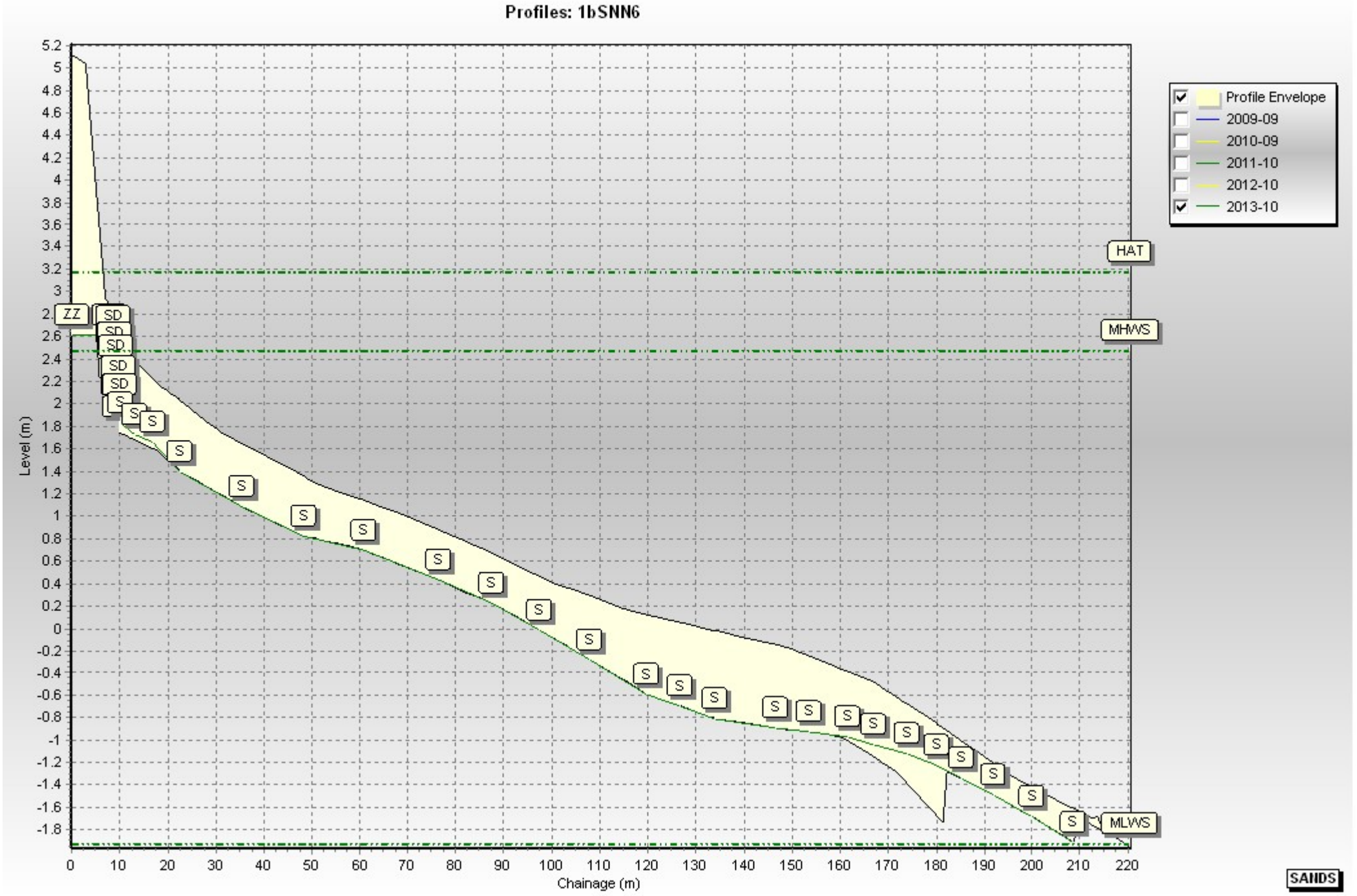
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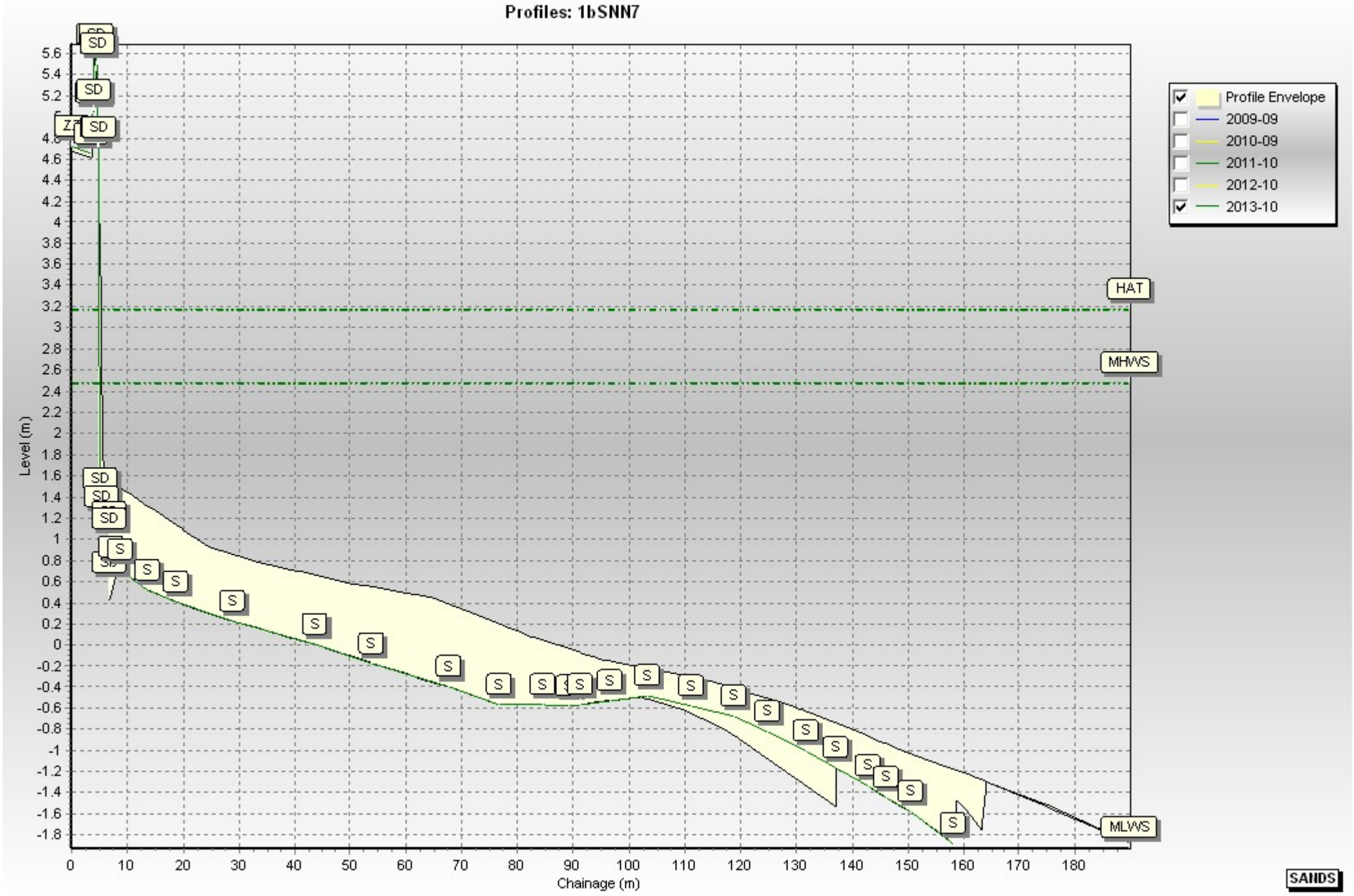
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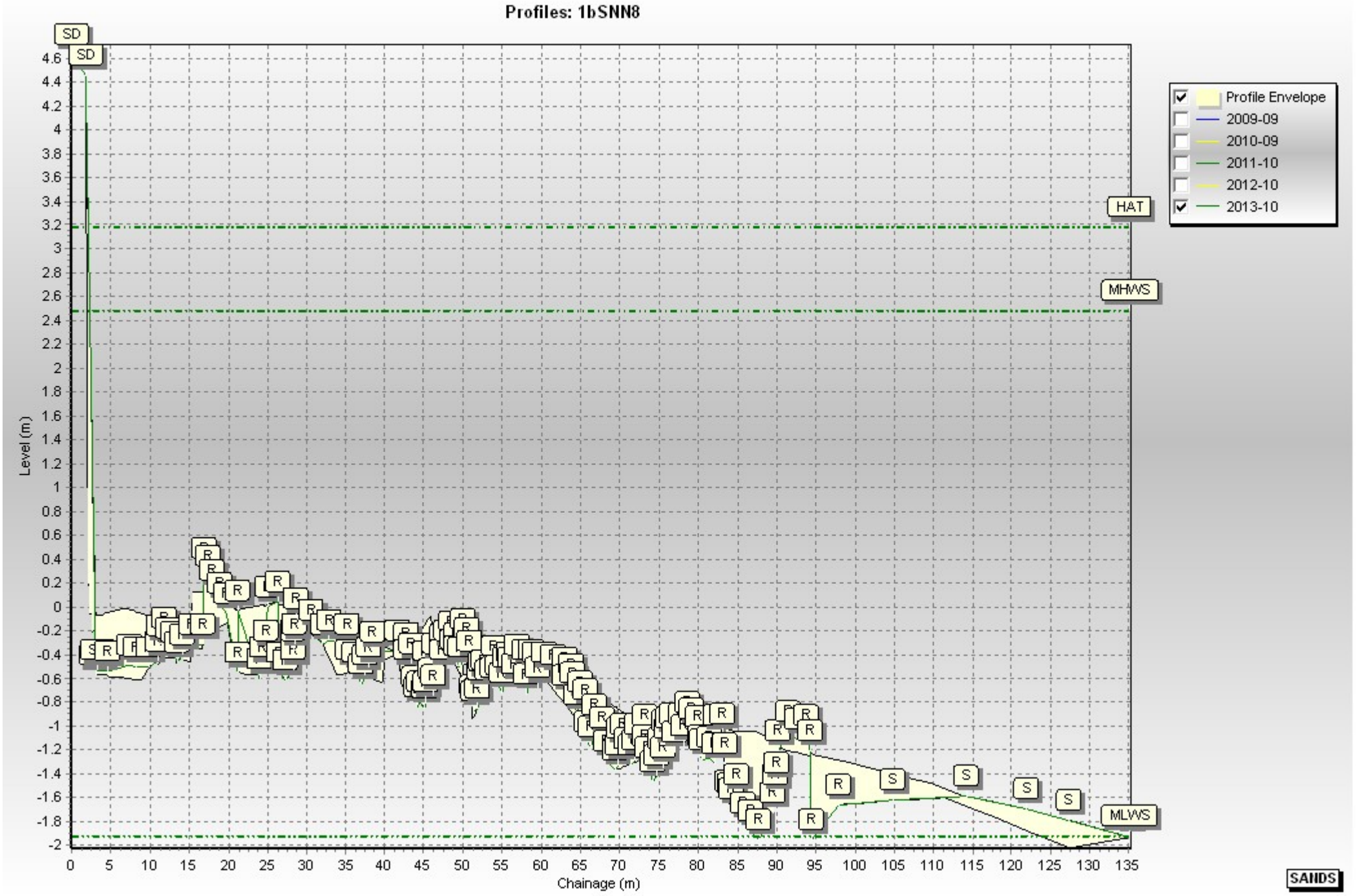
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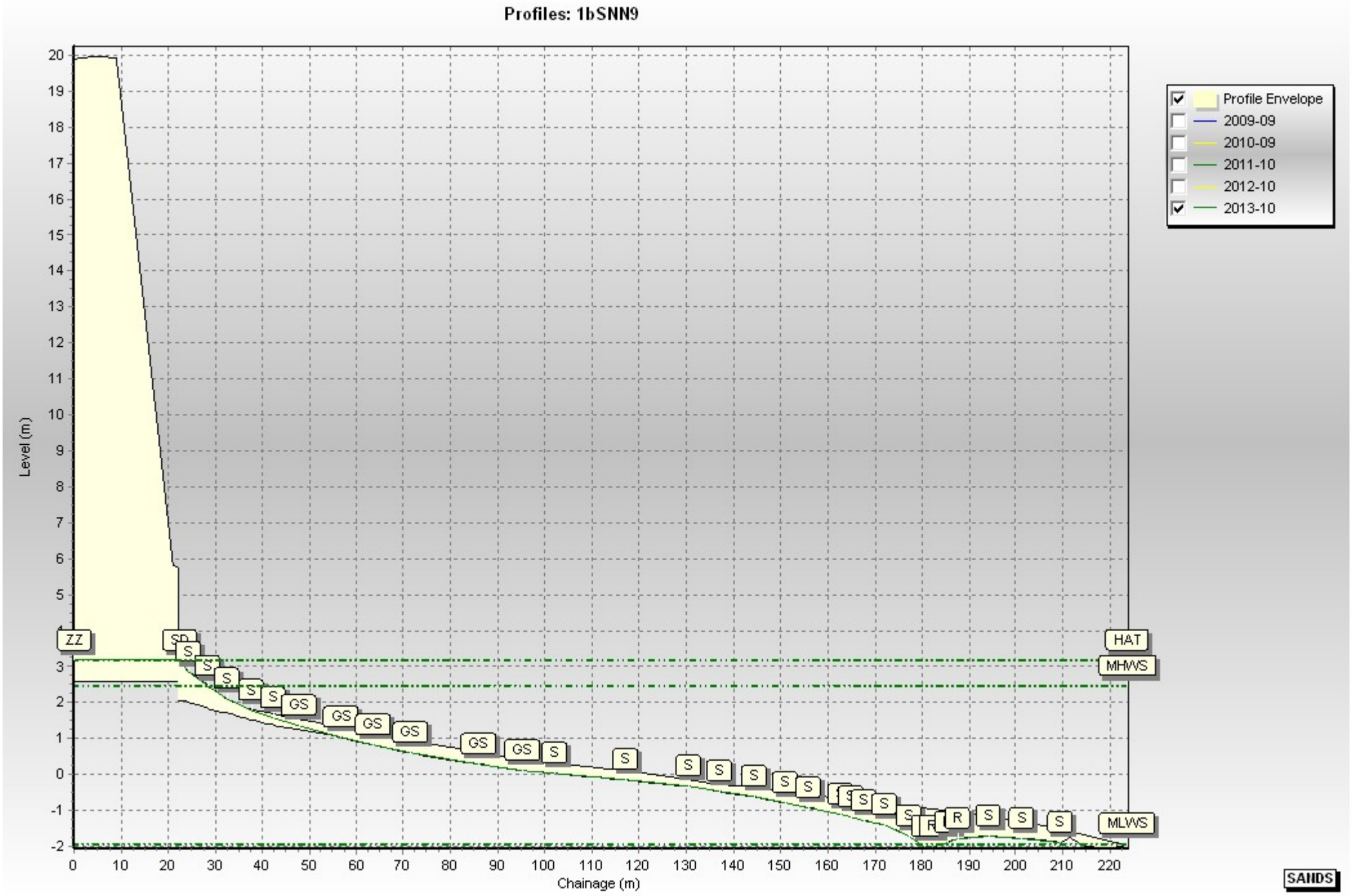
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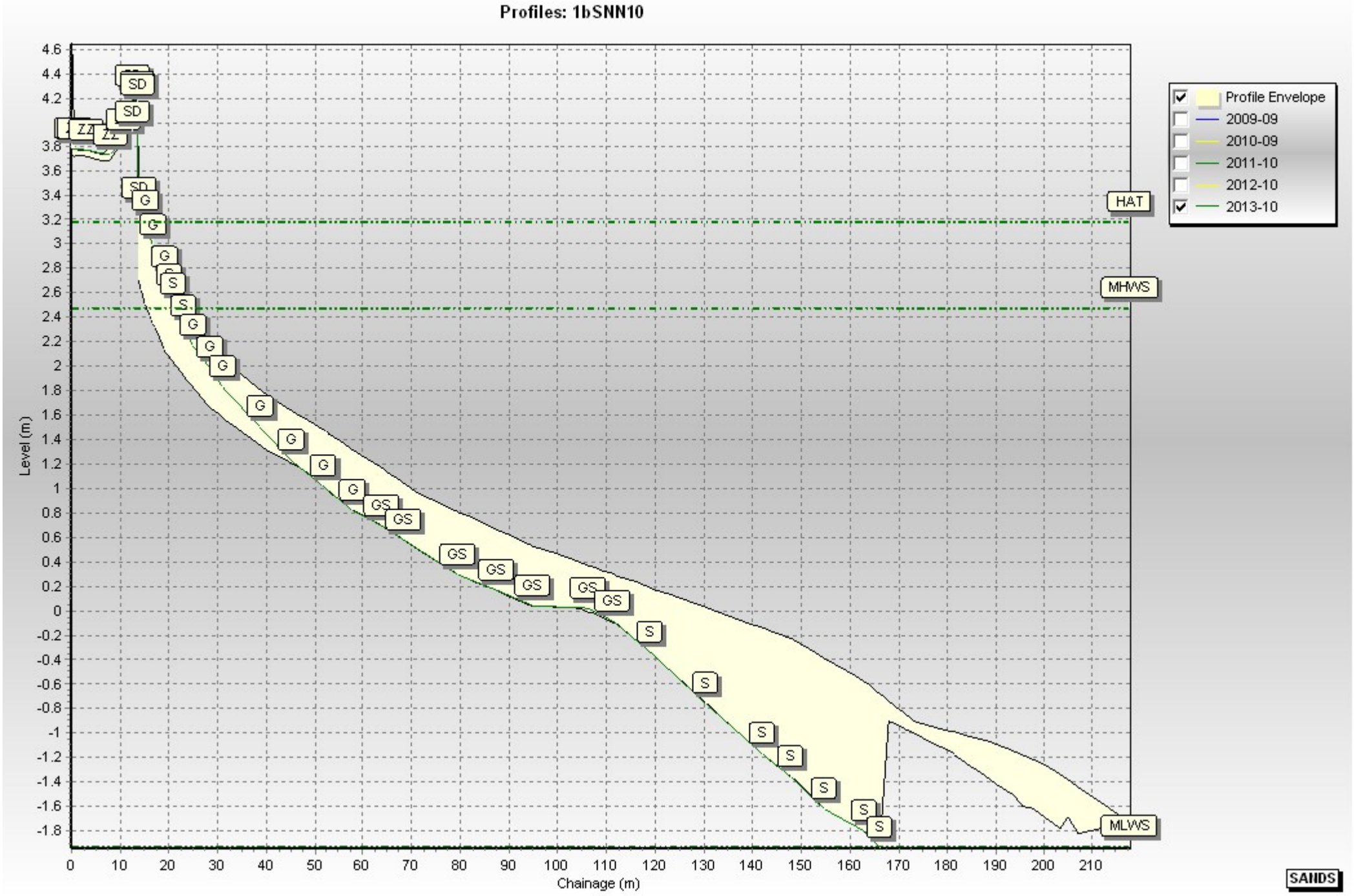
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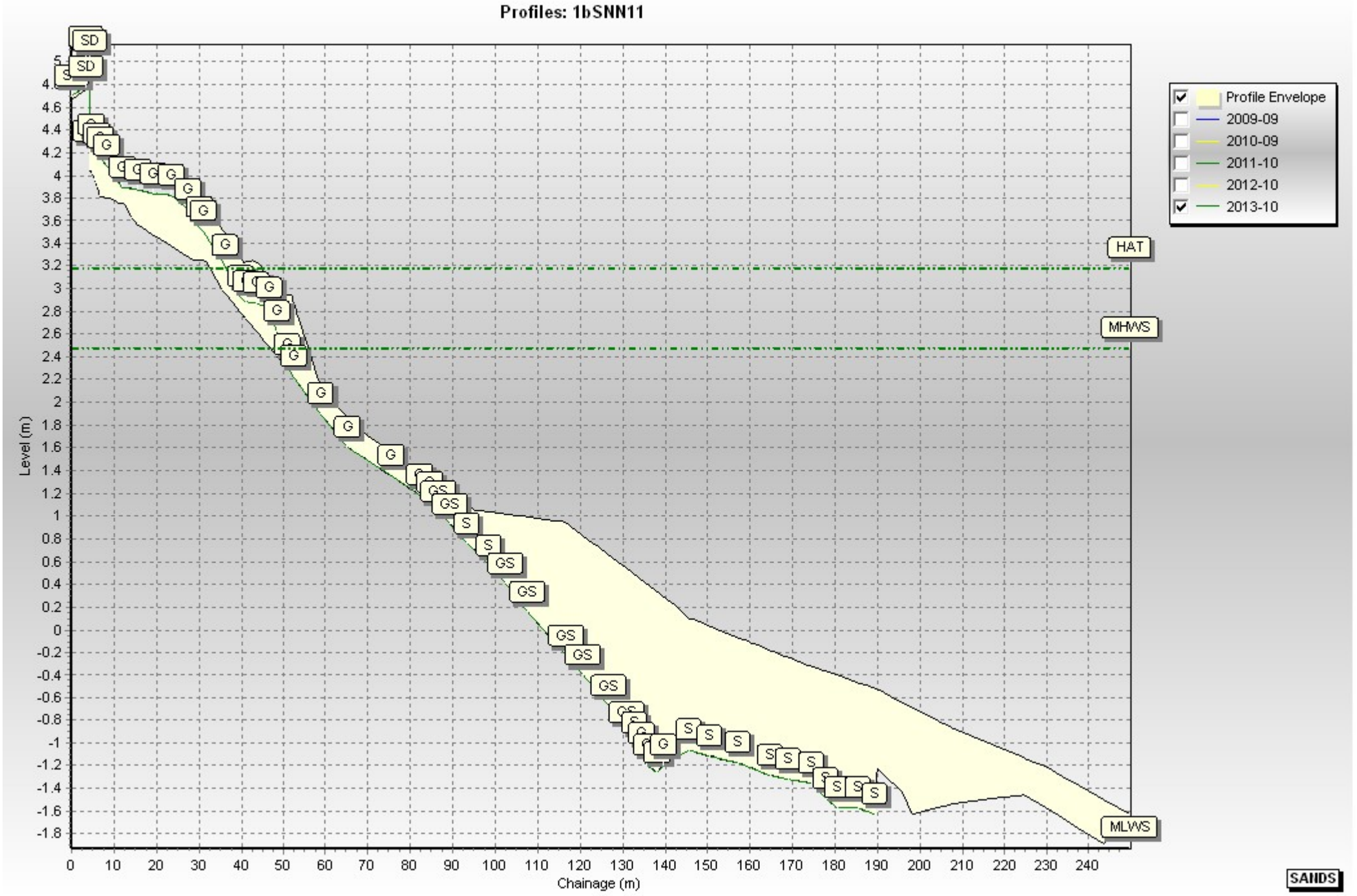
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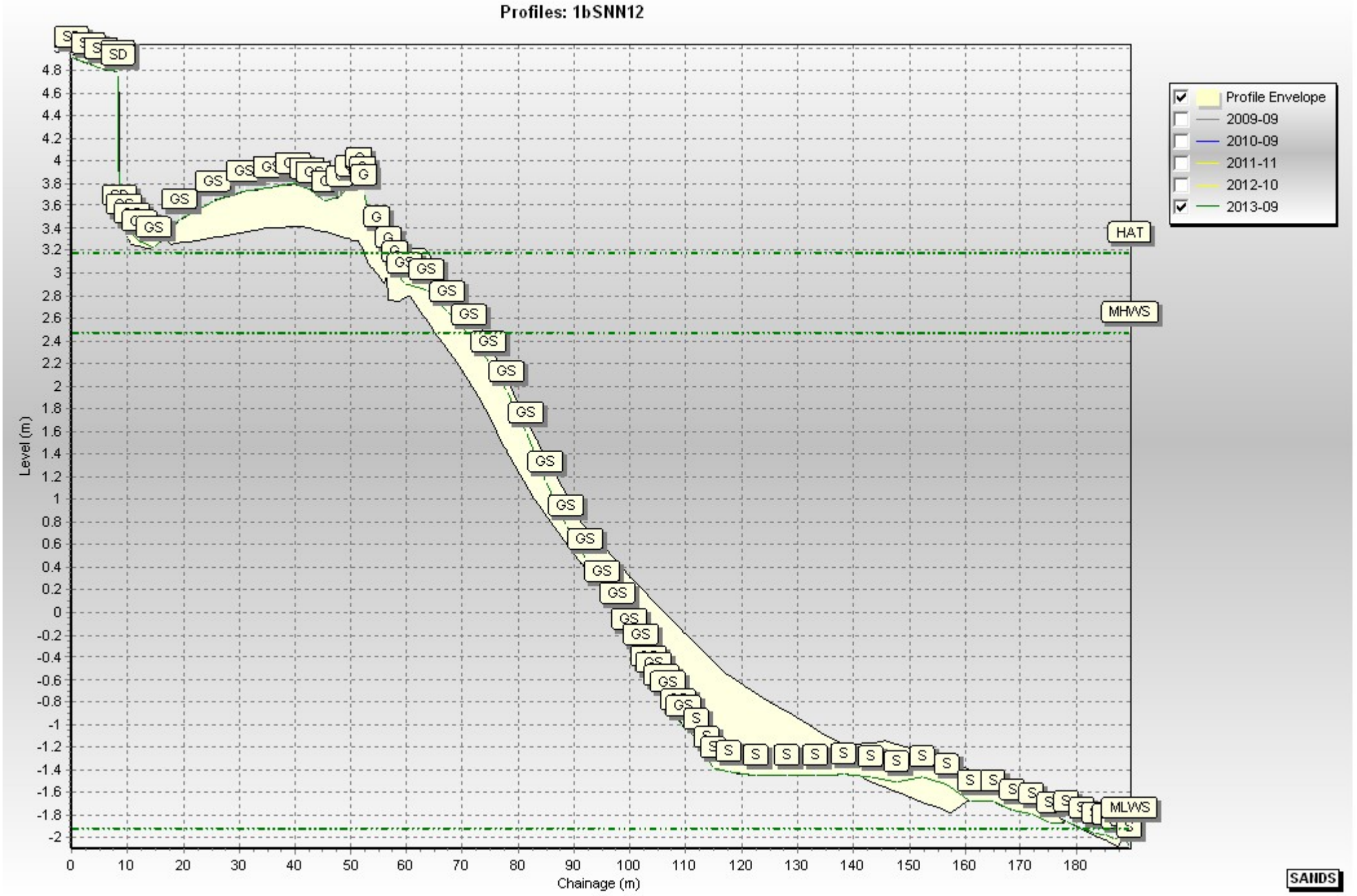
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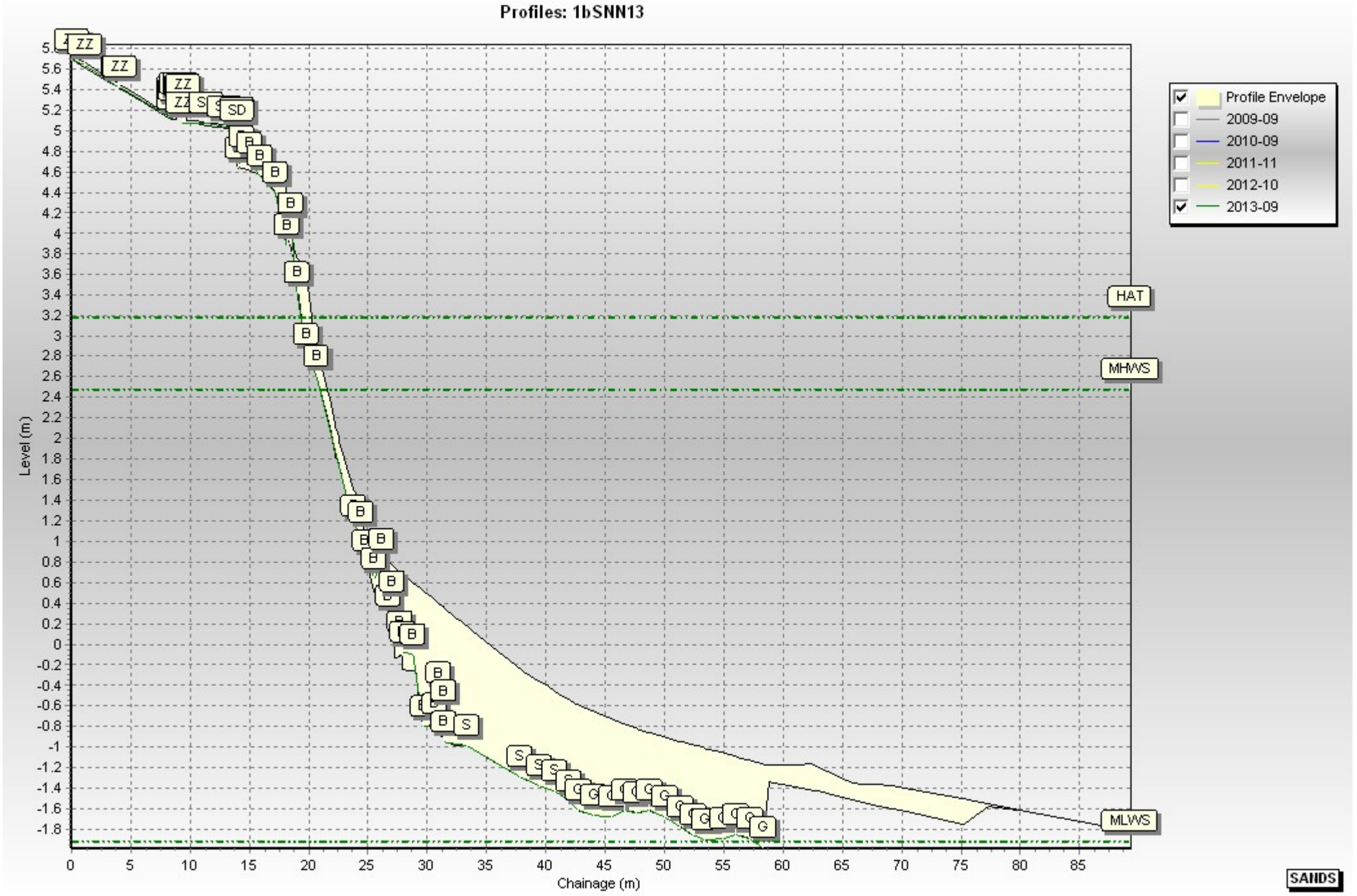
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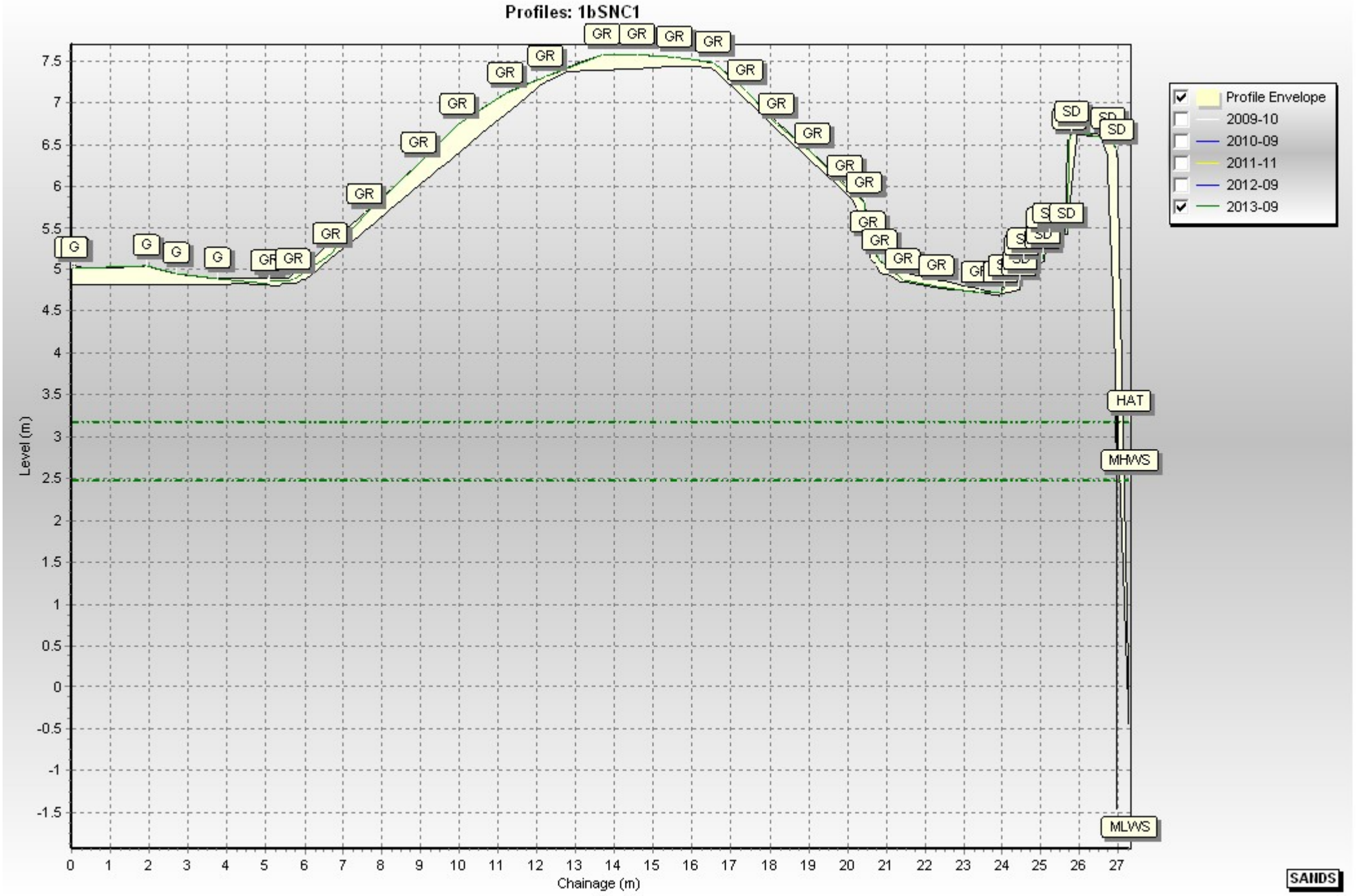
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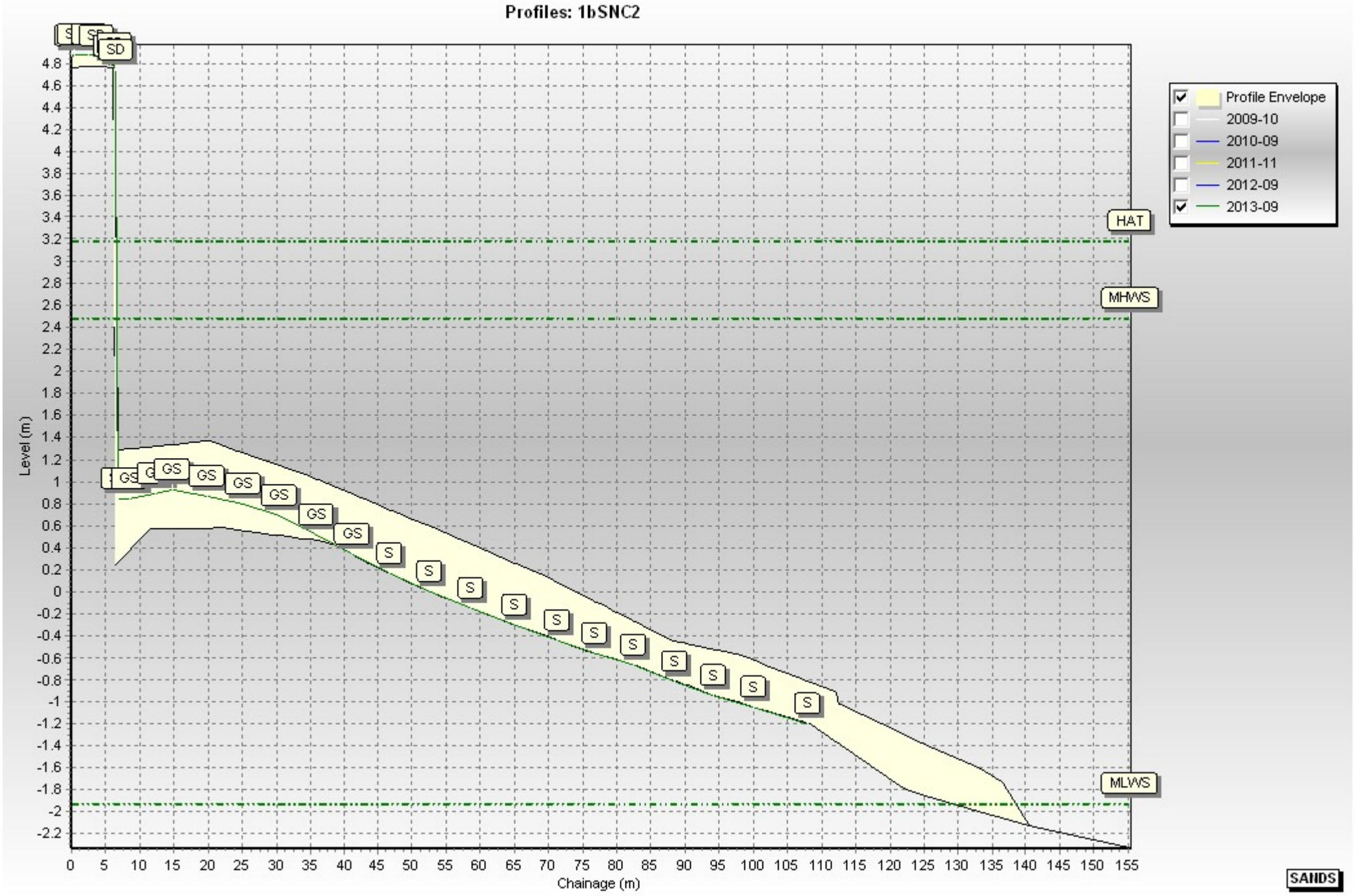
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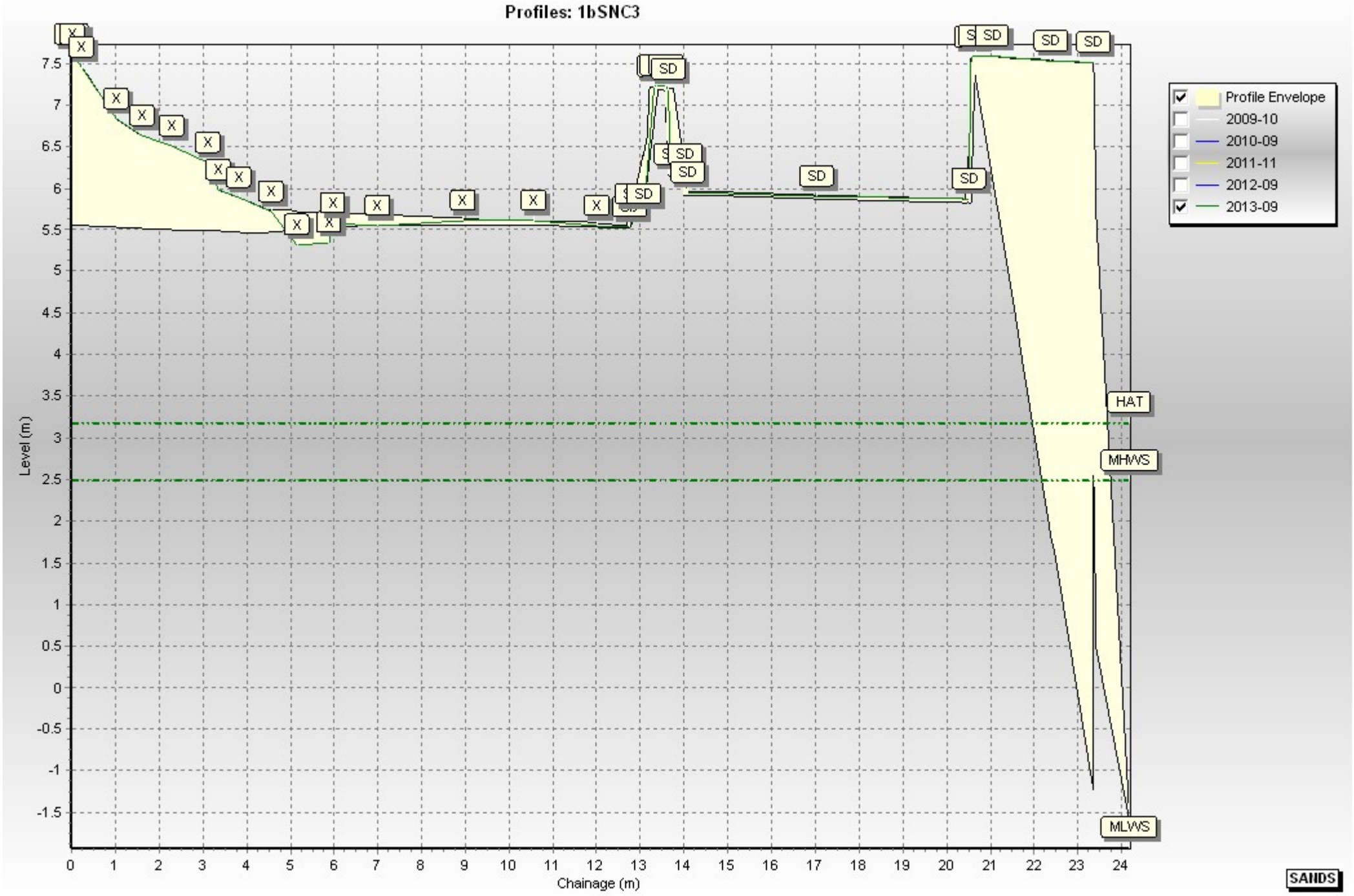
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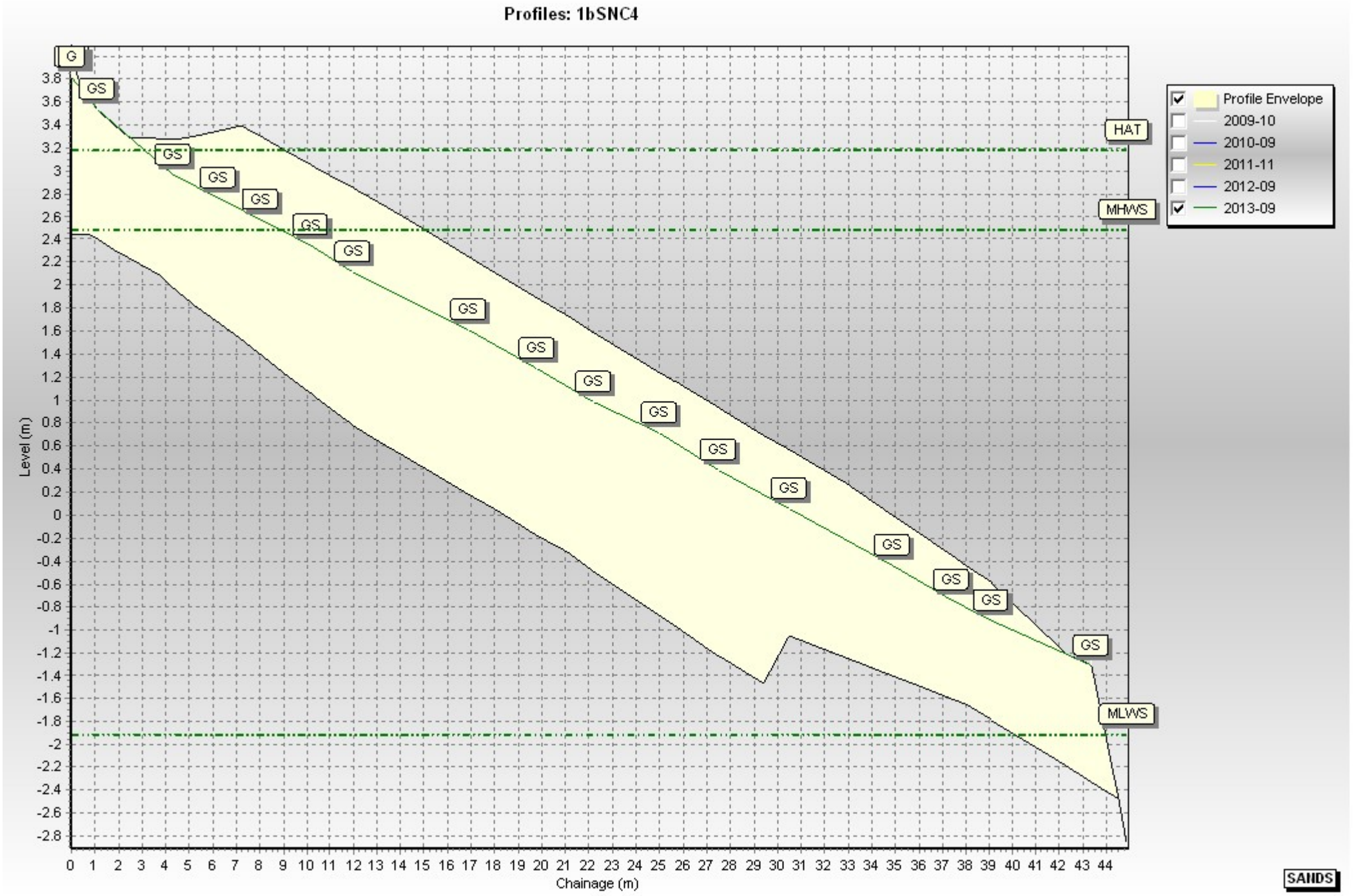
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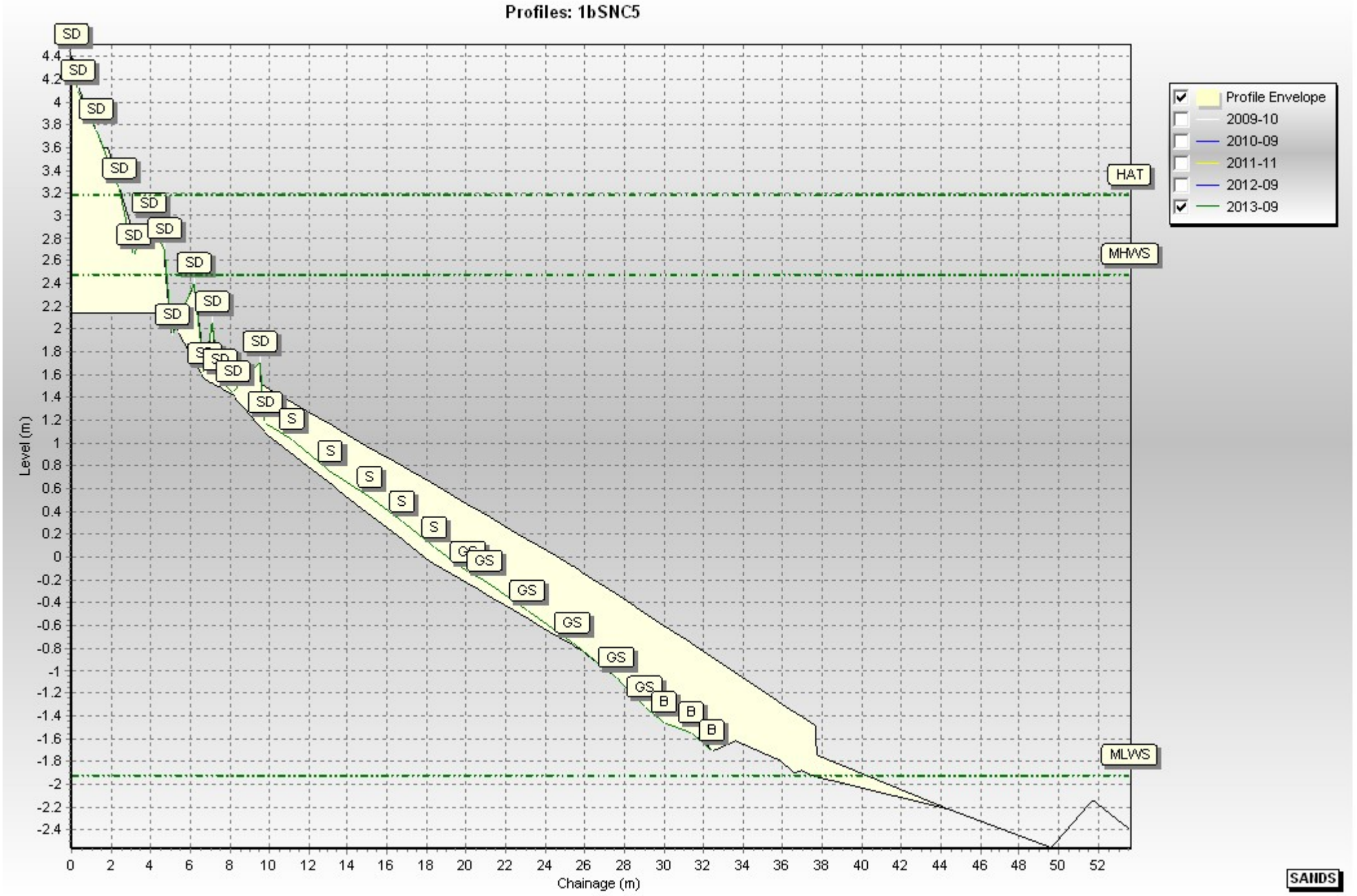
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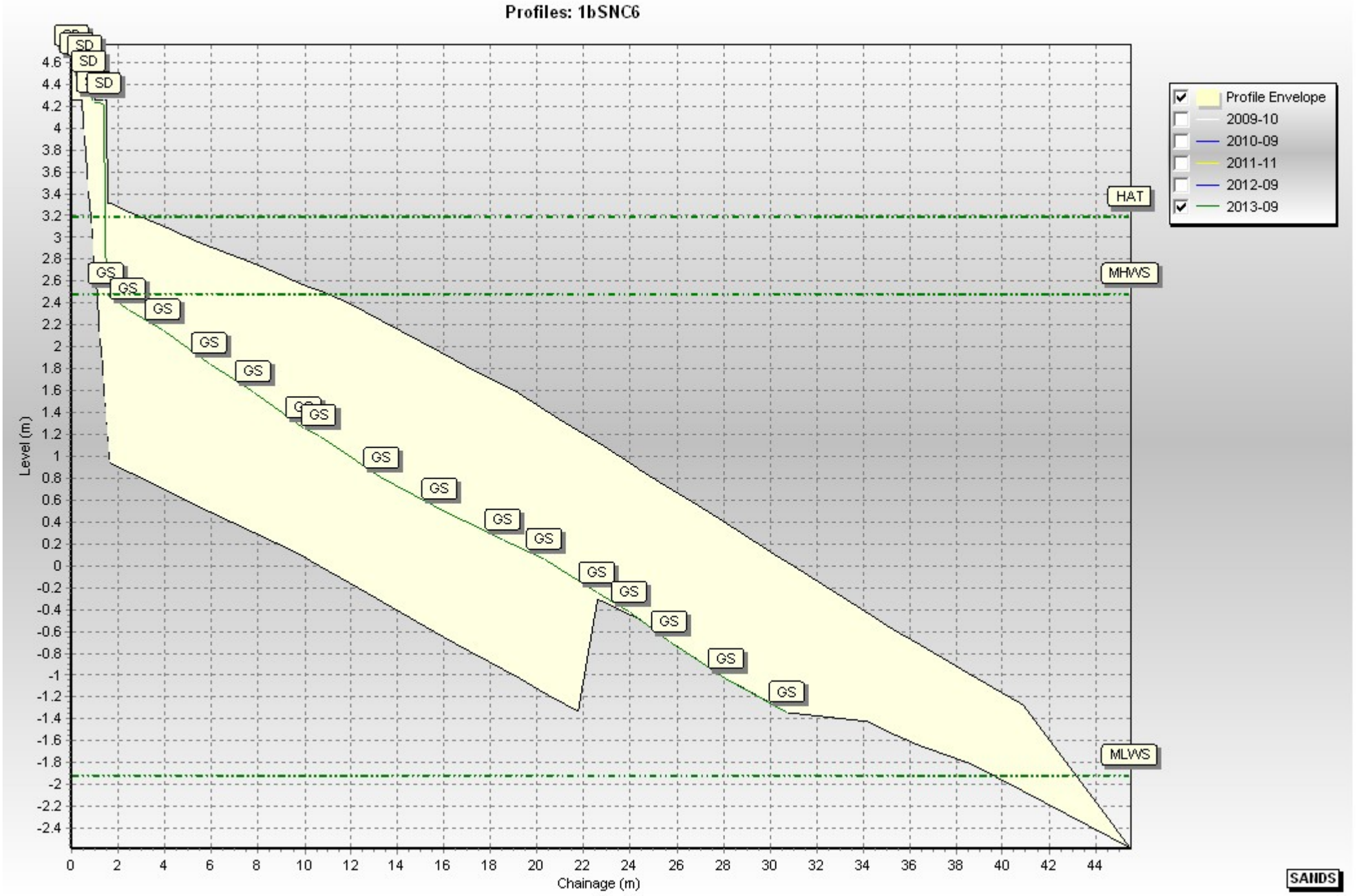
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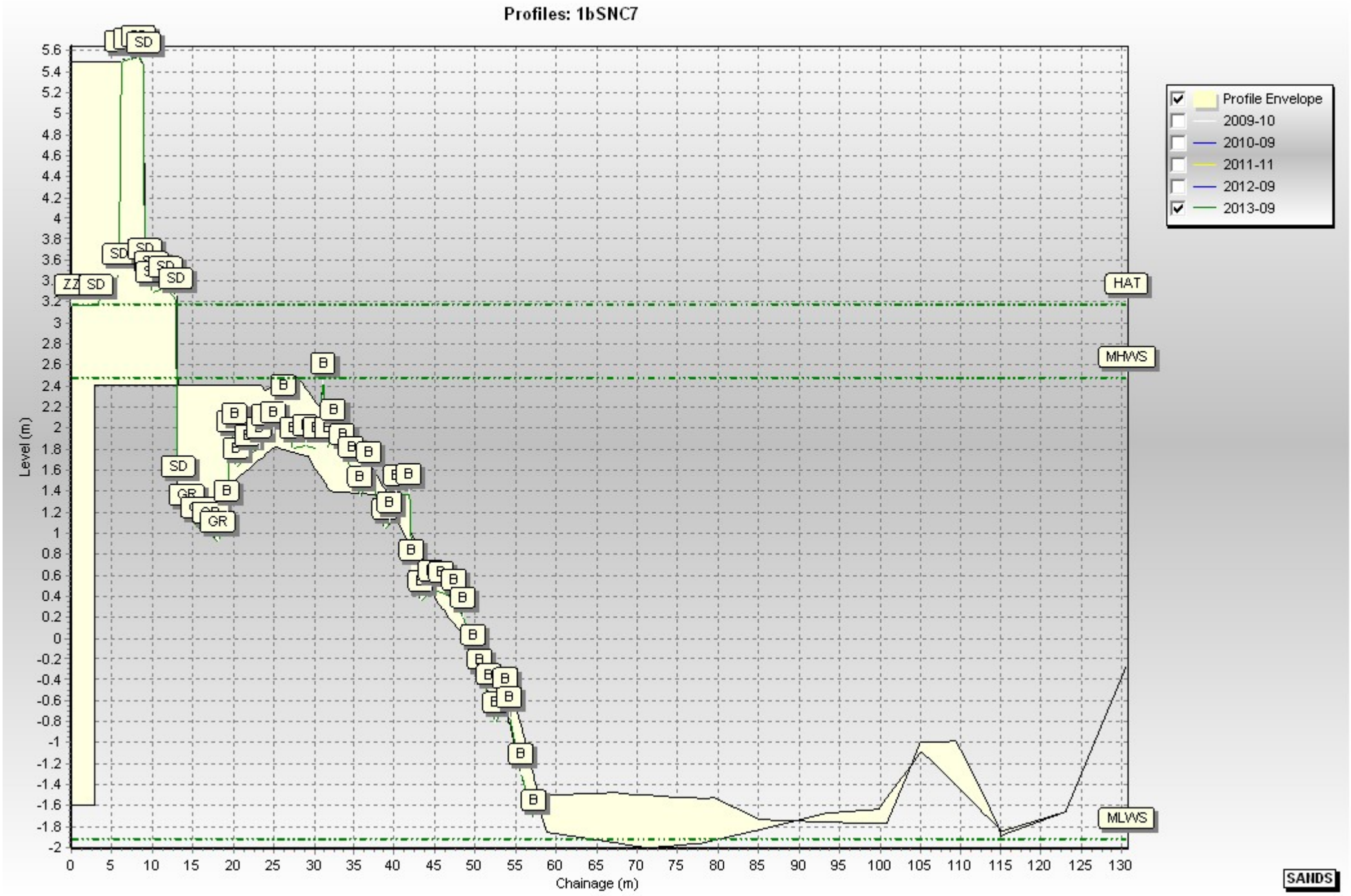
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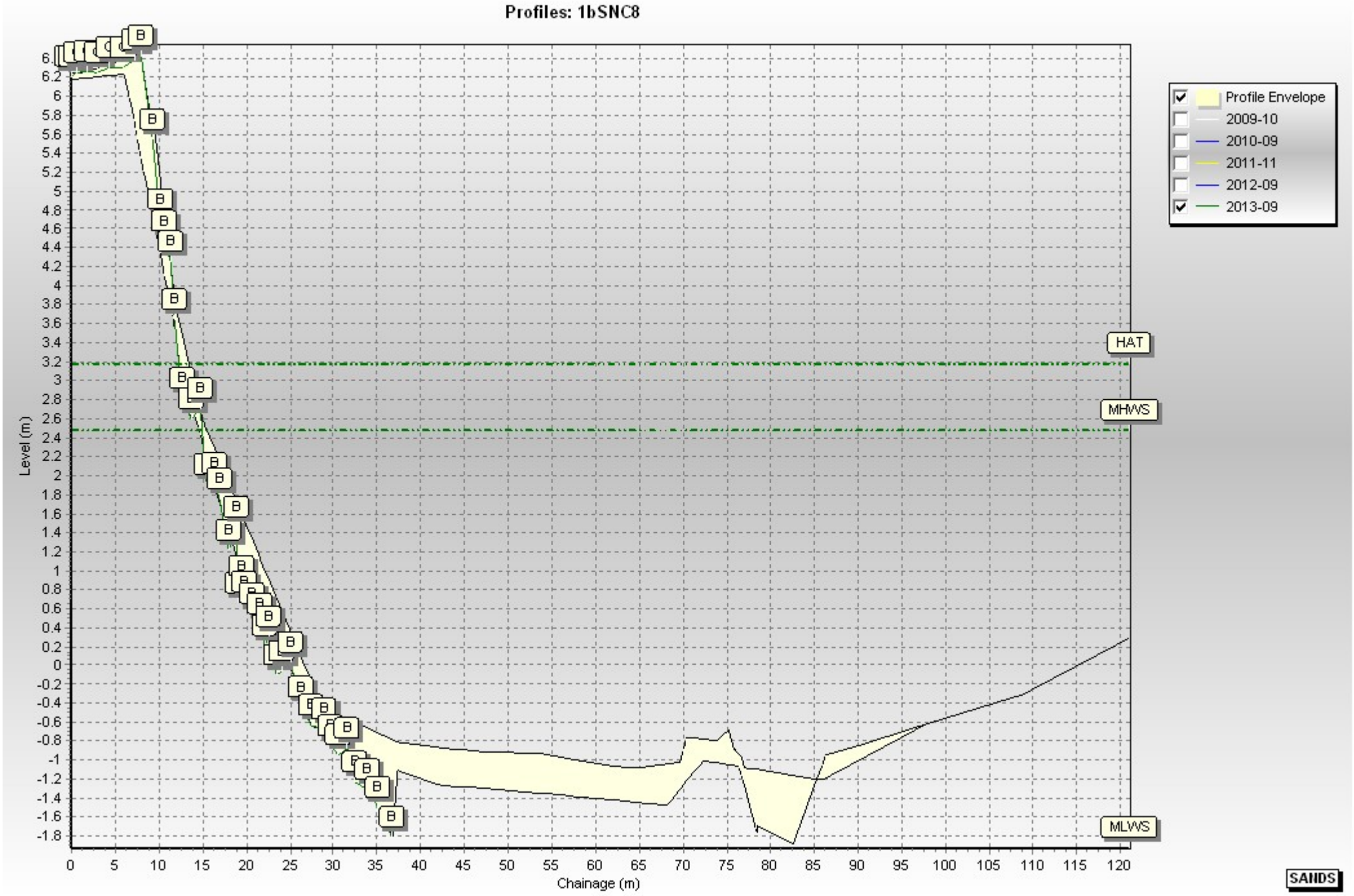
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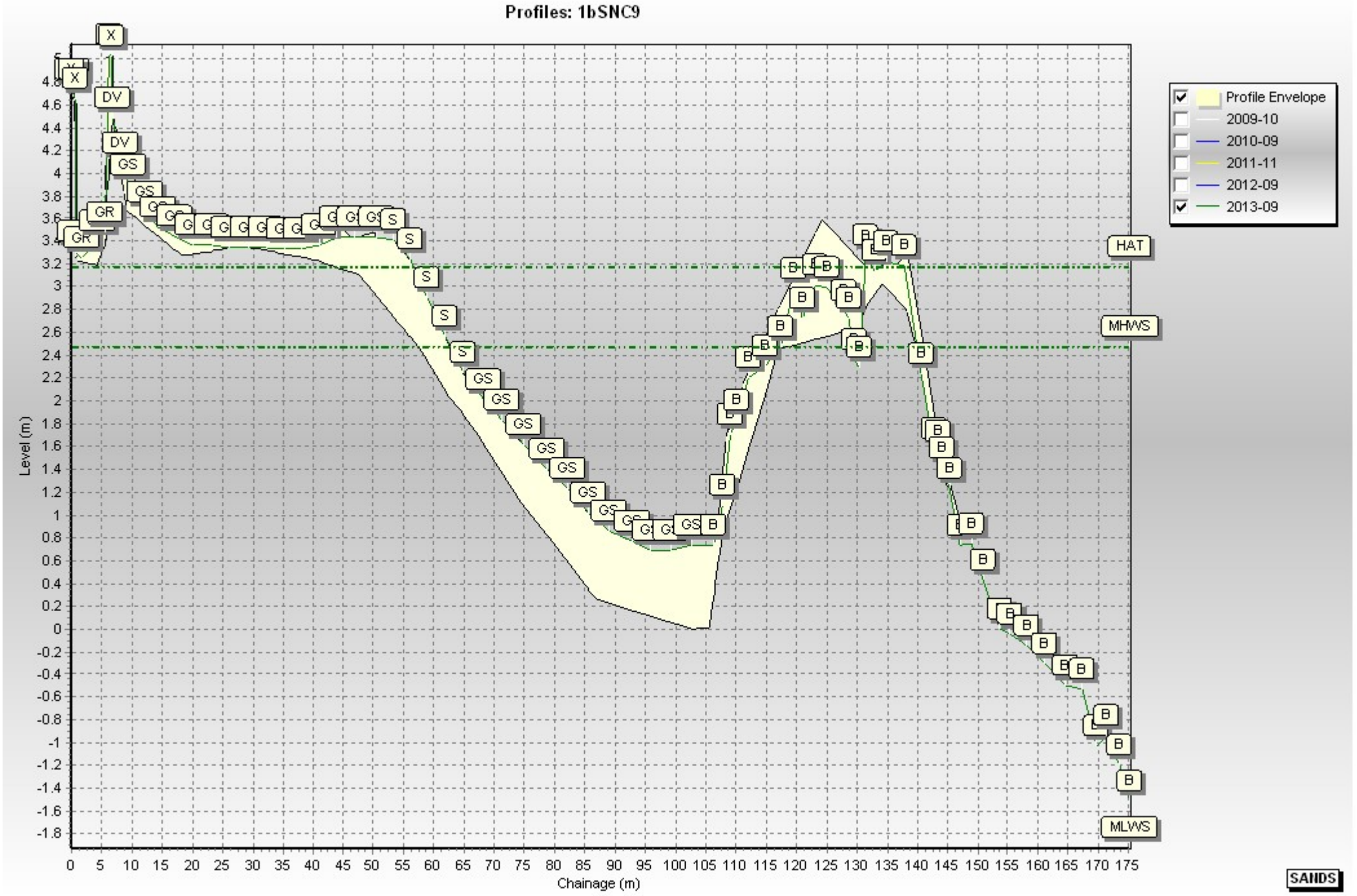
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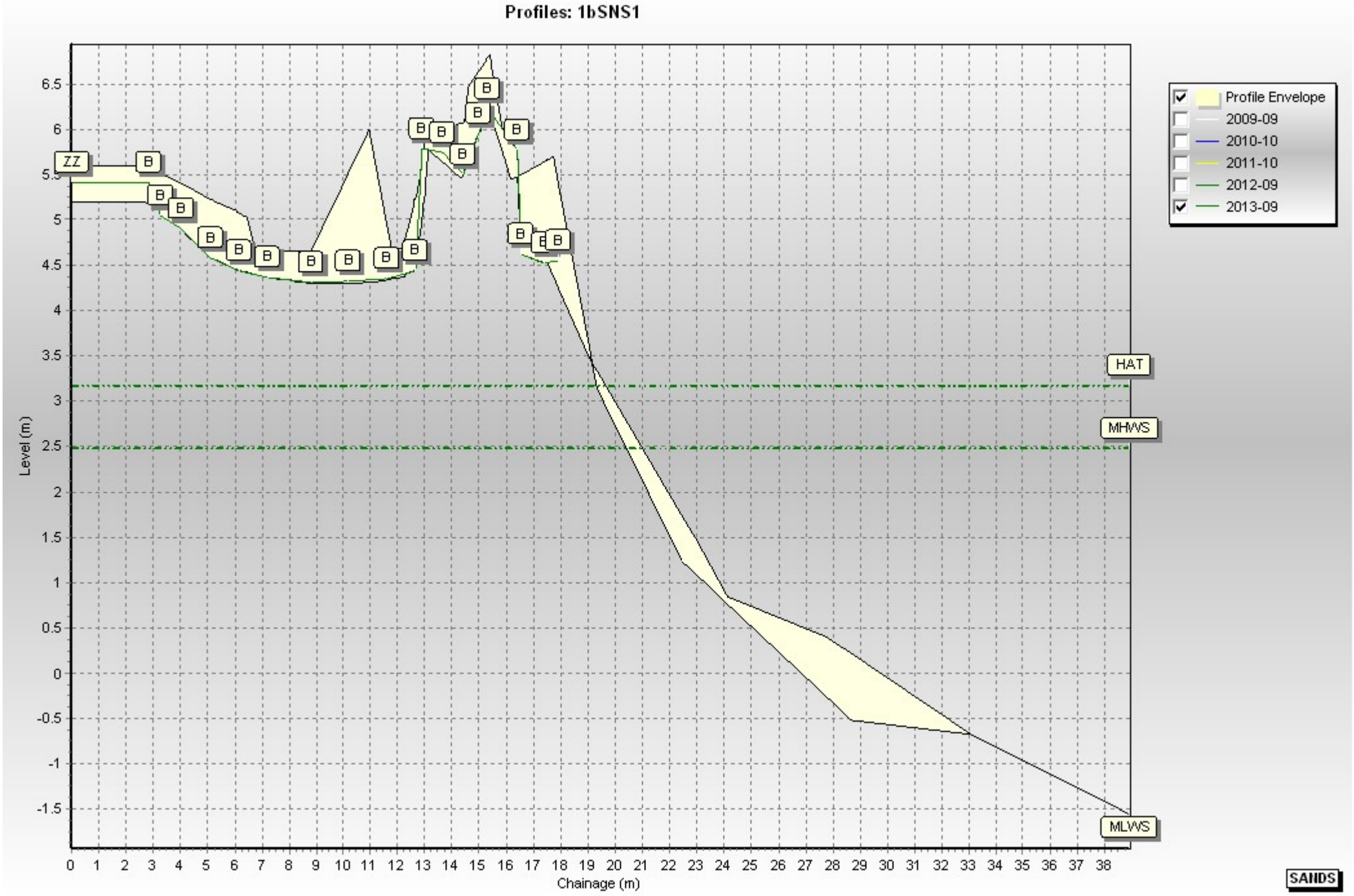
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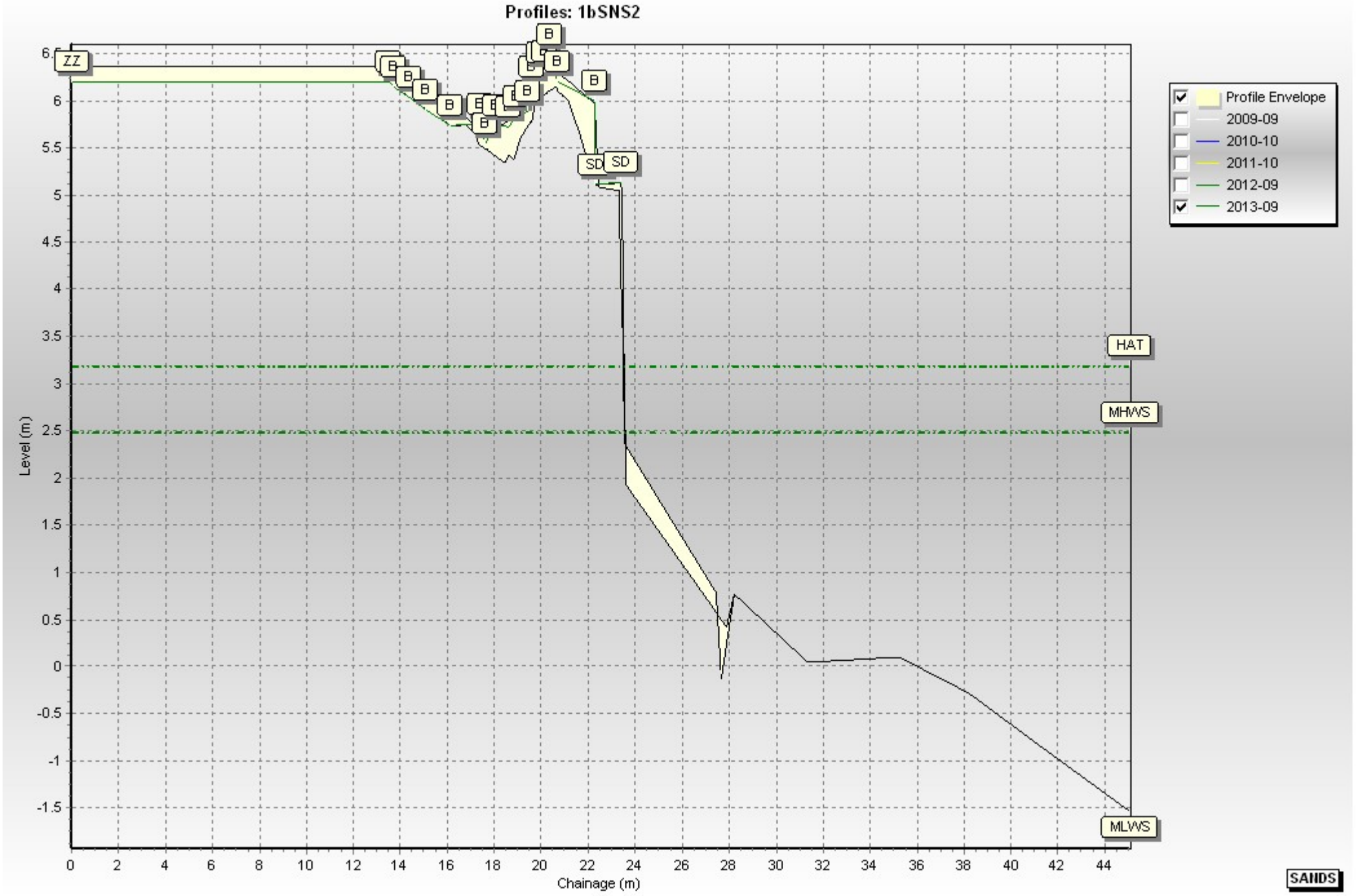
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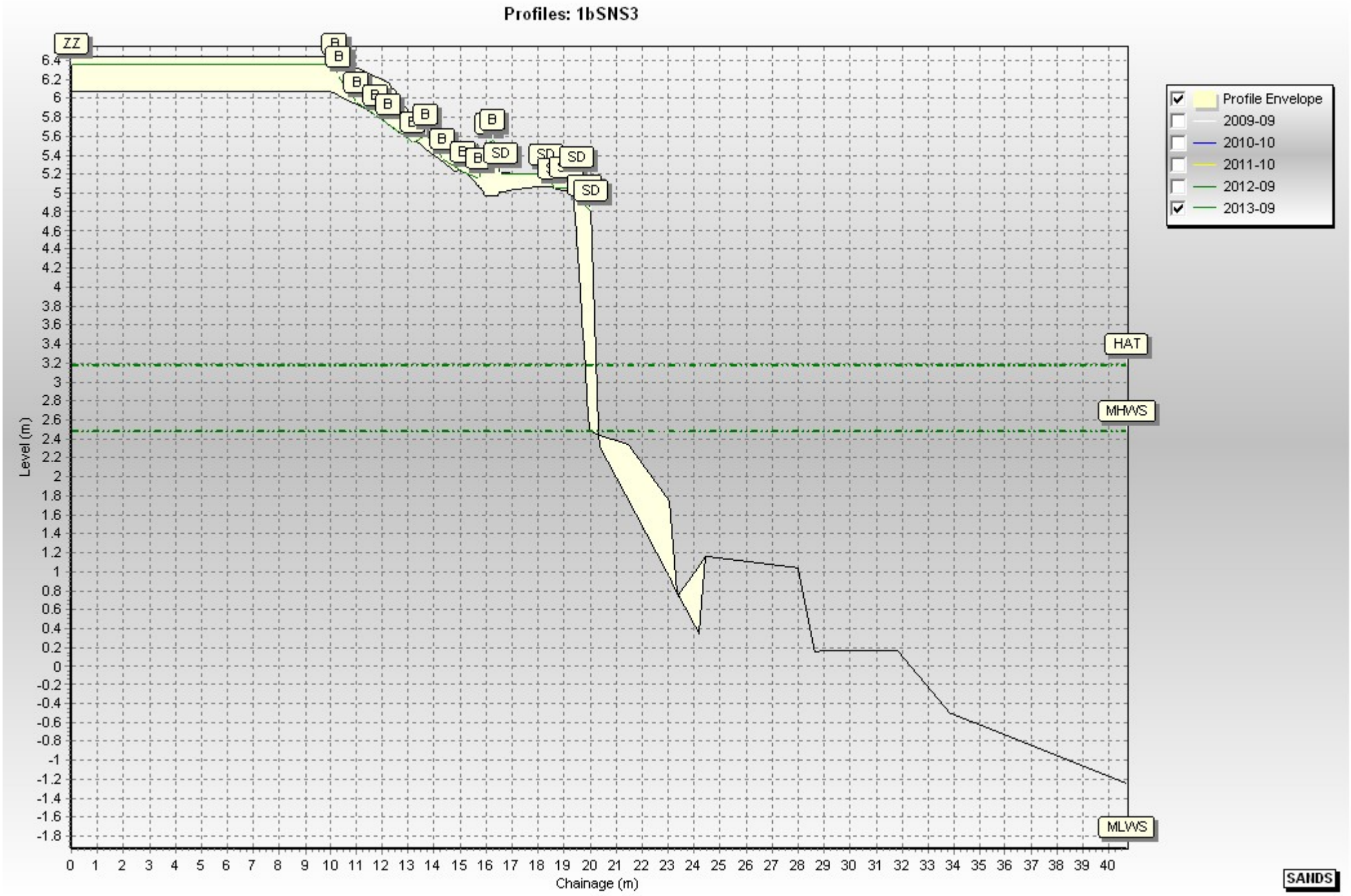
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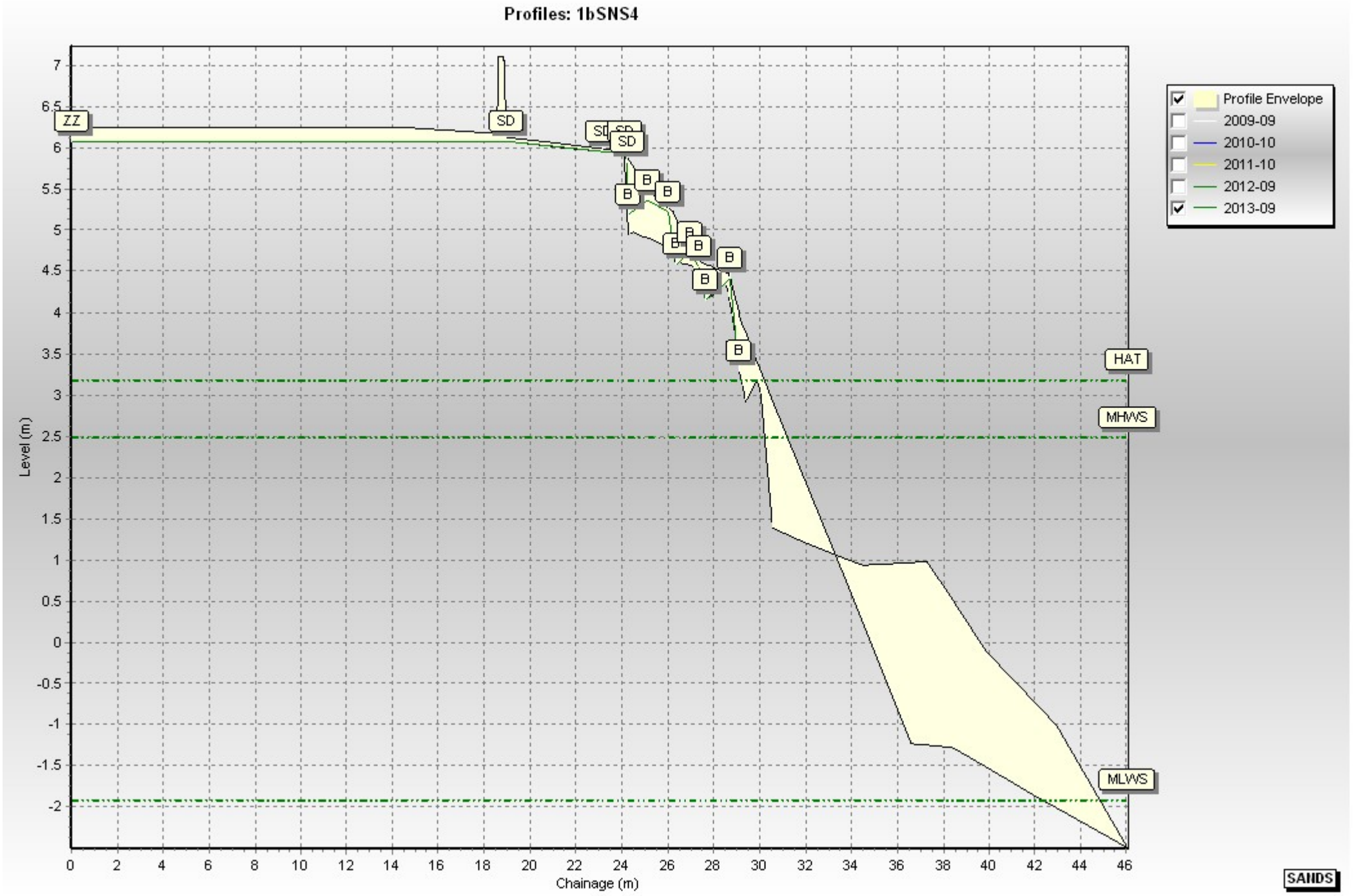
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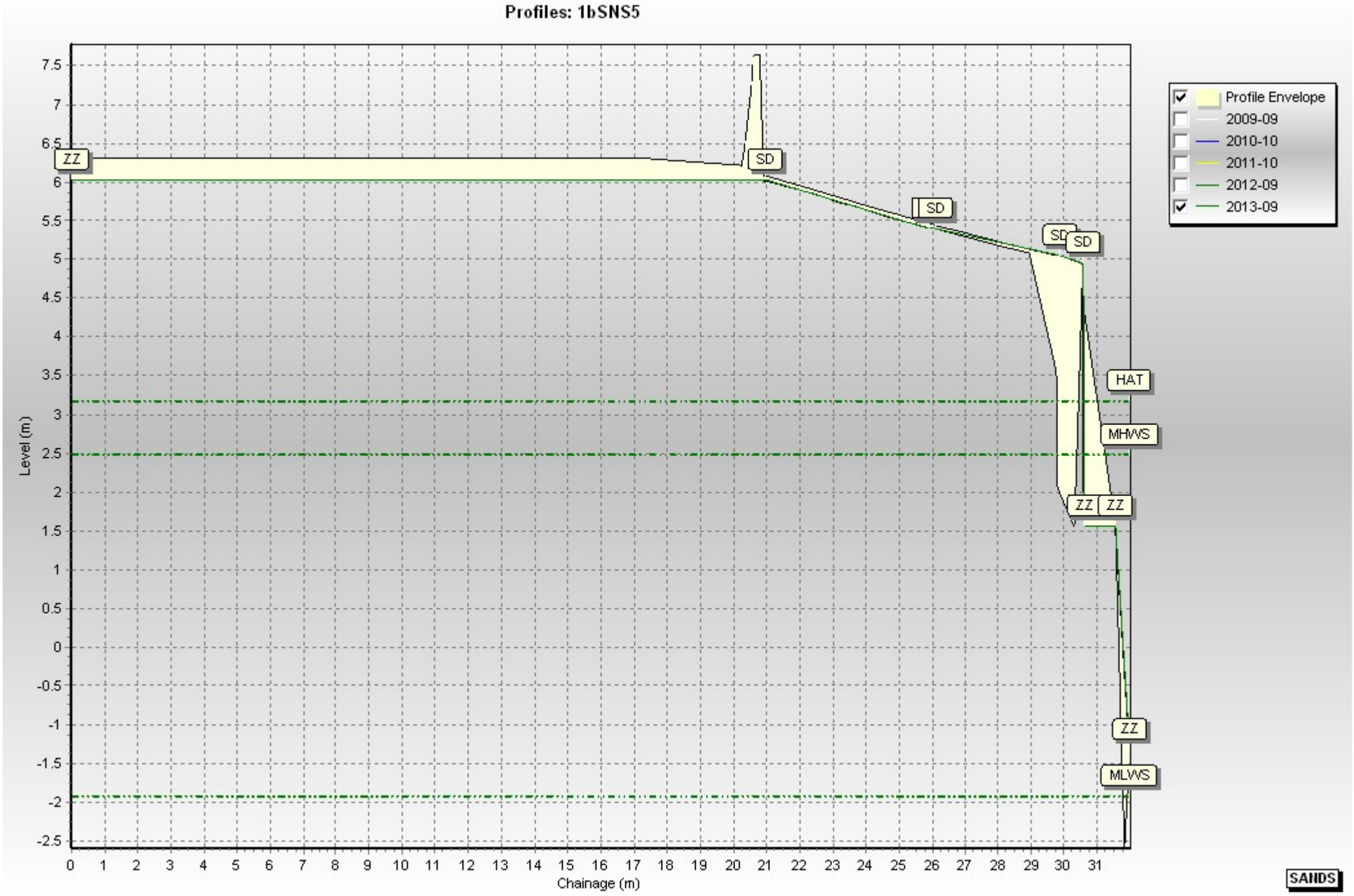
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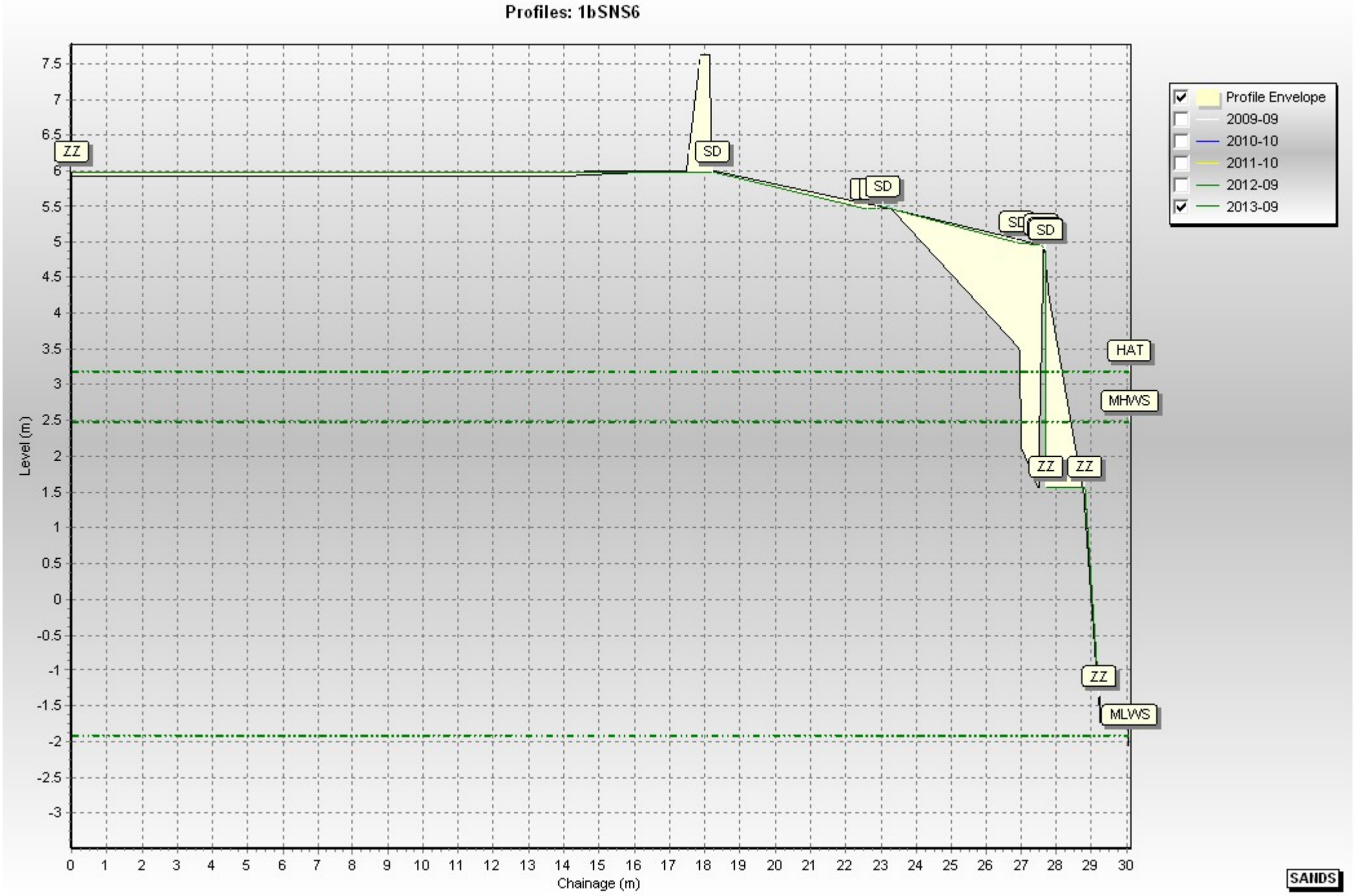
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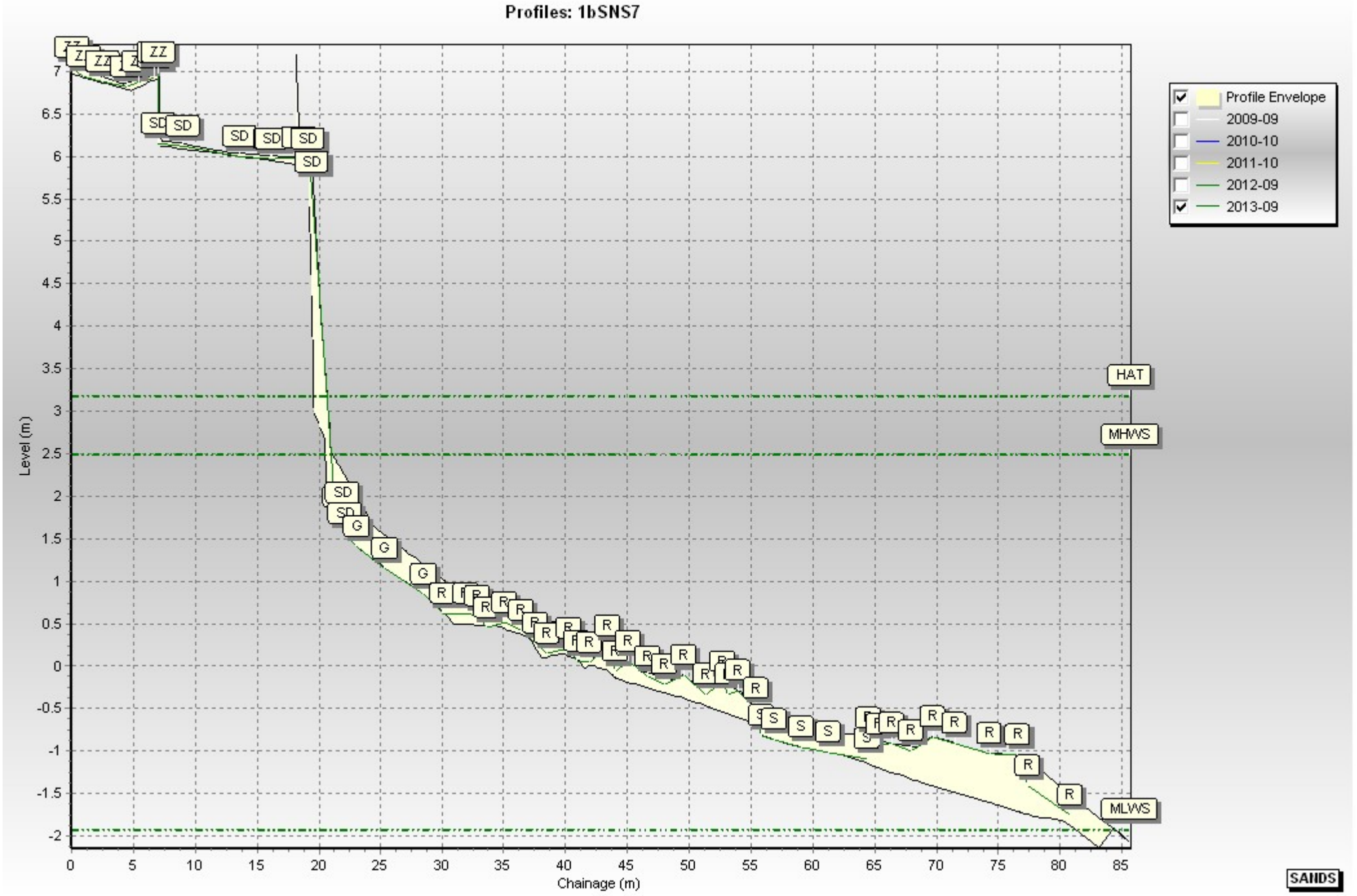
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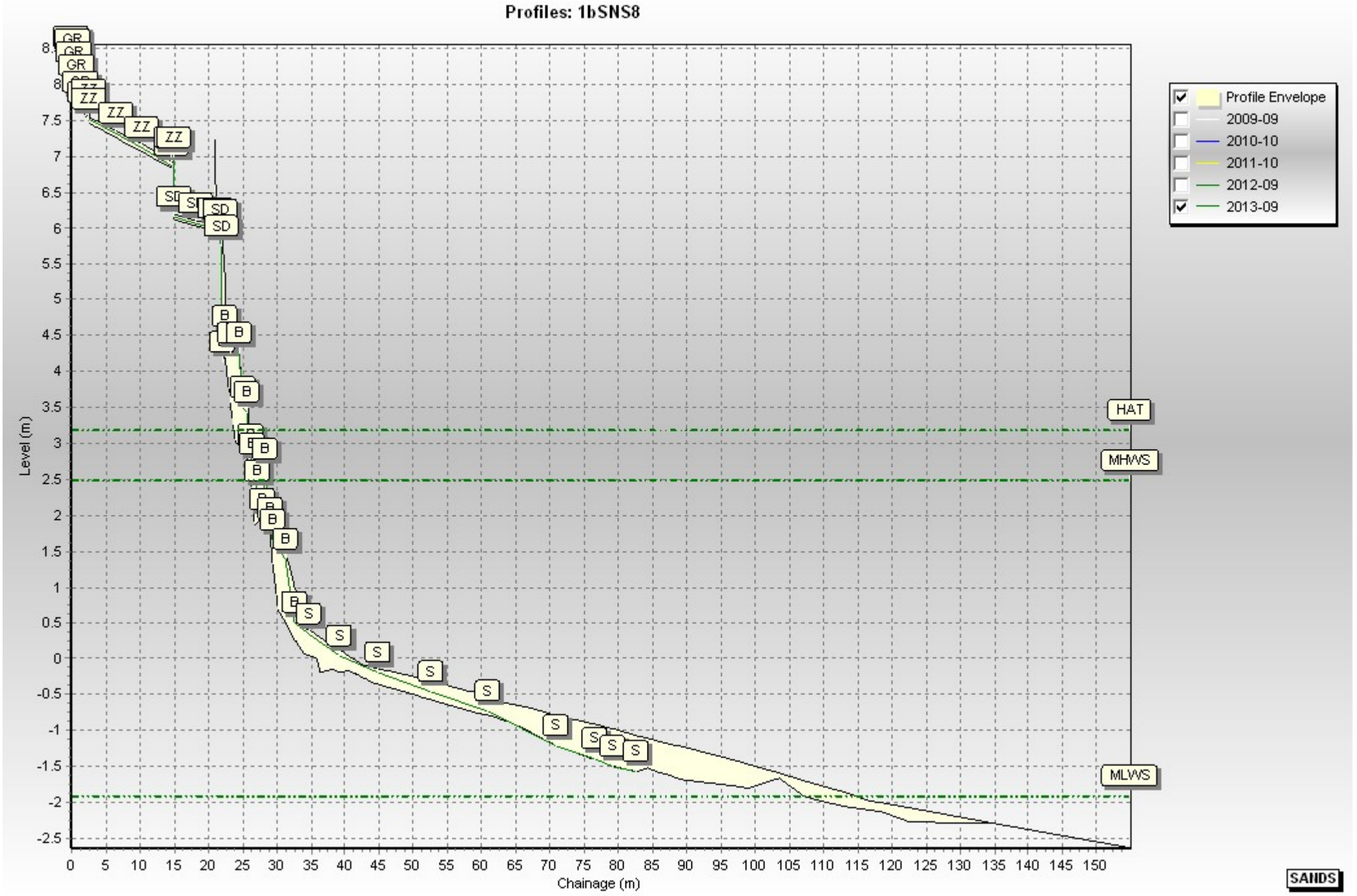
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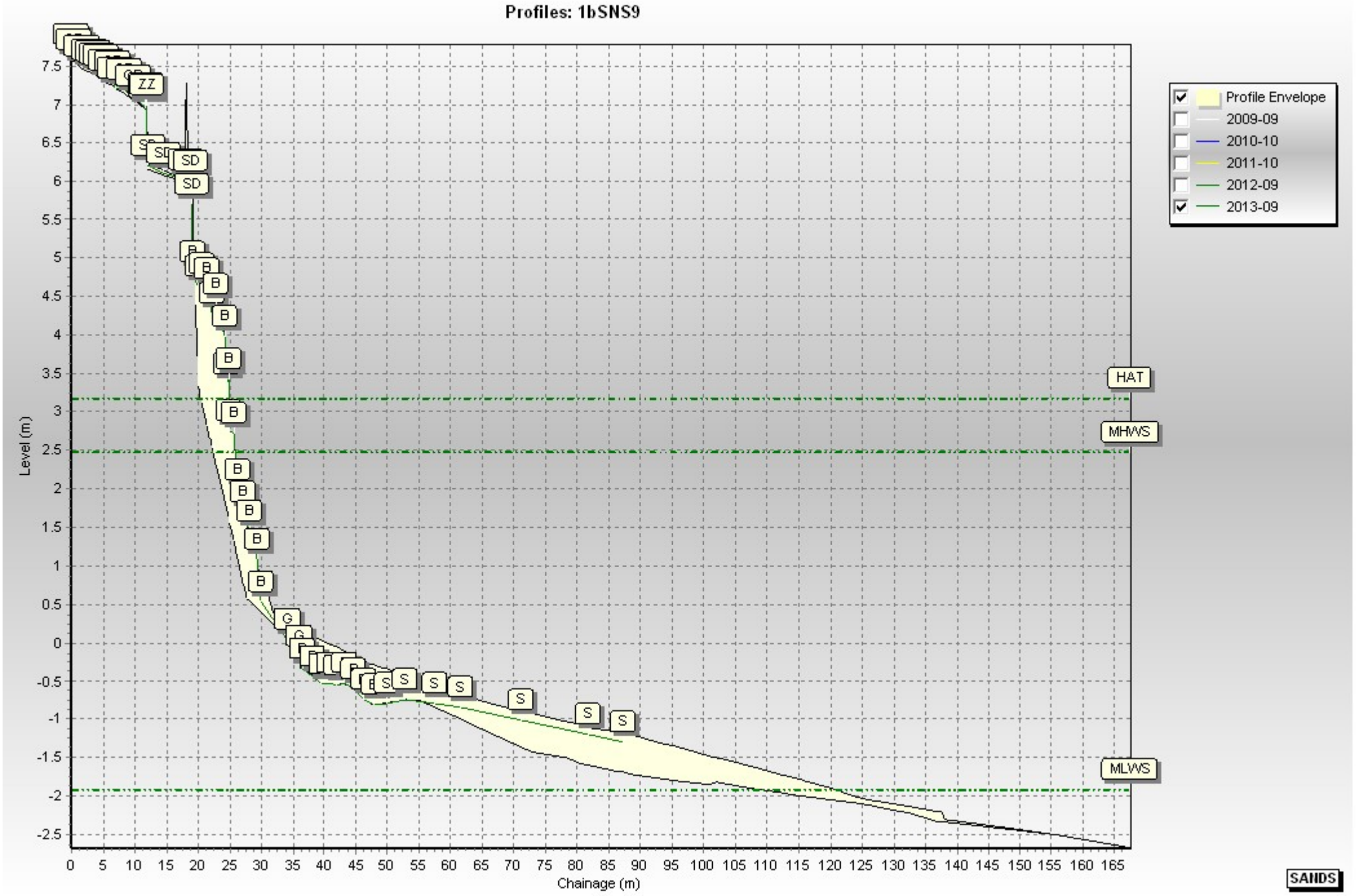
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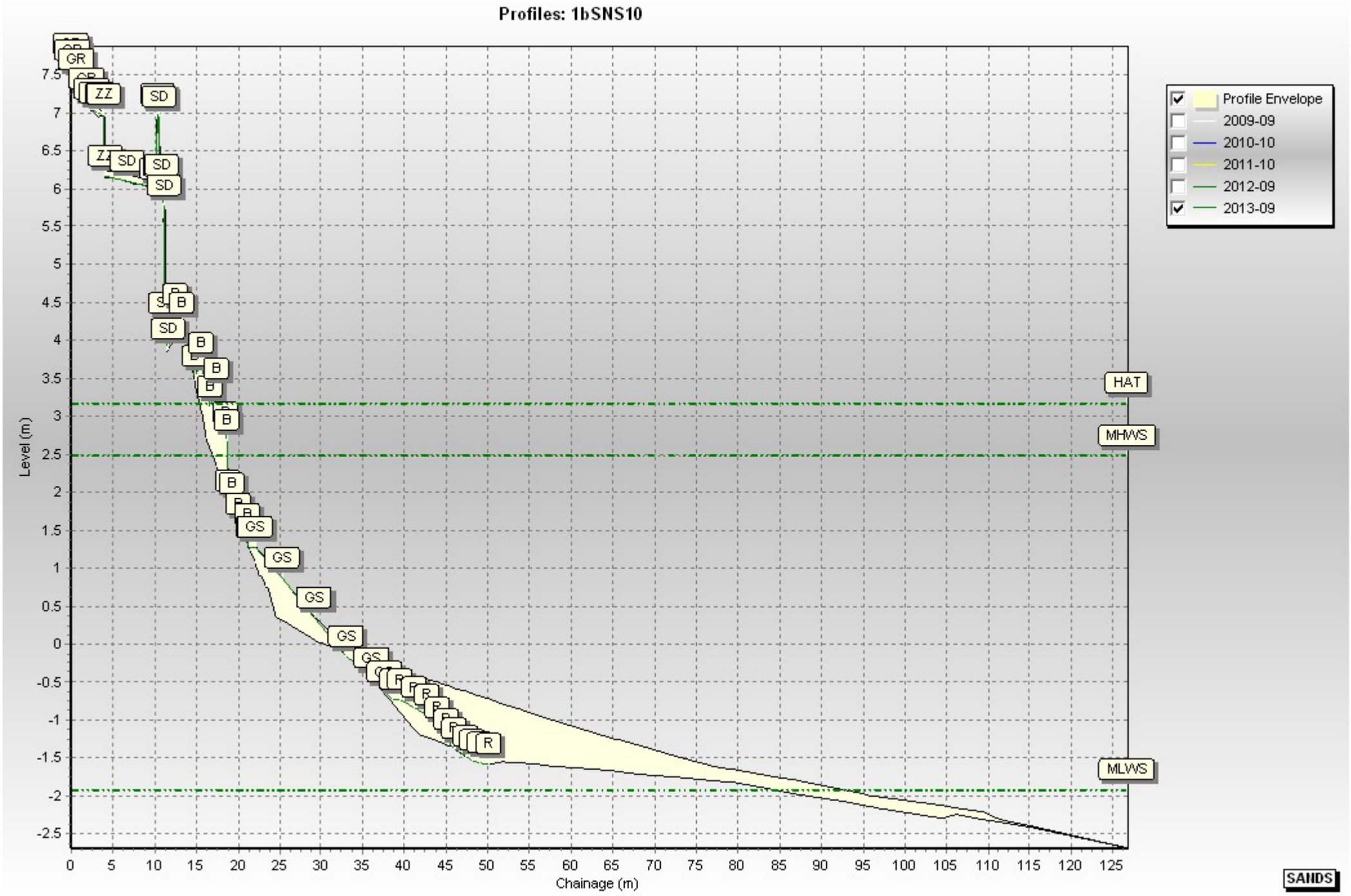
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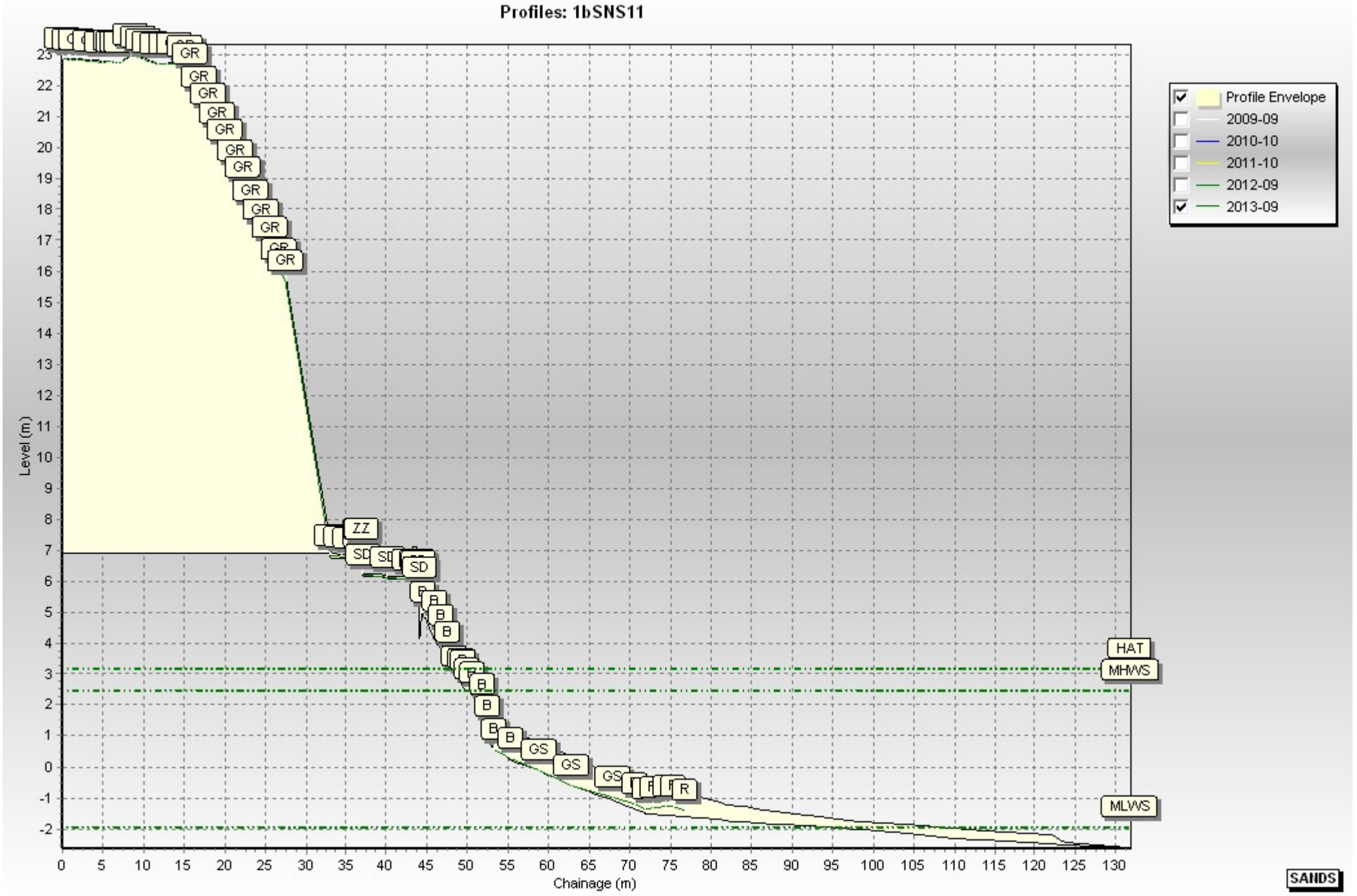
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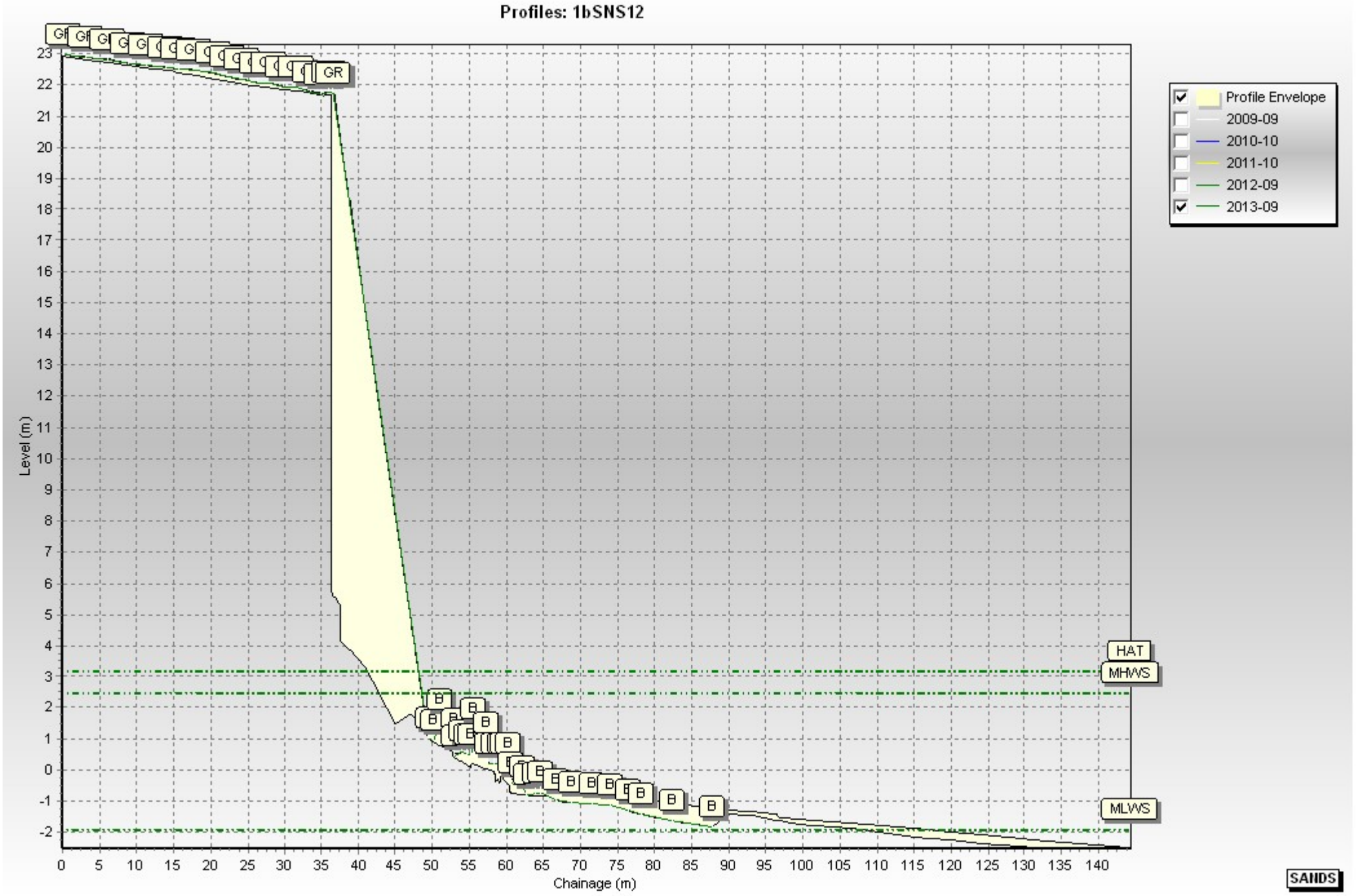
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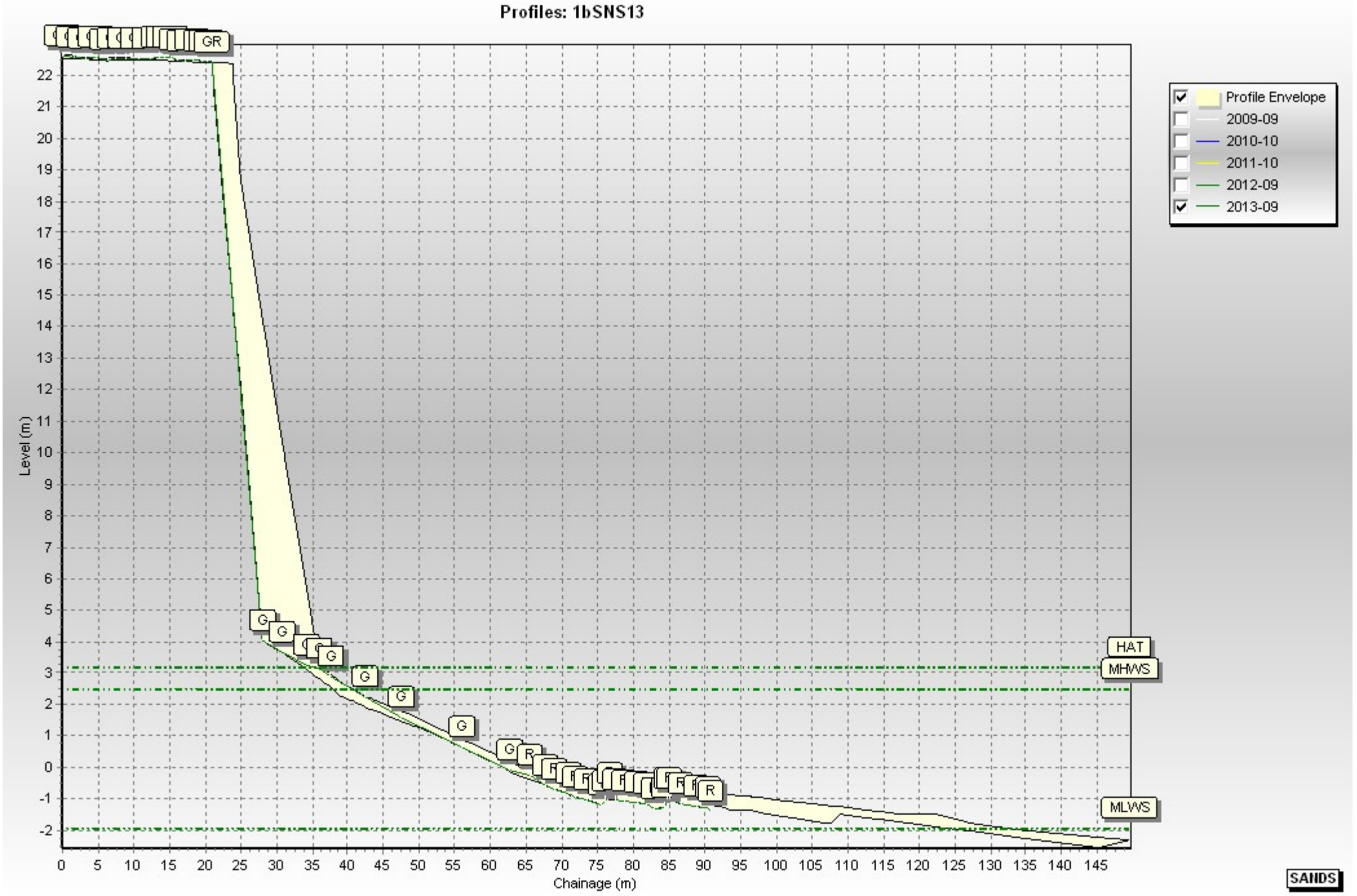
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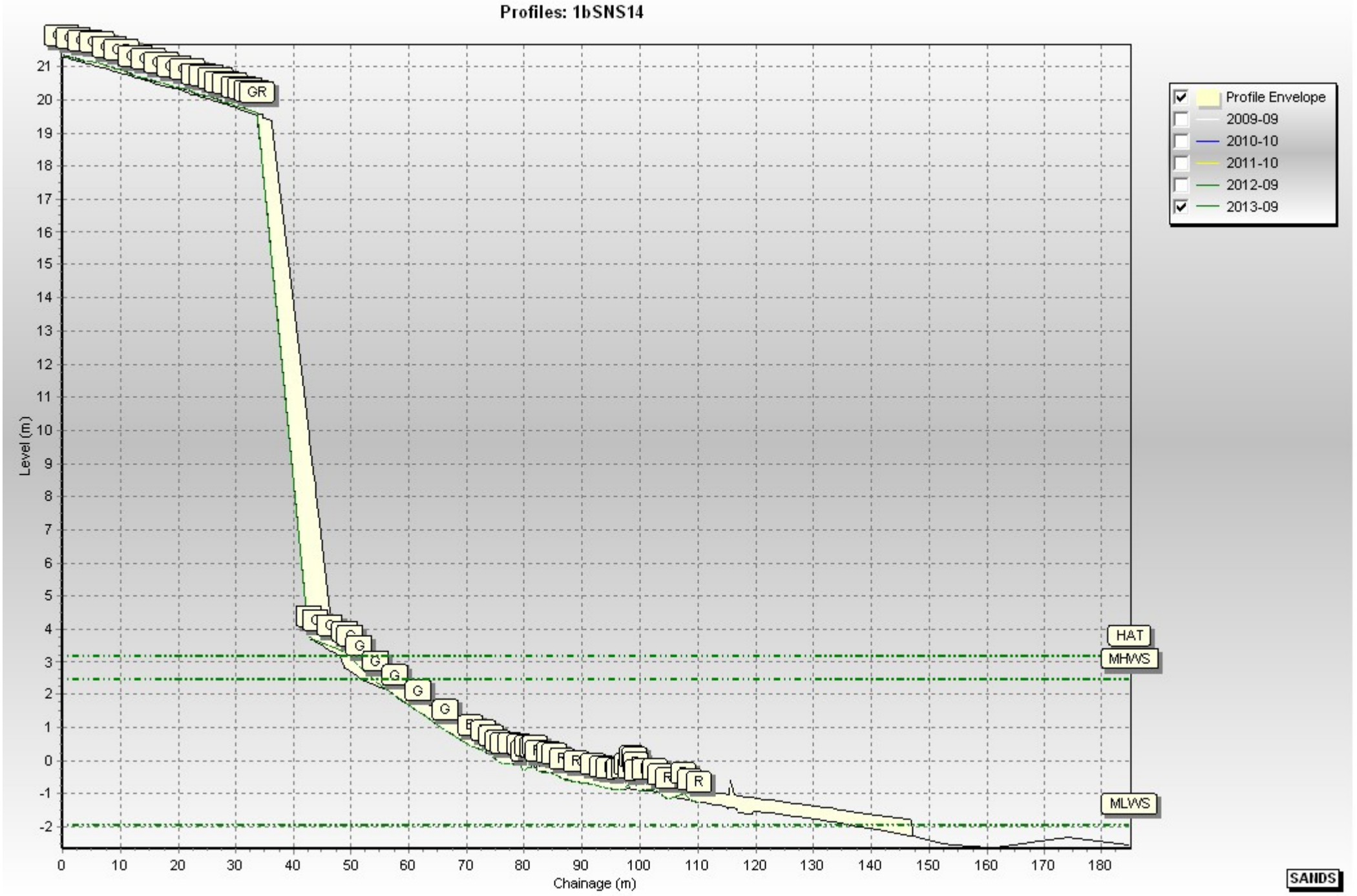
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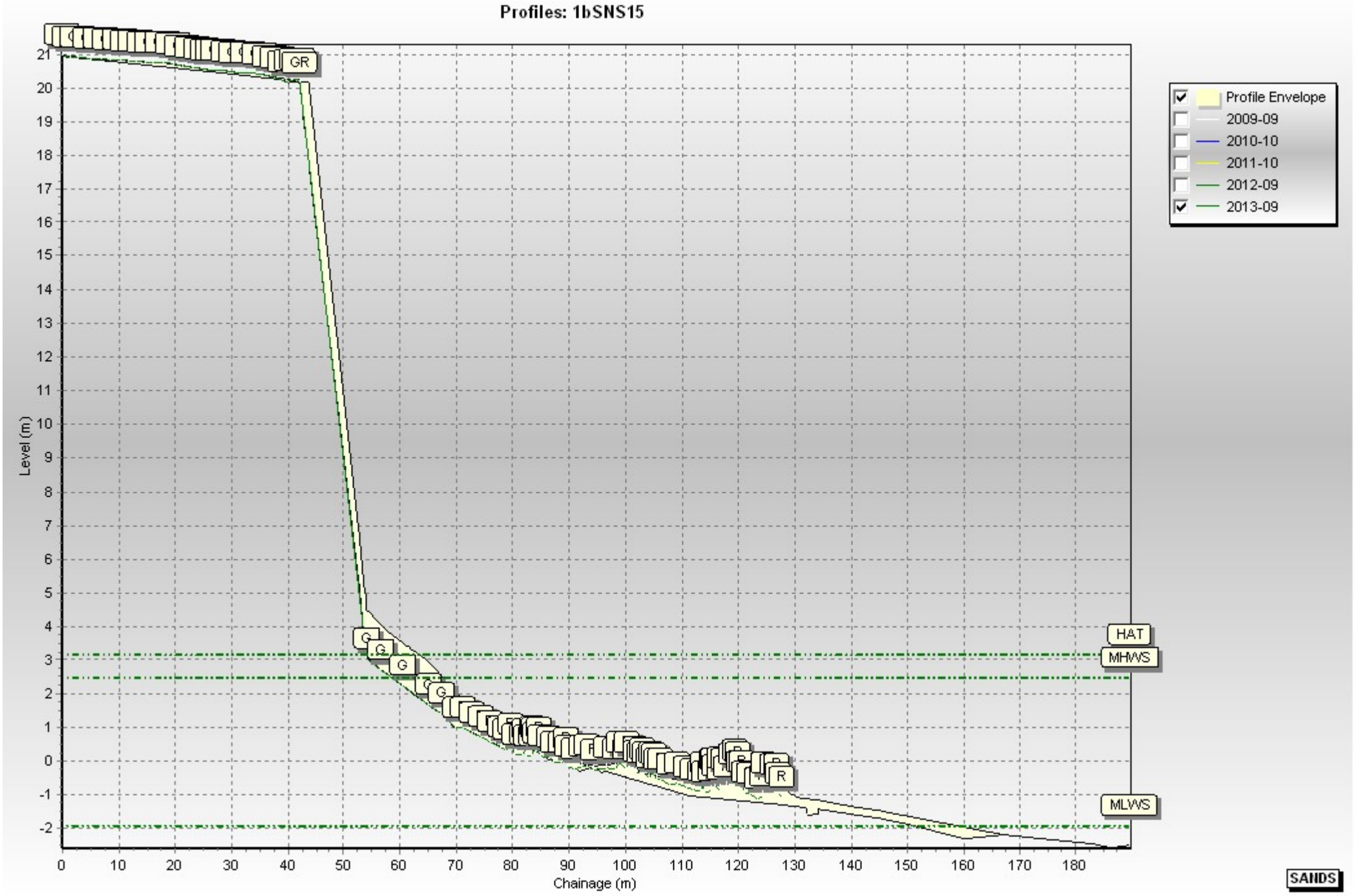
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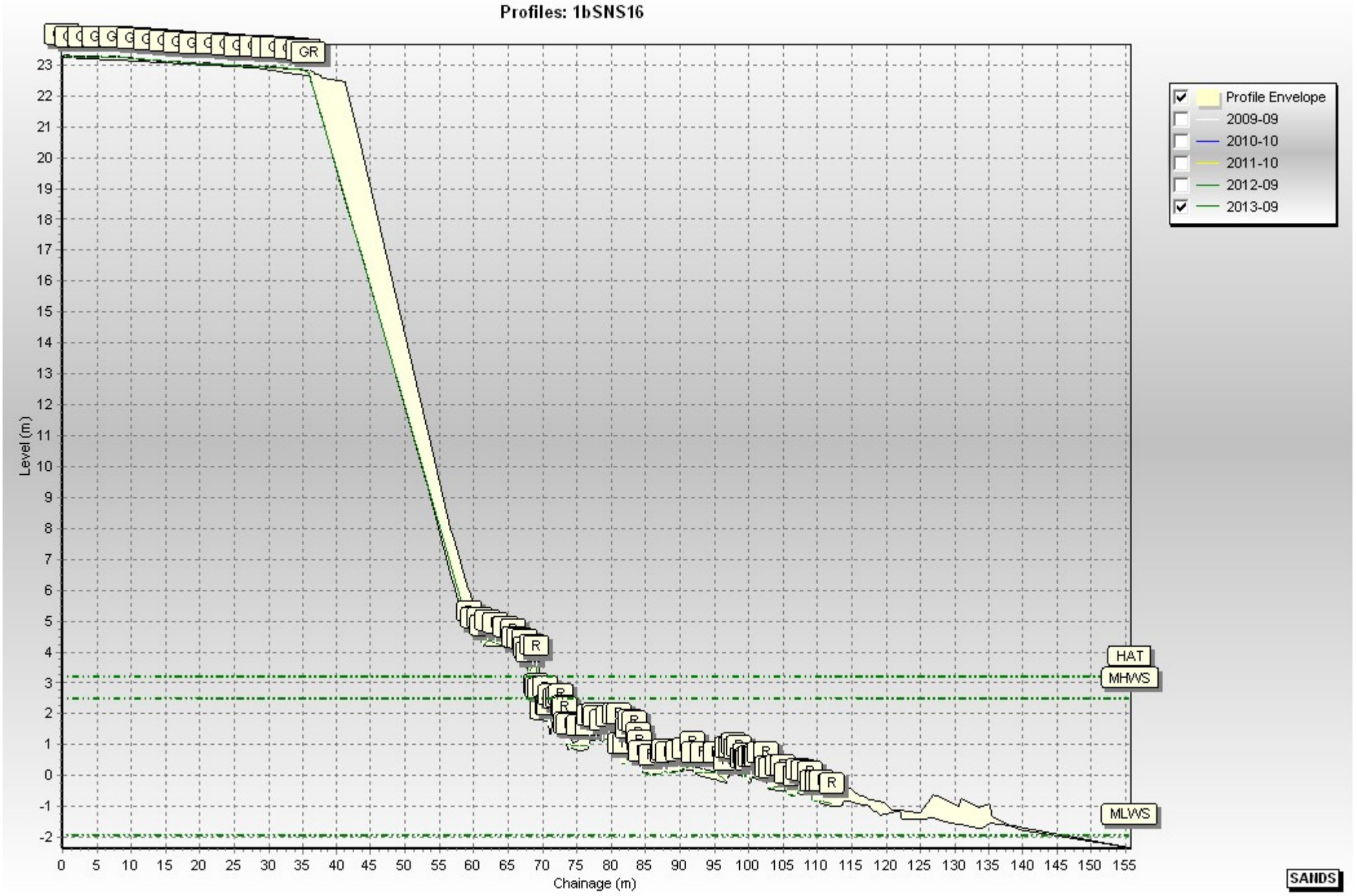
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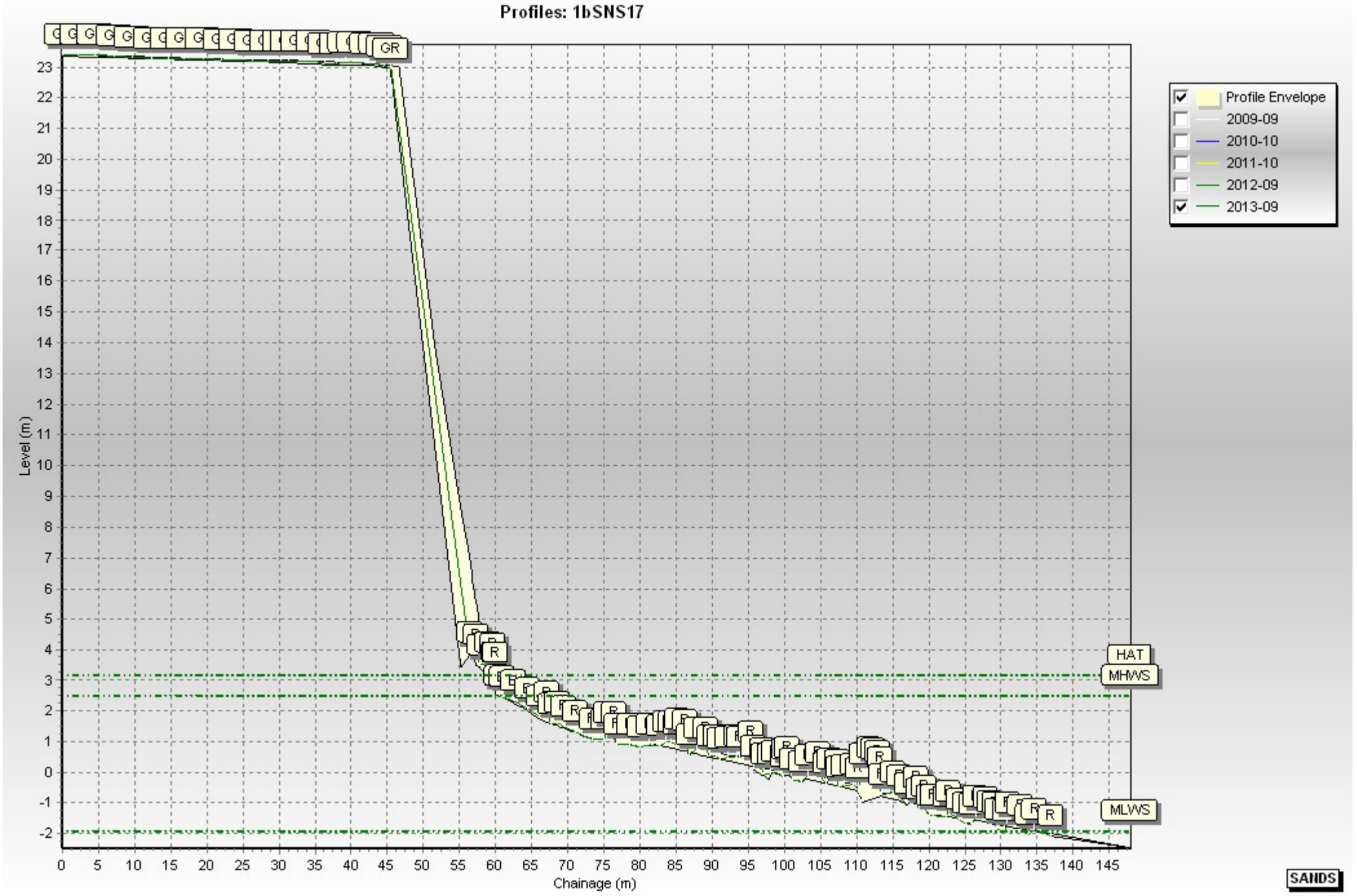
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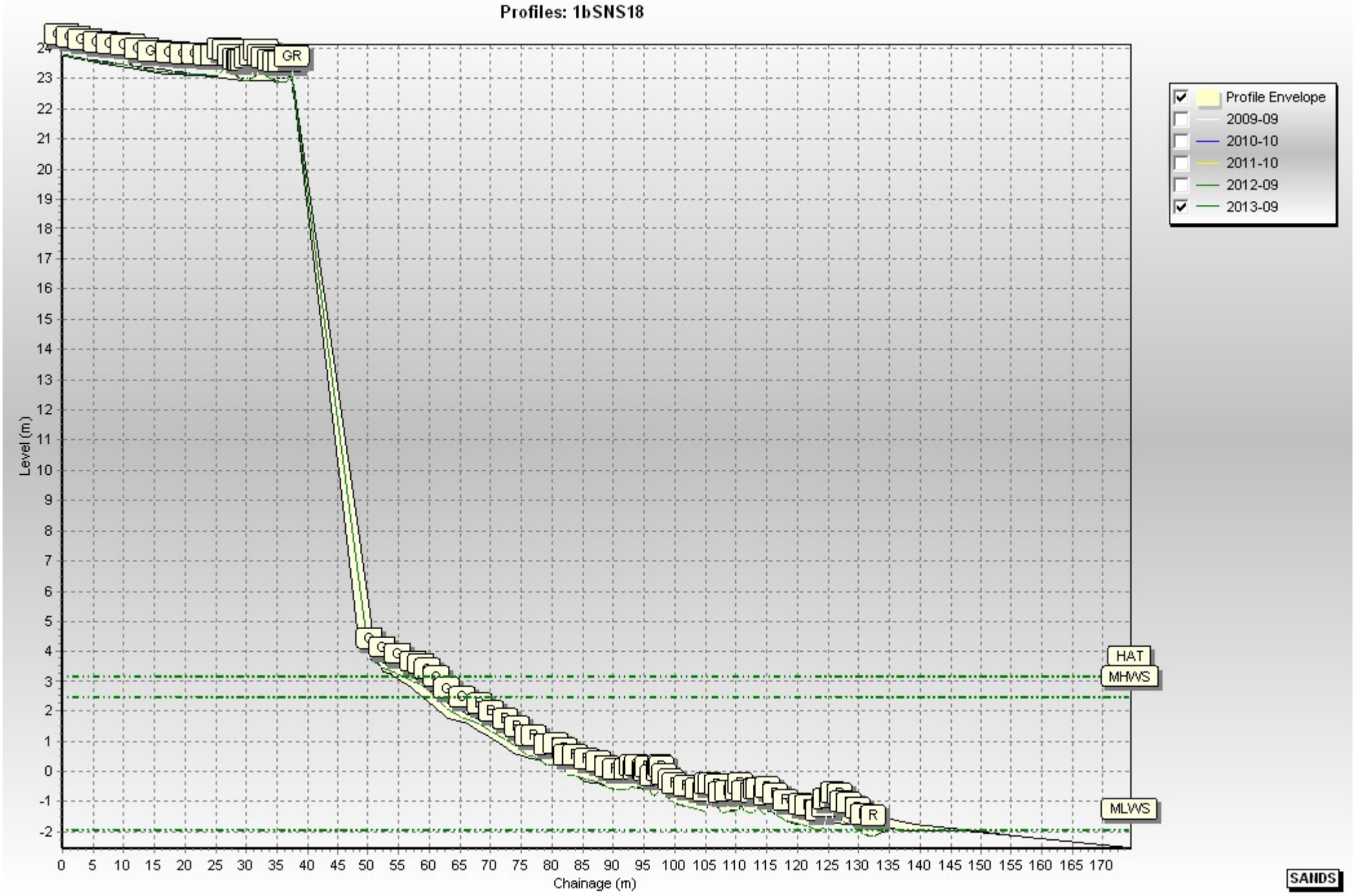
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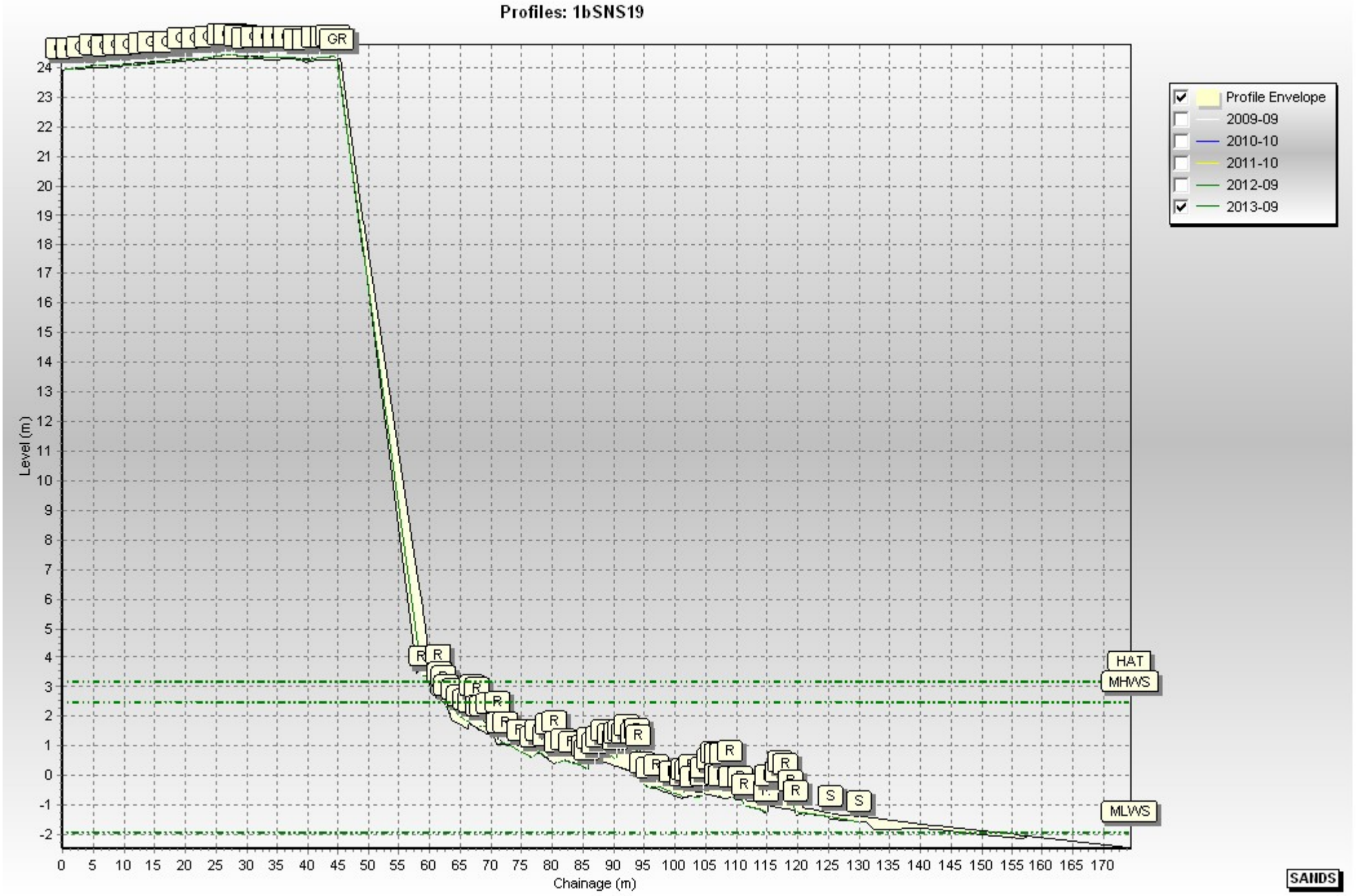
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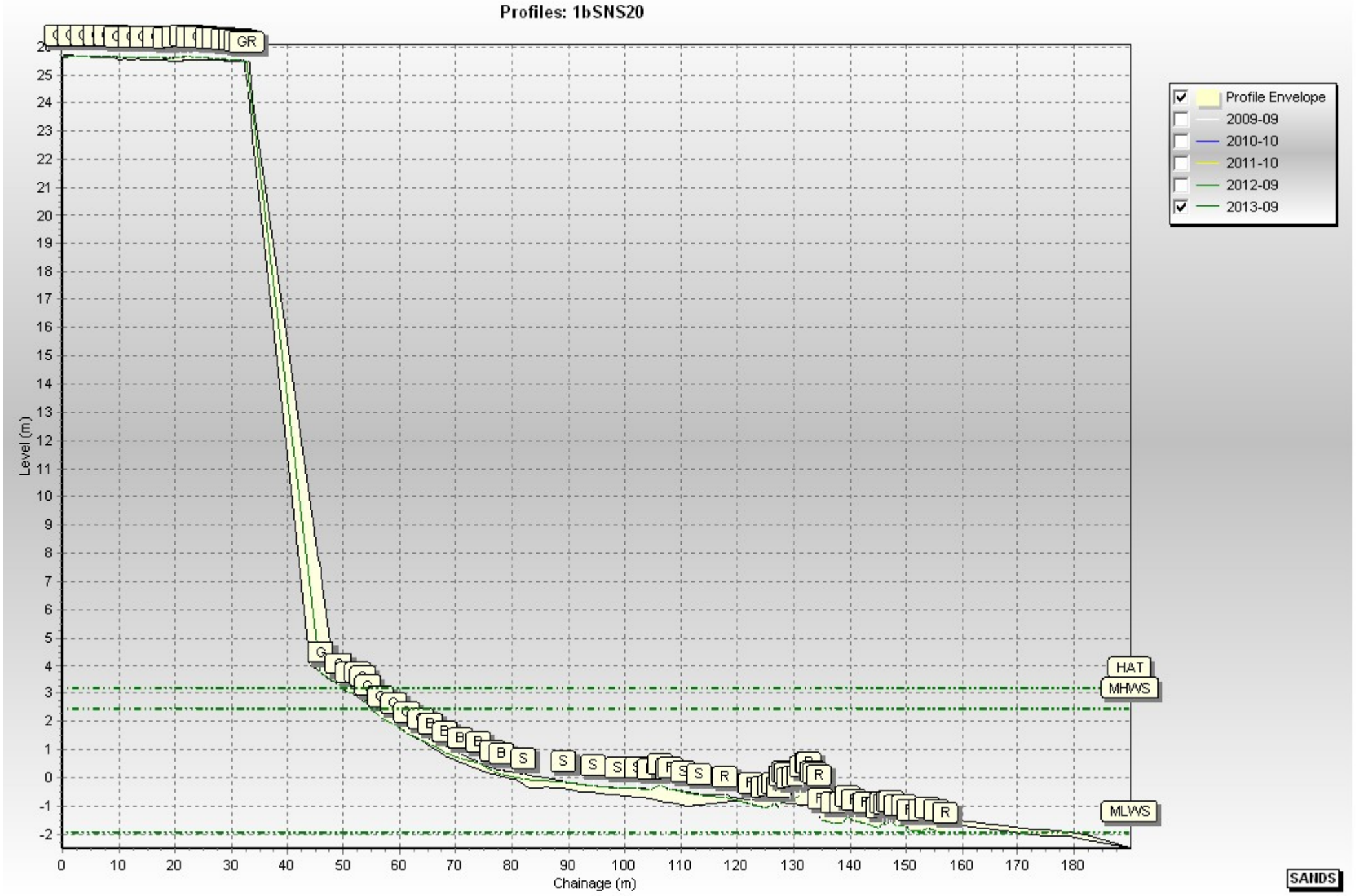
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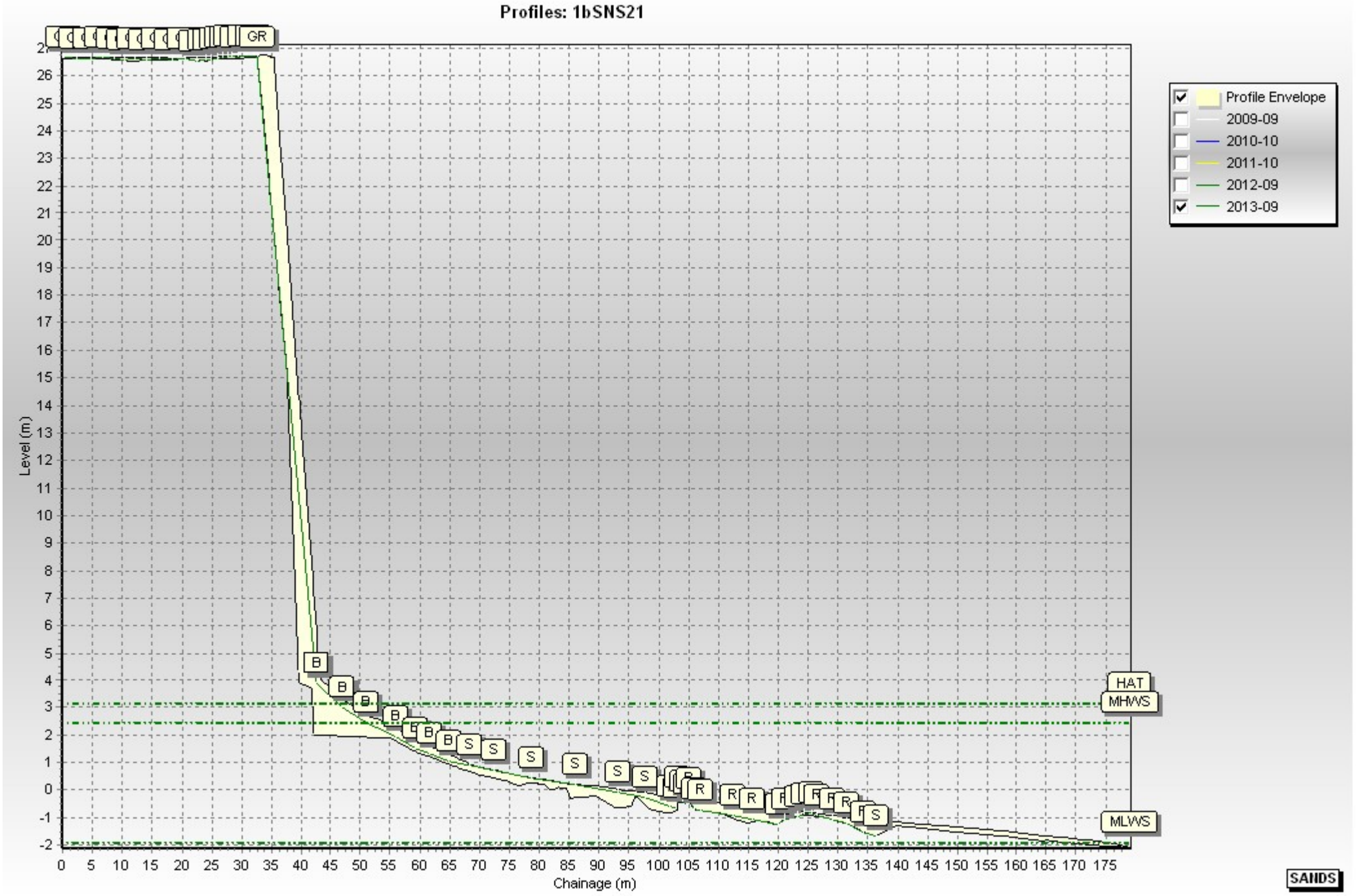
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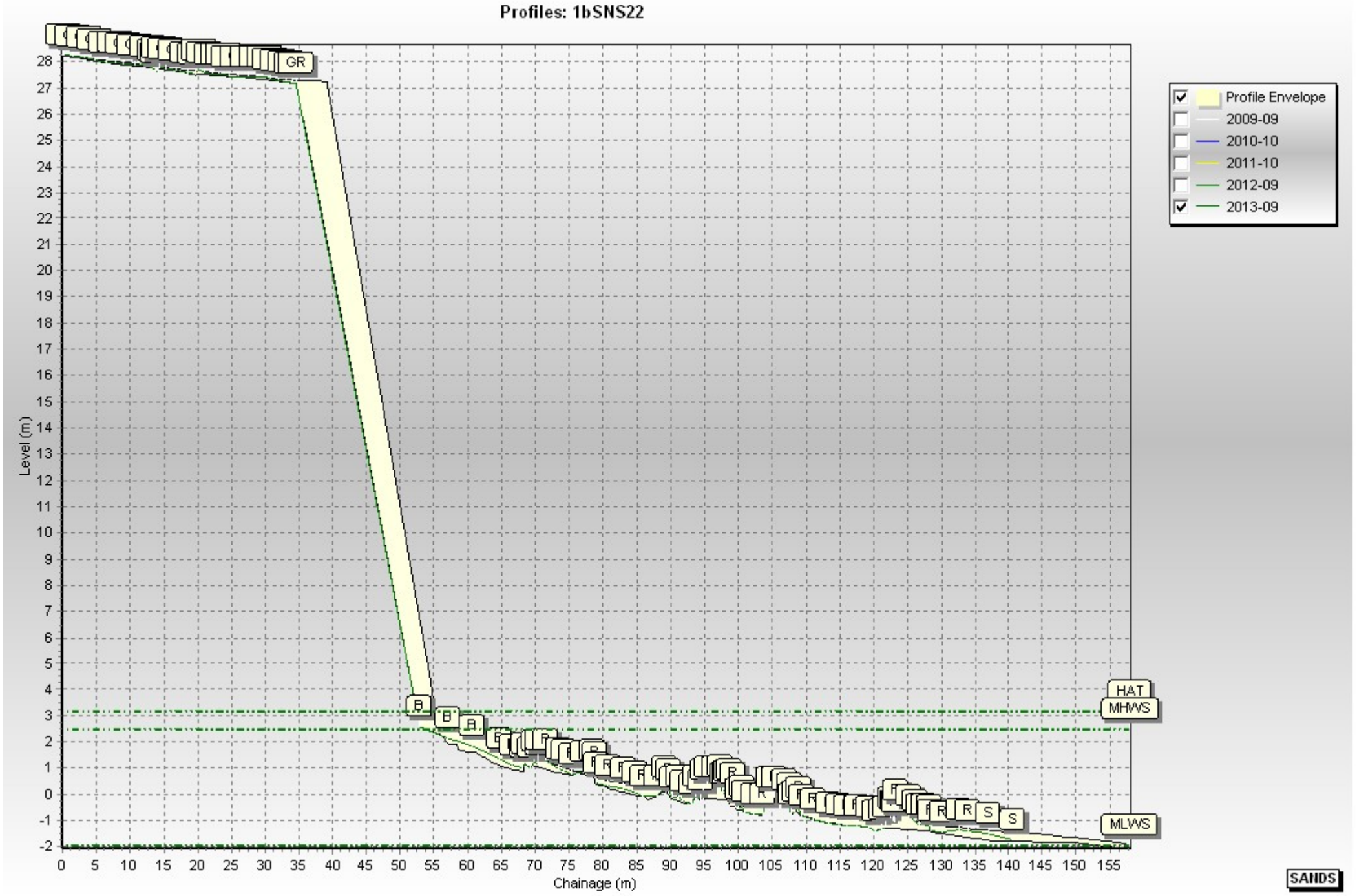
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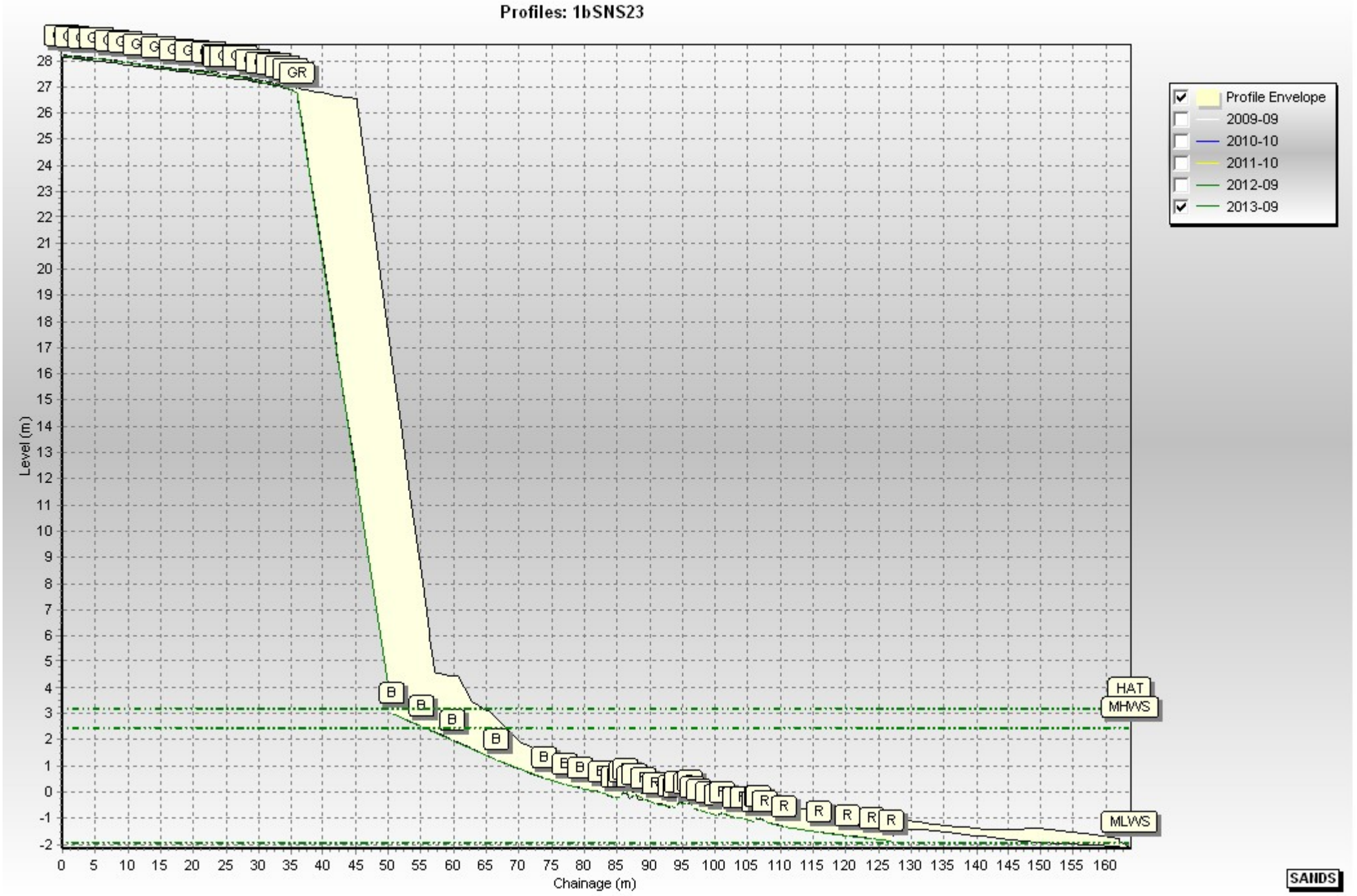
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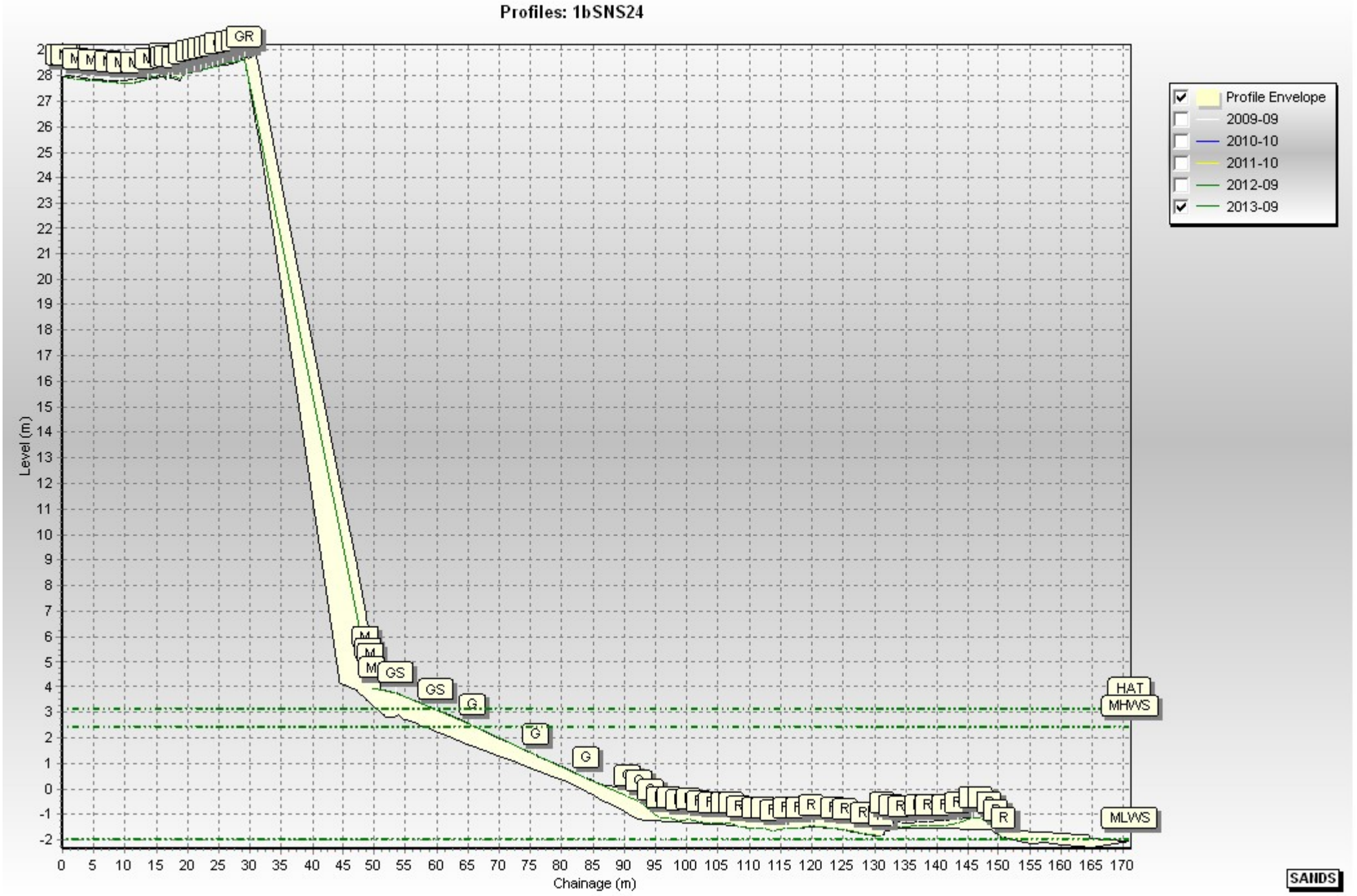
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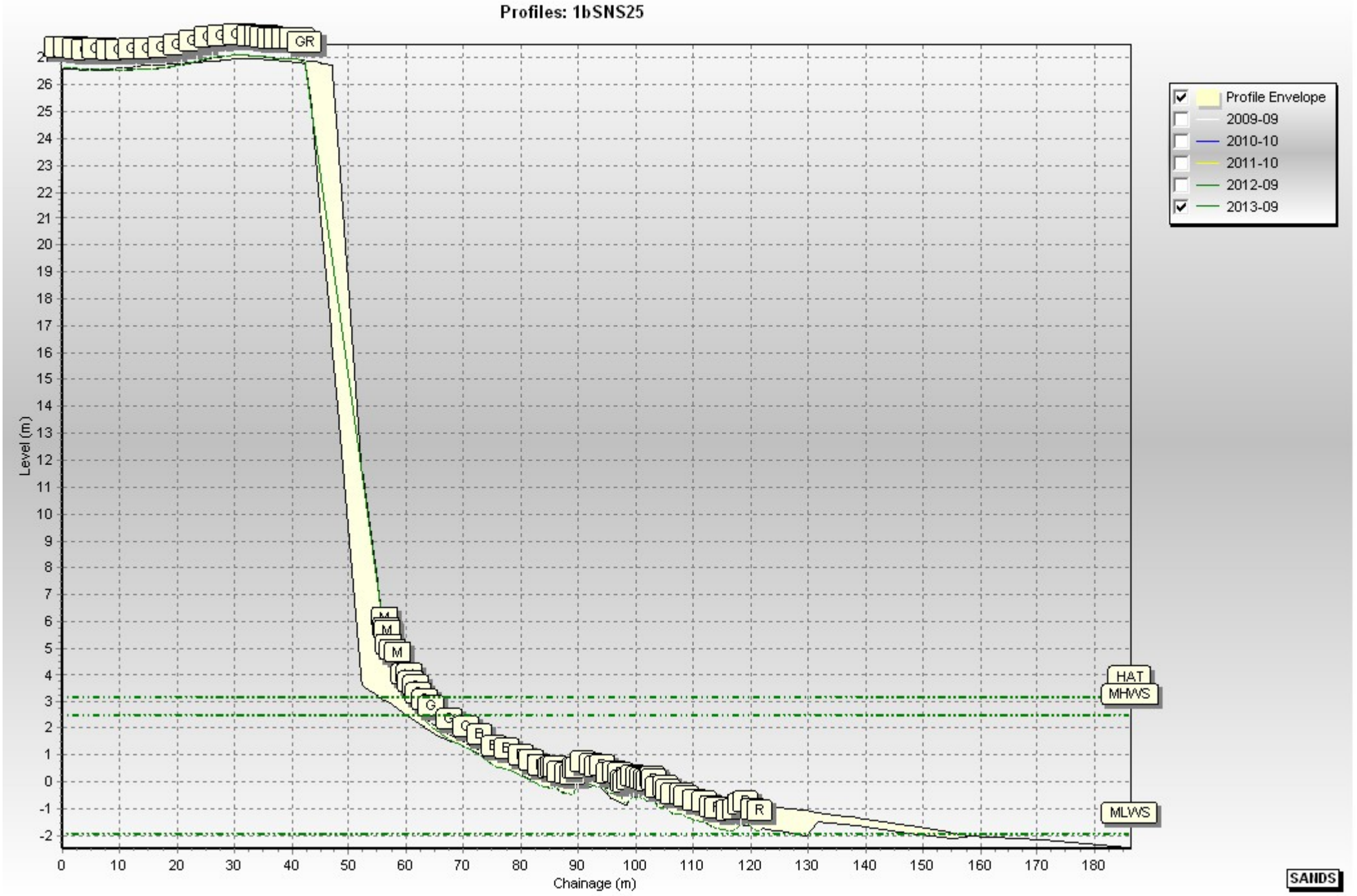
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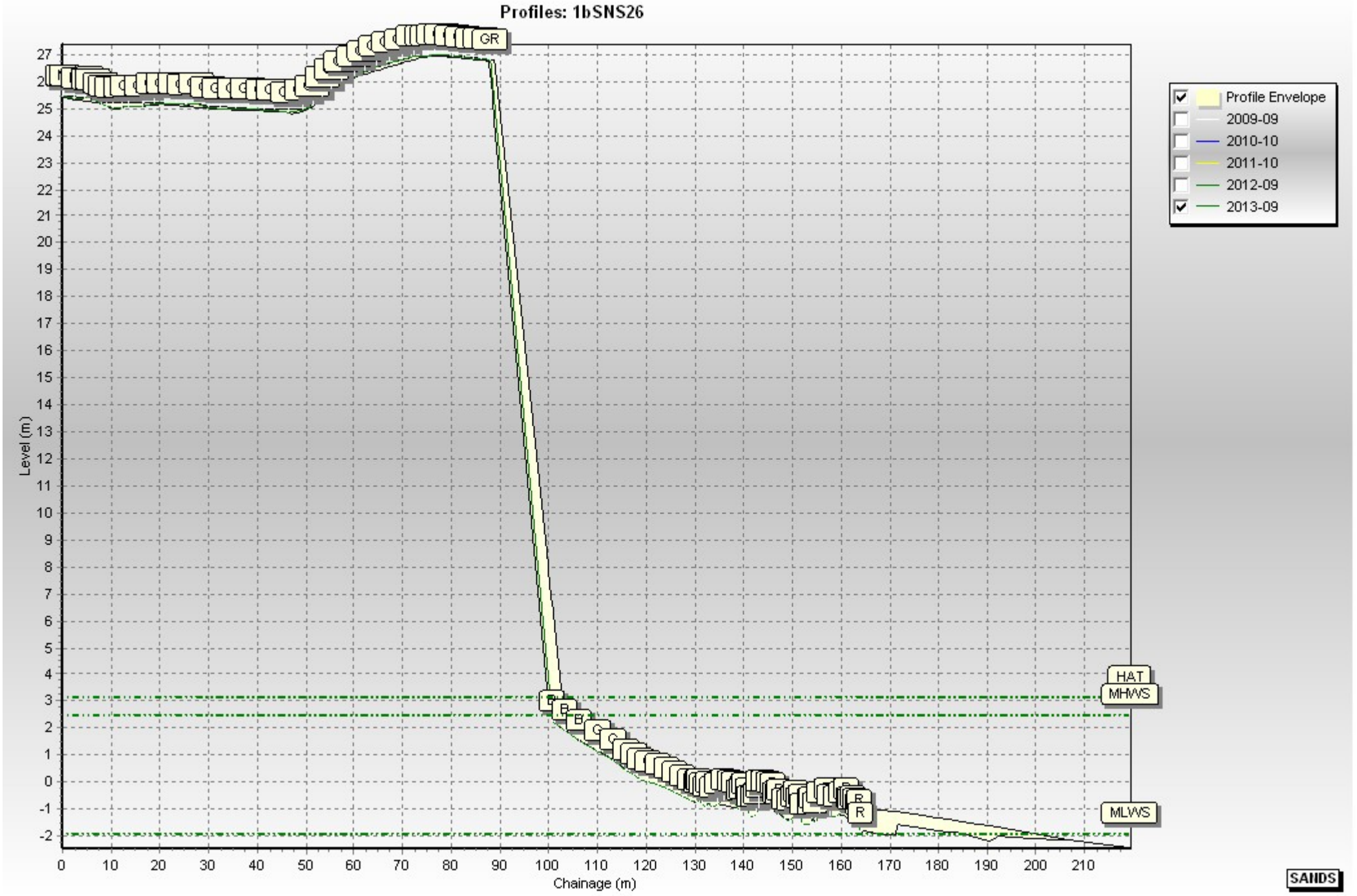
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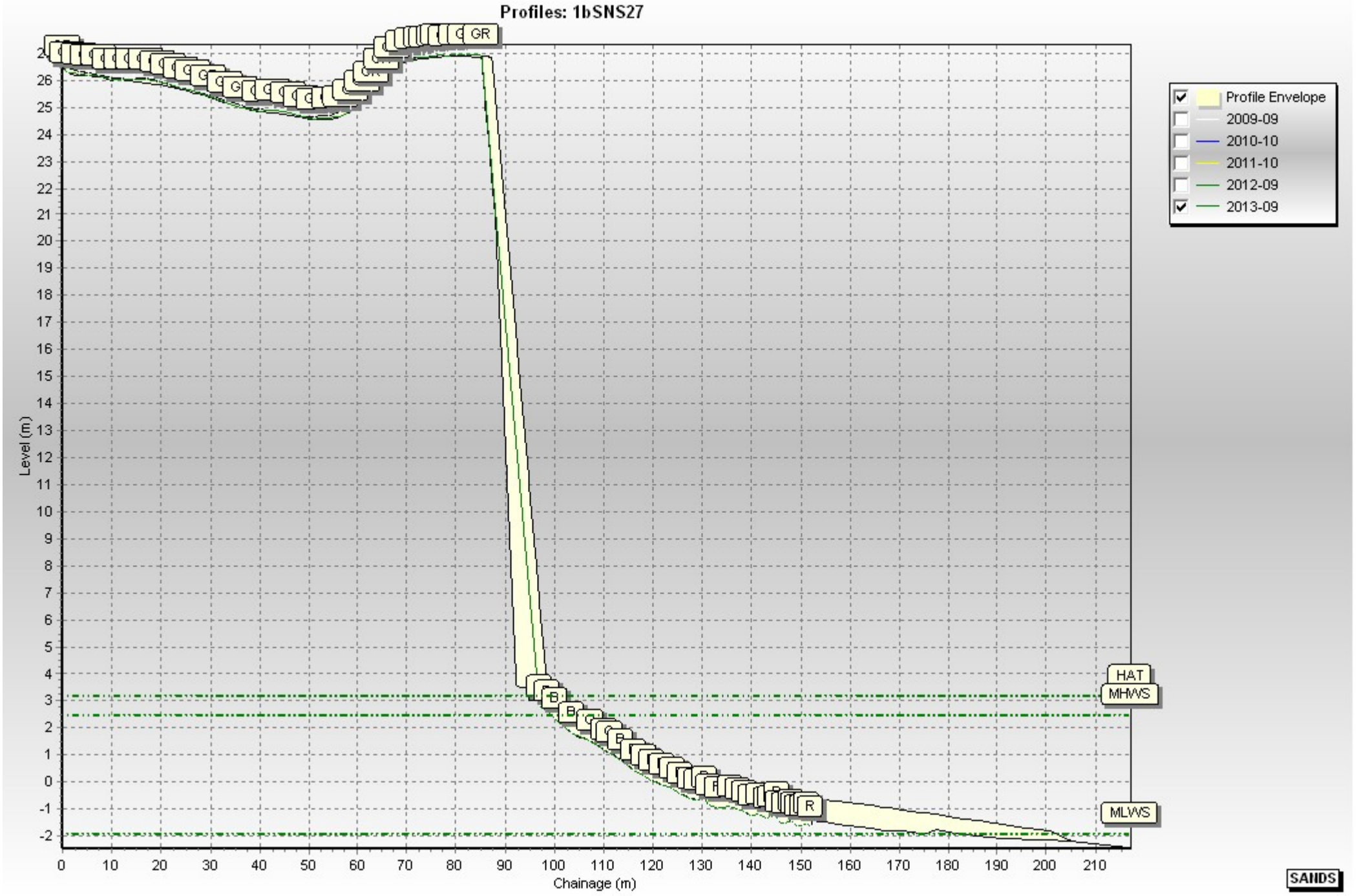
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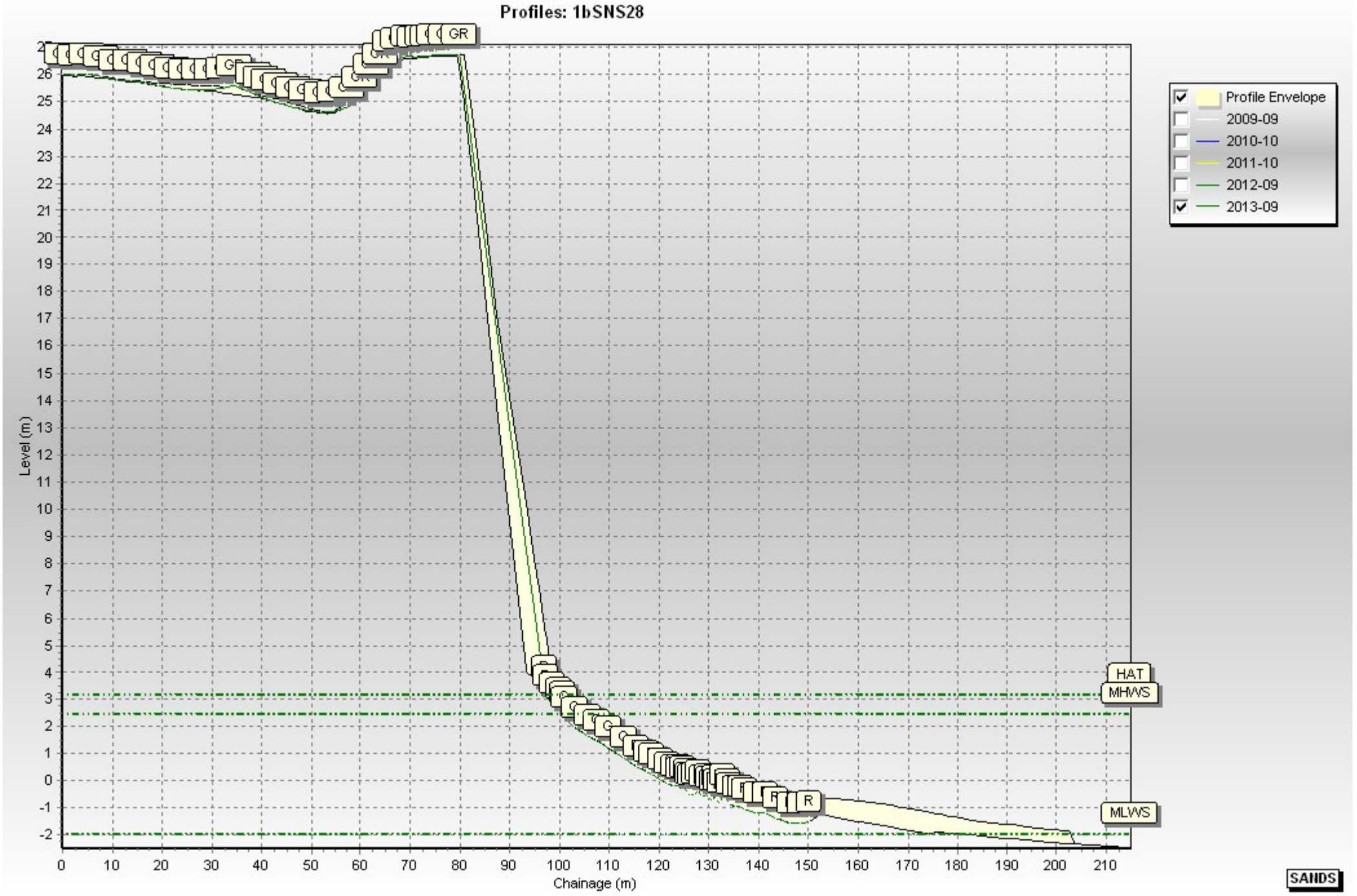
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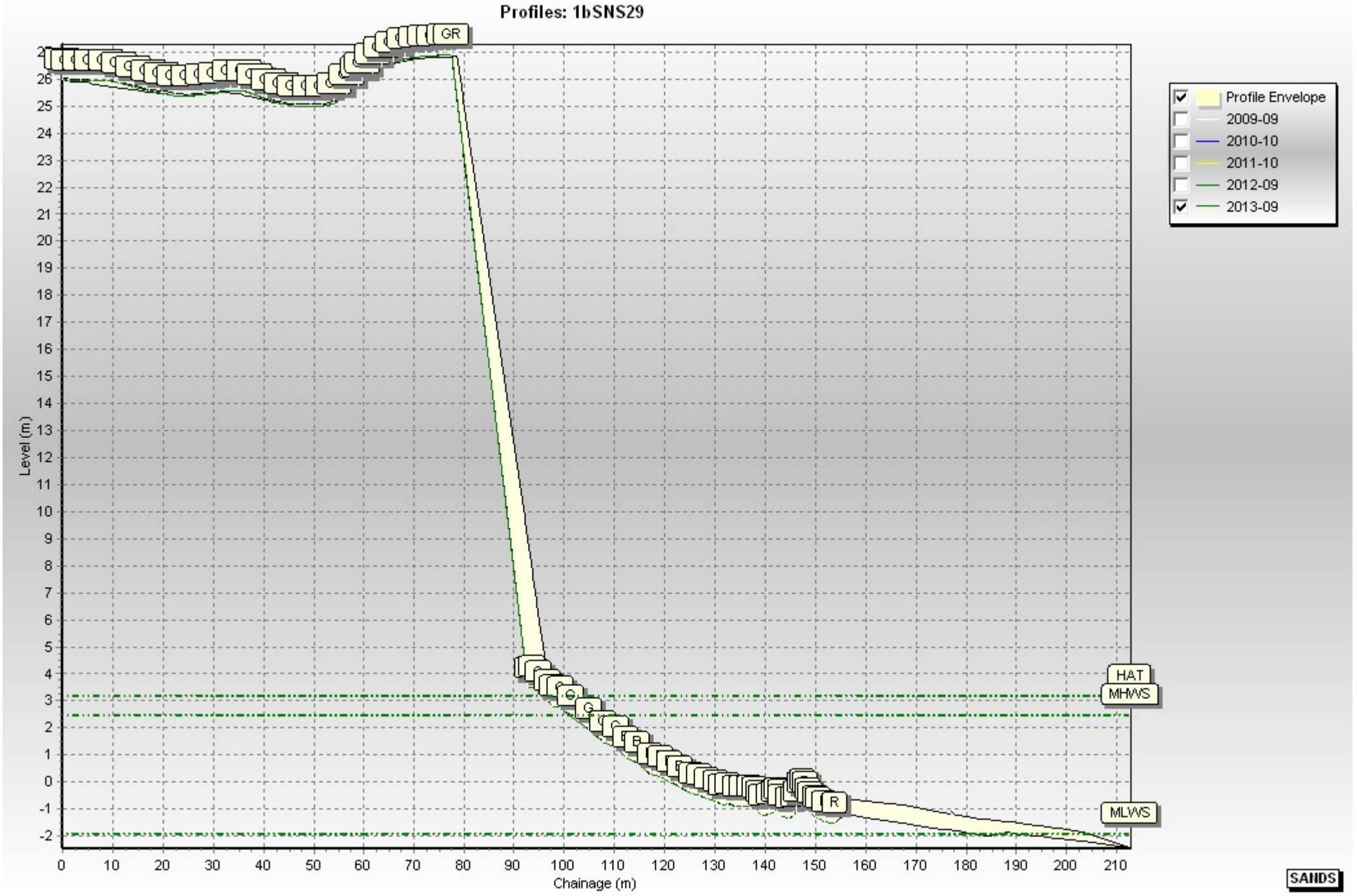
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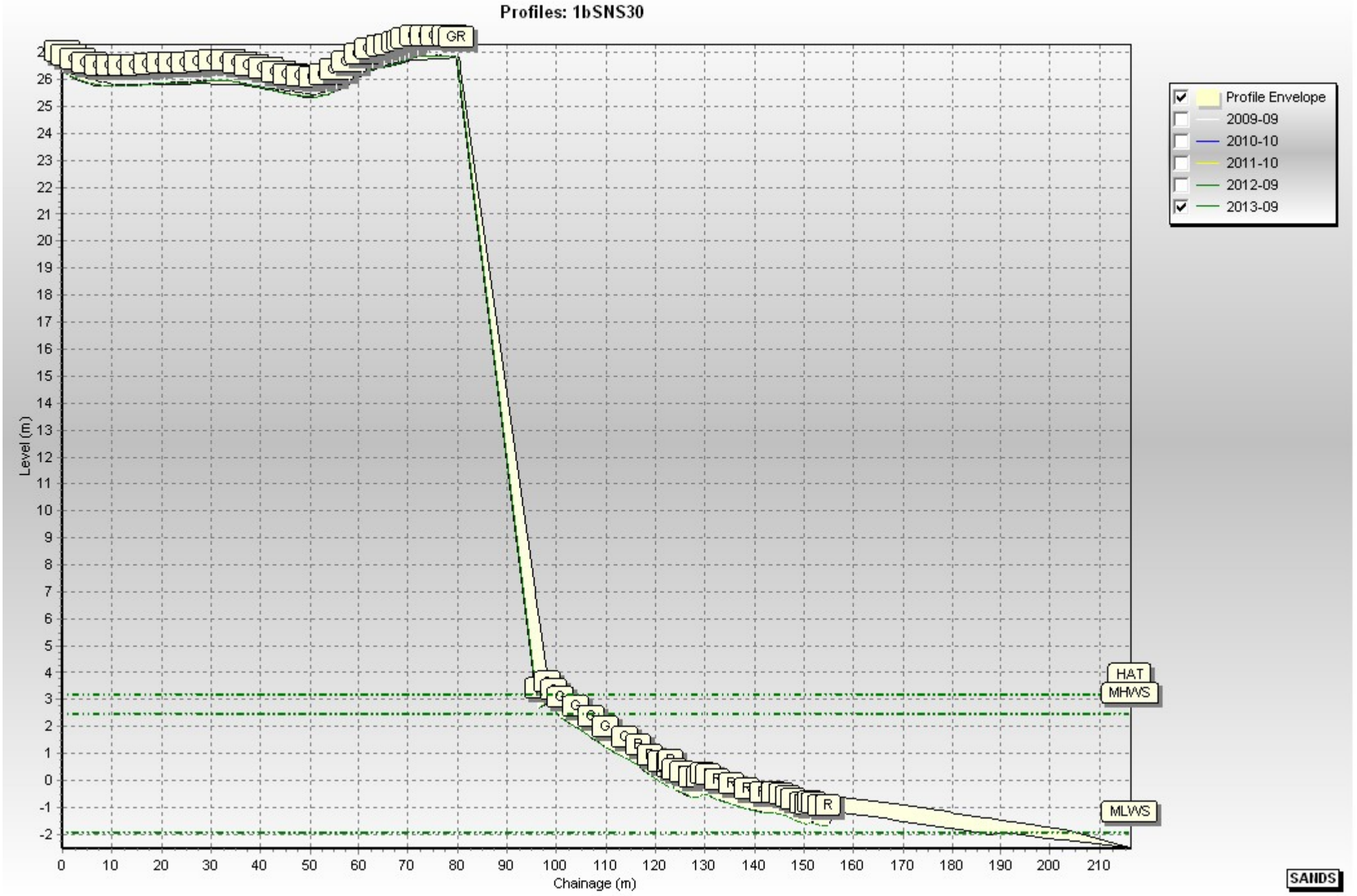
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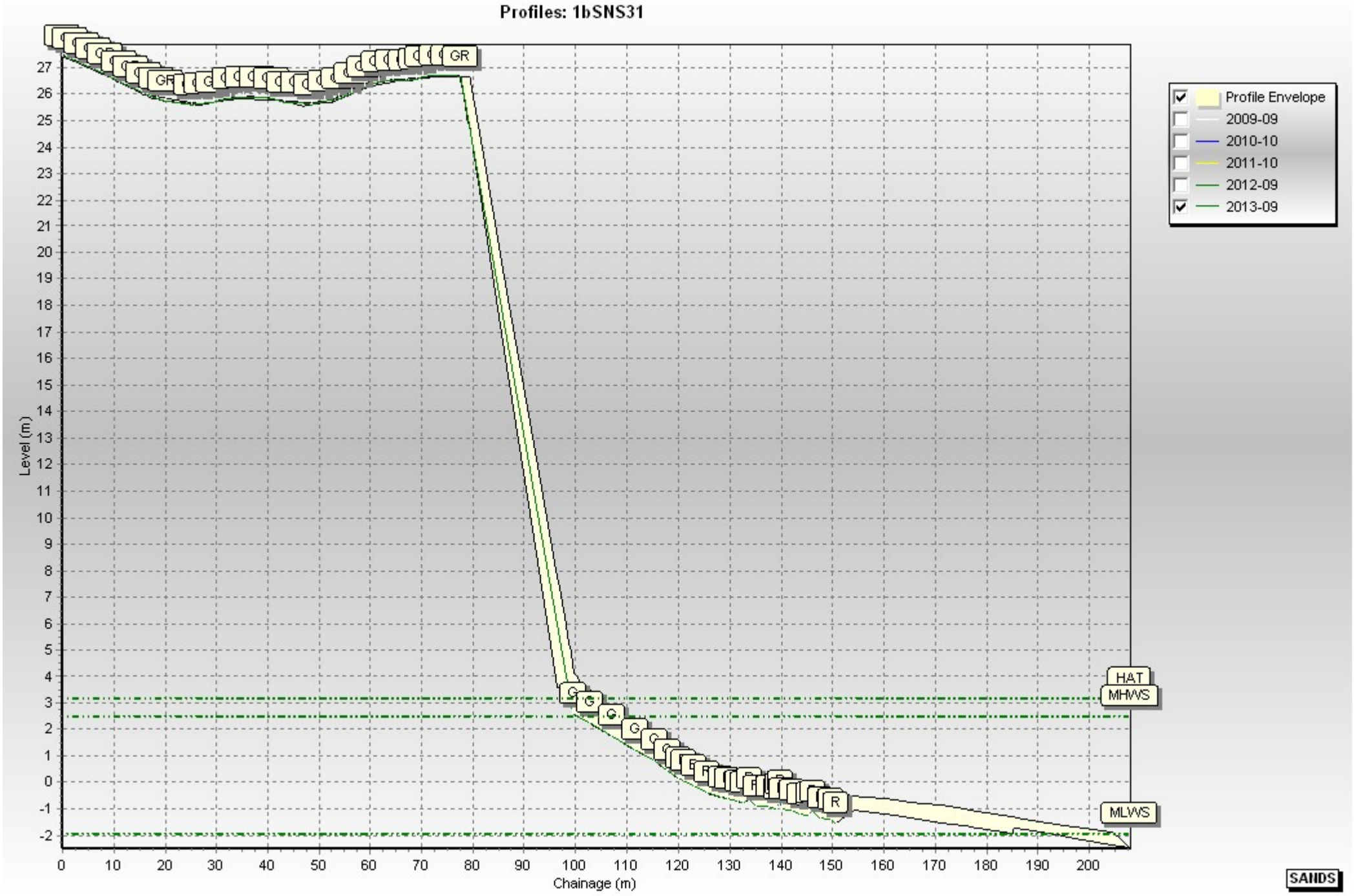
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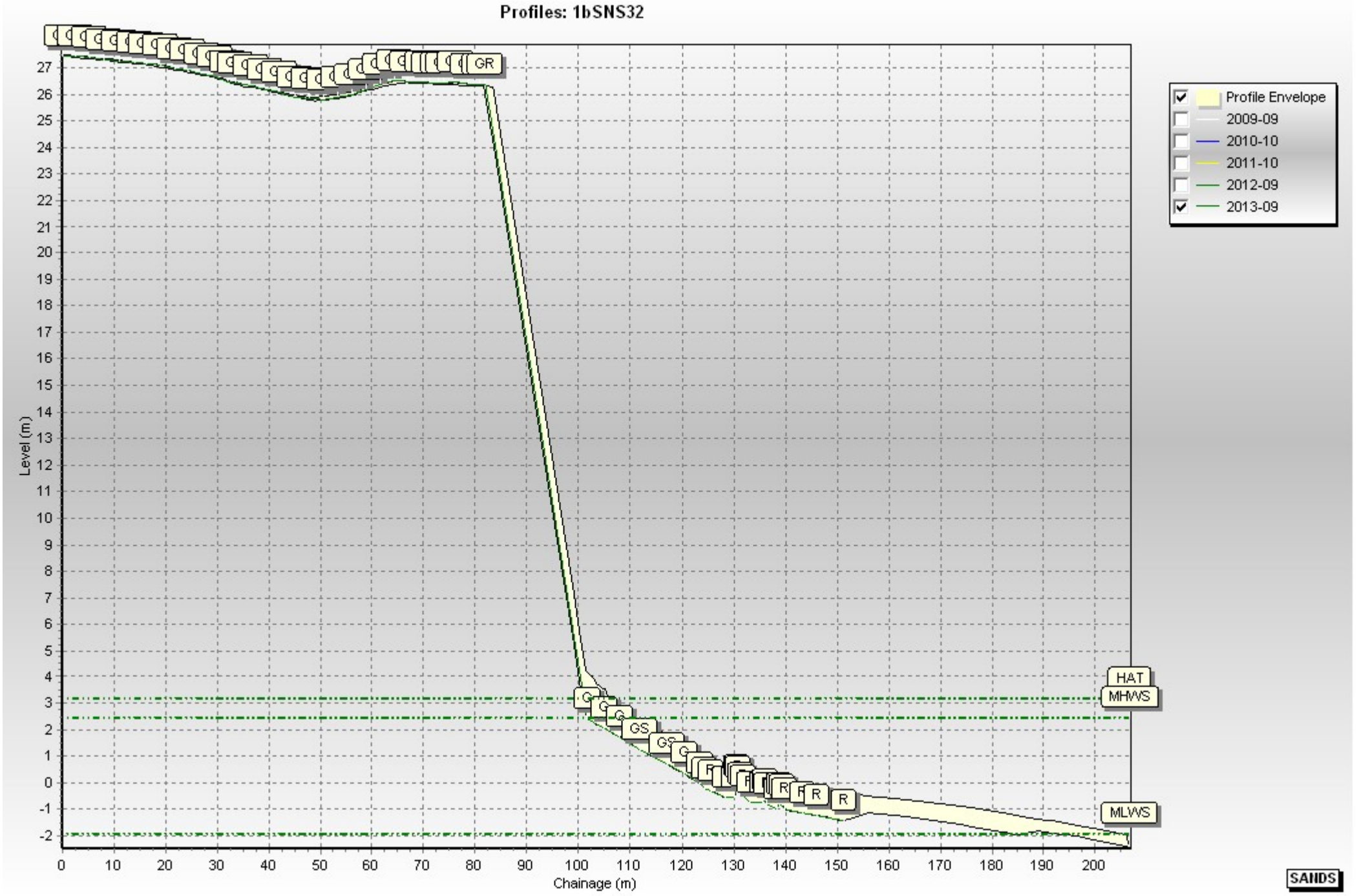
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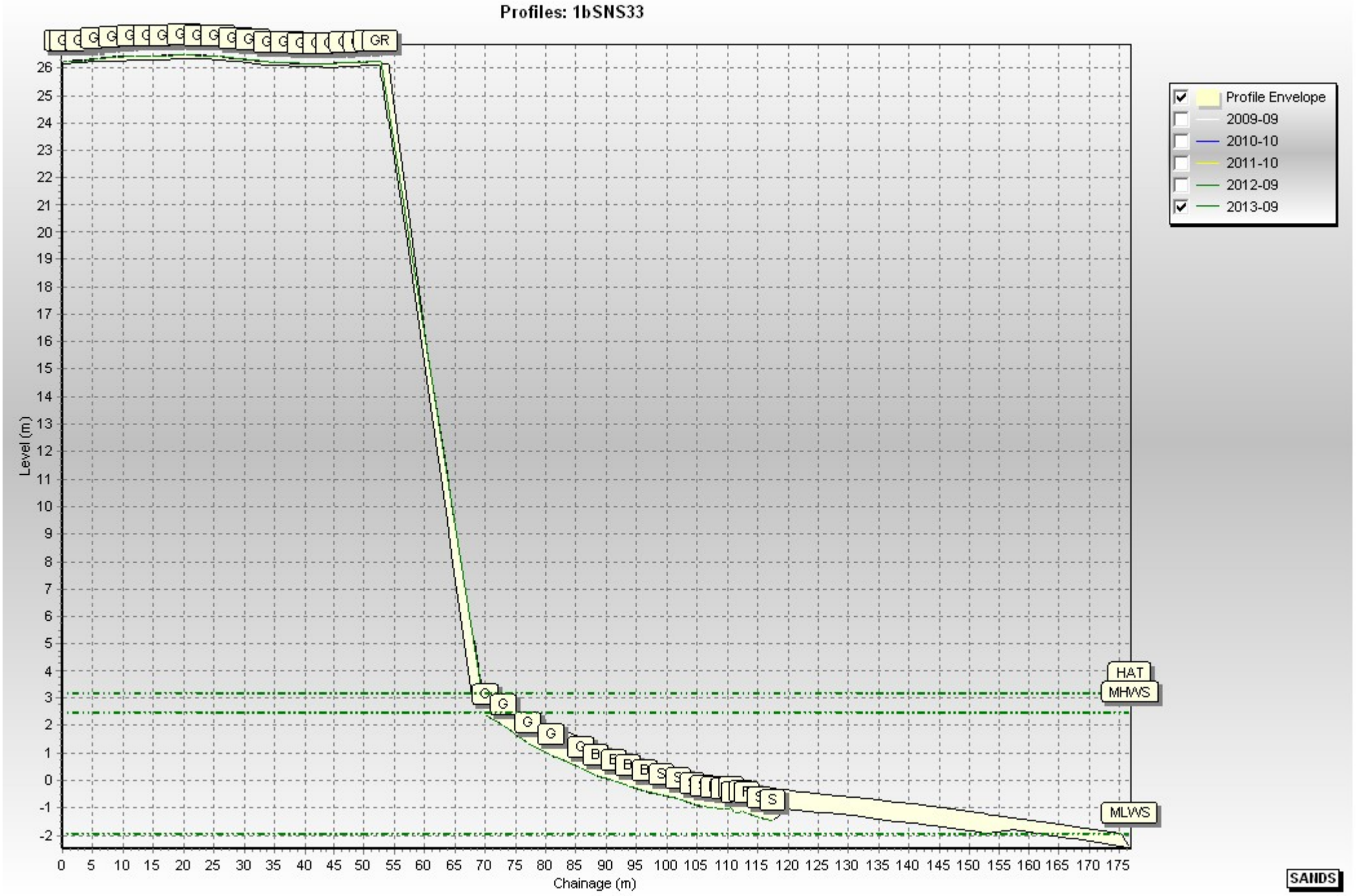
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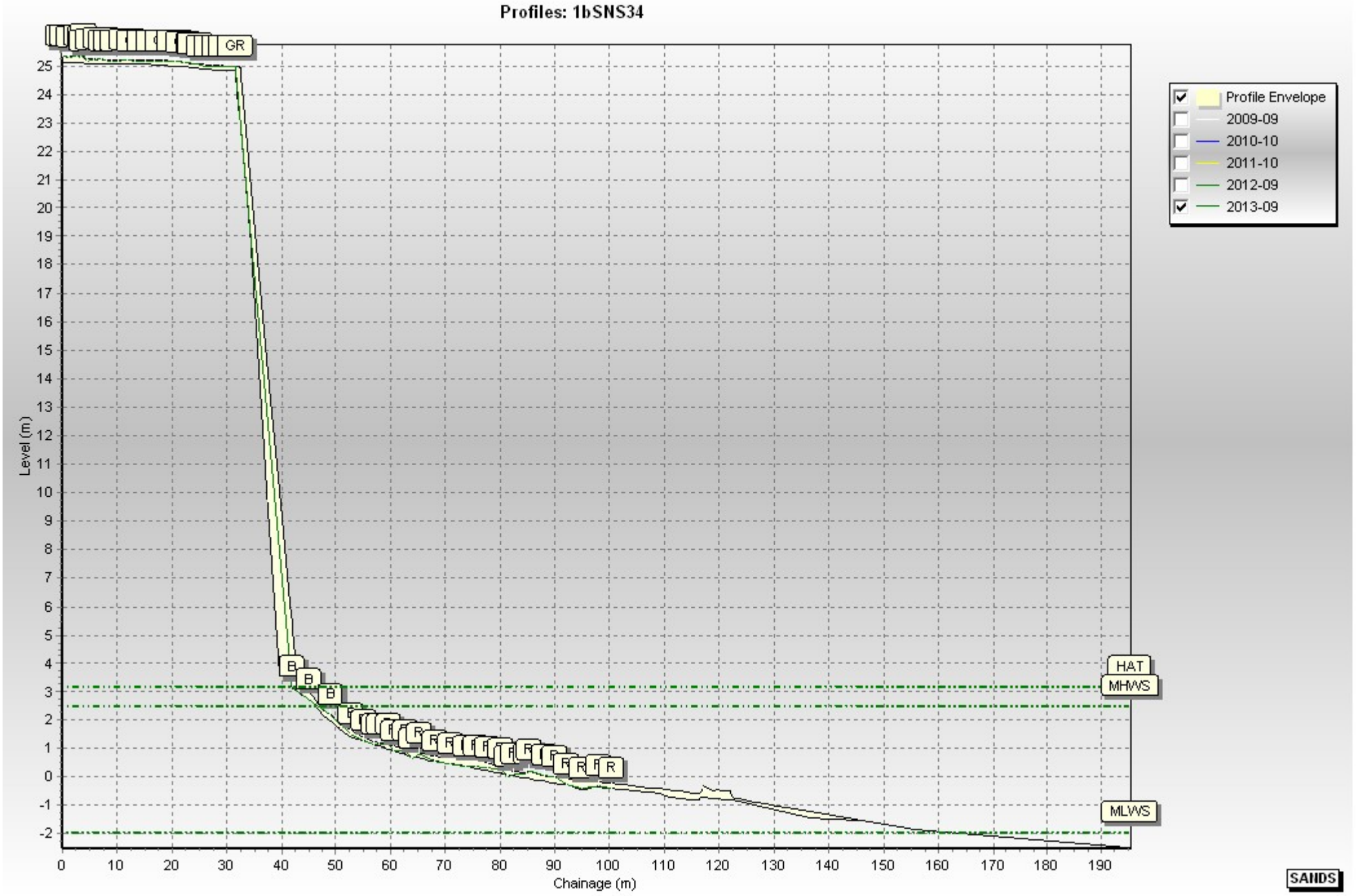
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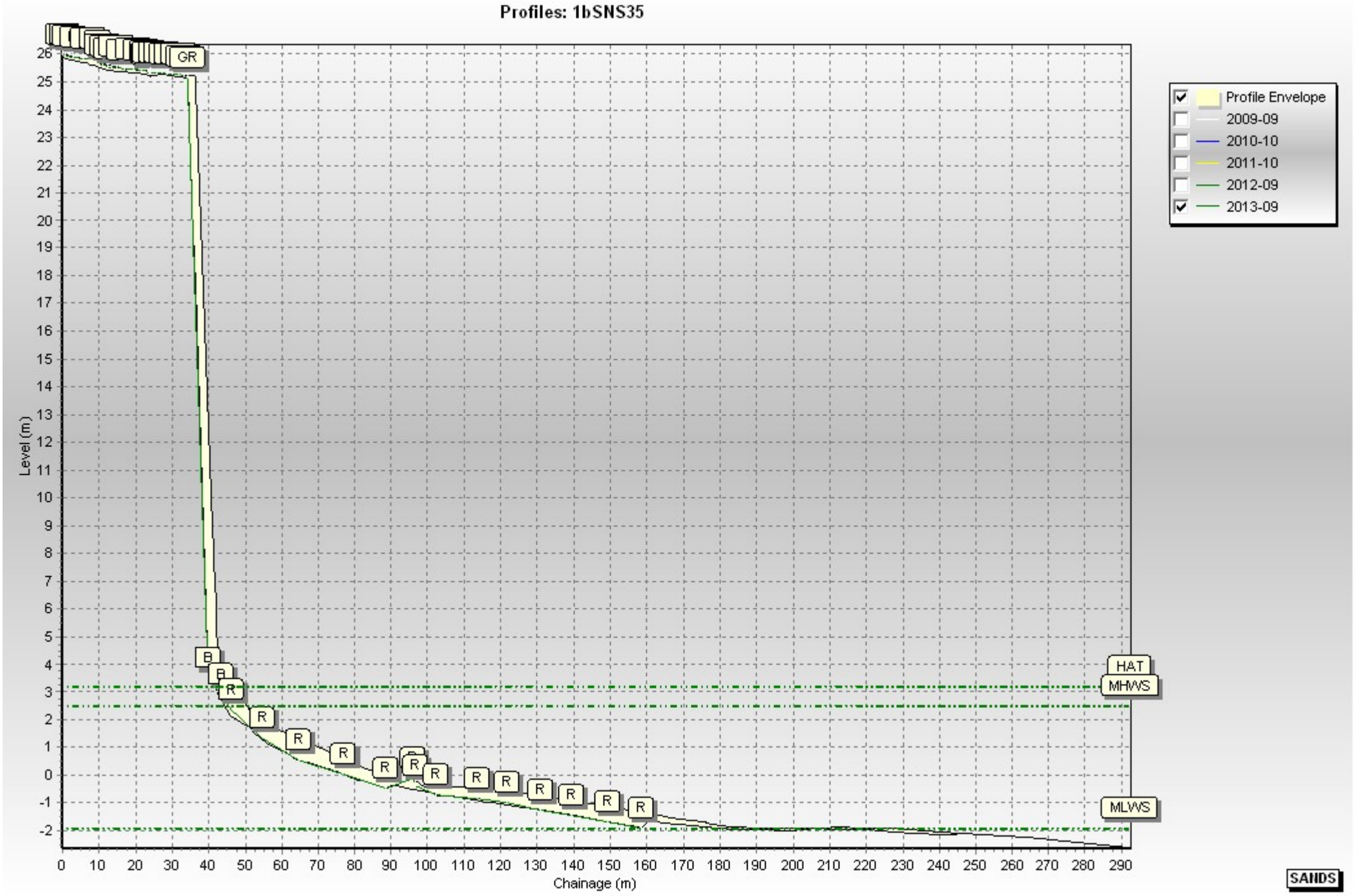
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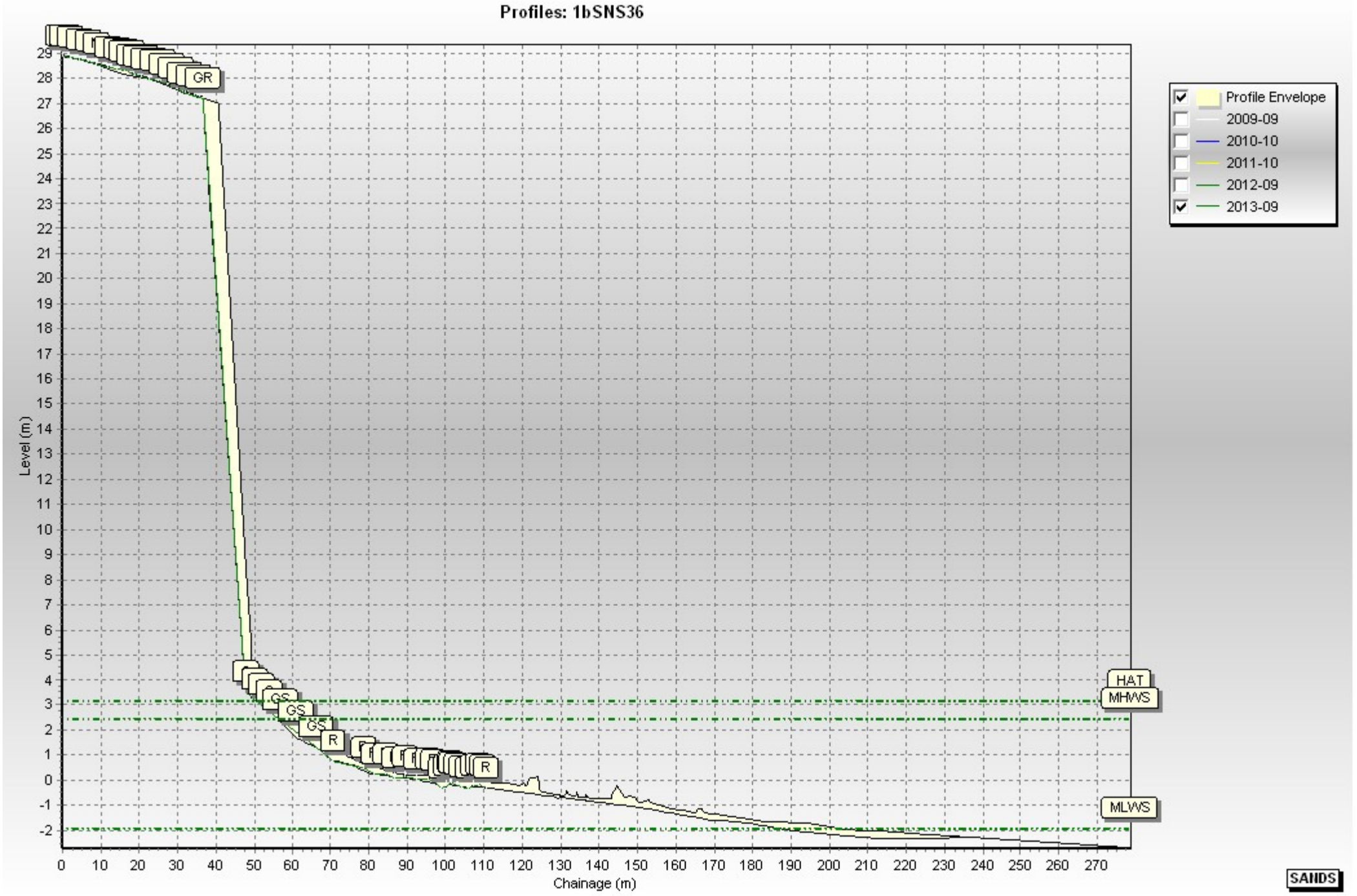
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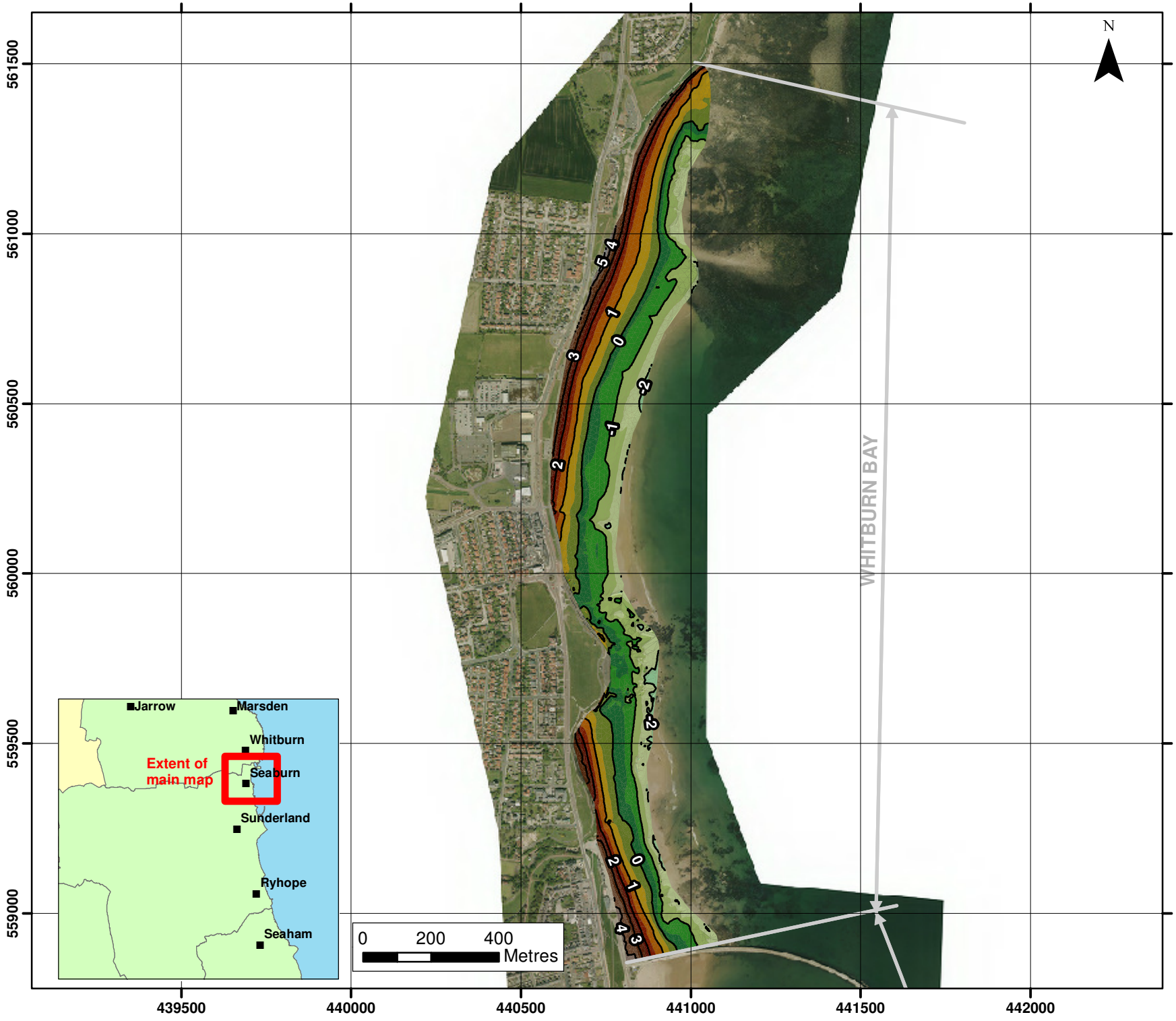
2010-10
2011-10
2012-09
2013-09
GR
GS
GS
GS
R
R
HAT
MHWS
MLWS
Level (m)
Chainage (m)
SANDS

Appendix B

Topographic Survey



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
- Contour 1m

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 6
Full Measures Survey
Autumn 2013

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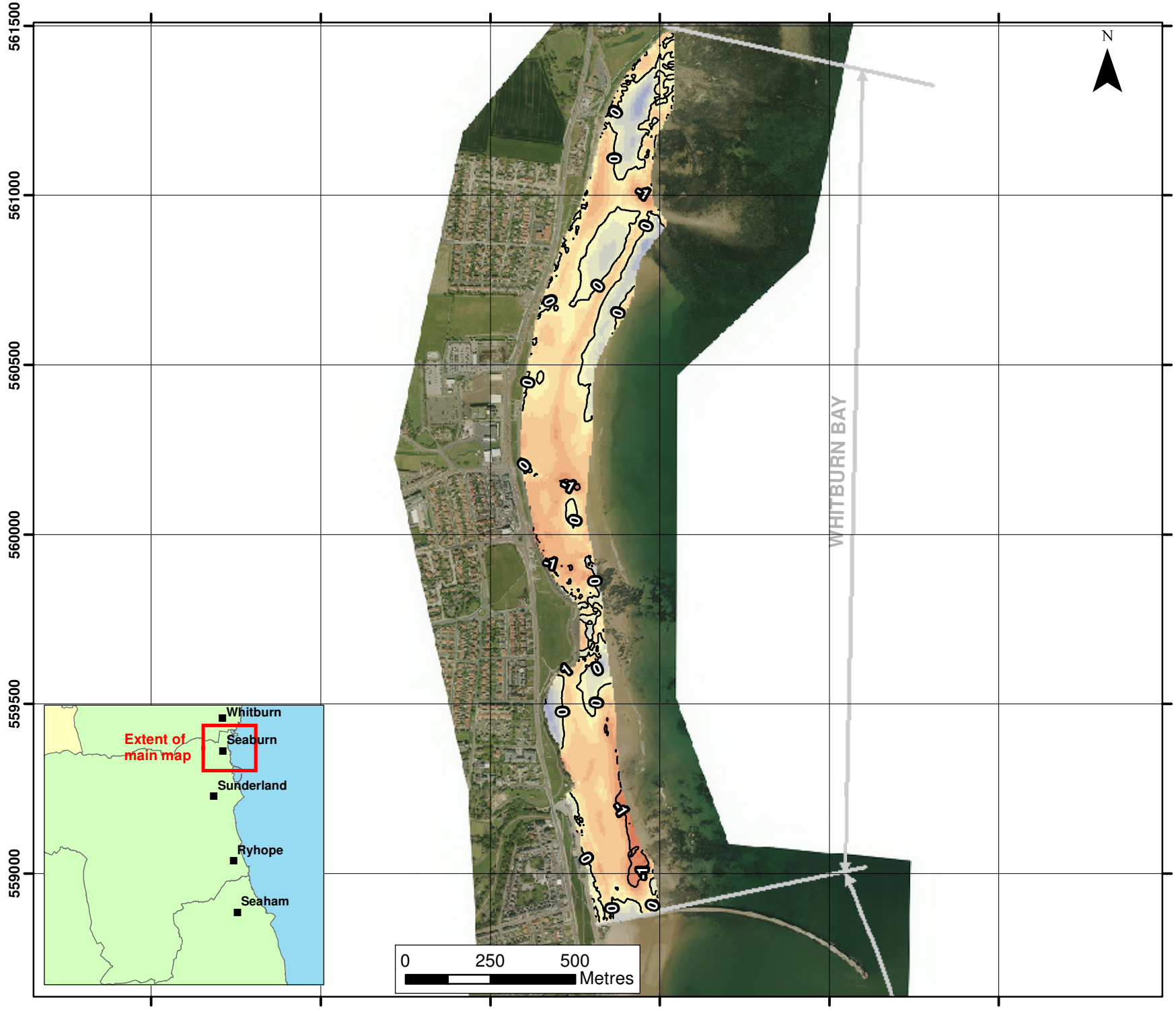

KEY Autumn 2012 and Autumn 2013
Change in elevation (m)

- <-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

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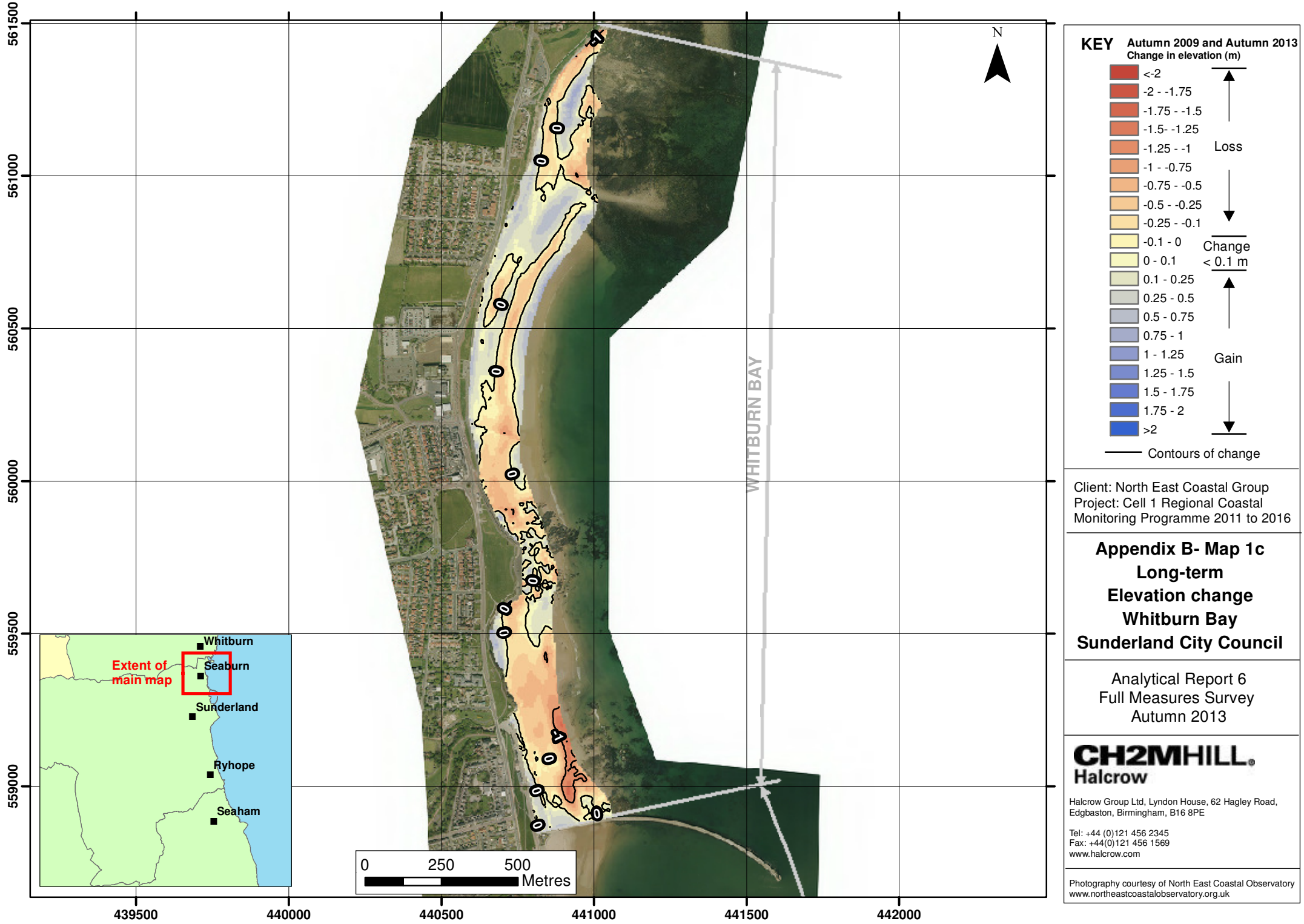

Client: North East Coastal Group
Project: Cell 1 Regional Coastal Monitoring Programme 2011 to 2016

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

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Full Measures Survey
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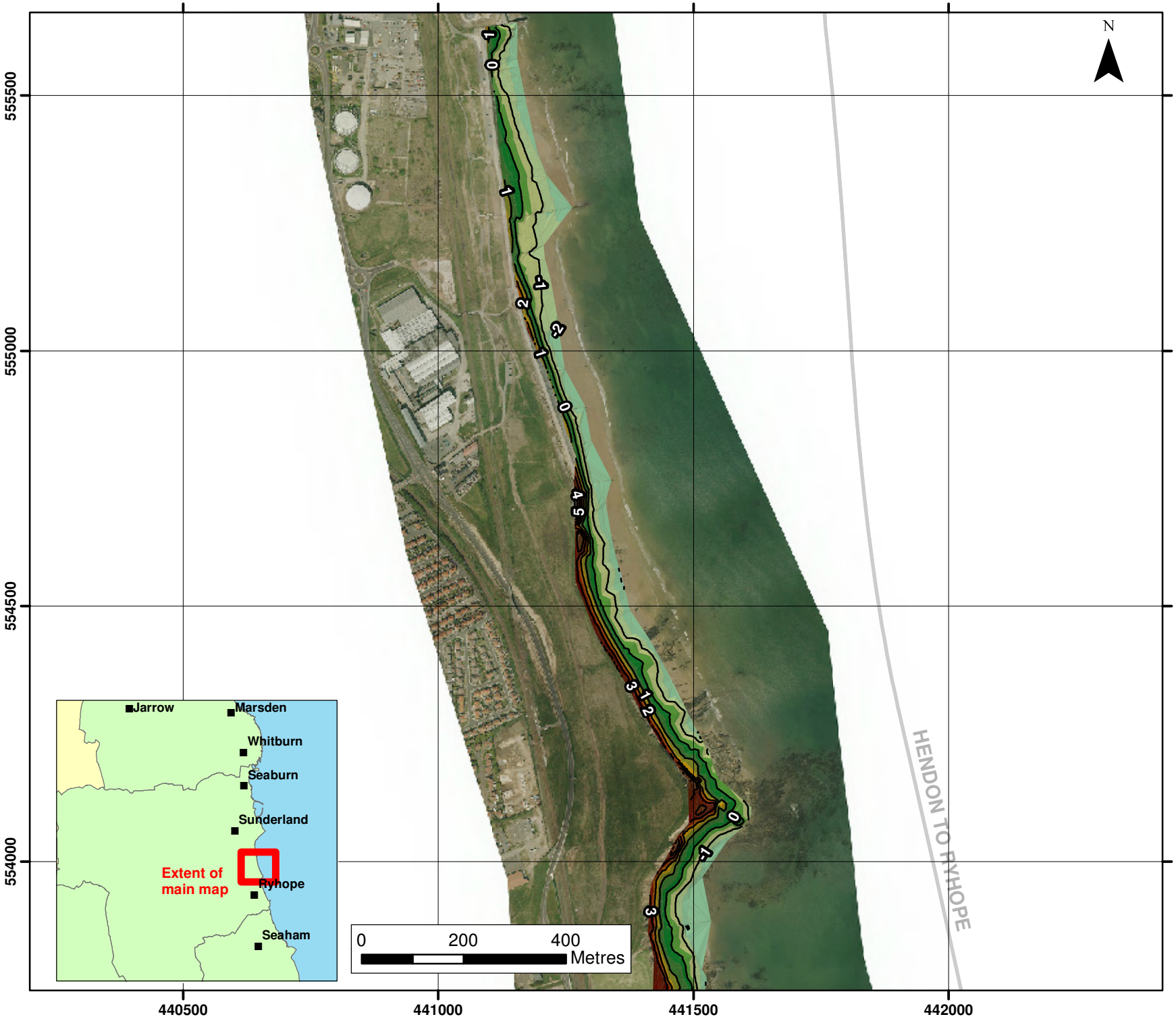

KEY

Elevation (m OD)

- 7 - 7.5
- 6.5 - 7
- 6 - 6.5
- 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
- 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

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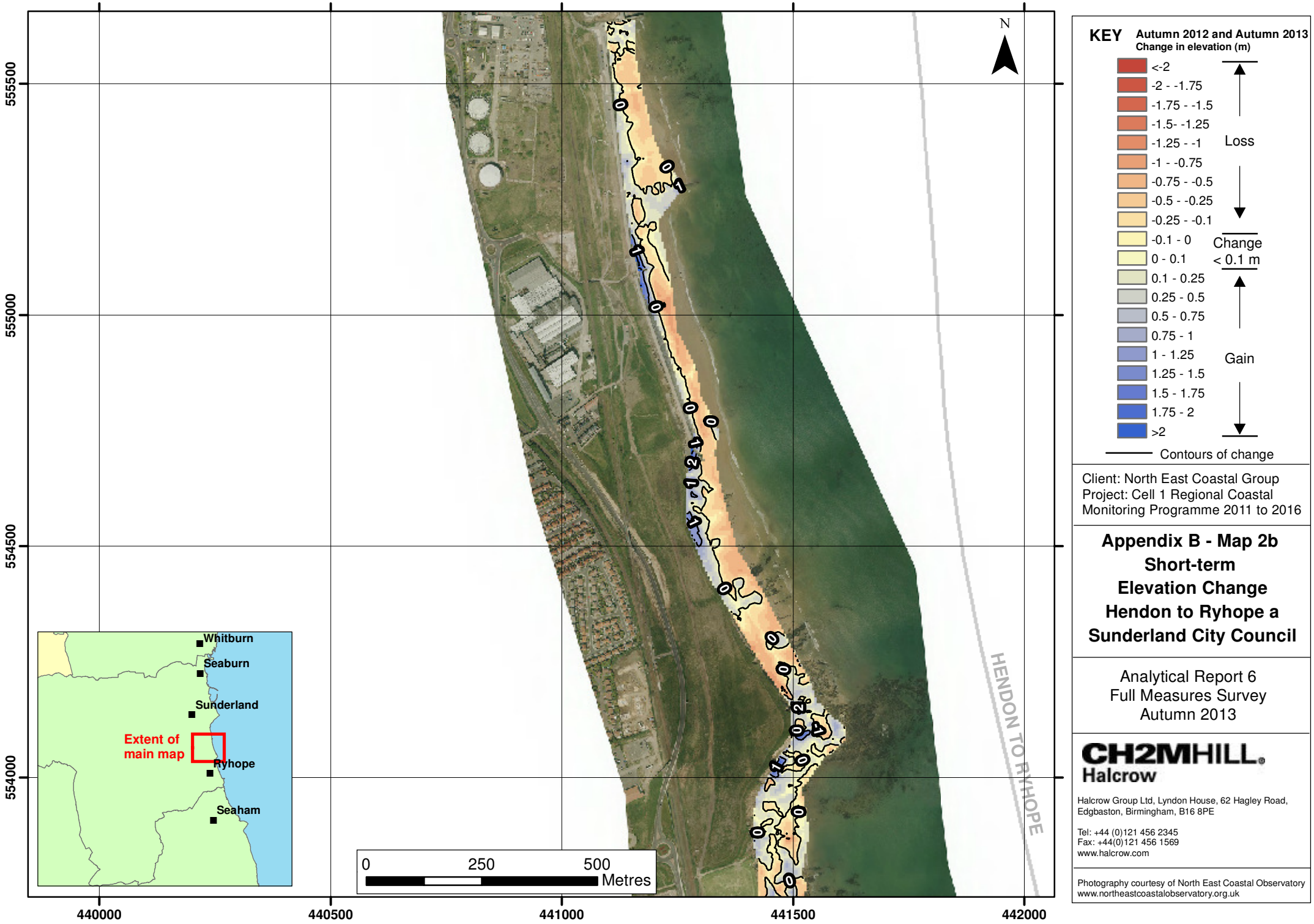

Client: North East Coastal Group
Project: Cell 1 Regional Coastal Monitoring Programme 2011 to 2016

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

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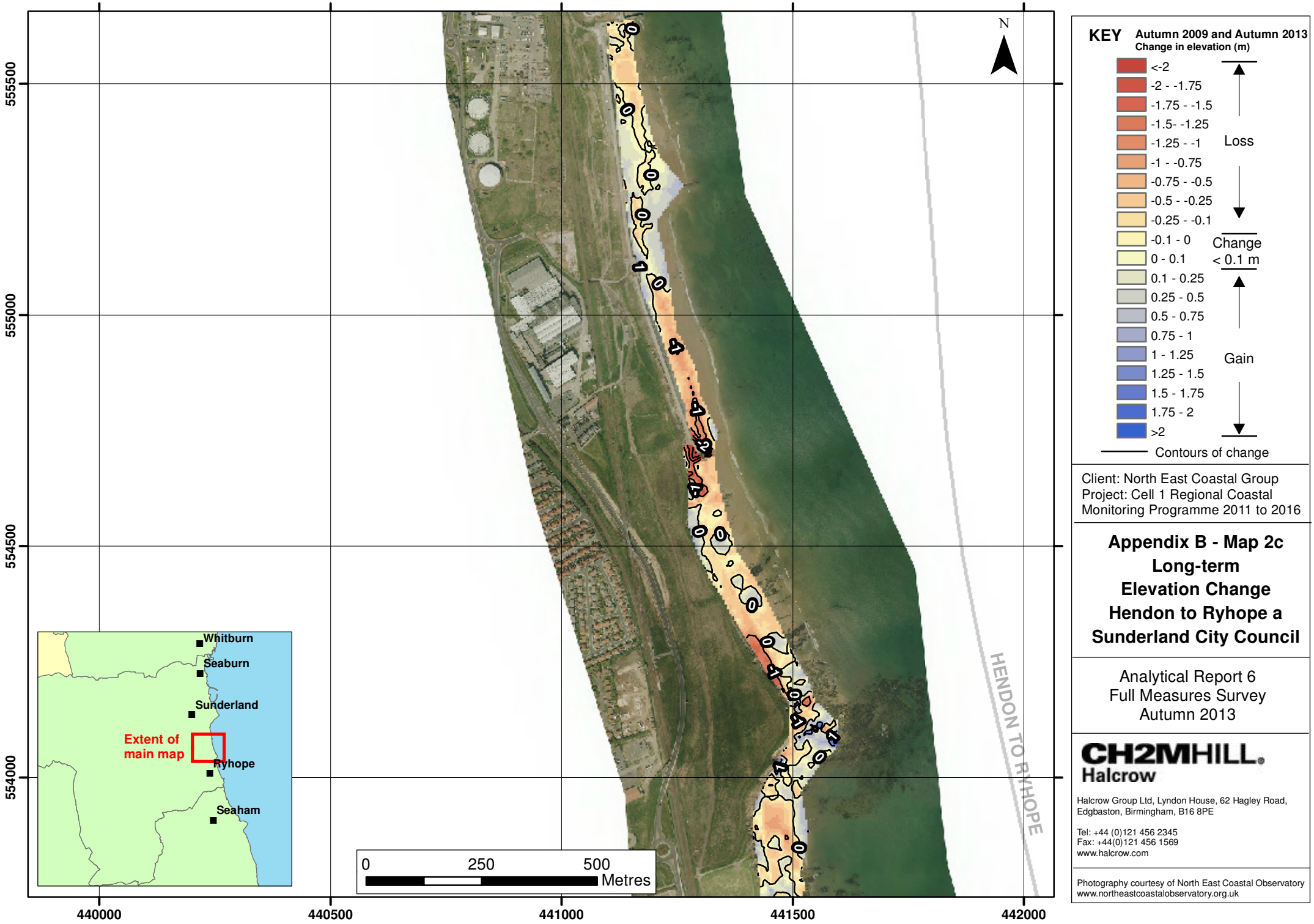

Client: North East Coastal Group
Project: Cell 1 Regional Coastal Monitoring Programme 2011 to 2016

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

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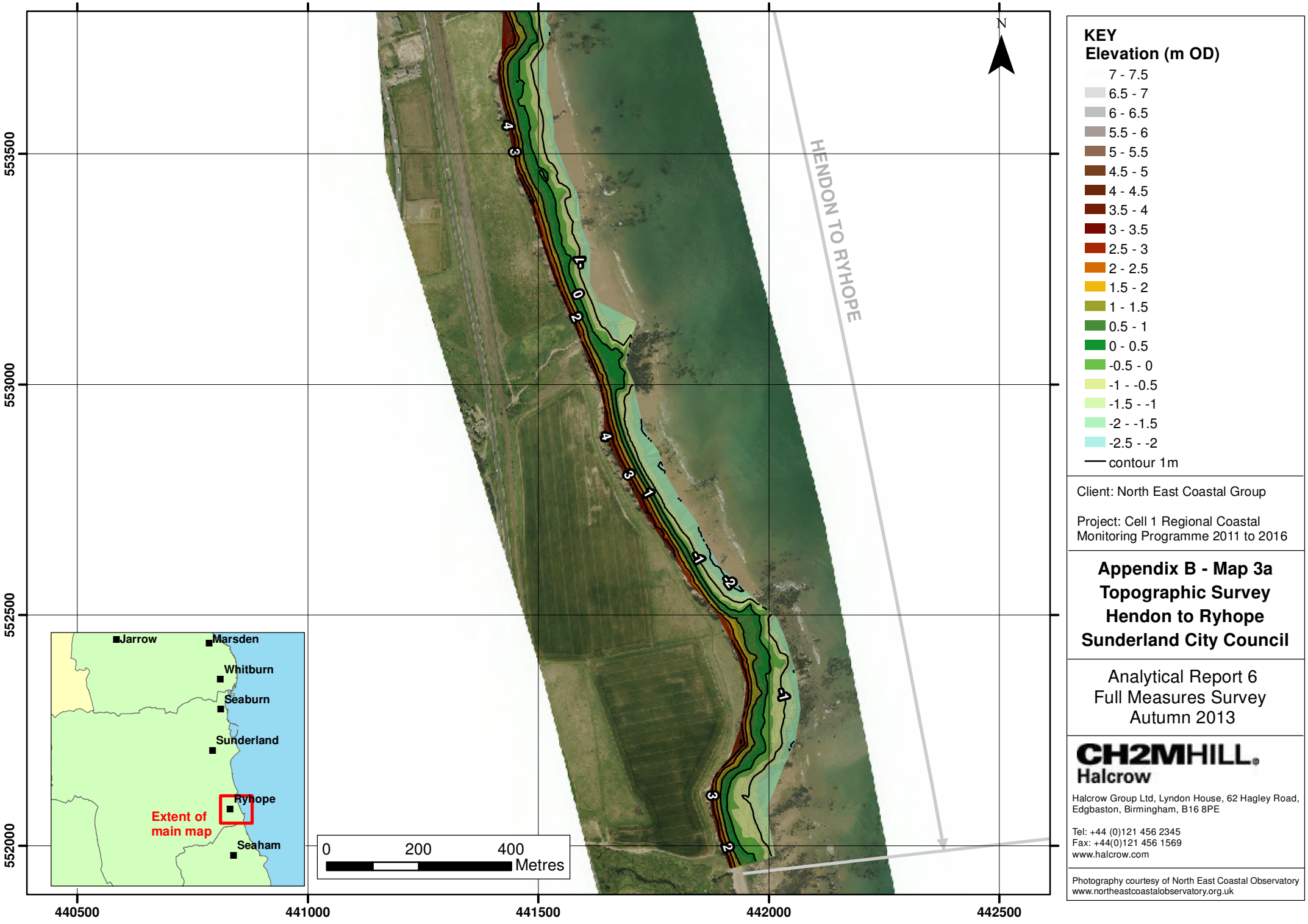

KEY
Elevation (m OD)

- 7 - 7.5
- 6.5 - 7
- 6 - 6.5
- 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
- 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 6
Full Measures Survey
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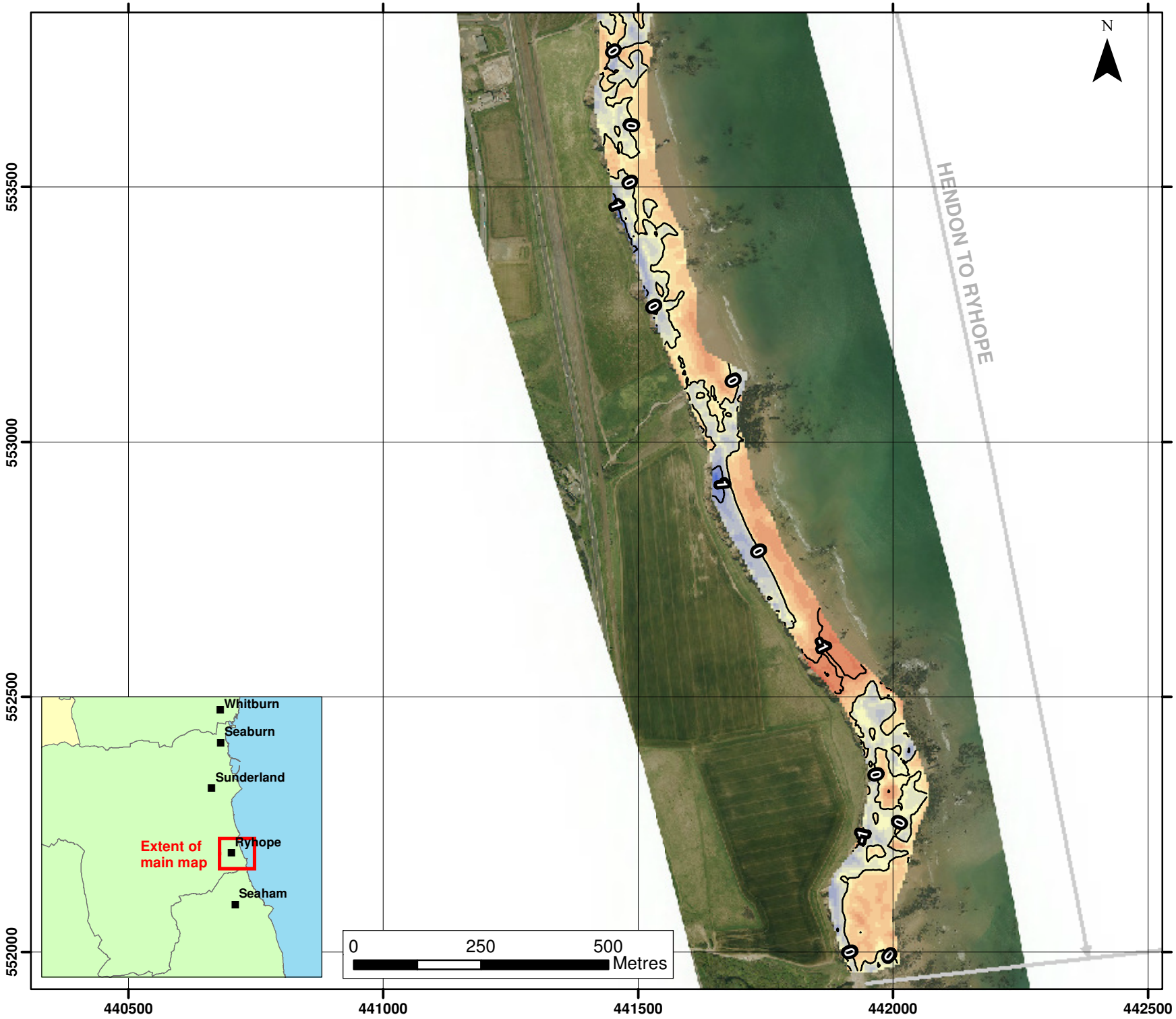

KEY Autumn 2012 and Autumn 2013
Change in elevation (m)

- <-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 3b Short-term Elevation Change Hendon to Ryhope b Sunderland City Council

Analytical Report 6
Full Measures Survey
Autumn 2013

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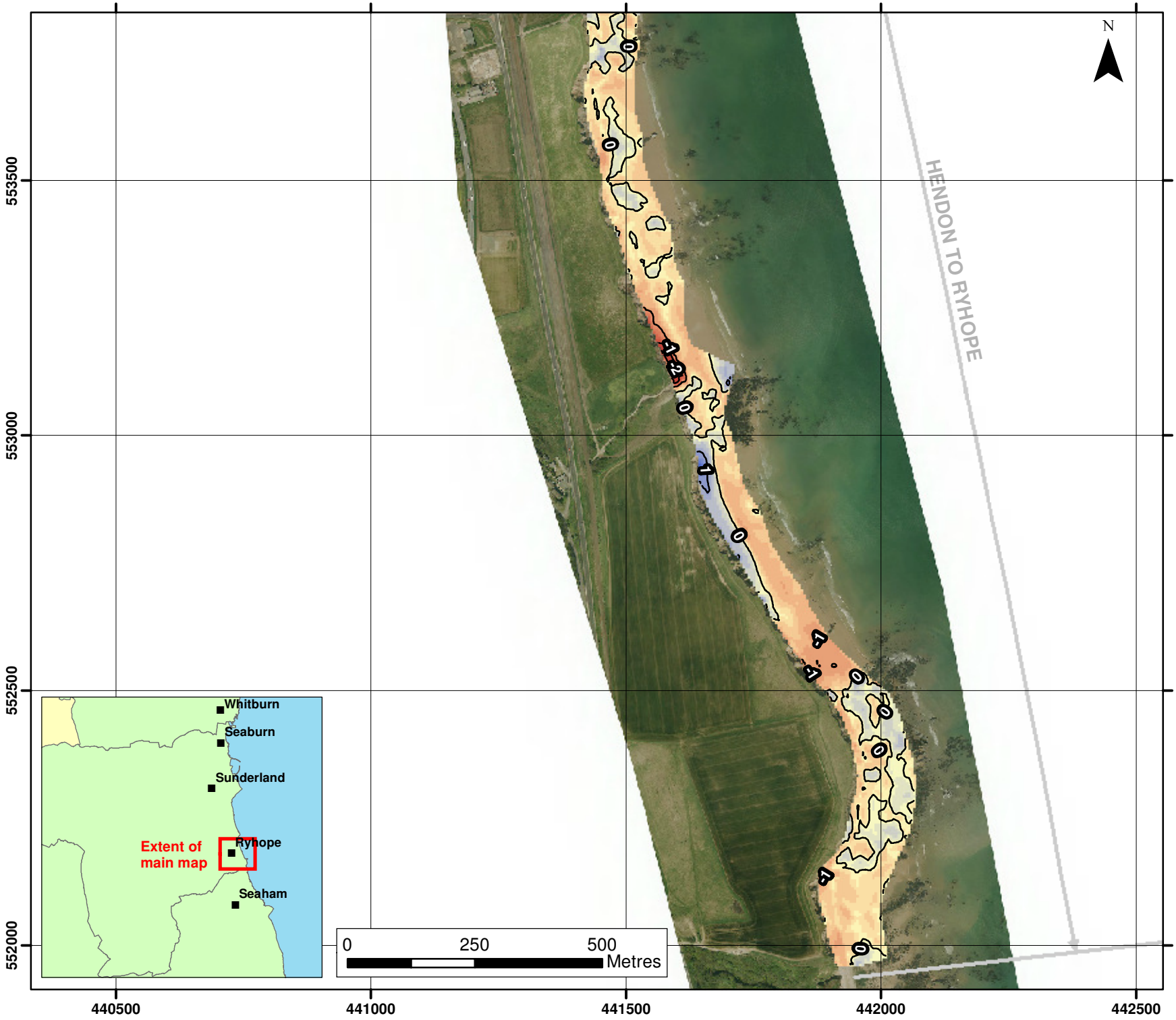

KEY Autumn 2009 and Autumn 2013
Change in elevation (m)

<-2	Loss
-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	Change < 0.1 m
0 - 0.1	
0.1 - 0.25	Gain
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	

Contours of change

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 6
Full Measures Survey
Autumn 2013

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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.

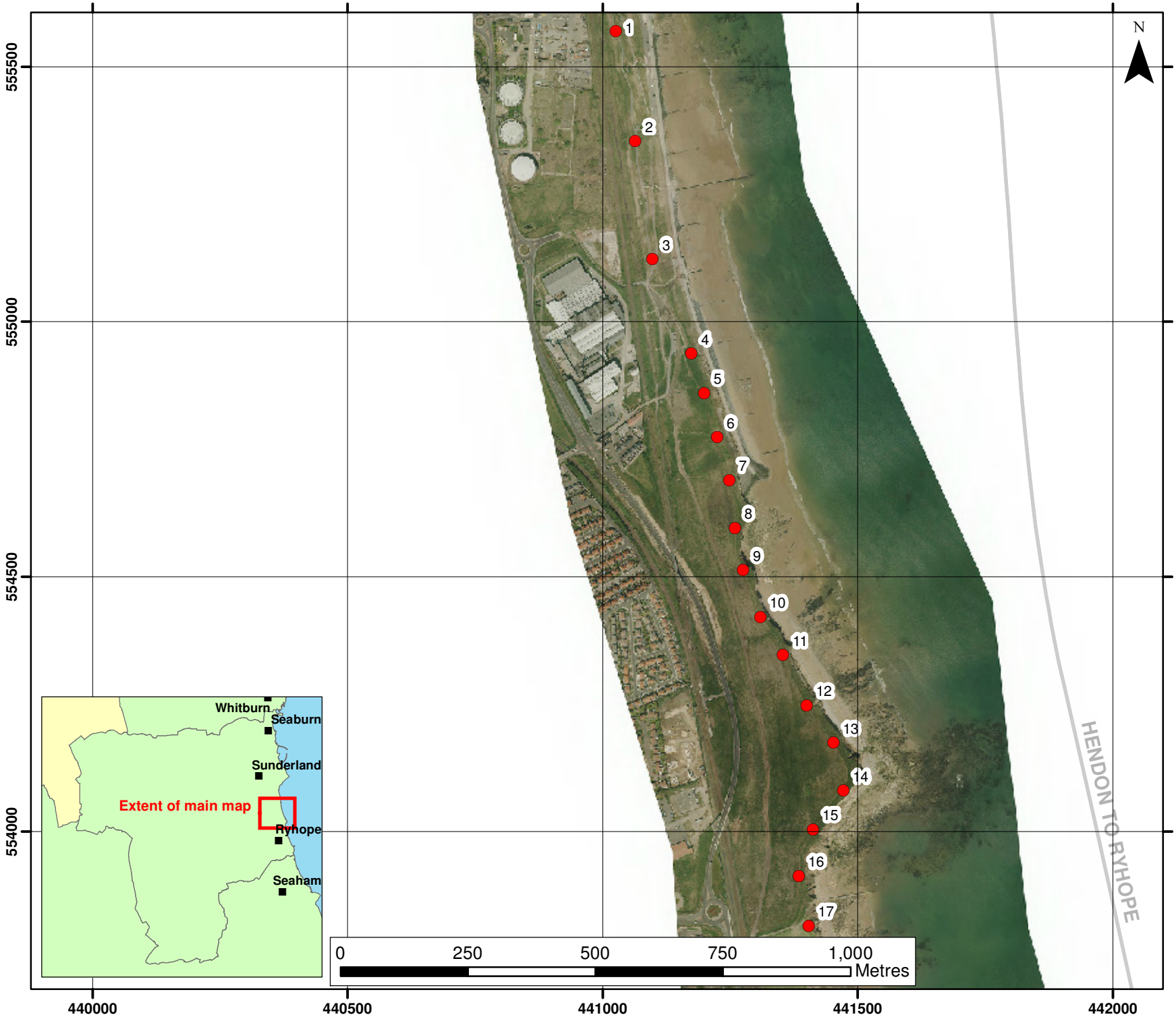
The cliff top surveys between Hendon and Ryhope are undertaken bi-annually. Measurements are taken from a fixed ground control point along a fixed bearing to the edge of the cliff top.

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	Baseline Survey (March 09)	Previous Survey (March 2013)	Present Survey	Baseline (March 2009) to Present (Sept 2013)	Previous (Mar 2013) to Present (Sept 2013)	Baseline (March 2009) to Present (Sept 2013)
1	441025.7	555571.1	75	8.16	8.5	8.5	0.3	0.0	0.1
2	441064.4	555355.1	85	7.09	6.5	5.4	-1.7	-1.1	-0.4
3	441098	555124	82	10.01	10.4	11.0	1.0	0.6	0.2
4	441174	554938.7	65	10.3	10.7	11.0	0.7	0.3	0.1
5	441199.1	554861.1	65	7.71	8.0	7.9	0.2	-0.1	0.0
6	441224.5	554774.2	71	10.83	11.0	11.1	0.3	0.2	0.1
7	441248.4	554690.3	74	10.18	10.4	10.5	0.3	0.0	0.1
8	441259.3	554596.6	101	10.08	10.2	10.2	0.1	0.0	0.0
9	441275.8	554513.4	66	10.52	6.6	6.6	-3.9	0.0	-0.9
10	441309.4	554421.3	58	8.77	6.3	6.3	-2.5	-0.1	-0.6
11	441354	554346.5	68	8.2	6.5	6.6	-1.6	0.0	-0.4
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	11.2	11.2	-0.4	0.0	-0.1

Ground Control Point Details				Distance to Cliff Top (m)			Total Erosion (m)		Erosion Rate (m/year)
Ref	Easting	Northing	Bearing	Baseline Survey (March 09)	Previous Survey (March 2013)	Present Survey	Baseline (March 2009) to Present (Sept 2013)	Previous (Mar 2013) to Present (Sept 2013)	Baseline (March 2009) to Present (Sept 2013)
14	441472.3	554080.5	127	7.33	7.4	7.3	0.0	-0.1	0.0
15	441413	554005.1	122	7.84	7.9	7.9	0.1	0.0	0.0
16	441384.8	553913.3	90	9.89	9.2	8.7	-1.2	-0.6	-0.3
17	441404.1	553815.5	93	6.32	6.2	6.0	-0.3	-0.1	-0.1
18	441404.1	553723.6	119	8.1	8.1	8.1	0.0	-0.1	0.0
19	441398.5	553632.8	78	8.23	5.8	5.7	-2.5	-0.1	-0.6
20	441438.3	553452.9	71	10.09	6.9	7.0	-3.1	0.1	-0.7
21	441506.1	553256.1	62	8.57	1.9	1.8	-6.8	-0.1	-1.5
22	441550.1	553158.7	103	6.57	3.8	3.6	-2.9	-0.2	-0.7
23	441585.2	553076.5	64	8.11	8.1	8.0	-0.1	-0.1	0.0
24	441624.4	552870.7	69	7.53	5.3	5.2	-2.3	0.0	-0.5
25	441689.1	552758	70	14.58	7.0	6.9	-7.7	-0.1	-1.7
26	441715	552713.3	54	12.87	12.8	12.7	-0.2	-0.1	0.0
27	441749.2	552674.4	62	14.56	10.7	10.6	-3.9	-0.1	-0.9
28	441776.6	552629.9	57	8.62	4.3	4.3	-4.4	0.0	-1.0
28A	441798.6	552586.3	56	13.63*	11.1	11.1	-2.6	-0.1	-0.7
28B	441817.4	552542.4	64	12.30*	11.4	11.4	-0.9	0.0	-0.2
28C	441852.2	552502.6	52	13.11*	13.1	13.0	-0.1	-0.1	0.0
29	441880.1	552471.6	83	15.46	15.2	15.2	-0.3	-0.1	-0.1
30	441921.4	552269	97	8.55	7.8	7.7	-0.8	0.0	-0.2
31	441853.1	552094	75	11.2	7.9	7.5	-3.7	-0.4	-0.8
32	441883.3	551988.5	96	9.82	6.2	6.2	-3.6	-0.1	-0.8



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

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Full Measures Survey
Autumn 2013

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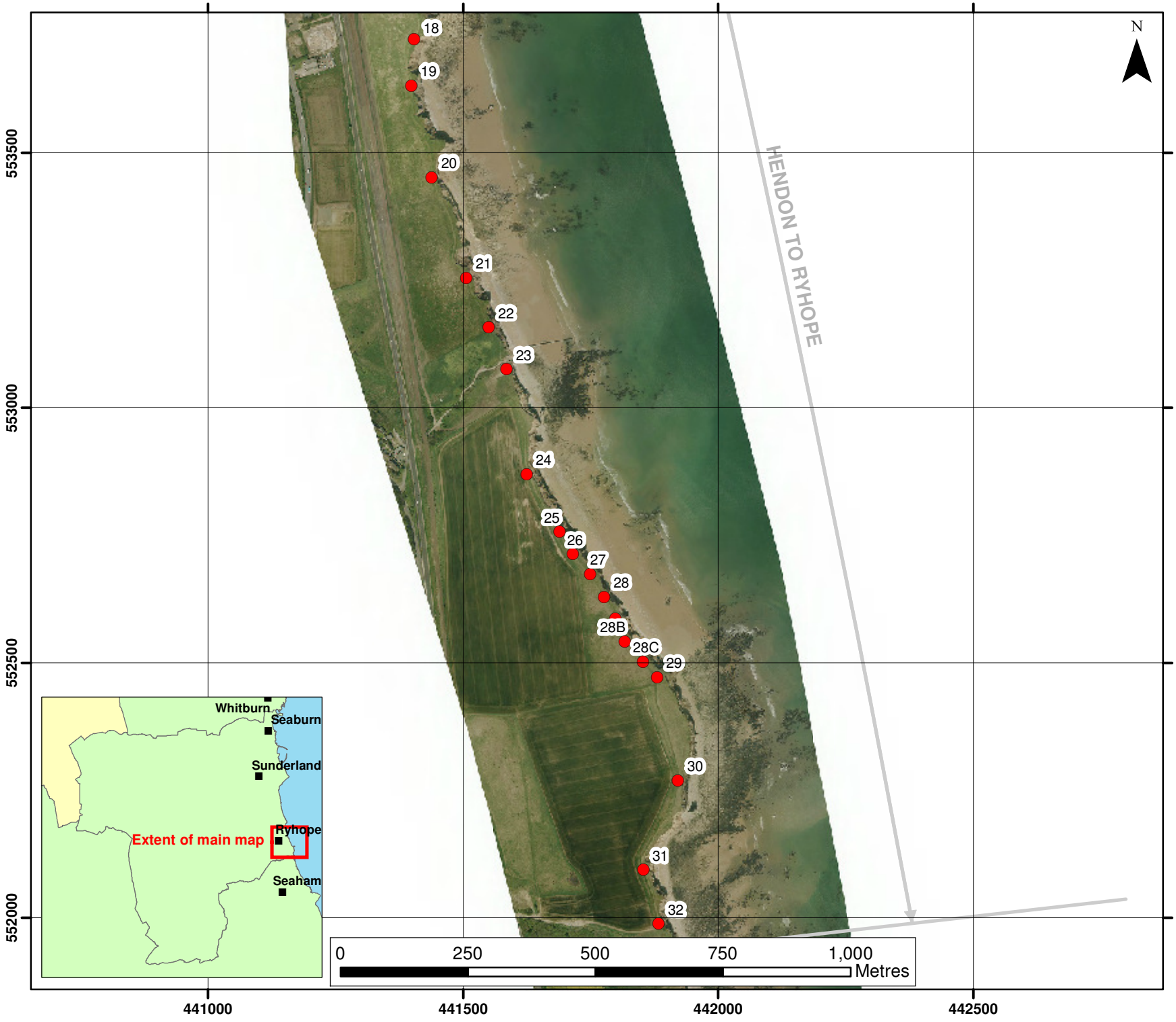

KEY

- 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 6
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