The Scottish Salmon Company

Hydrographic Report

Gometra, Isle of Mull

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1 Introduction

This report describes the methods used to collect hydrographic data at the existing Scottish Salmon Company (SSC) Gometra fish farm, and presents the outcomes of the survey exercise.

These deployments were carried out by SSC, using a Teledyne RD Instruments Acoustic Doppler Current Profiler (ADCP) Workhorse, mounted in a weighted seabed frame.

Analysis was carried out in accordance with the Scottish Environmental Protection Agency (SEPA) guidelines (Aquaculture Modelling - Regulatory Modelling Guidance for the Aquaculture Sector. Version 1.1, July 2019).

2 Site Description

The hydrographic survey site, at Gometra fish farm, was located on the north coast of Gometra, Loch Tuath (Figure 2.1). There were 16 x 100 m circumference cages, held in one group (8 x 2), on site at the time of the survey. Within the survey area, the seabed slopes northwards with depths reaching approximately 23-32 m around the site.

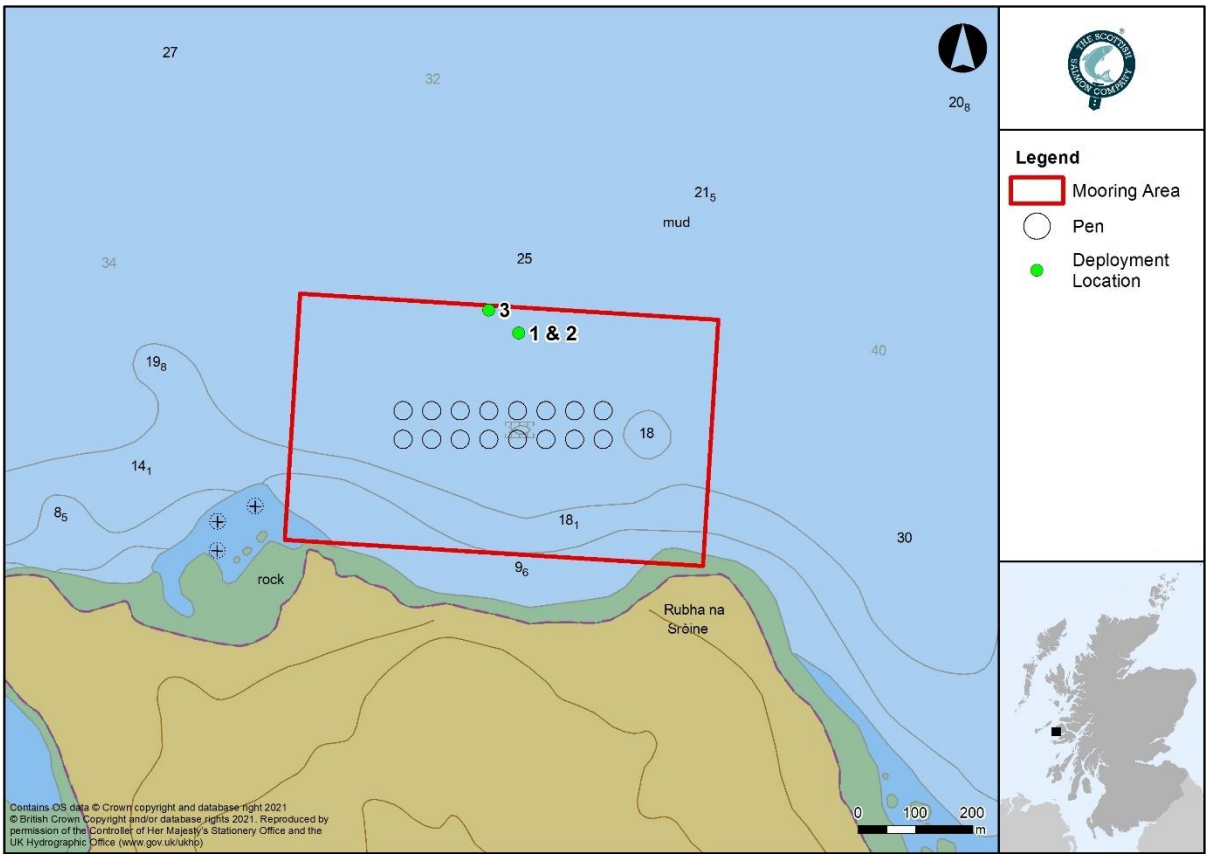

Figure 2.1 Location of the Gometra site and locations for all current meter deployments (green dots).

3 Materials and Methods

3.1 Bathymetry Survey

SSC conducted a bathymetry survey to collect data around the site in October 2011, using a Garmin portable chart plotter with acoustic sounder (Figure 3.1). Boat GPS was used at the start of the survey to verify accuracy to return positional information (WGS84). Both devices received a minimum of eight satellite coverage throughout the survey. Recorded depths were corrected to Chart Datum CD using Admiralty Total Tide software and referenced against tide predictions for the secondary port Sound of Ulva.

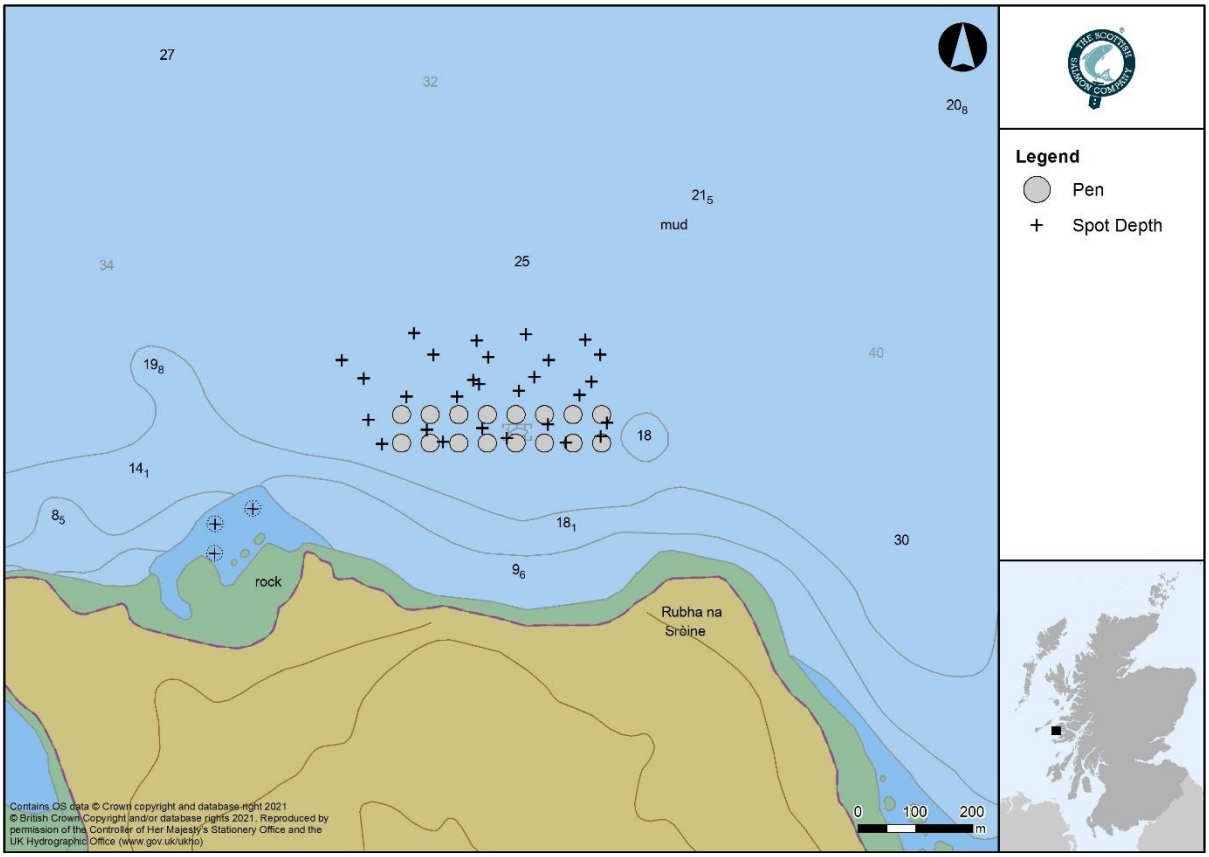

Figure 3.1 Bathymetry spot depths during the survey in October 2011.

Surveyed bathymetric data was then combined with land form data and charted bathymetry from the survey area, to provide a comprehensive overview of bathymetry within the area around the fish farm location.

3.2 Current Meter Set-up

An ADCP was used to record current data at the Gometra salmon farm during three seperate deployments. The ADCP was installed in a mooring frame with 20° free gimbal movement that automatically levels the instrument when deployed on the seabed. The Workhorse ADCP is a 500kHz medium range, acoustic Doppler current profiler, which allows multiple, simultaneous sampling strategies with site specific cell size. This allows for current measurements throughout the water column, up to 50 m depths. Further information on the ADCP can be found at:
http://www.teledynemarine.com/adcps/marine-measurements

The ADCP was deployed three times in 2017, in order to collect at least 90 days of current meter data. The details of these deployments are shown in Table 3.1. Further details are provided in Appendix 1. The transducer head was 60 cm from the base of the mooring frame.

Table 3.1 Gometra deployment details

	Deployment	Start date/time	End date/time	Location (OSGB36)	Location (WGS84)
Gometra 1	1	28/08/2017 14:00	21/09/2017 22:00	136309E, 742617N	56° 30.090'N 006° 17.200'W
Gometra 2	2	12/10/2017 16:20	30/11/2017 16:00	136309E, 742617N	56° 30.090'N 006° 17.200'W
Gometra 3	3	06/12/2017 14:00	14/01/2018 00:20	136257E, 742657N	56° 30.110'N 006° 17.253'W

Initial depth soundings were taken at the deployment site, in order to determine the depth the ADCP would be situated in during high tide and in order for the appropriate cell size to be determined. The ADCP was configured at the time of deployment, having established the water depth and expected tidal range on site. This was carried out on the instrument settings using a laptop with wireless connectivity.

3.3 Magnetic Variation

No magnetic variation correction was made to the ADCP during the deployment, this was undertaken after the instrument was recovered and data downloaded. A convergence value of -3.57° was applied. The grid magnetic angle applied was 0.12° for the first and second deployment, and 0.15 for he third, and final, deployment . This gave an overall declination of -3.45°, -3.45° and -3.42, respectively.

This was determined using the World Magnetic Model, produced jointly by the United States National Oceanographic and Atmospheric Administration's National Geophysical Data centre. Further details can be found at:

http://www.geomag.bgs.ac.uk/data_service/models_compass/wmm_calc.html

3.4 Data Processing

Data was downloaded and viewed using 'Velocity', a bespoke software for use with Teledyne instruments. Initial checks were done on the data to determine if the deployments were successful. In particular, pitch and roll, and heading were analysed to confirm that the deployment was successful, with the instrument orientated upright, and no unexpected movement. From the software, the data was extracted to text files and then later further processed in MATLAB and Microsoft Excel.

SEPA specifies that data should be presented for specific depths, therefore the data was selected against the following requirements:

- Sub-surface: from a depth of 5m below the lowest predicted spring tide during the deployment period;
- Cage-bottom: at a depth corresponding to the bottom of the cages at mean sea level (+/- 1m);
- Near-bed: as close to the bed as predictable (<3m).

For all deployments, the near-bottom cell chosen was cell 1, giving a height above the seabed of 2.48 m, with depths ranging from 29.76 m to 35.62 m. Each cage-bottom and sub-surface cell for each deployment was calculated based on recorded depths. The calculated cell number and their depths are shown in Table 3.2.

Table 3.2 Summary of the cell number and their depths for each dataset.

Deployment		Near-bottom Cell	Cage-bottom Cell	Sub-surface Cell
Gometra 1	Cell Number	1	34	43
	Distance from sebed (m)	2.48	22.18	27.58
	Distance from surface (m)	29.76	8.18	2.78
Gometra 2	Cell Number	1	33	41
	Distance from sebed (m)	2.48	21.57	26.37
	Distance from surface (m)	30.07	9.10	4.30
Gometra 3	Cell Number	1	33	42
	Distance from sebed (m)	2.48	21.57	26.97
	Distance from surface (m)	31.22	10.25	4.85

The distance to the near-bed cell is automatically calculated based on the configuration settings of the instrument. This is the distance from the transducer to the centre of the first cell, which equated to 1.88 m for all deployments. This number is then added to the height of the transducer head from the seabed, to give the actual height of the centre of the first cell, 2.48 m, which is within the remit of the SEPA criteria.

Standard deviation has been assessed throughout the deployment to identify accurate and reliable data for near-bed, cage-bottom and sub-surface cells. The instrument standard deviation is determined using the deployment settings when the meter is programmed. Standard deviation for both deployments were within the SEPA criteria of 0.02 cm/s.

4 Results and Discussion

4.1 Bathymetry Survey

Bathymetry data was gathered in October 2011, using a Garmin portable chart plotter with acoustic sounder. A combination of the collected depth data and Admiralty chart data was used to represent the bathymetry around the Gometra site (Figure 4.1). The mean wetted depth for the 2 km x 2 km area was 21.55 m.

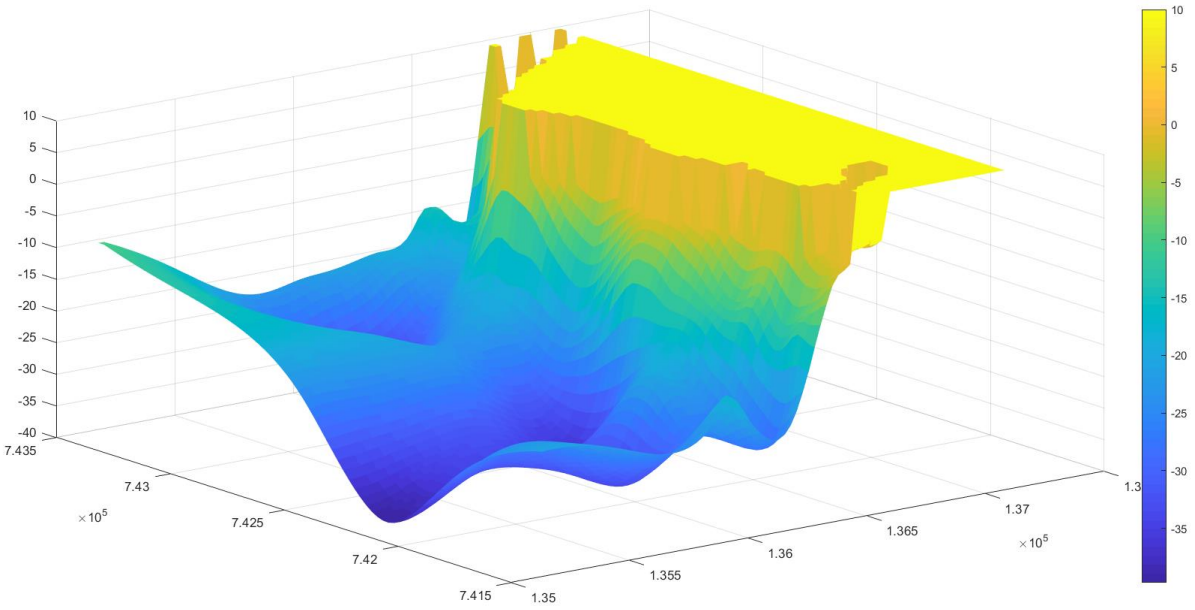

Figure 4.1. A three dimensional figure displaying bathymetry data for a 2 km x 2 km grid around the Gometra site.

4.2 Current Data

During the initial processing stages, heading, pitch and roll were analysed to ensure the deployments were successful, this is presented in Table 4.1, Figure 4.2 to Figure 4.4. These values are within the accepted range for successful deployments.

Table 4.1. Pitch, roll and heading range for the three Gometra deployments.

Deployment	Pitch (°)	Roll (°)	Heading (°)
Gometra 1	3.9	2.3	4.0
Gometra 2	4.3	2.4	7.0
Gometra 3	1.2	2.4	4.0

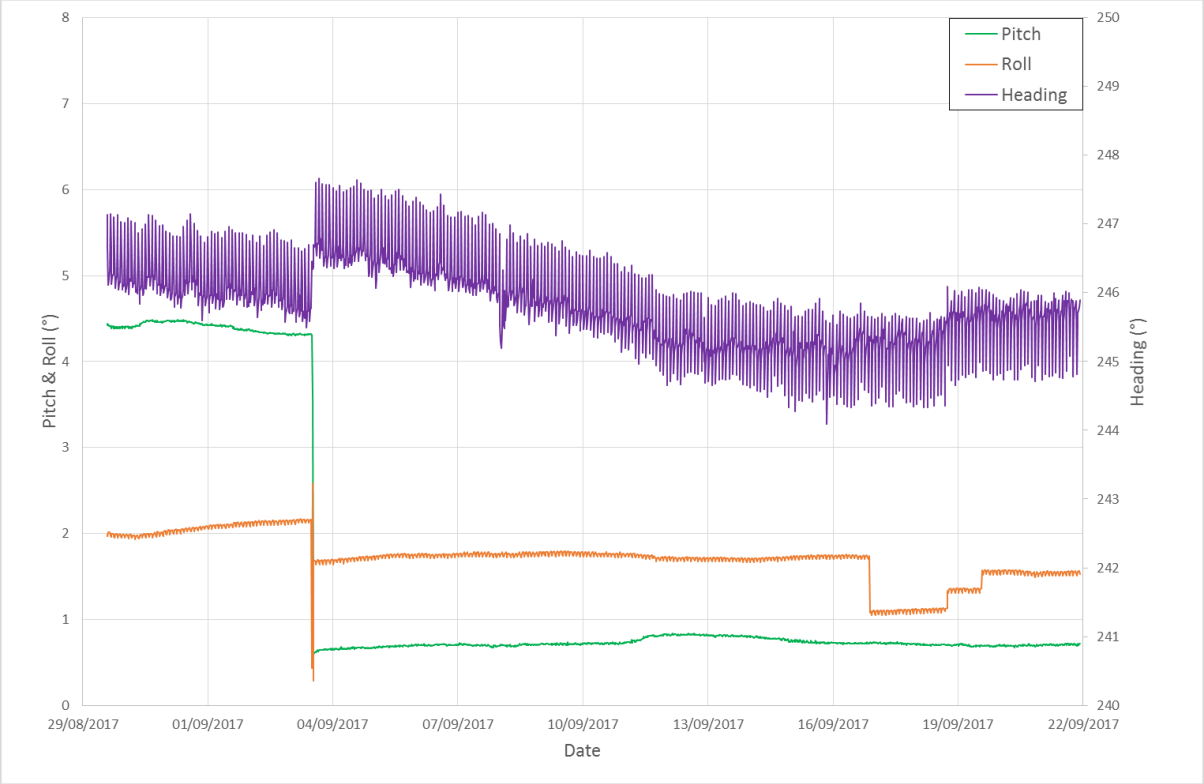

Figure 4.2. Heading, pitch and roll for Gometra deployment 1, from 29/08/2017 - 21/09/2017.

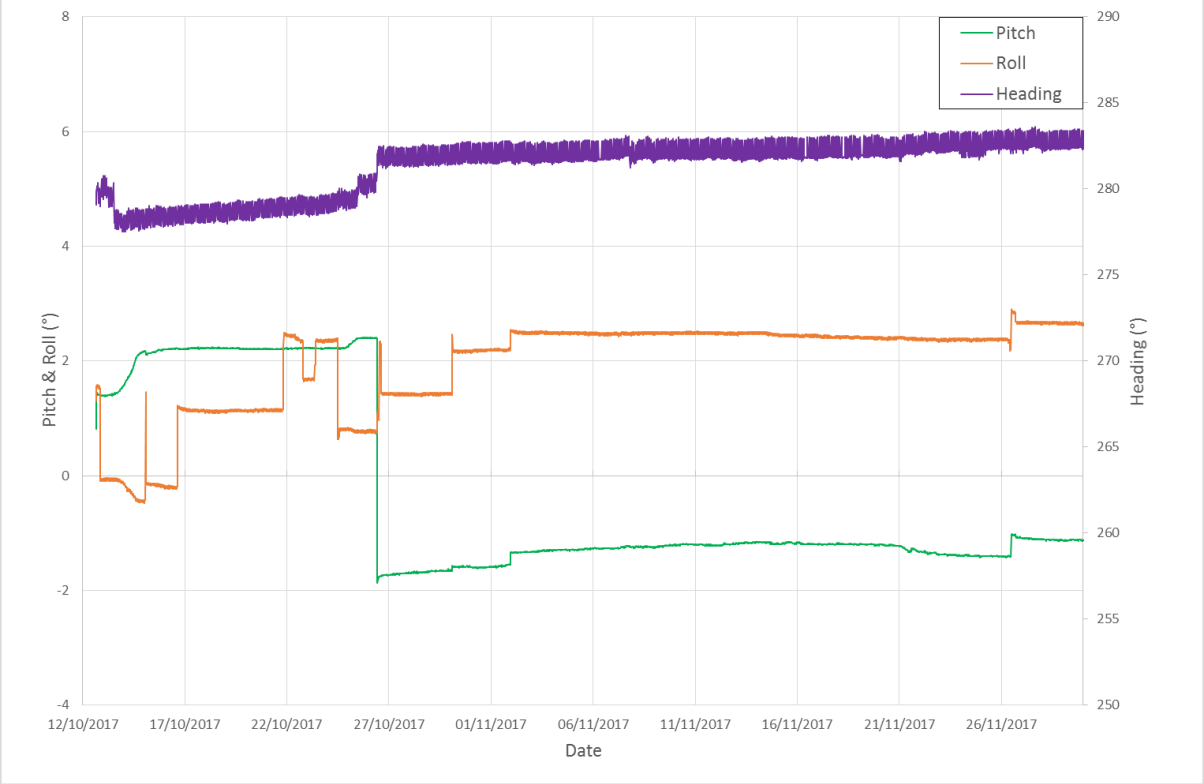

Figure 4.3. Heading, pitch and roll for Gometra deployment 2, from 12/10/2017 - 30/11/2017.

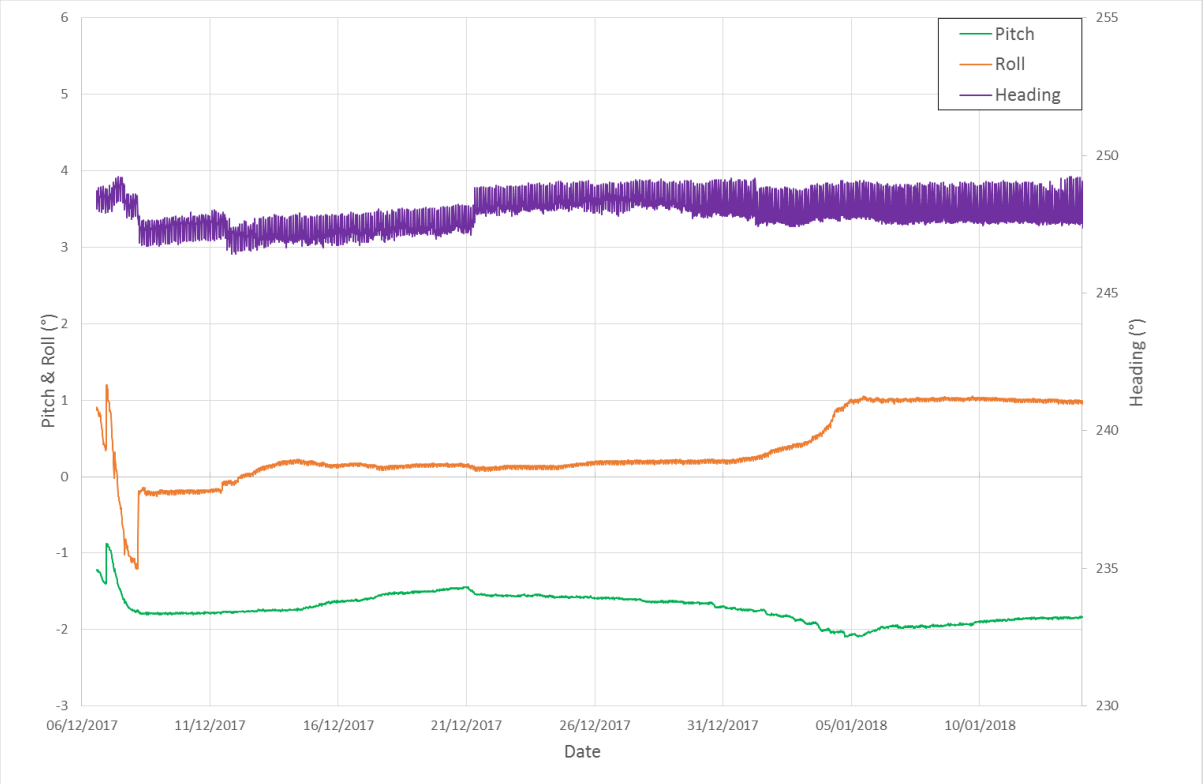

Figure 4.4 Heading, pitch and roll for Gometra deployment 3, from 6/12/2017 - 14/01/2018.

A summary of the current data is shown in Appendix 1, and the SEPA HG analysis summary details are provided in Appendix 2.

A summary of the current data is shown in Table 4.2 to Table 4.4. Over the course of the first deployment, the sub-surface, cage-bottom and near-bed cells had averages of 10.3 cm/s, 10.4 cm/s and 8.3 cm/s respectively. This gave an overall average of 9.7 cm/s. Over the course of the second deployment, the sub-surface, cage-bottom and near-bed cells had averages of 9.4 cm/s, 9.5 cm/s and 8.3 cm/s respectively. This gave an overall average of 9.1 cm/s. Finally, over the course of the third deployment, the sub-surface, cage-bottom and near-bed cells had averages of 10.1 cm/s, 9.6 cm/s and 8.9 cm/s respectively. This gave an overall average of 9.5 cm/s. The orientation of the velocities was 275° to 300°, consistent with a parallel flow to the shoreline. Further details on hydrographic meter deployment results are provided in Appendix 1.

The mean residual currents for the sub-surface, cage-bottom and near-bed cells are 6.9 cm/s, 6.5 cm/s and 3.2 cm/s for the first deployment (with an overall average of 5.5 cm/s); 5.5 cm/s, 5.4 cm/s and 2.6 cm/s for the second deployment (with an overall average of 4.5 cm/s); and 5.7 cm/s, 5.7 cm/s and 3.3 cm/s for the third deployment (with an overall average of 4.9 cm/s). The direction of the residual current at all depths was between 257° and 283°, which was similar to that of the combined velocity. The residual currents recorded during all deployments show that there is some wind influence in the upper water column, in the same direction as tidal flow. This influence decreases in the near-bed cell, where tidal flow is the dominant flow.

Table 4.2. Summary of currents recorded at Gometra deployment 1.

	Mean Speed (cm/s)	Residual Speed (cm/s)	Residual direction °T	Major axis °T
Sub-surface	0.10	0.07	283	285
Pen-bottom	0.10	0.07	266	285
Near-bed	0.08	0.03	282	300

Table 4.3. Summary of currents recorded at Gometra deployment 2.

	Mean Speed (cm/s)	Residual Speed (cm/s)	Residual direction °T	Major axis °T
Sub-surface	0.09	0.06	262	280
Pen-bottom	0.10	0.05	257	275
Near-bed	0.08	0.03	271	290

Table 4.4. Summary of currents recorded at Gometra deployment 3.

	Mean Speed (cm/s)	Residual Speed (cm/s)	Residual direction °T	Major axis °T
Sub-surface	0.10	0.06	263	280
Pen-bottom	0.10	0.06	260	280
Near-bed	0.09	0.03	277	295

The data collection took place over a period of one year, therefore it was necessary to undertake data 'stitching'. Data was 'stitched' together to form a 93-day dataset in such a way as to minimise error between Spring-Neap cycles. Table 4.5 shows the four datasets and their Spring-Neap cycle, in the order in which they were 'stitched' together.

Table 4.5 Gometra current meter tidal cycles.

Dataset	Deployment	Start	Tide	Spring Time (days)	End	Tide	Spring Time (days)
Gometra 1	1	29/08/2017 14:00	2.5 hrs before low	6 after	13/09/2017 16:20	0.5 hrs before low	5 after
Gometra 2	2	12/10/2017 16:20	0.5 hrs before low	5 after	21/11/2017 13:40	0.25 hrs after low	1 after
Gometra 3	3	06/12/2017 14:00	0.25 hrs after low	1 after	14/01/2018 00:20	3.75 hrs before high	5 before

The depth records shown by the current meter pressure sensor cells corresponded to the rise and fall of the tide, as checked with Total Tide software for the deployment periods; high and low tides corresponded with small variations of +/- 9 minutes.

The SEPA HG analysis spreadsheet for the 93 days of current data is shown in Appendix 2. For the 93-day dataset the sub-surface, cage-bottom and near-bed cells had averages of 10.0 cm/s, 10.0 cm/s and 8.7 cm/s respectively. This gave an overall average of 9.6 cm/s. The orientation of the velocities was west-northwest at the near-bed, cage-bottom and sub-surface cells. Similar to the individual deployments this orientation of the flow is parallel to the shoreline. The mean residual currents for the sub-surface, cage-bottom and near-bed cells are 5.8 cm/s, 6.0 cm/s and 3.2 cm/s, with an overall average of 5.0 cm/s. The direction of the residual current at all selected cells was west to west-northwest.

5 Summary of Meteorological Data

SEPA have determined that meteorological data is no longer required in the assessment of site hydrographic conditions, due to the use of 90-days of hydrographic data. This longer deployment schedule has been achieved through multiple deployments, an extended time period and likely represents different seasons of the year. This provides a more realistic representation of conditions experienced at the site, compared with the previous methodology of short current meter deployments. Through post-processing, the hydrographic data has been used to analyse full flow and tide only flow conditions for the deployment periods, thus assessing the influence of meteorological conditions on the site.

6 Conclusion

Bathymetry and hydrographic data have been collected at the Gometra site. The results from three deployments, totalling 93 days of data collection, have been presented in this hydrographic report. These data are believed to be reliable and representative of the location of the site.

Overall, the recorded data are indicative of a moderate to well-flushed site, typical of the open location, and are considered suitable for further use in modelling. These datasets are considered to provide a good basis for hydrodynamic and bath treatment modelling.

Meteorological data was not collected.

7 Appendices

7.1 Appendix 1: Summary of current meter data for Gometra deployments

Table 7.1. Summary of currents recorded at Gometra 1st deployment ('Gometra 1').

No. of records	1681		
Start date / time	29/08/2017 14:00		
End date / time	21/09/2017 22:00		
	Near-bed	**Cage-bottom**	**Sub-surface**
Cell Number	1	34	43
Mean speed (m/s)	0.083	0.104	0.103
Residual speed (m/s)	0.032	0.065	0.069
Residual direction °T	278	262	279
Major axis °T	295	280	280
Residual parallel (m/s)	0.030	0.061	0.069
Residual normal (m/s)	-0.009	-0.020	-0.001
Amplitude parallel (m/s)	0.123	0.139	0.134
Amplitude normal (m/s)	0.053	0.059	0.058
Resuspension Threshold (9.5 cm/s)	35%	46%	46%

Table 7.2. Summary of currents recorded at Gometra 2nd deployment ('Gometra 2').

No. of records	3528		
Start date / time	12/10/2017 16:20		
End date / time	30/11/2017 16:00		
	Near-bed	**Cage-bottom**	**Sub-surface**
Cell Number	1	33	41
Mean speed (m/s)	0.083	0.095	0.094
Residual speed (m/s)	0.026	0.054	0.055
Residual direction °T	268	253	258
Major axis °T	285	275	275
Residual parallel (m/s)	0.025	0.051	0.053
Residual normal (m/s)	-0.008	-0.020	-0.016
Amplitude parallel (m/s)	0.118	0.129	0.126
Amplitude normal (m/s)	0.061	0.054	0.058
Resuspension Threshold (9.5 cm/s)	35%	42%	42%

Table 7.3. Summary of currents recorded at Gometra 3rd deployment ('Gometra 3').

No. of records	2768		
Start date / time	06/12/2017 14:00		
End date / time	14/01/2018 00:20		
	Near-bed	**Cage-bottom**	**Sub-surface**
Cell Number	1	33	42
Mean speed (m/s)	0.089	0.096	0.101
Residual speed (m/s)	0.033	0.057	0.057
Residual direction °T	274	256	259
Major axis °T	290	275	275
Residual parallel (m/s)	0.031	0.054	0.055
Residual normal (m/s)	-0.009	-0.018	-0.015
Amplitude parallel (m/s)	0.118	0.130	0.130
Amplitude normal (m/s)	0.064	0.047	0.065
Resuspension Threshold (9.5 cm/s)	42%	45%	48%

7.2 Appendix 2: HG analysis spreadsheets for the Gometra deployments.

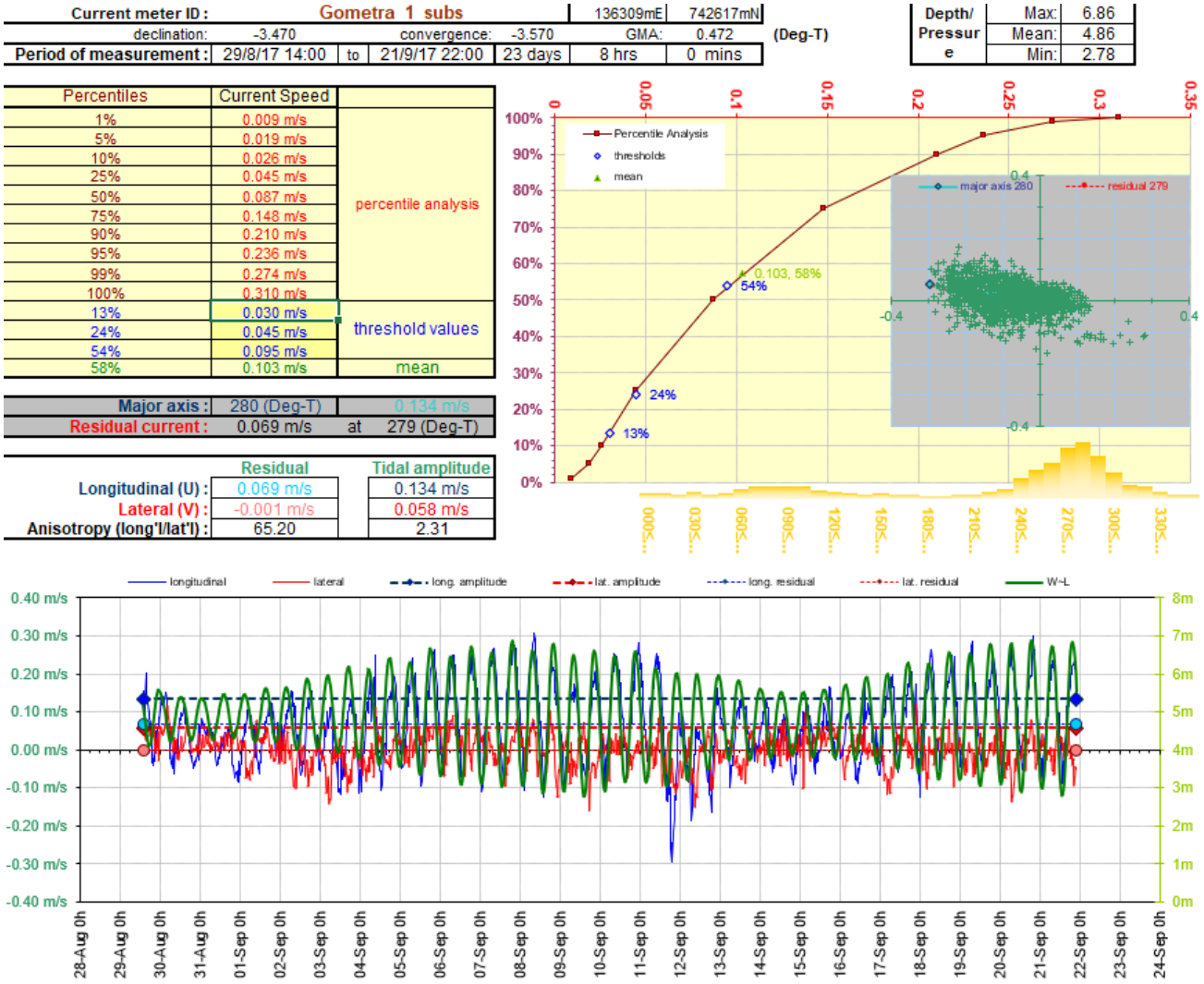

Figure 7.1. HG analysis summary of the sub-surface cell for Gometra 1st deployment.

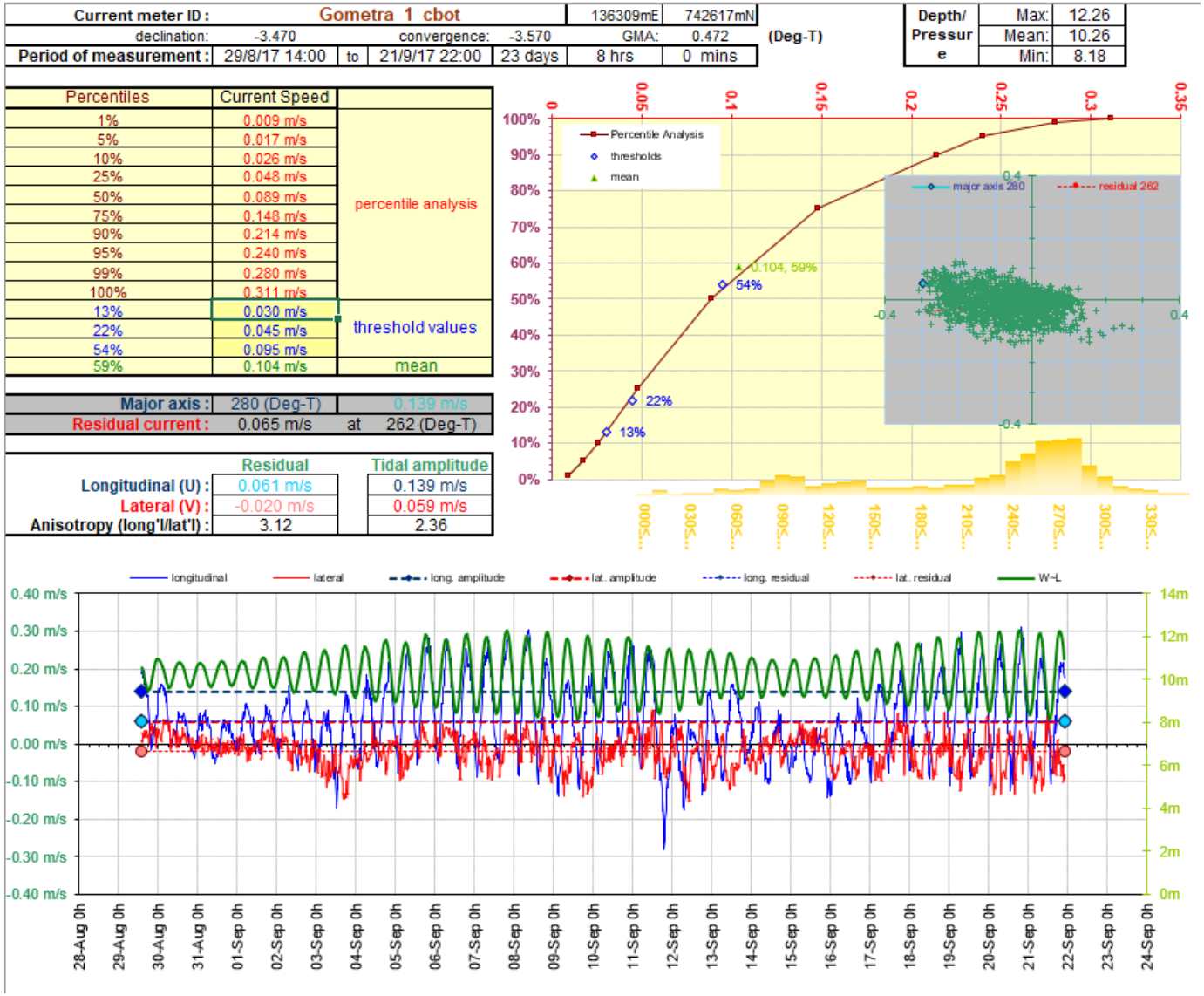

Figure 7.2. HG analysis summary of the cage-bottom cell for Gometra 1st deployment.

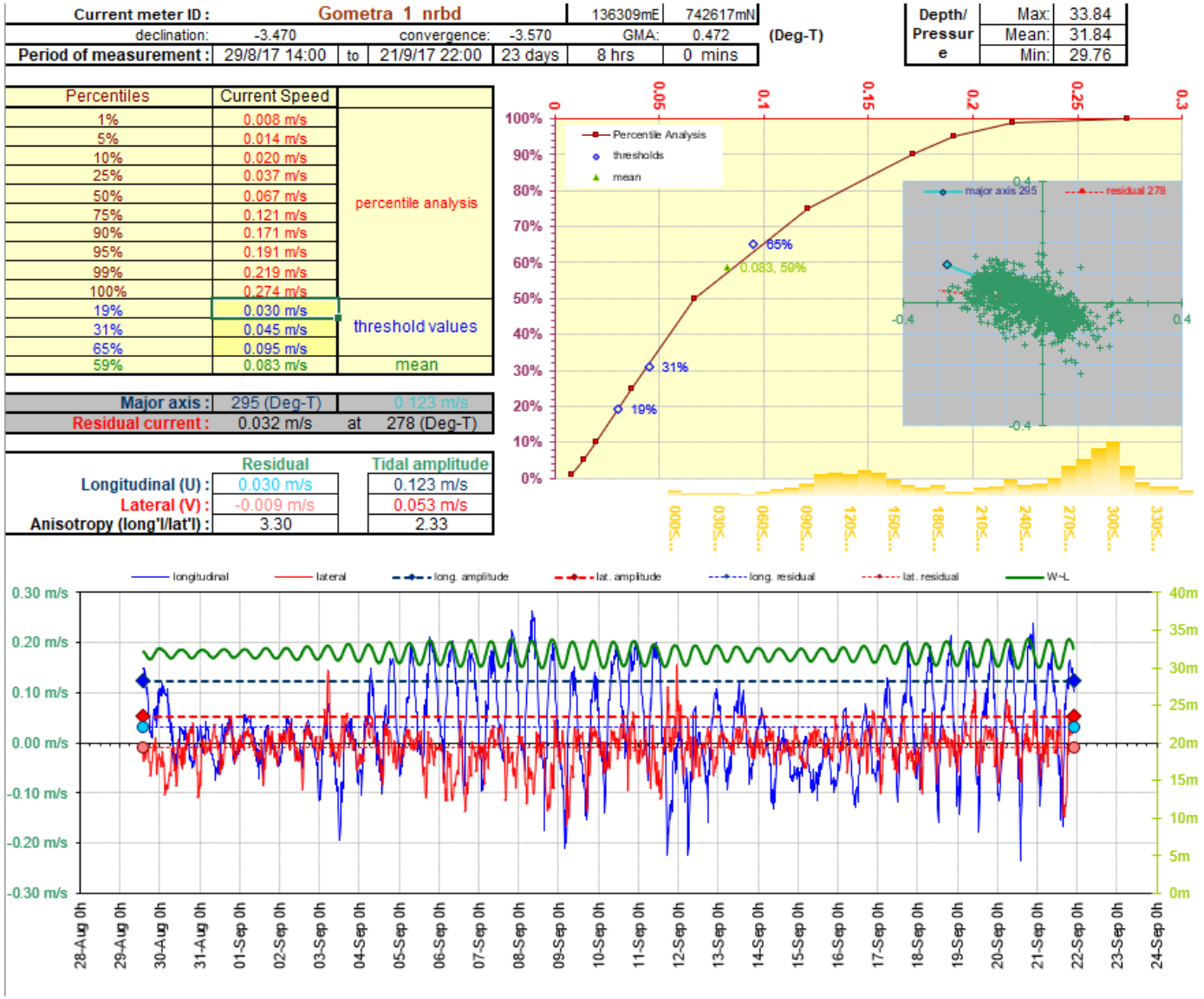

Figure 7.3. HG analysis summary of the near-bed cell for Gometra 1st deployment.

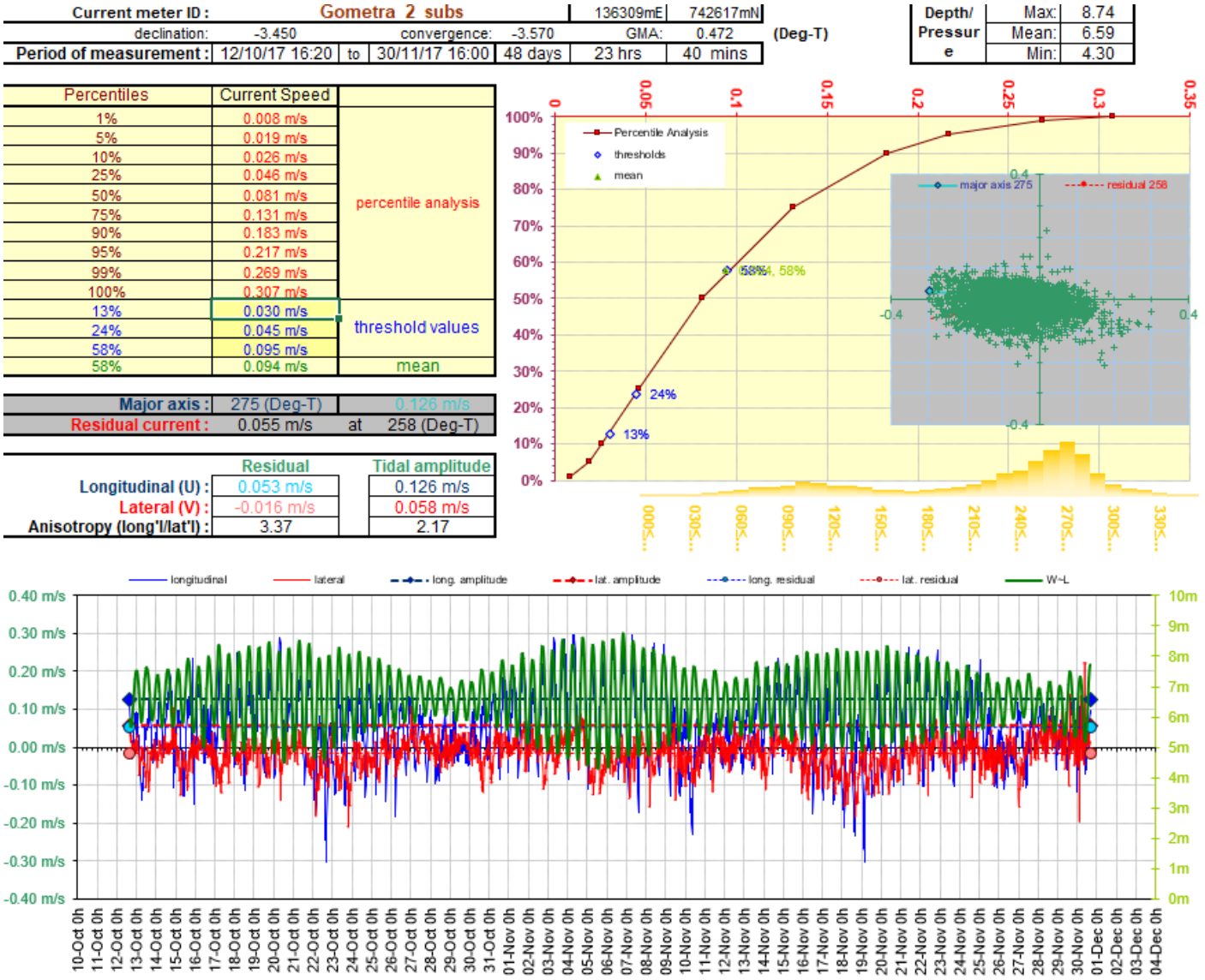

Figure 7.4. HG analysis summary of the sub-surface cell for Gometra 2nd deployment.

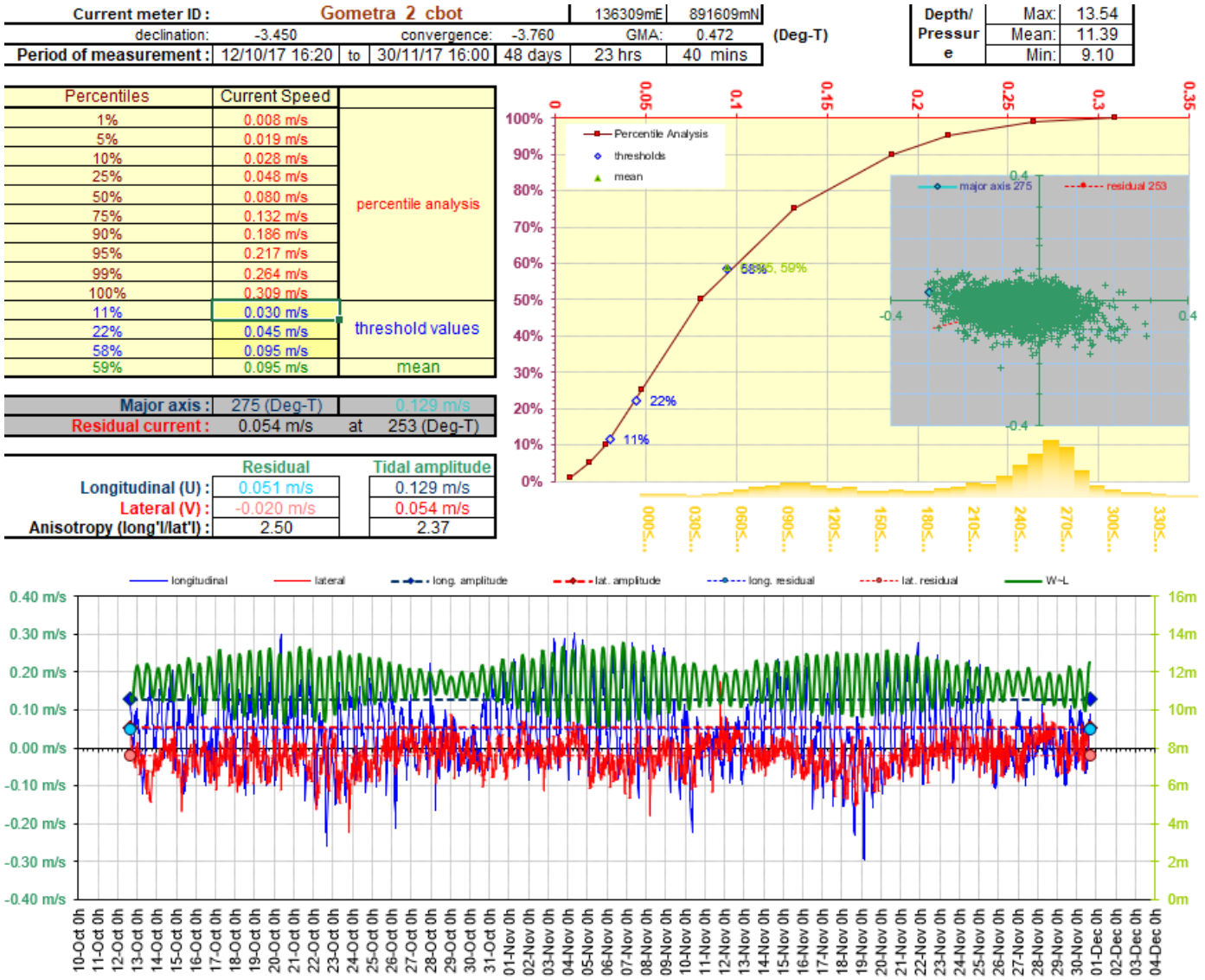

Figure 7.5. HG analysis summary of the cage-bottom cell for Gometra 2nd deployment.

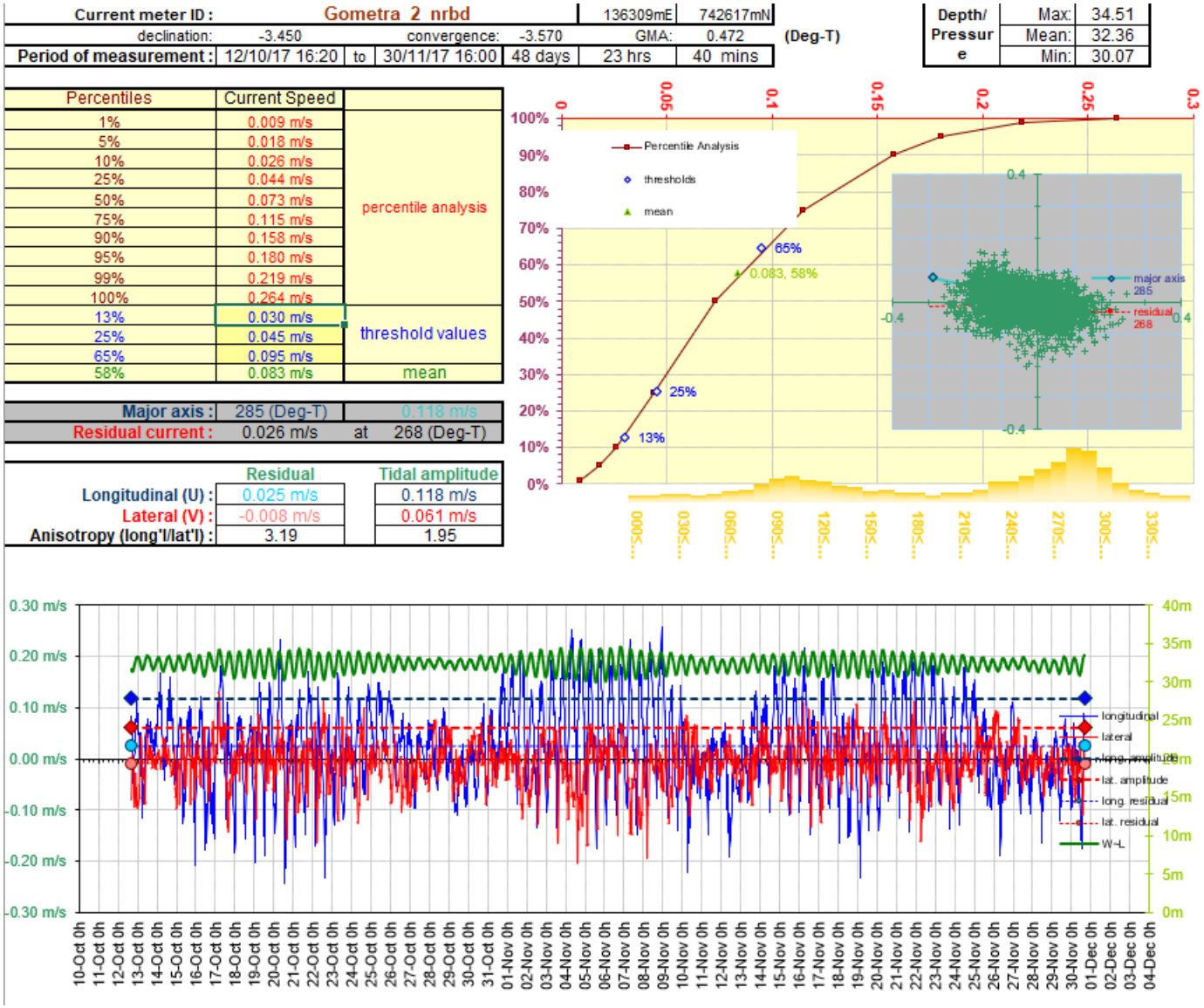

Figure 7.6. HG analysis summary of the near-bed cell for Gometra 2nd deployment.

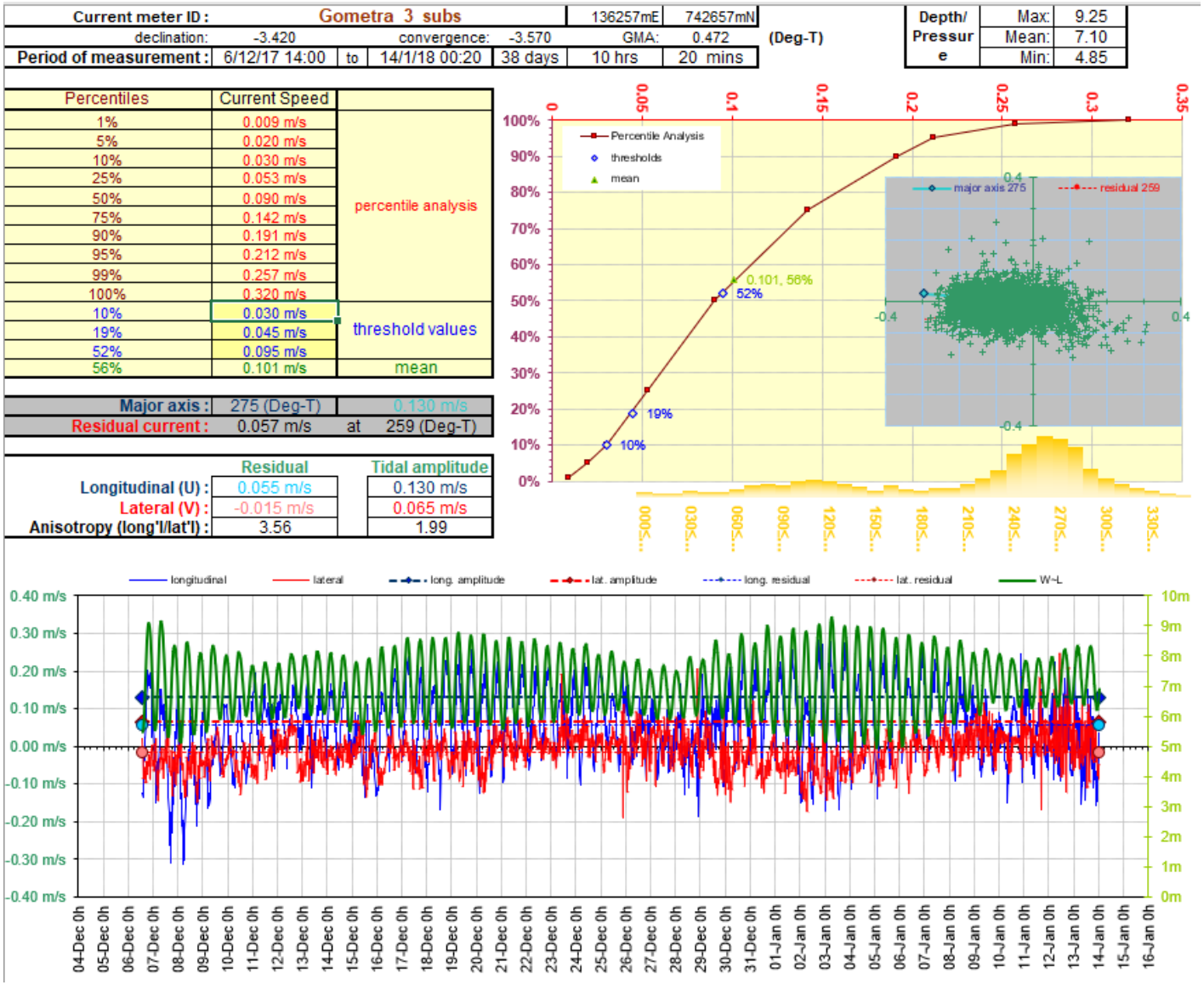

Figure 7.7. HG analysis summary of the sub-surface cell for Gometra 3rd deployment.

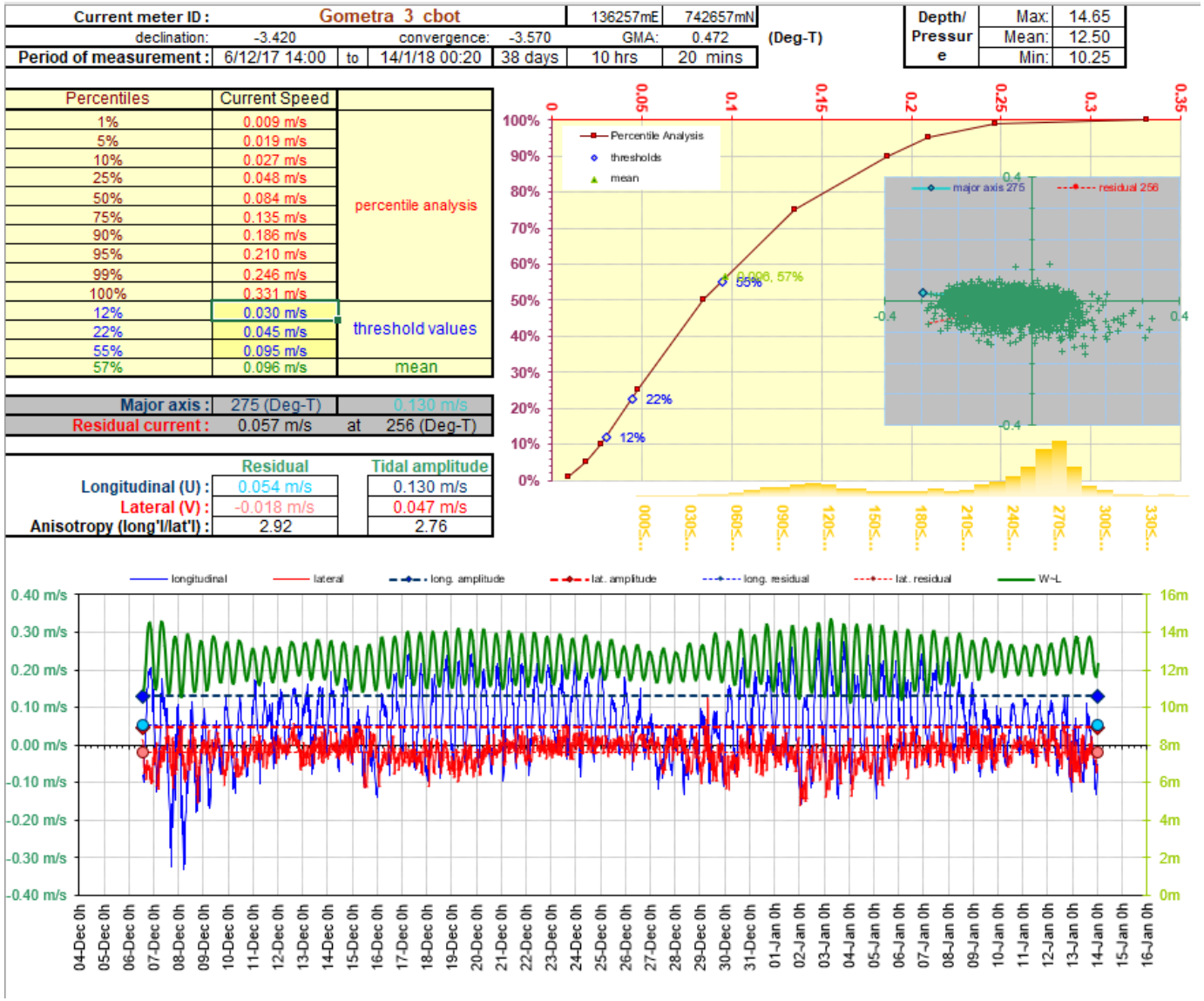

Figure 7.8. HG analysis summary of the cage-bottom cell for Gometra 3rd deployment.

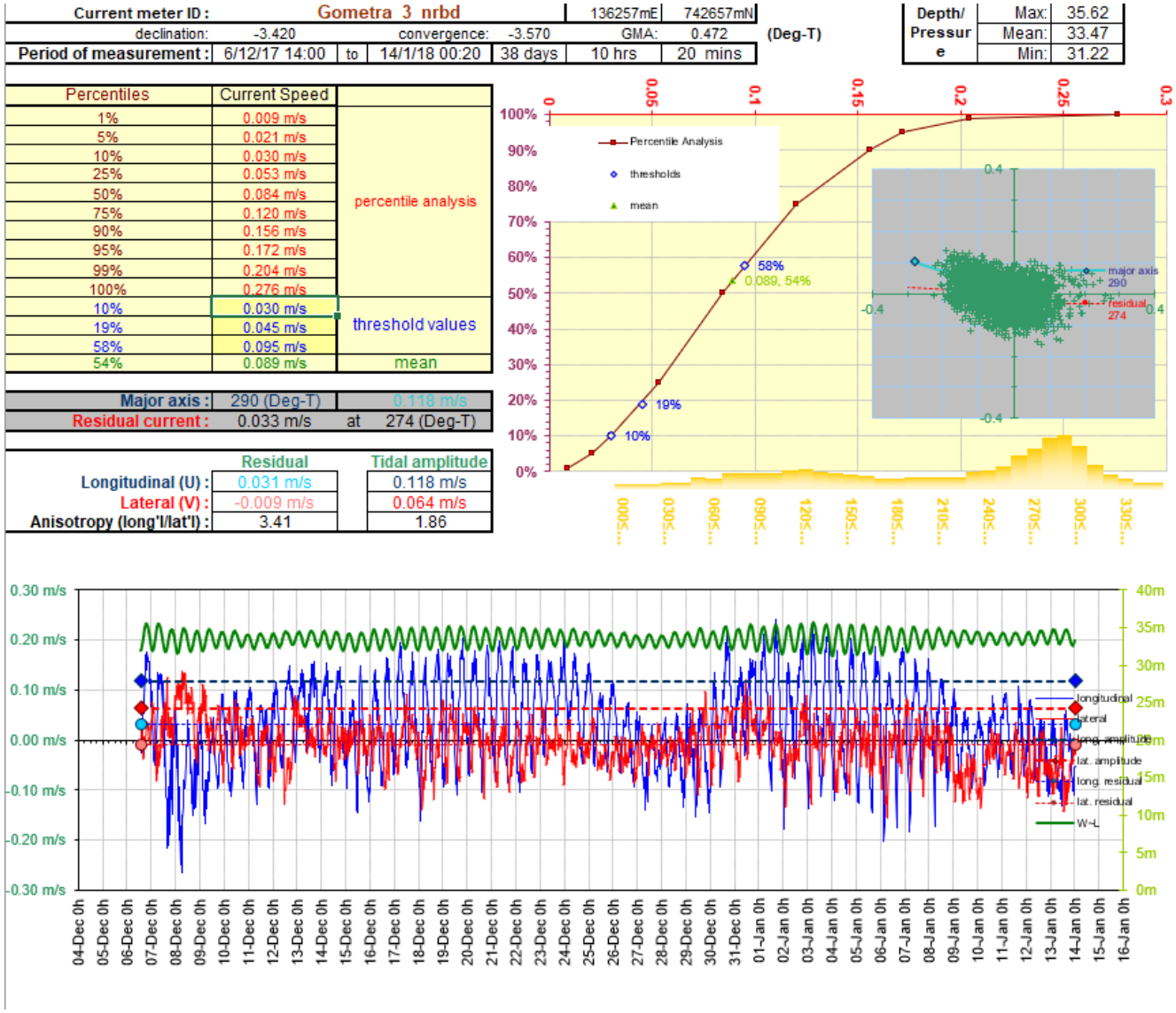

Figure 7.9. HG analysis summary of the near-bed cell for Gometra 3rd deployment.

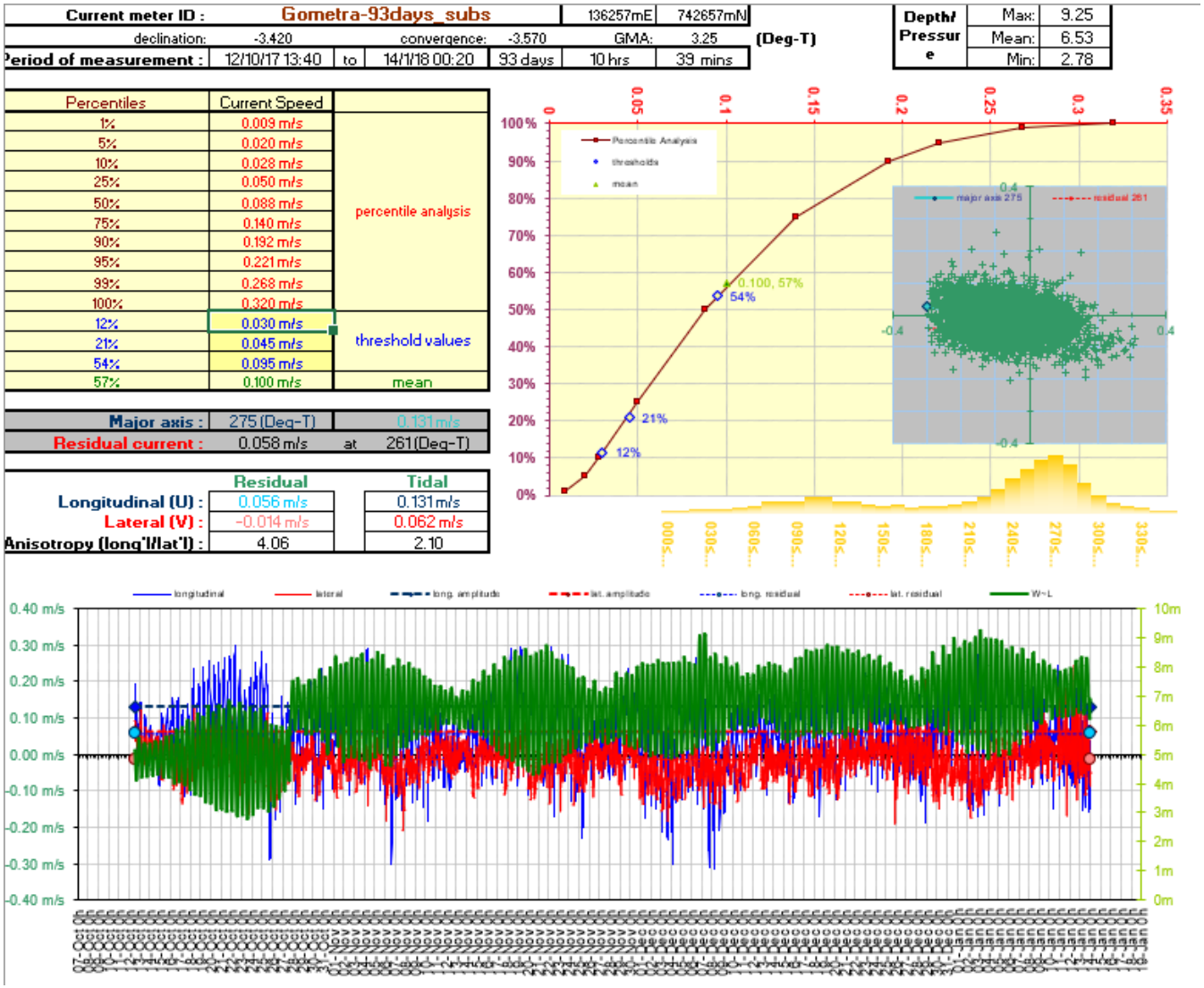

Figure 7.10. HG analysis summary of the sub-surface cell for Gometra 93 days.

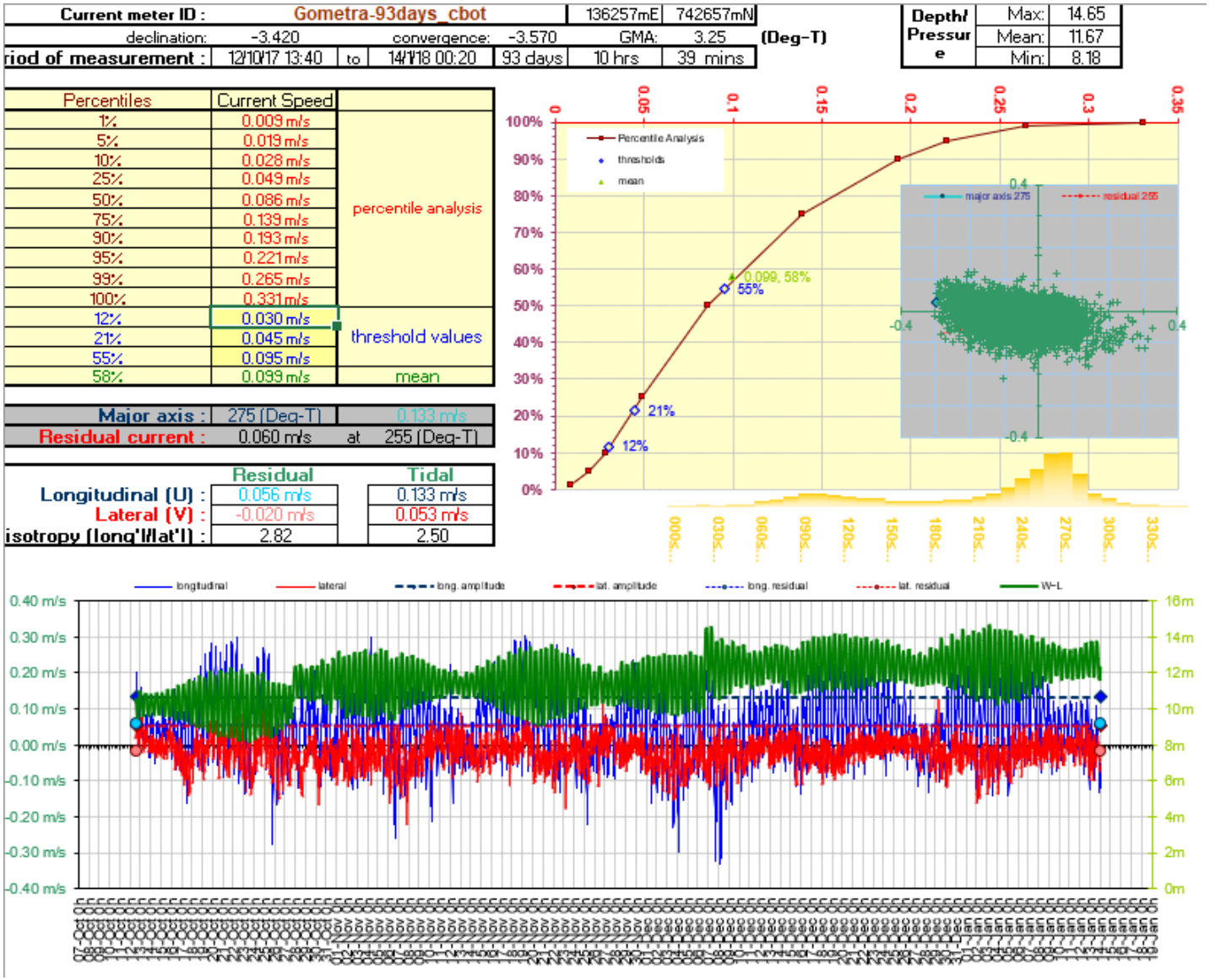

Figure 7.11. HG analysis summary of the cage-bottom cell for Gometra 93 days.

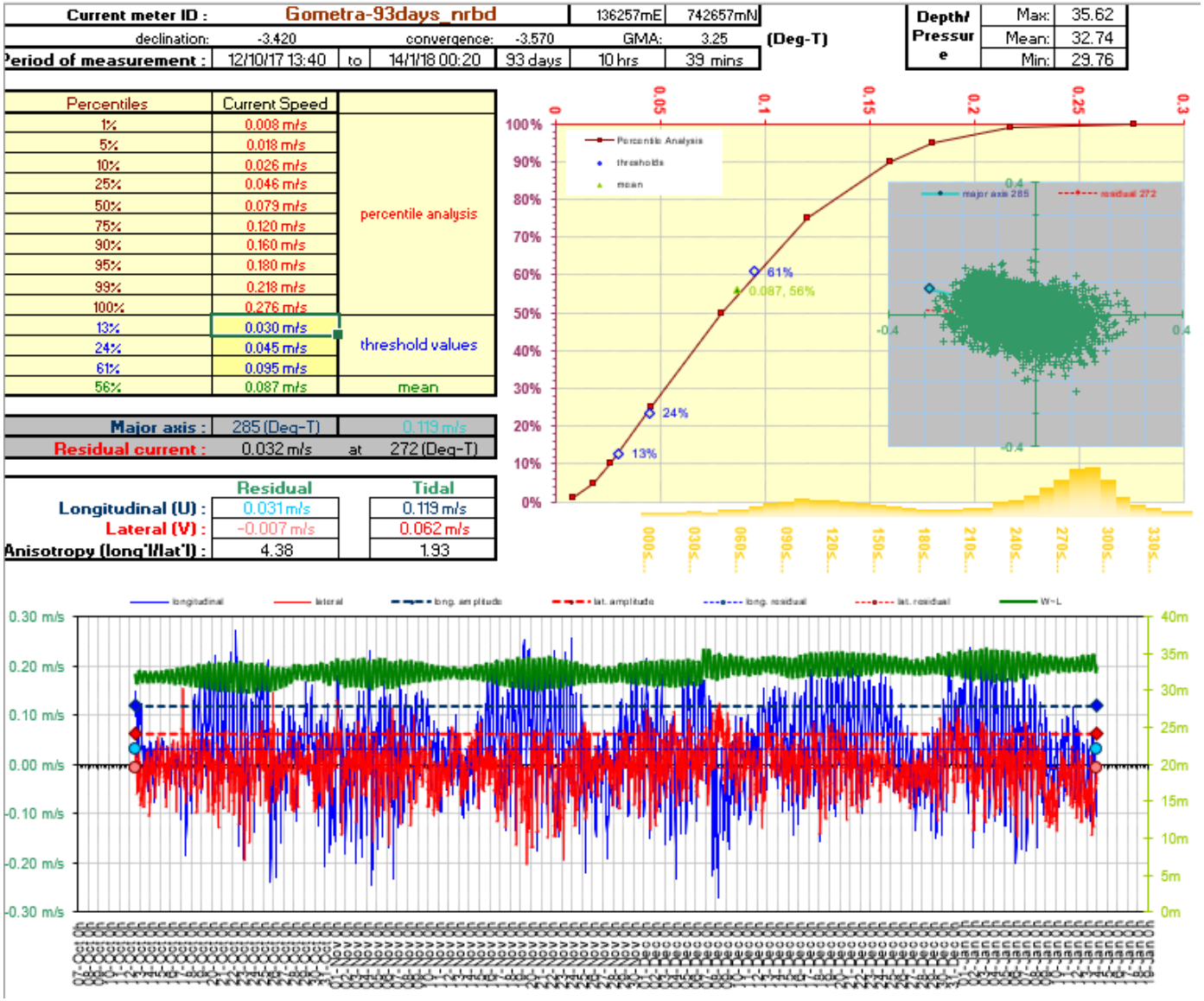

Figure 7.12. HG analysis summary of the near-bed cell for Gometra 93 days.