# Preliminary Environmental Information Report Volume 2

## Appendix 18.1 Sediment Dispersion Modelling

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# LionLink

## Sediment Dispersion Modelling Report

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PORT & COASTAL SOLUTIONS

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# 1 Introduction

On behalf of National Grid Ventures (NGV), Collaborative Environmental Advisors Ltd (CEA) commissioned Port and Coastal Solutions Ltd (PCS) to provide sediment dispersion modelling services for the LionLink Project ('the Project'). The sediment dispersion model ('the model') will support the environmental impact assessment process by determining the zone of influence over which suspended sediment may be dispersed as a result of cable installation activities including:

- seabed preparation activities including sandwave clearance; and
- cable burial by plough or jet trencher.

The modelling will help assess the potential risk to sensitive receptors, including the Sizewell nuclear power station cooling water intakes and marine designated sites.

This report outlines the development and application of the numerical modelling tools applied for the study and presents results from the modelling undertaken.

## 1.1 Study Area

The offshore components of the Project comprise proposed High Voltage Direct Current (HVDC) Submarine Cables which would route from landfall at Walberswick in Suffolk across the Southern North Sea to the boundary between the UK and Netherlands Exclusive Economic Zone (EEZ), a distance of approximately 185 km. Within Dutch waters the HVDC Submarine Cable would connect to a Dutch Offshore Wind Farm (OWF) chosen by TenneT, the Dutch transmission system owner and operator. The proposed Offshore HVDC Submarine Cable Corridor (which is nominally 500 m wide) is shown in Figure 1.

Based on tidal excursions along the route (informed by the UK Renewables Atlas (ABPmer et al., 2008)), an initial Study Area of 15 km around the proposed Offshore HVDC Submarine Cable Corridor was adopted for the assessment of effects. This Study Area is expected to include all areas of potential impact. The extent of the Study Area was verified by the modelling assessment.

The main focus is on the inner part of the proposed offshore HVDC Submarine Cable Corridor, since the key receptors including bathing waters, the Outer Thames Estuary Special Protection Area (SPA) and the Sizewell nuclear power stations intakes are located in this area. In addition, the percentage of fines and the flow speeds are highest in these areas resulting in the largest potential plume spread for sediment disturbed by construction or maintenance activities.

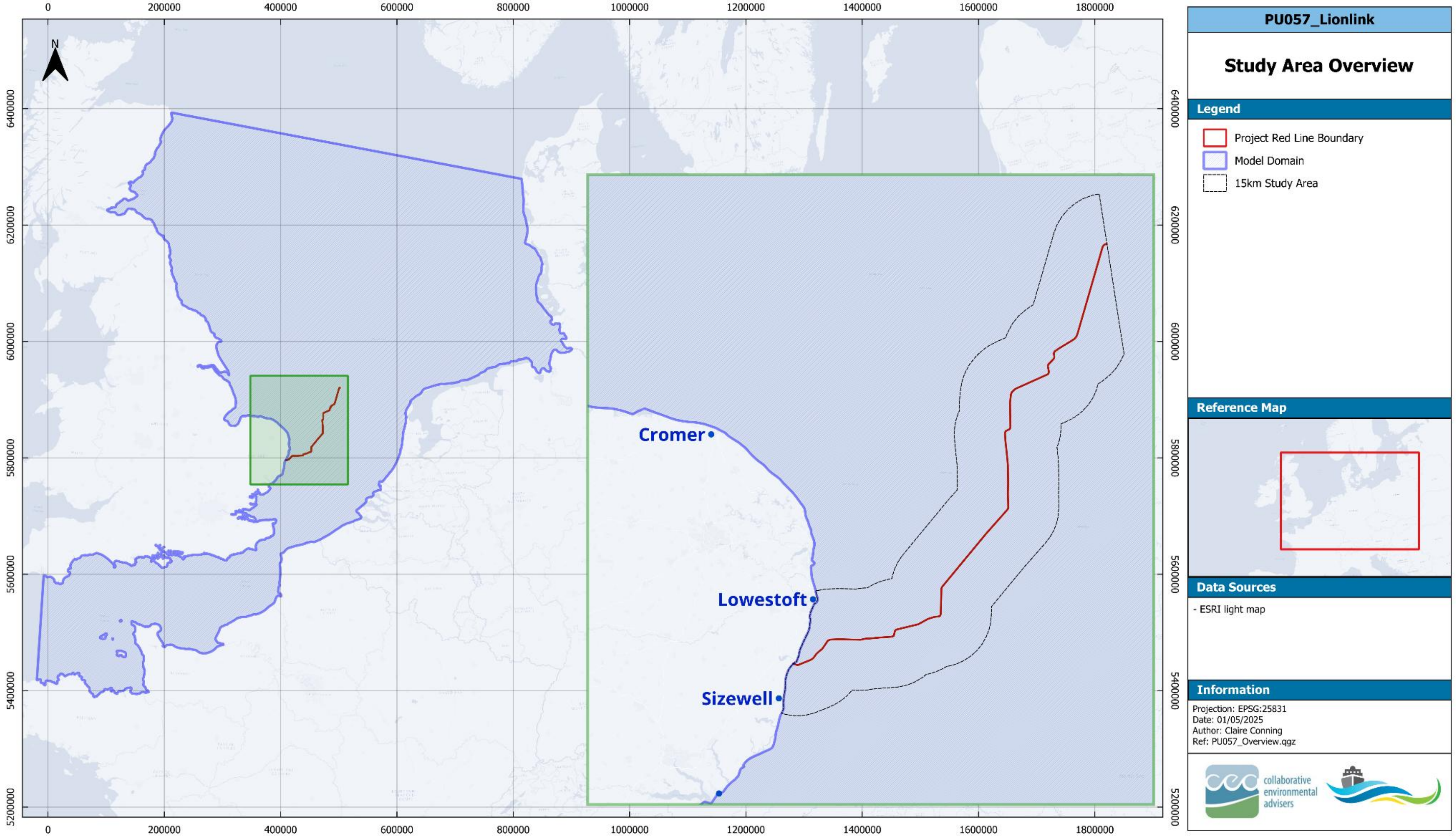


**Figure 1. Study Area.**

## 1.2 Report Structure

This report is structured as follows:

- an introduction to the study is provided in **Section 1**;
- the numerical modelling approach is described in **Section 2;**
- the model performance is assessed in **Section 3**;
- descriptions of the installation activities simulated by the model are provided in **Section 4**;
- the results of the numerical modelling are provided in **Section 5**; and
- a summary of the key findings from the study are presented in **Section 6**.

The following conventions are adopted throughout, unless otherwise stated:

- locations are given in ETRS89 UTM31N;
- depths are provided relative to Mean Sea Level (MSL);
- current directions are quoted as directions to;
- wave and wind directions are quoted as directions from;
- time is quoted relative to Universal Time Coordinated (UTC); and
- volumes are in-situ cubic metres.

# 2 Modelling Approach

The numerical modelling approach adopted in this study is described in the following sections.

## 2.1 Software

A numerical model extending across the Study Area has been configured in the MIKE software suite, which is developed by the Danish Hydraulics Institute (DHI).

The MIKE suite is internationally recognised state of the art software which has previously been adopted in the UK and internationally for similar assessments. The MIKE suite includes modules which allow the necessary processes relevant to the dispersion of fine sediment. In particular, the following modules were applied in this study:

- Hydrodynamic (HD) module: this simulates water level variations and flows in response to a variety of forcing functions (including tide and wind); and
- Particle Tracking (PT) module: this simulates the transport of particulates driven by the flows from the HD module. The PT module includes the key processes (moving source terms, settling, advection and dispersion) required for simulating the dispersion of fine sediment as required by this study.

The applied modules adopt a flexible mesh (FM) which allows the spatial resolution of the model mesh to be varied across the model domain. This enables suitable model resolutions to be adopted throughout, ensuring the model accuracy and efficiency can be balanced. For example, areas of interest (i.e. the Study Area) and areas with complex topographic and bathymetric features can have a higher mesh resolution while a lower mesh resolution can be adopted away from these areas (and particular in deeper waters) to ensure efficient model run times.

## 2.2 Model Mesh

The LionLink model builds upon an established and validated MIKE FM HD model covering the Southern North Sea and English Channel (SNSEC) (PCS, 2025). For use in this Project the SNSEC model mesh was extended to include the full LionLink Study Area and the resolution of mesh was increased along the proposed offshore HVDC Submarine Cable Corridor and along the adjacent coastline where a number of notable bathymetric features exist.

The resulting LionLink HD model extends across the English Channel and the North Sea. The Southern boundary extends between Plymouth on the English coast and Roscoff on the French coast and the Northern boundary extending between Peterhead on the Scottish coast to Ferring on the Dutch coast (Figure 2). The model is built in the ETRS89 / UTM zone 31N projection (EPSG 25831).

In general, the model mesh resolution is as follows:

- 100 m mesh cell arc lengths in shallow coastal regions around Lowestoft and Sizewell, along the inshore ~50km of the Study Area and areas of more complex morphology;
- 1,800 m mesh cell arc lengths along other coastal regions and the offshore ~130 km of the Study Area; and
- 5,000 m mesh cell arc lengths outside of the Study Area and in areas away from the coast.

The model mesh is shown across the full model extent in Figure 2. The mesh is also shown along the proposed offshore HVDC Submarine Cable Corridor to show the model resolution in more detail in Figure 3. The model mesh comprises of more than 370,000 elements.

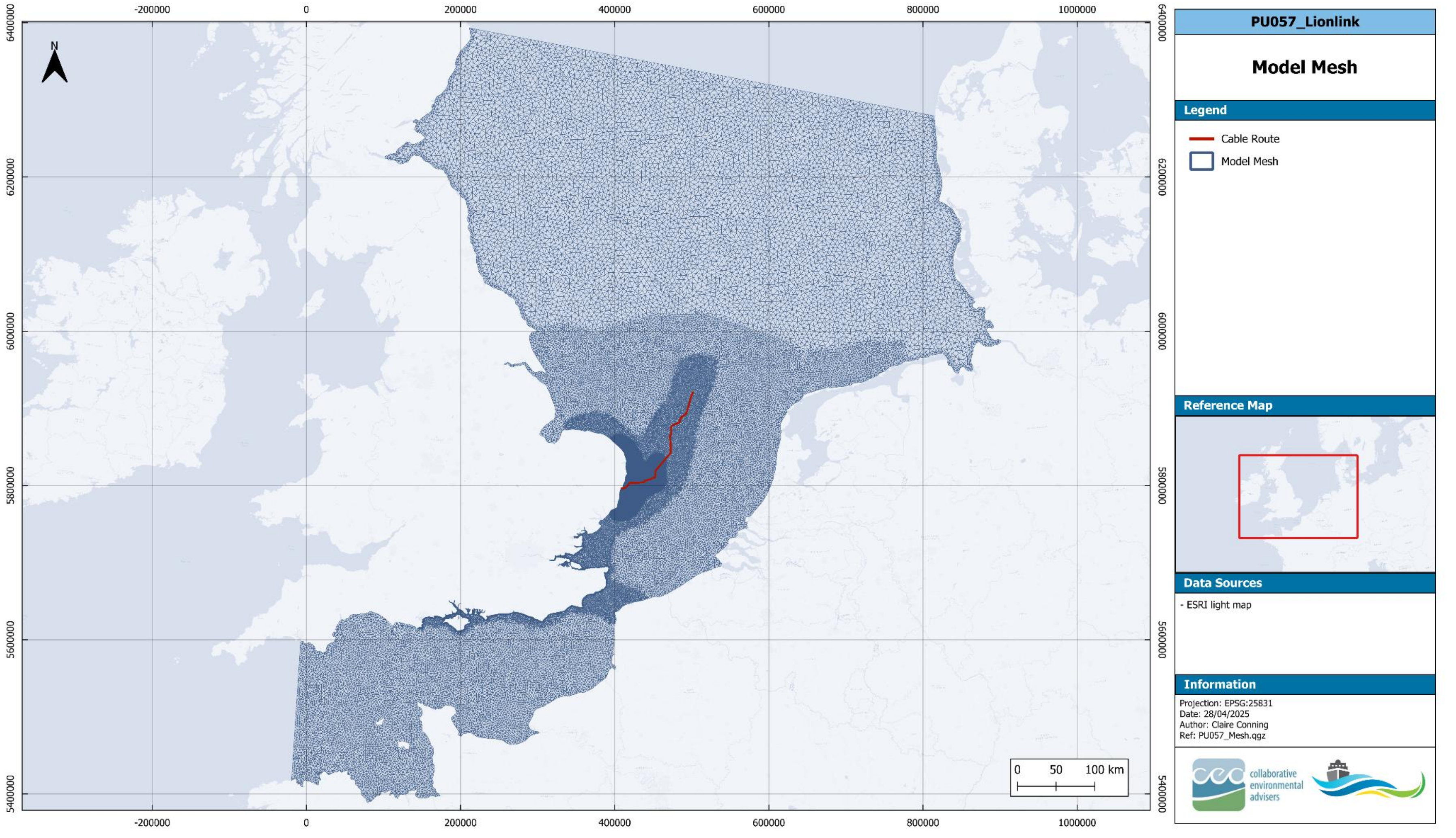


**Figure 2. Model mesh overview.**

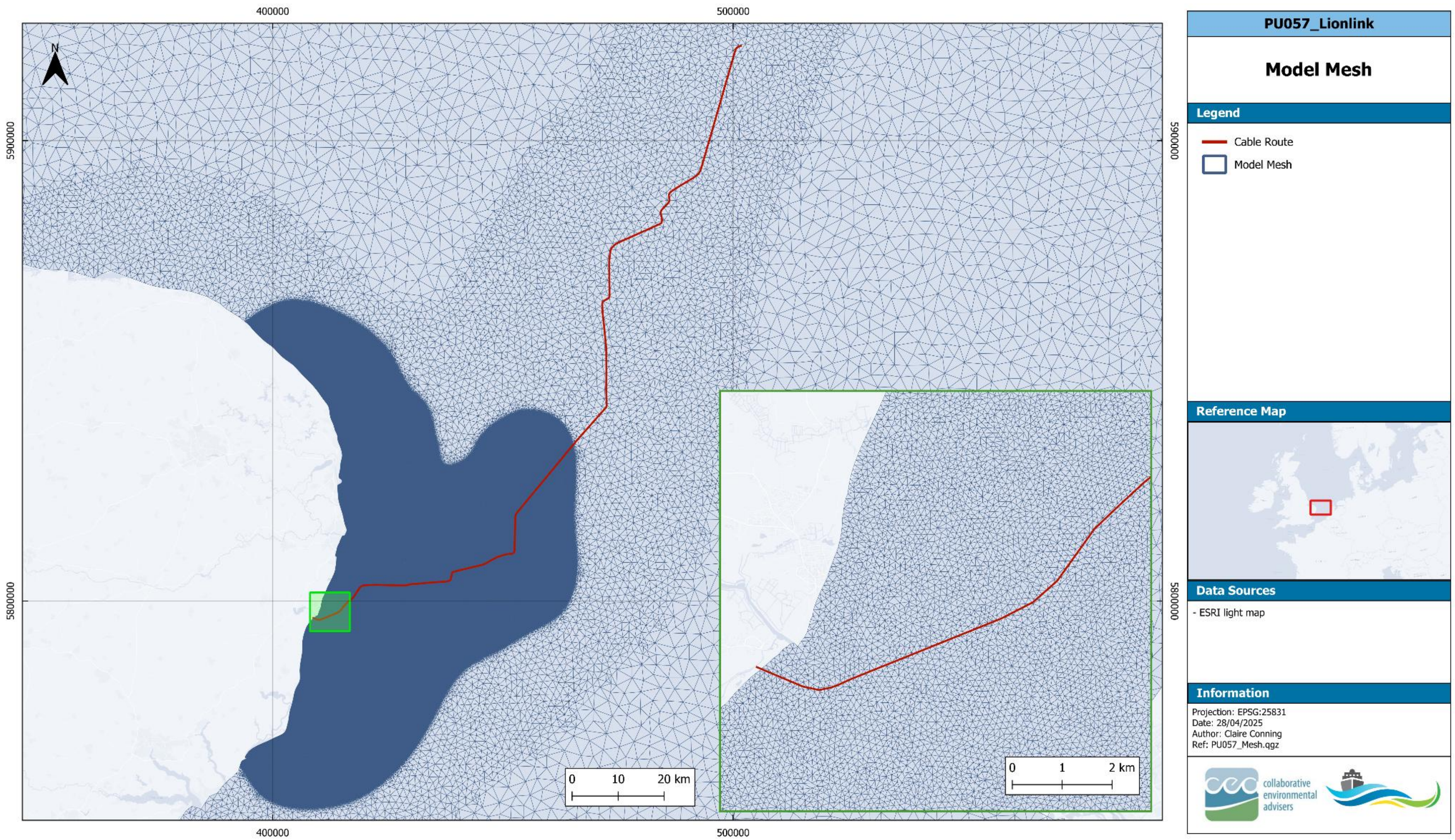


**Figure 3. Inshore region model mesh.**

## 2.3 Model Boundaries

The offshore boundaries are driven by time series of water levels which were derived from the Finite Element Solution (FES) global tide model 2012 (Carrère, 2012). To capture tidal variations along the offshore boundaries, the north boundary is split into 115 points and the west boundary is split into 55 points (equivalent to 1 point approximately every 5 km).

## 2.4 Bathymetry

The bathymetry is comprised of:

- project specific bathymetry – Survey data was collected along the proposed offshore HVDC Submarine Cable Corridor at 0.5 m resolution;
- survey data from the United Kingdom Hydrographic Office (UKHO) Admiralty Inspire portal. This includes multibeam and singlebeam data from surveys collected within the Study Area over the period 1982 to 2024; and
- European Marine Observation and Data Network (EMODnet) Digital Terrain Model (DTM), 2020 which has a 1/15th arc minute resolution (approximately 60 m by 115 m).

The coverage of the various datasets is shown in Figure 4.

All data were projected to a common projection (ETRS89 / UTM31N) and vertically corrected to a common datum (MSL using the Vertical Offshore Reference Frame (VORF) high resolution surface model) before combining. Preference was given to the project specific bathymetry and then UKHO surveys (with preference given to the most recent surveys) and with the EMODnet DTM used to fill any gaps.

The resulting bathymetry is shown in Figure 5 and Figure 6.

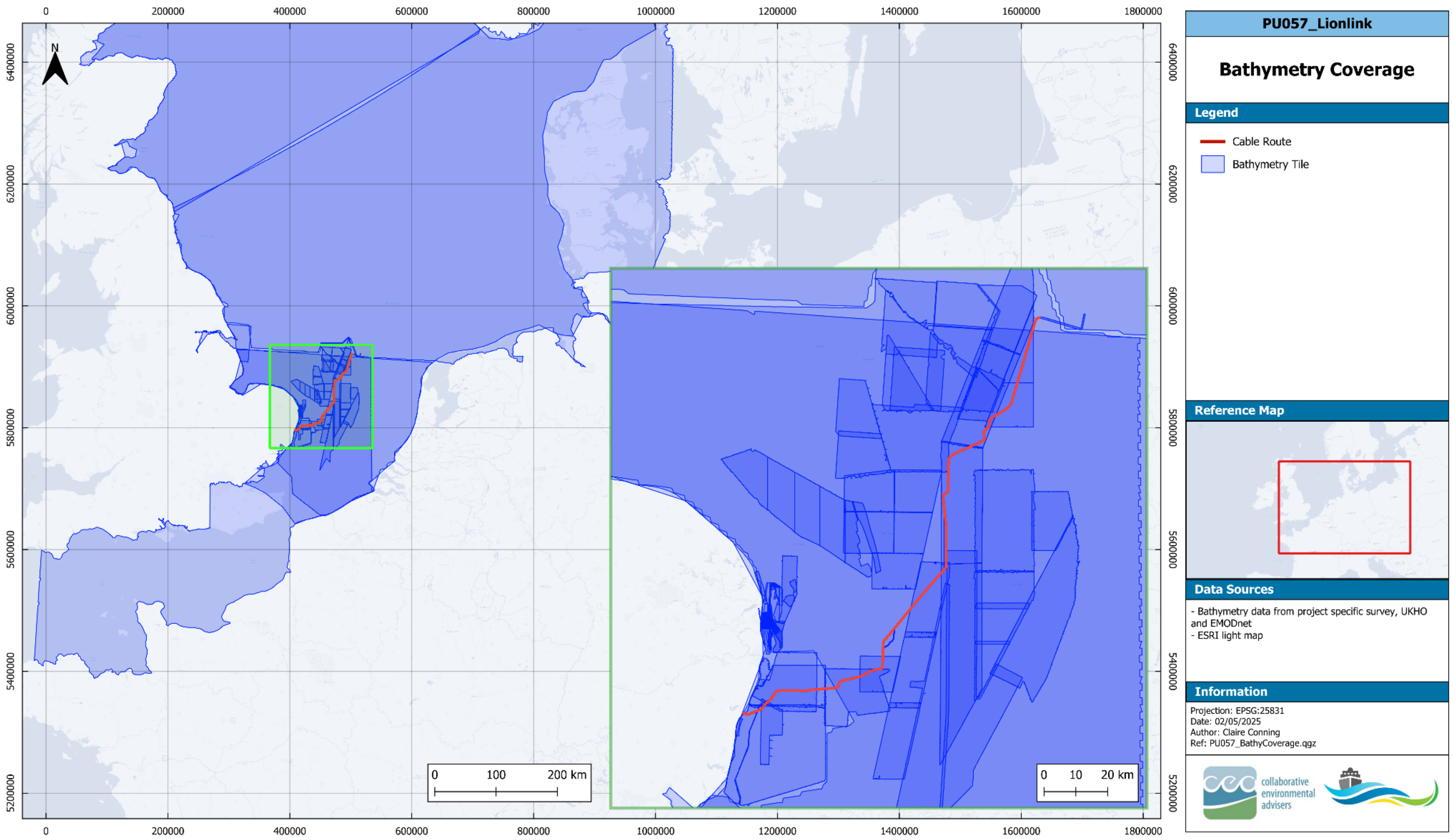


**Figure 4.** **Bathymetry coverage.**

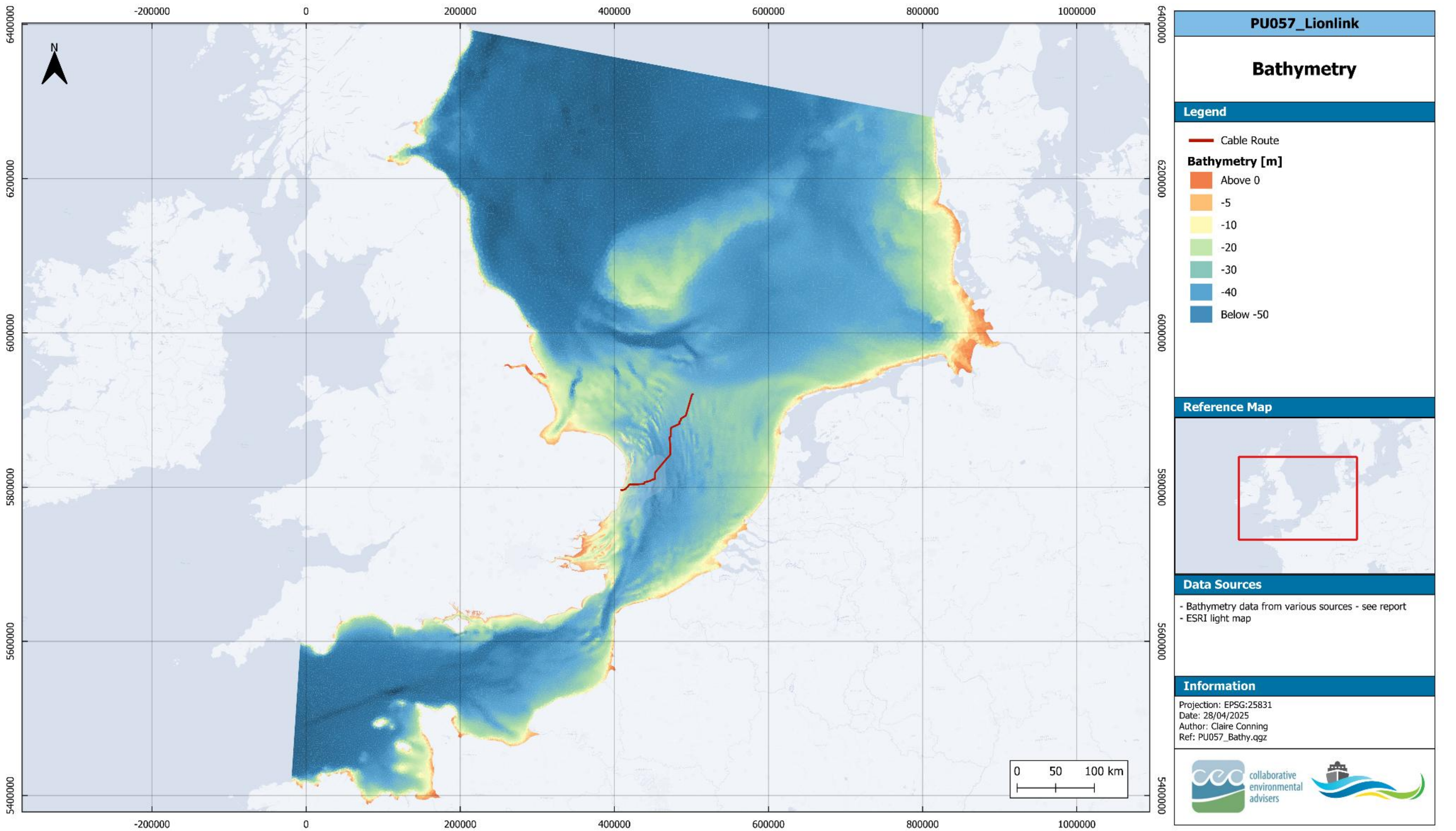


Figure 5. Bathymetry overview.

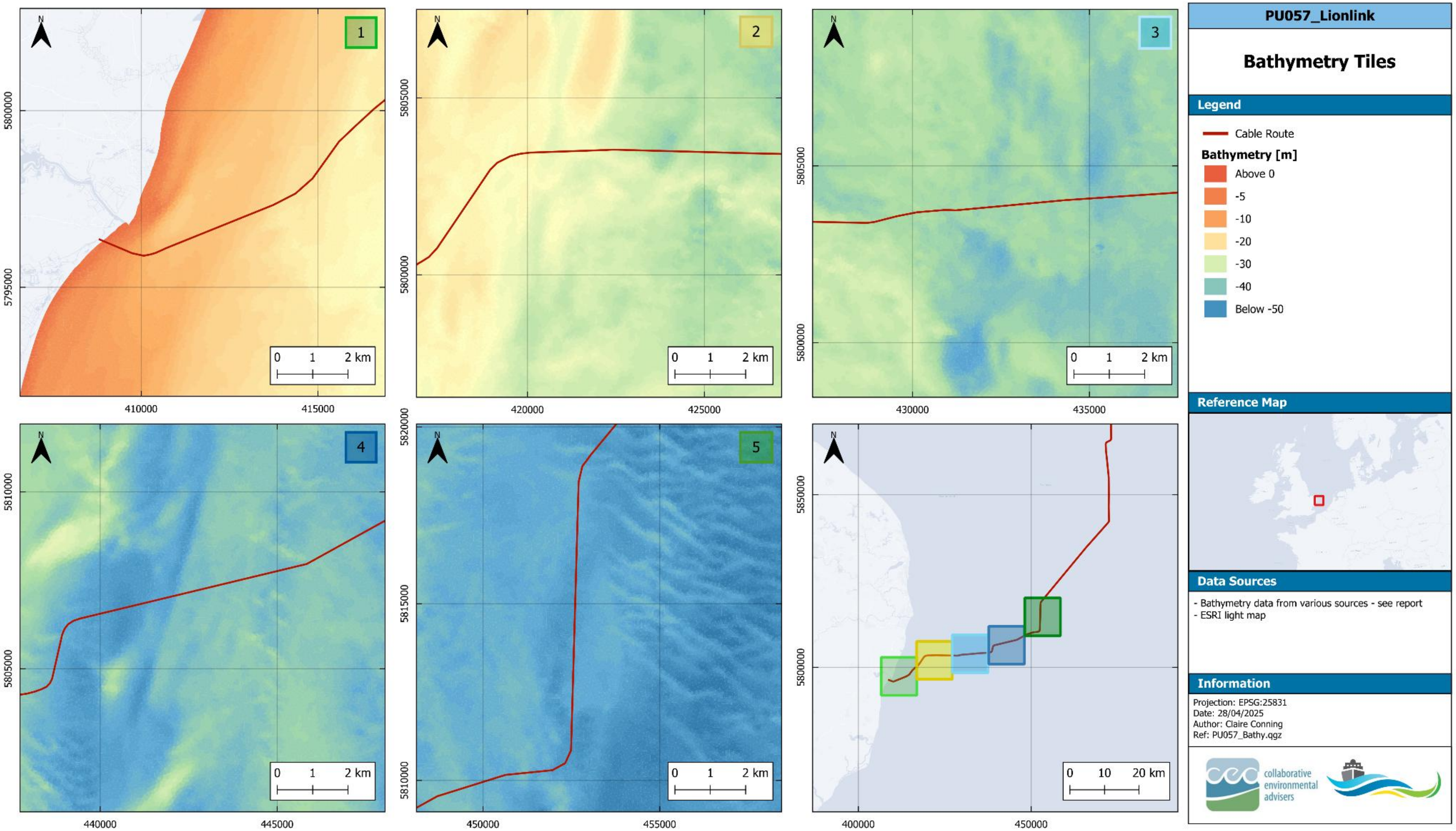


**Figure 6. Inshore model bathymetry.**

# 3 Model Calibration

Model calibration is the process of specifying model parameters so that the model reproduces observed data to a suitable level of accuracy. The key parameters for consideration in any model calibration process are the forcing conditions (which can include the open sea boundaries, wind conditions and freshwater flows, although only open sea boundaries are included in this model), bed roughness and model grid resolution. A number of sensitivity tests were undertaken as part of the calibration process to best define all model parameters.

Calibration is an essential stage in the development of robust numerical modelling tools. However, there is currently no universal agreement on criteria for assessing coastal and estuarine numerical model calibration, partly because the procedure is both model/location and context dependent (Pye et al., 2017). A number of studies have proposed calibration criteria including FWR (1993); Bartlett (1998); ABPmer (2013); and Williams and Esteves (2017), while guidance provided in Pye et al., (2017) referred to criteria presented in ABPmer (2013). The criteria do not significantly vary between sources and all authors acknowledge that their prescribed standards provide a good basis for assessing model performance, but experience has shown that sometimes they can be too prescriptive. Further they all agree on the need for visual checks to also be undertaken and note that under certain conditions, models can meet statistical calibration standards but appear to perform poorly. Conversely, seemingly accurate models (based on a visual assessment) can fall short of the guidelines. Consequently, a combination of both statistical calibration standards and visual checks should be used to ensure that the model can suitably replicate the local hydrodynamic regime.

Validation is the process of testing the model performance against separate data and conditions than considered during model calibration. The validation is carried out with no further adjustment of model parameters and is an important process for providing additional confidence in the model setup.

## 3.1 Calibration Metrics

For the present study, metrics and standards from Williams and Esteves (2017) relating to water levels and flows have been adopted for assessing the model performance as these are considered to provide a comprehensive summary. The metrics and standards are detailed in the following subsections.

### 3.1.1 Water Levels

In terms of the water levels, the following metrics have been considered:

- modelled water levels (WL) should be within ±0.1 m in absolute terms of the observed water levels, or 10% of the spring range and 15% of the neap range in relative terms. Level differences are calculated at the time of high water and low water to ensure that the model captures the tidal range. The calibration guideline standard is considered to be met if it falls within either the absolute or relative standard;
- root mean square (RMS) surface elevation difference to be < 0.2 m; and
- mean phase difference to be within 15 minutes in coastal locations. Phase differences are calculated at HW, LW and throughout the time series.

### 3.1.2 Flows

In terms of the flow speeds, the following metrics have been considered:

- differences should be less than 0.10 m/s in absolute terms, or 10 to 20% in relative terms, these are calculated at the time of peak flood (PF) and peak ebb (PE). This ensures that models capture the correct residual flow (since if flood and ebb are not separated a model could consistently over predict the flood and underpredict the ebb or vice-versa so that the differences cancel each other out). The calibration guideline standard is considered to be met if it falls within either the absolute or relative standard;

- directions at the time of PF and PE should be within 10 degrees; and
- the RMS of flow speed difference should be within 0.2 m/s.

## 3.2 Calibration Data

This study has drawn on open source data available online for model calibration. Water level data are available at three sites in the area of interest with high quality data obtained from National Tide and Sea Level Facility (NTSLF) class ‘A’ tide gauges, as detailed in Table 1 and shown in Figure 7.

Data for current speeds and directions are available from tidal diamonds located along the proposed offshore HVDC Submarine Cable Corridor. This data was obtained from Admiralty Total Tide (ATT), which provides predicted tidal information based on the UK Hydrographic Office's tidal database. The locations of water level and flows calibration data are summarised in Table 1 and Table 2, respectively and shown in Figure 7.

**Table 1. NTSLF calibration water level data.**

| Name | Start date | End date | Easting | Northing |
|---|---|---|---|---|
| Whitby | 1980 | Present | 265934 | 6044063 |
| Cromer | 1988 | Present | 385854 | 5866319 |
| Lowestoft | 1964 | Present | 415152 | 5814382 |

**Table 2. ATT calibration flow data.**

| Name | Easting | Northing |
|---|---|---|
| TD_SN014Q | 406954 | 5785510 |
| TD_SN014P | 411237 | 5795630 |
| TD_SN014D | 418992 | 5790305 |
| TD_SN014E | 419609 | 5807168 |
| TD_SN014T | 420621 | 5813642 |
| TD_SN014H | 431624 | 5798643 |
| TD_SN014G | 431464 | 5811624 |
| TD_SN014S | 443387 | 5804242 |
| TD_SN014O | 449185 | 5816415 |
| TD_SN015AA | 483301 | 5865847 |
| TD_SN015X | 492055 | 5876949 |
| TD_SN015AD | 477594 | 5890901 |
| TD_SN015AI | 496543 | 5901974 |

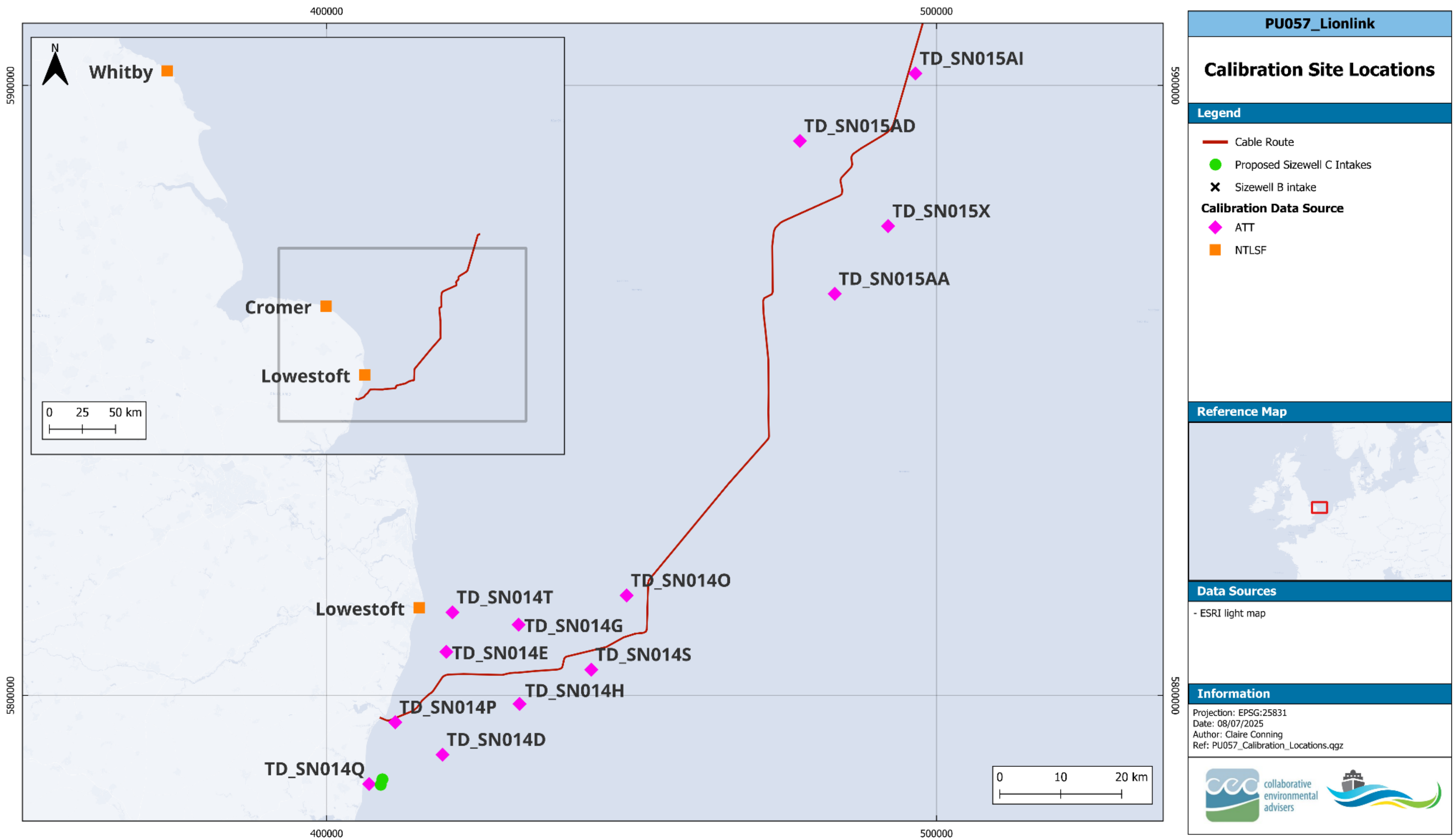


Figure 7. Calibration data locations.

### 3.2.1 Data Limitations

Ahead of comparing modelled parameters against measured or re-predicted data, it is important to consider any limitations with the calibration data, as it is not desirable to force a model to simulate conditions which are not representative. As noted in Section 3.2.1, the water level data from NTSLF are considered to be high quality.

The provenance of ATT data used for flow predictions is not known but can be subject to a number of shortcomings including:

- being historic in nature from a time when instrument accuracy may have been limited. This is likely to be particularly problematic in areas of faster flows, with instruments from fixed moorings (and even more so from boat surveys) being unlikely to remain on station, inducing artificial flows;
- being representative of surface flows, rather than depth averaged flows. Surface flows can be strongly influenced by non tidal forcing and the rotation of surface flows at slack water periods is often opposed to the rotation of the depth average flow; and
- being collected over a short duration and then scaled to represent flows for other tidal periods without detailed harmonic analysis to account for either the full influence of the tide and/or the removal of meteorological influences.

## 3.3 Hydrodynamic Model Calibration

The model has been calibrated over a 15 day spring-neap period in January 2023.

During the calibration process, sensitivity testing to the model boundary conditions, mesh resolution and bed roughness was undertaken. Parameters were adapted in an iterative manner to improve the agreement in modelled and observed timings and magnitudes of peaks and ranges in water levels and flows.

A roughness map based on water depths (using lower Manning Numbers, representative of a rougher bed in shallower waters and higher Manning Numbers, representative of a smoother bed in deeper waters) was found to provide the best agreement between modelled and predicted flows within the Study Area and the calibration results presented are based on the model setup with that spatially variable bed roughness.

### 3.3.1 Calibration Approach

For the HD model, the statistics defined in Section 3.1 were calculated and assessed against the quoted guideline standards. It is reiterated here that the data available for model calibration is subject to its own limitations and these were taken into consideration during the calibration process.

### 3.3.2 Water Levels

Plots of modelled water levels against the NTSLF water levels are shown in Figure 8 to Figure 10. The plots show that the model replicates the shape, diurnal variability, phasing and amplitude of the tidal wave across the three sites, although there is a slight phase difference at Whitby with the model tidal curve early relative to the measured tidal curve. The difference in phase reduces into the model domain so that the model phasing at Lowestoft, which is located in the Study Area is in good agreement with the measured water levels.

A statistical comparison between the modelled and measured water level data are provided in Table 3. The plots and statistics show that the model meets the calibration guidelines for water levels presented in Section 3.1 and that in particular, the model replicates the measured water levels at Lowestoft to a very good degree of accuracy.

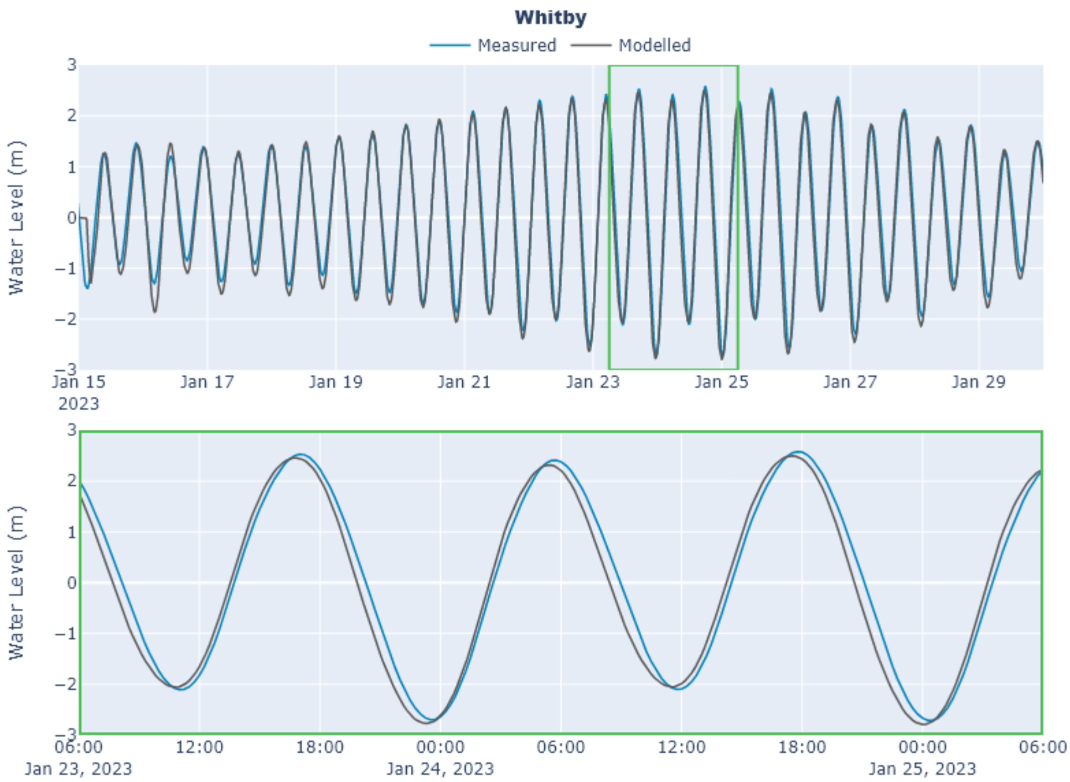


**Figure 8. Modelled and measured water levels at Whitby (NTSLF).**

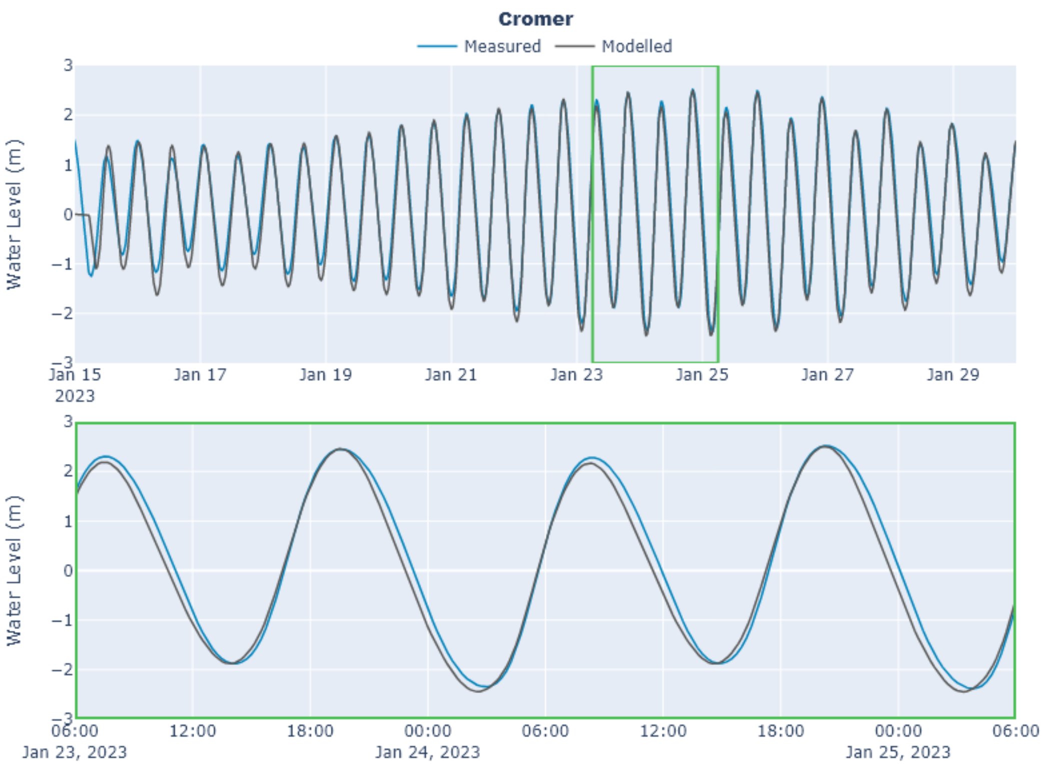


**Figure 9. Modelled and measured water levels at Cromer (NTSLF).**

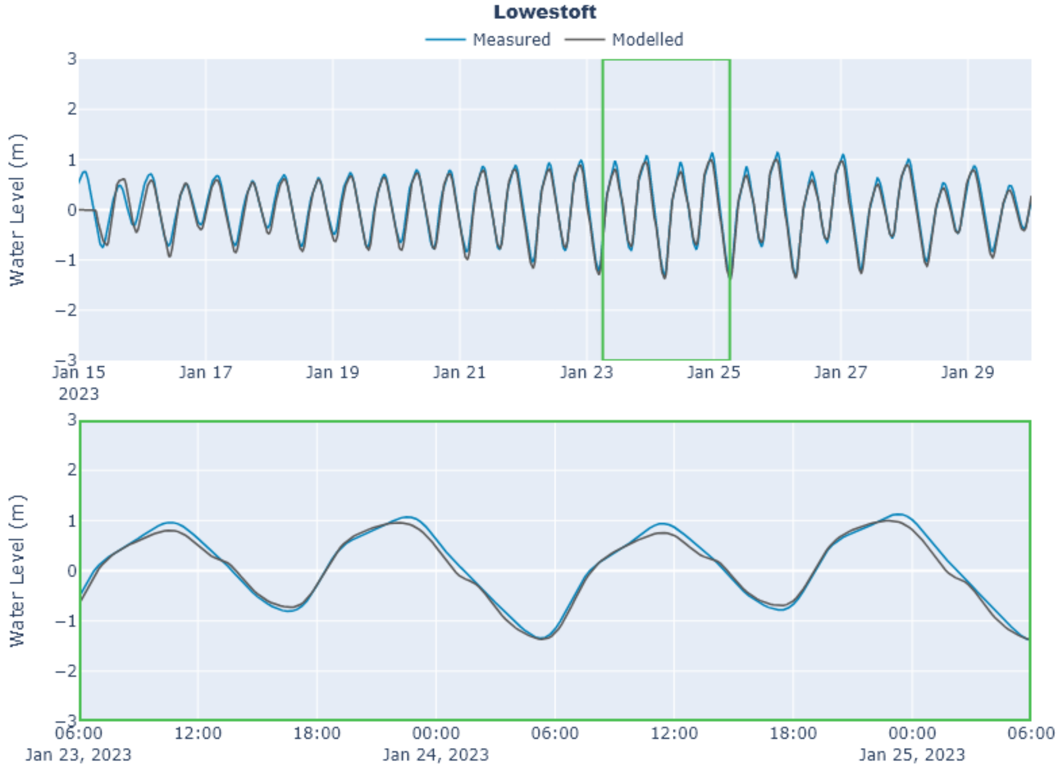


**Figure 10. Modelled and measured water levels at Lowestoft (NTSLF).**

**Table 3. Statistical comparison of modelled and predicted water levels for model calibration.**

| Site | WL difference (m) | | | WL difference (%) | | Phase difference (minutes) | | |
|---|---|---|---|---|---|---|---|---|
| | HW | LW | RMS | HW | LW | HW | LW | All |
| Whitby | 0.08 | -0.05 | 0.16 | 2 | -1 | -9 | -9 | -15 |
| Cromer | 0.15 | -0.03 | 0.16 | 4 | -1 | 3 | -6 | -7 |
| Lowestoft | -0.03 | 0 | 0.09 | -2 | 0 | -5 | 11 | -1 |

*Notes: Differences are modelled minus predicted/measured so that positive values indicate that the model value is high/late relative to predicted/measured.*

## 3.3.3 Flows

Plots of modelled flow speeds and directions against the ATT data are shown in Figure 11 to Figure 23. Visual comparisons of the modelled and measured flows indicate that the model generally replicates the areas of faster flows, the timing and magnitude of peak flows, the timing of slack periods and the flow directions to a good degree of accuracy. A statistical comparison of the modelled flows against the ATT data is provided in Table 4. The RMS difference is within the guideline standard at all except two sites (where it is 0.01 and 0.02 m/s outside). However, there are some notable visual and statistical differences between the modelled flows and ATT flows, including:

- at TD_SN014P (Figure 12) the model is early relative to the measured flow, particularly on spring tides. The statistical comparison shows this difference to be an average of 34 minutes throughout the tide. The phasing difference does not persist throughout the spring-neap cycle, with a good agreement in phasing on the neap tide. Given the known limitations with ATT data and the fact that such a variable phase difference is not apparent at other locations, or within the water level data it is not considered likely that the phasing in the model is incorrect at this location. All other metrics fall within the calibration guideline standards at this site;

- at TS_SN014D (Figure 13) and TD_SN014G (Figure 17) the modelled spring tide flows are faster than the ATT flows. This could be due to a low temporal resolution for the ATT flows (suggested by the blocky nature of the flow curve) and given the better agreement on neap tides, this difference is not believed to be indicative of an over prediction of modelled flows at these locations;
- at TD_SN014T (Figure 15) the modelled flow directions are not well aligned with those from ATT. This site is located in the nearshore area towards the northern boundary of the Study Area where there are a number of notable bank features. Flows may be locally realigned around such features, which can change of time in response to ongoing morphological change;
- at TD_SN014S (Figure 18) the southward modelled flood flow speeds are slower than those from ATT. The flood dominance in ATT flows at this location is much stronger than at other nearby locations (such as TD_SN014O) and it is possible that predicted flows are based on analysis of a period of relatively strong surge or wind driven flow. However, the potential for the model to underpredict the southward flow residual in this region should be considered when assessing the results from any sediment dispersion modelling.
- at TD_SN015AA (Figure 20) and TD_SN015X (Figure 21) the modelled flows tend to be faster than the ATT flows, despite this the RMS difference falls within the guideline standard. The tidal diamonds are located at the offshore end of the proposed offshore HVDC Submarine Cable Corridor, beyond the main area of interest for this study.

**Table 4. Statistical comparison of modelled and predicted flows for model calibration.**

| Site | Speed difference (m/s) | | | Speed difference (%) | | Direction difference (°) | | Phase difference (minutes) |
|---|---|---|---|---|---|---|---|---|
| | PF | PE | RMS | PF | PE | PF | PE | All |
| TD_SN014Q | 0.04 | 0.02 | 0.08 | 7 | 3 | -2 | -1 | 14 |
| TD_SN014P | 0.01 | -0.05 | 0.10 | 1 | -5 | -4 | -14 | **-34** |
| TD_SN014D | 0.09 | **0.20** | **0.21** | 7 | **17** | -2 | -2 | -5 |
| TD_SN014E | 0.08 | 0.07 | 0.16 | 6 | 5 | 2 | 1 | 8 |
| TD_SN014T | -0.15 | -0.07 | 0.18 | -9 | -5 | **-25** | **15** | 9 |
| TD_SN014H | -0.08 | -0.12 | 0.16 | -6 | -9 | -3 | -1 | 7 |
| TD_SN014G | **0.23** | **0.23** | **0.22** | **21** | **19** | 5 | 0 | **19** |
| TD_SN014S | **-0.24** | 0.12 | 0.19 | **-15** | 10 | 2 | 0 | -3 |
| TD_SN014O | -0.11 | 0.00 | 0.15 | -8 | 0 | 5 | -2 | -11 |
| TD_SN015AA | **0.25** | **0.13** | 0.19 | **35** | **20** | -2 | **15** | -9 |
| TD_SN015X | **0.16** | 0.08 | 0.15 | **22** | 12 | 10 | 2 | **-51** |
| TD_SN015AD | 0.06 | -0.03 | 0.12 | 7 | -4 | 4 | -6 | -8 |
| TD_SN015AI | 0.05 | 0.02 | 0.14 | 6 | 3 | **28** | 1 | **-41** |

*To Note: Values in **bold** are outside of the guideline standard.*

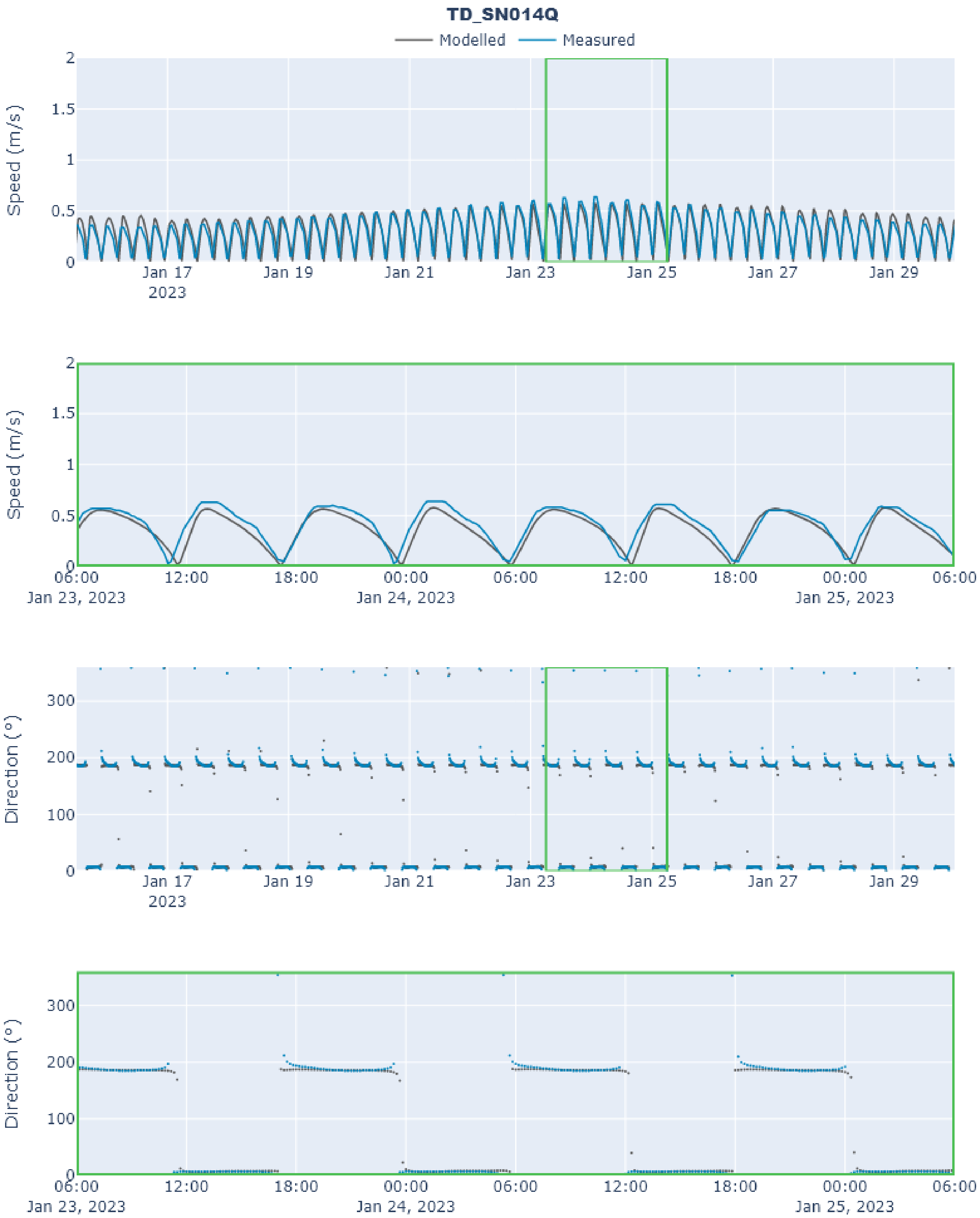


**Figure 11. Modelled and measured flows at TD_SN014Q (ATT).**

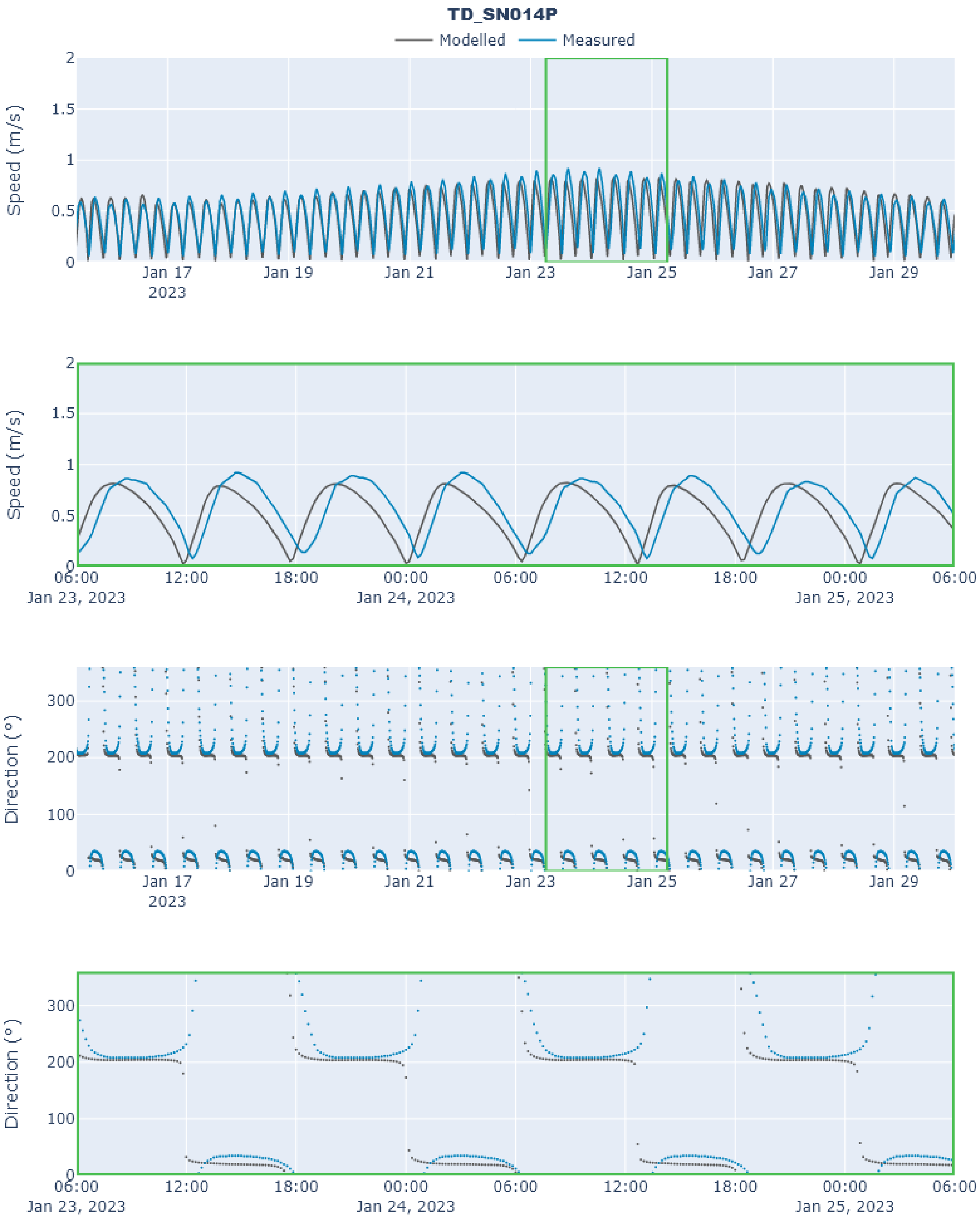


**Figure 12. Modelled and measured flows at TD_SN014P (ATT).**

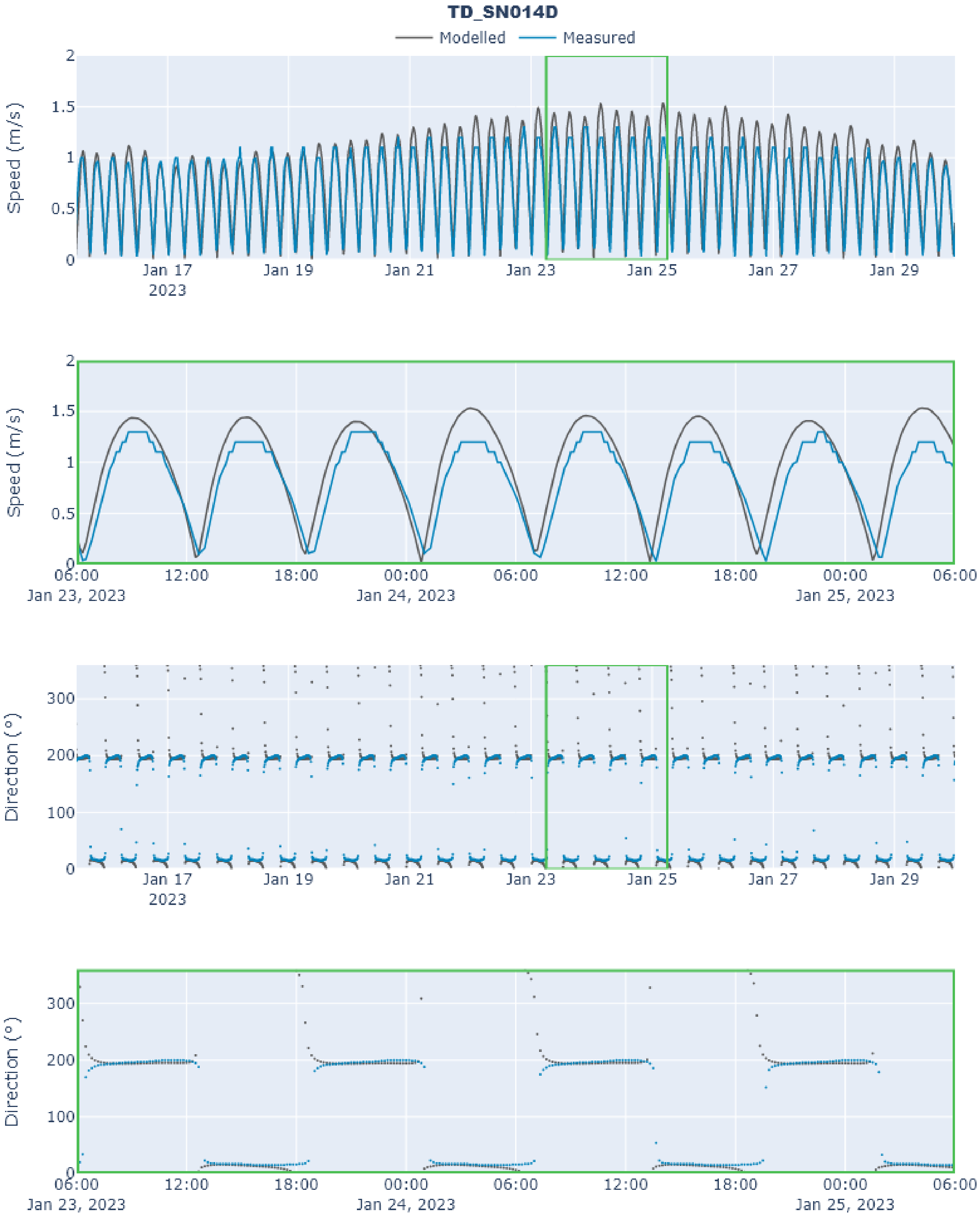


**Figure 13. Modelled and measured flows at TD_SN014D (ATT).**

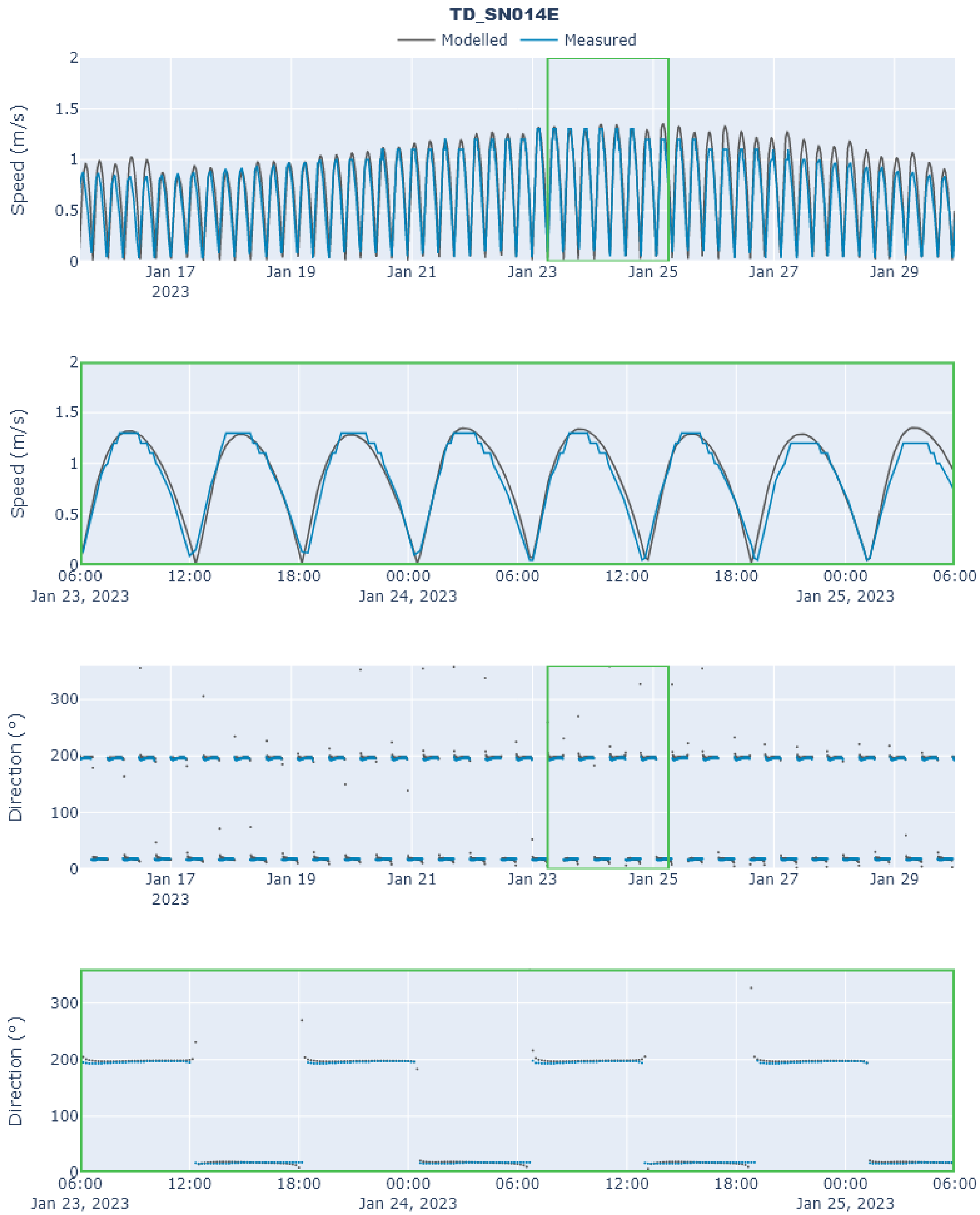


**Figure 14.** **Modelled and measured flows at TD_SN014E (ATT).**

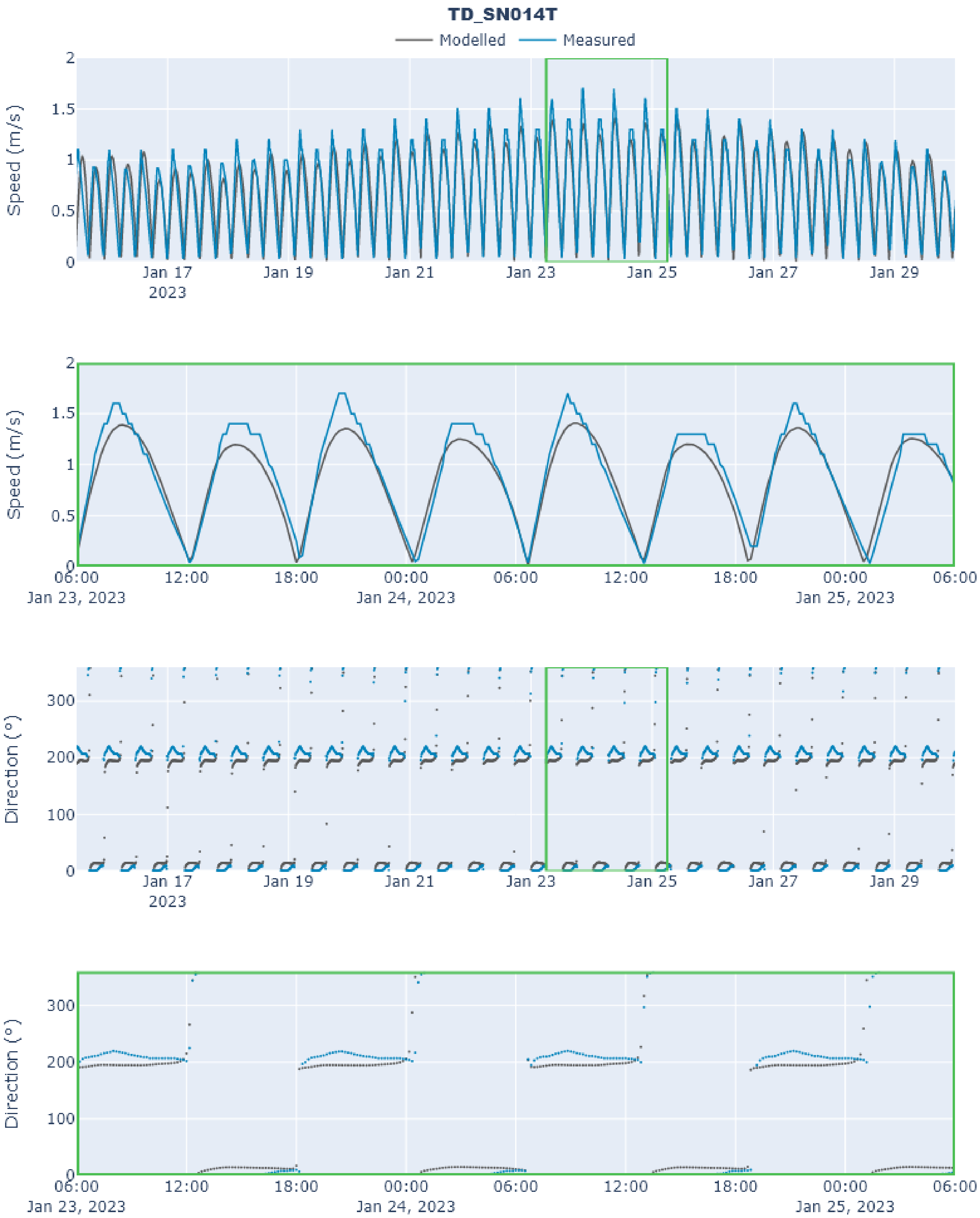


**Figure 15. Modelled and measured flows at TD_SN014T (ATT).**

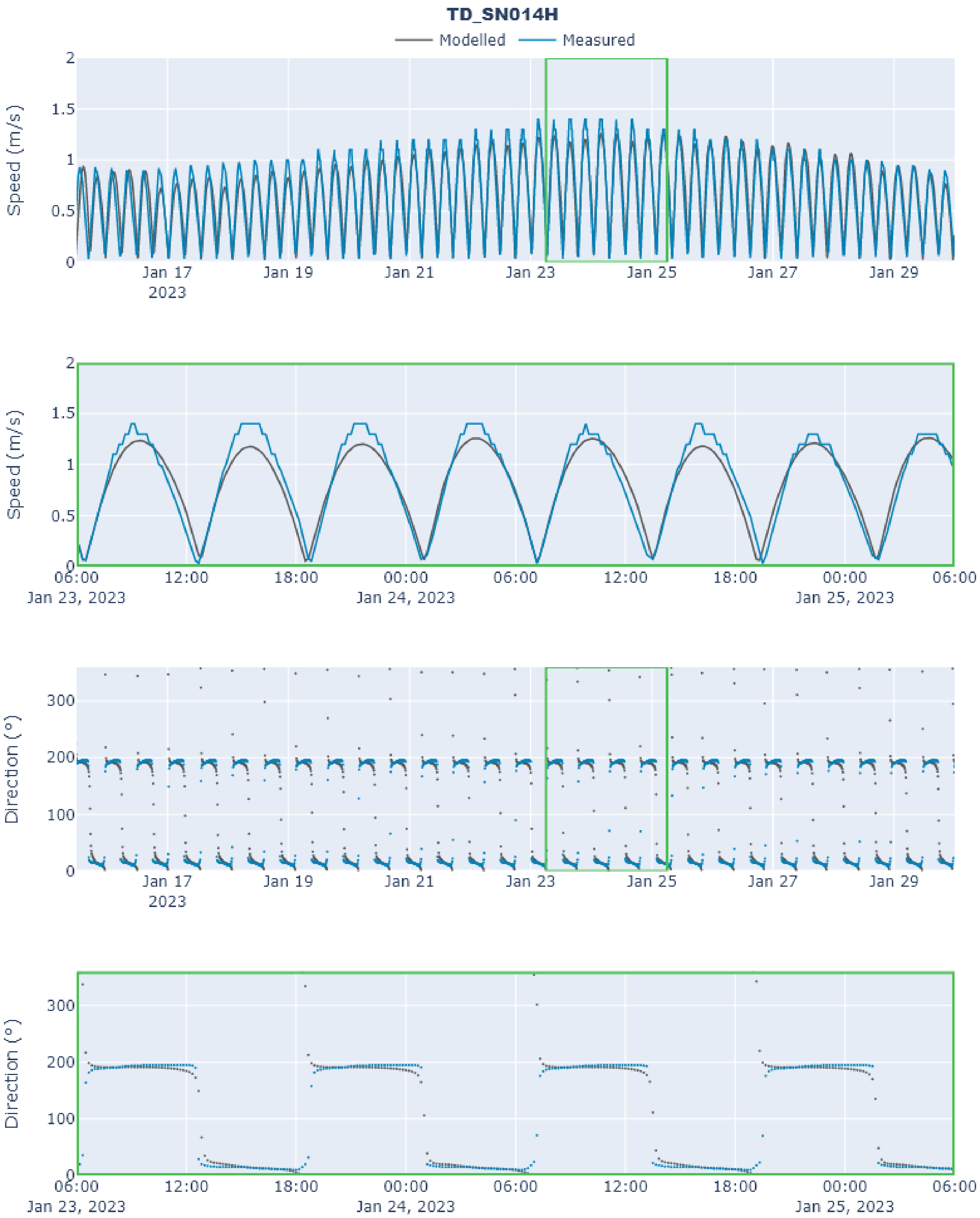


**Figure 16. Modelled and measured flows at TD_SN014H (ATT).**

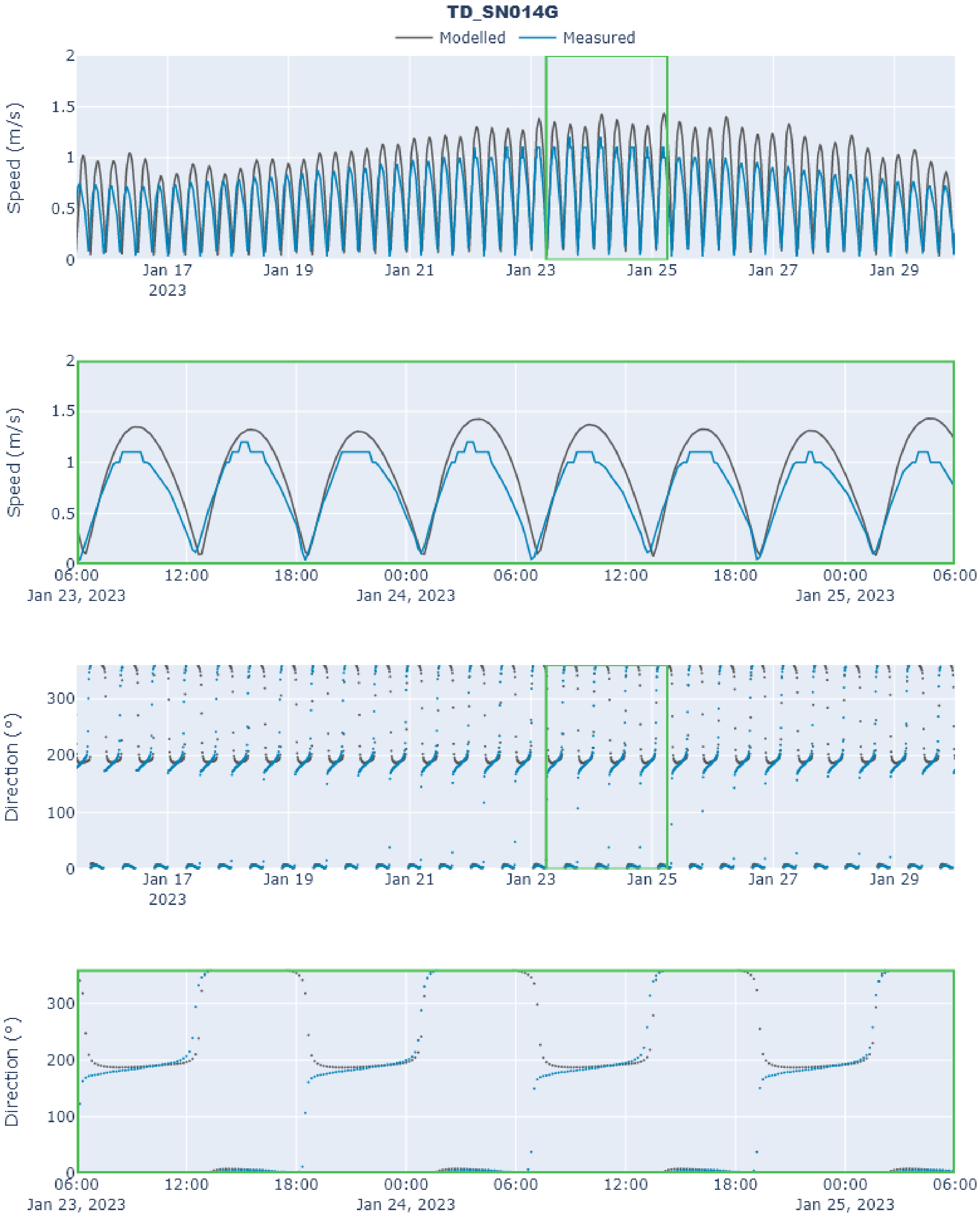


Figure 17. Modelled and measured flows at TD_SN014G (ATT).

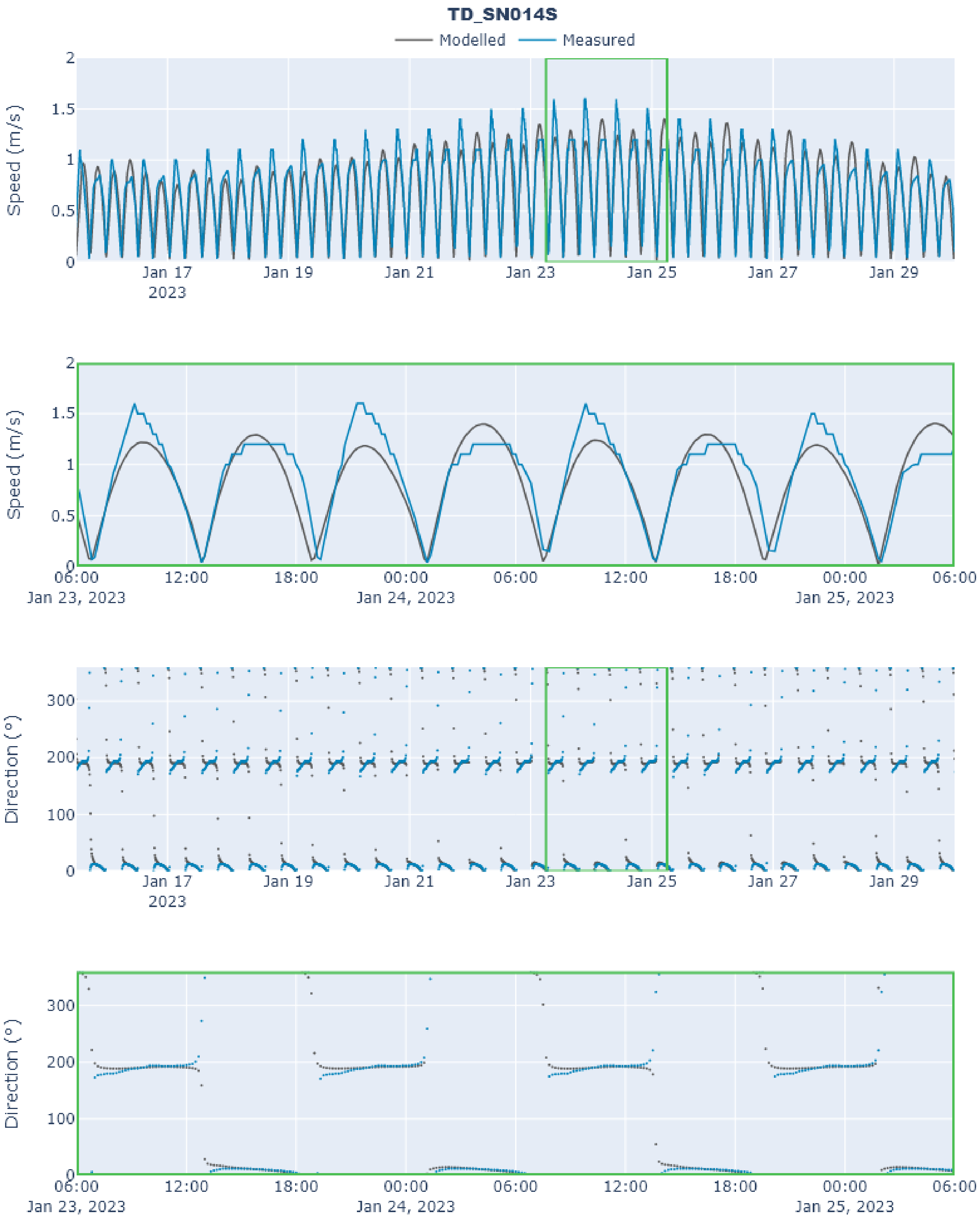


**Figure 18. Modelled and measured flows at TD_SN014S (ATT).**

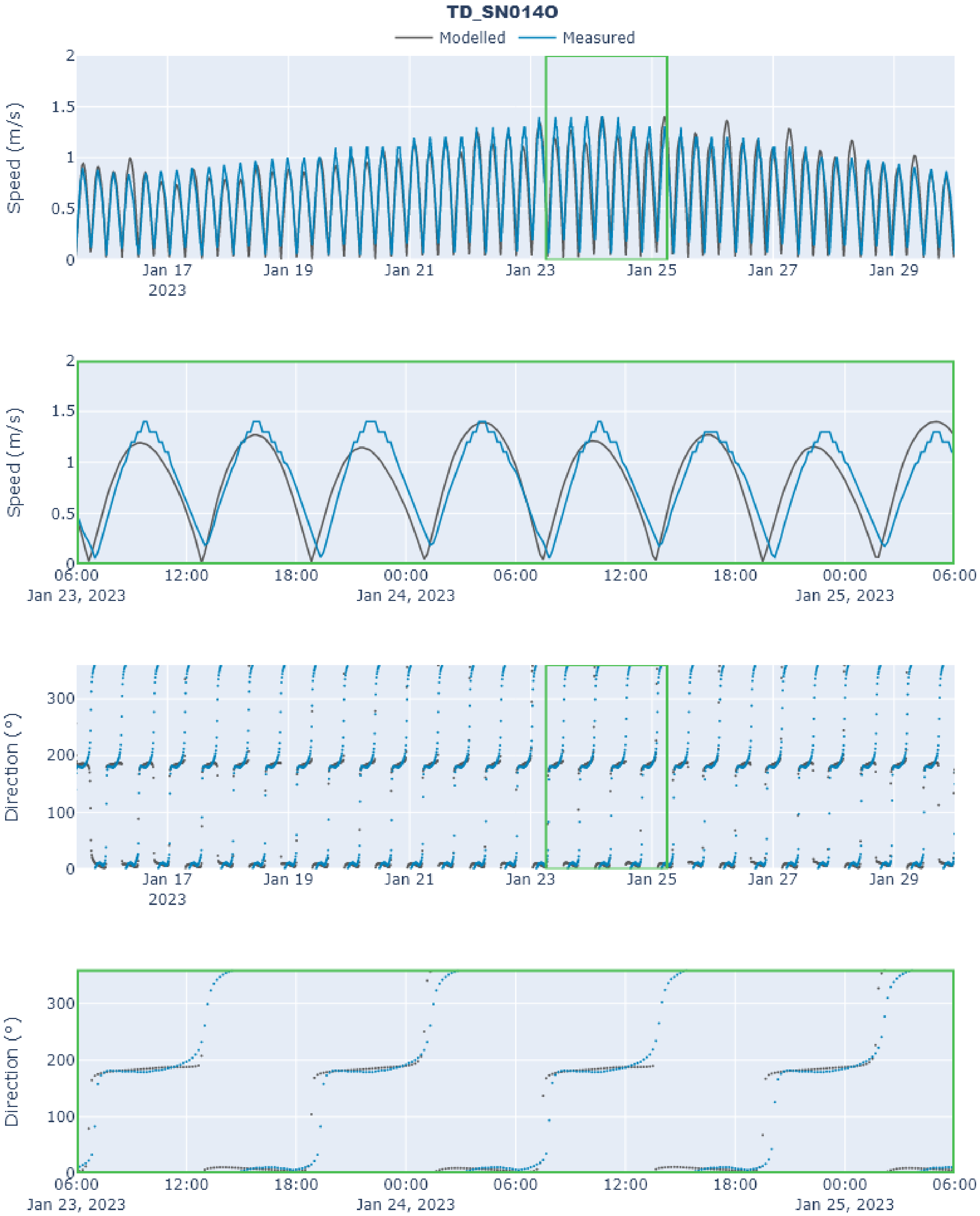


**Figure 19. Modelled and measured flows at TD_SN014O (ATT).**

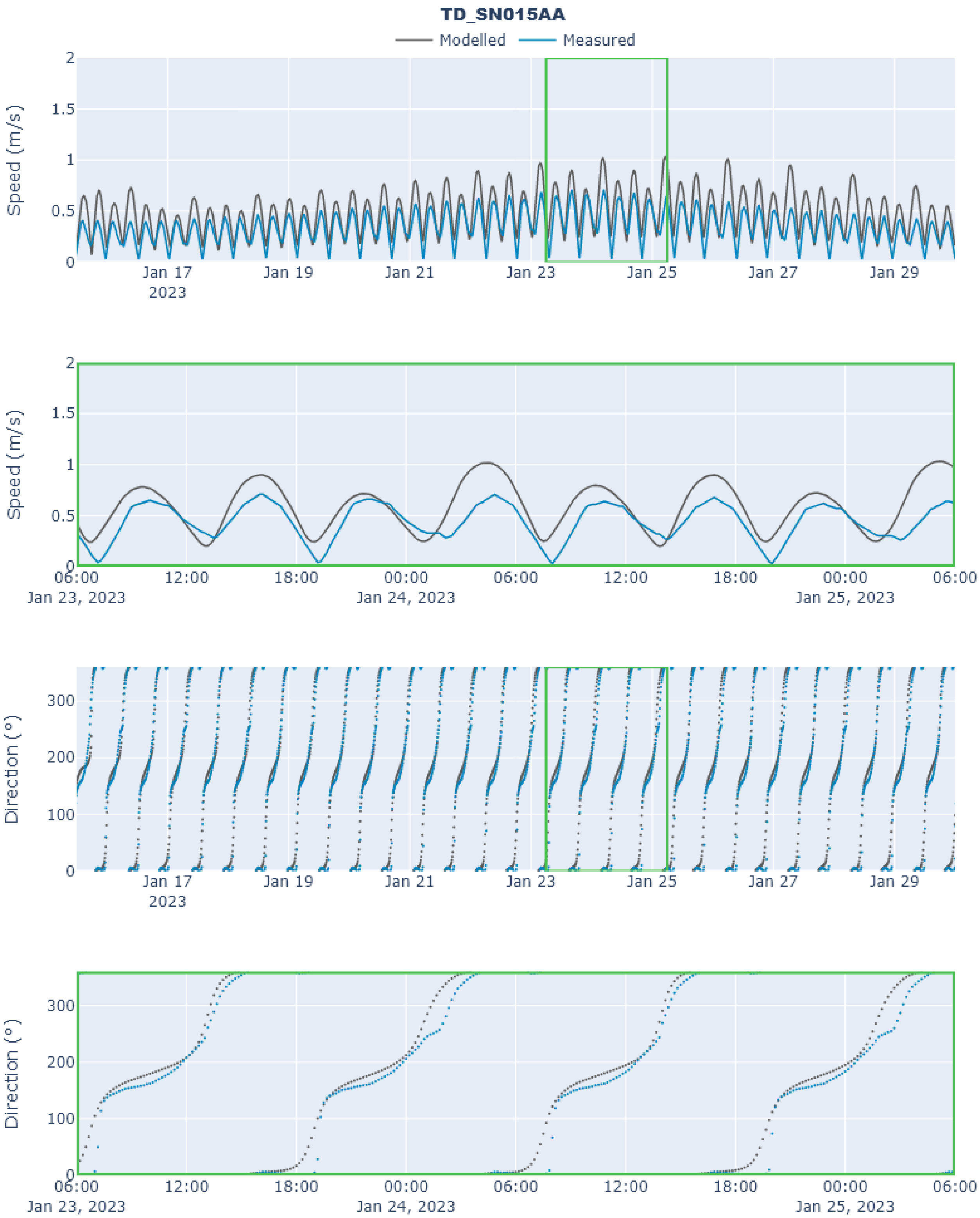


**Figure 20. Modelled and measured flows at TD_SN015AA (ATT).**

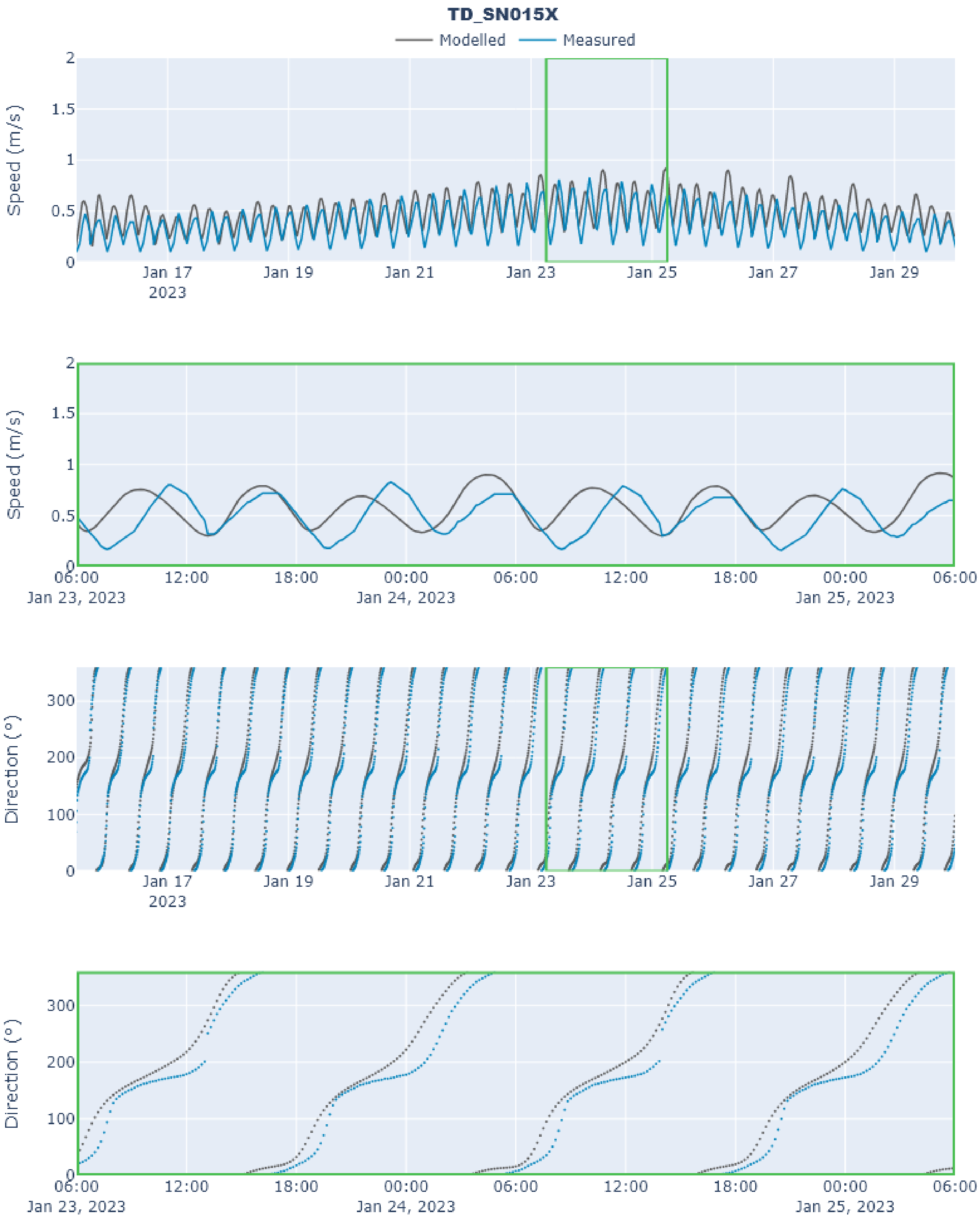


Figure 21. Modelled and measured flows at TD_SN015X (ATT).

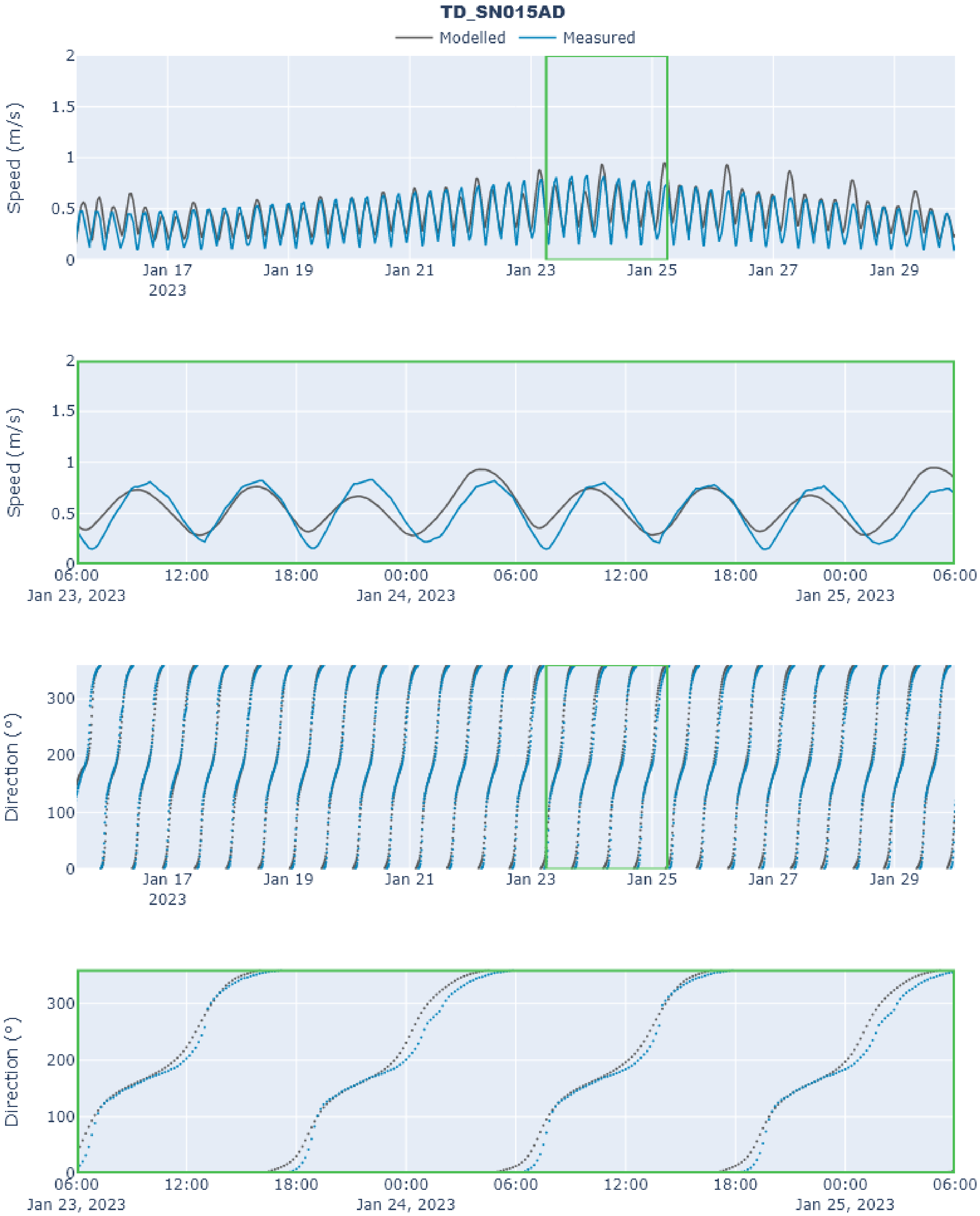


**Figure 22. Modelled and measured flows at TD_SN015AD (ATT).**

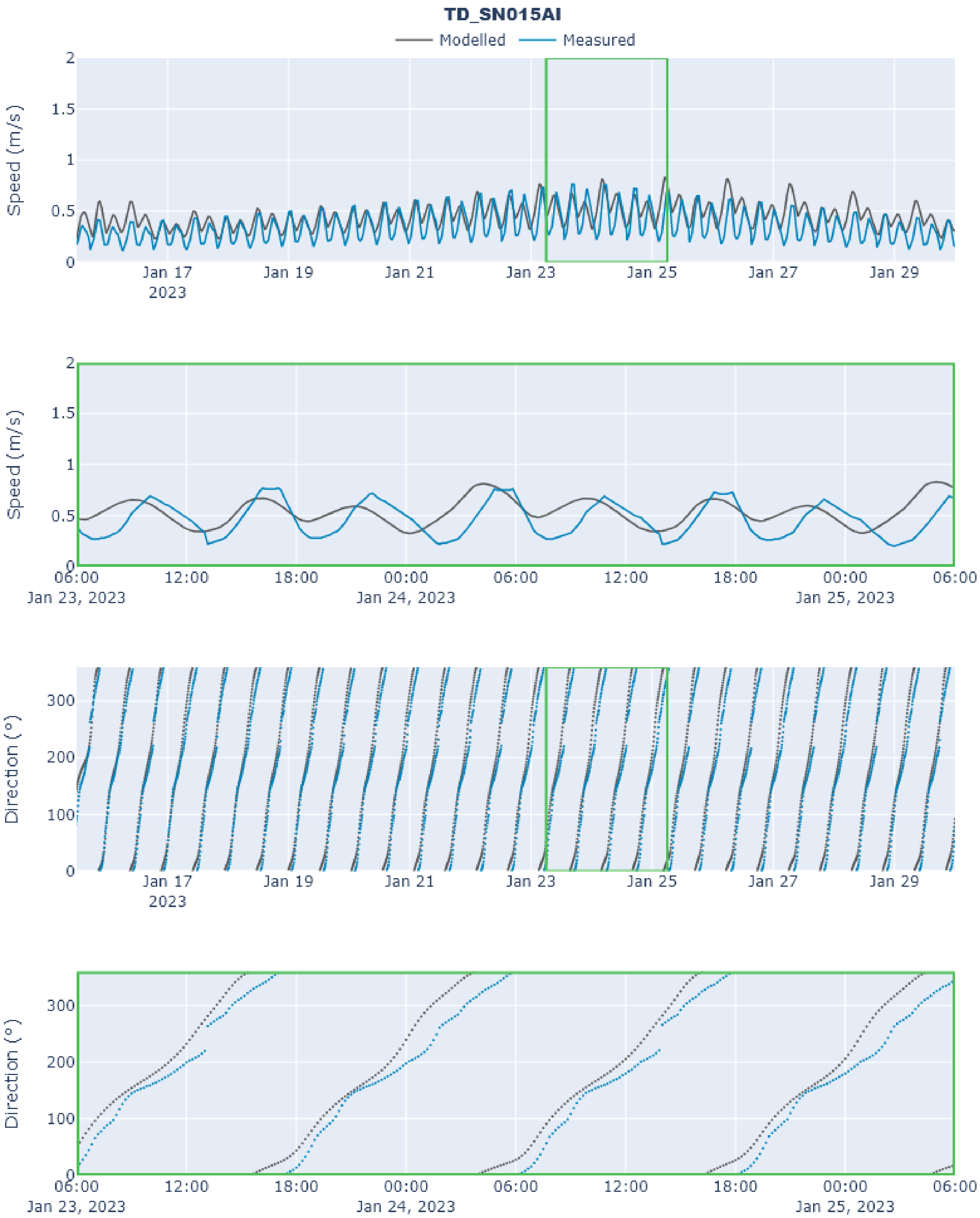


**Figure 23. Modelled and measured flows at TD_SN015AI (ATT).**

## 3.4 Hydrodynamic Model Validation

Historical Mooring data from 19 sites (detailed in Table 5) within the model domain were obtained from the British Oceanographic Data Centre Holdings (BODC) for model validation. The BODC data measurements provide flows at a single depth and are historical in nature, spanning a wide range of dates. The flow measurements were harmonically analysed and the derived constituents were used to predict flows for the model run period to allow comparisons to be made. However, there are shortcomings with the use of the BODC data including:

- in areas of natural ongoing morphological change or in areas of anthropogenic change, the measured flows may not be representative of present-day flow patterns;
- harmonic analyses can introduce a source of error, particularly for data series which are less than 35 days duration; and
- flows measured at a single depth may not be representative of depth average flows, particularly for flows measured close to the bed.

Figure 24 and Figure 25 show scatter envelopes for the 19 BODC sites within the model domain. The plots show the similarity in shape, scale and orientation between the re-predicted BODC and modelled tidal ellipses providing further confidence in the model performance across a wider area beyond the Study Area.

**Table 5. BODC validation flow data.**

| BODC Site | Easting | Northing | Water Depth (m) | Measurement depth (m) |
|---|---|---|---|---|
| b0010307 | 246897 | 6074072 | 53 | 17 |
| b0010448 | 227610 | 6110524 | 57 | 16 |
| b0010528 | 336584 | 5936275 | 21 | 17 |
| b0014216 | 383468 | 5910776 | 23 | 12 |
| b0014308 | 449049 | 5813201 | 44 | 13 |
| b0015293 | 337841 | 5911735 | 17 | 5 |
| b0016604 | 376608 | 6028011 | 42 | 13 |
| b0016929 | 306174 | 6012627 | 54 | 16 |
| b0196216 | 238618 | 6063021 | 26 | 21 |
| b0196253 | 250554 | 6081864 | 65 | 20 |
| b0196277 | 256416 | 6091022 | 74 | 24 |
| b0196290 | 276288 | 6040189 | 52 | 16 |
| b0196333 | 293930 | 6068701 | 68 | 18 |
| b0248577 | 460935 | 5840724 | 49 | 14 |
| b0464752 | 306252 | 5964417 | 17.6 | 16.8 |
| b0591984 | 551849 | 5829686 | 30 | 23 |
| b0592084 | 313669 | 5987018 | 45 | 25 |
| b0593118 | 384255 | 6085122 | 46 | 15 |
| b0593192 | 322645 | 5993316 | 56 | 17 |


**Figure 24. Tidal Ellipses for BODC sites included in model validation.**

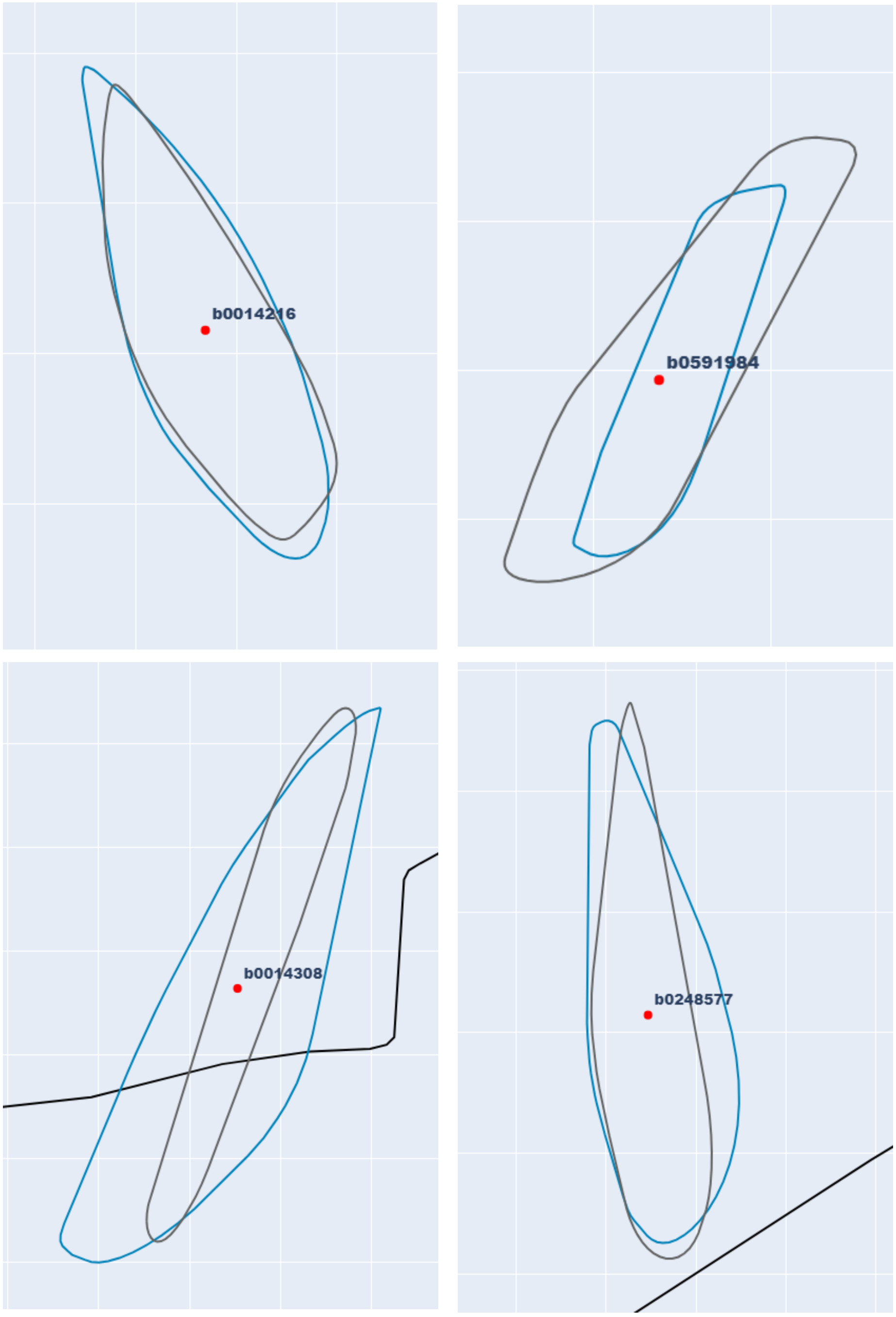


**Figure 25. Example tidal ellipses for various BODC sites (measured data in blue, modelled data in grey).**

# 4 Modelling of Installation Activities

This section brings together the relevant design and environmental characterisation information for the Project and defines the numerical modelling scenarios developed to assess the installation impacts of the Project, relating to fine sediment dispersion.

To address uncertainty in the design parameters and to maintain flexibility, the approach for assessment considers the Maximum Design Scenario (MDS). Details informing the MDS have been drawn from the proposed scheme description presented in Chapter 2 of the Preliminary Environmental Impact Report (PEIR) (NGV, 2025 in prep.).

In lieu of legislative standards for the assessment of impacts to Suspended Sediment Concentration (SSC), the assessment compares the predicted increases in SSC against the typical background SSC.

Data from the Cefas Suspended Sediment Climatology model (Cefas, 2016) provides long term average (1998 to 2015) annual and monthly readings of non-algal SPM (note that Cefas use the term non-algal SPM rather than SSC, but these terms are analogous and further discussion adopts the term SSC). Annual average SSC values across the study area are highly variable, ranging from around 5mg/l at the offshore extent of the Proposed Offshore Scheme up to 47mg/l close to the proposed Landfall Site.

There is some seasonality in SSC, with highest values of more than 10mg/l at the offshore extent of the Proposed Offshore Scheme and more than 70mg/l close to the proposed Landfall Site during winter months. The higher SSC during winter months is associated with wave-stirring of sediment from the seabed during storm events, which occur more frequently in the winter months. During such conditions, values can reach greater than 80mg/l offshore, with up to 170mg/l having been recorded at the coast.

It should be noted that these measurements of SSC are representative of near-surface conditions under non-storm/cloud free conditions and as such are likely to provide an underestimate of average conditions, particularly in close proximity to the seabed. Other studies have shown that there are likely to be frequent short-term increases in background SSC in the near-bottom waters as a result of natural events, with much higher values during storm events (UKMMAS, 2010).

These SSCs provide a natural background context for the assessment of effects of any temporary increases in SSC that may arise from installation activities for the Project.

## 4.1 Seabed Preparation

Prior to the start of submarine cable installation it is essential to ensure the route is clear of obstructions that may hinder installation works. The types of seabed preparation activity that may be required are:

**Boulder clearance** – for areas with large stones and/or boulders, there may be a requirement to move these out of the way. A plough would be towed across the seabed, pushing the boulders to both sides creating a cleared swathe 5-10 m wide. Alternatively individual boulders could be moved using a grab deployed from a vessel.

**Pre-lay grapnel run (PLGR) –** A vessel tows a wire with a string of specially designed hooks, or grapnels, along the centreline of the cable route snagging debris on the seabed and within the top 0.5 m – 1.0 m of the seabed. Debris caught with the grapnel would be recovered to the vessel for appropriate licenced disposal ashore.

**Pre-sweeping of sandwaves -** To avoid potential future cable exposure in areas with mobile sediments, the cables may need to be buried below the non-mobile reference level (NMRL), which is the depth below the sandwaves at which stable seabed is present. To achieve burial to the required level below NMRL pre-sweeping of the sandwaves is required. Pre-sweeping is undertaken using either a controlled flow excavator

(CFE)[1] or a trailing suction hopper dredger (TSHD)[2], with a TSHD typically required for clearance of larger sandwaves (>3 m high).

**Cutting Out of Service (OOS) Cables –** Permission will be sought from asset owners to cut OOS cables crossed by the Project. The OOS cable would be snagged using a grapnel and then cut, with approximately a 100 m section of cable being removed from the seabed. The cut ends would be tied to a weight and placed on to the seabed.

The removal of boulders and debris typically disturb only small volumes of sediment, much less than during cable installation and therefore these activities have not been assessed using numerical modelling tools. Pre-sweeping of sand waves has a greater potential to disturb larger volumes of sediment and an assessment of likely sediment release volumes has been undertaken.

Ripples and sandwaves have been identified along 8-9% of the route, equivalent to a length of 14.2 km. The area to be pre-swept would be wide enough for the passage of the burial equipment at the base of the sandwave, typically between 10 to 20 m. Where pre-sweeping is required, it would be undertaken several days to a few weeks in advance of cable lay and burial to ensure the path remains open for cable installation to take place.

**Table 6. Sand wave clearance parameters (taken from NGV, 2025).**

| Parameter | Fully bundled solution (1 trench) |
|---|---|
| Length of cable route requiring sandwave clearance (%) | 8.18 % |
| Length of cable route requiring sandwave clearance (km) | 14.2 km |
| Maximum clearance width (m) | 20 m |
| Total area of seabed disturbed by sandwave clearance ($km^2$) | 0.29 $km^2$ |
| Maximum volume of sediment disturbed by sandwave clearance ($m^3$) | 167,243 $m^3$ |

Examples of sandwaves along the proposed offshore HVDC Submarine Cable Corridor are shown in Figure 26. To further quantify the volume of sediment required for sandwave clearance at discrete areas of the proposed offshore HVDC Submarine Cable Corridor to inform the modelling scenario, cross sectional bathymetry profiles were extracted at the following locations:

- **Profile 1:** at KP58, area of relatively large sandwaves (approx. 9 m in height and 640 m in length).
- **Profile 2:** at KP108, area of small sand waves (approx. 3 m in height and 270 m in length).
- **Profile 3:** at KP118, area of small sand waves (approx. 2 m in height and 240 m in length).

These locations were selected as areas with repeat bathymetric surveys, allowing further analysis on sandwave migration rates. Pre-sweeping may be required at other locations along the proposed offshore HVDC Submarine Cable Corridor, including at locations closer inshore (KP14 to KP26, KP34 to KP37 and KP42.5 to KP44.5) and along the proposed development route (which takes a more southerly route than the proposed offshore HVDC Submarine Cable Corridor between KP55 and KP60).

The wavelengths, heights and areas were calculated for each sandwave identified along each profile. Applying an average sandwave clearance width of 15 m, sandwave volumes were calculated per sandwave (see Table 7).

[1] A technique that uses highly pressurised water directed at the seabed to push sediment to either side of a trench, also commonly referred to as a mass flow excavator (MFE).
[2] A dredging vessel that uses a suction pipe (the trailing drag head) to suck up sediment off the seabed. The sediment is discharged into a compartment (the hopper) on the vessel. The sand can either be retained in the hopper or deposited back on the seabed by opening the hopper doors, alternatively it can be side cast as the dredging occurs to allow the sand to settle away from the trench.

The approximate volumes of sandwaves along each profile are:

- Profile 1 = 1,484,200 m³;
- Profile 2 = 15,400 m³; and
- Profile 3 = 14,500 m³.

Sandwaves along the proposed development route show similar wavelengths and heights to those along the proposed offshore HVDC Submarine Cable Corridor between KP55 and KP60. Therefore the approximate sandwave volumes along Profile 1 remain applicable for the proposed development route.

Using the position of sandwave peaks along the profile, sandwave migration rates were estimated by comparing results from repeat bathymetry surveys. The approximate migration rates of the sandwaves for each profile are detailed in Table 8, shown in Figure 27 to Figure 29 and summarised below:

- Profile 1 = **3.7 m/yr** in a north-eastward direction (ranging from 2.1 – 5.1 m/yr);
- Profile 2 = **1.4 m/yr** in a northward direction (ranging from 0.7 – 2.3 m/yr); and
- Profile 3 = **2.9 m/yr** in a northward direction (ranging from 2.2 – 3.8 m/yr).

Sediment properties and metocean conditions along the proposed development route are similar to those along the proposed offshore HVDC Submarine Cable Corridor between KP55 and KP60. Therefore the approximate migration rates for Profile 1 would remain applicable for the proposed development route.

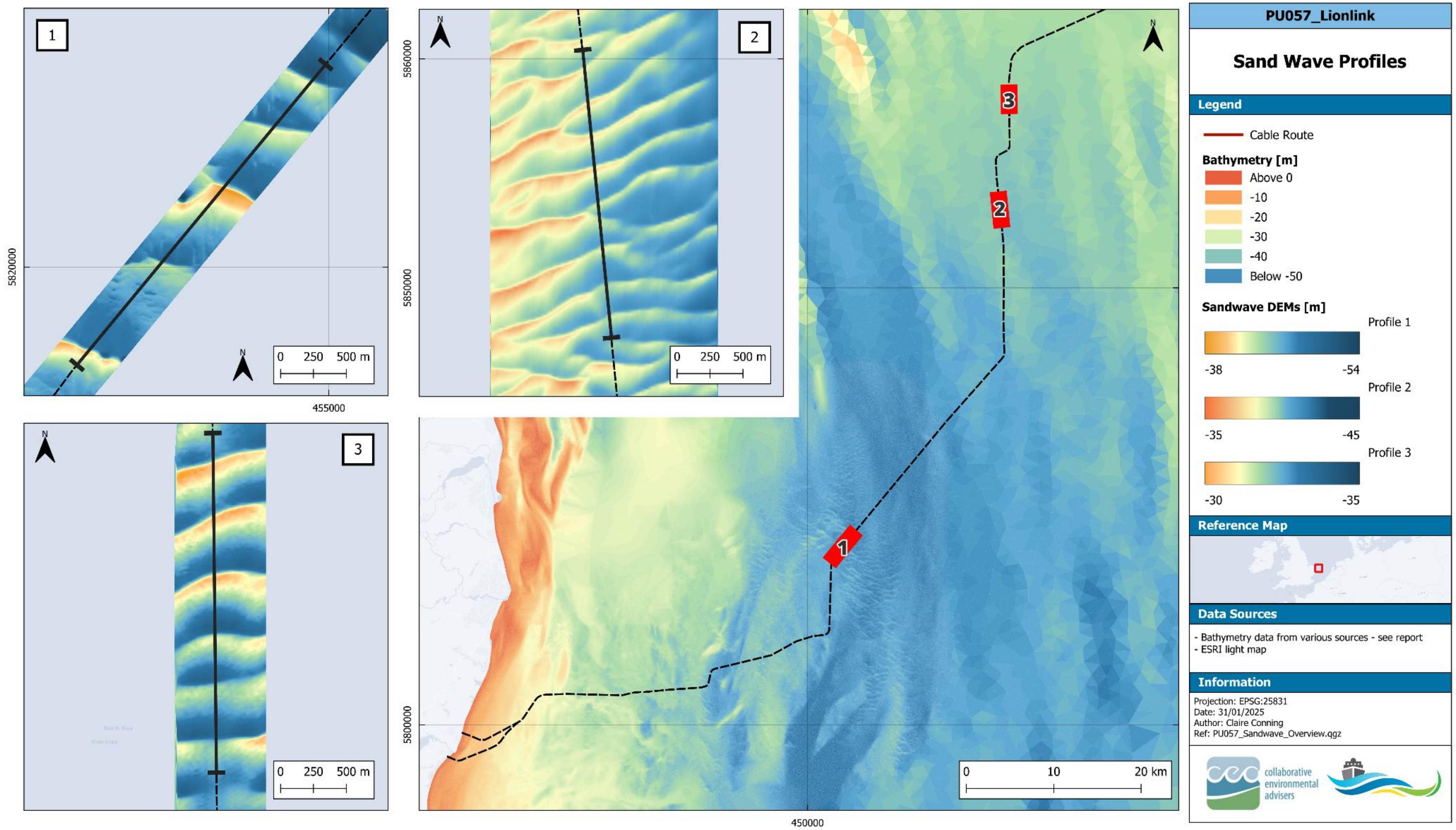


Figure 26. Examples of sandwaves along the proposed offshore HVDC Submarine Cable Corridor.

**Table 7. Results from high level sandwave analysis.**

| | Year | Sand wave number | Wavelength (m) | Wave height (m) | Area ($m^2$) | Volume ($m^3$) | Average Volume ($m^3$) per wave |
|---|---|---|---|---|---|---|---|
| Profile 1 | 2024 | 1 | 480 | 9.8 | 2151 | 32,266 | 37,258 |
| | | 2 | 521 | 7.8 | 1683 | 25,252 | |
| | | 3 | 815 | 10.8 | 3907 | 58,607 | |
| | | 4 | 741 | 7.5 | 2150 | 32,244 | |
| | 2017 | 1 | 480 | 10.0 | 2229 | 33,438 | |
| | | 2 | 551 | 8.1 | 1792 | 26,873 | |
| | | 3 | 791 | 10.6 | 3820 | 57,296 | |
| | | 4 | 732 | 7.3 | 2139 | 32,085 | |
| Profile 2 | 2024 | 1 | 265 | 2.0 | 184 | 2,754 | 3,841 |
| | | 2 | 247 | 3.1 | 257 | 3,862 | |
| | | 3 | 265 | 2.9 | 278 | 4,171 | |
| | | 4 | 292 | 3.0 | 305 | 4,568 | |
| | 2014 | 1 | 269 | 1.9 | 176 | 2,635 | |
| | | 2 | 267 | 3.0 | 263 | 3,946 | |
| | | 3 | 249 | 2.7 | 282 | 4,226 | |
| | | 4 | 281 | 3.1 | 305 | 4,571 | |
| Profile 3 | 2024 | 1 | 230 | 1.8 | 184 | 2,764 | 2,808 |
| | | 2 | 241 | 1.8 | 194 | 2,903 | |
| | | 3 | 259 | 2.2 | 257 | 3,857 | |
| | | 4 | 221 | 1.8 | 181 | 2,715 | |
| | | 5 | 230 | 1.3 | 153 | 2,301 | |
| | 2014 | 1 | 222 | 1.5 | 163 | 2,446 | |
| | | 2 | 260 | 1.6 | 181 | 2,710 | |
| | | 3 | 249 | 2.2 | 238 | 3,565 | |
| | | 4 | 224 | 1.6 | 167 | 2,502 | |
| | | 5 | 244 | 1.3 | 155 | 2,318 | |

**Table 8. Sandwave migration analysis results.**

| | Sand wave number | Migration Rate (m/yr) | Average Migration Rate (m/yr) |
|---|---|---|---|
| Profile 1 | 1 | 3.4 | 3.7 |
| | 2 | 2.1 | |
| | 3 | 5.1 | |
| | 4 | 4.2 | |
| Profile 2 | 1 | 0.7 | 1.4 |
| | 2 | 1.4 | |
| | 3 | 2.3 | |
| | 4 | 1.1 | |
| Profile 3 | 1 | 2.6 | 2.9 |
| | 2 | 3.5 | |
| | 3 | 3.8 | |
| | 4 | 2.3 | |
| | 5 | 2.2 | |

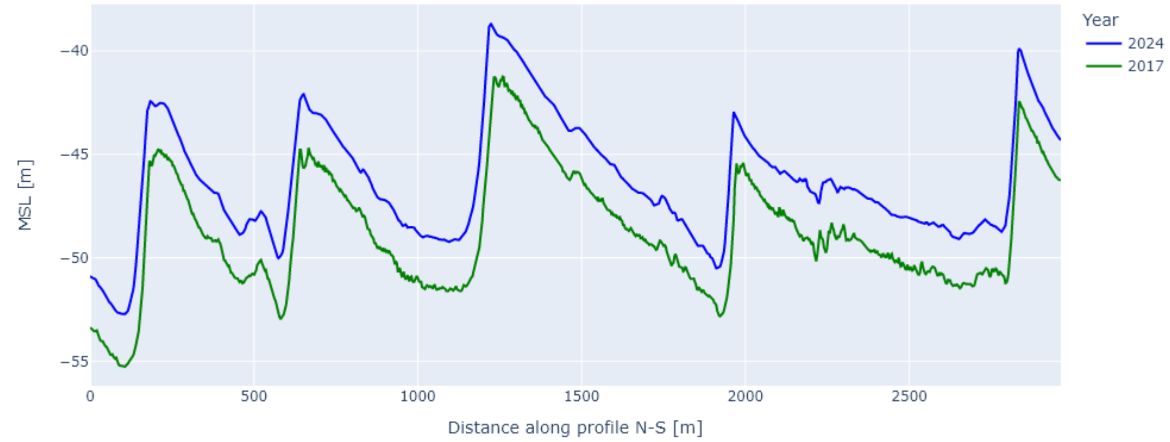


**Figure 27.** **Sandwaves at profile 1 for 2024 and 2017.**

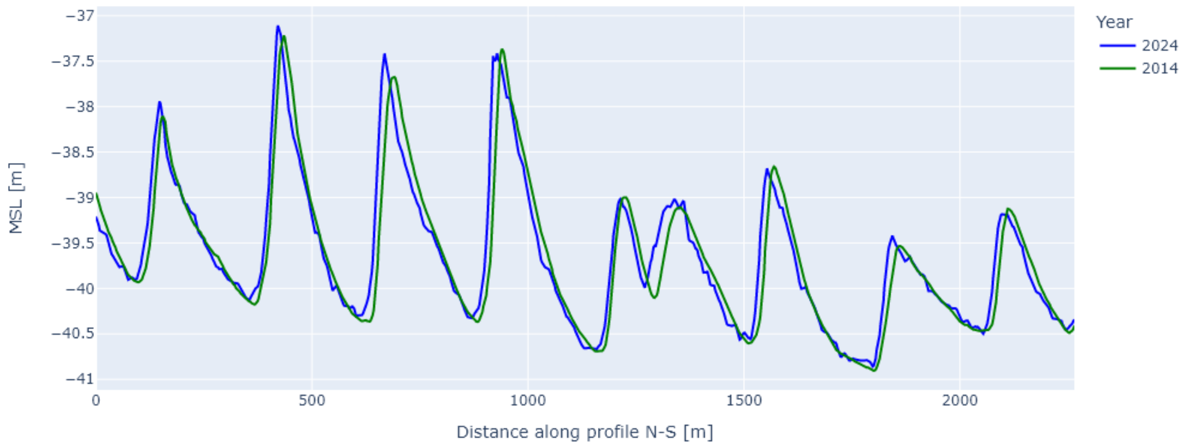


**Figure 28.** **Sandwaves at profile 2 for 2024 and 2014.**

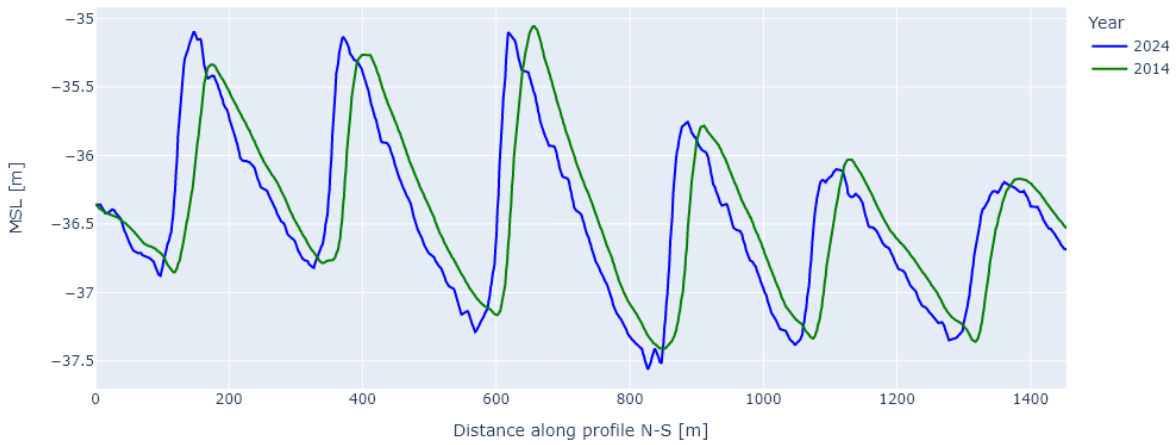


**Figure 29.** **Sandwaves at profile 3 for 2024 and 2014.**

### 4.1.1 Sandwave Clearance Model Scenario

If seabed material is dredged, sediment be disposed of in a licensed disposal area within the proposed Offshore HVDC Submarine Cable Corridor. The preference would be for the dredged spoil to be returned to the seabed in the vicinity of the dredged area where practical, with sediment release from the dredger by the opening of the hopper doors. While it is possible that sandwave clearance could be undertaken by CFE or TSHD, TSHD provides a worst case both with respect to the rate of fine sediment release and potential for greater dispersion with sediment released at a greater height above the bed. Sandwave clearance by TSHD has therefore been simulated in the model.

The following assumptions have been made to define the sediment release rates associated with sandwave clearance to apply in the model:

- Dredger specification**:**
  - Hopper capacity: 35,000 m³;
  - Hopper when full (80% of capacity): 28,000 m³;
  - Dredge speed: 2 kts; and
  - Transit speed: 12 kts.
- Sediment composition:
  - 8.8% of fines, comprised of 35% coarse silt, 20% medium silt, 32% fine silt and 13% clay (based on project survey data, NextGeo (2025)); and
  - dry sediment density: 1,400 $kg/m^3$
- Activity specification
  - 30 mins of dredging before overflow starts.
  - dredging duration to fill hopper: 4 hrs
  - disposal duration: 15 mins.

Based on these assumptions the dredge rate is 2,700 kg/s and the disposal rate is 44,000 kg/s.

The plume sources for a TSHD at the dredging location are related to draghead stir-up and overflow losses. At the placement site, the plume source is related to the bottom-door placement activity.

Becker (2014) summarises the reasonable ranges for source term fractions based on results from field monitoring campaigns and practical experiences. Draghead releases are quoted to be in the range of 0 to 3%, overflow losses are in the range of 0 to 20% and losses from bottom-door placement are in the range 0 to 10%. The upper values of these ranges have been adopted to provide a conservative assessment.

The following source terms were therefore applied in the model to simulate the release of fine sediment during dredging:

- Bed disturbance: 3% of fines released at 2 m above the seabed = 7.2 kg/s
- Overflow: 20% of fines released at the sea surface = 48.0 kg/s; and
- Placement 10% of fines released at the sea surface = 383.8 kg/s.

The source terms for bed disturbance and placement were simulated along the area of largest sandwaves (at profile 1), which given the sandwave volume and dredge rate, took just over six dredger loads (~25 hours) to complete. The dredging was timed to occur on a large spring tide to ensure the maximum overall plume spread.

Based on the vessel speed when dredging, five repeat tracks (alternating between a northeast and a southwest direction of travel) were completed along a 3 km section of the proposed HVDC Submarine Cable Corridor per dredger load. Placement alternated between a location 200 m to the southwest and 200 m to the southeast of the dredge track for each load.

**Table 9. Fines modelling source terms for cable installation.**

| Source Term | Model Source Term for Each Fine Fraction (kg/s) | | | |
|---|---|---|---|---|
| | Coarse Silt 31-63 µm | Medium Silt 16-31 µm | Fine Silt 4-16 µm | Clay <4 µm |
| Bed disturbance | 2.5 | 1.5 | 2.3 | 0.9 |
| Overflow | 16.7 | 9.9 | 15.2 | 6.2 |
| Placement | 133.7 | 79.0 | 121.4 | 49.7 |

## 4.2 Cable Burial

A number of options are being considered for cable burial including the use of:

- **jet trencher** - fluidises the bed layer by injecting water into the seabed allowing pre-laid cables to sink to the required burial depth;
- **conventional narrow share cable plough** - as the plough is pulled through the seabed it cuts and lifts a wedge of soil, the cable is then fed into the plough and guided down through the share to the base of the trench and wedge is placed back in.
- **advance cable ploughs (vertical injectors) -** deep burial ploughs using water jets fitted within the plough share to fluidise material at the leading edge of the share. Can achieve deeper burial depths (i.e., 3-6 m).
- **mechanical cutter** - used in hard or gravelly sediments such as clay and weak bedrock to pre-cut a trench.

Whilst cable burial is the preferred option, rock placement can also be used to protect submarine cables by covering the cable with a continuous berm of graded rock. The berm is typically made up of two layers, a filter layer and then a layer of armour. The size of the berms will depend on the location of the berm and seabed conditions and will be individually designed. The berm is typically constructed using a fall pipe vessel which would place rock over the cable.

The offshore design specification is for all cables to be within a single trench. The maximum trench depth is 1.8 m and the maximum trench width is 5 m. Assuming a rectangular trench, the cross sectional area would be 9 m$^2$.

Burial speeds are expected to range from 100 m – 500 m per hour depending on the equipment used and the ground conditions. Achieving the full trench dimensions at the expected installation speeds would require a productivity of 900 m$^3$/hour to 4,500 m$^3$/hour. Values at the lower end of this range provide a more realistic productivity rate that could be achieved, particularly in soils with a higher percentage of fines. To avoid an overly conservative assessment based on an unrealistic productivity rate, it has been assumed that the faster installation rate would achieve a smaller trench cross sectional area of 2.25 m$^2$ (a 3 m wide, 1.5 m deep triangular trench), yielding a productivity of 1,125 m$^3$/hour.

### 4.2.1 Sediment Composition Survey Data

A geotechnical survey was conducted in which surface grabs were taken in order to determine sediment composition along the proposed offshore HVDC Submarine Cable Corridor. Results showed a high percentage of fines in some sections, particularly inshore of KP8 where the average percentage of fines from seven samples was 66.6%. The samples collected further offshore had a much lower percentage of fines with an average of 7.8% of fines for 69 samples collected offshore of KP8. The average particle size distribution (PSD) and breakdown of fines in samples collected inshore and offshore of KP8 are provided in Table 10.

In addition to surface grabs, samples from vibrocores were also analysed for PSD. Samples from the upper 2 m of the seabed were found to have a broadly similar PSD to the surface samples, with a slight

**Table 10. Nearshore and offshore sediment compositions**

| | Gravels (>2000 µm) | Sands (63-2000 µm) | Fines (<63µm) | | | | |
|---|---|---|---|---|---|---|---|
| | | | Total Fines | Coarse Silt | Medium Silt | Fine Silt | Clay |
| Nearshore | 1.8% | 31.6% | 66.6% | 14.2% | 12.3% | 25.2% | 14.9% |
| Offshore | 5.7% | 86.5% | 7.8% | 1.3% | 1.6% | 3.5% | 1.4% |

## 4.2.2 Jet Trencher Model Scenario

Of the potential cable burial options, jetting is likely to be a worst case with respect to the potential for the formation and dispersion of a sediment plume. This is because the sediment release is likely to be at a greater height above the seabed and the sediment disturbance rate is expected to be higher than for other options (for example based on typical trench dimensions and burial speeds for a plough, the rate of sediment release into the water column would be around one quarter of those based on typical trench dimensions and burial speeds for a jet trencher). To maintain flexibility in the consented design, cable burial by jet trencher has therefore been simulated in the model.

The following assumptions have been made to define the sediment release rates associated with cable burial to apply in the model:

- Scenario 1: Installation speed 100 m/hour and productivity of 900 $m^3$/hour. The cable burial would take around 75 days to complete;
- Scenario 2: Installation speed of 500 m/hour and productivity of 1,125 $m^3$/hour; The cable burial would take around 15 days to complete;
- Sediment composition applied inshore of KP8:
  - 66.6% of fines, comprised of 21% coarse silt, 18% medium silt, 38% fine silt and 23% clay; and
  - dry sediment density: 900 kg/$m^3$; and
- Sediment composition applied offshore of KP8:
  - 7.8% of fines, comprised of 16% coarse silt, 21% medium silt, 45% fine silt and 18% clay; and
  - dry sediment density: 1,400 kg/$m^3$.

Assuming 30% of the sediment removed from the trench is released into the water column (Intertek, 2017; Gooding et al., 2012)[3,4], and considering the assumptions outlined above the source terms have been calculated for the 100 m/hour and 500 m/hour installation rates and these are summarised in Table 11. Due to the different sediment composition along the route, different sediment source terms are applied inshore and offshore of KP8.

A moving source term is applied in the model to simulate the cable burial at the appropriate cable burial rate. To provide a conservative assessment, the source term was applied at a height of 5 m above the seabed. In reality much of the sediment released in the water column will be at heights of less than 5 m and will settle more quickly back to the bed than sediment released at 5 m.

[3] Intertek (2017), Modelling of sediment disturbance during trenching of the proposed Viking Link interconnector. P19960_R4158_Rev3.
[4] Gooding, S., Black, K., Boyde, P. and Boyes, S. (2012). Environmental Impacts of Subsea Trenching Operations. Offshore Site Investigation and Geotechnics: Integrated Technologies – Present and Future, 12-14 September, London, UK.

The model was applied to simulate the dispersion of sediment during 30 days, spanning a full lunar cycle. For the quickest installation rate of 500 m/hour, sediment releases were only applied for the first 15 days of the run (with the full installation completed in this time). For the slowest installation rate of 100 m/hour, sediment releases were applied over the full run period, simulating cable burial along the inner 40% of the proposed offshore HVDC Submarine Cable Corridor.

During cable burial there will be some downtime due to weather, equipment and vessel maintenance, repositioning, cable crossing and jointing. The cable laying operations can generally continue in weather conditions up to force 7 winds and waves heights of up to 3 m. However, continual installation is assumed in the modelling process as it provides a worst-case assessment.

**Table 11. Fines modelling source terms for cable burial.**

| Installation Rate (m/hr) | Cable Section | Model Source Term for Each Fine Fraction (kg/s) | | | |
|---|---|---|---|---|---|
| | | Coarse Silt 31-63 µm | Medium Silt 16-31 µm | Fine Silt 4-16 µm | Clay <4 µm |
| 100 | Inshore of KP8 | 9.81 | 8.46 | 17.36 | 10.31 |
| | Offshore of KP8 | 1.39 | 1.79 | 3.80 | 1.51 |
| 500 | Inshore of KP8 | 12.26 | 10.57 | 21.70 | 12.89 |
| | Offshore of KP8 | 1.74 | 2.24 | 4.75 | 1.89 |

# 5 Results

Results showing the predicted impacts to suspended sediment concentration (SSC) and sedimentation from the numerical model simulations are presented in the following sections, with results for the sandwave clearance and cable burial presented in Section 5.1 and Section 5.2, respectively. The results are presented in the form of:

- spatial maps of statistical representations of the predicted increase in SSC due to the sediment released by the installation activities, including the maximum SSC in each model grid cell and percentile plots of the SSC calculated for the period over which activities were simulated;
- spatial maps of the sedimentation depth at the end of the model simulation due to the sediment released by the installation activities; and
- time series plots of the predicted SSC and sedimentation depth due to the sediment released by the installation activities.

The plots shown vary depending on the model simulation, with the plots aimed at providing an understanding of the key results from each installation activity.

It is important to note the following:

- the plots show the increase in background SSC and sedimentation associated with the installation activity (i.e. they do not include the natural background SSC and sedimentation outlined in Section 4;
- the spatial maps of the maximum SSC and percentiles do not show an actual representation of the SSC at any point in time, rather they are duration-based plots which show statistical summaries of the SSC over a defined period of time; and
- the model does not simulate the dispersion of any sediment which will rapidly settle to the bed (either in a dynamic plume or for the larger grain sizes). SSC and sedimentation close to the sediment release locations will be higher than from the settling of the fine grained passive plume simulated in the model and the model therefore only assesses the mid to far field effect.

The maximum SSC demonstrates the maximum concentrations that occurred at the given grid cell across the simulation period. The percentile plots show the value which the SSC is below for a given percentage of time over a defined period. The statistics are calculated over a 2 to 30 day period depending on the model simulation (to reflect differences in the time activities were ongoing). The percentiles for sandwave clearance are calculated over a 2 day period, the percentiles for the 100 m/hour cable burial rate are calculated over 30 days and the percentiles for the 500 m/hour cable burial rate are calculated over 15 days. For reference the number of hours that the SSC exceeds background levels for different calculation periods and percentiles is provided in Table 12. In all cases the maximum is calculated over the entire model simulation period.

**Table 12. Hours that SSC exceeds background levels for different calculation periods and percentiles.**

| Percentile | Hours exceeding background SSC levels calculated over different periods | | |
|---|---|---|---|
| | 30 days | 15 days | 2 days |
| 50th | 360 | 180 | 24 |
| 80th | 144 | 72 | 9.6 |
| 90th | 72 | 36 | 4.8 |
| 95th | 36 | 18 | 2.4 |
| 99th | 7.2 | 3.6 | 0.5 |

The sediment thickness calculation is based on a low sediment density (180 kg/m$^3$), representative of freshly deposited fine-grained sediment. Over time sediment deposited in areas of lower flow would compact and the thickness of deposits will reduce, while sediment deposited in areas of faster flow would be resuspended by tidal flows (again reducing the thickness of deposits). The model is setup so that once sediment is deposited on the bed, no erosion occurs – this setup provides an indication of the maximum thickness of deposits. The source terms associated with resuspension of any deposited sediment will be much lower than those associated with the installation activities (and would be similar to what naturally occurs) and as such the subsequent thickness of redeposited material would be lower than that shown for the initial sediment deposition (i.e. resuspension would result in a greater spread of sediment on the bed but with a smaller thickness than shown).

To aid the assessment of impacts for the Preliminary Environmental Impact (PEI) Report a number of other metrics were calculated including:

- the maximum area predicted to experience increases in SSC of more than 5 mg/l[5] background concentration and for individual model timesteps;
- the maximum area predicted to experience increases in SSC of more than 5 mg/l for any model timestep;
- the maximum area within designated sites predicted to experience increases in SSC of more than 5 mg/l for individual model timesteps (presented as a total area and as percentage of the designated site area);
- the maximum area within designated sites predicted to experience increases in SSC of more than 5 mg/l for any model timesteps (presented as a total area and as percentage of the designated site area);
- the total time where SSC is predicted to experience increases in SSC of more than 5 mg/l;
- the total time where SSC within designated sites is predicted to experience increases in SSC of more than 5 mg/l;
- the area predicted to experience sedimentation of more than 1 mm; and
- the area within designated sites predicted to experience sedimentation of more than 1 mm (presented as a total area and as percentage of the designated site area).

These metrics are presented in Table 15 to Table 18.

## 5.1 TSHD Sandwave Clearance

Map plots of the maximum and 95$^{th}$ percentile increase in SSC are shown in Figure 30 and Figure 31, respectively, showing the area where SSC increases above 0.5 mg/l are predicted to occur. Timeseries plots of the SSC and sedimentation over a 2 day period at a number of extraction points are shown in Figure 33 to Figure 39 and summarised in Table 13. Statistics are calculated over a 2 day period. Most sediment is released at the surface and as such will be dispersed throughout the water column. SSC is therefore shown as a depth average value. At some locations in the water column the actual SSC could therefore be higher than shown.

The plots show that SSC increases of more than 0.5 mg/l are constrained within the Study Area. SSC increases of around 50 mg/l occur along the dredge track and the highest SSC increases (over 1000 mg/l in some instances) are associated with the disposal of dredged material at either end of the dredged track. As shown in the time series plots, high SSC values are short-lived, especially those associated with disposal. SSC peaks generally occur for less than an hour before reducing to SSCs of <10 mg/l. The 95$^{th}$ percentile SSC increase is typically less than 5 mg/l except for a small area to the east of the dredge track where it remains less than 10 mg/l, indicating that the higher concentrations persist for periods of hours or less.

[5] 5 mg/l is the lowest annual average SSC within the Study Area – any changes below this are unlikely to be detectable against natural variations in SSC.

The dredging was timed to occur on a large spring tide (116% of a mean spring) to ensure the maximum overall plume spread. On neap tides the flows speeds are approximately half those on flood tides and as such the plume spread on neap tides would be expected to be around half that shown.

A map plot of the sedimentation at the end of the model simulation is presented in Figure 32, showing that the area where sedimentation with a thickness above 0.1 mm is predicted to occur is constrained within the Study Area. Sedimentation is predicted to be less than 1 mm except for a localised area along the dredge track (constrained to within the proposed offshore HVDC Submarine Cable Corridor) and around the two placement locations, where sedimentation exceeds 10 mm. SSC and sedimentation at both the southwestern and southeastern disposal sites are shown as timeseries in Figure 34 and Figure 35, respectively.

**Table 13. Table of SSC and sedimentation time series locations for the TSHD sandwave clearance installation scenario.**

| Location | Figure Number | Easting | Northing |
|---|---|---|---|
| Along cable route | Figure 33 | 454343.3 | 5820775 |
| Southwestern disposal site | Figure 34 | 453244 | 5819120 |
| Southeastern disposal site | Figure 35 | 455131 | 5821410 |
| 500 m south of cable route | Figure 36 | 454345.4 | 5820274 |
| 1 km north of cable route | Figure 37 | 454349.5 | 5819777 |
| 2 km south of cable route | Figure 38 | 454346.4 | 5818778 |
| 10 km north of cable route | Figure 39 | 454325.7 | 5810778 |

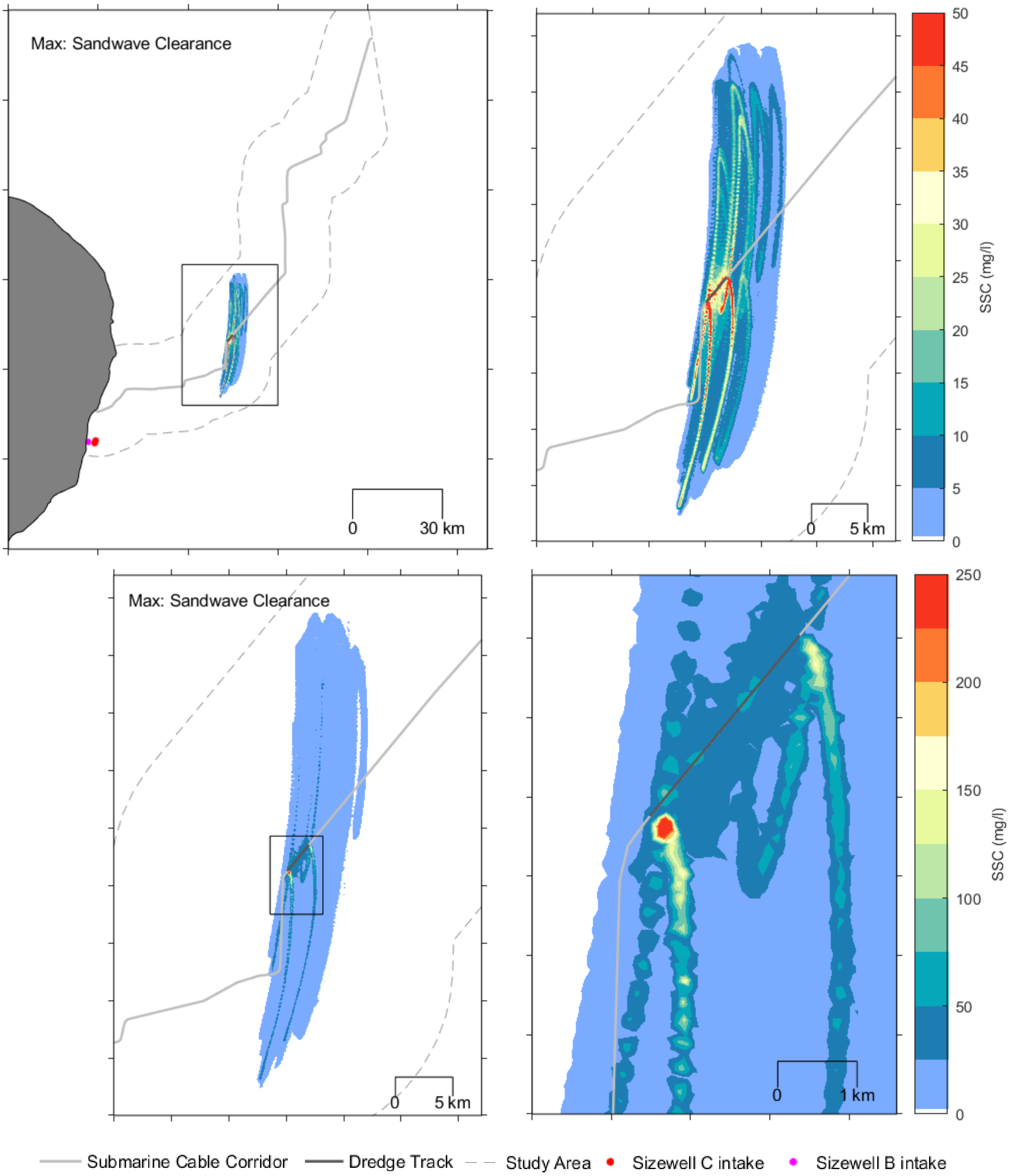


**Figure 30. Modelled maximum SSC from the PT model simulation for the TSHD sandwave clearance scenario. Upper and lower panels show the same result but at different zoom levels with different colour palettes.**

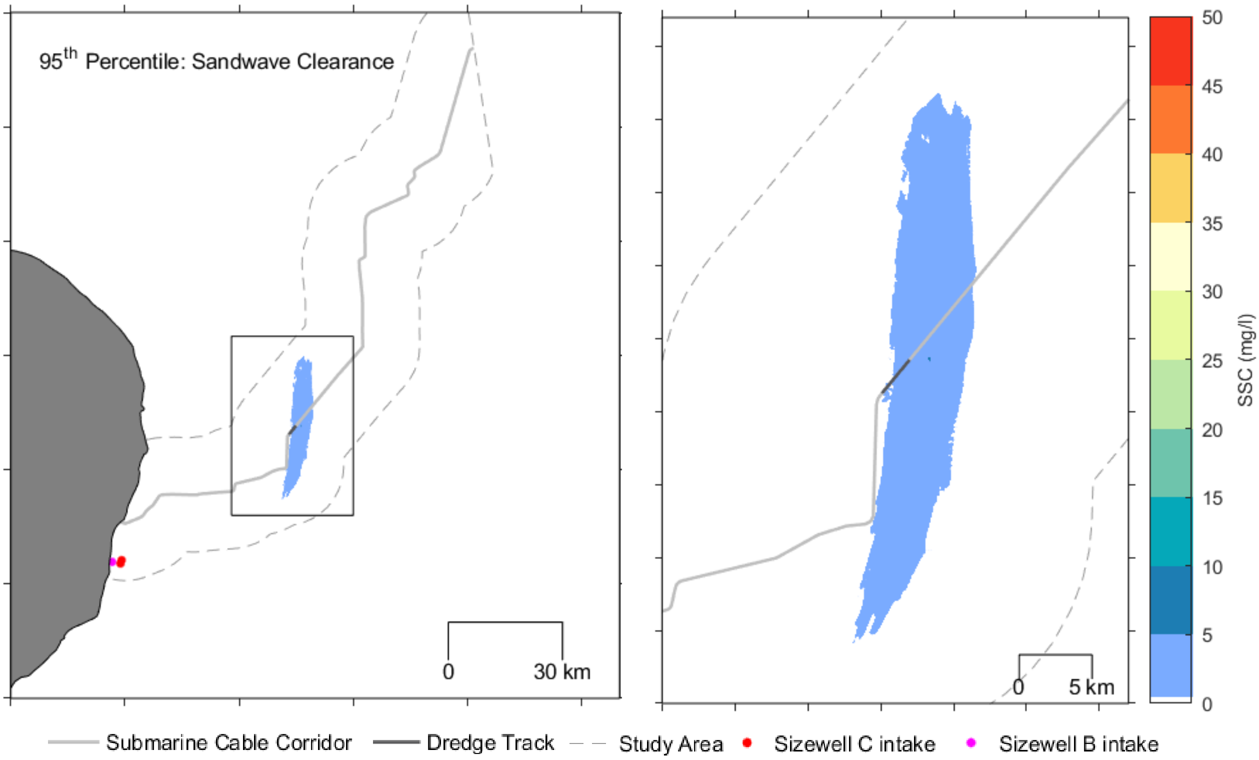


**Figure 31. Modelled 95th percentile SSC from the PT model simulation for the TSHD sandwave clearance scenario.**

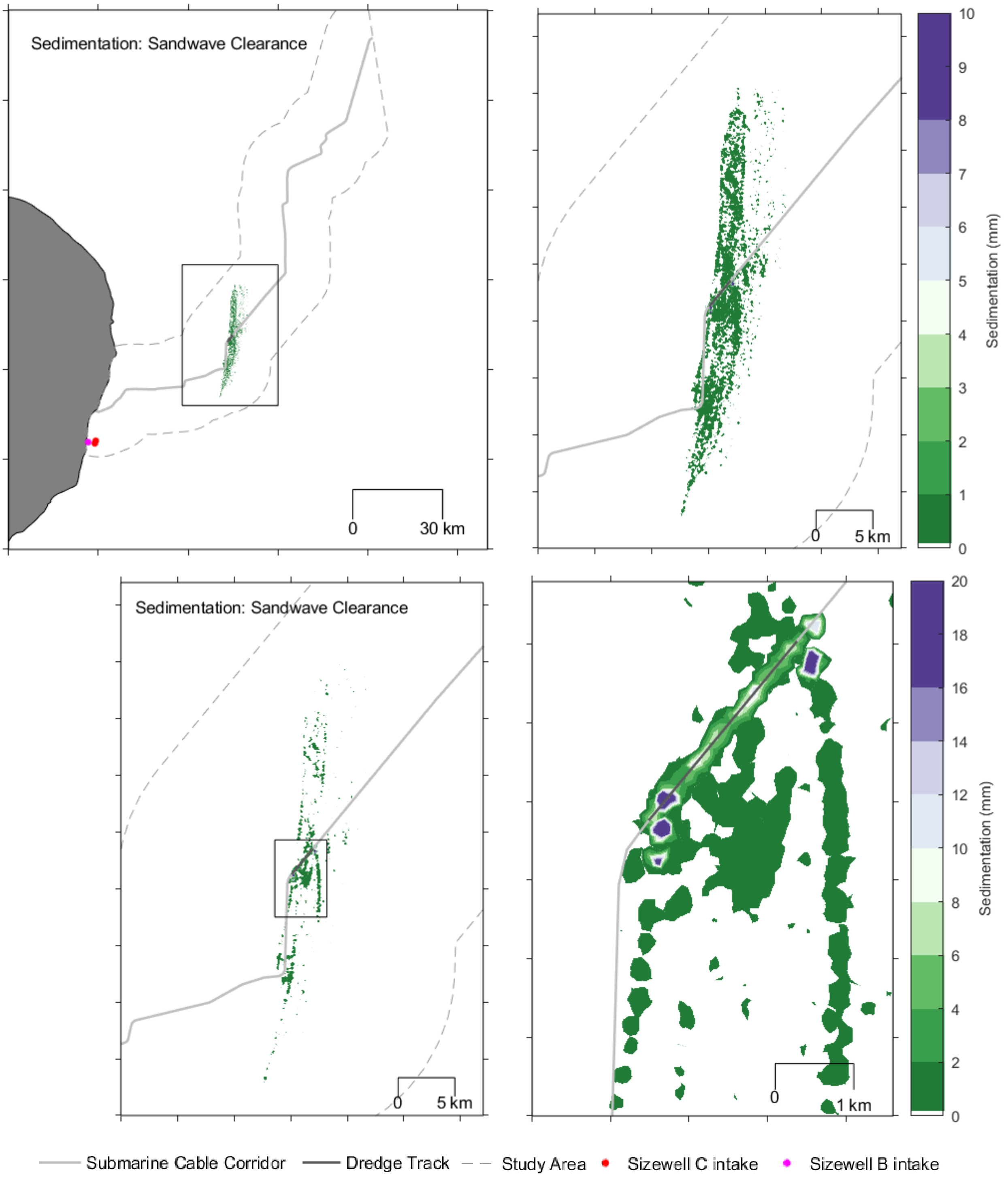


**Figure 32.** **Modelled sedimentation from the PT model simulation for the TSHD sandwave clearance installation scenario. Upper and lower panels show the same result but at different zoom levels with different colour palettes.**

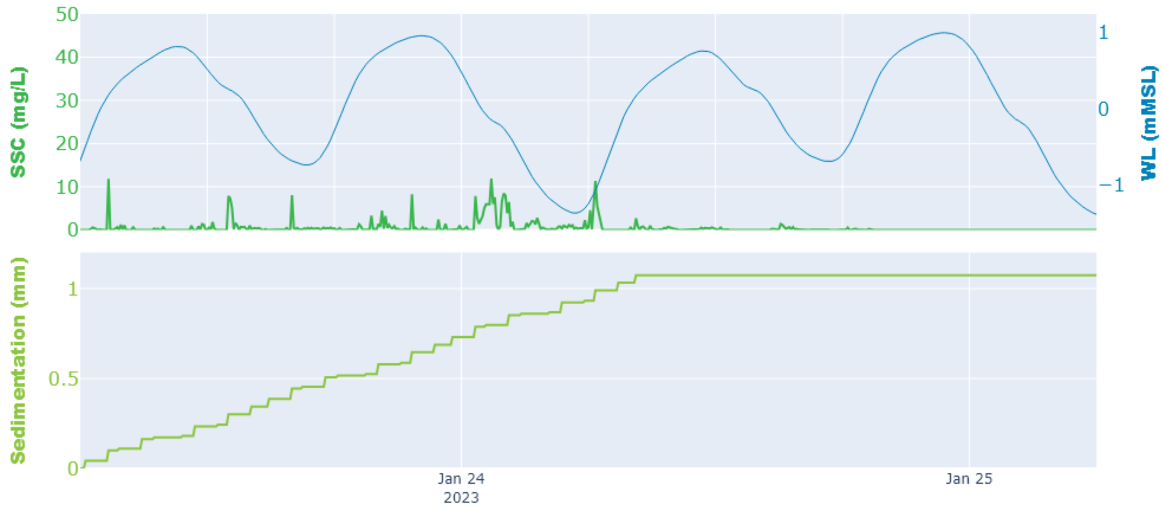


Figure 33. Modelled SSC and sedimentation at a location along the cable route.

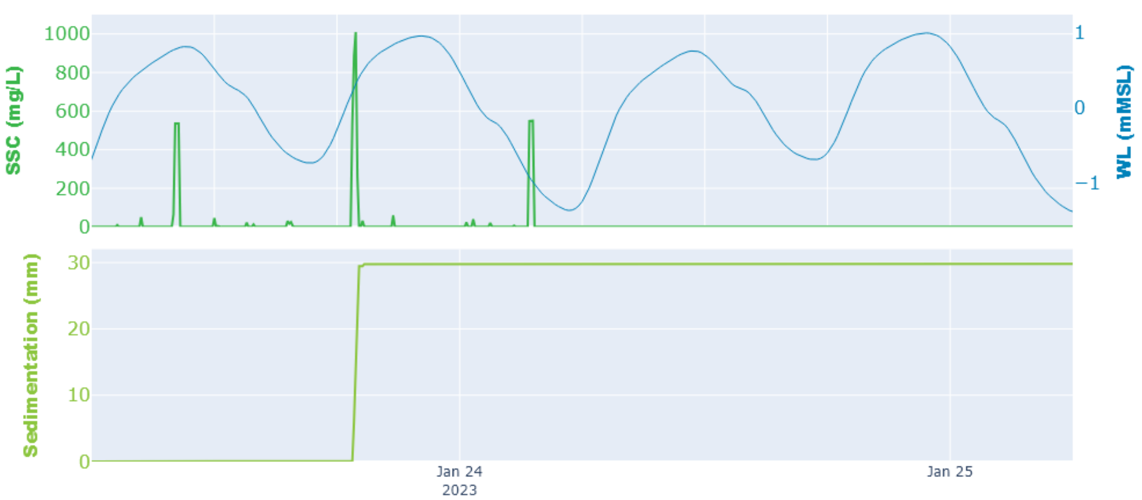


Figure 34. Modelled SSC and sedimentation at the southwestern disposal site.

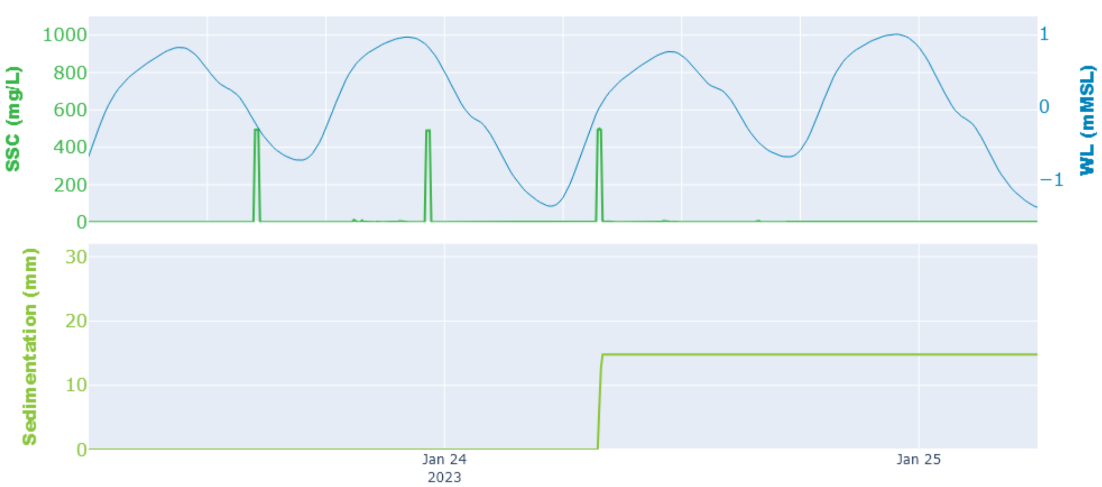


Figure 35. Modelled SSC and sedimentation at the southeastern disposal site.

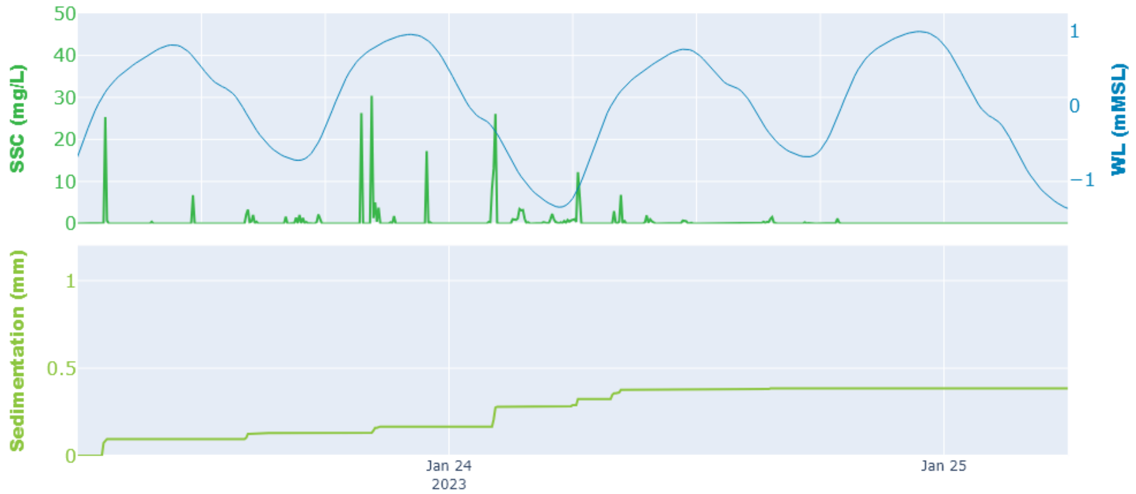


**Figure 36. Modelled SSC and sedimentation at a location 500 m south of the cable route.**

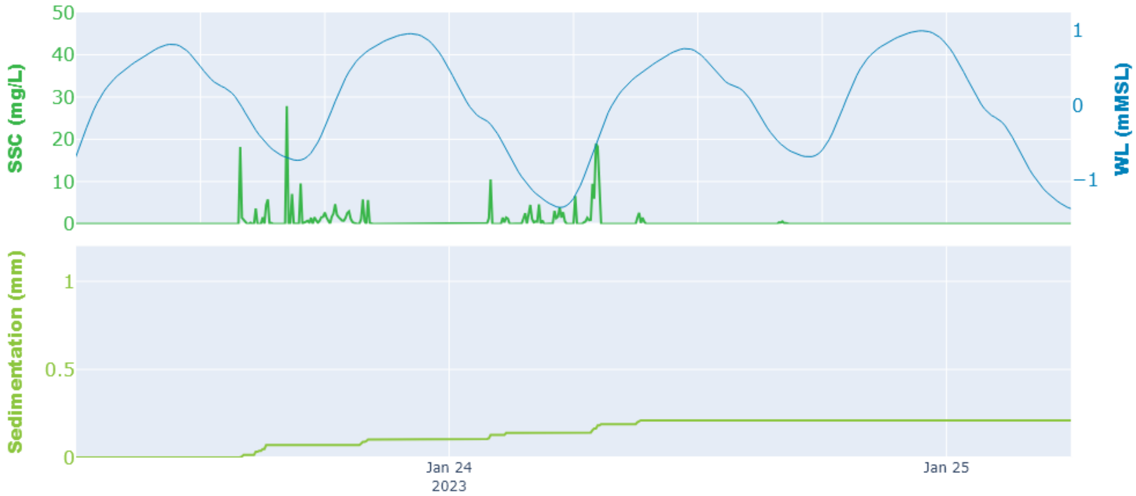


**Figure 37. Modelled SSC and sedimentation at a location 1 km north of the cable route.**

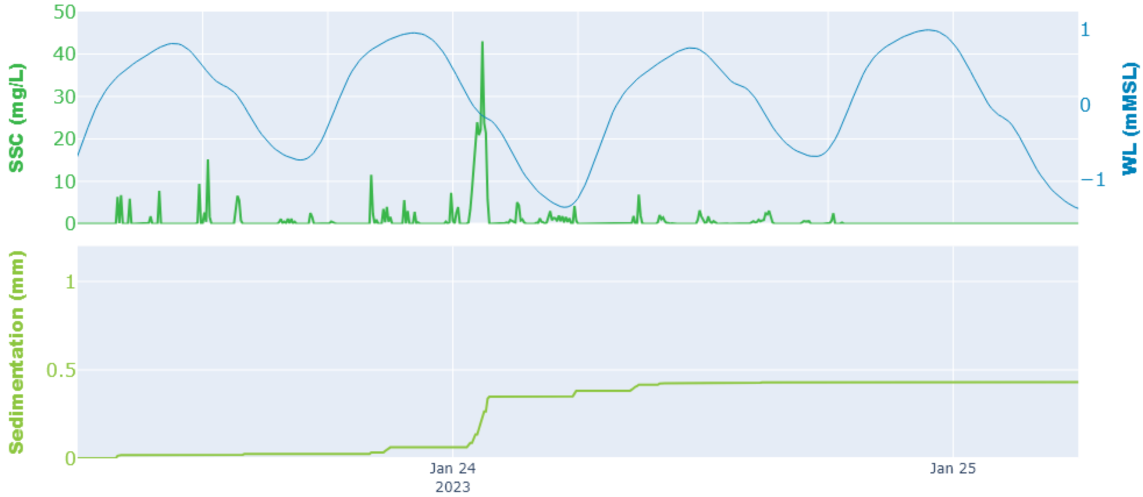


**Figure 38. Modelled SSC and sedimentation at a location 2 km south of the cable route.**

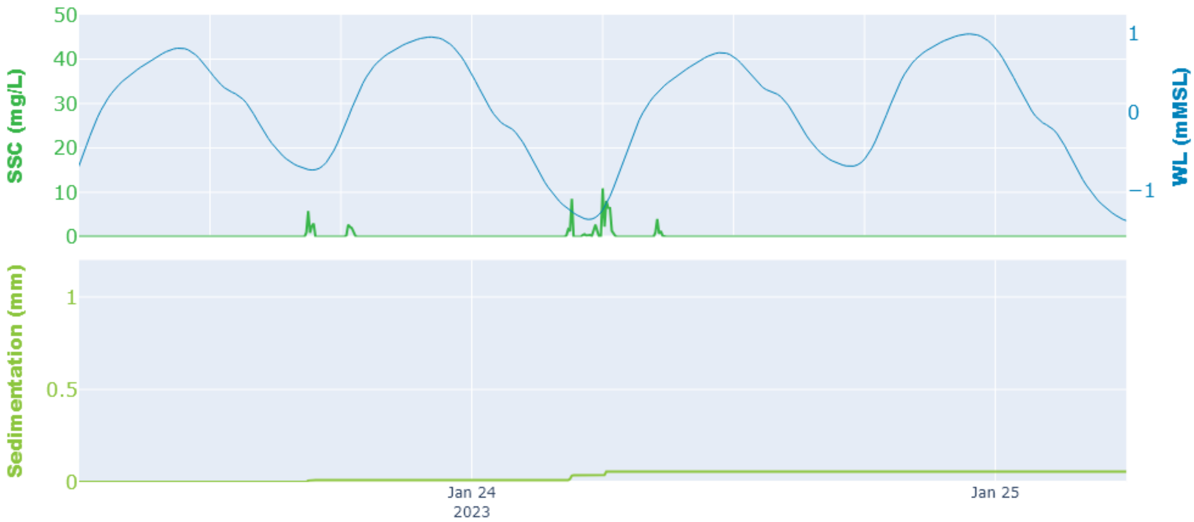


**Figure 39. Modelled SSC and sedimentation at a location 10 km north of the cable route.**

## 5.2 Cable Burial

The maximum and 99th percentile SSC are shown in Figure 40 and Figure 41, respectively for an installation speed of 100 m/hour and in Figure 42 and in Figure 43, respectively for an installation speed of 500 m/hour. Statistics are calculated over a 30 day and 15 day period for the 100 m/hour and 500 m/hour installation speeds, respectively. The source terms in the model are applied at 5 m above the bed and the SSC is shown for the layer within 5 m of the bed, representing the near-bed SSC. SSC higher in the water column would be lower than the values shown.

Timeseries plots of the SSC and sedimentation for both installation speeds over a 15 day period at a number of extraction points are shown in Figure 46 to Figure 56 and are summarised in Table 14.

To provide an assessment of the potential for impact at the Sizewell nuclear power stations, SSC and sedimentation values were extracted for all modelled grain sizes at the Sizewell B and Sizewell C intakes and for a location to the east of the intakes where higher SSC was predicted in the model. If the timing of the cable burial, for the same range of tide, was to occur at a different phase in the tide to that modelled, these higher SSC peaks could occur at the Sizewell C intake locations.

**Table 14. Table of SSC and sedimentation time series locations for the 100 and 500 m/hour jet trencher cable burial scenarios.**

| Location | 100 m/hour rate | | | 500 m/hour rate | | |
|---|---|---|---|---|---|---|
| | Figure no. | Easting | Northing | Figure no. | Easting | Northing |
| Along cable route | Figure 46 | 411628 | 5796482 | Figure 52 | 414019 | 5797477 |
| 500 m south of cable route | Figure 47 | 411785 | 5796009 | Figure 53 | 413981 | 5796981 |
| 1 km south of cable route | Figure 48 | 411631 | 5795477 | Figure 54 | 413783 | 5796509 |
| 2 km south of cable route | Figure 49 | 411654 | 5794479 | - | - | - |
| 5 km south of cable route | - | - | - | Figure 55 | 412409 | 5792747 |
| 100 m east of Sizewell C intake (north) | Figure 50 | 409234 | 5786271 | - | - | - |
| 800 m east of Sizewell C intake (north) | | | | Figure 56 | 410938 | 5786271 |
| Sizewell C intake (north) | Figure 51 | 409134 | 5786271 | - | - | - |

The plots show the following:

- the nearshore region (inshore of KP8) has the highest maximum SSC of more than 50 mg/l along the cable route for both installation speeds due to the significantly larger proportion of fine sediments in this area;
- SSC increases of more than 20 mg/l extend approximately 10 km from the proposed offshore HVDC Submarine Cable Corridor inshore of KP8 and approximately 5 km from the proposed offshore HVDC Submarine Cable Corridor offshore of KP8;
- for the 100 m/hour installation speeds SSC increases of more than 5 mg/l extend up to 15 km and 10 km from the proposed offshore HVDC Submarine Cable Corridor inshore and offshore of KP8, respectively;
- for the 500 m/hour installation speeds, SSC increases of more than 5 mg/l extend slightly further from the offshore HVDC Submarine Cable Corridor than for the 100 m/hour installation speed (up to 15 km both inshore and offshore of KP8 but reducing further offshore where tidal excursions reduce). This is due to the higher source terms associated with the faster installation speed;
- increases in SSC from the cable burial above 5 mg/l are mainly constrained within the Study Area. The only exception to this is associated with cable burial around KP5 to KP10 where increases in SSC of up to 15 mg/l extend 1.5 km to the north of the Study Area. This results from the higher percentage of fines and the close alignment of the cable route with the flow direction in this region;
- Increased SSC of more than 0.5 mg/l does not extend into the Greater Wash Marine Protected Areas (which is more than 4 km north of the northern extent of the Study Area).
- increases in SSC at the Sizewell C intakes are not predicted to exceed 5 mg/l, although if the relative timing of the cable burial in the tide was different to that modelled, increases of up to 20 mg/l could have occurred;
- increases in SSC at the Sizewell C intake are predicted to be comprised of the finest sediment fraction (clay) modelled and to be very short lived (of the orders of hours or less);
- increases in SSC at the Sizewell B intake is not predicted to exceed 0.5 mg/l; and
- the 99$^{th}$ percentile increase in SSC is much lower than the maximum with no increases above 5 mg/l for either installation speed, highlighting the short-duration of the SSC increases shown in the maximum SSC plots.

Map plots of the sedimentation at the end of the model simulation are shown for the 100 m/hour and 500 m/hour installation speed in Figure 44 and Figure 45, respectively, showing the area where sedimentation with a thickness above 0.1 mm is predicted to occur.

When interpreting the plots it is important to note that the model simulates the dispersion of the fine sediment suspended in the water column. The remainder of the sediment is expected to settle within close proximity to the disturbance site and as such sedimentation thickness immediately adjacent to the trench will be higher than that shown from the modelling.

Sedimentation is predicted to be less than 1 mm except for a localised area (within 500 m of the release location) along the proposed offshore HVDC Submarine Cable Corridor, where sedimentation of the fines can exceed 10 mm (remaining less than 12 mm) and 8 mm (remaining less than 10 mm) for the 100 m/hour and 500 m/hour installation speeds, respectively. Sedimentation of more than 0.1 mm is constrained to within the Study Area, with a more extensive area of sedimentation associated with the slower installation speed – this is due to the greater mass of sediment released for this scenario. No sedimentation of more than 0.1 mm is predicted to occur at the Sizewell B and Sizewell C intakes for either installation speed.

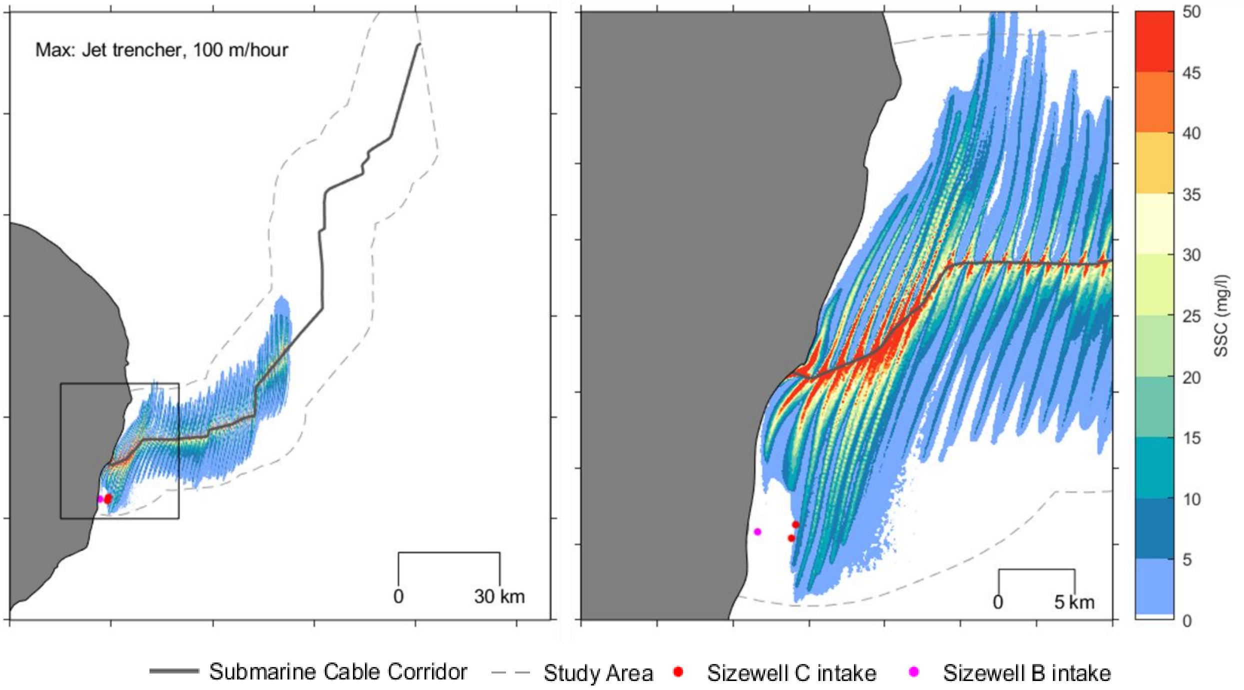


**Figure 40. Modelled maximum SSC from the PT model simulation for the 100 m/hour jet trencher cable burial scenario.**

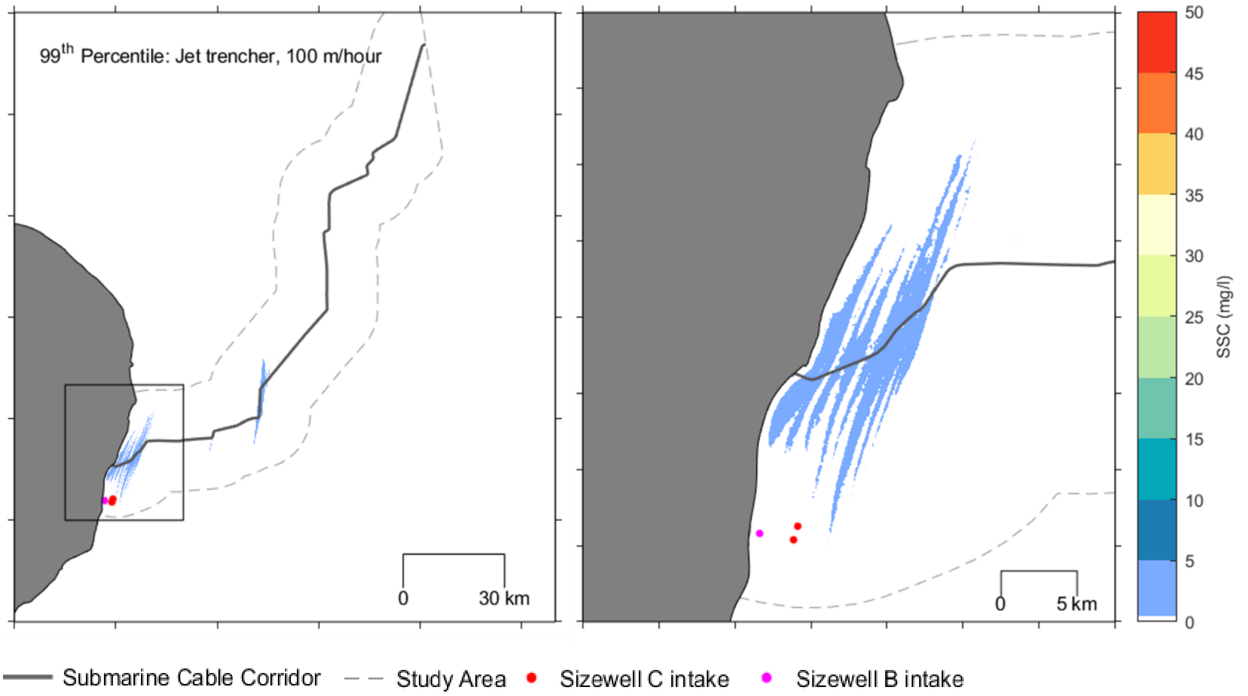


**Figure 41. Modelled 99th percentile SSC from the PT model simulation for the 100 m/hour jet trencher cable burial scenario.**

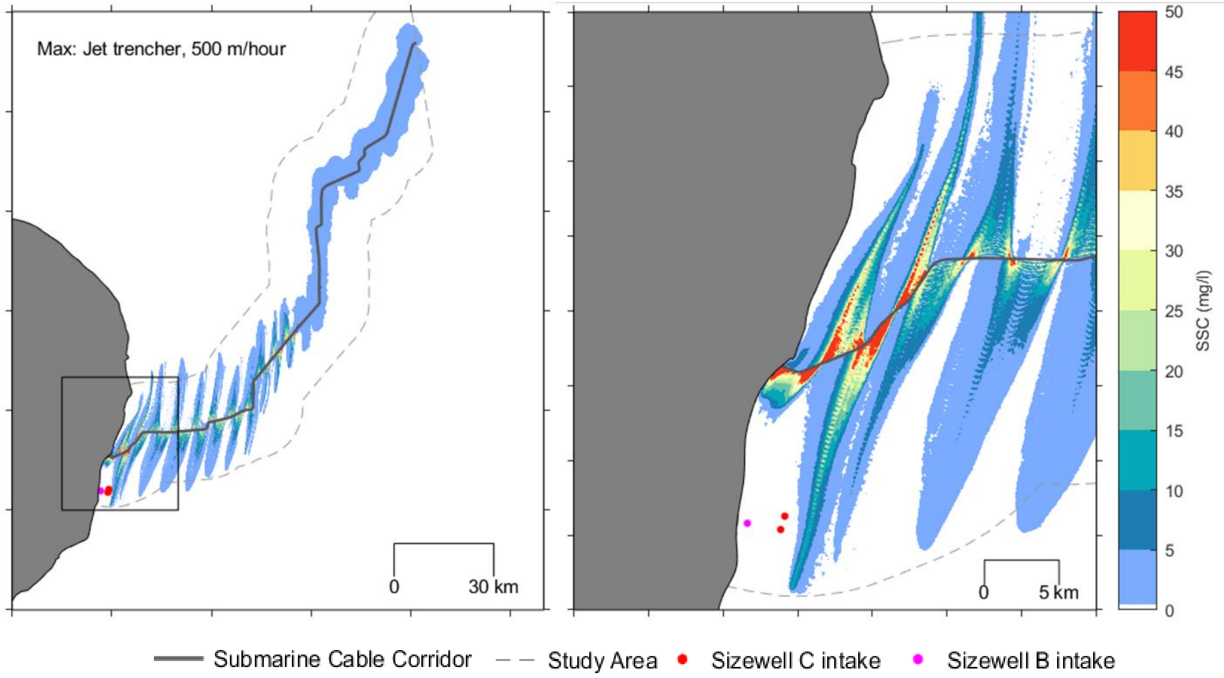


**Figure 42.** **Modelled maximum SSC from the PT model simulation for the 500 m/hour jet trencher cable burial scenario.**

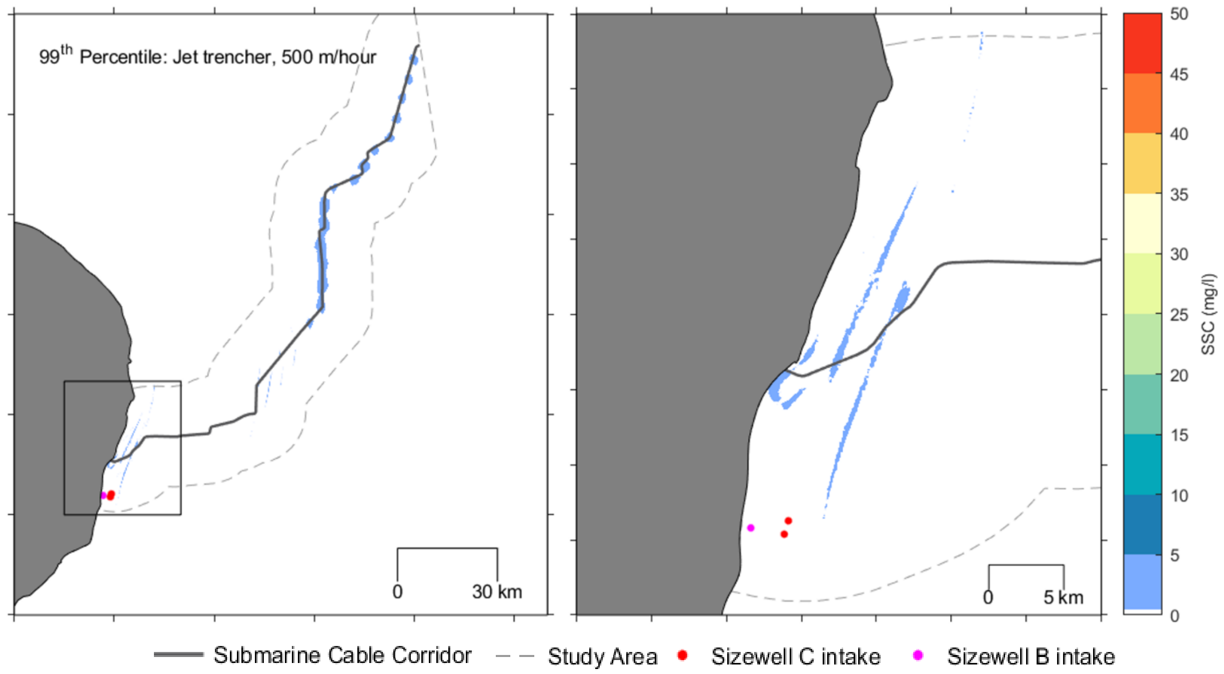


**Figure 43.** **Modelled 99th percentile SSC from the PT model simulation for the 500 m/hour jet trencher cable burial scenario.**

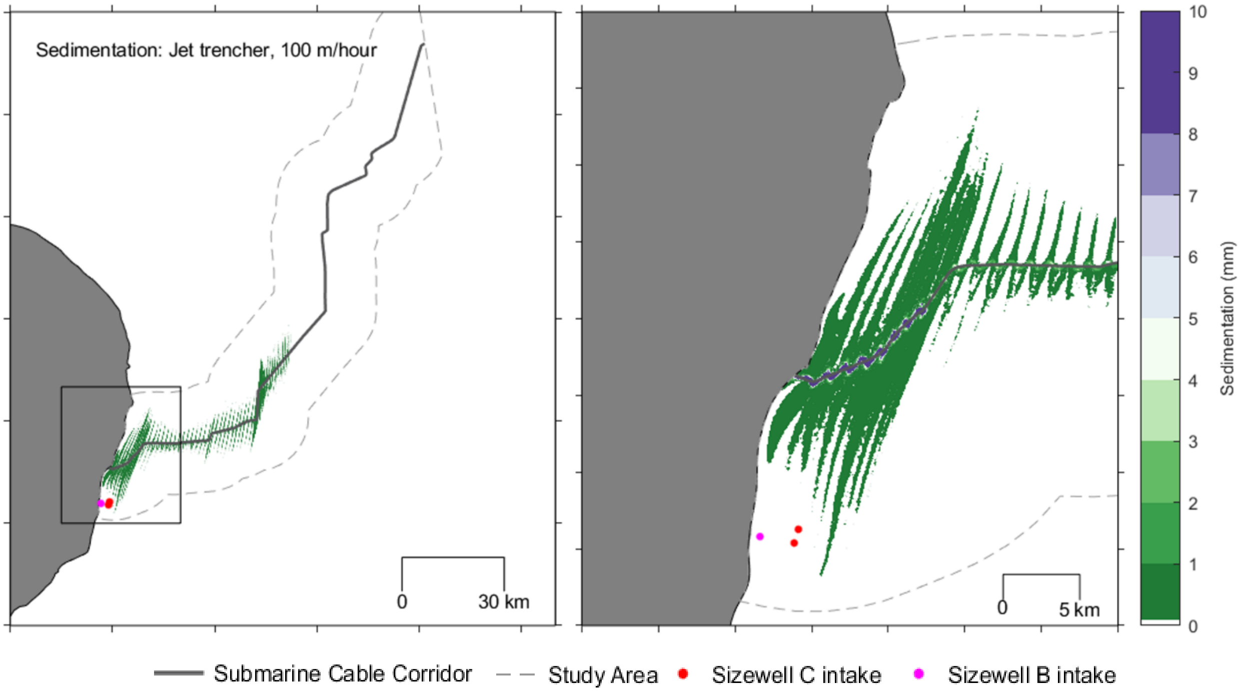


**Figure 44. Modelled sedimentation from the PT model simulation for the 100 m/hour jet trencher cable burial scenario.**

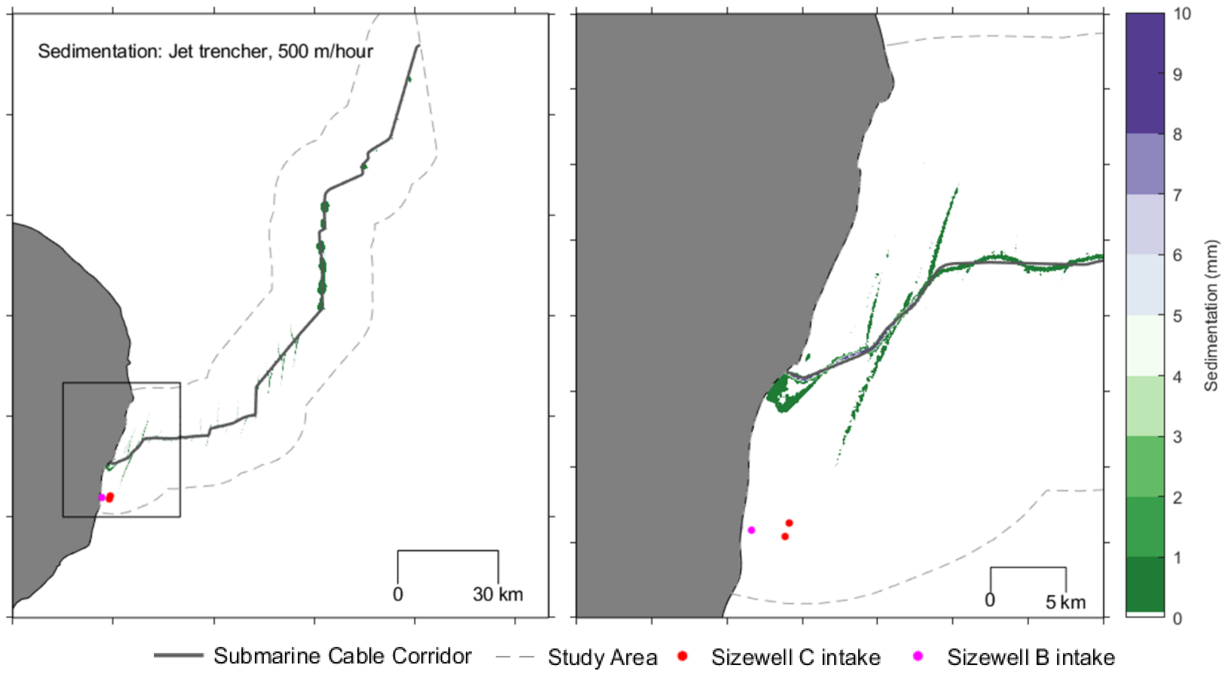


**Figure 45. Modelled sedimentation from the PT model simulation for the 500 m/hour jet trencher cable burial scenario.**

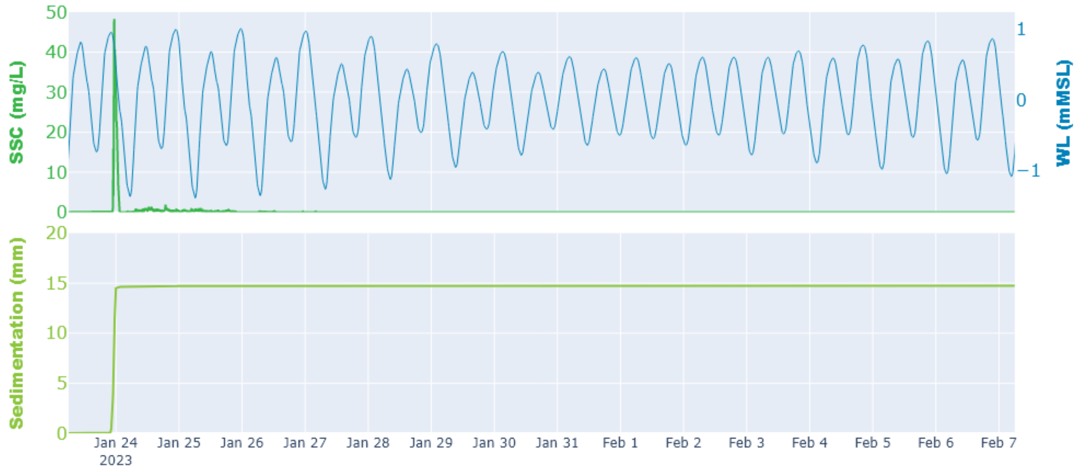


**Figure 46.** Modelled SSC and sedimentation at a location along the cable route for the 100 m/hour jet trencher cable burial scenario.

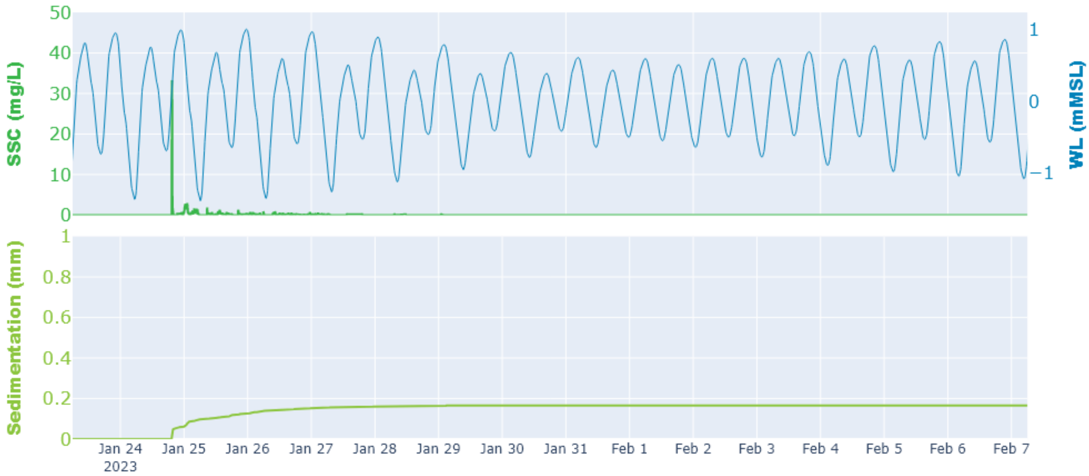


**Figure 47.** Modelled SSC and sedimentation at a location 500 m to the south of the cable route for the 100 m/hour jet trencher cable burial scenario.

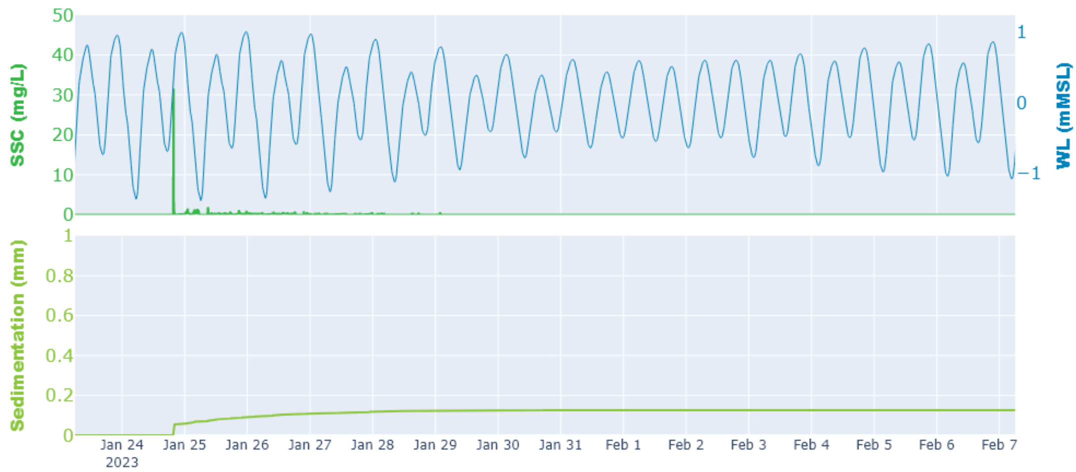


**Figure 48.** Modelled SSC and sedimentation at a location 1 km to the south of the cable route for the 100 m/hour jet trencher cable burial scenario.

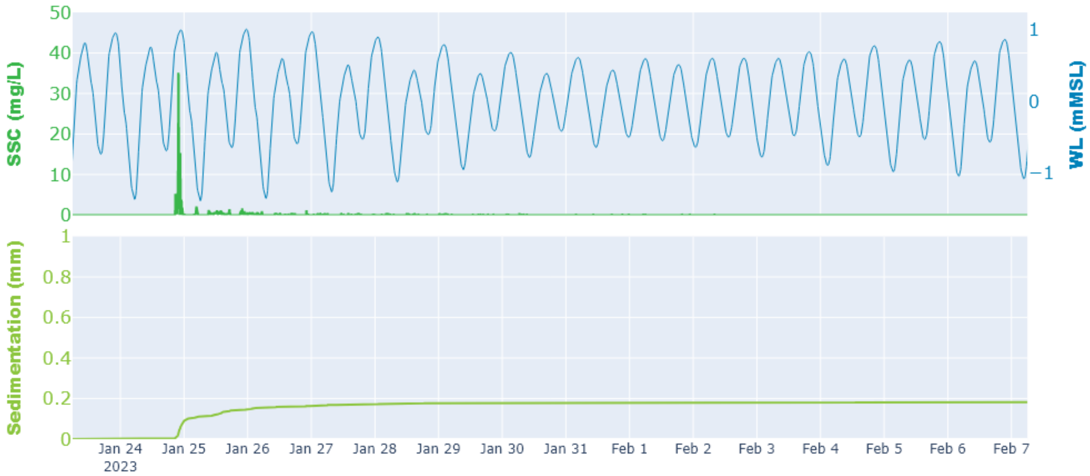


**Figure 49. Modelled SSC and sedimentation at a location 2 km to the south of the cable route for the 100 m/hour jet trencher cable burial scenario.**

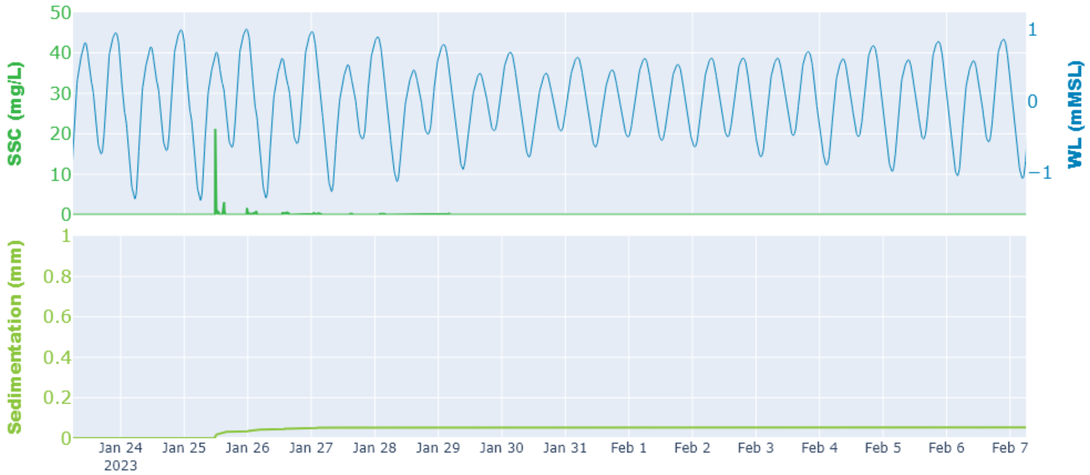


**Figure 50. Modelled SSC and sedimentation at a location 100 m east of Sizewell C intake (north) for the 100 m/hour jet trencher cable burial scenario.**

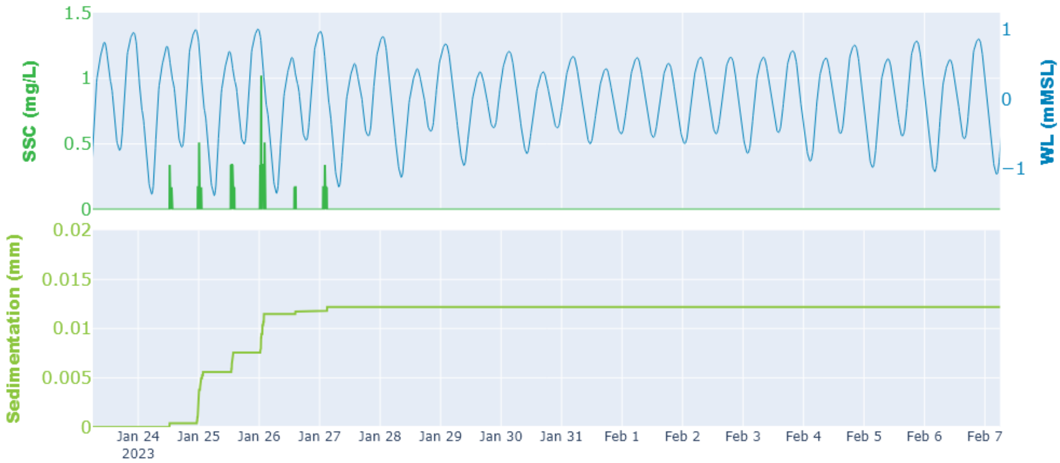


**Figure 51. Modelled <u>clay</u> SSC and sedimentation at Sizewell C intake (north) for the 100 m/hour jet trencher cable burial scenario.**

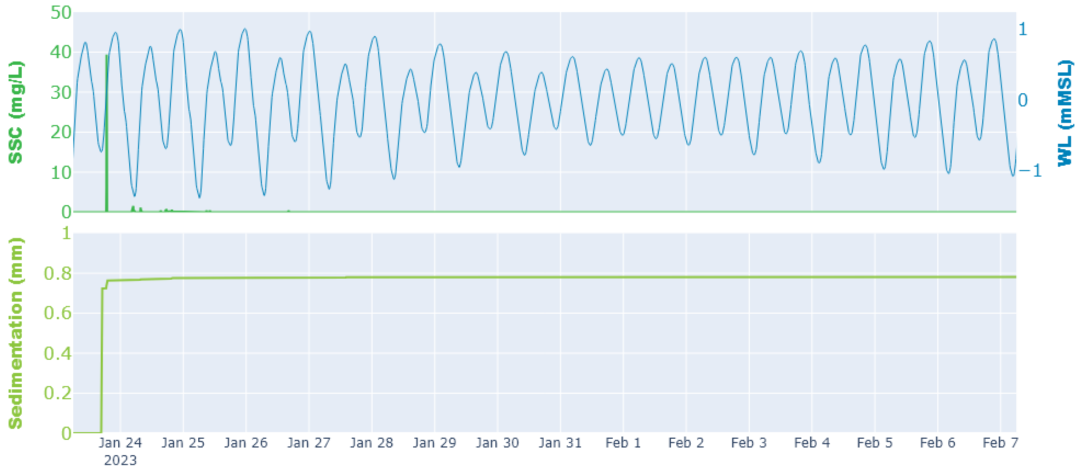


**Figure 52.** **Modelled SSC and sedimentation at a location along the cable route for the 500 m/hour jet** trencher cable burial scenario.

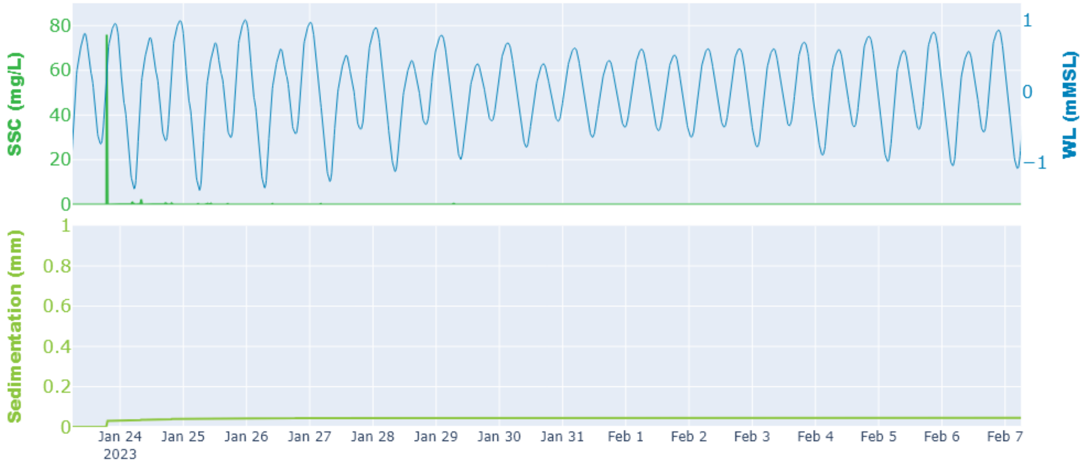


**Figure 53.** **Modelled SSC and sedimentation at a location 500 m to the south of the cable route for the 500 m/hour jet trencher cable burial scenario.**

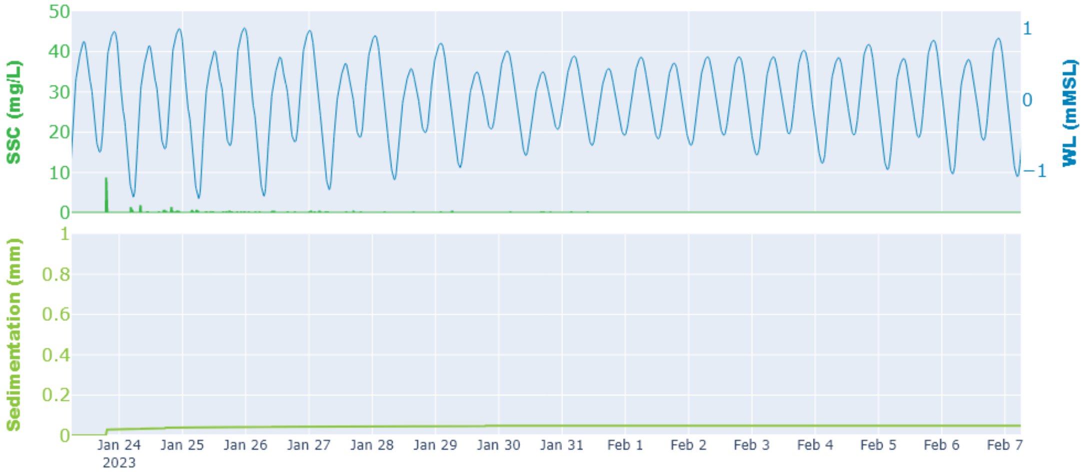


**Figure 54.** **Modelled SSC and sedimentation at a location 1 km to the south of the cable route for the 500 m/hour jet trencher cable burial scenario.**

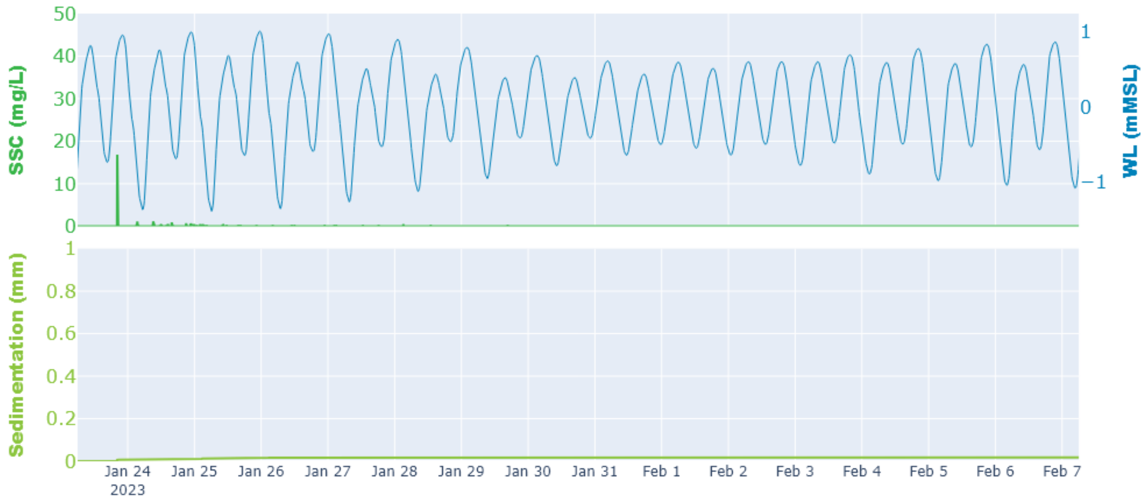


**Figure 55. Modelled SSC and sedimentation at a location 5 km to the south of the cable route for the 500 m/hour jet trencher cable burial scenario.**

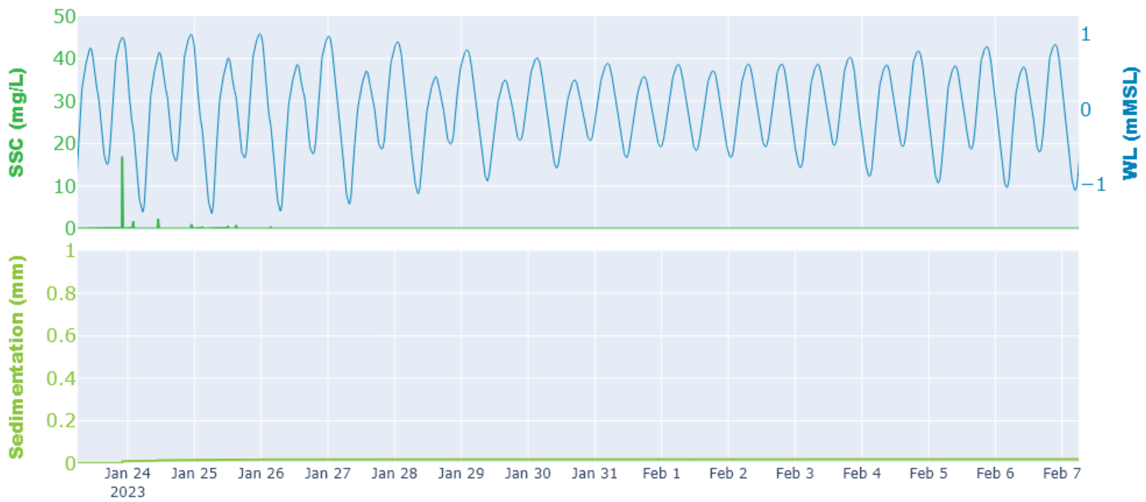


**Figure 56. Modelled SSC and sedimentation at a location 800 m east of Sizewell C intake (north) for the 500 m/hour jet trencher cable burial scenario.**

## 5.3 Assessment of Impacts

The key areas of impacts for each installation activity are summarised in Table 15 to Table 18. There were no SSC increases above 5 mg/l and no sedimentation above 1 mm predicted to occur within the Haisborough Hammond and Winterton Marine Protected Area (MPA) or within the North Norfolk Sandbanks and Saturn Reef MPA.

The results show that approximately 20% of the Outer Thames Estuary SPA (only considering the two polygons of the SPA which intersect with the proposed offshore HVDC Submarine Cable Corridor) is predicted to be affected by SSC of more than 5 mg/l with the largest impact from cable burial at the slower installation rate of 100 m/hour. The area predicted to be impacted at any one time is much smaller, being less than 0.1% of the area. The duration of time where SSC is increased by 5 mg/l at any point within the Outer Thames Estuary SPA is 18 days. Less than 0.5% of the Outer Thames Estuary SPA is predicted to be affected by sedimentation of more than 1 mm thick, constrained within the proposed offshore HVDC Submarine Cable Corridor.

Approximately a quarter of the bathing water (BW) of Southwold Pier and all of the BW of Southwold the Denes are predicted to be affected by SSC of more than 5 mg/l at any time. However, the time of impact is very short being less than 1 hour and less than 2 hours at Southwold Pier and Southwold the Denes, respectively.

**Table 15. Maximum areas predicted to experience increases in SSC of more than 5 mg/l at any one time.**

| Area | Sandwave Clearance | | Cable Burial: 100 m/hour | | Cable Burial: 500 m/hour | |
|---|---|---|---|---|---|---|
| | $m^2$ | % | $m^2$ | % | $m^2$ | % |
| Full Model Domain | 2242719 | - | 1480441 | - | 1563154 | - |
| Study Area | 2242719 | 0.04 | 1480441 | 0.03 | 1563154 | 0.03 |
| Outer Thames Estuary SPA | 6903 | 0.00 | 1480441 | 0.09 | 1294997 | 0.08 |
| Southwold Pier BW | 0 | 0.00 | 17165 | 12.23 | 0 | 0.00 |
| Southwold The Denes BW | 0 | 0.00 | 97747 | 78.11 | 0 | 0.00 |

**Table 16. Maximum areas predicted to experience increases in SSC of more than 5 mg/l at any time.**

| Area | Sandwave Clearance | | Cable Burial: 100 m/hour | | Cable Burial: 500 m/hour | |
|---|---|---|---|---|---|---|
| | $m^2$ | % | $m^2$ | % | $m^2$ | % |
| Full Model Domain | 175475701 | - | 538850735 | - | 326724522 | - |
| Study Area | 175475701 | 3.42 | 538504760 | 10.48 | 325060635 | 6.33 |
| Outer Thames Estuary SPA | 38845 | 0.00 | 312738530 | 19.62 | 164052816 | 10.29 |
| Southwold Pier BW | 0 | 0.00 | 33132 | 23.60 | 0 | 0.00 |
| Southwold The Denes BW | 0 | 0.00 | 125136 | 100.00 | 0 | 0.00 |

**Table 17. Total time where SSC is predicted to experience increases of more than 5 mg/l.**

| Area | Sandwave Clearance | | Cable Burial: 100 m/hour | | Cable Burial: 500 m/hour | |
|---|---|---|---|---|---|---|
| | hours | days | hours | days | hours | days |
| Full Model Domain | 94.8 | 4 | 719.0 | 30 | 177.3 | 7 |
| Study Area | 94.8 | 4 | 719.0 | 30 | 177.3 | 7 |
| Outer Thames Estuary SPA | 0.8 | 0 | 423.2 | 18 | 88.4 | 4 |
| Southwold Pier BW | 0.0 | 0 | 0.9 | 0 | 0.0 | 0 |
| Southwold The Denes BW | 0.0 | 0 | 1.9 | 0 | 0.0 | 0 |

**Table 18. Total area predicted to experience sedimentation of more than 1 mm.**

| Area | Sandwave Clearance | | Cable Burial: 100 m/hour | | Cable Burial: 500 m/hour | |
|---|---|---|---|---|---|---|
| | $m^2$ | % | $m^2$ | % | $m^2$ | % |
| Full Model Domain | 785152 | - | 14331842 | - | 6427626 | - |
| Study Area | 785152 | 0.02 | 14331842 | 0.28 | 6427626 | 0.13 |
| Outer Thames Estuary SPA | 0 | 0.00 | 5801721 | 0.36 | 2734712 | 0.17 |
| Southwold Pier BW | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 |
| Southwold The Denes BW | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 |

# 6 Summary

As part of the NGV LionLink Subsea Cable Project, a hydrodynamic model of the Southern North Sea and English Channel has been configured in the Mike FM software suite and calibrated to replicate tidal water levels and flows in the study domain. The developed hydrodynamic model has been used to conduct sediment dispersion modelling which will support CEA's consultation process by determining the zone of influence over which suspended sediment may be dispersed as a result of cable burial activities.

The HD model was shown to replicate the key tidal characteristics including the shape, phasing and amplitude of the tidal variations in water level. The model also replicated the key flow features across the study area including the timing and magnitude of peak and slack flows, the areas of fastest tidal flows and the change from rectilinear to rotational flow from offshore to inshore.

The HD model was applied to drive a PT model to simulate the release and dispersion of fine sediment disturbed during installation of the LionLink subsea cable.

**Pre-sweeping:** Results show that increases in SSC of more than 5 mg/l are constrained within the Study Area and are short lived (generally occurring for less than 2.4 hours). Sedimentation is predicted to be less than 1 mm except for a localised area along the dredge track (constrained to within the proposed offshore HVDC Submarine Cable Corridor) and around the two placement locations, where sedimentation exceeds 10 mm. Sedimentation of more than 0.1 mm is constrained to within the Study Area.

**Cable Burial:** Results show that maximum increases in SSC of more than 5 mg/l are mainly constrained to within the Study Area. The only exception to this is associated with cable burial between KP5 and KP10 where the higher percentage of fines and closer alignment of the cable route with the flow direction could result in a build-up in SSC which is then advected beyond the Study Area by the relatively fast tidal flows. Increases in SSC of more than 5 mg/l are short lived (occurring for hours or less). Increases in SSC at the Sizewell B intake were predicted to be less than 0.5 mg/l. Increases in SSC at the Sizewell C intakes of up to 20 mg/l could occur for cable installation on spring tides, comprised mainly of clay sized sediment particles. Such increases are very short lived and given the fine sediment size would most likely remain in suspension within the cooling water system. The Sizewell C power station is not expected to be operational at the time of the LionLink cable installation, but similar sediment plumes could develop in the event of unforeseen cable repair, particularly within the section between KP3 and KP10. Undertaking repairs on neap tides and/or the ebbing tide could mitigate the risk of increased SSC at the Sizewell C intakes if the numbers quoted raise operational concerns for the power station. Sedimentation is predicted to be less than 1 mm except for a localised area along the proposed offshore HVDC Submarine Cable Corridor. Sedimentation of more than 0.1 mm is constrained to within the Study Area. No sedimentation of more than 0.1 mm is predicted to occur at the Sizewell B and Sizewell C intakes.

**Impacts at key receptors:** Neither the Haisborough Hammond and Winterton MPA nor the North Norfolk Sandbanks and Saturn Reef MPA were predicted to be affected by an increase in SSC of more than 5 mg/l or sedimentation of more than 1 mm as a result of the construction activities simulated in the model. Approximately 20% of the Outer Thames Estuary SPA (only considering the two polygons of the SPA which intersect with the proposed offshore HVDC Submarine Cable Corridor) is predicted to be affected by an increase in SSC of more than 5 mg/l, with the largest impact from cable burial at the slower installation rate of 100 m/hour. The area predicted to be impacted at any one time is much smaller, being less than 0.1% of the SPA areas which intersect the proposed offshore HVDC Submarine Cable Corridor. The duration of time where SSC is increased by more than 5 mg/l at any point within the Outer Thames Estuary SPA is 18 days, although the duration of time exceeded at any one point will be much less than this (order of hours). Less than 0.5% of the Outer Thames Estuary SPA is predicted to be affected by sedimentation of more than 1 mm thick, constrained within the proposed offshore HVDC Submarine Cable Corridor.

Approximately a quarter of the Southwold Pier BW and all of the Southwold the Denes BW are predicted to be affected by SSC of more than 5 mg/l at some point during the model simulation, but the impact time is short (1 to 2 hours).

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