DBS Offshore Wind

RWE Renewables UK Dogger Bank South (West) Limited

RWE Renewables UK Dogger Bank South (East) Limited

Dogger Bank South Offshore Wind Farms

Assessment of Coastal Processes at the Dogger Bank South Landfall

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Glossary

Term	Definition
Array Areas	The DBS East and DBS West offshore Array Areas, where the wind turbines, offshore platforms and array cables would be located. The Array Areas do not include the Offshore Export Cable Corridor or the Inter-Platform Cable Corridor within which no wind turbines are proposed. Each area is referred to separately as an Array Area.
Array Cables	Offshore cables which link the wind turbines to the Offshore Converter Platform(s).
Astronomical Tide	The predicted tide levels and character that would result from the gravitational effects of the earth, sun, and moon without any atmospheric influences.
Bathymetry	Topography of the seabed.
Beach	A deposit of non-cohesive sediment (e.g. sand, gravel) situated on the interface between dry land and the sea (or other large expanse of water) and actively 'worked' by present-day hydrodynamic processes (i.e. waves, tides and currents) and sometimes by winds.
Bedforms	Features on the seabed (e.g. sand waves, ripples) resulting from the movement of sediment over it.
Clay	Fine-grained sediment with a typical particle size of less than 0.002mm.
Climate Change	A change in global or regional climate patterns. Within this chapter this usually relates to any long-term trend in mean sea level, wave height, wind speed etc, due to climate change.
Closure Depth	The depth that represents the 'seaward limit of significant depth change', but is not an absolute boundary across which there is no cross-shore sediment transport.
Coastal Processes	Collective term covering the action of natural forces on the shoreline and nearshore seabed.
Cohesive Sediment	Sediment containing a significant proportion of clays, the electromagnetic properties of which causes the particles to bind together.

Term	Definition
Construction Buffer Zone	1km zone around the Array Areas and Offshore Export Cable Corridor, and 500m zone around the Inter-Platform Cabling Corridor. Construction vessels may occupy this zone but no permanent infrastructure would be installed within these areas.
Current	Flow of water generated by a variety of forcing mechanisms (e.g. waves, tides, wind).
Dogger Bank South (DBS) offshore wind farms	The collective name for the two Projects, DBS East and DBS West.
Ebb Tide	The falling tide, immediately following the period of high water and preceding the period of low water.
Effect	Term used to express the consequence of an impact. The significance of an effect is determined by correlating the magnitude of the impact with the value, or sensitivity, of the receptor or resource in accordance with defined significance criteria.
Erosion	Wearing away of the land or seabed by natural forces (e.g. wind, waves, currents, chemical weathering).
Expert Topic Group (ETG)	A forum for targeted engagement with regulators and interested stakeholders through the EPP.
Flood Tide	The rising tide, immediately following the period of low water and preceding the period of high water.
Glacial Till	Poorly sorted, non-stratified and unconsolidated sediment carried or deposited by a glacier.
Gravel	Loose, rounded fragments of rock larger than sand but smaller than cobbles. Sediment larger than 2mm (as classified by the Wentworth scale used in sedimentology).
High Water	Maximum level reached by the rising tide.

Term	Definition
Horizontal Directional Drill (HDD)	HDD is a trenchless technique to bring the offshore cables ashore at the landfall and can be used for crossing other obstacles such as roads, railways and watercourses onshore.
Hydrodynamic	The process and science associated with the flow and motion in water produced by applied forces.
In Isolation Scenario	A potential construction scenario for one Project which includes either the DBS East or DBS West array, associated offshore and onshore cabling and only the eastern Onshore Converter Station within the Onshore Substation Zone and only the northern route of the onward cable route to the proposed Birkhill Wood National Grid Substation.
Inter-Platform Cable Corridor	The area where Inter-Platform Cables would route between platforms within the DBS East and DBS West Array Areas, should both Projects be constructed.
Inter-Platform Cables	Buried offshore cables which link offshore platforms.
Intertidal	Area on a shore that lies between Mean High Water Springs (MHWS) and Mean Low Water Springs (MLWS).
Landfall	The point on the coastline at which the Offshore Export Cables are brought onshore, connecting to the onshore cables at the Transition Joint Bay (TJB) above mean high water.
Long-Term	Refers to a time period of decades to centuries.
Low Water	The minimum height reached by the falling tide.
Mean High Water Springs	MHWS is the average of the heights of two successive high waters during a 24 hour period.
Mean Low Water Springs	MLWS is the average of the heights of two successive low waters during a 24 hour period.
Mean Sea Level	The average level of the sea surface over a defined period (usually a year or longer), taking account of all tidal effects and surge events.
Megaripples	Bedforms with a wavelength of 0.6 to 10.0m and a height of 0.1 to 1.0m. These features are smaller than sand waves but larger than ripples.

Term	Definition
Neap Tide	A tide that occurs when the tide-generating forces of the sun and moon are acting at right angles to each other, so the tidal range is lower than average.
Nearshore	The zone which extends from the swash zone to the position marking the start of the offshore zone (~20m).
Numerical Modelling	Refers to the analysis of coastal processes using computational models.
Offshore	Area seaward of nearshore in which the transport of sediment is not caused by wave activity.
Offshore Development Area	The Offshore Development Area for ES encompasses both the DBS East and West Array Areas, the Inter-Platform Cable Corridor, the Offshore Export Cable Corridor, plus the associated Construction Buffer Zones.
Offshore Export Cable Corridor	This is the area which will contain the offshore export cables (and potentially the ESP) between the Offshore Converter Platforms and Transition Joint Bays at the landfall.
Offshore Export Cables	The cables which would bring electricity from the offshore platforms to the Transition Joint Bays (TJBs).
Pleistocene	An epoch of the Quaternary Period (between about 2 million and 10,000 years ago) characterised by several glacial ages.
Sand	Sediment particles, mainly of quartz with a diameter of between 0.063mm and 2mm. Sand is generally classified as fine, medium or coarse.
Sand Wave	Bedforms with wavelengths of 10 to 100m, with amplitudes of 1 to 10m.
Scour Protection	Protective materials to avoid sediment erosion from the base of the wind turbine foundations and offshore substation platform foundations due to water flow.
Sea Level	Generally, refers to 'still water level' (excluding wave influences) averaged over a period of time such that periodic changes in level (e.g. due to the tides) are averaged out.

Term	Definition
Sea-Level Rise	The general term given to the upward trend in mean sea level resulting from a combination of local or regional geological movements and global climate change.
Sediment	Particulate matter derived from rock, minerals or bioclastic matter.
Sediment Transport	The movement of a mass of sediment by the forces of currents and waves.
Shore Platform	A platform of exposed rock or cohesive sediment exposed within the intertidal and subtidal zones.
Short-Term	Refers to a time period of months to years.
Significant Wave Height	The average height of the highest of one third of the waves in a given sea state.
Spring Tide	A tide that occurs when the tide-generating forces of the sun and moon are acting in the same directions, so the tidal range is higher than average.
Surge	Changes in water level as a result of meteorological forcing (wind, high or low barometric pressure) causing a difference between the recorded water level and the astronomical tide predicted using harmonic analysis.
Suspended Sediment	The sediment moving in suspension in a fluid kept up by the upward components of the turbulent currents or by the colloidal suspension.
The Applicants	The Applicants for the Projects are RWE Renewables UK Dogger Bank South (East) Limited and RWE Renewables UK Dogger Bank South (West) Limited. The Applicants are themselves jointly owned by the RWE Group of companies (51% stake) and Masdar (49% stake).
The Projects	DBS East and DBS West (collectively referred to as the Dogger Bank South Offshore Wind Farms).
Tidal Current	The alternating horizontal movement of water associated with the rise and fall of the tide.
Tidal Range	Difference in height between high and low water levels at a point.

Term	Definition
Wave Climate	Average condition of the waves at a given place over a period of years, as shown by height, period, direction etc.
Wave Height	The vertical distance between the crest and the trough.
Wavelength	The horizontal distance between consecutive wave crests (or alternative troughs).
Wind Turbine	Power generating device that is driven by the kinetic energy of the wind.

Acronyms

Acronym	Definition
BGS	British Geological Survey
CBRA	Cable Burial Risk Assessment
CCO	Channel Coastal Observatory
CD	Chart datum
Cefas	Centre for Environment, Fisheries and Aquaculture
CPS	Cable Protection System
DBS	Dogger Bank South
DCO	Development Consent Order
DEFRA	Department for Environment, Food and Rural Affairs
DML	Deemed Marine Licence
EIA	Environmental Impact Assessment
ES	Environmental Statement
ETG	Expert Topic Groups
HDD	Horizontal Directional Drilling
IHO	International Hydrographic Organization
JNCC	Joint Nature Conservation Committee
LAT	Lowest astronomical tide
MCZ	Marine Conservation Zone
MHWS	Mean High Water Spring
MLWS	Mean Low Water Spring
MMO	Marine Management Organisation
NCERM	National Coastal Erosion Risk Mapping

Acronym	Definition
NE	Natural England
OD	Ordnance datum
OECC	Offshore Export Cable Corridor
RCP	Representative Concentration Pathway
SAC	Special Area of Conservation
SSSI	Site of Special Scientific Interest
UKCP	UK Climate Projections
WCS	Worst Case Scenario
WFD	Water Framework Directive

1 Introduction

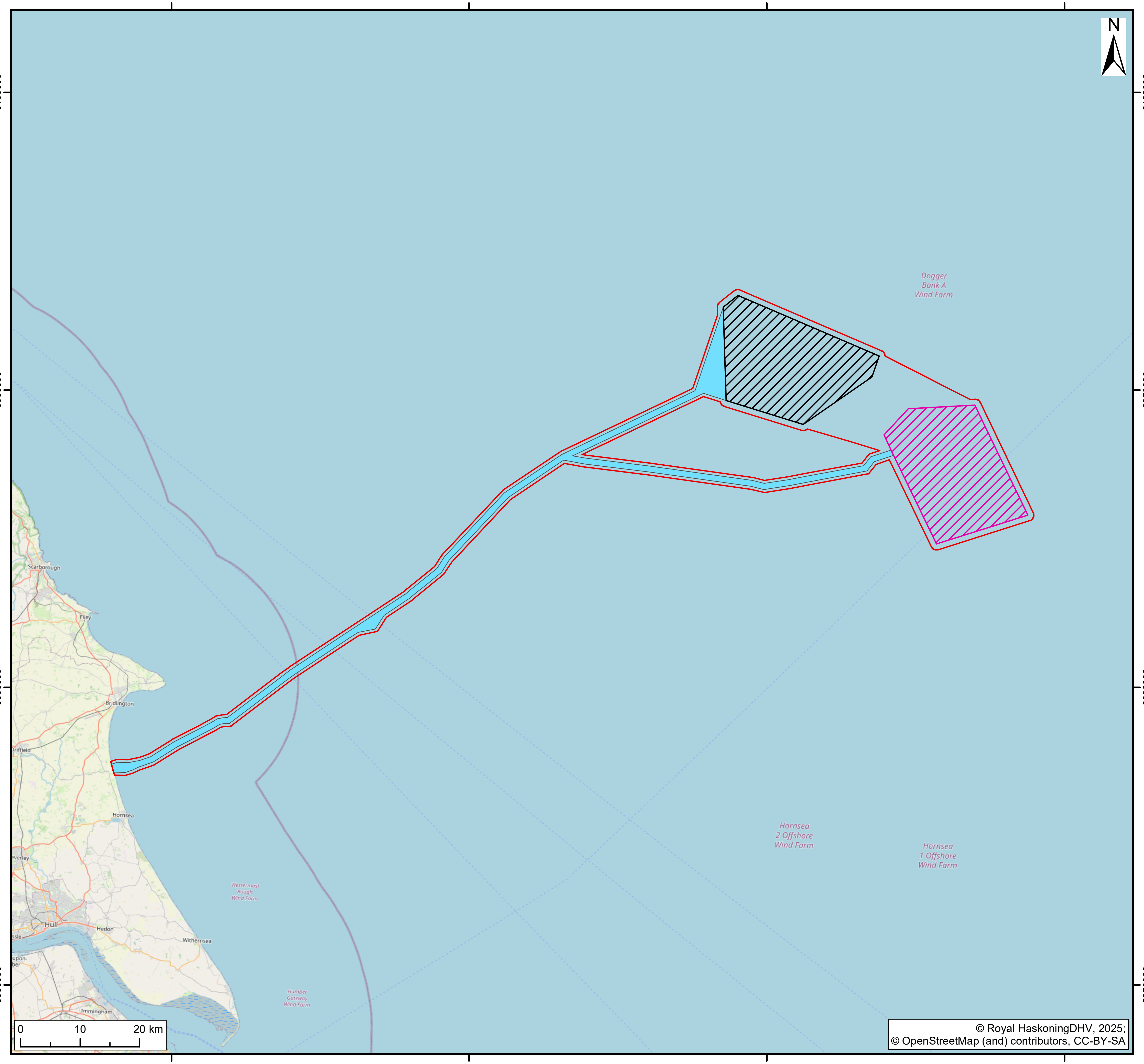
RWE Renewables UK Dogger Bank South (East) Limited and RWE Renewables UK Dogger Bank South (West) Limited (hereafter referred to as 'The Applicants'). are proposing to develop the Dogger Bank South (DBS) offshore wind farms (DBS) (hereafter referred to as 'the Projects') comprising Dogger Bank South East and Dogger Bank South West in the southern North Sea, approximately 100-120km off the Yorkshire coast (**Figure 1-1**).

Within **Chapter 8 Marine Physical Environment** [APP-080], an assessment of changes in bedload sediment transport due to cable installation activities at the landfall (operational effect) and due to the presence of cable protection measures (operational impact) was undertaken based on the worst case scenario at the time of Development Consent Order (DCO) submission.

This technical note provides supplementary information, including the results of new sediment transport modelling, to address the comments and questions raised by interested parties during examination (see **Table 2-1**) in relation to the following topics:

- Nearshore cable protection measures and their potential effect on longshore and nearshore sediment transport pathways;
- Defining sediment transport pathways in the Array Areas to support the assessment of effects on bedload sediment transport due to the presence of cable protection measures within the Dogger Bank SAC; and,
- Updating the assessment of effects at the landfall following changes to the project parameters outlined **in Project Change Request 1 – Offshore and Intertidal Works** [AS-141].

It should be noted that the information provided in this report will be incorporated into the next revisions of **Chapter 8 - Marine Physical Environment** [APP-080] and **Appendix 8-3 - Marine Physical Processes Modelling Technical Report (Revision 3)** [REP2-017] to be submitted at Deadline 7 of Examination.



Legend:

- Offshore Development Area
- DBS West Array Area
- DBS East Array Area
- Offshore Export Cable Corridor

SUI	REV	DATE	DESCRIPTION	DRW	CHK	APR
S2	P01	16/04/2025	Suitable for information	SM	CC	

Title:

Location of the Offshore Development Area

Figure: 1-1 | Drawing No: PC2340-RHD-OF-ZZ-DR-Z-1042

Co-ordinate system: WGS 1984 UTM Zone 31N | Page Size: A3 | Scale: 1:650,000

Project: Dogger Bank South Offshore Wind Farms

Report: 14.7 Review of Flamborough Front

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DBS Offshore Wind

2 Summary of comments and questions

The Applicants have been consulting with interested parties during the examination period. A record of comments and questions, and the Applicants responses have been collated in **Table 2-1**. The key points raised are summarised as follows.

2.1 Nearshore cable protection

Throughout the examination period, Natural England and the Marine Management Organisation (MMO) have raised comments and questions about the requirements for cable protection measures across the Projects. Within the nearshore, Natural England have advised that no remedial (surface laid) cable protection should be placed on the seabed in water depths less than 10m. However, due to the presence of shallow chalk bedrock in the nearshore, the Applicants cannot exclude the requirement for protection but have instead committed to not installing any remedial cable protection between 350m seaward of the mean low water spring datum to the 10m water depth contour, and have also committed to reducing the maximum height of the cable protection within the nearshore from 1.4m to 0.5m.

Despite these commitments, Natural England and the MMO are concerned these cable protection measures will disrupt sediment longshore and nearshore sediment transport pathways potentially affecting coastal receptors including Smithic Bank, the Holderness Inshore MCZ and the Humber Estuary SAC. They maintain a position that they disagree with the assessment of bedload transport at the landfall due to cable installation activities and the presence of cable protection measures.

The Applicants have undertaken a conceptual assessment using published literature, empirical equations and expert judgment to provide the evidence base to inform the assessment outlined in **Chapter 8 Marine Physical Environment** [APP-080] (noting this approach has always been considered appropriate and proportionate for all other offshore wind farm Environmental Impact Assessments [EIAs], including those making landfall on the Holderness coast). However, to support the conclusions of the assessment in relation to nearshore cable protection measures, they have committed to undertaking sediment transport modelling at the landfall. The results of this modelling are presented below in section 5.4.

2.2 Offshore cable protection

Questions and comments about cable protection measures are not limited to the nearshore area and there has been ongoing discussion through examination about the effect of cable protection measures on the Dogger Bank SAC. Natural England advised a seabed mobility assessment is carried out to inform the cable burial risk assessment. This was undertaken prior to submission of the DCO - the results were used to inform the assessment outlined in **Chapter 8 Marine Physical Environment** [APP-080] and the full technical report was provided at Deadline 3 (**Bed Mobility and Thermal Environment** [REP3-032]).

However, Natural England have maintained their position that there is insufficient information to support the assessment of changes to bedload sediment transport and seabed morphology due to the presence of cable protection measures on Dogger Bank. The Applicants have committed to compiling all available information regarding sediment transport to provide a supplementary figure showing sediment transport pathways within the Array Areas. The data and information underpinning this figure is not new and is already available in **Chapter 8 Marine Physical Environment** [APP-080] and **Bed Mobility and Thermal Environment** [REP3-032]). However, a narrative is provided in section 5 to support interpretations of this figure in relation to the assessment of changes in bedload sediment transport due to cable protection measures.

2.3 Update to assessment of significance at the landfall

The Applicants submitted a change request to the Examining Authority, which was accepted into examination on the 21st January 2025. As part of this request, there were changes to the project parameters at the landfall which removed the 'short' trenchless option with exit pits in the intertidal zone and committed to a 'long' trenchless option with exit pits in the subtidal zone (see Table 3-2 of **Project Change Request 1 – Offshore and Intertidal Works** [AS-141]). This resulted in a change to the worst case scenario underpinning the original assessment and following advice, the Applicants have committed to updating the marine physical environment assessment of effects at the landfall. These updates are presented below in section 7.

Table 2-1 Comments and responses to date

ID	Comment	Response
The Applicants' Responses to Written Representations [REP2-057]		
REP1-074:1.9.10	1.9.10 The MMO notes NE's concerns that the conservation objectives for the Holderness Inshore MCZ would be hindered regarding cable protection being placed on the nearshore causing permanent disruption to nearshore and longshore sediment transport on the Holderness Coast and impact features of the Holderness Inshore MCZ, the Humber Estuary SAC and Smithic Bank.	Please see the Applicants response to NE stated in Response to Natural England's Relevant Representations [AS-048] (RR-039: NE3) below: '*The Applicants' position is that any Offshore Export Cables associated with the Projects will be buried beneath the intertidal zone at the landfall, and 350m seaward of mean low water spring (MLWS). No seabed cable protection will be used within these areas. Cable protection will be limited to 10% of the cumulative length of all cables laid between 350m seaward of MLWS and the 10m depth contour as measured against the lowest astronomical tide before the commencement of construction. This is secured in condition 3 of the DMLs 3 and 4 of the Draft DCO [APP-027]. The final locations and volumes of cable protection will not be known until later in the project development cycle. The assessment presented in section 8.7.4.5 of Chapter 8 Marine Physical Environment [APP-080], which identified no likely significant effects in EIA terms, is based on the application of these embedded mitigation measures, with the receptors assessed being informed by the Benthic Ecology and Physical Processes Expert Topic Group (ETG) held on 29th January 2024 (see record of the minutes from this meeting in Appendix F1 - Minutes of meetings – ETG [APP-043].*' The assessment presented in section 8.7.4.5 of Chapter 8 Marine Physical Environment [APP-080] considers the effect of cable protection in relation to bedload transport and states: "*if the protection does present an obstruction to this bedload transport the sediment would first accumulate on one side or both sides of the obstacle (depending on the gross and net transport at that location) to the height of the protrusion (up to 1.4m). With continued build-up, it would then form a 'ramp' over which sediment transport would eventually occur by bedload processes, thereby bypassing the protection. The gross patterns of bedload transport across the export cables would therefore not be affected significantly.*"
REP1-074:2.3.1	2.3 Coastal processes 2.3.1 The MMO notes that NE has suggested that the need for 10% of cumulative cable length to be protected within the nearshore zones could be reduced and named examples from Northern Endurance Partnership and Hornsea Project Four where this has been done successfully. The MMO agrees that the cable protection should be reduced as much as possible to prevent any disruption within the nearshore zone. It has also been suggested that beach profile change monitoring should be undertaken regardless of the location of the trenchless technique to confirm beach recovery and monitor cable burial success. The MMO also agrees that this should be undertaken.	The Applicants acknowledge this comment and can confirm that the use of remedial cable protection will be minimised as far as is practicable, evidencing its use, where it might be deemed necessary, through Cable Burial Risk Assessments supported by site information obtained through field surveys. The evidence that the Applicants hold relating to ground conditions in the nearshore section of the Offshore Export Cable Corridor suggest that cable protection may be needed in this location. The Applicants note that the DBS Projects make landfall in a location that that is different to those used by the projects named. It might reasonably be expected that ground conditions are also different at these locations, as the composition of the sea floor can vary greatly across small spatial scales. Thus, the Applicants suggest that limited parallels of relevance to DBS can be drawn from these projects. As part of Project Change Request 1 – Offshore and Intertidal Works [AS-141], the Projects have removed the short trenchless crossing at landfall. Therefore, the trenchless bore exit pits will not be located on the beach so there will be no recovery from cable installation activities at Landfall as there is no impact. Therefore, the Applicants disagree with the need to monitor beach recovery. The bore will be located at a sufficient depth below the beach to ensure it is not exposed during the lifetime of the Project. An assessment of beach platform lowering over a 16 year period was undertaken and the results outlined in the Coastal Erosion Rate Technical Note (AS-116). The results show that there is both erosion and accretion over short time scales (<5 years). Over the medium term (16 years) the morphology of the intertidal area remained relatively unchanged. The study covered a 2km stretch of the coast and will be used to support the approach to trenchless cable installation at the landfall
The Applicants' Reponses Deadline 2 Documents [REP3-028]		

ID	Comment	Response
REP2-064:2	**Nearshore cable protection** <u>Natural England's Risk and Issues Log Deadline 2, Point B23</u> Natural England have previously advised [RR-039] that we cannot rule out an adverse effect on integrity for the Humber Estuary SAC due to the current condition allowing 10% of the cumulative export cable length to be protected from 350m seaward of MLWS to the 10m depth contour. Whilst we welcome the Applicant's commitment to the separate bundling of pairs of the export cables outlined in the updated Cable Statement [AS-079], we note that it has not been secured in the DCO and updated cable protection estimates and assessments have not been provided. *We also note the Applicant's response [AS-048] which states that for navigational safety, cable protection within the 10m depth contour would be limited to a height of no greater than 50cm and as such rock placement would not be used in this area with alternative solutions to be considered such as mattresses. However, this is also not a commitment that has been secured and no evidence has been provided to demonstrate that 50cm will not disrupt longshore sediment transport towards the Humber Estuary SAC and Spurn Point. We therefore advise that further evidence is provided, or that the original commitments advised in our Relevant Representation are secured.*	Regarding cable bundling, the Applicants direct Natural England to the response (REP1-067:B49) in The Applicants' Responses to Deadline 1 Documents [REP2-058] which states: '…The commitment to cable bundling has been made in the Cable Statement (Revision 2) [AS-078]. Each Deemed Marine Licence (Schedules 10-14) presented in the Draft DCO (Revision 5) [REP1-004] contains a condition (such as condition 15 (1) (g) in Schedule 10) which states that construction activities may not commence until a final cable statement (in accordance with the cable statement) has been submitted to and approved in writing by MMO, in consultation with Trinity House, the MCA, the relevant statutory nature conservation body and UKHO as appropriate. Through this mechanism this commitment is secured by the Draft DCO as it stands and no updates to the Application are necessary.' The Applicants note that the height of cable protection is secured in the Deemed Marine Licences (DMLs) and direct Natural England to the response as stated in the Response to Natural England's Relevant Representation [AS-048]. *(RR-039:B35) …'Regarding the potential height of cable protection measures within the 10m depth contour, as noted in paragraph 189 of Chapter 14 Shipping and Navigation [APP-121] the Applicants would follow the guidance contained in MGN 654 in relation to cable protection, namely that cable protection would not change the charted water depth by more than 5%, unless otherwise agreed with the Maritime and Coastguard Agency and Trinity House. This commitment is secured within the following conditions of the DMLs:* *• DML 1 & 2 – Condition 15;* *• DML 3 & 4 – Condition 13; and* *• DML 5 – Condition 11.* *As such, within the 10m depth contour the Applicants would be limited to a cable protection height of no greater than 50cm. Therefore, rock placement would not be used within the 10m depth contour, with other design solutions (such as concrete mattresses) being required should a need for cable protection measures be identified in the final design of the Projects.'* The Applicants have assessed changes to bedload sediment transport due to cable protection measures as having a negligible significance of effect (see Section 8.7.4.5. of Chapter 8 Marine Physical Environment [APP-084]). The evidence base to support this assessment is presented in paragraph 298 which is restated below: *'In a study at Easington along south Holderness, HR Wallingford (2011) showed that most of the longshore transport from wave breaking occurs close to the shoreline, within approximately 250m of the cliff line. Seaward of this, the wave-driven sediment transport is effectively zero. Given the similar shore profile gradients at the landfall and Easington (East Riding of Yorkshire Council, 2014) the conclusion can be drawn that the active zone at the landfall is similar in width to that at Easington. Hence, sediment transport driven by waves seaward of 250m from the cliffs at the landfall is very low (although still within the closure depth) and there will be no effect on these processes by the presence of the cable protection structures.'* The Applicants have committed to limiting the length of cable protection measures in the nearshore to 10% of the distance from 350m of Mean Low Water Springs (MLWS) to the 10m water depth contour. The maximum distance between these two points within the Offshore Export Cable Corridor is 1164m. Therefore, the approximate length of cable protection measures would be 116m per cable trench (assuming the cables were laid in a straight line). At these lengths they would not create a complete blockage effect to longshore sediment transport. This indicative length of cable protection is shown Figure C-1 in Appendix C of this document. They will also only protrude 50cm above the seabed, so would not create a complete blockage effect in the water column and sediment would bypass the structures both over and around them. Therefore, there would be no effect in terms of sediment supply to the

ID	Comment	Response
		Humber Estuary Special Area of Conservation (SAC) and Spurn Point which are located 40km away from the landfall, especially considering the extremely high volumes of sediment delivered to the Holderness coast through cliff erosion, given it is the fastest eroding coast in the UK. To further demonstrate the limited effects that cable protection in the nearshore environment would have, the Applicants are undertaking modelling of an indicative case of this feature and the effect it would have on the wave regime in the area – given that wave generated currents are the principal driver of sediment movement in the vicinity of the Projects' landfall location. A technical note detailing this modelling will be provided at Deadline 5.
REP2-069:B23	*We cannot rule out an adverse effect on integrity for the Humber Estuary SAC due to the current condition allowing 10% of the cumulative export cable length to be protected from 350m seaward of MLWS to the 10m depth contour. We advise that alternative methods of cable burial and/or protection should be explored in line with the mitigation hierarchy, to remove or reduce the need for cable protection between MLWS and the 10m contour. If cable protection is not removed from the project envelope, the commitment and associated DCO condition should be refined to only placing cable protection within -9 and -10m below LAT, as the Applicant has already identified this as being the area potentially requiring cable protection. See also C13. (6.1, 7.5, 7.8)* No change - See Appendix B2 of Natural England's Deadline 2 submission for further detail.	See the Applicants' response to this matter in Table 2-6, REP2-064:2 above.
REP2-069:B28	*There is insufficient information regarding the location and significance of cable crossings and nearshore cable protection measures relative to Smithic Bank to support the assessment conclusions. The potential exchange of sediment between South Smithic and the Holderness Coast should be considered when assessing impacts to the nearshore and circulatory sediment transport processes due to the presence of nearby cable protection measures and cable crossings. (7.8)* No change. We continue to advise that more detailed information is needed regarding the proposed cable crossing with the Hornsea Four export cable corridor, and its proximity, to Smithic Bank, in order to better understand potential impacts on nearshore sediment transport processes.	The Applicants maintain their position regarding this matter as provided in response to RR-039: B42 in the Response to Natural England's Relevant Representations [AS-048] and reiterated below: *The sediment transport processes controlling the development and evolution of Smithic Bank are landscape-scale, both spatially and temporally. Bathymetry evidence suggests that since 1979 there have been large-scale changes to the morphology of the bank over wide areas, including areas that will be occupied by the proposed Offshore Export Cable Corridor. These changes constitute a significant movement of large volumes of sand, which will continue. The volume of sand transport that will be interrupted by any cable protection near Smithic Bank will be extremely small (orders of magnitude less) in comparison to the much larger volume being transported due to natural physical and sedimentary processes. Hence, the continued high-volume movement of sand within and around Smithic Bank will not be significantly affected by the relatively small volumes of sand that may be intercepted by the cable protection. See Figure 8-2 - Location and Indicative sediment transport pathways across Smithic Bank derived from bedform geometry (in Chapter 8 - Marine Physical Environment Figure 8-1 to Figure 8-13 [APP-081]) which presents the Offshore Export Cable Corridor in relation to the Smithic Bank (as delimited by the Joint Nature Conservation Committee (JNCC)).* *There will also be no potential for effect on bedload sediment transport at cable protection at cable crossing points. This is because the locations of the crossings are outside and seaward of the boundary of Smithic Bank on a coarse seabed in deeper water and not subject to processes driving the bank evolution. The nearest crossing is with the Hornsea Project Four cable corridor to the east of the bank. The positions of the cable crossings are outside the sediment transport pathway controlling the form and function of Smithic Bank or any sediment exchange with the coast.* Regarding the proposed cable crossing with the Hornsea Four export cable corridor, as detailed in Table 5-17 of Chapter 5 Project Description (Revision 3) [REP1-009] the maximum estimated parameters for Offshore Export Cable crossings are as follows: • Maximum estimated width per crossing – 15.2m

ID	Comment	Response
		• Maximum estimated length per crossing – 400m • Maximum estimated height per crossing – 1.4m As the exact routing of the Hornsea Project Four offshore export cables will not be known until that project enters its detailed design phase, it is not yet known where exactly the Projects Offshore Export Cables would cross the Hornsea Project Four offshore export cable. As such, the Applicants are unable to provide any more detailed information regarding the Hornsea Project Four offshore export cable crossing at this time. To help indicate where any crossings may take place, the Applicants have provided Figure D-1 in Appendix D which details the location where the Hornsea Project Four export cable route and the Projects Offshore Export Cable Corridor overlap, and hence where any crossings may occur.
REP2-069:B29	*There is insufficient information to support the assessment of changes to bedload sediment transport and seabed morphology due to the presence of cable protection measures on Dogger Bank. We advise that, firstly, the Applicant should attempt cable burial across Dogger Bank to avoid placement of cable protection measures within Dogger Bank SAC. Secondly, a seabed mobility assessment should be carried out to inform the cable burial assessment and, thus, the requirement for cable protection measures. Lastly, if cable protection measures are found to be necessary, potential changes to seabed sediment transport processes and seabed morphology should be fully assessed for the WCS option for cable protection measures on Dogger Bank. (7.8)* No change - See Appendix B2 of Natural England's Deadline 2 submission for further detail.	See the Applicants' response to this matter in Table 2-6, REP2-064:3 above. The Applicants note that first principle of cable protection is for cables to be buried. The final CBRA for the Projects will be written to maximise cable burial wherever the seabed conditions allow. Installation of any additional cable protection measures represents a risk mitigation measure, with the Applicants committing to minimising the use of external cable protection measures in commitment C092 of the Commitments Register (Revision 2) [REP2-025], as secured in the Cable Statement (Revision 3) [REP2-039] The Bed Mobility & Thermal Environment [document reference: 13.7], previously used to inform Chapter 8 - Marine Physical Environment [APP-080] and referenced in that chapter, has been submitted at Deadline 3 to provide further evidence of the work the Applicants have undertaken to characterise the baseline environment within the Offshore Development Area.
REP2-069:B9	*We advise that identification of regional scale sediment transport pathways is an important part of the baseline characterisation. Sediment transport pathways have been identified only for the landfall, adjacent coastline, nearshore and westernmost section of the Offshore Export Cable Corridor (OECC). We advise the Applicant to establish or infer sediment transport pathways for the remainder of the OECC and array areas. (7.8.1)* No change. We continue to advise that the Applicant should seek to establish a baseline characterisation of the sediment transport pathways that may be affected by the presence of the DBS projects	The Applicants maintain their position regarding this matter as provided in response to RR-039: B19 in the Response to Natural England's Relevant Representations [AS-048] and reiterated below: *A search of available evidence regarding regional sediment transport pathways along the Offshore Export Cable Corridor reveals no relevant information is available. Research into regional pathways is restricted to areas south of the Offshore Export Cable Corridor (e.g. Kenyon & Cooper, 200524; the Southern North Sea Sediment Transport Study25; DTI Strategic Environmental Assessment26). Details of seabed mobility specific to the Offshore Export Cable Corridor are presented in detail in Section 8.5.8 of Chapter 8 Marine Physical Environment [APP-080] which is a more useful baseline for impact assessment than regional information.* The Applicants cannot provide more information on the identification of regional sediment transport pathways other than that referenced above. The spatial limitations to our baseline assessment are driven by the availability of published literature and information, and also the location of marine bedforms that are used to understand sediment transport pathways. There are no regional scale marine bedforms in 'the remainder of the OECC and array area' to provide information on sediment transport pathways in these areas. Therefore, we rely on the tidal current directions to infer sediment transport direction which is defined in section 8.5.5. of Chapter 8 Marine Physical Environment [APP-080]. If Natural England are aware of any other data sources in addition to those referenced in this response, the Applicants can consider these and provide a further update on this item later in the examination process. To this end, we await the provision of any further information or advice from Natural England.
REP2-064:3	**Changes to bedload sediment transport and seabed morphology**	The Applicants would like to reiterate that the final version of the CBRA will not be completed within the time frame of examination. There will also be no updates to the existing CBRA within the time frame of examination. This is because there is no new information or data available to the Applicants that can provide any further

ID	Comment	Response
	Natural England's Risk and Issues Log Deadline 2, Point B29 Natural England previously advised [RR-039] that there is insufficient information to support the assessment of changes to bedload sediment transport and seabed morphology due to the presence of cable protection measures on Dogger Bank. We advised seabed mobility assessment should be carried out to inform the cable burial assessment and, thus, the requirement for cable protection measures. The Applicant has clarified in [AS-156] 'The Applicants' Responses to January 2025 Hearing Action Points (Revision 2) (Tracked)' that the Cable Burial Risk Assessment (CBRA) and cable routing studies will include seabed mobility assessment, but that final versions of these documents are unlikely to submitted during the Examination process. Natural England do not expect final versions of these documents to be submitted within Examination timeframes, but we advise that endeavours are made to provide updated outline versions including a more detailed assessment on bedform migration rates and directions, thickness of the mobile sediment layer and distribution, scour potential, and a refinement of the sediment transport model (including consideration of predicted wave height changes and increased storminess).	understanding than has already been documented. The Applicants are in the process of planning additional surveys for summer 2025. When the results become available, they will feed into the CBRAs as they are further updated post consent. The final CBRAs will be appended to any final Cable Statements submitted by the Applicants in fulfilment of the relevant DML Conditions relating to this matter, such as condition (such as condition 15 (1) (g) in Schedule 10). Hence, Natural England will have sight of, and opportunity to comment on, these documents and any related engineering proposals as part of the DML condition discharge process. The current understanding of seabed mobility is outlined in section 8.5.8. of Chapter 9 Marine Physical Environment [APP-080]. This baseline understanding is based on a Projects-specific seabed mobility study undertaken by the Applicants to inform the assessment (MarineSpace, 2023). The study assesses multiple bathymetric surveys to quantify bed level change and shows that levels of change are of the order of 0.2m over an 11 year period in the Array Area. This study has been provided for consideration during the examination period, see the Bed Mobility & Thermal Environment [document reference: 13.7] submitted at Deadline 3. As noted above, it is expected this document will be superseded as further site investigation and design work is completed prior to construction. The Applicants re-iterate that, as noted above, there are protections written into the Draft DCO that will ensure that Natural England have the opportunity to review the information requested once it is available as part of the process of discharging DML conditions.
The Applicants' Responses to Deadline 3 Documents and Additional Submissions [REP4-088]		
REP3-060: B23	Initial Relevant Representation - *We cannot rule out an adverse effect on integrity for the Humber Estuary SAC due to the current condition allowing 10% of the cumulative export cable length to be protected from 350m seaward of MLWS to the 10m depth contour. We advise that alternative methods of cable burial and/or protection should be explored in line with the mitigation hierarchy, to remove or reduce the need for cable protection between MLWS and the 10m contour. If cable protection is not removed from the project envelope, the commitment and associated DCO condition should be refined to only placing cable protection within -9 and -10m below LAT, as the Applicant has already identified this as being the area potentially requiring cable protection. See also C13. (6.1, 7.5, 7.8).* Deadline 3 status - No change. Please see B49 with respect to further action needed in response to the Applicant's updated Cable Statement [REP2-040] which could progress this issue.	To further demonstrate the limited effects that cable protection in the nearshore environment would have, the Applicants are undertaking modelling of an indicative case of this feature and the effect it would have on the wave regime in the area – given that wave generated currents are the principal driver of sediment movement in the vicinity of the Projects' landfall location. A technical note detailing this modelling will be provided at Deadline 5.
REP3-051.3	<u>Section 8.1.4</u> Natural England welcomes the proposal of a subtidal exit pit. Whilst we agree with the Applicant that this has the potential to reduce the risk of sediment transport being disrupted, further evidence is required to demonstrate whether project mitigation is sufficient. Natural England advises that further evidence is presented on the reduction in sediment transport disruption.	To further demonstrate the limited effects that cable protection in the nearshore environment would have the Applicants are undertaking modelling of an indicative case of this feature and the effect it would have on the wave regime in the area. The modelling is focused on wave generated currents given they are the principal driver of sediment movement in the vicinity of the Projects' landfall location. A technical note detailing this modelling will be provided at Deadline 5. In addition, the Applicants provided Figure C-1 in Appendix C of The Applicants' Responses to Deadline 2 Documents [REP3-028] which illustrates the potential worst case extent of protection in the worst case location in the nearshore area at a regional scale.

ID	Comment	Response
REP3-057: MCZ.1.2	(ExQ1) *Are you satisfied that the Applicants' proposed mitigation reduces the risk of activities associated with the Proposed Development to a level that has no significant risk of hindering the conservation objectives of the Holderness Inshore and Holderness Offshore MCZs? If so, are you satisfied with the way this is secured in the draft DCO? If not, can you explain how you consider the draft DCO should be amended?* Natural England is satisfied that there are no significant risks that would hinder the conservation objectives of the Holderness Offshore MCZ. For Holderness Inshore MCZ, we are satisfied that mitigation to avoid direct impacts (i.e. no jack up vessels or anchoring within the MCZ) have been appropriately secured within the draft DCO. However, we advise that the conservation objectives could be hindered due to the current DML condition allowing 10% of the export cable to be protected from 350m seaward of MLWS to the 10m depth contour. Further, we highlight that the updated CBRA assessment [REP2-040] indicates that more of the export cable route is expected to be difficult to achieve target burial depth in than previously predicted, although the export cables now also to be bundled. We advise that the Applicant should provide updated information on the areas this would fall within in the 10m depth contour, and the implications for Holderness Inshore MCZs.	To further demonstrate the limited effects that cable protection in the nearshore environment would have, the Applicants are undertaking modelling of an indicative case of this feature and the effect it would have on the wave regime in the area – given that wave generated currents are the principal driver of sediment movement in the vicinity of the Projects' landfall location. A technical note detailing this modelling will be provided at Deadline 5.

3 Realistic worst case scenario

The Applicants' submitted **Project Change Request 1 - Offshore & Intertidal Works** [AS-141] to the Examining Authority, which was accepted into examination on the 21st January 2025. The following changes are relevant to the topics discussed in this technical note:

- Change 4: Reduction of cabling within the Array Areas, plus associated seabed preparation and cable protection; and
- Change 5: Removal of the short trenchless crossing at the landfall.

In addition, the Applicants have committed to the bundling of Offshore Export Cables in pairs (secured within the **Cable Statement (Revision 4)** [document reference: 8.20]), which is itself secured within in the **Draft Development Consent Order (DCO) (Revision 8)** [document reference: 3.1] under Condition 15 of Deemed Marine Licences (DMLs) 1 and 2, Condition 13 of DMLs 3 and 4 and Condition 11 of DML 5.

Table 3-1 below details the changes to the marine physical environment realistic worst case scenario in relation to the topics discussed in this technical note.

Table 3-1 Realistic worse case scenario parameters relevant to the topics discussed in this technical note

	Parameter			
	DBS East in isolation	**DBS West in isolation**	**DBS East and West concurrently and / or in sequence**	**Notes and rationale**
Construction - In the instance of sequential development of the two Projects, up to a two-year lag between construction activities is possible, final overall area would be identical to the concurrent design scenario				
Changes in suspended sediment concentration and transport due to trenchless crossing installations Changes to bedload sediment transport due to cable installation at the landfall	No. of trenchless duct installations = 3 Trenchless transition bore spacing = 10-100m Size of each landfall exit pit – 26m length x 6m width x 6m depth Total volume of sediment excavated from landfall exit pits = 2,808m^3	No. of trenchless duct installations = 3 Trenchless transition bore spacing = 1 10-100m Size of each landfall exit pit – 26m length x 6m width x 6m depth Total volume of sediment excavated from landfall exit pits = 2,808m^3	No. of trenchless duct installations = 6 Trenchless transition bore spacing = 10-100m Size of each landfall exit pit – 26m length x 6m width x 6m depth Total volume of sediment excavated from landfall exit pits = 5,616m^3	If DBS East and DBS West are built together there will be one phase of trenchless duct installation. Technique for trenchless cable installation is not yet decided, however Horizontal Directional Drilling (HDD) is preferred. Number of trenchless duct installations assumes ducts for two power cables, one communications cable and one spare for each Project In Isolation Landfall exit pits would be located within the subtidal area only. Volumes of sediment disturbed by subtidal exit pit installation assumed to fall within volumes of sediment disturbed during cable installation activities.
Operation				
Changes to bedload sediment transport and seabed morphology due to the presence of cable protection measures	<u>Seabed footprint of cable protection</u> Total footprint of array cable protection – 326,700m^2 Total footprint of inter-platform cable protection – 37,088m^2 Total footprint of export cable protection – 502,421m^2 Estimated number of array / inter-platform cable pipeline / cable crossings – 21 Total footprint of pipeline / cable crossing material (array cables and Inter-Platform Cables) – 55,200m^2 Total number of cable crossing for export cable - 12	<u>Seabed footprint of cable protection</u> Total footprint of array cable protection – 326,700m^2 Total footprint of inter-platform cable protection – 37,088m2 Total footprint of export cable protection – 396,750m^2 Estimated number of array / inter-platform cable pipeline / cable crossings – 21 Total footprint of pipeline / cable crossing material (array cables and Inter-Platform Cables) – 55,200m^2 Total number of cable crossing for export cable - 12	<u>Seabed footprint of cable protection</u> Total footprint of array cable protection – 653,400m^2 Total footprint of inter-platform cable protection – 247,760m^2 Total footprint of export cable protection – 899,171m^2 Estimated number of array / inter-platform cable pipeline / cable crossings – 53 Total footprint of pipeline / cable crossing material (array cables and Inter-Platform Cables) – 175,040m^2 Total number of cable crossing for export cable - 24	Cable protection measures will include a combination of rock or gravel burial (rock berms), concrete mattresses, protective aprons or coverings, bagged solutions and bridging. The worst case will be for small wind turbines as they are greater in number and require a greater length of cable which may require protection. Assumes 10% of the route will require remedial protection within the Dogger Bank SAC site boundary. Assumes 20% of the of the route will require remedial protection outside of the Dogger Bank SAC site boundary. Nearshore cable protection will be limited to between 350m seaward of the

	Parameter			
	Total footprint of pipeline / cable crossing material (export cables) – 73,600m² Total seabed footprint of all cable protection - 995,009m²	Total footprint of pipeline / cable crossing material (export cables) – 73,600m² Total seabed footprint of all cable protection - 889,338m²	Total footprint of pipeline / cable crossing material (export cables) – 147,200m² Total seabed footprint of all cable protection - 2,122,571m²	men low water spring datum and the 10m water depth contour. Offshore Export Cables will be buried in pairs in a single trench per Project.

Deemed Marine Licences (DMLs) 3 and 4 presented within the Draft DCO [document reference 3.1] contain conditions (Condition 3 within each DML) which restrict the deposition of cable protection entirely between Mean High Water Springs and 350 metres seaward of Mean Low Water Springs. Within the area between 350 metres seaward of MLWS and the 10-metre depth contour as measured against Lowest Astronomical Tide (as at the date of commencement of construction of the licensed activities), no more than 10% of the length of the Offshore Export Cables will be protected.

Based on these commitments, the worst case location of cable protection measures in the nearshore would be in the shallowest water depths, where waves would have the greatest potential to mobilise and transport sediment. For the purpose of the numerical modelling presented in section 4, the location of the proposed nearshore cable protection structures are defined in **Table 3-2** and **Figure 3-1**.

The nearshore cable protection consists of two parallel hump-like structures which are 50m apart and have the same length. The dimensions of the modelled nearshore cable protection are as follows: Length 140m, Width 15m and Height 0.5m.

Table 3-2 Coordinates of nearshore cable protection lengths 1 and 2

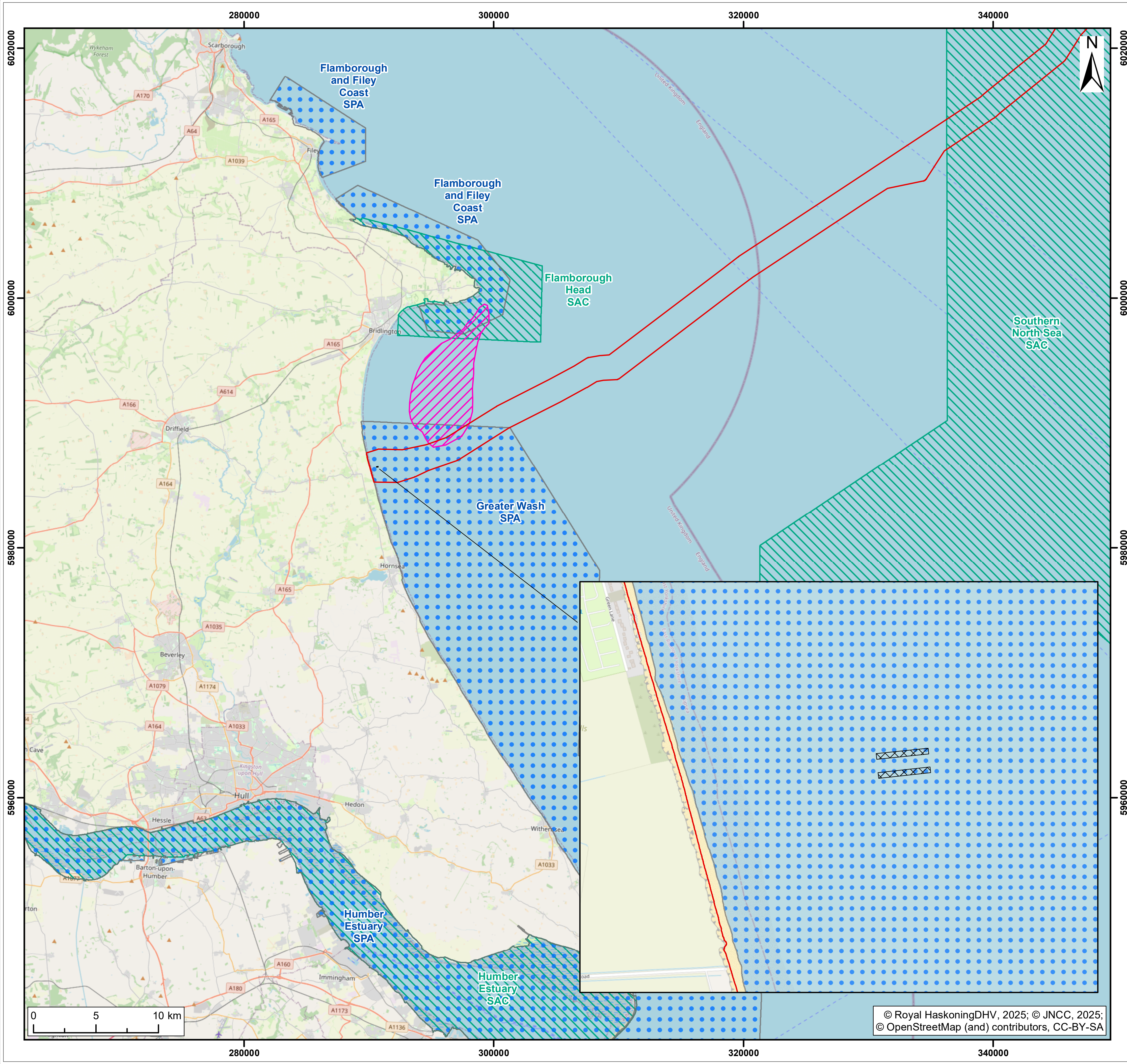
Cable Protection	Longitude	Latitude
Length 1 - start	-0.19188	53.9847
Length 1 - end	-0.19399	53.98451
Length 2 - start	-0.19177	53.98425
Length 2 - end	-0.19388	53.98406

It should be noted that the protection scenario used in this modelling is highly precautionary, with the characteristics of the protection feature modelled being very unlikely to resemble anything that might actually be constructed. The main reasons for this include:

- The closeness of the features to the shore – and therefore the most active zone for sediment transport in the near shore area. This is highly precautionary, because it is likely that any protection would be installed further from shore than indicated, as it is likely that the landfall trenchless installation would target a punchout in waters deeper than indicated in the modelling
- The overall lengths of the protection features. This is precautionary, because it is unlikely that any protection installed would reach the lengths used to deliver this modelling work
- The fact that a single, continuous structure has been modelled. This is highly precautionary, because it is likely that if any protection is installed it will comprise

more than one much shorter features, which would provide a smaller barrier to sediment transport
- The height of the structure is highly precautionary given the Applicants have committed to compliance with MGN654, which limits the height of remedial protection features causing changes in water depths of no more than 5%. The height used is precautionary as the uniform 0.5, height would exceed the limitations of MGN654

Whilst acknowledging that the design envelope used for modelling purposes is highly precautionary, the Applicants believe that the parameters used provide a high level of value in terms of their ability to demonstrate potential impacts.



Legend:

- Offshore Development Area
- Cable Protection Area
- Smithic Bank
- Special Protection Area (SPA)
- Special Area of Conservation (SAC)

SUI	REV	DATE	DESCRIPTION	DRW	CHK	APR
S3	P02	16/05/2025	Suitable for review & comment	SM	CM	CC
S2	P01	14/03/2025	Suitable for information	JH	CM	CC

Title:

Estimated Worst Case Length of Cable Protection in the Nearshore Environment

Figure: C-1 | Drawing No: PC2340-RHD-OF-ZZ-DR-Z-1072

Co-ordinate system: WGS 1984 UTM Zone 31N | Page Size: A3 | Scale: 1:300,000

Project: Dogger Bank South Offshore Wind Farms

Report: 13.3 The Applicants' Reponses to Deadline 2 Documents

Royal HaskoningDHV Enhancing Society Together

DBS Offshore Wind

4 Wave modelling

4.1 Introduction

Waves are the principal drivers of sediment transport in the nearshore. Therefore, any changes in wave regime due to the presence of cable protection measures could change sediment transport regimes locally. To inform the assessment of changes to bedload sediment transport and seabed morphology due to the presence of cable protection measures, wave modelling was undertaken. The methods and results are outlined below.

4.2 Wave Model Description

The calibrated wave model described in **Appendix 8-3 Marine Physical Processes Modelling Technical Report (Revision 3)** [REP2-017] was used in the assessment of the effect of the nearshore cable protection structures on the wave climate. The location of the nearshore cable protection is shown in **Figure 4-1** in relation to the full MIKE21-SW model extent.

The nearshore cable protection was incorporated into the MIKE21-SW model using high resolution bathymetry data acquired for the Projects.

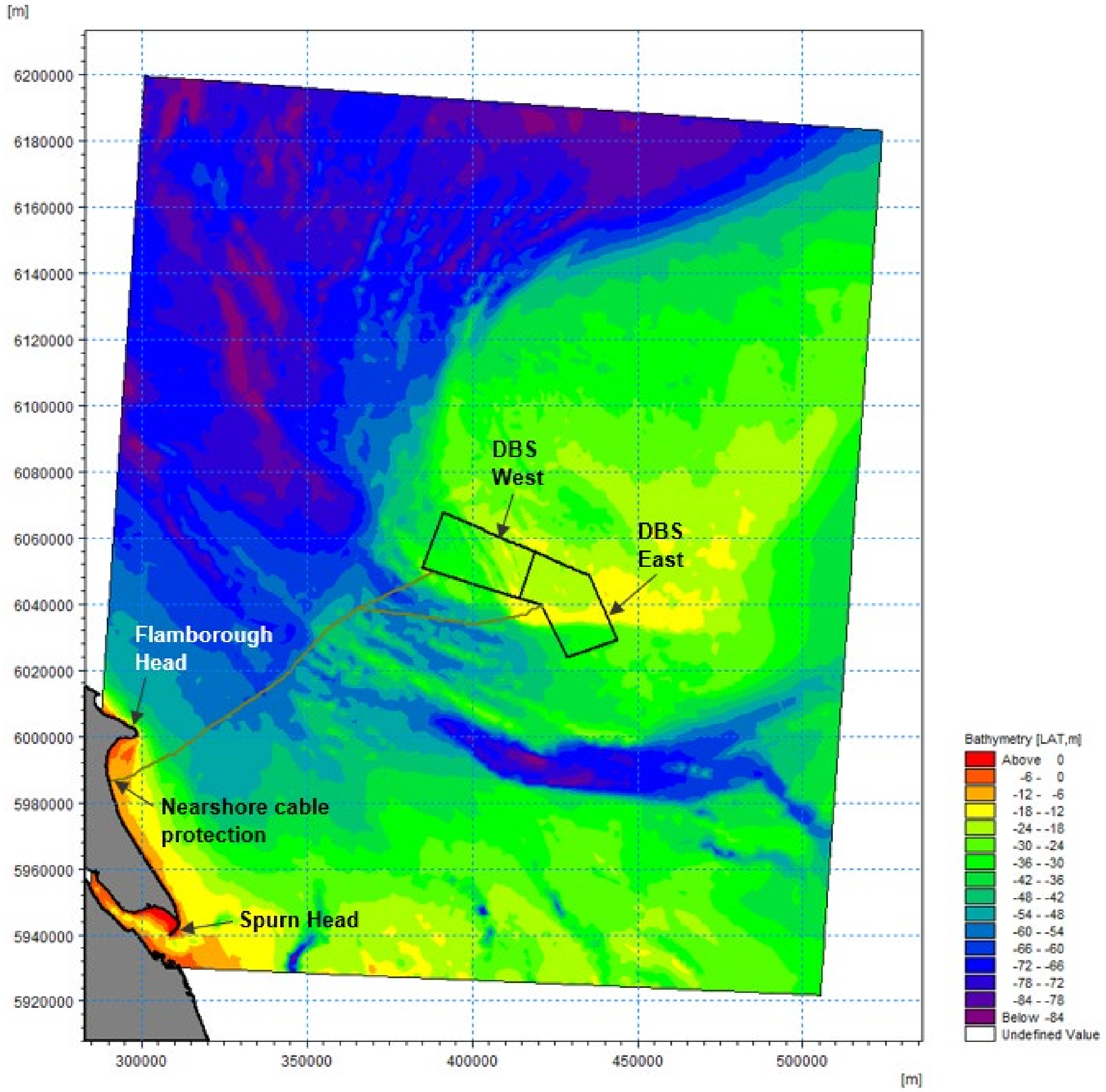


Figure 4-1 Location of the nearshore cable protection in context to the full extent of MIKE21-SW model domain

4.3 Wave Model Runs

The MIKE21-SW model has been run for the following layouts and wave conditions:

- The 'Baseline' without nearshore cable protection,
- The 'Option' with nearshore cable protection,
- Three return periods, namely 50%ile, 1 in 1 year and 1 in 100 years,
- Two wave directions, namely waves coming from 'North' and 'East', and

- Two water levels, namely Mean High Water Spring (MHWS) of 6.1 mCD and Mean Low Water Spring (MLWS) of 1.2 mCD based on the Admiralty Tide Tables at Bridlington.

Table 4-1 summarises the wave model input parameters, including wave height, wave period, wave direction, wind speed and wind direction.

Table 4-1 MIKE21-SW model input parameters

Return Period	Direction Sector	Wave Height (Hs, m)	Wave Period (Tp, s)	Wave Direction (°N)	Wind Speed (m/s)	Wind Direction (°N)
50%ile	North (345 – 15 degN)	1.75	8.72	345	8.0	345
50%ile	East (75 – 105 degN)	1.52	6.84	90	7.5	90
RP1	North (345 – 15 degN)	6.40	11.13	345	17.8	345
RP1	East (75 – 105 degN)	4.54	8.69	90	15.7	90
RP100	North (345 – 15 degN)	11.60	14.98	345	23.0	345
RP100	East (75 – 105 degN)	8.35	11.80	90	19.8	90

4.3.1 Wave Model Results for MHWS Runs

This section presents the results for the wave model runs that were simulated using MHWS.

Figure 4-2 to **Figure 4-7** show the significant wave height for the 'Baseline' conditions at the nearshore cable protection for all return periods and wave directions respectively for MHWS.

Figure 4-8 to **Figure 4-13** show the difference in significant wave height in metres between the 'Baseline' and 'Option' conditions at the nearshore cable protection for all return periods and wave directions respectively for MHWS. A positive difference value means wave height would increase by the presence of the nearshore cable protection, and a negative value means wave height would decrease.

Figure 4-14 to **Figure 4-19** show the difference in significant wave height as a percent between the 'Baseline' and 'Option' conditions at the nearshore cable protection for all return periods and wave directions respectively for MHWS.

All figures represent the two nearshore cable protection lengths as black hashed areas.

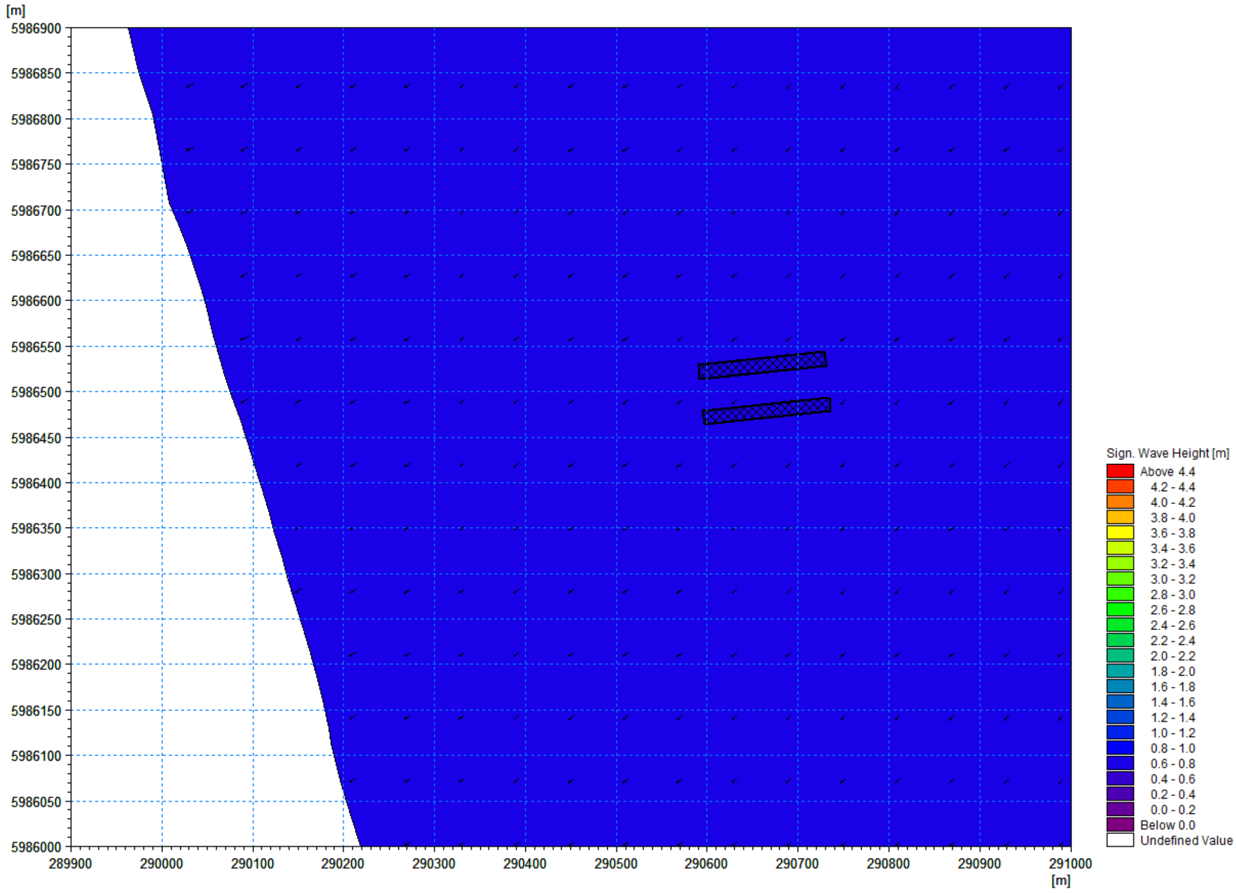


Figure 4-2 Significant wave height for 'Baseline' with 50%ile wave condition coming from 'North' - MHWS

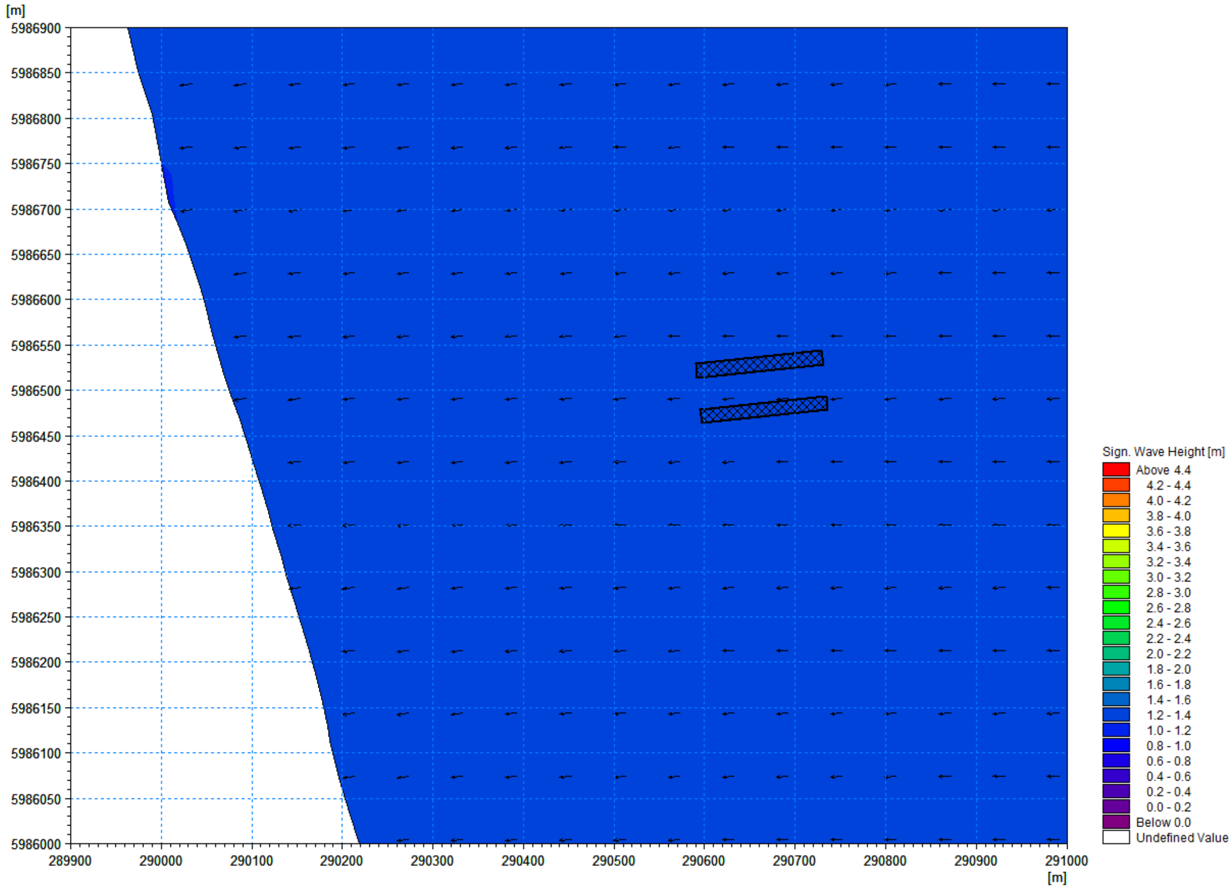


Figure 4-3 Significant wave height for 'Baseline' with 50%ile wave condition coming from 'East' - MHWS

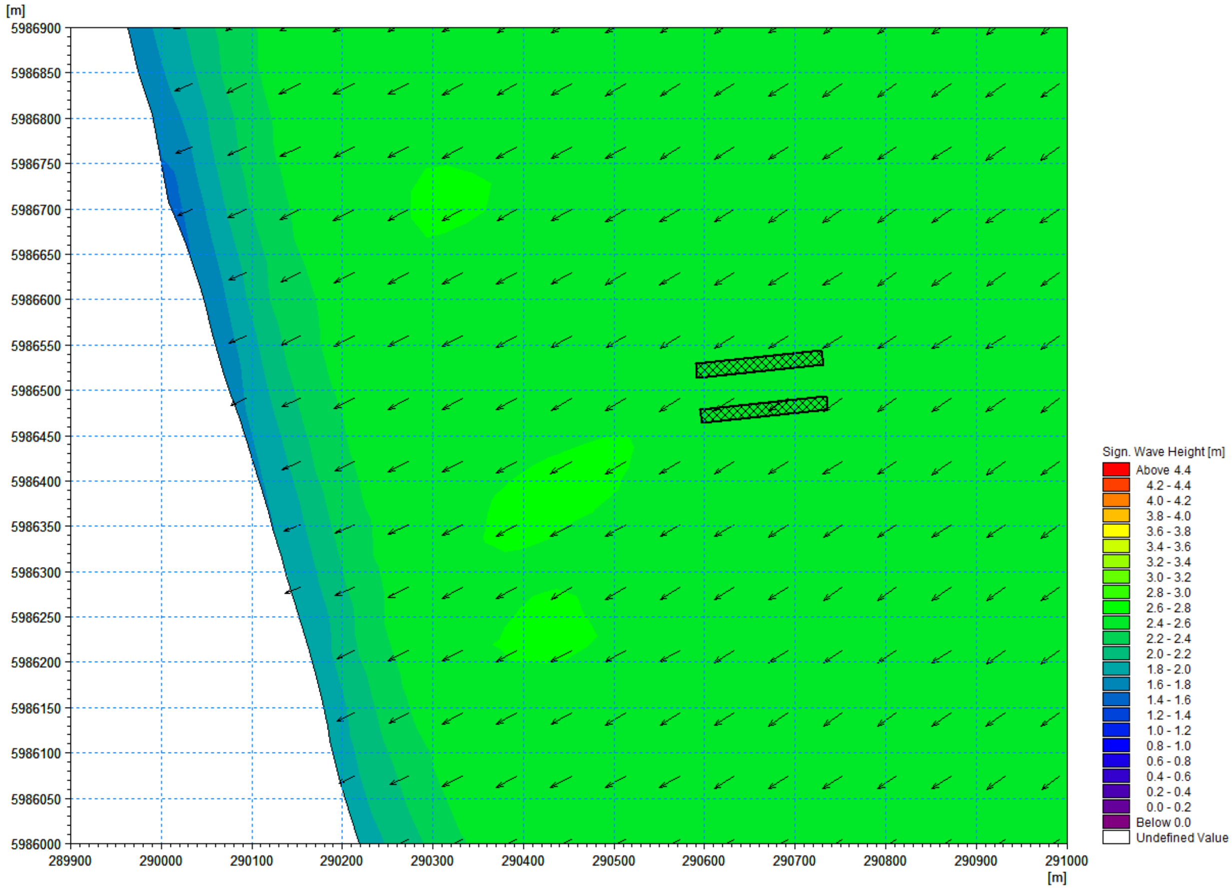


Figure 4-4 Significant wave height for 'Baseline' with 1 in 1 year waves coming from 'North' - MHWS

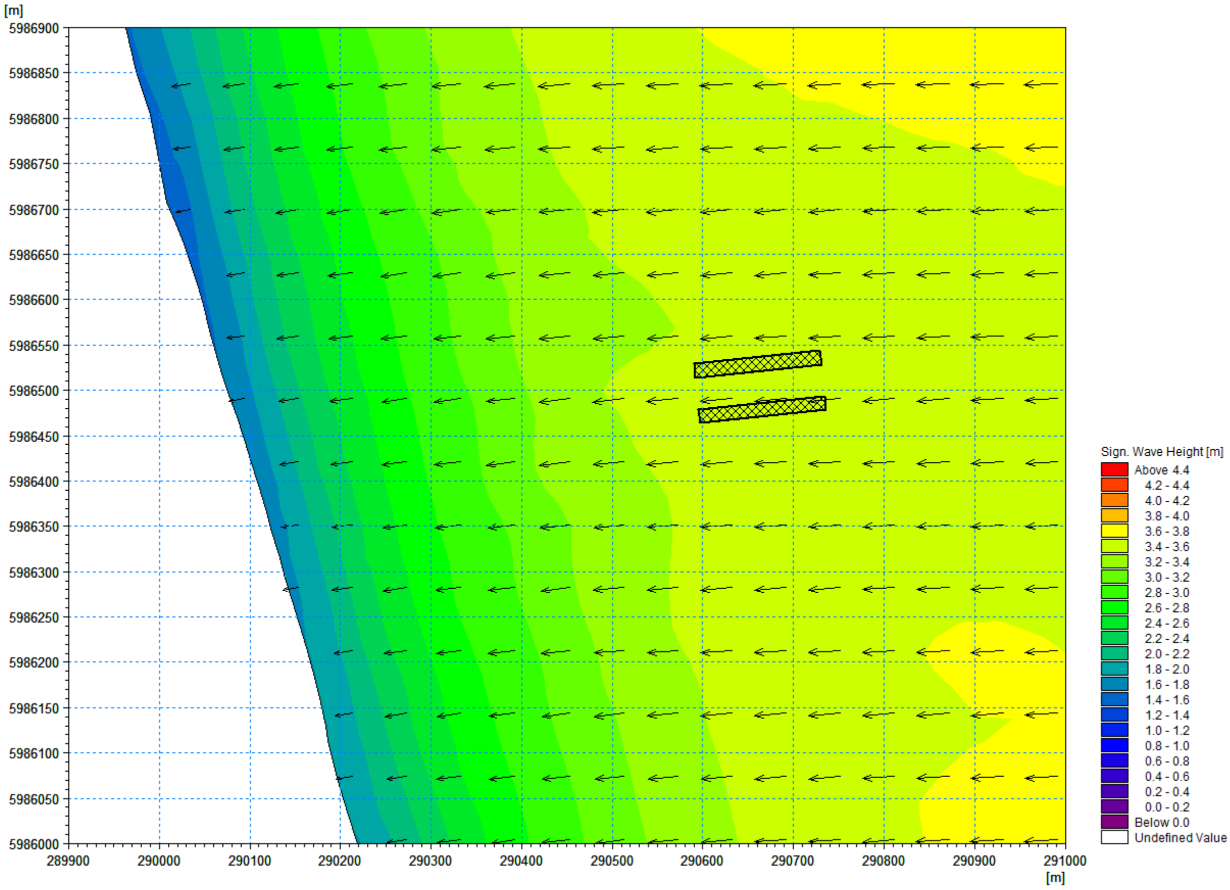


Figure 4-5 Significant wave height for 'Baseline' with 1 in 1 year waves coming from 'East' - MHWS

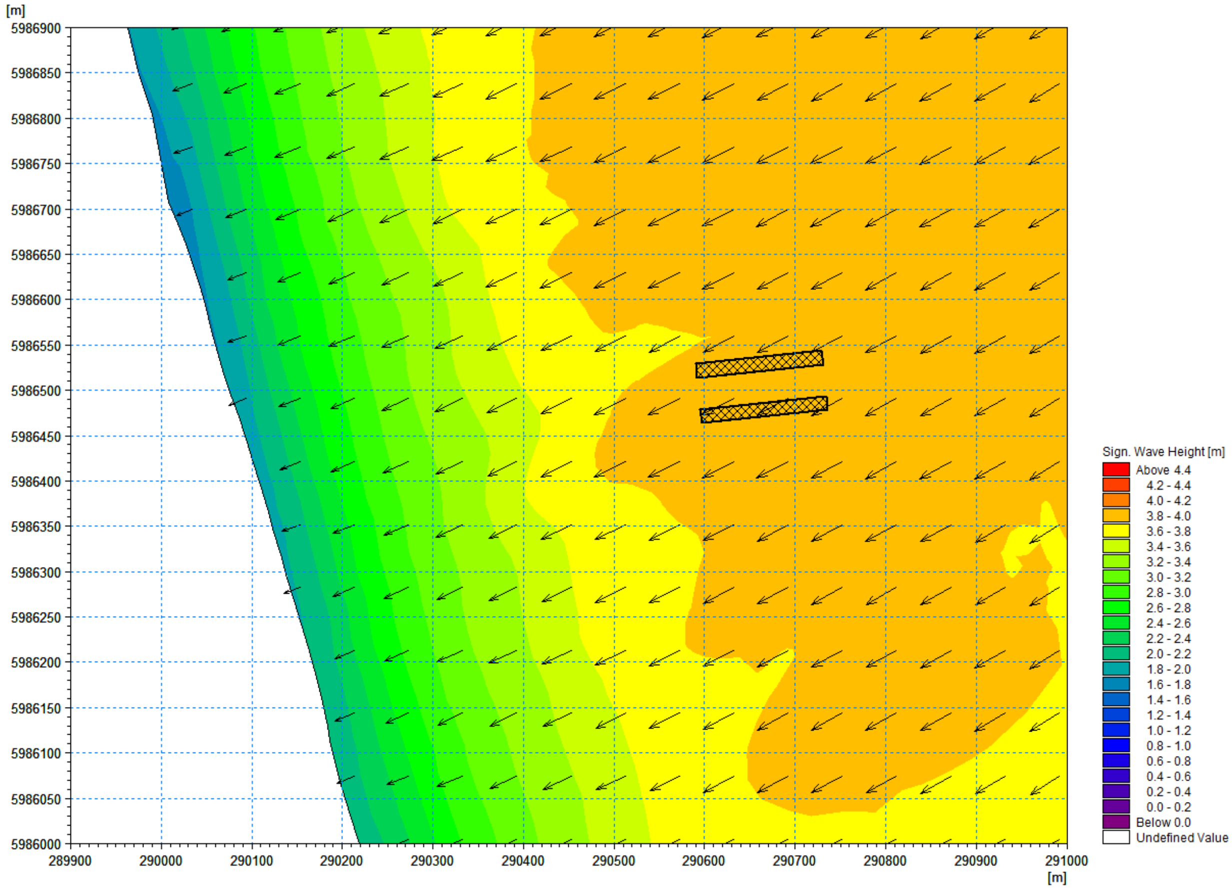


Figure 4-6 Significant wave height for 'Baseline' with 1 in 100 year waves coming from 'North' - MHWS

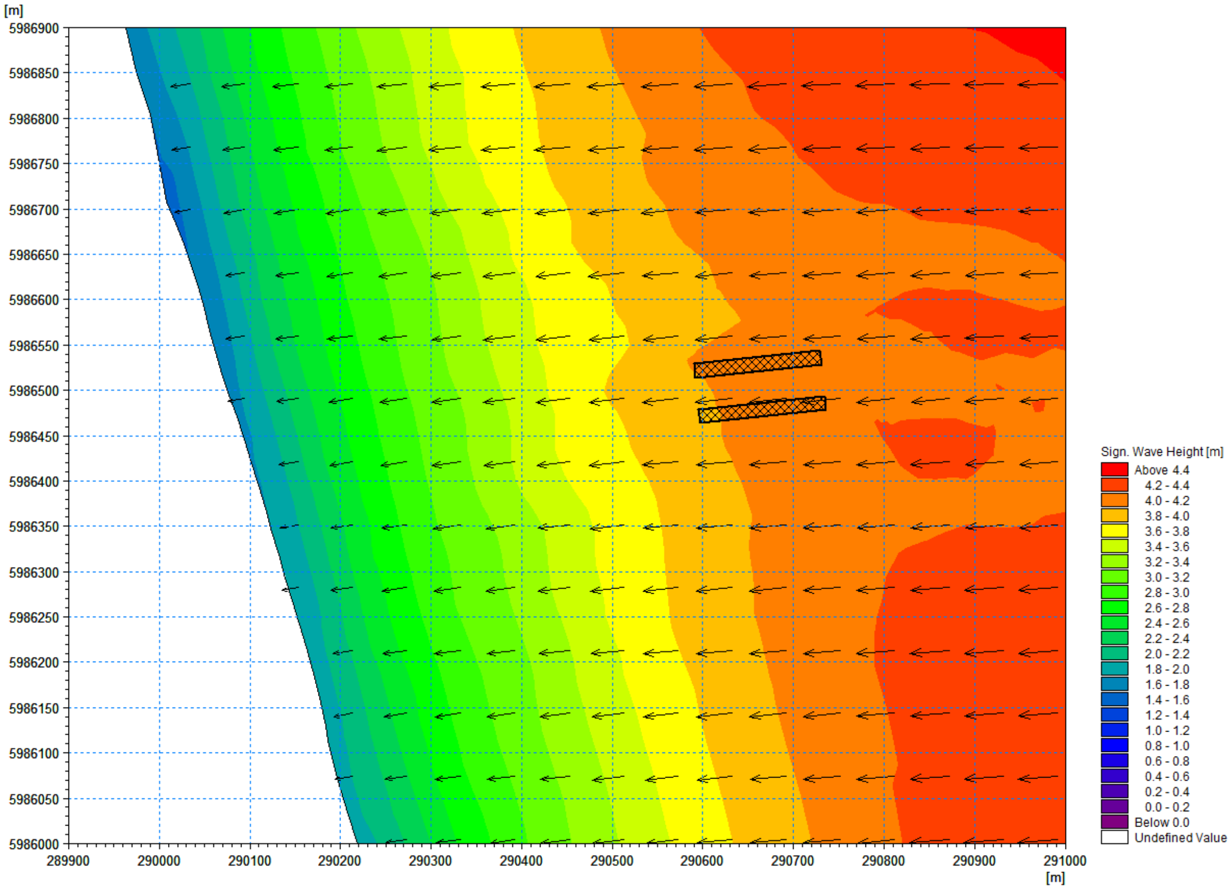


Figure 4-7 Significant wave height for 'Baseline' with 1 in 100 year waves coming from 'East' - MHWS

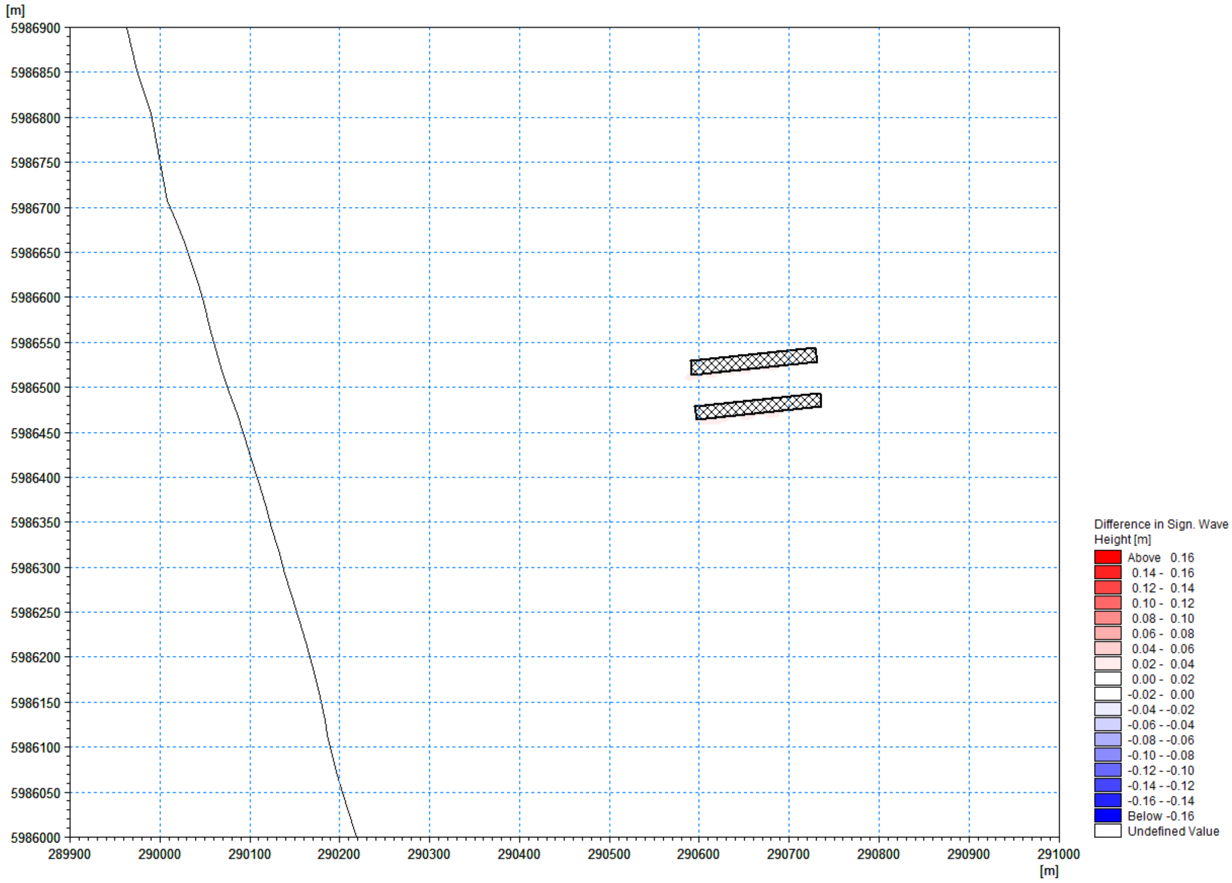


Figure 4-8 Difference in significant wave height in metres between 'Baseline' and 'Option' for 50%ile wave condition coming from 'North' - MHWS

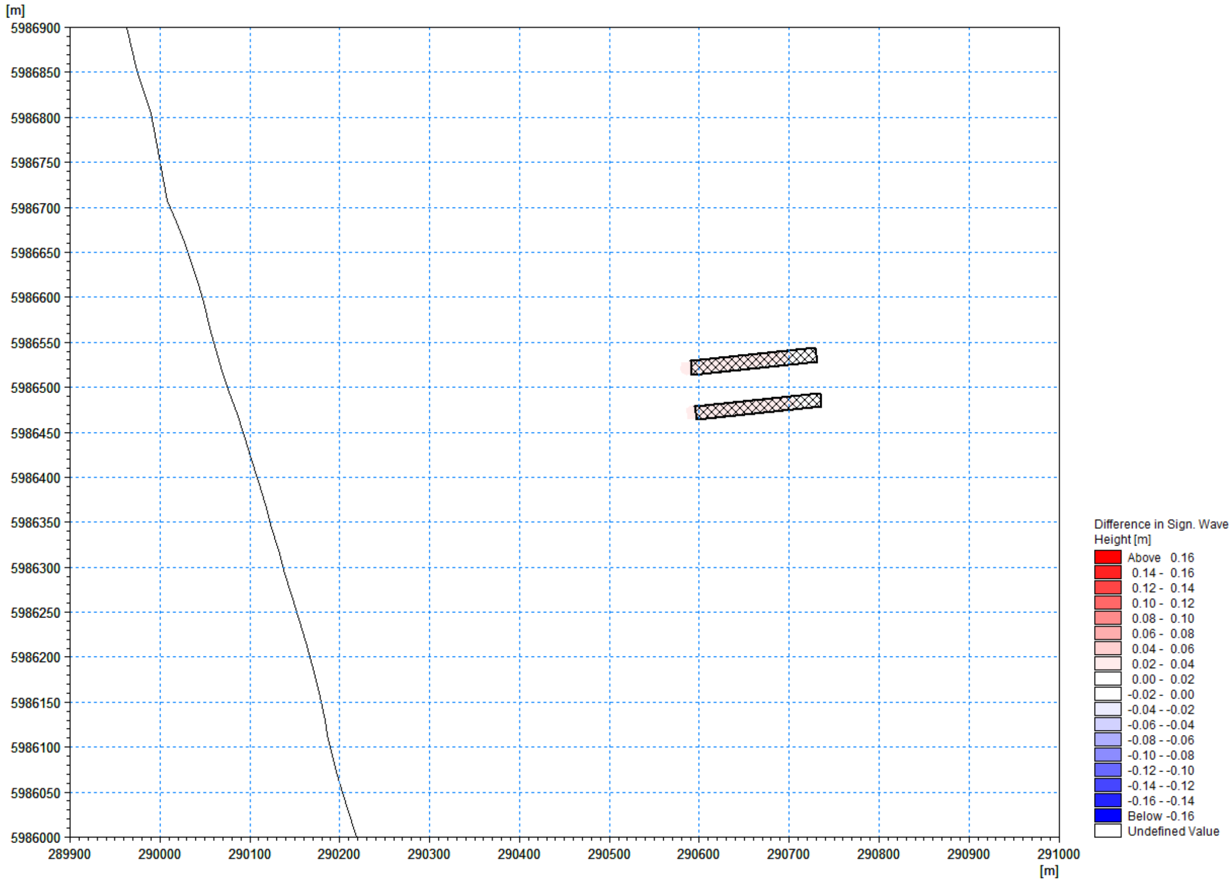


Figure 4-9 Difference in significant wave height in metres between 'Baseline' and 'Option' for 50%ile wave conditions coming from 'East' - MHWS

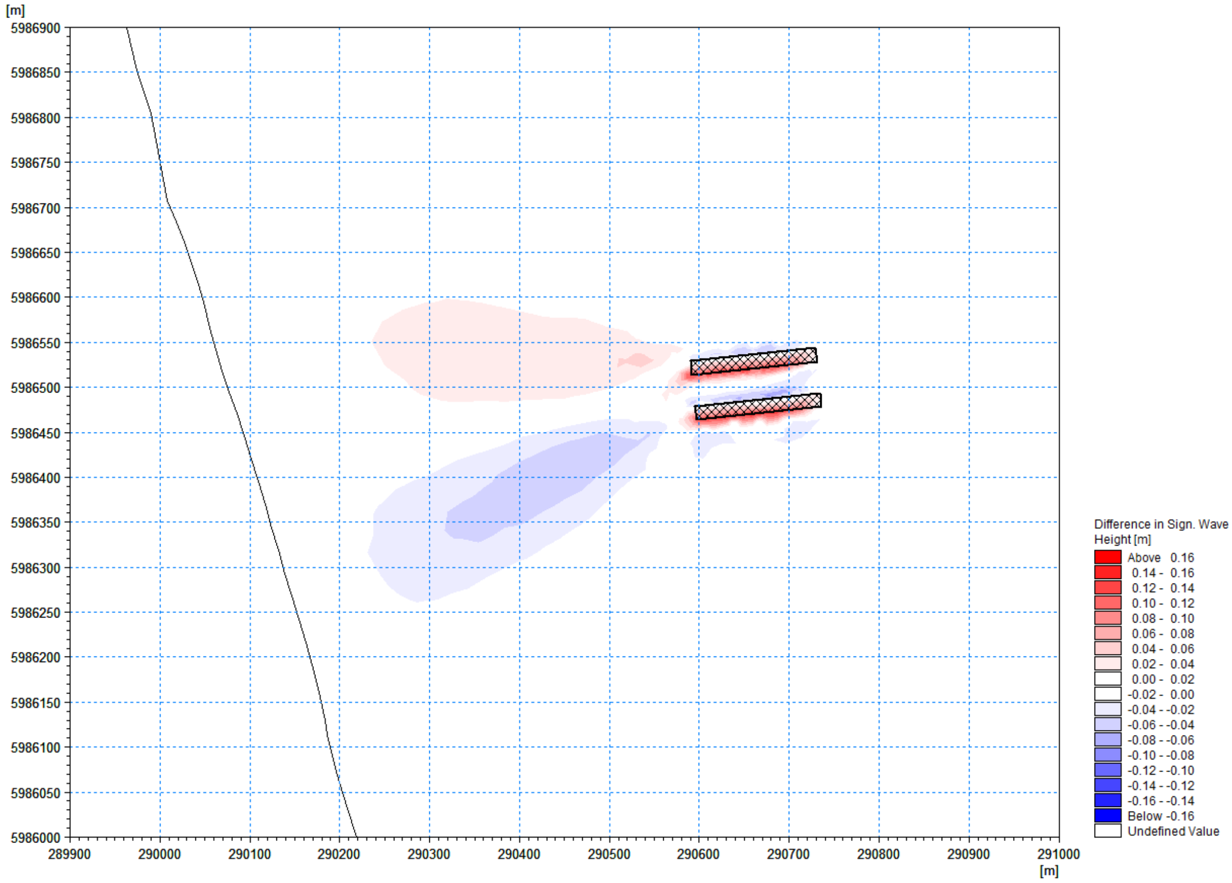


Figure 4-10 Difference in significant wave height in metres between 'Baseline' and 'Option' for 1 in 1 year waves coming from 'North' - MHWS

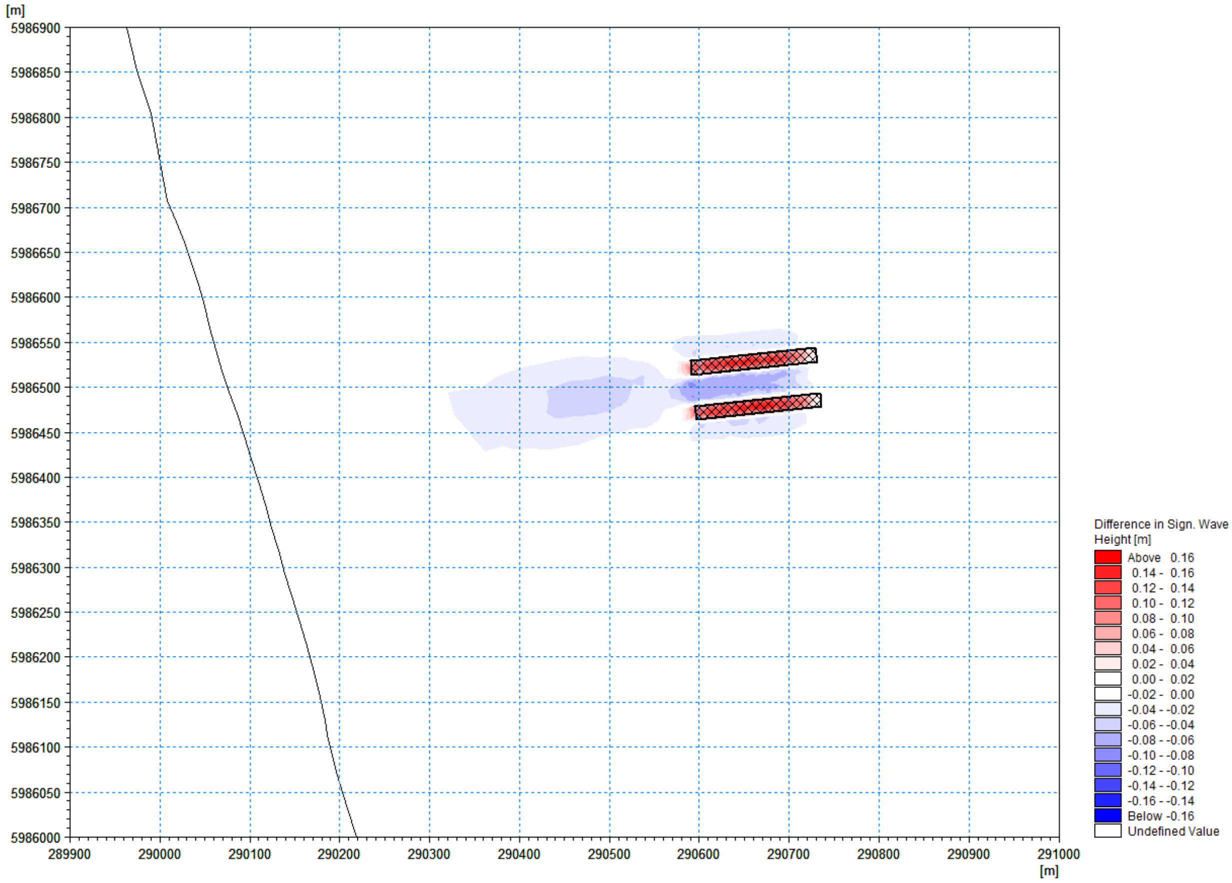


Figure 4-11 Difference in significant wave height in metres between 'Baseline' and 'Option' for 1 in 1 year with waves coming from 'East' - MHWS

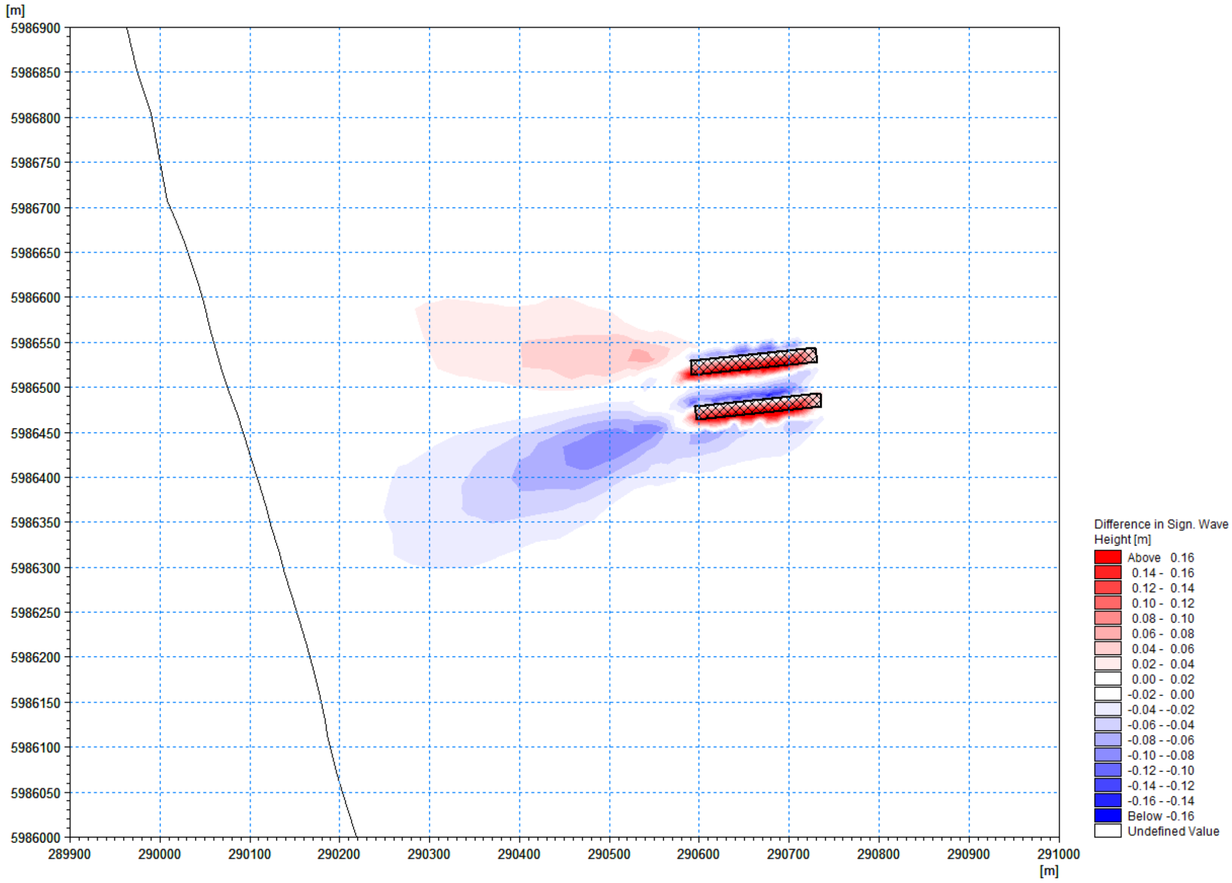


Figure 4-12 Difference in significant wave height in metres between 'Baseline' and 'Option' for 1 in 100 year waves coming from 'North' - MHWS

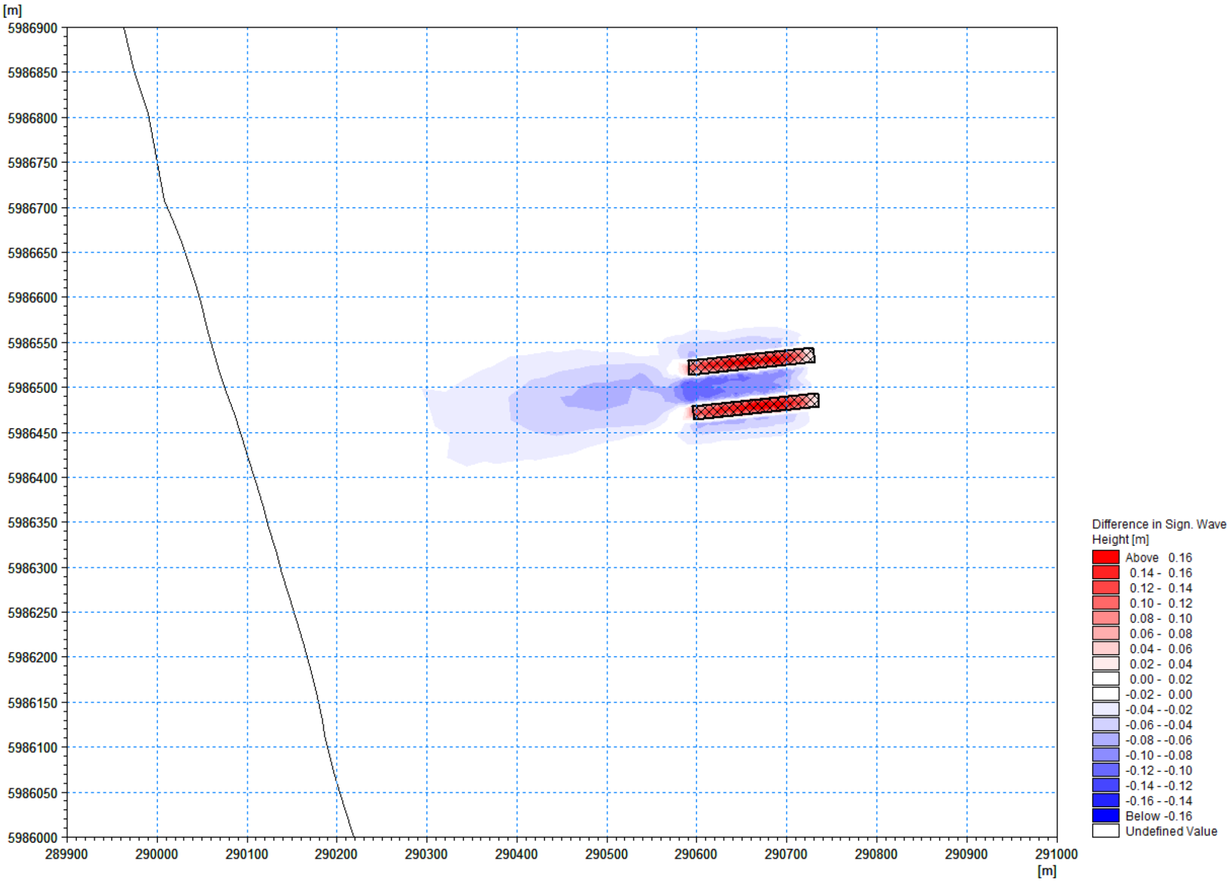


Figure 4-13 Difference in significant wave height in metres between 'Baseline' and 'Option' for 1 in 100 years with waves coming from 'East' - MHWS

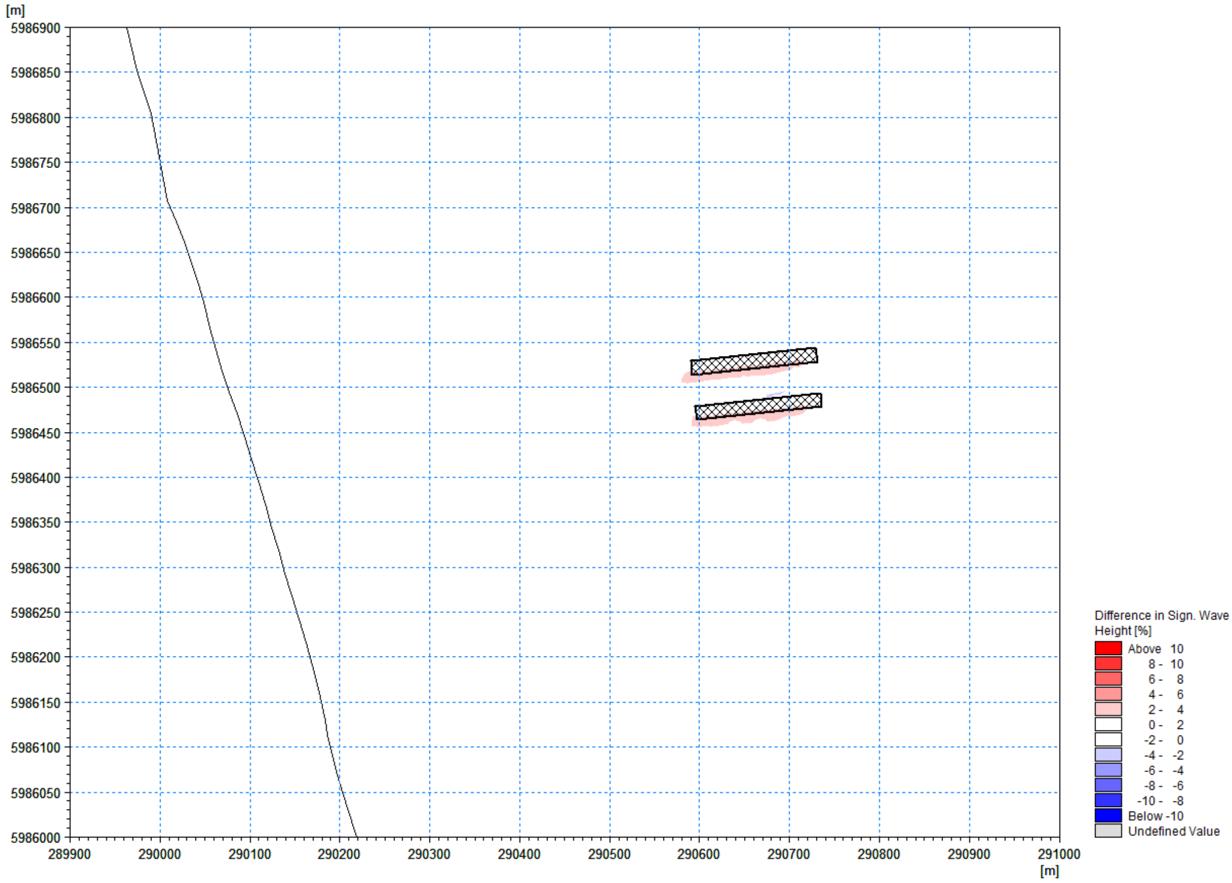


Figure 4-14 Difference in significant wave height in percent between 'Baseline' and 'Option' for 50%ile wave condition coming from 'North' - MHWS

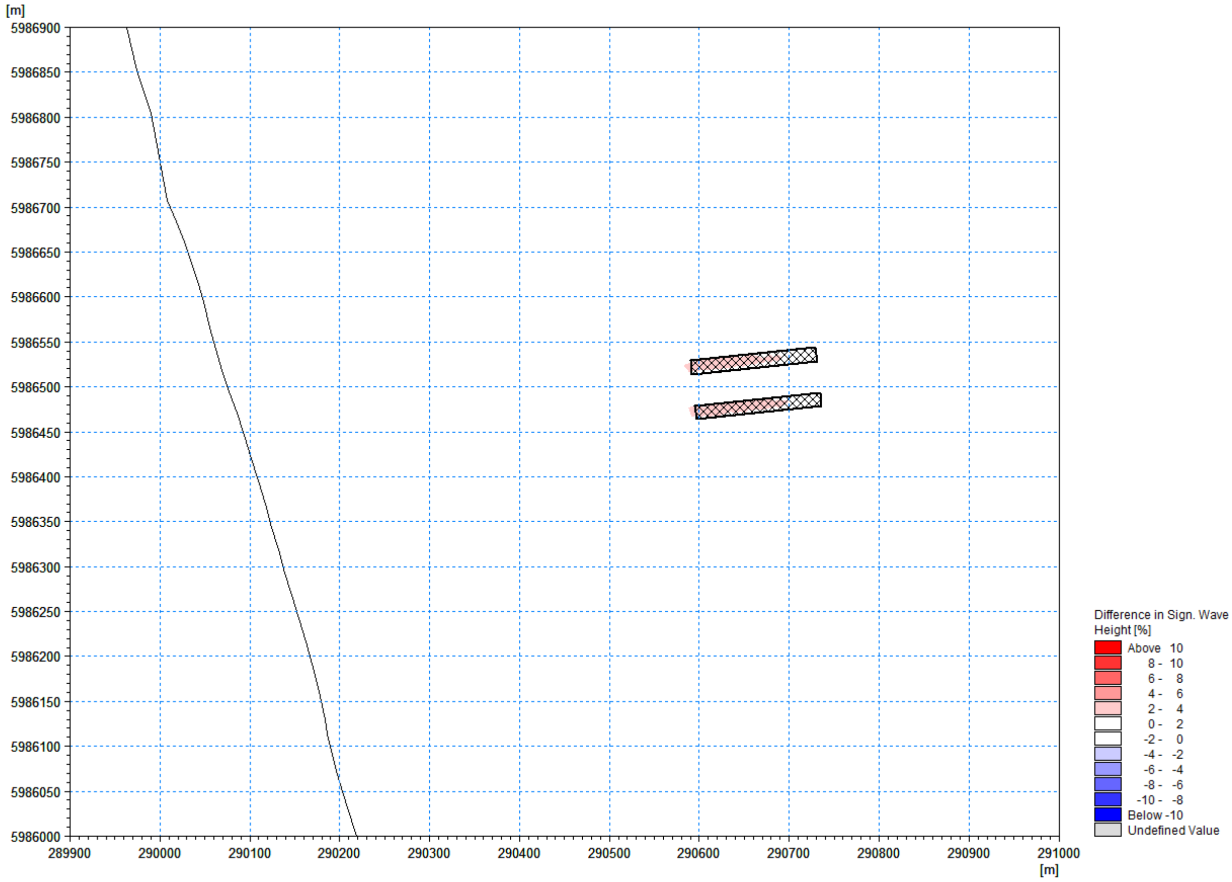


Figure 4-15 Difference in significant wave height in percent between 'Baseline' and 'Option' for 1 in 50%ile wave condition with waves coming from 'East' - MHWS

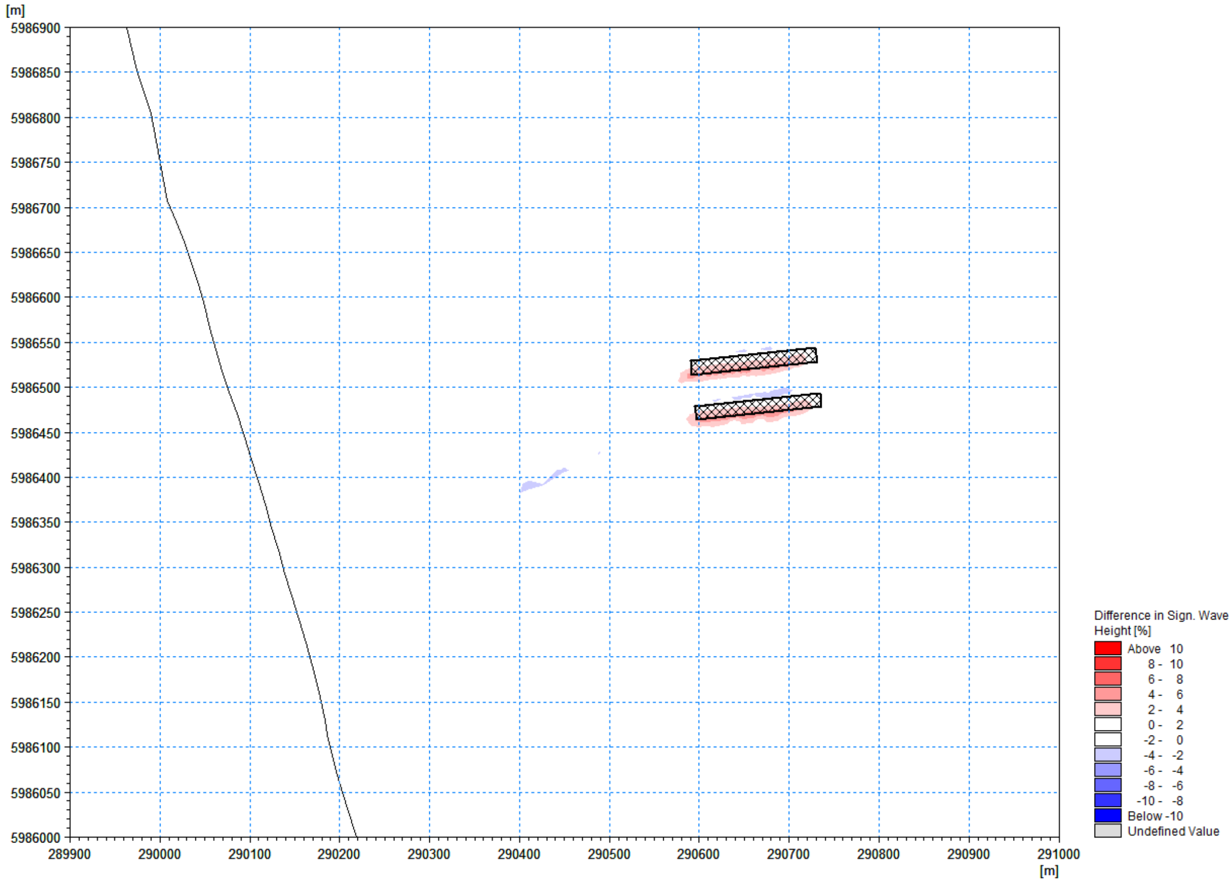


Figure 4-16 Difference in significant wave height in percent between 'Baseline' and 'Option' for 1 in 1 year with waves coming from 'North' - MHWS

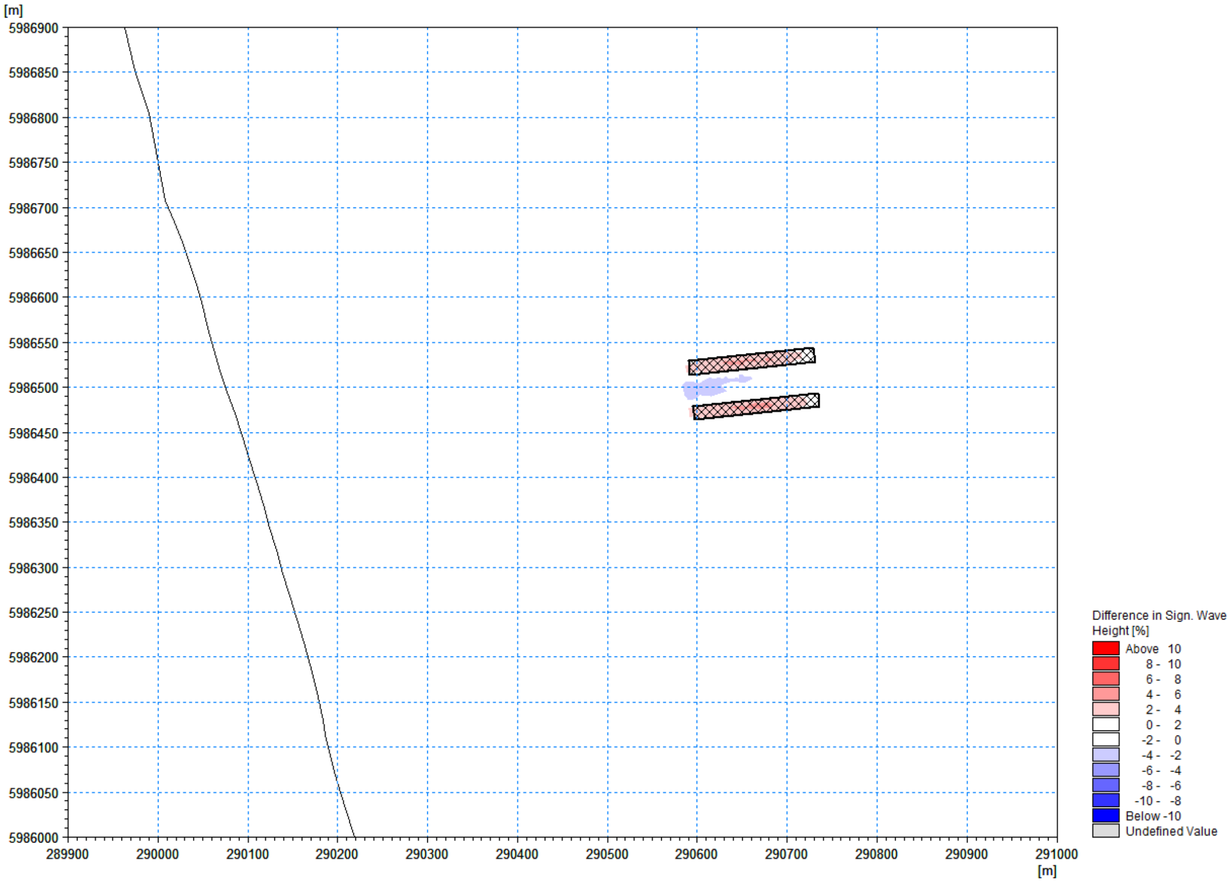


Figure 4-17 Difference in significant wave height in percent between 'Baseline' and 'Option' for 1 in 1 year waves coming from 'East' - MHWS

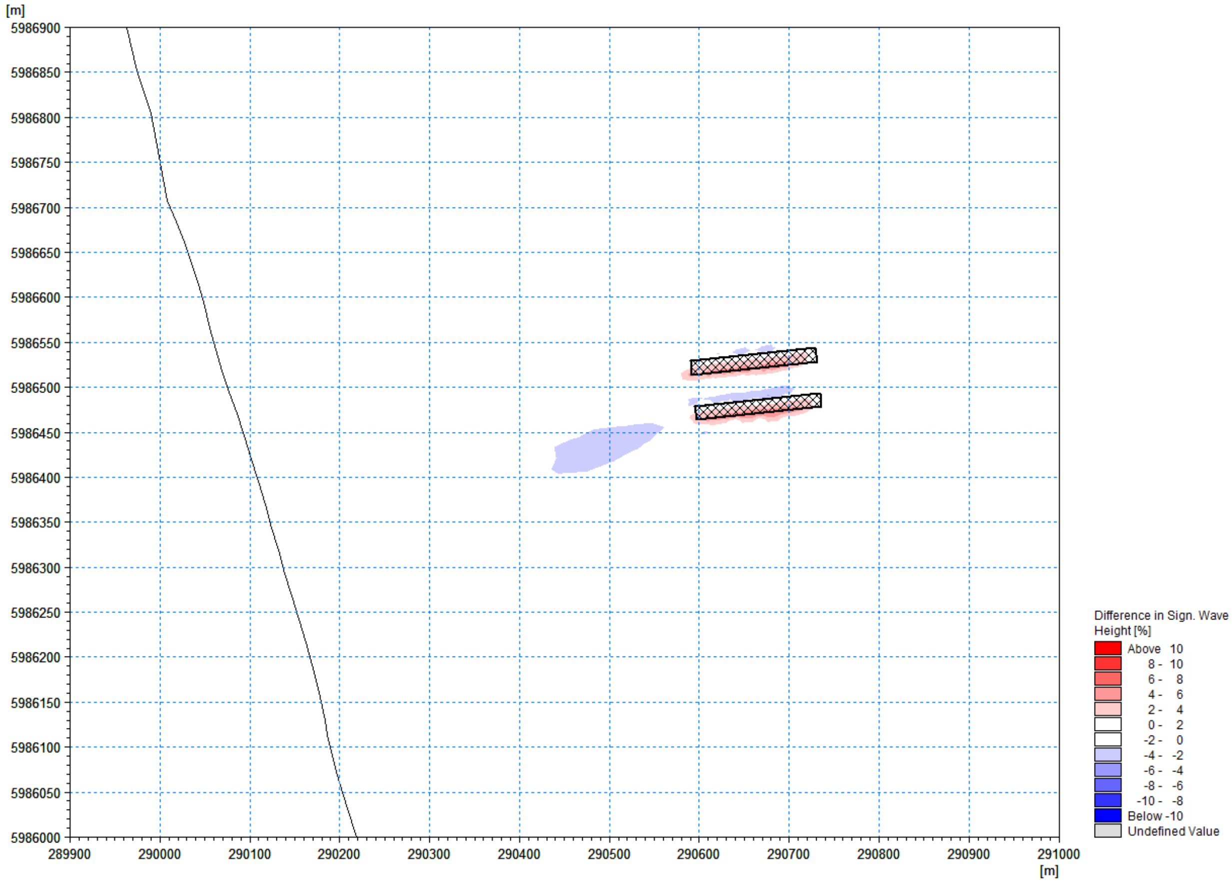


Figure 4-18 Difference in significant wave height in percent between 'Baseline' and 'Option' for 1 in 100 years with waves coming from 'North' - MHWS

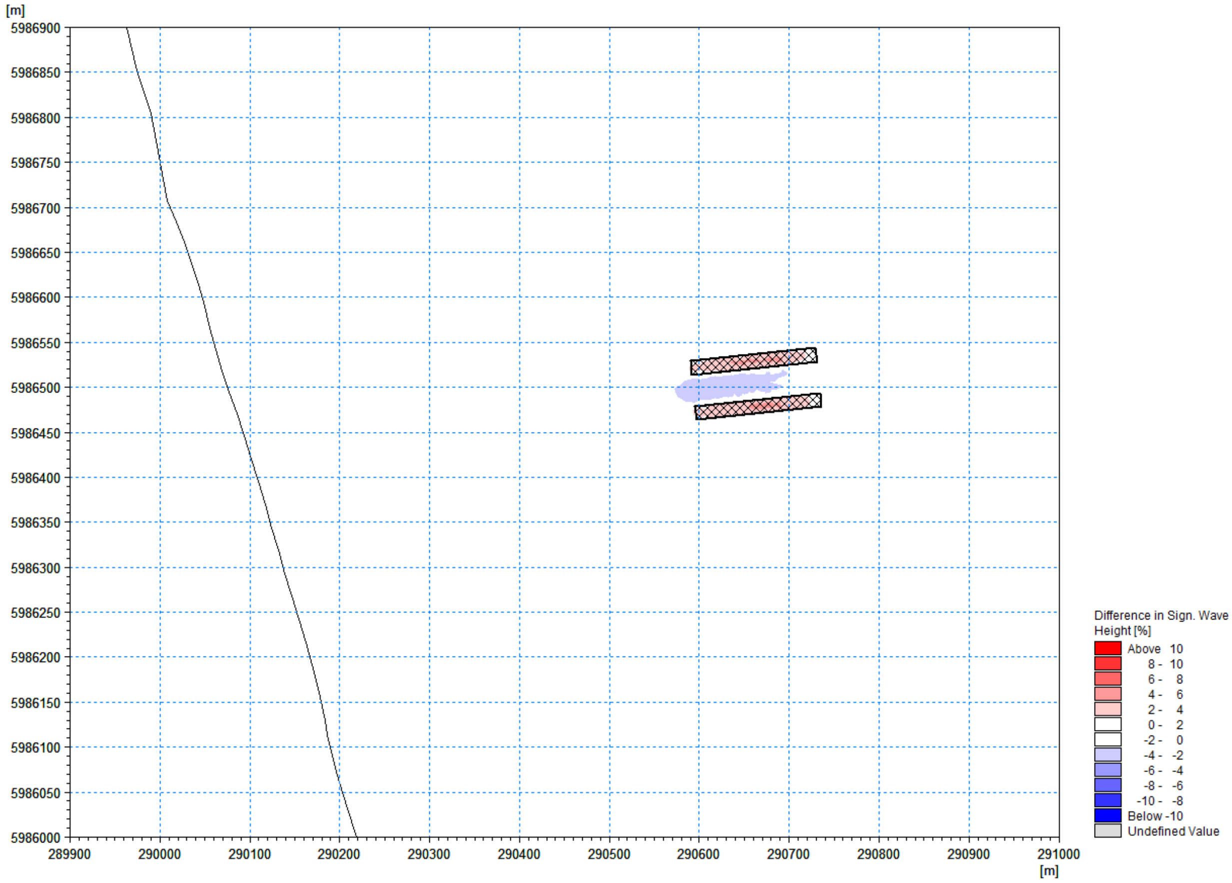


Figure 4-19 Difference in significant wave height in percent between 'Baseline' and 'Option' for 1 in 100 year waves coming from 'East' – MHWS

4.3.2 Discussion on Wave Model Results for MHWS Runs

This section discusses the wave model runs that were simulated using MHWS.

The difference in significant wave height between the 'Baseline' and the 'Option' for 50%ile wave conditions for both wave directions is approx. +0.04m and is located wholly within the 50m separation distance between the lengths of external cable protection.

The significant wave height between the 'Baseline' and the 'Option' for 1 in 1 year waves coming from 'North' is increased by up to +0.19m at the cable protection and reduced by up to -0.13m between the two cable protection structures. Either side of the cable protection the significant wave height is reduced by up -0.06m. There is an area of increased significant wave height (+0.02m to +0.05m) that extends from the northern cable protection in a north-westerly direction by approx. 350m. An area of reduced significant wave height (-0.02m to -0.06m) extends from the southern cable protection in a south-westerly direction by approx. 380m.

The significant wave height between the 'Baseline' and the 'Option' for 1 in 1 year waves coming from 'East' is increased by up to +0.16m at the cable protection and reduced by up to -0.09m between the two cable protection structures. Either side of the cable protection the significant wave height is reduced by up to -0.04m and an area of 250m extends towards the shoreline where the significant wave height is also reduced by between -0.02m to 0.05m.

The significant wave height between the 'Baseline' and the 'Option' for 1 in 100 year waves coming from 'North' shows a similar pattern as for 1 in 1 year waves, but with an increase in magnitude; with the significant wave height at the cable protection increased by up to +0.31m and a reduction in significant wave height between the two cable protection structures by up to -0.23m. There is an area of increased significant wave height (+0.02m to +0.07m) that extends from the northern cable protection in a north-westerly direction by approx. 300m. An area of reduced significant wave height (-0.02m to -0.1m) extends from the southern cable protection in a south-westerly direction by approx. 360m.

The significant wave height between the 'Baseline' and the 'Option' for 1 in 100 year waves coming from 'East' shows a similar pattern as for 1 in 1 year waves, but with an increase in magnitude; with the significant wave height at the cable protection increased by up to +0.19m and a reduction in significant wave height between the two cable protection structures by up to -0.14m. Either side of the cable protection the significant wave height is reduced by between -0.02m to -0.06m and an area of 280m extends towards the shoreline where the significant wave height is also reduced by between -0.02m to 0.07m.

When the changes in significant wave heights are expressed in percent the changes between the 'Baseline' and the 'Option' for 50%ile wave conditions for both wave directions are less than +/-5% and any changes occur only locally at the cable protection.

The percentage change in significant wave height between the 'Baseline' and the 'Option' for 1 in 1 year waves coming from 'North' are less than +8% in areas of increased significant wave height, which occur only locally at the cable protection, and less than -5% in areas of reduced significant wave height, which occur only on the northerly side of the two cable protection structures.

The percentage change in significant wave height between the 'Baseline' and the 'Option' for 1 in 1 year waves coming from 'East' are less than +5% in areas of increased significant wave height, which occur only local at the cable protection, and less than -3% in areas of reduced significant wave height, which occur only in between the two cable protection structures.

The percentage change in significant wave height between the 'Baseline' and the 'Option' for 1 in 100 year waves coming from 'North' are less than +8% in areas of increased significant wave height, which occur only locally at the cable protection, and less than -6% in areas of reduced significant wave height, which occur on the northerly side of the two cable protection structures. There is also a small area where wave heights are reduced by less than 3% that extends by approx. 130m towards the shore from the southern cable protection.

The percentage change in significant wave height between the 'Baseline' and the 'Option' for 1 in 100 year waves coming from 'East' are less than +5% in areas of increased significant wave height, which occur only locally at the cable protection and less than -4% in areas of reduced significant wave height, which occur only between the two cable protection structures.

4.3.3 Wave Model Results for MLWS Runs

This section presents the results for the wave model runs that were simulated using MLWS. It was anticipated changes to wave regime may be amplified during MLWS tides when compared to MHWS water levels due to a reduction in water depth.

Figure 4-20 to **Figure 4-25** show the significant wave height for the 'Baseline' conditions at the nearshore cable protection for all return periods and wave directions respectively for MLWS.

Figure 4-26 to **Figure 4-31** show the difference in significant wave height in metres between the 'Baseline' and 'Option' conditions at the nearshore cable protection for all return periods and wave directions respectively for MLWS. The difference value in positive means wave height would increase by the presence of the nearshore cable protection, and vice visa.

Figure 4-32 to **Figure 4-37** show the difference in significant wave height in percent between the 'Baseline' and 'Option' conditions at the nearshore cable protection for all return periods and wave directions respectively for MLWS A positive difference value means wave height would increase by the presence of the nearshore cable protection, and a negative value means wave height would decrease..

All figures represent the two nearshore cable protection lengths as black hashed areas.

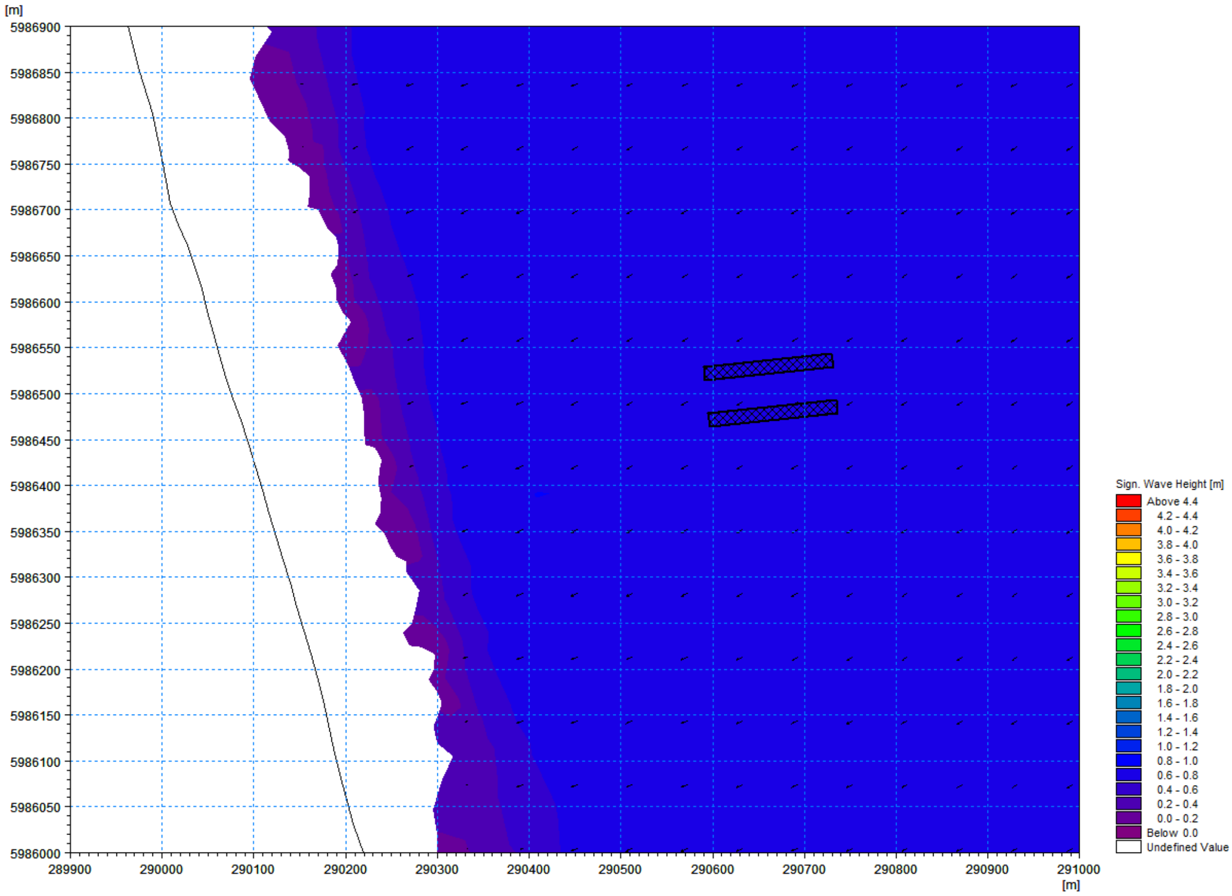


Figure 4-20 Significant wave height for 'Baseline' with 50%ile wave condition coming from 'North' - MLWS

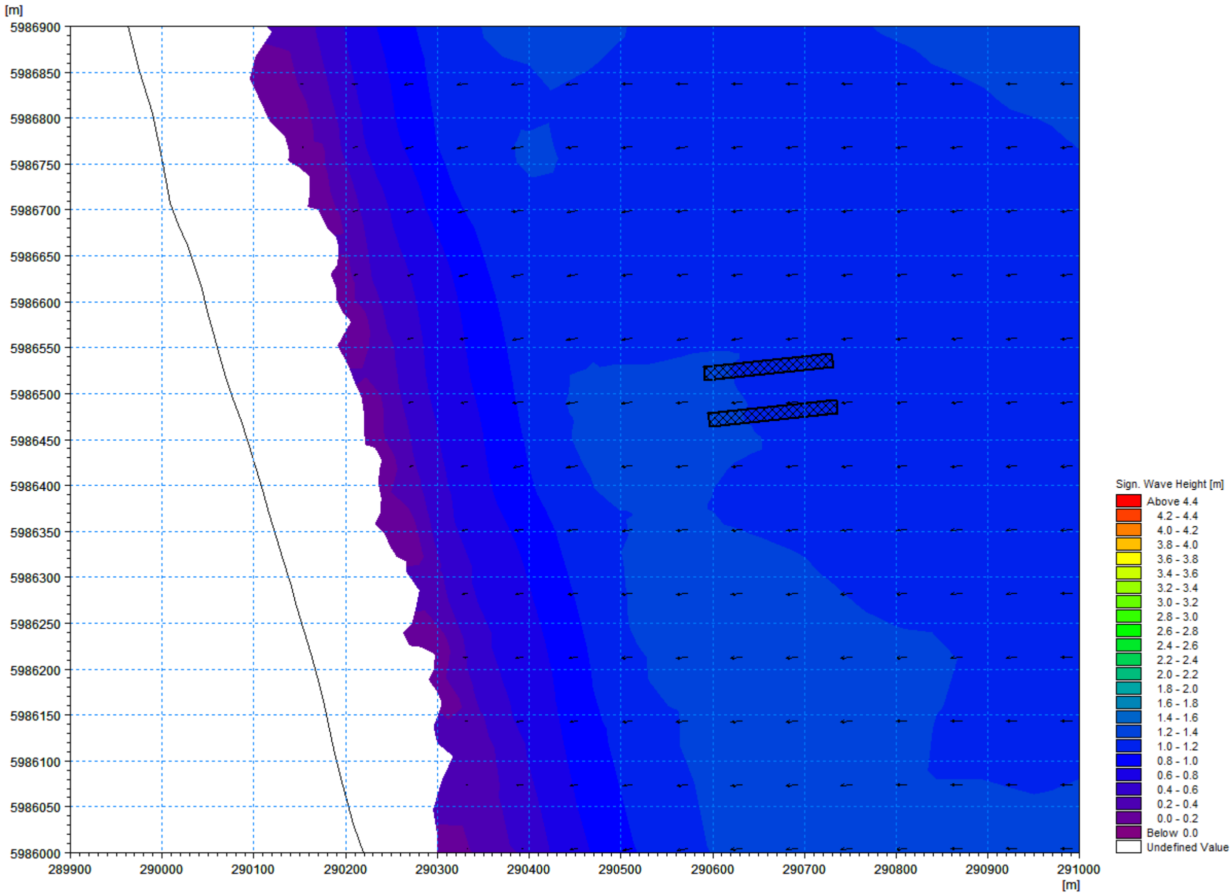


Figure 4-21 Significant wave height for 'Baseline' with 50%ile wave condition coming from 'East' - MLWS

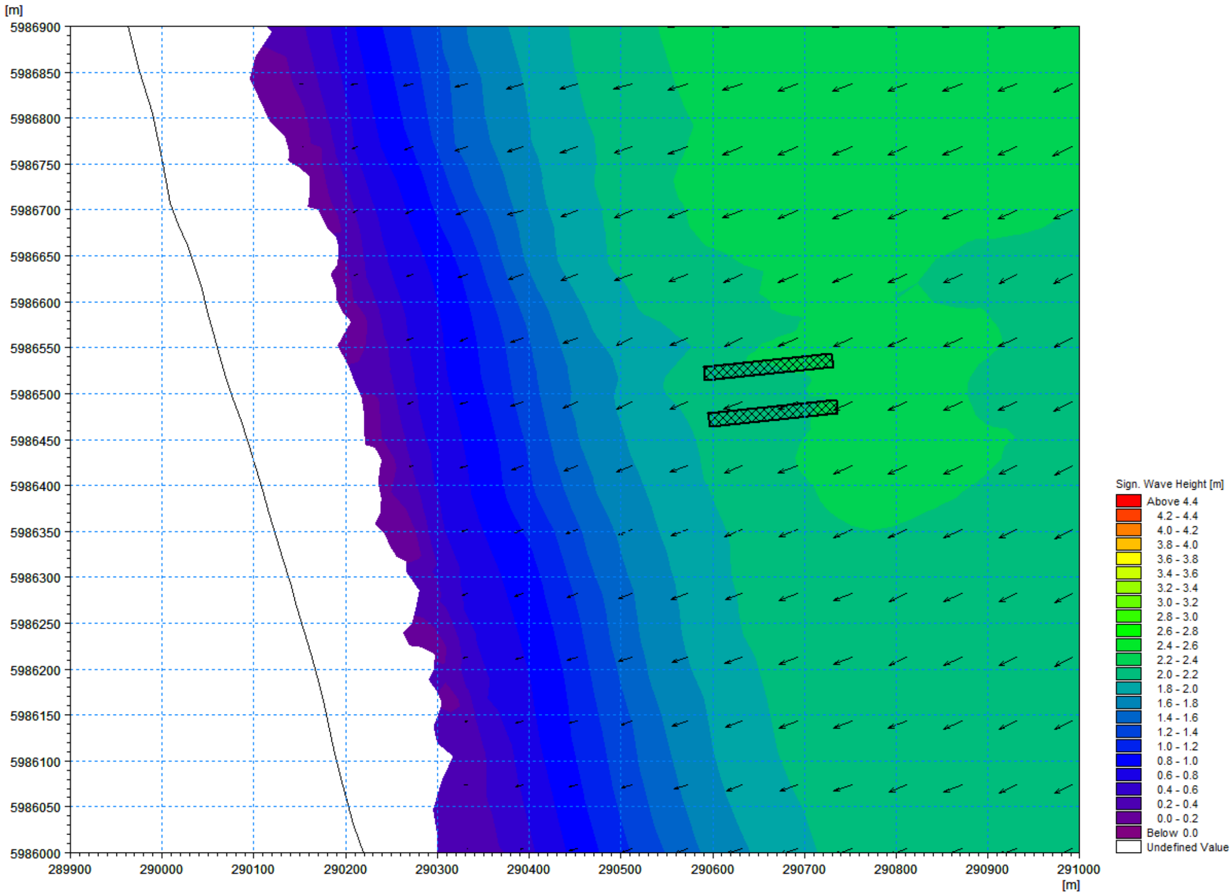


Figure 4-22 Significant wave height for 'Baseline' with 1 in 1 year waves coming from 'North' - MLWS

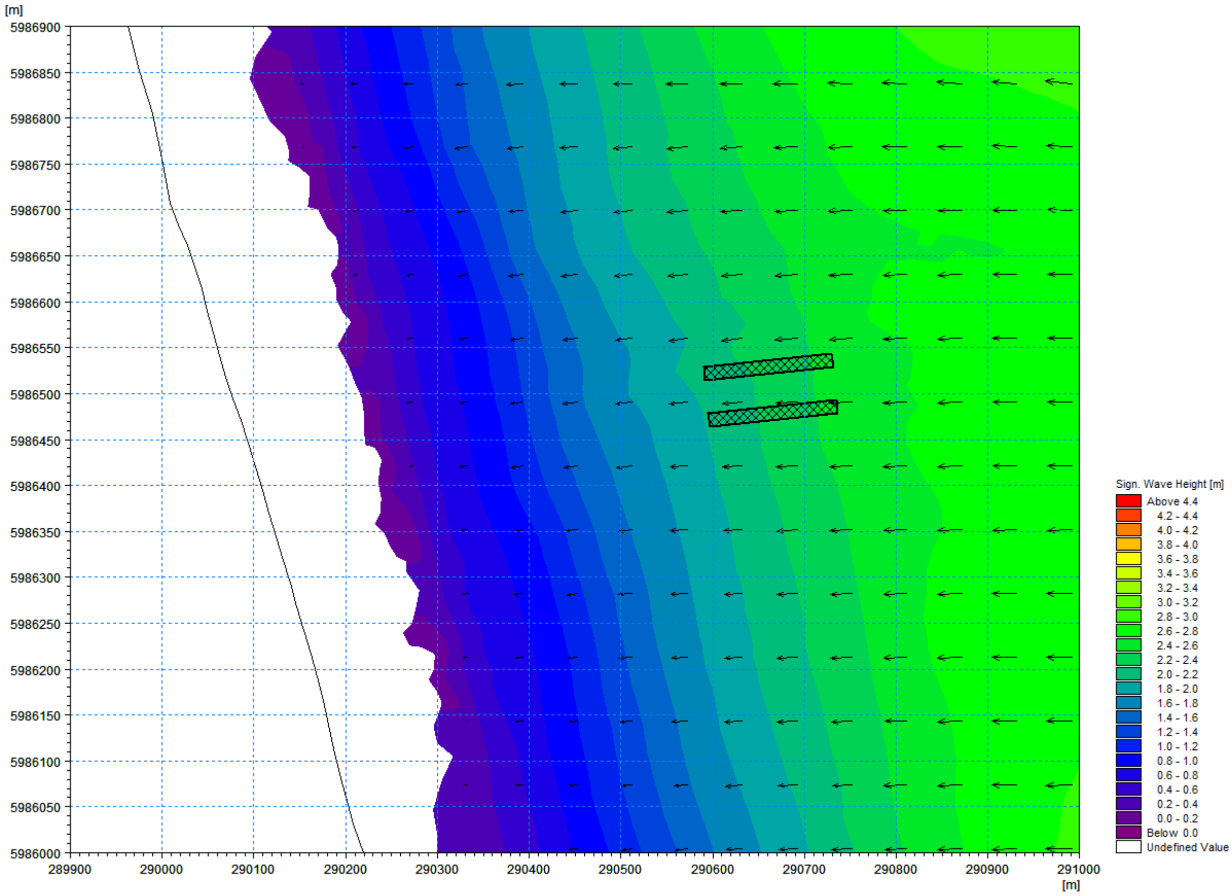


Figure 4-23 Significant wave height for 'Baseline' with 1 in 1 year waves coming from 'East' - MLWS

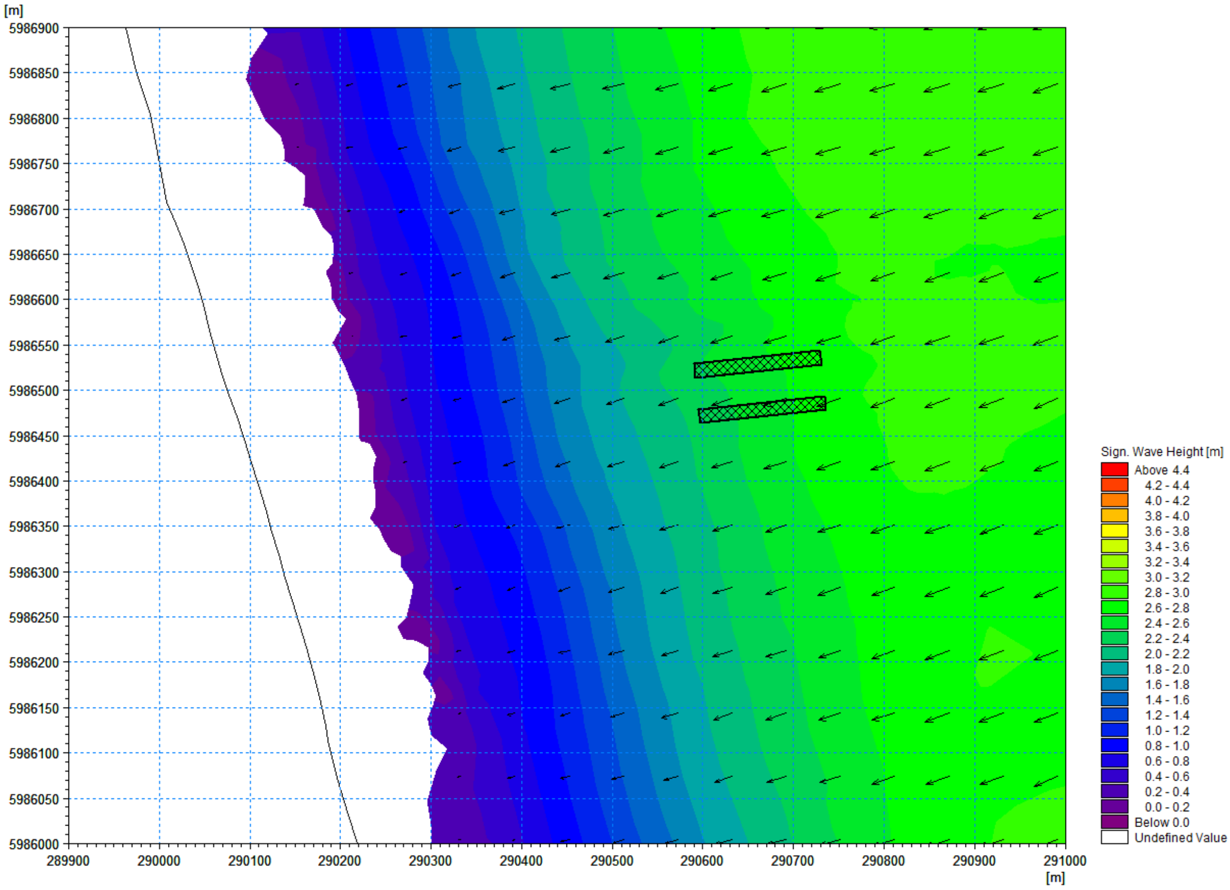


Figure 4-24 Significant wave height for 'Baseline' with 1 in 100 year waves coming from 'North' - MLWS

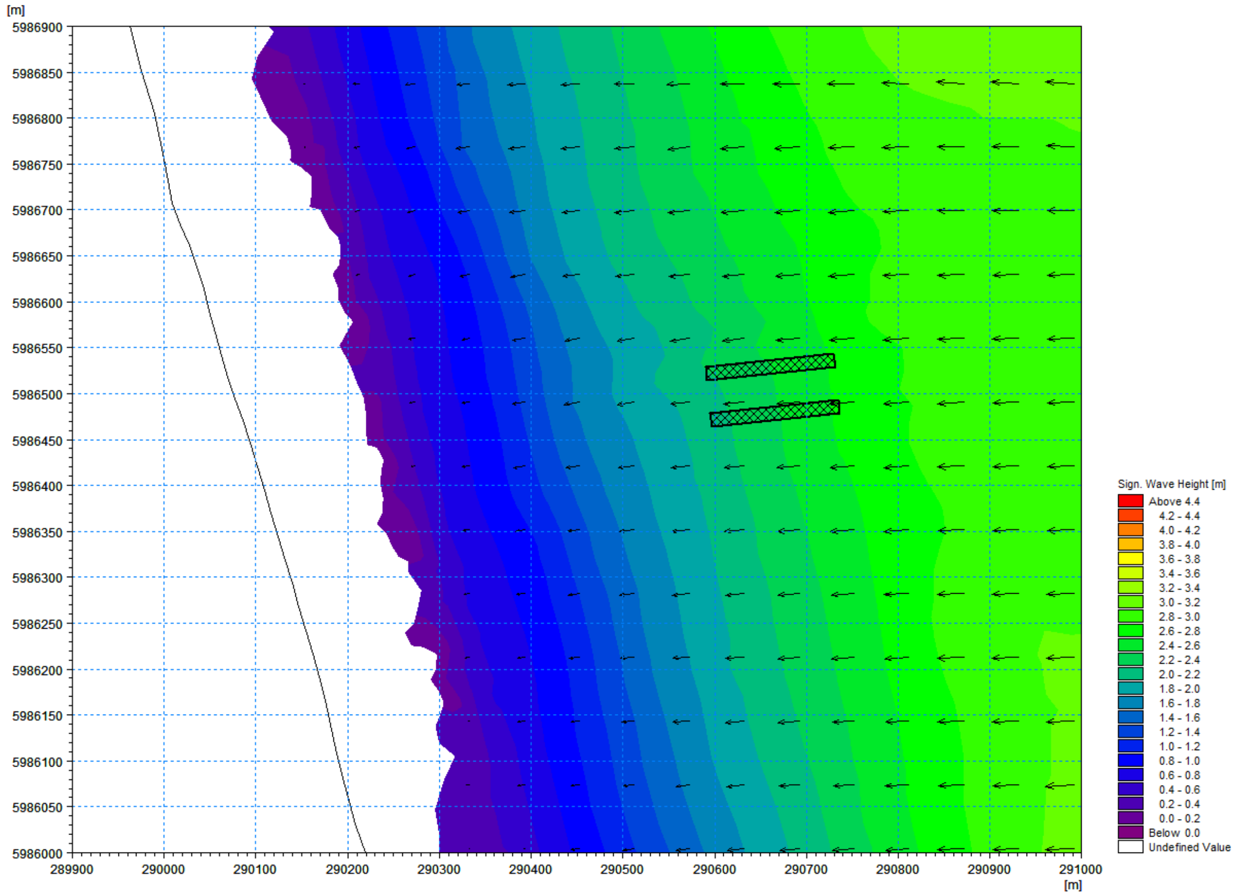


Figure 4-25 Significant wave height for 'Baseline' with 1 in 100 year waves coming from 'East' - MLWS

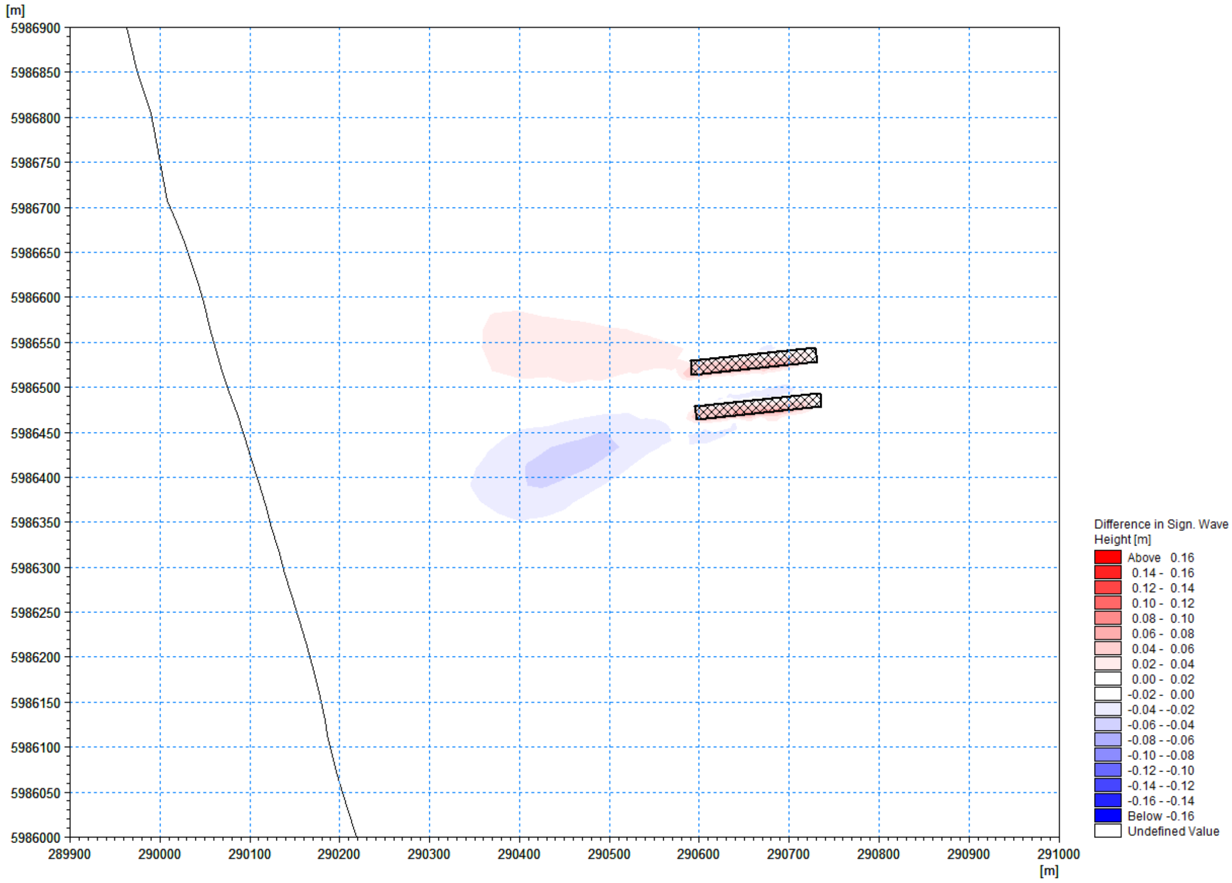


Figure 4-26 Difference in significant wave height in metres between 'Baseline' and 'Option' for 50%ile wave condition coming from 'North' - MLWS

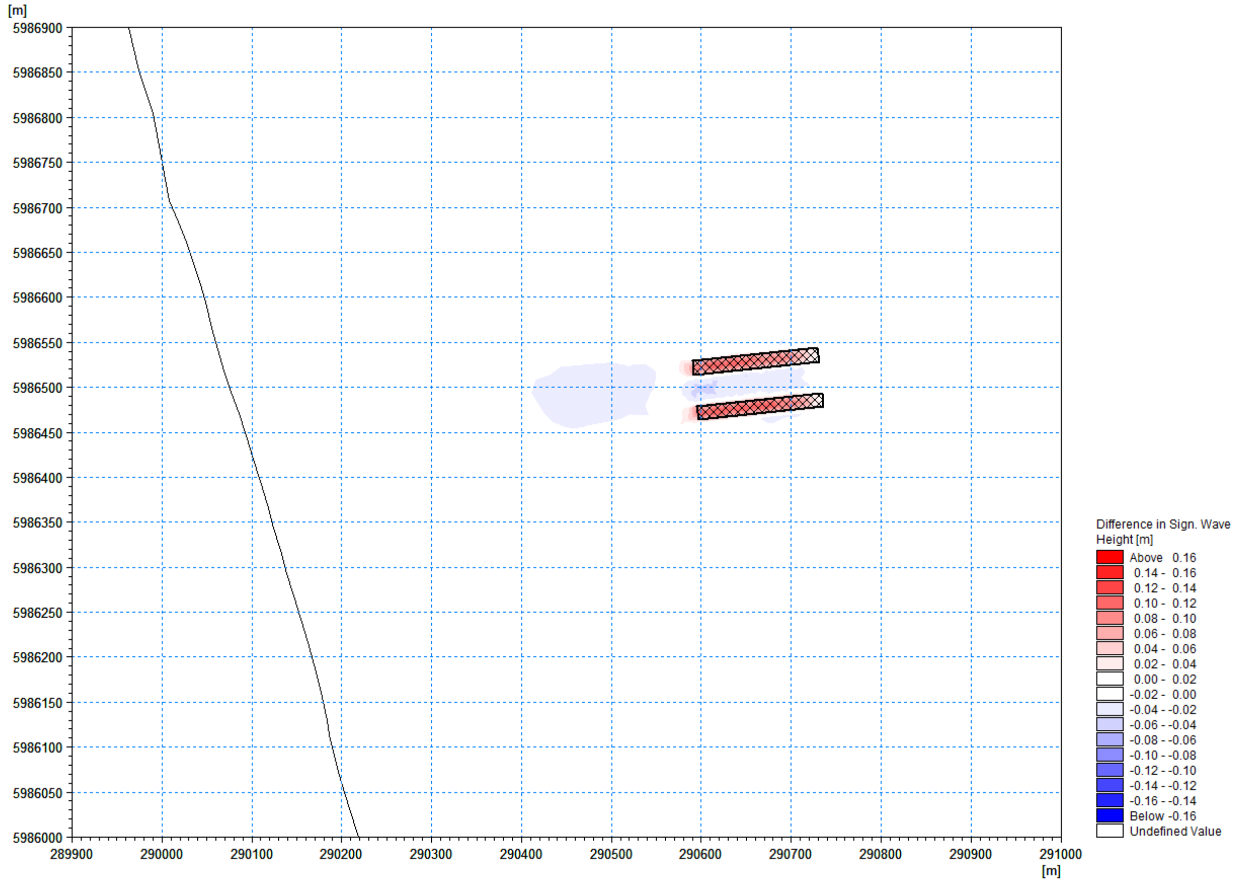


Figure 4-27 Difference in significant wave height in metres between 'Baseline' and 'Option' for 50%ile wave conditions coming from 'East' - MLWS

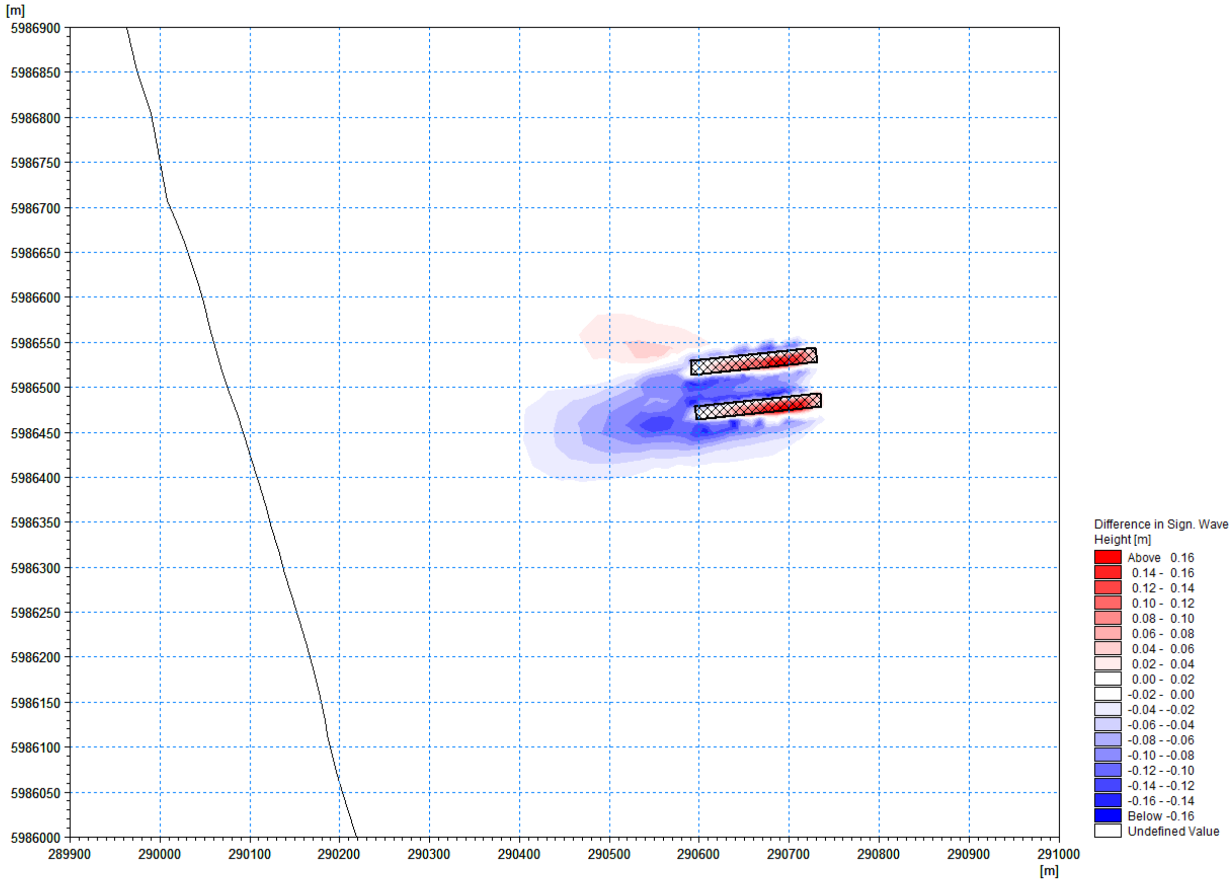


Figure 4-28 Difference in significant wave height in metres between 'Baseline' and 'Option' for 1 in 1 year waves coming from 'North' - MLWS

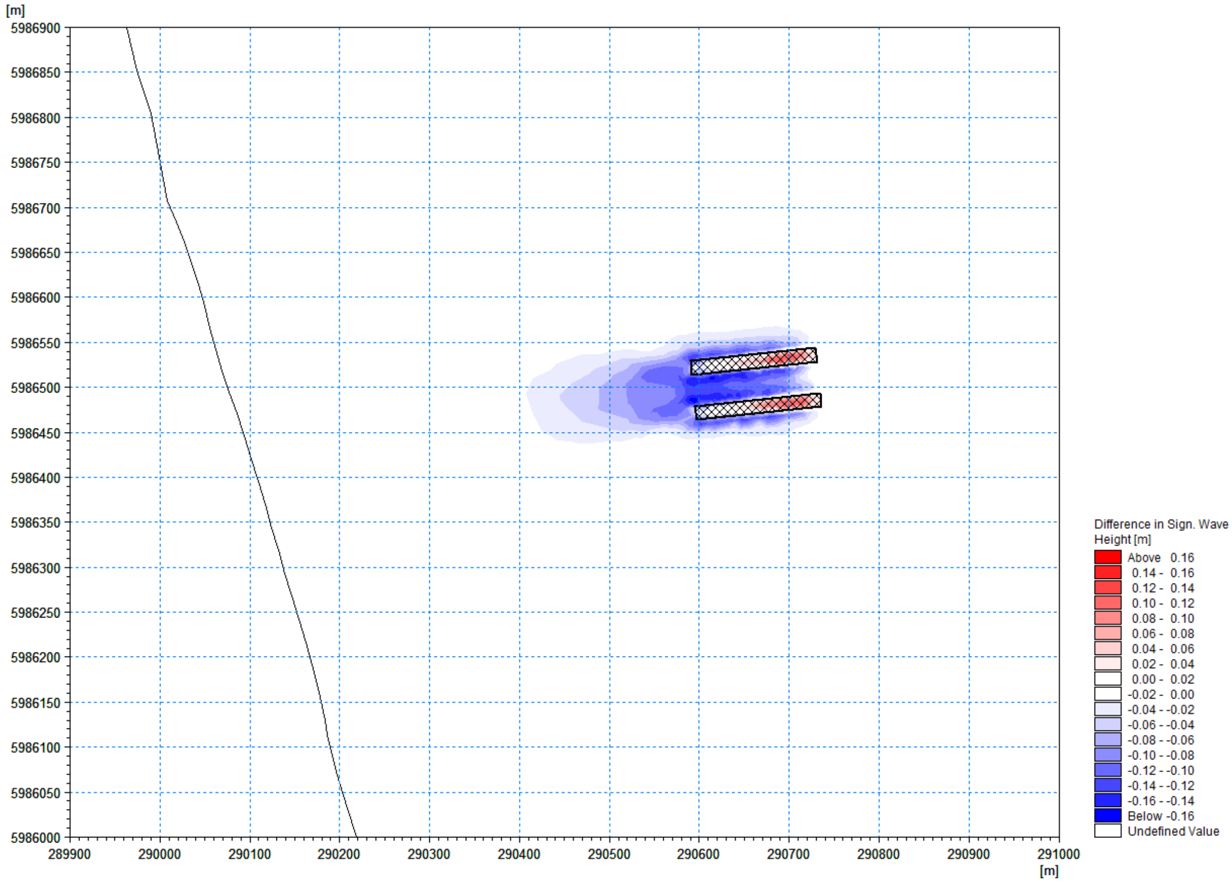


Figure 4-29 Difference in significant wave height in metres between 'Baseline' and 'Option' for 1 in 1 year with waves coming from 'East' - MLWS

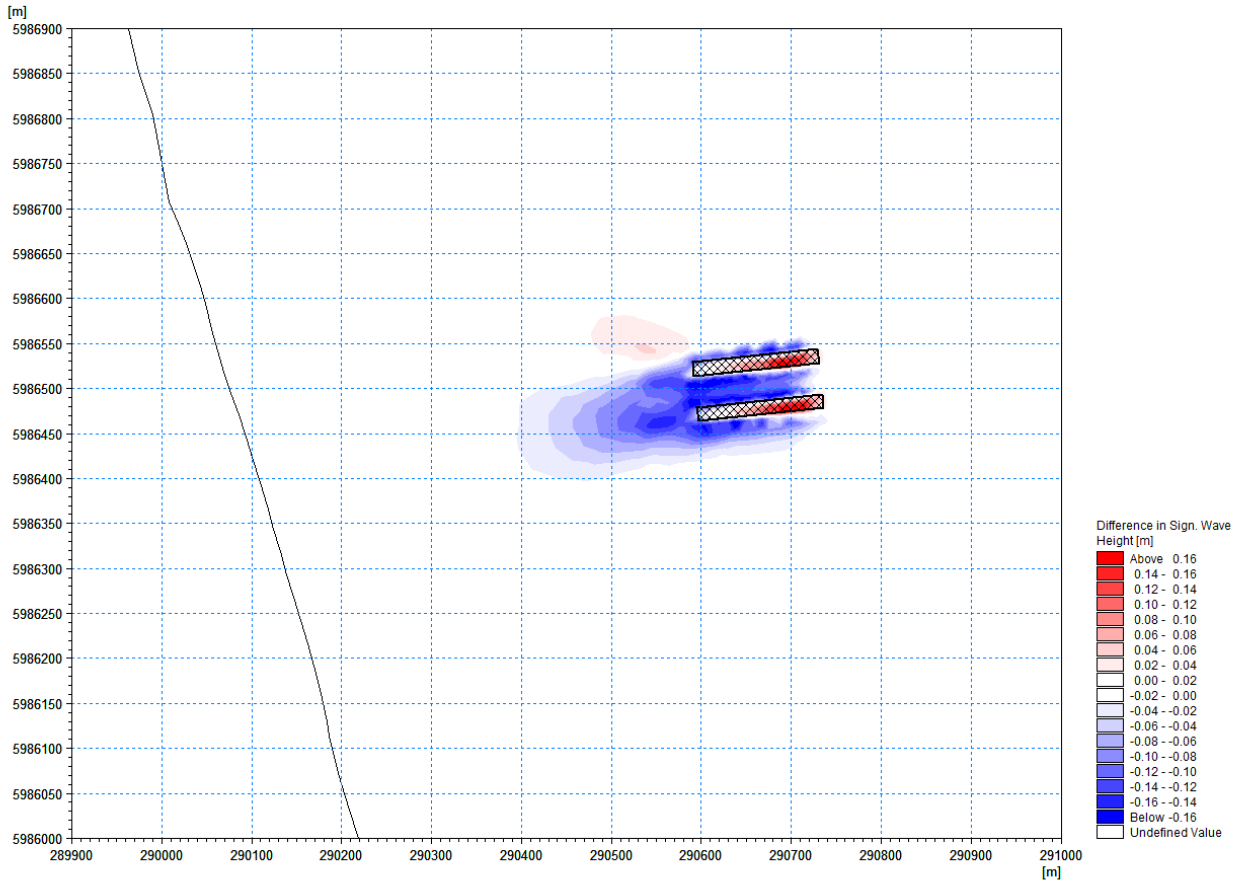


Figure 4-30 Difference in significant wave height in metres between 'Baseline' and 'Option' for 1 in 100 year waves coming from 'North' - MLWS

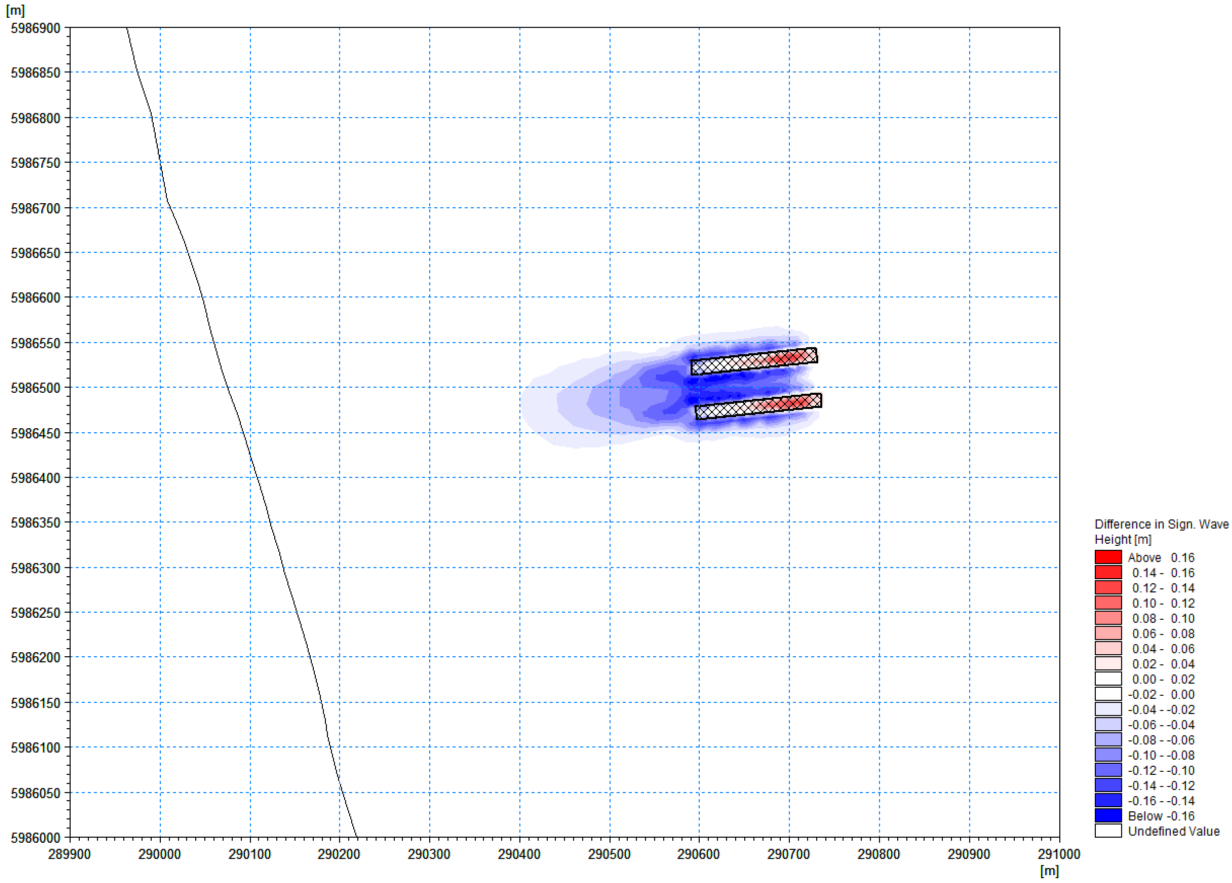


Figure 4-31 Difference in significant wave height in metres between 'Baseline' and 'Option' for 1 in 100 years with waves coming from 'East' - MLWS

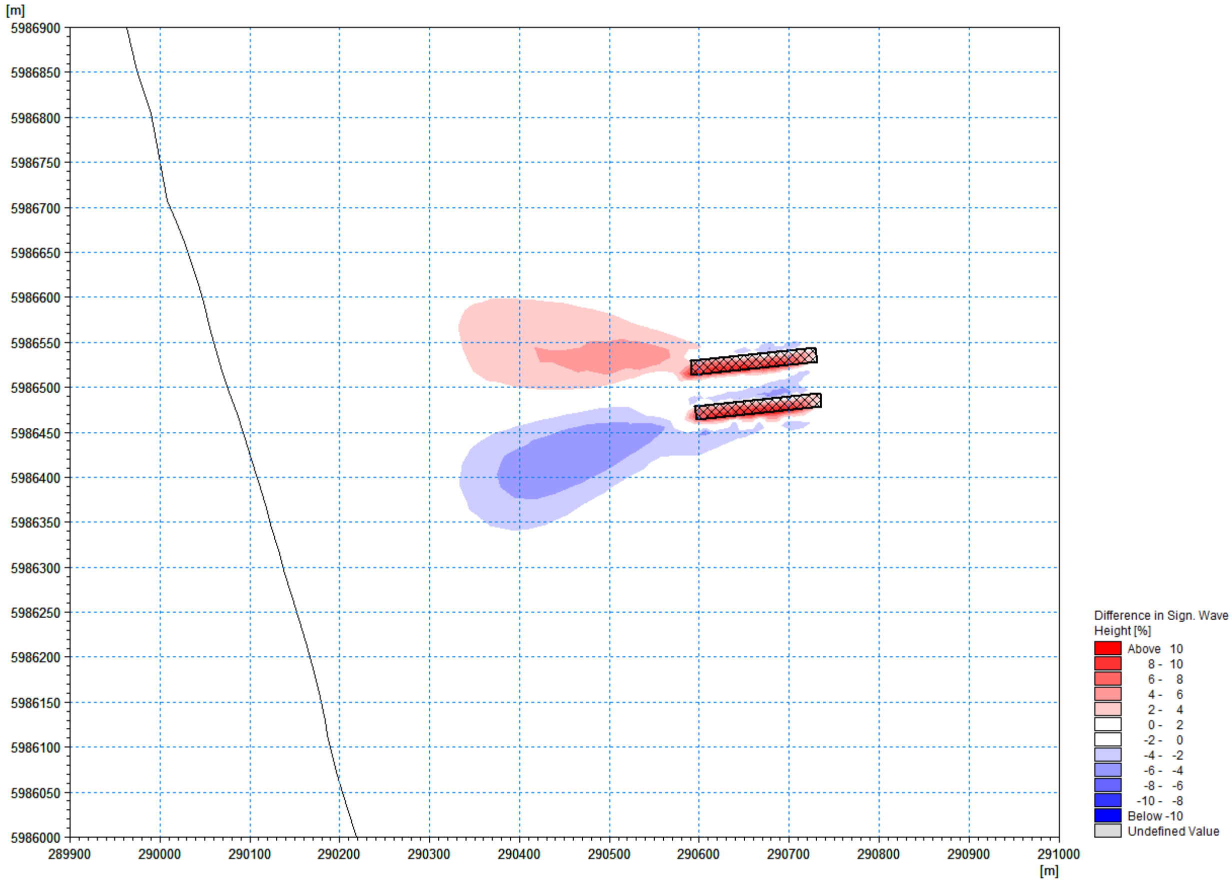


Figure 4-32 Difference in significant wave height in percent between 'Baseline' and 'Option' for 50%ile wave condition coming from 'North' - MLWS

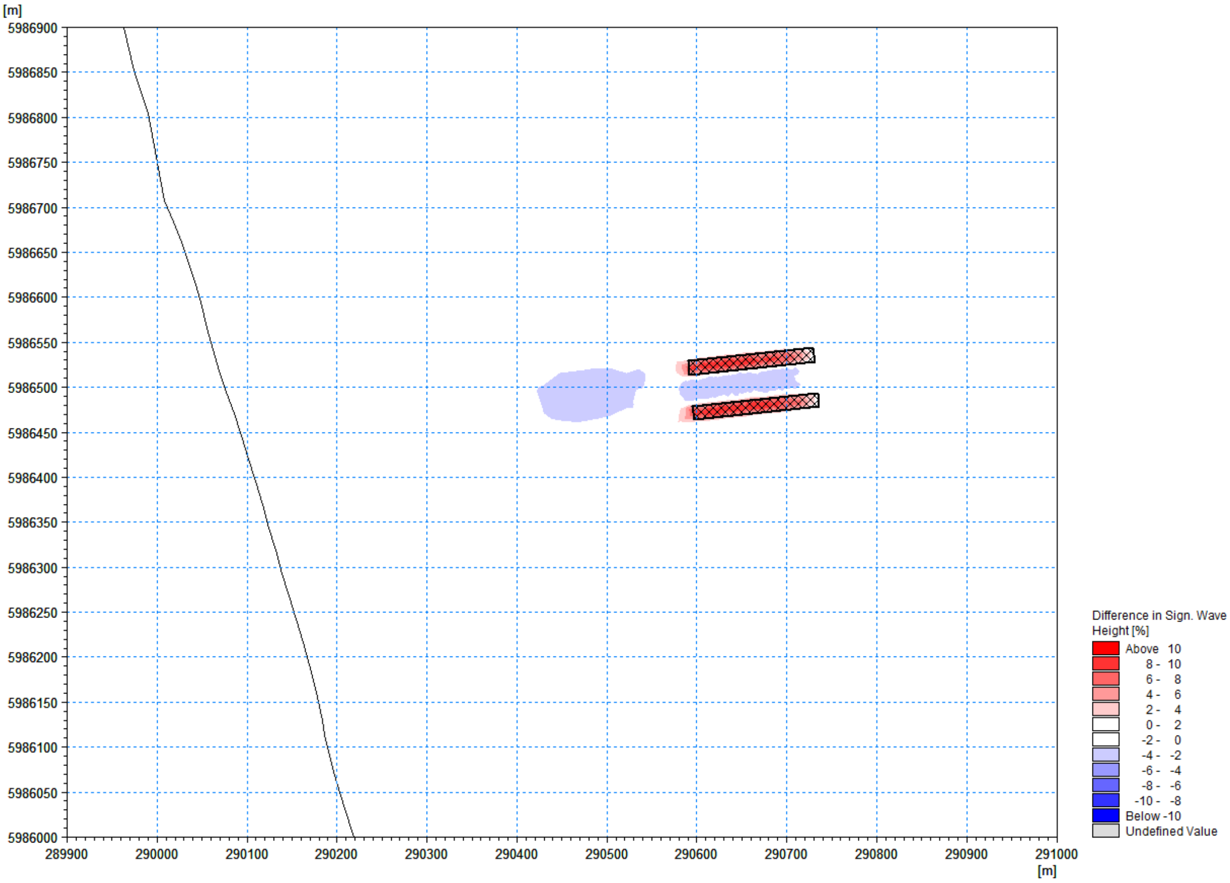


Figure 4-33 Difference in significant wave height in percent between 'Baseline' and 'Option' for 50%ile wave condition with waves coming from 'East' - MLWS

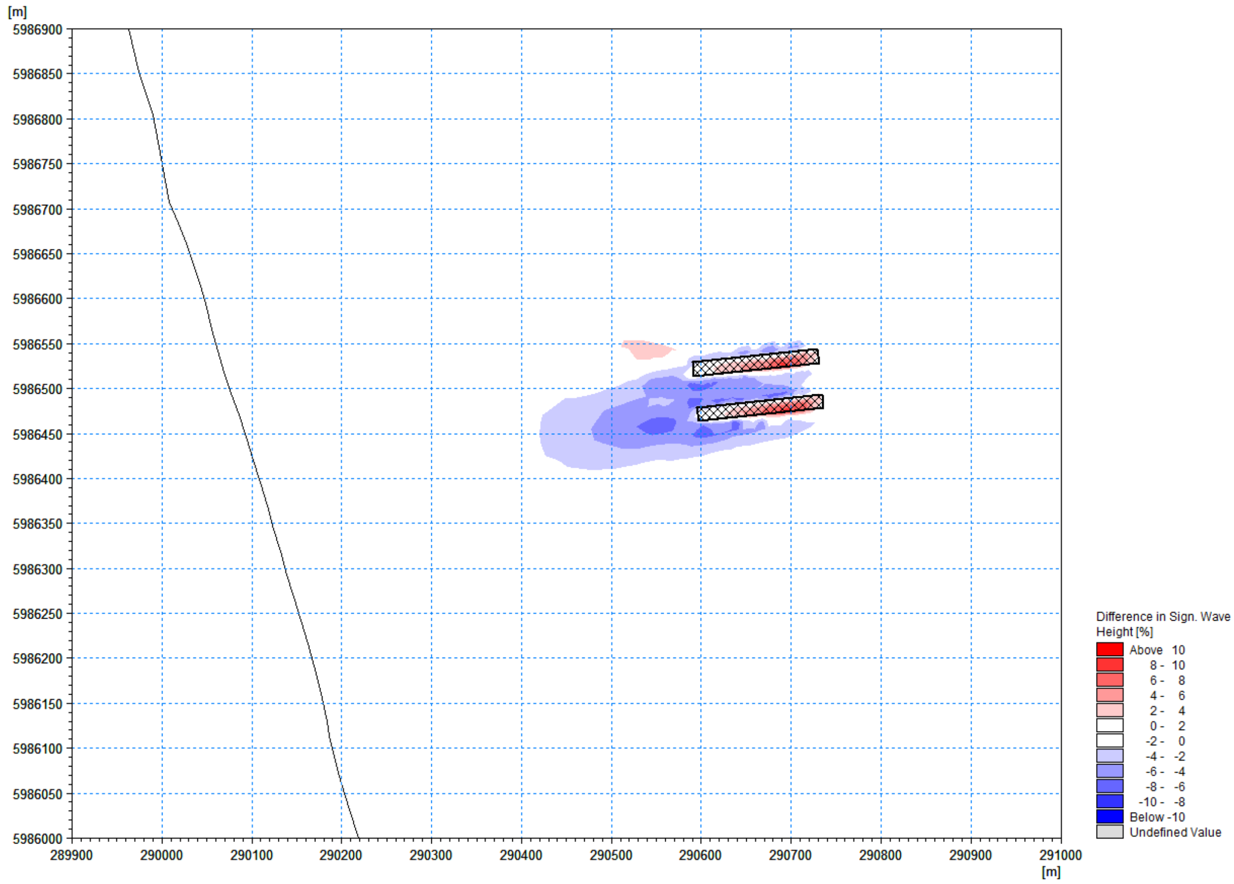


Figure 4-34 Difference in significant wave height in percent between 'Baseline' and 'Option' for 1 in 1 year with waves coming from 'North' - MLWS

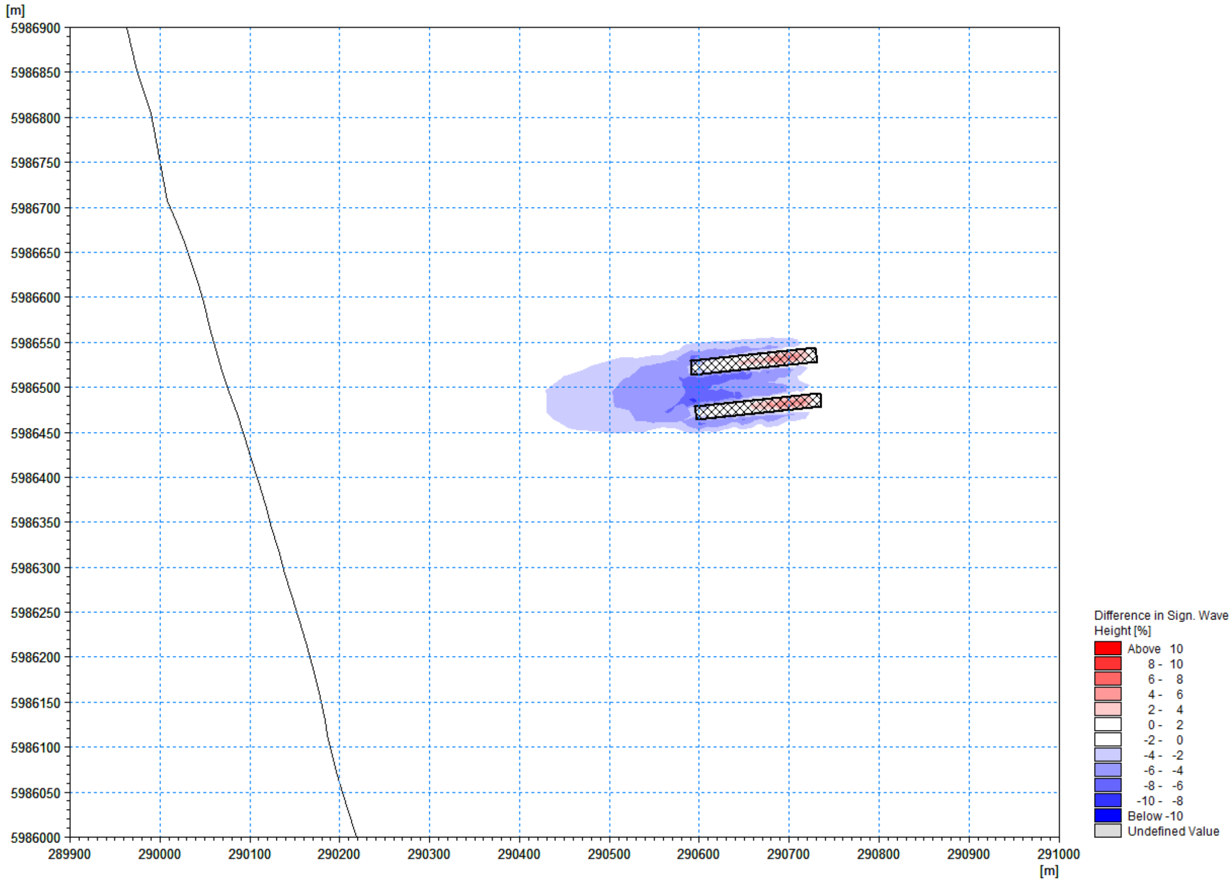


Figure 4-35 Difference in significant wave height in percent between 'Baseline' and 'Option' for 1 in 1 year waves coming from 'East' - MLWS

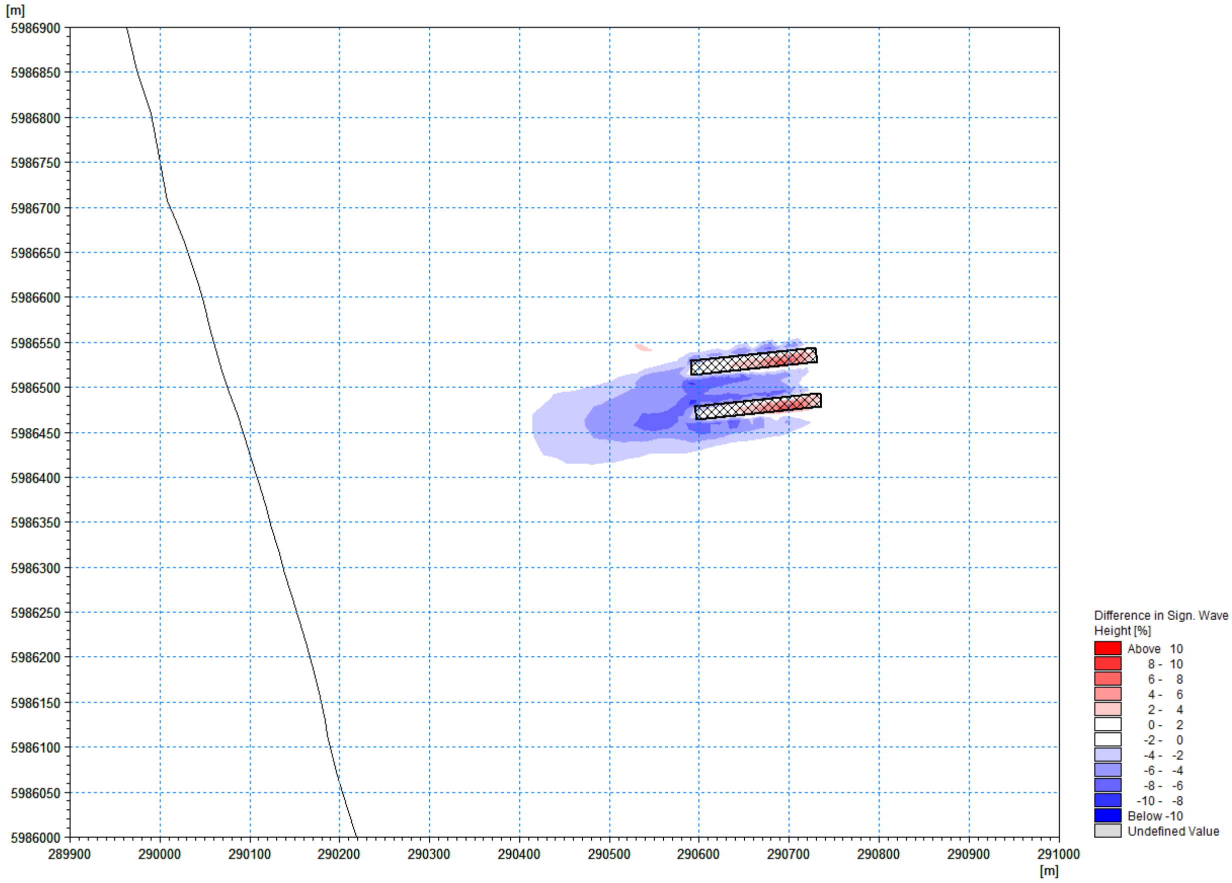


Figure 4-36 Difference in significant wave height in percent between 'Baseline' and 'Option' for 1 in 100 years with waves coming from 'North' - MLWS

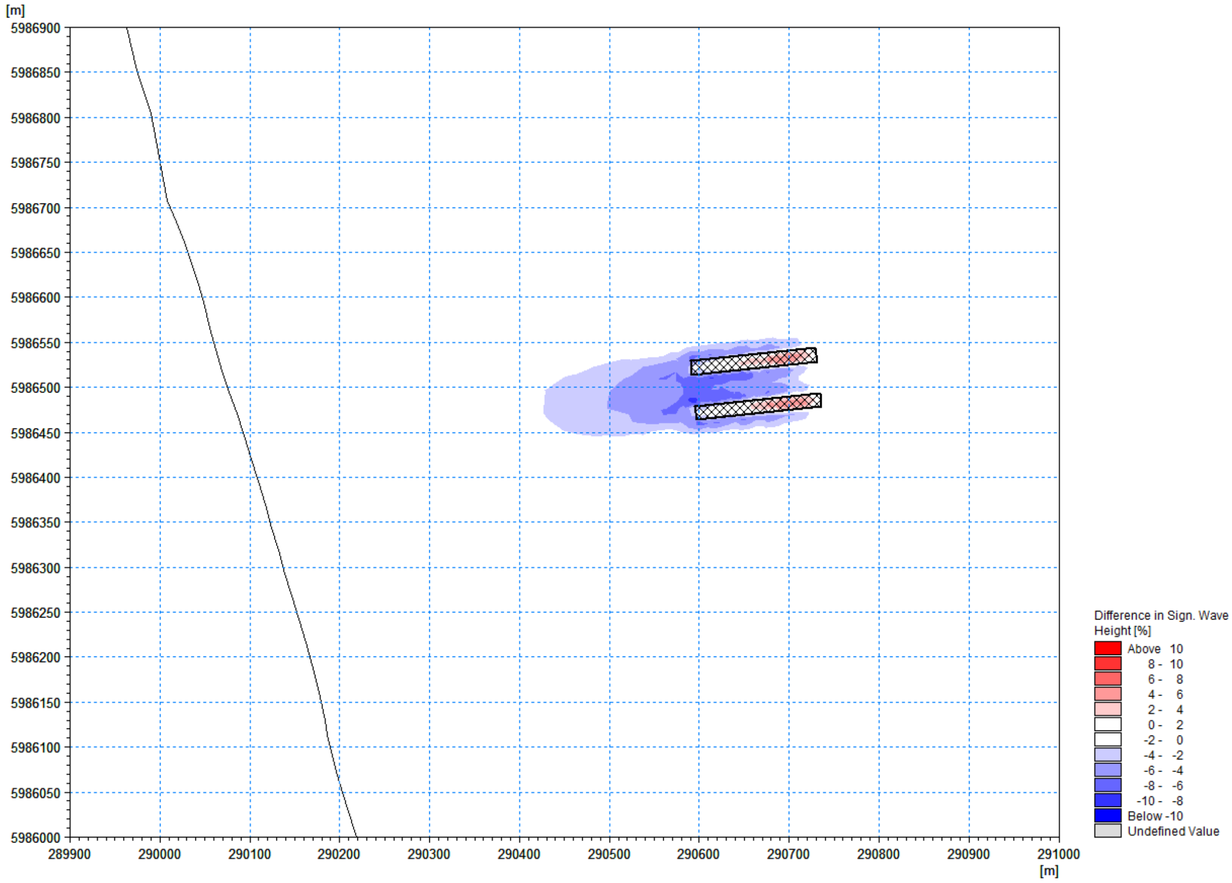


Figure 4-37 Difference in significant wave height in percent between 'Baseline' and 'Option' for 1 in 100 year waves coming from 'East' – MLWS

4.3.4 Wave Model Results Discussion for MLWS Runs

This section discusses the wave model runs that were simulated using MLWS.

The significant wave height between the 'Baseline' and the 'Option' for the 50%ile with waves coming from 'North' is increased by up to +0.09m at the cable protection and reduced by up to -0.04m either side of the cable protection. There is an area of increased significant wave height (+0.02m to +0.04m) that extends from the northern cable protection in a north-westerly direction by approx. 230m. An area of reduced significant wave height (-0.02m to -0.06m) extends from the southern cable protection in a south-westerly direction by approx. 250m.

The significant wave height between the 'Baseline' and the 'Option' for the 50%ile with waves coming from 'East' is increased by up to +0.12m at the cable protection and reduced between -0.02m to -0.05m between the cable protection. There is an area of reduced significant wave height (-0.02m to -0.04m) that extends from the cable protection in an easterly direction by approx. 170m.

The significant wave height between the 'Baseline' and the 'Option' for 1 in 1 year waves coming from 'North' is increased by up to +0.22m at the cable protection and reduced by up to -0.24m between the two cable protection structures. Either side of the cable protection the significant wave height is reduced between -0.02m to -0.16m. There is an area of increased significant wave height (up to +0.05m) that extends from the northern cable protection in a north-westerly direction by approx. 110m. An area of reduced significant wave height (-0.02m to -0.15m) extends from the cable protection in an easterly direction by approx. 190m.

The significant wave height between the 'Baseline' and the 'Option' for 1 in 1 year waves coming from 'East' is increased by up to +0.16m at the cable protection and reduced by up to -0.21m between the two cable protection structures. Either side of the cable protection the significant wave height is reduced between -0.02m to -0.14m and an area of 180m extends towards the shoreline where the significant wave height is also reduced by between -0.02m to 0.12m.

The significant wave height between the 'Baseline' and the 'Option' for 1 in 100 year waves coming from 'North' shows a similar pattern as for 1 in 1 year waves, but with a slight increase in magnitude; with the significant wave height at the cable protection increased by up to +0.24m and a reduction in significant wave height between the two cable protection structures by up to -0.29m. There is an area of increased significant wave height (up to +0.05m) that extends from the northern cable protection in a north-westerly direction by approx. 100m. An area of reduced significant wave height (-0.02m to -0.17m) extends from the cable protection in an easterly direction by approx. 200m.

The significant wave height between the 'Baseline' and the 'Option' for 1 in 100 year waves coming from 'East' shows a similar pattern as for 1 in 1 year waves, but with a slight increase in magnitude; with the significant wave height at the cable protection increased by up to +0.18m and a reduction in significant wave height between the two cable protection structures by up to -0.23m. Either side of the cable protection the significant wave height is reduced by between -0.02m to -0.14m and an area of 190m extends towards the shoreline where the significant wave height is also reduced by between -0.02m to 0.14m.

When the changes in significant wave heights are expressed in percent the significant wave height between the 'Baseline' and the 'Option' for the 50%ile waves coming from the 'North' are increased by up to +13% at the cable protection and reduced by up to -6% in small areas in between and either side the cable protection. There is an area of increased significant wave height (+2% to +6%) that extends from the northern cable protection in a north-westerly direction by approx. 250m. An area of reduced significant wave height (-2% to -6%) extends from the southern cable protection in a south-westerly direction by approx. 260m.

The significant wave height between the 'Baseline' and the 'Option' for the 50%ile with waves coming from the 'East' are increased by up to +10% at the cable protection and reduced by between -2% to -4% between the cable protection as well as in an area extending eastwards by approx. 150m.

The significant wave height between the 'Baseline' and the 'Option' for 1 in 1 year waves coming from 'North' are increased by up to +10% at the cable protection and reduced by between -2% to -8% in areas either side of the cable protection and in an area extending eastwards by approx. 170m.

The significant wave height between the 'Baseline' and the 'Option' for 1 in 1 year waves coming from 'East' are increased by up to +7% at the cable protection and reduced by up to -10% between the cable protection structures and reduced between -2% to -4% in an area extending eastwards by approx. 150m.

The significant wave height between the 'Baseline' and the 'Option' for 1 in 100 year waves coming from 'North' are increased by up to +9% at the cable protection and reduced by up to -11% between the cable protection structures and reduced between - 2% to -7% in an area extending eastwards by approx. 180m.

The significant wave height between the 'Baseline' and the 'Option' for 1 in 100 year waves coming from 'East' are increased by up to +7% at the cable protection and reduced by up to -11% between the cable protection structures and reduced between - 2% to -6% in an area extending eastwards by approx. 160m.

5 Nearshore Sediment Transport Modelling

5.1 Introduction

Sediment transport modelling was undertaken to determine if the highly precautionary worst case scenario for cable protection in the nearshore was located within the zone of active wave-driven sediment transport and if so, how do sediment budgets might be affected. The outputs of the sediment transport modelling have been used to update the assessment of changes to bedload sediment transport and seabed morphology due to the presence of cable protection measures in section 7 of this report.

5.2 Sediment transport model description

MIKE modelling suite contains a 1-dimensional sediment transport model, 'LITDRIFT '. This simulates longshore sediment transport dynamics in response to wave (propagation, shoaling and dissipation and variability in radiation stresses) and tidal current forcing processes, to predict annual sediment budgets for coastal regions.

The study utilised the 1-dimensional (1D) sediment transport modelling software LITDRIFT, which is part of the MIKE modelling software package developed by DHI. The model simulated 44 years of longshore sediment transport along the cross shore profile where the proposed nearshore cable protection would be located, to understand the effect to which the structure would have on the local sediment transport regime.

The model was forced with, a timeseries of wave conditions obtained from the UK MetOffice hindcast wave model and a timeseries of current speeds derived from RHDHV's calibrated hydrodynamic model, as described in **Appendix 8-3 - Marine Physical Processes Modelling Technical Report (Revision 3)** [REP2-017]. The model predicted the volume of sediment which would be "trapped" by the cable protection structure on an annual basis, to understand the potential effects on the broad-scale sediment transport processes along the Holderness coast.

5.3 Model Setup

5.3.1 Input Data

A timeseries of hindcast wave conditions (1980 – 2024) was obtained from the UK MetOffice regional wave model which covers the continental shelf waters around the UK, at the location presented in **Figure 5-1**, at approximate bed level of -15mCD. The resolution of the hindcast model in this region is on an approximate 1.5km grid. A summary of the wave climate is presented in the wave rose in **Figure 5-2**, which demonstrates the predominant wave direction is coming from NNE to ENE, with a smaller proportion of the wave climate approaching from ESE to SSE.

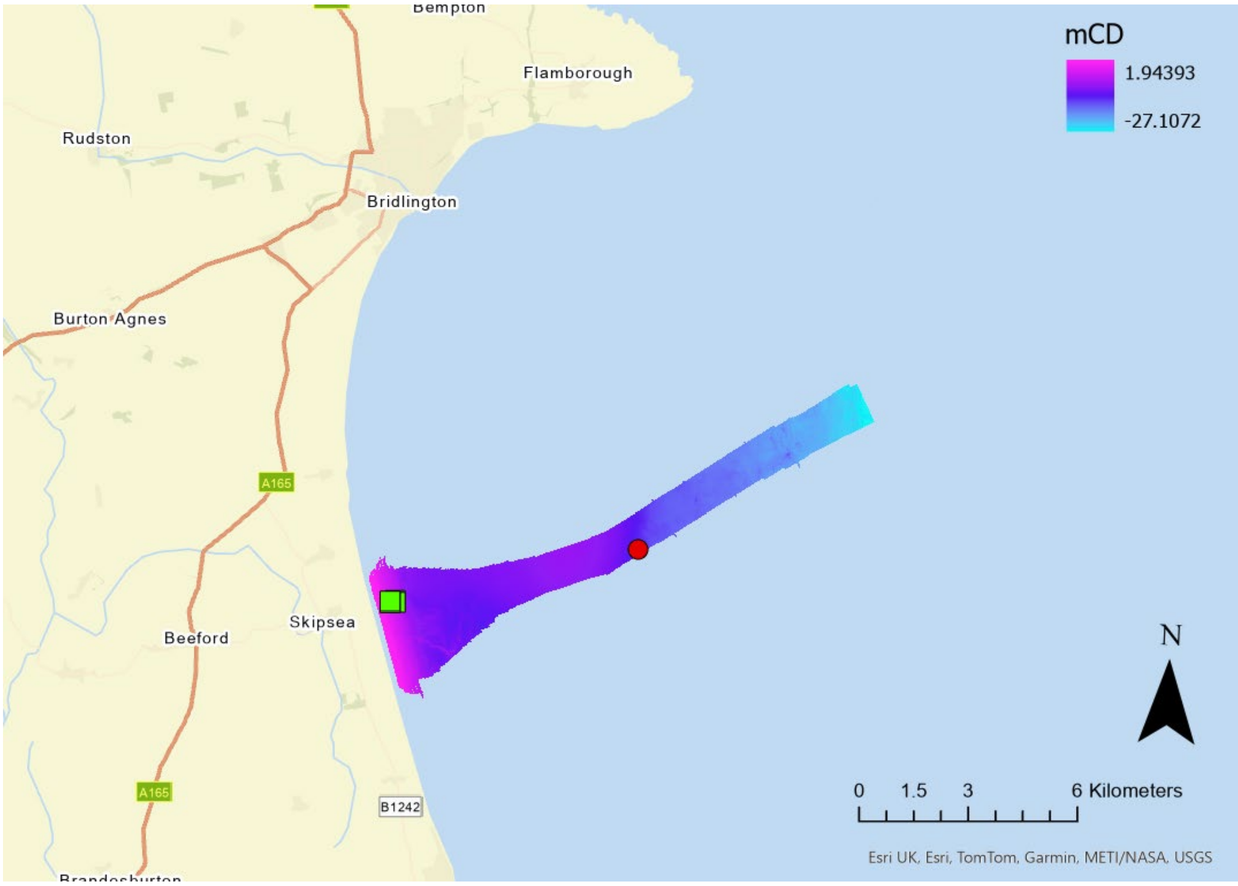


Figure 5-1 Location of UK MetOffice wave model extraction (red dot: 54°N, 0.0909°W), cable route bathymetry survey and cable protection (green area)

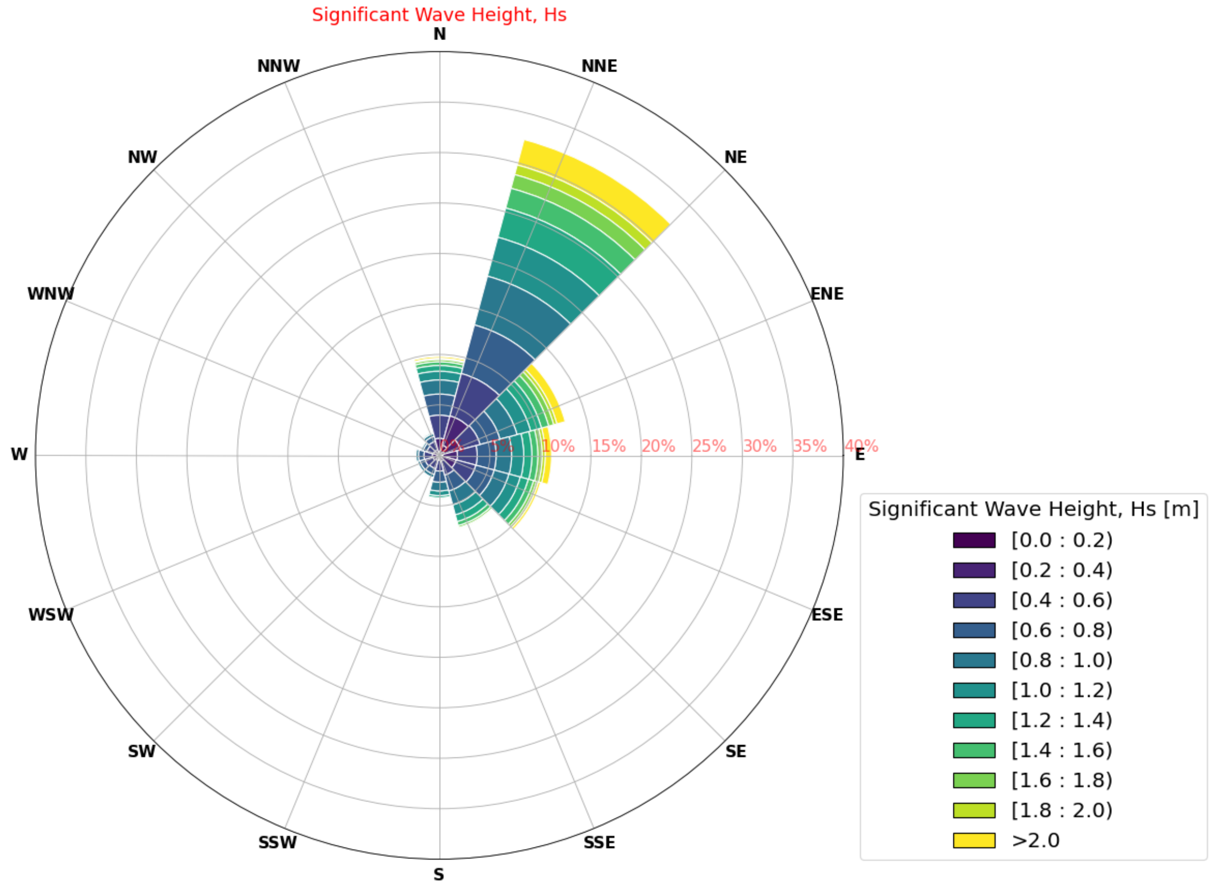


Figure 5-2 Rose of NWS model hindcast wave data timeseries by NWSUK MetOffice model (1980 – 2014)

A timeseries of predicted astronomic tides from the International Hydrographic Organization (IHO) station at Bridlington provides the varying water levels at the project site. The site is defined as macro-tidal with a spring tide range of up to 6.5m.

A timeseries of current speeds covering a typical spring neap cycle was extracted from the calibrated hydrodynamic model described in **Appendix 8-3 - Marine Physical Processes Modelling Technical Report (Revision 3)** [REP2-017]. These were obtained from the location of the cable protection. A timeseries of these tidal currents are presented in **Figure 5-3**.

High resolution multibeam bathymetric survey data was obtained which covers the nearshore part of the offshore cable corridor (**Figure 5-1**). In the intertidal zone and upper beach, this dataset is supplemented by 2022 LiDAR data from the Environment Agency/DEFRA national LiDAR data programme. This LiDAR data was available at 1m resolution. The LiDAR and bathymetric surveys were combined to obtain a single 1D profile extending from the upper beach to the offshore extent of the sediment transport model, where the wave forcing data has been extracted from the UK MetOffice model (red dot in **Figure 5-1**). This combined profile is presented in **Figure 5-4**.

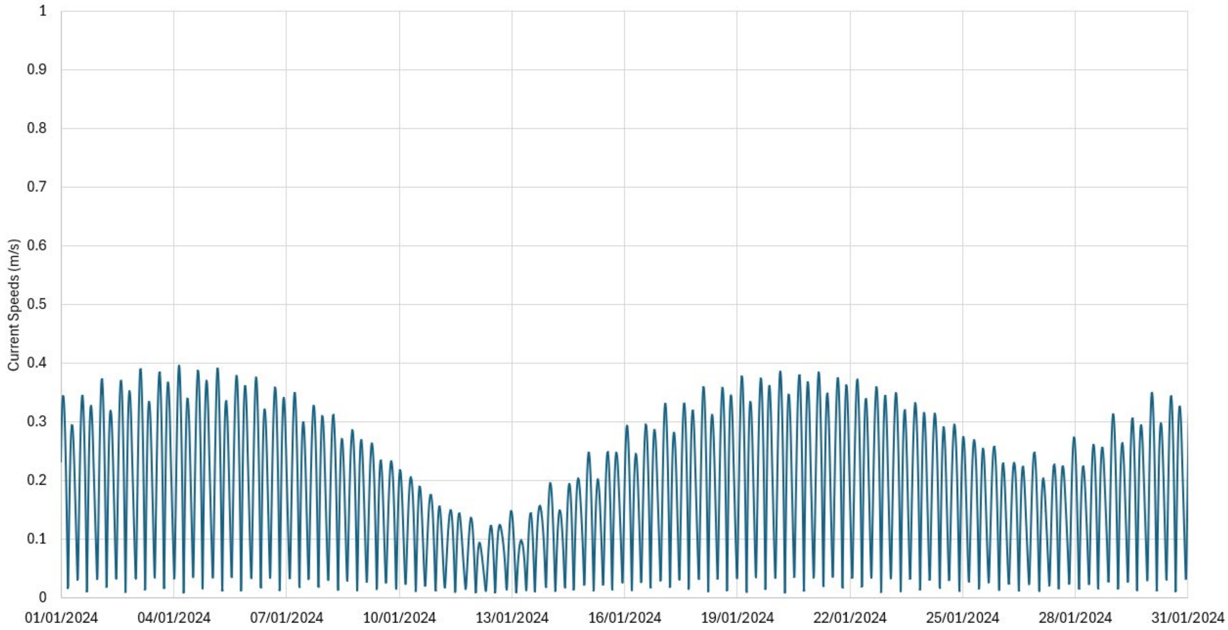


Figure 5-3 Modelled current speed from RHDHV calibrated model, at location of cable protection

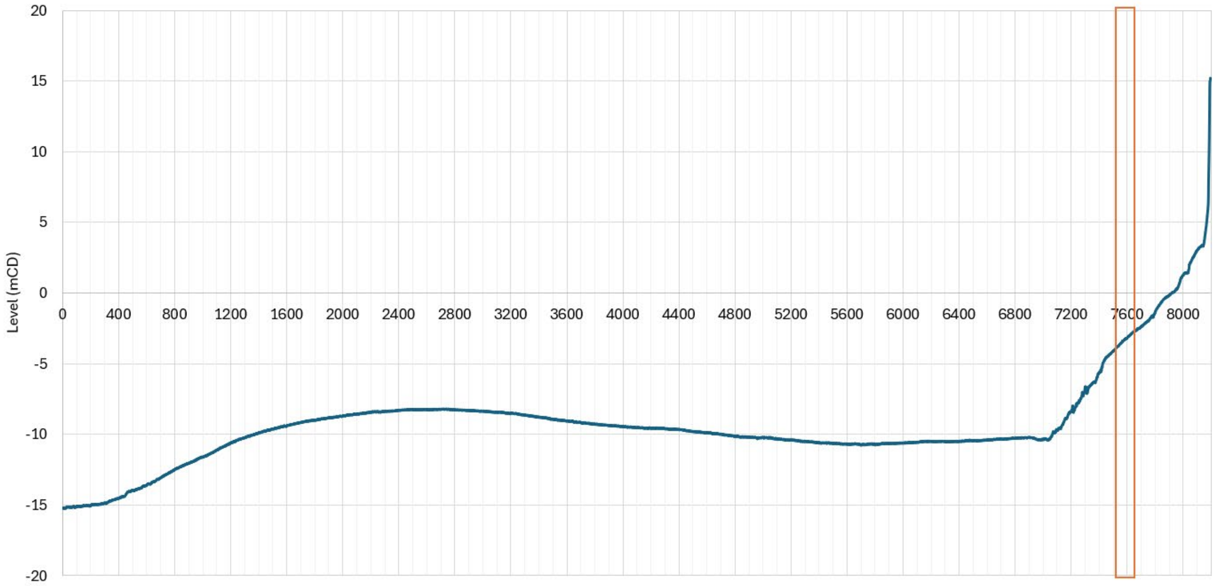


Figure 5-4 Input profile for sediment transport model, combined from LiDAR and bathymetric surveys. Orange extent shows position and length of cable protection ~140m (between 7504m and 7646m)

Sediment data was collated from the Fugro geophysical survey summarised in the report – Fugro (2022). The most nearshore surface sediment grab sample location 'ST177' was selected, being situated within the extent of profile presented in **Figure 5-4** and would therefore provide an accurate representation of seabed characteristics for the profile.

For the purpose of this modelling, it is assumed that these characteristics are uniform across the entire cross-shore profile. From a particle size distribution (PSD) curve for sediment at 'ST177', the sediment properties were estimated at; D16 = 80µm, D50 = 142.4µm and D84 = 235µm.

5.3.2 Model Settings

The inputs to the MIKE 'LITDRIFT' model include, wave forcing, water level, currents, seabed profile and standard sediment transport settings, these are described in the following sections. The model simulation longshore sediment transport across 44 years of data (1980 – 2024).

The wave forcing at the offshore end of the 1D profile (-15mCD) included root mean square wave height Hrms, peak wave period Tp, mean wave direction and reduction factor (0.5). The hindcast timeseries from the UK MetOffice model covered all years of the simulation 1980 – 2024.

A varying water level was applied for the model simulation from the predicted astronomic tide levels at Bridlington from the IHO tidal database, which covered the full simulation, 1980 – 2024.

The spring-neap timeseries of current speed extracted from the calibrated RHDHV hydrodynamic model, was repeated to cover the entire simulation period.

The horizontal grid resolution of the 1D 'LITDRIFT' model is a constant 1m for the full length of the profile.

The standard sediment transport settings for the 'LITDRIFT' model are summarised in **Table 5-1**. Where data were not available, a combination of user experience, software developer guidance and literature was used to define the model settings. Where relevant, settings were kept uniform across the entire cross-shore profile.

Table 5-1 'LITDRIFT' 1D sediment transport settings

Parameter	Selected Value
Profile Orientation	75°N
Bed Roughness	0.004m (0.008m model sensitivity - see Section 5.4.1)
Wave Definition	Type: Battjes & Janssen Gamma: 0.8 (0.65 – 0.95 model sensitivity - see Section 5.4.1)
Sediment Properties	Type: Graded sand Relative density: 2.65 D50: 0.1424mm Grading (√D84/D16): 1.71

Parameter	Selected Value
Ripples	Included (Excluded model sensitivity - see Section 5.4.1)
Critical Shields Parameter	0.045
Wave Theory	Stokes 5th order

5.3.3 Cable Protection Structure

The location of the proposed cable protection structure was situated between -2.75mCD and -4.08mCD (chainage 7504m to 7646m in Figure 5-4), extending approximately 140m in the offshore direction.

5.4 Model Results

5.4.1 Model Sensitivity

The sensitivity of the model settings on the predicted model results are presented in this section, to attempt to quantify the magnitude of model uncertainty when interpreting the results. Bed roughness, ripples, breaking wave index (gamma) and tidal currents are investigated in this section, through a series of 5 year model simulations (1980 – 1985). The baseline model settings are presented in **Table 5-1**. Cross sectional profile plots of net sediment transport are presented for the three sensitivity parameters above (**Figure 5-5**, **Figure 5-6**, **Figure 5-7** and **Figure 5-8**, respectively), along with percentage change in annual sediment transport rates in

Table 5-2.

Seabed roughness of the beach profile will vary across its cross-section due to changes in grain size, grain sorting and seabed features such as ripples and bedforms. Therefore, it is difficult to estimate an exact value of bed roughness for the beach profile. The production value of 0.004m was the default value suggested by the software developer (DHI), as well as the commonly used value for fine sandy beach environments within the literature (Hendriyono et al (2015), Saha and Rahman (2022)).

The presence and size of ripples and bedform structures on a beach will vary depending on wave conditions, together with profile shape and sediment properties. Ripples will affect the drag force properties of flow over the bed so play an important role in the quantity of sediment transported. In the 'LITDRIFT' setup, ripples are either included or excluded. For the sensitivity test the associated empirical coefficients for 'included' ripples are kept as default, as recommended by the software developer, DHI.

Breaking wave index (gamma) within a beach environment is usually assumed as a constant ~0.8 for the purpose of engineering design. Although in reality this parameter varies depending on profile slope, wave steepness and relative water depth (Goda (2010)). However, in the 'LITDRIFT' model setup a constant value is specified both temporally and spatially along the profile, so it is useful to understand the how the model performs under varying gamma values.

Within the intertidal zone, the influence of tidal currents on the overall sediment transport regime is typically insignificant, however, due to the vertical position of the proposed cable protection (-2.75mCD and -4.08mCD) it is important to understand its potential significance on model results.

Based on the results for initial sensitivity simulations, the model predicts that the cable protection is situated within the active wave transport zone.

To understand the sensitivity of the model results to bed roughness, a value of 0.008m was used as a 100% increase on the production value. The model was simulated for 5 years using both bed roughness values and the results of this sensitivity test are presented in **Figure 5-5**.

Table 5-2 summarises the percentage change in modelled sediment transport rates, suggests that for the full cross-shore profile (down to the offshore extent of the active wave transport zone), there is a 24.5% decrease in the net annual sediment transport rate, by increasing the bed roughness from 0.004m to 0.008m.

To understand the sensitivity of the model results to ripples, a 5-year simulation excluding ripples was undertaken. **Figure 5-6** and **Table 5-2** demonstrate that excluding ripples into the model setup will result in a small decrease in sediment transport throughout the active wave transport zone. The reduction in annual net sediment transport is -2.9%.

To understand the sensitivity of the model results to breaking wave index (gamma), additional simulations were undertaken varying gamma to 0.65 and 0.95. **Figure 5-7** and **Table 5-2** demonstrate that increasing (decreasing) the gamma index results in a small increase (decrease) in sediment transport throughout the active transport zone. The increase/decrease in annual net sediment transport in response to changing gamma was predicted to be approximately 9%.

To understand the sensitivity of the model results to tidal currents, a 5-year simulation excluding tidal currents was undertaken. **Figure 5-8** and **Table 5-2** demonstrate that the influence of tidal currents within the active wave transport zone is insignificant (<1%).

Based on this model sensitivity test where bed roughness, gamma, ripples and tidal currents were investigated **(Table 5-2**), it is advised to include a +/- 25% as a factor of model uncertainty, when interpreting and adopting results presented in this report.

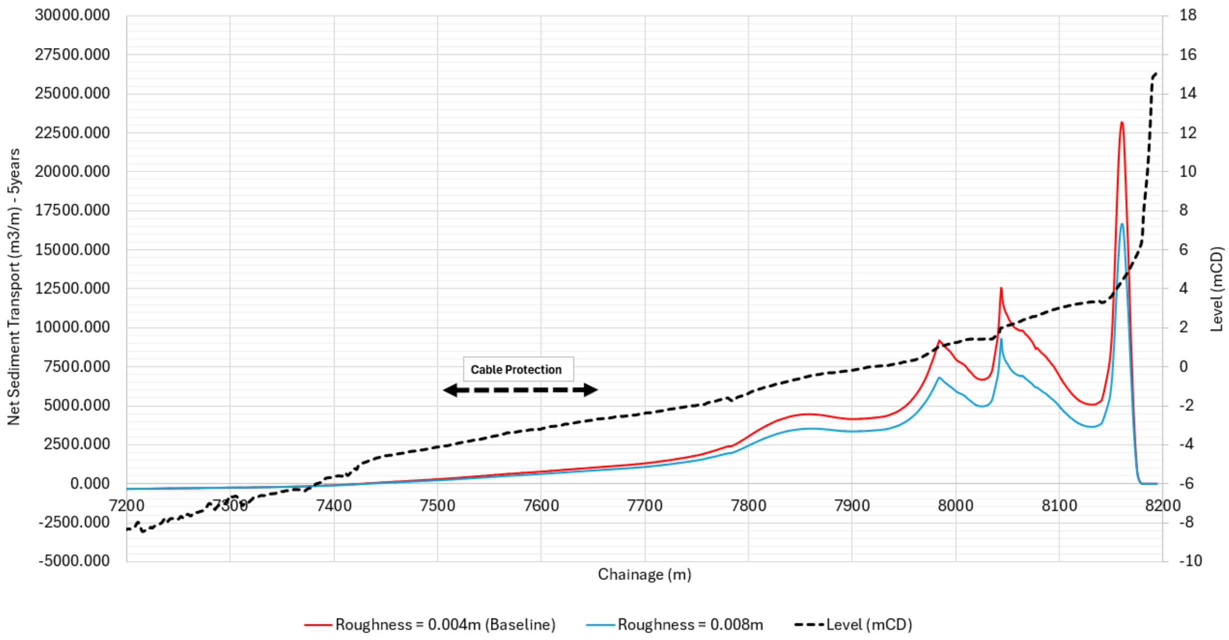


Figure 5-5 Results of model sensitivity test on bed roughness

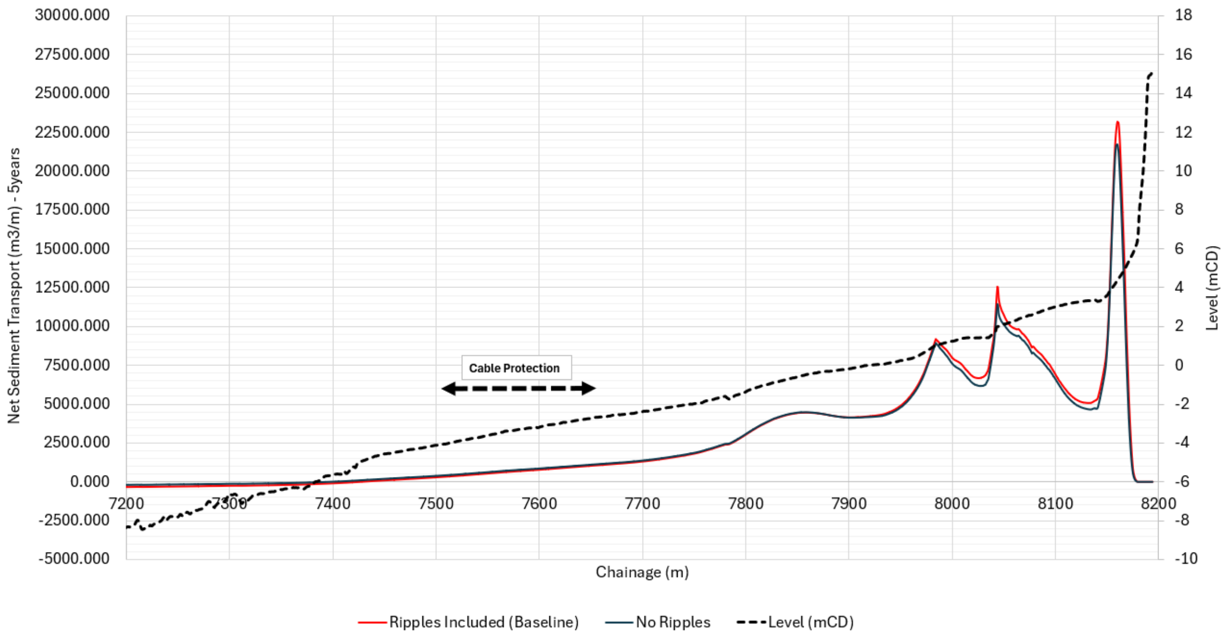


Figure 5-6 Results of model sensitivity test on ripples

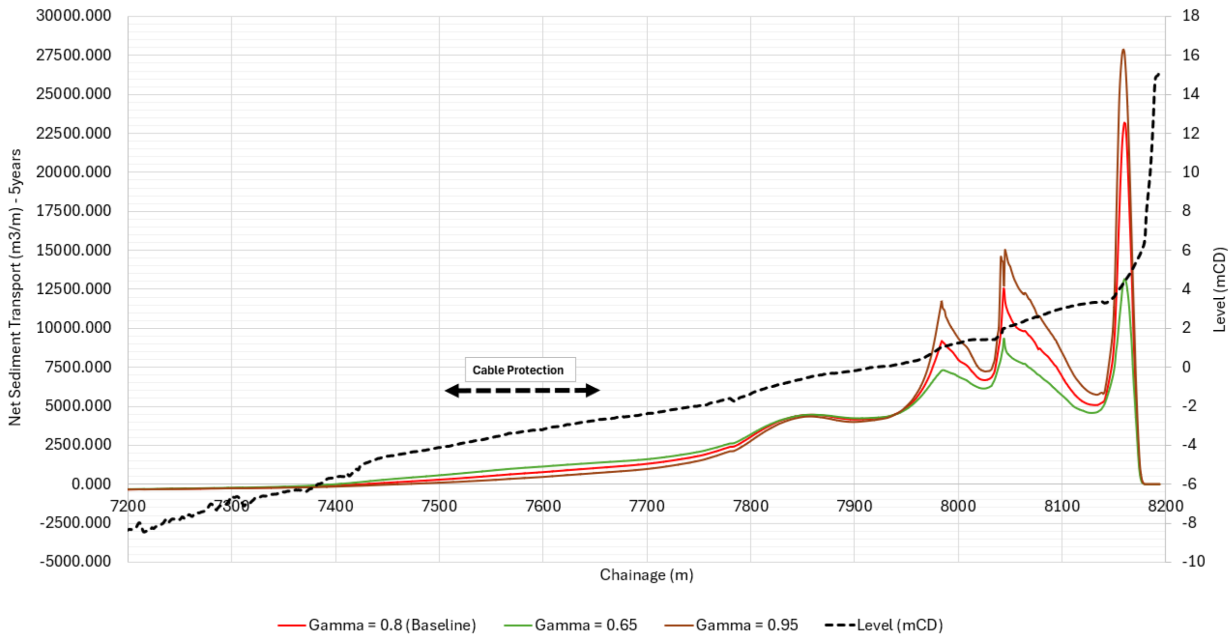


Figure 5-7 Results of model sensitivity test on breaking wave index (gamma)

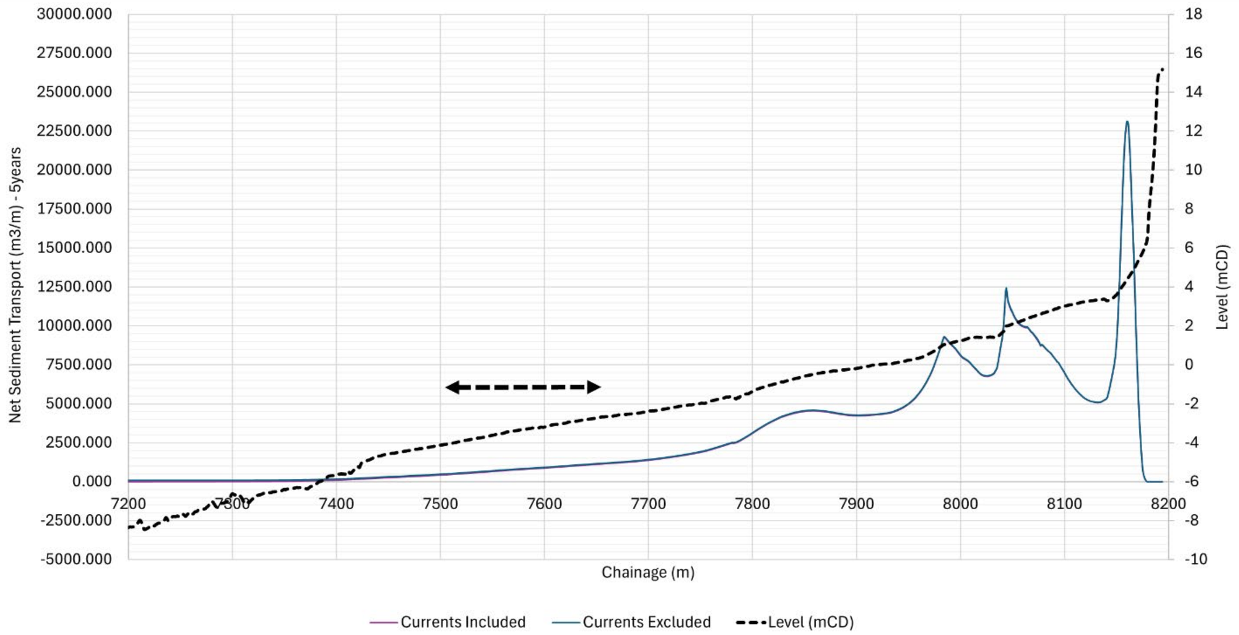


Figure 5-8 Results of model sensitivity test on tidal currents

Table 5-2 Percentage (%) change in annual net sediment transport within the active wave transport zone

Sensitivity Parameter	% Change in Annual Net Sediment Transport
Roughness = 0.008m	- 24.5%
Gamma = 0.65	- 8.6%
Gamma = 0.95	+ 8.8%
Ripples Excluded	- 2.9%
Tidal Currents Excluded	+ 1.0%

5.4.2 Model Assumptions

For the purpose of this sediment modelling study, the following assumptions have been made for 1D 'LITDRIFT' simulations, which are important to consider when interpreting and adopting the results in the following report sections. These assumptions are listed in preceding paragraphs.

Current speed applied in the model is constant along the cross-shore profile, extracted from the calibrated RHDHV hydrodynamic model.

The sediment properties outlined above (D50, grading and roughness) are assumed to be constant for the entire cross-shore profile, based on one sediment grab sample 'ST177' from the Fugro (2022) study.

The profile for the beach is described by a combination of LiDAR and bathymetry data, from 2022 and 2023, respectively.

Non-erodible bed features such as rock or consolidated mud which may be present in the cross-shore profile and lower cliff face are not included in the simulations, therefore, the rates and quantities presented in the report are based on this conservative potential sediment transport assumption, that all material in the model is erodible fine sand.

When using predicted sediment transport results to quantify the effect of the cable protection, it is assumed that the structures would block 100% of material. In reality this is a conservative assumption, as a proportion of the material would be transported around or over the top of the structures as bedload or suspended sediment. In addition to this, material would 'pile up' on either side of the structures which would further reduce the blockage effect of the structure. Based on the model results presented below it is estimated that sediment accumulation would occur until a ramp is formed and sediment would then bypass the structure after a duration of 1 month, based on the average annual sediment transport rates. However, there is great uncertainty in this number due to the complex transport modes created by the presence of the structures, therefore, for this study we assume the structures provide a 100% blockage to the transport of sediment, as a conservative assumption for subsequent effect on the overall coastal processes.

5.4.3 Production Results

The results of the production 'LITDRIFT' model simulation is presented in **Figure 5-9** and **Figure 5-10** below. Where the graphs indicate the average and maximum net, positive (southward directed transport) and negative (northward directed transport) annual longshore sediment transport (m^3/m) across the profile, calculated from the 44-year simulation. The annual average and annual maximum sediment transport rates are calculated from the total transport for each of the 44 years, in the timeseries of model results.

The model predicts that the net transport within the active transport zone is in a southerly direction (positive/southward), as expected from the direction of predominant waves in the UK MetOffice model data (**Figure 5-2**). Whereas offshore of this region, the net transport is in a northerly direction (negative/northward) as these are influenced by tidal currents and not wave driven sediment transport.

The results indicate that the majority of the transport is located shoreward the cable protection structure, with peak active transport zones around 1.5mCD (200m from base of cliffs), 2.5mCD (120m from base of cliffs) and 4.5mCD (at the base of the cliffs), due to wave driven processes. However, the model predicts that there is some degree of sediment transport around the location of the cable protection.

Using the results of the 44 year simulation, the annual net longshore sediment budget calculated for the extent of the active wave transport zone is 507,690m^3 in a southward direction.

Using the length of the cable protection of 140m, the predicted annual longshore sediment transport rates presented above, with units m^3/m, are used to estimate a volume of sediment 'blocked' on an annual basis (m^3). These calculations assume that there is no bypassing of sediment around or over the structures which is highly conservative as the structures do not occupy the full water column so sediment will bypass them. These results are presented in **Table 5-3** , showing volume of 'blocked' material on the northern (positive/southward transport) and southern (negative/northward transport) sides of the structures. Across the 44 year 'LITDRIFT' simulation, the annual average and annual maximum (within a single year) values are presented.

The largest volume of 'blocked' sediment is on the North side of cable protection structures where average and maximum annual 'blocked sediment' volumes are 25,048m^3/year and 53,214m^3/year, respectively. The volume of sediment 'blocked' on the southern side is a smaller quantity, at 3,774m^3/year and 11,046m^3/year for average and maximum, respectively. **Table 5-3** demonstrates that this quantity of 'blocked' sediment, on average equates to less than 4.2% of the total annual net sediment transport for the active wave transport zone.

This 4.2% is compared with the natural inter-annual variability in net longshore transport rates across the 44-year model simulation in **Figure 5-11**. This demonstrates the insignificant effect of the cable protection structures (+/- 4.2% around average in dashed red lines) on the annual net longshore sediment transport rates, compared with the natural inter-annual variability due to metocean and hydrodynamic forcing properties.

As discussed in the previous sections of the report, it is important to consider the modelling assumptions and estimated model uncertainty when interpreting and adopting these values.

Further, it is important also to recognise the highly precautionary nature of the worst case scenario used in this modelling.

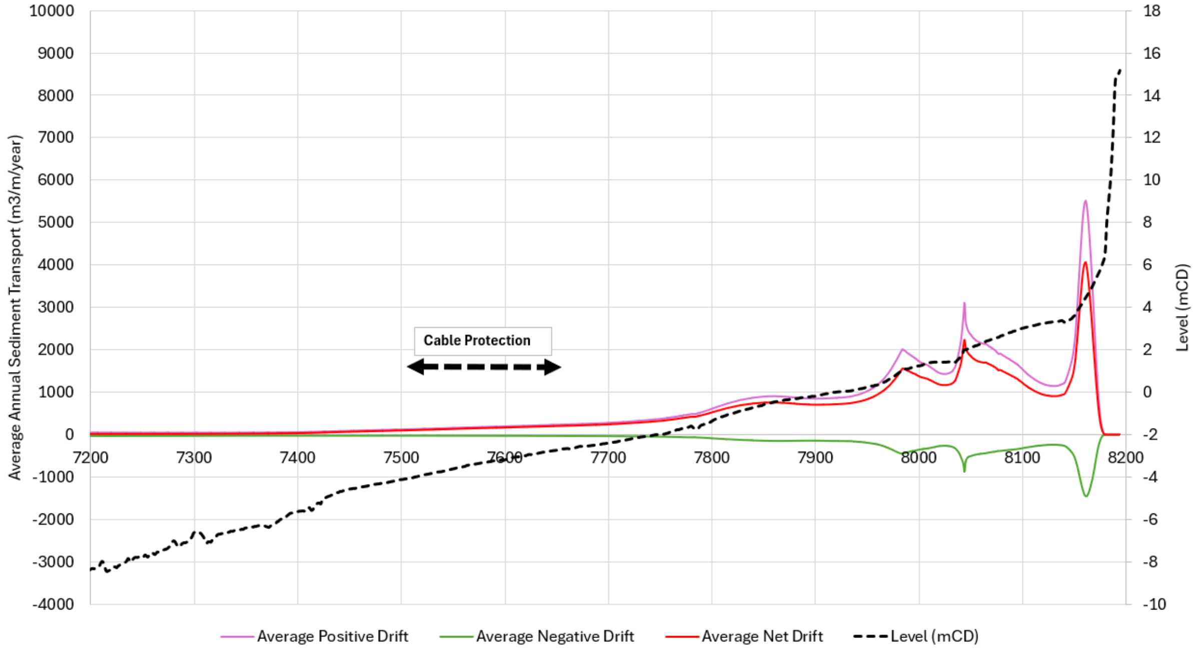


Figure 5-9 Average annual sediment transport (m3/m/year) between 1980 – 2024

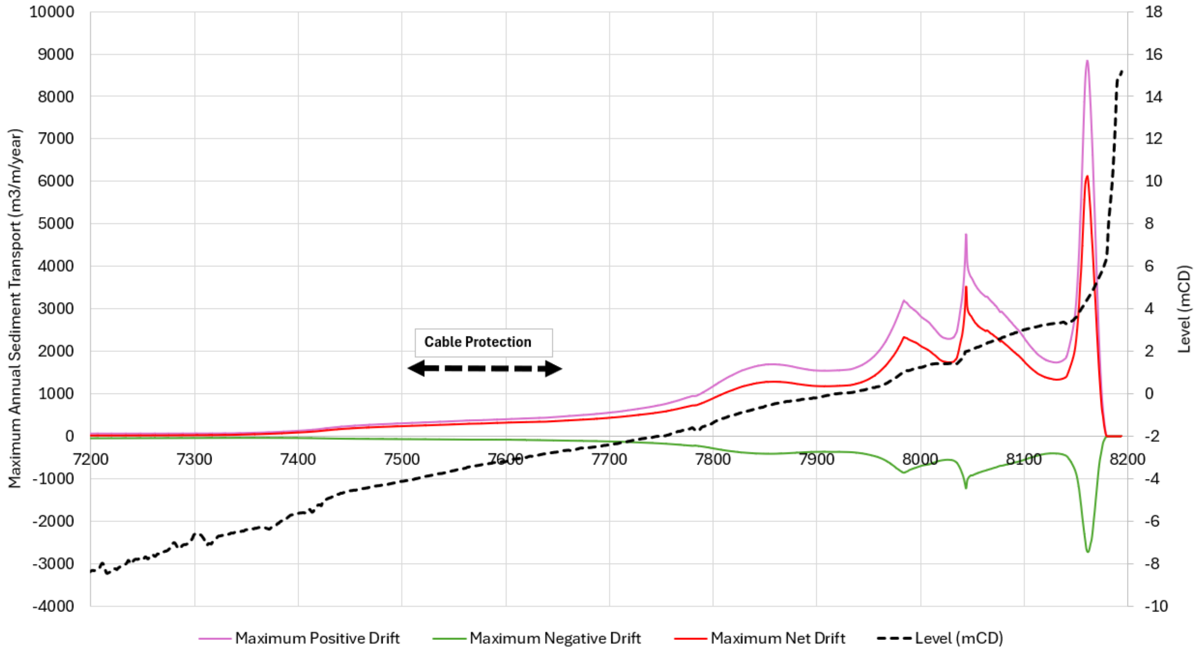


Figure 5-10 Maximum annual sediment transport (m3/m/year) between 1980 - 2024

Table 5-3 Annual average and annual maximum volume of sediment (m^3) 'blocked' by the cable protection structures, compared with the annual sediment budget

Area	Volume of Sediment 'Blocked' (m^3/year) (140m Cable)		Annual Sediment Transport Budget (m^3/year)		Percentage (%)		Percentage (%) Including Model Uncertainty	
	Average	Max	Average	Max	Average	Max	Average	Max
North Side (Southward Transport)	25,048	53,214	635,618	1,077,924	3.9%	4.9%	2.9% - 4.9%	3.7% - 6.1%
South Side (Northward Transport)	3,774	11,046	127,198	269,451	3.0%	4.1%	2.3% - 3.7%	3.1% – 5.1%
Net	21,274	42,168	507,690	808,474	4.2%	5.2%	3.2% - 5.2%	3.9% - 6.5%

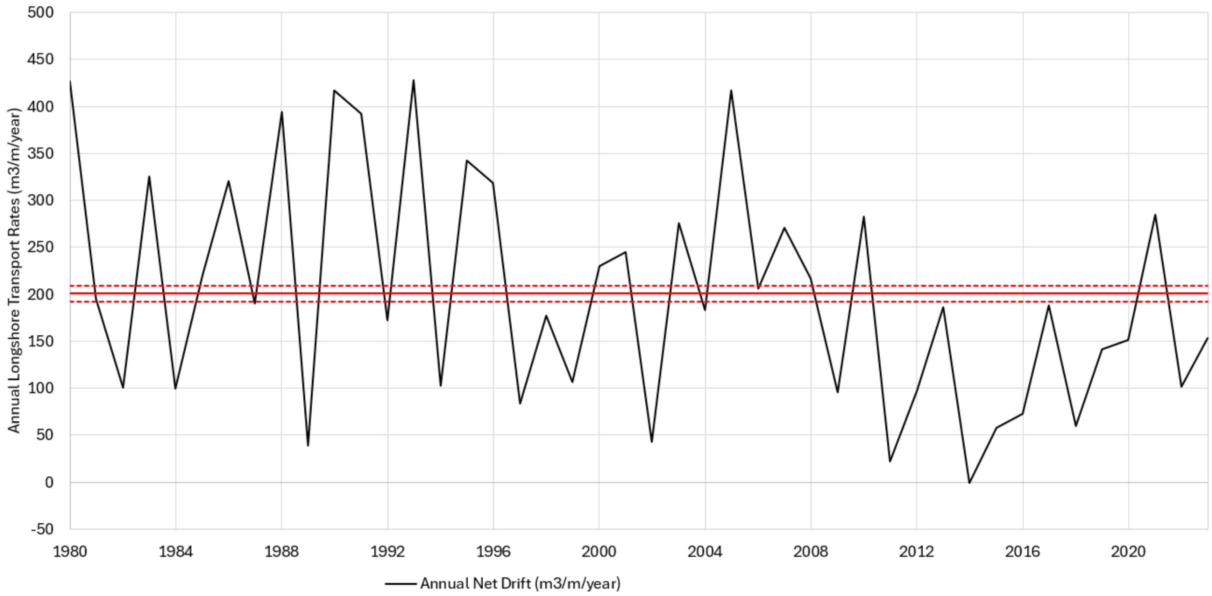


Figure 5-11 Inter-annual variation in net longshore sediment transport rates (1980 – 2024). Solid red line indicates average value and dashed red line indicate +/- effect of cable protection structures.

6 Sediment Transport Pathways

6.1 Introduction

This section collates all morphological, sedimentological, hydrodynamic and wave data and information to map sediment transport pathways across the marine physical environment study area.

6.2 Bathymetry and seabed features

The minimum and maximum water depths across the Array Areas and Inter-Platform Cable Corridor are approximately 12m below Lowest Astronomical Tide (LAT) and 40m below LAT, respectively (**Volume 7, Figure 8-1** (application ref: 7.8.1)). A bathymetric profile across the Array Areas and Inter-Platform Cable Corridor (**Figure 6-1**) shows the seabed rises from north-west to south-east up the western flank of Dogger Bank and then becomes broadly flat across the top of the bank before falling again on the southern flank.

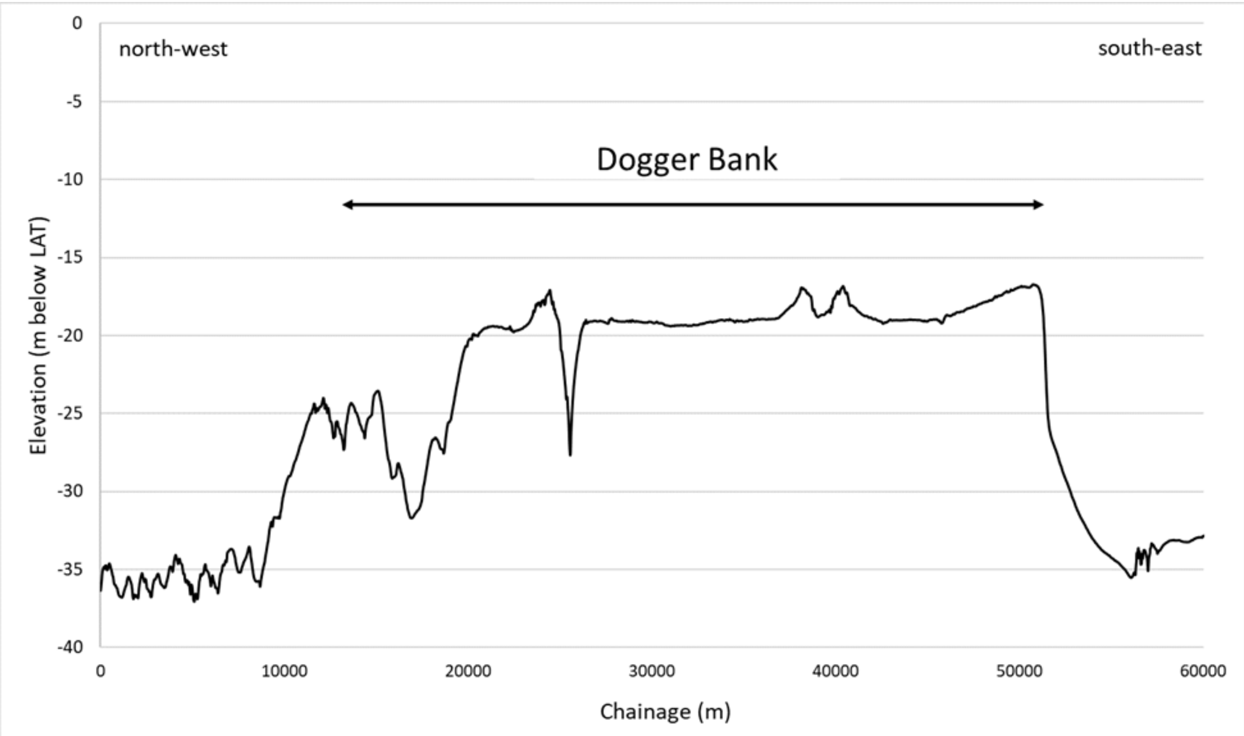


Figure 6-1 Seabed profile from bathymetry data acquired in 2022 across the Array Areas and Inter-Platform Cable Corridor (Source: Fugro, 2023a). Location of profile is shown on Volume 7, Figure 8-1 (application ref: 7.8.1).

The seabed along the Offshore Export Cable Corridor gently slopes from the landfall where water depths are shallow, to a maximum of 60m below LAT about 8km offshore. Water depths then shallow to a minimum of 15m below LAT as the Offshore Export Cable Corridor approaches the Array Areas. This is shown in bathymetric profiles across the Offshore Export Cable Corridor to the DBS East Array Area and DBS West Array Area (**Figure 6-2** and **Figure 6-3**).

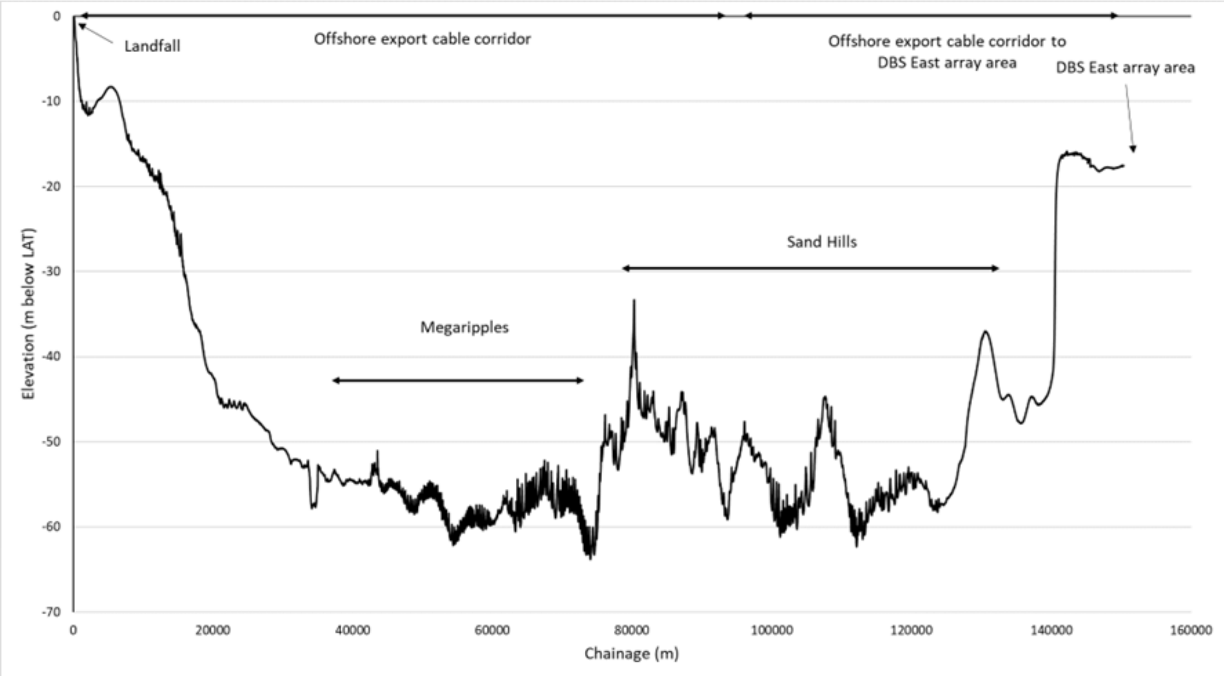


Figure 6-2 Seabed profile from bathymetry data acquired in 2022 across the proposed Offshore Export Cable Corridor, from landfall (south-west) to the DBS East Array Area (north-east) (Source: Fugro, 2023b)

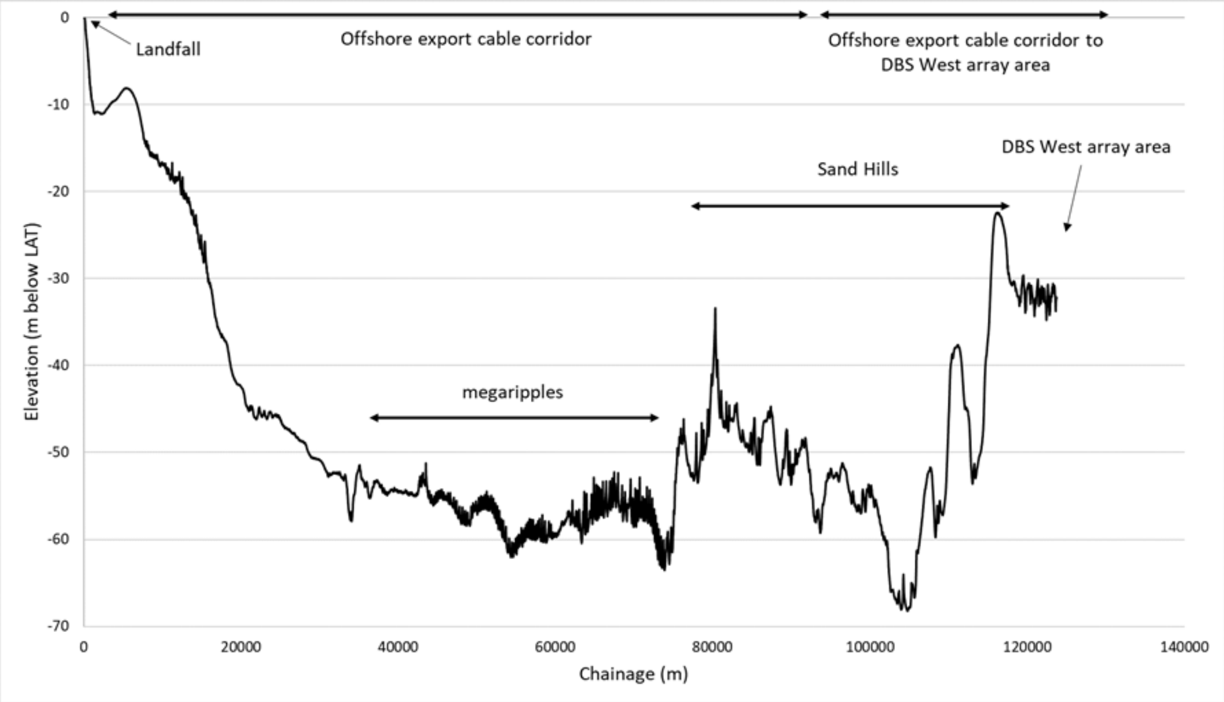


Figure 6-3 Seabed profile from bathymetry data acquired in 2022 across the proposed Offshore Export Cable Corridor, from landfall (south-west) to the DBS West Array Area (north-east) (Source: Fugro, 2023b)

The Offshore Export Cable Corridor is located to the south of Smithic Bank, a north-east to south-west aligned offshore sand bank. Smithic Bank rises to a minimum depth of about 6m below Ordnance Datum (OD) (**Volume 7, Figure 8-2 (application ref: 7.8.1)**). The western inshore flank of the bank is about 5km offshore from Bridlington before the bathymetry deepens down its eastern flank to its edge around 18m below OD. The inshore flank of the bank has a much steeper slope than that of the seaward flank.

The extent of Smithic Bank has been delimited by JNCC as outlined on **Volume 7, Figure 8-2 (application ref: 7.8.1)**. The Offshore Export Cable Corridor avoids this area and is located directly to the south. The British Geological Survey's fine-scale maps of seabed geomorphology Offshore Yorkshire (BGS, 2023) have defined Smithic Bank as a morphological feature and show it is more limited in extent then that defined by JNCC and is located approximately 3.5km north of the Offshore Export Cable Corridor. Surrounding Smithic Bank the seabed is covered by a sheet of sand (BGS, 2023) that partially extends into the Offshore Export Cable Corridor.

Approximately 40km along the Offshore Export Cable Corridor (from landfall) megaripples are present, gradually transitioning to larger bedforms (**Figure 6-7** and **Figure 6-8**). From about 77km offshore, the Offshore Export Cable Corridor crosses an area of seabed covered by linear sand banks aligned north-west to south-east located in a region referred to as 'Sand Hills' (**Volume 7, Figure 8-1 (application ref: 7.8.1)**). These banks form longitudinal or sub-parallel to the dominant tidal currents and are considered to be static (over a period of decades), although they may be superimposed with other mobile bedforms such as megaripples or sand waves. The Offshore Export Cable Corridor connecting to the DBS East Array Area and DBS West Array Area lies at the northern edge of Sand Hills. Approximately 40km of the Offshore Export Cable Corridor to the DBS East Array Area crosses the Sand Hills area, whereas only 20km of the Offshore Export Cable Corridor to the DBS West Array Area crosses this region.

6.3 Bedload sediment transport

Tidal currents are the dominant driver of bedload sediment transport across the Array Areas and Inter-Platform Cable Corridor. The dominant sediment transport pathways are therefore expected to be towards the north-west (determined by the residual currents) (see **Appendix 8-3 – Marine Physical Processes Modelling Technical Report (Revision 3)** [REP2-017]).

The range of tidal current speed over a full tidal cycle ranges from 0.1 to 0.5m/s. Considering the dominant grain size of seabed sediment is sand (see **Chapter 8 Marine Physical Processes** [APP-080]), using the Hjulstrom curve to predict sediment transport potential, theoretically sediments on the seabed will go through phases of erosion and transport as bedload throughout a tidal cycle (**Figure 6-4**). There is limited potential for deposition. This suggests the seabed is continually mobile. The tidal ellipse data (Figure 8-4 of Chapter 8 Marine Physical Environment [APP-080]) shows there is no strong current direction on top of Dogger Bank in the Array Areas and there circular naturae suggests sediment is continuously recycled. Along the margins of Dogger Bank, the current directions are more elliptical and suggest sediment transport pathways are to the northwest (**Figure 6-5**).

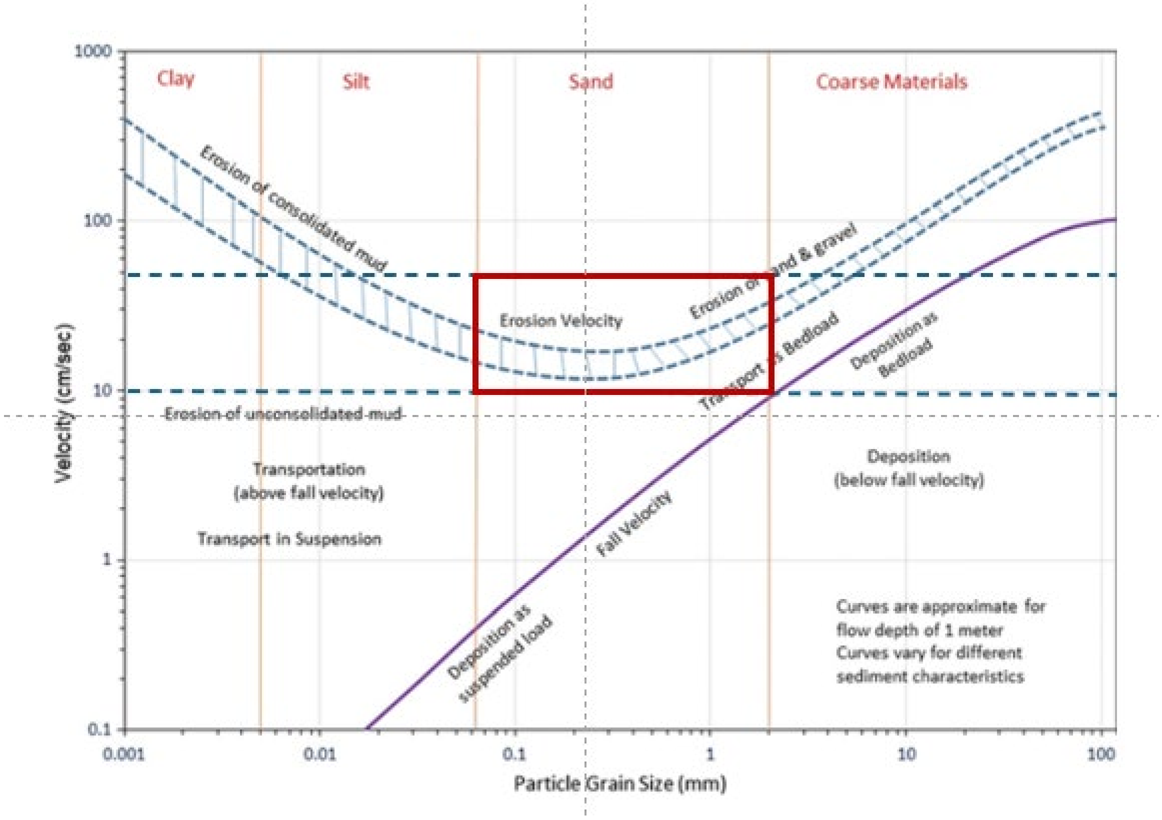
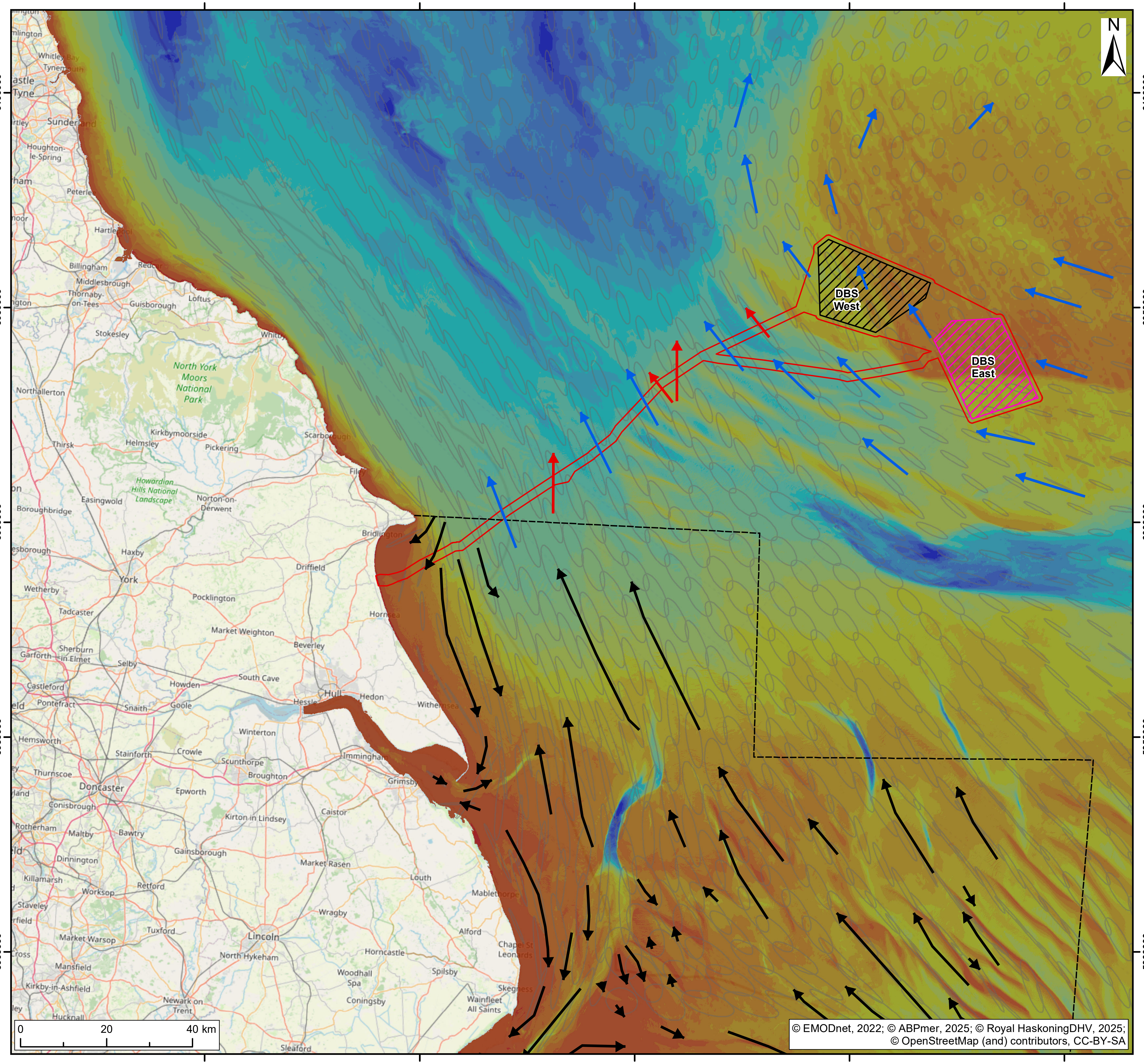


Figure 6-4 Huljstrom curve showing sediment transport potential. Blue dashed line represents the range of tidal currents speed within the Array Areas. The red box delimits the dominant grain size of seabed sediments.



Legend:

- Offshore Development Area
- DBS East array area
- DBS West array area
- Spring Tidal Ellipse
- Extent of available data on sediment transport pathways

Sediment Transport Pathways

- Sediment transport direction inferred from bedforms
- Sediment transport pathways (Kenyon & Cooper, 2015)
- Transport direction inferred from residual tidal currents

Bathymetry (LAT)

> 0	-30 - -34.9	-60 - -64.9
0 - -9.9	-35 - -39.9	-65 - -69.9
-10 - -14.9	-40 - -44.9	-70 - -74.9
-15 - -19.9	-45 - -49.9	-75 - -79.9
-20 - -24.9	-50 - -54.9	-80 - -84.9
-25 - -29.9	-55 - -59.9	-85 - -89.9
		< -90

SUI	REV	DATE	DESCRIPTION	DRW	CHK	APR
S3	P02	16/05/2025	Suitable for review & comment	SM	CM	CC
S2	P01	17/11/2023	Suitable for information	JH	SB	HC

Title:

Sediment transport pathways along the offshore export cable corridor

Figure: 8-5 Drawing No: PC2340-RHD-OF-ZZ-DR-Z-0619

Co-ordinate system: WGS 1984 UTM Zone 31N | Page Size: A3 | Scale: 1:900,000

Project: Dogger Bank South Offshore Wind Farms

Report: Environmental Statement

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The hydrodynamic modelling undertaken by the Applicants indicates bed shear stress within the Array Areas and Inter-Platform Cable Corridor are highest on the spring tide (to the northwest) ranging from 0.2 to 0.7 N/m² (**Figure 6-6**). Within the Array Areas, bed shear stress is comparable on top of Dogger Bank with a general reduction in bed shear stress towards the north. However, in the DBS West Array Area, bed shear stress is relatively higher on the slope/margin of Dogger Bank and in the DBS East Array Area, bed shear stress is lower on the bank margin. The bathymetry of Dogger Bank and sand banks in the Sand Hills area likely moderates bed shear stress locally.

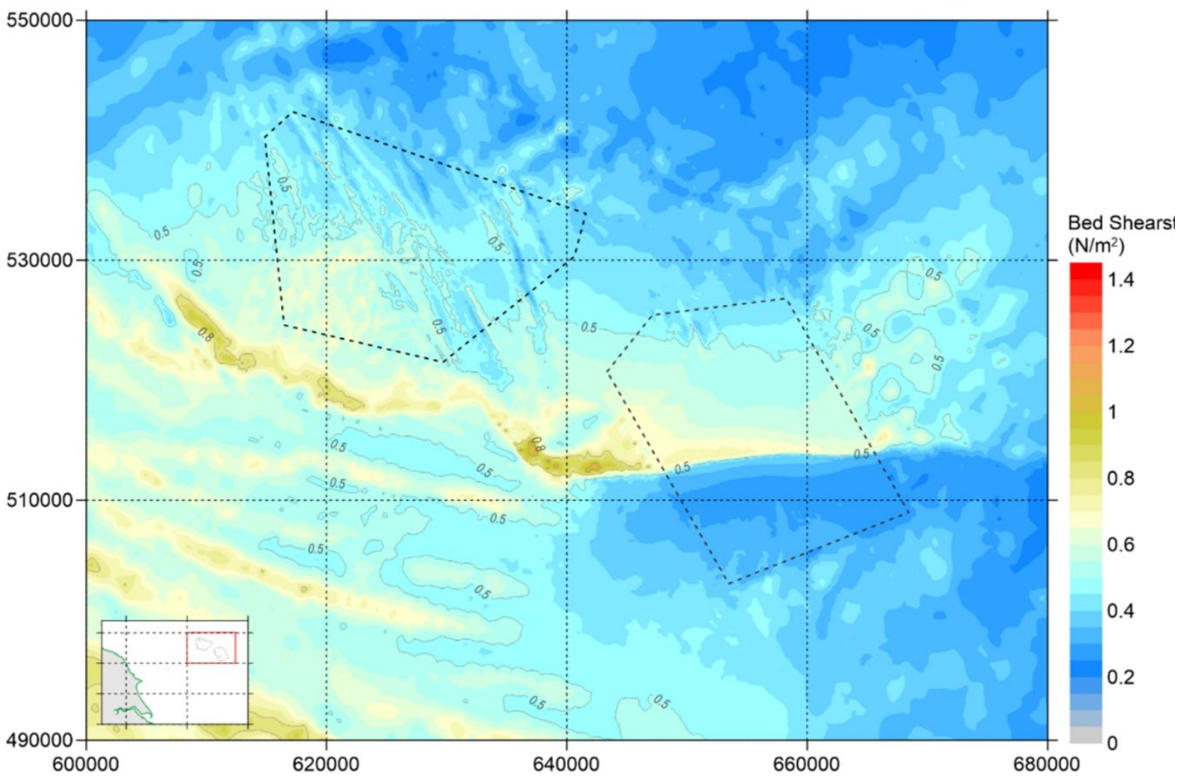

Figure 6-6 Bed shear stress of peak northwest going currents on the spring tide

The combination of water depth plus tidal variation means that waves are unlikely to be a major influence on bedload sediment transport along the Offshore Export Cable Corridor, apart from in shallower water in the nearshore.

In the nearshore, the seaward limit which marks the effective boundary of wave-driven sediment transport is called the 'closure depth' and can be calculated using the methods of Hallermeier (1978). For the seabed offshore from the landfall, the closure depth would be located at around 7m below LAT. This is supported by sediment transport modelling (section 5) which shows that waves are not active in water depths greater than 6mCD.

Regional sediment transport pathways (Kenyon & Cooper, 2005) suggest sediment transport pathways in the nearshore part of the Offshore Export Cable Corridor are to the south to south-south-east whereas further offshore they are towards the north-northwest, with a bedload parting zone located about 30km from the coastline (**Volume 7, Figure 8-5** (application ref: 7.8.1)). Sediment transport modelling at the landfall confirms that the net longshore sediment transport pathway is from north to south and, considering there is no active wave transport in water depths greater than 6m (relative to OD), the sediment transport pathways further offshore are dominated by tidal currents which are relatively low due to the sheltering effect of Flamborough Head.

Sediment transport pathways in and around Smithic Bank are driven by a tidally generated gyre which creates rotational currents (and sediment transport pathways) around the feature. Evidence of active bedload sediment transport is most prominent at the northern end of the bank (North Smithic) where large sand waves are observed (CCO 2014). This area is also associated with strongest tidal flows as water is forced past the headland. The asymmetric profile of these sand waves offers supporting evidence for net clockwise directions of bedload transport around the bank. On the eastern outer flank, the sand wave asymmetry is with the flood tide, moving sands to the south-west and onto the bank, whereas for the western inner flank the ebb tide dominates through a distinct channel between the bank and the headland to develop a net sediment pathway to the north-east (**Volume 7, Figure 8-5** (application ref: 7.8.1)). The tidal gyre provides a mechanism to maintain the morphology of Smithic Bank which is sheltered by Flamborough Head to the north.

The bank is shallowest (depths less than 3m below CD) towards the northerly inshore flank where a steep slope drops around 6m into the ebb tidal channel. The bank morphology shows evidence of responding to both waves and tides (CCO, 2014). Tidal flows are a key influence on driving sand wave migration whereas wave attenuation through refraction and shoaling are likely to be a main cause of smoothing and broadening the profile of the southern extents of the bank. The shallow profile of Smithic Bank provides some sheltering to the leeward coastline around Bridlington, especially during periods of stormy waves (Scott Wilson, 2010).

There are no bedforms between Smithic Bank and the Holderness coast within the ebb tidal channel as currents sweep sediment northwards towards Flamborough Head. There is relatively little sediment exchange between Smithic Bank and the Holderness coast to the south (and vice versa) which is supported by studies of sediment provenance undertaken by Pye & Blot (2015) who defined a boundary between a 'Flamborough' influence in and around Smithic Bank and a 'Holderness Cliffs' influence, located to the south of Smithic Bank (**Volume 7, Figure 8-5** (application ref: 7.8.1)).

6.4 Seabed mobility

Mobile bedforms have an asymmetric profile. Sediment is transported up the shallow slope to the crest where it cascades down the steeper slope. The direction the steeper slope faces is therefore an indicator of sediment transport direction. This process is driven by tidal asymmetry and when the seabed is in equilibrium with the tidal regime, the associated dominant sediment transport will align with the net residual current.

In the case of the Offshore Export Cable Corridor the nearshore bedforms are likely static, as they have symmetrical profiles. Further offshore, bedforms are asymmetric with a steeper north to northwest slope, indicating the dominant direction of bedform migration.

Bedform migration speed can be determined by comparing bathymetric data sets collected over the same feature at different times. Site-specific bathymetric data was acquired by Fugro in 2022 across the Array Areas, Inter-Platform Cable Corridor and Offshore Export Cable Corridor (**Volume 7, Figure 8-6** (application ref: 7.8.1)), gridded at a resolution of 2m for interpretation.

Within the nearshore section of the Offshore Export Cable Corridor (the first 35km from landfall) other bathymetric datasets are available (see **Bed Mobility & Thermal Environment** [REP3-032). These include surveys by NetSurvey Ltd (2011) and MMT (2016). Further offshore, there are no other datasets of this resolution in areas of seabed bedforms that can be used to quantity bedform migration speeds. Therefore, any assessments of seabed mobility here are based on theoretical relationships and conceptual understanding.

In the nearshore a series of shore parallel ridges are present before joining the southern margin of Smithic Bank (**Volume 7, Figure 8-6** (application ref: 7.8.1)). Here, exposed glacial tills with an irregular surface morphology have been reworked into shore parallel ridges. There is no evidence from repeat bathymetry surveys that these features are mobile.

From 7.5km into the Offshore Export Cable Corridor from landfall a series of shore parallel ridges are present. Comparisons of bathymetric surveys showed over two years bed level changes of up to 0.6m. However, the assessment in **Bed Mobility & Thermal Environment** [REP3-032] indicates uncertainty in the rate of migration, due to insufficient dataset resolution, and it is concluded the ridge features are overall static despite evidence of bed level change. Shallow relief, north-northwest to south-southeast trending linear depressions terminate against or navigate around the ridge structures. These features are also considered to be immobile.

Small localised symmetrical scour pits are present around the wreck of the Ville De Valenciennes (UKHO ID: 6469; **Chapter 17 Offshore Archaeology and Cultural Heritage** [APP-133]), 0.7m and 1.4m deep, indicating the seabed is mobile in this locality, likely due to changes in current speeds around the wreck. This wreck is located 18km along the southern margin of the Offshore Export Cable Corridor in an area of seabed interpreted as being static. This suggests that in areas where mobile bedforms are absent, there is still potential for scour to occur locally around seabed objects.

Within the **Bed Mobility & Thermal Environment** [REP3-032] report, a comparison was made between the Fugro (2022) and MMT (2016) bathymetric data where it overlaps (between 15km and 35km along the Offshore Export Cable Corridor from landfall) and bed level change was shown to be near zero (± 0.2 m) over a six year period, indicating any features here are immobile.

Megaripples are located in the Offshore Export Cable Corridor from 40km to 45km offshore of the landfall (**Volume 7, Figure 8-6** (application ref: 7.8.1), and **Figure 6-7** and **Figure 6-8**). The crests of these bedforms are orientated west-southwest to east-northeast and the features have approximate wavelengths of 11 m and heights of up to 0.5m. These bedforms become superimposed on larger west to east orientated sand waves, with a wavelength of 200m and height of 2m (**Figure 6-7).**

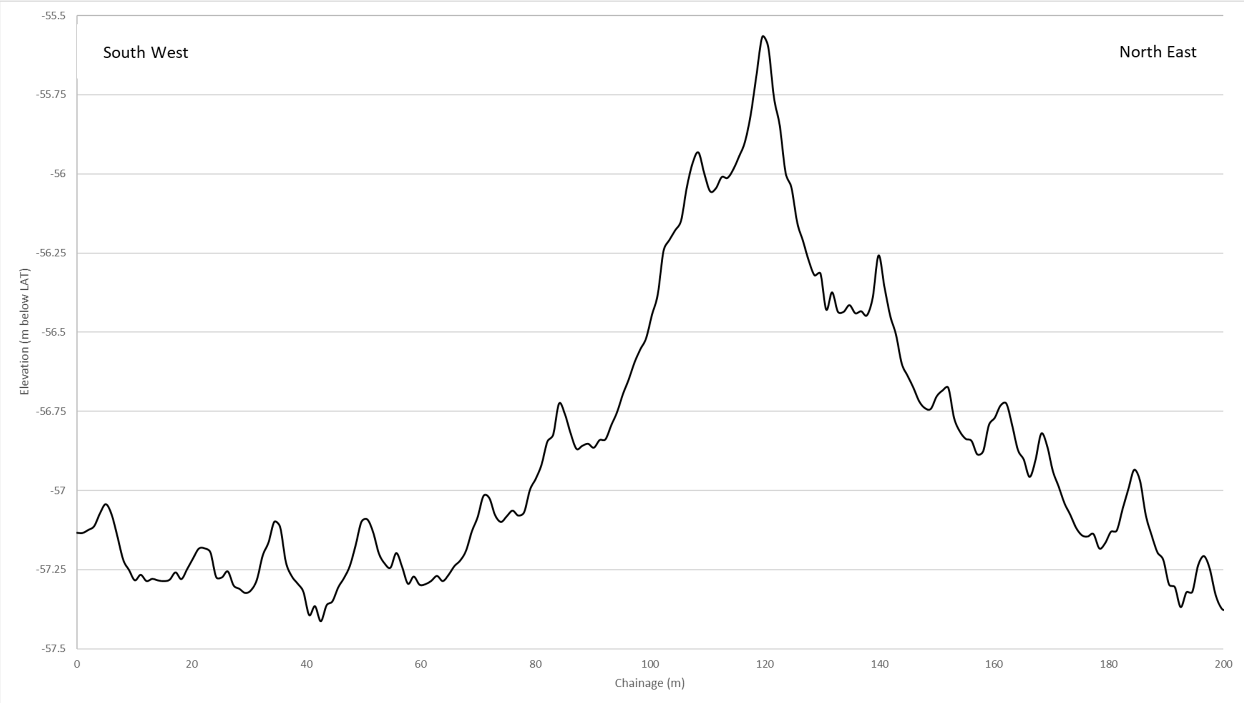

Figure 6-7 Profile of bedforms at approximately 50km into the Offshore Export Cable Corridor from landfall.

The megaripples and sand waves were interpreted in **Bed Mobility & Thermal Environment** [REP3-032] as being static considering their symmetrical profile and assessment of morphological change around the Langeld Gas Pipeline (located within the area of megaripples) supported this interpretation. The pipeline was installed in a trench between 2005 and 2006 and shows no evidence of backfill over a 16 year period supporting the argument that the seabed at this location is stable.

Within the Sand Hills region of the Offshore Export Cable Corridor, sand waves superimposed with megaripples are present on the margins of sand banks (**Volume 7, Figure 8-6** (application ref: 7.8.1), and **Figure 6-7** and **Figure 6-8**). The megaripples have wavelengths of up to 20m and heights of <0.6m. The sand waves have wavelengths of 100 to 500m and reach heights up to 5.5m, orientated east to west. They are asymmetric in profile suggesting they are mobile and the dominant sediment transport is towards the north.

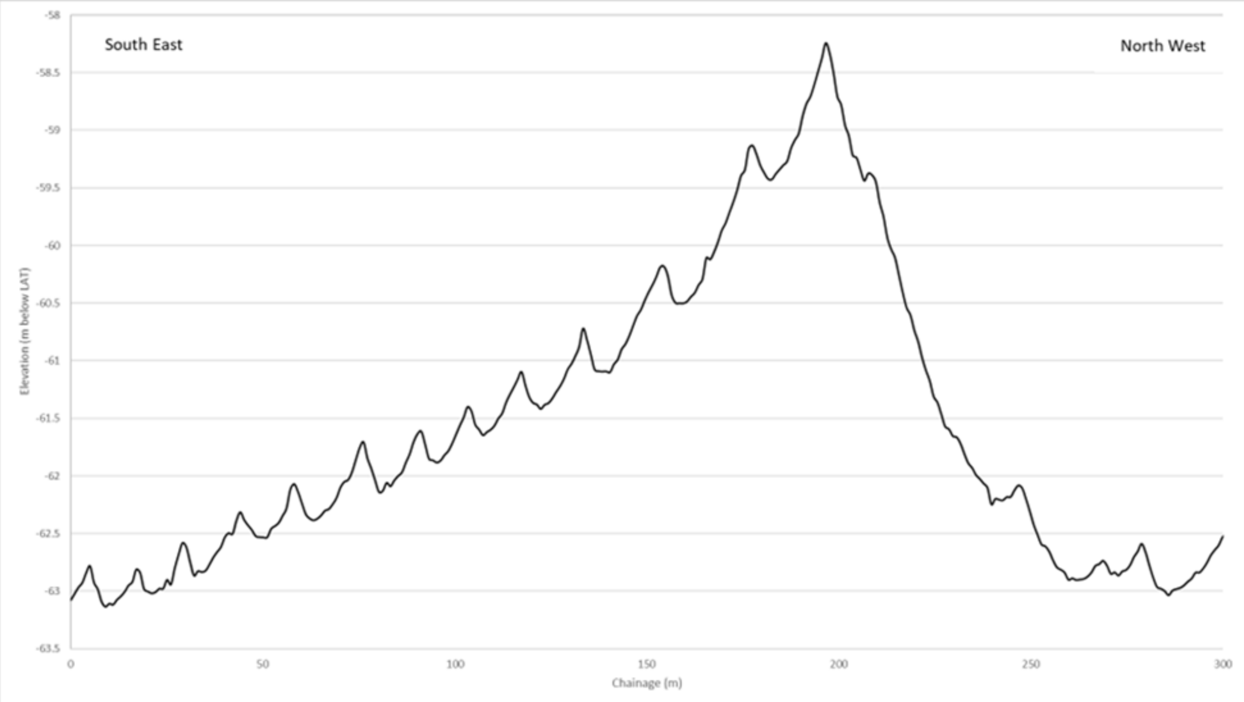

Figure 6-8 Profile of bedforms at approximately 85km into the Offshore Export Cable Corridor from landfall.

The Offshore Export Cable Corridor (before splitting into Offshore Export Cable Corridors connecting to the DBS East and West Array Areas) crosses the crests and troughs of large scale sand banks, superimposed by sand waves and megaripples (**Volume 7, Figure 8-6** (application ref: 7.8.1)). The sand banks are symmetrical orientated north-northwest to east-southeast orientation. The sand banks have heights of >10m and wavelengths of >10km. The sand waves have heights of 2 to 4m and wavelengths of 100 to 200m, these are orientated east to west with asymmetry indicating a steeper slope to the north. The megaripples have maximum heights of 0.6m and wavelengths of 20m, these are orientated east to west or west-southwest to east-southeast. The megaripples are also asymmetrical with a steeper slope facing north-northwest. This suggests mobility north to northwest, similar to other bedforms in the Sand Hills region.

The megaripples remain present along the Offshore Export Cable Corridor connecting to DBS West Array Area. Sand waves become patchier, maintaining east to west orientation at heights of 2m and wavelengths of 350m. These features continue to cross the static sand banks until reaching DBS West Array Area. The same features also occur along the Offshore Export Cable Corridor connecting to DBS East Array Area, but fewer bedforms are present as the Offshore Export Cable Corridor approaches the DBS East Array Area. Fewer sand banks and superimposed features are present in this section of the Offshore Export Cable Corridor.

7 Updates to ES Assessment

7.1 Potential effects during construction

7.1.1 Changes in suspended sediment concentration and transport due to trenchless crossing installations

7.1.1.1 Description of change

The Offshore Export Cable will be connected to the Onshore Export Cable using trenchless techniques below the cliffs. The worst case scenario is a 'long trenchless' option which sees the bore pits exit in the subtidal zone. The bore exit pits will be excavated to provide access to connect the onshore export cable to the offshore export cable. A maximum of six exit pits may be required. Each pit will be 26m length, 6m width and 2m depth, separated by a distance of 10-100m, running in a line parallel to the shoreline. Installation of the exit pits will occur over a duration of 18 months but each individual pit will be open for a maximum of four months within this period. The Projects have committed to not installing cofferdams during cable installation.

As a result of the excavation process, suspended sediment concentrations will be elevated above prevailing conditions. Changes in suspended sediment concentrations due to Offshore Export Cable trenching have been modelled in **Appendix 8.2 Marine Physical Processes Modelling Technical Report** [AS-139], with the model extent including the nearshore area of seabed where the exit pits will be located. Cable trenching is comparable in terms of seabed disturbance to the excavation of exit pits as the sediment disturbed would become mobilised as either suspended sediment or bedload.

The modelling indicates that in the nearshore, suspended sediment concentrations may reach a maximum of 750 mg/l in the bottom layer (concentrations are lower in the middle and surface layers). The sediment plume created by the disturbance extends a maximum of 1km from the boundary of the Offshore Export Cable corridor (**Figure 7-1**). Background suspended sediment concentrations in the nearshore can reach up to 300 mg/l during storm events (Pye & Blott, 2015).

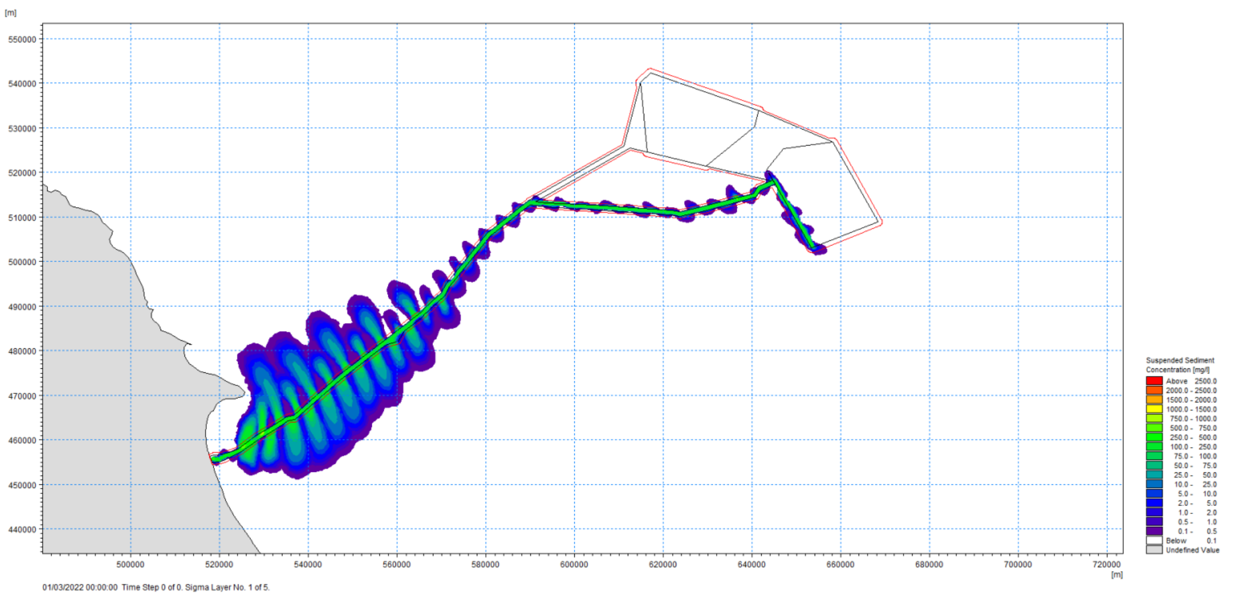

Figure 7-1 Maximum suspended sediment concentration (bottom layer) due to trenching of the Offshore Export Cable

Once mobilised, the sediment dispersion modelling indicates the suspended sediment will dissipate rapidly over a period of less than 1.5 hours after which it is deposited on the seabed resulting in a maximum change in seabed level of up to 0.05m locally within the Offshore Export Cable corridor (**Figure 7-2**), at which point prevailing conditions will resume and the seabed will recover to baseline conditions over a period of weeks to months.

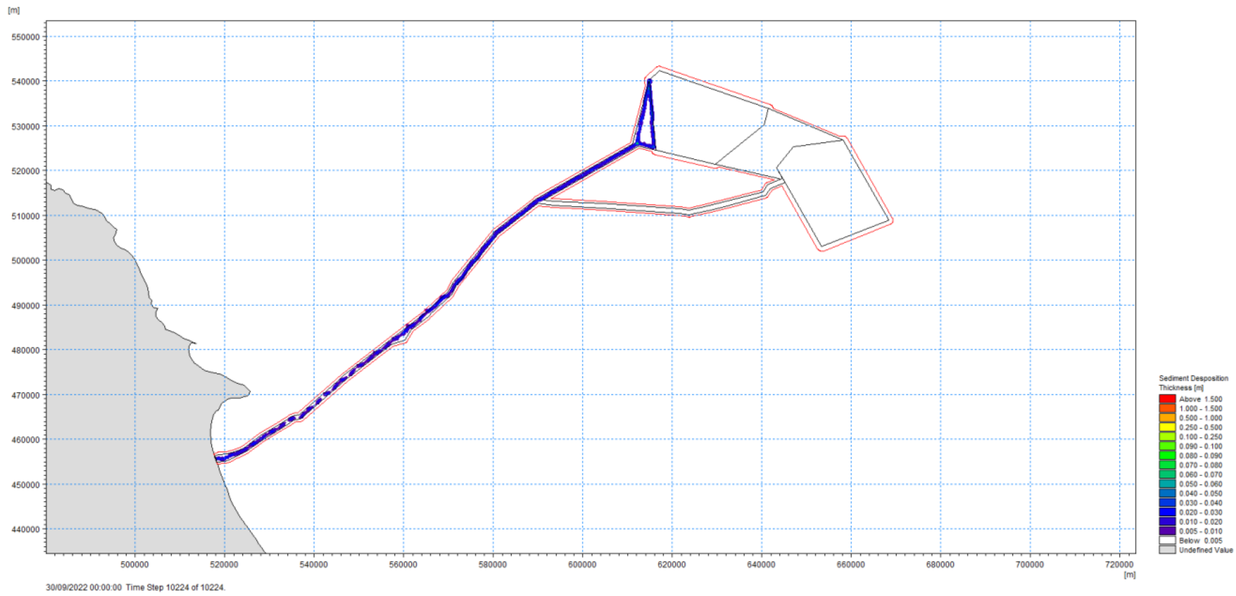

Figure D-38: Total Sediment Deposition Thickness – Export Cable Route to DBS West – Trenching

Figure 7-2 Total sediment deposition thickness as a result of deposition of suspended sediment disturbed during Offshore Export Cable installation

Once the Offshore Export Cable is installed, the excavated pits will be backfilled manually or left to backfill naturally, depending on the ground conditions and sediment composition at each exit pit location.

7.1.1.2 Magnitude of Impact – DBS East or DBS West in Isolation

The magnitude of impact for the worst case scenario due to cable installation at the landfall assumes the trenchless bore exit points are located in the subtidal zone (**Table 3-1**). If the Projects are built in isolation, a maximum of three bore exits pits will be required during a single construction phase of 18 months and each bore pit will be open for a maximum of four months.

There is potential for suspended sediment concentrations to reach 750mg/l which is almost double what would be expected during a storm event but the resultant change in seabed level is small (<5cm) and changes are limited to the near-field (within 1km of Offshore Export Cable corridor). The changes are also short-lived (<1.5 hours) and once the disturbed sediment is redeposited, it becomes remobilised by tides and waves and the seabed recovers to baseline conditions. Based on these results, informed by numerical modelling, the magnitude of impact is defined as **Negligible** for both the near-field and far-field, as outlined in **Table 7-1**.

Table 7-1 Magnitude of Impact on Suspended Sediment Concentrations Under the Worst Case Scenario Due to Cable Installation at the Landfall

Location	Scale	Duration	Frequency	Reversibility	Magnitude of Impact
Near-field	Low	Negligible	Negligible	Negligible	Negligible
Far-field	Negligible	Negligible	Negligible	Negligible	Negligible

*The near-field impacts are confined to a small area, likely to be up to a kilometre from the cable installation activity.

7.1.1.3 Magnitude of Impact – DBS East and DBS West Together

If DBS East and DBS West are built together (concurrently or sequentially) a maximum of six bore exit pits will be required. Therefore, the volume of sediment excavated (5,616m^3) and footprint of disturbance will be double if the Projects are built together, when compared with the in isolation scenario. However, there will be no change to the construction timeframe and all exit pits will be installed during a single phase that will not exceed 18 months, and each individual pit will not be open for more than four months. Therefore, as with the in isolation scenario, the changes will be short lived and the seabed will recover quickly. Whilst the volume of sediment disturbed is larger when compared to the in isolation scenario, the scale of the impact is comparable as the increase in volume is not significant when compared to the net sediment budget modelled at the landfall. Therefore, the magnitude of impact for the worst case scenario due to cable installation at the landfall if DBS East and DBS West are built together will be the same as outlined in **Table 7-1.**

7.1.1.4 Sensitivity of Receptor

Changes in suspended sediment concentrations due to cable installation at the landfall may impact the geological features of the Holderness Inshore MCZ, Smithic Bank and marine waters. The sensitivity and value of these receptors to changes in suspended sediment concentration is given in **Table 7-2**.

The geological feature that defines the designation of the Holderness Inshore MCZ is Spurn Head which is located 52km south of the landfall. Spurn Head is an active coastal landform that has formed at the mouth of the Humber Estuary due to net longshore sediment transport along the Holderness coast from north to south. Spurn Head is highly tolerant to changes in suspended sediment concentrations as any sediment within the water column will be continually mobilised within the active wave zone. If sediment is deposited during periods of low wave energy, the beach and nearshore seabed would recover near instantaneously (<1 year) as waves remobilise sediment. Whilst the value of the Holderness Inshore MCZ is high due to its designated status, based on its high tolerance to and high recoverability, its sensitivity to changes in suspended sediment concentrations is **negligible**.

Smithic Bank is located to the north of the Offshore Export Cable corridor and the construction buffer crosses the southernmost tip of the bank. Smithic Bank is a tidal sand bank that has formed in the lee of Flamborough Head where a tidal gyre creates rotational currents around the bank. There are large sand waves present on top of Smithic Bank which are mobile indicating the sediments are mobile.

The receptor has a high tolerance to changes in suspended sediment concentration in the water column as bedload sedimentary processes dominate. The receptor can also recover rapidly (<1 year) from changes in seabed level due to deposition of suspended sediment through remobilisation and redeposition.

The value of Smithic Bank is defined as low as the receptor is not designated but is of local importance for marine geology and sediment processes. There is no evidence Smithic Bank is a source of sediment to the Holderness coast which would be of regional importance. It is a localised sediment cell that is restricted in extent to the lee of Flamborough Head where hydrodynamic conditions support its continued development. Considering it has high tolerance and recoverability, and low value, the sensitivity of Smithic Bank to changes in suspended sediment concentrations is **negligible**.

Table 7-2 Sensitivity and Value Assessment for Morphological Receptor

Receptor	Tolerance	Recoverability	Value	Sensitivity
Holderness Inshore MCZ Geological features	High (Negligible)	High (Negligible)	High	Negligible
Smithic Bank	High	High	Low	Negligible
Marine waters (inshore)	High	High	High	Negligible

7.1.1.5 Significance of Effect – DBS East or DBS West in Isolation

The effects on suspended sediment concentrations due to cable installation at the landfall are considered to have a **negligible** magnitude of impact and **negligible** sensitivity of the receptors considered in **Table 7-2**, resulting in likely **negligible** significance of effect. No additional mitigation is proposed.

7.1.1.6 Significance of Effect – DBS East and DBS West Together

Construction of DBS East and DBS West together (concurrently or sequentially) would not result in a greater magnitude of impact than DBS East or DBS West in isolation as for both scenarios, there will be one phase of cable installation activity and whilst the volumes of sediment disturbed will be greater, the maximum extent of the plume will remain the same as it is determined by the tidal regime, and the sediment deposited will be redistributed. Therefore, the significance of effect is the same as outlined in section 7.1.1.5 and considered to have a likely **negligible** significance of effect, due to a **negligible** magnitude of impact and **negligible** sensitivity. No additional mitigation is proposed.

7.1.2 Changes to bedload sediment transport due to cable installation at the landfall

7.1.2.1 Description of change

The Offshore Export Cable will be connected to the Onshore Export Cable using trenchless techniques below the cliffs. The worst case scenario is a 'long trenchless' option which sees the bore pits exit in the subtidal zone. The bore exit pits will be excavated to provide access to connect the onshore export cable to the offshore export cable. A maximum of six exit pits may be required. Each pit will be 26m length, 6m width and 2m depth, separated by a distance of 10-100m, running in a line parallel to the shoreline. Installation of the exit pits will occur over a duration of 18 months but each individual pit will be open for a maximum of four months within this period.

The Applicants have committed to not installing cofferdams in the exit pits. Therefore, there will be no upstanding structures within the nearshore zone that could potentially interrupt sediment transport. The exit pits will be excavated up to 2m below ground level, potentially creating localised sediment sinks. The excavated sediment will be deposited on the seabed next to the exit pits where it will become mobilised by tidal currents and waves. The construction activities require the pits to remain open for up to four months. If sediment begins to accumulate in the pits, it will be re-excavated and deposited on the seabed next to the exit pits.

The excavated sediment will comprise slightly gravelly sand based on nearshore seabed grab samples and particle size distribution data, and potentially glacial till if the overlying seabed sediments are less than 2m in thickness. The maximum volume of sediment excavated for the worst case scenario of six exit pits will be 5,616m^3. These values are extremely low when compared with estimates of sediment yield from the Holderness coast (50 km of coastline) due to cliff and shore platform erosion of 4 million m^3/year (Balson et al. 1998).

At a local scale, there is limited information on sediment yield due to coastal erosion of the cliffs at the landfall. However, using the average coastal erosion rate from historic data (see Table 8-20 of **Chapter 8 Marine Physical Environment** [APP-080]) of 1.3m per year, the width of the Offshore Export Cable corridor at landfall (excluding construction buffer) of 1,400m and the average cliff height of 9m, a volume of up to 163,80m^3 could be eroded from the landfall on a yearly basis.

The sediment transport modelling undertaken in section 5 predicts an annual net sediment budget of 507,690m^3 per year along a cross shore profile aligned with the centre of the Offshore Export Cable corridor (**Table 5-3**).

The excavated material will be disposed of directly on the seabed where tidal currents and to a lesser extent waves, will mobilise and redistribute it as a combination of suspended sediment and bedload.

Upon completion of trenchless duct installation and following export cable installation, the trenches will be backfilled manually or left to backfill naturally, depending on the ground conditions and sediment composition at each exit pit location.

7.1.2.2 Magnitude of Impact – DBS East or DBS West in Isolation

If the Projects are built in isolation, a maximum of three exits pits will be required during a single construction phase of 18 months, with each pit open for a period of up to four months. The volume of material disturbed during excavation of the exit pits will be 936m^3 which is relatively small (0.2%) when compared to the annual net sediment transport budget of 507,690m^3 per year. As the excavated sediment will be disposed of on the seabed adjacent to the exit pits, this sediment will become remobilised as bedload and there will be no net loss of sediment from the system. The impact will only occur during cable installation (infrequent) and the seabed would return to its original condition relatively quickly (<1 year) once the activity has ceased. Therefore, the magnitude of impact would be **negligible** (**Table 7-3**).

Table 7-3 DBS East and DBS West in Isolation Magnitude of Impact on Bedload Sediment Transport Under the Worst Case Scenario for Cable Installation at the Landfall

Location	Scale	Duration	Frequency	Reversibility	Magnitude of Impact
Near-field	Low	Low	Negligible	Negligible	Negligible
Far-field	Low	Low	Negligible	Negligible	Negligible

*The near-field impacts are confined to a small area, likely to be up to a kilometre from the cable installation activity.

7.1.2.2.1 Magnitude of Impact – DBS East and DBS West Together

If DBS East and DBS West are built together (concurrently or sequentially) a maximum of six bore exit pits will be required, installed during a single phase that will not exceed 18 months. The duration of the construction phase will not increase but the volume of sediment disturbed will double to 1,872m³ when compared with the in isolation scenario. However, this remains relatively small (0.4%) in comparison to the annual net sediment transport budget. As the excavated sediment will be disposed of on the seabed adjacent to the exit pits, this sediment will become remobilised as bedload and there will be no net loss of sediment from the system. The impact will only occur during cable installation (infrequent) and the seabed would return to its original condition relatively quickly (<1 year) once the activity has ceased. Therefore, the magnitude of impact would be **negligible** (Table 7-4).

Table 7-4 DBS East and DBS West Together Magnitude of Impact on Bedload Sediment Transport Under the Worst Case Scenario for Cable Installation at the Landfall

Location	Scale	Duration	Frequency	Reversibility	Magnitude of Impact
Near-field	Low	Low	Negligible	Negligible	Negligible
Far-field	Low	Low	Negligible	Negligible	Negligible

*The near-field impacts are confined to a small area, likely to be up to a kilometre from the cable installation activity.

7.1.2.3 Sensitivity of Receptor

The landfall is located at the Holderness Cliffs and near the Withow Gap Skipsea SSSI. However, as the exit pits will be located in the subtidal zone, there will be no direct impacts on these receptors.

The Holderness Inshore MCZ is located directly to the south of the Offshore Export Cable corridor. However, the geological feature of its designation is Spurn Head which is located 53km away. Spurn Head has some tolerance to changes in bedload sediment transport as it already adjusts to a highly variable sediment budget (as demonstrated in **Figure 5-11**) driven by ongoing and episodic coastal erosion and the prevailing wave regime. However, Spurn Head would be able to recover relatively quickly (<1 year) to any changes in bedload sediment transport. Whilst it has high value considering its designated status, given its low tolerance and negligible recoverability, the Holderness Inshore MCZ geological feature is assigned a **low** sensitivity to changes in bedload sediment transport as outline in **Table 7-5**.

Smithic Bank is located directly north of the Offshore Export Cable Corridor. Smithic Bank is sensitive to change in bedload sediment transport. However, sediment transport pathways at the landfall are dominated by a net sediment transport direction north to south. Furthermore, Smithic Bank is an active and dynamic sand bank and its morphology is constantly changing due to natural variability in the sediment budget and storm events (see section 6). Therefore, it has some tolerance to changes in bedload sediment transport. Given its dynamic and mobile nature it can also recover relatively quickly (<1 years) from and changes.

The value of Smithic Bank is defined as low as the receptor is not designated but is of local importance for marine geology and sediment processes. There is no evidence Smithic Bank is a source of sediment to the Holderness coast which would be of regional importance. It is a localised sediment cell that is restricted in extent to the lee of Flamborough Head where hydrodynamic conditions support its continued development. Considering it has low tolerance and negligible recoverability, and low value, the sensitivity of Smithic Bank to changes in suspended sediment concentrations is defined as **negligible** (**Table 7-5**).

Table 7-5 Sensitivity and Value of Morphological Receptors

Receptor	Tolerance	Recoverability	Value	Sensitivity
Holderness Inshore MCZ Geological features	Some (Low)	High (Negligible)	High	Low
Smithic Bank	Some (Low)	High (Negligible)	Low	Negligible

7.1.2.3.1 Significance of Effect – DBS East or DBS West in Isolation

The effects on bedload sediment transport due to cable installation at the landfall (excavation of subtidal exit pits) are considered to have a **negligible** magnitude of impact and a **low** and **negligible** sensitivity of the receptors considered in **Table 7-5**, resulting in likely **negligible** significance of effect. No additional mitigation is proposed.

7.1.2.4 Significance of Effect – DBS East and DBS West Together

Construction of DBS East and DBS West together (concurrently or sequentially) would not result in a greater magnitude of impact than DBS East or DBS West in isolation as for both scenarios, there will be one phase of cable installation activity and the volumes of sediment disturbed, despite a greater number of excavations being required, remain low in comparison to background sediment yield due to coastal erosion. Therefore, the significance of effect is the same as outlined in section 7.1.2.3.1 and considered to have a likely **negligible** significance of effect, due to a **negligible** magnitude of impact and a **low** and **negligible** sensitivity. No additional mitigation is proposed.

7.2 Potential effects during operation

7.2.1 Changes to bedload sediment transport and seabed morphology due to the presence of cable protection measures

7.2.1.1 Description of change

As a worst-case scenario, cable protection measures would need to be installed to protect any shallow or surface-laid cables. There is potential that burial of the export cables would not practicably be achievable within the nearshore (subtidal) part of the offshore cable corridor from the mean low water spring tide mark (130m from the base of the cliffs) to water depths less than 10m due to the presence of chalk bedrock in the shallow subsurface (**Volume 7, Figure 8-3** (application ref: 7.8.1)). Cable protection measures may take the form of rock armour, concrete mattresses, steel bridging / ducting, Cable Protection System (CPS) ducting / articulated pipe (cast iron or plastic), concrete bridging and / or rock bags.

Cable protection may also be required in other areas of the Offshore Export Cable Corridor, Array Areas and Inter Platform Cable Corridor. Furthermore, cable protection would be required at cable / pipeline crossings or in areas where bedrock is exposed at seabed. The location of known cable / pipeline crossings along the Offshore Export Cable Corridor is shown in **Volume 7, Figure 8-13** (application ref: 7.8.1) and it is those that are in shallow water that would have the greatest effect as their height above the seabed (worst case scenario of 1.4m or 0.5m in water depths of less than 10m) would occupy a relatively larger proportion of the water column and increasing the blockage effect.

Interpretation of the nearshore geophysical data has provided an estimate of the anticipated amount of cable protection required in the nearshore subtidal area, approaching the Holderness coast. The data indicates that burial or trenching will be achievable for 90% of the route from the mean low water spring tide level out to the 10m depth contour (approximately 1,050m from mean low water spring). In addition, the Applicants have committed to no cable protection in the intertidal zone and from mean low water spring tide to 350m seaward of this tidal datum (included in the 90% above). At the landfall, the mean low spring tide line is about 130m seaward of the cliffs. This means that from the cliffs to approximately 480m seaward (across the intertidal zone and shallow subtidal zone), the cables will be buried and have no effect on coastal processes.

The effects that export cable protection may have on the marine physical environment primarily relate to the potential for interruption of sediment transport processes and the footprint they present on the seabed. In areas of active sediment transport, any linear protrusion on the seabed may interrupt bedload sediment transport processes in the nearshore and along the coast during the operational phase. Depending on their water depth relative to the prevailing wave and tide regime, any measures in areas closest to the coast have the potential to affect longshore sediment transport processes and circulatory pathways across any nearshore banks such as the Smithic Bank.

Longshore sediment transport modelling has been undertaken to determine the potential impact of the worst-case scenario for cable protection measures in the nearshore zone in relation to sediment transport budgets (section 5). The results show the maximum offshore limit of wave driven sediment transport is 800m from the cliff line in water depths of 5.75m below CD. This supports the predictions made using empirical calculations of 'closure depth' following the methods of Hallermeier (1978). For the seabed offshore from the landfall, this would typically be in around 6m of water based on the average significant wave heights recorded by the Hornsea buoy.

Although the influence of waves can reach 800m from the base of the cliffs at the landfall, the majority of longshore sediment transport occurs within 250m of the cliff line (**Figure 5-9**) and the magnitude of wave driven transport decreases with distance offshore within the closure depth. These results align with evidence from other studies along the Holderness coast. In a study at Easington along south Holderness, HR Wallingford (2011) showed that most of the longshore transport from wave breaking occurs close to the shoreline, within approximately 250m of the cliff line.

As the worst case for nearshore cable protection measures would be located in a zone of active sediment transport, there is potential for localised interruptions to bedload sediment transport during the operational phase of the Projects. The longshore sediment transport modelling (section 5) indicates that an average of 4.2% of the annual net sediment budget could be interrupted if the cable protection measures occupied the full water column creating a complete blockage. However, the Applicants have committed to using cable protection with maximum height of 0.5m above the seabed in water depths of less than 10m. Considering the water depth range at the location of the cable protection measures is -2.8 to -3.8 mLAT, the cable protection would occupy between 17% and 14% of the water column at LAT meaning over 80% of the water column would be 'open' allowing sediment to bypass the structure. AT MHWS, the structures would occupy <6% of the water column. Therefore, interruptions to sediment transport will be less than was modelled and the changes are likely to be of the order of a 1% when compared to baseline conditions (the value of 1% was determined assuming a 25% blockage effect of the water column). Even these values are precautionary as these are based on the LAT water depth and over the operational lifetime of the Projects, water levels will be higher than this most of the time allowing even more sediment to bypass the structures.

The results of the nearshore wave modelling shown in section 4 show there are localised changes in significant wave height which occur primarily within 20m of the structures. As waves are the primary driver of sediment transport in the nearshore, the results can be used to infer broader sediment transport pathways. The modelling indicates the structures could lead to reduction in significant wave height by 10% compared to the baseline within 380m of the structures, with an increase in wave height directly above the structure as they create a 'reef' when water levels are at their lowest. A reduction in significant wave height would theoretically reduce the duration when waves are acting on the seabed potentially leading to an increase in deposition with sediment accumulating around the margins of the cable protection.

The wave modelling results support the conceptual assessment which predicted that sediment would first accumulate on one side or both sides of the obstacle (on the northern side in the nearshore where net sediment transport is from north to south). With continued build-up, it would then form a 'ramp' over which sediment transport would eventually occur by bedload processes, thereby bypassing the protection. The gross patterns of bedload transport across the export cables would therefore not be affected significantly.

Over the operational lifetime of the projects, there is potential for localised scour on the southern side of the cable protection measures in the nearshore where wave heights are potentially higher (as modelled in section 4). The underlying geology in the nearshore is glacial till overlying chalk bedrock and these are relatively resistant to erosion when compared with sandy seabed sediments so the potential for scour is relatively low. Water depths will also be higher due to sea-level rise which could theoretically reduce the potential for scour as certain size waves no longer interact with the seabed. However, a change in storm frequency and intensity may be expected which could lead to more storm-event induced scour and erosion.

There is also potential for seabed lowering across the entire Offshore Export Cable Corridor as the cross-shore profile adjusts to sea-level rise, coastal erosion and shore platform lowering. **Figure 7-3** shows a hypothetical cross shore profile at the landfall using predicted rates of coastal erosion for the RCP 8.5 70th percentile sea-level rise scenario (see the **Coastal Erosion Technical Note** [REP2-024]). As a worst case climate change scenario this predicts that the seabed could lower by up to 6m over the operational lifetime of the Projects. However, there is considerable uncertainty in these predictions.

The approach simply translates the existing shoreline profile landward in line with predictions of cliff recession and sea-level rise. Coastal systems adapt dynamically and are not static, therefore, the shore profile may be different in 2074 to the present day. Furthermore, the predictions of cliff recession used here may be overestimated in comparison to predicted rates of coastal retreat defined by NCERM2 (see Table 2.7 of the **Coastal Erosion Technical Note** [REP2-024]) The approach also assumes continuous down wearing of the seabed which would be unlikely as the underlying geology comprises till with chalk bedrock potentially sub cropping within 2m of the seabed. Finally, as the cable protection measures will be more resistant than the surrounding seabed, they may not wear at the same rate and over time, they could protrude slightly higher, (relative to the seabed) than when installed.

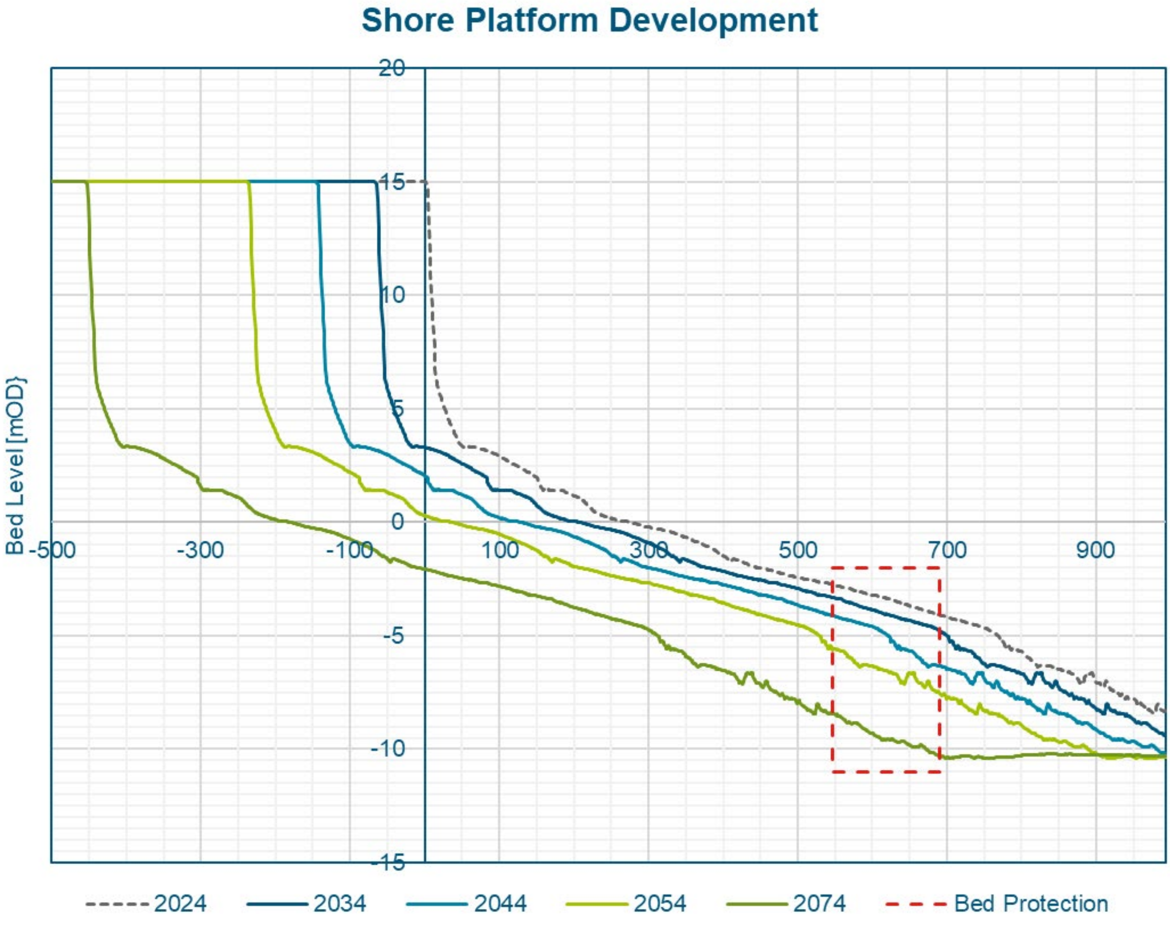

Figure 7-3 Predicted shoreline evolution at the landfall based on predictions of cliff recession under the RCP 8.5 70th percentile sea-level rise scenario. The location of nearshore cable protection measures are shown by the red dashed line.

It is likely a degree of scour will occur at the cable protection measures over the operational lifetime of the Projects but this scour will be small, localised and occur over a long time period and the effects on bedload sediment transport would not be observable but possibly detected through repeat bathymetric surveys.

7.2.1.2 Magnitude of Impact – DBS East or DBS West in Isolation

If DBS East and DBS West are built in isolation, cable protection will be required at cable and pipeline crossings and may also be required in localised areas where it is not possible to bury the cable. If cable DBS East or DBS West are built in isolation, up to 995,009m^2 or 889,338m^2 of cable protection may be deployed, respectively (see **Table 3-1**). In the nearshore (less than 10m water depth) a single cable trench (and associated cable protection if required) will be utilised if the Projects are built in isolation as the Applicants have committed to bundling the export cables. The cable protection will be emplaced for the full duration of the operational phase of the Projects (30 years).

The magnitude of impact has been considered separately for cable protection deployed inshore of the closure depth (defined as 6m water depth based on the numerical modelling in section 5), where bedload sediment transport is driven by waves, and offshore of the closure depth where tidal currents are the predominant driver of bedload sediment transport. Inshore of the closure depth, the effects on bedload transport are small (<1% of the baseline) and well within the range of natural variability (see **Figure 5-11**) and the scale of the impact is defined as being low (**Table 7-6**). The duration and frequency of the impact will be high as the cable protection measures will be present for the operation lifetime of the Projects but once they are removed, any changes to bedload sediment transport will be fully reversed. It is likely a degree of scour will occur at the cable protection measures over the operational lifetime of the Projects but this scour will be small, localised and occur over a long time period and the effects on bedload sediment transport would not be observable but possibly detected through repeat bathymetric surveys. Therefore, the magnitude of impact inshore of the closure depth would be low (**Table 7-6**).

Offshore of the closure depth, the scale of the impact on bedload sediment transport is considered to be negligible as the tidal currents will allow sediment to accumulate on one or more sides of the cable protection until it forms a ramp and sediment can bypass the structures meaning there would be no (or an extremely small) change to bedload sediment transport. The magnitude of impact is therefore, considered to be negligible offshore of the closure depth as whilst the duration and frequency of the impact will be high, once removed, there will be no change to bedload sediment transport (**Table 7-6**).

Table 7-6 Magnitude of Impact on Bedload Transport and Seabed Morphology Under the Worst Case Scenario Due to Cable Protection Measures

Location	Scale	Duration	Frequency	Reversibility	Magnitude of Impact
Inshore of closure depth	Low	High	High	Negligible	Low

Location	Scale	Duration	Frequency	Reversibility	Magnitude of Impact
Offshore of closure depth	Negligible	High	High	Negligible	Negligible

7.2.1.3 Magnitude of Impact – DBS East and DBS West Together

If DBS East and DBS West are built together (concurrently or sequentially), the number (and total length) of cables will double when compared to the in isolation scenario and as a result, a greater number of cable / pipeline crossings will be required), resulting in a total footprint for cable protection of 2,122,571m². Offshore of the closure depth, at each cable crossing, the cables will be separated from one another by 100m. Inshore of the closure depth, the cables will be separated from one another by 50m as a worst case scenario. Despite there being potential for cable protection being located in close proximity (within 100m), there will be a space between each cable which will create an uninterrupted pathway for sediment transport.

Inshore of the closure depth, the magnitude of impact on bedload sediment transport due to cable protection measures will be **low** which is the same as presented for the in isolation scenario presented in section 7.2.1.2 (**Table 7-7**). This is because the scale of impact remains low (<1%) as predicted by the numerical modelling shown in section 5, despite the cable protection footprint being double.

Offshore of the closure depth, the scale of impact remains negligible as whilst the footprint of the cable protection is larger, it remains extremely small, for example, the worst case footprint of cable protection is DBS East and DBS West are built together is 1.2km² which is equivalent to 0.0095% of the area covered by the Dogger Bank SAC. Furthermore, as bedload sediment can bypass the structures (around and over the top), there would be no (or an extremely small) change to bedload sediment transport. The magnitude of impact will be **negligible** (**Table 7-7**).

Table 7-7 Magnitude of Impact on Bedload Transport and Seabed Morphology Under the Worst Case Scenario Due to Cable Protection Measures

Location	Scale	Duration	Frequency	Reversibility	Magnitude of Impact
Inshore of closure depth	Low	High	High	Negligible	Low
Offshore of closure depth	Negligible	High	High	Negligible	Negligible

7.2.1.3.1 Sensitivity of Receptor

Temporary interruptions to bedload sediment transport due to the presence of cable protection in the nearshore zone have the potential to impact coastal receptors. Further offshore, Dogger Bank may also be affected by cable protection measures. The value and sensitivity of these receptors is presented in **Table 7-8**.

Smithic Bank is located directly north of the Offshore Export Cable Corridor. Smithic Bank is sensitive to change in bedload sediment transport. However, sediment transport pathways at the landfall are dominated by a net sediment transport direction north to south and there is no clear pathway to impact. Furthermore, Smithic Bank is an active and dynamic sandbank and its morphology is constantly changing due to natural variability in the sediment budget and storm events (see section sediment transport). Therefore, it has some tolerance to changes in bedload sediment transport. Given its dynamic and mobile nature it can also recover relatively quickly (<1 years) from and changes.

The value of Smithic Bank is defined as low as the receptor is not designated but is of local importance for marine geology and sediment processes. There is no evidence Smithic Bank is a source of sediment to the Holderness coast which would be of regional importance. It is a localised sediment cell that is restricted in extent to the lee of Flamborough Head where hydrodynamic conditions support its continued development. Considering it has low tolerance and negligible recoverability, and low value, the sensitivity of Smithic Bank to changes in bedload is defined as **negligible** (**Table 7-8**).

The Holderness Inshore MCZ is located directly to the south of the Offshore Export Cable corridor. However, the geological feature of its designation is Spurn Head which is located 53km away. Spurn Head has some tolerance to changes in bedload sediment transport as it already adjusts to a highly variable sediment budget (as demonstrated in Figure 5 11) driven by ongoing and episodic coastal erosion and the prevailing wave regime. However, Spurn Head would be able to recover relatively quickly (<1 year) to any changes in bedload sediment transport. Whilst it has high value considering its designated status, given its low tolerance and negligible recoverability, the Holderness Inshore MCZ geological feature is assigned a **low** sensitivity to changes in bedload sediment transport as outlined in **Table 7-8**.

Dogger Bank as a geomorphological and geological feature has some tolerance to changes in bedload sediment transport. Its formation is linked to glacial processes that occurred during the last glacial period (see section 8.5.2 of **Chapter 8 Marine Physical Environment** [APP-080]) and only the uppermost sediments are potentially mobile and susceptible to changes in bedload sediment transport. However, there is evidence from construction activities within other offshore wind farms on Dogger Bank that show the seabed can recover quickly (see **Appendix 8-2 -Met Mast Survey Analysis** [APP-083]). Therefore, the sensitivity of Dogger Bank to changes in bedload sediment transport is low (**Table 7-8**).

Table 7-8 Sensitivity and Value of Morphological Receptors

Receptor	Tolerance	Recoverability	Value	Sensitivity
Smithic Bank	Some (Low)	High (Negligible)	Low	Negligible
Holderness Inshore MCZ Geological features	Some (Low)	High (Negligible)	High	Low
Dogger Bank	Some (Low)	High (Negligible)	High	Low

7.2.1.4 Significance of Effect – DBS East or DBS West in Isolation

Offshore of the closure depth, the effects on wave-driven bedload sediment transport and seabed morphology arising from the presence of export cable protection measures would not extend far beyond the direct footprint. Here, any changes in sediment transport will largely be driven by tidal currents. Receptors located offshore of the closure depth include Dogger Bank and parts of Smithic Bank and the geological features of the Holderness Inshore MCZ. Considering the low to negligible magnitude of impact and low to negligible sensitivity of these receptors to changes in bedload sediment transport due to the presence of cable protection measures, the effects offshore of the closure depth are likely to be of **negligible** significance of effect and therefore not significant in EIA terms. No additional mitigation is proposed.

There is potential for the cable protection measures to affect net sediment transport direction in the nearshore which would potentially effect parts of Smithic Bank and the geological features of the Holderness Inshore MCZ. If cable protection does present an obstruction to bedload transport, then a continued build up would form a 'ramp' over which sediment transport would occur by bedload processes, thereby bypassing the protection. The gross patterns of bedload transport across the export cable would therefore not be affected significantly. Considering the low magnitude of impact inshore of the closure depth and the negligible sensitivity of Smithic Bank as a receptor, the significance of effect will be **negligible** and therefore not significant in EIA terms. No additional mitigation is proposed.

7.2.1.5 Significance of Effect – DBS East and DBS West Together

Construction of DBS East and DBS West together would not result in a greater magnitude of impact than DBS East or DBS West in isolation. Therefore, the significance of effect is the same as outlined in section 7.2.1.4 and considered to have a likely negligible significance of effect due to the negligible to low magnitude of impact and the negligible to low sensitivity. No additional mitigation is proposed.

8 Conclusions

Based on the advice of Interested Parties during the examination period of the Projects, additional numerical modelling has been undertaken at the landfall to provide additional evidence to support the conclusions in relation to sediment transport at the landfall during construction and operation.

The modelling results show the presence of cable protection measures in the nearshore could, on the basis of a highly precautionary and deeply unlikely scenario, affect longshore sediment transport budget, but the effects are extremely small, at less than 1% of the annual budget.

To inform the assessment of changes to bedload sediment transport, all available morphological, sedimentological and hydrodynamic data has been used to update Figure 8-5 of **Chapter 8 Marine Physical Environment** [APP-080] (presented in **Figure 6-5** of this report). This improves the baseline understanding of sediment transport pathways around the Array Areas.

The conclusions of the ES in relation to sediment transport have been reviewed following the changes to the project parameters outlined in **Project Change Request 1 – Offshore and Intertidal Works** [AS-141]. There are no changes to the assessment of changes in suspended sediment concentration or bedload sediment transport during the construction phase of the Projects.

The assessment of changes in bedload sediment transport due to the presence of cable protection measures during the operational lifetime of the Project has been updated from a negligible significance of effect to a **low significance of effect**, based on the outputs of the sediment transport modelling which indicate the scale of impact may be low (appose to negligible) resulting in a low magnitude of impact inshore of the closure depth. However, the assessment remains not significant in EIA terms and no mitigation is proposed.

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