Morlais Project

Metocean and Physical Processes Numerical Modelling Supplementary Note

Applicant: Menter Môn Morlais Limited

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1 Introduction

Following Natural Resources Wales (NRW) review of the metocean conditions and coastal processes chapter of the Morlais Project Environmental Statement (ES), and two subsequent meetings of the Physical Processes Working Group (12th December 2019 and 24th January 2020), this supplementary note summarises the results of the new numerical modelling completed by HR Wallingford and re-addresses the potential operational impacts of the Project on waves, tidal currents and sediment transport.

An overarching comment from NRW was that the scale of original assessment was not proportionate to the scale of the Project. Hence, the new modelling campaign including hydrodynamic, waves, and sediment transport modelling was completed by HR Wallingford (2020, Document Number DER6261-RT001-R01-00) to support a re-assessment of impacts.

The note is structured in a question (bold italic)/answer format and is divided into two parts; model set-up / calibration / validation, and operational impacts.

2 Model Set-up, Calibration and Validation

All the data and methodology related to the set-up, calibration and validation of the new models is presented in HR Wallingford (2020, Document Number DER6261-RT001-R01-00) which NRW has received. The information is not repeated here.

Model set-up: It is unclear how the turbines and infrastructure have been represented in the model.

The method used to represent the devices in the new models is addressed in HR Wallingford (2020, Document Number DER6261-RT001-R01-00).

Model validation, water levels: The word 'current' is used instead of 'depth' in paragraph 2. Where the graphs are labelled 'observed' this is in fact harmonic analysis on the astronomical tide. NRW recommends actual data are used to validate the 2D model rather than a harmonic dataset.

The validation of the new models is addressed in HR Wallingford (2020, Document Number DER6261-RT001-R01-00).

Model validation, current velocities: The currents shown as 'observed' are harmonically reproduced currents rather than 'true data'. NRW requests clarification on whether the IEC TS 62600-201 guidelines show this approach is acceptable as a way of validating the model.

The validation of the new hydrodynamic model is addressed in HR Wallingford (2020, Document Number DER6261-RT001-R01-00).

Further model verification: With regards to position 2, NRW notes that the model is over-predicting at low current speeds, under-predicting at mid-high current speeds and over-predicting at very high current speeds. Position 1 seems 'messier' with little pattern. The tidal ellipses also show better alignment at position 2.

The verification of the new hydrodynamic model is provided in HR Wallingford (2020, Document Number DER6261-RT001-R01-00).

Figures 7-8 – 7-15: It is unclear how the total footprint blockage effects from the devices and associated infrastructure have been placed into the model. The effects also disappear 'off the page'.

The method used to represent the devices in the new models is addressed in HR Wallingford (2020, Document Number DER6261-RT001-R01-00). The total zone of influence of the effects are presented at both large and small scales in HR Wallingford (2020, Document Number DER6261-RT001-R01-00) to capture all the influence.

3 Operational Impacts

A re-assessment of operational impacts based on the results of the numerical modelling is provided below. For the purposes of impact assessment, the impacts are divided into those at each individual device, those in the near-field (within the bounds of the array and up to 500m away from cables), and those in the far-field (beyond the bounds of the array and greater than 500m from cables).

3.1 Hydrodynamics

Executive Summary: It is stated that the study was: "commissioned to provide a baseline assessment of the effects of resource extraction on the level of resource available to adjacent projects". Such a study is therefore not designed for environmental assessment, it is for design purposes, which means there are drawbacks with using this approach for environmental assessment.

The submitted hydrodynamic modelling report is aimed at understanding the energy resource available within and between the berths rather than for environmental impact assessment and is missing key information such as the proposed worst-case scenario of 620 devices and associated infrastructure pertaining to a 13ha direct footprint. We disagree with the rationale provided.

Although the original HR Wallingford modelling was primarily undertaken for resource modelling, its outputs, in terms of changes in the tidal regime, are equally valid for the environmental assessment. The new hydrodynamic modelling effort, which utilises the same model but with an updated worst case scenario, is presented in HR Wallingford (2020, Document Number DER6261-RT001-R01-00) and is not repeated here.

The maximum turbine assessment is for 408 turbines; this is less than the worst-case scenario described in the ES (620) and therefore not suitable for assessing the worst-case scenario for environmental impacts. It is unclear from Volume III how all the devices and associated infrastructure have been modelled and therefore the magnitude and temporal scale cannot be fully resolved.

The new hydrodynamic model of HR Wallingford (2020, Document Number DER6261-RT001-R01-00) has been run using a worst-case scenario of 620 devices. The worst-case scenario is fully described in HR Wallingford (2020, Document Number DER6261-RT001-R01-00) and not repeated here.

Operational Impact 1: Changes to the Tidal Regime Due to Presence of Structures in the Project - NRW cannot agree with the magnitude of effect as there is still uncertainty within the assessment. It is unclear from Volume III how all the devices and associated infrastructure have been modelled and therefore the magnitude and temporal scale cannot be fully resolved. Scenario four considers 200 fewer turbines (408) compared to the worst-case scenario (620); whilst the energy rating may be the same, the infrastructure and spatial extent of change will be greater with >200 more turbines within the water column.

The presence of the devices and their foundation or support structures has the potential to alter the baseline tidal regime, particularly tidal currents. Any changes in the tidal regime may have the potential to contribute to changes in seabed morphology due to alteration of sediment transport patterns. To investigate this issue, numerical modelling has been used to determine the changes in the baseline tidal regime arising from the worst-case scenario.

The modelled worst-case scenario comprises 620 sea-bed mounted devices, 112 electrical sea bed hubs, eight surface-piercing electrical hubs (each 6m diameter) and nine cable routes with rock bag protection. This is considered the worst-case scenario because it is the largest number of devices that could be used to achieve the maximum 240MW export capacity of the Project, and all the devices would have some form of interaction with the sea bed via their foundations or moorings. Sea-bed mounted devices would have the greatest blockage effect on tidal currents passing around them. The worst-case device configuration is described in Figure 3.1. Details of the method used to represent devices and structures in the flow model are provided in HR Wallingford (2020, Document Number DER6261-RT001-R01-00).

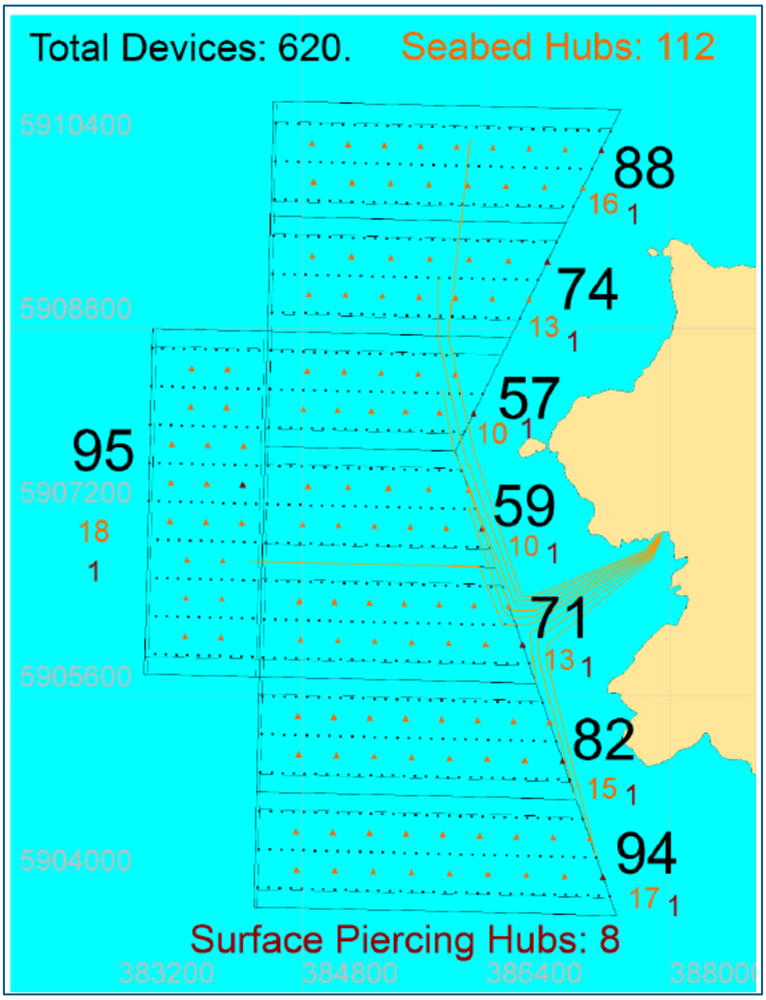


Figure 3.1. Worst case scenario for effects on tidal currents

For the purposes of the impact assessment, the results of the hydrodynamic modelling that are presented are changes to peak flood and peak ebb flows due to the devices. These two scenarios produce the worst case predicted changes to tidal current velocities. The predicted changes are both negative (green and blue colours in the following figures, corresponding to a decrease in current velocity) and positive (yellow, orange and red colours in the following figures, corresponding to an increase in current velocity) (Figure 3.2 and Figure 3.3). By analysing the positive and negative changes to peak flows on the flood and ebb tides over the entire simulation period the changes in velocity (either positive or negative) was predicted.

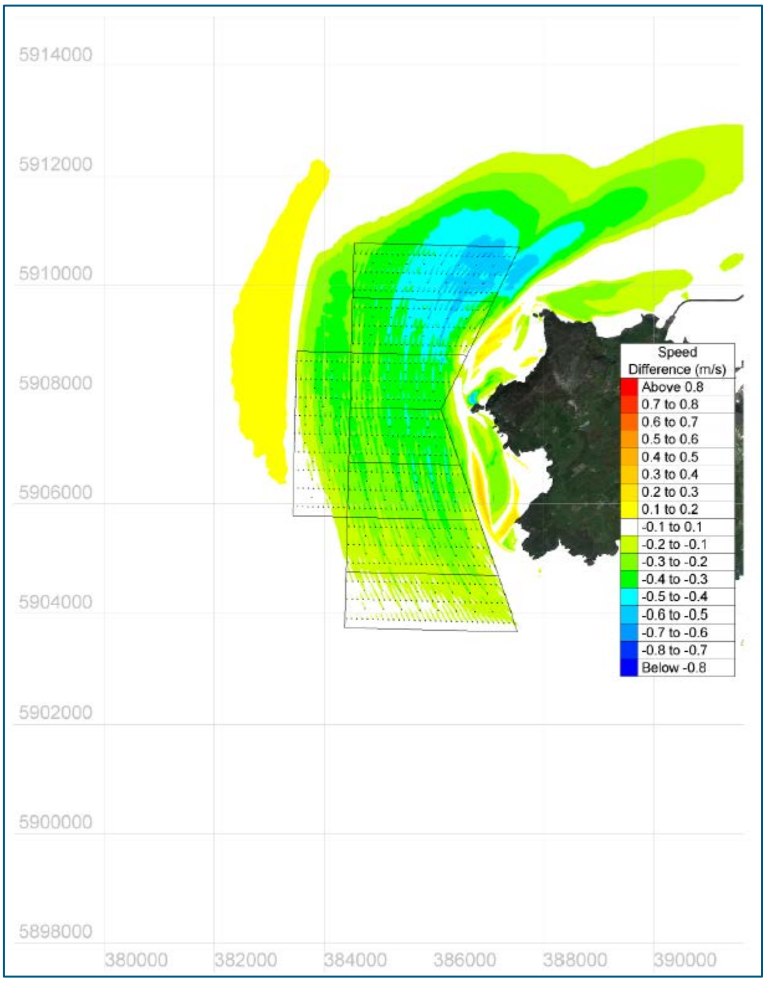


Figure 3.2. Change in mean spring tide peak flood flow velocity over the 29.5-day simulation period (HR Wallingford, 2020, Document Number DER6261-RT001-R01-00)

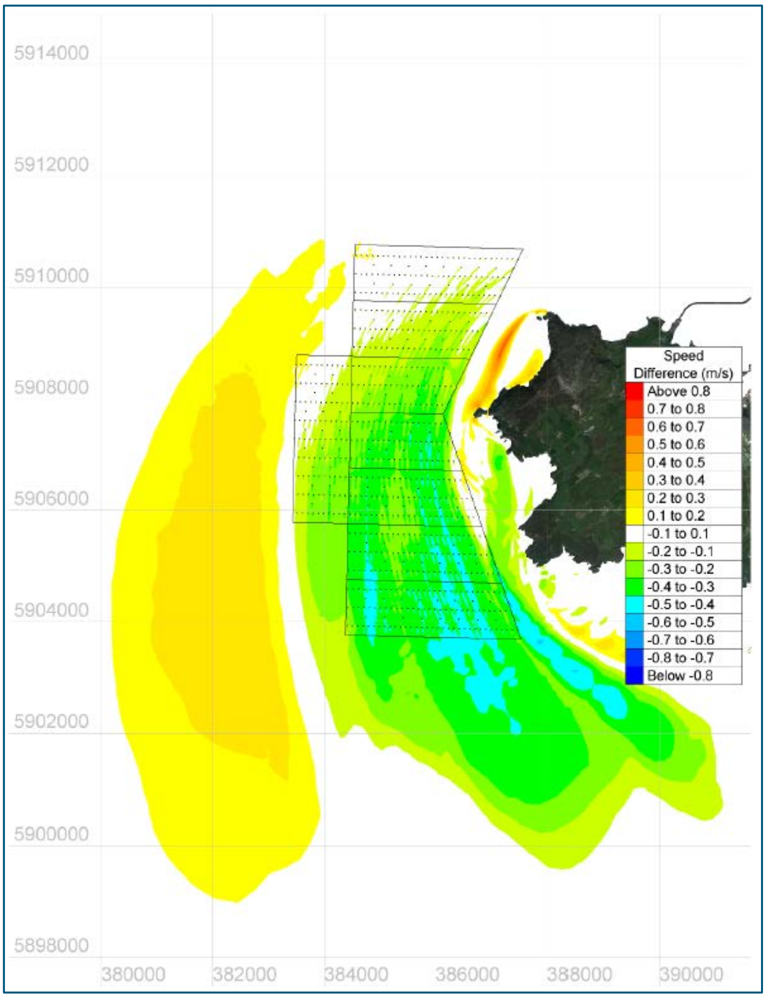


Figure 3.3. Change in mean spring tide peak ebb flow velocity over the 29.5-day simulation period (HR Wallingford, 2020, Document Number DER6261-RT001-R01-00)

The predicted changes confined to the array site are reductions in tidal current velocities. The zone of influence of effect tends to follow the axes of baseline tidal flows, extending northeast beyond the array on a flood tide and south-southeast beyond the array on an ebb tide.

On the flood tide, the magnitude of these predicted reductions is mainly less than 0.5m/s with the reduction increasing in a northerly direction as more devices impact upon the current regime. Beyond the northern extent of the array the effect gradually lessens until the change is effectively zero approximately 4km northeast of the array. There are no predicted effects on currents into Holyhead Bay. Similar magnitude changes occur on the ebb tide but progressing from lower to higher reductions in a southerly direction within the array, before reducing to background levels about 4km south of the array boundary. Approximate maximum predicted reductions across the array and beyond the northern and southern boundaries are up to 30%. Given that the absolute maximum current velocities are high (greater than 2m/s), then a change up to 0.5m/s would still mean the current velocities would be high enough to sweep the sea bed clear of sediment and to maintain the mobility of bedforms (i.e. there would be only small changes to sediment distribution caused by these reductions). This magnitude reduction in tidal current flow would continue to result in a residual current flow of high velocities.

In Abraham's Bosom, there are no predicted changes to current velocities caused by the array on both the flood tide and ebb tide. On the ebb tide, there is a potential change in Gogarth Bay with modelled increases of up to 0.4m/s across the inner part and greater than 0.8m/s in a north-northeast direction around the outer perimeter. Although, these are relatively high changes in tidal current velocity they are not manifest in changes to sediment transport and bed level change predicted by the sediment transport model (see Section 3.3).

Based on the qualitative and quantitative modelling assessments the likely magnitudes of effect are shown in Table 3.1. These magnitudes are the same as those assessed in the original ES.

Table 3.1. Magnitude of effects on tidal regime due to the presence of structures in the Project

Location	Scale	Duration	Frequency	Reversibility	Magnitude of Effect
Device	Medium	High	Medium	Negligible	Medium
Near-field	Low - Medium	High	Medium	Negligible	Low - Medium
Far-field	Negligible	High	Medium	Negligible	Negligible

3.2 Waves

There is no wave modelling or understanding presented of meteorological effects regarding project interactions and potential near and far-field impacts, despite this being advised by the applicant's own modelling conclusions and raised previously by NRW.

The new wave modelling campaign is described in HR Wallingford (2020, Document Number DER6261-RT001-R01-00) and not repeated here.

Operational Impact 2: Changes to the Wave Regime Due to Presence of Structures in the Project - NRW cannot agree with the magnitude of effect as there is still uncertainty within the assessment. No wave data or modelling has been carried out for the site and only a desk-based study on wind farm devices as a proxy. NRW does not feel this is adequate given the scale of the project.

Once installed within the array, tidal devices and their associated foundations or support structures will have the potential to affect the baseline wave regime. The changes could lead to a modification of the wave regime downstream of the array and could result in changes in sea bed morphology due to alteration of sediment transport patterns. To investigate this issue, numerical modelling has been used to determine the changes in the baseline wave heights arising from the worst-case scenario.

The modelled worst-case scenario for waves is different to that for tidal currents. It comprises 60 floating devices located in the southern part of the array (as they are not allowed to be located in the northern part), 310 sea-bed mounted devices, 60 sea bed hubs, and eight surface-piercing hubs. This configuration of devices would have the greatest effect on waves. Floating devices would have a greater impact on waves than sea-bed mounted devices as they can directly block waves. As the sea-bed mounted structures are located in relatively deeper water (30-40m depth) the effect of these structures on waves would be lower. The worst-case device configuration is described in Figure 3.4. Details of the method used to represent devices and structures in the flow model are provided in HR Wallingford (2020, Document Number DER6261-RT001-R01-00).

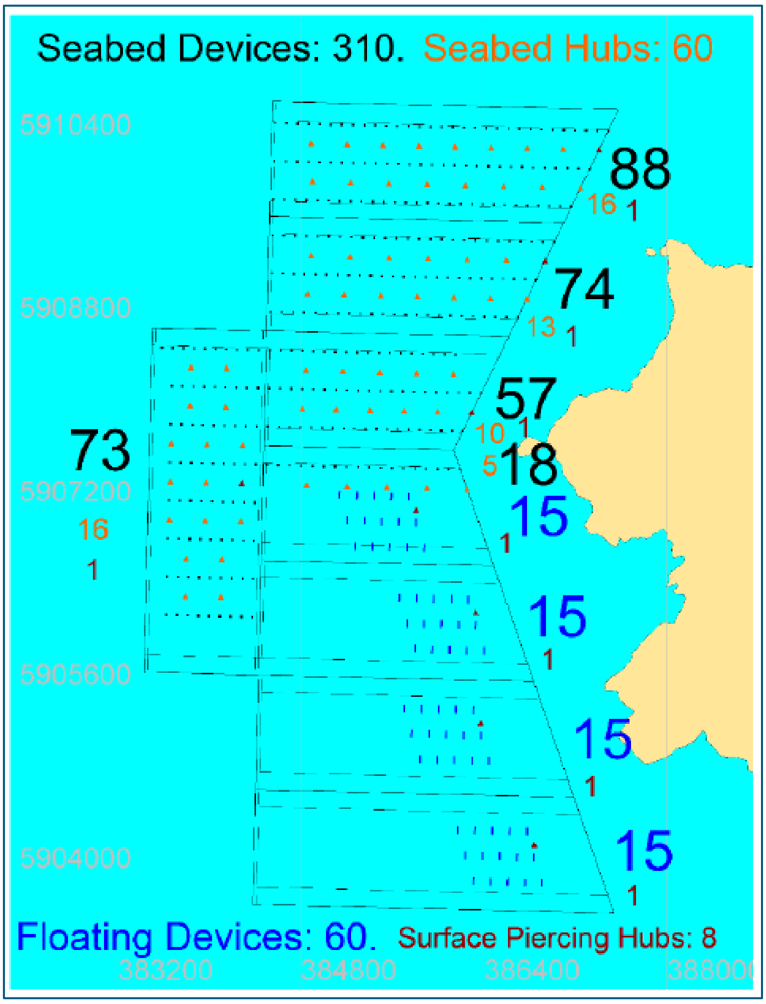


Figure 3.4. Worst case scenario for effects on waves

For the purposes of the impact assessment, the results of the wave modelling are presented for typical and extreme conditions from five directions (210º, 240º, 270º, 300º and 330º). Results from 210º (the predominant wave direction) and 300º are presented in Figure 3.5. Results from the other three directions are presented in HR Wallingford (2020, Document Number DER6261-RT001-R01-00). Seven locations have also been chosen for specific analysis representing areas of geomorphological interest. These are Cemlyn Bay (Point 1), Langdon Ridge (Point 2), South Stack sand bank (Point 3), Gogarth Bay (Point 4), Abraham's Bosom (Point 5), Rhosneigr (Point 6) and Aberffraw (Point 7). The results from 210º and 300º are presented in Figure 3.6.

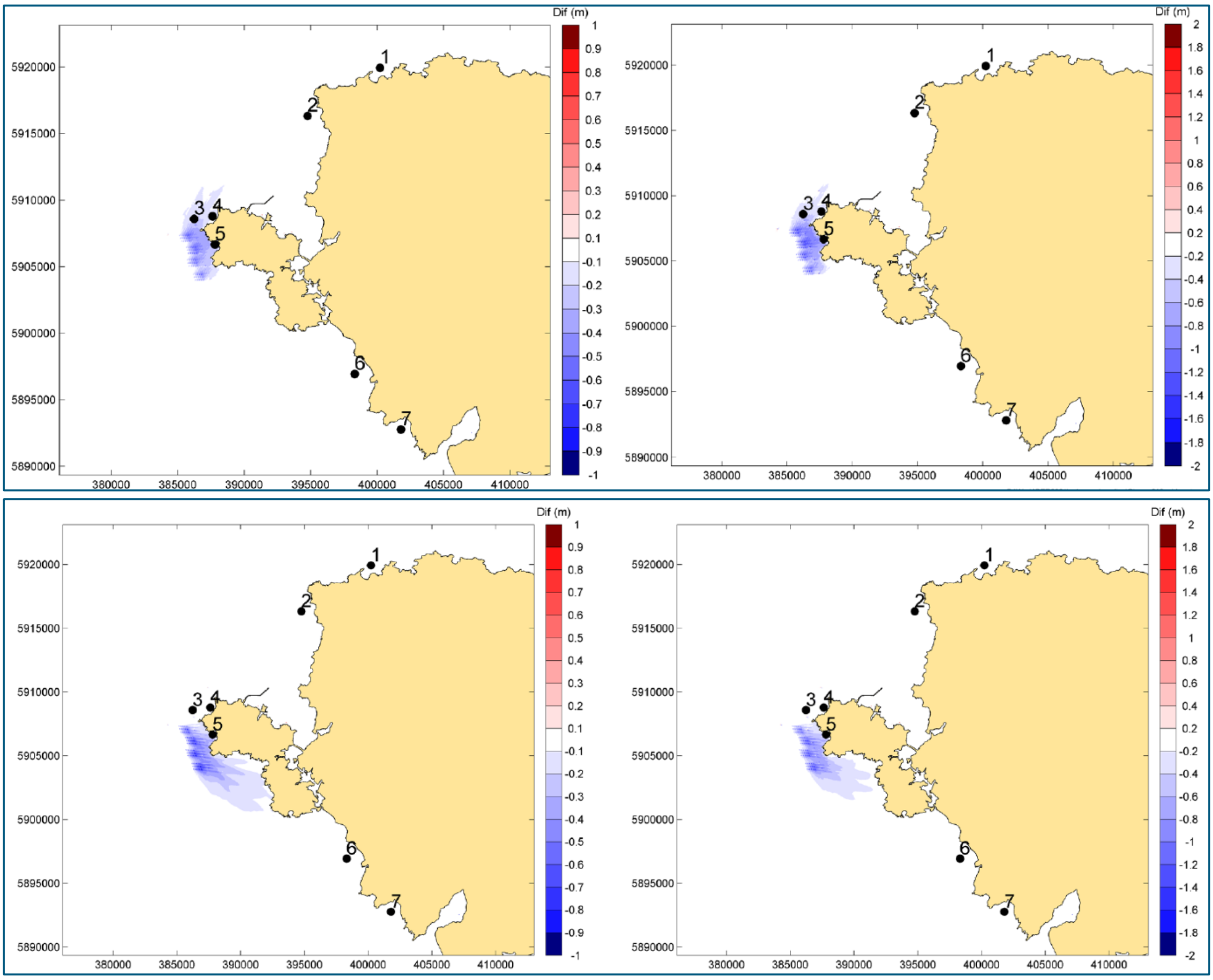
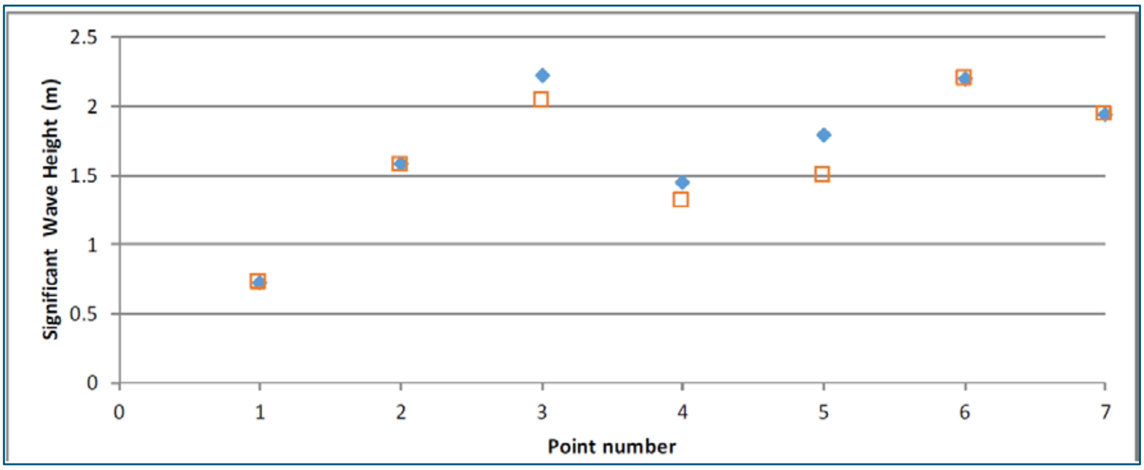


Figure 3.5. Difference in wave height for a representative condition (left) and extreme condition (right) for wave approaching from 210º (top) and 300º (bottom) (HR Wallingford, 2020, Document Number DER6261-RT001-R01-00)



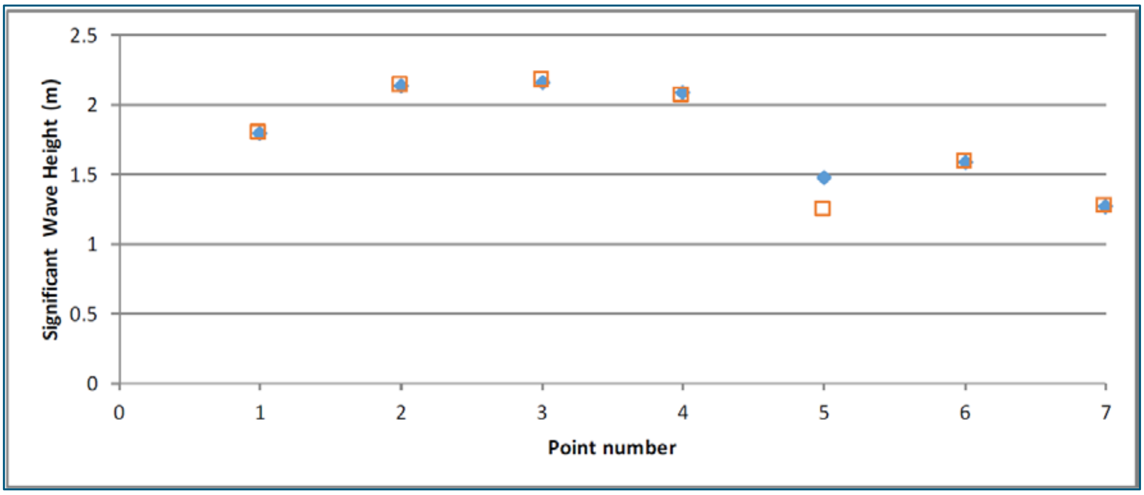


Figure 3.6. Comparison of baseline wave heights with wave heights with the devices in place at seven points along the coast from waves approaching from 210º (top) and 300º (bottom). Location of points is shown in Figure 3.5 (HR Wallingford, 2020, , Document Number DER6261-RT001-R01-00)

In all cases where there is a predicted change towards the coast it is a reduction in wave height. The wave heights at the points distant from the array (1, 2, 6, 7) do not change. There are also no changes to waves in Holyhead Bay. There are changes to wave heights at the critical receptors; South Stack sand bank (Point 3), Gogarth Bay (Point 4), and Abraham's Bosom (Point 5).

Predicted reductions in wave height at the sand bank occur with waves from 210º but not from 300. They are about 0.2-0.3m for both typical and extreme waves. For Gogarth Bay, 300º directed waves have no effect, whereas reductions of 0.2-0.3m are predicted for waves from 210º. Abraham's Bosom presents a different prediction, where wave heights are affected from both directions. From both 210º and 300º, the reduction is predicted to be about 0.3-0.4m for both typical and extreme conditions.

With respect to the bays, the main effect of changes in wave height would be within the active wave zone (inside the closure depth). This is typically 5-10m water depth and much of Abraham's

Bosom and Gogarth Bay are deeper than this and so outside the direct zone of influence of waves. Inside the closure depth the wave climate is highly energetic leading to a rocky coast with shore platforms and headlands enclosing bays (with a sandy bed) with beaches composed of shingle and some sand. A reduction in wave height of 0.2-0.4m is unlikely to upset the pattern of erosion, transport and deposition at the coast as the wave energy is still high. However, there may be more potential for deposition (accretion) of sand in the enclosed bays with a reduction in wave energy in the deeper parts. This could be a positive effect providing more protection to the coast from waves as they are attenuated across a higher sea bed.

In terms of the effect on the South Stack sand bank, it is driven predominantly by currents and so waves may only have an effect along its crest. However, the crest is in deeper water and is likely to be below wave base.

Based on the above assessment the likely magnitudes of effect are shown in Table 3.2. These magnitudes are the same as those assessed in the original ES.

Table 3.2. Magnitude of effects on wave regime due to the presence of structures in the Project

Location	Scale	Duration	Frequency	Reversibility	Magnitude of Effect
Device	Medium	High	Medium	Negligible	Medium
Near-field	Low	High	Medium	Negligible	Low
Far-field	Negligible	High	Medium	Negligible	Negligible

3.3 Sediment Transport

Operational Impact 3: Changes to the Sediment Transport Regime Due to Presence of Structures in the Project - NRW cannot agree with the magnitude of effect as there is still uncertainty within the assessment. The worst-case scenario of device number and footprint varies throughout the document but would benefit from a standard approach. NRW would recommend consideration of work by Bangor University to understand tidal turbine impacts on morphodynamics such as: S.P. Neill, J.R. Jordan, S.J. Couch. Impact of tidal energy converter (TEC) arrays on the dynamics of headland sand bank. Renew Energy, 37 (1) (2012), pp. 387-397

There is no operational impact assessment of the potential for Suspended Sediment Concentration change over the long term because of altered current velocities.

Operational Impact 4: Increases in Suspended Sediment Concentrations Due to Sea Bed Scour Induced by the Project - NRW cannot agree with the magnitude of effect as there is still uncertainty within the baseline suspended sediment environment.

Operational Impact 6: Changes to the Morphology and Sediment Transport Regime Due to Offshore Cable and Cable Protection (including Nearshore and Landfall) - NRW requires further information on the export cable protection measures to be used on the identified sand features to be able to assess Operational Impact 6.

Changes in the sediment transport regime (both bedload sediment transport and suspended sediment transport) will arise as an indirect effect, consequent upon changes in the tidal and/or wave regimes caused by tidal devices, their foundations and cable protection. To investigate this issue, numerical modelling has been used to determine the changes in sediment transport rates and the resulting evolution of the sea bed arising from the worst-case scenario. Details of the model set-up including sediment particle size inputs and simulations are provided in HR Wallingford (2020, Document Number DER6261-RT001-R01-00).

For the purposes of the impact assessment, the results of the sediment transport modelling are presented as changes to the residual transport of the total load (bedload and suspended load combined) (the average of all the transport over the time of the simulation) (Figure 3.7). The results are also presented as erosion / deposition to show predicted changes in sea bed levels and scaled up to change over a year (Figure 3.8). Hence, this part of the note incorporates both operational impact 3, operational impact 4 and operational impact 6 of the ES.

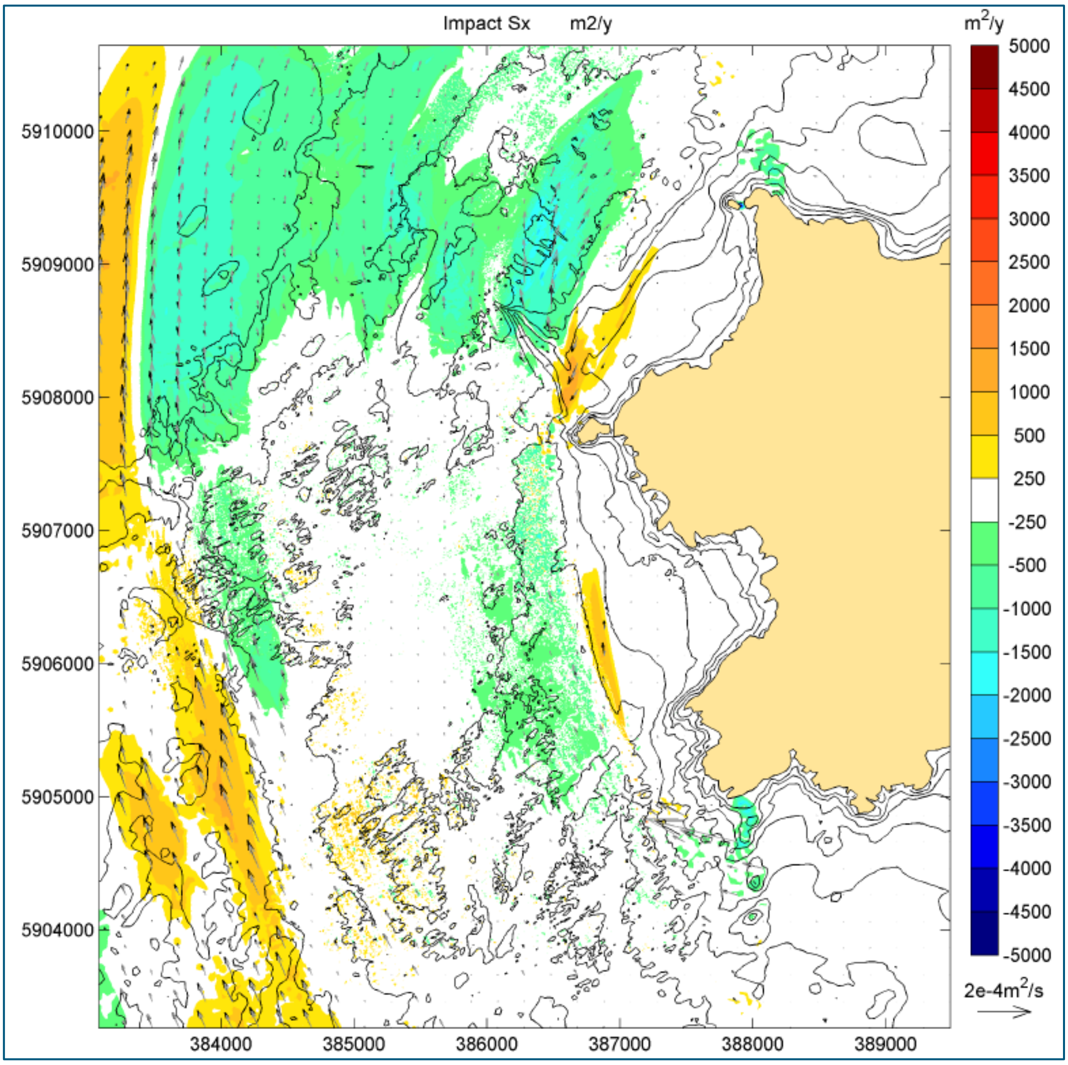


Figure 3.7. Changes in yearly averaged residual sediment transport due to the Project (HR Wallingford, 2020, Document Number DER6261-RT001-R01-00)

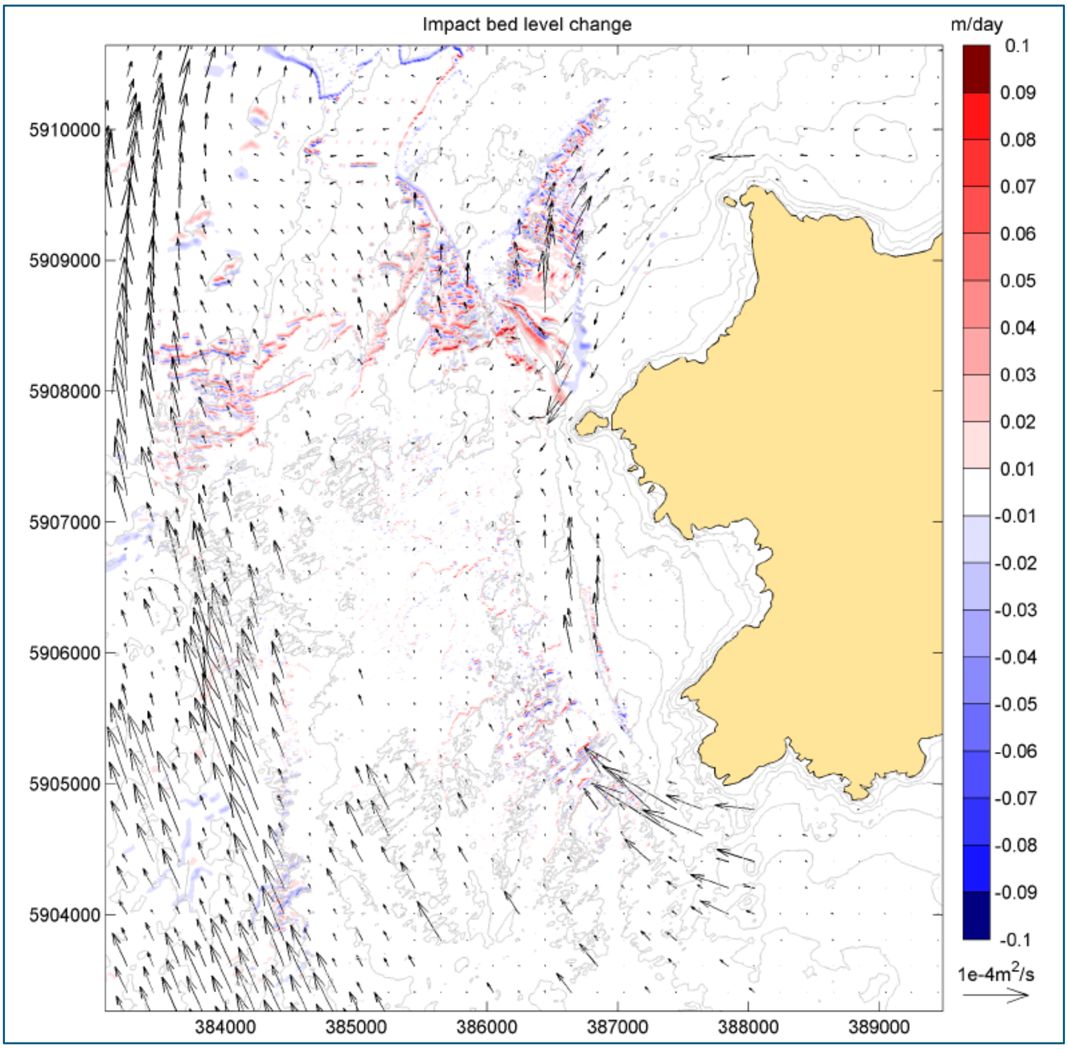


Figure 3.8. Changes in bed level change due to the Project (HR Wallingford, 2020, , Document Number DER6261-RT001-R01-00)

Figure 3.7 shows the changes in yearly averaged residual sediment transport due to the Project. Comparing these predictions with the baseline residual transport shows that they are less than 10-20% of the baseline residual transport. The drag of the devices, which would reduce the tidal current velocities in the array results in a predicted reduction in the sediment transport rates. Transport rates over the sand waves offshore from Gogarth Bay are predicted to be 10-20% lower with the devices in place. This means that the migration rates of the sand waves, which is currently about 30m/year (measured using bathymetry comparisons) would reduce by about 5m/year, which would be within the natural variation of the measured migration rates. Offshore from the array, the predicted flow velocities are higher, and the resulting residual transport rate is also predicted to be higher.

An increase in residual transport rate is also predicted to occur north of South Stack at the periphery of Gogarth Bay, and towards South Stack, but there is a predicted reduction in residual transport away from South Stack further offshore. This means that the circulation of sediment to and from South Stack sand bank would change; the residual transport away from the offshore tip is predicted to reduce whilst the return residual transport to the nearshore part of the bank is predicted to increase. This could lead to a reconfiguration of the bank with the offshore tip potentially moving slightly north. However, the volume of sediment that is moving towards the bank (a gain of about 2,000m^3 per spring-neap cycle) is very small compared to the volume of the bank (850,000m^3), and so the size of the bank is unlikely to change significantly in the long-term. This would also be within the natural variation of the position of the bank.

The main bed level changes are predicted to occur north of South Stack in the vicinity of the sand bank and the associated sand waves to its north (Figure 3.8). The bed level changes predict a re-shaping of the bank and sand waves, where they would be adapting their shapes to a form driven by the altered tidal currents. The magnitude of these changes is like the observed natural changes defined by the comparison of historic bathymetries (HR Wallingford, 2020, Document Number DER6261-RT001-R01-00).

Based on the above assessment the likely magnitudes of effect are shown in Table 3.3 (operational impact 3), Table 3.4 (operational impact 4) and Table 3.5 (operational impact 6). These magnitudes are the same as those assessed in the original ES.

Table 3.3. Magnitude of effects on sediment transport regime (operational impact 3) due to presence of structures in the Project

Location	Scale	Duration	Frequency	Reversibility	Magnitude of Effect
Device	Low	High	Medium	Negligible	Low
Near-field	Negligible	High	Medium	Negligible	Negligible
Far-field	Negligible	High	Medium	Negligible	Negligible

Table 3.4. Magnitude of effects on suspended sediment concentration (operational impact 4) due to presence of structures in the Project

Location	Scale	Duration	Frequency	Reversibility	Magnitude of Effect
Device	Low	High	Medium	Negligible	Low
Near-field	No change	No change	No change	No change	No change
Far-field	No change	No change	No change	No change	No change

Table 3.5. Magnitude of effects on morphology and sediment transport regime due to offshore cable and cable protection

Location	Scale	Duration	Frequency	Reversibility	Magnitude of Effect
Near-field	Negligible	High	Medium	Negligible	Negligible
Far-field	Negligible	High	Medium	Negligible	Negligible

3.4 Morphology

Operational Impact 5: Loss of Sea Bed Morphology Due to Footprint of Structures in the Project - NRW cannot agree with the magnitude of effect as there is still uncertainty within the project and no assessment has been made.

The sea bed morphology would directly be impacted by the footprint of each foundation structure within the array. This would constitute a 'loss' in natural sea bed area during the operational life of the Project. The worst-case scenario footprint for morphological impacts is 2,172,672m^2 based on:

- Maximum seabed footprint of devices: 74,790m^2
  - 590 devices with the largest foundation footprints and 120 hubs to maximise footprint, as follows:
  - 4.
- Swept area of catenary cables: 2,055,000m^2;
- Export cable footprint (cables and protection systems plus rock bags): 11,745m^2;
- Array cable footprint (cables and protection systems plus rock bags): 30,040m^2;
- Maximum footprint cable tails: 120m^2;
- Maximum footprint of 40 ADCPs: 280m^2;
- Footprint of eight seabed mounted environmental monitoring units: 112m^2;
- Footprint of 60 navigation and marker buoy moorings: 540m^2; and
- Footprint of five sea level environmental monitoring buoy moorings: 45m^2.

The total worst-case direct foundation footprint across the Project represents only 0.19% of the total sea bed area within the array site (39,778,074m^2). Also, given the nature of the sea bed morphology, comprised mostly of rock or coarse sediments, the potential for adverse effects is limited.

Based on the above assessment the likely magnitudes of effect are shown in Table 3.6. These magnitudes are the same as those assessed in the original ES.

Table 3.6. Magnitude of Effects on Sea Bed Morphology Due to Footprint of Structures in the Project

Location	Scale	Duration	Frequency	Reversibility	Magnitude of Effect
Device	Low	High	Medium	Negligible	Low
Near-field	No change	No change	No change	No change	No change
Far-field	No change	No change	No change	No change	No change

Operational Impact 7: Changes to the Morphology and Sediment Transport Regime Due to Inter-Array Cable and Cable Protection - NRW requires further information on the inter-array cable protection measures to be used on the identified sand features to be able to assess Operational Impact 7.

Typically for an offshore energy project, the preferred method for inter-array cable protection would be burial. However, these are mainly offshore wind projects located in sedimentary environments, while across most of this array site such burial is not possible due to the hard substrates present. As a result, the cables will be laid on the sea bed and protected and secured at strategic points. The effects that such works may have on physical processes primarily relate to the potential for interruption of sediment transport processes.

Across much of the array (where the inter-array cables will be installed), there is little mobile sediment available for bedload transport. This is because the sea bed has generally been swept to rock by the strong tidal currents. The exceptions to this are the South Stack sand bank and megaripples in the south and southwest of the Project, where sediment is mobile. In the updated project design the South Stack sand bank feature will be avoided by all cables, and hence there will be no impact on its functioning within the wider system. There will only be local disruption to megaripple movement, as they will migrate over the top of the low-lying laid cables.

Based on the above qualitative assessment the likely magnitudes of effect are shown in Table 3.7. These magnitudes are the same as those assessed in the original ES.

Table 3.7. Magnitude of effects on morphology and sediment transport regime due to inter-array cables

Location	Scale	Duration	Frequency	Reversibility	Magnitude of Effect
Near-field	Negligible	High	Medium	Negligible	Negligible
Far-field	Negligible	High	Medium	Negligible	Negligible

Operational Impact 8: Changes in Sea Bed Level Due to Indentations During Maintenance in the Project - NRW disagrees with the magnitude of effect being 'Negligible'. There is not enough information presented to assess changes to the geomorphological receptors, such as; position, duration, size and frequency to assess Operational Impact 8.

A conservative worst-case scenario of the number of maintenance activities would include a maximum two turbine locations visited per day with the potential for anchoring and/or use of a jack up barge during these visits, as well as ten cable repairs with each repair activity taking up to five days. The location of maintenance works will be subject to the location of the infrastructure and will therefore be influenced by the micro-siting during the construction phase. Therefore, a suitably conservative assessment has been provided in ES Chapter 7, Operational Impact 8 and that due to the predominance of exposed bedrock, with occasional gravel, cobbles and boulders, the legs / anchors of the vessels will not cause significant effects (i.e. scars or indentations). In areas where megaripples are present (in the south and southwest of the Project), there will be local effects on the sand surface. However, due to the high tidal energy environment across these areas, any depressions are likely to be re-worked soon after the legs / anchors are removed.

Based on this qualitative assessment the likely magnitudes of effect are shown in Table 3.8. These magnitudes are the same as those assessed in the original ES.

Table 3.8. Magnitude of effects on sea bed levels due to indentations during maintenance

Location	Scale	Duration	Frequency	Reversibility	Magnitude of Effect
Near-field	Negligible	Negligible	Negligible	Negligible	Negligible
Far-field	No effect	Negligible	Negligible	Negligible	Negligible