HORIZON NUCLEAR POWER

WYLFA NEWYDD

ENERGY WORKING FOR BRITAIN

Wylfa Newydd Project

6.4.12 ES Volume D - WNDA Development D12 - Coastal processes and coastal geomorphology

PINS Reference Number: EN010007

Application Reference Number: 6.4.12

June 2018

Revision 1.0

Regulation Number: 5(2)(a)

Planning Act 2008
Infrastructure Planning (Applications: Prescribed Forms and Procedure) Regulations 2009

Horizon Internal DCRM Number: WN0902-JAC-PAC-CHT-00044

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12 Coastal processes and coastal geomorphology

12.1 Introduction

12.1.1 This chapter describes potential changes to coastal and marine processes and effects on coastal geomorphology receptors resulting from the construction, operation and decommissioning of the Power Station, other on-site development as described in chapter A1 (introduction) (Application Reference Number: 6.1.1.), Marine Works and the Site Campus within the Wylfa Newydd Development Area. It also considers potential effects at the registered Holyhead North marine disposal site (IS043), herein referred to as the Disposal Site.

12.1.2 Please refer to chapter B12 (coastal processes and coastal geomorphology) (Application Reference Number: 6.2.12) for the technical basis for the assessment including a summary of legislation, policy and guidance; key points arising in consultation that have guided the coastal and marine processes and coastal geomorphology assessment; and assessment methodologies and criteria.

12.1.3 The assessment herein supports the application for development consent and also the application for a Marine Licence for marine construction works and marine dredging and disposal, required separately under the Marine and Coastal Access Act 2009. Specifically, the Marine Licence application contains a site characterisation report which has been informed by the studies referred to in this Chapter.

12.2 Study area

12.2.1 This section describes the study area(s) relevant to the coastal and marine processes and assessment of effects on coastal geomorphology receptors for the Wylfa Newydd Development Area and the Disposal Site.

12.2.2 A full description of the methodology used for the identification of the study areas for the assessment of effects upon coastal and marine processes and coastal geomorphology at the Wylfa Newydd Development Area and the Disposal Site is provided in chapter B12 (Application Reference Number: 6.2.12).

12.2.3 Three separate study areas have been defined for coastal and marine processes and geomorphology (figures D12-1 and D12-2, Application Reference Number: 6.4.101). These are:

- Firstly, a study area for coastal geomorphology receptors close to the Power Station Site potentially affected by changes to waves and currents caused by Marine Works (such as the breakwater).
- Secondly, a wider study area covering the potential extents of sediment plumes and sediment deposition on geomorphology receptors and the seabed close to the Wylfa Newydd Development Area. Fine sediments

released from Licensable Marine Activities such as dredging have the potential to be carried large distances.

- Thirdly, a study area to capture the potential extents of sediment plumes and sediment deposition on geomorphology receptors and the seabed close to the Disposal Site. Fine sediments released from Licensable Marine Activities such as disposal have the potential to be carried large distances.

12.2.4 Figures D12-1 and D12-2 (Application Reference Number: 6.4.101) show the extent of the three study areas for investigations at the Wylfa Newydd Development Area and the Disposal Site. These areas have been determined primarily through identification of the likely extent of potential change (in coastal and marine processes) and modelling with particular respect to sensitive geomorphological receptors.

12.2.5 Whilst taking into account the guidance given on coastal cells and sub-cells in Technical Advice Note 14 [RD1], expert knowledge and experience of geomorphological and hydrodynamic processes operating within the wider marine environment was applied to determine the three study areas prior to knowing the results of the modelling. The refinement of these areas using more detailed information as it became available through the wave, current and sediment plume modelling work is explained in more detail in chapter B12 (Application Reference Number: 6.2.12).

12.2.6 The study area extent has been informed by both hydrodynamic and wave modelling investigations which employ a series of nested model grids with the ability to detect changes far into the Irish Sea. The nested model grids function together at increasing resolutions, with the finest detail centred upon the site of proposed activity. These grids are used to predict the likely extent of potential effects of Licensable Marine Activities upon coastal and marine processes.

12.2.7 Data on key geomorphological features (for coastal water receptors) were initially collected by field survey in 2014 (for a distance of approximately 2km east and 3km west from Wylfa Head (also referred to on figure D12-2 (Application Reference Number: 6.4.101) as points A and B). Expert geomorphological assessment informed by available literature was used. The points demarking this study area are major promontories around which significant littoral sediment transport would not be anticipated.

12.2.8 For the purposes of this study, the area of investigation reflects boundaries implemented within the hydrodynamic and wave models used to support this assessment. Broadly, there is a shelf sea boundary (the regional context), an intermediate boundary (the majority length of the northern coastline of Anglesey, and extending approximately 3km offshore) and a detailed inner boundary area (encompassing the development site and coincident with the marine area between Trwyn Cemlyn in the west to Llanlleiana Head in the east, and extending approximately 2km offshore). By capturing the range of spatial scales associated with the various oceanographic processes, the adoption of these spatial scales facilitates a robust assessment of the sediment regime at, and in the vicinity of, the Wylfa Newydd Power Station.

12.2.9 The 'final' study areas were chosen for the Wylfa Newydd Development Area based on the hydrodynamic modelling results (figure D12-2, Application Reference Number: 6.4.101). The model was run with successive tidal excursions allowing the areal extents of potential effects to be determined. The modelling could have been extended as far as needed into the Irish Sea around Anglesey but in practice narrower study areas (based on the modelling grids) were defined.

12.2.10 The wave and current modelling investigations have demonstrated that potential changes in waves, currents and sediment processes (excluding fine sediment) resulting from the proposed scheme, would be highly unlikely to extend beyond the embayment i.e. that it operates as a closed system.

12.2.11 Fine sediments released from Licensable Marine Activities such as dredging have the potential to be carried large distances. Again the hydrodynamic modelling results were used to refine the study area by determining the potential extent of effects on the plume and associated sediment deposition. The modelling showed there would be no discernible effects beyond the outer grid (70m medium resolution). Chapter B12 (Application Reference Number: 6.2.12) explains this definition of study areas in more detail.

12.2.12 This assessment has built upon the findings of several historic and recent investigations. These include the findings of:

- detailed oceanographic and geophysical studies undertaken by Titan Environmental Surveys Ltd. (hereafter referred to as Titan) [RD2];
- computational spectral wave transformation model: SWAN (Simulating Waves Nearshore) for surface waves (see appendix D12-3, Wylfa Newydd Main Site Wave Modelling Report, Application Reference Number: 6.4.82);
- hydrodynamic modelling: Delft3D for tidal currents and coupled currents plus waves at the Wylfa Newydd Development Area (appendix D13-8 Marine Hydrodynamic Modelling Report – Wylfa Newydd Development Area, Application Reference Number: 6.4.90) and the Disposal Site (appendix D13-12 Marine Hydrodynamic Modelling Report – Disposal Site, Application Reference Number: 6.4.94);
- Coastal Geomorphology Baseline for Wylfa Newydd Project – 2014 (see appendix D12-1, Application Reference Number: 6.4.80); and
- sediment regime baseline study (see appendix D12-2, Sediment Regime, Application Reference Number: 6.4.81).

12.2.13 The SWAN wave model study covers the whole of the north Anglesey coastline (see appendix D12-3, Application Reference Number: 6.4.82). The model has four nested grids with increasing resolution of 500m, 200m, 50m and 20m centred on the Wylfa Newydd Development Area.

12.2.14 The Delft3D hydrodynamic model mesh also encompasses the whole of Anglesey, and embedded within it, includes nested grids at both study areas. This means that closer to the area of potential effects more detailed higher resolution modelling has been used and 'nested within' a much wider area covered by coarser modelling. At the Disposal Site, the outer grid was upgraded by the addition of a 3-dimensional (70m) grid covering 10.6km by 13km with 10 vertical layers. These defined the study area to capture the key changes within the disposal area (figure D12-1, Application Reference Number: 6.4.101). At the Wylfa Newydd Development Area a mid-resolution (70m) grid and a high resolution (23m) inner grid extend approximately 3.5km and 1.5km respectively, to the east and west (figure D12-2, Application Reference Number: 6.4.101).

12.2.15 The extent of potential effects, defined through the hydrodynamic modelling and sediment regime baseline studies provided in appendix D13-8 (Application Reference Number: 6.4.90) and appendix D12-2 (Application Reference Number: 6.4.81), was also cross-checked with the location of sensitive geomorphological receptors identified within section 12.3.

12.2.16 Based on desk study data, the model outputs and field investigations, the defined study area around the Wylfa Newydd Development Area includes the coastal zone between the Hen Borth (A) and the Llanbadrig headland (B) (see figure D12-2, Application Reference Number: 6.4.101). Within this area, there are three main embayments: Cemlyn Bay, Porth-y-pistyll and Cemaes Bay (see appendix D12-1, Application Reference Number: 6.4.80).

12.2.17 Two remote but important designated sites for coastal geomorphology on Anglesey have been considered for inclusion within the assessment; these are Newborough Warren (important for its coastal features) at a distance of 30-60km and Tywyn Aberffraw (a large intact dune system) at a distance of 25-55km from the development. On account of distance from the source of potential effects (both from the Wylfa Newydd Development Area and the Disposal Site) and the prevailing dominant currents from the south-west passing through the Irish Sea [RD3] the literature confirms that the potential for transport is very low. Furthermore, through investigation of transport pathways using the extended nested grids of the SWAN wave and Delft3D hydrodynamic modelled scenarios (see appendices D12-13 (Application Reference Number: 6.4.82), D13-8 (Application Reference Number: 6.4.90) and D13-12 (Application Reference Number: 6.4.94)), both sites are shown to be beyond the limit of detectable change. On that basis, both of these sites have been scoped out from this assessment.

12.2.18 The method to define the extent of the Disposal Site study area is outlined in chapter B12 (Application Reference Number: 6.2.12) and appendix D13-12 (Application Reference Number: 6.4.94). The north-western corner of the Disposal Site is the furthest point from shore at approximately 15km from Holyhead harbour and, at its nearest point, approximately 18km from Porth-y-pistyll. The total area of the site is approximately 28.8km^2. Studies of the hydrodynamics and benthic ecology have been carried out and are reported in appendix D13-2 (Benthic Ecology Report) (Application Reference Number: 6.4.84) and chapter D13 (the marine environment) (Application Reference Number: 6.4.13). For the purposes of this assessment only, marine processes and geomorphology at the Disposal Site are reported in this chapter (Application Reference Number: 6.4.12).

Other topic receptors

12.2.19 The results of the coastal and marine processes and geomorphology assessment for both the Wylfa Newydd Development Area and at the Disposal Site have also been used to inform other topics. This includes chapter D13 (Application Reference Number: 6.4.13), chapter D7 (soils and geology) (Application Reference Number: 6.4.7) and chapter D11 (cultural heritage) (Application Reference Number: 6.4.11). Specific elements of this study of interest to other topics are noted in table D12-1.

Table D12-1 Relevance to other topics

Topic	Environmental Statement chapter number	Topic receptor / activities potentially affected by changes in coastal and marine processes
Cultural heritage	D11 (Application Reference Number: 6.2.11)	• Archaeological site west of Wylfa Head, site of wreck near cooling water outfall, Porth Wnal.
Soils and geology	D7 (Application Reference Number: 6.2.7)	• Regionally Important Geological Sites (RIGS) along the coast. • Dolerite intrusion at cooling water outfall, Porth Wnal.
The marine environment	D13 (Application Reference Number: 6.2.13)	• Benthic habitat.
Shadow Habitat Regulations Assessment (HRA) Report	n/a (Application Reference Number: 5.2)	• Benthic habitat.
Water Framework Directive (WFD) Compliance Assessment	(Application Reference Number: 8.26)	• Hydromorphology quality elements for The Skerries, Anglesey North and Cemlyn Lagoon water bodies.
Other permits and licences	n/a	• Environmental Permit and Marine Licence.

12.3 Baseline environment

12.3.1 This section provides a summary of the baseline conditions for coastal and marine processes and coastal geomorphology within the study area described in section 12.2.

12.3.2 The baseline conditions of the two key areas are described separately below, firstly for the proposed Wylfa Newydd Development Area, followed by the Disposal Site.

Wylfa Newydd Development Area – coastal and marine processes

12.3.3 Summary baseline information for the present-day physical oceanographic environment provided in this section includes the character and functioning of waves and tidal currents (hydrodynamics); bathymetry; boundary materials (bedrock and superficial geology) and sediments that underpin the coastal and marine processes. Further details on wave, hydrodynamic and the sediment regime baselines can be found within appendix D13-8 (Application Reference Number: 6.4.90) and appendix D12-2 (Application Reference Number: 6.4.81).

Waves, tides and currents

Waves

12.3.4 There are two types of wave affecting the Wylfa Newydd Development Area study area, namely swell waves originating outside the area (from the Irish Sea), and locally generated wind waves. Waves therefore vary in response to a number of factors:

- wind conditions;
- the fetch over which winds can blow and generate waves;
- water levels;
- orientation of the coastline and dominance of headlands and rock outcrops; and
- inshore bathymetry.

Wave climate

12.3.5 Studies close to the Wylfa Newydd Development Area [RD4] examined a variety of sources in relation to the wave climate, which included field data from an oceanographic monitoring campaign. Four fixed monitoring stations, deployed between August 2010 and February 2011 (see figure D12-2 (Application Reference Number: 6.4.101) for three located within the study area), revealed (at mooring station S2) a predominant offshore wave direction from the west [RD4]. The locally complex coastline includes west-, north- and east-facing shorelines. [RD4] reports that the orientation of the coastline and shelter afforded by rocky island groups, such as the Skerries, prevent swell waves approaching from the south-west. Incoming waves are refracted around the coastline along the north coast, approaching predominantly from 270º to 90º [RD4]. Consequently, further inshore the predominance of westerly waves is no longer evident. Both to the west and east of Wylfa Head (at mooring stations S9 and S11 respectively), waves have been shown to have a predominant north-westerly direction (appendix D12-3, Application Reference Number: 6.4.82).

12.3.6 Significant wave heights recorded at the fixed moorings have been observed to be lower in the sheltered bays compared with offshore. The average significant wave height west of Wylfa Head was 0.68m (recorded between

October 2010 and January 2011) compared to the equivalent value at the furthest offshore fixed mooring of 1.24m [RD4].

12.3.7 As waves enter shallower waters, wave energy can penetrate to the seabed; orbital motions associated with wave progression, if sufficiently powerful, can give rise to sediment mobilisation. During storms, waves can be a powerful agent bringing sediments into suspension.

12.3.8 As waves enter shallower water they undergo a transformation known as ‘shoaling’ due to changes in the ratio of wave height to water depth. For example, as the bathymetry changes toward the coastline, there is a reduction in wave height with distance shorewards associated with a gradual dissipation of wave energy. Of the order of 50% reductions in wave height offshore to the inner embayments are indicated via the SWAN and Delft3D models.

12.3.9 As the water depth further decreases closer inshore, wave height increases prior to breaking. At this stage the water is shallow and wave-induced currents can form, caused by the wave breaking introducing a variation in shear stress over the width of the surf zone. Although complex, generally there are two types of current considered: those perpendicular i.e. at 90 degrees to the shore (shore normal) and those parallel to the shore (shore parallel or longshore).

12.3.10 The 2012 Wylfa Coastal Processes Study [RD4], found that longshore currents with potential to transport sediments along the sheltered coastline (littoral drift) tended to be weak. This is because of the effects of shoaling within the bays and wave diffraction around the headlands. Where weak longshore currents did exist, their energy decreased as they expended energy by transporting sediment along the shoreline. This type of sediment movement brings about a natural adjustment in the orientation of the beach front, realigning it to face the incoming waves [RD4].

12.3.11 Sediment transport induced by wave action in exposed locations may occur in a general easterly direction along the north Wales coast. At some localities, waves capable of moving material along the shoreline via littoral drift effects may change direction depending on the prevailing wind directions.

12.3.12 For the purposes of this assessment, the modelling of wave conditions has been undertaken using the wave transformation model SWAN, (as reported in appendix D12-3, Application Reference Number: 6.4.82). The wave model baseline results describe the locally complicated conditions for modelling. This is explained with reference to the highly variable coastline and differences in wave environment of the near and offshore environments. Effects of waves within the harbour of the Wylfa Newydd Development Area have been modelled using the wave disturbance model ARTEMIS, as seen in appendix D12-3 (Application Reference Number: 6.4.82).

12.3.13 Present-day (‘present day (2023)’) and evolving (‘foreseeable future (2087)’) 35.5 year-long wave climate records were generated by the SWAN model for a range of scenarios and these are reported within the Further Wave Model, Phase 2 study in appendix D12-3 (Application Reference Number:

6.4.82). Wave conditions for the present day baseline scenarios (table D12-2) are based upon a location (referred to as offshore point 3) approximately 1.8 km north of Wylfa Head, which is a reference validation point common to both models (SWAN and Delft3D, see figures D12-1 and D12-2) (Application Reference Number: 6.4.101).

Table D12-2 Wave conditions relating to summer and winter climate for present day (2023) baseline scenarios in SWAN model

Season / Sector / Event	Wave height (meters)	Wave period (seconds)	Direction (degrees)
Summer			
	0.60	3.3	254
Winter / North			
50th percentile	0.93	4.1	360
90th percentile	2.49	6.0	343
99th percentile	4.21	7.8	345
Winter / North-east (NE)			
50th percentile	0.89	4.0	57
90th percentile	2.29	5.9	39
99th percentile	3.48	6.9	36
Winter / North-west (NW)			
50th percentile	1.17	4.4	309
90th percentile	2.76	6.5	329
99th percentile	4.03	7.5	303

Note: Three wave directions used for the winter period. The location of the wave generation was offshore Point 3 (Application Reference Number: 6.4.82).

12.3.14 As described in appendix D12-3 (Application Reference Number: 6.4.82), the foreseeable future (2087) baseline scenario outputs reflect precautionary values for climate change conditions of sea level rise and increases in storm events recommended within the most up-to-date UK Climate Predictions 2009 (UKCP09) and Welsh government guidance.

12.3.15 Figure D12-3 (Application Reference Number: 6.4.101) shows a selection of SWAN model outputs showing baseline wave heights distributions in four panels. A typical westerly wave is shown for present day (2023) summer conditions (top left image). The summer baseline scenario represents typical calm conditions. Extreme conditions are represented by winter 99th percentile (or 1% probability) waves arising from the northeast sector (lower right image) and northwest sector (upper right image). A future (2087) scenario is also shown for a winter, 99th percentile northwest sector wave condition (lower right image). All three winter wave scenarios show wave heights greater than 1m over large sections of the Esgair Gemlyn ridge, with the highest waves shown arising from the northeast sector, depicted as rising up to 2m high in the central part of the shingle ridge (see appendix D12-3, Application Reference Number: 6.4.82).

12.3.16 Irrespective of time frames shown, the scenarios selected for figure D12-3 (Application Reference Number: 6.4.101) show the best representation of the potential range of wave heights and behaviour for calm and extreme storm conditions. Baseline waves entering Cemlyn Bay from the north-east are shown to generate the greatest heights at the rear of the bay, by the Esgair Gemlyn shingle ridge, due to the long fetch and alignment with the orientation of the headlands and embayment. Baseline waves arising from the north-west are shown to be lower at the rear adjacent to Esgair Gemlyn, but higher overall. In particular, north-westerly waves are the highest at Porth-y-pistyll, this pattern is observed for present day as well as under the foreseeable future (2087) baseline scenario, which includes the potential effects of climate change. The full range of scenario results can be found in appendix D12-3 (Application Reference Number: 6.4.82).

12.3.17 Baseline wave conditions (defined within SWAN) have also been incorporated into the Delft3D hydrodynamic model to represent combined scenarios with tidal currents. Within the Delft3D model, the combined scenarios have drawn upon wave boundary conditions taken from the same offshore point (3) (defined within the SWAN model area in appendix D12-3, Application Reference Number: 6.4.82). Four coupled (waves plus currents) scenario conditions have been created as described in table D12-3. These include scenarios for an average or typical wave condition, a higher winter wave condition and a more extreme 'high wave from the north' wave condition. The three wave conditions have been selected to represent varying directions, distances (fetch) and wave heights (for more detail, see appendix D13-8, Application Reference Number: 6.4.90).

Table D12-3 Wave conditions represented within the Delft3D model for the assessment of waves and currents combined

Wave conditions represented within Delft3D model		Description of wave boundary condition	
	Wave height (m)	Wave period (seconds)	Direction (degrees)
No wave	n/a	n/a	n/a
Typical	0.91	6.0	228.1
Winter	2.0	6.2	343.7
High north wave (98th percentile)	2.85	6.9	358.3

Tides and currents

12.3.18 Tidal data for north Anglesey, recorded at Cemaes Bay, indicate that semi-diurnal cycles occur approximately every 12.4 hours. Tidal currents are particularly strong off Anglesey [RD2].

12.3.19 Early studies [RD2] reported characteristic spring tide currents recorded off Wylfa Head with peak (depth averaged) velocities in excess of 2m/s. These currents flow from west to east on the flood tide and strongly east to west on the ebb tide. At the furthest offshore oceanographic monitoring station (S2) the mid-ebb currents have been recorded as being consistently stronger than those of the mid-flood tide. Between August 2010 and February 2011, the maximum recorded mid-ebb current speed at S2 was 2.3m/s. Mooring station S4, just over 1km offshore of Wylfa Head, had maximum current speeds (depth averaged) of 2.01m/s.

12.3.20 The Titan report [RD2] found that "*tidal currents offshore of Wylfa Head are rectilinear in an East-West orientation and current velocities are strongest at maximum tidal streaming HW+2. Current velocities over ebb were greater than those recorded over flood and there was a distinct spring-neap current variation with currents being greater over springs than neaps*"

12.3.21 This aligns with wider studies of currents and sediment transport within the Irish Sea which indicate the dominance of offshore currents flowing west to east, aligned with prevailing currents arising in the Irish Sea and flowing from the south-west [RD3].

12.3.22 The four hydrodynamic model scenarios shown in figure D12-4 (Application Reference Number: 6.4.101) indicate the typical range of currents and energy across the tidal conditions for spring, neap, ebb and flood combinations. The model outputs reveal a pattern of high offshore velocities (in excess of 2m/s for peak spring tides) northward of an arc running across the principal headlands (including Trwyn Cemlyn in the west, Wylfa Head and across to Llanlleiana Head in the east) and far lower velocities within the inshore embayments (of Cemlyn and Cemaes). These results concur with the observed mean velocities of the offshore monitoring stations (S2 and S4) which were found to be approximately double those of the onshore stations (S9 and S11) (see appendix D12-2, Application Reference Number: 6.4.81).

12.3.23 Contrary to the Holmes and Tappin [RD3] description of (west to east) offshore sediment movement, the observed and modelled baseline results (presented in figure D12-4) (Application Reference Number: 6.4.101) agree with one another, indicating the strongest offshore currents to be on the spring ebb tide, flowing from east to west, with weaker currents on the flood tide, flowing west to east. All four scenarios depicted in figure D12-4 (Application Reference Number: 6.4.101) reflect the presence of the strongest tidal currents beyond the headlands of Wylfa Head and Trwyn Cemlyn under all spring/neap and flood/ebb tide conditions in contrast to the sheltered conditions within Cemlyn Bay and Porth-y-pistyll, to the west of the Wylfa Newydd Development Area.

12.3.24 The Wylfa Head promontory causes a stable eddy structure to form in Cemlyn Bay (to the west) and Cemaes Bay (to the east) on both the flood and ebb tides (see figure D12-4) (Application Reference Number: 6.4.101) and this is more pronounced during spring tides. The rotation and strength of eddies varies over the flood-ebb cycle. The maximum current speeds recorded at the fixed moorings (figure D12-2) (Application Reference Number: 6.4.101) were 0.95m/s (at S9, to the west of Wylfa Head in Cemlyn

Bay) and 1.1m/s (at S11, to the east of Wylfa Head in Cemaes Bay). These observed values concur with the modelled velocity magnitude data presented in figure D12-4 (Application Reference Number: 6.4.101). The modelled tidal currents within figure D12-4 (Application Reference Number: 6.4.101) also illustrate how the headland itself influences the direction and energy of the flows.

12.3.25 Figure D12-4 (Application Reference Number: 6.4.101) shows modelled offshore tidal flows of greater than 0.8m/s, during all tidal conditions, with inshore current speeds within Cemlyn and Cemaes Bays shown to be lower, predominantly below 0.4m/s during the mid-ebb scenario runs. The action of the eddies, propagating from the effect of strong currents north of Wylfa Head, assists with interchange and mixing of water within and between the two bays.

12.3.26 The evolving baseline shows a similar pattern of tidally-related currents. However, the potential effects of climate change upon longer term scenarios associated with sea level rise and more frequent events do not make significant differences within the results of the Delft3D model itself, other than increasing the overall water depths. Where these effects are identified as changes in wave height (e.g. via increased storminess), they have been indicated through the SWAN and ARTEMIS wave model results (see appendix D12-3, Application Reference Number: 6.4.82) and as such are reported in the assessment section of this report.

12.3.27 The tidal range (assuming average meteorological conditions) recorded nearby at Cemaes gauge is given in table D12-4 [RD5]. It is important to note, however, that meteorological conditions differing from the average (such as strong or prolonged winds) would cause differences between predicted and actual tide levels.

Table D12-4 Tidal range at Cemaes gauge measured in metres relative to Ordnance Datum (mOD)

Tide level	mOD
HAT (Highest Astronomical Tide)	+3.9
MHWS (Mean High Water Springs)	+3.0
MHWN (Mean High Water Neaps)	+1.5
MSL (Mean Sea Level)	+0.1
MLWN (Mean Low Water Neaps)	-1.3
MLWS (Mean Low Water Springs)	-2.8
LAT (Lowest Astronomical Tide)	-3.6

12.3.28 Tidal height measurements have also been collected every 15 minutes over a 12-month period (March 2010 to February 2011) at the jetty of the Existing Power Station. These data also demonstrate a semi-diurnal tidal signal with a maximum measured range of 7.5m. The maximum and minimum recorded tidal heights were +3.9mOD to -3.6mOD generally in line with the range recorded at Cemaes.

12.3.29 Table D12-5 provides sea levels for a range of extreme water levels for both Cemaes and off Wylfa Head and the probability of occurrence. These levels are taken from a publication by the Department for Environment, Food and Rural Affairs/Environment Agency [RD6] aimed at providing more consistency in managing for extreme events. These levels are based on extrapolation of data limited to less than 100 years of records, they should therefore be treated with caution especially for the higher return period events.

Table D12-5 Extreme sea level events (mOD) [RD6]

Return period (years)	Annual probability of occurrence	Cemaes Bay (mOD)	Off Wylfa Head (mOD)
1	100%	+3.9	+3.7
5	20%	+4.1	+3.9
10	10%	+4.1	+4.0
100	1%	+4.4	+4.2
200	0.5%	+4.4	+4.3
1,000	0.1%	+4.6	+4.4
10,000	0.01%	+4.7	+4.6

Bathymetry, geology and sediments

Bathymetry

12.3.30 Bathymetric surveys of the study area, undertaken by Titan in 2009 [RD2], have been used to define the underlying seabed topography. The bathymetry (features and shape of the seabed) around the Wylfa Newydd Development Area (shown in figure D12-5) (Application Reference Number: 6.4.101) reveals a shallow coastal shelf mostly within the embayments. This shore platform slopes gently away from the coast to approximately -20mOD, before dropping steeply away to depths of -30mOD to -40mOD to the north beyond the headlands.

12.3.31 Within the outer bays, distinctive subtidal rocky seabed knolls (irregular outcrops) rise 4m to 5m above the seabed floor with occasional islands rising above the sea surface.

12.3.32 The coastline around the Wylfa Newydd Development Area is characterised by rocky headlands and intertidal or littoral zones (rock platforms), indented by small coves such as Cemlyn Bay with small areas of shingle and sand beach (pocket beaches) with relatively low cliffs to the rear. Many of the low cliffs are formed of highly erosive superficial deposits of glacial origin, such as those at the coastal drumlin feature, Hen Borth (see appendix D12-1 (Application Reference Number: 6.4.80) for more detail).

12.3.33 At Wylfa Head, large rocky outcrops dominate with the nearshore seabed consisting of an irregular wave-like rock head surface. The seabed offshore rapidly shelves off into deep waters. Here the seabed is generally composed of exposed diamicton (poorly sorted sediments from terrestrial erosion, suspended in a matrix of mud or sand) and bedrock with a veneer of sand and gravels, associated with local lag deposits (consisting of coarser materials with the fine particles washed out) draped over its surface. The British Geological Survey characterises the seabed in the area (generally) as 'sandy gravels' [RD7].

Geology

12.3.34 The local geology of the study area includes ancient Precambrian metamorphic bedrock types consisting of mica schist and psammite. Alongside these, the oldest formations of the Mona and Gwna groups are exposed at the Geological Site of Special Scientific Interest (SSSI) Llanbadrig – Dinas Gynfor, located east of Cemaes Bay, where they are interbedded with Ordovician sedimentary rock types [RD7].

12.3.35 The underlying geology of the seabed, consisting of the wave cut platform of the continuing geological formations with rocky outcrops, makes the area unfavourable for trawling activity. As a result, the subtidal sediments and associated benthic habitats within the bays remain relatively undisturbed by human activities.

12.3.36 Superficial deposits consist of glacial lag, occurring in some locations as drumlins, and reworked as shingle beaches and bars. Most notable of these is the formation of the Esgair Gemlyn shingle bar (or storm beach) located between Cemlyn Lagoon and Cemlyn Bay. This historic shingle feature provides the shoreward limit of the Cemlyn Lagoon Special Area of Conservation (SAC). Further superficial littoral deposits of sands and fine gravels are found at Cemaes Bay.

12.3.37 Parts of the coastal areas within the study area are designated as RIGS in recognition of their educational value for exposed geological successions. Anglesey has also been awarded UNESCO Global Geopark status [RD8]. The Anglesey Geopark (GeoMôn) was assigned in 2009 for its geological heritage which spans four eras and 12 geological periods. A full assessment of the effects upon local geological receptors, (including the RIGS) is provided within chapter D7 (soils and geology) (Application Reference Number: 6.4.7) of this Environmental Statement.

The Porth Wnal Dolerite

12.3.38 The Porth Wnal Dolerite is an important geological feature which is assessed separately within chapter D7 (Application Reference Number: 6.4.7). The igneous dolerite is a hard metamorphic rock and as such would not be affected by changes in coastal or marine processes during the design life of the Power Station. It is therefore not considered as a coastal geomorphology receptor within this chapter.

Wylfa Newydd Development Area – coastal geomorphology

12.3.39 A summary of the baseline conditions for coastal geomorphology is provided in this section of the report including the receptors identified. Further details relating to the coastal geomorphology baseline can be found within appendix D12-1 (Application Reference Number: 6.4.80).

12.3.40 Due to the local geology, the coastal environment is extremely varied comprising of rocky headlands with deep coves and embayments as a result of the differential erosion of the many distinctive solid and drift rock types that occur locally.

12.3.41 The coastal and seabed geomorphology around the Wylfa Newydd Development Area has been shaped by dynamic coastal and marine processes operating over a range of spatial and temporal scales. These include complex interactions between tidal currents, waves, cyclical circulation patterns and sediment fluxes within the system. Together these determine the physical form and functioning of the supratidal, intertidal, seabed and sedimentary features along the coastline. The coastal geomorphology walkover assessment (which covered three sub-cells of the Shoreline Management Plan (SMP) [RD9]) was able to identify the likely extent of effects upon the form and functioning of these coastline features.

12.3.42 Whilst significant geomorphological processes (erosion and deposition) can occur at a local scale along exposed littoral zones, the Anglesey coastline is predominantly composed of exposed hard rock and is therefore highly resistant to erosion (see appendix D12-1, Application Reference Number: 6.4.80).

Sediments

Subtidal sediments

12.3.43 Prior to the Holocene marine transgression, the eastern Irish Sea was covered by a complex suite of clastic sediments laid down by the retreating glaciers and their outwash plains. The upper parts of these sediments have been subsequently reworked as sea level rose during the early to mid-Holocene. The modern hydrodynamic regime has been operating for around the last 5,000 years. Approximate albeit dynamic equilibrium has been reached on the sea bed of the Irish Sea whilst coastal forms and features have continued to evolve during this period (see appendix D12-2, Application Reference Number: 6.4.81).

12.3.44 Figure D12-6 (Application Reference Number: 6.4.101) shows the extent of marine sediment sampling and character of sediments based upon seabed samples (grabs, boreholes) around the Wylfa Newydd Development Area. Further benthic habitat investigations including the nature of local underlying materials (i.e. bedrock or sediment characteristics) are reported in appendix D13-2 (Application Reference Number: 6.4.84). These are found to be predominantly rocky and exposed in the intertidal zone, with some mobile sandy sediments within the Porth-y-pistyll area. These findings reflect the mapping of fine sediments and bedrock areas shown on figure D12-7 (Application Reference Number: 6.4.101).

12.3.45 The sediment samples represented on figure D12-6 (Application Reference Number: 6.4.101) have been taken offshore along the north of Anglesey with the majority focused within the Cemlyn Bay and Cemaes Bay subtidal areas.

The points and data shown, represent those recorded in 2010. Analysis of the sediment regime has taken into account all data arising from surveys carried out during 2010, 2011 and 2015 plus the benthic habitat surveys in 2014.

12.3.46 The character of the subtidal seabed and sediment features have been revealed by side-scan sonar surveys undertaken by Titan in 2009 [RD2] (figure D12-7, Application Reference Number: 6.4.101). These surveys show extensive areas of relatively featureless smooth sandy and sandy-gravel seabed, in particular a contiguous area close to the inner part of Cemlyn Bay. One area of coarser gravel sediments is indicated within Cemaes Bay. Additional sediment sampling data from benthic grabs (2010, 2011 and 2015) and boreholes collected during 2010 [RD10] and 2016 by Fugro Seacore Ltd. (Fugro) (appendix 12-2, Application Reference Number: 6.4.81) depicted in figure D12-7, (Application Reference Number: 6.4.101), reveal muddy sands in areas without the influence of tidal currents and wave energy. This was mainly shown to be in Cemaes Bay in the sheltered lee of Wylfa Head at BH101 and WS20.

12.3.47 Figure D12-7 (Application Reference Number: 6.4.101) reveals a significant area of exposed bedrock around the headlands and fringes of Cemlyn Bay and Porth-y-pistyll, with rocky pinnacles also indicated on side scan imagery [RD2]. A patchy and uneven veneer of sandy gravel overlies an extensive region of bedrock offshore of Cemlyn Bay and the north and west of Wylfa Head, with areas of featureless and largely smooth sandy gravel substrate.

12.3.48 Discrete areas of megaripples are weakly apparent within the subtidal sandy seabed. These weak megaripple features represent a relatively stable bedform that reflects the character and direction of near-bed flow patterns [RD11] and do not represent a particular kind of benthic habitat.

12.3.49 The sediment grab sample data have been analysed for particle size with sediment characterisation depicted by percentages of gravel, sand and silt for each site (located in figures D12-6 and D12-7) (Application Reference Number: 6.4.101). The sediment characterisation shows a wide variation of lag deposit textures. These consist mostly of highly unsorted coarser materials overlying a predominantly irregular undulating rockhead surface with some local exposures of diamicton.

12.3.50 These lag deposits have most probably been historically swept up and transported into local bays, contributing to the formation of the subtidal, intertidal and beach deposits within the bays. Additional locations of sediment borehole samples from a geotechnical investigation undertaken in 2010 by Fugro [RD10]. are also presented in figure D12-7 (Application Reference Number: 6.4.101). Borehole sampling was limited to those locations where sediments were of adequate depth. Away from the coastal zone, the rocky seabed has a steep gradient of approximately 1:30, falling away to the north-west. The geotechnical investigation reports that, along the coastal margin, the seabed largely consists of bedrock other than at cove entrances.

12.3.51 In locations where borehole data have been obtained, typically the thickness of sediment layers range from 0.5m of sandy gravels to more than 30m of mixed sediments (mainly firm sands and gravels) (table D12-6). With depth, there are boulder clay/diamicton sequences formed during and following the last glaciation (when sea levels were much lower, by around 130m).

Table D12-6 Sediment thicknesses (based on Fugro, 2011 [RD10])

Borehole reference	Description of superficial sediment sequences overlying weathered solid bedrock
BH401	Total depth = 3m, comprising from surface down: • 0.5m silty sand; • 1.0m very dense silty sand; • 1.0m very dense gravelly sand; and • 0.5m very coarse sand.
BH402	Total depth = 2.65m, comprising from surface down: • 0.62m of very dense sand; • 0.41m of gravel and cobbles; • 0.08m of rounded cobble; • 0.39m stiff gravelly clay; • 0.42m brown gravelly sand; • 0.23m of gravelly sand; and • 0.5m dense sandy gravel.
BH403	Total depth = 6m, comprising from surface down: • 1.0m loose gravelly sand; • 1.5m medium dense gravelly sand; • 1.0m sand with pockets of gravelly clay; • 1.0m soft to firm gravelly clay; • 1.0m firm gravelly sandy clay; and • 0.5m very dense sandy gravel.
BH404	Total depth = 0.8m, comprising from surface down: • 0.8m gravelly sand.
BH405	Total depth = 2.6 metres, comprising from surface down: • 1.3m very dense silt, gravelly sand; and • 1.3m very dense sandy gravel.
BH406	Total depth = 4.65m, comprising from surface down: • 2.65m dense to very dense clayey sandy gravel; • 1.5m of gravel and cobbles grading to gravelly sandy silt; • 1.0m firm to stiff clayey silt; and • 0.5m gravel.
BH407	Total depth = 1.0m, comprising from surface down: • 1.0m very dense sandy gravel.
BH408	Total depth = 0.5m, comprising from surface down: • 0.5m sandy gravel with a low cobble content.

Borehole reference	Description of superficial sediment sequences overlying weathered solid bedrock
BH410	Total depth = 32.6m, comprising from surface down: • 0.9m sand; • 0.9m soft sandy clay; • 0.7m very sandy gravel; • 6.0m sandy gravel medium dense; • 2.9m stiff gravelly clay; • 0.6m clayey silt; • 16.6m gravelly clay sand; • 2.0m firm medium silty clay; • 0.45m silty sand; • 0.25m sandy gravelly silt; • 0.5m silty clay; and • 0.87m stiff clay.
BH412	Total depth = 1.64m, comprising from surface down: • 1.64m gravel.
BH413	Total depth = 0.5m, comprising from surface down: • 0.5m gravelly coarse sand.

12.3.52 Whilst figure D12-7 (Application Reference Number: 6.4.101) shows a high degree of correlation between the grab sampling and the sediment features, repeat grab sampling in 2010, 2011 and 2015 also indicated changes in the distribution of superficial sediments, reflecting the dynamic nature of the subtidal environment.

12.3.53 Analysis of the present baseline conditions for sediments and their potential for transportation along the seabed within the study area included an investigation of expected bed shear stress. Shear stresses [measured as Newtons per square meter or N/m^2] arise at the seabed due to water motions related to tidal and wave induced currents). Shear stress was calculated using the hydrodynamic Delft3D model for a range of scenarios (appendix D13-8, Application Reference Number: 6.4.90). Characterisation of baseline seabed shear stress for tide only scenarios included investigation of spring and neap phases for mid-flood and mid-ebb conditions.

12.3.54 A range of coupled tide and wave scenarios for these conditions have also been run to include the typical wave condition, the winter wave condition and the high north wave condition (as defined in table D12-3). The results (detailed in appendix D13-8, Application Reference Number: 6.4.90) reveal a wide range of baseline shear stress. The highest (current-induced) bed shear stresses are found during powerful spring tides specifically during the mid-ebb phase; co-occurrence of waves during spring tides potentially enhances the bed shear stress in sufficiently shallow waters. Figure D12-8 (Application Reference Number: 6.4.101) shows bed shear stresses during a spring ebb tide situation under each aforementioned wave condition.

12.3.55 The baseline results for seabed shear stress shown in figure D12-8 (Application Reference Number: 6.4.101) reveal, through a series of 'snap shots' in time, a dynamic marine environment. For all scenarios, the seabed shear stress energy levels remain highest offshore. The lower values are located within the coastal embayments. During the summer wave energy from comparatively small waves does not penetrate to the seabed within the embayments. However, during winter shear stresses, due to the presence of larger waves, increase across these inshore areas in particular, when wave direction is from the north. The most extreme conditions depicted by the high north wave (or P98) scenario have a 1:50 or 2% annual probability of occurrence.

12.3.56 To assess whether, and where geographically, the bed shear stresses (figure D12-8, Application Reference Number: 6.4.101) are sufficiently powerful to mobilise the two most abundant sediment types (sands, gravels), consideration is given to the 'critical' value of stress above which sediments move (table D12-7). Figure D12-9 (Application Reference Number: 6.4.101) shows maps indicating where a) sand (left panel, up to 1mm in diameter) and b) fine gravels (right panel, up to 8mm in diameter) would be expected to be mobilised by a spring ebb tide, plus (respectively) the typical wave (relatively calmer) and the high north wave (more dynamic) condition.

Table D12-7 Critical shear stress by particle-size classification for determining approximate condition for sediment mobility at 20°C (adapted from USGS Scientific Investigations Report 2008-5093 [RD12])

Particle classification name	Ranges of particle diameters (mm)	Critical bed shear stress (N/m^2)
Coarse cobble	128 – 256	112 – 223
Fine cobble	64 – 128	53.8 – 112
Very coarse gravel	32 – 64	25.9 – 53.8
Coarse gravel	16 – 32	12.2 – 25.9
Medium gravel	8 – 16	5.7 – 12.2
Fine gravel	4 – 8	2.7 – 5.7
Very fine gravel	2 – 4	1.3 – 2.7
Very coarse sand	1 – 2	0.47 – 1.3
Coarse sand	0.5 – 1	0.27 – 0.47
Medium sand	0.25 – 0.5	0.194 – 0.27
Fine sand	0.125 – 0.25	0.145 – 0.194
Very fine sand	0.0625 – 0.125	0.110 – 0.145
Coarse silt	0.0310 – 0.0625	0.0826 – 0.110
Medium silt	0.0156 – 0.0310	0.0630 – 0.0826
Fine silt	0.0078 – 0.0156	0.0378 – 0.0630

12.3.57 The results of the foregoing analysis reveal that, under baseline conditions, particles of sand would only be mobilised within the bays under high (north) energy wave and spring tidal regimes, and this area is widespread in inshore regions. Gravel mobilisation is largely confined to the offshore zone, but isolated pockets of gravel transport under the high north wave occur inshore in each of the major bays (Cemaes, Cemlyn, Porth-y-Pistyll) The two scenarios represented in figure D12-9 (Application Reference Number: 6.4.101) reflect two contrasting energy states under spring mid-ebb tidal conditions.

12.3.58 The observational data (captured during the sediment sampling campaign) and sediment regime baseline analysis (reported in appendix D12-2 (Application Reference Number: 6.4.81) generally support the foregoing analyses, but indicate a supply limited system. Across the four oceanographic monitoring stations there is evidence of a very weak (but perceptible) daily tidal (fine particle) resuspension signal, and an associated, but again weak, spring neap lunar variation. These cyclic periods of suspension increase nearbed sediment concentrations (variable according to site) by up to about a factor of five above ambient background concentrations (see table D12-10). Water quality samples (taken using a lund tube which captures an integrated sample of water from the surface to 10 m depth) showed the baseline mean background concentration to be 6.4mg/L. The observed range of 3.1mg/L to 25mg/L (average minimum and maximum values) is relatively low compared to other UK average values for suspended solids. More detail of water quality sampling methodology, data and analyses can be found in appendix D13-1 Water Quality and Plankton Survey Report (Application Reference Number: 6.4.83).

12.3.59 The observational data provide some indication of the change in nearbed suspended sediment concentration during high energy storms; a storm characterised by a maximum offshore wave height of 4m raised nearbed sediment concentrations to 289mg/L at site S4 on 13–15 November, 2010.

Inter and supra tidal sediments

Seabed and intertidal zone

12.3.60 Transport of sand and gravels in the Irish Sea beyond the intertidal or littoral zone has been demonstrated in many studies as having a dominantly eastward direction as shown by the insert in figure D12-5 (Application Reference Number: 6.4.101), [RD3]. However, the observed data suggest an offshore dominance of east to west ebb-flow tidal currents at the Wylfa Newydd Development Area [RD2].

12.3.61 While there could be some exchange across the littoral zone, the movement of sediment into this area from offshore is, however, considered to be minimal [RD13]. Sand and gravel lag deposits remaining within shallower waters following the marine transgression have been swept into the many coves in the area. These then form quasi-permanent littoral deposits such as the beaches around the fringes of Cemlyn and Cemaes bays (see appendix D12-2, Application Reference Number: 6.4.81)

12.3.62 Normally sediments captured in such bays would undergo some longshore drift or recirculation within the bay itself, but the sediment would generally be unable to escape from the enclosed system due to the relatively high wave energy conditions affecting the headlands. A preliminary expert geomorphological assessment undertaken in 2010 stated: "…*embayments along the north Anglesey coast generally act as closed sediment compartments, with little or no exchange of sediment from one bay to the next, and only limited supply of new sediment at the present day from eroding sections of open coast between the bays*…." [RD13].

12.3.63 For example, Cemlyn Bay and Porth-y-pistyll could be described from a geomorphological perspective as bay-head or pocket beaches contained within a low-lying embayment bounded by parallel headlands (between Trwyn Cemlyn and Wylfa Head). As such, Cemlyn Bay could also be described as a re-entrant trap, whereby introduced sediment may undergo longshore drift within the bay itself, but would be unable to escape the bay due to the high wave-energy conditions affecting the headlands [RD14].

Cemlyn Bay

12.3.64 To the west of Porth-y-pistyll within Cemlyn Bay, a substantial deposit of mainly coarse material consisting of gravels, cobbles and some sands has formed a dynamic shingle ridge/storm beach. This feature is open to the north end, where a maintained fixed weir structure regulates the tidal flow exchange with a saline/brackish lagoon landwards of the protective shingle ridge. Due in part to the sheltered conditions afforded by the shingle ridge and resulting attraction to breeding seabirds, the Cemlyn Bay and Lagoon have been designated with SSSI, Special Protection Area (SPA) and SAC status.

12.3.65 The form and function of Cemlyn Lagoon has in part been dependent upon the accumulation and endurance of the shingle barrier beach (Esgair Gemlyn). Previous work has suggested that the origins of the coarse sediments within the shingle ridge feature are a legacy deposit (swept up by the Holocene transgression), likely to be supply-limited and therefore vulnerable to change [RD13].

12.3.66 Preliminary expert geomorphological assessment based largely on previous studies, historical maps and aerial photographs, a site visit and a limited sedimentological analysis indicated: "…*there are no obvious sources of new sediment supply to the barrier and any future acceleration in sea level rise will make it increasingly difficult for the barrier to maintain its relative crest level and an equilibrium cross-sectional profile*…." [RD13].

12.3.67 Characterisation of the present intertidal sediments of the Esgair Gemlyn shingle ridge has been informed by baseline geomorphological field and desk studies supplemented by aerial imagery including LiDAR Digital Terrain Model data. The findings of these studies concur with earlier expert geomorphological assessment and sediment particle size data are summarised below in table D12-8 [RD13].

Table D12-8 Characterisation of sediment on shingle ridge (Source: [RD13])

Location	Sorting	Type	Average particle size (D50)
Upper beach/ridge crest	Moderately well sorted	Medium gravel	20-35mm
Mid-beach	Moderately sorted	Finer gravel	7-17mm
Lower beach	Poorly sorted	Fine/sandy gravel	5-9mm

12.3.68 Desk studies based upon historic map analyses report that the longer term evolution of the Esgair Gemlyn position will be a landward migration (rollback) of the feature by less than 0.2m/year [RD13]. However, future rollback is predicted to be uneven across the feature with the greatest risk of erosion to the east adjacent to the car park area at transect P10 (figure D12-10) (Application Reference Number: 6.4.101).

12.3.69 A topographic investigation into the dynamic nature and form of the Esgair Gemlyn shingle ridge was undertaken via a comparative analysis of LiDAR Digital Terrain Model data surveyed in 2010 and provided online by the Welsh Government [RD15] with new LiDAR data obtained from surveys undertaken by Jacobs in May 2017.

The 2017 (0.25m resolution) and 2010 (1m resolution) LiDAR data have been used to create cross-sectional profiles at the same transect locations established by earlier investigations [RD13]. This enabled a spatial and temporal snapshot comparison of the ridge crest locations and elevations across the transects shown in figure D12-10 (Application Reference Number: 6.4.101). The results provide an indication of the nature and extent of change during this period measured as metres Above Ordnance Datum (mAOD). Of particular interest within this period are changes in the ridge profile which may have occurred during the storm events of 2012/13, which anecdotally may have affected the profile of the shingle ridge [RD16].

12.3.70 Results of the LiDAR investigations shown in table D12-9 and illustrated in figure D12-10 (Application Reference Number: 6.4.101) represent instantaneous snap shots within the recent historic baseline.

Table D12-9 LiDAR data – comparison of 2010 and 2017 transects shown in figure D12-10 (Application Reference Number: 6.4.101)

Transect	Crest height (mAOD)				Crest location		
	2010	2017	Change (m)	% Change	2010	2017	Change (m, degrees)
P10	5.49	5.47	-0.02	-0.42	233494, 393138	233494, 393136	-0.99
P8	5.17	5.36	0.19	3.74	233279, 393213	233279, 393213	0.00
P6	4.69	4.89	0.20	4.21	233097, 393356	233098, 393357	0.99
P3	4.13	4.11	-0.02	-0.57	232987, 393699	232987, 393699	0.00

12.3.71 Comparison of the 2010 and 2017 LiDAR data reveals minor changes in the elevation of the ridge crest, with a slight lowering of the crest (by 0.02m) towards the eastern end at transect P10. In contrast, the middle to western section of the ridge reveals a modest increase in elevation of the ridge crest of approximately 0.2m.

12.3.72 A landward migration of the ridge crest by approximately 1m at the eastern end of the ridge suggests a flattening of the ridge profile, however only a slight (-0.02m) reduction in elevation was observed. The converse seaward migration of an equal distance and crest elevation by +0.2m evident at the western end suggests the possible movement of material from east to west along the ridge; however, more detailed observations would be needed to substantiate this. An increase in the crest level between these two points of +0.19m is also accompanied by a steeper profile on the seaward face (figure D12-10) (Application Reference Number: 6.4.101).

12.3.73 These overall changes within the data support the conclusions of the 2010 and 2016 studies that this is a dynamic feature [RD13] [RD17]. Both investigations reveal the dynamic baseline condition of the shingle ridge feature; and, potentially greater vulnerability of the ridge to coastal processes under existing and future climatic conditions at the eastern end adjacent to the car park.

12.3.74 The greater risk of over-washing and flattening of the profile, potentially leading to connection with small islands within the lagoon, is also recognised within the local SMP: SMP21 St. Ann's Head to Great Orme Head (Western Wales) SMP2, [RD9], especially in relation to predictions of future sea level rise.

Suspended solids

12.3.75 The baseline mobilisation and deposition of fine sediment within the study area have been inferred through modelling using the Delft3D model based on the following data sources:

- Turbidity data gathered at near-bed (Acoustic Doppler Current Profiler, ADCP) mooring locations by Titan Environmental Services during 2010 and 2011 (converted to background suspended solid concentrations of <15mg/L); and
- additional water quality sampling at points indicated in figure D12-6 (Application Reference Number: 6.4.101).

More detail of water quality sampling methodology, data and analyses can be found in appendix D13-1 (Application Reference Number: 6.4.83).

12.3.76 A summary of the water quality data, shown in table D12-10 below, indicates 'background' average suspended solid concentrations to have low variability between sampling locations. Concentrations typically range between 5mg/L and 8mg/L. Maximum concentrations show more variation, ranging between 9mg/L and 46mg/L, with a mean value of 25mg/L.

Table D12-10 Suspended solid concentrations at water quality (WQ) monitoring points

Monitoring point	Average (mg/L)	Maximum (mg/L)	Minimum (mg/L)	No. of samples
WQ1	6	17	3	66
WQ2	6	23	3	68
WQ3	8	47	3	68
WQ4	7	30	3	68
WQ5	6	23	3	68
WQ6	6	10	4	8
Mean	6	25	3	n/a

12.3.77 Results reported by Halcrow [RD4] from their modelled dredging scenario show very moderate sedimentation rates, with less than 1.0mm of fine sediment accumulation in Cemlyn Bay (even considering a long calm period); negligible amounts in Cemaes Bay and predicted accumulation of less than 0.5mm of fine sediment at the location of the breakwater. Over time, waves and currents would redistribute any sediment that is settling out of the suspended load. More detail for the sediment regime baseline, drawing upon all available sediment data and analyses, is provided in appendix D12-2 (Application Reference Number: 6.4.81).

12.3.78 Baseline suspended sediment levels represented within the hydrodynamic model show very low levels of fine sediment deposition up to 2mm in depth during calm conditions at the western side of the heads of all embayments (for details, see appendix 13-8, Application Reference Number: 6.4.90)

Sediment regime

12.3.79 A detailed study of the baseline sediment regime in proximity to the Wylfa Newydd Development Area has been undertaken specifically for this report by Partrac Ltd. The study identifies the sources, transport and supply pathways of sediment types to the different features which function as donors or receptors within the study area (appendix D12-2, Application Reference Number: 6.4.81).

12.3.80 Utilising the investigations of the existing sediment characteristics, a seabed mobility analysis and knowledge of hydrodynamic processes, this information has been drawn together to develop a conceptual understanding of the baseline sediment regime in the area of the Wylfa Newydd Development Area.

12.3.81 The conceptualisation of the baseline sediment regime, detailed within appendix D12-2 (Application Reference Number: 6.4.81), provides an improved understanding of the interactions, transport and exchange of sediments operating both temporally and spatially along this section of coast in particular within the 'closed' embayments. These interactions have also been considered alongside any external interactions beyond the study area. A detailed explanation of the linkages, processes and in particular sediment exchange is elaborated within appendix D12-2 (Application Reference Number: 6.4.81), from which the resulting conceptual diagram is provided in figure D12-11 (Application Reference Number: 6.4.101).

12.3.82 The conceptual sediment regime presented in figure D12-11 (Application Reference Number: 6.4.101) illustrates the hypothesised direction and dynamics of sediment movement within the study area. The major sediment transport pathways, driven by the offshore tidal currents are shown by the larger arrows. The dominant ebb (east to west) current residual, observed in the fixed monitoring station data, drive the corresponding major sediment pathway towards the west to the north of the headlands.

12.3.83 Around the headlands, with deflection into the embayments weaker potential sediment transport pathways for finer sediments exist and are represented by thinner arrows. Whilst within the bays, the potential for periodic onshore-offshore transport under extreme storm conditions is shown by the dashed and double ended arrows.

12.3.84 Along the rock platform foreshore, thin lags of gravel are present, probably sourced from the local cliffs immediately behind. There is not considered to be significant levels of transport of coarse sediments alongshore or between embayments.

Coastal geomorphology baseline

12.3.85 Coastal geomorphology is typically defined as the landforms and processes under the influence of waves and currents across the tidal range. For the purposes of this chapter, the geomorphological receptors of the coastal zone within the study area are defined as those under the influence of coastal and marine processes. This includes the seabed or sublittoral zone, intertidal or littoral zone and supra-littoral zone where receptors could be affected by storm wave action.

12.3.86 Appendix D 12-1 (Application Reference Number: 6.4.80) and also in chapter B12 (Application Reference Number: 6.2.12), further details of the survey methodology and a photographic record of the key receptors are provided.

The following provides a summary of key features most relevant to this assessment.

12.3.87 Within the survey area, the coastline is composed of mainly hard rock cliffs with pockets of sandy bays. The exposed hard geology and superficial drapes of glacially derived lag deposits (drift/till) have been clearly identified. However, much of the unconsolidated material along the coastline, deposited during the glacial period and subsequent deglaciation following the Holocene marine transgression, has since been removed and redistributed by waves and tidal currents within the marine environment [RD18].

12.3.88 Six key coastal geomorphology types/ features have been identified during the walkover survey (see table D12-11). At the local scale, most key coastal geomorphology features have been represented including a number of beach cusps, a small tombolo and remnant sand dunes. Due to the steep nature of the joining topography, very short lengths of 'tidal estuary' on several unnamed tributary streams have been observed. For example, at Cemaes village approximately 100m of watercourse was determined to have both freshwater and saline influences in appendix D12-1 (Application Reference Number: 6.4.80).

Table D12-11 Geomorphological types, feature description and locations

Type	Description and locations
Type 1	Hard rock cliff. • Generally composed of hard rock types, principally the Gwna 'Melange'. Stack and island formation observed. • Found to have a few isolated (localised) storm beaches composed of small numbers of cobbles and pebbles at spots where there has been preferential erosion of weaker strata, localised pools, possibly a mix of saline and freshwater.
Type 2	Crescent-shaped bay with natural cliffs. • Found in both Cemaes and Cemlyn bays.
Type 2(a)	As above but with artificial wall at head of beach. • Found in both the Cemaes and Cemlyn bays (e.g. Traeth Mawr in Cemaes Bay).
Type 3	Saltmarsh (localised). • Assemblage of plants found in localised patches in Cemaes Bay (total is less than 1ha).
Type 4	Crescent-shaped bay (with shingle beach/barrier). • Found in the Cemlyn Bay (namely the Esgair Gemlyn). • Largely a natural feature, although there is anecdotal evidence that breaches may have

Type	Description and locations
	been artificially repaired in the past. Material forming the beach derived from reworking of glacial sediments over geological timescales along neighbouring cliffs and offshore.
Type 5	Man–made lagoon behind shingle beach. • Found in Cemlyn Bay. • This feature is not or is no longer natural and has been formed (in part) by a weir that dams water back along the shoreline.
Type 6	Hard rock platform exposed at low tide (with cliffs of softer unconsolidated material behind). • The softer cliffs (composed of unconsolidated glacially derived deposits) have been eroded back by the sea, leaving a hard rock platform on the foreshore. • Found in Cemlyn Bay notably at Hen Borth.

12.3.89 The shingle ridge or bar separating the outer Cemlyn Bay from the Cemlyn Lagoon, known as Esgair Gemlyn, has special ecological features (vegetation), and provides a protective function to the designated SSSI, SAC and SPA lagoon habitats inland and the nesting terns. As a result, the shingle above the high water mark is also protected under the SAC designation. It is therefore regarded as a sensitive receptor (including from a geomorphological perspective).

12.3.90 As a dynamic coastal feature, the morphology of the shingle ridge is also responsive to nearshore wave and tidal energy, performing a dissipative role in high energy events. During storm events the dissipation of wave energy will naturally lower the height of the shingle ridge. This adjustment also increases the likelihood of the ridge being overtopped or breached during storm events, for example during December 2013 [RD19].

12.3.91 The shingle ridge is managed by the North Wales Wildlife Trust who monitor the wildlife and habitat of the Cemlyn Bay SAC. The 2016 North Wales Wildlife Trust Cemlyn Wardens Report [RD20] notes that the shingle on the ridge '*will move during prolonged periods of high winds.*'; however, no 'rocky shore transects' were carried out during that period.

12.3.92 The findings of the coastal geomorphology baseline study in appendix D12-1 (Application Reference Number: 6.4.80) indicate stable geomorphological features under typical conditions, with longer term potential instability for sedimentary features under extreme conditions. This is due to the ancient geology, combined with relict features arising from the remnants of glacial lag deposits exposed following the Holocene marine transgression.

Coastal geomorphology receptors

12.3.93 Further to the assessment methodology presented in chapter B12 (Application Reference Number: 6.4.12), the specific coastal geomorphology receptors identified are listed in table D12-12, together with the value assigned for the purposes of this assessment.

12.3.94 The methodology for determining value of geomorphology receptors is partly based upon the scarcity and characteristics of the feature. However, the structure and processes of some common geomorphological features underpin the resilience of functional habitats that are important to protected species and the integrity of sites designated for their ecological importance. Taking a geomorphological perspective, Cemlyn Bay is treated separately to Esgair Gemlyn and Cemlyn Lagoon, even though all lie within the Cemlyn Bay SAC/SSSI.

Table D12-12 Geomorphological receptors and value

Geomorphology Receptor	Description	Value
The seabed (including intertidal and subtidal)	• This covers the area within Porth-y-pistyll and surrounding bays west of Wylfa Head. • Valued as low due to its sensitivity and tolerance to accommodate coastal and marine processes change. Receptor occupies the study area. • It is also considered to be the only geomorphology receptor potentially effected by dredge disposal at the Disposal Site. • The Porth Wnal Dolerite is included as a receptor in chapter D7 (soils and geology) (Application Reference Number: 6.4.7) and does not form part of the geomorphological value.	Low
Cemaes Bay	• This is situated immediately to the east of Wylfa Head. • Receptor has moderate natural characteristics. It is considered to have a slightly higher sensitivity than the surrounding seabed. • This is part of the Anglesey Terns SPA. • The Porth Wnal Dolerite is included as a receptor in chapter D7 (Application Reference Number: 6.4.7) and does not form part of the geomorphological value.	Medium
Cemlyn Bay	• This is situated immediately to the west of Wylfa Head. Receptor has moderate natural characteristics and is uncommon on a regional scale.	Medium

Geomorphology Receptor	Description	Value
	• Part of the Cemlyn Bay SAC/SSSI and Anglesey Terns SPA.	
Esgair Gemlyn	• A shingle ridge situated about 400m from the Wylfa Newydd Power Station at its central point. • This is considered an important geomorphological feature in its own right and is relatively uncommon. • It provides a protective function to the adjacent designated Cemlyn Lagoon. • Designated as part of the Cemlyn Bay SAC/SSSI, and is part of the Anglesey Terns SPA.	High
Cemlyn Lagoon	• Designated as part of the Cemlyn Bay SAC/SSSI. The existence of the lagoon is dependent on the presence of Esgair Gemlyn. • Designated as part of the Anglesey Terns SPA.	High
Hen Borth Cliff	• A geological SSSI which is an important (cliff) exposure of a glacial drumlin feature located approximately 1,500m from the Wylfa Newydd Power Station at its central point. • Taken to be an important geomorphological feature. • This is part of the Anglesey Terns SPA.	High

Designated sites for coastal geomorphology

12.3.95 Whilst it has been previously noted that descriptions of the Geological SSSI and RIGS (including the Porth Wnal Dolerite coastal outcrops) are reported within chapter D7 (Application Reference Number: 6.4.7), the glacial cliff Hen Borth has been included within this report as a geomorphology receptor. This allowed for the investigation of possible pathways for sediment supply from the cliff to Cemlyn Bay and in particular, the Esgair Gemlyn shingle ridge.

12.3.96 In line with desk study findings, the baseline sediment regime report (appendix D12-2, Application Reference Number: 6.4.81) and Delft3D modelling results (appendix D13-8) confirmed that there is no linkage under baseline conditions between sediment supply from current erosion and sediment transport processes from Hen Borth to receptors within Cemlyn Bay in appendix D12-2 (Application Reference Number: 6.4.81).

Designated WFD water bodies

12.3.97 As noted in chapter B12 (Application Reference Number: 6.2.12), three WFD designated coastal water bodies are located partly or wholly within the Wylfa Newydd Development Area study area. There is no WFD water body at the Disposal Site as it is more than one nautical mile from the coast. The three WFD water bodies are The Skerries, Anglesey North and Cemlyn Lagoon. The status objectives of coastal WFD water bodies depend on the condition of specific quality elements for various characteristics including coastal geomorphology, water chemistry and marine ecology (table D12-13). The Skerries and Anglesey North WFD water bodies have an overall ecological status of 'high' and 'good' respectively.

12.3.98 The Cemlyn Lagoon WFD water body has been designated as a Heavily Modified Water Body due to its use for flood protection. It therefore has an objective to achieve Good Ecological Potential. The Cemlyn Lagoon WFD water body is currently achieving good potential.

12.3.99 The potential effects upon the specific WFD hydromorphological quality elements are assessed separately to those upon the geomorphological receptors indicated above (in table D12-12) for the purposes of this report. The detailed assessment of WFD compliance is reported in a separate supporting report to the application for development consent; however, the WFD objectives for the coastal WFD water bodies have also been taken into consideration in this chapter.

Table D12-13 WFD coastal water bodies [RD21]

Description	The Skerries water body	Anglesey North water body	Cemlyn Lagoon water body
Water body ID	GB611010390000	GB 641010620000	GB610100083000
River Basin District	Western Wales	Western Wales	Western Wales
Heavily Modified Water Body designation (cycle 2)	No	No	Yes – flood protection
2015 Overall status	High	Moderate	Good

Disposal Site

12.3.100 The Disposal Site covers the northern half of the Holyhead Deep (IS040) disposal site which was closed in April 2017, due to consent of the Minesto Deep Green Holyhead Deep Project. The Disposal Site is contained within the geographical area demarking the registered Disposal Site at Holyhead North (IS043), which was opened following consent of that project. Historical environmental data for Holyhead Deep have therefore been utilised for the Disposal Site due to the geographical overlap in these two sites.

12.3.101 The Environmental Statement and supporting technical appendices for the Minesto Deep Green Holyhead Deep Project [RD22] have been drawn upon to understand the baseline and to characterise the marine environment of the Disposal Site.

12.3.102 Horizon has also undertaken bespoke hydrodynamic modelling and benthic habitat investigations of the Disposal Site to supplement the data and information available from Minesto. This is reported in appendix D13-12 (Application Reference Number: 6.4.94) and appendix D13-8 (Application Reference Number: 6.4.90) respectively.

12.3.103 The Irish Sea has been extensively surveyed by numerous researchers and organisations. Information contained within the Minesto Environmental Statement has been further supplemented by published data to provide a more robust and comprehensive assessment of baseline conditions [RD22].

12.3.104 The Disposal Site is a rectangular area off the northwest coast of Anglesey in the Irish Sea. The site is located approximately 12km northwest of Holy Island, Anglesey and 18km from the Wylfa Newydd Development Area. The size of the site is 3.45nm (nautical miles) by 2.4nm [RD23].

12.3.105 High resolution multibeam bathymetry data collected by SEACAMS between 2013 and 2014 [RD22] show that much of the Disposal Site had a depth of between 40m and 60m. A significant part is formed of a trench with depths ranging between 70m and 100m. There are then shallower parts to the north with depths ranging between 35m and 40m.

12.3.106 Under typical wave conditions in the baseline, due to the water depths, wave energy is not anticipated to reach to the seabed. Studies (including previous work by Minesto) have shown that across the site as a whole bed shear stresses are dominated by tidal processes. However, in rare, extreme wave conditions (e.g. an 8m wave) then it is possible for some wave interaction on the seabed outside the trench area

Physical processes

12.3.107 The Irish Sea is a high-energy shelf sea [RD24] where tides are principally driven by semi-diurnal lunar and solar forces [RD25]. The tidal range in the eastern Irish Sea is high, with amplitudes of 7m in Liverpool Bay and around 4m at Anglesey resulting in high tidal current velocities. More detail of hydrodynamic data, modelling and analyses can be found in appendix D13-12 (Application Reference Number: 6.4.94).

12.3.108 Within the vicinity of the Disposal Site, depth averaged tidal currents generally range between 1.75m/s and 2m/s, with velocities exceeding 2.5m/s during spring tides. Tidal current velocity tends to vary little with depth, except near the seabed, where there is a high shear layer a few metres thick [RD25].

12.3.109 Bed shear stress in the waters off Anglesey, including at the Disposal Site, is dominated by tidal processes [RD26]. Bed shear stress generally ranges from $6N/m^2$ to $10N/m^2$, decreasing to $4N/m^2$ in the northern most depression (SEACAMS, Johnsson, pers. comm. [RD22]). Minesto stated that current induced scour at this water depth does not bring about any material changes to the seabed.

12.3.110 The North Atlantic Oscillation Index dictates the inter-annual variability in wind and wave climate in the Irish Sea. Owing to the enclosed nature of the Irish Sea, the majority of waves are locally generated and therefore have a short period and significant wave height [RD25].

12.3.111 Due to its location at approximately 12km from Holy Island, waves at the Disposal Site are not affected by the coastline. The effect of local bathymetry on the contemporary wave climate at the site is also greatly reduced by the depth of water. Characterisation of the wave climate can be summarised using maximum values for the 50-year return period, which has a 2% probability of recurrence in any year (table D12-14).

Table D12-14 Maximum 50-year return values for hydrodynamic processes in the Irish Sea [RD24]

Hydrodynamic process	Return values
Wave period	10 seconds within the Irish Sea; 15 seconds at the outer entrance, where it is characterised by high energy swell waves
Significant wave height	Between 8m and 10m within the Irish Sea
Mean wind speed at a height of 10m	Between 34m/s and 36m/s, with gusts up to 50m/s; directed from the north, northeast and southeast.

Geomorphology

12.3.112 Due to the depth of water and distance from the coastline, the geomorphology at the Disposal Site is defined by the local bathymetry, seabed features (bedrock form and sediments) and their interaction with the tidal currents rather than waves.

12.3.113 Sediment pathways defined by [RD3] indicate the movement of mobile materials driven by tidal processes from the southwest to northeast.

12.3.114 Based on an understanding of the site characteristics at the Disposal Site, the seabed is the only geomorphology receptor relevant to this topic. As noted in table D12-12, due to the extensive and common coverage of the seabed receptor, its value is considered to be low.

Evolution of baseline

12.3.115 The evolution of baseline considers the likely changes to coastal and marine processes arising naturally that are expected to have an effect upon geomorphological receptors identified within this report. Such changes could include meteorological/ climatic change effects such as ambient temperature, precipitation, storm frequency and intensity, and sea levels. Whilst the changes to temperature and precipitation are identified as aspects of climate change of primary relevance to other topics (e.g. chapter D8 surface water and groundwater, Application Reference Number: 6.4.8 and in chapter D13 the marine environment, Application Reference Number: 6.4.13), the associated effects of storm frequency and sea levels are considered relevant to this chapter. As such these are represented within the evolving baseline scenarios.

12.3.116 For the purposes of this report, projected trends are based upon data published by UKCP09 (formerly UK Climate Impacts Programme) [RD27]. Additional refinement based on 2016 Welsh Government guidance [RD28] is also represented within the SWAN wave model results (appendix D12-3, Application Reference Number: 6.4.82).

Sea level rise projections

12.3.117 The projected sea level rise has also been derived using UKCP09 guidance and the latest Welsh Government [RD28] and English [RD29] guidance on relative sea level rise. Within the SWAN model, the 'reasonably foreseeable' future sea level rise allowances from 2008 to 2023, to 2087 and to 2187 are 0.05m, 0.67m and 2.12m, respectively (0.07m, 0.48m and 1.48m in Phase 2) with no additional allowance for surge (appendix D12-3, Application Reference Number: 6.4.82). However, it is recognised that there is continuing uncertainty with respect to sea level rise.

12.3.118 Different sea level rise scenarios could affect the scale of an effect, or the timing of changes, to coastal and marine processes and associated geomorphology.

12.3.119 Within the wave and hydrodynamic models, the effects of future climatic and/or sea level rise are both represented through the application of more extreme wave conditions and elevated wave heights and water levels. appendix D13-8 (Application Reference Number: 6.4.90) provides more detail of how these effects have been included within these modelled outputs.

12.3.120 The Wales Coastal Group Forum (2011) Shoreline Management Plan 2 (SMP2) [RD9] provides a broad-scale assessment of the risks associated with coastal evolution resulting from future sea level rise. It also presents a policy framework to address risk both to people and to the environment in a sustainable manner.

Coastal erosion

12.3.121 The SMP2 [RD9] estimates potential baseline erosion rates from both monitoring and historical maps. It makes a distinction between basic erosion of the shoreline and cliff recession, affecting the crest of cliffs and coastal slopes. SMP units within the study area include Cemaes Bay, Wylfa Head and Cemlyn Bay and headland. Table D12-15 indicates baseline erosion rates for the Cemlyn and Cemaes units provided within SMP2 [RD3].

Table D12-15 Baseline erosion rates [RD9]

Coastal unit	Rate of erosion (m/year)	Comments	100-year range for erosion (m)
Cemlyn	0.05 – 0.1	Roll back of shingle ridge, sensitive to sea level rise	20-45
Cemaes	0.2	Defended frontage	20-70

12.3.122 Within the study area hard rock cliffs are prevalent with rates of erosion that are likely to be substantially lower than the 0.05m/year erosion rate cited in table D12-15 which includes softer gravel areas [RD9].

12.3.123 It is worth noting that the values within the Wales Coastal Group Forum 2011 report [RD9] also concur with those reported for the Esgair Gemlyn feature in Pye and Blott [RD13] and [RD17]. Here analysis of historic maps also determined an average rate of landward migration of the shingle ridge of less than 0.2m/year in the period 1887 to 1990.

Cemlyn Bay and headland

12.3.124 The open western shoreline, composed of relatively hard rocks, will erode slowly. Previous work suggests that the Esgair Gemlyn (figure D12-10) (Application Reference Number: 6.4.101) is in no immediate danger of a major breach and that over-washing is relatively infrequent and small scale [RD13]. However, the frequency of over-washing appears to have increased along the central part of the barrier since 2000 and a severe event could occur at any time.

12.3.125 Studies in 2010 emphasise that there are no obvious new supplies of sediment to the beach. As a result, any future acceleration of sea level rise will make it difficult for the barrier to maintain its height and there could be a rapid landward movement of the shingle ridge as it adopts a flatter profile. By 2100, over-washed shingle could cover the area of the lagoon now occupied by the islands and a new tidal inlet could ultimately develop.

12.3.126 Historical map analysis indicates the greatest movement of the Esgair Gemlyn shingle ridge to be at the eastern end, adjacent to the car park which is currently protected by a short length of sea wall, and frequently inundated by high storm waves.

12.3.127 Future overtopping of the shingle ridge is likely to continue to be focused at this location along the ridge extent under evolving conditions. The potential for large events typically associated with changing climatic patterns to trigger threshold or stochastic events is increasingly acknowledged and recognised. In particular, the cost of ‘holding the line’ in coastal defences has come under scrutiny.

12.3.128 In recognition of the long-term outlook, the SMP2 [RD9] also suggests that for more stable features, such as fully developed shingle beaches, there will be a natural roll back and landward migration potentially in the range of 10m to 40m over 100 years. To prepare for potential stochastic events or adapt to longer term changes, options including managed realignment have been recommended in SMP2 for consideration.

Wylfa Head

12.3.129 The risk from coastal flooding, sea level rise and erosion are considered to be low due to the predominantly higher ground with hard bedrock. The regulator, Natural Resources Wales, has advised that, based on the current understanding of coastal erosion in the area, the site could potentially be protected from the effects of coastal erosion.

Cemaes Bay

12.3.130 The breakwater at Cemaes village currently provides protection to the harbour. In the absence of defences, the coastal slope to the western side of the village would suffer significant toe erosion and encourage slope instability in the area. The shoreline would realign with significant erosion at its southern end. The wall along the main beach follows the crest of the beach. However, without the defences the beach would roll back exposing the toe of the coastal slope behind.

12.3.131 The SMP2 [RD9] also recognises that where there are softer cliffs and shorelines (not protected with walls), the rate of erosion is likely to increase with sea level rise. This could equate to a factor of 1.7 to 2.5 times the existing base erosion rate over 100 years.

Flood Consequences Assessment

12.3.132 A Flood Consequences Assessment is provided as appendix D8-3 (Application Reference Number: 6.4.28) of chapter D8 (Application Reference Number: 6.4.8).

12.3.133 In particular, the risk of coastal flooding is included within these assessments. For the purposes of coastal and marine processes and geomorphology assessment, the potential for change from existing baseline conditions is first investigated, followed by the likely significance of these changes to the geomorphological receptors identified within the zone of potential effect.

Encroachment

12.3.134 The Anglesey Local Flood Risk Management Strategy [RD30] identifies coastal development as a potential issue in two respects. Apart from its effect on flood and coastal erosion risk, this process can lead to the degradation and loss of intertidal coastal habitats and natural shoreline flood defences. Such habitats are progressively being lost, trapped between coastal development, including defences such as breakwaters or temporary causeways, and rising sea levels.

12.3.135 With a rise in sea level, together with increased wave height and intensity, the potential for inland inundation with a consequential loss of low-lying intertidal habitat becomes more likely.

12.4 Design basis and activities

12.4.1 This section sets out the design basis for this assessment of effects. It sets out where any assumptions have been made to enable the assessment to be carried out at this stage in the evolution of the design. This section also identifies the embedded and good practice mitigation contained within the Mitigation Route Map (Application Reference Number: 8.14). Mitigation would be adopted to reduce adverse effects as inherent design features or by implementation of standard industry good working practice. It is to be achieved through the Design Access Statement (Application Reference Number: 8.2.1 and 8.2.2), the Code of Construction Practice (Application Reference Number 8.6) and the Marine Works Sub-CoCP (Application Reference Number: 8.8).

12.4.2 As described in chapter D1 (proposed development) (Application Reference Number: 6.4.1), the application for development consent and Licensable Marine Activities is based on a parameter approach. The hydrodynamic and wave modelling reported in this chapter, has been undertaken in line with the tolerances within the Parameter Plans and Works Plans (Application Reference Number: 2.3). The hydrodynamic modelling included sensitivity testing of the model to a change in positioning of the western breakwater and in dredged depth. The hydrodynamic model was shown to be insensitive to a change in dredge depth of 1m; however, it was found to be sensitive to an east west shift in breakwater position. Taking a precautionary approach based on current modelling outputs and professional judgement, it was considered likely that the wave model would also be sensitive to the breakwater position. The assessment described within this chapter has therefore taken into consideration the flexibility afforded by the parameters and a worst case scenario has been assessed within the parameters described in chapter D1 (Application Reference Number: 6.4.1).

Construction

12.4.3 The construction activities of particular relevance to the determination of potential changes to coastal and marine processes and assessment of effects on geomorphology receptors are described in the text below. Where there is uncertainty in design at this planning stage ahead of detailed final design, this is identified in the discussion of design and assumptions presented in subsequent sections.

12.4.4 Pre-construction activities (Enabling Works) carried out as part of site preparation and clearance with potential to affect coastal and marine geomorphology receptors due to release of fine sediments have been considered separately within the WFD Compliance Assessment (Application Reference Number: 8.26).

12.4.5 Potential effects fall into two main categories: firstly, the physical loss of materials, either through direct action e.g. dredging, or indirectly through adjustment e.g. erosion. Secondly, the physical gain of materials through deposition. These two potential effects are considered for each proposed activity.

12.4.6 The total area of seabed likely to be lost to allow for the construction of the Marine Works is approximately 30ha. This figure represents the worst case scenario given the current design.

Drainage network

12.4.7 The drainage network within the Wylfa Newydd Development Area has the potential to affect the input of sediments to the coastal and marine study area, in particular affecting deposition on the seabed. The preliminary design for surface water drainage network (in appendix D8-8, Application Reference Number: 6.4.33) shows that embedded mitigation including sediment treatment ponds (stated in volume 2 (Power Station Site) of the Design and Access Statement, Application Reference Number: 8.2.2) will reduce total suspended solid concentrations to at or below limits contained within guidance for pollution prevention.

Concrete batching plant

12.4.8 A concrete batching plant and associated infrastructure with a total area of 3.6ha would be integrated with the construction of the Marine Off-Loading Facility (MOLF). Potential effects (loss) would arise where the plant is partially constructed over approximately 2ha of the intertidal zone.

Temporary access ramp

12.4.9 To facilitate installation of the western breakwater, a temporary access ramp would be constructed at the southern end of Porth-y-pistyll. This would consist of a slipway ramp, suitable for specialist landing craft and used to import the large-scale construction plant.

12.4.10 The temporary ramp would be approximately 12m wide and up to 160m long. Construction would be from crushed rock either won from the Power Station Site or imported. Levelling and grading works would be carried out within tidal windows, with the toe of the ramp at low water spring tide level.

12.4.11 There would be temporary effects on the littoral profile and sublittoral bathymetry, potentially affecting nearshore currents, waves and suspended sediment transport.

12.4.12 The ramp would be dismantled after use and materials re-used on site or disposed of appropriately. This is anticipated to be approximately three months after construction.

Temporary barge berth

12.4.13 A temporary berthing and unloading facility would be required to accommodate barges importing construction materials for subsequent Temporary Marine Works (e.g. quay wall materials for the MOLF).

12.4.14 The berth would be located to the south of (and adjacent to) the planned site of the eastern breakwater (see figure D1-9) (Application Reference Number: 6.4.101). Its structure would comprise a modular retaining wall constructed using either steel shipping containers filled with crushed rock or other suitable fill, or another suitable modular type retaining wall structure. An area behind the retaining wall would be backfilled to create a working platform for a mobile tracked/crawler crane behind the retaining wall. An area in front of the retaining wall would be filled and levelled with rock to create a platform onto which barges could be grounded as the tidal level falls. An access ramp would be provided from the quay level down to the beach in front of the quay to facilitate plant access for maintenance of the platform.

12.4.15 There would be changes to the seabed receptor (including the intertidal zone) adjacent to the eastern breakwater (in the vicinity of MOLF construction)

12.4.16 Once the MOLF is part-constructed and the temporary barge berth is not required, it would be removed. Materials arising from removal of the temporary barge berth would be re-used on site or off site in accordance with the Contaminated Land: Applications in Real Environments code of practice (CL:AIRE Service)

Temporary cofferdam and temporary causeway

12.4.17 A temporary cofferdam (approximately 350m long) and temporary causeway (approximately 400m long) (see figure D1-9) (Application Reference Number: 6.4.101) would be constructed using rubble stone and rock armour deposited on the seabed and intertidal zone. A water tight seal would be created either using steel pile walls or interlocking steel tubular piles. The construction of the temporary cofferdam and causeway are expected to take approximately 8 months. On completion of the inner harbour works the temporary cofferdam and causeway would be removed over an anticipated period of approximately 12 months. An indicative construction schedule is provided in section 1.5 of chapter D1 Proposed Development (Application Reference Number: 6.4.1).

12.4.18 In terms of coastal and marine processes, the presence of these temporary structures would have a temporary effect on littoral profile; sublittoral bathymetry; currents and waves during temporary exclusion and dewatering of the area. From a geomorphology receptor perspective there would be changes to the seabed (including intertidal zone).

12.4.19 Dewatering of the cofferdam would involve the discharge of pumped water over the side of the cofferdams into the sea. With the exception of the initial dewatering of the inner harbour, the suspended sediment concentrations of marine dewatering activities would be monitored and limited to guidance for pollution prevention.

12.4.20 Construction would take approximately eight months and dewatering approximately ten days, with four pumps in use. The structures would be dismantled after approximately 12 months on completion of Temporary Marine Works using a reversal of installation methods.

Dredging and excavation

12.4.21 Superficial soft sediments will be dredged from the outer harbour to provide a solid foundation for the breakwaters and MOLF, and to ready the area for excavation which is required to create sufficient depth for the intake and navigation channel. The term ‘inner harbour’ refers to the area inside the temporary cofferdam whilst the term ‘outer harbour’ refers to the remaining area in Porth-y-pistyll requiring excavation.

12.4.22 The target dredge depth for the inner harbour is -10mAOD (plus a tolerance of 1m, which is related to excavation by drill-and-blasting in dry condition).

Dredging soft sediments

12.4.23 The superficial soft sediment (mainly sands and gravels) would be removed by conventional dredging plant such as a backhoe dredger, cutter suction dredger or trailing suction hopper. For the purpose of the assessment the worst case upper limit of soft sediment that would be dredged is a bulked volume of 242,000m^3 (equating to a saturated density of approximately 352,000 wet tonnes, based on a specific gravity of 1.6), although the values are likely to be considerably less.

Dredging of the outer harbour

12.4.24 Outside the temporary cofferdam, the bedrock would be initially fractured by peckering with a breaker and then ripped out and dredged with a barge mounted excavator and loaded into barges. The duration of this activity would be about 16 months. For the purposes of the assessment the worst case upper limit of rock that would be removed from the outer harbour by wet excavation is a bulked volume of 368,000m^3 (equating to an in situ density of approximately 709,714 tonnes, based on a specific gravity of 2.7). Dredged bedrock would be re-used for the construction of the cores of the western and eastern breakwaters where appropriate (i.e. geotechnically suitable) and practical (i.e. available when the breakwater construction requires it), or exported off-site for re-use. The remaining dredged bedrock that cannot be re-used would be disposed of at the Disposal Site.

Dry excavation of the inner harbour

12.4.25 Within the inner harbour, dry excavation would take around 14 months in total with preliminary excavation beginning onshore up to the 0mAOD and taking around six months. Once the cofferdam was put in place, drilling and rock fracturing by blasting would be carried out for approximately seven months.

12.4.26 Approximately 500,000m^3 bedrock would be excavated in the dry, including the excavation directly in front of the Cooling Water (CW) intake structure. The excavated material would be re-used or disposed of appropriately.

Re-use and disposal of dredged materials

12.4.27 Dredged material arising from the wet excavation works would be re-used on-site (e.g. for core material in the CW intake breakwaters) or off-site where practicable, and the remaining material would be disposed of at sea.

12.4.28 Disposal of excavated rock and soft sediments would be carried out at the Disposal Site. The worst case volume for material that could require disposal at sea is approximately 610,000m^3. This would comprise approximately 368,000m^3 of bulked rock material and 242,000m^3 of bulked soft sediment.

12.4.29 Assuming a barge with approximate capacity of 3,500m^3, it would take 35 days to dispose of the sediment. However, this assumes a continual series of disposal events without break and is therefore a worst case with regard to the sediment plume and any corresponding deposition on the seabed (see appendix D13-12, Application Reference Number: 6.4.94).

12.4.30 Rock would be disposed of over the duration of the wet excavation works, taking approximately 16 months (chapter D1 Application Reference Number: 6.4.1).

Vessel movement

12.4.31 Movements of vessels during construction potentially cause changes to surface waves and sedimentation caused by local sheltering or reflection effects.

Western and eastern breakwaters

12.4.32 Two breakwaters are required to protect the CW intake and MOLF from wave action. Their presence would create a sheltered area of water within Porth-y-pistyll to optimise wave conditions for operation of the CW intake equipment. The breakwaters would also ensure safe conditions for vessels accessing and berthing at the MOLF.

12.4.33 The western breakwater would be detached from the shoreline with a crest height of between 10mAOD and 14mAOD and a length of 400m.

12.4.34 The eastern breakwater would be shore-connected with a crest height of between 9mAOD and 12.2mAOD and approximately 150m in length.

12.4.35 Construction and materials for the breakwaters are described in chapter D1 (Application Reference Number: 6.4.1). Both breakwaters would be rock filled structures covered with pre-cast concrete armour arranged as a precise grid and where practical rock armour. The interlocking concrete armour would provide surficial roughness to dissipate the energy of incoming waves, reducing the reflective energy potential. Superficial soft deposits on the seabed would be removed initially by standard dredging plant, such as a cutter suction dredger and/or backhoe dredger, prior to placement of a gravel erosion mat on the breakwater footprint for scour protection, followed by rubble stone mounding. It is expected that the removal of soft sediments would run for approximately 10 months. Approximately 220,000m^3 (in-situ) is the maximum volume of superficial deposits that would be dredged across the site (including both material under the breakwater and elsewhere).

12.4.36 The western breakwater would be constructed predominantly from land, by building a temporary causeway supporting a haul road to allow delivery of material in dump trucks. The causeway and subsequently the permanent western breakwater would be gradually extended as more material is added. Parts of the breakwater could also be constructed by offloading from a barge and placing rock, material or concrete into position.

12.4.37 The eastern breakwater would also be constructed from land working seawards using similar methods, materials and plant as for the western breakwater (see chapter D1, Application Reference Number: 6.4.1). Following subsequent removal of the temporary causeway, the gap between the land and the permanent western breakwater, would maintain a circulating flow of water. This would allow for localised currents to maintain mixing and the dispersion of any fine suspended sediments within the harbour area.

12.4.38 From a coastal and marine processes perspective there would be changes to the littoral profile, sublittoral bathymetry and nearshore currents and waves. There would be potential effects on the seabed (including the intertidal zone).

MOLF

12.4.39 The MOLF is required to facilitate the construction of the Power Station and would therefore be constructed early in the programme and be operational throughout the Power Station construction phase (see figures D1-2). The MOLF has been co-located near the CW intake structure to ensure a marine footprint that is as small as possible.

12.4.40 The MOLF would consist of the following components.

- A Bulk Quay consisting of two platforms with maximum surface area approximately 65m x 30m. The platform level would be +5mAOD to +6mAOD.
- A Roll-on Roll-off (Ro-Ro) MOLF (berthing facility) with a quay length of approximately 100m by 40m width to enable deliveries of bulk materials by sea. The footprint of the Ro-Ro MOLF would be approximately 0.7ha.
- A Layby berth to provide a safe haven for mooring when other berths are occupied.

12.4.41 Further details on the construction and materials for these facilities are provided in chapter D1 (Application Reference Number: 6.4.1). For the purposes of this assessment, a worst case scenario for temporary works with the greatest footprint has been assumed. This is considered to be:

- preparation of the sub-base for both the bulk material and Ro-Ro MOLF would require rock to be cut and profiled using excavation in the dry by drill-and-blasting;
- construction of the bulk material MOLF and Ro-Ro quay would involve the installation of pre-cast concrete block structures placed on the sub-base; and
- the Ro-Ro MOLF would be constructed in the dry behind a cofferdam.

12.4.42 Examples of the types of construction plant required are identified in table D12-16. This is not a complete plant list but the anticipated levels of effects based on this plant list are not significant and not sensitive to any minor variations envisaged.

12.4.43 From a coastal and marine processes perspective there would be changes to the littoral profile and sublittoral bathymetry would potentially affect nearshore currents, waves and suspended sediment concentrations. From a geomorphology receptor perspective there would be effects on the seabed and intertidal zone.

Table D12-16 Equipment proposed for dredging and excavation activities

Plant required for construction
• jack-up platforms; • variety of cranes; • barges for the transport of materials; • drilling rigs; • dredgers; and • work and safety boats.

12.4.44 The MOLF would operate on a 24-hour basis throughout the whole construction period which is expected to last seven years. Different types of vessels (Ro-Ro, Lo-Lo bulk vessels including barges) would use the MOLF to transport general equipment, cement and aggregate.

Shore protection

12.4.45 Adequate shore protection would be provided where dredging or excavation could lead to shore erosion and/or unacceptable wave overtopping discharges. Locations for shore protection would include:

- between the eastern breakwater and the shoreline (approximately 80m in length); and
- between the two bulk MOLF platforms.

Shore protection would take the form of rock revetments or seawalls and would be tied-in with the adjacent structures (e.g. breakwaters, quay walls). The toe of the shore protection would be below MLWS at the dredged seabed depth, which would be approximately -10mAOD.

Shore protection would affect the littoral profile, nearshore currents and waves. There would be changes to the geomorphology receptor, seabed (including the intertidal zone).

Cooling Water intake and outfalls

12.4.46 The Cooling Water System is described in chapter D1 (Application Reference Number: 6.4.1). The location of the CW intake would be at Porth-y-pistyll, with the CW outfall located at Porth Wnal (adjacent to the outfall of the Existing Power Station).

12.4.47 Cooling Water tunnels would be primarily excavated by controlled drilling and blasting. The discharge channels at the CW outfall would be constructed using a cut-and-cover methodology. At both locations rock excavation would be completed in the dry behind cofferdams.

12.4.48 At the Porth-y-pistyll CW intake, an additional cofferdam constructed using pre-bored piles would be required in front of the intake. This would remain in place after removal of the inner harbour cofferdam as the tunnelling works and installation of forebay infrastructure would take longer than the marine excavation and construction works.

12.4.49 From a coastal and marine processes perspective, the littoral profile, sublittoral bathymetry and nearshore currents and waves would all be potentially affected. There would also be potential release of suspended sediment during temporary exclusion and dewatering of the area. The seabed would be subject to a soft sediment dredge with bedrock blasted to excavate or ripped out to a level area of -10mAOD.

12.4.50 The cofferdam at the CW outfall would be constructed using one of three options:

- Twin sheet piled wall gravity structures;
- Twin tubular pile wall gravity structure; or
- Rock bund type cofferdams similar to the semi-dry cofferdam (not considered for the Cooling Water intake structure).

12.4.51 It is anticipated that blasting/chemical splitting could be used for local areas of hard rock. Each discharge tunnel would be approximately 1.1km in length from the seal pit to point of discharge (approximately 200m of cut and cover and 900m of bored tunnel).

12.4.52 The CW outfall discharge tunnels would have a common concrete apron. Construction would take approximately eight months and removal around 12 months. There would be a temporary effect on littoral profile, sublittoral bathymetry, currents and waves during temporary exclusion and dewatering of the area.

Basis of assessment and assumptions

12.4.53 This section sets out where any additional assumptions have been made to enable the assessment of construction activities to be carried out at this stage in the evolution of the design.

12.4.54 The assessment of potential changes to coastal and marine processes resulting from the construction activities described above has been investigated through two model platforms. The hydrodynamic model, Delft3D, primarily investigates the fully built condition, while the wave model, SWAN (with ARTEMIS inside the harbour area) investigates potential changes in waves for the construction activities under two scenarios to reflect the presence of temporary as well as the permanent structures present during the construction period. The two construction scenarios are summarised as:

- ‘partially built’ – with cofferdam area and partial extent of western breakwater; and
- ‘fully built’ – with full extents of MOLF Ro-Ro quay and western/eastern breakwaters.

12.4.55 Embedded and good practice mitigation has been considered in the initial assessment to ensure that realistic scenarios (including a worst case) have been assessed as a starting point before consideration of further mitigation.

Embedded mitigation

12.4.56 The design and construction of the breakwaters, MOLF, CW intake and outfall structures and dredging activities would include a number of features consistent with reducing changes to coastal and marine processes and effects on coastal geomorphology receptors (as shown in volume 2 of the Design and Access Statement, Application Reference Number: 8.2.2). These primarily include footprints as small as practicable for the breakwaters and the temporary causeway and compressing the length of time for construction.

12.4.57 Potential effects of additional fine sediments in watercourses discharging to the marine environment would be mitigated through the construction drainage system designed to reduce the mobilisation and transport of fine suspended sediments, as detailed in volume 2 of the Design and Access Statement (Application Reference Number: 8.2.2) and the Main Power Station Site sub-CoCP (Application Reference Number: 8.7).

Good practice mitigation

12.4.58 Good practice mitigation during construction would include adhering to the following:

- Wylfa Newydd Code of Construction Practice (Application Reference Number: 8.6);
- Main Power Station Site sub-CoCP (Application Reference Number: 8.7); and
- Marine Works sub-CoCP (Application Reference Number: 8.8); and

These documents contain specific mitigation measures in relation to air, noise, traffic, and water quality, including the implementation of appropriate guidance for pollution prevention.

Operation

12.4.59 Potential effects arising from construction may continue into the operational phase. Licensable Marine Activities specifically carried out during operation and relevant to coastal and marine processes and geomorphology are detailed in the text below.

MOLF and breakwaters structures

12.4.60 All or part of the MOLF may be retained for use during Power Station operation. Whilst the bulk quay is expected not to be required, the Ro-Ro quay may be used for delivery of replacement parts which are Abnormal Indivisible Loads (AIL) to avoid road transport. It is currently assumed that only one vessel per year would use the MOLF during operation.

12.4.61 During operation the western breakwater would be a standalone structure with no connection between the breakwater and the land to allow through flow of water.

Power Station operation

12.4.62 The process of abstraction of seawater is not regarded to be applicable to coastal geomorphology receptors.

12.4.63 Discharges from the CW outfall could cause localised changes to coastal and marine processes and effect the seabed as a consequence of locally increased shear stresses.

Maintenance dredging and disposal

12.4.64 Dredging is likely to be required to maintain sufficient depth in front of the intake and to allow continued access to the MOLF. The dredged material would be deposited at the Disposal Site. The volume of dredged material (sediment) would be significantly smaller than that for the capital dredging programme and consist largely of dispersive material.

Basis of assessment and assumptions

12.4.65 The following assumptions are made to determine potential changes to coastal and marine processes and coastal geomorphological receptors:

- The CW abstraction and associated discharge would vary according to the state of the tide during the lifetime of the Power Station Site resulting in a variation of flows.
- Vessel movements inside the harbour would be limited to maintenance dredging activities and very infrequent movements (<1 per year) linked to the delivery of abnormal indivisible loads during operation.

Embedded mitigation

12.4.66 The key embedded mitigation for operation of the western breakwater (after removal of the temporary causeway) would be a gap between it and the land to enable continued throughput and flushing of water and sediment as defined in volume 2 of the Design and Access Statement (Application Reference Number: 8.2.2).

12.4.67 As stated in volume 2 of the Design and Access Statement (Application Reference Number: 8.2.2), the western breakwater would be designed to include interlocking concrete armour. The function of this armour would be to increase surface roughness on the west and north-west facing perimeter increasing the absorption of incident wave energy thus reducing the reflection of that energy. Such features also have additional potential environmental benefits with respect to habitat provision, as described within chapter D13 (Application Reference Number: 6.4.13).

12.4.68 The management of the intake and outfall flows includes a number of features intended to reduce changes to erosion or deposition, as stated in volume 2 of the Design and Access Statement (Application Reference Number: 8.2.2). These include designing as small a footprint to the structures as practicable and compressing the length of time taken to construct.

12.4.69 As stated in volume 2 of the Design and Access Statement (Application Reference Number: 8.2.2) the CW intake velocity has been designed not to exceed 0.3m/s at Lowest Astronomical Tide which is 3.6m below AOD. This has been designed to mitigate localised erosion and scour as far as practicable inside the inner harbour area.

Good practice mitigation

12.4.70 Management strategies would be set out in the Wylfa Newydd Code of Operational Practice (CoOP) (Application Reference Number: 8.13). This would outline how targets, to be agreed with regulators, would be achieved with respect to management and implementation.

Decommissioning

12.4.71 Licensable Marine Activities associated with decommissioning are detailed in chapter A1 (Application Reference Number: 6.1.1). Of particular relevance to coastal geomorphology receptors would be removal of structures including the cooling water intake and outfall.

Basis of assessment and assumptions

12.4.72 The details of decommissioning are not known at this time and to facilitate assessment a number of assumptions have been made:

- Wylfa Newydd Power Station would operate for 60 years;
- both reactors would be decommissioned simultaneously;
- removal of structures including the intake, outfall and MOLF, but not the breakwaters.
- civil structures greater than 1m depth would be left in situ and backfilled or grout filled, including the discharge water channel and the discharge water tunnels; and
- removal of structures would be carried out using the same type of equipment and methods as for construction.

Embedded mitigation

12.4.73 Embedded mitigation during decommissioning would be based upon standard construction best practice applicable at the time.

Good practice mitigation

12.4.74 Good practice mitigation during decommissioning would be based upon standard construction best practice applicable at the time.

12.5 Assessment of effects

12.5.1 This section presents the findings of the changes to coastal and marine processes and assessment of effects on geomorphology receptors associated with construction, operation and decommissioning at the Wylfa Newydd Development Area, and disposal of material at the Disposal Site.

12.5.2 Building upon previous studies [RD4], new evidence within this assessment includes wave, current and sediment modelling using the best available information with industry-accepted approaches including Delft3D hydrodynamic and SWAN wave models (as detailed in chapter B13; (Application Reference Number: 6.2.13)). The 2012 assessment [RD4] was undertaken for a similar layout for the Marine Works, but with a western breakwater greater than 500m in length and permanently connected to the shoreline. The current design of the western breakwater is for a structure 400m in length and disconnected from the shoreline. The design has evolved to reduce the effects upon the marine environment, as described below.

12.5.3 The assessment that follows firstly considers potential changes to coastal and marine processes as a result of the construction and operation of Marine Works. Decommissioning is considered here only in brief as this would be subject to a separate and more detailed Environmental Impact Assessment investigation.

12.5.4 Coastal and marine processes (comprising of waves, tidal currents and sediments) are driven by the levels and patterns of prevailing energy including (but not limited to) the wind, gravity, temperature, tidal cycles, diurnal patterns etc. Such patterns can be predictable, periodic (cyclical) or unexpected and subject to random (or stochastic) changes depending upon seasonal and/or climatic variations, for example sudden extreme storm events, with the ability to bring about shifts in boundary thresholds.

12.5.5 Analyses of the scale of potential changes (to waves, currents and bed shear stresses leading to effects upon the sediment regime, including fine sediment plumes) informs the assessment of potential effects upon coastal geomorphology receptors.

12.5.6 Comparative analyses of the modelled results have been undertaken to compare the baseline without the Power Station or 'no PS' conditions and those with the Power Station or 'with PS'. These two conditions have been used to assess the potential effects of the Power Station for both the construction and operational periods. More information on the assessment approach is provided in chapter B12 (Application Reference Number: 6.2.12) with further details of modelling methodology and results provided in appendix D13-8 (Application Reference Number: 6.4.90).

12.5.7 It is important to note that detection of differences (between the 'with PS' and 'no PS' model scenarios) are limited by the sensitivity of the model to small changes in flow field and other variables. As such they should not be interpreted as absolute values but as indications of the likely scale and direction of potential change.

Construction

12.5.8 The proposed Licensable Marine Activities described in section 12.4 could have the potential to affect already complex and dynamic coastal and marine processes over short and longer term time frames and at different scales. The following assessment is focused upon potential changes to these processes which could lead to a significant effect upon the geomorphology receptors.

Determination of changes to coastal and marine processes

12.5.9 Changes to coastal and marine processes associated with construction within the Wylfa Newydd Development Area have been identified through hydrodynamic (Delft3D) (appendix D13-8, Application Reference Number: 6.4.90) and wave (SWAN) (appendix D12-3, Application Reference Number: 6.4.82) modelling investigations.

12.5.10 Investigations of potential changes to coastal and marine processes during construction have been focused upon two key sets of modelled results. These include both the predicted changes to surface wave conditions (in SWAN at the Wylfa Newydd Development Area); as well as the predicted changes to coupled tidal currents and wave (in Delft3D at the Wylfa Newydd Development Area and at the Disposal Site) in relation to:

- effects upon wave height adjacent to Esgair Gemlyn;
- effects upon seabed shear stress and associated sediment mobilisation patterns resulting from new structures and Licensable Marine Activities associated with the Power Station; and
- the dispersal and deposition of material arising from sediment plumes generated by drainage discharge and dredging activities within the Wylfa Newydd Development Area and for dredging at the Disposal Site.

Waves and tidal currents

12.5.11 To investigate the possible effects of the proposed Licensable Marine Activities upon waves and tidal currents, a selection of 'with PS' scenarios have been run (primarily within SWAN) at various stages of the proposed construction activities ('partially built' and 'fully built', as noted in section 12.4 under *Basis of assessment and assumptions*). These scenarios have then been compared to the baseline model predictions. It is important to note the rarity of the northerly 99th percentile wave conditions (i.e. with a 1 in 100 probability of occurrence) which have been selected for this assessment, to represent 'worst case scenario' winter storm conditions. For the assessment of effects around Cemlyn Bay, Cemaes Bay and the wider offshore marine environment, an investigation of significant wave heights has been undertaken.

12.5.12 Additional model runs have been undertaken to test the sensitivity of the results for a wider range of wave directions, taking in additional wave directions from the west to the north-east at 5 degree intervals. The additional sensitivity runs have been reported within appendix D12-3 (Application Reference Number: 6.4.82). Localised changes in wave height modelled during the extreme 99th percentile condition for waves approaching from the north-west and west under a future foreseeable scenario (2087) are shown to be minimal, occurring over the widest area for the lowest band wave heights (below 1m). Potential increases between 0.1m and 0.2m in localised areas would remain within the range of existing variability under baseline conditions.

12.5.13 The Delft3D hydrodynamic model has been used to assess the potential influence of the Licensable Marine Activities associated with the Wylfa Newydd Project on the tidal currents during construction (appendix D13-8, Application Reference Number: 6.4.90). This work has allowed a determination of changes to current speeds and associated bed shear stresses. Overall the work has shown that changes of tidal current speeds are minimal. These changes, specifically in relation to bed shear stress, are described below.

12.5.14 Analysis of all wave scenarios run within SWAN has revealed the greatest potential changes in wave heights for the largest waves approaching the near shore occurs with the most severe winter storm (99th percentile) waves arising from the northwest. As noted in the baseline section (12.3) waves entering Cemlyn Bay from the north-east wave direction are aligned with the headlands and the orientation of the western breakwater, therefore the marine structures have a lesser effect upon the height of waves entering from that direction. In contrast, waves entering from the north-west are directed towards the breakwater, therefore a reflection off the structure is observed (figure D12-12, Application Reference Number: 6.4.101).

12.5.15 Figure D12-12 (Application Reference Number: 6.4.101) shows two indicative comparisons of modelled wave height for the strongest (99th percentile) winter wave arriving from the north-west. The upper images allow comparison between the baseline and partially built scenario (with cofferdam and partial breakwater), whilst the lower images compare the baseline and the fully built scenario (with breakwaters and MOLF). Please note, for the fully built scenario, results within the wave modelling report were found to be very similar for both time periods modelled (appendix D12-3, Application Reference Number: 6.4.82). Hence the foreseeable future scenario shown, is indicative of a worst case rare winter storm event irrespective of time period. Both pairs of images show the effect of wave reflection at the western breakwater under severe storm conditions, with localised increases in wave height. However, within Cemlyn Bay, wave heights are low and changes in wave height appear to be very small.

12.5.16 Figure D12-13 (Application Reference Number: 6.4.101) compares the differences in wave height using images generated by the SWAN model for four paired scenarios, selected for different wave directions and conditions. The first (top left image) shows present day summer wave conditions with a small decrease in wave height behind the western breakwater ranging between -0.1m to -0.2m. The lower left image depicts severe winter storm conditions, with waves from the north-east under a present day fully built scenario. Here the small decrease in waves adjacent to the western breakwater reflects the alignment of waves to the structure. Some small areas of increased wave height immediately north of and within the harbour area are depicted alongside of decreases in wave height in more sheltered areas.

12.5.17 For the summer (typical) and winter (worst case) wave conditions shown in figure D12-13 (Application Reference Number: 6.4.101), the SWAN model outputs show extensive areas where the change in wave height ranges between -0.1m and +0.1m (shown in white).

12.5.18 The upper and lower right images of figure D12-13 (Application Reference Number: 6.4.101), showing the differences in wave height for severe storm conditions with winter waves from the north-west, complement those presented in figure D12-12 (Application Reference Number: 6.4.101) for a present day partially built scenario (top right) and a foreseeable future fully built scenario (lower right). By looking at difference maps (figure D12-13) (Application Reference Number: 6.4.101) increased wave heights resulting from the reflection of the waves from the western breakwater can be seen. This contrasts with a decrease of wave heights within the sheltered harbour area itself. In both scenarios the increased height of reflected waves west of the breakwater is localised and dissipates within outer parts of Cemlyn Bay.

12.5.19 A very small area of increased wave height is also depicted towards the rear of Cemlyn Bay under the foreseeable future fully built scenario. On figure D12-12 (lower left image) (Application Reference Number: 6.4.101), it can be seen that baseline wave height values in this location are relatively low, within the range of 1.0m to 1.2m, potentially rising to 1.2m to 1.4m and therefore lower than the baseline values for storm waves from the north-east (shown in figure D12-3) (Application Reference Number: 6.4.101) in the same location. These differences have been further investigated through time series data generated by the SWAN model and reported in appendix D12-3 (Application Reference Number: 6.4.82).

12.5.20 Within the SWAN model, a set of points were chosen to investigate modelled data outputs through time series generated by the 35.5-year model run (appendix D12-3, Application Reference Number: 6.4.82). This assessment used two points to interrogate the data:

- Point 8: immediately west of the western breakwater; and
- Point 6: within Cemlyn Bay, adjacent to Esgair Gemlyn.

12.5.21 Statistical analyses of the data for time series at points west of the western breakwater (point 8) and adjacent to Esgair Gemlyn (point 6) were undertaken to further investigate to potential effects under worst case winter storm scenarios. Selected results for the present day northerly winter storm conditions for partially built and fully built scenarios are provided in table D12-17.

Table D12-17 Changes in wave height (SWAN model results) for worst case (winter, 99th percentile wave) present day (2023) scenarios over 35.5-year model period

Point	Difference (partially built minus baseline) in significant wave heights for present day winter wave from north-west sector		Difference (fully built minus baseline) in significant wave heights for present day winter wave from north-east sector	
	Difference as mean significant wave height (%)	Difference as 99%ile significant wave height (%)	Difference as mean significant wave height (%)	Difference as 99%ile significant wave height (%)
6 (Cemlyn Bay)	+2%	+1%	+1%	-1%
8 (Western Breakwater)	+7%	+9%	-14%	-10%

Source: SWAN (appendix D12-3, Application Reference Number: 6.4.82)

12.5.22 The differences in wave heights for the partly built and fully built structures under present day (2023) scenarios (shown in table D12-17) are extracted from the 35.5-year time series for the 50th and the 99th percentile values. These metrics were chosen to represent the average and worst case, respectively. These data have been chosen to match the 'difference' (scenario minus baseline) images shown in figure D12-13 (Application Reference Number: 6.4.101) for the present day winter storm 99th percentile conditions for partially built (top right image) and fully built (lower left image) scenarios presented as the worst case.

12.5.23 The results for the present day fully built scenario with storm waves approaching from the northwest are very similar to the foreseeable future result, which are presented in the operational assessment section. More detail of the full set of scenario results can be found in appendix D12-3 (Application Reference Number: 6.4.82).

12.5.24 Immediately west of the western breakwater (point 8) the differences in wave height predicted by the wave model include the following potential changes.

- Under a partially built scenario, with the cofferdam in place, and storm waves approaching from the north-west, there could be a change in wave height ranging between +7% to +9%.
- Under a fully built scenario, with storm waves approaching from the north-east, there could be a change in wave height ranging between -14% to -10%.

12.5.25 Adjacent to the Esgair Gemlyn within Cemlyn Bay (point 6).

- Under a partly built scenario, when the cofferdam is in place, with storm waves approaching from the north-west, there could be a change in wave height ranging between -1% and +2%.

- Under a fully built scenario, with storm waves approaching from the north-east, there could be a change in wave height ranging between +1% and -1%.

12.5.26 In 2012, investigations by [RD4] predicted a potential increase in wave height of 0.25m west of the proposed western breakwater, due to the reflection of waves from a breakwater structure greater than 500m in length and connected to the shoreline. The increase in wave height adjacent to the Cemlyn Bay shingle barrier beach, Esgair Gemlyn, was predicted to be in the range of 10cm to 15cm. This increase was associated with only a very narrow band of wave directions (approaching from a westerly direction), for smaller waves and not for the most extreme waves [RD4].

12.5.27 By comparison, for the partially-built condition the 2017 SWAN investigations (appendix D12-3, Application Reference Number: 6.4.82) for a 400m breakwater, disconnected from the shoreline presented in this report found localised decreases in wave height under all wave conditions and small areas of increased wave height for winter storm conditions only. The SWAN results have shown the greatest potential increases in wave heights under winter storm conditions arising from the north-west to occur in small areas up to a maximum of 0.4m (figure D12-13) (Application Reference Number: 6.4.101). Statistical analysis of data from immediately to the west of the western breakwater (at point 8), shows an increase ranging between +7% and +9% upon a baseline wave height of 3.0m to 3.5m (figure D12-3) (Application Reference Number: 6.4.101). At the head of Cemlyn Bay adjacent to Esgair Gemlyn (at point 6), under the same winter storm conditions, an increase in wave height ranging between +1% and +2% is indicated upon a baseline wave height of 1.0m to 1.2m (figure D12-3) (Application Reference Number: 6.4.101).

12.5.28 At the same locations, decreases in wave height of up to -14% west of the western breakwater (at point 8) and -1% adjacent to Esgair Gemlyn (at point 6) are calculated for storm waves arising from the northeast. This is due in part to sheltering effects and the broad alignment of the western breakwater structure with the more powerful waves entering the bay from the northeast.

12.5.29 Additional wave simulations, carried out using the SWAN wave model, were conducted to explore the sensitivity to offshore wave direction, providing results at 5^{o} spacing within the W, NW, N and NE sectors for the '2087 reasonably foreseeable' conditions, applying the same wind conditions as for the 99^{th} percentile condition in the sector. The full set of results are provided in appendix D12-3 (Application Reference Number: 6.4.82). The results indicate, for waves approaching from the west, a larger extent of potential increase in wave height, ranging between 0.1 and 0.2m occurring to the west of Cemlyn Bay. Comparison with the baseline wave conditions shows this change to be effective upon smaller wave heights up to 1m. Therefore. the predicted potential increases in height for storm waves approaching from the west would be within the range of wave conditions currently occurring within Cemlyn Bay for storm waves approaching more directly from the north east. The modelled results showing a small extent of change on the largest waves are confirmed as those approaching from the north-west sector, as presented in figure D12-13 (Application Reference Number: 6.4.101) and reported above. All results for baseline and changes in wave height are provided in appendix D12-3 (Application Reference Number: 6.4.82).

Sediment processes

12.5.30 Alterations to combined waves and tidal current patterns indicated by the Delft3D hydrodynamic model have been used to investigate potential changes to sediment mobilisation and transport processes which could cause scour and/or deposition to geomorphological receptors identified in the baseline section (table D12-12). In particular, these investigations focused on the potential effects arising from predicted local changes in coastal and marine processes upon the shingle ridge feature (Esgair Gemlyn) and lagoon of the Cemlyn Bay SAC, both identified as receptors of high value.

12.5.31 Encroachment associated with construction of the breakwaters and MOLF within Porth-y-pistyll could also affect tidal currents and waves in that location. In combination with the excavation of the seabed (to -10mAOD), it is expected that the overall potential changes to the hydrodynamics within the harbour area could lead to an increase in the deposition of fine sediments. Based upon the hydrodynamic model results for changes in bed shear stress, this effect would be periodic and of a small magnitude. Furthermore, the baseline concentrations of fine suspended sediments within Cemlyn Bay reported in section 12.3 are shown to be relatively low. Embedded mitigation within the design, comprising the opening at the landward end of the western breakwater, would allow tidal currents to maintain a circulation of flow, keeping deposition to a minimum.

12.5.32 Hydrodynamic model investigations into the potential effect of fine sediment deposition from combined natural and artificial sources during the construction period have also been carried out. Changes to bed shear stress and sediment entrainment have been used specifically to determine where, and to what extent, existing sediment pathways could be affected. The findings of the investigations reported below are those considered as significant to the assessment of potential effects. Further information on the methodology and additional model results for waves and hydrodynamic processes are located within appendix D13-8 (Application Reference Number: 6.4.90).

Changes in bed shear stress

12.5.33 Bed shear stress acts to mobilise material at the seabed. Tidal currents then transport the suspended material either by saltation (i.e. particles ‘bounce’ along the seabed) or in suspension, depending on the size of particle and their specific density. Spring tidal conditions over a flood-ebb cycle have been selected as the most dynamic to represent worst case scenario for the determination of changes in bed shear stress for the fully built condition. It is important to note that potential changes in bed shear stress have been assessed in relation to baseline values, sediment mobility potential (table D12-7) and the presence of local sediments, to determine the significance of effect upon the geomorphological receptors.

12.5.34 Critical to the assessment of potential effects is the determination of localised changes in bed shear stress which could lead to additional scour/erosion or deposition. [RD4] reported maximum differences in bed shear stresses that would be typically low, ranging between 0.2N/m² and 0.3N/m² following construction of an extended (500m) breakwater connected to the shoreline.

12.5.35 The modelling outputs presented in figure D12-14 (Application Reference Number: 6.4.101) show the bed shear stresses for fully built 'with PS' scenarios (including a 400m breakwater, disconnected from the shoreline) for the same range of wave and (spring mid-ebb) tidal conditions presented in the baseline section (figure D12-8) (Application Reference Number: 6.4.101). Comparison between the two sets of figures confirms that the same areas of highest bed shear stress have been predicted to occur close to the shore near the headlands to the west of Cemlyn Bay (Trwyn Cemlyn) for all wave conditions. Comparatively high levels of bed shear have also been indicated to the west of Porth-y-pistyll for winter waves. Under both baseline and fully built scenarios, values of greater than 12N/m² (with potential to mobilise coarse gravels where present) have been predicted in the same locations, with slightly different spatial coverage predicted at Porth-y-pistyll due to the presence of the new structures.

12.5.36 Changes over a full spring cycle are indicated in figure D12-15 (Application Reference Number: 6.4.101). For the high north wave scenario, the patterns of bed shear over a full spring tidal cycle are changed by the presence of the breakwaters but do not increase in their magnitude. At the Esgair Gemlyn, a small decrease in bed shear stress has been indicated towards the eastern end of the shingle ridge (figures D12-8 and D12-15, lower right image) (Application Reference Number: 6.4.101).

12.5.37 Within the bays (Cemlyn, Porth-y-pistyll and Cemaes) the changes to bed shear stress are minimal and, with the exception of Porth-y-pistyll, highly localised. In the head region of Cemlyn Bay near to the ridge the results show no change in bed stress, save except for a small localised zone to the north and associated with the ebb tidal delta of the lagoon drainage system. Within Porth-y-pistyll the changes are clearly dominated by a reduction in bed shear stress (figure D12-15) (Application Reference Number: 6.4.101) with the only increases occurring to the north of the bay, between the breakwaters, and then only during the infrequent high north wave scenario.

12.5.38 In terms of the modelled decreases to bed shear stress, values in most areas range between -0.1N/m² and -0.5N/m² with some very small pockets of maximum bed shear stress decreasing to between -0.5N/m² and -1.0N/m².

12.5.39 As with the predicted decreases, the modelling of bed shear stress has predicted comparatively small increases from the baseline environment (see above), and in the context of these changes, the greatest increases were generally shown to occur in areas dominated by bedrock e.g. Cerrig Brith and Trwyn Cemlyn, with almost all modelled increases <1.0N/m². The exception are some highly localised areas where bed shear stress is predicted to increase, under certain wave conditions, to between 1.0N/m² and 3.0N/m². These increases are constrained to bedrock areas at Cerrig Brith and Trwyn Cemlyn, and during the high north wave an area just west to the mouth of the Cooling Water outfall. In areas of sediment floored seabed, where an increase is bed shear stress was predicted, it was usually less than 0.5N/m^2.

12.5.40 Changes adjacent to the breakwaters are generally predicted to manifest as reductions in bed shear stress, the main exceptions being increases in a small area between the breakwaters during the infrequent high north wave condition and also around Cerrig Brith under all spring tide conditions (figure D12-15) (Application Reference Number: 6.4.101).

12.5.41 For the high north wave, the increase in bed shear between the marine structures coincides with wave model outputs which indicate a wave funnelling effect in the same area.

12.5.42 Based upon the results of the modelling studies, overall changes in bed shear stress have been found to range mostly between -0.1N/m^2 and +0.1N/m^2 (figure D12-15) (Application Reference Number: 6.4.101). Changes in bed shear stress ranging between -0.1N/m^2 and +0.1N/m^2 are judged to generate no more than minor differences in terms of the transportable sediment fraction for both sands and gravels. Far larger differences in stress are required to generate significant changes to mobilisation of these grain sizes (if indeed sand or gravel materials are present).

12.5.43 As noted above, these positive and negative changes in maximum bed shear stress represent potential increases or decreases in sediment entrainment where they coincide with soft sediments. The significance of these changes upon the geomorphological receptors is discussed in the following sections.

Changes to fine sediments

12.5.44 Within the Delft3D model, predictions of changes to coupled waves and tidal currents have been used to investigate the potential effects of dispersal and deposition of a fine sediment plume which could be generated during construction by spillage from dredging activities and the introduction of suspended sediments from the drainage discharge across the Wylfa Newydd Development Area (appendix D13-8, Application Reference Number: 6.4.90).

12.5.45 The modelling shows, for a range of hydrodynamic scenarios the extent and depth that sediment could be dispersed and deposited on the seabed from dredging activities and drainage discharge. A primary objective of the modelling has been to determine whether any changes in the mobilisation and subsequent deposition of fine sediment could arise from construction activities; and the potential distribution and depth of changes in deposition patterns resulting from such changes.

12.5.46 The Delft3D model investigation included potential sources of increased suspended sediment concentrations from:

- the dredging of softer sediments (overburden) in breakwater locations;
- the excavation and removal of weathered bedrock in the CW intake channel and breakwater locations;

- barge disposal of dredged materials at the Disposal Site (appendix D13-12, Application Reference Number: 6.4.94); and,
- discharge to the marine environment from the drainage system at various locations from within the Wylfa Newydd Development Area (appendix D13-8, Application Reference Number: 6.4.90).

12.5.47 Increased fine sediment input could also come from dewatering of the dredged materials in the barge hold during construction at the Wylfa Newydd Development Area (to maximise capacity) as well as the subsequent release of sediment from the barge at the Disposal Site.

12.5.48 Halcrow [RD4] showed that where the settling velocity of larger particles is higher (e.g. 1mm/s) then the sediment would deposit nearer to the source. Smaller particles with a lower settling velocity (e.g. 0.2mm/s) would travel further and become more widely distributed, having therefore a potentially reduced effect over a wider area. The finest sediments with the lowest settling velocities (e.g. around 0.05m/s) would tend to remain in suspension and are therefore carried much greater distances.

12.5.49 Calm conditions (with no waves) have been represented within the hydrodynamic model Delft3D as a worst case scenario for the modelling of suspended fine sediment. This is due to the enhanced potential for fine sediments to settle locally to greater thicknesses or to be deposited at geomorphologically sensitive locations, such as the Esgair Gemlyn. Results indicate the extent to which fine sediments could still be carried under calm conditions, by tidal currents without surficial wave action, and the predicted settling depth and distribution on the seabed.

12.5.50 Results from the modelling indicate the dispersal of fine sediment under the action of tidal currents alone during calm conditions would take place rapidly. The potential deposition from dredging activity (see figure D12-16) (Application Reference Number: 6.4.101) will be greatest under the footprint of the dredging and therefore coincide with the area removed during dredging. Hence consideration is given to the seabed and thus geomorphological features that are beyond the footprint, with maximum deposition on the seabed being 0.5cm or less out-with the Wylfa Newydd Development Area. The greatest deposition from drainage discharge will be around the various discharge points to the marine environment (see figure D13-29, Application Reference Number: 6.4.101).

12.5.51 Within the inner area of Cemlyn Bay (see figures D12-16 and D13-29, Application Reference number 6.4.101), deposition of less than 0.1cm depth of sediment (equivalent to approximately the diameter of a coarse sand grain) would potentially occur during calm conditions (for details see appendix D13-8 (Application Reference Number: 6.4.90)). Due to the likely depth and location of deposition on existing soft sediments, the magnitude of this change upon the (low value) seabed is therefore considered to be negligible.

12.5.52 Under typical wave conditions, previous studies [RD4] indicate that within Cemlyn Bay and near to the proposed dredging locations, tidal currents and wave activity would combine to rapidly redistribute sediment which could have settled on the seabed. According to the literature, increased suspended sediment concentrations from Marine Works are generally short term (reverting to background levels less than one week after activity) and deposited within less than 1km from activity [RD4]. The hydrodynamic model results also show that the addition of a typical wave would assist the dispersal of fine sediments so deposition would be less than 0.1cm depth across the whole study area (see figure D12-16, lower image) (Application Reference Number: 6.4.101).

12.5.53 Other proposed Licensable Marine Activities (described in section 12.4) likely to release fine sediments into the water column would include the removal of the temporary causeway. In comparison with the proposed main dredging activities, the quantity of possible spillage would be considerably lower, the effects localised and shorter term. The magnitude of potential change in fine sediment deposition compared to background levels would therefore be negligible. The potential effects of increases in suspended sediment upon water quality are reported within chapter D13 (Application Reference Number: 6.4.13).

12.5.54 Table D12-18 summarises the changes to coastal and marine processes from the combined Licensable Marine Activities based on the outputs of the SWAN and Delft3D models.

Table D12-18 Summary of changes to coastal and marine processes during construction (partially built scenarios)

Coastal process	Change anticipated
Wave climate	Wave height: ranging between -14% to +9% in localised areas (for 1% probability events).
Tidal currents/waves	Bed shear stresses: ranging between +/- 1.0N/m^2 in localised areas.
Sediment dispersion and deposition	Deposition associated with dredging activities: <1mm maximum in localised areas.

Assessment of effects on coastal geomorphology receptors

12.5.55 This section presents the findings of the assessment of potential effects upon the coastal geomorphology receptors during construction. The effects at the Disposal Site are discussed under a separate section owing to its different offshore characteristics and geographical location away from the coastline.

The seabed and intertidal zone

12.5.56 Potential effects on the seabed and intertidal zone are summarised as:

- increased fine sediment deposition transported via new drainage pathways to the sea;
- increased fine sediment deposition due to dredging/excavation works;
- increased fine sediment input into the sea during construction of permanent structures;

- short-term changes to seabed and intertidal zone associated with temporary structures and their removal;
- loss of seabed and intertidal zone geomorphological features associated with permanent structures; and
- sediment mobilisation (erosion / deposition) caused by changes of bed shear stress.

12.5.57 New drainage pathways to the sea from the land surface and modified watercourses at Porth-y-pistyll and Cemlyn Bay would increase the potential for release and transport of suspended fine sediment and subsequent deposition on the seabed. Embedded mitigation measures to control fine sediment supply at source would include a new sustainable drainage system with settling ponds to trap particles at source (chapter D8; Application Reference Number: 6.4.8). Mitigation for fine sediment release from the land surface is covered in the Mitigation Route Map (Application Reference Number: 8.14) and the Code of Construction Practice (Application Reference Number 8.6). Within the dynamic coastal environment adjacent to the proposed Wylfa Newydd Development Area, any additional suspended sediment released would be rapidly dispersed, temporary and of short duration (see figure D13-23, Application Reference Number: 6.4.101). The resultant potential for increased sediment deposition from the drainage discharge is shown in figure D13-29 (Application Reference Number: 6.4.101) and is shown to be localised around the points of discharge. Worst case deposition of less than 1cm would be seen within 10s of metres from the point of discharge. Within Cemlyn Bay deposition would be less than 0.2cm under worst case conditions. Therefore, the magnitude of the change on the seabed (a low value receptor) would be small, resulting in a negligible significance of effect.

12.5.58 As noted above, the release of suspended sediments into the sea during construction dredging activities would have the potential to deposit no more than 0.5cm depth of fine sediment upon the seabed outside of the Wylfa Newydd Development Area (see figure D12-16, Application Reference Number: 6.4.101). Furthermore, hydrodynamic investigations confirm that tidal currents would rapidly disperse fine sediment inputs to near background concentrations even during calm conditions. There would be little or no degradation of the receptor. Therefore, the magnitude of effect of sediments released during construction dredging activities upon the low value seabed has been assessed to be negligible, resulting in a negligible significance of effect.

12.5.59 The release of suspended fine sediments into the sea during construction of temporary structures would also have the potential for deposition on the seabed. However, hydrodynamic investigations confirm that tidal currents would rapidly disperse fine sediment inputs to near background concentrations even during calm conditions. There would be little or no degradation of the receptor, with recovery expected relatively quickly. Therefore, the magnitude of effect of sediments released during construction dredging activities upon the low value seabed is considered to be negligible, resulting in a negligible significance of effect.

12.5.60 The release of suspended sediment into the sea during construction of permanent structures (including the two breakwaters and the Ro-Ro MOLF) would have potential for deposition. However, due to Licensable Marine Activities taking place within cofferdam exclusion areas, the effects would be contained within the enclosure. Any dewatering activities would monitor fine sediments, to ensure levels did not exceed limits given in the Environment Agency Pollution Prevention Guidance Notes. Although these have been withdrawn and are being replaced in Wales by Guidance for Pollution Prevention the contractor would be required to follow these. If required additional procedures such as settlement would be provided to meet this limit in chapter D1 (Application Reference Number: 6.4.1).

12.5.61 Therefore, the magnitude of effect of sediments released during construction of permanent structures upon the seabed (a low value receptor) has been assessed as negligible effect.

12.5.62 The footprint of the non-permanent structures (temporary ramp, berth and cofferdams) would represent a temporary loss of a relatively small area of the seabed (a low value receptor) and would experience a short-term and reversible effect. Embedded mitigation would include the removal of all temporary structures, with restoration of the seabed to its previous condition. The temporary structures would therefore lead to a small magnitude of change on the seabed (a low value receptor), resulting in a negligible effect.

12.5.63 The construction of the MOLF and breakwater structures would result in loss of natural seabed but would have a relatively small footprint totalling approximately 30ha.

12.5.64 As part of the embedded mitigation to mitigate the loss of seabed, the footprint of excavation has been reduced as far as practicable. The effect of Licensable Marine Activities upon the surrounding seabed could lead to some limited degradation, with recovery expected in the short-term. In this context, with the small magnitude of change in coastal and marine processes and low sensitivity of the seabed receptor, the significance of effect of the construction of permanent structures upon the seabed has been assessed as minor.

12.5.65 As noted in the previous section of the assessment, changes in bed shear stress (and associated sediment mobilisation) due to the presence of the new breakwater structures would be of small magnitude. The resulting significance of this localised effect upon the low value seabed receptor has therefore been assessed as minor.

12.5.66 Based on the of the potential changes in bed shear stress (spatial distribution, magnitude and extent), the baseline characteristics of underlying substrate in the location of change (where sediments are present), the overall significance of the effect on the seabed (a low value) receptor is assessed to be negligible.

Cemaes Bay

12.5.67 Potential effects on Cemaes Bay during construction are summarised as:

- increased fine sediment deposition associated with construction dredging activities and drainage discharge; and
- increased coarse sediment mobilisation or erosion associated with changes in coastal and marine processes.

12.5.68 Cemaes Bay is separated by the headland of Wylfa Head from any localised effects of scour or deposition resulting from construction activities within Porth-y-pistyll. Hydrodynamic (Delft3D) model investigations of the sediment plumes from dredging and drainage discharge show the pattern of fine sediment dispersion and deposition. The model results show no deposition in Cemaes Bay from dredging and only localised plumes and deposition (within 10's metres) at the drainage discharge points from the Wylfa Newydd Development Area (see figures D12-16 and D13-29, Application Reference Number: 6.4.101). Due to the dynamic nature of the coastal environment around Wylfa Head and Cemaes Bay, suspended sediment would be rapidly dispersed to background concentrations.

12.5.69 As noted above, the potential effect of fine sediment inputs associated with construction dredging activities reported within appendix D13-8 (Application Reference Number: 6.4.90) confirm no change to the suspended sediment load within Cemaes Bay and therefore no effect on Cemaes Bay, a low value receptor.

12.5.70 The potential magnitude of the change of fine sediment transported via new drainage pathways upon Cemaes Bay has also been assessed to be negligible, and therefore there would be no effect on Cemaes Bay, a low value receptor.

12.5.71 Similarly, small magnitudes of change in bed shear stress would also have little to no effect on coarse sediment mobilisation in Cemaes Bay. Small pockets of increased and decreased bed shear, predicted in various locations under all wave scenarios, lie within the lowest ranges of +0.1N/m^2 to +0.5N/m^2 and -0.1N/m^2 to -0.5N/m^2 respectively. Areas where increased bed shear have been predicted are mainly coincidental with bedrock seabed or rocky intertidal zone. Changes to coastal and marine processes would be of negligible magnitude, resulting in little or no degradation with no permanent effect upon the integrity of the low value Cemaes Bay receptor. It is therefore considered that the significance of effect on this receptor would be negligible.

Cemlyn Bay

12.5.72 Potential effects on Cemlyn Bay during construction are summarised as:

- increased fine sediment deposition transported via new drainage pathways and/or dredging/excavation works;
- short-term changes to seabed and intertidal zone associated with temporary structures and their removal; and
- loss of seabed and intertidal zone geomorphological features associated with permanent structures.

12.5.73 As noted above and shown in appendix D13-8 (Application Reference Number: 6.4.90) modelling from the drainage discharge confirm a negligible magnitude of change in the fine sediment deposition within Cemlyn Bay. Results from the drainage discharge show a minor increase in sediment deposition under worst case conditions of less than 0.2cm in Cemlyn Bay (also see figure D13-29, Application Reference Number: 6.4.101). Deposition results from dredging activities in Cemlyn Bay also show minor increases of sediment deposition under worst case conditions of less than 0.5cm in the outer bay and less than 0.1cm in the inner bay (see figure D12-16, Application Reference Number: 6.4.101). However, these worst case results would not affect the integrity of the receptor with little or no degradation. The potential magnitude of the change of fine sediment transported via new drainage pathways and from dredging activity deposited within Cemlyn Bay, a medium value receptor, has therefore been assessed to be negligible, resulting in a minor significance of effect.

12.5.74 Similarly, small magnitudes of change in bed shear stress would also have little effect on coarse sediment mobilisation in Cemlyn Bay. Areas of increased and decreased bed shear, that have been predicted in various locations under all wave scenarios, lie mainly within the lowest ranges of $+0.1N/m^2$ to $+0.5N/m^2$ and $-0.1N/m^2$ to $-0.5N/m^2$ respectively, with some very small patches within the higher ranges of $+0.5N/m^2$ to $+1.0N/m^2$ and $-0.5N/m^2$ to $-1.0N/m^2$ respectively.

12.5.75 Embedded mitigation would include the concrete armour at the western breakwater along the seaward perimeter to increase roughness and dissipate the energy of incoming waves thus reducing the extent of changes to wave energy through reflection. Areas where increased bed shear have been predicted are mainly coincidental with bedrock seabed or rocky intertidal zone. Comparison with the baseline values in areas of soft sediments has shown these changes would be of negligible magnitude with little or no degradation likely and no permanent effect upon the integrity of the medium value Cemlyn Bay receptor. It has therefore been assessed that the proposed construction of both temporary and permanent structures would have a minor significance of effect upon Cemlyn Bay.

Esgair Gemlyn

12.5.76 Potential effects on Esgair Gemlyn during construction are summarised as:

- increased fine sediment deposition on the shingle ridge, Esgair Gemlyn resulting from construction activities; and
- changes to form and/or integrity of Esgair Gemlyn due to changes in coastal and marine processes (e.g. wave action) resulting from construction activities at Porth-y-pistyll.

12.5.77 The potential risk of increased deposition of additional suspended load from the marine environment upon the high value Esgair Gemlyn receptor has been investigated through the hydrodynamic (combined tidal currents and waves) plume modelling scenarios (appendix D13-8, Application Reference Number: 6.4.90). Potential effects from a change in fine sediment deposition upon the Esgair Gemlyn could include smothering or could impair the hydrological connection between the sea and Cemlyn Lagoon.

12.5.78 The outcomes of baseline studies (reported in appendix D12-2, Application Reference Number: 6.4.81) show no linkage or pathway between potential sources of fine sediment from fluvial sources and Esgair Gemlyn. Furthermore, the modelling investigations (see appendix D13-8, Application Reference Number: 6.4.90) also depict the potential movement and deposition of fine sediment from dredging activities and drainage discharge during construction under calm conditions (representing a worst case scenario) to be limited to a localised area close to where the dredging of sediment would occur and at the point of discharge from the Wylfa Newydd Development Area. Potential worst case deposition is predicted to be less than 0.1cm at Esgair Gemlyn. The magnitude of potential change in fine sediment deposition upon Esgair Gemlyn, which is a high value receptor, has therefore been assessed to be negligible, resulting in a negligible significance of effect.

12.5.79 With regard to coarse sediments Esgair Gemlyn has been identified in the literature as a legacy feature with no significant longshore sediment processes [RD13] and is therefore assessed in this context. Wave action, when influenced by the long fetch of open water of the Irish Sea to the north, has the potential to maintain geomorphological processes during high energy conditions. Potential changes in wave height indicated by model outputs suggest there could be an effect during a narrow band of high energy waves coming from northerly directions. During typical summer conditions the increase has been shown to be negligible (appendix D12-3, Application Reference Number: 6.4.82). For several wave scenarios, a decrease in wave height has been predicted by the model, especially for waves from the northeast.

12.5.80 For worst case scenarios, such as rare (99th percentile) winter waves arising from north-westerly directions during construction activities, this could represent a potential increase in wave height up to approximately +2% (for a partially built scenario; see table 12-17) and up to approximately +4% (for a fully built scenario; table 12-19). These percentages would affect baseline values in the range of 1.0m to 1.2m resulting in an increase of up to approximately +0.05m under present day winter storm conditions. The increased wave height is lower than that of baseline storm waves arising from the northeast, consequently this change is within the range of natural variation.

12.5.81 Due to the uncertainty of climate change effects upon the magnitude and frequency of storm events and the high value of the Esgair Gemlyn receptor, a precautionary approach has been taken. The magnitude of change has been assessed to be small, resulting in a minor significance of effect on Esgair Gemlyn, a high value receptor.

12.5.82 A topographic assessment of Digital Terrain Model data of the Esgair Gemlyn comparing historic LiDAR data [RD15] with recent cross profile dimensions (obtained by Jacobs in 2017) shows short-term adjustments cannot be relied upon as firm indicators of change, but do confirm the dynamic nature of the feature. When assessed in combination with the historic data presented by earlier studies [RD13], the evolving baseline condition for the shingle ridge feature appears to be that infrequent high energy events could have a small effect upon the eastern end of the shingle ridge leading to a lowering and landward movement of the ridge crest.

12.5.83 Within this context, the potential maximum increase in a relatively low winter wave height of 4% is confirmed as negligible. The significance of effect on the shingle ridge (Esgair Gemlyn), a high value receptor, is considered to be negligible Cemlyn Lagoon.

12.5.84 Potential effects on Cemlyn Lagoon during construction are summarised as:

- Increased wave height leading to overtopping into Cemlyn Lagoon.

12.5.85 For the Nant Cemlyn (which drains to the Cemlyn Lagoon) specific measures to manage the discharge of sediment would be undertaken during construction of Mound E (as stated on the Main Power Station Site sub-CoCP, Application Reference Number: 8.7). Flow would be diverted into the Afon Cafnan until vegetation establishes and risk of sediment discharge (as agreed with NRW) would be low

- No polyelectrolyte dosing will be employed for discharge E1;
- From the point of commencement of earthworks on the west of Mound E onwards, no water will be discharged into Nant Cemlyn via discharge E1 until vegetation has re-established and risk of sediment run off is agreed with NRW to be low;
- After establishment of vegetation, if there are any additional bulk earthworks on the west of Mound E resulting in a risk of sediment discharge, no water will be discharged into Nant Cemlyn via discharge E1 until re-establishment has been again been agreed in writing with NRW; and
- During the above period(s) all water to be diverted and discharged into the Afon Cafnan via discharge E2.

12.5.86 Therefore, the magnitude of change has been assessed as negligible. The significance of effect of fine sediment runoff from drainage pathways upon the high value Cemlyn Lagoon has therefore been assessed as negligible.

12.5.87 The small magnitude changes in wave height during construction at times of extreme events and their potential effect upon the lagoon boundary, Esgair Gemlyn are discussed above. Taking a precautionary approach, the magnitude of potential effects upon Cemlyn lagoon, a high value receptor, due to possible increases in overtopping has been assessed to be small, resulting in only a minor significance of effect.

Hen Borth

12.5.88 Due to the distance of Hen Borth from the proposed marine construction activities at the Wylfa Newydd Development Area and prevailing tidal currents (detailed in appendix D13-8, Application Reference Number: 6.4.90), there is very little potential for this high value geomorphological receptor to be affected. Analysis of the sediment regime baseline (reported in appendix D12-2, Application Reference Number: 6.4.81) further explains and supports these findings.

12.5.89 Assessment of potential effects of construction activities upon coastal and marine processes has determined that there would be negligible changes which could result in either deposition or the accelerated erosion of the Hen Borth cliff formation. It is therefore assessed that there would be negligible significance of potential effects during the period of construction at Hen Borth (a high value receptor).

Disposal Site (seabed)

12.5.90 During construction, the Disposal Site would be used to receive a combination of fine and coarse sediment as well as rock material generated by dredging activities at the Wylfa Newydd Development Area. It is intended that the rock material will be microsited near to the eastern margin of the Disposal Site.

12.5.91 Characterisation of the site and the assessment of potential effects at the Disposal Site are based upon the results of 3D sediment transport modelling within Delft3D.

12.5.92 Dispersal and deposition investigations for the expected disposal regime of sands and silts considered the potential effects of two daily disposals of 3,500m^3 for 35 days up to a total volume of 242,000m^3 of bulked soft sediment. Rock disposal comprising approximately 368,000m^3 of bulked rock material has been investigated in relation to possible changes in seabed processes (appendix D13-8, Application Reference Number: 6.4.90). The worst case volume for all material that could require disposal at sea is approximately 610,000m^3.

12.5.93 Specific potential effects could be:

- deposits building up the seabed and altering the bathymetry; and
- alteration of flow velocities due to deposits from dredging.

12.5.94 The Modelling shows only very limited build-up of sediment on the seabed in terms of both thickness (0.43m) and lateral extents (figure D12-17) (Application Reference Number: 6.4.101). This compares to water depths at the Disposal Site which range from approximately 45m and 90m (Application Reference Number: 6.4.101). The model runs have indicated rapid dispersal of fine material with concentrations reducing to background levels within 48 hours (Application Reference Number: 6.4.94).

12.5.95 In comparison to other Licensable Marine Activities at the previous Holyhead Deep Disposal Site, the Wylfa Newydd Development Area dredge operations (fine fraction estimated at 1,568m^3/day) would be considerably smaller than other disposals e.g. port dredge operations (fine fraction estimated at 15,000m^3/day). The magnitude of the potential effect upon the seabed (a low value receptor) specifically as a result of sediment disposals from the Wylfa Newydd Development Area has been assessed to be small, resulting in a negligible effect.

12.5.96 Disposal of rock on the seabed has been shown to have a small magnitude of effect on surrounding flow velocities (local flow accelerations) (Application Reference Number: 6.4.94). The significance of effect has therefore been assessed to be negligible in the context of seabed (a low value receptor) at that location (appendix D13-12, Application Reference Number: 6.4.94).

12.5.97 On the basis of the Delft3D modelling results, the overall magnitude of effect of the combined dredge disposal activities for the Wylfa Newydd Development Area construction activities has been assessed as small and the significance of the effect upon the seabed (a low value receptor) is therefore minor.

Operation

Operation of the MOLF, the CW intake and outfall

12.5.98 The operational lifespan of the Power Station Site (60 years) is expected to begin after approximately 10 years of construction. The assessment of potential effects has involved investigations into the likely changes in coastal and marine processes (i.e. waves and tidal currents) which could lead to changes in geomorphological processes (i.e. sediment erosion, transport and deposition) which over time are likely to establish a new dynamic equilibrium.

Determination of potential changes to coastal and marine processes

12.5.99 Longer term conditions, including progressive sea level rise and other episodic changes such as the magnitude and frequency of storm events, have been represented in the evolving baseline and post-development model outputs. However, it is noted that the uncertainty of prediction is greater for future scenarios in appendix D13-8 (Application Reference Number: 6.4.90). A breakdown of the assessment of potential changes to coastal and marine processes has been considered first, followed by the associated effects upon geomorphological receptors.

Waves, tidal currents and seabed shear stresses

12.5.100 The same effects on waves, tidal currents and seabed shear stresses from the marine layout are taken to occur in the operational phase as those towards the end of the construction phase. Therefore, the assessment on geomorphology receptors is taken to be the same already made.

12.5.101 Additionally, during operation, the potential changes to waves have been investigated in comparison with the current and evolving baseline using the SWAN modelling results (appendix D12-3, Application Reference Number: 6.4.82). Wave changes during the operational period for the ‘worst case’ winter storm scenario (represented by the 2087 reasonably foreseeable winter 99th percentile, north-west sector results) is illustrated in figure D12-13 (lower right image) (Application Reference Number: 6.4.101).

12.5.102 This map shows extensive areas of no discernible change in wave heights under future ‘worst case scenario’ storm conditions. Areas of decreased wave height appear alongside of localised increases in wave height, mainly adjacent to the new marine structures and within the new harbour area.

12.5.103 Further statistical analyses of the model time series were carried out to investigate local changes west of the western breakwater and at the head of Cemlyn Bay adjacent to Esgair Gemlyn. A summary of the predicted percentage changes in wave height at model points 6 and 8 is presented in table D12-19 below.

Table D12-19 Changes in wave height (SWAN model results) for reasonably foreseeable (2087) scenarios over 35.5 -year model period

Point	Difference (fully built minus baseline) in significant wave heights for reasonably foreseeable (2087) winter wave from north-west		Difference (fully built minus baseline) in significant wave heights for reasonably foreseeable (2087) winter wave from north-east	
	Difference in mean significant wave height (%)	Difference in 99% significant wave height (%)	Difference in mean significant wave height (%)	Difference in 99% significant wave height (%)
6 (Cemlyn Bay)	+4%	0.8%	0%	0%
8 (Western Breakwater)	+10%	+11%	-14%	-12%

Source: SWAN (appendix D12-3, Application Reference Number: 6.4.82)

12.5.104 The results provided in table D12-19 show the differences in wave heights for the two wave height metrics for the partly built and fully built structures under the reasonably foreseeable future (2087) scenarios extracted from the 35.5-year time series. Both baseline and partially/fully built foreseeable future datasets represent an increase in wave heights and wind speeds by 10%, and a corresponding increase in wave period of five seconds, as representative of the future climatology. The foreseeable future datasets also correspond to increased water levels of 0.62m.

12.5.105 These data correspond to difference plots (images) shown in figure D12-13 (Application Reference Number: 6.4.101) for the reasonably foreseeable future (2087), winter storm 99th percentile conditions for fully built northwest and fully built northeast scenarios, presented as a common wave direction) and the worst case (northeast).

12.5.106 Immediately west of the western breakwater (point 8) the differences in wave height predicted by the wave model include the following potential changes:

- Under a fully built scenario and storm waves approaching from the north-west, there could be a change in wave height ranging between +10% to +11%.

- Under a fully built scenario, with storm waves approaching from the north-east, there could be a change in wave height ranging between -12% to -14%.

12.5.107 Adjacent to the Esgair Gemlyn within Cemlyn Bay (point 6):

- Under a fully built scenario with storm waves approaching from the north-west, there could be a change in wave height ranging between +4% and 0.8%.
- Under a fully built scenario, with storm waves approaching from the north-east, there could be no change in wave height.

12.5.108 During model runs for the northwest wave direction, a localised area to the west of Cemlyn Bay of slightly elevated wave height (figure D12-13, lower right image) (Application Reference Number: 6.4.101) is evident; potentially a result of shoaling across the ebb tidal delta deposit formed by the long term drainage from the lagoon. Elsewhere, and across the majority of Cemlyn Bay, changes in wave height within the bay are negligible.

12.5.109 Potential changes to wave heights in Cemlyn Bay under future storm conditions i.e. for the highest waves arising from the northwest, are depicted across most of Cemlyn Bay as having no discernible change (figure D12-13) (Application Reference Number: 6.4.101). Statistical analysis of data adjacent to Esgair Gemlyn (at point 6), show a change in wave heights ranging between +0.8% and +4% upon a baseline wave height of 1.2m to 1.4m (figure D12-3) (Application Reference Number: 6.4.101). The lower right image in figure D12-13 (Application Reference Number: 6.4.101) shows a very small area of increase in wave height at an area of shallow seabed associated with the lagoon ebb tidal delta. Here the shoaling of waves in combination with the angle of wave reflection and deflection around the Trwyn Cemlyn headland combine to generate a small increase in wave height under winter storm conditions with waves from the north-west. It is however important to note that this locally increased wave height would remain lower than the predicted height of storm waves arising from the northeast.

12.5.110 For storm waves arising from the northeast, statistical analysis identified no change in wave height at Esgair Gemlyn (point 6). West of the western breakwater (at point 8), the results indicate a potential decrease in wave height ranging between -12% to -14% upon a baseline wave height of 3.0m to 3.5m (appendix D12-3, Application Reference Number: 6.4.82).

Sediment processes

12.5.111 The potential for effects upon the sediment regime due to wave action under increased sea level and/or increased frequency or intensity of storm conditions associated with climatic change would potentially have an effect in the near shore zone (appendix D12-2; Application Reference Number: 6.4.81). In this context, within the evolving baseline there is a recognised potential for higher waves and more intense storm surges to act upon mobile sediments in sensitive parts of the coastline. The implications for the high value Esgair Gemlyn shingle ridge receptor are discussed below.

Sediment plume study and deposition

12.5.112 Dredging is likely to be required to maintain sufficient depth in front of the intake and to allow continued access to the MOLF, but is not considered within the assessment.

Assessment of effects on coastal geomorphology receptors

12.5.113 During operation, potential effects upon the geomorphology receptors have been assessed using the Delft3D model and SWAN model outputs for tidal currents and waves over longer term scenarios. The geomorphology receptors potentially affected during operations include the seabed (low value) and high value Esgair Gemlyn.

The seabed (and intertidal zone)

12.5.114 The Delft3D model investigations include the ongoing operation of the cooling water structures upon coastal and marine processes, including the discharge flows from the CW outfall. Changes to bed shear stress depicted in figure D12-15 (Application Reference Number: 6.4.101) indicate small areas of increased bed shear at the CW outfall location. However, these coincide with locations where soft sediments are not present and therefore no changes to sediment mobilisation would occur. At the CW intake some decreases in bed shear are predicted under winter and high north wave scenarios; however, under no wave and typical wave scenarios, there would be no discernible change. It has therefore been assessed that the magnitude of effect upon the seabed (a low value receptor), of the operation of both the cooling water intake and outfall would be negligible, resulting in a negligible significance of effect.

12.5.115 Changes in sediment entrainment patterns due to the presence of permanent structures over the medium and long-term would be expected to be similar to those reported for construction activities (above) but with potentially increased frequency for high energy events. There would be no changes to the pathway or linkage between the current seabed sediment supply and other geomorphological receptors. Potential changes are likely to be of small magnitude, with increases or decreases falling within the range of natural variability under the full range of conditions, with opportunities for recovery. Therefore, significance of potential longer term effects of permanent structures upon the low value seabed receptor would be minor.

12.5.116 There is uncertainty associated with sea level rise as part of the evolving baseline. The Delft3D model results predict that long-term changes to seabed shear stress would not be discernibly affected by a rise in sea level, as the percentage change in water depth would be minimal. The frequency of storm events could however have implications for the magnitude and frequency of bed shear stress.

Cemaes Bay

12.5.117 Due to the distance between the Power Station Site and Cemaes Bay, and the limited extent of the effects of operational activities, the magnitude of longer term effects has been shown by the modelling results to be negligible.

Therefore, the significance of effect on Cemaes Bay (a low value receptor) has been determined to be minor.

Cemlyn Bay

12.5.118 Potential effects on Cemlyn Bay during operation could include changes to the seabed and intertidal zone geomorphological features resulting from the presence of permanent structures.

12.5.119 Over longer time periods, changes in wave heights predicted by the SWAN wave model for the worst case scenario, winter 99th percentile storm waves from the northwest sector (figure D12-13, lower right images) (Application Reference Number: 6.4.101) predict no change in significant wave heights for the majority of the area across Cemlyn Bay. In some sheltered areas decreases in wave height have been shown, whilst in other locations, small areas of slight increase up to a maximum of +11% (immediately west of the western breakwater) are predicted. Adjacent to Esgair Gemlyn, statistical analysis indicates more modest increases of up to +4% (table D12-19).

12.5.120 For storm waves arriving from the northeast, statistical analysis has confirmed a 0% wave height increase adjacent to Esgair Gemlyn and a -12% to -14% decrease to the west of the western breakwater (table D12-19).

12.5.121 Changes in bed shear stress arising in construction would be expected to continue (as noted earlier). The hydrodynamic modelling results indicate only localised changes in sediment mobilisation in the outer bay and offshore areas. The longer term magnitude of changes in bed shear stress on the medium value receptor, Cemlyn Bay is considered to be small, with disturbance in the range of natural variability and short term recovery. Therefore, the significance of effect has been determined as minor.

Esgair Gemlyn

12.5.122 Longer term potential effects of increased significant wave height upon the Esgair Gemlyn shingle ridge have been investigated through wave model reasonably foreseeable (2087) scenarios, which have taken account of climate change influences. The predicted changes in wave height for a worst case scenario winter storm discussed above (see also figure D12-13, lower right image) (Application Reference Number: 6.4.101), show that the magnitude of the changes to wave height would be relatively small compared to the evolving baseline conditions. Therefore, the significance of effect upon the high value Esgair Gemlyn has been assessed to be minor.

12.5.123 Predicted changes due to climatic change alone recognised within the SMP2 [RD9], would be unchanged with or without the Power Station.

Cemlyn Lagoon

12.5.124 Modelling has demonstrated that the magnitude of effects on Cemlyn Lagoon arising from changes in coastal and marine processes (including changes in wave height) resulting from the operation of the Power Station would be small. The effect of potential changes in wave height and associated risk of overtopping would be small and within the range of natural variation. The value of the receptor is high but the significance of effect has been assessed as minor.

Hen Borth

12.5.125 Due to the distance of Hen Borth from the Power Station Site and the limited extent of the effects of operational activities, the magnitude of longer term effects on coastal and marine processes has been shown by the modelling results to be negligible. Therefore, the significance of effect of operation activities upon Hen Borth, a high value receptor, has been determined to be negligible.

Disposal Site

12.5.126 During operations, the Disposal Site would be used to receive occasional inputs of fine sediment material generated by maintenance dredging activities. The volume of the material required to be removed would be considerably lower than that for the capital dredging work undertaken during construction, possibly representing less than ten percent. The dredged material would be fines and highly dispersive in nature. The magnitude of change would be negligible. The significance of the effect upon the seabed (assessed as a low value receptor) has therefore been determined to be negligible.

Decommissioning

Determination of changes to coastal and marine processes

12.5.127 Since decommissioning would not commence until after the 60-year operating period, there are uncertainties associated with the specific characteristics of the environmental baseline conditions that would apply at that time. The works required to decommission the Power Station Site would be subject to a separate Environmental Impact Assessment assessing the effects in detail against the baseline conditions at that time. The effects summarised below mainly relate to the construction works required to remove the structures.

12.5.128 Construction activities required during decommissioning would be likely to result in a temporary increase of fine sediment input to the sea. This additional suspended sediment could also lead to increased deposition, potentially affecting coastal geomorphology receptors such as the seabed at Porth-y-pistyll and Cemlyn Bay. Potential sources of additional material could include:

- changes in the suspended sediment load of runoff and discharges reaching the sea from land surfaces;
- removal of inland drainage systems; and
- removal of Permanent Marine works.

12.5.129 These potential effects would be reduced by the incorporation of mitigation, including adherence to construction good practice, sediment control and government planning policy. The magnitude of change on any of the coastal geomorphology receptors has been assessed as being small and therefore resulting in a minor significance of effect.

Transboundary effects

12.5.130 The physical distances between the Power Station Site and Disposal Site and the nearest point of land on the Irish coast is in excess of 100km. The assessment has shown that changes to waves and currents are localised to Cemlyn Bay (including Porth-y-pistyll) and to the Disposal Site and do not extend for more than a couple of kilometres. The suspended sediment plume arising from dredging and disposal is potentially more extensive, the modelling showing that it can extend for up to about 12km. However even at these distances the amounts of sediment deposition on the seabed would be negligible and probably not detectable. There would therefore be no transboundary effects arising from changes to coastal or marine processes.

12.6 Additional mitigation

12.6.1 In accordance with chapter B1 (Application Reference Number: 6.4.1), embedded and good practice mitigation measures relevant to coastal and marine processes and coastal geomorphology were taken into account when determining the ‘pre-mitigation’ significance of effects. These are detailed in section 12.4 of this chapter: Design basis and activities.

Construction

12.6.2 No significant effects have been identified through the assessment work carried out and therefore there would be no need for additional mitigation.

Operation

12.6.3 No significant effects have been identified through the assessment work carried out and therefore there would be no need for additional mitigation.

Decommissioning

12.6.4 No significant effects have been identified through the assessment work carried out and therefore there would be no need for additional mitigation.

12.7 Residual effects

12.7.1 No significant adverse effects were identified for coastal and marine processes and geomorphology.

12.7.2 Minor effects identified in the assessment of effects section are summarised in appendix I3-1 (master residual effects table) (Application Reference Number: 6.9.8).

12.8 References

Table D12-20 Schedule of references

ID	Reference
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