HORIZON NUCLEAR POWER

WYLFA NEWYDD

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D12.1 Executive summary

D12.1.1.1 Horizon Nuclear Power Wylfa Limited (Horizon) is currently planning to develop a new nuclear power station at Wylfa, Anglesey. The Wylfa Newydd DCO Project requires a number of applications to be made under different legislation. As a nationally significant infrastructure project under the *Planning Act 2008*, the construction and operation must be authorised by a Development Consent Order.

D12.1.1.2 Jacobs UK Ltd (Jacobs) has been commissioned by Horizon to undertake a coastal geomorphology baseline assessment to assist in identifying suitable geomorphological receptors and to then inform the various applications, assessments and permits that will be submitted for approval. This report summarises the findings from a desk study/walkover survey conducted along the coastline in November 2014. It also summarises specific geomorphological work undertaken for the National Trust within Cemlyn Bay in 2010.

D12.1.1.3 This appendix does not cover the offshore baseline including the Holyhead North Disposal Site. Rather this aspect of the baseline is referenced in the Sediment Regime appendix D12-2 Sediment Regime (Application Reference Number: 6.4.81) and in volume D12 Coastal processes and coastal geomorphology (Application Reference Number: 6.4.12).

D12.1.1.4 The study area for coastal geomorphology receptors was initially chosen during a walkover survey and extends approximately 2km east of Wylfa Head to 3km west. A classification of the coastal geomorphology of this study area has been developed which is bespoke to this report. This has helped form a view on the “sensitivity” of the coastal features/ receptors.

D12.1.1.5 The study area falls within three Water Framework Directive coastal water bodies, namely Anglesey North and the Skerries, both currently recorded as being at good status; and Cemlyn Lagoon (which is defined as Heavily Modified). Designated sites within the study area are:

- The Cemlyn Bay SAC, including the Esgair Gemlyn shingle beach and the Cemlyn lagoon
- The Cemlyn Lagoon SSSI
- The Ynys Feurog, Cemlyn Bay and the Skerries SPA
- Hen Borth Cliff (a Geological SSSI)

D12.1.1.6 None of these designations are for geomorphology per-se, but geomorphological forms and processes are vital to the structure and function of designated sites. This report also draws upon information contained within the West Wales Shoreline Management Plan (SMP2) [RD1].

D12.1.1.7 The key findings are that the study area as a whole is made up mainly of hard rock cliffs with pocket sandy bays. The hard geology was covered by ice sheets in the last glaciation and loose material eroded/detached in this period has since been moved and sorted by currents driven by tidal and wave forces. Offshore, the sea floor is composed of a mixture of solid with outcropping bedrock, boulders, cobbles, gravels and sands. Sediments have gathered locally together to form beaches along the shore including the shingle ridge (Esgair Gemlyn) in Cemlyn Bay. Cemlyn Bay and Cemaes Bay both appear typical of a re-entrant trap whereby sediment is retained within a relatively closed system. Both bays are bounded by headlands. Whilst there will be local sediment movement, the topography is not that of a coastline conducive to longshore sediment transport.

D12.1.1.8 The work by Pye and Blott (2010) suggests that Esgair Gemlyn (the shingle barrier) currently is in no immediate danger of a major breach and that over-washing is relatively infrequent and small scale. The rate of retreat indicated by historical maps is low (less than 0.2m per year since the late 19th century). The authors also suggested that there are no obvious signs of new sediment supply to the barrier. The frequency of over-washing appeared to have increased along the central part of the barrier since 2000, and a severe event could occur at any time, potentially leading to breaching at the narrowest and/or lowest point [RD2]. This work was updated in a subsequent report in 2016 which in particular showed that the Esgair Gemlyn did not suffer serious damage during the stormy winter of 2013-2014 [RD3].

D12.1.1.9 In terms of long-term evolution of the baseline, the rocky coast throughout the study area will typically be extremely slow to change, even with strong tidal currents. This is because of the hard geology, although baseline information indicates that there will locally be some increase of erosion risk as a consequence of rising sea levels.

D12.1.1.10 In particular, Pye and Blott (2010) suggested that the frequency and severity of over-washing of Esgair Gemlyn is to increase, leading to a more rapid landward movement of the barrier and adoption of a flatter profile [RD2; RD3]. By 2100, over-washed shingle may cover the area now occupied by the islands and in the longer term a new tidal inlet could develop in this area. They indicated that consideration will therefore need to be given to the options to re-locate or modify the islands in the medium term (2030-2060) as part of a managed realignment approach (SMP2, (2011)) [RD1]. Further details are given in Annex B.

D12.1.1.11 This geomorphological baseline assessment in this report has enabled the selection of a series of receptors as follows:- .

- the seabed (including inter-tidal);
- Cemaes Bay;
- Cemlyn Bay;
- Esgair Gemlyn;
- Cemlyn Lagoon; and
- Hen Borth, a geological SSSI located to the west within the study area.

D12.2 Introduction

D12.2.1 Overview

D12.2.1.1 Horizon is currently planning to develop a new nuclear power station at Wylfa, Anglesey. The Wylfa Newydd Project will require a number of applications to be made under different legislation. As a nationally significant infrastructure project under the *Planning Act 2008*, the construction and operation must be authorised by a Development Consent Order. The Wylfa Newydd Project has a number of marine activities that could potentially have environmental effects, including two breakwaters, a Marine Off-Loading Facility, the intake and outfall for cooling water discharges and associated dredging and disposal of bedrock and sediments.

D12.2.1.2 Jacobs has been commissioned by Horizon to undertake a coastal geomorphology baseline assessment to assist in identifying suitable coastal geomorphology receptors and to subsequently inform the various applications, assessments and permits submitted for approval. This baseline assessment is contained within this appendix and comprises a coastal geomorphology walkover survey undertaken by Jacobs in November 2014, informed by a desk study. The report also contains the findings of a geomorphological study undertaken by Pye and Blott [RD2; RD3] for the National Trust. The latter is specifically for the shingle beach (Esgair Gemlyn) in Cemlyn Bay which is a designated wildlife site and is known to be a feature potentially sensitive to change in the future. The shingle ridge, together with a water control structure to its northern end, supports a brackish lagoon which sits to its landward side.

D12.2.1.3 This appendix does not cover the offshore baseline including the Holyhead North Disposal Site. Rather this aspect of the baseline is referenced in the Sediment Regime appendix (Application Reference Number: 6.4.81) and in volume D12 of the Environmental Statement (Application Reference Number: 6.4.12).

D12.2.2 Report purpose

D12.2.2.1 The objective of the coastal geomorphology baseline report is to provide information which will assist in identifying suitable geomorphological receptors for the assessment of effects due to activities associated with the Wylfa Newydd Project. It provides insight into the character and sensitivity of the coastline and associated geomorphological and sedimentological processes. It summarises the potential evolution of baseline in light of projections of future climate and associated sea-levels.

D12.2.2.2 The report is specifically intended to provide information for the Environmental Impact Assessment and Habitats Regulation Assessment. It also provides information which is used in the Water Framework Directive (WFD) assessment associated with this Wylfa Newydd DCO Project. There is also the need for a specific assessment of dredging activities (as part of a Marine Licence application).

D12.2.2.3 This report does not however make an assessment of potential impacts from the Wylfa Newydd Project. Rather this is addressed in the Environmental Statement chapters B12 (Application Reference Number: 6.2.12) and D12 (Application Reference Number: 6.4.12). Information is drawn from the oceanographic interpretative report [RD4] to better understand the context for geomorphological processes operating in the offshore area proposed to be dredged, the nearshore zone and on beaches. Summary and interpretation of bathymetry and sediment regime data/information is dealt with separately in appendix D12-2 (Application Reference Number: 6.4.12). The results of wave modelling and wave transformation and combined waves and current modelling (for baseline scenarios) are also dealt with in Appendix D12-3 (Application Reference: 6.4.82) and Appendix D13-8 (Application Reference: 6.4.90).

D12.2.2.4 Annex A provides a glossary of terms used in this report.

D12.3 Methodology

D12.3.1 Desk study method

D12.3.1.1 The coastal geomorphology baseline assessment is based on a combination of a desk study, which reviews the existing information, and a site visit to allow baseline observations to be made.

D12.3.1.2 The desk study comprised a review of the existing information within the following documentation (see Table D12.3-1 below)

Table D12.3-1 References sources (References given in full in section 16)

RD	Source	Relevance
RD 1	Wales Coastal Forum. 2011.	Shoreline Management Plan characterising the coastal baseline and evolution of the baseline.
RD2	Pye, K. and Blott, S.J. 2010.	Historic maps, photographs and other more recent topographical data showing changes to the coastline over time (particularly Esgair Gemlyn and Cemlyn Bay more widely).
RD3	RD1 Pye, K. and Blott, S.J. 2016.	Update on a 2010 study showing evolving baseline (using LIDAR) too compare with other measurements
RD4	Horizon Nuclear Power. 2012.	Oceanographic interpretative report providing wave, currents and bathymetric information.
RD5	Natural Resources Wales. 2015.	River Basin Management Plan characterising the coastal baseline and depicting pressures/ issues affecting the coastal water bodies.
RD6	Horak, J.M. and Evans, J.A. 2011.	Paper characterising important geological characteristics of the cliffs.
RD7	Greenly, E. 1919.	Provides an understanding of the geology of the coastline
RD8	Bowen, D. Q. 1977.	Provides an understanding of the Holocene transgression and sea bed sediments of the Irish Sea.
RD9	British Geological Survey. 2000. (amended 2008).	Includes an understanding and characterisation of Regionally Important Geological Sites at Wylfa.
RD10	UK Climate Impact Programme.2009	Provides data/ information on sea level rise scenarios.

RD	Source	Relevance
RD11	Coombe. E.D.K. 1998.	Understanding of the evolution of Chesil Beach (Dorset) during the Holocene transgression
RD12	Jacobs. 2011.	Suspended sediments data recorded off Wylfa Head between May 2010 and October 2011(useful as sediment characterisation).
RD13	Jacobs. 2013.	Wylfa Water Quality Surveys at Wylfa used to characterise sediments.
RD14	Horizon Nuclear Power. 2011.	Earlier study by Halcrow that helps characterise the baseline coastal processes of Cemlyn Bay.
RD15	British Geological Survey. 1995.	Allows characterisation of sea bed sediments in the vicinity of Wylfa (and the wider Irish Sea).
RD16	Fugro. 2011.	Offshore ground investigation characterising seabed sediments (and depths of sediments)
RD17	Natural Resources Wales. 2015.	Water Framework Directive water body quality elements. Characterises coastline.
RD18	Pethick, J. 1984.	Provides an explanation of how coastal processes and geomorphology (including re-entrant traps)

D12.3.2 Study area method

D12.3.2.1 This section concerns the study area for coastal geomorphology features/ receptors close to the Wylfa Newydd Development Area potentially affected by changes to waves and currents caused by marine activities (such as the breakwater). The selection of study areas is dealt with in more detail in chapters B12 (Application Reference: 6.2.12) and D12 (Application Reference: 6.2.12) of the Environmental Statement. It does not specifically address other chosen study areas such as coverage of 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 activities such as dredging have the potential to be carried large distances.

D12.3.2.2 The study area was not agreed with NRW upfront. Rather expert knowledge of geomorphological and hydrodynamic processes operating within the wider marine environment informed by the desk study (including good practice) was then applied a priori to determine the probable extent of the study area for geomorphology receptors (see also chapters B12 (Application Reference Number: 6.2.12) and D12 (Application Reference Number: 6.4.12)). The points demarking this study area are major promontories around which it is not anticipated there would be significant littoral sediment transport. Support to this study area choice was tentatively given by evidence provided in the previous work by Halcrow on coastal processes at Wylfa Newydd Development Area [RD14].

D12.3.2.3 The study area extent has more recently been informed/ endorsed by both hydrodynamic and wave modelling investigations (only recently known since last meeting with NRW) 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 a range of resolutions, with the finest detail centred upon the proposed activity site. These nested grids are used to predict the potential effects of activities upon coastal and marine processes.

D12.3.2.4 Wave and current modelling demonstrate 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 embayments, approximately 2km east and 3km west from the Wylfa Newydd Development Area.

D12.3.3 Site walkover method

D12.3.3.1 A walkover survey was undertaken on 19th and 20th November 2014 to assess the contemporary baseline conditions for coastal geomorphology. The principal aim of this survey has been to assess the sensitivity of features as context in the selection of specific receptors. This was a process of ‘due diligence’ undertaken by two PhD qualified geomorphologists. Their aim was to identify ‘unique’ local features potentially ‘lost’ as a consequence of the marine activities.

D12.3.3.2 To gain maximum visibility of the shoreline and nearshore zone features the surveys were undertaken (as far as possible) during low tide or near low tide. Low water was predicted to be at about 14.00 each day and the surveys were undertaken between 10.00 and 16.00.

D12.3.3.3 The walkover study area extended approximately 2km east of the Existing Power Station site (Ty’n Llan on the Llanbadrig Peninsula) to 3km west (Hen Borth). This study area (for geomorphological features/receptors) was provisionally determined during the site walkover itself. A photographic record of the general character of the coastline was collected and key photographs are recorded in this report.

The length of coast within the Existing Power Station fenced boundary was not walked (for security reasons) and photographs were not allowed of the secured area.

D12.3.3. Method for valuing receptors

D12.3.3.4 The criteria ultimately used to select and determine the importance (value) of the receptors under consideration are defined in Table D12.3-2. Receptors were selected on the basis of the desk study information and the walkover survey. This process is more fully discussed in Chapters B12 (Application Reference Number: 6.2.12) and D12 (Application Reference Number: 6.4.12).

Table D12.3-2 Criteria for value of a coastal geomorphology receptor

Value	Topic-specific criteria
High	Receptor is of international/national importance, e.g. a geological/geomorphological SSSI or an ecologically-designated SAC, SPA or SSSI which is heavily dependent on its geomorphology, or an area which meets the published selection criteria for designation, irrespective of whether or not it has yet been notified. Receptor occupies a very small part of the study area. Receptor is rare or uncommon on an international or national scale. Receptor has important natural characteristics. Receptor has high economic value.
Medium	Receptor is of regional/county importance, e.g. it is a designated feature. Receptor occupies a relatively small part of the study area. Receptor is rare or uncommon on a regional/county scale. Receptor has moderate natural characteristics. Receptor has moderate economic value.
Low	Receptor is of district/local importance, e.g. it is a designated feature of a local site. Receptor physically occupies a relatively large part of the study area. Receptor is relatively common. Receptor has some natural characteristics. Receptor has low economic value.
Negligible	Receptor is of very low importance. Receptor is ubiquitous covering a very large part of the study area. Receptor is abundant.

Value	Topic-specific criteria
	Receptor has very few or no natural characteristics. Receptor has very low/no economic value.

D12.4 Desk study characterisation

D12.4.1 Overview

Characteristics and origins of the coastline

D12.4.1.2 Overall, the Anglesey coastline is predominantly hard bedrock and therefore resistant to erosion. The study area on the northern coast is rocky consisting of low cliffs separated by small pocket bays. The general unconstrained behaviour of the coast is for very slow erosion of the hard rock geology.

D12.4.1.3 The hard geology was covered by ice sheets during the last glaciation. Locally, the geomorphology is extremely varied as a result of the differential erosion of the many distinctive solid and drift rock types that occur. Loose materials eroded or detached over this period have since been moved and sorted by currents driven by tidal and wave forces. The seabed floor has been shown to have a mix of solid and outcropping bedrock, boulders, cobbles, and gravels/sands with fine silt in varying proportions. Coarser gravel and sand sediments have locally gathered to form small beaches.

Solid geology

D12.4.1.4 The solid geology within the study area is largely made up of a ‘melange’ within the north Wales Gwna Group [RD6]. This can be described as a body of rock composed of chaotically arranged blocks of strata in a finer-grained matrix. Sedimentary mélanges, termed olistostromes, originate by submarine avalanching, gravity sliding or slumping. The Llanbadrig peninsular is the informal type locality for the Gwna Mélange. It has been interpreted as part of a Peri-Gondwanan complex although the age of deposition remains contentious. It contains enormous limestone blocks of several hundreds of metres in size. Using strontium isotope chemostratigraphy, Horak and Evans [RD6] found that the limestone was deposited somewhere between the late Tonian (850-1000 million years ago) and earliest Cryogenian (635-850 million years ago). It forms a hard solid geology.

D12.4.1.5 The stretch of coastline forming the eastern part of the study area (from Cemaes to Ogof Gynfor) highlights national and internationally important geological sites. At Trwyn Y Parc there are numerous 'Miocene pipes' in the Gwna limestone. In addition, Precambrian stromatolites are preserved in the very pure limestones of Gadlys Quarry. At Porth Padrig, Ordovician strata are exposed behind the beach, together with the White Lady, a small sea stack composed of white quartzite; an assemblage of clasts from very small to very large. The cliff section at Ogof Gynfor is an important site for demonstrating the unconformity between Gwna rocks and Arenig Ordovician sandstones [RD7].

Drift geology

D12.4.1.6 During the Quaternary Period (the last 2.6 million years), Anglesey has been covered, on a number of occasions, by Irish Sea ice from the north-east [RD8; RD9]. The Quaternary ice movements can be assessed from stony till deposits along the coast. Hen Borth (which has a Site of Special Scientific Interest (SSSI) named after it) lies to the west and provides an exposure through the long axis of a drumlin, revealing clearly the internal structure and composition of the feature. In the upper part of some of the sequence, cryoturbation structures and frost wedges provide evidence for periglacial conditions. The composition of storm beaches, such as that at Cemlyn Bay, is likely to be glacially-derived cobbles and gravels, and to result from the Holocene marine transgression.

Soils

D12.4.1.7 According to the Soil Survey of England and Wales, the soil map unit is ‘East Keswick 1’ and is present across the study area (see [RD9]). This is described as a deep loam, derived from drift from Palaeozoic sandstone and shale. It consists of fine loamy soils and similar soils with slowly permeable sub-soils and slight seasonal waterlogging.

Coastal processes

D12.4.1.8 Titan Environmental Services Ltd (Titan) undertook work on oceanographic processes [RD4] between 2009 and 2012. Their results indicate that winds were dominated by south-westerly winds with some north-easterly winds. Titan found that wave directions in Cemlyn and Cemaes Bays were most commonly from the north-west rather than from the predominant south-westerly wave direction due to diffraction around the Anglesey headland. Significant wave heights in the shelter of the bays were lower than offshore. Average significant wave height to the west of Wylfa Head was 0.68m (recorded October 2010 to January 2011).

D12.4.1.9 Complex flow regimes were found to exist offshore. The tidal currents were observed to be essentially rectilinear flowing predominantly

towards the west and west-south-west during ebb and predominantly towards the east during a flood tide [RD4].

D12.4.1.10 Eddy formation was observed to occur in the western Cemlyn Bay and eastern Cemaes Bay either side of Wylfa Head. Current velocities were found to be highest around the tip of Wylfa Head reaching velocities of 1.2ms^{-1} (during a flood tide) and up to 0.7ms^{-1} during the ebb flood. At the furthest offshore mooring, the ebb currents were found to be stronger than the flood tide, the maximum recorded between August 2010 to February 2011 at 2.3ms^{-1}.

Seabed

D12.4.1.11 The seabed is defined here as the bed covered by the sea, either permanently or during low tide. Thus seabed is taken to include the inter-tidal and sub-tidal zones. It is a relatively common resource and throughout the Wylfa Newydd Development Area the seabed floor has been affected by glaciation. During the walkover the seabed (where visible at low tide) was found to consist of an irregular wave-like rock-head surface, in turn partly covered by a boulder clay complex (0.8 to 6.5m thickness). Large rocky outcrops dominate with a depth of 30-40m next to the Existing Power Station. Further from shore, the seabed consists of smooth, tidally swept sediments and poorly defined bed forms. The sand and gravel lag moved onshore from the seabed during the Holocene marine transgression has created beaches such as those at the back of Cemlyn and Cemaes Bay.

Bays and Sediments

D12.4.1.12 The embayments along the north Anglesey coast generally act as closed sediment compartments with little or no exchange between bays and only limited sediment supply from eroding sections of coast between bays. Interaction between currents and topographical features around Anglesey generate complex three-dimensional circulation patterns that influence the distribution of sediments [RD4]. Where hard rock cliffs have been eroded away, local bays have formed, giving rise to a crenulated shoreline. Along the northern coast, the various bays tend to be deeply indented, with relatively small pocket beaches within larger bays, between major headlands extending out into deeper water [RD4]. Sediment tends to have become trapped within these bays. The SMP2 indicates that longshore transport tends to be weak because of the effects of shoaling within the bays, and diffraction around the headlands. If longshore currents do exist, they tend to reduce as they push sediment towards one side of the bay, and the beach line rotates to face the incoming waves (Figure D12.4-1)

D12.4.1.13 The gravel specifically within Cemlyn Bay is derived from glacial material originally deposited over a wide area, including potentially sediment derived from offshore [RD2; RD3]. Sand and gravel is likely to have moved onshore during the Holocene marine transgression (circa 7000 to 5000 years before present). The supply of new sediment at the present day appears to be very restricted and may not balance an overall loss in sediment volume due to inter-particle attrition in the surf zone.

D12.4.1.14 Similar processes are thought to have operated at other storm beaches in the UK. For example, there is extensive literature for Chesil Beach which had formed at or slightly seaward of its present position by 4000-5000 years before present when sea level approached its present elevation. Cores described by Coombe [RD11] suggest that the initial Chesil Beach was predominantly sandy rather than gravel-rich, with layers of shells and coarser materials indicative possibly of intervals of over-washing.

D12.4.1.15 Sediments are covered in detail in the second Appendix to this chapter of the Environmental Statement. Significant information has been assimilated during the studies for the Wylfa Newydd Project. This includes grab samples and suspended sediment data [RD11; RD12], seabed sediments mapping [RD13; RD14] and results from boreholes as part of a geotechnical investigation [RD15].

Figure D12.4-1 North-facing beach at Porth-Wylfa in Cemaes Bay

Esgair Gemlyn and lagoon

D12.4.1.16 The SPA of Ynys Feurig, Cemlyn Bay and The Skerries is located on the north and west coasts of Anglesey. The SPA comprises three separate areas. Ynys Feurig lies on Anglesey's west coast close to Valley airfield, with Cemlyn Bay situated on the north coast several kilometers from the Existing Power Station and the Skerries lie 3km off Carmel Head.

D12.4.1.17 Geomorphologically, the most important area is the Cemlyn shingle storm beach (Esgair Gemlyn) which forms a bar between a tidal lagoon and the open shore [RD2; RD3]. The shingle bar is disconnected at its northern end where an historic weir structure is used to control water levels within the lagoon. The shingle habitats, together with saltmarsh developing around the lagoon and brackish pools further inland, are an unusual combination of habitats, partly sustained by the managed water levels.

D12.4.1.18 A study was completed in 2010 by Pye and Blott [RD2] for the National Trust. This was essentially based on Expert Geomorphological Assessment [RD2]. It was concerned with a preliminary geomorphological assessment of past and possible future geomorphological evolution of the area, focusing on the Cemlyn shingle barrier and lagoon, and taking into account current projections of future climate and sea-level change. The study involved an evaluation of existing published and unpublished scientific information related to the site and wider area, an examination of historical maps and aerial photographs, a site visit, limited sedimentological analysis, and evaluation of the implications of recent UKCP09 climate projections for the area [(RD10]. The key findings of the study were:

- The frequency of over-washing of the shingle barrier appears to have increased along the central part of the barrier since 2000, and a severe event could occur at any time, potentially leading to breaching at the narrowest and/or lowest point.
- The rate of retreat indicated by historical maps is low (less than 0.2m per year since the late 19th century).
- There are no obvious signs of new sediment supply to the barrier and therefore 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.
- The frequency and severity of over-washing are therefore likely to increase, leading to a more rapid landward movement of the barrier and adoption of a flatter profile.
- Landward extension of the shingle is most likely to occur where the barrier crest is currently lowest (close to the artificial islands).
- By 2100, over-washed shingle may cover the area now occupied by the islands and in the longer term a new tidal inlet could develop in this area.

- Consideration therefore will need to be given to the options to re-locate or modify the islands in the medium term (2030-2060).
- An increase in the frequency of barrier over-washing and higher rates of percolation through the barrier are likely to increase lagoon salinity.

D12.4.1.1 This work was updated in a subsequent report in 2016 which in particular showed that the Esgair Gemlyn did not suffer serious damage during the stormy winter of 2013-2014 [RD3].

D12.4.2 Historical coastal changes

D12.4.2.1 The SMP2 [RD1] provides a broad-scale assessment of the risks associated with coastal evolution and presents a policy framework to address risks to people, and the developed, historic and natural environment, in a sustainable manner. Further details are given in Annex 2. The document also provides specific advice to operating authorities in their management of defences. The SMP2 [RD1] estimates potential baseline erosion rates from both monitoring and historical data such as old maps. A range of potential erosion has been assessed in terms of variation from the baseline rate and sensitivity to rise of sea level. The SMP2 [RD1] makes a distinction between basic erosion of the shoreline and cliff recession, affecting the crest of cliffs and coastal slopes. An allowance has been made for ongoing sea-level rise, recognised as a significant factor in the future (Table D12.4-1).

Table D12.4-1 Baseline erosion rates

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

D12.4.2.2 It is also generally recognised in the SMP2 [RD1] that where there are softer cliffs or shorelines suffering from erosion, the rate of erosion is likely to increase with sea-level rise. This might be by a factor of 1.7 to 2.5 times the existing base erosion rate over 100 years. Where there are more stable features, such as fully developed storm beaches, there would be a natural roll back of the beach potentially in the range of 10m to 40m, dependant on the precise nature of beach and the coast behind. As beaches erode or roll back this could result in re-activating landslides and slope instability along previously stable shorelines. A long-term strategy of managed realignment is therefore noted as a future option for the sustainable development of historic features such as the Esgair Gemlyn shingle ridge [RD1].

D12.4.2.3 Existing defences to shore-line erosion are at a very local level, such as the sea wall at Cemaes and a further historic wall close to Bryn Aber on the northern coast. There are existing defences for the Existing Power Station, described as being in good condition in the SMP2 (RD1). There is also a concrete pier construction (old lifeboat ramp) immediately to the east of Wylfa Head in Cemaes Bay (Figure D12.4-2) Annex B2 provides a more detailed summary taken from the SMP2 covering the units Cemaes, Wylfa and Cemlyn Bay [RD1].

Figure D12.4-2 Concrete structure to east of Wylfa Head

D12.4.3 Coastal and fluvial water bodies

D12.4.3.1 The WFD descriptions are taken from the Western Wales River Basin Management Plan (Table D12.4-2) (RD1). The boundaries of these coastal water bodies relative to the extent of the geomorphological study area are shown in Figure D12.4-3 (updated from the 2015 River Basin Management Plan) [RD5].

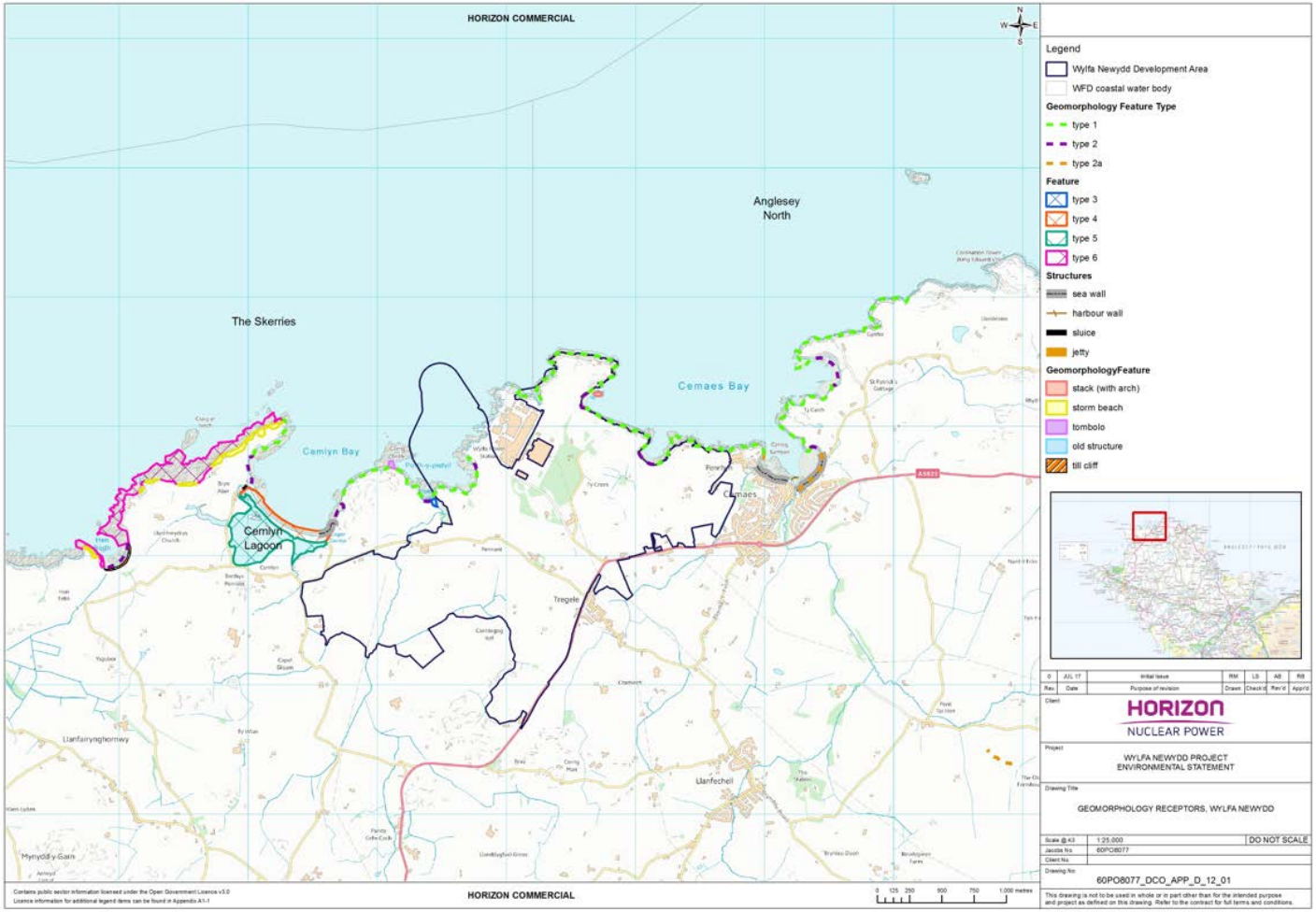
Table D12.4-2 Baseline description for the relevant coastal water bodies (RD1)

Water body ID	GB611010390000	GB641010620000	GB6101000083000
Water body name	The Skerries	Anglesey North	Cemlyn Lagoon
River Basin District	Western Wales	Western Wales	Western Wales
HMWB designation (cycle 2)	No	No	Yes – Flood Protection (Transitional and Coastal (TraC) Waters)
Typology	Exposed macro-tidal	Moderately exposed macro-tidal	Coastal
Protected area	Yes	Yes	Yes
Overall status	High	Moderate	Good
Overall objective	High by 2015	Good by 2021	Good by 2015
Overall ecological objective	High by 2015	Good by 2015	Good by 2015

HMWB = Heavily Modified Water Body

D12.4.3.2 A number of un-named smaller streams and the Wygyr watercourse enter the sea throughout the study area (Figure D12.4-3). In the 2015 River Basin Management Plan [RD5] these have been subsumed into the respective coastal water bodies.

Figure D12.4-3 Geomorphological Features within the study area



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D12.5 Contemporary characteristics from walkover

D12.5.1 Introduction

D12.5.1.1 This section describes the result of the walkover survey (for baseline coastal geomorphology) and also summarises the baseline data collected to inform modelling and assessment scenarios.

D12.5.2 Coastal geomorphology types identified during walkover

D12.5.2.1 The walkover included sections of The Skerries, Anglesey North and the Cemlyn Lagoon WFD water bodies (see Figure D12.4-3)) located within the study area. Several key coastal geomorphology types/ features were identified during the walkover (Table D12.5-1) and these have been used to characterise the study area and are also shown in table D12.5-1. It was felt important to identify key geomorphology types/features as background context for the (subsequently) chosen receptors. Each type has been ascribed a sensitivity. So for example hard rock cliffs (in geomorphological terms) have been given a low sensitivity. This is because it is resistant to erosion and change is likely to be outwith the design life of any project.

Table D12.5-1 Key coastal geomorphology types identified

Type reference	Description and locations	Sensitivity	Key photographs (found in Appendix D12-3 of this document)
Type 1: Hard rock cliff	Generally composed of hard rock types, principally the Gwna Mélange. Stack and island formation observed. Has a few isolated localised 'storm beaches' composed of small numbers of pebbles/cobbles where there has been preferential erosion of weaker strata. Localised pools, possibly a mix of saline and freshwater. Found in both The Skerries and Anglesey North water bodies.	Low (hard rock cliffs are slow to change)	Figure C.1and figure C.2 show rock pool and storm thrown stones; figure C.3 shows typical storm beach and figure C.4 depicts a pond formed in melange; figure C.5 shows typical melange coastline with a localised accumulation of

Type reference	Description and locations	Sensitivity	Key photographs (found in Appendix D12-3 of this document)
			deposits and localised pools.
Type 2: Crescent-shaped bay with natural cliffs	Found in both the Skerries and Anglesey North water bodies.	Low (a relatively common feature of these two water body extents)	See Figure C.6 and Figure C.7.
Type 2 (a): As above but with an artificial wall at top of beach	Found in both the Skerries and Anglesey North water bodies.	Low (a relatively common feature of these two water body extents but with the added factor of being artificially modified with a wall at the top of the beach)	Figure C.8
Type 3: Saltmarsh (localised only)	Found in Anglesey North water body and Cemlyn Lagoon water body at Esgair Gemlyn.	Moderate (vulnerable to change but very localised and any consequent erosion would be localised)	Figure C.9.
Type 4: Crescent-shaped bay (with storm beach / barrier)	Largely a natural feature, although there is anecdotal evidence that breaches may have been repaired (by man) in the past. Sediments forming the beach derived from erosion of glacial sediments along neighbouring cliffs and offshore. Found in the Skerries water body.	Low (a relatively common feature of these two water body extents) to High (presence of a unique storm beach)	Figure C.10 and Figure C.11.

Type reference	Description and locations	Sensitivity	Key photographs (found in Appendix D12-3 of this document)
Type 5: Man-made lagoon behind storm beach	This feature is not natural and formed (in part) by a weir which dams water back along the coastline. Found in the Skerries and Cemlyn Lagoon water bodies.	Moderate (substantially a man-made feature and limited geomorphological processes)	Figure C.12 and Figure C.13 show downstream and upstream of the weir structure (respectively).
Type 6: Hard rock platform exposed at low tide (with softer till cliffs behind)	Softer cliffs (composed of till deposits) have eroded back by the sea, leaving hard rock platform on the foreshore. Found in the Skerries water body.	Moderate (earth cliffs vulnerable to erosion)	Figure C.14 shows typical rock platform with glacial till (drift) above.

D12.5.2.2 These types represent the broadest categories possible. At a micro-scale level, most coastal types were represented including very localised numbers of beach cusps – see Figure D12.5-1 (a small tombolo), Figure D12.5-2 (tide partially out) and Figure D12.5-3 (tide out) and potentially remnant sand dunes. These are particularly notable features forming part of the types/ receptors that could be lost by marine activities.

Figure D12.5-1 Beach cusp

Figure D12.5-2 Tombolo (covered by tide)

Figure D12.5-3 Tombolo (as Fig D12.5-2) with tide out

Figure D12.5-4 Tidal limit

D12.5.2.3 Due to the steep nature of the joining streams, very short lengths of tidal 'estuary' were observed. For example, at Cemaes Village about 100m

length of water body was determined to have both freshwater and saline influences (see Figure D12.5-4).

D12.5.2.4 The lengths through the Existing Power Station site were neither mapped nor photographed, but looking at map evidence these are likely to be Type 1.

D12.6 Identification of receptors

D12.6.1.1 The geomorphological baseline assessment of geomorphological types/ features has provided important background to the choice of suitable geomorphological receptors. The receptors chosen include key geomorphological features, some of which form part of sites designated for ecological or geological reasons.

D12.6.1.2 The identification of geomorphology receptors and their value was through expert geomorphological assessment by two PhD qualified geomorphologists examining desk study and where possible field survey including bathymetry, geology and sediments. This was also informed by experience of previous studies looking at the potential effect of a similar arrangement of marine activities on nearshore coastal features. A range of receptor types were selected from high value with relevant designation (e.g. Esgair Gemlyn) to low value common features (such as the seabed). This selection is shown in summary in Table D12.6-1 below and is also explained in chapter B12 (Application Reference Number: 6.2.12) with baseline condition described fully in chapter D12 (Application Reference Number: 6.4.12).

Table D12.6-1 Key coastal morphology receptors identified

Geomorphology receptor	Description	Value	WFD water body
The seabed (including inter-tidal)	This covers the area within Porth-y-pistyll and surrounding bays west of Wylfa Head. Seabed has been included as a matter of due diligence by the two geomorphologists who conducted the survey. This is because an area of seabed footprint would be lost to the Scheme.	Low	Skerries and Anglesey North water bodies
Cemaes Bay	This is situated to the east of Wylfa Head within the Anglesey North WFD water body. It is a unique northwards facing pocket bay. It also contains some unique (albeit localised) geomorphological features.	Medium	Anglesey North water body
Cemlyn Bay	This is situated within the Skerries WFD water body immediately to the west of Wylfa Head. It is defined here as a different entity from Esgair Gemlyn and Cemlyn	Medium	Skerries water body

Geomorphology receptor	Description	Value	WFD water body
	Lagoon (listed below) which are to the south and “separate”.		
Esgair Gemlyn	A shingle beach situated about 400m from the Wylfa Newydd Development Area at its central point, protected as part of the Cemlyn Bay SAC. This is considered a relatively rare important geomorphological receptor.	High	Cemlyn Lagoon water body
Cemlyn Lagoon	This is designated as an SAC and SSSI and is also covered by the Ynys Feurig, Cemlyn Bay and the Skerries SPA. The existence of the lagoon is dependent on the presence of Esgair Gemlyn. Although now predominantly artificial through water levels, it is considered an important and relatively rare geomorphological specialist feature, integral to Esgair Gemlyn.	High	Cemlyn Lagoon water body
Hen Borth Cliff	A geological SSSI which is an important (cliff) exposure of a glacial drumlin feature located approximately 3000m from the Wylfa Newydd Development Area at its central point. This is considered a relatively unique geomorphological receptor.	High	Skerries water body

D12.7 Conclusions and further work

D12.7.1.1 From a geomorphological perspective, the coastline within the study area can be characterised as predominantly hard rocky cliffs (which are very slow to erode) with pocket sandy bays. There are very strong tidal currents around and offshore from Wylfa Head. The geology of the offshore and nearshore zones is complicated by the effects of glaciation. There are areas of hard bedrock but then also extensive cover of drift deposits locally. These glacially-derived materials have been moved by tidal currents and wave forces acting over the past 5000-7000 years, locally forming beaches including the Esgair Gemlyn shingle ridge. Cemlyn Bay and Cemaes Bay both appear typical of a re-entrant trap whereby sediment is locally retained within a predominantly enclosed system.

D12.7.1.2 The Esgair Gemlyn and its associated lagoon have been selected as key geomorphology receptors for the assessment of effects. They form an important component of the Cemlyn Bay SAC/SPA/SSSI. A study by Pye and Blott [RD2] suggested that this feature would evolve more rapidly in the future due to climate change and associated sea-level rise. Whilst the shingle ridge is largely protected by the topography from prevailing south-westerly winds, it will be vulnerable to increasing sea levels and storms, leading to movement landward (retreat) in the future and especially during severe events. The ridge will adopt a lower profile eventually and parts of the lagoon will be threatened from encroachment and over-washing (up to 2100). Pye and Blott [RD2; RD3] also suggested that there is limited evidence of fresh sediment supply from either local cliffs or offshore and that this may also contribute to the vulnerability of the shingle ridge.

D12.7.1.3 The geomorphological baseline assessment in this report has enabled the selection of a series of receptors. The selection of these receptors is explained in detail in chapters B12 (Application Reference Number: 6.2.12) and D12 (Application Reference Number: 6.4.12) of the Environmental Statement but in summary these are:

- the seabed (including inter-tidal);
- Cemaes Bay;
- Cemlyn Bay;
- Esgair Gemlyn;
- Cemlyn Lagoon; and
- Hen Borth.

D12.8 References

Table D12.8-1 Schedule of references

RD	Reference
RD1	Wales Coastal Forum. 2011. *West of Wales Shoreline Management Plan 2* (SMP2), *Cardigan Bay and Ynys Enlli to the Great Orme Coastal Groups*. [Online]. [Accessed: 12 October 2016] Available from: http://www.westofwalessmp.org/content.asp?nav=23&parent_directory_id=10.
RD2	Pye, K. and Blott, S.J. 2010. *Cemlyn Bay and Adjoining Areas, Anglesey: Geomorphological Assessment*. Report prepared for the National Trust, Swindon. Kenneth Pye Associates Ltd, External Investigation Report EX1208.
RD3	Pye, K. and Blott, S.J. 2016. Cemlyn, Anglesey: Further Geomorphological Assessment. Report prepared for the National Trust, Swindon. Kenneth Pye Associates Ltd, External Investigation Report EX20671.
RD4	Horizon Nuclear Power. 2012. *Wylfa Oceanographic Interpretative Report*. Titan Environmental Surveys Ltd for HNP, WYL-TES-PAC-REP-00024 CS0268/V1/Final.
RD5	Natural Resources Wales. 2015. *Western Wales River Basin Management Plan 2015 – 2021 Summary*. [Online]. [Accessed: January 2016]. Available from: https://www.gov.uk/government/collections/river-basin-management-plans.
RD6	Horak, J.M. and Evans, J.A. 2011. *Early Neoproterozoic limestones from the Gwna Group, Anglesey*. Geological Magazine, 148, 1, 78-88.
RD7	Greenly, E. 1919. *The Geology of Anglesey, Memoirs of the Geological Survey of England and Wales*, Volume 1, 388pp.
RD8	Bowen, D. Q. 1977. *The coastal of Wales*, 223-256, in Kidson, C. and M.J. Tooley (eds). *The Quaternary history of the Irish Sea*. Seel House Press: Liverpool.
RD9	British Geological Survey. 2000 (amended 2008). *Regionally Important Geological Sites*. [Online]. [Accessed: 12 May 2017]. Available from: https://www.bgs.ac.uk/research/ukgeology/Wales/Geoconservation.html.

RD	Reference
RD10	UK Climate Impact Programme. [Online]. [Accessed: 2 July 2015]. Available from: http://www.ukcip.org.uk/.
RD11	Coombe. E.D.K. 1998. *Holocene Palaeoenvironments of the Fleet Lagoon*. PhD Thesis: University of Oxford.
RD12	Jacobs. 2011. *Suspended sediments data recorded off Wylfa Head between May 2010 and October 2011*.
RD13	Jacobs. 2013. *Wylfa Water Quality Surveys Report 2013*, W202.01-S5-PAC-REP-00008.
RD14	Horizon Nuclear Power. 2011. Wylfa MOLF Coastal Processes Study. Halcrow for RWE/ HNP. WYL-PD-PAC-REP-00009.
RD15	British Geological Survey. 1995. *Sediments in the Eastern Irish Sea. IPR/125-18CY*. Nottingham: British Geological Survey, NERC.
RD16	Fugro. 2011. *Wylfa New Build, Intermediate offshore ground investigation 2010.* Geotechnical Ground Report: C1369/ NEA101007.
RD17	Natural Resources Wales. 2015. *Water Framework Directive water body quality elements. WFD Data Download.* [Online]. [Accessed: May 2017]. Available from: http://waterwatchwales.naturalresourceswales.gov.uk/en/ May 2017.
RD18	Pethick, J. 1984. *An Introduction to Coastal Geomorphology.* Edward Arnold, London, 260pp

Appendix D12-1 Glossary

Term	Description
Crenulate Shoreline	A term which can be applied to a rocky coastline. Referred to as having a notched outline or edge. Crenulate-shaped bays are quite common on exposed sedimentary coasts. Crenulate-bay beaches occur with the presence of two consecutive headlands and a predominant wave approach oblique to the alignment of the up-coast and down-coast headlands. Oblique persistent swell striking a shoreline transports sediment alongshore and sculptures a headland-dominated coast into crenulate-shaped bays.
Crescent-shaped	Refers to a beach in a half-moon or crescent-shape.
Cusp	A beach cusp is a shoreline formation composed of various grades of sediment in an arc pattern. The embayment contains the finer grained sediment, whilst the outer edges are composed of coarser material. They nearly always occur in a regular pattern with cusps of equal size and spacing appearing along stretches of the coastline.
Diffraction	Wave diffraction occurs when waves encounter an obstacle such as an island or breakwater. After passing the obstacle, the waves turn into the region behind the island and carry wave energy and the wave crest into a so-called shadow zone.
Drumlin	A small elongated hill formed by glacial ice acting on unconsolidated till material.
Dune	Sand dunes are small ridges or hills of sand found at the top of a beach, above the usual maximum reach of the waves. They form from wind-blown sand that is initially deposited against an obstruction. If vegetation begins to grow on the dune, its roots will help to bind the sand together and stabilise the dunes. Only remnant dunes are locally apparent in the study area.

Term	Description
Gwna Melange	A famous group of rock formations consisting of a chaotic agglomeration of blocks, strips and lenticels of all sizes of limestone, quartzite, lava, jasper, schist etc., set in a schistose matrix of micas and chlorite. This is considered now to have formed by submarine sliding of large volumes of unconsolidated or partly consolidated sediment on an inclined sea floor, possibly triggered by earthquake shocks, and is known as an olistostrome. Fine exposures of the Gwna Melange occur in the cliffs of the Llanbadrig Dinas Gynfor SSSI near Cemaes. The age of these sediments has traditionally been considered to be Pre-Cambrian but recent study of microfossils suggests that they may be at least partly Cambrian.
Miocene pipes	The Miocene is a geological epoch from 5-23 million years ago. A pipe is formed through rock by geological processes and can become filled with more recent sediments.
Periglacial	Refers to places on the edges of glacial areas, describing geomorphological processes that result from seasonal thawing of snow in areas of permafrost, with runoff freezing into ice wedges and other structures.
Pocket beach	Defined as a small beach typically between two headlands. Pethick (1984) (RD17) has previously described these as ‘Sediment tight’ features. In practice, relatively little is known about the sediment transport processes of such features. Whilst it may be difficult for sediment to move around a headland, little is known about interactions between the beach and offshore zones (littoral drift) and fluvial inputs. In some parts of the world, pocket beaches are thought to be at least in part formed by sediments derived from (now) submerged channels due to sea-level rise.
Saltmarsh	A saltmarsh may be defined as the vegetation (usually dominated by flowering plants) that occurs on muddy shores between approximately mean high water neap and extreme high water spring tides.

Term	Description
Sediment Cell	A sediment cell is defined as a length of coastline, which is essentially self-contained as far as the movement of sand and other sediment is concerned such that the interruption to such movement in one cell should not have a significant effect on adjacent sediment cells. The boundaries of the sediment cells generally coincide with large estuaries or prominent headlands.
Stack	Stacks stand alone and no longer attach to adjacent cliffs. At high tide, they will usually be tall rocks rising from the sea just offshore, though at low tide it may be possible to walk out to them across the beach. Stacks form when there is an area of weakness in the cliffs that can be attacked by the sea, weakened further, and eroded away. The most typical way in which this happens is when a weakness in an exposed headland becomes a cave, the cave is enlarged from both ends to form an arch, and finally the top of the arch collapses leaving the seaward pillar (the upright bit nearest the sea) as a stack.
Storm beach	An expanse of gravel thrown onto a coast by a storm. A storm beach is a beach typically affected by particularly fierce waves, usually above the high-tide mark.
Stromatolite	These are ancient fossil records dating back as far as 3.5 billion years. They are accretionary structures formed in shallow water by trapping, binding and cementation of sedimentary grains by matts of microorganisms.
Tombolo	Tombolos are sandbars or spits created through the process of longshore drift. A tombolo is formed where a spit continues to grow until it reaches an island, forming a link with the mainland, similar to bridges.

Appendix D12-2 Detailed descriptions of SMP2 units

Cemaes Bay	
Description	Cemaes village is the most significant development along this section of the coast within the study area. The village is situated to the south-western corner of Cemaes Bay, formed between the two headlands of Wylfa Head (to the west) and Trwyn Buarth (to the east). The main area of development is centred on the harbour, which is to the south-east of the main bay. This sub-bay faces out in a north-westerly direction and is formed between the headlands of Trwyn y Penrhyn on the southern side and Trwyn y Parc to the north. The sub-bay is cut almost square through the hard rock geology and the northern flank of the bay is formed of steep hard rock cliffs. The southern flank is a more gently rising coastal slope on which the village has been built. The harbour itself is formed on a further rock ridge. At the head of the sub-bay there is a relatively wide beach (Traeth Mawr) backed by softer coastal slopes, with some development, and rising to the main A5025. The village extends slightly to the west of Trwyn y Penrhyn, along the top of the rocky cliffs. South of Trwyn y Penrhyn, a sea wall protects a promenade and road (Ffordd y Traeth) running along the shoreline as far as the properties on the headland at Penrhyn. To the western end of this promenade, a small stream runs down to the shoreline. There is a small pocket beach in this area and localised sand and shingle deposits front the sea wall. However, much of the foreshore through to the harbour is rock outcrop. The harbour itself is protected by a large masonry breakwater. A relatively new promenade protects the coastal slope to the east of the harbour, incorporating a small car park. The Afon Wygyr runs in a steeply-sided valley in the lee of the harbour breakwater and is tidal for a very short length of less than 100 metres.

Cemaes Bay	
Existing defences	Man-made defences are:- • a sea wall along Ffordd y Traeth; • the main breakwater and defences within the harbour area; • and the promenade wall to the east of the harbour. The latter structure is relatively new and follows around the crest of much of the sandy/shingle beach to the eastern part of the village. The sea wall along Ffordd y Traeth has a relatively high crest wall above the height of the road (SMP2) (RD4).
Unconstrained scenario	According to the SMP2, the coastal slope to the western side of the village would suffer significant toe erosion in the absence of defences, precipitating slope instability in the area. The harbour breakwater would realign with significant erosion at its southern end. The new wall along the main beach follows the crest. Without this defence the beach would roll back exposing the toe of the coastal slope behind. The SMP2 Policy for this shoreline is 'Do Nothing/Hold the Line'.

Cemaes Bay	
Coastal processes	The main offshore wave energy is from a south-westerly to northerly direction. Without the constraint of hard rock sections within Cemaes Bay, the bay would probably have a uniform curving backshore facing north. However, the rock within the main bay holds this shoreline forward, with several sub-bays set back around this uniform curve (SMP2). This would suggest that the waves entering the sub-bay within which the village sits is limited by direction, tending to be channelled through the narrow entrance before spreading out within the softer wider head of the bay. The area would also be likely to be subject to relatively long period waves generated over a significant offshore fetch. Most likely there is significant reflection off the steep hard cliffs on the northern side, giving rise to an interaction of incident and reflected waves hitting the southern shoreline, particularly in the area just seaward of the harbour. This is likely to be a high energy location and with sea-level rise this situation will become worse. With this type of behaviour, there is significant and long-term pressure for the coast to realign. This would be modified depending on exposure of rock beneath the general coastal slope but is still indicative of the typical extent to which the bay might develop in the long term, probably beyond the period of SMP2. Despite the increased wave energy, the coast is held well forward of this suggested line by the structures at the harbour and the ridge running down through the village in the area of the harbour. The development of a sandy beach both in this area and within the various bays with Cemaes Bay would suggest that there is some nearshore supply of sediment and (where there is sufficient width in the shoreline system) there is the capacity for some beach formation.

Appendix D12-3 Figures

Figure C.1: Type 1 Near Ty'n-llan

Figure C.2: Type 1 Near Ty'n-llan

Figure C.3: Storm thrown sediments (Type 1)

Figure C.4: Rock pool (Type 1)

Figure C.5: Rock pool (Type 1) at Llanbadrig

Figure C.6: Porth Padrig (Type 2)

Figure C.7: Porth Padrig (mixed sediments)

Figure C.8: Type 2 (a) Traeth Mawr

Figure C.9: Localised saltmarsh at Trwyn Pencarreg (Type 3)

Figure C.10: Esgair Gemlyn (Type 4)

Figure C.11: Esgair Gemlyn (Type 4)

Figure C.12: Artificial lagoon (Type 5)

Figure C.13: Man-made lagoon (Type 5)

Figure C.14: Softer cliff above rock platform (Type 6)