South West of England Regional Development Agency

Wave Hub
Environmental Statement

June 2006

Halcrow

South West *of* England
Regional Development Agency

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Contents Amendment Record

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1 Introduction

1.1 The Wave Hub proposals

Background

1. The South West of England Regional Development Agency (SWRDA) is proposing the Wave Hub project to provide the electrical infrastructure necessary to support and encourage developers of wave energy converter devices (WECs) to generate electricity from wave energy.

2. Wave Hub will facilitate WEC development through final demonstration and pre-commercialisation development stages by allowing developers to install, operate and monitor commercial-scale WECs in realistic offshore marine conditions over a number of years. In this respect, Wave Hub will perform the function of a WEC proving zone for the efficient delivery of power derived from renewable wave energy.

3. Wave Hub supports:

- the UK government's energy policy by contributing towards the UK's drive to meet the challenges and achieve the goals of the new energy policy including a 60% reduction in carbon emissions by 2050; and

- the South West region's commitment to encouraging technologies for renewable energy generation that will contribute to the region's renewable energy target of 11% - 15% of electricity production by 2010.

4. Wave Hub will be based onshore at Hayle, Cornwall. The offshore elements of Wave Hub, including the WECs, will be situated in approximately situated some 10 nautical miles out to sea off St Ives Head (see Figure 1.1).

Wave Hub infrastructure

5. Wave Hub's infrastructure can be divided into three main components. This infrastructure provides the

6. Firstly, there will be offshore infrastructure comprising four underwater power converter units (PCUs; i.e. transformers and circuit breakers that receive power generated by the WECs) connected back to a termination and distribution unit (TDU) via semi-flexible connector cables placed on the seabed within a 4km x 2km deployment area. Various aids to navigation will be positioned around the deployment area. It is within the deployment area that the WECs and their associated infrastructure (e.g. anchors, moorings, cables) will be installed.

7. Secondly, there will be a 25km sub-sea cable comprising power cables and fibre-optic communications connecting the Wave Hub's offshore infrastructure and onshore infrastructure.

8. Thirdly, there will be onshore infrastructure at Hayle comprising a new substation and other operational facilities. The new substation will provide an intermediary connection point for the cable to the 33kV bulk electricity system operated by Western Power Distribution (WPD) at the existing Hayle substation complex from where electricity generated at the Wave Hub will be passed into the regional and national electricity supply networks (e.g. the National Grid).

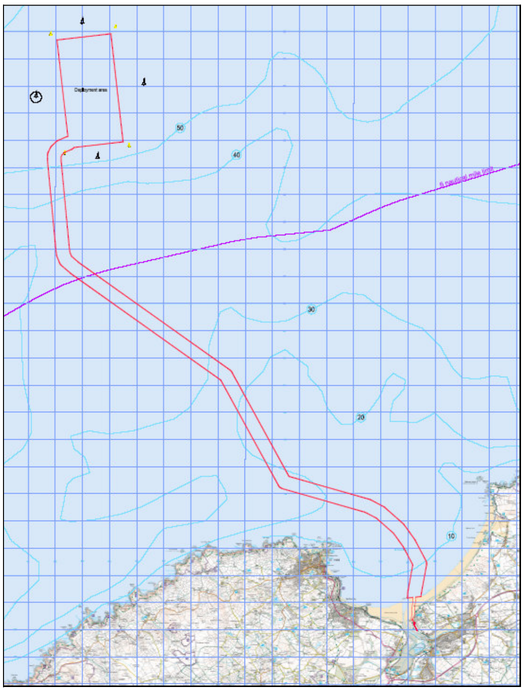


Figure 1.1 Wave Hub development area

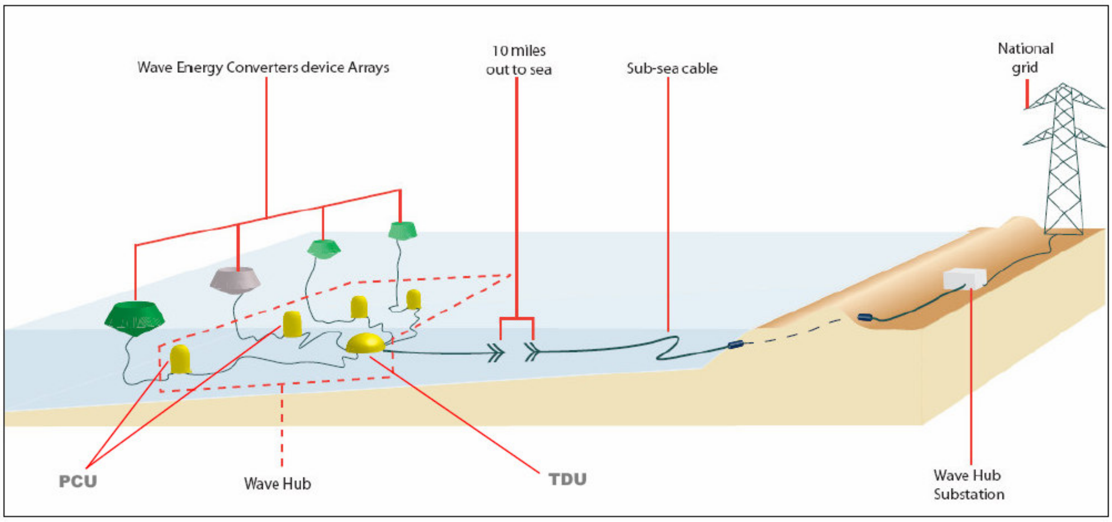


Figure 1.2 Conceptual illustration of the Wave Hub

Wave energy converters

9. The WECs do not form part of the Wave Hub's infrastructure but are material to its consideration as a project and the consent application supported by this Environmental Statement.

10. In essence, all WECs comprise a carcass (made of steel, concrete or composites), electrical and hydraulic equipment, electronic control and telecommunications equipment, and moorings.

11. All WECs will be floating or semi-submersible, connected to the Wave Hub's PCUs by cable, and anchored to the seabed via varying numbers of mooring lines. WEC units may take a number of forms, with varying outputs, operating ranges, numbers in an array, and spacings.

12. The main types of WECs will be oscillating water column devices (partially submerged), buoyant moored devices (floating on or just below the surface of the sea), or hinged contour devices (floating on the surface of the sea). Figure 1.3 provides an illustration of some of the WECs that are under development.

13. Different developers will be able to connect either individual WECs or arrays of WECs to a PCU at any one time. All WECs and their moorings / anchors will be installed within the same 4km x 2km deployment area as used for the Wave Hub's PCUs and TDU.

14. By virtue of providing four PCUs, the deployment area will accommodate four connections from a WEC or an array of WECs.

Figure 1.3 Examples of WEC Devices (top to bottom: Pelamis, PowerBuoy and FO^3 devices)

Energy generation

15. Wave Hub will have a maximum output of 20MW (i.e. 4 PCUs x 5MW). This output effectively limits the scale and/or number of WECs and WEC arrays that can be connected to the Wave Hub.

16. At 20MW, Wave Hub will produce the equivalent amount of energy to power approximately 7,500 average UK homes. In local terms, this translates to around 3% of Cornwall's domestic energy requirement.

1.2 Statement of need

National energy needs

1. Wave Hub presents an opportunity to address the challenges and goals of the government's new energy policy, as set out in the Energy White Paper, *Our Energy Future – Creating a Low Carbon Economy* (TSO, 2003), by advancing innovative emerging technologies for renewable wave energy and aiding delivery of a more diverse energy system by 2020 and a 60% reduction in carbon emissions by 2050.

Regional energy needs

2. In addition, Wave Hub should support the South West region's commitment to encouraging technologies for renewable energy generation that will contribute to the region's renewable energy target of 11% - 15% of electricity production by 2010. The region has been identified as having considerable potential for offshore renewable energy generation because it has a good wave and tidal stream resource, is relatively accessible, has a reasonably strong local electrical network, and is subject to less extreme weather conditions than other parts of the UK.

Business case

3. The following case for Wave Hub has been taken from the Wave Hub *Summary Business Case* (Arthur D Little, February 2005). It addresses the question, why is Wave Hub important to the UK?

4. "Wave Hub is the only proposal at an advanced stage to support deployment of arrays of different [wave energy converter] devices in the world. This concept can play a significant role in developing an international industry, while ensuring UK dominance in the market. Consequently, it is in a unique position to provide the basis of a real competitive strength for the UK."

5. "Wave Hub addresses the support gap between initial devices, typically less than 2MW, and the arrays of several devices that will be required for commercial viability. There is some limited private and public sector support for the development of single devices, but this is primarily for initial trials, such as those being conducted at EMEC [European Marine Energy Centre Ltd]. Once wave energy projects reach the supported commercial or commercial stage of deploying arrays, the current ROC [Renewables Obligation Certificate] system in conjunction with the premium payments proposed by the DTI [Department of Trade and Industry] may be able to secure sufficient returns. This was emphasised by a recent DTI Innovation Review [February 2004] which highlighted the need for 'accelerated staged trials to discover whether feasible cost-effective solutions can be developed'."

6. "To address this gap, DTI has announced its support for the sector through its Wave and Tidal Stream Energy Demonstration Scheme. This will provide critical support for WEC developers both through capital grants and revenue support."

7. "Wave Hub de-risks the development of initial arrays of WEC devices and enables developers to participate in the Wave and Tidal Stream Energy Demonstration Scheme through provision of shared infrastructure and a structured approach to consenting issues. The Wave Hub is a 'plug and play' model (as mentioned in the Innovation Review) that will support several devices over a long period of time."

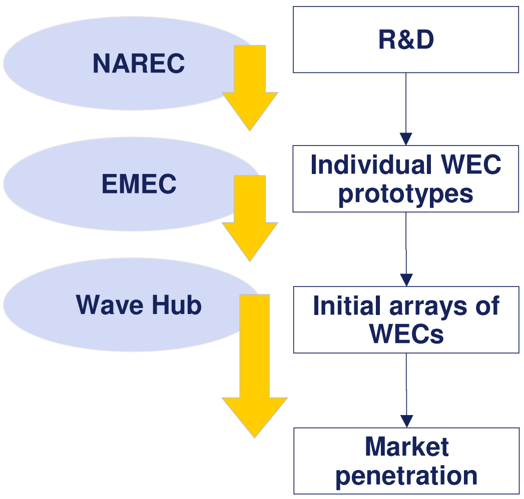


Figure 1.4 Wave Hub's position in the UK drive to develop wave energy markets (adapted from Regen SW)

8. "Wave Hub thus fills a critical gap in the UK government's framework for supporting the development of wave energy and allows the DTI, the Department of Environment, Food and Rural Affairs (DEFRA) and the Crown Estate to deal with consents, permits and leases in a structured way through the emerging 'Proving Zone' concept. Wave Hub is an excellent fit with the scheme and will help ensure the UK retains a leading position because:

- Wave Hub meets a stated market need;
- Wave Hub provides a location and infrastructure that allows developers and regulators to understand the key issues affecting future commercial development of wave power;
- Wave Hub facility substantially reduces the [capital] costs of consents and construction and reduces investors' perception of project risk in terms of EIA and consents [and earlier entry into the market];
- The facility could encourage private sector investment into the emerging wave energy industry;
- It complements rather than overlaps with initiatives such as EMEC;
- Wave Hub is device independent – if one technology is not successful the project will not fail;
- The Wave Hub is designed to allow shared-used and re-use of grid access and permitting;
- The concept is closely aligned with the objectives of the proposed DTI Wave and Tidal Stream Energy Demonstration

Scheme. Among other activities, the scheme will assist the development of this new industry through infrastructure projects such as Wave Hub and general environmental studies to complement project specific EIAs."

1.3 Consent route

1. The proposed consent route for the Wave Hub project is a composite consent application for the Wave Hub infrastructure and WECs via Section 36 of the Electricity Act 1989 together with a consent under the Coast Protection Act 1949 and a licence under the Food and Environmental Protection Act 1985.

2. The proposal in a Section 36 consent application can include onshore works such as an electrical substation. Accordingly, the application for the Wave Hub under the Electricity Act includes an application for deemed planning permission under Section 90 of the Town and Country Planning Act 1990 to cover the proposed onshore infrastructure.

1.4 Requirement for Environmental Impact Assessment

1. The proposed consent route for the Wave Hub requires various approvals to be in place prior to its installation. The regulations relating to this project implementing the environmental impact assessment (EIA) process are as follows:

- Electricity Act 1989 - Electricity Works (Assessment of Environmental Effects) (England and Wales) Regulations 2000;
- Coast Protection Act 1949 – Harbour Works (Assessment of Environmental Effects) Regulations 1999; and
- Town & Country Planning Act 1990 – Town & Country Planning (Environmental Impact Assessment) (England and Wales) Regulations 1999.

2. The regulations identified above transpose into UK legislation the requirements of the European Community Directive 85/33/EEC, as amended by 97/11/EC, on the *Assessment of the Effects of Certain Public and Private Projects on the Environment*. The statutory approvals required under the aforementioned legislation are administered by the Marine Consents and Environment Unit (MCEU) on behalf of DEFRA and the DTI.

3. In addition, the application includes for an approval without a formal EIA route, namely the Food and Environment Protection Act 1985.

1.5 The Environmental Statement

1. This report – the Wave Hub Environmental Statement – documents the EIA process undertaken for the Wave Hub project in accordance with the relevant EIA regulations and will be submitted as part of the consent applications.

2. The Environmental Statement is divided into the following sections:

- Section 1: Introduction;
- Section 2: Project Description, which describes the Wave Hub project including its construction, operation and

decommissioning, and the WECs to be deployed and operated at the Wave Hub;

- Section 3: Alternatives, which describes the alternative options considered for the Wave Hub project (e.g. onshore connection point, positioning of the deployment area, cable route);

- Section 4: EIA Process, which describes the stages of the EIA process undertaken to date and leading up to the preparation of this Environmental Statement;

- Section 5: The Planning and Policy Framework, which includes information on the planning context of the region, statutory and non-statutory plans and policies of relevance to the study area;

- Sections 6 - 18: covering various environmental parameters (i.e. coastal processes, water and sediment quality, soil quality, terrestrial ecology, ornithology, marine ecology, fisheries, navigation, landscape, cultural heritage and archaeology, road traffic and access, tourism and recreation, noise and air quality, and socio-economy) in terms of the baseline environmental conditions, impact assessments, mitigation measures and residual impacts;

- Section 19: Conclusions, which includes a summary of the environmental impacts and includes information on residual environmental impacts (both beneficial and adverse), outstanding issues to be addressed during detailed design and cumulative environmental impacts (both beneficial and adverse);

- Section 20: proposals for monitoring;

- References; and,

- Technical appendices, which provide supporting information for the Environmental Statement.

3. In addition, a non-technical summary (NTS) of this Environmental Statement has been prepared. This is available as a separate document.

2 Project description

2.1 Introduction

1. This section of the Environmental Statement describes in detail the Wave Hub project, including its concept, design development, location development, infrastructure, construction, operation and maintenance, and decommissioning, and provides information about the types of WECs that could be deployed at Wave Hub.

2. All relevant information required for the EIA process has been made available. Other information, particularly concerning specific details about the WEC devices is not available for reasons of commercial confidentiality.

3. The alternatives considered for the Wave Hub project and the reasons for identifying the preferred option are detailed in Section 3.

2.2 Wave Hub concept

1. The Wave Hub project is proposed by SWRDA to support and encourage developers of WEC devices through the final demonstration and pre-commercialisation stage of development, allowing them to install and operate WECs to commercial scale conditions over a number of years.

2. To achieve this aim SWRDA will provide the Wave Hub infrastructure and establish an operating company such that several different WEC development companies can install, operate and decommission WECs or arrays of WECs in a context of lower risk and reduced complexity.

3. It is anticipated that the Wave Hub project will bring a variety of direct and indirect benefits to the south west region, such as:

- Production of a significant amount of clean, renewable energy in the south west region (up to 20MW);
- Promotion of the south west region as a leader in the field of wave power electricity generation;
- Potential creation of a number of new jobs; and
- Creation of new industry and expansion of existing industry capable of manufacturing, deploying, maintaining, inspecting, repairing and decommissioning the potentially wide range of devices likely to be deployed.

2.3 Wave Hub design development

Original design

1. The original design for the Wave Hub was developed during the Technical Feasibility Study (TFS) from August 2004 to February 2005 (see Figure 2.1). The original design comprised a 33kV connection to the WPD substation at Hayle, a 33kV cable, one TDU and six PCUs (rated at 5MW each and transforming from 33kV to 11kV) on the seabed. This design allowed for up to 30MW of renewable energy production.

2. This selection was made after extensive analysis of a range of alternatives against criteria which included fit to functional specification,

safety, risk to project, environmental impact, and cost. The availability of proven equipment was a core consideration for some of these criteria.

3. During the Wave Hub's design development phase from March 2005 to May 2006 the options for equipment supply have been thoroughly investigated. Further discussions have been held with the prospective users of Wave Hub (i.e. the WEC developers) and detailed environmental and geotechnical investigations have been made as well as further consultations with interested parties. There has also been a study of the procurement strategy. Although the final results from some of the studies are still awaited there is a good level of confidence that they will not require significant alterations to the design as now established to the extent that all relevant information for the EIA process has been made available.

Proposed design

4. The outcome of the work since March 2005 has been that the basic elements of the original design remain (as shown in Figure 2.1), but there are significant changes to the details of the electrical design. The TFS established that a connection capacity of 30MW is readily available at Hayle substation while the Wave Hub Project Vehicle Study identified 20MW as the maximum capacity needed for the early years at least to ensure a deliverable business plan. Consequently, the TFS design allowed for a 30MW main cable giving expansion potential without the high cost of laying a new cable. Any later expansion of offshore capacity would be expensive due to the cost of mobilisation and working offshore.

5. However, the design development has found that there is not a sufficient case to justify investing now in future expansion options. There would be a significant increase in capital cost and additional connection charges from the distribution network operator with an uncertain prospect of demand greater than 20MW. Accordingly, the electrical design for the Wave Hub's system has been set at a maximum capacity of 20MW.

2.4 Wave Hub deployment area

Size

1. The TFS undertaken from August 2004 to February 2005 indicated an appropriate design solution for the Wave Hub's offshore infrastructure and the WECs to be a 1km x 3km deployment area within a 2km x 4km area marked for navigation. Since March 2005, the complex nature of the sea bed, the short-listing of WEC developers and the WEC array parameters has confirmed a 2km x 4km deployment area to be sufficient to provide four slots for WECs and their mooring splays. Therefore, the deployment area is proposed to be 2km x 4km.

Location

2. Originally, the deployment area was to be located in approximately 50 metres of water, approximately 10 nautical miles to the north of St Ives. However, the location has been revised to its proposed location (see Figure 2.2) for the reasons described in the following paragraphs.

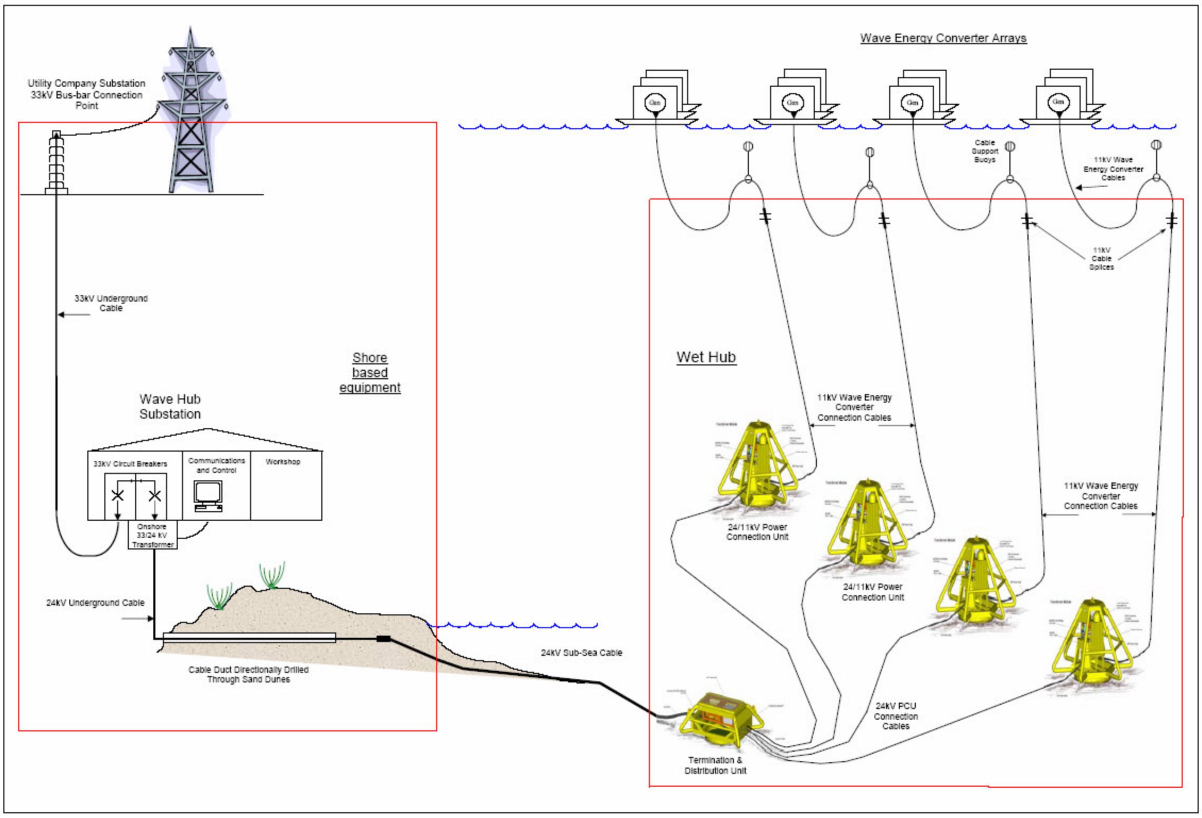


Figure 2.1 Wave Hub design including WECs

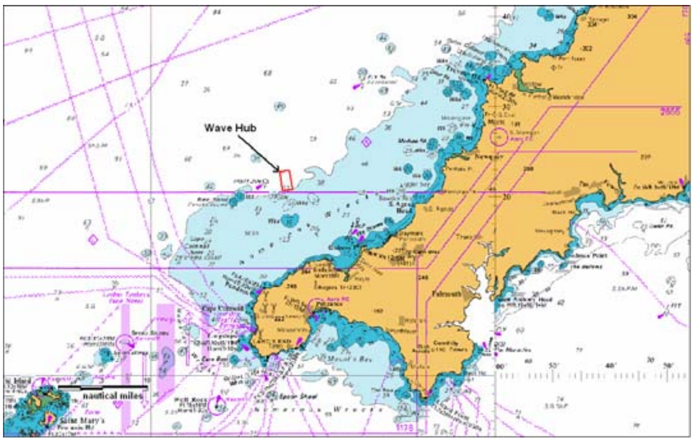


Figure 2.2 Offshore location of Wave Hub's deployment area

6. Since the reaffirmation of the deployment area size and location through further design and consultation, detailed offshore geophysical, geotechnical and environmental surveys have been completed for the proposed cable route corridor and offshore deployment area. These were completed in detail for the deployment area (as originally proposed) and more coarsely for the surrounding area with dimensions approximately 8km west-south-west to east-north-east by approximately 6+km north-north-west to south-south-east (see Figure 2.3). The survey lines in the surrounding area were termed 'regional lines'.

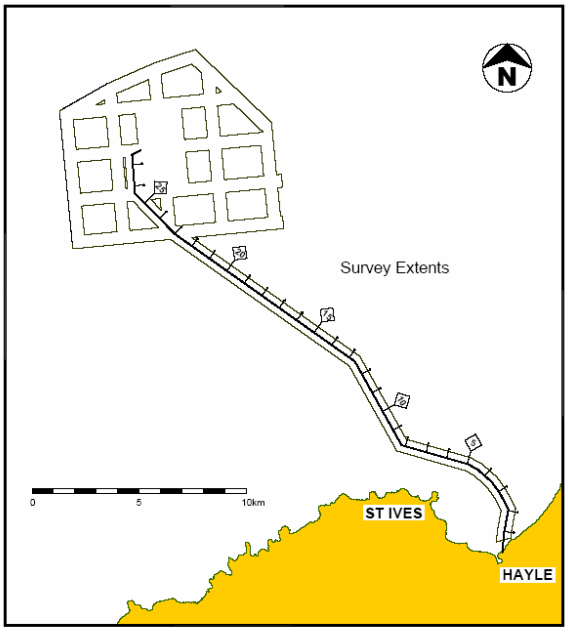


Figure 2.3 Extent of Wave Hub geophysical survey, including regional lines (EGS, 2006)

3. Subsequently, through the detailed Navigation Risk Assessment (NRA) consultations, concerns have been raised over the potential deviation of northbound vessels from Land's End traffic separation scheme (TSS) towards the Wave Hub site when giving way to vessels coming down channel from Avonmouth, even though the northbound lane of the TSS is some 16 nautical miles to the south-west of Wave Hub's deployment area.

4. Nevertheless, in the first instance as an early mitigation measure to minimise this concern, the location of the deployment area has been moved 4km east-north-eastwards.

5. The movement of the original deployment area to the revised location is illustrated in Figure 2.4. It is the revised location that is the subject of the Wave Hub consent applications and is addressed by this Environmental Statement.

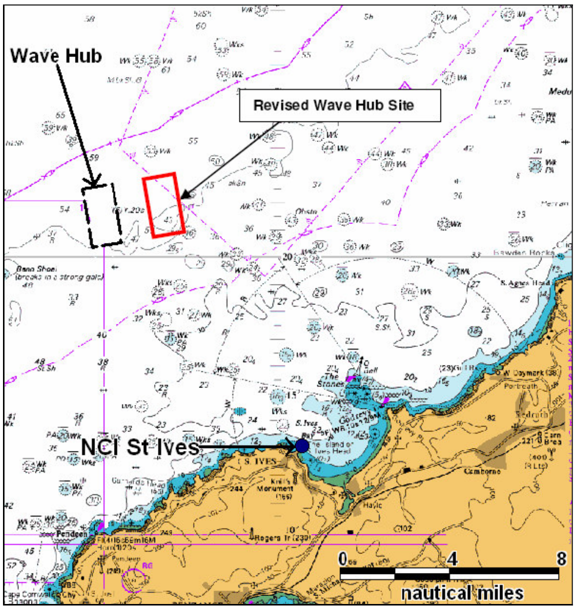


Figure 2.4 Original and revised locations of Wave Hub's deployment area

6. The Ordnance Survey grid references and latitudes / longitudes for the four corners of the Wave Hub deployment area are:

- North-west corner: OS N 59694 E142066 and WGS84 N50°22'50'' W5°37'56'';
- North-east corner: OS N 59918, E144053 and WGS84 N50°22'59'', W5°36'06'';
- South-east corner: OS N 55943, E144501 and WGS84 N50°20'52'', W5°35'34''; and
- South-west corner: OS N 55793, E142514 and WGS84 N50°20'42'', W5°37'14''.

7. The Wave Hub's offshore infrastructure (i.e. the PCUs and TCU), the WECs (including their lateral movement) and all associated moorings / anchoring systems will be positioned within the deployment area.

Aids to navigation

8. Various navigation aids will be positioned around the deployment area. It is expected that the marking of the deployment area will be made in accordance with the International Association and Marine Aids to Navigation and Lighthouse Authorities' (IALA) Recommendation O-131 on The Marking of Offshore Wave and Tidal Energy Devices (IALA, 2005).

9. IALA's Recommendation O-131 states that "areas containing surface or sub-surface energy extraction devices (wave and/or tidal) should be marked by appropriate navigation buoys in accordance with the IALA Buoyage System, fitted with corresponding topmarks and lights. In addition, active or passive radar reflectors, retro reflecting material, racons and/or Automatic Identification System (AIS) transponders should be fitted as the level of traffic and degree of risk requires."

10. IALA's Recommendation O-131 also states that "the boundaries of the wave and tidal energy extraction field should be marked by Navigational Lighted Buoys, so as to be visible to the Mariner from all relevant directions in the horizontal plane, by day and by night. Taking the results of a risk assessment into account, lights should have a nominal range of at least 5 (five) nautical miles. The Northerly, Easterly, Southerly and Westerly boundaries should normally be marked with appropriate IALA Cardinal mark. However, depending on the shape and size of the field, there may be a need to deploy lateral or special marks." The following paragraphs describe the infrastructure that is predicted to be in place, subject to confirmation by Trinity House.

11. Given that Trinity House has not formally advised on the aids to navigation required at the time of preparing this Environmental Statement, two scenarios are described for the deployment area. Both scenarios have the positions of the navigation aids as shown in Figure 2.5.

12. Firstly, as a typical scenario, it is expected that the deployment area will be marked by four Class 2, colour-coded steel buoys 4.5m above sea level as cardinal marks 500 - 1000 metres to the north, east, south and west of the deployment area (with five nautical mile white lights), and by four special marks for the corners of the deployment area (with two nautical miles yellow lights).

13. Secondly, as a more conservative, worst case scenario, it may be necessary for the deployment area to be marked by four Class 1, colour-coded steel buoys 6.5m above sea level as cardinal marks 500 - 1000 metres to the north, east, south and west or the deployment area (with nine nautical mile white lights), and by four special

marks for the corners of the deployment area (with two nautical miles yellow lights).

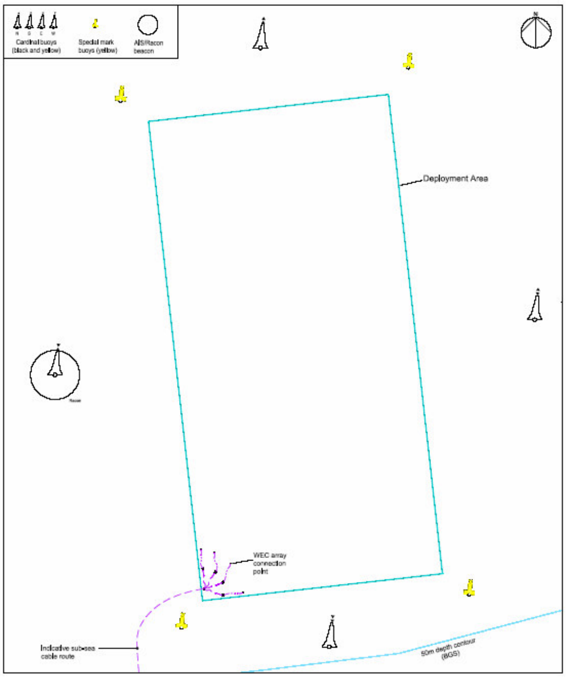


Figure 2.5 Indicative positions of aids to navigation around the deployment area

Anchors for aids to navigation

14. A Mooring Assessment Study (Halcrow / HPA, 2006) has been undertaken to identify preliminary mooring and anchoring requirements for buoys. The mooring system is based on extreme environmental event design conditions including loads on device types due to wind, waves and currents. Accordingly, it is assumed to represent a conservative, worst case scenario.

15. The *Mooring Assessment Study* identified the need for one mooring chain from a buoy's tail rod connector to a seabed clump anchor. The mooring line will need to be up to 80m in length to allow enough slack for a maximum wave crest height.

16. The Mooring Assessment Study identified that a cast iron sinker with dimensions of 1.2m (length) x 1.2m (breadth) x 0.25m (height) is recommended. The cast iron sinker is expected to have a dry weight of 3047kg.

Area to be avoided

17. It is proposed that an application will be made to the MCA in conjunction with the UK Safety of Navigation (UKSON) committee to consider giving the deployment area the status of an ATBA. Normally the IMO would decide on this matter, but in the case of the Wave Hub it is anticipated that the decision will fall to the Maritime and Coastguard Agency (MCA) in consultation with the Department for Transport (DfT) and the DTI because the deployment area is located within UK territorial seas.

18. According to http://www.dti.gov.uk/renewables, an ATBA "is a routeing measure comprising an area within defined limits in which navigation is either difficult or where it is exceptionally important to avoid incidents including collisions and groundings and which should be avoided by all ships, or certain classes of ships."

19. The purpose of ATBAs and other routeing measures is, according to www.dti.gov.uk/renewables, "to aid the safety of navigation by requiring or advising certain categories of ships or ships carrying certain cargoes to follow designated routes or to avoid certain areas of the sea. Ships' routeing may also be used for preventing the risk of pollution or other damage to the marine environment in or near environmentally sensitive sea areas."

20. In accordance with the International Maritime Organisation's (IMO) General Provisions on Ships' Routeing, governments which establish routeing measures wholly within their territorial seas (as is proposed for ATBA concerning the Wave Hub's deployment area) are requested by the IMO to design them in accordance with IMO guidelines and criteria and submit them to the IMO for adoption. It is UK policy to abide by this guidance, so that all routeing measures have international acceptance, although the UK reserves the right to implement a routeing measure if it is compliant with international law but not approved by the IMO.

21. According to http://www.dti.gov.uk/renewables, "once a routeing measure has been agreed with the IMO, the DfT / MCA will take the steps necessary to implement it formally. The routeing measures must be marked on charts, promulgated in Notices to Mariners and the IMO's Ships' Routeing 4 publication updated. The routeing measure will generally apply 6 months after it has been adopted by the IMO."

22. In terms of navigation, the ATBA will be a recommendatory routeing measure because it will have no statutory basis. The ATBA's application to vessels will be agreed when it is adopted and will be described in its description in the IMO's Ships' Routeing publication.

23. Unless expressly provided otherwise, the application of Chapter V (Safety of Navigation) of the Safety of Life at Sea (SOLAS) Convention will apply to all vessels on all voyages. Although the DTI / MCA can decide to what extent the provision of certain regulations apply for ships below 150 gross tonnage engaged on any voyage, ships below 500 gross tonnage not engaged on international voyages and fishing vessels, no such determination exists of Regulation 10 dealing with Ships' Routeing.

24. However, compliance with the international Regulations for Preventing Collision at Sea 1972 as amended (COLREGS) is mandatory for all vessels on the high seas, and in all waters connected to the high seas and navigable by seagoing vessels, used or capable of being used as a means of transportation on water.

25. Therefore, the ATBA for the Wave Hub's deployment area would apply to all vessels.

2.5 Wave Hub offshore infrastructure

1. The Wave Hub's offshore infrastructure will include a TDU connected via four semi-flexible cables to up to four PCUs.

Termination and distribution unit

2. The TDU is a passive unit comprising lengths of busbar enclosed in an oil-filled water-tight enclosure which performs the basic function of splitting the main power cable into four. An artist's impression of a TDU is shown in Figure 2.6.

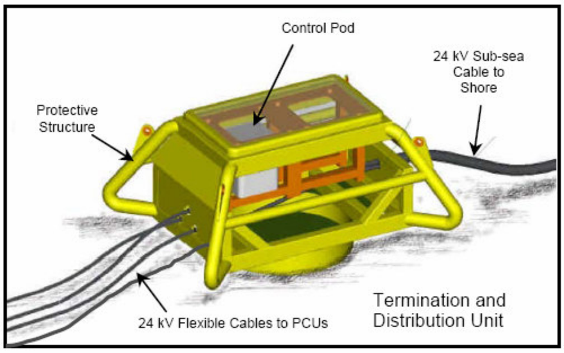


Figure 2.6 Artist's impression of a TDU

3. The TDU has four connection points and 20MW capacity. The unit will have a life to match that of the whole Wave Hub infrastructure, nominally 25 years.

4. A key requirement is that there should be no moving parts or electronic components. It should not contain any parts that require maintenance. The TDU is a completely passive device with no moving parts and no power will be needed to make it operate. This being the case, it is assumed that there will never be any reason to retrieve this unit from the seabed until decommissioning.

Power converter units

5. Wave Hub's concept design is for four PCUs rated at 5MW each. An artist's impression of a PCU is shown in Figure 2.7.

6. During the TFS (August 2004 to February 2005), it was determined that sub-sea transformers of 5MW are commercially available but a single unit of 30MW would require development. It was therefore decided that each connection to an array of WEC devices from one WEC developer would have a dedicated PCU of 5MW rating.

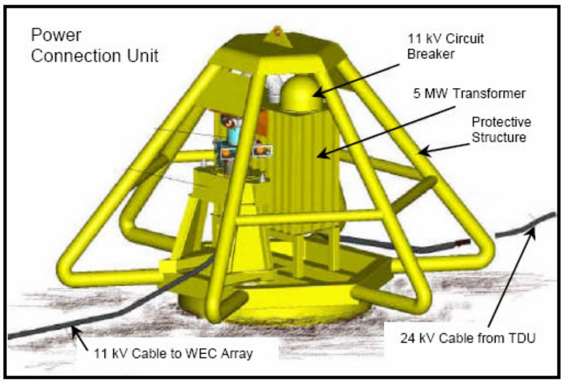


Figure 2.7 Artist's impression of a PCU

7. The PCU will contain metering facilities and a low voltage supply from an auxiliary transformer to supply control and signalling equipment.

8. The PCU therefore comprises the following main components:

- A 11kV circuit breaker that protects the transformer 11kV winding in the event of a fault on the 11kV cable and protects the 11kV cable in the event of a fault on the transformer 11 kV winding;
- A 11/24 kV transformer that steps up the voltage output from the WECs to that suitable for transmission; and,
- A 24kV circuit breaker that protects the transformer 24kV winding in the event of a fault on the 24kV cable and protects the 24kV cable in the event of a fault on the transformer 24kV winding.

9. It may be necessary to make some modification to the electrical equipment within the PCUs to accommodate different specifications for different WECs. For example, the PCU could have a 6.6kV transformer and associated switchgear. The modifications are not expected to change the PCU protective framework, but may change the electrical equipment within it and may require additional WEC connection cables, for example, if two sockets are provided. Modifications will not change the power capacity of Wave Hub, which will be up to 20MW.

10. The PCUs components will be built inside a protective framework. Both sides of the PCUs' transformers will be protected by very low maintenance switchgear with remote control and

metering facilities. This will allow remote re-settable protection and isolation of each unit.

11. The PCUs will be designed for ease of installation and retrieval from the surface via a floating crane. The PCUs' electrical components will sit within a protective structure connected to a base designed to locate the unit securely onto the seabed. The sealed electrical equipment within a PCU can be removed from the protective structure and base, and raised to the surface as a separate unit for repair or maintenance since it is assumed that the PCU will be demountable from its base.

Connectors

12. Dry mate connectors or fixed penetrators will be used throughout for power connections for cost and availability reasons. These connections will be made in the factory or on board the installation vessel. Conversely, wet mate connectors will be used for fibre optic connections due to the difficulty in making good joints on a vessel at sea. All fibre connections at the TDU will be spliced and sealed before final installation.

13. Table 2.1 provides a summary of the Wave Hub's offshore infrastructure items.

2.6 Wave Hub cable

1. The power connection from the offshore equipment to the shore will be made using a single 3-core, 24kV - 20MW rated sub-sea cable. The cable will comprise three power core cables surrounded by a lead /steel sheath. The cable will be twisted along its length to cancel out the electromagnetic phasing within the three individual cables.

Table 2.1 Offshore infrastructure items (ARC, 2006)

Infrastructure	Description
4 x semi-flexible 11kV cables	Approx. 6km of 3 core armoured sub-sea cable with integrated fibre optic communication conductors.
4 x PCUs	A water-tight protective casing containing 11kV circuit breaker 11/24 kV 5MW transformer, 24kV circuit breaker, metal frame, and sited on concrete/steel base.
TDU	A passive unit which provides a connection from the 4 x 24kV cables from the PCUs to the single 24kV cable to the shore substation. Contains busbars enclosed in oil-filled water tight protective casing. Sited on concrete/steel base.
8 x navigation buoys	4 x Class 2, 3m steel/plastic Cardinal buoys and 4 x Special Mark steel/plastic buoys

2. The sub-sea cable will also house a number of fibre optic communications conductors running in protective tubes. Steel layers (i.e. armour) will surround the umbilical cable. They will be designed to resist seabed conditions that cause the cable to rub against the seabed and will be robust enough to withstand impact by trawling fishing gear. The sub-sea cable will be approximately 250mm in diameter and approximately 25km in length.

3. The 500m wide corridor for the cable route was chosen to avoid known wrecks and sudden changes in topography such as relict shorelines. The knowledge gained from an offshore geophysical survey data has been captured and processed for the entire original cable corridor. Key features of the geophysical investigation were an unmarked wreck, good sediment availability in St Ives Bay, and extensive rocky terrain seawards

from there. The geophysical survey data led to an indicative cable route within the corridor.

4. The sub-sea cable will be buried to the maximum practical depth which may be between 2m and 3m below the seabed surface where sufficient sediment makes this possible. Geophysical data suggests that the first 8km of the cable may be buried (i.e. across St Ives Bay). Further offshore, where there is insufficient sediment to allow burial, the remaining 17km of cable will be laid on the surface of the seabed. No rock protection over the cable is proposed.

5. On landfall, the cable will be buried between 2m and 3m below the beach level and drilled through the sand dune system. The cable will extend directly to a new substation at Hayle.

6. Table 2.2 provides a summary of the Wave Hub's cable infrastructure items.

Table 2.2 Cable infrastructure items (ARC, 2006)

Infrastructure	Description
24kV cable	Approx 25km of 3 core, armoured sub-sea cable with integrated fibre optic communication conductors

2.7 Wave Hub onshore infrastructure

1. The onshore infrastructure will be situated adjacent to the existing substation facility at Hayle which is operated by Western Power Distribution (see Figure 2.8).

2. The onshore infrastructure will include a substation building (see Figure 2.9) and other facilities outdoors (as shown in the layout on Figure 2.10).

3. The ground conditions in this area are particularly poor; the geotechnical data from this area detail extensive made ground. Accordingly, a single storey substation building, which will be relatively light-weight, is proposed to sit on a concrete slab within which trenches will be provided to house the incoming Wave Hub sub-sea cable.

4. An illustrative footprint of the building is shown in Figure 2.9. It has been sized to accommodate all associated electrical facilities for the Wave Hub. As the manufacturers for the various Wave Hub components have not yet all been determined, the final size of the various electrical components is unknown and, therefore, some dimensions are based upon current industry standards. However, it is considered that the overall dimensions of the constructed building are the maximum dimensions likely to be adopted.

5. The substation facilities will include:

- Power quality room;
- Circuit breaker room;
- Metering room;
- Control room with space for WEC developers' transmission equipment;
- Mess room with associated facilities for the various operators who will be monitoring equipment or providing maintenance on an occasional basis; and
- Remotely operated vehicle (ROV) workshop and garage.

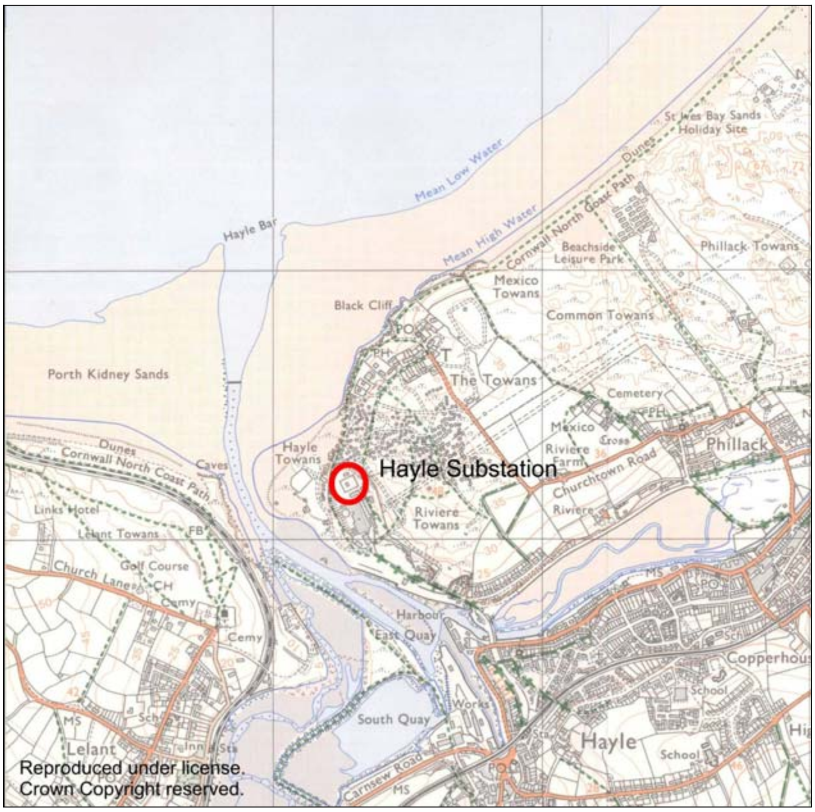


Figure 2.8 Onshore infrastructure location plan

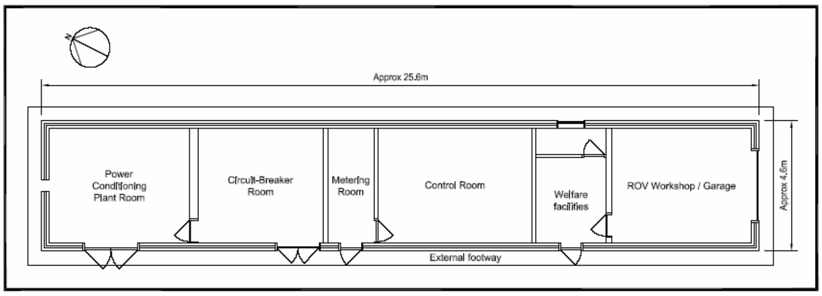


Figure 2.9 Illustrative footprint of the sub-station building

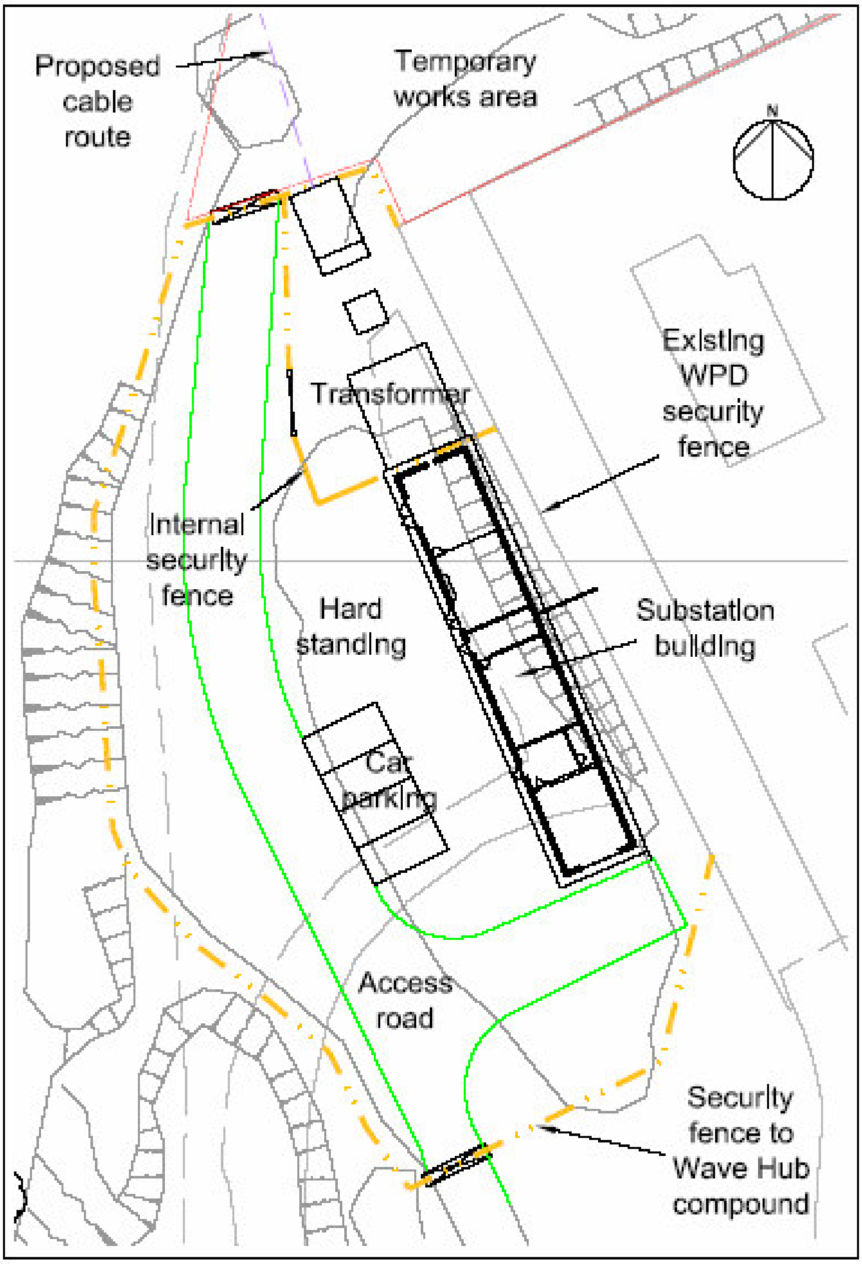


Figure 2.10 Onshore infrastructure layout plan

6. The building structure has been considered as a conventional brick clad masonry or rendered building for durability and aesthetic reasons.

7. The control room will contain the SCADA (Supervisory, Control and Data Acquisition) and communications equipment for control of the Wave Hub's offshore infrastructure via local and remote controls. The communications system (for monitoring and recording operational parameters) will also connect to the WECs via the fibre optic cables integrated with the power cables into the umbilical cable to provide remote access facilities for the operators. Internet connection will also be established.

8. At the north end of the building, there will be an outdoor area which will accommodate:

- Cable sealing ends;
- 24kV circuit breaker; and
- Transformer.

9. The area will be bounded by fencing of the same height as that of the compound.

10. The proposed access road is approximately 250m in length and lies over "made" ground, as does the compound track and turning area. The proposal is to re-grade the track and compound area and surface this with a reinforced gravel track placed over the top. It is assumed that in the longer term the access track will be replaced by new roads as part of the wider site redevelopment of Hayle harbour.

11. A car parking area has been defined and the turning head will accommodate vehicles up to the size of a fire truck, as well as enabling access and loading to the workshop area.

12. The compound is located within an area which is relatively flat, albeit with a small soil stockpile. The objective is to construct new works above, or only marginally below, existing ground levels, to avoid disturbance of the made ground below.

13. To the north of the compound, an area has been identified for the location where the Wave Hub sub-sea cable will emerge through the dunes. This area will be used on a temporary basis for temporary works such as the drill pit during directional drilling of the cable duct beneath the sand dune.

14. Security fencing to match the existing WPD sub-station is proposed. The final alignment of this fencing is to be confirmed in negotiation with the landowner.

15. A low voltage electrical supply will provide for building services and power for communications. A water supply will be provided from the local main and a septic tank will need to be installed at the substation for foul drainage. Surface water run-off will be drained to a swale (i.e. a depression to retard peak drainage flows) adjacent to the access road.

16. Table 2.3 provides a summary of the Wave Hub's onshore infrastructure items.

Table 2.3 Onshore infrastructure items (ARC, 2006)

Infrastructure	Description
Cable splitter chamber	Concrete chamber
Cable trenches	Concrete ducts
Transformer area	Cable sealing ends, 24 kV circuit breaker, 24kV/33kV transformer, fencing
Substation building	Single storey brick-clad building on concrete slab over made ground. May be a steel framed, clad building
Foundation slab	Reinforced concrete raft foundations and/or some form of ground improvement or piles founded at depth within the sands / gravels or bedrock may be present in transformer area.
Access road, compound track and turning area	250m metalled road
Car parking area	Concrete over made ground.
Drill pit and storage	Concrete lined excavated pit.
Security fencing	1.9m high secure fencing surrounding transformer.
Low voltage electricity supply	Trenched service cable.
Water line from mains	Trenched water supply
Septic tank	Buried Plastic Tank and associated sewerage pipes

2.8 Wave energy converters

1. The WECs do not form part of the Wave Hub infrastructure but are material to the consent application and are, therefore, included within the description of the Wave Hub project and subject to impact assessment.

WEC information development

2. In January 2005, the TFS initially identified 29 WEC developers in the marine energy industry of which 13 WEC developers returned detailed information in response to a questionnaire with the outcome that most saw the provision of a Wave Hub facility as an attractive prospect. Subsequent to the findings of the TFS, the marine energy industry has inevitably moved on such that WECs are now at different stages of development and not all have taken positive forward steps.

3. In July 2005, 15 WEC developers responded to express their interest in the Wave Hub and were invited to provide further technical information on their devices to progress the development phase of Wave Hub. The information on mooring design, electrical details, power generation, environmental concerns and required services was requested to support the Wave Hub’s design engineers production of a universally acceptable ‘hub’ design for a number of likely developers whilst also providing further details for the EIA and connection conditions for WPD.

4. Of the 15 WEC developers contacted, only seven returned useful information on their device and some responses were more detailed than others. One WEC developer returned a completed detailed questionnaire while five developers met with design engineers to discuss their WECs. One developer provided a copy of an expression of interest. Potentially seven developers indicated their availability for a possible Wave Hub deployment date in 2007.

5. In February 2006, SWRDA named three companies it has chosen as cooperating partners for the proposed Wave Hub project from 2007 on the basis that the WEC developers are sufficiently advanced with their devices, have the resources to deliver their projects, and are committed to working with stakeholders in Cornwall through the Cornwall Sustainable Energy Partnership (CSEP) to capture the economic benefits of Wave Hub for Cornwall and the South West region.

6. The following description is based on the information contained in the Wave Hub *Technical Feasibility Study Report* (Halcrow, 2005) and publicly released information including input from the three WEC developers currently working with SWRDA as cooperating partners to Wave Hub.

WEC devices

7. WEC devices may take a number of forms, with varying outputs, operating ranges, numbers in an array, and spacing. All WECs will be floating or semi-submersible, connected to the Wave Hub's PCUs by cable and anchored to the seabed via various numbers of mooring lines. The main types of device and how they generate electricity are described below.

8. Oscillating water column (OWC) device (e.g. ORECon device (see Figure 2.11):

- Consists of a partly submerged structure containing a column of water which is open to the sea below the water surface;
- Air is trapped above the surface of the water column;
- As waves enter and exit the collector, the water column moves up and down and acts like a piston on the air;
- Air is channelled towards a turbine and forces it to turn; and
- The turbine is coupled to a generator to produce electricity.

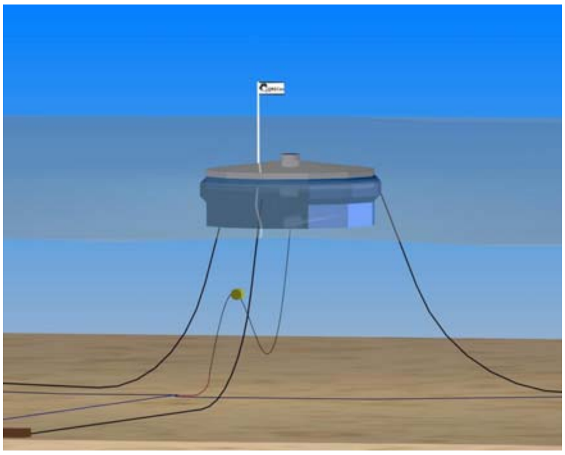


Figure 2.11 Example of an OWC device – ORECon (source: ORECon)

9. Overtopping device (e.g. Wave Dragon (see Figure 2.12) or Wave Plane devices):

- Consists of a structure over which the waves topple, a reservoir to collect the water and hydro turbines at the bottom of the reservoir;
- The head of collected water turns the turbines; and
- The turbines are coupled to generators to produce electricity.

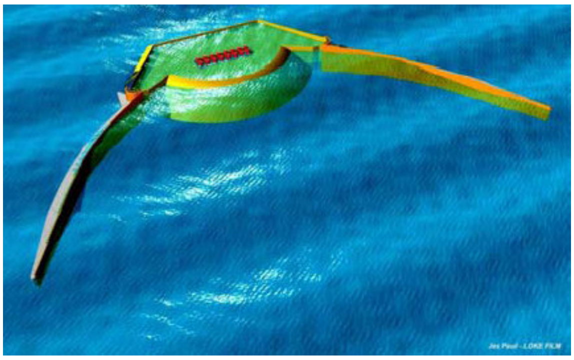


Figure 2.12 Example of an overtopping device – Wave Dragon (source: Wave Dragon)

10. Point absorber device (e.g. PowerBuoy (see Figure 2.14) or FO^3 devices (see Figure 2.15):

- A floating structure that absorbs energy in all directions;
- Designed so as to resonate – move with larger amplitudes than the waves themselves; and
- The power take-off system may take a number of forms, depending on the configuration of displacers/reactors.

11. Attenuator device (e.g. Pelamis device (see Figure 2.13)):

- A long floating structure like the terminator;
- Orientated parallel to the waves rather than facing them; and
- Rides the waves like a ship and movements of the device can be restrained so as to extract energy.

12. Three WEC developers are working with SWRDA as partners on the Wave Hub project and are in the process of developing the WECs known as Pelamis P750 (Ocean Prospect Ltd), PowerBuoy (Ocean Power Technologies Ltd) and the FO^3 (Fred. Olsen Ltd).

13. The Pelamis P750 (see Figure 2.13) is a semi-submerged, articulated structure composed of cylindrical sections linked by hinged joints. The wave-induced motion of these joints is resisted by hydraulic rams, which pump high-pressure oil through hydraulic motors which drive electrical generators to produce electricity.

14. The Pelamis device has dimensions of approximately 150m (length) x 3.5m (diameter), and an estimated height of 1.5m above the water surface.

Figure 2.13 Pelamis device (source: Ocean Prospect Ltd)

15. The PowerBuoy device (see Figure 2.14) is a free floating WEC that is loosely moored to the seabed. The buoy's float moves up and down on the central spar as the waves pass. This mechanical movement drives a hydraulic pump that forces hydraulic fluid through a rotary motor connected to an electrical generator.

Figure 2.14 PowerBuoy device (source: Ocean Power Technologies)

16. OPT are currently designing a PB150 PowerBuoy device with an output of 150kW and larger models are planned to 500kW and above. A 150kW device will have a float of up to 12m diameter and the central spar, about which the float moves up and down, will have a draught of up to 33m and a maximum diameter of 3m. The estimated height above the water surface of the Powerbuoy is approximately 4m.

17. An array of PowerBuoy devices would have a spacing of approximately 10 diameters apart at Wave Hub (see Figure 2.22).

18. Fred Olsen's FO^3 device (see Figure 2.15) is a multiple point-absorber system that utilises a number of floating buoys attached to a light and stable floating platform to convert the wave energy to electricity.

19. The FO^3 device has dimensions of approximately 33m (width) x 33m (depth) x 25 (height), and has a maximum height of 13m above the water surface.

Figure 2.15 FO^3 device (source: Fred Olsen)

WEC layouts

26. The WECs and their associated infrastructure (i.e. moorings, anchors, cables) will be connected to the PCUs and installed within the deployment area. Figures 2.16, 2.17 and 2.18 provide three example layouts for various WEC types at Wave Hub.

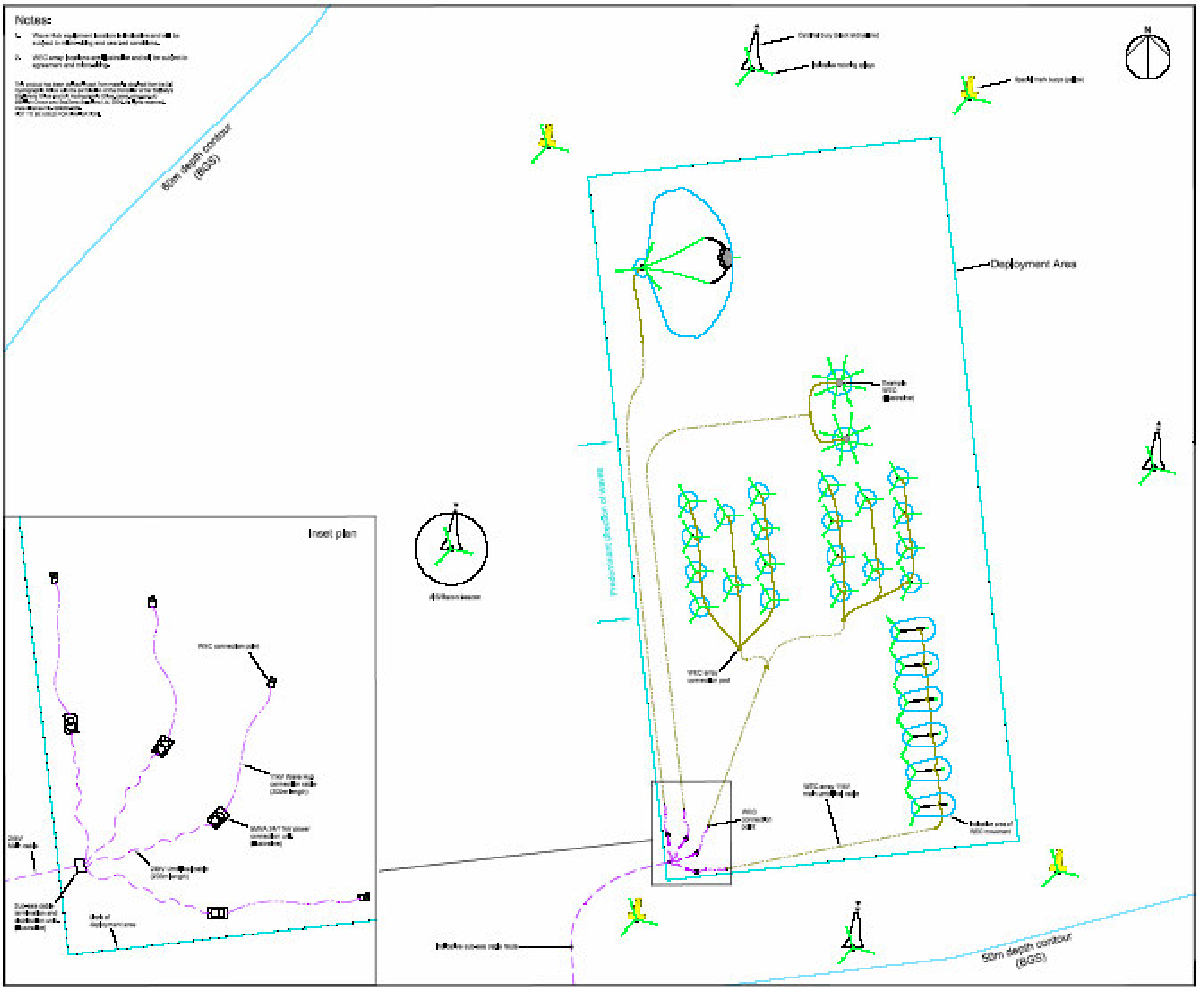


Figure 2.16 Example offshore layout 1 comprising 1 TDU, 4 PCUs, connector cables, aids to navigation and the following WECs (from top to bottom):

- *1 overtopping device;*
- *2point absorber devices;*
- *20 point absorber devices; and*
- *6 attenuator devices.*

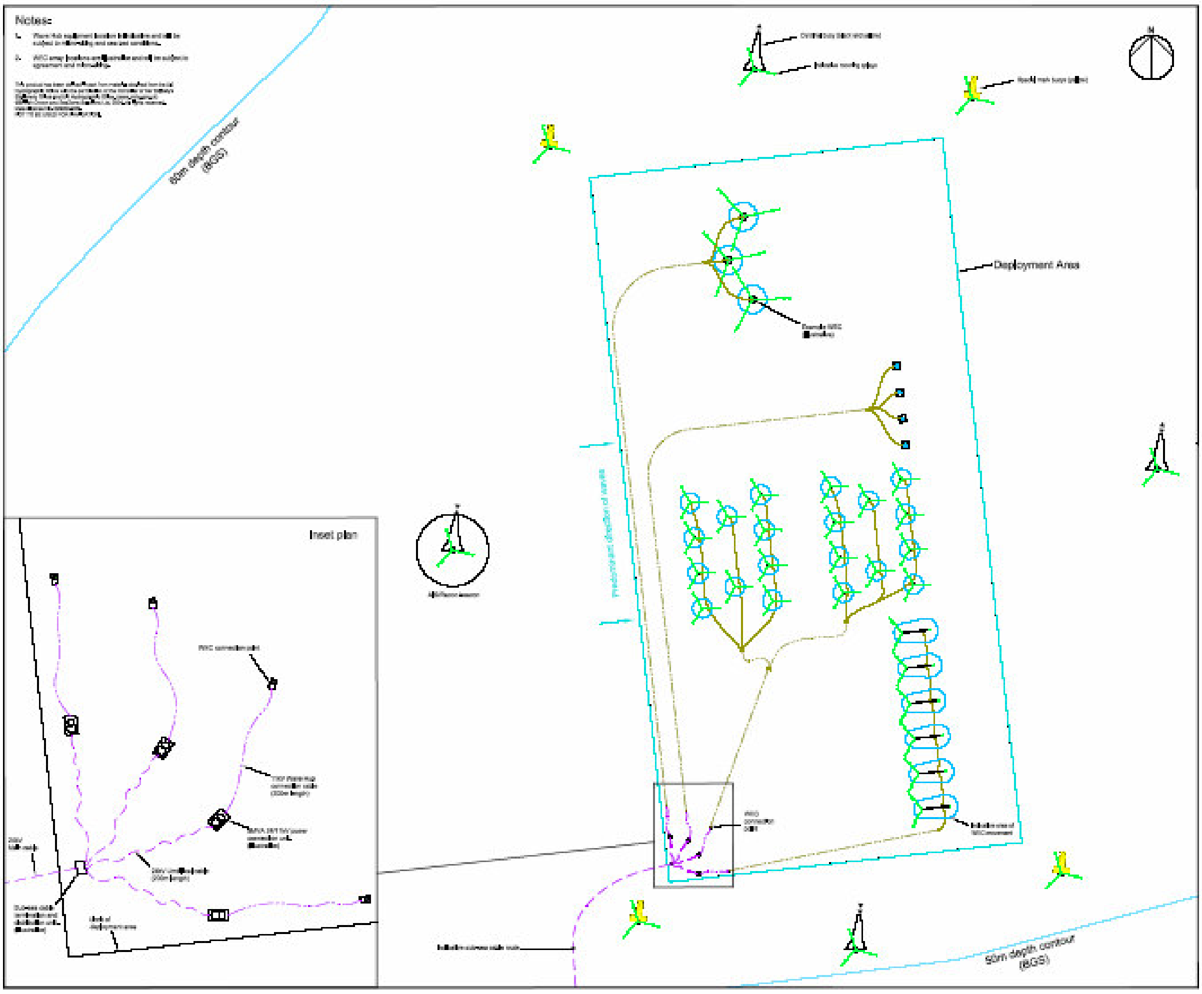


Figure 2.17 Example offshore layout 2 comprising 1 TDU, 4 PCUs, connector cables, aids to navigation and the following WECs (from top to bottom):

- *3 oscillating water column devices;*
- *4 point absorber devices;*
- *20 point absorber devices; and*
- *6 attenuator devices.*

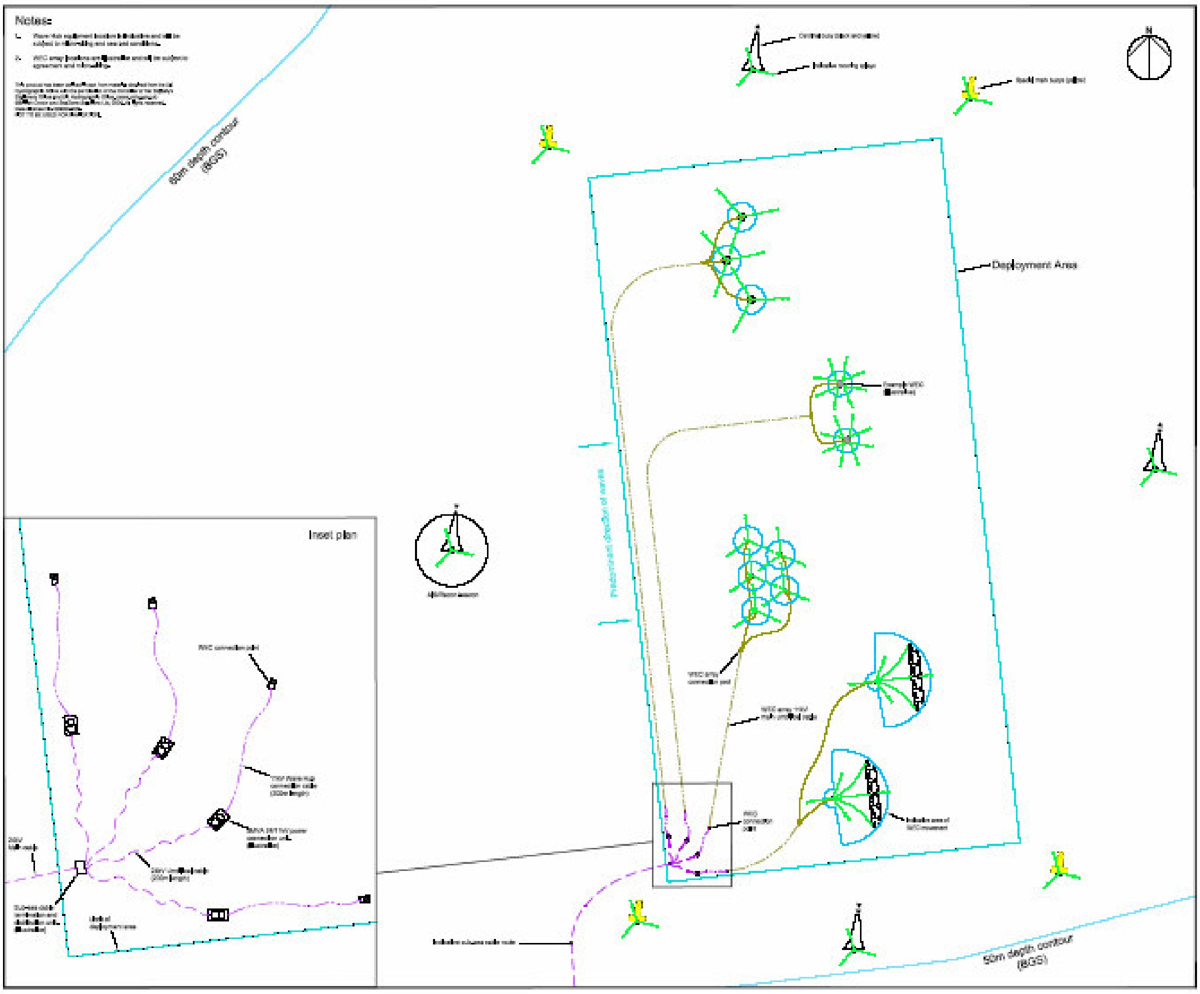


Figure 2.18 Example offshore layout 3 comprising 1 TDU, 4 PCUs, connector cables, aids to navigation and the following WECs (from top to bottom):

- *3 oscillating water column devices;*
- *2 point absorber devices;*
- *5 oscillating water column devices; and*
- *2 overtopping devices.*

Aids to navigation

27. Various navigation aids will be positioned around the deployment area. It is expected that the marking of the WECs will be made in accordance with IALA Recommendation O-131 on the Marking of Offshore Wave and Tidal Energy Devices.

28. IALA's Recommendation O-131 states that "when structures are fixed to the seabed and extend above the surface, they should be marked in accordance with the recommendations contained in the marking of offshore wind farms – O-117."

29. In addition, IALA's Recommendation O-131 states that "taking into account environmental considerations, individual wave and tidal energy devices within a field which extend above the surface should be painted yellow above the waterline. Depending on the boundary marking, individual devices within the field need not be marked. However, if marked, they should have flashing yellow lights so as to be visible to the mariner from all relevant directions in the horizontal plane. The flash character of such lights should be sufficiently different from those displayed on the boundary lights with a range of not less than 2 nautical miles."

30. Furthermore, IALA's Recommendation O-131 states that "consideration should be given to the provision of AIS [automatic identification system] as an Aid to Navigation (IALA Recommendation A-126) on selected peripheral wave and/or tidal energy devices."

Extinguished navigation rights

31. The consent application for the Wave Hub project will include a request that the DTI declares that public rights of navigation are extinguished where under the Electricity Act the WECs will interfere with rights of navigation. Because the WECs will be moored (rather than fixed) devices, each WEC will "swing" over a defined area of seabed and the declaration will need to relate to each WEC within a margin for lateral movement rather than just to a fixed point.

32. It is anticipated that the declaration so made will come into force in respect of any phase of the WECs operation after installation and shall cease to continue if the WECs are permanently removed.

33. The purpose of extinguishing navigation rights is to provide a statutory defence against a claim of public nuisance for interfering with navigation rights.

Safety zones

34. The consent application for the Wave Hub project will include a request that the DTI takes account of safety zones likely to be made under the Energy Act. Safety zones will be determined and granted on a WEC-specific basis.

35. Safety zones will extend up to 500m from WEC devices or arrays of WECs, including their lateral movement, and may overlap. In addition, safety zones could extend beyond the boundary of the 2km x 4km deployment area.

36. The worst case scenario for the total combined area of the safety zones is 15km^2 (i.e.

5km by 3km), but this magnitude is very unlikely since it could only occur if:

- WECs were positioned along the external boundaries and corners of the deployment area and distributed evenly within the deployment area; and
- Safety zones were implemented to the maximum extent of 500m.

37. However, in reality this is very unlikely to happen because:

- The maximum power generation of the Wave Hub will be 20MW, potentially limiting the numbers and therefore the positioning and distribution of WECs within the deployment area that could create worst case conditions;
- The mooring splays of the WECs may extend beyond the lateral extent of the WECs and their lateral movement, potentially preventing positioning along the external boundaries of the deployment area that could create worst case conditions;
- Wave shadow effects can compromise the operation and power generation of the WECs, potentially preventing an even distribution within the deployment area that could create worst case conditions (e.g. the position of one WEC device behind another along the northern and southern boundaries of the deployment area could compromise energy generation due to the wave shadow effect during the predominantly westerly wave direction);
- All four PCU slots within the deployment area may not be operational at any one time, potentially preventing a layout of WECs that could create worst case conditions; and
- Safety zones may not be implemented to the maximum extent of 500m, reducing their extent beyond the deployment area that could create worst case conditions.

38. Accordingly, to inform the EIA process, typical case scenarios for the potential areas for the safety zones have been calculated by applying the maximum 500m extent of safety zones to the example layouts of WECs that form part of the consent application (as shown in Figures 2.19, 2.20 and 2.21).

39. Under these scenarios, the safety zones will add the following areas to the 8km^2 covered by the deployment area:

- Example layout 1 = 1.4km^2 beyond the deployment area (see Figure 2.19);
- Example layout 2 = 1.0km^2 beyond the deployment area (see Figure 2.20); and
- Example layout 3 = 0.6km^2 beyond the deployment area (see Figure 2.21).

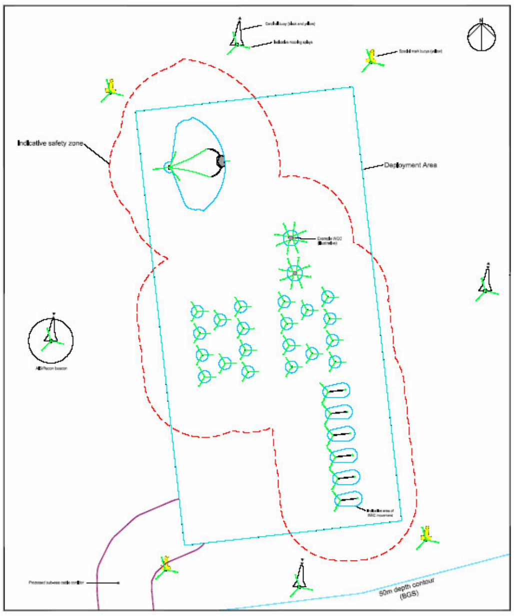


Figure 2.19 Indicative extent of safety zone areas for example offshore layout 1

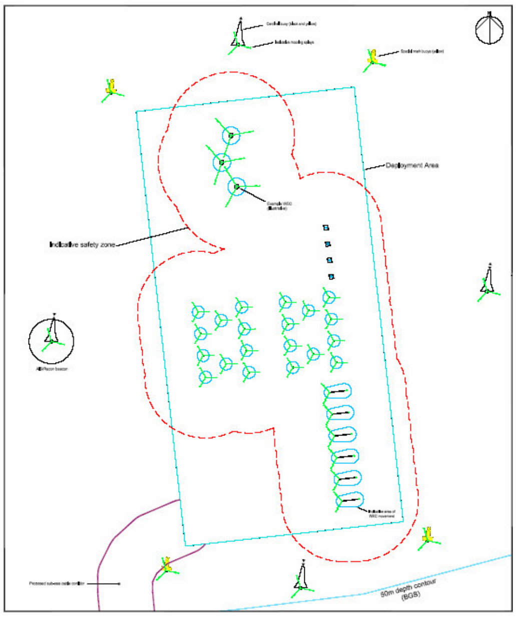


Figure 2.20 Indicative extent of safety zone areas for example offshore layout 2

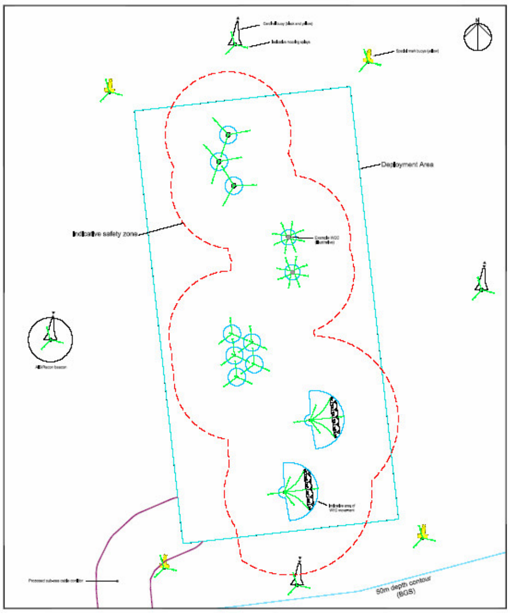


Figure 2.21 Indicative extent of safety zone areas for example offshore layout 3

WEC moorings

40. A Wave Hub *Mooring Assessment Study* (Halcrow / HPA, 2006) has been undertaken to identify preliminary mooring (and anchoring) requirements for two generic WECs (a box shape device and a vertical cylinder shape device). The generic shapes are a similar size to the maximum size of WEC expected to be deployed at Wave Hub and best resemble various WEC devices (compared to more complex shapes).

41. The mooring systems are based on extreme environmental event design conditions including loads on device types due to wind, waves and currents. Accordingly, they are assumed to represent a conservative, worst case scenario.

42. The anchoring systems were based on seabed conditions comprising firm sands overlying

stiff clays, as informed by geophysical survey data. Five anchor types were considered, namely drag embedment / fluke anchors, pile anchors, caisson anchors, gravity / clump weight anchors, and propellant / special embedment anchors against factors such as suitable capacity, ease of installation and cost.

43. The mooring systems identified by the Wave Hub *Mooring Assessment Study* have been used to inform the EIA process rather than the mooring information (where available) for specific WECs. This approach has been taken because the mooring systems identified by the *Mooring Assessment Study* are believed to be more conservative and site specific than the mooring information for specific WECs where mooring designs are not based on specific investigation relating to the Wave Hub's deployment area conditions.

44. The Wave Hub *Mooring Assessment Study* identified the need for a catenary mooring system for box shape WECs consisting of twelve mooring lines arranged in clusters of three lines at each corner.

45. The mooring lines comprise 15m segments of 142mm chain at the upper end, 185m segments of 144mm diameter mid-length polyester rope, and 50m segments of 142mm chain connected to seabed anchors. The upper chains are used to tension and adjust the line lengths, while the lower chains provide wear protection at the seabed.

46. A single line mooring configuration was found to be not practical for a box shape WEC due to the excessive load to be resisted by the mooring line. Instead, a second mooring system was developed similar to the first one but with twelve mooring lines connected to the centre of the bottom.

47. The Wave Hub *Mooring Assessment Study* identified the need for a catenary mooring system for vertical cylinder shape WECs consisting of six mooring lines connected to the circumference of the base at an angular spacing of 60 degrees.

48. The mooring lines comprise 15m segments of tail chain at the upper end, 185m segments of 130mm diameter mid-length polyester rope, and 50m segments of bottom chain connected to seabed anchors. The anchor segments are oversized for a vertical cylinder shape WEC but proved that a six line arrangement is practical. Line sizes could be reduced at later design stages.

49. A second mooring system was developed similar to the first one but with six mooring lines connected to the centre of a WECs base.

WEC anchors

50. The Wave Hub *Mooring Assessment Study* recommended an anchoring system for a box shape WEC consisting of tubular anchor piles approximately 1.2m diameter and 15m long either driven or drilled into the seabed. These anchors are commonly used offshore.

51. The Wave Hub *Mooring Assessment Study* recommended an anchoring system for a vertical cylinder shape WEC consisting of tubular anchor piles approximately 1.0m diameter and 10m long either driven or drilled into the seabed. Pile sizes could be optimised at later design stages

for the line loads developed. These anchors are commonly used offshore.

Other WEC mooring systems

52. For the purposes of this Environmental Statement, the mooring and anchoring systems identified by the Wave Hub *Mooring Assessment Study* are used to inform the EIA process since they are considered to be conservative and there is a lack of WEC developer information available concerning WEC mooring systems designed for conditions at the Wave Hub's deployment area (e.g. water depth, seabed).

53. However, Ocean Power Technologies' mooring system for the PowerBuoy device has been developed and is available to inform the EIA process. The Powerbuoy device will use a compliant, three point mooring system at 120 degrees intervals with anchors at 110m distance from the central spar, with auxiliary sub-surface buoys (ASBs). Tether lines from the ASBs connect to the central spar of the PowerBuoy device. The compliancy of the system allows the spar to move with tidal variation and survive heavy seas.

54. Anchors may be shared by more than one mooring line, as indicated by the conceptual mooring arrangement for 30 Powerbuoys deployed at Wave Hub, as shown on Figure 2.22. This arrangement requires 66 anchors for 30 Powerbuoys. Mooring lines will consist of a combination of wire rope, chain and shackle components.

55. Anchors on the seabed will be specified and sized to meet calculated anchoring forces as well as the local seabed conditions. Anchoring systems could consist of gravity base anchors with concrete/ steel ballast or grouted piles. Given the existing knowledge of the geophysical conditions at the Wave Hub deployment area, Ocean Power Technologies believe it to be highly likely that they would proceed with the grouted pile option. The grouted pile would comprise a single piece, long, circular steel tube (pile) is placed into a pre-drilled hole, or jacket, and cemented in place with grout; and

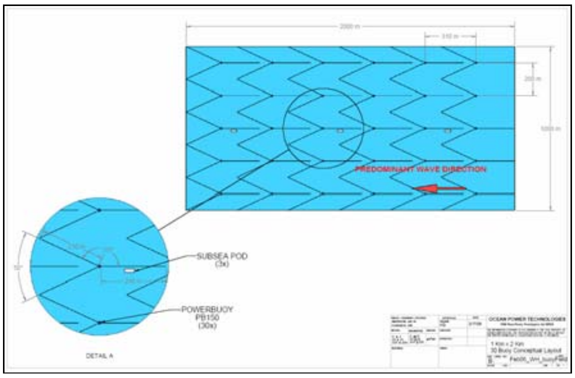


Figure 2.22 Conceptual layout of 30 PowerBuoys (source: Ocean Power Technologies)

WEC deployment and arrangement

56. Figures 2.16, 2.17 and 2.18 provide three example layouts for WEC devices at the deployment area. Different developers will be able to connect either individual WECs or arrays of WECs to a PCU at any one time. Developers will be able to build up the number of WECs in an array and replace WECs with larger scale devices.

57. All variations will be within the limits of the consent application. For example, Wave Hub will have a maximum output of 20MW. This output effectively limits the scale and/or number of WECs and WEC arrays that can be connected to the Wave Hub. Therefore, one PCU could accommodate up to 30 150kW PowerBuoy devices

generating 4.5MW, could not accommodate four 1.5MW FO[3] devices generating 6MW.

58. Developers will be encouraged to connect their WECs to the Wave Hub for a limited duration before removing them from the site to enable other devices to be connected. The required time duration for testing and improving the WECs is not known at this stage but should become clearer during the development process and from discussions within the industry.

59. As shown in Figures 2.16, 2.17 and 2.18, all WECs and their moorings / anchors will be installed within the same 4km x 2km deployment area.

60. Table 2.4 provides a summary of the WEC's infrastructure items.

Table 2.4 WEC infrastructure items (ARC, 2006)

Infrastructure	Description
WECs	To be specified by developer
11kV cable	Up to 3km of 3 core, armoured sub-sea cable with integrated fibre optic communication conductors
Moorings	Chain/man-made fibre rope (or as otherwise specified by developers)
Anchors	As specified by developers. WEC anchoring systems will be device dependent but may range from easily removable clump weights to rock anchors. Tubular anchor piles between 1-1.2m diameter and between 10-15m long

2.9 Wave Hub construction and installation

1. The following methodology for construction of the Wave Hub is a suggested methodology based on experience of constructing similar infrastructure.

2. In reality, the appointed contractor will choose his own preferred methodology but will be constrained by the Specification for the Works to ensure that any requirements for the construction methodology are implemented such that any environmental impacts will be no more than would result from the methodology described in the following paragraphs.

Offshore infrastructure

3. The Wave Hub's offshore infrastructure (i.e. the PCUs, TDU and connecting cables) will be pre-fabricated off site by a specialist manufacturer and, it is expected, will be transported from their point of origin to a suitable harbour for loading aboard a deployment vessel; which will probably be the cable laying vessel.

4. The TDU will be delivered with four flexible 24kV cables already connected and packaged so that they can be dry connected to the four PCUs prior to their installation. The PCUs and TDU will be installed from the vessel directly to base plates positioned on the seabed.

5. The base plates will not be bolted to the seabed but will be held on the seabed by gravity. Spikes maybe built into the design of the base plates to improve their grip on the seabed. The connecting cables will rest on the seabed.

Cable - offshore

6. The sub-sea cable will be constructed by a specialist manufacturer off site and, it is expected, will be transported to the Wave Hub site on a cable-laying vessel.

7. At the offshore end, the main sub-sea cable to the TDU will be dry connected at the surface before the TDU is lowered to the seabed.

8. Construction will involve a cable ship (see Figure 2.23) laying the cable from the landfall site at Hayle to the offshore location within the cable route corridor (see Figure 2.24).

9. The cable will be stored on deck and laid directly from the vessel to the sea floor. There will be no need to build a landing stage or any temporary structure fixed to or mounted on the seabed.

Figure 2.23 Example of a cable-laying vessel

10. The cable will be trench buried in the seabed sediments wherever possible, although much of the cable route lies over outcropping bare rock. Inshore, in St Ives Bay, the seabed comprises sandy sediment and it is anticipated that the cable will be buried between 2m and 3m below the seabed's surface, possibly using a cable plough device (see Figure 2.25).

Figure 2.24 Indicative working corridor for cable installation from the beach to the deployment area

Figure 2.25 Example of an offshore cable plough

11. In order to protect the cable from damage and to protect the interests of other marine users, the design seeks to bury the cable in the seabed sediment wherever possible. However, burial will not be possible along the cable route from approximately 8km offshore and the uneven nature

of the seabed means that there is the potential that the cable may be left hanging over gaps between obstructions. In such circumstances there is a risk that certain activities (trawling, anchoring) may snag on cable spans. Therefore, the construction process will address ways to minimise cable spans as described in the following paragraphs.

12. Spanning potential has been considered by an interpretation of the Wave Hub's geophysical survey data (EGS, 2006) concerning the seabed features along the cable corridor. The interpretation indicates that exposed rock bedding planes are on the seabed between c.8km and c.23km from the shore. These bedding planes have the appearance of generally parallel ridges, separated by troughs. The alignment of these bedding planes varies along the cable route, being parallel / oblique to the cable lay direction between c.8km and c.20km offshore, and generally perpendicular to the cable route between c.20km to c.23km offshore. Therefore, the spanning potential along the cable route will be a function of cable orientation, ridge spacing and trough depth between ridges.

13. It is the c.20km to c.23km section of the cable route where the ridges are approximately perpendicular to the cable route and there is the most potential for spans. Although bathymetric images of the seabed give an impression of a rough seabed, section lines drawn along the route from the geophysical survey data when viewed at true scale with no vertical exaggeration provide a better indication of seabed roughness. Distances between ridges generally vary between 5m and 30m, with gentle inclined troughs reaching maximum depths of 2m but more usually between 0.5m and 1.0m. Given that the cable does have some degree of flexibility, there will be some degree of cable sag into the troughs, reducing spanning heights.

14. Given the potential for cable spans, the installation method for the cable will be based on an avoid-reduce-remedy approach to reducing spans:

15. The first step is to avoid spans by:

- Route the cable over sediment: the route selection seeks to maximise the cable run over sediment;
- Bury the cable where possible: where the cable runs over sediment, the cable will be buried to the maximum practical depth between 2m and 3m; and
- Careful alignment of the cable on bare rock sections: where the cable cannot be routed over sediment and/or buried, the cable lay alignment will seek to ensure that the cable is positioned in such a way that it is in physical contact with the seabed by following the troughs between ridges as far as is possible. This will be achieved by the use of detailed bathymetric and geotechnical data from the pre-installation survey.

16. The second step is to reduce spans by:

- Consider cable specification changes: Where it is not possible to follow natural features and where spanning may occur, consideration will be made to specifying a higher level of cable flexibility to enable the cable to sag more into troughs. This will be particularly relevant in the c.2.5km length of the cable route beyond 20km offshore where the ridges run perpendicular to the route of the cable; and

- Lay cable with slack: the cable lay specification will require the contractor to lay the cable to defined levels of slack, as excess tension could encourage spanning.

17. The third step is to remedy spans by:

- Post-installation inspections and repositioning: at the conclusion of the cable lay, an ROV inspection of the complete cable route will be undertaken, and any spans positively identified. Where the obstruction is localised (e.g. the cable may rest on a boulder), a partial lift and repositioning of the cable may be possible. Should repositioning not be physically possible, mitigation measures may be applied; and

- Apply mitigation measures: for spans where there is the evidence of the possibility of other marine activities (trawling or anchoring) crossing the cable, consideration will be given to appropriate mitigation measures to protect other marine users and the cable integrity. These may be physical measures, such as rock covering or the use of concrete mattresses, or navigation guidance measures such as specific warnings on navigation charts.

Cable - onshore

18. The onshore component of the cable laying will take approximately 20 days to complete. It will involve a continuation of the cable laying from the sea by ploughing it below the beach as far as a cable duct above high water on the beach. It is envisaged that there will need for an approximate working corridor 100m wide across the beach along the cable route (see Figure 2.26), plus an allocated access route of 10m width. The working area will be marked and guarded to prevent public access during the cable laying for reasons of health and safety. Markings will be limited (i.e. no fencing) due to tidal conditions.

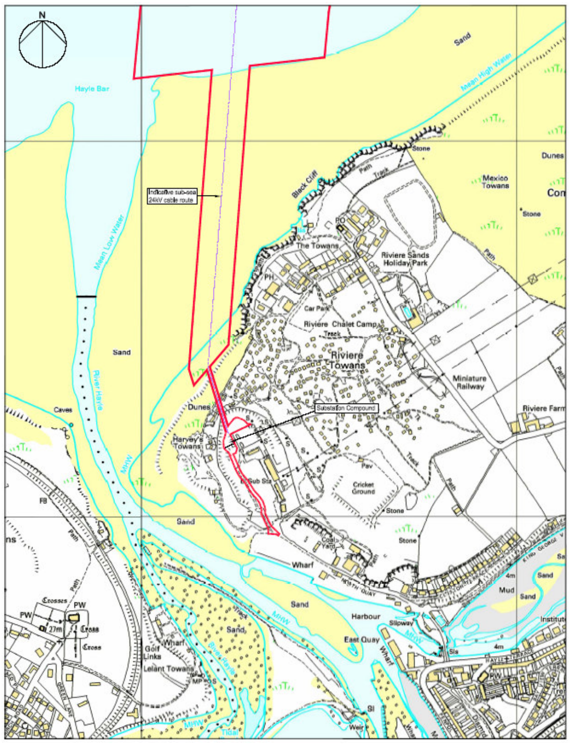


Figure 2.26 Indicative working corridor for cable installation across the beach

19. The excess cable will be laid out on the beach before it is pulled through a pre-drilled cable duct below the dunes and into the substation area. Directional drilling beneath the dunes will use a drilling fluid. There will be a small amount of drilling fluid released at the drill break out. A

trench will be dug to allow any of the drill waste to be caught. This may mean that the appointed contractor will need to line any trench that will be used to catch drilling fluid to prevent pollution.

Onshore infrastructure

20. The first construction activity onshore will be to clear the site of the existing rubble, waste materials and scrub vegetation to create a level working area. Excavation works will be minimised and limited to levelling the site and, if necessary, providing the concrete raft foundation for the substation building. Ground excavation works will be minimised, probable raft foundation under the building but the site will need to be levelled.

21. The one-storey substation building will be built as close as possible to the existing substation. Standard building construction methods will be used to construct the substation building which will entail the laying of a concrete base slab on which will be built a two-skin brick block masonry structure.

22. A 2.4m high steel palisade galvanised security fence with matching 4m wide gates at each end will be erected around the compound. This fencing will match the fencing around the existing substation.

23. A 4m wide track will be constructed to provide access into compound. Construction will require the laying of a 200mm thick gravel sub-base track with the option to asphalt it at a later date.

24. Other excavation works will be limited to shallow trench construction for installation of utilities such as water supply, cables and drains.

25. The land boundary for onshore infrastructure compound is shown by the purple line in Figure 2.27. Additional temporary works will take place in the area demarcated by the red line in Figure 2.27; for example, directional drilling.

Construction traffic

26. All the offshore Wave Hub equipment will be deployed from vessel(s) and will not require any road delivery of construction equipment and materials to Hayle.

27. The cable will be laid across the seabed from a specialist cable laying vessel and will not require any road delivery of construction equipment and materials to Hayle.

28. Onshore, cable installation through the beach will require ploughing equipment to be brought to site by road. Other equipment is likely to include a one-off delivery of tracked excavators / tractors and possibly a small crane (approximately 10 tonnes), generators, health and safety fencing, etc.

29. Cable-laying through the dunes will require directional drilling equipment to be brought to site. This equipment will require one-off deliveries of a plough machine. In addition, it is likely that a low draught barge / tug will be present in shallow water nearshore.

30. Construction of the onshore infrastructure will require the delivery of various construction materials including concrete, bricks, crushed rock, slates/tiles, fencing, electrical equipment (e.g. the transformer) and utilities equipment (e.g. a septic tank).

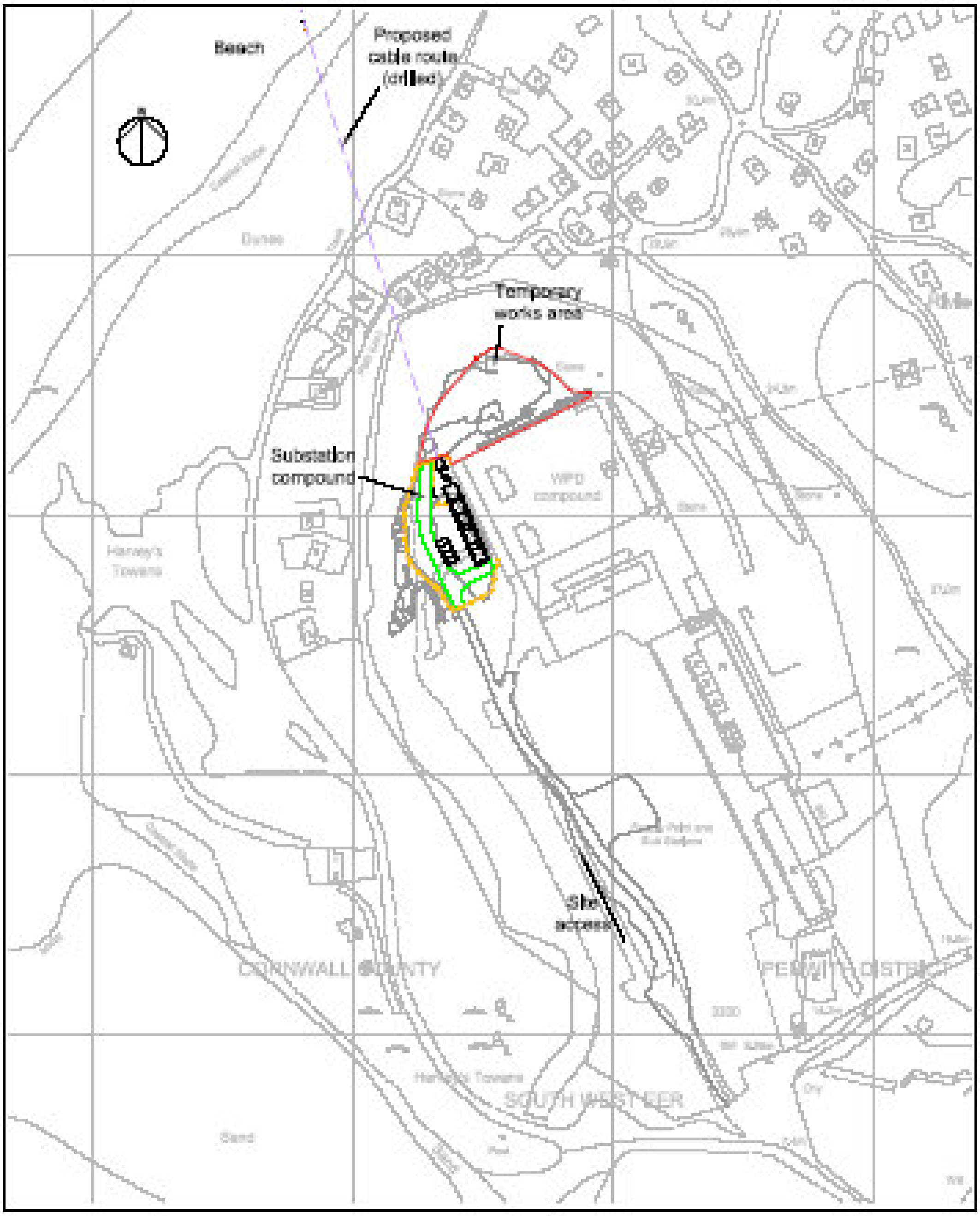


Figure 2.27 Onshore work land boundaries

31. The following construction traffic is expected:

- 11-12 tonnes of bricks / blocks = 3 trucks;
- 50m^3 of concrete = 10 x 6m^3 capacity concrete trucks;
- 200m^3 crushed rock = 20 x 20 tonnes trucks;
- Roof tiles / slates = 1 truck;
- Fencing = 1 truck;
- Transformer = 1 low loader (up to 60 tonnes capacity);
- Other electrical equipment = 5 trucks; and
- Utilities equipment = 5 trucks.

32. In total, it is estimated that the onshore infrastructure will require up to 50 trucks accessing the site by Kings Memorial Road, equating to 100 truck movements (i.e. to and from site). Deliveries will be spread over the duration of the works, but it is assumed most deliveries will occur early in the construction of the substation building.

33. The onshore site will be cleared prior to construction and there will be some excavation. These works are anticipated to create waste materials that will require trucks to take the waste off-site for disposal at an appropriate waste disposal facility. It is estimated that there will be 12 x 12-15 tonnes truck loads of on-site debris and excavated material to be removed, equating to up to 30 truck movements.

34. The WECs and their anchoring / mooring systems will be deployed from vessels and will not require any road delivery of construction equipment and materials. The number of vessels needed to deploy the WECs will depend on the different devices, but two vessels are anticipated for most WECs.

35. It is estimated that between 6 to 15 staff will be on site for the construction works. For example, the directional drilling may require around six staff, while six to ten staff may be involved with constructing and fitting out the substation building. Staff would drive to and from the site every day.

Construction schedule

36. If the consent application is successful, it is expected that Wave Hub will be constructed in the spring/early summer of 2008.

37. The entire installation of the Wave Hub's offshore infrastructure and the cable is expected to take 55 days to complete and will be ideally spread over spring and early summer to coincide with the calmest weather and sea conditions. Vessels will not be working continuously during this period due to pre-construction preparation and downtime caused by inclement weather. In fact, of the 55 days offshore work, the TDU installation, PCUs installation, cable-laying, cable inspection and (if necessary) repositioning is expected to take around 20 days. Weather and sea conditions will affect the duration of these works by an additional 35% (i.e. 7 days) if the works are undertaken from May to September, and by 75% (i.e. 15 days) if the works are undertaken from October to April.

38. The onshore works are expected to extend over several months (up to 6 months). Much of the onshore work will be undertaken prior to the offshore works to the extent that once the cable is laid it can be pulled through the dunes and

connected to the sub-station facilities and WPD's electricity network. The timing of this work is less weather dependent and therefore it is not necessarily limited to a particular time of year.

2.10 WEC construction and installation

1. If Wave Hub is constructed in the spring/early summer of 2008, then WECs can be installed from that time.

2. The WECs and their moorings and anchoring systems will be constructed off site.

3. The anchors will be installed prior to deployment of the WECs and their moorings. On the basis that piled anchors will be required, the construction will involve installation by either driving or drilling and grouting the piles into the seabed from a floating crane or workboat. The bottom segments of the mooring chains will be pre-attached to the pile anchors before installation and will lie on the seabed temporarily until recovered in order to connect to the WECs.

4. The WECs and the upper segments of their mooring chains will be pre-fabricated and, it is expected, will be brought to site either by towing behind a vessel or by being transported on a vessel from which they will be deployed directly into the sea. For example, Figure 2.28 shows the Pelamis device being transported behind a vessel and deployed with tug assistance.

5. At this point the WECs will be connected to their previously installed anchoring system. The WEC based mooring components, top chains and polyester ropes will be pre-connected to a WEC's hull onshore. The polyester ropes will be connected to the bottom chains and anchors from workboats or tugs while the WEC is held in position. Finally, the mooring lines will be tensioned using portable chain jacks and then permanent chain stoppers will be set when the WEC is in its final position.

Figure 2.28 Pelamis deployment (source: Ocean Prospect Ltd)

2.11 Wave Hub operation and maintenance

Operating company

1. At the time of preparing this Environmental Statement, an operating company for Wave Hub was yet to be identified. However, the options at this time were that either the SWRDA (at least initially) and/or a local university would operate Wave Hub.

2. It is anticipated that Wave Hub's operating company will comprise one and a half full time staff carrying out day to day operating and maintenance activities and managing various call out contracts and services. The key activities of the operating company will be to:

- Construct Wave Hub;
- Be responsible for meeting all legal and financial obligations of operating Wave Hub for the duration of operation;

- Take responsibility for abandoned WECs and all end of life assets in case of default by a WEC owner;
- Operate and maintain physical assets;
- Operate wave measurement buoys and other environmental monitoring devices;
- Be responsible for notifying the DTI, the MCA and other stakeholders on future information requirements relating to consents of WECs coming forward and checking compliance with environmental requirements established under the consent application;
- Manage commercial operation of Wave Hub including connection contract with WPD;
- Maintain and repair sub sea cable and transformers;
- Maintain relationships on lease, consents etc with UK government and regulators;
- Monitor arrays of WECs and provide 24/7 cover;
- Market availability of berths at Wave Hub to other developers;
- Notify deployment and removals; and
- Take overall responsibility for health and safety especially in offshore operations.

Operation

3. Wave Hub's operational system is intended to be relatively autonomous during the 25 year design life. However, system performance and condition monitoring will be required as would response to SCADA and other system alarms. Data logging and backing up will, to an extent, be automatic but a degree of intervention will be required.

4. In order to conduct the operation and maintenance tasks, significant external resource requirements will need to be met by service contracts. This will include resources necessary to provide 24 hour cover in order to respond to system alarms (e.g. system failures which affect Wave Hub's availability), data loss, and emergencies involving developer's WECs which may affect the Wave Hub system or WECs, etc. Such resource would also be required to undertake environmental monitoring, quality health and safety support, electrical connection maintenance and operation, etc.

5. The operational and maintenance tasks associated with the Wave Hub infrastructure can be grouped into the following four categories:

- Normal operation - all Wave Hub functions would be monitored and controlled remotely. Normal response would be automatic, though some operator intervention may be required;
- Routine maintenance - includes items which are expected to require attention as a result of normal operation;
- Minor repair - repair tasks cover those which respond to actual or predicted failure. These tasks may affect any system but would not be expected to be required on passive and structural items; and

- Major repair - major repair is considered to include those items which require significant external resources to conduct.

6. The operation and maintenance tasks to be undertaken for the Wave Hub project are listed in Table 2.5.

7. One of the factors in the choice of the sub-sea design and infrastructure for Wave Hub was the maintainability in the marine environment. Deploying the PCUs and TDU on the seabed reduces the exposure of the Wave Hub's offshore infrastructure to the dynamic weather and sea conditions at the surface. However, any intervention such as transformer repair or replacement, whether sub-sea or surface, will be equally reliant on suitable specialist vessel availability, weather and sea-state. Additionally, the ability to provide a replacement or repair is dominated by replacement equipment availability times. These have been indicated by the supplier as being in the order of four to six months for the PCUs. Accordingly, the Wave Hub's offshore infrastructure has to be very reliable and require minimal maintenance.

8. The PCUs employ equipment that has been developed for use in the offshore oil and gas industry and incorporate technology designed to withstand extreme depths and pressures where high reliability is a top priority in order to maintain production. Due to their operational environment, these units are designed to be, essentially, maintenance free. Nevertheless, the modelling undertaken for the *Wave Hub Technical Feasibility Study Report* (Halcrow, 2005) suggests that the potential failure rate of the transformers in the PCUs, based on current industry figures, is a dominant risk and that such failures may occur once in the life for each transformer. However it must be stressed that the data used in determining mean time between failures was not drawn from such sub-sea transformers (but from transformers used in the offshore oil and gas industry as there is little other data) and, therefore, may be overly pessimistic.

9. The transformers in the PCUs will be cooled by oil, which will reduce the effects of bio-fouling. The cooling oil will be ecologically friendly (i.e. biodegradable). The design of the transformer will ensure that routine oil replacement, top-up or purification shall not be required during the operational lifetime.

10. The TDU will be a completely passive operational device with no moving parts and no power requirement. It is unlikely to be moved from the seabed since it comprises nothing that should fail or require maintenance in its lifetime.

11. If necessary, the PCUs and TDU will be designed to be demountable with the use of a ROV without the need or use of specialist tools.

12. The associated equipment (e.g. cables, circuit breakers and SCADA) does not employ novel technology and there is an overall low level of complexity.

Monitoring

13. Monitoring of the Wave Hub's offshore infrastructure is likely to take place automatically with data transferred onshore via fibre-optics cables within the main sub-sea cable and connectors.

Table 2.5 Wave Hub operation and maintenance tasks

Task Category	Task Description
Normal Operation	Wave Hub equipment safety monitoring
	Developers' device output monitoring and measurement
	Condition monitoring and maintenance planning
	Response to failures and consequent remote reconfiguration
	Connection/disconnection of devices
	Environmental data monitoring and storage
	QHSE Services e.g. QHSE Management Systems, Audits, Risk Assessments etc
Routine Maintenance	Annual maintenance of 8 navigational buoys
	Subsea cable and equipment inspection for damage, marine growth levels and scouring
	PCU Transformers cleaning (marine growth removal) may be required
	Waverider buoy (if required) and environmental inspection (e.g. cetacean monitor)
	SCADA test (alarm systems etc.)
	HV Maintenance (e.g. inspection and test of protection systems in Wave Hub Sub Station)
	Calibration and checking of system and device power metering equipment
Minor Repair	Repair/replacement of minor electrical components in shore-side equipment e.g. SCADA module
	Waverider buoy (if required) / environmental monitoring equipment recovery / refurbishment / re-placement
Major Repair	Failures affecting the sub-sea PCU or TDU requiring recovery and repair/replacement
	33kV/11kV cable failure or damage requiring repair/replacement (including subsea connectors and splices)
Long term Tasks	Refurbishment of navigational buoys

Maintenance

14. It is considered that routine maintenance will mainly consist of sub-sea inspection using a ROV and may involve cleaning of the transformer cooling surfaces to remove marine growth if this becomes excessive

15. The cable will not require maintenance.

16. It is assumed that the shore-based components of the Wave Hub electrical equipment (i.e. the substation circuit breakers and power conditioning equipment) will be maintained under contract by WPD, the regional electricity network operator.

Operation and maintenance schedule

17. The following list provides indicative durations for a selection of annual operation and maintenance activities offshore (excluding downtime due to weather):

- Maintenance of eight navigation buoys – 1 hour per buoy;
- Sub-sea cable and equipment inspection for damage, marine growth levels and scouring – 1 day;
- PCU transformers cleaning (marine growth removal) – 4 days; and
- Wave rider buoy and environmental monitoring equipment mooring inspection – 1 day (if required).

2.12 Wave energy converter operation and maintenance

1. The Wave Hub project will facilitate the installation and operation of WECs in commercial scale conditions over a number of years. During this period, the WEC developers will take their devices through the final demonstration and pre-commercialisation stage of development. Although the Wave Hub has a 25 year design life, developers will be encouraged to connect their WECs to the Wave Hub for a limited duration then remove them from the site to enable other WECs to be connected and developed.

Energy generation

2. The maximum power output from the Wave Hub is 20MW, assuming all four PCUs and all four WEC areas within the deployment area are being used, and the deployed WECs are operating to the maximum capacity (5MW per PCU).

3. Fully operational, the Wave Hub could produce the equivalent amount of energy to power approximately 7,500 average UK homes. In local terms, this translates to around 3% of Cornwall.

4. The potential energy generation by the three companies that are expected to operate WECs at three of the four PCUs available at the Wave Hub could be:

- Ocean Prospect Ltd intends to trial up to 10 Pelamis devices. However, it is anticipated that six devices could be deployed at Wave Hub, with each device outputting 750kW (i.e. 6 x 750kW = 4.5MW);
- Ocean Power Technologies plan to install up to a 4.5MW project with its PowerBuoy

device. It is anticipated that an arrays of 30 devices will be operated with each device initially outputting 150kW (i.e. 30 x 150kW = 4.5KW). While the current power output per PowerBuoy is 150kW, Ocean Power Technologies plan to increase the output to 250kW and then up to 500kW per buoy and these larger sizes may be installed later when developed; and

- Fred Olsen Ltd wants to develop its FO^3 device further at the Wave Hub. It is anticipated that two platforms each generating 1.5MW will be installed at Wave Hub (2 x 1.5MW = 3MW).

Cooling systems

2. Some WECs will operate some type of cooling system. Depending on the manufacturer, hydraulic cooling systems could use water, oil or biodegradable oil.

Corrosion protection systems

3. Some WECs will operate some type of corrosion protection system. Depending on the manufacturer, the system could use, for example, paints or cathodic protection with sacrificial anodes.

Anti-fouling systems

4. Some WECs will operate some type of anti-fouling system. Depending on the manufacturer, the system could use, for example, standard marine anti-fouling coatings / paints. Anti-fouling paints tend to have a design life around ten years. Anti-fouling paints tend to require movement within the water with characteristics similar to sea-going vessels rather than a relatively stationary WEC device operating at Wave Hub. Accordingly, regular maintenance may be required to remove fouling on a six-monthly or annual basis.

Monitoring

5. Monitoring of the WECs will be the responsibility of the device developers and will be undertaken to establish performance in real conditions, position (e.g. using a global positioning system; GPS), and maintenance needs (e.g. the hydraulic oil level).

6. Monitoring is likely to take place automatically on the WECs with data transferred onshore via fibre-optics cables within the main sub-sea cable and connectors.

Maintenance

7. Maintenance activities for WECs in general are likely to include activities such as cleaning, including removal of fouling, re-application of anti-fouling systems, removal of debris trapped by the device, etc.

8. Depending on the type of device and maintenance activity, maintenance may take place within the deployment area, or at a nearby harbour. For example, debris would be cleared at sea, but re-applications of anti-fouling paints would take place at a harbour. Maintenance at sea will require a standard work boat moored alongside the device at which it is working.

9. Depending on the type of device, the maintenance schedule may include six-monthly or annual inspections and off-site maintenance every three or more years. For example, Ocean Power Technology expects maintenance of the

PowerBuoy device to take place every three to four years in a harbour.

2.13 Wave Hub and WECs decommissioning

1. The Wave Hub will be decommissioned after the planned lifetime of operation. The description for this section of the Environmental Statement is informed by the Wave Hub *Decommissioning Plan* (ARC, 2006).

Pre-decommissioning studies

2. ARC has identified the following studies for undertaking prior to decommissioning the Wave Hub project:

- Offshore cable survey to identify the exact location and condition of the cable prior to lifting; and
- Onshore phase 1 and 2 environmental audit of the substation facility to ascertain whether there has been any contamination arising from the Wave Hub project (e.g. from disturbance) to the ground in the vicinity of the substation, and whether there will be a requirement for the removal and/or subsequent clean up of areas of the site.

Offshore infrastructure

3. The TDU and PCUs along with their interconnecting cable shall be lifted from their bases and removed by vessel for on shore dismantling and recycling. The TDU and PCUs will be designed to be easily demountable from the base plate anchors, so they can be decommissioned by simple removal. It is anticipated that the base plates will be removed by lifting them from the seabed. The interconnecting power cables will also be recovered.

4. All components of the TDU and PCUs can be recycled. The oil can be drained and sent for recycling whilst the steel shells and any internal switchgear, transformers etc shall also be recycled.

5. The four 11kV cables (approximately 2km each) between the WEC umbilical positions and will be recovered by the cable recovery vessel for onshore recycling.

6. The 24kV interconnecting cables (approximately 200m each) between the PCUs and TDU will be recovered along with the units themselves by the cable recovery vessel for onshore recycling.

7. All aids to navigation will be lifted and brought to shore along with their moorings and anchors. The buoys and their moorings will have been subject to periodic maintenance and replacement and should be in suitable condition to be refurbished and re-used. Any components that have reached their end of their operational life will be sent for recycling.

8. It is proposed that the lifting and removal of aids to navigation is conducted by the buoy maintenance vessel used to conduct the periodic maintenance.

Cable

9. The 25km of sub-sea cable shall, as far as practicable, be recovered by a cable-laying vessel. The cable will be separated from the TDU at the connector and recovered onto a suitable capacity

cable drum onboard the vessel. The cable will then be brought ashore for recycling.

10. The vessel will limited to an extent dependent on its draught and other capabilities in recovering the near shore section of cable. The cable will be cut at the end terminated and buried at a suitable point offshore.

11. Further assessment will be required with regard to the potential removal of the nearshore and beach sections of cable. However, it is expected that this section of the cable will be disconnected from the sub-station, pulled through the cable duct beneath the dunes and excavated from the beach. From the beach, the cable will be winched aboard the cable-laying vessel.

Onshore infrastructure

12. It is assumed that all onshore infrastructure will be removed. However, there will be some elements that to remove would present a high risk of contaminated material being released (e.g. the cable duct running under the dunes). In this circumstance the cable duct may be left in situ.

WECs

1. The WECs will be decommissioned at various times during the operational life of Wave Hub following their trial periods (i.e. it is not envisaged that the same WECs will remain at Wave Hub for the duration of the project). The description for this section of the Environmental Statement is informed by the Wave Hub *Decommissioning Plan* (ARC, 2006).

2. The WECs will be disconnected from the power cables and anchors / moorings and removed either by towing away or by hoisting onto a vessel. Each WEC will be brought onshore for reuse as far as practical. Where the WEC has exceeded its operational life it shall as far as practicable be recycled.

3. WEC device moorings and non-pile anchors (e.g. clump weights) will be removed and brought ashore with the WEC device for subsequent disposal by re-use or re-cycling. The mooring system will be removed by reversing the installation process that will include slackening off chain tension to allow disconnection from the bottom chain segments that are attached to the anchor piles. The bottom chain segments will be removed by cutting at the pile and recovered using ROV equipment.

4. Pile anchors may be cut below the natural sea-bed level at such a depth to ensure that any remains are unlikely to become uncovered. In the event an anchor is to remain in situ, this shall be decided on a case by case basis as part of the WEC developers' individual decommissioning plans.

5. The removal of WECs and mooring lines will be carried out using by vessels appropriate to the task and engaged by the WEC developers.

Post-decommissioning studies

13. ARC have identified the following studies for undertaking prior to decommissioning the Wave Hub project:

- A survey shall be undertaken to verify sea bed clearance to ensure that all infrastructure and debris has been removed, and to identify the location of any debris that has accidentally been left on the seabed which may have arisen from the project or as part of the decommissioning operation itself.

- Some post-decommissioning monitoring of any accumulation and deterioration of material left on the seabed to ensure there is no subsequent adverse impact on navigation, other uses of the sea or the marine environment. Monitoring could identify any new or increased risks posed by remaining materials (e.g. where cables and foundations may have become exposed due to natural sediment dynamics and appropriate action could then be taken to mitigate the risks; and

- A landscape and visual impact assessment to ensure that the Wave Hub project area has been returned to, as far as is possible, the condition to which it was in prior to the start of the project.

3 Alternatives

3.1 Introduction

1. This section of the Environmental Statement describes the alternative options considered during studies for the Wave Hub *Technical Feasibility Study Report* (Halcrow, 2005) and the Wave Hub *Detailed Design Report* (Halcrow, 2006). The key alternatives considered are the site selection for the following elements of the project:

- Onshore infrastructure including Wave Hub's connection to the electricity network and a cable landfall point (see Section 3.2);
- Offshore infrastructure, namely the deployment area for Wave Hub's offshore infrastructure and the WECs (see Section 3.3); and
- The cable route (see Section 3.4).

2. Alternatives for the offshore infrastructure equipment are also considered (see Section 3.5).

3. The alternative options considered for the Wave Hub were evaluated as a function of physical, technical, environmental and economic factors. In this section of the Environmental Statement, particular reference is made to the environmental matters that influenced the choice of the preferred option (i.e. the Wave Hub project as described in Section 2) over its alternatives.

3.2 Site identification: onshore

Electrical connection point options

4. The electricity network operator for Devon and Cornwall, Western Power Distribution, identified nine potential connection points accessible from the north Cornwall/west Devon coast with a potential generation capacity in excess of 15MW.

5. Of these, Hayle and Newquay (at Trevemper) were selected for further study on the basis that they were proximate to a suitable wave climate and accessible from the coast. The WPD 132/33kV substation at Hayle was assessed by WPD as offering the best location point of connection to the mainland electrical system on technical grounds and ease of access to the shore.

Landfall point options

6. In a similar way, the coast between Land's End and Hartland was screened for potential landfall points. Table 3.1 presents the constraints identified during this process, and describes the significance assigned to each.

7. The results of the screening exercise identified very few landfall points to be suitable for the development of the Wave Hub. Potential landing sites were available in reasonable proximity (<5km) to both the Hayle and Newquay electrical connection points.

Table 3.1 Constraints considered during the onshore site selection

Constraint	Reason for including	Significance rating
Network constraints Distance to nearest suitable network connection	Proxy for cost and technical difficulties in laying the cable from the shore to the connection point	0-1km – green 1-5km – yellow 5-10km – orange >10km - red
	Development must not affect the integrity of these sites	Red
Environmental constraints National designations: Sites of Special Scientific Interest, National Parks, National Nature Reserves, Local Nature Reserves, Environmentally Sensitive Areas, Areas of Outstanding Natural Beauty, Heritage Coast	Development should not affect the integrity of these sites	Orange
	Identified as being of national importance	Red
Environmental constraints Geology: Geological Conservation Review sites, Regionally Important Geological Sites	Identified as being of national importance	Orange
Environmental constraints Heritage: Scheduled Ancient Monuments	Identified as being of national importance	Orange
Physical constraints Presence of cliffs	Cable laying would be very difficult	Red
Physical constraints Presence of an estuary	Dynamic environment not suitable for cable laying	Red
Physical constraints Presence of sand dunes	Constraint to cable laying	Orange
Key: **Red** = unsuitable for development, **Orange** = subject to significant constraints, **Yellow** = subject to some constraints, **Green** = suitable for development		

8. There is a distance of at least 3.5km between potential landfall sites and the Newquay substation, and therefore the logistics of a landside cable route at Newquay are likely to be more complex than at Hayle.

Landfall site options at Hayle

9. Accordingly, landfall sites close to Hayle were considered in more detail once Hayle was chosen as the preferred electrical connection point. Four alternative cable landing sites close to the Hayle connection point were considered.

10. Option 1: Hayle Beach (Hayle Towans). The beach on the eastern side of the Hayle estuary mouth is the closest landing site to the proposed sub-station site, and therefore likely to be the least costly option. It also does not fall within any nationally designated nature conservation, landscape or archaeological sites. Due to the strong tidal influence at the site, it is considered that laying a cable beside the Hayle River estuary is acceptable, as the lesser river outflow is constrained sufficiently such that it would be highly unlikely to unbury a cable situated nearby.

11. Option 2: Gwithian Beach. Gwithian beach, to the north of Hayle, provides an alternative landing to the Hayle sites as the beach is not backed by dunes designated as a Site of Special Scientific Interest (SSSI), and the South West Water storm-water outfall provides a precedent for development of marine connections through the foreshore. However, this site has significant constraints: the landing site is approximately 4.7km from the sub-station at Hayle (7.2km by road); the beach and nearshore are heavily used by the public; there are archaeological sites of importance close to the foreshore at Gwithian; and the Gwithian to Mexico Towans SSSI would potentially be affected by the route of the cable.

12. Option 3: Riviere Towans. The landing site at the edge of the Riviere Towans, although closer to Hayle than Gwithian, is a less promising option primarily because the beach is backed by the Gwithian to Mexico Towans SSSI through which the cable would need to pass, and it is at a greater distance from the substation than Option 1 and therefore would be of greater cost.

13. Option 4: Carbis Bay. Carbis Bay, on the western side of the estuary, constitutes the site least affected by wave action, and therefore the easiest site for cable laying. However, this site also has significant constraints: the cable would need to pass from a rock cliff backed bay along a branch rail line, and across the estuary, all of which would be difficult, costly and incur environmental impacts; the site is a popular recreational beach; and the beach is backed by residential and tourist development.

14. The selection process identified Option 1 (Hayle Beach) to be the preferred landfall option on technical, financial and environmental grounds. The route is several hundred metres long, and although it passes through sand dunes, it does not lie within any environmentally designated nature conservation, landscape or archaeological sites.

Preferred onshore site

15. In summary, determining the preferred onshore option between Hayle and Newquay for the landfall and electrical connection of the Wave Hub was a function of electrical network, environmental and physical constraints. The key characteristics of Hayle as the most appropriate electrical connection point and landfall for the cable are:

- Proximity to a favourable wave climate and water depth for wave energy development;
- Proximity to a suitable electricity grid connection point; and
- Availability of a landfall which does not cross any environmentally designated sites.

3.3 Site identification: offshore

Offshore site options

1. Similarly to the methodology used to select the preferred onshore option, the constraints identified during the offshore site identification and the significance assigned to each are detailed in Table 3.2.

2. The first key constraint was the UK territorial waters limit. Prior to the establishment of Renewable Energy Zones, under current UK legislation it would only be possible to grant consent for the operation of an offshore demonstration generating scheme within UK territorial waters. Outside of this limit it is currently not possible for the consenting authority to extinguish rights of navigation or establish the required safety zones. This restricts the location of Wave Hub to within the 12 nautical mile limit.

3. The second key constraint was water depth. Water depth also represents a practical limitation for the development. Wave energy developers have specified a preference for anchoring in 50m to 60m of water for deep water WECs. This water depth is necessary to ensure that long period and amplitude waves are not affected by the seabed.

4. The third key constraint was a military exercise area. The presence of a military exercise area is likely to be a significant constraint in selection of a site for Wave Hub facilities off Newquay, Hayle or Camborne. Consultation with the Ministry of Defence (MOD) has indicated that whilst development adjacent to the boundaries of the exercise area may be tolerated, development within the body of the area would restrict the operational requirements and would not be acceptable.

5. The fourth key constraint was navigation. As part of the Wave Hub deployment area selection process, a series of consultations with marine users and an extended traffic survey was undertaken. Consultations with the MCA, fisheries organisations, and the survey results have identified two vessel traffic routes through the study area.

Table 3.2 Constraints considered during the offshore site selection

Constraint	Reason for including	Significance rating
Physical and Technical Constraints 12 nautical mile limit	Development and consents outside this limit would be significantly more complex, additional risks from non-UK fishing vessel activity	Outside 12nm limit – red
	Hub needs to be at approximately 50-60m depth for current Developer requirements	>60 m red
Physical and Technical Constraints Presence of bare rock	Cable cannot be buried therefore requires armour and is at risk of damage	Orange
Physical and Technical Constraints Presence of sediment	Cable cannot be buried therefore requires armour and is at risk of damage	Orange
Environmental Constraints Marine Nature Reserves	Development should not affect the integrity of these sites	Orange
Environmental Constraints Sensitive Marine Areas	Identified as being of national importance	Orange
Environmental Constraints Wrecks	Of heritage importance, areas of heavy fishing activity	Orange
Environmental Constraints Spawning and nursery areas for important commercial species	Important for maintaining fisheries, but will not necessarily affects by the development	Orange
Marine Users In-service and out-of-service fibre optic cable routes	Development not permitted - maintenance works for existing cables would pose a risk to other cables in close proximity	Cable route – red 0 - 500m, buffer zone – orange
	Reported cable faults from existing sub-sea cables may indicate particularly severe seabed rock conditions.	100m buffer zone – red
Marine Users Shipping lanes	Development would be difficult and potentially dangerous, shipping lanes would need to be diverted	Orange
Marine Users Designated anchorage sites	Development not permitted, anchors cause major damage to cables	Red
Marine Users Ministry of Defence military exercise areas	Development not permitted, anchors cause major damage to cables	Red
Key: **Red** = unsuitable for development, **Orange** = subject to significant constraints, **Yellow** = subject to some constraints, **Green** = suitable for development		

6. The primary shipping route impacting on the study area is from the Land's End TSS heading north-east towards Hartland Point and onwards towards Avonmouth, Sharpness and Newport. Whilst initial views that the majority of vessels tend to stand off beyond Bann Shoal before setting course to Hartland, the traffic survey results indicate that this is only true for deeper draft vessels. This shoal forms the north eastern projection of a range of shoals that make up Cape Cornwall Bank. During gales breaking waves over these features are normally to be avoided. Return vessels traversing from Hartland to the TSS tend to all pass to seaward of Bann Shoal.

7. There is thus a potential advantage in placing the deployment area of the Wave Hub in the lea of this natural obstacle to shipping to reduce the chance of collision. It is expected that little wave energy will be lost due to the presence of Bann Shoal in normal conditions, and the presence of breaking waves on the shoal may actually help to improve the survivability of WECs on the site in extreme events. Whilst the data from the traffic survey does not confirm this pattern, the survey was undertaken in summer in generally fine weather conditions and is believed to be representative for commercial shipping.

Determining the deployment area

8. The physical area of the deployment zone required for the Wave Hub needs to be a reasoned compromise between what is currently known about potential Wave Hub users' requirements, and limiting the area of sea-take. The methodology used for the site selection of the deployment area is summarised in Table 3.3.

Preferred deployment area

9. Such is the presence of constraints in the offshore area that there are only two potential sites for deployment areas for the Wave Hub: one close to Hayle, and one close to Newquay.

10. With the suitability of the onshore landing and electrical connection point, Hayle consolidated its status as the preferred option through its proximity to a relatively unconstrained offshore area in an appropriate depth of water. The preferred site of the deployment area at Hayle is located in approximately 50-60m of water in a good wave climate, inside of the 12 nautical mile limit, outside the military exercise area, behind the Bann Shoal, avoiding known wrecks, and out of the known direct commercial shipping channels. The offshore site is shown on Figure 3.1 in the context of constraints described on Table 3.2.

11. Conversely, and taking into account the key constraints described above, Newquay, with a more difficult cable landing and a greater distance to the onshore electrical connection point, suffers from both shipping lane and military constraints forcing the site into water that is too shallow for most WEC devices. Additionally, as the distance from the shore is reduced, fishing and recreational activity also becomes more evident. The proximity to the shore could also potentially result in greater impact on the coastal processes and, in particular, the surf at Newquay.

Table 3.3 Methodology for determining the deployment area

Step	Item	Purpose
1	Technical and market assessment	An assessment of the technical and commercial merits of a range of WEC devices in the market was undertaken.
2	Shortlist WEC devices most likely to be deployed at Wave Hub	Drawing on the results of the above, expert opinion and wider commercial knowledge, the most likely devices that will be ready for deployment within the first years of operation of the Wave Hub were short-listed.
3	Financial modelling	The benefits of the development, in terms of inward investment to the industry and region need to be balanced against the capital and operating costs of the project. A detailed financial model was prepared to ensure the scale of the project, number of berths, and form of the project are acceptable.
4	Technical characteristics of short listed WECs	Very little information is yet available with respect to the manner in which arrays of devices will be deployed in practice. Therefore, where this information is not available, best practice in mooring systems has been used to estimate the size and shape anchor and chain splays that may be used.
5	Capacity for each array area set	The technical limitations of grid connection, sub sea equipment availability, and commercial factors set the numbers of array areas into which the deployment area should be split.
6	Consultation with marine users	Disruption to shipping is a major constraint, and the maximum size of the area of sea take has to be a function of balancing this concern against the operational requirements of the deployment area.
7	Preliminary array area layout design	For each of the short listed devices, a preliminary layout, with moorings, was designed to ensure that the device could be deployed within the area proposed

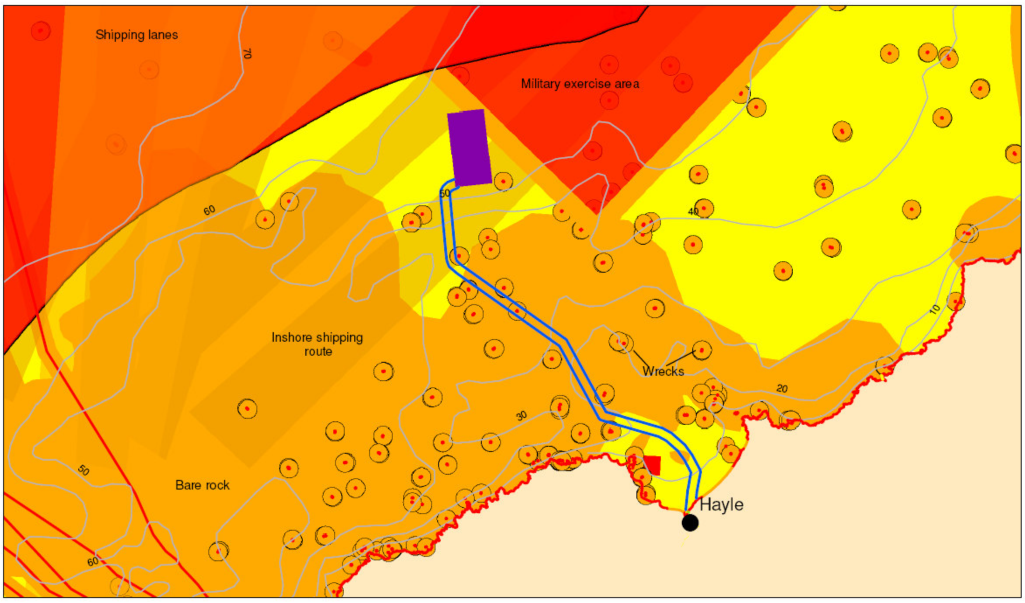


Figure 3.1 Newquay and Hayle offshore sites

12. To avoid these constraints at the Newquay site would necessitate a move outside the UK territorial waters with the restrictions concerning the ability to exclude navigation rights.

13. Table 3.4 compares these two most favourable sites of Hayle and Newquay. It can be seen from this analysis that the Hayle site has clear advantages and was therefore selected as the preferred offshore site for the Wave Hub's development following the completion of onshore and offshore site selection.

14. However, the Newquay site may well be appropriate as a future site for shallower water devices that may be developed in the future.

3.4 Site identification: cable route

15. A Wave Hub Cable Route Study was carried out by Global Marine Systems Ltd (GMSL) as part of the Wave Hub Technical Feasibility Study. The aim of the study was to assess potential constraints and influences on sub-sea cable routing and to make preliminary recommendations on the cable route.

16. The study investigated routing to shore grid connection points at Hayle and Newquay, potential landing sites in St Ives Bay, and offshore factors that would influence the siting of the deployment area. The results provided a detailed assessment of potential cable routes and landfall points, the results of which were fed into the site identification screening exercise.

Potential risks

17. The north coast of Cornwall is a high-energy environment, which complicates sub-sea cable planning, installation and maintenance. However, it is noted that the telecommunications industry has operated sub-sea cable systems with success in this environment for a considerable period through careful risk management.

18. Offshore, fishing activity is historically the primary risk to a sub-sea cable. Whilst there is a potential for the cable in this area to be snagged during its design life, this is likely to be a very infrequent occurrence. The cable will be marked on navigational charts and would clearly be identified as a hazard to fishing gear and crews. Additionally, the cable will only be surface laid in areas of rocky seabed, which are generally unsuitable for bottom trawls.

19. Inshore, St Ives Bay is one of the few areas on the north Cornish coast where anchor holding is known to be available, and vessels regularly shelter in the bay from southerly winds in bad weather.

Table 3.4 Comparison of Newquay and Hayle offshore sites

Factor	Newquay	Hayle	Comments
Proximity to favourable wave climate	Range of average mean wave power 11 – 20 kW/m of wave crest	Range of average mean wave power 16 - 25 kW/m of wave crest	Within 20 km of the shore, the wave energy climate is significantly greater at Hayle than Newquay
Proximity to required water depth (>50m)	Water depths of over 50m are available within 20km of connection point. May need to divert around Military Exercise Area or accept shallower water (30 - 40m)	Water depths of over 50m are available within 20km of connection point	Whilst similar distance to necessary water depth, the Newquay location is within Military Exercise Area, and may therefore not be acceptable
Cable route does not cross designated sites or rocky seabed	Seabed conditions are generally coarse sand and broken shell, with some bare rock towards the shore	Coarse sand and broken shell within St. Ives Bay, but cable route does cross areas of extensive rock	More difficult seabed conditions will be encountered at the Hayle site, but neither route crosses designated areas
Possible landing site	Landing limited to southern edge of Crantock Beach and Vugga Cove. Areas of high amenity value and adjacent to SSSI	Four potential sites within St. Ives Bay, but a clear preference for Hayle Beach, with short drilled duct	Landing on Hayle beach is preferable since it has a lower amenity value and is adjacent to formal industrial area
Distance to electrical connection point	Requires overhead or buried cable for 3 – 5 km (depending on routing)	350m buried cable	Hayle preferred due to shorter onshore connection length (and simpler solutions to landowner agreements)
Location of switchgear building	Either amongst village/hotel buildings in area of high amenity value, or in open country	In former power station site, adjacent to existing transformer station	Preferred location of switchgear building is as close to landing site as possible, as network operator can use statutory powers to acquire way leaves for onshore cable route. Hayle therefore provides a preferable solution
Electrical connection capacity	Connection capacity varies with cost: 6.5MW (£0.7M); 7.5MW (£1.2M); 21MW (2.2M); 30+ MW (£5.6M)	Connection capacity varies with cost: 30MW (£0.3M); 30+MW (£1.0M)	All connection capacities are quoted at 0.95 power factor for comparison

20. The exposed high-energy environment off the north Cornish coast will result in engineering operations being constrained by seasonal operational weather windows and the distance to ports (Falmouth, Milford Haven) suitable for deep draft vessels.

21. A summary of the cable risk analysis, based on known constraints, is presented in Table 3.5.

3.5 Number of PCUs

1. The concept design is for one TDU with four connection points and for four PCUs each rated at 5MW. During design development consideration was given to a TDU with 5 or 6 PCU connection points because:

- It would be more economic in the long term to provide the capacity if increased demand is positively foreseen;
- It would provide more flexibility and protection against a failure; and
- The provision could be made simply by leaving cable tails ready for connection to a PCU.

2. However, the future demand for anything more than 20MW is very uncertain. It could also be restricted by the area available for WEC installations, or by the consent conditions, or by the designation of the site for demonstration purposes only. There would be a significant increase in initial capital cost and additional connection charges from the distribution network operator for a reserved 30MW capacity with an uncertain prospect of demand greater than 20MW. Given these circumstances, it was decided to restrict the Wave Hub project to one TDU with four connection points for four PCUs, and 20MW capacity.

Table 3.5 Summary cable risk analysis

Risk	Description	Mitigation Measures	Estimated Remaining Risk	Comments
Rock	Abrasion	Routing and armouring	Medium	The lack of seabed sediment off the north Cornish coast is likely to result in the export cable being surface laid over a rocky seabed. Strong currents and wave action are likely to be strong enough to rock a cable, causing progressive damage.
Fishing	Static potting, netting and bottom trawling	Routing, burial and armour	High	The lack of seabed sediment off the north Cornish coast is likely to result in the export cable being surface laid. It is recommended that cable armour be maximised to act against interaction. Inshore, static pots (anchored) are likely to skid across a rock surface and be caught by the cable. Offshore, beam trawling may cause tangled gear and cable faults.
Shipping	Anchor penetration	Routing, burial and armour	Medium	Shipping interaction with the export cable is likely to be limited to anchoring within north Cornish coast bays, due to their sediment depths. Vessels particularly shelter from southerly and south-westerly winds. In these areas, burial will be imperative.
Tele-communications industry	Submarine cable interaction	Routing	Low to medium	The Hub lies inshore of commercial telecommunication routes. However, the permitting should ensure that submarine cables are avoided.
Groundswell	Sudden reduction in water depth and unexpected heavy seas hazardous to shipping	Tidal operational windows / operational awareness	Medium	Deep ocean swells arriving from the Atlantic are superimposed on tidally and wind induced shallow seas. Such conditions can beach craft in shallow water and can be destructive in storm conditions. With regard to an installed cable, the effect of groundswell is propagated to the seabed in shallow waters and may cause the cable to rock or strum on a rocky seafloor.
Weather	Downtime and hazard to shipping and equipment	Operational weather windows.	Medium	Operational weather windows should be carefully selected because the area is open to Atlantic weather fronts. It should be remembered that there are no major ports on the north Cornish coast.

4 The EIA process

4.1 Consent route

1. As outlined in Section 1, the proposed consent route for the Wave Hub project is a composite consent application for the Wave Hub infrastructure and WECs via Section 36 of the Electricity Act 1989, incorporating deemed planning permission under Section 90 of the Town and Country Planning Act 1990, together with a consent under the Coast Protection Act 1949 and a licence under the Food and Environmental Protection Act 1985.

Electricity Act 1989

2. Under Section 36 of the Electricity Act, consent is required from the DTI to construct, extend or operate a generating station with a capacity of more than 50MW (unless otherwise exempted) within UK territorial waters adjacent to England and Wales out to the 12 nautical mile limit (and any Renewable Energy Zone designated by the UK Government outside territorial waters under the Energy Act 2004).

3. Smaller schemes such as the Wave Hub were brought within the ambit of the Electricity Act when the DTI's powers under the Electricity Act were extended on 1 December 2001 by means of statutory order (SI2001/3642) to cover all offshore wind and water driven generating stations within territorial waters surrounding England and Wales above 1MW capacity.

4. Section 36(5) provides for conditions to be attached to any consent granted under Section 36, and these will be enforceable by the DTI. Onshore, conditions would be attached to a deemed planning permission under Section 90 of the Town and Country Planning Act 1990 and enforceable by the local planning authority (i.e. Penwith District Council).

Coast Protection Act 1949

5. Under Section 34 of the Coast Protection Act, consent is required from the Department for Transport (DfT) for the construction, alteration or improvement of any works on, under or over any part of the sea shore lying below the level of mean high water on spring tides (MHWS), or the deposit or removal of any object or materials below the level of MHWS. The purpose of the consent requirement is to ensure that the works will not be detrimental to navigation.

Food and Environment Protection Act 1985

6. Under Part II of Food and Environment Protection Act, a licence is required from the Department of the Environment, Food and Rural Affairs (DEFRA) for the placement of materials or structures in the sea and for the deposit of dredged materials, and is applied to UK territorial waters and the UK continental shelf.

7. The purpose of the Food and Environment Protection Act is to protect the marine ecosystem and human health, and to minimise interference and nuisance to other users of the sea and seabed.

4.2 Requirement for Environmental Impact Assessment

EIA Directive

1. European Council Directive 85/337/EEC, as amended by Council Directive 97/11/EC, on the Assessment of the Effects of Certain Public and Private Projects on the Environment (hereafter referred to as the EIA Directive) aims to ensure that consenting authorities have all the necessary environmental information when considering whether to grant consents for development likely to have a significant effect on the environment.

2. The EIA Directive requires EIA to be carried out in support of an application for development consent for certain types of major project listed in the EIA Directive at Annex 1, and at Annex 2 for other projects where they are likely to give rise to significant environmental effects.

3. Offshore windfarm developments are listed in Annex 2 as “installations for the harnessing wind power for energy production (windfarms)”, but wave energy developments such as Wave Hub are not specifically listed in Annex 2.

4. Nevertheless, Regulations (see below) applying the EIA Directive in England and Wales require EIA for applications under Section 36 of the Electricity Act, so a legal route exists for Wave Hub to require EIA.

EIA Regulations in England and Wales

5. There are various Regulations transposing the requirements of the EIA Directive into law applied in England and Wales. The Regulations relating to the Wave Hub project are:

- Electricity Act 1989 - Electricity Works (Assessment of Environmental Effects) (England and Wales) Regulations 2000;
- Coast Protection Act 1949 – Harbour Works (Assessment of Environmental Effects) Regulations 1999; and
- Town & Country Planning Act 1990 – Town & Country Planning (Environmental Impact Assessment) (England and Wales) Regulations 1999.

6. While the EIA Directive has not yet been directly applied to the Food and Environment Protection Act, Section 8(5) of the Act contains provisions such that DEFRA can require a licence applicant to "supply such information and permit such examinations and tests as in the opinion of the authority may be necessary or expedient to enable the authority to decide whether a licence should be issued to the applicant and the provisions which any licence that is issued to him ought to contain." DEFRA's policy is that this information shall include the equivalent of a formal Environmental Statement in support of all offshore windfarm projects to inform the process of impact assessment. There is no specific policy for wave energy projects.

EIA for the Wave Hub

7. Under the Electricity Works EIA Regulations (Reg.3) an application under Section 36 or 37 of the Electricity Act must be accompanied by an Environmental Statement if it:

- Falls within Schedule 1; and
- Falls within Schedule 2, including (a) a generating station the construction of which (or the operation of which) will require a Section 36 consent, but which is not Schedule 1 development, and (b) an electric line installed above ground with a voltage of 132 kilowatts or more, the installation of which will require a Section 37 consent.

8. Thus, despite the fact that wave energy projects are not listed in Annex 2 of the EIA Directive, they require EIA if they require an application under Section 36 of the Electricity Act.

9. It is for this reason that an Environmental Statement has been prepared to support the consent application for the Wave Hub project.

4.3 Scoping

1. Scoping is a key stage in the EIA process and is defined by the European Commission (2001) as "the process of determining the context and extent of the matters which should be covered in the environmental information to be submitted to a competent authority for projects which are subject to EIA."

Wave Hub environmental scoping

2. A Wave Hub *Environmental Scoping Report* was prepared by Halcrow (2005) on behalf of SWRDA. The study undertaken to prepare this report focussed on the preferred options for the Wave Hub's site, landfall, cable route and design, and was conducted in parallel with the various other technical feasibility studies. The objectives of the study were:

- To provide an overview of existing conditions and constraints;
- To identify and assess the key potential environmental impacts;
- To identify the need for additional baseline data collection;
- To summarise the concerns of statutory consultees and other stakeholders and demonstrate how they should be addressed; and
- To identify the scope for further studies and EIA.

3. The study involved the collection of baseline data (including an ecological survey at the onshore site and a desk study on contamination issues at the onshore site), consultation with relevant organisations, an assessment of planning issues, and an assessment of potential environmental impacts based on the findings of the data collection and consultation. Requirements for mitigation measures and monitoring were also identified.

Scoping opinion

4. A request for a formal scoping opinion was submitted to the DTI and DEFRA in February 2005. A copy of the Wave Hub *Environmental Scoping Report* was included with the request to provide the supporting information necessary for undertaking the scoping opinion.

5. Neither the DTI nor DEFRA had issued a scoping opinion at the time of preparing this Environmental Statement; however, they provided informal input to the scope through discussion at meetings.

4.4 Project description

1. A key issue for the EIA process is to ensure that the Wave Hub project, including the intended WEC devices, is described with sufficient precision to enable its environmental impacts to be properly assessed. This is a particularly important issue for the Wave Hub project given the composite nature of the consent application for the WEC devices and the absence of a scoping opinion. To facilitate transparency of the EIA process, the following paragraphs describe the methods used to assess the environmental impacts associated with the Wave Hub project.

2. It is established in the courts that to assess the likely environmental effects of a development there must be an adequate description of the development, which cannot be overcome by an "outline" application or use of reserved matters or conditions requiring the subsequent approval of various aspects of the development (R. v. Rochdale MBC ex parte Tew (1999) 3 Plr 74). Accordingly, it has been necessary to ensure that the EIA process leading to this Environmental Statement has been informed by an adequate description of the Wave Hub project.

3. While the components of the Wave Hub's infrastructure were well established and already described in detail following the Wave Hub *Technical Feasibility Study* (Halcrow, 2005), it was necessary to take a number of important actions to ensure that the characteristics of all likely WEC devices were adequately described to inform impact assessment and the preparation of this Environmental Statement.

WECs

4. The first action was to collect data about the WEC devices from the developers by conducting a WEC Assessment. The assessment invited 15 WEC developers to provide further technical information on their devices to progress the development phase of Wave Hub. The 15 developers were contacted with a request for detailed information on their devices to advance the progress of the Wave Hub through physical survey, detailed design development and the consenting application including the EIA process. As a precursor to a proposed meeting with each of the developers, a detailed questionnaire was circulated with the aim of establishing (amongst other aspects) for each device:

- Proposed Wave Hub deployment timeframe;
- WEC layouts and mooring design;

- WEC electrical design and protection;

- Verification of energy yield and generation characteristics; and

- Health, safety and environmental issues.

5. By completing the questionnaire the developers were contributing to help fulfil a number of objectives, namely:

- To provide most likely (or typical) and worst case scenarios for the EIA process;

- To progress negotiations with the electricity network operator (WPD) and establish a set of parameters to aid grid connection; and

- To determine the scale and precise location of the WEC deployment area.

Navigation aids

6. The second action was to establish the navigation aids and other safety measures for the deployment area and the WEC devices. This was undertaken through consultation (including hazard identification workshops) as part of the Wave Hub *Navigation Risk Assessment* (Anatec, 2006)). Accordingly, the project description was devised with respect to an ATBA routeing measure, extinguished navigation rights and maximum safety zones around the WECs. Trinity House were asked to provide definitive advice on the requirements for navigation aids but declined to comment, so typical and worst case scenarios were identified by reference to IALA requirements (i.e. the guidance applied by Trinity House).

Moorings and anchors

7. The third action was to establish potential mooring and anchor requirements for generic WEC devices and navigation aids (i.e. buoys) to be deployed at the Wave Hub. This information was established by the Wave Hub *Mooring Assessment Study* (Halcrow / HPA, 2006) and provided conservative assessments of the mooring and anchoring requirements for generic WECs devices (i.e. box shape and cylindrical shape WEC devices) and buoys.

Worst case scenarios

8. The fourth action was to apply information about Wave Hub project and the findings of the Wave Hub *Navigation Risk Assessment* (Anatec, 2006) and the Wave Hub *Mooring Assessment Study* (Halcrow/HPA, 2006), in order to establish a series of worst case scenarios to inform the impact assessments relating to the WECs and the navigation aids.

9. It was not necessary to determine worst case scenarios for the Wave Hub's infrastructure since the offshore infrastructure, cable and onshore infrastructure are consistent elements to the Wave Hub consent application to be made under the Electricity Act 1989.

10. The following worst case scenarios were derived for the WEC layouts:

- 120 Powerbuoy PB150 devices (i.e. 30 devices x 4 PCUs) requiring 264 anchors for mooring (i.e. 66 anchors for 30 devices x 4 PCUs) – this represents the worst case scenario for environmental impacts associated with disturbance of the seabed (largest number of anchors);
- 4 Wave Dragon devices (i.e. 1 device x 4 PCUs) – this represents the worst case scenario for environmental impacts associated with coastal processes (largest effect on hydrodynamics) and offshore birds (largest surface area); and
- 12 FO^3 devices (i.e. 3 devices x 4 PCUs) – this represents the worst case scenario for environmental impacts associated with landscape (largest structures above water level).

11. It is interesting to note that the three worst case WEC layouts all require the use of all four PCUs by the same WEC devices rather than a combination of devices as shown in the example WEC layouts accompanying the Wave Hub consent application to be made under the Electricity Act 1989.

12. A worst case scenario concerning anchor installation was derived for the anchoring requirements for the WEC mooring systems. This only concerned piled anchors since the worst case scenario was derived for environmental impacts relating to underwater noise. Accordingly, the worst case scenario assumes anchor piles will be driven into the seabed (rather than drilled), since this is the noisiest method, and was applied to the WEC layout with the most anchors (i.e. 120 Powerbuoy PB150 devices).

13. A worst case scenario was derived for the potential safety zones that could arise with the WECs in place. As described in Section 2, the worst case scenario for the total combined area of the safety zones is $15km^2$ (i.e. 5km by 3km) based on WECs being positioned along the external boundaries and corners of the deployment area and distributed evenly within the deployment area, and safety zones being implemented to the maximum extent of 500m.

14. In addition, a worst case scenario was derived for the navigation aids. This only concerned the cardinal buoys. Whilst it is expected that class two buoys will be used (height of 4.5m above sea level, 3m diameter at base, 1m diameter at focal plane/light level, with white light visible to mariners at a distance of 5 nautical miles (9.3km)), the worst case scenario assumes the use of class one buoys (height of 6.5m above sea level, 3m diameter at base, 1m diameter at focal plane/light level, with white light visible to mariners at a distance of 9 nautical miles (16.7km)).

15. Table 4.1 summarises the worst case scenarios for the impact assessments where such scenarios were required. Additional information is given in the impact assessments described in Sections 6 to 18.

Table 4.1 Worst case scenarios for impact assessment

Receptor	Impacts	Worst Case Scenario	Reasons
Coastal processes	Impacts on waves, tidal currents and sediment regime (operation)	4 Wave Dragon devices (perpendicular to predominantly westerly wave direction)	Wave Dragons comprise a ramp, reservoir and wave reflector arms which are overall some 250m wide and therefore block largest amount of waves and current and, therefore, the largest effect on the sediment regime
Water, sediment and soil quality	Impacts on water quality relating to disturbance of seabed sediment (construction and decommissioning)	120 Powerbuoy devices requiring 264 anchors	Largest number of anchors and, therefore, the largest potential to disturb seabed sediments and water quality
Ornithology	Impacts on intertidal birds (operation)	4 Wave Dragon devices (perpendicular to predominantly westerly wave direction)	Wave Dragons block the largest amount of waves and current and, therefore, the largest effect on the sediment regime in the estuary
Ornithology	Impacts on offshore birds (operation)	4 Wave Dragon devices	Largest potential area of sea physically occupied by WEC devices and, therefore, largest potential to affect bird behaviour
Marine ecology	Impacts on subtidal benthic ecology (construction and decommissioning)	120 Powerbuoy devices requiring 264 anchors	Largest number of anchors and, therefore, largest potential to disturb seabed (benthic) habitat and species
Marine ecology	Impacts on cetaceans (construction and decommissioning)	120 Powerbuoy devices requiring 264 anchors to be installed as driven piles	Largest number of anchors installed by noisiest method, and therefore, largest potential to affect cetaceans during installation due to piling noise and during decommissioning due to pile cutting
Marine ecology	Impacts on cetaceans (operation)	Unknown	No information on noise emissions from WECs
Fisheries	Impacts on commercial fisheries (operation)	Assume maximum extent of WEC-related safety zones ($15km^2$) around the entire deployment area	Maximum safety zone area and, therefore, maximum area over which fishing would be prevented
Landscape	Impacts on views offshore (operation)	12 FO^3 platforms and Class 1 buoys	Highest and bulkiest WECs devices, and highest and longest light penetration from cardinal buoys and, therefore, have the largest visual effect
Archaeology	Impacts on marine archaeology (construction and decommissioning)	120 Powerbuoy devices requiring 264 anchors	Largest number of anchors and, therefore, largest potential to affect seabed archaeology
Archaeology	Impacts on coastal archaeology (operation)	4 Wave Dragon devices (perpendicular to predominantly westerly wave direction)	Wave Dragons block the largest amount of waves and current and, therefore, the largest effect on the sediment regime at the coast
Tourism and Recreation	Impacts relating to surfing waves (operation)	4 Wave Dragon devices (perpendicular to predominantly westerly wave direction)	Wave Dragons block the largest amount of waves and, therefore, the largest effect on surfing waves at the coast

4.5 Baseline conditions

1. In addition, it is established in the courts that all necessary surveys to assess possible environmental impacts of a development must be carried out at the stage of EIA to establish whether there are any adverse effects (R v Cornwall CC ex parte Hardy (2001) Env LR 25). Table 4.2 identifies the surveys undertaken for Wave Hub to inform the EIA process.

2. In the absence of a scoping opinion, the scope of surveys to inform the EIA process was devised by a combination of consultation and reference to relevant guidelines.

3. The sufficiency of the surveys was potentially compromised by the repositioning of the Wave Hub deployment area by approximately 4km to the east-north-east of its original location. The repositioning occurred during the course of the EIA process when the surveys were either complete (e.g. subtidal ecology survey) or ongoing (e.g. cetacean monitoring, fish resource surveys). Accordingly, it was appropriate to make an assessment of whether the surveys required updating to take account of the new position of the deployment area. The assessment is presented in Table 4.2.

4. Not all surveys were directly affected by repositioning the deployment area; for example, the surveys for sediment quality, soil quality, terrestrial ecology, intertidal birds, intertidal ecology were unaffected because the surveys were not intended to cover the deployment area.

4.6 Impact assessment

5. The following paragraphs describe the basic procedure that was followed to assess the environmental impacts of the Wave Hub project. This procedure applies to most impacts except where stated otherwise in the methodology sections of the impact assessments (e.g. terrestrial ecology, ornithology and landscape).

6. The first step was to identify the environmental receptors / resources likely to be affected by the implementation of the proposed scheme through data collection, baseline surveys and consultation.

7. The second step was to identify the value or sensitivity of the environmental receptors / resources according to a five-point scale (i.e. very high, high, medium, low, and negligible), where appropriate.

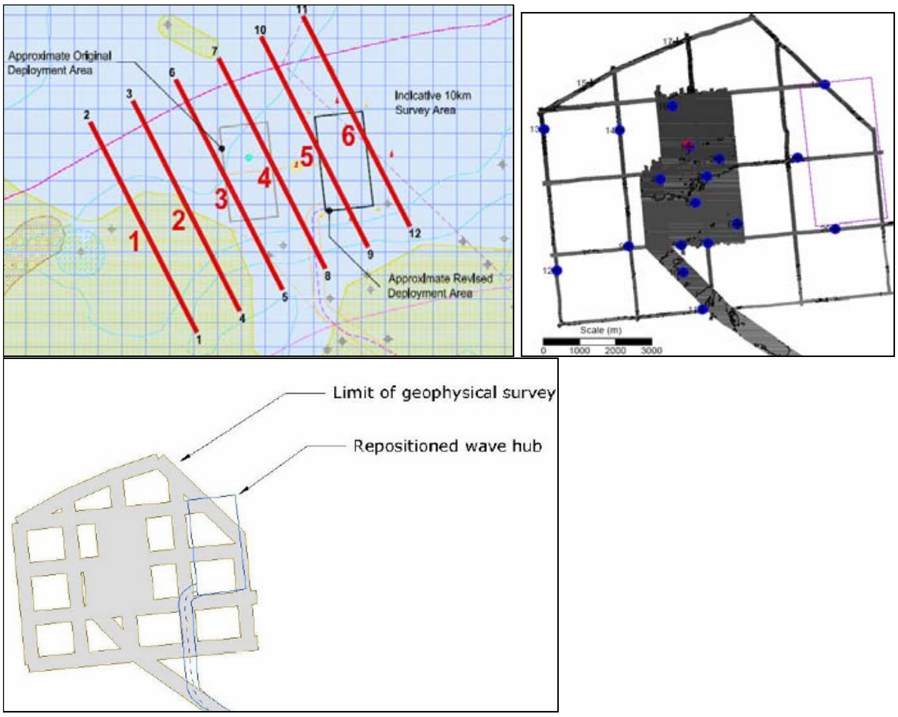
8. The third step was to consider the interactions of the Wave Hub project with the existing environmental receptor / resource conditions to identify the potential impacts (i.e. changes) as a consequence of the Wave Hub project during construction, operation and decommissioning.

9. The fourth step was to predict the magnitude of the potential impacts on environmental receptors / resources using predefined criteria. Magnitude was quantified on a four point scale (i.e. negligible, minor, moderate or major, including the scale (i.e. large to small) and nature (i.e. positive or negative) of the impact.

Table 4.2 EIA survey sufficiency following repositioning of deployment area

Survey	Description	Sufficient for EIA?	Reason
Wave climate	Wave rider buoy measuring wave characteristics	Yes	Although wave climate can be site specific, the distance between original and new deployment areas is reasonably small (in wave climate terms) and therefore the difference in wave climates between the two areas can be assumed to be small enough not to require additional wave climate survey. This assumption has been tested by comparing the recorded Wave Hub wave rider buoy data against Met Office wave model data recorded at wave rider buoy U04 during 2005. The new deployment area is positioned between the wave rider buoy and buoy U04; less than 3km from each. The comparison found good agreement between the recorded data and verifies the assumption.
Water quality	Sample collection and laboratory analysis for concentrations of total suspended solids	Yes	5 of 6 samples are situated near shore and are unaffected by new position of deployment area. The 1 affected sample is situated within the original deployment area. It is assumed that the TSS concentrations recorded by this sample are indicative of the general marine area where similar offshore conditions exist, rather than the site specific conditions at the original deployment area. In addition, applying the very low baseline TSS concentrations (all <3mg/l) recorded at the original deployment area maintains a very conservative methodology for the impact assessment.
Sediment quality	Sample collection and laboratory analysis for concentrations of contaminants	Yes	The samples are situated nearshore (within St Ives Bay) and are unaffected by new position of deployment area.
Soil quality	Sample collection and laboratory analysis for concentrations of contaminants	Yes	The samples are situated on land and are unaffected by new position of deployment area.
Terrestrial ecology	Phase 1 habitat survey	Yes	The survey is conducted on land and is unaffected by new position of deployment area.
Offshore birds	Monthly offshore bird counts over 1 year	Yes	The survey provides a high level overview of offshore birds in the wider study area rather than a site specific assessment of the deployment area, and the eastern survey transects cover the position of new deployment area (see Figure 4.1(a)).
Intertidal birds	Monthly intertidal bird counts over 1 year	Yes	The survey is conducted at Hayle beach and is unaffected by new position of deployment area.
Intertidal ecology	Benthic ecology survey with biotope mapping	Yes	The survey is conducted at Hayle beach and is unaffected by new position of deployment area.
Subtidal ecology	Sample collection and laboratory analysis and camera work for benthic ecology survey with biotope mapping	No	At best, 2 of the sample sites are within or near the boundary of the new deployment area. Insufficient coverage of the new deployment area (see Figure 4.1(b))

Cetaceans	TPOD device monitoring cetaceans	Yes	The survey provides a high level overview of cetacean behaviour rather than a site specific assessment of the deployment area. The TPOD data is considered to be representative given that cetaceans are constantly on the move so that their distribution does not generally show sharp local variations. For example, monitoring at Danish offshore windfarms shows similar trends and levels of cetacean activity at control sites up to 10km away.
Fish resources	Seasonal multi-gear fish ecology surveys over 1 year	Yes	Survey provides a high level overview of fish resources in the wider study area rather than a site specific assessment of the deployment area.
Marine archaeology	Geophysical survey including magnetometer	Yes	The geophysical survey lines cover the some of new deployment area - albeit in less detail than the original deployment area - and most of the revised cable route except a short section near the new deployment area (see Figure 4.1(c)). Overall, the survey provides approximately 50% coverage and only leaves uncertainty relating to unknown archaeological potential (rather than known sites, wrecks, etc), which can be dealt with though inspection of future geophysical survey, sediment samples, ROV video footage, etc.



Figures 4.1(a) (top left), 4.1(b) (top right) and 4.1(c) (bottom) New deployment area coverage by offshore bird, subtidal ecology and geophysical surveys

10. The fifth step was to quantify the significance of the potential effects on environmental receptors / resources based on the value/sensitivity and magnitude of the potential impacts (see Table 4.3) and with due consideration of the duration (temporary or permanent) and reversibility of the impacts.

11. The sixth step was to identify mitigation and/or enhancement measures to avoid, reduce or remedy environmentally unacceptable or unnecessary adverse impacts to environmentally acceptable levels.

12. The final step was to identify the potential residual impacts of the Wave Hub project after mitigation measures are successfully implemented.

13. The terms listed in Table 4.3 were applied to quantify the significance of impacts and residual impacts.

4.7 Uncertainty

14. 'A core issue for EIA is how to cope with decision-making under uncertainty' (Holling, 1978). By identifying the level of uncertainty associated with impact prediction, mitigation and monitoring programmes can be tailored to meet the requirements of the predicted impact. The following degrees of uncertainty were applied:

- Minor uncertainty, but outcome is sufficiently clear to enable a decision on impact assessment;
- Moderate uncertainty; there is an area of substantial uncertainty;
- Major uncertainty, true impacts are unknown and impact assessment is little more than an educated estimate.

15. In this Environmental Statement, uncertainty has been addressed through mitigation measures to reduce residual impacts and the uncertainty relating to residual impacts. For Wave Hub, the uncertainties revealed by the EIA process concern:

- Underwater noise impact on marine mammals during WEC operation (see Section 10.5); and
- Damage to potential (i.e. unknown) sites of cultural heritage and archaeological sites during construction of the Wave Hub's offshore infrastructure and cable, and installation of WEC devices (see Section 14.4).

16. Uncertainty for all impacts is summarised in the Impact Summary Tables in Section 19.

17. Note: terms concerning certainty of impacts used in Section 9 (e.g. "it is considered near certain…" pertain to the particular impact assessment methodology used in this section of the Environmental Statement.

Table 4.3 Assessment of significance of environmental effects and residual effects

Impact Magnitude	Receptor Value/Sensitivity			
	Very High	**High**	**Medium**	**Low**
Major Negative	Major adverse	Moderate adverse – Major adverse	Moderate adverse	Minor adverse – Moderate adverse
Moderate Negative	Moderate adverse - Major adverse	Moderate adverse	Minor adverse – moderate adverse	Minor adverse
Minor Negative	Minor adverse – Moderate adverse	Minor adverse – Moderate adverse	Minor adverse	Minor adverse
Negligible	No significant impact			
Minor Positive	Minor beneficial – Moderate beneficial	Minor beneficial – Moderate beneficial	Minor beneficial	Minor beneficial
Moderate Positive	Moderate beneficial – Major beneficial	Moderate beneficial	Minor beneficial – Moderate beneficial	Minor beneficial
Major Positive	Major beneficial	Moderate beneficial – Major beneficial	Moderate beneficial	Minor beneficial – Moderate beneficial

4.8 Consultation

1. Consultation is an integral part of the EIA process, it provides a mechanism for interested parties to express their opinions and share information about the proposed scheme. Implementing a consultation process at the early stages of a scheme's development will raise issues likely to be of concern/interest and facilitate their incorporation into a scheme at an early stage. Consultation with statutory and non-statutory stakeholders has been conducted throughout the EIA process for Wave Hub to enable stakeholders to express their views and contribute to the assessment of impacts and development of mitigation measures.

2. The following paragraphs describe the consultation processes undertaken as part of the EIA, summarise the key issues raised by consultees, and explain how these have been taken into account in the design of Wave Hub.

Impact identification

3. Consultation undertaken during the Environmental Scoping Study assisted in the identification of potential environmental impacts to be addressed in more detail in the Environmental Statement. Table 4.4 identifies the key concerns of the stakeholders (as reported in the *Environmental Scoping Study*) and the sections of the Environmental Statement where the concerns have been addressed.

Surveys and investigations

4. In the absence of a formal scoping opinion, consultation was undertaken to establish and agree the scope of various surveys and investigations; for example, for numerical modelling of waves (British Surfing Association, Surfers Against Sewage), for water quality and sediment quality surveys (CEFAS), for terrestrial ecology (English Nature), for offshore bird ecology survey (DTI, English Nature), for cetacean monitoring (English Nature), for fish ecology surveys and commercial fisheries study (local fishermen and industry representatives), for geophysical survey for archaeology and archaeological assessment (English Heritage), etc. Further information about the consultation undertaken in this respect is provided in subsequent sections of the Environmental Statement (see Sections 6 to 18) concerning the methodologies used to undertake the impact assessments.

Stakeholder meetings

5. An evening stakeholder meeting was held at Hayle on 5 October 2005. A series of presentations was made by SWRDA and Halcrow to provide an update for the Wave Hub project including a presentation specifically concerning the EIA process. A question and answer session was held after the presentations to allow the stakeholders to express their views and ask questions about the project.

Public exhibition

6. An all day (10:00 to 20:00) public exhibition was held at Hayle on 6 October 2005. The exhibition included information boards and a slide-show about the Wave Hub project, and was manned by representatives of SWRDA and Halcrow. An estimated 200

people attended throughout the day. Attendees were invited to complete a questionnaire about the Wave Hub. The objective of this was to gauge public perception of the proposed scheme.

4.9 Project team

1. The EIA process to the point of final preparation of this Environmental Statement was undertaken and managed by Halcrow on behalf of SWRDA.

2. Various studies were undertaken by Halcrow to inform the EIA process including the terrestrial ecology survey, offshore and intertidal bird surveys, the Wave Hub *Coastal Processes Study Report*, the Wave Hub *Report on Terrestrial Ground Conditions* (covering soil contamination).

3. Specialist environmental studies were also provided by the following parties:

- Alluvial Mining Ltd / Fugro – cetacean monitoring (TPOD), subtidal ecology survey, water quality survey, and sediment quality survey;
- Anatec – marine navigation surveys and navigation risk assessment;
- Cornwall Historic Environment Service (CHES) – archaeological assessment;
- EGS International – marine geophysical survey; and
- EMU Ltd – intertidal ecology survey, fish ecology survey and commercial fisheries study.

4. Various non-environmentally related studies by Halcrow helped to inform the EIA process (e.g. the Project Description, Alternatives and worst case scenarios). These studies included the Wave Hub *Final Design Report*, and the Wave Hub *Mooring Assessment Study*.

5. Other non-environmentally related studies that were conducted for Wave Hub and used to inform the EIA process included the Wave Hub *Wider Economic Impact Assessment* and *Summary Business Case* both by Arthur D Little, and the Wave Hub *Decommissioning Plan* by Abbot Risk Consulting (ARC).

Table 4.4 Summary of major issues identified by consultees by the Environmental Scoping Study

Receptor	Key concerns	Stakeholder rising the concern	Relevant sections of the ES
Nature conservation designations	Development should not affect the integrity of the SSSIs, St Ives Bay SMA	English Nature	8, 10
	Consider (and minimise) potential side effects on Hayle Estuary Reserve	RSPB	8
Terrestrial ecology	Consider impacts on terrestrial habitats, including sand deposition and associated sand dune movements near Hayle	Cornwall Wildlife Trust, Cornwall Tourist Board	8
Birds	Concerned about impacts on sediment movements in the estuary, and effect this might have on birds and their invertebrate prey	RSPB	9
	Investigate potential impacts on seabirds at sea	English Nature, Environment Agency, Environment Agency, Cornwall Wildlife Trust, RSPB	9
Benthic ecology	Minimise impacts on marine ecology. Cable route should avoid rocky areas where possible as they support benthic communities	English Nature, Cornwall Wildlife Trust	10
Important marine species	Investigate potential impacts on cetaceans and other important marine species – especially electromagnetic and noise impacts. Monitoring (over the long term if necessary) will be vital, as there is very little existing data. Avoid disturbance to St Ives Bay in Dec/Jan as large numbers of marine animals congregate there	English Nature, Environment Agency, Cornwall Wildlife Trust	10
Fisheries	Locate the Wave Hub so as to minimise the impact on important fishing areas. Concerned about possible future expansion of wave energy devices (and consequent reduction in their fishing grounds)	A range of fishermen operating in the Hayle area	11
	Investigate the potential for the devices to be located in spawning areas, thus becoming a *de facto* No Take Zone	English Nature, Cornwall County Council	11
Tourism and recreation	Minimise impacts on bathing water quality	Environment Agency	7
	Ensure that navigational safety features are incorporated into the design and that recreational boaters are kept informed	Royal Yachting Association	12, 16
	Model the potential for impact on wave climate that would reduce amenity value of St Ives Bay and nearby beaches for surfers	Surfers Against Sewage	16

Receptor	Key concerns	Stakeholder rising the concern	Relevant sections of the ES
Visual amenity and landscape character	The visual amenity and landscape character of the area should not be adversely affected	English Heritage, Cornwall County Council, Cornwall AONB Partnership, Countryside Agency, Hayle Town Council, National Trust, Cornwall Tourist Board, Cornwall Commercial Tourist Federation	13
Heritage and archaeology	Development should not affect the integrity of heritage and archaeological sites, both onshore and offshore. There are likely to be many undiscovered remains and features of importance in the nearshore area	English Heritage, Cornwall County Council	14
MoD training areas	Would be concerned if wave devices overlapped with a large part of their training area, a small amount of overlap is acceptable. Concerned about potential impacts on their operations in the area	Ministry of Defence	12
Traffic and navigation	Concerned about impacts on and disruption to shipping, and health and safety issues	Maritime and Coastguard Agency, Hayle Town Council	12, 15
Water	Care should be taken to avoid contamination of surface water	Environment Agency	7
Contaminated land	Investigate contamination of the land around the former power station site	Penwith District Council	7
Waves, tides and coastal processes	Impacts on these receptors should be investigated and minimised where possible. It will be important to monitor impacts on these receptors.	Cornwall County Council, Cornwall Wildlife Trust, Marine Conservation Society, Surfers Against Sewage	6

5 Planning and policy framework

5.1 Introduction

1. This section provides a summary of national, regional and local planning and policy relevant to the proposed Wave Hub project. In general, planning law applies differently to the terrestrial and marine environments, and these are therefore considered separately.

2. The onshore elements of the proposed development lie within Cornwall and in Penwith district. Each local authority has produced a statutory plan, and the plan contains a number of policies of relevance to the proposed development. The Wave Hub Environmental Scoping Report provided details of the relevant regional and local planning policies, and these are summarised below.

5.2 National energy policy

3. The government's new energy policy is set out in the Energy White Paper, Our *Energy Future – Creating a Low Carbon Economy* (TSO, 2003). It sets out the challenges addressed by the new energy policy, namely:

- Climate change due to carbon emissions and adoption of the Royal Commission on Environmental Pollution's (RCEP) recommendation that the UK should put itself on a path towards a reduction in carbon dioxide emissions of some 60% from current levels by about 2050;
- Decline of UK's indigenous energy supplies (i.e. oil, gas, nuclear and coal) and the maintenance of energy reliability, for example, through energy diversification into renewables; and
- Need to update much of the UK's energy infrastructure over the next two decades including adaptation to more renewables often in peripheral parts of the country or offshore.

4. To address these challenges, there are the following four goals of the new energy policy (TSO, 2003):

- "To put ourselves on a path to cut the UK's carbon dioxide emissions - the main contributor to global warming - by some 60% by about 2050, as recommended by the RCEP, with real progress by 2020;
- To maintain the reliability of energy supplies;
- To promote competitive markets in the UK and beyond, helping to raise the rate of sustainable economic growth and to improve our productivity; and
- To ensure that every home is adequately and affordably heated."

5.3 Planning Policy Statement for Renewable Energy (PPS 22)

1. This policy, PPS 22, deals primarily with general issues relating to the

implementation of national energy policy (as described above) and renewable energy planning policy. However, the policy states that contribution that offshore renewable energy can make to regional targets should be considered within regional spatial plans.

2. As noted in PPS 22, "Positive planning which facilitates renewable energy developments can contribute to all four elements of the Government's sustainable development strategy:

- Social progress which recognises the needs of everyone – by contributing to the nation's energy needs, ensuring all homes are adequately and affordably heated; and providing new sources of energy in remote areas;

- Effective protection of the environment – by reductions in emissions of greenhouse gases and thereby reducing the potential for the environment to be affected by climate change;

- Prudent use of natural resources – by reducing the nation's reliance on ever diminishing supplies of fossil fuels; and

- Maintenance of high and stable levels of economic growth and employment – through the creation of jobs directly related to renewable energy developments, but also in the development of new technologies. In rural areas, renewable energy projects have the potential to play an increasingly important role in the diversification of rural economies."

3. PSS 22 set out a range of key principles that regional planning bodies and local planning authorities should adhere to in their approach to planning for renewable energy.

5.4 Regional Planning Guidance for the South West (RPG10, 2001)

1. The South West's Regional Planning Guidance (RPG10) states that local authorities, energy suppliers and other agencies should support and encourage the region to meet the national targets for a minimum of 11% to 15% of electricity production to be from renewable sources by 2010. It further states that development plans should specify the criteria against which proposals for renewable energy projects will be assessed, balancing the benefits of developing more sustainable forms of energy generation against the environmental impacts, in particular on national and international designated sites.

5.5 Cornwall Structure Plan, September 2004 (Deposit Draft)

1. The following paragraphs present those policies that are of relevance to the proposed development:

POLICY 1: Sustainable Development (Principles)

2. This policy states that 'Development should bring about long term and sustainable improvement to Cornwall's economic, social and environmental circumstances without harming future opportunity.' This includes elements such as the conservation of

resources, minimising travel, fostering the links between the environment and the economy and the provision of employment to local communities

POLICY 2: Character Areas, Design & Environmental Protection

3. This policy states that 'The quality, character, diversity and local distinctiveness of the natural and built environment of Cornwall will be protected and enhanced. Throughout Cornwall, development proposals must respect local character' and that 'the conservation and enhancements of sites, areas, or interests, of recognised international or national importance for their landscape, nature conservation, archaeological or historic importance, including the proposed World Heritage Site, should be given priority in the consideration of development proposals'.

POLICY 3: Use of Resources

4. This policy states that 'Development must be compatible with the prudent use of natural and built resources and energy conservation.' This includes the re-use of previously developed land, the utilisation of renewable energy sources and sustainable construction principles.

POLICY 4: Maritime Resources

5. This policy states that 'An integrated and co-ordinated approach to the coast will be taken to support the economic importance and conservation value of the maritime environment. Development relating to the coast, estuaries and maritime environment should be considered against the need to ensure the conservation of the environment for its own sake and for the economic importance of fishing and the other activities it supports. Development should avoid pollution of coastal or marine waters and minimise any harmful effects on coastal processes.

6. Development should be within or well integrated with the existing developed coast and help enhance the quality of the environment and economic regeneration of the coastal towns. Waterside sites within the developed coast should be safeguarded for uses needing such locations giving priority to the maritime industries. The undeveloped coast should be protected. Local Plans should designate coastal zones where appropriate to take account of economic and social opportunity and environmental protection'.

POLICY 7: Renewable Energy Resources

7. This policy states that 'Provision should be made for renewable energy generation to maximise environmental and economic benefits while minimising any adverse local impacts.

8. A range of technologies for renewable energy production (for heat and electricity) will be encouraged. Schemes for electricity generation will contribute to a Cornwall target of about 93MW of installed capacity from renewable resources by 2010. This should be through development that increases local benefits, particularly diversification of the rural economy, and minimises any adverse effects on the natural or built environment. In respect of land-based wind energy, the scale and location of development should respect landscape

character and distinctiveness and reflect, in particular, countywide priorities to avoid adverse effects on the Area of Outstanding Natural Beauty, significant intrusion into coastal landscapes, and the unreasonable proliferation of turbines in the landscape.

9. Local Plans should consider potential sites and locations for all forms of renewable energy development against these considerations and should establish clear criteria or appropriate locations for development to contribute to the Cornwall target'.

POLICY 13: Tourism and Recreation

10. This policy states that 'The quality and opportunity for tourism and recreation should be enhanced by improvements to the existing resource through appropriate new provision' and that 'Development should not harm visitor facilities or other features that contribute to Cornwall's attraction for tourism and recreation.'

5.6 Penwith Local Plan Deposit Draft 1998, incorporating Proposed Modifications 2003

1. The following paragraphs present the relevant polices from the Local Plan:

Coast and Countryside

2. CC1 – Development will not be permitted where it would significantly harm the landscape character, amenity, nature conservation, archaeological, historic or geological values of the coast and countryside of Penwith.

3. CC2 – Proposals which maintain, enhance and facilitate the enjoyment and understanding of landscape character, amenity, nature conservation, archaeological, historic and geological values in the coast and countryside will be permitted.

4. CC6 – Development will not be permitted where it would cause significant harm to the character and amenity of the Areas of Great Landscape Value

5. CC7 - Proposals for development which would significantly harm the nature conservation value or geological interest of a Site of Special Scientific Interest will not be permitted.

6. CC8 – Development will not be permitted where it would significantly harm the nature conservation or geological interest of Areas of Great Scientific Value, Cornwall Nature Conservation Sites, Regionally Important Geological-Geomorphological Sites, Ancient Woodland Sites and Local Nature Reserves, development will not be permitted unless there is no significant adverse impact on nature conservation or geological values. Where development is permitted, any impact on such values must be minimised and conditions will be imposed, or a planning obligation sought, to ensure that mitigating measures are undertaken.

7. CC14 – Proposals for development which would have a significant adverse effect on the shoreline or adjacent coastal waters in terms of its landscape character, amenity, nature conservation, archaeological, historical and geological values will not be permitted.

8. CC15 – Proposals for development which would damage scheduled ancient monuments and other nationally important archaeological remains, or their setting, will not be permitted.

Towns and Villages

9. TV15 – Where proposals for re-use of previously developed land, including the reclamation of derelict land, in towns and villages involve sites likely to contain contaminated or toxic materials prior investigations will be required to determine the extent of contamination and, where necessary, measures to avoid pollution during and after implementation will be secured through the use of conditions.

5.7 Review of Wave Hub with planning and policy framework

1. It is concluded that the proposed development does not conflict with any of the relevant plans or polices at the local and regional level.

2. In a number of cases, Wave Hub is in accordance with plans and policies. Of particular importance, the proposed development makes a significant contribution towards policies relating to sustainable development and regional targets for the generation of energy from renewable sources.

3. In particular, Wave Hub presents an opportunity to contribute towards the UK's drive to meet the challenges and achieve the goals of the new energy policy including a 60% reduction in carbon emissions by 2050, which the white paper states "we are likely to need renewables by then to be contributing at least 30% to 40% of our electricity generation, and possibly more. We therefore need to develop a framework which encourages the development of a range of renewable options and make significant changes to our institutions and systems" (TSO, 2003).

6 Coastal processes

6.1 Introduction

1. This section of the Environmental Statement addresses the potential impacts of the Wave Hub proposals on coastal processes.

2. The *Environmental Scoping Report* (Halcrow, 2005) identified that Wave Hub had the potential to result in alterations to the wave climate and coastal processes.

3. Much of the information contained in this section is drawn from the *Coastal Processes Study Report* (Halcrow, 2006; Appendix A).

6.2 Methodology

Data collection

1. Various sources of data were used to inform the *Coastal Processes Study Report*. The latest available data was used to determine baseline conditions for water levels (typical and extreme), offshore wave conditions (including desktop review of available data, Met Office wave model data, joint probability and extremes analysis), tidal streams and currents, and sediment regimes in the offshore, transitional and nearshore zones.

2. A full list of data source references is provided in Appendix A.

Survey

3. A wave rider buoy (see Figure 6.1) was deployed close to the proposed location of the Wave Hub (50°21'30" N, 5°40'0" W, depth 52m Chart Datum) between 30 Jan 2005 and 12 April 2006 to enable data from two winter periods to be obtained. The recorded wave data was compared against coincident data from the Met Office Wave Model UK waters grid point U04 which is close to the location of the wave buoy.

Figure 6.1 Wave Hub's wave rider buoy

Worst case scenario

1. The impacts of the Wave Hub project have been assessed under two scenarios concerning the layout of WECs:

- Typical case WEC layout scenario based on the WEC layout shown in example layout 2 to the consent application comprising one Wave Dragon device, two Fred Olsen FO[3] devices, thirty PowerBuoy devices, and six Pelamis devices and the

Wave Hub's offshore infrastructure; and

- Worst case WEC layout scenario based on a WEC layout comprising four west-facing Wave Dragon devices and the Wave Hub's offshore infrastructure. Four Wave Dragons were chosen to represent worst case scenario because they have the largest effect on waves and currents, and therefore also have the largest effect on sediment regime. Only four Wave Dragon devices would be present at the Wave Hub because each device has a power output of 5MW and Wave Hub is designed with a maximum output of 20MW with each of the four PCUs being able to accommodate 5MW.

2. In terms of wave direction, data analysis and consultation with the BSA and SAS identified that waves approaching from the west was considered to represent the worst case scenario for assessing potential impacts on surf conditions under the *Coastal Processes Study Report*.

Surfing wave scenarios

3. Also, consultation with the British Surfing Association and Surfer Against Sewage identified various categories of surf scenarios to establish modelling assumptions (see Table 6.1). In particular, the *Coastal Processes Study Report* has taken the following surf scenarios forward for impact assessment:

- Typical small wave surf - long period but smaller wave height. Suitable for beginner to advanced surfers. Actual breaking wave height under head high (<2m). Long periods mean the waves have good shape despite lacking height. Again they consist of swell waves generated outside the local area. (Note that this surf type is not just restricted to the summer season); and

- Typical big wave surf - long period and large wave height, which produces the best surfable waves for intermediate to advanced surfers. Actual breaking wave height will vary along the coast depending on the degree on refraction etc but should generally be at least over head high (2m to 3m+). Consists of swell waves that have propagated in from storms far out in the Atlantic.

4. It should be noted that the approach to the description and assessment of the potential effects of the proposed development on the hydraulic, hydrodynamic and sedimentary regime is different from that adopted for other parameters in this Environmental Statement. With respect to this section, the effects of Wave Hub are described as predicted changes to the existing conditions. The consequences of these predicted changes are then assessed as potential impacts on other environmental parameters where appropriate.

5. This approach is adopted as it is not appropriate to describe changes to the hydraulic, hydrodynamic and sedimentary

regime is terms of their significance; rather, the changes manifest themselves as potential impacts, which can be described in terms of their significance, on other environmental parameters. Accordingly, the reader is referred to the related impacts in other parts of this Environmental Statement at the end of sections 6.4 and 6.5.

Table 6.1 Surf scenarios used in the Coastal Processes Study Report

Hs (m)	T (s)	Description	Probability of occurrence
1	7	Example small wave surf conditions	Average probability of occurrence of 38% in a particular summer (1 May until 31 August). 45 days/122 days
1.6	5.4		Mean wave conditions
2	10		Average probability of occurrence of 8% in a particular summer. 10 days/ 122 days Average probability of occurrence of 13% in any particular year. 48 days per year.
3	12		Average probability of occurrence of 3% in any particular year. 13 days per year.
4	14		Average probability of occurrence of approx 1% in any particular year. Approx 3 days per year.
4	16	Example big wave surf conditions	Average probability of occurrence of 0.3% in any particular year. Approximately 1 day per year.
10	12		1 in 1 year return period wave conditions

6.3 Baseline conditions

Data collection

1. To describe the baseline conditions, latest available data has been presented on water levels (typical and extreme), offshore wave conditions (including desktop review of available data, Met Office wave model data, joint probability and extremes analysis), tidal streams and currents, and sediment regimes in the offshore, transitional and near-shore zones.

2. A full description of the baseline conditions is provided in the *Coastal Processes Study Report*. A summary of the baseline conditions is provided in the following sub-sections.

Water levels

3. Table 6.2 summarises the typical and mean water levels, excluding sea level rise (at 5mm/year) and excluding surge (1 in 50 year period surge at St Ives is 1.0m).

Table 6.2 Typical and extreme water levels

Typical water levels	Water level (mODN)
Mean Low Water Springs (MLWS)	-2.6
Mean High water Springs (MHWS)	+3.2
Extreme water levels	**Water level (mODN)**
1 in 20 year return period	+3.6
1 in 50 year return period	+3.7
1 in 100 year return period	+3.8

Offshore wave climate

4. The annual mean wave power at the Wave Hub deployment area has been estimated as between 21kW/m and 25kW/m (see Figure 6.2) (DTI, 2004). Full details of the offshore wave climate based on various sources are provided in the *Coastal Processes Study Report*.

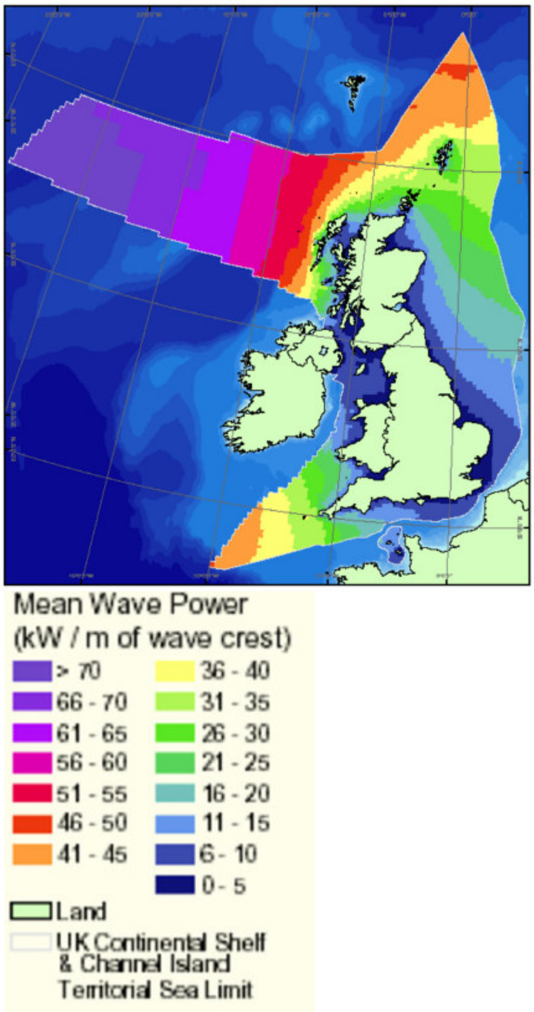


Figure 6.2 UK annual mean wave power (DTI, 2004)

5. For many years, the Met Office has run global and regional wave models to provide forecasts of sea state. The sea state at any point may be thought of as the sum of many individual waves each of a particular direction and frequency. This can be represented as the wave energy spectrum, where the wave energy in each frequency and each direction is known.

6. To inform the description of offshore wave climate, 17 years of data was obtained from the Met Office and was analysed to provide an offshore wave rose, time series plots of typical resultant and swell wave heights and periods, extreme wave conditions and joint probability analysis scatter plots.

7. Table 6.3 summarises the typical and extreme offshore wave climate. The offshore wave rose produced from the analysis of Met Office data is shown in Figure 6.3.

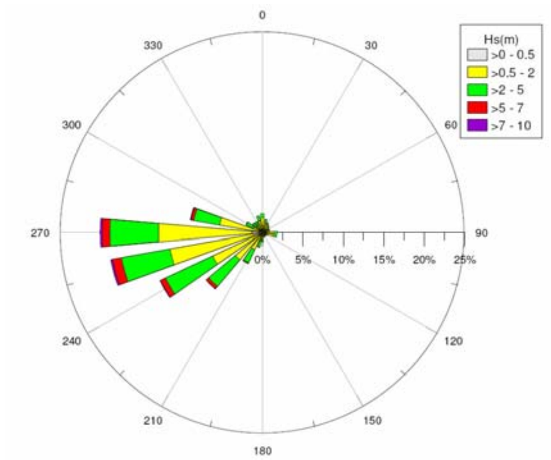


Figure 6.3 Offshore wave rose

Table 6.3 Typical and extreme wave conditions

Typical offshore wave conditions	Hs (m)	T (s)
Small surfing wave scenario (e.g. typical summer surfing waves which have a 38% probability of occurrence between 1 May and 31 Aug	1.0	7.0
Mean wave climate	1.6	5.4
Big surfing wave scenario (e.g. classic surfing waves with low which have a 0.3% probability of occurrence throughout the year	4.0	16.0
Typical offshore wave conditions (all directions)	**Hs (m)**	**T (s)**
1 in 1 year return period	10.4	12.1
1 in 50 year return period	13.8	13.9
1 in 100 year return period	14.4	14.1

Tidal currents

8. The typical and extreme tidal currents in the vicinity of the proposed Wave hub are summarised in Table 6.4.

Table 6.4 Typical and extreme tidal currents

Typical tidal current (typically parallel to the coast)	Extreme tidal current (1 in 50 year return period surface current
1.0m/s to 1.2m/s	1.6m/s

Sediments

9. The following descriptions are taken from the Wave Hub *Coastal Processes Study Report*.

10. Sediments in the offshore zone (i.e. -60mCD to -40mCD) are thin (c.1m depth) and patchy, predominantly medium to coarse-grained sand and fine to coarse grained gravel. The predominant offshore sediments are gravelly sand and sandy gravel which overlie, in layers typically less than one metre thick, the mudstone/shale bedrock.

11. It is speculated that very little change has occurred on the seabed over the past 100 years since no major features, in response to construction/ destructive forces, have been recorded.

12. As water depth exceeds 40m the opportunity for sediment movement is unfavourable, but may occur during storm conditions.

13. Sediments in the transitional zone (i.e. -40mCD to -10mCD) were typically dense olive grey coloured sand and gravel as well as shelly-sandy gravel, which are typically 0.2m thick overlying the mudstone/ shale bedrock. The thin superficial sediment cover becomes increasingly intermittent towards the offshore zone, which suggests that there may be an exchange of sediment between the nearshore and the offshore zone.

14. Transport in deep water is mainly related to currents as the influence of waves is limited to shallow depths (i.e. less than 10m). As water depth exceeds 10m and sediment on the seabed is limited and predominantly coarse the opportunity for sediment movement is unfavourable, but may occur during storm conditions.

15. St Ives Bay is believed to be a sediment sink supplied by the River Hayle and offshore sediments. There are unlikely to be significant sediment inputs from the River

Hayle since freshwater flows are generally small except during times of fluvial flooding, also the entrance channel has historically required dredging suggesting that this area is a sediment sink.

16. There are no significant quantities of sand offshore, sediments are thin (c. 1m depth) and patchy, predominantly medium to coarse grained sand and fine to coarse grained gravel. Under contemporary conditions the offshore sediments are believed to be largely immobile. There is limited input or export of sediment to St Ives Bay which can be considered as a closed sediment system.

17. The beaches are comprised mainly of sand. The beach profile demonstrates typical seasonal changes with lowering of beach levels and the creation of an intertidal bar during winter. Limited beach profile is available, but it has been suggested that beach levels can reduce by up to 1.8m following storms.

18. The plan shape of the beach suggests longshore drift in the estuary mouth from both the west and east. The dunes to the west of the proposed cable landfall are eroding and this could potentially extend eastwards in the future.

19. Rapid accretion occurs in the channel at the mouth of the estuary, which was previously dredged and sluiced to maintain a shipping channel. The alignment of the channel appears to be stable.

6.4 Identification of predicted effects

Effect of Wave Hub on wave conditions

General waves

1. WEC devices generate electricity by taking and converting energy derived from passing waves. Therefore, WECs have the potential to change the general wave conditions.

2. Halcrow's regional wave model MWAVE was used to assess impacts on wave conditions. A description of the model is provided in the *Coastal Processes Study Report*.

3. Wave modelling was undertaken using spectral waves to demonstrate the impact of WEC devices on a typical sea state which is comprised of many different waves approaching from many different directions.

4. For the purposes of this impact assessment, modelling was undertaken on a 1 in 1 year return period storm driven wave event with a wave height of 10m and a wave period of 12 seconds coming from a predominantly westerly direction (i.e. 270^{o}).

5. For the worst case WEC layout, modelling predicts up to a 5% magnitude reduction in wave heights at the coast during a 1 in 1 year return period storm, as shown in Figure 6.6.

6. For the typical case WEC layout, modelling predicts up to a 3% magnitude reduction in wave heights at the coast during a

1 in 1 year return period storm, as shown in Figure 6.7.

7. Wave modelling results show that wave heights are reduced in the sheltered sea area behind the WEC devices. As wave energies can propagate through the (semi-) floating WEC devices, waves can re-build after a distance of about 5km, depending upon the width and nature of the WEC devices.

Surfing waves

8. In addition to assessing the impact on general wave conditions, specific investigations were undertaken to assess impacts on surfing waves. Following joint probability analysis of the Met Office data and discussions with British Surfing Association and Surfers Against Sewage, the offshore wave conditions identified in Table 6.1 were defined and used to assess the impact of the Wave Hub project on wave conditions at the shore; that is, examples of typical small and big surfing waves.

9. Halcrow's regional wave model MWAVE was used to assess impacts on surfing wave conditions.

10. Wave modelling was undertaken using monochromatic waves to demonstrate the impact of WEC devices on surfing waves at the coast. Monochromatic waves were used to consider the impact of a single wave condition approaching from a single direction (i.e. to simulate a long period swell wave approaching from the North Atlantic) because surfers are primarily concerned with long period swell waves.

11. A comparison of impacts relative to tide conditions identified that the worst case impact under the worst case WEC layout scenario during big wave surf conditions occurs at mean low water spring tides (MLWS) rather than at MHWS or at mean sea level (MSL) (see *Coastal Processes Study Report*).

12. Under the worst case WEC layout scenario, the impact of the WEC device array layout with four west-facing Wave Dragon devices during mean wave conditions will be a reduction in wave heights at the coast of up to 13%.

13. For the example small and big surfing wave conditions, modelling predicts a reduction in wave heights at the coast of up to 11% (see Figures 6.8.and 6.9).

14. Figure 6.8 shows that the change in small wave surfing conditions will be focussed along a c.20km section of the north Cornish coast, reducing surfing wave heights at breaks at St Agnes, Droskyn and Penhale by up to 11%.

15. Figure 6.9 shows that the change in big wave surfing conditions will be focussed along a 20+km section of the north Cornish coast, reducing surfing wave heights at breaks at Portreath, Portowan and Chapel Porth by up to 11%.

16. A comparison of Figures 6.8 and 6.9 demonstrates the refraction of longer period waves (i.e. during big wave surfing conditions).

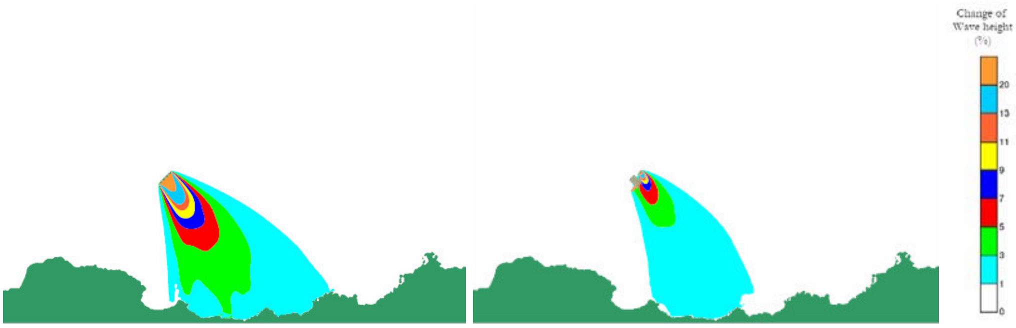


Figure 6.6 (left) and Figure 6.7 (right) Change under the typical case WEC layout scenario to wave height during 1 in 1 year storm event conditions (Hs 10m, T 12s)

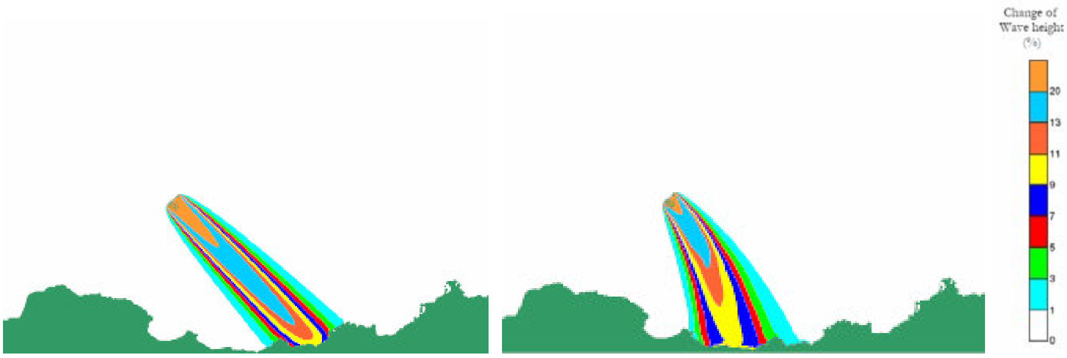


Figure 6.8 (left) and Figure 6.9 (right) Changes under the worst case WEC layout scenario to wave heights during small wave surfing conditions (Hs 1m, T 7s) and during big wave surfing conditions (Hs 4m, T 16s) respectively

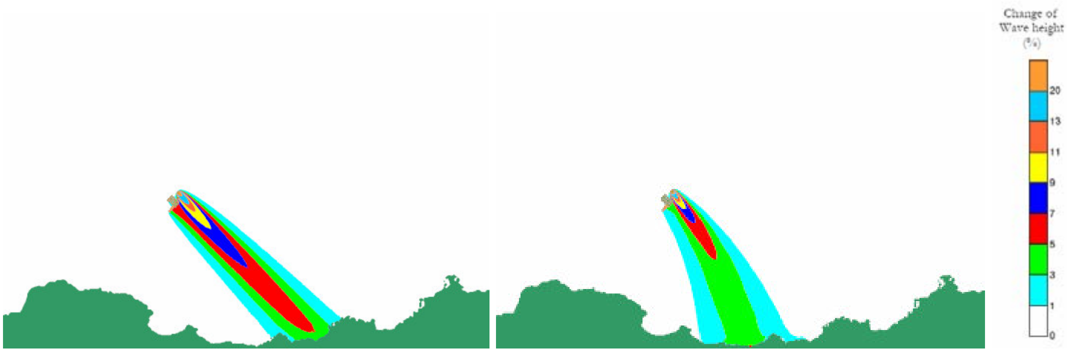


Figure 6.10 (left) and Figure 6.11 (right) Changes under the typical case WEC layout scenario to wave heights during small wave surfing conditions (Hs 1m, T 7s) and during big wave surfing conditions (Hs 4m, T 16s) respectively

17. Under the typical case WEC layout scenario, the impact of the various WEC types during mean wave conditions will be a reduction in wave heights at the coast of up to 5%.

18. For the example small and big surfing wave conditions, modelling predicts a reduction in wave heights at the coast of up to 5% (see Figures 6.10.and 6.11).

19. Figure 6.10 shows that the change in small wave surfing conditions will be focussed along a c.15km section of the north Cornish coast, reducing surfing wave heights at breaks at St Agnes, Droskyn and Penhale by up to 5%.

20. Figure 6.11 shows that the change in big wave surfing conditions will be focussed along a c.20km section of the north Cornish coast, reducing surfing wave heights at breaks at Portreath, Portowan and Chapel Porth by up to 5%.

21. A comparison of Figures 6.10 and 6.11 demonstrates the refraction of longer period waves (i.e. during big wave surfing conditions).

22. The effects of Wave Hub on wave conditions are used to inform the EIA process with regard to the following impacts:

- Impacts on surfing during WEC operation (see Section 16.5).

Effect of Wave Hub on tide conditions

23. Due to the difference in the WECs devices used for the typical and worst case WEC layout scenarios, two models were used to assess impacts on tidal currents; namely DAWN and FLOW3D. Descriptions of the models are provided in the *Coastal Processes Study Report*.

24. The impact of the worst case WEC layout scenario (i.e. four west-facing Wave Dragon devices) on the surface currents during flood and ebb tidal flows will be limited to a change in current speeds of up to -0.8m/s and +0.6m/s within a box 15km x 15km surrounding the deployment area. The predicted change to tidal currents does not extend to the coast. Figures 6.12 and 6.13 show flow speed changes.

25. The impact of the typical case WEC layout scenario on surface currents during the flood and ebb tidal flows will be a change in current speeds of up to -0.8m/s and +0.6m/s within a box 15km x 15km surrounding the deployment area. The predicted change to tidal currents does not extend to the coast. Figures 6.14 and 6.15 show flow speed changes.

26. The effects of Wave Hub on tide conditions are used to inform the EIA process with regard to the following impacts:

- Impact on interidal marine ecology (see Section 10.5); and
- Impact on subtidal marine ecology (see Section 10.5).

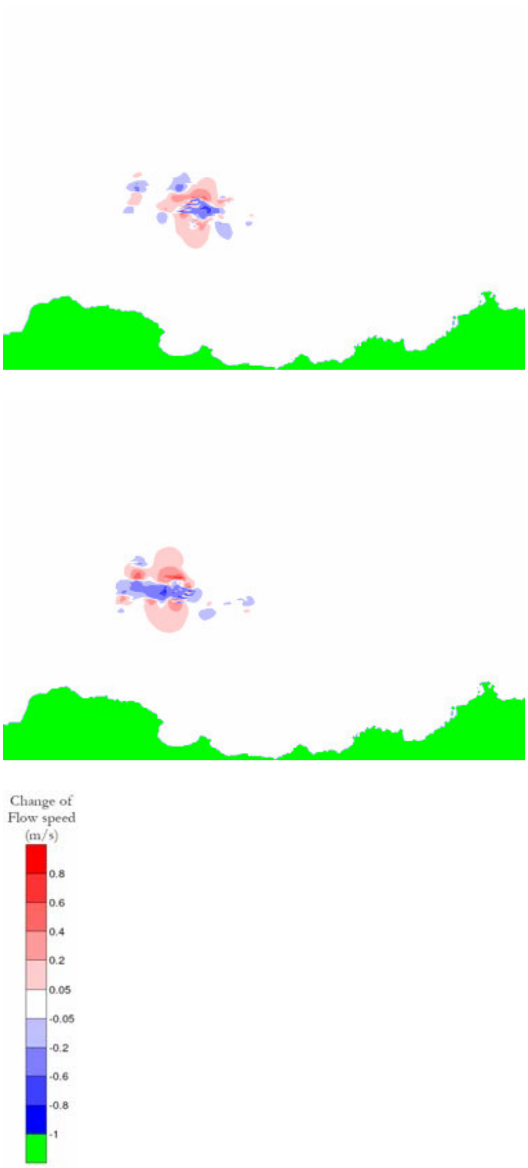


Figure 6.12 (top) and Figure 6.13 (bottom) Changes under the worst case WEC layout scenario to flood tidal flow speed and ebb tidal flow speed respectively

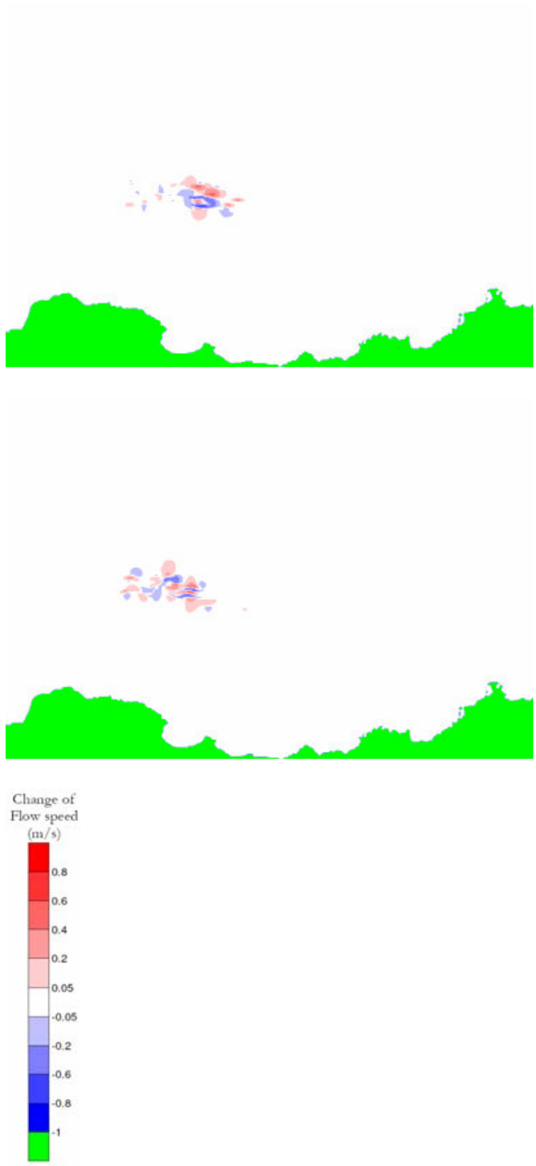


Figure 6.14 (top) and Figure 6.15 (bottom) Changes under the typical case WEC layout scenario to flood tidal flow speed and ebb tidal flow speed respectively

Effect of WECs on sediment conditions

20. Sediment transport modelling was undertaken to illustrate the predicted effects of the Wave Hub on the general patterns of sedimentation. Predicted effects are shown as depths of erosion and accretion over a period of 48 hours.

27. The results of the sediment transport modelling for the WEC device layouts (worst case and typical case layout scenarios) are similar, but the worst case scenario shows changes over a larger area. This impact occurs because:

- The current flow patterns with or without the WECs are almost the same; and

- Although the proposed WEC devices have an impact on wave patterns, this effect is not discernable at the seabed in water depths of more than 50m.

28. Figures 6.16 and 6.17 show the predicted effect of the worst case WEC layout on the sediment transport regime with and without the existing wave and current regime respectively. Without the existing sediment transport regime in place, the resultant impact of the WECs is confined to small areas near the shore.

29. Figures 6.18 and 6.19 show the predicted effect of the typical case WEC layout on the sediment transport regime with and without the existing wave and current regime respectively. Without the existing sediment transport regime in place, the resultant impact of the WECs is confined to very small areas near the shore.

Effect of Wave Hub offshore infrastructure and cable on sediment conditions

Offshore/transitional zone (-40mCD to -10mCD)

30. During the operational phase, the offshore infrastructure (TDU, PCUs and connectors) and the sub-sea cable (where it is laid on the seabed) have the potential to have an effect on sediment transport, with such effects being highly localised to the location of the structures. The potential effects can be summarised as follows:

- Disruption of existing sediment movement due to the presence of the offshore infrastructure and cable. There is limited potential for this since little change has occurred on the seabed over the past 100 years;

- Localised scour and potential burial of the offshore infrastructure and cable. Since offshore sediments typically occur in layers less than one metre thick this is unlikely to be a significant issue. However sub-sea facilities should be founded on bedrock to prevent undermining/overturning and cables should be placed on bedrock on the seabed to prevent the creation of a free span following scour of sediment during storm conditions;

- Movement of offshore sediments following storm conditions which may lead to localised burial of offshore infrastructure and the cable;

- Abrasion of the mudstone/ shale on the seabed if the offshore infrastructure and cable are not anchored sufficiently;
- Sub-sea facilities and cables should be anchored or weighed down to prevent flow induced vibration which could lead to damage and/or severance;
- Potential abrasion of cables where they pass over jagged outcrops of rock on the seabed;
- Marine growth and associated impacts on the offshore infrastructure and cable;
- The offshore infrastructure and cable need to be protected against trawl board or anchor loading.

31. Offshore cables will need to be weighted or anchored to prevent uplift and abrasion against exposed rock outcrops during storm conditions and will be buried in seabed sediments inshore of -20mCD.

Near-shore zone (below -10mCD)

32. For both WEC device layouts considered in the assessment, the predicted change to the wave climate and currents will not result in a discernable effect on sediment transport and beach levels along the north Cornish coast; that is, a change of less than 0.2m in beach levels during extreme storm events. This change is minimal when compared to current typical seasonal and temporal changes to the level of the beach, which can reduce by up to 1.8m in places following severe storms, removing material from the upper beach to create an intertidal bar some distance offshore. During less severe wave conditions this material is returned to the beach from the intertidal bar.

33. No long term impacts would result from cable burial, provided the cable is buried to a sufficient depth to prevent future exposure.

34. The potential for further erosion of the beach must be considered when determining the necessary buried level for the cable in the near-shore zone.

35. The effects of the WECs and the Wave Hub's offshore infrastructure and cable on sediment conditions are used to inform the EIA process with regard to the following impacts:

- Impact on water quality due to turbidity from sediment disturbance (see Section 7.5);
- Impact on subtidal marine ecology (see Section 10.5); and
- Impact on coastal archaeological sites due to sand deposition and erosion during Wave Hub operation (see Section14.5).

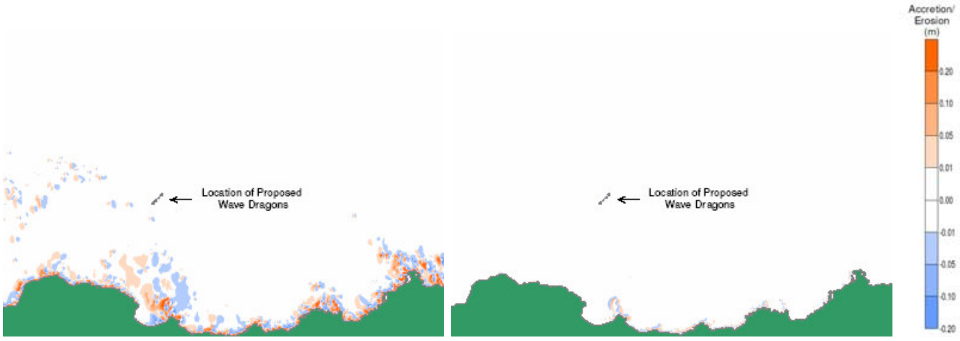


Figure 6.16 (left) and Figure 6.17 (right) Prediction of the effect of the worst case WEC layout on the sediment transport regime with and without the existing wave and current regime respectively

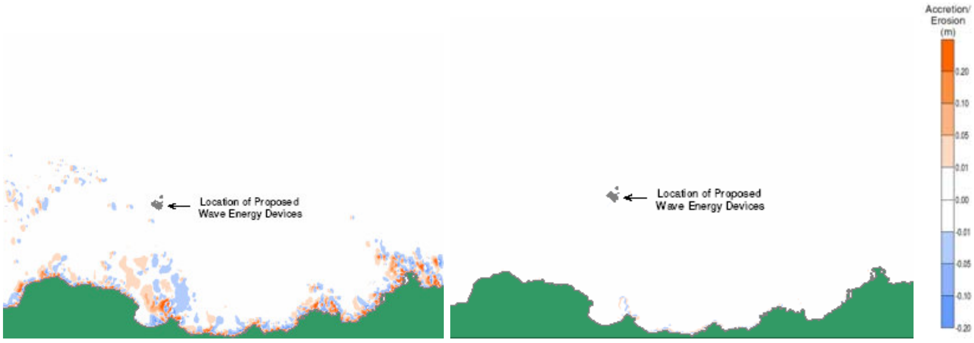


Figure 6.18 (left) and Figure 6.19 (right) Prediction of the effect of the typical case WEC layout on the sediment transport regime with and without the existing wave and current regime respectively

7 Water, sediment and soil quality

7.1 Introduction

1. This section addresses the potential impacts on water, sediment and soil quality that were identified by the Wave Hub *Environmental Scoping Study* (Halcrow, 2005). The impacts were:

- Impacts on marine water quality due to pollution (accidental or otherwise) during construction and decommissioning;
- Impacts on marine water quality due to pollution (accidental or otherwise) around the Wave Hub and WEC arrays during operation.
- Impacts on marine water quality due to turbidity from sediment disturbance during cable laying and offshore infrastructure construction and decommissioning;
- Impacts on marine sediment quality due to sediment disturbance during construction and decommissioning.

2. Also, consultation during the Wave Hub *Environmental Scoping Study* revealed that the Environment Agency was concerned that Wave Hub could affect bathing water quality (see Table 4.4), so this potential impact is addressed.

3. In addition, the Wave Hub *Environmental Scoping Study* identified that contaminated soils and ground conditions could cause impacts on water quality depending on the degree to which onshore construction (and decommissioning) activities cause disturbance and release contaminants.

4. Accordingly, another impact considered under this section of the Environmental Statement is the potential impact on water quality due to contaminated ground disturbance during construction and decommissioning.

7.2 Methodology

Baseline survey for turbidity

1. To address the potential impact relating to turbidity, a water quality survey was undertaken to establish the baseline conditions for total suspended solids (TSS). The scope of the survey, including sampling and analytical requirements, was devised in consultation with the Centre for Environment, Fisheries and Aquaculture Science (CEFAS).

2. Water samples were collected from five sampling stations positioned along the inshore part of the cable route within St Ives Bay (see Figure 7.1) and from a sixth sampling station further offshore positioned at the Wave Hub's deployment area.

3. Three water samples were collected at each of the six sampling stations from the surface, mid-depth and near-bed positions in the water column. The depth of each sample was recorded. In total, 18 water samples were collected.

4. It was proposed that the survey would be undertaken twice in order to obtain data covering any seasonal variation that may occur between summer and winter. However, the significant wave heights that occur off the north Cornish coast combined with the availability of a suitable survey vessel meant that the survey for water quality missed the summer period and only one survey was undertaken. This approach is considered to be satisfactory for informing the EIA process because the TSS concentrations were very low (see Section 7.3), and therefore provide a very conservative impact assessment.

Baseline survey for sediment quality

1. To address the potential impact relating to contaminated sediments, a sediment quality survey was undertaken to establish the baseline conditions for the inshore sediments along the cable route within St Ives Bay. The scope of the survey, including sampling and analytical requirements, was devised in consultation with CEFAS.

2. The survey's geographic scope was limited to the sediments of St Ives Bay since beyond the bay the seabed comprises outcropping rock (i.e. no sediment) along the cable route and patchy coarse-grained sandy gravels at the deployment area (i.e. sediment with physico-chemical conditions that offer relatively little potential to concentrate significant levels of contaminants, particularly given the distance from potential pollution sources). The survey's contaminant scope was limited to metals and organotins because only these parameters were believed to have local sources (i.e. Hayle River and Red River).

3. Sediment samples were collected from five sampling stations positioned along the inshore part of the cable route across St Ives Bay (see Figure 7.1 at the same coordinates from where water quality samples were collected.

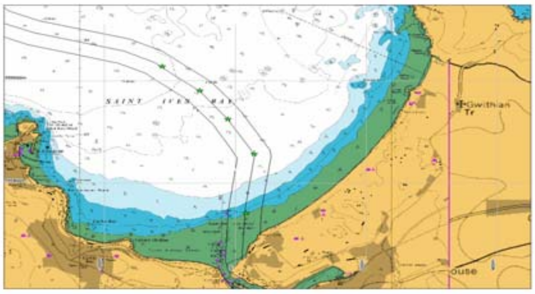


Figure 7.1 Water and sediment quality survey positions within St Ives Bay

4. Two sediment samples were collected at each sampling station - one from the seabed's surface and one at up to 1m depth below it – except at station 4 where only a surface sample could be collected. Nine samples were collected in total.

5. Analyses were performed for the following parameters:

- Physico-chemical parameters - particle size distribution (PSD), total organic matter (TOC) content; and
- Chemical contaminants - metals (arsenic (As), cadmium (Cd), chromium (Cr), copper (Cu), mercury

(Hg), nickel (Ni), lead (Pb), zinc (Zn), tributyl-tin (TBT) and dibutyltin (DBT).

6. It was agreed with CEFAS that analyses for other chemical contaminants such as hydrocarbons, polychlorinated biphenyls (PCBs), etc were not required for this survey.

Baseline survey for soil quality

7. The investigations undertaken to inform the *Report on Terrestrial Ground Investigations* (Halcrow, 2005) included laboratory testing for contaminants. The scope of the survey is summarised in Table 7.1.

8. Given the history of the site, the *Report on Terrestrial Ground Conditions*, notes that "it was felt necessary to analyse for a wide range of possible contaminants that may be present in samples of made ground recovered from both the level area of the proposed site compound and the two large spoil heaps. The tests were undertaken primarily such that the potential risks to construction workers involved in handling these materials could be identified and appropriate procedures adopted to mitigate against these hazards; but also to consider the long-term effects on personnel visiting the site compound and the environmental impacts on water quality (both river and sea) of leaving these materials in situ."

Table 7.1 Chemical and contamination testing

Parameter	No. of Samples	Parameter	No. of Samples
Arsenic (Total)	12	Sulphate as SO_3 (2:1 water extract)	12
Boron (Soluble)	12	pH	12
Cadmium (Total)	12	PCB (as Aroclors)	12
Chromium (Hexavalent)	12	TPH risk assessment (C_6 to C_{40})	12
Chromium (Total)	12	Total TPH (C_6 to C_{40})	12
Copper (Total)	12	Total Aliphatic Hydrocarbons (C_5 to C_{40})	12
Lead (Total)	12	Total Aromatic Hydrocarbons	12
Mercury (Total)	12	BTEX (Total)	12
Nickel (Total)	12	PAH suite	12
Selenium (Total)	12	PAH (Total)	12
Tin (Total)	12	PCB's	5
Zinc (Total)	12	Moisture Content	12
Cyanide (Complex)	12	% Stones	12
Cyanide (Free)	12	VOC's	12
Cyanide (Total)	12	SVOC's	12
Organic Matter	12	Asbestos	6
Sulphate (Total) as SO_3	12	WAC	5

Assessment criteria for water quality

9. EC Directive 76/464/EEC on pollution caused by certain dangerous substances on the aquatic environment (referred to as the Dangerous Substances Directive) is transposed into UK legislation. The Dangerous Substances Directive establishes List I substances, which are regarded as particularly dangerous because of their toxicity, persistence and bioaccumulation to the extent that pollution by these substances must be eliminated, and List II substances, which are regarded as less dangerous but which have a deleterious effect on the aquatic environment to the extent that pollution by these substances must be reduced.

10. The Dangerous Substances Directive stipulates uniform emission standards (UESs, also known as limit values) and environmental quality standards (EQSs) as approaches for the control of List I substances. All member states are required to establish EQSs for List II substances on a national level. EQSs for List II substances have been implemented in the UK by the Surface Waters (Dangerous Substances) (Classification) Regulations 1997 and 1998.

11. The EQSs for List I and List II substances form the impact assessment criteria for marine and fresh water where water quality may be affected by the disturbance of contaminated sediment and soils.

12. In addition, EC Directive 76/160/EEC concerns the quality of bathing waters and establishes mandatory and guideline standards for water quality using three microbiological parameters (total coliforms, *Escherichia coli* and faecal streptococci) measured in a 100ml water sample. The standards are shown in Table 7.3.

Table 7.2 EQSs for selected List I and II dangerous substances

Parameter	List	EQS Type	Units	Marine water EQS	Fresh water EQS
Arsenic	II	AA	µg/l	25	50
Cadmium	I	AA	µg/l	2.5	5
Chromium	II	AA	µg/l	15	5-250
Copper	II	AA	µg/l	5	1-28
Mercury	I	AA	µg/l	0.3	1
Nickel	II	AA	µg/l	30	50-200
Lead	II	AA	µg/l	25	4-250
Zinc	II	AA	µg/l	40	8-500
TBT	II	MC	µg/l	0.002	0.002

AA = annual average, MC = maximum concentration

Table 7.3 Water quality standards under the EC Bathing Waters Directive

Standard	Total coliforms	*Escherichia coli*	Faecal streptococci
Mandatory	10,000/100ml	2000/100ml	None
Guideline	500/100ml	100/100ml	100/100ml

Assessment criteria for sediment quality

13. There are no quantified EQSs defining in situ quality for UK sediments. Guidance is given only for the substances under EC Dangerous Substances Directive List I (i.e. mercury and cadmium) as 'standstill (no deterioration)'. Without quantified UK

standards, the following guidelines from other sources have been used to assess the baseline level of contamination present in the sediments along the nearshore cable route and their potential to affect water quality:

- CEFAS's guideline action levels for assessing the disposal of dredged material at sea (see Table 7.4, derived from CEFAS, 2000); and
- Canadian sediment quality guidelines for the protection of aquatic life (see Table 7.5, derived from CCME, 2002).

Table 7.4 CEFAS action levels for the disposal of dredged material at sea

Parameter	Units	Action Level 1	Action Level 2
Arsenic	mg.kg-1	10	25-50
Cadmium	mg.kg-1	0.2	2.5
Chromium	mg.kg-1	20	200
Copper	mg.kg-1	20	200
Mercury	mg.kg-1	0.15	1.5
Nickel	mg.kg-1	10	100
Lead	mg.kg-1	25	250
Zinc	mg.kg-1	65	400
TBT + DBT	mg.kg-1	0.1	1

14. CEFAS's action levels are non-statutory criteria used by DEFRA/MCEU as part of a weight-of-evidence approach to licensing the disposal of dredged material at sea under the Food and Environment Protection Act 1985. The action levels act as potential triggers for further assessment and do not constitute pass or fail criteria. In this context, licence refusal is unlikely if contaminant concentrations are below level 1 and likely if contaminant concentrations are above level 2, and further assessment may be required if contamination concentrations are between levels 1 and 2.

15. The Canadian sediment quality guidelines for the protection of aquatic life constitute threshold effect levels (TELs) and probable effect levels (PELs) that indicate in situ sediment quality with respect to biological effects. The two levels form three biological effects ranges for chemical contaminants as follows:

- Minimal effect range below the TEL where adverse biological effects occur rarely;
- Possible effect range between the TEL and PEL where adverse biological effects occur occasionally; and
- Probable effect range above the PEL where adverse biological effects occur frequently.

16. The TEL also acts as an interim sediment quality guideline (ISQG) level (CCME, 1999). Cole et al (1999) recommend that "in the absence of any UK standards, these guidelines can be used as a first approximation in assessing whether organisms are at risk from sediment concentrations of toxic substances."

17. Table 7.5 shows the TELs and PELs. Nickel, TBT and DBT are not included under the Canadian guidelines.

Table 7.5 Canadian sediment quality guidelines for the protection of aquatic life

Parameter	Units	TEL	PEL
Arsenic	$mg.kg^{-1}$	7.24	41.6
Cadmium	$mg.kg^{-1}$	0.7	4.2
Chromium	$mg.kg^{-1}$	52.3	160
Copper	$mg.kg^{-1}$	18.7	108
Mercury	$mg.kg^{-1}$	0.13	0.7
Lead	$mg.kg^{-1}$	30.2	112
Zinc	$mg.kg^{-1}$	124	271

18. There are no sediment quality assessment criteria for the physico-chemical parameters (i.e. PSD, solids, TOC): these data are used to assist the assessment of metals and organotins.

19. Since the impacts relating to contaminated sediments relate to water quality, the EQSs identified in Table 7.2 are applied as impact assessment criteria.

Assessment criteria for soil quality

20. Since the impacts relating to contaminated soil relate to water quality, the EQSs identified in Table 7.2 are applied as impact assessment criteria.

Worst case scenario

21. The worst case scenario for the impact assessments only concerns impacts relating to seabed sediment disturbance within the deployment area. The worst case scenario for seabed disturbance is considered to be the WEC layout that provides the greatest numbers of anchors for moorings. Accordingly, the worst case scenario is a maximum of 264 anchors for WECs based on connection of 30 PowerBuoy devices to each of the four PCUs, and assuming 66 anchors per array of 30 devices.

7.3 Baseline conditions

Water resources

1. The Wave Hub *Environmental Scoping Study* reported the following water resources in the study area:

- No water courses run through the onshore site, the closest being the Hayle River (estuary) at a distance of approximately 200m and the Red River;
- Seven sewage and final/treated effluent discharge consents to controlled waters are located between 500m and 1km of the site and one discharge consent for miscellaneous discharges (mine / groundwater) is located 855m from the site - all operated by South West Water;
- Six licensed abstractions within 1km of the site. The nearest abstraction is attributed to CEGB Hayle, is located 415m south of the site, and is for tidal water. The remaining five abstractions are operated by West

Cornwall Golf Club and are groundwater derived;

- No public water supply abstractions are within 1km of the site; and

- 11 groundwater and surface water abstractions are located between 1km and 2km from the site. Two groundwater abstractions are for private domestic supply, one is for the commercial bottling of spring water, and the remainder are for spray irrigation. The surface water abstractions are used for spray irrigation.

Pollution incidents

2. The Wave Hub *Environmental Scoping Study* reported seven pollution incidents within 1km of the site reported on the Substantiated Pollution Incident Register. A Category 3 – Minor Incident - was reported 195m south-east of the site and comprised general biodegradable material. The remaining six incidents comprised commercial / construction / demolition material, crude sewage petrol and lubricating oils. No details of the receptors are given.

Bathing water quality

There are three bathing waters near and either side of the Wave Hub cable landfall site known as Towans Hayle, Towans (Gwithian and Godrevy) and Carbis Bay. The bathing waters are generally unaffected by the microbiological parameters that can affect water quality and have been classified as 'excellent' in the majority of the last 10 years (see Table 7.6).

Table 7.6 Bathing water quality monitoring results 1994-2004 (www.environment-agency.gov.uk)

Year	Hayle Towans	Gwithian / Godrevy Towans	Carbis Bay (Porth Kidney Sands)
1994	Excellent	Excellent	Excellent
1995	Excellent	Excellent	Excellent
1996	Excellent	Good	Excellent
1997	Excellent	Excellent	Excellent
1998	Excellent	Excellent	Excellent
1999	Excellent	Excellent	Excellent
2000	Excellent	Excellent	Excellent
2001	Excellent	Excellent	Excellent
2002	Excellent	Excellent	Excellent
2003	Excellent	Excellent	Excellent
2004	Excellent	Excellent	Excellent

Total suspended solids

3. The survey data for TSS (see Table 7.7) show that concentrations are generally low, with many samples yielding concentrations of <3mg/l.

4. The highest concentration of 18mg/l was recorded in the surface water at sampling station VC3.

Seabed sediments

5. Particle size analysis (PSA) shows that the sediment within St Ives Bay predominantly comprises sand (>95%) with very small fractions of silt and pebbles based on Friedman and Sanders Size Scales 1978.

The mean grain sizes for sediment within St Ives Bay ranges from 0.154mm to 0.314mm. The mean of the mean grain sizes is 0.230mm (see Table 7.8).

Table 7.7 Water quality results for total suspended solids (in mg/l)

Depth	VC1	VC2	VC3	VC4	VC5	VC6
Surface	<3	<3	18	7	<3	<3
Mid-depth	6	<3	<3	<3	<3	<3
Near bed	<3	<3	5	<3	<3	<3

Table 7.8 Sediment results for sediment type (based on PSA) and mean grain size

Size	Unit	VC1a	VC1b	VC2a	VC2b
Pebble	%	0.23	0.96	0.37	0.28
Sand	%	99.33	98.67	98.66	98.64
Silt	%	0.44	0.37	0.97	1.08
Mean size	mm	0.281	0.267	0.146	0.174
Size	**Unit**	**VC3a**	**VC3b**	**VC4a**	**VC5a**
Pebble	%	0.03	2.53	3.26	84.73
Sand	%	98.28	95.67	93.82	11.9
Silt	%	1.69	1.8	2.92	3.38
Mean size	mm	0.154	0.314	0.276	19.84

6. Further offshore, at the Wave Hub deployment area, PSA shows that the sediment is much coarser, predominantly comprising pebbles (c.85%) with smaller amounts of sand (c.12%) and silt (c.3%) based on Friedman and Sanders Size Scales 1978. The mean grain size (c.19.8mm) is much greater than the mean grain sizes recorded in St Ives Bay.

7. The TOC contents of the samples collected in St Ives Bay (VCs 1 to 4) range from <0.4% to 6.4%. The TOCs at sampling station 1 (at 4% and 6.4%) were higher than TOC contents of samples collected further into St Ives Bay (sampling stations 2-4 at <0.4% to 1.1%) suggesting the nearshore sediments are affected more by land based sources of organic matter.

8. The TOC content at the Wave Hub and WEC deployment area is very low, with sampling station VC5 yielding TOCs at <0.4% (see Table 7.9).

9. Data for metals contents of the samples are shown in Table 7.10. There does not appear to be a distinct trend to the horizontal distribution of metals with distance offshore except for relatively elevated concentrations of cadmium, chromium, copper, nickel lead and zinc at sampling station 5. There does not appear to be any distinct trend to the vertical distribution of metals between the surface and subsurface samples.

10. Data for organotins contents of the samples are also shown in Table 7.9. All data for TBT and DBT were recorded at levels below the respective detection limits of the analytical equipment in all samples.

Table 7.9 Sediment results for depth, solids and TOC

Parameter	Unit	VC1a	VC1b	VC2a
Depth	m	0.0	1.05	0.0
Solids	%	91.1	85.4	68
TOC	%	6.43	4.01	1.11
Parameter	**Unit**	**VC2b**	**VC3a**	**VC3b**
Depth	m	1.0	0.0	0.8
Solids	%	77.8	68.2	74.4
TOC	%	<0.4	<0.4	<0.4
Parameter	**Unit**	**VC4a**	**VC5a**	**VC5b**
Depth	m	0.0	0.0	0.7
Solids	%	75.6	80.8	90.7
TOC	%	0.52	<0.4	<0.4

Table 7.10 Sediment results for metals and organotins (all in units of mg/kg)

Parameter	Units	VC1a	VC1b	VC2a	VC2b	VC3a	VC3b	VC4a	VC5a	VC5b
Arsenic	mg/kg	26.2	15.3	32.7	7.52	46.2	46.1	19.7	5.25	13.8
Cadmium	mg/kg	0.079	0.04	0.072	0.019	0.063	0.058	0.045	0.247	0.497
Chromium	mg/kg	3.34	3.47	11.3	9.49	8.26	8.36	12.4	37.6	78.8
Copper	mg/kg	13.6	13.7	35.3	3.98	48.5	51.6	17.3	55.3	101
Mercury	mg/kg	0.003	0.001	0.007	0.002	0.006	0.003	0.006	0.003	0.003
Nickel	mg/kg	4.45	5.16	8.53	7.62	7.21	7.38	7.07	32.4	46.1
Lead	mg/kg	8.9	6.95	15.8	2.77	13.7	12.8	15.7	14.6	36.9
Zinc	mg/kg	34.7	32.5	43	15.8	40.7	36.6	33.1	171	274
TBT	mg/kg	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008
DBT	mg/kg	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007

11. When compared against the CEFAS action levels for the disposal of dredged material at sea, most survey data (74%) are below the Action Level 1; the remainder are between the Action Levels 1 and 2 (26%) (see Table 7.11). No data are above Action Level 2 (0%). Most data for cadmium, chromium, mercury, lead, nickel, zinc, TBT and DBT are below Action Level 1. Some copper data are below Action Level 1 and some are between Action Levels 1 and 2. All arsenic data are between Action Levels 1 and 2.

Table 7.11 Comparison of sediment quality results against CEFAS action levels for the disposal of dredged material at sea

Parameter	No. of Samples < Action Level 1	No. of Samples Action Level 1 – Action Level 2	No. of Samples > Action Level 2
Arsenic*	0	9	0
Cadmium	7	2	0
Chromium	7	2	0
Copper	4	5	0
Mercury	9	0	0
Lead	8	1	0
Nickel	7	2	0
Zinc	7	2	0
TBT	9	0	0
DBT	9	0	0
Total (%)	67 (74%)	23 (26%)	0 (0%)

* Assumes Action Level 2 = 50mg.kg^{-1}

12. When compared against the Canadian sediment quality guidelines for the protection of aquatic life most data (70%) are below the TEL; the remainder are between the TEL and PEL (27%) and above the PEL (3%) (see Table 7.12). Most data for cadmium, chromium, mercury, lead and zinc are below the TEL; the remainder are between the TEL and PEL. Most copper data are between the TEL and PEL; the remainder are below the TEL. Most arsenic data are between the PEL and TEL; the remainder are above the PEL – these are the only data above the PEL. There are no TELs or PELs for nickel, TBT and DBT.

Table 7.12 Comparison of sediment quality results against Canadian sediment quality guidelines for the protection of aquatic life

Parameter	No. of Samples < TEL	No. of Samples TEL - PEL	No. of Samples > PEL
Arsenic	0	7	2
Cadmium	9	0	0
Chromium	8	1	0
Copper	3	6	0
Mercury	9	0	0
Lead	8	1	0
Nickel	-	-	-
Zinc	7	2	0
TBT	-	-	-
DBT	-	-	-
Total (%)	44 of 63 (70%)	17 of 63 (27%)	2 0f 63 (3%)

Soil conditions

13. According to the Wave Hub *Report on Terrestrial Ground Conditions* "the proposed sub-station and access are located in a former sand pit that was worked during the late-19th and early-20th centuries, which created a distinctive bowl shape within the sand dunes. From the 1930s onwards the area was developed into a power station which was subsequently demolished during the late-1970s to early-1980s. During this period made ground materials were deposited across much of the site, including the area of the proposed sub-station and access track. Dumping of materials in recent years has resulted in a number of large spoil heaps within the site compound."

14. "Intrusive ground investigation works within the proposed site compound have revealed the presence of deep (>5m) variable made ground materials, comprising principally of gravelly sands with pieces of concrete and other man-made materials including plastic, electrical wire, timber and metal. These are underlain by dune sands and gravels to bedrock at approximately 10m below ground level."

15. According to the Wave Hub *Report on Terrestrial Ground Conditions* "Groundwater levels were recorded at depth (10m below ground level) in the proposed site compound area and at depth beneath the sand dunes (i.e. below the proposed elevation of the directional drill)."

16. The findings of the contamination survey conducted as part of the Wave Hub *Report on Terrestrial Ground Conditions* recorded that "Of the determinands tested for, four samples recorded concentrations of arsenic that would classify them as hazardous waste using mirror entries of the European Waste Catalogue (EWC). These samples of made ground were obtained from TP5 and TP6 within the site compound and TP7 and TP8 from the large stockpile near the eastern side of the site.

17. "Concentrations of arsenic recorded in three leachate samples exceed the Environmental Quality Standard (EQS) of 50ug/l. Raised arsenic concentrations are common in Cornwall due to the mineralogy of many of the host rocks prevalent in the county. The high leachate concentrations will dictate that the spoil will be classified as stable non-reactive for disposal purposes." In addition, "the copper leachate concentrations are also considered relatively high at 20µg/l. The source of the raised copper concentrations is unknown but the fill is likely to have originated from the former power station." The results of all tests completed for arsenic and copper are summarised in Tables 7.13 and 7.14.

18. "A sample obtained from TP5 recorded a polyaromatic hydrocarbon concentration of 110mg/kg. This exceeds the 100mg/kg limit permitted for waste materials to be classified as inert. However, all other hydrocarbon concentrations were low."

Table 7.13 Summary of arsenic and copper concentrations in made ground samples

Exploratory Hole	Sample Depth	Arsenic (Total)	Copper (Total)	Description
	(m bgl)	(mg/kg)	(mg/kg)	
TP1	0.8 – 1.7	93	170	Black gravelly Sand
TP2	0.0 – 0.3	270	350	Grey brown very gravelly Sand
TP3	1.6 – 2.0	44	65	Black ashy Sand
TP4	0.8 – 2.0	140	1900	Brown gravelly Sand
TP5	1.0 – 2.0	1700	1800	Black/grey gravelly Sand
TP6	0.1 – 0.4	610	720	Brown gravelly Sand
TP7	0.5 – 1.5	480	150	Brown very gravelly Sand
TP7	1.9 – 2.5	150	120	Brown/black sandy gravelly Clay
TP8	1.0 – 1.2	460	430	Brown very gravelly Sand
TP9	0.3 – 1.2	320	250	Brown very gravelly Sand
TP10	0.2 – 1.0	200	180	Brown very gravelly Sand
TP11	0.5 – 1.5	97	92	Brown very sandy Gravel

Table 7.14 Summary of arsenic and copper concentrations in water samples

Exploratory Hole	Sample Depth	Concentration in Eluate		Amount Leached	
	(m bgl)	(mg/l)	(mg/l)	(mg/kg)	(mg/kg)
TP7	1.9	<0.05	0.06	<0.10	<0.60
TP8	1.0	<0.05	<0.05	<0.10	<0.50
TP9	0.3	<0.05	0.07	<0.10	<0.70
TP10	0.2	<0.05	<0.05	<0.10	<0.50
TP11	0.5	<0.05	<0.05	<0.10	<0.50

7.4 Potential impacts during construction and decommissioning

Impact on water quality due to pollution

1. There is a risk that the offshore infrastructure, cable, WECs, mooring anchors and the equipment and materials necessary to install and remove them will contain substances that could impact on water quality when construction and decommissioning works are taking place in, on, over or near water.

2. The principal types of substances that may pose a risk to water quality are mineral oil based coolants and hydraulic fluids (and possibly biodegradable oils) in the PCUs and some WECs. The use of coolants, hydraulic fluids and paints in the WEC devices is not consistent, so for the purposes of this assessment it is assumed that they are used in all WECs. It is expected that oil coolants and hydraulic fluids will be contained within sealed units should pose no risk to water quality. The reason for this assumption is that it is not in the interests of the Wave Hub operating company or the WEC developers to have equipment that requires routine replacement or top-up of coolants and/or hydraulic fluids due to unnecessary leaks.

3. In terms of the vessels and equipment used to install and remove the Wave Hub infrastructure and WECs, the principal types of substances that may pose a risk to water quality are fuels, lubricants and coolants. In theory, the vessels and equipment should not pose any risk to water quality since these substances should not leak under normal circumstances.

4. Overall, normal activities during the construction and decommissioning of the Wave Hub and the WECs should not cause a pollution event that could affect water quality, including bathing water quality (since construction and decommissioning should not change concentrations of microbiological parameters). Nevertheless, it is worth recognising that any construction and decommissioning activity of this nature could have an adverse impact on water quality where it takes place in, on, over or near water. No impact is predicted to occur under normal conditions but there is non-quantifiable risk of a pollution event due to damage, negligence and/or accidents so precautionary preventative mitigation measures are recommended.

Mitigation and residual impact

5. All contractors involved in the construction, installation, deployment and decommissioning off the Wave Hub's offshore infrastructure, the sub-sea cable, the WEC devices, the buoys, etc should be prepared for a pollution event and should have in place the following precautionary preventative mitigation measures to reduce the impact of a pollution event:

- A pollution event contingency plan adapted for the relevant construction and/or decommissioning activities;
- Emergency contacts should be easily accessible and used (e.g. MCA, Environment Agency);

- Suitable spill kits and absorbents to deal with any spill; and

- Staff responsible to deal with any pollution incident that are fully trained in the correct procedures to follow should a pollution event arise.

6. No impact is predicted to occur under normal conditions but precautionary preventative mitigation measures will reduce the impact should a pollution event occur.

Impact on water quality due to turbidity from sediment disturbance

7. The Wave Hub *Environmental Scoping Study* identified a potential impact to water quality if sediments disturbed during construction and decommissioning are released into the water column to increase TSS concentrations and affect turbidity (i.e. the interference of light's passage through water due to the presence of suspended matter scattering and absorbing light). The potential for this impact will depend on:

- The potential for Wave Hub and WEC construction and decommissioning activities to disturb sediment – as informed by the project description and the worst case scenario;

- The physical nature of the seabed sediment to be disturbed – as informed by the PSA undertaken as part of the sediment quality survey – and how it affects turbidity; and

- The sensitivity of the receiving environment (i.e. the water column) to changes in TSS and turbidity – as informed by the TSS recorded by the water quality survey.

8. Two aspects of the Wave Hub project have most potential to release sediment from the seabed:

- Firstly, the installation and removal of the Wave Hub's offshore infrastructure and WECs at the deployment area; and

- Secondly, the installation and removal of the sub-sea cable.

9. The impacts associated with each of these activities are considered separately in the following paragraphs.

10. Firstly, the installation of the Wave Hub's offshore infrastructure and WEC devices will require the following activities that will cause sediment disturbance to the following magnitudes:

- Placement of the anchors for the TDU and four PCUs (i.e. pre-fabricated base plates with spikes or a lip that settle into the seabed) (magnitude = 1 + 4 x c.5m^2 = 25m^2);

- Installation of anchors for the WECs' moorings (worst case scenario being a maximum of 264 anchors for WECs based on connecting 30 PowerBuoy devices to each of the four PCUs in the deployment area, and assuming 66 anchors per 30 devices) (magnitude = 264 x max 1.5m diameter piles = 467m^2); and

- Installation of clump weight anchors for buoys' moorings (maximum of eight anchors based on four cardinal buoys and four marker buoys and assuming one anchor per buoy) (magnitude = 8 x 2m^2 = 16m^2).

11. Correspondingly, removal will require the following activities during decommissioning:

- Retrieval of the anchors for the TDU and PCUs (magnitude = 1 + 4 x c.5m^2 = 25m^2);

- Retrieval of the clump weight anchors for the buoys (magnitude = 8 x 2m^2 = 16m^2); and

- Cut-off of all anchors for the WECs and buoys (264 x max 1.5m diameter piles = 467m^2).

12. Construction and decommissioning works will take place from vessels operating at the water's surface. Some vessels may drop anchors, but it is assumed that there will be no construction / decommissioning equipment fixed to the seabed, such as jack-up platforms, due to the depth of water (50+m).

13. PSA results from the sediment survey show that the sediment in the deployment area predominantly comprises pebbles (c.85%) with a mean grain size of 19.8mm. Due to its rapid settling velocity and limited ability to affect the water column's optical properties, coarse-grained material of this size has very little potential to be disturbed in such as way that it is released into the water column for sufficient time to change TSS concentrations and/or affect turbidity, even in the water column at the Wave Hub deployment area where baseline TSS conditions are low (<3mg/l).

14. Secondly, the installation of the sub-sea cable will require laying on the seabed and burial during construction and direct retrieval during decommissioning. The cable will only be buried in, and pulled out of, seabed sediment along up to 8km of the (approximately) 25km sub-sea cable route where it runs through St Ives Bay. Assuming a conservative cable route construction width of 5m (although the cable diameter is only 0.25m), it is predicted that the magnitude of sediment disturbance would be approximately 40,000m2, or 4ha.

15. There is no worst case scenario for the cable, but a conservative impact assessment has been made by assuming the disturbance, due to cable-laying will be 5m wide.

16. Cable burial will not possible along the rest of the cable route due to the presence of outcropping rock and insufficient sediment, so there will be no discernable impact during this part of the cable laying and removal activities.

17. PSA results from the sediment survey show that sediment in St Ives Bay predominantly comprises sand (>95%) with a mean grain size of 0.230mm. Due to its moderate settling velocity and moderate ability to affect the water column's optical properties,

medium-grained material of this size has limited potential to be disturbed in such as way that it is released into the water column for sufficient time to change TSS concentrations and/or affect turbidity, even in the water column in St Ives Bay where baseline TSS conditions are low (18mg/l and lower), particularly near the bed (5mg/l and lower).

18. In summary, the magnitude of the sediment disturbance in terms of area of affected seabed is estimated to be 508m^2 (25 + 16 + 467m^2) for the offshore infrastructure and will take place as a series of one-off short-term events (i.e. days in duration) during initial construction and again during final decommissioning. Smaller areas of sediment disturbance could also take place during intermediary installations and retrievals of new WECs at Wave Hub over the 25 years design life. In addition, the magnitude of the sediment disturbance in terms of area of affected seabed is estimated to be 40,000m^2 (8000m x 5m) for the cable and will take place as a one-off short-term event (i.e. days in duration) during initial construction and again during final decommissioning. Although baseline TSS concentrations are low, the water column is not particularly sensitive to short-term, localised changes to turbidity. For example, it is already regularly disturbed over larger areas by other uses of the seabed, including trawling for fish.

19. Accordingly, the construction and decommissioning of the Wave Hub's offshore infrastructure and WECs will have little potential to increase TSS concentrations and turbidity to extents that would significantly impact water quality over the existing conditions. A series of small-scale short-term, reversible negligible impacts on turbidity are predicted.

Mitigation and residual impact

20. No mitigation measures are necessary. The residual impacts will remain negligible.

Impact on water quality due to contaminated sediment disturbance

21. The Wave Hub Environmental Scoping Study identified a potential impact to water quality if contaminated sediment is disturbed during installation of the Wave Hub's offshore infrastructure and cable laying. The risk of this impact was considered to be low, but for the purposes of this EIA the following paragraphs assess the potential impact of construction, operation and decommissioning the Wave Hub and WECs on water quality by refining the impact assessment based on new survey information regarding the levels of contaminants in the seabed sediment in St Ives Bay. The potential for this impact will depend on:

- The potential for Wave Hub and WEC construction and decommissioning activities to disturb sediment – as informed by the project description;
- The chemical nature of the seabed sediment to be disturbed – as informed by the contaminant concentrations recorded as part of the sediment quality survey; and

- The sensitivity of the receiving environment (i.e. the water column) to changes in contaminant concentrations – as informed by EQSs established under the EC Dangerous Substances Directive.

22. It is the construction and decommissioning of the Wave Hub's offshore infrastructure and WECs at the deployment area and the construction and decommissioning of the sub-sea cable that have most potential to release sediment from the seabed. However, for this impact assessment, the sediments at the deployment area are sufficiently coarse-grained and distant from potential contamination sources that there is little potential for significant concentrations of contaminants to be present. In addition, due to the presence of outcropping rock along 17km of the 25km cable route from St Ives Bay to the Wave Hub and WEC deployment area, there will be no disturbance of sediment during this part of the cable laying and removal activities. In conclusion, neither of these activities have the potential to release contaminated sediment into the water column and to cause an impact on water quality.

23. Given the above conclusion, the impact assessment in the following paragraphs concerns the release of contaminated sediment disturbed by cable burial during construction and cable removal during decommissioning activities taking place along up to 8km of the (approximately) 25km sub-sea cable route where it runs through St Ives Bay. No worst case scenario is applicable to this impact assessment.

24. A sediment quality survey was undertaken to identify the concentrations of contaminants in the sediment for the purpose of informing this impact assessment. The survey recorded concentrations of eight metals and two organotins. The results of the survey are presented in Section 7.3 and Appendix B. Comparisons of sediment quality survey data to the CEFAS action levels for the disposal of dredged material at sea suggest that the sediments exhibit relatively low levels of contamination for most metals, and moderately elevated levels of contamination for arsenic and copper. Comparisons of sediment quality survey data to the Canadian sediment quality guidelines for the protection of aquatic life suggest that the sediments exhibit relatively low levels of contamination for most metals and moderately elevated levels of contamination for arsenic and copper, except for two samples that exhibit high elevated levels of contamination for arsenic. As an indicative assessment of whether the sensitivity of aquatic life to the sediments, the survey data suggest that the risk of an adverse impact would be most likely to occur rarely (70%), less likely to occur occasionally (27%), and very unlikely to occur frequently (3%). In conclusion, the survey results indicate a generally low magnitude of metals contamination except for arsenic and copper, and a negligible magnitude (i.e. below detection limits) of organotins contamination, suggesting a low or negligible potential to cause an impact on water quality except for arsenic and copper.

25. Given the above conclusion, the following paragraphs concern a refined impact assessment, namely the release of arsenic

and copper from sediment disturbed by cable burial during construction and cable removal during decommissioning in St Ives Bay. Arsenic and copper are used as indicator contaminants for this impact assessment since they represent the most likely contaminants in the sediment to impact on water quality.

26. For this refined impact assessment, an equilibrium partitioning approach is used to derive criteria to establish whether the sediment in St Ives Bay contains sufficient concentrations of contaminants to pose a threat to water quality. Under this approach, the risk of an adverse impact on water quality relates to the concentrations of arsenic, copper and the organic material (TOC) associated with the sediment. Sediment criteria derived from equilibrium partitioning provide a set of values that may be tentatively considered as safe sediment concentrations (Webster and Ridgway, 1984). That is, sediment with arsenic and copper concentrations less than the criteria are not expected to cause an impact on water quality.

27. Sediment significance criteria for water quality (Csed) are calculated using published partition coefficients based on organic carbon content (Koc), water EQSs (Cw/cr), and the sediment's total organic carbon content (TOC), where Csed = KocCw/crTOC. Using TOC values for the St Ives Bay of 0.4% and 6.4%, the derived significance criteria are 1.3mg/kg and 20.8mg/kg for arsenic and 34mg/kg and 544mg/kg for copper.

28. Comparison of the survey results for arsenic (from 5.25mg/kg to 46.2mg/kg) to the significance criteria based on equilibrium partitioning (1.3mg/kg and 20.8mg/kg) shows that the sediment in St Ives Bay contains concentrations of arsenic that, at the point of release from the sediment, could exceed the marine EQS for arsenic established under the Dangerous Substances Directive (25µg/l).

29. Comparison of the survey results for copper (from 3.34mg/kg to 101mg/kg) to the significance criteria based on equilibrium partitioning (from 5.25mg/kg to 46.2mg/kg) shows that the sediment in St Ives Bay contains concentrations of copper that, at the point of release from the sediment, could exceed the marine EQS for copper established under the Dangerous Substances Directive (5µg/l).

30. While the above comparisons suggest that arsenic and copper releases from sediment could adversely affect water quality, it is important the recognise that, after the point of release, the concentrations of arsenic and copper released will undergo major dilution in the water column. For example, if arsenic or copper were released at concentrations ten times the amount of the EQSs, only ten litres of water would dilute the concentrations to the EQSs, and 100 litres of water would dilute the concentrations to ten times below the EQSs.

31. Hence, the magnitude of arsenic and copper releases will be very low given the potential of the water column to dilute the concentrations released by cable laying and removal. Similarly, the sensitivity of the water column to arsenic and copper releases, even given the application of EQSs, will be very low once dilution is taken into account.

32. Overall, it is concluded that cable laying and removal will result in very small-scale, short-term, very localised (i.e. in the vicinity of the cable, near the seabed) impact on water quality since it would increase the concentrations of arsenic and copper in the near-bed part of the water column. After initial dilution, the released arsenic and copper will be quickly diluted to concentrations below the EQSs and, therefore, the impact will be of negligible magnitude, with no significant impact predicted.

33. In addition, there will be no impact on bathing water quality since construction and decommissioning should not change concentrations of microbiological parameters due to sediment disturbance.

Mitigation and residual impact

34. No mitigation measures are recommended and a very small-scale, short-term minor adverse impact will remain.

Impact on water quality due to contaminated ground disturbance

35. There is the potential for concentrations of arsenic and copper in leachates from the ground at the onshore site to affect the quality of water and groundwater due to ground disturbance during construction and decommissioning activities. Given the onshore location, no worst case scenario is applicable to this impact assessment.

36. The survey identified concentrations of arsenic in three leachate samples that exceed the freshwater EQS of 50µg/l and marine EQS of 25µg/l. Raised arsenic concentrations are common in Cornwall due to the mineralogy of many of the host rocks prevalent in the county. The copper leachate concentrations are also considered relatively high at 20µg/l with respect to the freshwater EQS of 1-28µg/l (depending on the $CaCO_3$ concentration of the water) and the marine EQS of 5µg/l. The source of the raised copper concentrations is unknown but the fill is likely to have originated from the former power station. Accordingly, there is the potential for leachates from contaminated ground materials to affect receiving surface and ground water if a hydrological pathway is in place.

37. A simple source-pathway-receptor model can be used to assess the potential for this impact. In this case, the impact source is assumed to be the arsenic and copper leachates that could be generated during construction and decommissioning activities disturbing the areas of contaminated ground. The impact receptors are assumed to be groundwater and surface water. Borehole investigations described in the Report on Terrestrial Ground Conditions have recorded groundwater as follows: “Water levels recorded in the sub-station area are close to 10m below ground level and typically >5m below the proposed directional drill elevation, except close to the exit position where the tidally affected groundwater level could be within 1m to 2m of the drill elevation. Further along the beach groundwater levels will be at the ground level within the tidal zone.” Nearby surface waters include the Hayle River and the sea. Therefore, both the source and receptors for the impact model can be established.

38. The impact pathway is assumed to be hydrological routes between the source and the receptors that allow dissolved arsenic and copper to migrate through the ground as far as the groundwater or surface water. In terms of ground conditions, the Report on Terrestrial Ground Conditions states that "the sub-station area is underlain by variable made ground overlying sands and gravels to siltstone / sandstone bedrock at approximately 10m below ground level. The proposed route of the directional drill is indicated to be through the dune sands and should remain above the beach gravels and bedrock." These types of materials are permeable. For example, the dune sands are considered likely to have a coefficient of permeability of around 4 x 10-04m/s. This means that an impact pathway already exists for arsenic and copper.

39. Accordingly, a new impact pathway created by onshore construction or decommissioning works (e.g. excavation works for the new substation and/or directional drilling through the dunes for the cable) is unlikely to increase the impact over existing conditions and therefore an impact of negligible magnitude on water quality is anticipated. Overall, no significant impact is predicted.

Mitigation and residual impact

40. No mitigation measures are required since construction and decommissioning works are not expected to significantly affect existing conditions.

41. Overall, no significant residual impact is predicted.

7.5 Potential impacts during operation

Impact on water quality due to pollution

1. As for construction and decommissioning, there is a risk that the Wave Hub's offshore infrastructure, the WECs and the equipment and materials necessary to operate and maintain them will contain substances that will impact on water quality as a result of normal activities.

2. The principal types of substances that may pose a risk to water quality are mineral oil based coolants and hydraulic fluids (and possibly biodegradable oils), and anti-fouling paint.

3. With regard to the Wave Hub, the TDU, connectors and the sub-sea cable do not contain any substances that could affect water quality and do not pose pollution risk to water quality. The PCUs contain cooling oil but are designed to be leak resistant because the cooling oil is essential to the functioning of the transformers. Since the cooling oil is contained in a sealed unit requiring no maintenance, the PCUs should pose no risk to water quality unless the units are accidentally damaged during their operational lifetime activities.

4. The PCUs will be subject to some anti-fouling maintenance (possibly once or twice a year), but this will involve high pressure jet spraying of seawater using the ROV rather than the application / re-application of anti-fouling paints and should pose no risk to water quality since potentially polluting substances will not be used.

5. The use of coolants, hydraulic fluids and paints in the WEC devices is not consistent, so for the purposes of this assessment it is assumed that they are used in all WECs. As for the PCUs, it is expected that oil coolants and hydraulic fluids will be contained within sealed units requiring no maintenance and should pose no risk to water quality. The reason for this assumption is that it is not in the interests of the WEC developers to operate equipment that requires routine replacement or top-up of coolants and/or hydraulic fluids.

6. If the WECs are to require the re-application of anti-fouling paints, it is expected that the devices will be removed from the deployment area and the paint removal and applied under controlled conditions, and therefore should pose no risk to water quality.

7. In terms of the vessels and equipment used to maintain the Wave Hub, WECs and the buoys, the principal types of substances that may pose a risk to water quality are fuels, lubricants and coolants. In theory, the vessels and equipment should not pose any risk to water quality since these substances should not leak under normal activities.

8. Overall, normal activities during the operation and maintenance of the Wave Hub and the WECs should not cause a pollution event that could affect water quality including bathing water quality (since operations should not change concentrations of microbiological parameters). Nevertheless, it is worth recognising that any operation and maintenance activity of this nature could have an adverse impact on water quality where it takes place in, on, over or near water. No impact is predicted to occur under normal conditions but there is non-quantifiable risk of a pollution event due to damage, negligence and/or accidents so precautionary preventative mitigation measures are recommended.

Mitigation and residual impact

9. All contractors involved in the operation and maintenance of the Wave Hub's offshore infrastructure, the sub-sea cable, the WEC devices, the buoys, etc should be prepared for a pollution event and should have in place the following precautionary preventative mitigation measures to reduce the impact of a pollution event:

- A pollution event contingency plan adapted for the relevant construction and/or decommissioning activities;
- Emergency contacts should be easily accessible and used (e.g. MCA, Environment Agency);
- Suitable spill kits and absorbents to deal with any spill; and
- Staff responsible to deal with any pollution incident that are fully trained in the correct procedures to follow should a pollution event arise.

10. No impact is predicted to occur under normal conditions but precautionary preventative mitigation measures will reduce the impact should a pollution event occur.

Impact on water quality due to turbidity from sediment disturbance

11. The Wave Hub *Environmental Scoping Study* identified a potential impact to water quality if sediments disturbed during operation are released into the water column to increase TSS concentrations and affect turbidity. The potential for this impact will depend on:

- The potential for sediment scour around the Wave Hub and WEC infrastructure on the seabed – as informed by the Wave Hub *Coastal Processes Study Report*;
- The physical nature of the seabed sediment to be disturbed – as informed by the PSA undertaken as part of the sediment quality survey – and how it affects turbidity; and
- The sensitivity of the receiving environment (i.e. the water column) to changes in TSS and turbidity – as informed by the TSS recorded by the water quality survey.

12. As informed by the Wave Hub *Coastal Processes Study Report*, the following activities could disturb sediment at the seabed to various magnitudes:

- Localised scour around the sub-sea infrastructure including the TDU and four PCUs (1 + 4 x c.5m^2 = 25m^2).

5. Abrasion of the mudstone / shale on the seabed if sub-sea infrastructure and cables are not anchored sufficiently. The worst case scenario for scour and abrasion is based on a maximum of 264 anchors and mooring cables for WECs based on connecting 30 PowerBuoy devices to each of the four PCUs in the deployment area, and assuming 66 anchors for 30 devices. Assuming that each mooring cable can abrade up to 25m of seabed (due to slack) over a 60^o angle, this means abrasion could occur over 86,394m^2, which equates to approximately 1.1% of seabed within the deployment area (i.e. 86,394m^2 of 8,000,000m^2); and

- Potential abrasion of the unburied sub-sea cable (17km in length) where it passes over jagged outcrops of rock on the seabed.

13. The *Coastal Processes Study Report* notes that "For both WEC device layouts [i.e. worst case and typical case scenarios] the resultant change to the wave climate and currents will not have a discernable effect on sediment transport…" and therefore the operation of the WEC devices is predicted to have no impact on water quality by inducing sediment disturbance.

14. As for construction and decommissioning, operation and maintenance works will take place from vessels operating at the water's surface. Some vessels may drop anchors, but it is assumed that there will be no equipment fixed to the seabed, such as jack-up platforms, due to the depth of water (50+m).

15. PSA results from the sediment survey show that the sediment in the deployment area predominantly comprises pebbles (c.85%) with a mean grain size of 19.8mm. The *Coastal Processes Study*

Report notes that "Since offshore sediments typically occur in layers less than one metre thick, significant scour will be unlikely." In addition, due to its rapid settling velocity and limited ability to affect the water column's optical properties, coarse-grained material of this size has very little potential to be disturbed in such as way that it is released into the water column for sufficient time to change TSS concentrations and/or affect turbidity, even in the water column at the Wave Hub deployment area where baseline TSS conditions are low (<3mg/l).

16. Although baseline TSS concentrations are low, the water column is not particularly sensitive to short-term localised changes to turbidity. For example, it is already regularly disturbed over larger areas by other uses of the seabed, including trawling for fish.

17. In summary, despite the magnitude of the potential sediment scour and/or abrasion, the operation of the Wave Hub's offshore infrastructure and WECs will have little potential to increase TSS concentrations and turbidity to extents that would significantly impact water quality over the existing conditions; therefore, no significant impact is predicted.

Mitigation and residual impact

18. The *Coastal Processes Study Report* recommended the following measures to minimise scour and abrasion of the seabed.

- Sub-sea infrastructure should be founded on bedrock to prevent undermining/overturning and cables should be placed on bedrock on the seabed to prevent the creation of a free span following scour of sediment during storm conditions;
- Sub-sea facilities and cables should be anchored or weighed down to prevent flow induced vibration which could lead to damage and/or severance;
- Offshore cables will need to be weighted or anchored to prevent uplift and abrasion against exposed rock outcrops during storm conditions and will be buried in seabed sediments inshore of -20mCD.

19. The mitigation measures will benefit the integrity of the Wave Hub and WECs' infrastructure on the seabed by reducing scour and abrasion. No significant residual impact is predicted.

8 Terrestrial ecology

8.1 Introduction

1. This section of the Environmental Statement provides an assessment of impacts of the proposed Wave Hub development on terrestrial ecology.

2. The objectives of the ecological assessment undertaken to inform the EIA process are as follows:

- To consult with statutory and non-statutory organisations regarding the proposed works;
- To define the existing ecological conditions of the site, including a review of the site in its local and regional ecological context;
- To determine the existing ecological value of the site;
- To assess the significance of the ecological effects, both negative and positive, of the proposed project;
- To demonstrate that the proposed project works will meet the legal requirements relating to protected sites and species;
- To identify mitigation measures for any adverse ecological effects; and
- To assess the significance of any residual ecological effects (i.e. those still remaining following mitigation).

8.2 Methodology

1. The assessment has been undertaken in accordance with draft assessment guidelines published by the Institute of Ecology and Environmental Management (IEEM), and comprises the following elements:

- Ecological baseline and evaluation;
- Assessment of significance of ecological effects;
- Mitigation measures; and
- Residual effects.

Strategic review

2. In order to set the assessment of the site in context, a strategic review of ecological plans and strategies was undertaken. This ultimately determines the ecological acceptability of the proposed works in terms of a local, regional and national context.

3. Key documentation reviewed for the biodiversity assessment includes:

- The UK Biodiversity Action Plan (UK Biodiversity Partnership 1994-2004);
- Cornwall Biodiversity Action Plan (Cornwall Biodiversity Initiative 1998-2004); and

- Planning Policy Statement 9 – Biodiversity and Geological Conservation (ODPM August 2005).

Desk study and consultation

4. Existing ecological information for the site and surrounding area (up to a 2 km radius around the wave hub deployment site, cable route and landing site) was gathered as part of the scoping exercise through consultation with a number of organisations and interest groups, including:

- Environmental Records Centre for Cornwall and Isles of Scilly (ERCCIS);
- English Nature;
- Cornwall Wildlife Trust; and
- Royal Society for the Protection of Birds.

Ecological survey

5. Ecological survey work was undertaken during 2004 and 2005 to determine the habitats and species present on the site. This survey comprised the following elements:

- A walkover survey undertaken by an ecologist during September 2004 to identify the broad habitats present and potential for protected species. This covered a wide area around the electricity substation site; and,
- An Extended Phase One Habitat Survey based on the standard Phase 1 methodology, undertaken in May and July 2005. This survey was focussed on the proposed location of the new substation buildings, and identified the key habitats present within this area and the presence or potential presence of protected species. In addition, a specific search was undertaken for a number of rare or local plant species known to be present in the area. The main survey was undertaken during May, with an additional visit in July to target species that may not previously have been evident.

6. The surveys were undertaken in good weather conditions at times of year favourable for the survey of most species. Copies of the survey reports, which include habitat plans, can be found in Appendix C.

Evaluation

7. To evaluate the significance of impacts it is important to establish the value, or sensitivity, of the site or feature upon which the effect is to occur. The IEEM assessment guidelines have been used to undertake this evaluation.

8. This approach evaluates features in accordance with their value within a geographic frame of reference. Each feature is considered to be of value on the following scale:

- International;
- UK;
- National (i.e. England);

- Regional;
- County;
- District;
- Local / Parish; and / or
- Within immediate zone of influence only.

9. For sites value is assessed within the context of statutory and non-statutory designations. For example, internationally important sites include Special Areas of Conservation (SACs), Special Protection Areas (SPAs) and World Heritage Sites (where designated for their natural heritage). Nationally important sites are designated as Sites of Special Scientific Interest (SSSI).

10. Within the context of Cornwall, sites of county value receive non-statutory protection as County Wildlife Sites. These do not receive legal protection, but are afforded a degree of protection through the local planning system.

11. The evaluation must also take into account areas that meet the criteria for designation at a particular level, but have not been designated. Where this is the case, the same value would be assigned to that feature as it would have if designated. Conversely, some designated sites may be degraded and would therefore no longer meet the criteria by which the designation was made. Their value would therefore be downgraded to reflect this change.

12. Where a site does not contain features that are would not meet the criteria for sites of local value, but nevertheless have some biodiversity value, these are assessed as being of value 'within immediate zone of influence only'.

13. For species the evaluation is based on a number of criteria such as distribution, rarity, population trends and ecology (for example some species would be expected to occur at low numbers within an area, or could be particularly vulnerable to disturbance).

14. A number of species receive statutory protection through legislation such as the Wildlife and Countryside Act 1981 (as amended). However, although species receiving legal protection may also have a high conservation value, the assessment of their value is made on the basis of their biodiversity importance and geographical context.

Assessment of impacts

15. The IEEM guidelines approach to assessing ecological significance of impacts has been used.

16. For each receptor the likely impacts and effects are described. This description includes, where appropriate, information on the magnitude, extent, duration and timing of the impacts, as well as an indication in the confidence in the prediction.

17. The value of the receptor is then used to determine the geographic level at which the impact is significant. A significant impact can be considered that which would affect the integrity of the feature within that

geographical context. For example, if the impacts would result in damage to the integrity of a population of county importance, then this would be a 'significant impact to a feature of county value'. However, the effect might not be significant in the context of the county population, but would cause a local decline. The impact might then be considered to be significant within the context of, for example, the parish.

Mitigation and enhancement measures

18. Where adverse effects have been identified, mitigation measures have been proposed as far as possible. Opportunities for ecological enhancement have also been identified.

Residual effects

19. Residual ecological effects are those that occur following mitigation and enhancement. An assessment of the significance of these effects has also been undertaken, following the evaluation and assessment procedures detailed above.

Worst case scenario

20. No worst case scenario applies to terrestrial ecology since all potential impacts are unrelated to different layouts of WECs, anchors, buoys and safety zones.

8.3 Baseline conditions

Designated sites

1. The site of the proposed works are not covered by any national or international terrestrial designations. They are, however, covered by two local non-statutory nature conservation designations, as follows:

- Area of Great Scientific Value: the entire Hayle estuary, the area encompassed by the Gwithian to Mexico Towans SSSI (described below) and the beach from Porth Kidney Sands to Godrevy Point has been identified by Penwith District Council as an area of county-wide significance for its nature conservation interest (Penwith District Plan 1998; shown in Figure 8.1). The Local Plan states that development will not be permitted where it would significantly harm the nature conservation or geological interest at this site; and

- Cornwall Nature Conservation Site: the same area described above has also been designated a Cornwall Nature Conservation Site by the Cornwall Wildlife Trust, recognising its countywide nature conservation value.

2. There are two SSSIs in close proximity to proposed area of works (shown in Figure 8.1; citations included in Appendix C):

- Hayle Estuary and Carrack Gladden SSSI, covering the Hayle estuary, Copperhouse and Carnsew Pools, and Porth Kidney Sands to the west of the estuary. The SSSI's principal significance is the populations of migrating and wintering birds that it attracts. The boundary of the SSSI lies on the far (western) side of the estuary channel from the proposed work area, approximately 200m away at its nearest point; and

- Gwithian to Mexico Towans SSSI, covering the majority of the dune system between Hayle and Gwithian. This complex and extensive dune system stretches for approximately 3km, rises to a height of over 60m, and supports a rich and diverse flora. The boundary of the SSSI lies approximately 400m to the east of the proposed work area at its nearest point.

3. The RSPB owns much of the Hayle estuary and manages it as a Nature Reserve:

- Hayle Estuary Nature Reserve, covering the majority of the Hayle Estuary, and constituting one of the RSPB's most important nature reserves for migrant and wintering birds. The reserve is managed with the aim of maintaining and enhancing habitat and species diversity, with minimum human disturbance.

Habitats and flora

4. The results of the Phase 1 habitat survey are shown in Figure 8.2 and described in the following paragraphs.

5. The proposed and existing electricity substations lie in a coastal location dominated by dune habitats. To the northeast is Riviere Towans, a large area of holiday chalets interspersed with gardens, scrub and some remnant dune vegetation. To the north is an area of relatively undisturbed dunes that run into dune cliffs above Towan's beach. To the west lies an informal car park and further dune habitats, running down to the mouth of the Hayle Estuary.

6. The substation itself lies within a semi-natural 'bowl', dominated by dune habitats. The banks form a partial screen from the nearby holiday chalets and have been thinly planted with sapling tree species, such as sycamore *Acer pseudoplatanus* and pedunculate oak *Quercus robur*.

7. The enclosed site at the base of the slopes has been heavily disturbed and is dominated by spoil heaps, tipped waste and bare ground. As a consequence, the site largely consists of vegetation associated with disturbed ground including ruderals, such as charlock *Sinapis arvensis*, scrub, such as bramble *Rubus fruticosus*, and garden escapes, such as montbretia *Crocosmia x crocosmiiflora.* Gradation from ruderal vegetation, through to scrub and finally to a dune species dominated by marram grass *Ammophila arenaria* occurs on the bank slopes from bottom to top respectively.

8. Six rare or notable plant species were targeted during the extended phase 1 survey. These were pyramidal orchid *Anacamptis pyramidalis*, sea holly *Eryngium maritimum*, ivy broomrape *Orobanche hederae*, yellow bartsia *Parentucellia viscose*, wild mignonette *Reseda* lutea, and balm-leaved figwort *Scrophularia scorodonia.*

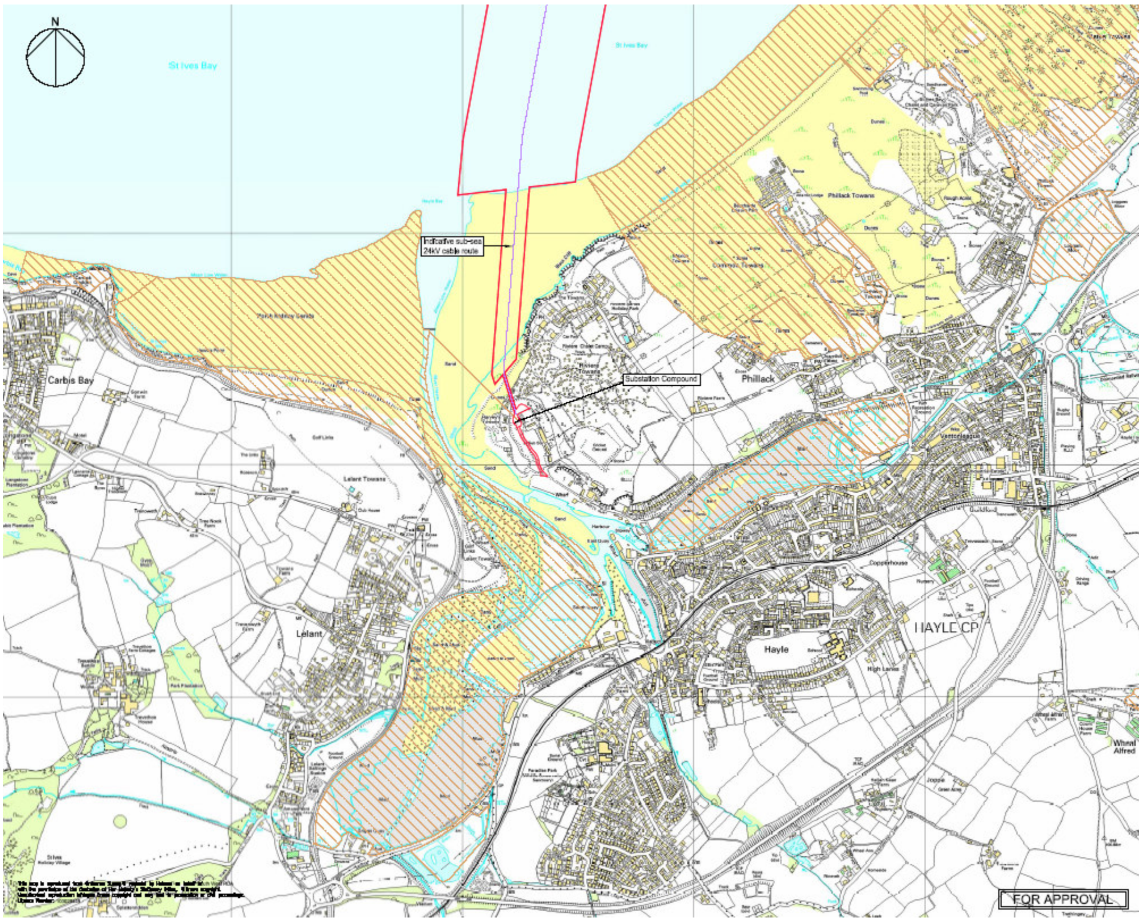


Figure 8.1 Boundaries of SSSIs (shaded areas) relative to proposed Wave Hub development boundary (red lines)

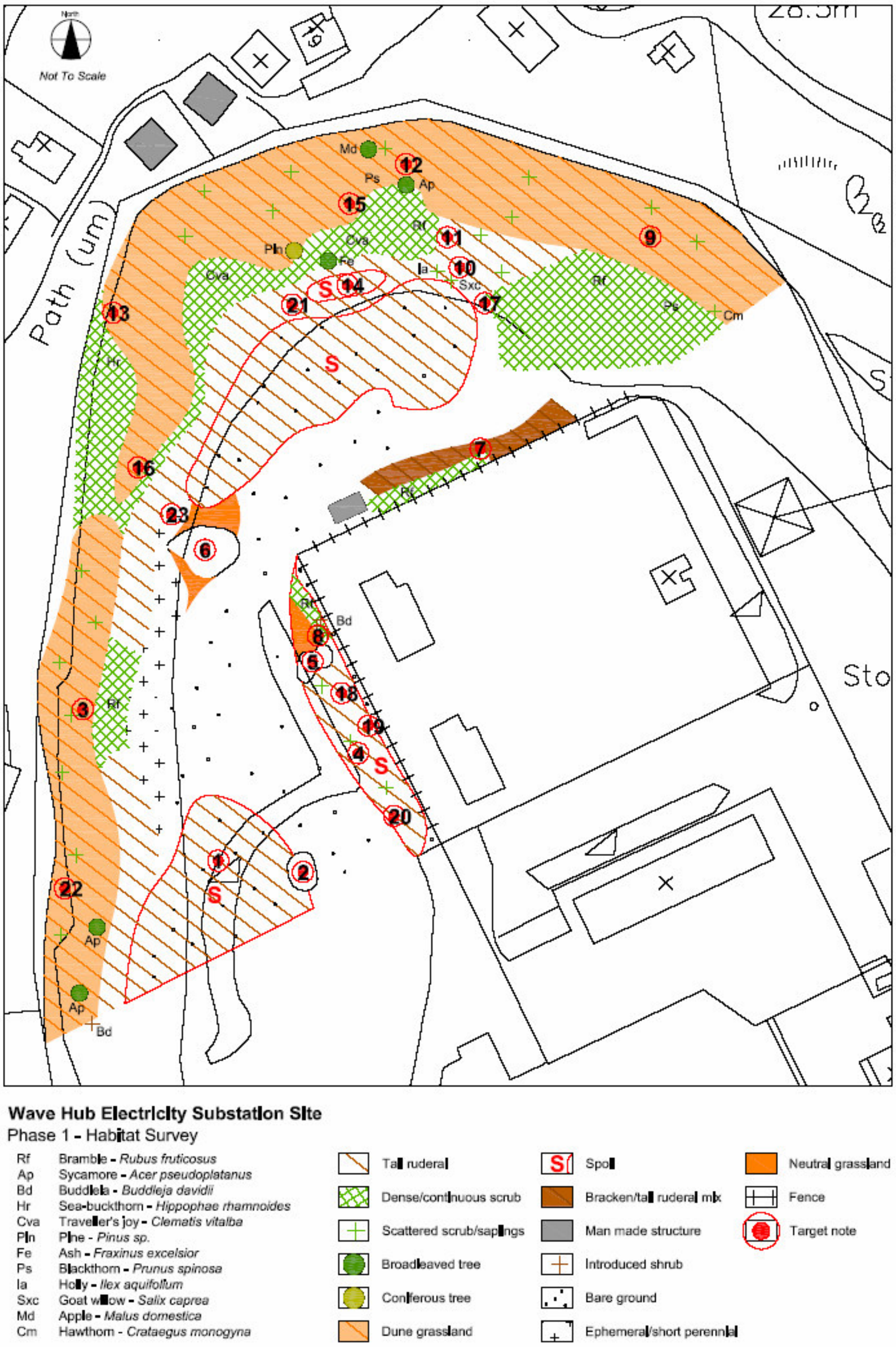


Figure 8.2 Phase 1 habitat survey plan

9. Of these, only balm-leaved figwort was recorded from within the survey area. A number of plants were present around the spoil heap and lower slopes. None of the other species was recorded during the May or July surveys, although common broomrape *Orobanche minor* was noted on the dune slopes.

10. Other plant species recorded included species typical of coastal / dune habitats such as viper's bugloss *Echium vulgare*, recorded just outside the survey area, <5m south of target note 20. Vervain *Verbena officinalis* was noted on the dune slopes. Rest-harrow *Ononis spinosa* was flowering on the disturbed ground.

11. No invasive species such as Japanese knotweed *Fallopia japonica* were recorded within the survey area.

Birds

12. A number of birds were recorded using the area. These were dunnock *Prunella modularis*, linnet *Carduelis cannabina*, song thrush *Turdus philomelos*, greenfinch *Carduelis chloris*, goldfinch *Carduelis carduelis*, chaffinch *Fringilla coelebs*, whitethroat *Syvlia communis*, blackbird *Turdus merula* and robin *Erithacus rubecula*.

13. Species such as whitethroat and dunnock are likely to be nesting within scrub on the dune slopes, and it is expected that other species are foraging in the area.

Reptiles

14. The Phase 1 habitat survey identified features within the proposed work area that are likely to support reptiles. During the second visit in July 2005, a common lizard *Lacerta vivipara* was observed basking on dumped timber within the area.

15. Data supplied by ERCCIS identifies records of common lizard, adder *Vipera berus* and slow worm *Anguis fragilis* from the area around Riviere Towans, although the most recent records are from 1992. However, additional reptile survey work has been undertaken on behalf of ING as part of the EIA for the proposed Hayle harbour redevelopment, and this includes areas directly adjoining the proposed Wave Hub substation site. This survey has confirmed that the habitats present are highly suitable for reptiles, with good numbers of all three species identified as part of the survey. A total of 35 artificial refugia were placed in an area of approximately 19.7ha, and eight survey visits made between June and September. The highest count of each of the species recorded during a single visit was 61 slow worms, 5 adders and 11 common lizards. These numbers are indicative of a 'key reptile site' in accordance with the guidance published by Froglife.

16. No further survey work has been undertaken for reptiles, following consultation with English Nature, as the existing available data is considered to be adequate to undertake the assessment.

Invertebrates

17. A number of invertebrates were recorded during the Phase 1 survey. These included butterfly species such as Gatekeeper *Pyronia tithonus*, orange-tip *Anthocharis cardamines* and green-veined white *Pieris napi*. Several large skipper butterflies *Ochlodes venatus* were observed during the July visit, suggesting that there is a breeding colony close by. The dune slope in the south-west corner of the site was noted to be of particular significance for invertebrates. The presence of rabbits has maintained close-cropped vegetation and bare sand. Numerous mining bees were observed *Andrena* sp. in this area.

Other species

18. No other protected species were recorded during the surveys, and no features were recorded likely to support protected species such as bats, badgers, great-crested newts or otters.

19. Evidence of use by rabbits was noted during the surveys.

Ecological evaluation

20. This section provides an evaluation of the ecological value of the features identified within the proposed area of works for the electricity substation, based on IEEM guidelines.

Designated sites

21. The Area of Great Scientific Value and Cornwall Nature Conservation Site, within which the proposed area of works lie, are assessed as being of county value.

22. The two SSSIs, whose boundaries lie within 500m of the proposed work area, are assessed as being of national value.

Habitats and flora

23. Habitat associated with the proposed substation site can broadly be divided into two types; ruderal and waste ground habitats associated with disturbed areas on the basin floor, and dune habitats occurring on the adjoining slopes.

24. The ruderal and waste areas contain widespread, easily recreated habitats and therefore have a limited conservation vale. This is further degraded by the presence of non-native species and dumped waste. However, these areas do provide features that can be used by some animal species, including reptiles. These habitats, therefore, are considered to be of value within immediate zone of influence only.

25. The dune habitats around the site are of variable quality, being somewhat degraded on the lower slopes due to the disturbed influence, but increasing in quality moving up the slopes. Coastal dunes are a UK and Cornwall BAP priority habitat, with an estimated 54,500ha within the UK as a whole, 11,897ha in England and 1,250ha in Cornwall. The survey site forms an outlying fragment of the Hayle / Gwithian Towans dune system, which covers a total area of approximately 400ha.

26. The dune slopes around the proposed substation cover an area of approximately 0.4ha. This represents 0.03% of the Cornwall resource, and 0.1% of the local resource of dune habitat. Although the dunes form part of a wider network of national importance, the area around the proposed substation is somewhat degraded and fragmented, and is not considered to form an element upon which the wider integrity of the system depends. Dune habitats around the substation site are therefore assessed as being of local value.

27. The site is notable for the presence of balm-leaved figwort, a Red Data Book species with a restricted UK distribution, although it can be locally common where it does occur, particularly in south Devon and parts of Cornwall. Detailed survey of this species has been undertaken on behalf of ING as part of the EIA for the proposed Hayle Harbour redevelopment, and this found a total of 708 plants within the harbour area. This survey did not include the area of the proposed substation, nor the wider Hayle / Gwithian Towans dune system to the east, where the species is listed as part of the SSSI citation. It is estimated that there are less than 20 plants of this species within the proposed substation survey area, representing a maximum of 2% of the local population. The population within the substation site is therefore assessed as being of local value.

Birds

28. All wild birds (with the exception of game birds) receive protection against killing or injury under the Wildlife and Countryside Act 1981 (as amended). Under terms of this Act, it is also an offence to damage or destroy the nest or eggs of any wild bird. In addition, birds listed on Schedule 1 of the Act are also protected against disturbance whilst nesting.

29. A number of birds are identified within the UK and Cornwall BAPs as priority species. In addition, a list of species of conservation concern has been identified by the UK's principle nature conservation organisations, categorised into species of high conservation concern ('Red List' species) and medium conservation concern ('Amber List' species).

30. Of the species recorded on the site, linnet and song thrush are UK and Cornwall BAP species, and 'Red List' species of conservation concern. Dunnock is an 'Amber List' species. All of these species are common and widespread within the UK, but have been identified due to significant population declines in the latter half of the twentieth century. No species listed on Schedule 1 of the Wildlife and Countryside Act breed within the work area.

31. Within the area of proposed work there is limited availability of habitat likely to support nesting birds, with more suitable habitat occurring on the adjacent dune slopes. The value of the work area itself is therefore assessed as being of importance for nesting birds within the immediate zone of influence only, and adjacent areas of dune and scrub habitats assessed as being of local value.

Reptiles

32. All six native reptile species are protected under UK law. The more common species (i.e. those encountered at this site) are protected under parts of Section 9 of the Wildlife and Countryside Act 1981 and amendments. This prohibits the following:

- Deliberately or recklessly killing or injuring (but not taking); and
- Keeping, transporting, selling or exchanging.

33. In practice this means that reasonable measures must be taken to avoid the incidental mortality of common reptiles during works.

34. Existing survey information and desk study has confirmed that populations of slow worm, common lizard and adder are present within the dune system. The numbers recorded are indicative of a 'key reptile site' in accordance with the guidance published by Froglife. The proposed work area includes features that will be used by basking and foraging reptiles. However, this area has been heavily disturbed and has a reduced value in the context of the surrounding semi-natural habitats. Therefore, whilst the wider dune complex and associated areas is probably of district or county value for reptiles, the work area is assessed as being of local value.

Invertebrates

35. As with reptiles, the wider dune system at Hayle is known to support important invertebrate populations. For example, the citation for the nearby Gwithian to Mexico Towans SSSI lists a number of butterfly species such as silver-studded blue *Plebejus argus* and pearl-bordered fritillary *Boloria euphrosyne*. However, although the dune slopes around the work area include features that will be utilised by invertebrates, the work area itself is considered to have a limited value, and is unlikely to support species that do not occur widely in the area. The site is therefore assessed as being of importance for invertebrates within the immediate zone of influence only.

Other species

36. No other species of significant conservation value have been identified.

8.4 Potential impacts during construction and decommissioning

1. The potential impact of the proposed works upon the species and habitats within the proposed development area are considered below. Where appropriate, further work is suggested to minimise or avoid any potential impacts upon the ecological receptors concerned or to ensure conformity with current wildlife protection legislation. The terminology used to describe the assessment of impacts follows those recommended by the IEEM.

Potential impact on designated sites

2. The proposed work area does not lay within any statutory nature conservation sites, although the boundary of the Hayle Estuary SSSI and RSPB reserve lies approximately 200m to the west of the cable landing route.

Due to the constrained nature of the proposed works, no significant impacts on these areas can be foreseen during construction and decommissioning of the Wave Hub. It should be noted that an assessment of impacts on ornithological interests, for which the Hayle Estuary is principally designated, is presented in Section 9.

3. The new substation site and dunes through which the cable will be passed lie within an area designated as an Area of Great Scientific Value and Cornwall Nature Conservation Site. A more detailed discussion of the effects on habitats and species is presented below. However, due to the relatively low value of the areas that will be affected, it is not considered that this would compromise the integrity of the wider designated areas. It is therefore considered that there will be no significant impacts the non-statutory designated sites.

Mitigation and residual impact

4. No mitigation measures are recommended. There will remain no residual impact.

Potential impact on habitats and flora

5. The Wave Hub's substation building will be located on the floor of the 'basin'. The majority of vegetation within this area will be cleared, resulting in the permanent loss of approximately 1500m^2 (0.15ha) vegetation, predominantly ruderal and bramble scrub communities characteristic of disturbed ground.

6. Directional drilling for the cable will be undertaken from within the footprint of the compound area. There will be no additional disturbance of the dune slope habitats as the cable duct will be approximately 3m below the foot of the slope. There will be some noise and vibration associated with the drilling operation, but this will be in the same order as other construction activity on the site.

7. It is not considered that the proposed works will have a significant impact on the integrity of dune habitats adjoining the work area. However, the permanent loss of habitats on the basin floor will result in a significant impact on a feature of importance within the immediate zone of influence only.

8. It is expected that a small number of balm-leaved figwort plants at the base of the dune slope will be destroyed or damaged during the construction works. This would result in a significant impact on a feature of local value.

Mitigation and residual impact

9. All areas of retained vegetation should be protected by identifying and fencing clear work areas.

10. Balm-leaved figwort plants that might be destroyed during construction should be transplanted to suitable receptor sites in the immediate vicinity. This species is a long-lived perennial, and appears to thrive in a variety of habitats including grassland and scrub margins, and a variety of disturbed / waste ground communities. Translocation should be undertaken in accordance with the recommendations in the rare plant survey

report undertaken on behalf of ING. This suggests that plants would be best moved at the end of the growing season, once the plant has started to die back. Receptor sites will be located on the dune slopes above the substation site, for example adjacent to informal footpaths that cross the dunes.

11. A pre-construction survey for invasive plants should be undertaken to ensure species such as Japanese knotweed have not established since the original survey work. If encountered, consultation with the Environment Agency and other interested parties will be undertaken to agree suitable control measures and working practices to prevent the spread of these species.

12. With the provision of the mitigation described above, it is considered that there will be a short-term adverse impact on habitats and flora, of importance within the immediate zone of influence only. There will be no significant long-term impacts.

Potential impact on protected and notable species

13. With respect to birds, the proposed works will result in the permanent loss of bramble scrub that has the potential to provide nesting habitat for common and widespread bird species, and foraging habitat for a variety of passerine birds. There will therefore be a permanent significant impact on a feature of importance within the immediate zone of influence only.

14. There will also be the potential for disturbance to birds using the surrounding areas due to noise, vibration and visual disturbance. This would result in a significant temporary reversible impact on a feature of local value.

15. With respect to reptiles, the proposed works will result in the permanent loss of habitat used by basking and foraging reptiles, and could potentially result in the accidental killing of a small number of reptiles. This is assessed as a significant impact on a feature of local value.

16. With respect to invertebrates, the proposed works will result in a loss of features on the floor of the basin that are likely to support a limited range of invertebrate species. The nature of the habitats in this area will mean that the species present in such an area are likely to be mobile and adaptable. It is unlikely that the integrity of invertebrate populations will be significantly affected by the proposals. There will therefore be no significant impact on invertebrate populations.

Mitigation and residual impact

17. With respect to birds, all vegetation clearance should be undertaken between September and February, outside of the bird nesting season, to prevent contravention of the Wildlife and Countryside Act (1981) through disturbance and destruction of nesting and nest building birds.

18. Should birds be suspected of nesting on site at any time then works in the immediate area should be halted and an experienced ecologist called to site to assess the situation. Nesting or nest building birds on site may result in works in the immediate area halting

until such a time as an ecologist considers breeding to be complete.

19. As identified above, clear working areas should be identified and fenced around retained vegetation to reduce disturbance.

20. With the provision of the mitigation described above, it is considered that there should be a short-term adverse residual impact on birds, of importance within the immediate zone of influence only. There will be no significant long-term impacts.

21. With respect to reptiles, prior to the commencement of works, a reptile translocation should be undertaken from within the proposed work area in accordance with best practice recommended in the Herpetofauna Worker's Manual.

22. The translocation is likely to require a minimum of 15-20 visits. Artificial refugia ('tins') made from a mixture of 50x50cm and 1m x 1m sections of roofing felt will be placed in suitable habitat at a density of 50 'tins' / 0.1ha. Refuges would have to be laid out well in advance of emergence from hibernation at the end of March / beginning of April. A reptile fence would be erected around the work area prior to the commencement of the translocation.

23. The capturing should be carried out in good weather conditions until five sequential visits with no reptiles recorded are completed. In addition, direct search and capture would be undertaken, combined with a destructive search of suitable habitat, once tinning has been completed.

24. Translocation sites should be established through use of suitable adjacent habitat. In order to minimise competition with existing populations, reptile habitats will be improved where necessary to create additional foraging, breeding and hibernation sites. This should comprise the provision of log or rubble piles in appropriate locations. In addition, similar features for reptiles could be created within the works area on completion of the works to allow recolonisation from adjoining areas.

25. With the provision of the mitigation described above, it is considered that there will be no significant residual impact on reptiles.

Invertebrates

26. It is considered that no mitigation measures are required. There will be no significant residual impact on invertebrates.

8.5 Potential impacts during operation

1. It is concluded that the proposed scheme does not have the potential to result in impacts on terrestrial ecological interest. The ongoing impacts on terrestrial ecology that arise as a consequence of the construction of the scheme (such as localised habitat loss) are encompassed within the assessment of potential impacts arising during construction and decommissioning (Section 8.4).

9 Ornithology

9.1 Introduction

1. This section considers the potential impacts on birds associated with the construction, operation and decommissioning of the Wave Hub. This includes intertidal species in the vicinity of the cable landing site, and seabirds using the offshore area around the Wave Hub itself. This section does not deal with terrestrial bird species, as these are covered in the Terrestrial Ecology section (Section 8).

2. The *Environmental Scoping Report* (Halcrow 2005) identified a number of potential impacts on birds, and these are summarised below:

- Disturbance to offshore and intertidal birds during construction;
- Effects on the Hayle Estuary SSSI, which is notified for its wintering bird populations; and
- Positive or negative impacts on offshore birds due to the presence of WECs, for example through providing a marine refuge for prey species, or physically obstructing access to feeding areas.

3. The impact assessment has therefore focussed on the possible effects on birds using the intertidal area around the cable landing site, and seabirds using the area around the Wave Hub deployment area.

9.2 Methodology

1. Baseline conditions for the EIA have been obtained mainly through site survey, although a desk study has been undertaken to obtain relevant existing data. Full survey reports for intertidal birds and offshore seabirds are included in Appendices D and E respectively. These reports have been used to provide a description of the baseline conditions presented in the following sub-sections, and allowed an assessment of the potential impacts to be made. The assessment has been undertaken using guidance provided by IEEM, as described in Section 8.

2. The assessment for offshore impacts must take into account the fact that the type and number of devices that will be deployed over the 25 year period is not known at present. Therefore, a worst case scenario approach has been adopted, whereby it is assumed that arrays are composed entirely of devices that would have the greatest foreseeable impact.

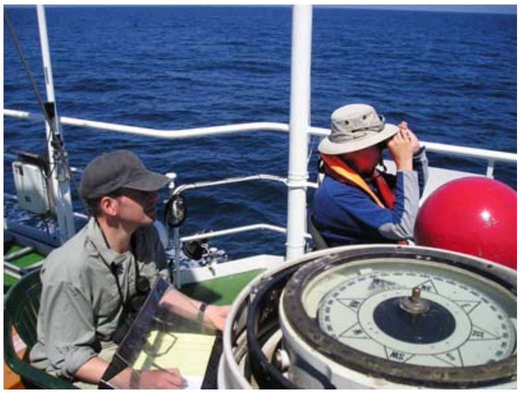


Figure 9.1 Offshore seabird survey being undertaken from 'Terramare,' June 2005

Intertidal bird survey

4. The full survey report is included at Appendix D. The following paragraphs summarise the methodology adopted for the intertidal bird survey.

5. The objective of the survey was to establish use of the intertidal area at Towan's Beach, Hayle, by shorebirds. The area surveyed is shown on Figure 9.2.

6. Ten surveys were undertaken between February 2005 and January 2006. The survey methodology was designed to establish the species and number of birds using the intertidal area around the proposed landing site throughout the year. Monthly surveys were undertaken during the winter months and bi-monthly surveys during the summer (February-May, July, and September-January). Each survey comprised hourly instantaneous counts of birds through a half-tide cycle, from high tide to low tide. The survey area was divided into three sections, shown on Figure 9.2.

7. The species and number of birds using each of the three areas was recorded each hour during the half-tide cycle. Other features that might influence bird use, for example the presence of people and dogs, were also recorded as appropriate.

8. In addition, previous bird records from the area were obtained from a data search undertaken by ERCCIS and from the 2004 Cornwall Bird Report published by the Cornwall Birdwatching and Preservation Society.

Offshore bird survey

9. Full details of the offshore seabird survey are provided in Appendix E. The survey methodology is summarised below.

10. The objective of the survey was to establish the extent of use by seabirds in the vicinity of the proposed wave hub deployment area.

11. Given that the proposed Wave Hub is a novel scheme in the context of UK offshore waters, there is no specific guidance or standard methodology for surveys to inform an assessment of impacts on seabirds. The methodology that was adopted, therefore, was modified from the approach used to assess the impacts of offshore windfarms. This was based on two key references:

- Komdeur, J. et al. (Eds) 1992. Manual for aeroplane and ship surveys of waterfowl and seabirds. IWRB Spec. Publ. 19;

- Camphuysen, C. J. *et al.* 2004. Towards standardised seabirds at sea census techniques in connection with environmental impact assessments for offshore windfarms in the UK. COWRIE / KNIOZ.

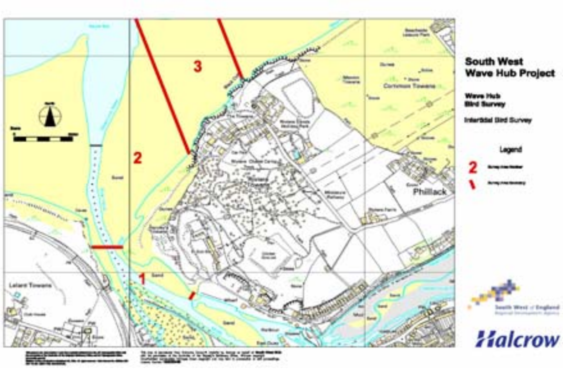


Figure 9.2 Intertidal bird survey areas

12. The methodology and approach was discussed and agreed with English Nature, the DTI, the Joint Nature Conservation Committee (JNCC) Seabirds at Sea Team, and the RSPB.

13. The survey area covered a 10 x 10km square centred on the proposed wave hub location. The square was orientated to lie approximately parallel to the coast (see Figure 9.3).

14. It was initially proposed that 12 monthly surveys would be undertaken in a one year period between March 2005 and February 2006. However, it was recognised that the exposed nature of the site would mean that weather conditions might prevent some surveys being undertaken. It was therefore agreed with English Nature and the DTI that where a survey in any month could not be undertaken then a survey in the following month would be essential for the integrity of the results to be maintained.

15. Surveys were undertaken from three different vessels during the twelve month period; each providing an observation platform with an eye height at least 5m above sea level, in accordance with the recognised guidelines, and a cruising speed of 8-10 knots.

16. The surveys were undertaken using 300m line transects with sub-bands and 'snap-shots' for flying birds in accordance with the methods developed by the European Seabirds at Sea (ESAS) Team, and recommended in the COWRIE guidelines. Each survey comprised six 10km long transects running south-east to north-west (i.e. perpendicular to the coast), each 2km apart. The approximate transect lines are shown on Figure 9.3. Two observers were used for each survey. In addition to seabirds, all cetaceans and elasmobranchs observed during the surveys were recorded.

17. It was originally intended that data would be analysed using Distance software in order to determine population density. However, the relatively small amount of data obtained was not sufficient to allow this type of analysis. The 'raw' observed density has therefore been calculated, using standard correction factors for birds on the water from The Atlas of Seabird Distribution in North-west European Waters ('The Atlas'). The correction factor varies between species; for example, a very visible species such as Gannet *Morus bassanus* has a correction factor of 1.0, while less prominent species such as razorbill *Alca torda* have a correction factor of 1.5. This method provides a relatively crude estimate of density compared to other distance sampling statistical methods such as 'kriging'. However, the relatively small amount of data gathered means that this more basic analysis is considered appropriate for this survey.

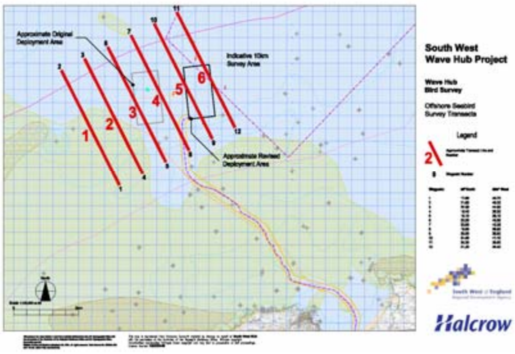


Figure 9.3 Offshore bird survey area

18. Consultation was undertaken with ERCCIS, JNCC, RSPB and the Cornwall County Bird Recorder to obtain exiting records for the area. This consultation revealed that there is very little available data for offshore seabird records in the area. The main source of available data, therefore, is The Atlas of Seabird Distribution in North-west European Waters. Although this report was published in 1995 it remains the most comprehensive analysis of seabird distribution around the UK. These data have been used to compare the species densities encountered during the surveys.

Worst case scenario

1. No worst case scenario applies to intertidal birds since all potential impacts are unrelated to different layouts of WECs, anchors, buoys and safety zones. However, during the Wave Hub *Environmental Scoping Study* the RSPB raised the concern the operational WECs may affect sediment movements in the estuary to the extent that birds' feeding behaviour could be affected at the Hayle Estuary SSSI (see Table 4.4). Using the Wave Hub *Coastal Processes Study Report,* the worst case scenario concerning potential changes to sediment dynamics is four Wave Dragon devices because they block the largest amount of waves and current and, therefore, the largest effect on the sediment regime at the coast.

2. The worst case scenario is applied to impacts relating to offshore birds where their behaviour may be affected by the presence of the WECs. Four Wave Dragon devices have been chosen as the worst case scenario because they would occupy the largest sea area that could affect bird behaviour.

9.3 Baseline conditions

Intertidal birds

1. Full details of the intertidal bird survey results can be found in the survey report (Appendix D).

2. The survey work undertaken during 2005 and 2006 established that the intertidal area at Towan's Beach, Hayle, is used by a limited number of gulls and wading birds throughout the year A total of 18 species (excluding carrion crow and pied wagtail) were recorded using the intertidal zone and beach above the high tide line.

3. At high tide, the easterly part of Towan's beach (area 2 on Figure 9.2) maintains an area of exposed sand, and this is used by some roosting birds. Similarly, a small sand-spit in area 1 is occasionally used by roosting birds. Area 3 is entirely covered at

high tide, and becomes exposed approximately 2 hours afterwards.

4. Virtually all of the survey area is dominated by sandy substrates, and consequently there are limited opportunities for feeding waders and other birds. The Hayle Estuary, which lies very close to this site, provides an abundance of suitable feeding sites. It is therefore not surprising that few birds are present once the tide recedes. The beach is also subject to regular human disturbance by dog walkers during the winter months and holidaymakers during the summer.

5. The largest concentrations of birds were recorded between September and December. During this period small groups of waders were roosting on the beach, attracted by a small pool that had formed due to a shift in the sands. This pool had disappeared in January, and this was reflected by a reduction in the numbers of birds. Notable peak counts included 46 oystercatcher and 21 sanderling during the September survey, 49 ringed plover in October, and an estimated 580 dunlin present at a single count in December.

6. Small numbers of herring, great black-backed and lesser black-backed gulls use the beach for 'loafing' throughout the tidal cycle. The majority of other species typically dispersed from the beach as the tide receded.

7. No published data was identified relating to use of Towan's Beach by birds. Wetland Bird Survey (WeBS) Data for the Hayle Estuary from the 2004 Cornwall Bird Report has been used to place the survey records into context. Monthly counts for key species recorded during the survey are summarised in Table 9.1.

Offshore birds

8. A detailed analysis of the offshore seabird survey results is provided in the survey report, in Appendix E. These results are summarised below.

9. A total of ten surveys were undertaken between March 2005 and January 2006, covering nine months. Poor weather prevented surveys during April, October and February, and a second survey was required in December as the first was abandoned after the first transect. This level of coverage met the requirements agreed with English Nature and the DTI.

10. A total of 13 seabird species were recorded during the survey. These were fulmar, gannet, great black-backed gull, guillemot, herring gull, kittiwake, lesser black-backed gull, manx shearwater, puffin, razorbill, shag and storm petrel.

11. Densities of bird species were generally recorded in the range 0.1 – 5.0 birds/km^2. Lowest densities were recorded during the September survey, where, for example, gannet density was just over 0.2 birds/km^2. When compared to historic data, relatively high densities of Manx shearwater and storm petrel were recorded during the May survey. However, this is in part due to a number of flocks of birds falling within the transect strip, leading to an artificially high recorded density.

12. A summary of results for six key species is provided in the following paragraphs. For each, a summary chart is presented showing the density of birds for each monthly survey, compared to data from The Atlas of Seabird Distribution in North-west European Waters for the Celtic Sea and English / Bristol Channel areas.

Fulmar

13. Figure 9.4 provides a summary of survey results for fulmar over the 12 month period.

14. Densities recorded during the survey were generally low, and usually equal to or lower than historic results from the Celtic Sea area, and slightly higher than the English / Bristol Channel area. The greatest concentrations of fulmar occur to the north and east of the UK, with lowest densities along the English Channel. The species breeds widely on cliffs in the southwest and moves into pelagic areas during the winter. The location of the wave hub site would probably be considered to be on the boundary of inshore waters and open ocean, and this may account for the similar densities throughout the year. The results obtained during the surveys therefore suggest that densities of fulmar within the survey area are similar to those that occur in the wider area.

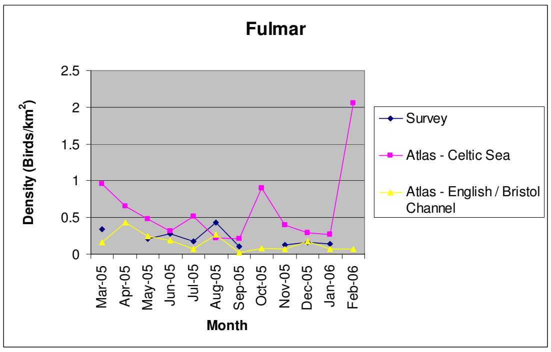


Figure 9.4 Summary of survey results for fulmar (Fulmarus glacialis) compared to data from The Atlas of Seabird Distribution in North-west European Waters

Manx Shearwater

15. Figure 9.5 provides a summary of survey results for Manx shearwater over the 12 month period.

16. Manx shearwater is a highly pelagic species that breeds on islands around the UK. The nearest colonies to the survey site occur on the Isles of Scilly, Lundy and off Pembrokeshire. Most of the estimated world population of c.340,000 – 410,000 pairs of Manx Shearwater breed in Britain and Ireland, and 45% of this population nests off Pembrokeshire (Mitchell et al, 2004).

Table 9.1 WeBS results for the Hayle Estuary in 2004, for species recorded during the intertidal surveys

Species	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Black-headed gull	410	493	179	40	1	18	188	306	308	167	812	333
Cormorant	7	8	2	5		2	6	4	10	19	4	4
Curlew	550	100	84	6	-	114	131	226	155	300	58	231
Dunlin	600	195	220	2	130	-	64	520	200	71	120	130
Golden Plover	-	-	-	-	-	-	-	-	-	359	35	200
Great black-backed gull	121	173	105	76	33	41	45	42	40	29	62	37
Grey heron	8	5	2	1	3	3	7	7	6	10	4	3
Herring gull	514	420	210	882	405	430	365	2822	710	482	680	705
Lesser BB gull	693	1034	850	342	4	20	4	130	30	36	34	29
Little Egret	12	16	9	13	4	3	21	17	14	22	20	3
Mediterranean gull	3	2	4	4	-	3	4	8		2	2	9
Oystercatcher	23	30	21	15	11	7	37	60	50	49	40	30
Ringed plover	35	-	1	4	16	-	15	350	5	25	15	4
Shag	-	-	-	-	-	-	-	-	-	-	-	-
Sanderling	2	-	-	-	90	-	39	65	20	7	-	-

17. A high density of this species was recorded during the May survey, but this is partly due to the presence flocks of 10-20 birds within the survey transect that have greatly inflated the overall density. Removing these from the data reduces density to 2.68 birds/km^2, which suggests that densities were probably genuinely higher than historic data from the Atlas. During this incubation period birds can wander widely from the nest site as each parent typically spends a six day 'shift' on the nest. It is therefore possible that the birds recorded were from any of the three breeding centres in the southwest. However, the fact that density during the remaining summer months was somewhat lower that the historic figures suggest that such high densities do not occur regularly. It seems likely, therefore, that densities within the proposed wave hub site are similar to those that occur in the wider area.

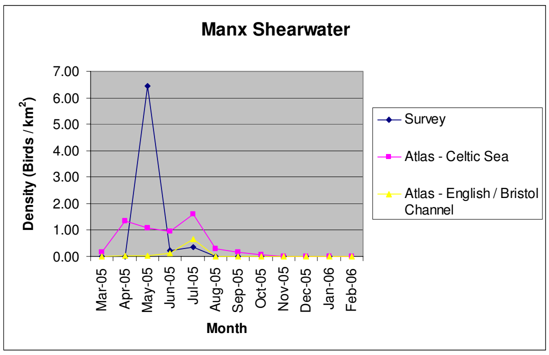


Figure 9.5 Summary of survey results for Manx shearwater (Puffinus puffinus) compared to data from The Atlas of Seabird Distribution in North-west European Waters

Storm Petrel

18. Figure 9.6 provides a summary of survey results for storm petrel over the 12 month period.

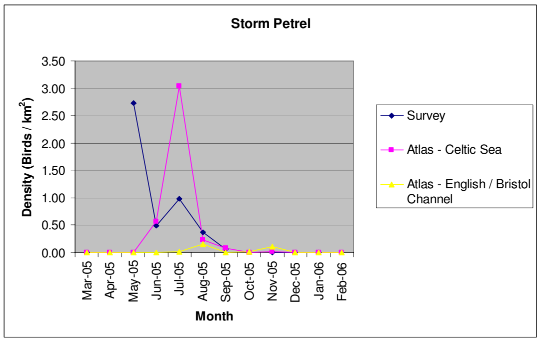


Figure 9.6 Summary of survey results for storm petrel (Hydrobates pelagicus) compared to data from The Atlas of Seabird Distribution in North-west European Waters

19. Like Manx shearwater, storm petrels nest on islands around the UK, with colonies on the Isles of Scilly and off Pembrokeshire. It is estimated that between 70,000 and 100,000 pairs nest around Britain and Ireland (Mitchell *et al.*, 2004). The very high density of birds recorded during the May survey is due to a large flock of birds recorded in transect associated with a fishing boat. Removing this flock from the analysis reduces density from 2.73 birds/km^2 to 0.11 birds/km^2. In general, therefore, densities appear to be in the same order of magnitude as those recorded in the atlas. The high density recorded for the Celtic Sea in July has been attributed to a slightly different survey technique used during surveys

in this area, and it is therefore likely that density has been exaggerated.

Gannet

20. Figure 9.7 provides a summary of survey results for gannet over the 12 month period.

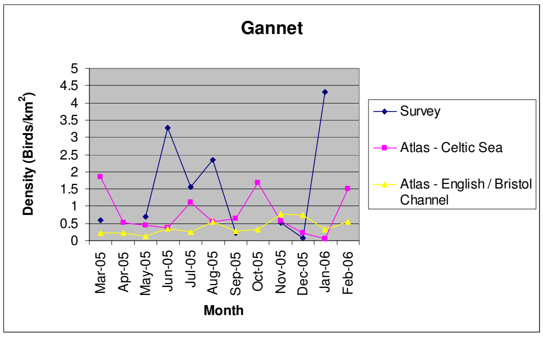


Figure 9.7 Summary of survey results for gannet (Morus bassanus) compared to data from The Atlas of Seabird Distribution in North-west European Waters

21. Gannets nest in large offshore colonies at a number of locations around the UK. The nearest to the wave hub site occur at Grassholm off Pembrokeshire and off southern Ireland, with a total UK population of 259,000 pairs (Mitchell *et al*., 2004). Densities of gannets during the surveys were typically some of the highest of all of the species, and from the above chart it is evident that densities were often above those recorded in the atlas. However, examination of the distribution maps from the atlas shows that 'hotspots' of high density can occur within the area between north Cornwall, south west Wales and southern Ireland, occasionally in excess of 5 birds / km^2.

22. Gannets were also one of the few species recorded showing feeding behaviour away from fishing boats, with occasional plunge dives observed.

Guillemot and Razorbill

23. Figures 9.8 and 9.9 provide a summary of survey results over the 12 month period for guillemot and razorbill respectively.

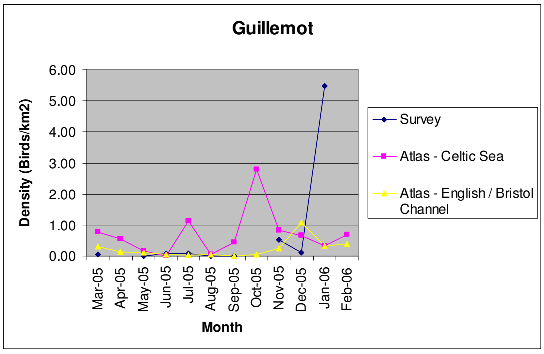


Figure 9.8 Summary of survey results for guillemot (Uria aalge) compared to data from The Atlas of Seabird Distribution in North-west European Waters

24. Guillemot and razorbill are cliff nesting species that are present widely around UK coasts, although guillemots are by far the most common species, with a British Isles population of 890,000 pairs against 110,000 pairs of razorbill. Low numbers of both species were recorded during the autumn and winter, with very few birds present during the summer months. Both species were present in high densities during the January survey, but informal observation during passage to and

from the survey area suggests that this density was typical of the wider area and was not the result of concentration around the Wave Hub site.

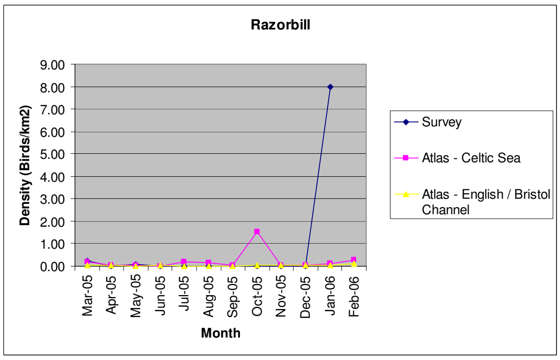


Figure 9.9 Summary of survey results for razorbill (Alca torda) compared to data from The Atlas of Seabird Distribution in North-west European Waters

Ecological evaluation of intertidal birds

1. Survey results indicate that the Towan's Beach area is used by small numbers of roosting birds at high tide during the winter months, and very low numbers of birds (mainly gulls) outside the high tide period. The generally low numbers of birds are attributed to the existing levels of human disturbance and lack of rich feeding substrate.

2. The most significant count obtained during the survey period was of an estimated 580 dunlin during a single count in December. This probably represents the bulk of the Hayle Estuary population, and approximately 9% of the peak wintering numbers (approximately 6300) across the whole of Cornwall (Wilson and Wislon, 2005). However, surveys indicate that such numbers do not occur on a regular basis, and that the highest densities of roosting birds occurred as the result of a temporary pool, which has since disappeared.

3. It seems likely, therefore, that the beach area is used on an occasional basis by small numbers of roosting birds from the nearby Hayle Estuary. The area would not be considered a critical resource for birds in this respect, and it is therefore assessed as being of local value for its intertidal bird interest when assessed in accordance with IEEM guidelines.

Ecological evaluation of offshore birds

4. The Wave Hub area falls outside of areas designated at an international or national level for their seabird interest. Survey results indicate that seabirds occur in the same order of density as those recorded in the Atlas of Seabird Distribution in North-west European Waters. There is no evidence to suggest that the area around the proposed Wave Hub site provides particularly important feeding areas for seabirds, nor that significant concentrations of any seabird species occur there.

5. However, data from the survey and the Atlas indicates that the wider area is used by birds from nationally and internationally important seabird colonies on the Scilly Isles, Lundy and off south Wales and would therefore be considered of national importance for seabirds. It is difficult to define the 'wider area', but a nominal polygon encompassing the Scilly Isles, Lands End, Lundy and the south west tip of Pembrokeshire has an area of approximately 8,300km^2. The Wave Hub deployment site covers an area of 8km^2, which is less that 0.1% of this polygon. In isolation,

therefore, the Wave Hub site can be considered to provide habitat used by seabirds forming part of nationally or internationally breeding populations. It does not, however, form a critical part of the areas used by these species, and is therefore assessed as being of local value for seabirds when assessed in accordance with IEEM guidelines.

9.4 Potential impacts during construction and decommissioning

Potential impact on intertidal birds

1. Potential impacts on birds using the intertidal area could occur in the following ways during the construction and decommissioning phases:

- Direct noise and visual disturbance to birds during cable laying/removal operations, caused by the presence of machinery and increased human activity;
- Physical loss of roosting and foraging habitat along the cable trench during construction; and
- Loss or degradation of roosting and foraging habitat due to accidental pollution during construction activities.

2. When the cable is laid, this will be achieved by directional drilling underneath the dune and part way down the beach, and through open trench on the lower part of the beach. For logistical reasons, this will be undertaken during the summer months, which also coincides with the period when bird use is at its lowest and existing human disturbance is at its highest. The duration of trenching works is expected to be less than one week.

3. Given the low level of bird use during the summer months, the short duration of the works and the wide availability of similar beach habitats nearby, it is considered near certain that there will be no significant impact on birds using the intertidal area during construction, when assessed in accordance with IEEM guidelines.

4. The impacts of decommissioning are likely to be similar in nature to the construction impacts. It is likely that cable recovery will be undertaken during the summer months to avoid poor weather, although at this stage there is greater uncertainty. It is therefore probable that there will be no significant impact on intertidal birds during decommissioning.

Mitigation and residual impact

5. The following mitigation is proposed in order to minimise any impacts on intertidal birds:

- All construction, maintenance and decommissioning works in the intertidal zone should be undertaken outside of the winter period (October to March);
- Where works during the winter cannot be avoided (for example for essential maintenance), these should not be undertaken for at least two hours after high tide where high tide

occurs early in the morning (i.e. within two hours of sunrise);

- The duration of work and extent of work area should be kept to a minimum; and

- Best working practices and adherence to the relevant Environment Agency Pollution Prevention Guidelines (PPGs) should be employed to minimise pollution risk.

6. With the provision of appropriate mitigation, it is considered near certain that there will be no significant residual impacts on intertidal birds.

Potential impact on offshore seabirds

7. Potential impacts on offshore seabirds during the construction and decommissioning phases could occur in the following ways:

- Disturbance primarily through increased shipping activity; and,

- Impacts of accidental pollution.

8. The key change to the Wave Hub area during the construction phase will be due to increased shipping activity required for the deployment of the hub itself, the power connection units, cabling between the units and to shore, and the WEC devices. Survey results indicate that there is little seabird feeding activity in this area, but construction activities may cause limited disruption to feeding birds where they are present.

9. No other significant effects on seabirds can be foreseen during the construction phase. Birds are unlikely to be attracted to construction activities during the day, although there is a small possibility that birds might be attracted by lights during any night time activity. On balance, the risk of collision or entanglement with the deployed structures or construction machinery is considered to be very low.

10. Any pollution incident during the construction or decommissioning phases has the potential to cause local mortality of seabirds, particularly species such as guillemot and razorbill that spend much of their time sitting on the surface of the sea and are therefore particularly vulnerable to surface pollutants. The main potentially polluting materials are lubricating and cooling oils used in the Wave Hub, power connection units and WECs, together with fuel and lubricants in service vessels and any construction or maintenance machinery. The relative volumes of these materials are small, and even in a worst case scenario, for example the leakage of all of the cooling oil from the Wave Hub, any effects are likely to be localised and short-lived. The likelihood of such an incident is assessed as being low (see Section 7).

11. It is therefore assessed that there will be no significant impacts on seabirds during the construction phase.

12. The impacts during decommissioning are likely to be similar to those that occurred during the construction phase. These will include physical disturbance due to increased shipping activity and risk of pollution. Any

benefit that has occurred as a result of the ATBA would be reversed once the site was decommissioned, and it can be envisaged that any increase in fish stocks that had occurred within the area would attract increased fishing activity, accelerating the rate of any reversal. However, as stated above the nature and extent of any benefit cannot be predicted, and so any reversal is also subject to uncertainty.

13. It is therefore considered near certain that there will be no significant impacts on seabirds during the decommissioning phase.

9.5 Potential impacts during operation

Potential impact on intertidal birds

1. The operational phase has the potential to give rise to similar impacts to those described above for the construction and decommissioning phases should maintenance be required to the cable. It is, however, considered unlikely that there will be any requirement for maintenance of the cable during the operational phase. However, it is possible that should any maintenance be required, this could be undertaken during the winter period. The duration of any maintenance works is likely to be less than one week, and any effects will be of short duration. It is therefore probable that there will be no significant impact on intertidal birds during operation.

2. The potential for sediment changes to affect the Hayle Estuary SSSI can be assessed by reference to the Wave Hub *Coastal Processes Study Report* and Section 6 of this Environmental Statement. The worst case scenario WEC device layout (four Wave Dragon devices) is predicted to change the wave climate and currents to the extent that it will not result in a discernable effect on sediment transport and beach levels along the north Cornish coast; that is, a change of less than 0.2m in beach levels during extreme storm events. This change is minimal when compared to current typical seasonal and temporal changes to the level of the beach, which can reduce by up to 1.8m in places following severe storms, removing material from the upper beach to create an intertidal bar some distance offshore. During less severe wave conditions this material is returned to the beach from the intertidal bar. Overall, if Wave Hub were to affect sediment dynamics in the estuary, it is predicted that the changes would not be discernable against the existing sediment regime.

3. Based on the above assessment, it is predicted that no significant impacts will occur on the bird interest of the Hayle Estuary SSSI during the life of the project.

Mitigation and residual impact

4. The mitigation described above for the construction and decommissioning phase is equally applicable here, namely:

- All works in the intertidal zone should be undertaken outside of the winter period (October to March);
- Where works during the winter cannot be avoided (for example for essential maintenance), these should not be undertaken for at least two hours after high tide where high tide

occurs early in the morning (i.e. within two hours of sunrise);

- The duration of work and extent of work area should be kept to a minimum; and
- Best working practices and adherence to the relevant Environment Agency Pollution Prevention Guidelines (PPGs) should be employed to minimise pollution risk.

5. With the provision of appropriate mitigation, it is considered near certain that there will be no significant residual impacts on intertidal birds.

Potential impact on offshore seabirds

6. Given that the proposed Wave Hub development is the first of its kind within the UK, the likely impacts will inevitably be subject to some uncertainty. However, the nature and scale of the development is altogether different from offshore windfarms, against which the proposals will inevitably be compared. During operation, it is anticipated that the WECs will be static or slow moving, and their effects would therefore be comparable to large buoys or moored ships.

7. Potential impacts on offshore seabirds during the operational phases could occur in the following ways

- Loss of feeding area due to the presence of WECs;
- Increased food availability as a result of the 'sanctuary' created by the ATBA;
- Risk of collision / entanglement with WECs, cabling and anchoring; and
- Disturbance / disorientation of birds due to lighting at night.

8. During the operational phase, there would be a physical loss of water surface available for feeding and resting birds due to the presence of the WECs. The greatest impact on birds would therefore occur with the deployment of the largest foreseeable devices. The Wave Dragon overtopping device is the largest. A single Wave Dragon occupies an area of 260m by 147m (i.e. 0.038km^2), although this includes the arms of the device, and so the area of sea physically occupied is significantly less (approximately 0.01km^2). One Wave Dragon occupies a sea surface area with a circle of radius 0.425km, equal to 0.57km^2. Therefore, as a worst case scenario it could be considered that a deployment of four such devices would result in the loss of 2.28km^2 of open water for a period of up to 25 years. Given that the sea around the deployment area is not considered to have any particular value to feeding and resting birds, and in the context of the total available area of sea for seabirds, such as loss is assessed as being negligible.

9. Marker buoys around the deployment area will include beacon lighting. It is known from experiences with lighthouses that night time illumination can attract birds, particularly migrating species. However, the intensity of lighting would be substantially less than for a

lighthouse, and there is no evidence to suggest that such a deployment would significantly affect bird behaviour.

10. It is expected that the creation of an ATBA will result in a substantial reduction or cessation of fishing activity within the deployment area. This has the potential to create a marine sanctuary, which may provide improved availability of food for seabirds. Evidence from the No Take Zone (NTZ) on Lundy Island has shown that lobster populations can recover very quickly in the absence of fishing. However, there is not sufficient available information to be certain of any change that might occur at the Wave Hub site. There is the possibility, therefore, that there could be a small beneficial effect on seabirds during the period of deployment.

11. On balance, therefore, it is assessed that there will be no significant impacts on seabirds during the operational phase of the Wave Hub, and unlikely that there will be a minor beneficial impact.

Mitigation and residual impact

12. The following mitigation is proposed in order to minimise any impacts on offshore seabirds:

- Best working practices must be employed and method statements produced for all construction, maintenance and decommissioning activities where there is a risk of pollution; and,
- Lighting at night time should only be permitted where required for safety and navigational purposes.

13. With the provision of appropriate mitigation, it is considered near certain that there will be no significant residual impacts on offshore seabirds.

10 Marine ecology

10.1 Introduction

1. This section considers the potential impacts associated with the construction, operation and decommissioning of the Wave Hub on marine ecology, comprising both intertidal and subtidal ecology. In addition, this section specifically considers the potential for impact on cetaceans and elasmobranches.

2. The *Environmental Scoping Study* (Halcrow, 2005) identified a number of potential impacts associated with the proposed scheme on marine ecology, as summarised below:

- Potential for an effect on marine ecology as a consequence of changes to water quality during the construction phase;
- Potential disturbance to marine communities in St Ives Bay due to the burial of the cable under the seabed;
- Potential for effect on marine habitats and species as a consequence of effects of the hydraulic and sedimentary regime of St Ives Bay;
- Potential impact on benthic communities as a result of habitat loss and disturbance due to the laying of the cable on the seabed and construction of the Wave Hub;
- Potential for habitat creation;
- Potential impact on cetaceans, elasmobranches (sharks and rays) and other marine species during the construction phase (e.g. due to water quality effects and noise) and during the operational phase due to noise generation; and
- Electromagnetic field disturbance potentially affecting elasmobranchs in particular, and possibly to other marine species.

3. Related to the above, during consultation for the Environmental Scoping Study English Nature commented that Wave Hub should not affect the integrity of the St Ives Bay Sensitive Marine Area (SMA). This comment is addressed in the impact assessments.

4. The potential impact of the construction and operational phases of the proposed scheme on fish resources (and commercial fisheries) are assessed in Section 11.

10.2 Methodology

1. The baseline conditions for intertidal and subtidal ecology are described on the basis of surveys undertaken as part of the EIA process and a search of available existing data. The intertidal survey was undertaken by Emu Ltd and subtidal surveys were undertaken by Fugro Surveys Ltd and Precision Marine Survey Ltd (the latter specifically covering the revised deployment area). Full survey reports are included at Appendices F (intertidal

survey) and G, H and I (subtidal survey). These reports, along with other available data as appropriate, have been used as the basis for the description of the baseline conditions in the following sub-sections and to allow an assessment of potential impacts associated with the proposed scheme to be made.

Intertidal ecology

2. The full survey report is included at Appendix F. The following paragraphs summarise the methodology adopted for the intertidal survey.

3. The survey of the intertidal area of Hayle Beach was undertaken in March 2005. The aim of the survey was to establish the nature of the biological communities of the intertidal area within the proposed corridor for the wave hub cable.

4. The survey comprised taking core samples along three transects that were established perpendicular to the shoreline and within the proposed area of the cable. Three replicates were taken at each sampling station within the upper, middle and low shore for subsequent macrofaunal analysis, with an additional sample taken for analysis of particle size distribution.

5. Macrobenthic samples were subsequently processed in the laboratory, and organisms were identified to species level (where possible) and enumerated. Biomass was determined to taxon level. Full details of the laboratory analyses are provided in Appendix F.

6. The quantitative macrofaunal data was subject to statistical analysis in order to describe the biological community structure within the surveyed area.

7. In addition to the quantitative survey described above, a Phase I biotope mapping exercise of the survey area was also undertaken, resulting in the production of maps showing the distribution of biotopes.

Subtidal ecology

Benthic macrofauna

8. The full subtidal survey reports are included at Appendices G, H and I. The following paragraphs summarise the methodology adopted for the surveys.

9. The subtidal surveys comprised taking seabed samples using a 0.1m^2 Hamon grab at 30 sampling stations. Samples were processed through a 1mm mesh and all specimens were identified to the lowest taxonomic level possibly (generally to species level).

10. Epibenthic samples were collected using a 2m beam trawl with a 20mm mesh net and 4mm mesh codend liner. The majority of the catch was identified in the field, with specimens that could not be identified returned to the laboratory for subsequent identification.

11. Full details of all survey methods, sample processing and analyses are provided in Appendices G, H and I.

Marine mammals

12. The Cornwall Wildlife Trust database contains sightings of cetaceans, whales, pinnipeds, and otters in the study area. This information was used to inform the description of the baseline conditions of the study area for marine mammals.

13. More detailed investigations on cetacean activity in the study area were undertaken as part of the EIA process. A device known as a T-POD was deployed in the area of the proposed Wave Hub. A T-POD is a self-contained submersible computer and hydrophone that recognizes and logs echo-location clicks from porpoises and dolphins. Data is subsequently processed on a computer to detect click trains and distinguish them from trains of clicks arising from boat sonar.

14. It should be noted that the data set is incomplete for the T-POD. The first deployment of the T-POD gave a good data set throughout the deployment (February 2005 to June 2005). The data from the second deployment had large gaps. The reasons for this are unknown, but it is thought that it could have been caused by a malfunction of the G-sensor within the T-POD. This POD was lost with the wave rider buoy during the third deployment, delaying the collection of a third set of data.

Elasmobranchs

15. A search of records held by the Marine Conservation Society and the Cornwall Wildlife Trust was undertaken in order to describe the baseline conditions for the study area. During the surveys for fisheries ecology and ornithology, sightings of basking sharks were also recorded.

Worst case scenario

21. No worst case scenario applies to intertidal ecology since all potential impacts are unrelated to different layouts of WECs, anchors, buoys and safety zones.

22. The worst case scenario for subtidal benthic ecology is 120 Powerbuoy devices requiring 264 anchors because this layout has the largest number of anchors and, therefore, largest potential to disturb seabed benthic habitat and species during construction and decommissioning.

23. The worst case scenario for marine mammals (and other species) due to noise during construction and decommissioning is 120 Powerbuoy devices requiring 264 anchors to be installed by pile driving methods because this layout because has the largest number of anchors installed by noisiest method, and therefore, largest potential to affect cetaceans during installation due to piling noise and during decommissioning due to pile cutting.

24. The worst case scenario for marine mammals due to noise during operation is unknown because there is no information on noise emissions for the operational WEC devices.

25. No worst case scenario applies to elasmobranchs (and other species) due to electromagnetic fields from the sub-sea cable because this impact is unrelated to different layouts of WECs, anchors, buoys and safety zones.

10.3 Baseline conditions

1. This section describes the baseline conditions for intertidal and subtidal ecology. Most of this section is informed by the surveys described in Section 10.2.

Designated sites

2. The only designated site in the marine area is the St Ives Bay MSA. The MSA is a non-statutory designation by which English Nature identifies the whole of St Ives Bay to be of national importance and notable for its marine animal and plant communities.

3. Gubbay (2001) describes the marine ecology of the SMA as follows: "Much of the seabed in the bay is sandy with a limited fauna where it is mobile. Buried within the sand are razor shells, the sea potato and sponges. Shoals of sand eels, plaice, dragonet, goby and rays frequent the area. Where there is sand-covered rock this is typically colonised by red and brown algae with some kelp. A belt of kelp overlying a mixed community of red and brown seaweeds typically dominates other rocky areas. At greater depths there is an abundance of sponges and anemones, while crustaceans make up a major part of the bottom-living mobile population. Large numbers of wrasse, pollack, young bib, poor cod and pipefish occur among the kelp forest".

Intertidal biotopes

4. The intertidal biotope survey identified a number of biotopes within the area surveyed. Figure 10.1 illustrates the location and extent of these biotopes. The biotopes recorded are described in the following paragraphs, with a full description of the findings of the survey provided in Appendix F.

5. The biotopes identified can be divided into littoral sediment biotopes and littoral rock biotopes. As can be seen from Figure 10.1, the vast majority of the intertidal area comprises the sediment biotope LS.LSa.MoSa ('Barren or amphipods dominated mobile sand shores'); the proposed cable route will pass through this biotope. No obvious infauna were recorded during the biotope survey, although analysis of the core samples from the mid shore area revealed that the infauna comprises mainly polychaete species.

6. On the lower shore, the core samples revealed that the infauna largely comprises the crustacean species *Pontocrates arenarius* and *Eurydice pulchra*. Copepods and the polychaete *Nephtys cirrosa* were also recorded, but in low numbers.

7. Results from the particle size analysis showed that sand was the dominant sediment at all sites. Medium sand accounted for 80% of the sediment at all sites, with coarse sand accounting for less than 3%, and mud representing a negligible component of the sediment (≤0.03%). The substrate is, therefore, characterised as clean sandy sediment subject to a high degree of disturbance by winds, tide and currents. The upper shore along the proposed route of the cable is backed by sand dunes.

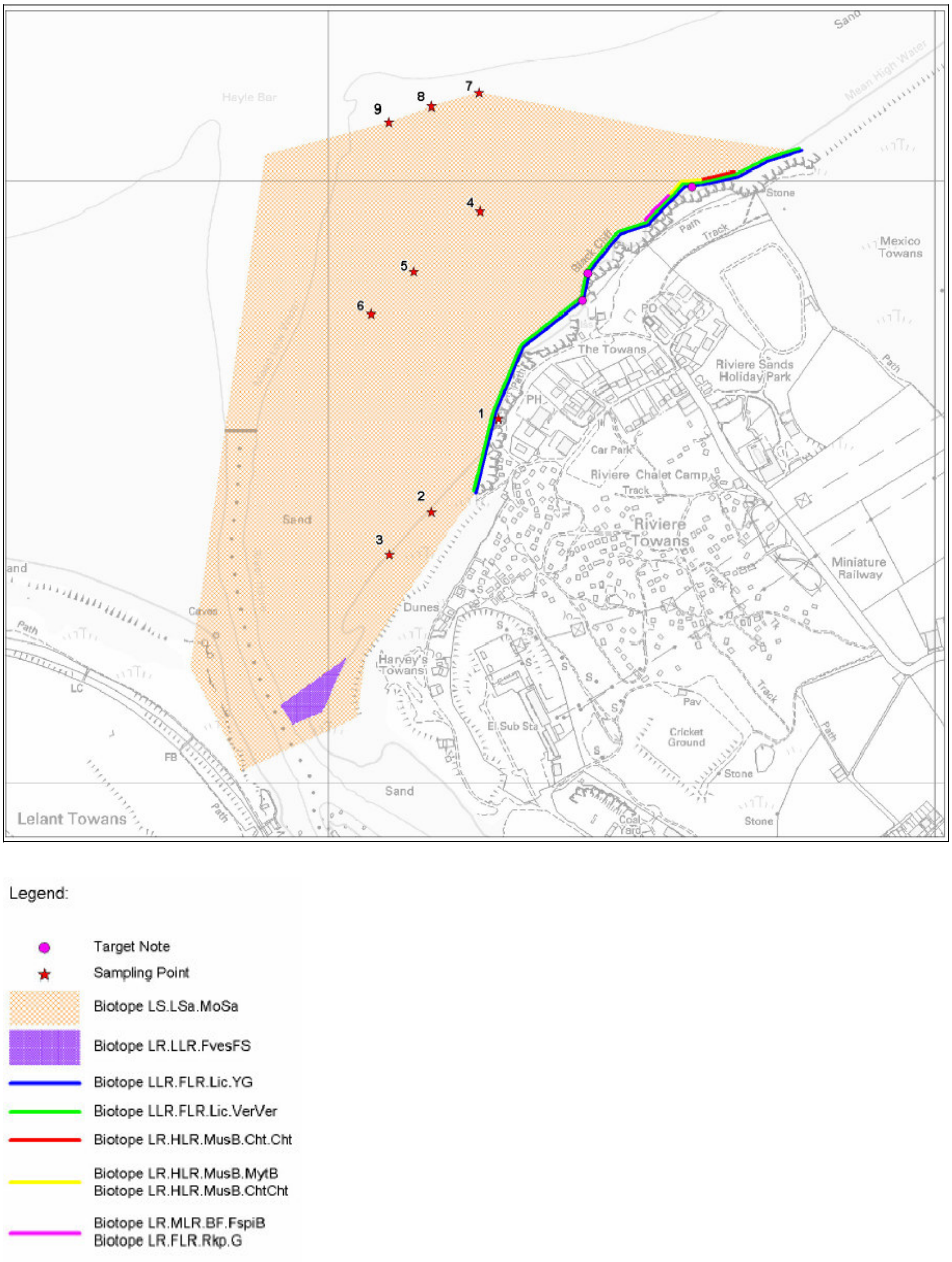


Figure 10.1 Intertidal biotope survey plan

8. Littoral rock biotopes are present to the east and west of the landfall of the proposed cable on the upper shore. At the mouth of the Hayle estuary, near the high water mark, there is a small area of rock supporting a fucoid population. This area is defined as the biotope LR.LLR.F.FvesFS ('*Fucus vesiculosus* on full salinity moderately exposed to sheltered mid eulittoral rock').

9. To the east of the proposed landfall of the cable, the biotopes recorded on the bedrock cliff are typical of exposed rocky shores. An upper-shore band of yellow and grey lichens, biotope 'Yellow and Grey lichens on supra-littoral rock' (LR.FLR.Lic.YG) was recorded along the whole length of the cliff. Below this a band of *Verrucaria*, biotope '*Verrucaria maura* on very exposed to very sheltered upper eulittoral fringe rock' (LLR.FLR.Lic.VerVer) occurred.

Subtidal benthic macrofauna

16. The following paragraphs summarise the key findings of the surveys. It should be noted that the surveys of the original deployment area and its surroundings were undertaken by Fugro Surveys Ltd (see Appendices G and H) and a subsequent survey of the revised deployment area was undertaken by Precision Marine Survey Ltd (see Appendix I). Together, these two surveys provide a broad-scale description of the nature of the subtidal benthic macrofauna of the area in and around the proposed deployment area for Wave Hub.

17. During the surveys undertaken by Fugro Ltd, a total of 276 infaunal species were recorded (excluding 56 colonial species, 1 meiofaunal species and 28 juvenile taxa). Of these species, approximately 44% are Annelida, 25% Crustacea, 21% Mollusca, 4.3% Echinodermata and 6% from other phyla.

18. In terms of abundance, Crustacea are dominant, making up approximately 51% of the fauna, with Annelida comprising 38%, Mollusca 6% and Echinodermata 3%.

19. Overall, the most abundant species is the crustacean *Pisidia longicornis* with an average abundance of approximately 55 individuals per sample. The next most abundant species comprise the annelid Serpulidae, four polychaetes, two amphipods, an isopod and an echinoid.

20. The surveys undertaken by Precision Marine Survey Ltd (see Appendix I) revealed that the benthic fauna of the revised deployment area is similar in terms of community composition to the original deployment area surveyed by Fugro Ltd. A description of the biotopes present in the revised deployment area is provided below.

21. On the basis of the findings of the subtidal ecological surveys, biotopes were assigned to describe the distribution and extent of subtidal communities. A biotope can be defined as a habitat with which a specific biological community is associated. Full details of the methodology for assigning biotopes are provided in Appendix G.

22. A summary of the biotopes identified in the surveys is provided in Table 10.1. Table 10.2 shows a habitat classification matrix showing the biotopes associated with different

sedimentary habitats. The following paragraphs summarise the distribution of biotopes in the area to the west of the proposed deployment area, encompassing the site of the original deployment area. It should be noted that the majority of the cable route is the same for the original and proposed (revised) deployment areas.

Near-shore cable route (approximately 5m to 32m below LAT)

23. The very exposed SAND substrate of the shallow circalittoral (approximately 5m below LAT) was found to have a community consistent with SS.SSA.IFiSa.IMoSa. This biotope grades into the SS.SSA.IFiSa.NCirBat (Figure 10.2) variants characteristic of the finer, more stable SAND substrates associated with the deeper infralittoral zone (14 to 20m below LAT). The *Pentapora fascialis, Halichondria panicea* and red algae on wave-exposed circalittoral rock biotope was identified from an isolated rock outcrop at around 20m depth.

Figure 10.2 Nephtys cirrosa and Bathyporeia spp. in infralittoral sand

24. Although this biotope was only seen once in the current study it may occur on the other shallow outcrops evident from the geophysical data. The PEBBLE sediment of the deepest section of the nearshore cable route area was found to have a community consistent with SS.SMX.OMx overlain by SS.SCS.CCS.PomB (see Figure 10.3).

Figure 10.3 Offshore circalittoral mixed sediment overlain by Pomatoceros triqueter with barnacles and bryozoan crusts on unstable circalittoral cobbles and pebbles

Offshore cable route (18m to 52m below LAT)

25. The habitat of the offshore cable route was predominantly bedrock and boulder, although isolated patches of PEBBLE substrate were also present.

26. Bedrock topography was apparently the main determinant of biotope distribution within the rock habitats. Raised outcrops were colonised by communities consistent with CR.MCR.EcCr.CarSp.PenPCom or the more diverse variant of CR.HCR.DpSp.

Table 10.1 Summary of biotopes identified during the subtidal surveys

Habitat Type		Biotope Complex		Biotope	
Code	**Name**	**Code**	**Name**	**Code**	**Name**
CR	Circalittoral Rock	CR.HCR.DpSp	Deep Sponge Communities	CR.HCR.DpSp	Deep Sponge Communities
CR	Circalittoral Rock	CR.HCR.Xfa	Mixed Faunal turf Communities	N/A	Flustra foliacea and encrusting sponges on wave-exposed circalittoral boulders
CR	Circalittoral Rock	CR.HCR.Xfa	Mixed Faunal turf Communities	CR.HCR.XFa.ByErSp	Bryozoan turf and erect sponges on tide swept circalittoral rock
CR	Circalittoral Rock	CR.HCR.Xfa	Mixed Faunal turf Communities	N/A	*Corynactis viridis* on wave-exposed circalittoral rock
CR	Circalittoral Rock	CR.MCR.Eccr	Echinoderms and Crustose Communities	N/A	*Pentapora fascialis*, solitary ascidians, *Halichondria panicea* and red algae on wave-exposed circalittoral rock
CR	Circalittoral Rock	CR.MCR.Eccr	Echinoderms and Crustose Communities	CR.MCR.EcCr.CarSp.PenPcom	Caryophyllia smithii and sponges with *Pentapora fascialis, Porella compressa* and crustose communities on wave-exposed circalittoral rock
CR	Circalittoral Rock	CR.MCR.Eccr	Echinoderms and Crustose Communities	CR.MCR.EcCr.FaAlCr.Bri	Brittlestar beds on faunal and algal encrusted, exposed to moderately exposed circalittoral rock
CR	Circalittoral Rock	CR.MCR.Eccr	Echinoderms and Crustose Communities	N/A	*Antedon bifida* on moderately exposed bedrock outcrops
CR	Circalittoral Rock	CR.MCR.Eccr	Echinoderms and Crustose Communities	CR.MCR.EcCr.CarSp.Bri	Brittlestar bed overlying coralline crusts, *Parasmittina trispinosa* and *Caryophyllia smithii* on wave-exposed circalittoral rock
SS	Subtidal Sediment	SS.SSA.IFiSa	Infralittoral Fine Sand	SS.SSA.IFiSa.IMoSa	Infralittoral mobile clean sand with sparse fauna
SS	Subtidal Sediment	SS.SSA.IFiSa	Infralittoral Fine Sand	SS.SSA.IFiSaNCirBat	*Nephtys cirrosa* and *Bathyporeia* spp. in Infralittoral Sand
SS	Subtidal Sediment	SS.SMX.CMx	Circalittoral mixed sediment	SS.SMX.OMx overlain by SS.SCS.CCS.PomB	Offshore circalittoral mixed sediment overlain by Pomatoceros triqueter with barnacles and bryozoan crusts on unstable circalittoral cobbles and pebbles
SS	Subtidal Sediment	SS.SMX.CMx	Circalittoral mixed sediment	SS.SMX.CMx.OphMx	*Ophiothrix fragilis* and / or *Ophiocomina nigra* brittlestar beds on sublittoral mixed sediment
SS	Subtidal Sediment	SS.SMX.CMx	Circalittoral mixed sediment	N/A	*Antedon bifida* beds with *Ophiothrix fragilis* on circalittoral mixed sediment
SS	Subtidal Sediment	SS.SMX.OMx	Offshore circalittoral mixed sediment	SS.SMX.OMx overlain by SS.SCS.CCS.Blan	Offshore circalittoral mixed sediment overlain by *Branchiostoma lanceolatum* in circalittoral coarse sand with shell gravel

Table 10.2 Habitat classification matrix showing the biotopes identified in the subtidal surveys

		ROCK HABITATS		**SEDIMENT HABITATS**	
		High Energy Rock (HR)	**Moderate Energy Rock (MR)**	**Sand (Sa)**	**Mixed Sediment (Mx)**
BATHYMERTRIC ZONE	Infralittoral			Infralittoral mobile clean sand with sparse fauna	
				Nephtys cirrosa and *Bathyporeia* spp. in Infralittoral Sand	
	Circalittoral	Deep Sponge Communities	*Pentapora fascialis*, solitary ascidians, *Halichondria panicea* and red algae on wave-exposed circalittoral rock		Offshore circalittoral mixed sediment overlain by Pomatoceros triqueter with barnacles and bryozoan crusts on unstable circalittoral cobbles and pebbles
		Flustra foliacea and encrusting sponges on wave-exposed circalittoral boulders	Caryophyllia smithii and sponges with *Pentapora fascialis, Porella compressa* and crustose communities on wave-exposed circalittoral rock		*Ophiothrix fragilis* and / or *Ophiocomina nigra* brittlestar beds on sublittoral mixed sediment
		Bryozoan turf and erect sponges on tide swept circalittoral rock	Brittlestar beds on faunal and algal encrusted, exposed to moderately exposed circalittoral rock		*Antedon bifida* beds with *Ophiothrix fragilis* on circalittoral mixed sediment
		Corynactis viridis on wave-exposed circalittoral rock	*Antedon bifida* on moderately exposed bedrock outcrops		Offshore circalittoral mixed sediment overlain by *Branchiostoma lanceolatum* in circalittoral coarse sand with shell gravel
			Brittlestar bed overlying coralline crusts, *Parasmittina trispinosa* and *Caryophyllia smithii* on wave-exposed circalittoral rock		

27. The flat bedrock plateaus had the dense brittlestar aggregations typical of CR.MCR.EcCr.FaAlCr.Bri, low diversity variants of CR.HCR.DpSp or CR.HCR.XFa.ByErSp. Boulder biotopes adjacent to bedrock outcrops were classified as either CR.HCR.DpSp,

28. CR.HCR.XFa.ByErSp or *Flustra foliacea* and encrusting sponges on wave-exposed circalittoral boulders.

Southern regional offshore and original Wave Hub deployment areas (32m to 58m below LAT)

29. The dominant biotope of the southern halves of these areas was SS.SMX.OMx overlain by SS.SCS.CCS.PomB. In places SS.SMx.CMx.OphMx and *Antedon bifida* beds and *Ophiothrix fragilis* on circalittoral mixed sediment were identified (Figure 10.4).

Figure 10.4 Antedon bifida beds with Ophiothrix fragilis on circalittoral mixed sediment

30. The distribution of rock biotopes again appeared to be determined by topography. The biotopes of steep rock outcrops were either the diverse variant of CR.HCR.DpSp, CR.HCR.XFa.ByErSp or A. bifida on moderately exposed bedrock outcrops. Bedrock plateaus were dominated by CR.HCR.XFa.ByErSp, CR.MCR.EcCr.CarSp.Bri (Figure 10.5) and the *Ophiocomina nigra* bed variant of CR.MCR.EcCr.FaAlCr.Bri; *Corynactis viridis* on wave-exposed circalittoral rock was identified from one outcrop in the south western regional offshore area (Figure 10.6)

Figure 10.5 Brittlestar bed overlying coralline crusts, Parasmittina trispinosa and Caryophyllia smithii on wave-exposed circalittoral rock

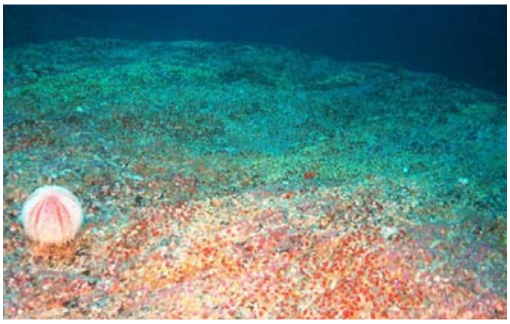


Figure 10.6 Corynactis viridis on wave-exposed circalittoral rock

Northern regional offshore and original Wave Hub deployment areas (50m to 64m below LAT)

31. The dominant biotope of these areas was SS.SMx.OMx overlain by SS.SCS.CCS.Blan. The *O. fragilis* dominated variant of CR.MCR.EcCr.FaAlCr.Bri (Figure 10.7) was identified from a bedrock outcrop in the north eastern regional offshore area and CR.HCR.XFa.ByErSp was found in the northern original Wave Hub deployment area.

Figure 10.7 Ophiocomina nigra brittlestar bed

Revised Wave Hub Deployment Area (50m to 60m below LAT)

32. Two clear biotope complexes have been identified in the deployment area. These biotopes indicate offshore circalittoral mixed sediments with relatively high diversity and moderate abundance. The shelly gravel biotope with *Branchiostoma lanceolatum* (SS.SMX.OMx. overlain by; SS.SCS.CCS.Blan) has been identified at four benthic stations sited predominantly in the northern and offshore sector of the deployment area; this agrees with the findings of the Fugro survey (Fugro, 2006) who also found this biotope in the northern offshore regional area. Those species identified as a result of the full analysis of the samples confirm that the assignation fits with the marine habitat classification (JNCC, 2004), and that the characterising species such as *Pisione remote*, *Polygorius* spp., *Echinocyamus pusillus*, *Glycera lapidum* and *Branchiostoma lanceolatum* were present in moderate abundance.

33. The second biotope identified is more complex in that it is an aggregation of more than one biotope, and is likely as a result of the close proximity of other soft sediment substrates and hard compact substratum on relatively moderate tidal streams along with a moderately exposed wave action. The characterisation of this biotope included offshore circalittoral mixed sediment overlain by *Pomatoceros triqueter* with barnacles and bryozoan crusts on unstable circalittoral cobbles and pebbles (SS.SMX.OMx. overlain by SS.SCS.CCS.PomB). Whilst *Pomatoceros triqueter* is a dominant faunal feature of these samples the density and diversity of barnacle and bryozoan species is not as high as recorded during the Fugro survey (Fugro 2006), and the substrata appear to be dominated by exoskeleton with no live material, this is also the case with *P. triqueter*, although to a lesser degree.

34. The relatively high diversity of other faunal taxa, especially polychaetes, would indicate that the area may be transitory between specific biotopes. There are similarities between the infauna recorded, especially polychaetes, to the biotope SS.SCS.CCS.MedLumVen, and as a consequence the biotope *Mediomastus fragilis*,

Lumbrineris spp. and venerid bivalves in circalittoral coarse sand or gravel is provisionally considered to be representative. A particular species that features heavily in these samples is *Pisidia longicornis*, and although it is not assigned a specific biotope niche, it is nevertheless the dominant faunal species within the samples, and representative of the sediment type.

35. The remaining benthic stations are all classified within the SS.SMX.OMx. overlain by SS.SCS.CCS.PomB and SS.SCS.CCS.MedLumVen biotope complex, these stations covered the southern inner and mid areas of the revised deployment area and cable route. This compares with the data collected by Fugro who recorded the similar SS.SMX.OMx. overlain by SS.SCS.CCS.PomB biotope complex within the cable route and southern area of the original deployment area.

Marine mammals

10. A number of species of marine mammals are recorded as being present in the study area from the Cornwall Wildlife Trust database. The vast majority of sightings are of bottlenose dolphins (427), with grey seal (72), common dolphin (17) and harbour porpoise (16) also being notable species.

11. Other species recorded less frequently comprise white sided dolphin, Risso's dolphin, striped dolphin, humpback whale, killer whale, minke whale, pilot whale, sei whale, otter and harp seal.

12. Results from the first deployment of the T-POD gave a good dataset for the period February to June 2005. The data indicate that the area is used regularly at low intensity by harbour porpoises and dolphins; it should be noted that it is not possible to distinguish the species present from the data. However, the two most commonly reported dolphins in the area are the bottlenose and common dolphin.

13. The data revealed that the level of cetacean activity varied considerably during the monitoring period and it is likely that longer term seasonal trends occur.

Elasmobranchs

14. The most frequently recorded shark species is the basking shark; during the ornithological survey (August 2005), 61 individuals were observed. A single individual of both the blue shark and thresher shark have also been recorded.

15. Basking sharks are seasonal visitors that feed in sheltered bays and off headlands during the summer months. They arrive off the Cornish coast in April and their numbers peak in May and June. Basking sharks are internationally protected with a listing on CITES (Convention on International Trade in Endangered Species).

16. The Wave Hub *Commercial Fisheries Study* (see Appendix J) demonstrates that a number of species of skate and rays are present within the coastal waters off north Cornwall and some of these species form part of the commercial fishery. It is not possible to determine precisely where these species occur in relation to the proposed Wave Hub deployment area, but even if they are not commercially fished at this location they are

highly likely to be present in the vicinity of the deployment area.

10.4 Potential impacts during construction and decommissioning

Disturbance to intertidal communities during construction and decommissioning of the cable

1. As described in Section 2.12, in order to install the intertidal section of the cable it will be necessary to either trench or plough in the intertidal area extending from (approximately) mean high water to mean low water. This impact assessment assumes that the cable will be installed by trenching method, since this provides for a more conservative impact scenario. The trench will be up to 3m deep and the cable will be laid in the trench and recovered with the beach material. The section of the cable beyond the mean high water mark to the substation will be installed by directional drilling through the dunes; this potential impacts associated with this aspect are described in Section 8. During decommissioning, the cable will be excavated from the intertidal area.

2. The distance between mean high water and mean low water along the proposed route of the cable is approximately 750m. There will be a requirement for the establishment of a working area either side of the proposed cable route; for the purposes of impact assessment, a total maximum working strip of 10m has been assumed for the trench, but a wider working area of 100m could be needed to accommodate equipment and vehicles. Overall, therefore, a total area of approximately 0.75ha has the potential to be disturbed by the installation of the cable in the trench. It is assumed that there will be a similar requirement for working area during both installation and decommissioning.

3. The installation and decommissioning of the cable will involve disturbance to the intertidal communities within the working strip, with the greatest level of disturbance being experienced within the 10m wide footprint of the trench itself. Elsewhere within the 100m working strip, disturbance to intertidal communities will be of a lower magnitude.

4. The intertidal biotope survey revealed that the intertidal communities within the proposed working area are not of particular conservation importance. These species present are characteristic of a sandy intertidal environment and are often found on mobile, non-cohesive sediments.

5. The installation and decommissioning of the cable are temporary activities (expected to take less than five days for each phase) and will not result in a longer term change to the substratum along the route of the cable given that the trench will be refilled with in situ beach sediments. The area affected during the installation and decommissioning of the cable would be rapidly recolonised by benthic invertebrate species from the surrounding area and effects on the benthic community will be of short term duration, with no overall longer term effect on the intertidal biotope. The species identified within the area to be affected during installation and decommissioning of the cable

are all highly mobile, and show a high level of recoverability to disturbance (www.marlin.ac.uk).

6. Therefore there will be no significant impacts to intertidal ecology during construction.

7. Overall, it is concluded that the sensitivity of the receptor is low and the magnitude of the impact is minor negative. The potential impact is, therefore, of minor adverse significance.

Mitigation and residual impact

8. It is recommended that the working strip is clearly delimited to prevent encroachment of construction and decommissioning activities beyond the minimum working strip required. This will ensure that impacts on the intertidal communities are limited as far as possible. Given that a maximum working strip for the trench and the wider working area has been assumed in the initial impact assessment, the residual impact is predicted to be of minor adverse significance.

Disturbance to subtidal benthic communities

9. The construction works have the potential to result in disturbance to subtidal benthic communities during trenching that is required to lay the cable in St Ives Bay (where sufficient depth of surface sediment is present) and during the installation of the offshore infrastructure (TDU, PCUs, moorings for the WEC devices and cable-laying). For each of these activities, the footprint of disturbance will be small and localised to the structure. For the TDU and PCUs, the installation involves the placement of the structures on the seabed. For much of its length, the cable will be laid on the surface of the seabed.

10. The installation of the Wave Hub's offshore infrastructure and WEC devices will require the following activities that will cause disturbance to the following magnitudes:

- Placement of the anchors for the TDU and four PCUs (i.e. pre-fabricated base plates with spikes or a lip that settle into the seabed) (magnitude = 1 + 4 x c.5m^2 = 25m^2);
- Installation of anchors for the WECs' moorings (worst case scenario being a maximum of 264 anchors for WECs based on connecting 30 PowerBuoy devices to each of the four PCUs in the deployment area, and assuming 66 anchors per 30 devices) (magnitude = 264 x max 1.5m diameter piles = 467m^2); and
- Installation of clump weight anchors for buoys' moorings (maximum of eight anchors based on four cardinal buoys and four marker buoys and assuming one anchor per buoy) (magnitude = 8 x 2m^2 = 16m^2).

11. The most significant disturbance is likely to be caused during the trenching to bury the cable in St Ives Bay. It is envisaged that approximately 8km of cable will be buried. Assuming a conservative cable route construction width of 5m (although the cable diameter is only 0.25m), it is predicted that the

magnitude of sediment disturbance would be approximately 40,000m^2, or 4ha.

12. The results of the biological survey showed that the seabed communities along the stretch of the cable route that will be buried are classified as the SS.SSA.IFiSa.IMoSa biotope (infralittoral mobile clean sand with sparse fauna) in shallower areas, grading into SS.SSA.IFiSa.NCirBat (*Nephtys cirrosa* and *Bathyporeia* spp. in infralittoral sand) in finer, more stable sand further offshore.

13. It is concluded that the seabed communities in the area affected due to the burial of the cable route will be disturbed during construction, with those species within the footprint of the trenching being affected. The predicted impact is considered to be limited to the footprint of the trenching and is, therefore, a localised impact.

14. The potential impact is predicted to be of minor negative magnitude. This is due to the fact that a relatively limited area of the two biotopes will be affected. In addition, the impact is considered to be temporary in that there will be no permanent loss of habitat.

15. The two biotopes that will be affected by the burial of the cable are considered to be of low sensitivity to disturbance and, following the initial disturbance impact, the affected communities would be expected to recover, primarily through recruitment from adjacent areas given the highly mobile nature of the species affected. The shallower water biotope is, in particular, of low sensitivity to disturbance as it has a sparse fauna and mobile sediments are one of the features of this biotope. Overall, the potential impact due to the burial of the cable is considered to be of minor adverse significance.

16. The remainder of the cable route will be laid on the surface of the seabed. The disturbance to seabed communities resulting from this aspect of the construction works is considered to be negligible and no significant impacts on seabed communities are predicted from this aspect of the construction works.

17. In the Wave Hub deployment area it is estimated that the construction works will result in a footprint of up to approximately 0.15ha (as calculated above). The biological surveys of this area demonstrate the seabed communities are diverse and the area supports a variety of biotopes of conservation interest. Whilst the species that constitute these biotopes are more sensitive to disturbance effects than in the sedimentary habitats of the shallower water areas, the overall footprint of the effect is limited and the impact is considered to be of minor negative magnitude.

18. The works at the deployment area represent a longer-term loss of seabed communities as the installation of the offshore infrastructure will result in the loss of approximately 0.15ha of seabed habitat. However, it is concluded that Wave Hub will not result in the loss of a particular biotope and, given the relatively low magnitude of potential impact, will not affect the integrity of any particular biotope. On this basis, it is concluded that the potential impact is of minor adverse significance.

Mitigation and residual impact

19. With respect to the deployment area, no mitigation measures are possible and the residual impact is predicted to be of minor adverse significance.

20. The works required to bury the cable are not possible to mitigate as the cable-trenching machine cuts a trench of the minimum width required. Therefore, it is not possible to limit the working area further. Consequently, the residual impact on seabed communities associated with the burial of the cable will be of minor adverse significance.

Potential impact on marine mammals due to effects on water quality

21. The potential impacts on water quality during the construction, operational and decommissioning phases are described in detail in Section 7. It is considered that the proposed scheme has the potential to affect water quality through the suspension of potentially contaminated sediments into the water column, increased turbidity and accidental pollution. This section assesses the overall potential for impact on marine mammals associated with these potential effects on water quality.

22. With respect to the suspension of potentially contaminated sediment, it is concluded in Section 7 that the burial of the cable during the construction phase, and its removal during the decommissioning phase, have the most potential to give rise to an effect on water quality.

23. It is concluded in Section 7 that the cable laying and removal will result in short-term, very localised (i.e. in the vicinity of the cable, near the seabed) effects and no significant impact on water quality is predicted. After initial dilution, potential contaminants will be quickly diluted no impact is predicted beyond the immediate vicinity of the cable route. In addition, the construction and decommissioning phases have little potential to increases total suspended solids and turbidity.

24. In light of the above, no significant impacts are predicted on marine mammals as a result of changes to water quality during the construction and decommissioning phases.

Mitigation and residual impact

25. No mitigation measures are required and no significant residual impacts are predicted.

Disturbance to marine mammals due to the generation of underwater noise during the construction phase

26. Marine mammals are known to use underwater sound in a number of ways, for example for communication between individuals, navigation and locating prey and predators. The generation of man-made noise, such as construction works in the marine environment, therefore has the potential to interfere with sound generated by marine mammals with resultant effects on behaviour. In addition to effect on behaviour, it is believed that physiological damage can also arise, although there are few reports of such effects. When considering the potential effects

of underwater noise on marine mammals it is important to identify whether or not effects will be biologically significant (i.e. noise that affects an animal's ability to grow, survive, and reproduce).

27. The construction phase will generate underwater noise from a number of sources such as the installation of the cable, installation of the PCUs and TDU and the movements of vessels. However, the most significant noise source during the construction phase is likely to be the installation of anchors and moorings for the WECs. As informed by the Wave Hub *Mooring Assessment Study*, this aspect of the construction phase will be undertaken by either percussive pile driving in the seabed or by drilling into the seabed, depending on the nature of the anchoring that is required for a particular WEC and the geotechnical properties of the seabed. However, for the purposes of the impact assessment it is assumed that pile driving (to some extent) will be required given that the noise generated by piling is greater than drilling; this ensures that the impact assessment considers a worst case scenario.

28. In terms of the WECs, the worst case scenario is taken to be a layout connecting 30 Powerbuoy devices to each of the four PCUs with 66 anchors per array of 30 devices; that is, 264 anchors in total.

29. It should be noted that this aspect of the construction works is subject to some uncertainty in terms of method, programming and duration given that the nature of the WECs, and the timing of their installation, cannot be confirmed at this stage. It is assumed that 10 anchors can be installed per day. Hence, the worst case scenario would require approximately 27 days of piling.

30. A significant amount of work on the generation of underwater noise during construction works, and the consequent potential impacts of such work on various species, has been undertaken in the last few years by Subacoustech Ltd. Some of this work has been published and is available for review. A number of studies have been undertaken in relation to the construction of offshore wind farms, although a range of different construction projects in the aquatic environment have been studied.

31. It should be noted at this point that the generation of underwater noise associated with construction projects is likely to be specific to the environment in which the project is being undertaken and the nature of the noise-generating activities that are being undertaken. COWRIE (2005) notes that the significant factors affecting noise level include pile diameter, local geology and bathymetry. Pile diameter and geology affect the impact energy needed to drive the pile, and geology and bathymetry determine the efficiency of noise generation and propagation.

32. Given the site-specific circumstances described above, two relevant case studies have been reviewed to describe the potential for generation of underwater noise during the installation of the moorings for the WECs.

33. The first case study relates to the measurement of underwater noise during piling at the Red Funnel Terminal in Southampton. This case study perhaps provides the most

relevant data to inform the assessment of potential impacts in this instance given that the piles used (914mm diameter) are similar to those that are proposed to be used for the anchors at Wave Hub (1000mm). It should, however, be noted that the ground conditions will affect the energy required to drive the piles and the local bathymetry will affect noise propagation.

34. In the above case study, the source level of impact piling was about 201 dB (referenced to 1uPA), with a transmission loss of about 0.15 dB per metre (COWRIE, 2004). The study included an assessment of the reactions of caged fish (brown trout) to piling noise. The study found that there was no startle reaction or physical injury to fish at 400m distance from the piling.

35. The second case study relates to the generation of underwater noise during construction for an offshore wind farm development at North Hoyle (Nedwell et al., 2003). Measurements were made of a variety of noise sources, including piling, which was considered to be the most significant aspect of the construction phase in terms of potential generation of underwater noise.

36. The measurements of piling noise at North Hoyle indicated a source level of up to 260dB (referenced to 1 μPa) at 1m from the source at 5m depth; noise decayed with distance.

37. It is considered that the noise generated by piling that will be required for the WECs' anchors is likely to be less than that recorded at North Hoyle by COWRIE (2003), and more similar to that reported in COWRIE (2005) for piling at Southampton. This is largely due to the fact that the North Hoyle study involved driving 50m long piles of 4m diameter which would support the wind farm turbines. The installation of such structures would require greater piling force compared with the installation of piles for the anchors for the WECs, which would be much less substantial structures (10m long and 1m diameter).

38. In light of the above, the piling noise quoted below is likely to be an overestimate of that which would be generated during the construction of Wave Hub but is used as the basis for impact assessment given the uncertainty associated with this assessment due to the site-specific nature of underwater noise generation during construction. This is confirmed by COWRIE (2005) which states that noise levels generated by the driving of smaller piles are lower than during driving larger piles.

39. Calculations of the levels of noise perceived by a variety of marine species (including bottlenose dolphin, harbour porpoise and harbour seal) (expressed as dB_{ht} units) at North Hoyle revealed that the majority of measurements were above the threshold at which significant avoidance reactions would occur. Therefore, it was concluded that behavioural effects (avoidance behaviour) could occur at several kilometres from the piling at North Hoyle (COWRIE, 2003), although the sensitivity of different species to underwater noise varies considerably.

40. It should be noted that the measurements at North Hoyle also comprised

measurements of drilling noise. Drilling occurs when piling into hard rock; after the initial impact hammering, sockets are drilled into the underlying rock for the piles. The noise associated with drilling was found to be significantly less than for pile driving and was below the threshold at which significant avoidance reactions would be expected to occur, although the noise could be detected several kilometres away.

41. Avoidance/displacement of marine mammals as a result of man-made noise is a commonly reported phenomenon. The Whale and Dolphin Conservation Society (2004) notes that such effects are not necessarily significant if they are of a short duration. However, if they are repeated or of long duration they may result in stress, debilitation and ultimately mortality.

42. On the basis of the above, it is concluded that piling may induce a reaction in marine mammals. The nature of the reaction can be inferred, on the basis of the two case studies described above, to be a startle and avoidance reaction. The severity of the reaction, in terms of area over which a reaction would occur, is not likely to be as significant as that described in the North Hoyle study given that the piles that would be used for the Wave Hub development would be of much lower diameter and would not require as much impact energy.

43. On the basis of the findings of the two case studies, it is predicted that, under a worst case scenario, avoidance behaviour may occur in the area local to the construction works at a distance of up to 1km. No lethal effects are predicted to arise as individuals will rapidly move away from the source of the disturbance and the effect will be very short term in nature, although a number of different piling events will be required for the installation of the various arrays of WECs.

44. The potential impact is considered to be of minor negative magnitude given that the effect of piling is expected to be relatively localised and is a temporary activity. It should also be noted that the geographical extent of potential impact as defined here is likely to be an overestimate given that the assessment of noise generation from piling relates to percussive pile driving, and there is a high possibility that piles will be drilled given the underlying bedrock at the deployment area. Overall, the worst case potential impact is predicted to be of minor adverse significance.

45. Although the construction phase will involve a number of other aspects that have the potential to generate underwater noise, the piling that may be undertaken represents the most significant source of possible underwater noise generation.

Mitigation and residual impact

46. Although there are a number of mitigation measures that can be applied to reduce the generation of noise by piling, most of these are untested and their practicability and effectiveness is questionable. With respect to minimising noise generation in this instance, it is considered that the most beneficial measure is to ensure that the correct specification of piles and pile driver is used for the works. This avoids the use of excessive energy (and noise generation).

47. It is also considered appropriate to use a 'soft' start up procedure. This entails commencing piling at low energy levels and gradually building up to full impact force. It is considered that this reduces the risk of injury to marine species as it allows them to move away from the source of disturbance.

48. Overall, it is predicted that the piling will result in a residual impact of minor adverse significance.

Disturbance to elasmobranchs due to the generation of underwater noise during the construction phase

49. The potential impact of underwater noise on elasmobranchs is considered in Section 11 which addresses the potential impact on fish species in general.

Potential for disturbance during seismic surveys

50. The Environmental Scoping Report made reference to the potential for disturbance to marine species during seismic surveying. It should be noted, however, that no seismic surveying is required for the proposed Wave Hub development.

10.5 Potential impacts during operation

Potential impact on marine mammals due to the generation of underwater noise

51. Given that the WECs are a new, developing technology no information exists regarding the generation of underwater noise from such devices. Indeed, the mechanism by which various devices may function is also uncertain due to the fact that the technology is under development.

52. Although the WECs are expected to generate underwater noise to a certain extent given that they will have some moving parts to generate electricity through wave energy, it is considered unlikely that such noise will be significant. This is due to the fact that the WECs will not contain mechanical components that require power (other than wave energy) to function (i.e. they are essentially passive devices). The TDU and PCUs are passive devices that sit on the seabed and do not have any moving parts.

53. It is predicted, therefore, that the potential for significant noise generation during the operational phase is low, although in view of the above there is uncertainty in this prediction.

54. It is predicted that the WECs will generate some degree of noise during the operational phase, but that such noise is unlikely to have a significant effect on marine mammals. It is predicted that the magnitude of the impact will be negligible, with no significant impacts on marine mammal populations.

55. As stated above, there is some uncertainty in the prediction of this potential impact and, therefore, monitoring proposals are recommended (see Section 20).

Potential impact of electromagnetic fields on sensitive marine organisms

56. The electricity that is generated by the Wave Hub will be transmitted between the

WECs and PDUs by 11kV cables and along the site to shore cable by a 24kV cable. All cabling that will be used for the proposed Wave Hub development, including the site to shore cable, will be AC cabling. The cable will have a steel/lead sheath.

57. Published literature on the potential environmental impacts of electromagnetic field (EMF) emitted by power cables largely relates to offshore wind farms given that a number of such schemes have recently been proposed around the UK coast. This information is directly relevant to the proposed Wave Hub study given that a similar type of cabling will be used as that which is used for wind farm developments, although it should be noted that site specific conditions will have an influence on the estimation of EMF that is generated.

58. The EMF generated by high voltage cabling is comprised of two different fields; an electric field (E) and a magnetic field (B). The E component is retained within industry standard cables, whereas the B component is detectable outside the cable. The B field subsequently induces a second electric field outside the cable (the induced electric field, termed iE field). Consequently, when assessing the potential impact on those marine species that are sensitive to EMF, it is the B field and iE field that are of relevance.

59. A number of studies on the potential for submarine power cables to impact on electrically and magnetically sensitive organisms have been commissioned by COWRIE. Of particular usefulness to this EIA is a review of current knowledge of sensitive species and the potential impacts of submarine power cables on these species has been undertaken (COWRIE, 2005) and a baseline assessment of electromagnetic fields generated by offshore wind farm cables (COWRIE, 2003).

60. This section focuses on the potential impacts of EMFs on elasmobranchs (sharks, skates and rays) and cetaceans (whales, dolphins and porpoises). As discussed in Section 10.3, the study area is of importance for a number of species belonging to these groups to a greater or lesser extent.

Elasmobranchs

61. By far the most commonly recorded shark within the study area is the basking shark. A number of species of skates and rays are also present throughout the study area and contribute towards the commercial fishery.

62. EMFs produced by the sub-sea cabling for Wave Hub have the potential to impact on elasmobranch behaviour given that these species have the ability to detect both electric and magnetic fields and use these forces for a number of purposes such as for navigation (migration) and for locating prey. Elasmobranchs detect prey by the electric fields that prey species induce in the surrounding seawater.

63. Recent modelling of EMF has been undertaken by the University of Liverpool as part of a study at the Kentish Flats offshore wind farm; the results of this modelling are discussed in COWRIE (2005).

64. The model compared two 33kV cables of different specification with

contrasting conductor sizes; one of 500mm^2 and the other of 185mm^2, carrying maximum current loads of 530A and 265A respectively. For the purposes of this assessment, the results for the larger conductor size are quoted given that this will be a similar specification to the cable that will be used for Wave Hub. The cable was also assumed to be coated with 10mm steel armour and had copper conductors. In the modelling simulation it was assumed that the cable was buried at 1.5m in the seabed.

65. The maximum electric field strength generated by the cable was 40µV/m in the seabed; the strength dissipated rapidly to only 1 or 2µV/m within a distance of approximately 10m from the cable. The estimated average electric field in the seabed was 20µV/m (this assumes that average generating conditions load cables with 50% of current at maximum output). At the interface between the seabed and the water, the maximum electric field strength generated by the cable is 2.5µV/m.

66. The above simulation provides a good comparison with the proposed Wave Hub cabling for the section of the cable that will be buried up to 3m in the seabed in St Ives Bay. For the remainder of the cable route that will be exposed on the surface of the seabed, the maximum electric field strength of 40µV/m is considered to be applicable, and this value would again dissipate rapidly with distance either side of the cable.

67. The available literature reports that elasmobranchs are likely to be affected by EMFs generated by the submarine cables. The response of elasmobranchs is variable depending on the intensity of the field that is generated. Gill and Taylor, 2001 (in CMACS, 2003) report that elasmobranchs can detect artificial bioelectric fields down to 0.5µV/m and avoid fields of 1000µV/m or greater.

68. On the basis of the modelling described above, COWRIE (2005) concludes that the maximum value of induced electric field strength generated (up to 40µV/m for the exposed section of the cable and up to 2.5µV/m at the surface of the seabed for the buried section of the cable) are within the range which may be detectable by elasmobranchs and potentially attractive to such species (0.5 to 100µV/m).

69. The potential for different elasmobranch species to be affected by EMFs varies depending on their typical habitats. Benthic species such as rays and skates have a higher potential to be affected as they are in contact with the seabed for much of the time. Pelagic species, such as basking sharks, inhabit the upper water column and, therefore, have a lower potential to be affected by EMFs than benthic species.

70. The literature also reveals that the potential for EMFs to interfere with the behaviour of elasmobranchs is greater when the cable is lying on the surface of the seabed. It seems generally accepted that when cables are buried within the seabed, there is very little potential for EMFs to affect electrically sensitive species.

71. In addition to the induced electric field discussed above, it is also relevant to consider the magnetic field (B) itself. Despite the high shielding that is built into cables to

minimise electric and magnetic field emissions, COWRIE (2005) report that modelling to investigate B field generation by the 33kV cable shows that the magnitude of the B field on the skin of the cable (i.e. within millimetres) is approximately 1.5µTesla; at the seabed-water interface, the maximum B field is 0.03µTesla (average of 0.015µTesla). This will be superimposed onto any existing B field such as the Earth's geomagnetic field which has a strength of approximately 50µTesla. The magnitude of the B field associated with the cable falls to background within 20m.

72. It is concluded on the basis of the above that there is a potential for the cabling required for the proposed Wave Hub to give rise to an impact on elasmobranchs as a result of the induced electric field. This effect is predicted to be localised to the route of the site to shore cable as the greatest intensity field would occur along the cable route itself. Either side of the cable, the induced electric field is rapidly dissipated.

73. The potential impact is likely to take the form of attraction to the cable route given the predicted magnitude of generation of induced electric field. It is considered unlikely that individuals will experience damage as a consequence of the induced electric fields. The attraction of elasmobranchs to induced electric fields of a certain strength is supported by Marra (1989) in Gill and Kimber (2005) who reports that biting elasmobranches damaged a major optical communication cable. The cable is, therefore, expected to result in a behavioural change in elasmobranchs in the vicinity of the cable.

74. It is proposed that the site to shore cable will be buried in the sediment by up to 3m in the near-shore waters of St Ives Bay. This will have the effect or reducing the intensity of the induced electrical field along up to 8km of the (approximately) 25km cable route. Further offshore, in areas of rocky seabed, the cable will lie on the surface of the seabed and this (approximately 17km) section of the cable route will, therefore, have the greatest potential to impact on elasmobranchs. However, it is expected that elasmobranchs will be able to detect and respond to the electric field along the whole length of the cable.

75. Overall, it is predicted that the magnitude of the potential impact will be minor negative given that the total zone of influence of the induced electric field is relatively localised to the route of the cable and pelagic species, such as basking sharks, are unlikely to be affected. Benthic species are more likely to be influenced by induced electric fields and it is predicted that they will be attracted to the cable. An effect is also likely to be detected where the cable is buried, but to a lesser degree than for the exposed cable section.

76. Although attraction to the cable route is expected, no effect on the elasmobranch population levels is expected given that damage to individuals is not expected to occur.

77. Although elasmobranchs are highly sensitive to induced electrical fields, the value of the receptor is considered to be of medium value overall in terms of its status as a commercial fish resource. It is, therefore,

concluded that the potential impact will be of minor adverse significance.

78. No significant impact is predicted as a consequence of magnetic fields generated by the cables given that the leakage of magnetic field is insignificant in the context of the background geomagnetic field generated by the Earth.

Cetaceans

79. A number of cetaceans found in UK waters have been recorded as being sensitive to magnetic fields (B fields) although they are not sensitive to electric fields. Cetaceans use the Earth's magnetic field to provide orientation during migrations; if a difference in the magnetic field is perceived, there is potential for disturbance to normal behavioural patterns.

80. As described above, COWRIE (2005) report that modelling to investigate B field generation by a 33kV cable shows that the magnitude of the B field on the skin of the cable (i.e. within millimetres) is approximately 1.5µTesla at most. This compares with the Earth's geomagnetic field which has a strength of approximately 50µTesla.

81. Given that the site to shore cable for the proposed Wave Hub will be 24kV, the magnetic field is expected to be insignificant compared with background magnetic fields. Combined with the fact that cetaceans are pelagic species, there is a very low potential for the Wave Hub's cable to affect cetaceans in this respect. Overall, no significant impact on cetaceans is predicted.

Mitigation and residual impact

82. It is considered that this impact is not possible to mitigate and residual impacts will remain as described above.

Potential for the WECs to act as a physical barrier to movement

83. The physical presence of the WECs has the potential to act as a barrier to marine mammals and elasmobranchs as they move through the area. However, the overall area affected by the deployment area (2km x 4km) will be limited and the proposal does not include substantial physical structures in relation to the nature of the environment in which it is located (i.e. the development site is not in an enclosed environment). As such, no significant impacts are predicted in this respect.

Mitigation and residual impact

84. No mitigation measures are required and no residual impact is predicted.

Potential for impact on benthic communities as a result of predicted effects on the sediment regime

85. A description of the predicted effects of Wave Hub on the sediment regime is provided in Section 6. It is concluded that predicted changes are of low magnitude and, in the offshore areas, will not give rise to a discernable effect on the seabed due to the depth of water at the deployment area. In the near-shore / intertidal area, no changes to current speeds are predicted, although minor

changes to the wave climate at the coast are predicted.

86. It is concluded that the predicted changes do not have the potential to affect the benthic community structure of subtidal or intertidal areas and, therefore, no significant impacts are predicted.

Mitigation and residual impact

87. No mitigation measures are required and no residual impact is predicted.

11 Fish resources and commercial fisheries

11.1 Introduction

1. This section addresses the potential impacts of the Wave Hub development on fisheries, including commercial fish resources and the fishing industry.

11.2 Methodology

1. In order to assist the EIA process, Emu Ltd was commissioned by Halcrow Group Ltd to undertake a Commercial Fisheries Study to provide a detailed understanding of commercial fisheries within the study area. In addition, a series of baseline surveys of the fishery resource were undertaken by Emu Ltd. The Wave Hub *Commercial Fisheries Study* is included at Appendix J and the findings of the baseline fisheries surveys are included at Appendix K. This section of the Environmental Statement summarises the key findings of the fisheries studies and presents the assessment of potential impacts associated with the construction, operation and decommissioning phases of Wave Hub.

2. Information on commercial fishing activity in the study area was collated from a number of different sources, comprising the following sources:

- DEFRA fisheries surveillance data;
- Consultations with the local fishing industry;
- Site visits;
- Analysis of DEFRA landings data;
- Academic studies, previous fisheries reports, Environmental Statements and other sources were studied; and
- The internet.

Worst case scenario

3. A worst case scenario was derived for the potential safety zones that could arise with the WECs in place and therefore prevent fishing taking place. The worst case scenario for the total combined area of the safety zones is 15km^2 (i.e. 5km by 3km) based on the unlikely occurrence that WECs are positioned along the external boundaries and corners of the deployment area, are distributed evenly within the deployment area, and safety zones are implemented to the maximum extent of 500m.

4. No worst case scenario is applied to other impact assessments because they do not relate to WEC layouts, anchors, buoys or safety zones.

11.3 Baseline conditions

Overview of DEFRA surveillance data

1. Fisheries surveillance data was obtained for the relevant ICES rectangle and sub-square (29E4 – Sub-Square 1) for the period 2000-2005 (although 2004 is the last complete year for which data is available). From these data, the following key observations were made:

- There is no significant trend in activity over the past 5 years;

- Fishing activity is highest in February and March during the sole fishery and lowest in November and December;

- U.K. vessels (47%) and French vessels (43%) account for the majority of sightings of active vessels;

- The great majority of French vessels are otter trawlers. Almost all of these fish outside the 12 mile limit;

- All the Belgian vessels are beam trawlers. Most sightings of these are outside the 12 mile limit;

- U.K. vessels use a number of different fishing methods in the area, including beam and otter trawling, potting and gill netting. Activity is spread across the whole of ICES rectangle 29E4, Sub-Square 1;

- Beam trawling activity is highest in February and March;

- Otter trawling activity is highest in January and February;

- Potting activity is highest in August and September;

- Gill netting activity is highest from June to October;

- Most of the otter trawling takes place outside of the 12 mile limit and will not be affected by the deployment area or any wider safety zones;

- Much of the beam trawling takes place outside of the 12 mile limit and will not be affected by the deployment area or any wider safety zones. However, some vessels are allowed to work inside the 12 mile limit and will be affected;

- Much of the potting takes place close to the deployment area and any wider safety zones and may be directly affected by the proposed development; and

- Gill netting will be little affected by the deployment area or any wider safety zones but will be impacted on by the construction of the sub-sea cable.

Findings of the consultation exercise with the local fishing industry

5. Consultations were held with the fishing industry in and around Hayle and Newlyn during August 2005. The aim was to gain more site-specific and detailed information than could be gleaned from official data sources and to canvass opinion on potential problems that the industry might have with the proposed scheme and the possible mitigations of these problems.

6. It should be noted that this consultation with local fishermen took place in August 2005, when some details of the Wave Hub were not fully developed and available.

7. Persons consulted included DEFRA officials, members of the Cornwall Sea Fisheries Committee, Cornwall Fish Producers Association, vessel owners and skippers of some of the vessels likely to be affected.

8. Based on this consultation exercise, the following key observations were made:

- Key species targeted in the wider study area include spider crab, edible (brown) crab, lobster, mackerel and sole;
- Other species of some seasonal importance include monkfish, bass, pollack, rays, plaice, cod, john dory, squid, turbot, herring and sprat;
- The fishery can be broadly divided into three main areas; (1) the inshore grounds, (2) the middle grounds and (3) the offshore fishery;
- A few larger beam trawlers target the sole fishery in the offshore grounds between February and April each year;
- Potting for brown crab begins in earnest in May with the season lasting through until November. Some local vessels fish a lot of their gear in and around the proposed Wave Hub deployment area;
- The summer spider crab fishery is a key component of the local fishery; this species is targeted in the inshore and middle grounds by pots and nets;
- Lobster is also targeted by many vessels working the middle and offshore grounds; and
- The other key fishery in this area is the summer mackerel hand-line fishery which has achieved Marine Stewardship Council accreditation as a sustainable fishery.

Structure of the local fishing fleet

Hayle

9. There are approximately 40 registered vessels of which around 10 are considered to be full time boats. Of these around four are full time fishing for mackerel, one fishes using an otter trawl and the remainder mostly deploy pots. Many vessels will switch between different fisheries at different times of the year.

St. Ives

10. It is reported that two vessels are potting full time from St. Ives and between 30 and 40 vessels handline for mackerel during the season. Some of the mackerel boats are reported to be based in Newlyn for the winter fishery.

Portreath

11. One large full time potter is reported to fish from Portreath alongside a number of smaller, mostly part-time boats.

Newlyn

12. Newlyn is a large fishing port with a fleet of hundreds of vessels. It is not possible

to state how many of these vessels fish within the study area at some time of the year, although it is likely that many fish in this area at least once each year. However, only a small number of vessels are reported to have any degree of dependence on this area. Most of the beam trawlers are too large to legally fish inside the study area, while many of the larger netters and trawlers will travel to deeper water and richer fishing grounds.

13. Based on discussions with local fishermen, it is estimated that there are approximately 85 inshore fishermen who fish in the immediate study area. This is a rough estimate and the actual number of fishermen who fish in the study area may vary widely throughout the year. Numbers working on larger, non-local vessels offshore cannot be estimated. It is also a generally accepted figure that each job at sea supports five jobs ashore in ancillary industries such as boat building, fish marketing and processing, engine repair, gear manufacture, etc.

Review of DEFRA landing statistics

14. Landings data from 29E4 for the period 2000 to 2004 was assessed in detail to identify the key trends in commercial fishing activity in the wider study area. The following key observations were made:

- Landings from 29E4 peaked in February /March. The peaks in February and March are mostly due to high earnings from the beam trawl fishery, mainly landing sole;
- Over 50% of fish caught in 29E4 were landed at Newlyn with the next most important ports being Brixham, Plymouth and Milford Haven;
- Beam trawling accounts for over 50% of the value of landings made from 29E4 over the reporting period. Potting was the second most important gear type in terms of landings, representing 17% of all landings;
- U.K. registered vessels of >10m in length were responsible for 75% of landings from 29E4;
- Unknown quantities of fish are landed by <10m vessels which are not recorded and do not show up in this data. Additionally, foreign vessels landing into non-UK ports make landings declarations to the country in which they land, irrespective of the fact that some of their fish may have been caught in UK waters. Belgian, French and Irish vessels all have access rights and quotas for some species in this area and some landings will be made into these countries; and
- The most valuable species in terms of landings were sole, edible crabs, monkfish, mackerel, lemon sole and lobsters.

15. Table 11.1 summarises information on the key commercial species landed from 29E4.

Table 11.1 summarises information on the key commercial species landed from 29E4

Rank	Species	% of total value of landings from 29E4	Main months of fishery	Landings since 2000	Main gear type and vessel	Main port of landing
1	Dover Sole	27%	Feb-March	Increase from 2000 to a peak in 2002 of just over £1 million and then a decline to 2004.	>95% landed by beam trawlers.	Newlyn
2	Edible Crab	9%	May-Oct	Marked decline from landings of nearly £0.5 million in 2000 to around a third of this value by 2003, followed by a slight rise in 2004.	>97% by pots.	Newlyn
3	Monkfish	8%	Feb-March	Peak landings of this species in 2001 and 2002, declining to a low in 2004.	83% landed by beam trawlers.	Newlyn
4	Mackerel	8%	May-Sept with a peak in Nov	Dramatic decline from a peak in 2000 to a tenth of that value in 2003.	94% by handline.	Newlyn and St. Ives
5	Lemon Sole	6%	Feb-March	Quite steady, slight dip in 2004.	90% by beam trawlers.	Newlyn
6	Lobster	5%	Apr-Sept	Steady apart from a poor year in 2003.	87% by pots.	Newlyn

The Hayle fishery

16. The following summarises the Hayle fishery on the basis of DEFRA landing statistics:

- The value of recorded landings into Hayle from rectangle 29E4 has peaked in 2001 and declined to around one third of that value by 2004;
- The great majority of landings (over 70%) are made between May and September;
- Pots account for over half of the value of landings whilst over a quarter are taken by otter trawls;
- Vessels of >10m take around 55% of the value of landings in Hayle while the remainder is taken by the <10m sector. No records of landings by foreign vessels are seen;
- The fishery from Hayle broadly divides into two sectors; >10m vessels using pots and <10m vessels trawling. This distinction is not absolute;
- Trawling takes place all year round, but the main potting season is during the summer months; and
- Crustaceans (lobsters, edible crabs and spider crabs) form the bulk (65%) of the value of landings into Hayle from 29E4.

The St Ives fishery

17. Although St Ives would not be directly impacted by the construction of the proposed Wave Hub and associated cables and onshore works, it is closer to the offshore deployment area than Hayle. Consequently, the pattern of fisheries from St. Ives has also been analysed.

- Annual landings from 29E4 into St. Ives have shown a decline from a peak of nearly £350,000 in 2000 to landings of around 5% of this value by 2003. A slight recovery is seen in 2004;
- In terms of seasonality, there is a clear peak of landings into St. Ives from June to September inclusive. This reflects the summer mackerel hand-line fishery that exists in this area during these months;
- The fishery is dominated over recent years by hand-lining, with potting as a secondary activity. Vessel analysis indicates that over 85% of landings into St. Ives from 29E4 are also made by the <10m sector. No foreign vessels were recorded as landing at St Ives; and
- Analysis by species shows a clear dominance of mackerel, accounting for over 80% of the value of landings. Crustacean species account for nearly all of the remainder, apart from a small catch of pollack in the early part of the year.

18. From the review of all the available data on commercial fisheries and consultation with the local industry it is clear that the study area supports a productive, well-established and diverse commercial fishery. The proposed Wave Hub project has the potential to result in adverse effects on the fisheries in this area. In order to try and assess any potential effects in more detail, all the representatives of the fishing industry consulted in August 2005 were questioned about what they felt would be the main source of disruption to commercial fishing activity should the development proceed.

19. While the general opinion was that such a scheme is desirable in theory, concern was expressed about the potential losses to fishing as a result of the scheme, and the possibility that, if successful, similar schemes could be proposed elsewhere along the north Cornwall coast.

20. The elements of the proposed scheme over which concern was expressed divide into four key categories:

- Construction of Wave Hub;
- Cable laying operations;
- Exclusion of fishing from the Wave Hub deployment area; and
- Future problems with the site to shore cable (operational phase) (e.g. interference with fishing gear).

21. The following sections assess the potential impacts associated with the construction and operational phases in detail, including all of those issues raised by commercial fishermen during the consultation exercise.

11.4 Potential impacts during construction and decommissioning

Potential for conflict between commercial fishing activity and construction works

1. The overall duration of the offshore works (including the installation of the cable) is predicted to last for a period of 55 days, although work would not be continuous during this period. Discrete items of works would take a much shorter duration of time. For example, it is envisaged that the installation of the piled anchors will take up to 20 days in total; once installed, it is envisaged that the deployment of the PCUs and TDU would be complete in up to 5 days. Under a worst case scenario, it is assumed that 10 anchors per day can be installed for the WECs, requiring approximately 27 days of piling. However, the WECs will be installed and removed throughout Wave Hub lifetime, so their impact relates to when Wave Hub is operational; therefore, this aspect of the impact is covered under Section 11.5. The cable laying will take a short duration of time, expected to be between 5 to 10 days. For the most part, the cable will be laid on the surface of the seabed and this aspect of the work will take less than 5 days. In shallower water, the cable would be buried beneath the seabed by up to 3m.

2. All construction works are likely to take place in late spring/early summer to take advantage of favourable weather conditions. For the purposes of impact assessment, it is

assumed that the construction works will occur within the March to May period.

3. The construction works for the Wave Hub will involve a number of aspects which will increase vessel movements. The TDU, PCUs and WECs will be manufactured off site and transported to the deployment area on a single deployment vessel to be installed. Prior to the deployment of the WECs, work vessels will be required to install piled anchors to which mooring chains will be attached; these chains will be subsequently attached to the WECs.

4. Details of the measures to be implemented to mitigate the potential impact of the proposed construction and decommissioning phases on navigation (including fishing activity) are described in Section 12. In short, the areas of the various construction works will be notified through Notices to Mariners. Consequently, there will be a need to avoid the area of the construction works for a limited period of time, with this area being clearly defined and notified.

5. In addition to the location of the works, construction vessels will have to be avoided when travelling to and from the construction site, although only a very limited number of vessels will be needed for the construction works at any one time. Fishing activity will not be prevented in the vicinity of the cable route, but a Notice to Mariners will be issued in order that fishermen (and other users of the inshore waters) are aware of the works and can plan their activities accordingly.

6. The potential for the proposed Wave Hub to impact on the path of other commercial vessels (i.e. other than fishing vessels) has been dealt with through the repositioning of the proposed deployment area away from commercial shipping lanes. As a consequence, although it is predicted that commercial vessels are likely to have to deviate paths on two shipping routes that pass either side of the deployment area, this deviation is a minor adjustment to the route and, therefore, the proposed scheme is not expected to give rise to an increased risk of conflict between fishing vessels and commercial shipping.

7. The main potential for conflict between the construction works and commercial fishing activity will be at the deployment area itself given that the construction works will be focussed in this area. Consultation with fishermen revealed that potting for brown crab, spider crab and lobster is the predominant activity in the vicinity of the proposed deployment area at this time of year, with some trawling undertaken for a variety of species (sole, ray and plaice). These activities also take place further inshore where tangle netting for spider crab is also undertaken and is an important activity at the time of year when the cable installation will be taking place.

8. It is concluded that the construction works will result in the temporary displacement of fishing within the vicinity of the construction works. The most significant effect will be in and around the deployment area as works in this area will take the longest period of time, with the cable laying being a relatively short term component of the construction works (less than 10 days, with the majority of the length of the cable being laid within 5 days as

it will be laid on the surface of the seabed for most of its length). Therefore, the potential for conflict with commercial fishing largely relates to works at the deployment area and specifically the effect of displacement of fishing activity.

9. It is predicted that the magnitude of the potential impact is minor negative in nature due to the short-term and temporary nature of the construction work and the relatively limited area of the inshore and offshore fishing grounds that will be affected in the context of the wider area. Nevertheless, it is also recognised that the construction works will result in the displacement of fishing activity to adjacent areas, thus increasing pressure on resources elsewhere. The presence of construction vessels, and their potential conflict with fishing activity, is assessed as part of the overall displacement effect given that construction vessels movements will be subject to Notices to Mariners.

10. The sensitivity/value of the receptor is considered to be high as the proposed deployment area and its surrounding waters constitute a proportion of an important resource to the local fishing industry. On the basis of these criteria, this impact during the construction phase is predicted to be of minor adverse significance.

Mitigation and residual impact

11. Other than notification of the construction works by Notice to Mariners, there are few measures that can be taken to mitigate this potential impact. It is proposed that a fisheries liaison system will be set up, with a fisheries liaison officer appointed. Although work will not take place over the main period for the sole fishery in the deployment area, the work will overlap with part of the season for potting and the inshore spider crab fishery in particular; this is unavoidable due to the need to take advantage of the favourable weather window.

12. Overall, it is predicted that the potential residual impact will be of minor adverse significance.

Potential effects of underwater noise generated during the construction phase on fish resources

13. As described in Section 10.4, the construction phase is predicted to generate underwater noise from a variety of sources. The most significant source of noise is expected to be piling that may be required for the installation of anchors for the WECs. It should be noted, however, that there are two broad approaches that may be adopted for the installation of the piles: percussive pile driving and drilling.

14. Drilling has a lower impact in terms of the sound level generated compared with percussive pile driving. However, for the purposes of the impact assessment, the worst case scenario of percussive pile driving is assumed.

15. The magnitude of noise generation during percussive piling is described in Section 10.4. This is an estimation of noise generated during piling works based on two scientific case studies that have been undertaken in relation to construction works in the marine environment. The actual noise generation

during construction works is dependant on site-specific conditions, but it is considered that the case studies provide a good estimation of the likely noise that would be generated by piling for the proposed Wave Hub development, should it be required.

16. It is concluded that fish are likely to show a startle and avoidance reaction to the piling in the localised area. The case study for the impact piling at Southampton did not observe a reaction in caged fish at 400m and, given that the specification of the piles used in that case study are similar to those for the proposed Wave Hub development, it is concluded that the effect will be relatively localised to the location of the piling.

17. In summary, it is concluded that the effect of piling noise will be minor negative in nature, with the receptor being of medium sensitivity. Overall, the impact is predicted to be of minor adverse significance.

Mitigation and residual impact

18. The mitigation measures described in Section 10.4 are equally applicable in this instance. In summary, the most beneficial measure is to ensure that the correct specification of piles and pile driver is used for the works. This avoids the use of excessive energy (and noise generation).

19. It is also considered appropriate to use a 'soft' start up procedure. This entails commencing piling at low energy levels and gradually building up to full impact force. It is considered that this reduces the risk of injury to marine species as it allows them to move away from the source of disturbance.

20. Overall, it is predicted that the piling will result in a residual impact of minor adverse significance.

Potential for effect on the food resource for fish during the construction phase

21. The construction phase has the potential to impact on the benthic invertebrate communities due to the laying of cables on the seabed, installation of the PCUs, TDU and interconnecting cables and installation of moorings for the WECs. Potential impacts comprise the direct effects of the proposed development (e.g. loss of communities within the development footprint) and potential indirect effects on water quality such as elevated turbidity in the water column and the potential suspension of contaminated sediments. The nature of the potential effects is described in Sections 10 (marine ecology) and Section 7 (water quality); the implications of these potential effects on the fisheries resource are described below.

22. In summary, it is concluded that the potential effects of the construction and decommissioning phases on water quality will be (at worst) of negligible significance in the short term. With respect to the potential direct loss of subtidal benthic communities, it is concluded that the impact will be localised and short term, although an impact of minor adverse significance is predicted.

23. Although the predicted direct impact on the subtidal benthic resource represents the loss of a proportion of part of the potential food resource for fish, the effect is not expected to affect feeding efficiency or fish populations and

consequently no significant impacts on fish are predicted.

Mitigation and residual impact

24. No mitigation measures are required and no significant residual impacts are predicted.

Potential effects on fishing activity during decommissioning

25. The work involved in the decommissioning phase is similar to the construction phase except that anchor piles will be cut off at the seabed rather than driven/drilled into the seabed. Accordingly, the overall effect of decommissioning on fishing activity and fish resources will be less significant given that there will be minimal generation of underwater noise and the duration of the decommissioning phase is likely to be less than the construction phase.

26. The impacts on fishing activity during decommissioning are considered to be restricted to the very short-term need to avoid the vessels that will remove the site to shore cable. The removal of the cable is expected to take only one or two days and, therefore, it is concluded that there will be no significant impact during decommissioning.

Mitigation and residual impact

27. No mitigation measures are required and no significant residual impacts are predicted.

11.5 Potential impacts during operation

Potential interference with fishing activity due to the presence of the sub-sea cable

1. During consultation with local fishermen, concern was expressed over the potential for the presence of the sub-sea cable to interfere with fishing activity. Specifically, there was concern over the potential for the establishment of an exclusion zone to fishing around the cable route. Other issues that the fishermen perceived could be problems associated with the cable are summarised as follows:

- Snagging of trawl gear, particularly if the cable is suspended between two high points;
- Snagging of pots during hauling; and
- The potential effects of electric fields emitted by the cables on elasmobranchs.

2. The latter potential effect is discussed in detail in Section 10.4.

3. In terms of the actual cable laying itself, the cable will be laid on the seabed where rock is exposed at the surface. This will be approximately 17km of the 25km cable route. Over this length, the exposed cable will be armoured by an outer layer/sheath of steel; it will not be armoured using rock. Inshore, where the sediments are predominantly sand, the cable will be buried up to 3m below the seabed surface. This will be approximately 8km of the 25km cable route.

4. As described in Section 2, a number of measures will be integrated into the cable installation method to protect the cable from damage and to protect the interests of other marine users, particularly with regard to spans where cable burial will not be possible and the uneven nature of the seabed means that there is the potential that the cable may be left hanging over gaps between obstructions. It is the c.20km to c.23km section of the cable route where the ridges are approximately perpendicular to the cable route and there is the most potential for spans. Distances between ridges generally vary between 5m and 30m, with gentle inclined troughs reaching maximum depths of 2m but more usually between 0.5m and 1.0m. Given that the cable does have some degree of flexibility, there will be some degree of cable sag into the troughs, reducing spanning heights.

5. Given the potential for cable spans, the installation method for the cable will be based on an avoid-reduce-remedy approach to reducing spans:

6. Spans will be avoided by maximising the routing the cable over sediment, by burying the cable where possible, and by carefully aligning the cable on bare rock to position the cable in such a way that it is in physical contact with the seabed by following the troughs between ridges as far as is possible.

7. Spans will be reduced by considering specification changes to the cable flexibility to enable the cable to sag more into troughs (particularly for the c.2.5km length of the cable route beyond 20km offshore where the ridges run perpendicular to the route of the cable) and specifying that the cable be laid to defined levels of slack as excess tension could encourage spanning.

8. Spans will be remedied by undertaking post-installation inspections (using a ROV) and partial lift and repositioning of the cable where possible. Should repositioning not be possible, mitigation measures may be applied for spans where there is the evidence of the possibility trawling or anchoring affecting the cable such as physical measures, (e.g. rock covering or the use of concrete mattresses) or navigation guidance measures (e.g. specific warnings on navigation charts). Accordingly, there should be minimal interference of the cable with fishing due to spans.

9. It is confirmed that no safety zone or exclusion zone of any form (e.g. an ATBA) will be established along the cable route. Therefore, during the operational phase there will be no form of restriction on fishing over the entire length of the cable route.

10. In areas where the cable is exposed on the seabed (i.e. rocky areas) many of the otter trawlers would merely shorten their towing warps, increase engine speed and “fly” their gear over the cable. Beam trawlers may just tow over it regardless, if they perceive it as offering little or no threat to their gear. If fishermen consider that the presence of the cable on the surface of the seabed represents a threat to their gear, then trawling is likely to be avoided over the cable route.

11. The position of the cable will be clearly identified on Admiralty Charts and made known to fishermen and so it will be

possible to avoid the cable if it is considered by fishermen that there is a risk of damage to their gear.

12. Although fishing will not be restricted along the cable route, it is considered that its presence represents an adverse effect on trawling activity in that the pattern of fishing could be influenced. It should be noted, however, that due to the rocky seabed along much of the cable route and restrictions on the size of vessels permitted to fish waters inside the 12 mile limit, trawling is not a significant method of fishing in this area.

13. Overall, it is concluded that the magnitude of the potential impact is negligible to minor adverse, with the sensitivity of the receptor being low. It is predicted that the potential impact will be of minor adverse significance.

Mitigation and residual impact

14. Other than the remedial measures built into the design, specification and installation method to avoid cable spans, and notifying the position of the site to shore cable, no mitigation measures are possible and the residual impact is predicted to be of minor adverse significance.

Exclusion of fishing activity in and around the Wave Hub deployment area

15. Through the consultation exercise undertaken with commercial fishermen, the most significant concern related to the potential for exclusion of fishing activity in and around the deployment area for the Wave Hub. It was apparent that the establishment of any form of exclusion zone would have a number of implications for fishing activity, comprising the following:

- Prevention of fishing activity within any exclusion zone that may be established;
- Increased fishing pressure on adjacent fishing grounds due to displacement of fishing from the proposed Wave Hub deployment area;
- Forcing static gear fishermen out of areas that are considered 'refuges' (i.e. areas where the potential for damage to their gear from trawlers is considered minimal; and
- Potential for increased conflict between fishing vessels and other commercial vessels should the latter be forced to avoid the proposed Wave Hub deployment area.

16. During the operational period of the WECs, navigation rights and safety zones will be declared around the (arrays of) WECs, pursuant to Section 95 of the Energy Act 2004. Extinguished navigation rights will extend to the WECs and their lateral movement. Each safety zone will extend up to a maximum of 500m from the outer edges of the WEC(s) around which it is to be established and it will be a criminal offence to enter the safety zone without permission. Therefore, although no formal 'exclusion zone' for fisheries will be established, extinguished navigation rights, the presence of safety zones around the WECs, and the fact that infrastructure such as PCUs,

TDUs and interconnectors will be in place, will, in effect, prevent fishing activity taking place in this area.

17. It should be noted that it is only in the safety zones that fishing will not be permitted; areas of the deployment area that are not within the safety zones will not be regulated, although they will be notified as being within any ATBA that is established for the deployment area.

18. If this potential impact is assessed in more detail and in the wider context, it could be argued that even if fishing in the area described above is prevented entirely over its maximum area of 15km^2 (i.e. the worst case scenario as described in Section 11.2), resulting in a 100% loss of value to the fishery from this area, a value of only £12,035 per annum would be lost. This represents just over 0.382% of the total value of landings from ICES statistical rectangle 29E4, which would be a negligible impact on the financial value of the wider fishery as a whole. However, it is extremely difficult to assign precise financial values in this manner and such an analysis is not sufficiently sensitive to take account of more localised impacts on individual fishermen who derive a greater proportion of their income from fishing within the proposed deployment area.

19. In reality, any disruption to fishing in this area may actually have a significant impact upon a few individual vessels that rely on this area for a large proportion of their landings, and subsequent profit. Further consultation with vessels identified as fishing in the proposed deployment area for a large proportion of the year will be required to explore this impact in more detail.

20. The displacement of vessels from the Wave Hub deployment area to other nearby areas will occur, increasing the fishing pressure on these grounds. As the closed area off Trevose Head has been enforced again in 2006, congestion may occur in the spring sole fishery.

21. Additionally, some parts of the proposed Wave Hub deployment area are effectively refuges where static gear fishermen, particularly offshore potters (approximately 2-3 vessels), have established fishing grounds and can fish with little fear of having their gear damaged or destroyed by those trawlers permitted to fish within the 12nm limit towing through it. It should, however, be noted that the majority of trawling activity is outside the 12nm limit. Many beam and otter trawlers from ports such as Newlyn fish in this area particularly at certain times of year, such as during spring. Estimates based upon consultation and review of DEFRA data suggests that between 20-30 Belgian vessels traditionally fish in this area during the January to March period each year, although recent reports suggest that this number has declined significantly during 2005. In addition, 2 vessels from Newlyn and 3 from Plymouth are reported to regularly fish in the area. The total number of UK beam trawlers that are of small enough engine capacity to work inside the 12 mile limit has reduced to around 20.

22. If this static gear fishing ground is lost, it may prove difficult for these operations to establish elsewhere in heavily trawled areas

(outside the 12 nautical mile limit) or in areas where existing static gear fisheries are already established (inside the 12 nautical mile limit).

23. In summary, the proposed deployment area and the establishment of safety zones is predicted to have the following impacts on local commercial fishing activity:

- A small number of vessels that fish static gear (specifically pots and, to a lesser degree, tangle nets) will potentially lose grounds and find it difficult to re-establish in the wider area (trawling activity outside 12nm and other established static gear fisheries within the 12nm limit);

- Larger potting vessels that are forced away from the deployment zone may move onto the middle grounds (i.e. further inshore from the deployment area) and compete for space with smaller boats that are already established in this area;

- Beam trawlers who regularly fish in this area in the period January to March, being relatively manoeuvrable, will be able to work around the edges of the deployment area, but may still lose areas of traditional ground in and around the proposed deployment area.

- Certain otter trawlers who regularly fish in this area in the period January to March and are often more constrained in their direction of towing due to the strong tides in the area may have to take a wide sweep to avoid the area and may consequently lose a larger part of their fishing area;

- Adjacent trawling grounds may become more heavily fished, and it will become increasingly difficult for static gear boats to find an area to fish; and

- The reduced fishing pressure within the deployment area may produce a beneficial effect on local fish resources which may, in turn, lead to benefits to commercial fishing vessels in the wider area.

24. Given the combination of the above consequences of the proposed Wave Hub development on commercial fishing activity, it is predicted that the impact will be of moderate negative magnitude. The receptor sensitivity is medium given that, although a relatively limited area will be affected, the proposed deployment area is of importance to the local fishing industry and, for a small number of fishermen, the deployment area is of particular importance. It is concluded that the overall impact will be of minor to moderate adverse significance.

Mitigation and residual impact

25. The prevention of fishing within part of the Wave Hub deployment area is unavoidable and there are no mitigation measures that can be put in place. The prevention of fishing would be expected to benefit fish resources within the area in which fishing is excluded as part of the deployment area will become a *de facto* No Take Zone,

and this has the potential to benefit fish resources outside the safety zones. However, the degree to which this potential beneficial effect would occur is difficult to predict.

26. It is concluded that the residual impact associated with the exclusion of fishing within the safety zones, and the knock on effects for fishing in the local area, will be of minor to moderate adverse significance.

12 Navigation

12.1 Introduction

1. During the consultation undertaken during the preparation of the *Environmental Scoping Study* (Halcrow, 2005) general concern was raised (by the Maritime and Coastguard Agency) over the potential for interference with commercial shipping and associated health and safety issues. In addition, the Royal Yachting Association highlighted the potential for conflict between recreational vessels and the proposed Wave hub development. Further concerns were raised by fishermen during the EIA process with respect to the potential for conflict with their activities.

2. In light of the above, Anatec were commissioned to perform a shipping and navigation assessment of the proposed development. The resulting Wave Hub *Navigation Risk Assessment* (Anatec, 2006) informs the EIA process and is included at Appendix L.

3. This section considers the potential impacts associated with the construction, operation and decommissioning of the Wave Hub on commercial and recreational navigation and is based on the findings of the Wave Hub *Navigation Risk Assessment*. This section summarises the methodology for the assessment, its findings and the potential for impact associated with the proposed development.

12.2 Methodology

Guidance

1. The *Navigation Risk Assessment* was undertaken in accordance with the following guidance:

- MCA (2004) Marine Guidance Note 275; and
- DTI (2005) methodology for assessing the marine navigational safety risks of offshore windfarms.

2. MCA Marine Guidance Note 75 highlights issues that need to be taken into consideration when assessing the impact on navigational safety from offshore renewable energy developments proposed for United Kingdom internal waters, territorial sea or in a Renewable Energy Zone (when established) beyond the territorial sea.

3. The DTI methodology is to be used as a template by developers in preparing their navigation risk assessments, and for government departments to help in the assessment of such developments. It is noted that whilst this has been written for offshore windfarms, the same principles can be applied to wave energy developments.

Consultation

4. During the preparation of the navigation assessment, consultation exercises were carried out during both the consultation and the assessment phases with organisations with an interest in navigational issues. A list of those organisations consulted during the

course of undertaking the navigation risk assessment is provided in Appendix L.

5. It should be noted that in addition to consulting fisheries organisations and local fishermen with respect to navigation issues, extensive consultation was also undertaken as part of the commercial fisheries study with respect to the potential effect on fisheries resources and fishing activity (which also considered navigation).

Maritime traffic survey

6. A key part of the navigation assessment is a maritime traffic survey. This 28 day survey used a combination of shore-based radar, automatic identification system (AIS) and visual observations. The survey was carried out over two 2-week surveys periods (20 May to 3 June 2005 and 29 July to 12 August 2005).

7. The results of the maritime traffic survey were used to identify shipping routes in the vicinity of the proposed Wave Hub deployment area, vessels type and destination. Information gathered from the survey on recreational vessel activity was supplemented with information published by the Royal Yachting Association (RYA), consultation with the RYA and Cruising Association. In formation gathered on fishing vessel activity was supplemented with information gained through the commercial fisheries study.

Worst case scenario

8. No worst case scenario was applied to impacts concerning navigation for the purposes of the EIA process. Some impacts relate to the sub-sea cable, for which there is no worst case scenario.

9. The risk of ship to WEC collisions is based on ships entering the boundary of the deployment area. This is a more conservative approach than assessing the risk of a collision with a WEC or array of WECs within the deployment area, and therefore a worst case WEC layout has not been used for impact assessment.

10. In addition, device-specific risk assessments will be required for each of the WECs to be deployed at Wave Hub so that their specific characteristics can be evaluated with respect to navigation prior to deployment, as described in the *Navigation Risk Assessment* (see Appendix L).

11. Ship to ship collision and re-routing risks are not covered by a worst case scenario because the routes would be beyond the deployment area and potential safety zones, and therefore a worst case scenario safety zone extent has not been used for impact assessment.

12.3 Baseline conditions

Local ports and harbours

12. There are no merchant shipping ports near to the proposed Wave Hub deployment area. The closest ports are small recreational and fishing harbours located at St. Ives and Hayle. Vessels anchor in St. Ives Bay (the best anchorage lies 5 cables east-south-east of St. Ives Head) in a depth of 16m.

Routeing measures

13. There is an IMO-adopted routeing measure in the form of the TSS off Land's End, between Seven Stones and Longships, located in the order of 16nm SW of the Wave Hub deployment area. The location of the TSS relative to the Wave Hub is presented in Figure 12.1. The northbound lane of the TSS is nearest to the Wave Hub deployment area.

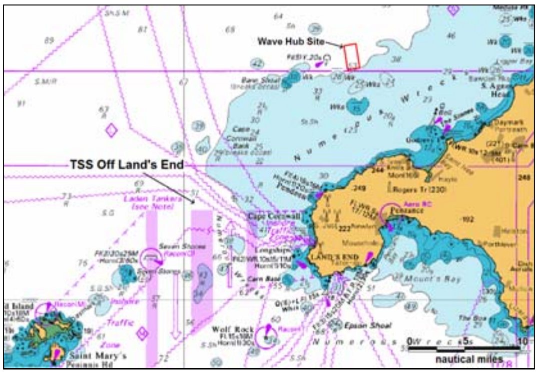


Figure 12.1 Location of TSS relative to the Wave Hub deployment area

Exercise areas

14. There are no charted submarine exercise areas in the vicinity of the Wave Hub deployment area. The Trevose Head Firing Range Firing Practice Area intersects the north-east corner of the deployment area.

Findings of the maritime traffic survey

15. The average number of tracks per day passing within 10 nautical miles of the Wave Hub deployment area was 44, with 79 tracks on the busiest day and 18 tracks on the quietest day. The survey revealed that the majority of tracks were made by cargo vessels (58%) and tankers (16%) (see Figure 12.2).

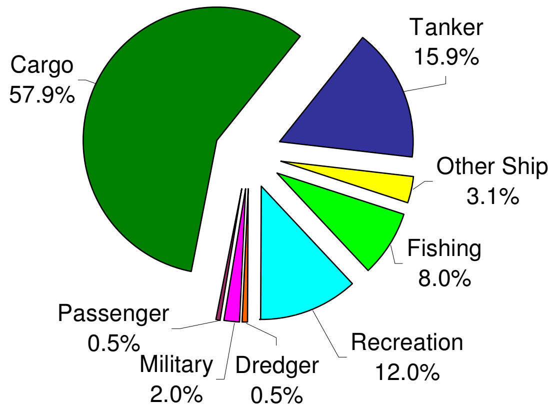


Figure 12.2 Vessel types identified within 10 nautical miles of the Wave Hub deployment area during the survey

16. A total of 122 tracks were identified to pass within the Wave Hub deployment area boundary (an average of 4 to 5 vessels per day) during the survey. Excluding unspecified vessels, the vast majority were cargo vessels (86%), with a small proportion of tankers (4%), fishing vessels (6%) and recreational vessels (1%).

17. From the survey, six main routes were identified passing in the vicinity of the proposed deployment area. The distribution of traffic on these routes has been analysed to identify the route mean positions and widths. The widths were defined based on the boundary within which 90% of the traffic passes on that route. The boundaries of the lanes encompassing 90% of the ships on the six routes overlaid on the AIS survey tracks is shown in Figure 12.3.

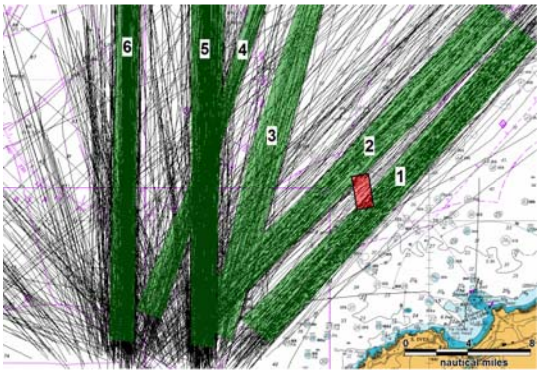


Figure 12.3 Boundaries of shipping lane width for the six main routes identified

18. All the route mean positions pass outside of the Wave Hub deployment area but it can be seen that Routes 1 and 2, heading between the Bristol Channel and the TSS off Land's End, pass very close to the Wave Hub deployment area and part of these shipping lanes pass through the deployment area.

Recreational vessel activity

19. In the area around the deployment area there are few marinas; the nearest recreational vessel facilities are at St. Ives and Hayle harbours. There are no general sailing areas or racing areas identified in the area. Medium use recreational routes (defined as popular routes on which some recreational craft will be seen at most times during summer daylight hours) are identified inshore close to St Ives Head and offshore outside the 12 nautical mile limit (i.e. well away from the Wave Hub deployment area).

20. During the maritime traffic survey, 98 recreational vessels (including 70 yachts) were tracked. Only one track (identified to be a yacht) passed through the deployment area. The survey revealed that the majority of the other vessels passed between the deployment site and the coast.

Fishing vessel activity

21. A moderate level of fishing activity (65 vessels) was observed in the overall survey area although this was concentrated near-shore with just five fishing vessels passing through the proposed deployment area.

22. For the purposes of the navigation assessment, an analysis of the fishing vessel density in the area of the Wave Hub deployment area using the latest 3-years of surveillance data presented in the Wave Hub *Commercial Fisheries Study* (2002 to 2004), which covers vessels of all sizes and nationalities, was made.

23. The analysis showed that in the ICES sub-square 29E4/1 as a whole, the main gear types sighted were beam trawlers (38%), unspecified trawlers (33%) and potters (21%). The predominant vessel nationalities were UK (58%), French (31%) and Belgian (11%). In terms of activity, 65% of sightings were engaged in fishing, 27% were steaming (on passage) and 8% were laid stationary (vessels at anchor or pair vessels whose partner vessel is taking the catch whilst the other stands by).

24. A single fishing vessel was sighted within the Wave Hub deployment area. This was a French-registered potter recorded in November 2002 on passage through the area (not engaged in fishing).

12.4 Potential impacts during construction and decommissioning

Potential for conflict between construction activities and navigation

1. The construction and decommissioning of Wave Hub infrastructure and WEC devices has the potential to result in conflict with navigation due to the presence of construction vessels.

2. The composite issues relating to the construction works were covered in the hazard identification workshop that was held for the proposed scheme. During the workshop it was acknowledged by consultees that the various devices would be installed in a specific way and therefore that different devices may have different requirements with respect to their installation. In light of this, it is recognised that device-specific risk assessments will be needed prior to the installation of WEC devices and this will also need to include the contractors undertaking the work.

3. The construction and decommissioning works will be planned and managed using principles which minimise the risk to navigation to a level that is as low as reasonably practicable to ensure the safety of those involved in the work and other maritime users. This will include the selection of contractors and the working vessels to ensure they are competent and capable of undertaking the work and also following offshore industry guidance and best practices.

4. As the details of the WEC devices cannot be precisely identified at this stage, the risk to navigation will be minimised by undertaking device-specific risk assessment prior to their installation. The objective of the workshops will be to identify all of the different activities which will be taking place and identify any potential hazards as well as appropriate mitigation measures and operating procedures relevant to the selected vessels and construction methods.

5. The above approach to the construction and decommissioning works will ensure that all practicable mitigation measures are put in place in order to minimise adverse impacts on navigation.

6. The installation of the Wave Hub offshore infrastructure is expected to take 55 days to complete, ideally spread over the late spring and early summer months. Vessels will not be working continuously during this period due to pre-construction preparation and downtime caused by inclement weather. In fact, of the 55 days offshore work, the TDU installation, PCUs installation, cable-laying, cable inspection and (if necessary) repositioning is expected to take around 20 days.

7. Given the above procedure for risk assessment and route for implementation of device-specific risk assessment, and short-term nature of the construction and decommissioning work, it is predicted that the risk to navigation will be negligible and no significant impacts are predicted.

Mitigation and residual impact

8. It is assumed that the device-specific risk assessments that will be required will lead

to the identification of mitigation measures to minimise the risk to navigation to a level that is as low as reasonably practicable. This assumption has been taken into account in the initial assessment of impact and, therefore, no significant residual impact is predicted.

12.5 Potential impacts during operation

Potential for a commercial effect on shipping as a consequence of re-routeing

1. As illustrated in Figure 12.3, the centre lines of two shipping lanes lie in close the proposed deployment area, and part of these lanes pass within the deployment area. As a consequence of the proposed Wave Hub, it is anticipated that these vessels navigating within Routes 1 and 2 will have to increase their clearance from the deployment area. The extent of this clearance and, therefore, passing distances from the deployment area will depend on the marking of the site and navigational advice issued by authorities, as well as the individual decisions of Masters on passing ships, which will vary based on type and size of ship, weather and tide conditions, sailing schedule, etc.

2. From Anatec's experience of analysing vessels passing other offshore developments in the North Sea and Irish Sea, it is anticipated that the average closest point of approach of Routes 1 and 2 from the site will increase by the order of 1 nautical mile.

3. A plot of this anticipated effect on the centrelines of the main shipping lanes (Routes 1 and 2) is presented in Figure 12.4. The other main routes (Nos 3 to 6) are not expected to be directly affected as they pass an average of over 5 nautical miles from the nearest part of the deployment area.

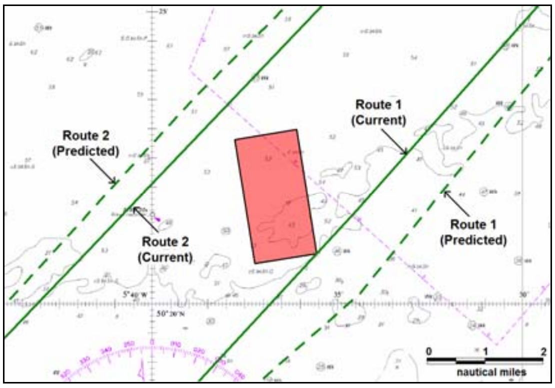


Figure 12.4 Anticipated impact of Wave Hub deployment area on Routes 1 and 2

4. In terms of the additional sailing distances for commercial shipping, given the typical voyages of vessels on Route 1 and 2 (e.g. Bristol to Spain) and the relatively small displacement of the routes, there is considered that there will be no significant impact on commercial shipping as a result of the Wave Hub deployment area being located at this site.

Mitigation and residual impact

5. No mitigation measures are required and it is predicted that there will be no residual impact.

Potential for a vessel to come into proximity with the deployment area as a consequence of having to deviate course due to interaction with other vessels

6. Analysis was performed of vessels passing in the vicinity of the deployment area to assess the potential for interaction between

traffic, in particular between northbound traffic to Milford Haven (Route 3) and south-west-bound traffic out of the Bristol Channel heading for the TSS off Land's End (Route 2). Potential interaction between these two lanes was highlighted as a concern during the consultation phase as the northbound vessels would be required by the Collision Regulations to give way, which could lead to these vessels moving to the east (i.e. altering course to starboard) towards the Wave Hub deployment area.

7. To investigate this, a "gate" was defined, as shown in Figure 12.5; if traffic on both these lanes passed through this gate at the same time, a give-way scenario could arise.

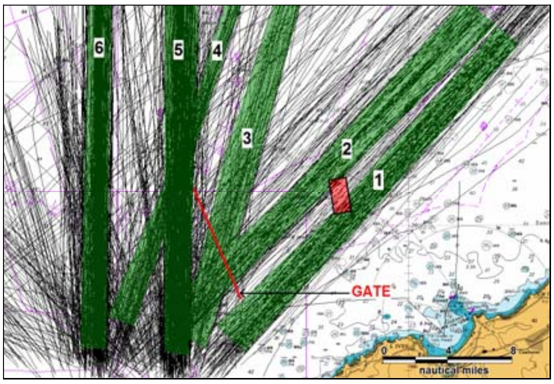


Figure 12.5 "Gate" used to analyse shipping interaction on Routes 2 and 3

8. The analysis indicates that the traffic on Routes 2 and 3 is fairly well dispersed over the 24-hour period, with the higher frequency of passages on Route 2. Given this, and the relatively low volumes of shipping on the routes, in particular Route 3 to Milford Haven, this analysis indicates that there is no obvious threat of a northbound vessel having to give-way to successive vessels heading south-west and hence come into proximity of the Wave Hub deployment. Consequently, no significant impact is predicted.

Mitigation and residual impact

9. No mitigation measures are required and it is predicted that there will be no residual impact.

Assessment of risk of vessel-to-vessels collisions

10. In order to predict the potential impact of the proposed Wave Hub development on the risk of vessel-to-vessel collisions it is necessary to compare the existing predicted risk with the predicted risk with the presence of the development.

11. A prediction of the existing vessel-to-vessel encounters has been carried out by replaying a fortnight of survey data at high-speed. It was predicted that most encounters occurred well to the west of the proposed Wave Hub deployment area in the higher traffic density area between the TSS off Land's End and The Smalls TSS. There were also high density areas further inshore near St Ives, where non-merchant traffic is highest (fishing and recreation).

12. The density of encounters in the vicinity of the Wave Hub was low to moderate. Within the deployment area, there were four encounters recorded over the period analysed.

13. Based on the existing routeing and encounter levels in the area, Anatec's COLLRISK model has been run to estimate the existing vessel-to-vessel collision risks in the local area around the Wave Hub deployment area. The traffic details input to the model are based on the survey analysis. Based on the modelling of the area, the baseline (existing) vessel-to-vessel collision risk level was estimated to be in the order of 1 major collision in 77 years.

14. The revised traffic pattern following the proposed Wave Hub development has been estimated based on the review of impact on navigation (see Figure 12.4). This assumes effective mitigation in the form of information distribution about the developments to shipping through Notices to Mariners, updated charts, liaison with ports, etc.

15. Based on vessel-to-vessel collision risk modelling of the revised traffic, the collision risk with the Wave Hub development in place was estimated to reduce slightly to 1 major collision in 94 years. The slight decrease is mainly due to the anticipated separation of traffic on Routes 1 and 2 in the vicinity of the Wave Hub, which reduces the probability of head-on encounters / collisions between this traffic which is heading in opposite directions. This outweighs the impact of a slight increase in overtaking encounters / collisions due to narrowing of Routes 1 and 2.

16. Overall, a potential impact of minor beneficial significance is predicted.

Mitigation and residual impact

17. No mitigation measures are required and it is predicted that there will be a residual impact of minor beneficial significance.

Assessment of the potential for ship collision with WEC devices

18. There are two main scenarios for passing ships colliding with the proposed WEC devices, as set out below.

Powered ship collision

19. The main risk of powered collision is from watch-keeper failure on the bridge of the ship. Based on modelling of the anticipated ship routeing pattern with the presence of the development (see Figure 12.4), the risk of collision is estimated to be approximately 1 in 177 years. This compares to the historical average for offshore installations on the UK continental shelf of 1 in 1,900 years. The risk associated with the proposed development is estimated to be an order of magnitude higher than for offshore installations generally, which reflects both the traffic density passing nearby and the large exposed area of the Wave Hub used in the modelling.

20. It should be noted that in terms of collisions with specific devices, these will occupy only a proportion of the site area. Therefore, the probability of collision on a device-specific basis is likely to be significantly lower.

21. The navigation assessment concludes that the frequency of an errant ship under power deviating from its route to the

extent that it comes into proximity with the Wave Hub deployment area is considered to be low.

22. On the basis of the above it is concluded that the magnitude of the impact is of low magnitude. Should a collision occur, it could (potentially) be highly significant although this will depend on the nature of the collision (e.g. size of the vessel, speed of the collision, weather conditions, etc). However, on the basis of the predicted low risk of collision the potential impact is considered to be of minor adverse significance.

Drifting ship collision

23. The risk of a ship losing power and drifting into a Wave Hub structure was modelled as part of the navigation assessment. This model is based on the premise that propulsion on a vessel must fail before a vessel will drift. The model takes account of the type and size of the vessel, number of engines and average time to repair in different conditions. Further details of this modelling are provided in the Wave Hub *Navigation Risk Assessment* (see Appendix L).

24. Based on local experience, anything adrift around the proposed Wave Hub deployment area tends to drift with the prevailing tidal currents (north-east/south-west) and is slowly blown inshore by the onshore winds.

25. The annual drifting ship collision frequency with the Wave Hub generic area based on wind-dominated drift (worst-case) was estimated to be an average of one drifting ship collision per 3,700 years. The relatively low risk estimate reflects the fact this is generally a low probability event. There have been no reported 'passing' drifting ship collisions with offshore oil and gas installation on the UK continental shelf in over 6,000 operational-years. Whilst a large number of drifting ships have occurred each year in UK waters, the vessels have been recovered in time (e.g. anchored, restarted engines or taken in tow).

26. It is again noted that in terms of collisions with specific devices, these will occupy only a proportion of the site area; therefore, the probability of drifting ship collision on a device-specific basis is likely to be significantly lower.

27. In light of this predicted very low level of risk, no significant impact is predicted. However, as described for powered ship collision, should a collision occur the outcome could potentially be highly significant.

Mitigation and residual impact

28. A range of measures are proposed in order to minimise the potential for collision/interaction between shipping and the Wave Hub deployment area and WEC devices. These measures all relate to navigational control and are described below:

Marking of the Wave Hub deployment area

29. It is likely that the deployment area itself will be marked. Based on the site layout, it is likely that four lighted cardinal buoys will be used to mark the four corners of the site. The buoys and their moorings will require to be designed to withstand the sea conditions in the

area. It is likely that the buoys will be of a size equivalent to the standard Class 2 buoy used by Trinity House (about 2 to 3 metres in diameter with a focal plane of 4 to 5 metres). The lights on such buoys have a nominal range of 5 nautical miles.

30. In addition it is likely that a Racon and/or automatic identification system (AIS) Aids to Navigation units will be required. There may also be a requirement to have additional cardinal buoys. The detail of the markings required will be provided by Trinity House. Whilst an AIS transceiver is proposed as a risk reduction measure, the necessary UK legislation to declare AIS as an aid to navigation has not been put in place, although this is currently being addressed.

Marking of individual structures

31. As the details of individual devices are as yet unknown, the markings of each individual device will need to be agreed with Trinity House. This will include requirements such as:

- Lighting;
- Passive radar reflectors;
- Retro reflecting material;
- AIS;
- Foghorn; and,
- Painting of device above waterline.

32. In order to avoid confusion from a proliferation of Aids to Navigation, full consideration will require to be given to the use of synchronised lighting, different light characters and varied light ranges.

Inspection, maintenance and contingency plans for aids to navigation

33. A reliable inspection, maintenance and casualty response regime will need to be put in place. Any aids to navigation will be subject to the Trinity House inspection and audit regime in a similar way to that applied to other locally provided aids to navigation and those exhibited at wind farms and other offshore installations.

34. The aids to navigation also need to meet the levels of availability that will need to be determined bearing in mind the location relative to shipping and relative importance, and the appropriate maintenance regime put in place accordingly. This will include having the necessary Aid to Navigation spares on hand and provision will be made at the design stage, where necessary, to ensure safe access for repair / replacement of aids.

Area to be avoided

35. In order to minimise risks to vessels navigating in the area and the devices, it is proposed that the area within which the devices are to be located is to be designated as an ATBA. An ATBA is a routeing measure comprising an area within defined limits in which either navigation is particularly hazardous or it is exceptionally important to avoid casualties and which should be avoided by all ships or certain classes of ships

36. The ATBA would essentially be the 4km x 2km area within which the devices will

be located and marked with navigational buoys at the four corners together with additional markings and lighting as required by Trinity House. The ATBA would be marked on all hydrographic charts covering the area. The effectiveness of the ATBA may be evaluated by periodic shipping surveys in the area.

Safety zones

37. In addition to the ATBA being in place for the deployment area in general, the consent application for Wave Hub requests that the DTI consider declaring safety zones around each individual WEC or array of WECs. It is expected that the safety zones will take into account the potential for the lateral movement of WECs and associated infrastructure and can extend for up to 500m from the WEC.

38. Safety zones will be established under the provisions of the Energy Act 2004 and define an area in which all vessels, other than authorised vessels, vessels seeking refuge in an emergency or emergency service vessels themselves, are not allowed to enter. Therefore, all fishing activity will be prohibited within the defined safety zones.

39. The existence of the safety zones will be published electronically and via Notices to Mariners. It is important for the Wave Hub deployment area and associated safety zones to be marked on hydrographic charts together with an appropriate note to advise / caution vessels navigating in the area.

40. The implementation of the above navigational control measures will ensure that all practicable measures have been taken to minimise the risk to navigation due to the presence of the Wave Hub development. Although the presence of the development inevitably represents an increased risk to shipping in the area, it is concluded that the above mitigation measures will reduce the risk to one of negligible magnitude.

41. Overall, it is predicted that there will be no significant residual impact.

Risk of fishing vessel collision

42. To provide an estimate of the collision risks associated with fishing vessels operating near the Wave Hub or steaming past the area, fisheries surveillance data has been used. Whilst surveillance sightings can only be considered a relative indicator of fishing activity, providing a series of snapshots of fishing activity within a defined area over time, it does provide a basis for calibrating a risk model of fishing vessel collisions in UK waters.

43. Anatec’s COLLRISK fishing vessel risk model has been calibrated using surveillance data for the UK along with offshore installation operating experience in the UK (oil and gas) and the experience of collisions between fishing vessels and UK continental shelf offshore installations (published by HSE). The ‘exposed target area’ is assumed to be the overall deployment area of the Wave Hub (i.e. 4km x 2km). This is obviously much larger than a normal offshore structure; therefore, the results should be viewed as indicating the frequency of fishing vessel incursions within the site as opposed to collisions.

44. Using the fishing vessel density and the 'exposed target area' as input to the model, the annual frequency of fishing vessel infringements was estimated to be 4 per year.

45. On the basis of the above, it is concluded that, without mitigation, the risk of fishing vessels infringing the deployment area is low and, in terms of risk, this represents a potential impact of minor adverse significance. However, as noted above, the consequence of a collision between a fishing vessel and a device could be highly significant.

Mitigation and residual impact

46. The various navigation control measures described above are applicable here, and no additional measures that are specific to fishing activity are proposed. With the implementation of the above mitigation measures, it is concluded that the frequency of vessel infringements will be reduced, and potentially avoided entirely. Consequently, it is predicted that there will be no significant residual impact.

Risk of collision between recreational vessels and the Wave Hub infrastructure

47. The main collision hazard from recreational vessels interacting with Wave Hub is a vessel colliding with a device either by becoming becalmed and drifting into the site or due to watchkeeping failure or navigational error and routeing through the site. In good conditions, the Wave Hub site (e.g. devices, markings and/or navaids) should be visible, especially as most activity occurs during daylight hours. In this case vessels, if competently skippered, will be able to navigate safely to avoid the site. Even if a vessel were to get into difficulty, most should be able to keep clear of the devices or anchor or moor if necessary to avoid drifting closer to the devices whilst they fix the problem or call for assistance.

48. The main risk of collision is considered to be in bad weather, especially poor visibility, where a small craft could fail to see the devices and inadvertently end up closer than intended. The risk of small craft being in the area during bad weather is reduced by the fact that most craft are fitted with radio receivers and VHF so will be able to listen to regular broadcasts of the weather forecast by the BBC and hourly by the Coastguard. It is also standard practice for harbours, marinas and clubs to post weather forecasts on notice boards.

49. Given the ready availability of weather forecasts and growing use of GPS, the risk of a vessel being in proximity to the Wave Hub in bad weather is considered to be low. In this scenario, a vessel unable to make way from the Wave Hub and unable to anchor due to water depth or adverse conditions, and therefore at risk of collision, may alert the Coastguard using VHF or flares.

50. Overall, a potential impact of minor adverse significance is predicted given that the risk of a collision is low.

Mitigation and residual impact

51. The various navigation control measures described above are also applicable here. Trinity House will consider the needs of small leisure craft by taking into account the

likely traffic type and density when determining the correct level of marking for the works for the site. Notification of the development to the recreational craft community will be widespread and information will be promulgated to yacht clubs, marinas, harbour masters, etc.

52. With the implementation of the above mitigation measures, it is concluded that the frequency of vessel infringements will be reduced, and potentially avoided entirely. Consequently, it is predicted that there will be no significant residual impact.

Potential for interaction between the site to shore cable and anchoring/trawling

53. The cable will be laid between the deployment area and the sub-station at Hayle. It is proposed that the cable will be buried between 2m and 3m in areas where the seabed is not hard rock. Given that there are surface sediments within St Ives Bay, it is proposed that the cable will be buried in the near-shore waters and will lie on the surface of the seabed further offshore. Any exposed cable, and cable not buried to sufficient depth, could be subject to damage from anchoring and trawling and/or pose a risk to fishing vessels which snag their gear on the cable.

54. In terms of anchoring, there is very little shelter along this coast and St. Ives Bay is one of few areas where vessels can shelter and anchor. During local consultation, it was stated that in bad weather up to 20 vessels could be anchoring in the area at any one time. Further consultations with Coastwatch at St. Ives stated that in recent years the maximum they have observed tends to be 3 to 4 and typically 1 to 2 merchant vessels with the occasional naval vessel or Trinity House tender. Figure 12.6 shows the position for anchoring as given in the Admiralty Sailing Directions for the area.

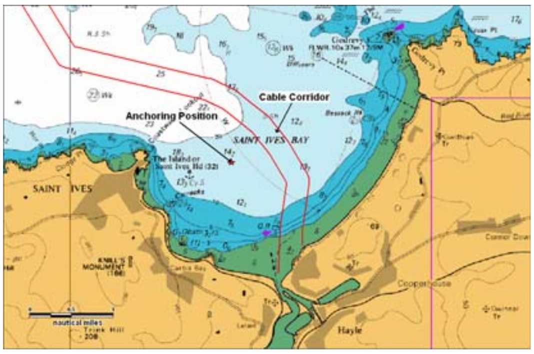


Figure 12.6 Anchoring position within St. Ives Bay relative to proposed corridor for the site to shore cable

55. Although the proposed cable route is to the east of the anchor position, vessels could anchor further to the east. Therefore, if not buried, the cable route will be exposed to anchoring and at risk from dragged anchors. Therefore, it is important that the cable is buried below the seabed in St Ives Bay (as proposed).

56. In addition to anchoring, the risk of fishing gear snagging on the cable also exists. At worst, this could lead to capsize of a vessel (e.g. if trawl doors were to be trapped under cable as a result of a span in the cable). However, following the installation of the cable it is proposed that the cable route will be surveyed to ensure that the cable is not suspended between two high points on the seabed. During this post-installation

inspection, if there are any spans in the cable then these will be rectified.

57. As described in Section 2, a number of measures will be integrated into the cable installation method to protect the cable from damage and to protect the interests of other marine users, particularly with regard to spans where cable burial will not be possible and the uneven nature of the seabed means that there is the potential that the cable may be left hanging over gaps between obstructions. It is the c.20km to c.23km section of the cable route where the ridges are approximately perpendicular to the cable route and there is the most potential for spans. Distances between ridges generally vary between 5m and 30m, with gentle inclined troughs reaching maximum depths of 2m but more usually between 0.5m and 1.0m. Given that the cable does have some degree of flexibility, there will be some degree of cable sag into the troughs, reducing spanning heights.

58. Given the potential for cable spans, the installation method for the cable will be based on an avoid-reduce-remedy approach to reducing spans:

59. Spans will be avoided by maximising the routing the cable over sediment, by burying the cable where possible, and by carefully aligning the cable on bare rock to position the cable in such a way that it is in physical contact with the seabed by following the troughs between ridges as far as is possible.

60. Spans will be reduced by considering specification changes to the cable flexibility to enable the cable to sag more into troughs (particularly for the c.2.5km length of the cable route beyond 20km offshore where the ridges run perpendicular to the route of the cable) and specifying that the cable be laid to defined levels of slack as excess tension could encourage spanning.

61. Spans will be remedied by undertaking post-installation inspections (using a ROV) and partial lift and repositioning of the cable where possible. Should repositioning not be possible, mitigation measures may be applied for spans where there is the evidence of the possibility trawling or anchoring affecting the cable such as physical measures, (e.g. rock covering or the use of concrete mattresses) or navigation guidance measures (e.g. specific warnings on navigation charts).

62. Given the above, it is considered that there is a low potential risk for interaction between the site to shore cable and the trawling and anchoring. However, given that the cable will be exposed on the surface of the seabed in rocky areas, there is a small increased risk to anchoring and trawling and, therefore, it is predicted that there will be an impact of minor adverse significance.

Mitigation and residual impact

63. In addition to the post-installation ROV survey of the cable route and the remedial measures built into the design, specification and installation method, there will also be regular post-installation surveys that will be carried out to ensure that the cable remains buried in St Ives Bay and does not become exposed. It is envisaged that there will be two inspections in the first year following installation followed by annual

surveys. Future survey plans will then be based on the findings of the initial surveys.

64. The 'as-laid' position of the cable should also be shown on the Admiralty Charts and best-practice offshore cable installation liaison and notification procedures applied.

65. The proposed remediation measures should sufficiently act as mitigation to ensure that the cable does not pose a significant threat to trawling and anchoring. Given that the route of the cable will be marked and notified, the potential for interaction with the cable is reduced and, therefore, no significant impact is predicted.

Potential for interactions between Wave Hub and the MoD Danger Area

66. The north-east corner of the Wave Hub's deployment area cuts across part of the southern boundary of the MoD's Danger Area (The Trevose Head Firing Range Firing Practice Area D001). The Danger Area supports MoD search and rescue helicopter training activities involving navigational procedures and surface retrieval activities.

67. Consultation revealed the MoD's concern that Wave Hub may affect the operation of helicopter mounted navigational equipment and location finding devices. This concern was to be the subject of an internal technical evaluation by the MoD, however, the *Navigation Risk Assessment* assess impacts on the following relevant navigation issues:

- Concerning structures and generators affecting sonar systems (e.g. fishing, industrial and military), no evidence has been found to date with regard to existing offshore structures to suggest that they produce any kind of sonar interference which is detrimental to the fishing industry, or to military systems. No impact is anticipated for the Wave Hub development;

- Concerning electromagnetic interference on navigation equipment, - it is noted that all equipment and cables will be rated and in compliance with design codes. In addition it is anticipated that any generated fields will be very weak and will have no impact on navigation or electronic equipment. No impact is anticipated for the Wave Hub development; and

- Concerning communications and position fixing, no significant impacts on VHF communications, Navtex, VHF direction finding, AIS, global positioning system (GPS), Loran C and microwave links (based on the experience of personnel/vessels operating around normally unattended offshore oil and gas platforms as well as trials carried out by the MCA at the North Hoyle Offshore Windfarm in Liverpool Bay off North Wales.

68. In addition, the MoD was concerned that vessel movements at Wave Hub supporting maintenance of the WEC devices may disrupt defence training activities. The north-east corner of Wave Hub's deployment

area intersects the Danger Area. As recorded in the Wave Hub *Navigation Risk Assessment*, there are "discussions with the MoD about this (non-navigational) issue". However, it is worth noting that in terms of search and rescue (SAR) for Wave Hub, the *Navigation Risk Assessment* states that the Wave Hub Operating Company will be required to:

- Assess the risks associated with the Wave Hub site in line with their Safety Management System (SMS) and use this assessment to form the basis for identifying scenarios to be considered within their emergency planning process;

- Endeavour to involve all appropriate parties in the forming of emergency response plans and operational procedures. This will include external organisations including the MoD;

- Hold discussions with each party (i.e. including the MoD) to ensure they have all the relevant details required to carry out the emergency response in an effective manner;

- Ensure all those involved in emergency response within Wave Hub are trained and competent;

- Prepare a written personal protection equipment programme for use by all Wave Hub employees working at the site and for those involved in emergency response;

- Conduct emergency response trials under realistic conditions to maintain competence and further improve the SMS using any knowledge gained;

- Test communication and shutdown procedures for the site twice per year; and

- Maintain suitable records of emergency responses to be used to further improve systems within the Wave Hub Operating Company and industry. The operator will require to be committed to sharing information with other companies within the renewable energy industry.

13 Landscape and views

13.1 Introduction

1. This section of the Environmental Statement assesses the potential impacts on the landscape and views. The potential impacts discussed in this section were identified in the Wave Hub *Environmental Scoping Study* (Halcrow, 2005) and through consultation with various stakeholders as described in the Wave Hub's *Landscape and Visual Impact Assessment* (Halcrow, 2006) (see Appendix M). With respect to the onshore elements of the scheme, the following potential impacts are identified:

- Effect of cable laying on the visual amenity of the beach during construction;
- Effect of cable laying on landscape features, specifically sand dunes;
- Effect of completed sub-station on visual amenity and landscape character; and
- Effect of the cable on visual amenity if exposed due to natural beach processes.

2. With respect to the offshore elements, the following potential impacts were identified in the Environmental Scoping Report:

- Effects of the offshore construction in views from land;
- Effects of WEC devices in views from land; and
- Effect of navigation lighting on night-time views from land.

13.2 Methodology

1. A landscape and visual impact assessment was carried out by chartered landscape architects within Halcrow. The methodology for the assessment is developed by Halcrow and draws upon best practice guidance as outlined in the Landscape Institute/IEMA (2002) *Guidelines for Landscape and Visual Impact Assessment* (second edition). The full assessment is included at Appendix M and forms the basis for this section of the Environmental Statement.

Sourcing of baseline data

2. Baseline information on the landscape and visual context of the study area has been gathered from a desk study of publicly available information, site visits in September 2005, and consultation with statutory consultees.

3. The desk study included a review of OS maps, existing and emerging Local and Structure Plans and policies, and Cornwall County Council's Landscape Character Assessment. It is understood that a new Landscape Character Assessment is currently in progress but that this was not available at time of writing.

4. Information on existing light pollution affecting night skies was sourced from the Campaign to Protect Rural England (CPRE) website and later communication. Information on atmospheric conditions affecting visibility was obtained from the Met Office.

Evaluation of existing landscape and visual sensitivity

5. The sensitivity of landscapes within the study area is evaluated with reference to National, Regional and Local designations indicating landscape, recreational, cultural or historic value.

6. 'Visual receptors' is a term that describes types of people who are likely to respond to visual change according to the reason why they are in a particular location. For the purposes of this assessment, the following distinctions (Table 13.1) are made between visual receptors.

Table 13.1 Sensitivity of visual receptors

Sensitivity to visual change	Type of visual receptor
High	Resident, walker; outdoor recreationist; tourist
Medium	Road user; commuter
Low	Worker

7. In addition, Table 13.2 identifies those indicators that are used to determine locations where response to visual change is likely to be the most significant.

Table 13.2 Sensitivity of visual receptor location

Location of visual receptor	Indicator of increased significance of location
Settlement and residential dwellings	Number of residents affected (the higher the number, the more significant); Presence of Listed Buildings and Conservation Areas where the site contributes to the setting
Rural landscape	National, regional or local landscape designation; Historic landscape with designed view affected by proposals; Rural recreation site/Country Park; picnic spot; panoramic viewpoint
Public right of way/ public access route	National trail/long distance route/promoted recreational route
Public highway	Promoted scenic route; principal approach to settlement or other sensitive site

8. The sensitivity of visual receptors is likely to be further affected by:

- The distance of the viewer from the proposal, whereby the further away the viewer is, the smaller the object becomes relative to the view as a whole;
- The influence of other similar elements in the view. This would reduce sensitivity to the proposals;
- How busy people are with other activities that draw focus away from the landscape and visual context, for example, driving on busy roads, working. Views from busy roads and

from places of work are therefore considered less sensitive; and

- For offshore elements, the effects of different atmospheric and sea conditions, which would affect visibility of objects from land.

Evaluation of darkness of night skies

9. CPRE has produced light pollution maps across the UK using data from US Air Force weather satellites. Scanners make repeated measurements of light upwards, capturing rays from various angles. The studies report figures focussed on land rather than sea areas, so there is no known existing baseline against which to measure the potential effect of proposed offshore lighting. However, data is available indication the light pollution experienced on land, and this is referred to in the assessment in terms of the context from where night-time views are experienced.

How visual impact is assessed

10. A number of viewpoints have been selected within the Zone of Theoretical Visibility (ZTV) of the proposals to represent the nature of the views experienced from sensitive landscapes and visual receptors from varying distances and directions. All viewpoints were selected from publicly accessible locations. Viewpoints were visited to verify visibility, and adjustments made so as to obtain the worst-case view from a particular point.

11. Photographs from the representative viewpoints have been taken using a standard 50mm lens in a 35mmm format. Panoramas were produced by splicing standard photographs together using graphics software. Minor retouching was used to ensure that colour variations at joins in photographs were eliminated.

12. The potential visibility of two WEC layouts (a worst case scenario and an example of a likely case scenario) has been predicted by generating wireline perspectives from representative viewpoints using a 3D computer model.

13. The predicted magnitude of visual impact experienced from the representative viewpoints has been assessed using the categories described in Table 13.3.

Worst case scenario

14. The landscape and visual impact has been based on two scenarios.

15. The likely layout for the WECs is based on example layout 2 (see Figure 2.17). The worst case layout is based on 12 FO^3 devices (i.e. 3 devices x 4 PCUs) because these are the largest and most bulky WEC devices.

16. Navigation aids are an important consideration for the landscape and visual impact assessment because of their height and lighting characteristics. There is the potential for a worst case scenario for the cardinal buoys. Whilst it is expected that class two buoys will be used (height of 4.5m above sea level, 3m diameter at base, 1m diameter at focal plane/light level, with white light visible to mariners at a distance of 5 nautical miles

(9.3km)), the worst case scenario assumes the use of class one buoys (height of 6.5m above sea level, 3m diameter at base, 1m diameter at focal plane/light level, with white light visible to mariners at a distance of 9 nautical miles (16.7km)).

Table 13.3 Categorising the magnitude of visual impact

Size class	Name	Appearance in central vision field	Modifying factors
Very large	Dominant	Commanding, controlling the view	Few
Large	Prominent	Standing out, striking, sharp, unmistakeable, easily seen	Few
Medium	Con-spicuous	Noticeable, distinct, catching the eye or attention, clearly visible, well defined	Many
Small	Apparent	Visible, evident, obvious	Many Limit of potential visual significance
Very small	Incon-spicuous	Lacking sharpness or definition, not obvious, indistinct, not clear, obscure, blurred, indefinite	Many
Negli-gible	Faint	Weak, not legible, near limit of visibility of human eye	Few

13.3 Baseline conditions

Landscape designations and policy context

Onshore infrastructure

1. The areas affected by the onshore elements of Wave Hub infrastructure are subject to statutory planning policies contained within Penwith District Local Plan and Cornwall County Structure Plan. These areas are not located within a landscape designated for its special quality or character. The nearest such designations are the Areas of Great Landscape Value (0.9 km to the north-east) covering undeveloped sand dunes within parts of the Towans, and 0.4km to the west covering undeveloped coast north of Lelant, and further west the hinterland of St Ives and Halsetown. The proposed World Heritage Site (Area 2: Port of Hayle) lies immediately to the south of the site.

2. Policy 3 '*Environmental Protection*' of the Cornwall Structure Plan applies, which states that 'The conservation and enhancement of sites and areas of European and National landscape, biodiversity, archaeological or historic importance, including the proposed World Heritage Site, will be given priority in the consideration of development proposals. Major development or proposals that have adverse effects on such sites and areas - including consideration of likely cumulative effects - will be unacceptable unless it can be shown that there is an overriding public need and lack of alternative sites.'

3. The proposed World Heritage Site 'Area 2 – Port of Hayle' is adjacent to the site. The Cornish Mining World Heritage Site Bid was submitted for nomination in January 2005. Following extensive assessment and inspection, a decision is expected during the summer of 2006. Issue 6 - *Protecting the visual setting and historical context of the site*, of the World Heritage Site key management

issues is relevant to the proposals. Policy 6 states that 'Developments outside the Site that will adversely affect its outstanding universal value will be resisted.'

4. Other policies within both the Cornwall County Structure Plan (2004) and the Penwith Local Plan (adopted 2004) seek to ensure that new development respects the local landscape character. Structure Plan Policy 2 'Character areas, design, and environmental protection' states that 'the quality, character, diversity and local distinctiveness of the natural and built environment of Cornwall will be protected and enhanced. Throughout Cornwall, development must respect local character and:

- Retain important elements of the local landscape, including natural and semi-natural habitats, hedges, trees, and other natural and historic features that add to its distinctiveness;
- Contribute to the regeneration, restoration, enhancement or conservation of the area;
- Positively relate to townscape and landscape character through siting, design, use of local materials and landscaping; ….'

5. Policy CC-1 of Penwith Local Plan states that 'development will not be permitted where it will significantly harm the landscape character, amenity, [and]….historic…values of the coast…of Penwith'.

6. Policy CC-14 also states that 'proposals for development which would have a significant effect on the shoreline or adjacent coastal waters in terms of its landscape character, amenity [etc]…values will not be permitted.'

Offshore elements

7. There are no known designations that identify and protect the open undeveloped character of coastal waters and seascapes from permanent built development. The policy context for offshore proposals therefore relates to land-based designations within their ZTV from where views out to sea may be considered sensitive to change. The following designations lie within the ZTV of the offshore site:

- Cornwall Area of Outstanding Natural Beauty (national significance);
- Cornwall Mining World Heritage Site (proposed) (international significance); and
- Areas of Great Landscape Value (local significance).

8. With reference to the policies outlined above for onshore proposals, the following impact assessments examine the extent to which two hypothetical layouts for WEC devices would result in adverse visual impact from the two nearest sections of the coast to the Wave Hub site that fall within the AONB, namely the section of coast to the west of St Ives Bay between Cape Cornwall and Clodgy Point, and the section of coast east of St Ives Bay between Godrevy Point and

Portreath. Both sections comprise unspoilt rugged coastlines offering outstanding coastal views, as indicated in Figure 13.1.

Figure 13.1 Typical coastal scenery west of St Ives within AONB (taken from Zennor Head)

Visual context

Onshore infrastructure areas

9. The site of the proposed sub-station compound and access track is concealed from wider external views by the surrounding and enclosing topography of sand dunes. The site is, however, potentially visible from a local footpath that circles the rim of the enclosing sand dunes to the east. Figure 13.2 shows the nature of the view from the edge of the adjacent holiday park to the north, where the site is seen in the context of the existing sub station.

10. Through analysis of topographic maps it is estimated that the area of beach across which the onshore section of the cable would be laid is likely to be visible from adjacent sections of coast within St Ives Bay, and adjacent elevated inland areas. People with a high sensitivity to visual change within 1km of the affected beach zone are likely to include:

- Users of the South West Coast Path;
- Residents of the holiday park that overlook the beach;
- Beach users; and
- Users of Lelant golf course.

Figure 13.2 View of sub station site from holiday park to north

11. The representative viewpoint towards the onshore site shown in Figure 13.3 indicates the nature of the beach affected by the proposals.

Offshore elements

12. The ZTVs of the hypothetical layouts for WEC devices are similar for the most likely layout and the worst case scenario layout.

Generally, the ZTV includes mainly the higher ground hugging the North Cornish coast from Cape Cornwall to St Agnes Head, with some inland areas included around Camborne and Redruth. These indicate little difference between.

Visual receptors

13. Table 13.4 below summarises the areas and routes within the ZTV from where people are likely to be highly sensitive to visual change.

Landscape character context

Onshore infrastructure site

14. The proposed sub-station and onshore section of the cable route are located in St Ives Bay Character Area as described in Cornwall County Council's Landscape Character Assessment (1994).

15. Key characteristics of the landscape are:

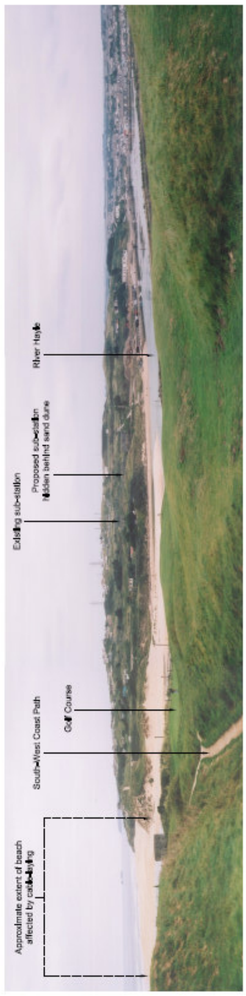
- A dramatic north facing sweeping bay with sandy beaches and gently undulating landform;
- Alluvial deposits from the River Hayle and associated marshes with important estuarine habitats;
- Extensive windblown sand dunes forming significant habitats and locations for many caravan parks and holiday chalets; and
- Historic town cores of St Ives, Lelant and industrial based Hayle and extensive post war development line the coast.

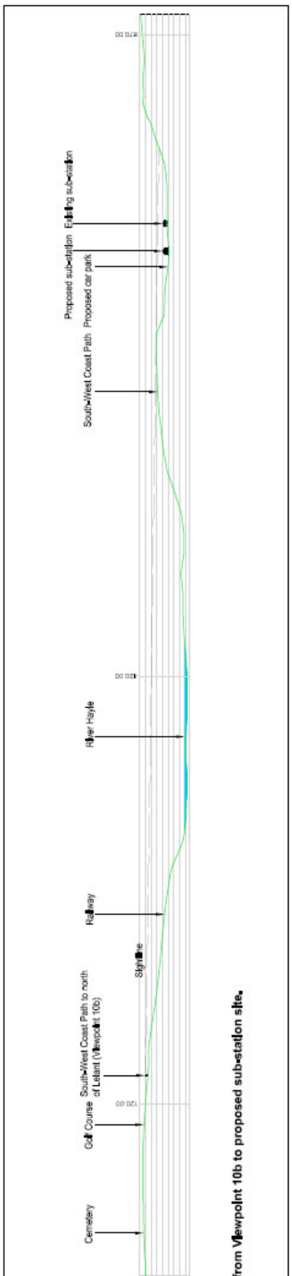
16. The setting of the onshore infrastructure sites is typical of the wider context. Key landscape features within the areas potentially affected by the proposals comprise:

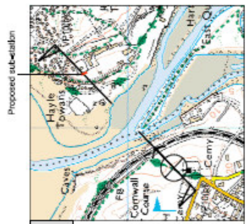
- Sand dunes scattered with holiday chalets; and
- Sandy beach edging the dramatic sweep of St Ives Bay.

17. The immediate landscape setting of the proposed sub-station site is dominated by the existing Hayle sub station. The main features of the sub-station are its utilitarian buildings, electricity pylons, overhead cables and security fencing. Other buildings in the vicinity comprise scattered single storey detached dwellings and holiday chalets of simple style. Materials vary from painted timber, rendered or concrete walls under pitched or flat roofs of slate, tile or concrete.

18. The site itself comprises waste ground of scrub and herb vegetation with areas of bare sandy soils and compacted stony made up ground. The vegetation is not visually significant in the wider context.







Viewpoint No.	Description	NGR SW	Approximate Elevation	Reasons For Selection of Viewpoint
10b	Looking north-east across Hayle Estuary from the South-West Coast Path near the church just north of Lelant	54827 E 37795 N	22mAOD	- SW Coat Path - Nearest publicly accessible point within Area of great Landscape Value

Figure 13.3 View towards the onshore construction site at Hayle

Table 13.4 Sensitive receptors (offshore site)

Location of sensitive receptors	Representative viewpoint
Cape Cornwall to Clodgy Point • AONB • South West Coast Path • National Trust Land • Area of Great Landscape Value	6: Rosewall Hill
St Ives Bay • South West Coast Path • Residential areas on elevated northern perimeter of St Ives • Residential areas on elevated eastern edge of Carbis Bay • Recreation users of St Ives Bay beaches and harbours	1a: St Ives Head
Godrevy Point to St Agnes Beacon • AONB • National Trust Land • Area of Great Landscape Value • South West Coast Path	7: Navax Point

Offshore infrastructure site

19. The coastal landscapes within the ZTV of the offshore site provide the foreground for views out to sea. These landscapes include the following Character Area as described in Cornwall County Council's Landscape Character Assessment (1994). Moving from west to east:

- Pendeen & St Just;
- North Coast (1d) from Portheras Cove to Clodgy Point;
- Central Hills (1c) including Rosewall and Trendrine Hills;
- Urban areas of St Ives, Carbis Bay, Hayle, Camborne and Redruth;
- St Ives Bay;
- North coast open, from Navax point to Bassetts Cove;
- Camborne- Redruth Mining; and
- North Coast Mining, from Bassett Cove to St Agnes Head.

Darkness of night skies

20. With reference to the light pollution map produced by the CPRE (Figure 13.4), areas of darkness are decreasing due to poor lighting design and wasteful light sources. The light is measured on a range from 0 to 255 (0 means the satellite is detecting no light in that pixel and 255 means the satellite's detector is saturated with light). Within the ZTV, St Ives and Rosewall Hill fall into the 50.01-150 range of brightness because of the concentration of people in the urban area. Navax Point experiences darker night skies falling into the 1.71-50 range. It is a less populated area in a more secluded rural setting and is, therefore, more sensitive to any impact from potential light sources. Further west (from around Porthmeor) the skies are again slightly darker in the 1.71-50 range.

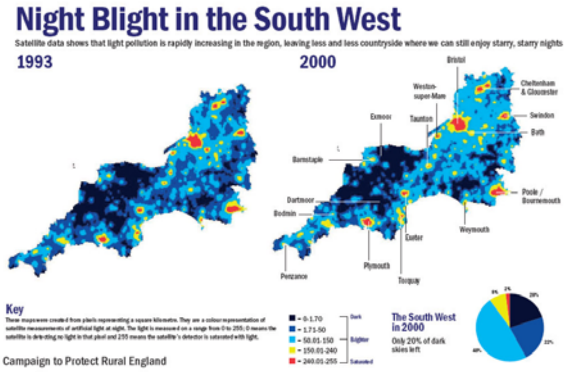


Figure 13.4 Light pollution map for the South West

Variations in visibility

21. Met Office data indicates that for locations over 20km from the Wave Hub site, the site would not be visible due to atmospheric conditions for an average of 38.5 days out of 100.

13.4 Potential impacts during construction and decommissioning

Potential impact of cable laying on the visual amenity of the beach

1. Cable laying across the beach could potentially adversely affect local visual

amenity. During a maximum period of 20 days in late spring or early summer, a cable plough and other construction traffic will be moving within the 100m cable route working width across approximately 1km of beach.

2. Given the size of the vehicles to be used, construction activity on the beach is not likely to exert a visual influence beyond a distance of around 500m. Within a range of 100m, the visual magnitude of construction machinery will range from prominent, conspicuous or apparent, depending on distance away.

3. Within this radius, people likely to have a high sensitivity to visual change include beach users, walkers along the South West Coast Path and residents of the holiday park overlooking the beach. Although such people may experience moderate adverse visual impact at close range, this will be for a relatively short duration and may indeed result in some public interest in activities. Due to the size of the beach, people using it are able to move away from areas where the magnitude of visual impacts is unacceptable to them.

Mitigation and residual impact

4. Possible annoyance at the temporary adverse visual impacts experienced may be reduced if information were made available to the public at entrance points onto the beach, along the coast path, and within the holiday park, informing them of the Wave Hub project and apologising for inconvenience.

5. Cable laying across the beach could result in adverse temporary visual impacts for some beach users, walkers and residents within a 100m radius of the construction area, although the inconvenience of such impacts can be tempered by informing the public of the reasons for disruption. Due to the short duration and localised nature of effects, their overall significance is considered to be of minor adverse significance.

Potential impact of cable laying on landscape features, particularly sand dunes

6. Cable laying could potentially directly affect the integrity and vegetation cover of the sand dunes through which they must pass if an inappropriate construction technique were employed. However, in recognition of the fragility of the sand dunes and the need to conserve their integrity, the cable beneath the dunes will be installed by directional drilling. This method for laying of cables through the sand dunes will ensure that this local landscape feature is conserved. There will be no direct impact upon the sand dunes.

Mitigation and residual impact

7. No mitigation measures are required and there will be no residual impact.

Potential impact of offshore construction in views from land

8. The magnitude of the visual impact during construction work would be small when it is near to the coast where the vessels would be obviously visible but not dominating the open seascape view. As the construction vessels and focus of the work move away from the coastline towards the deployment area, the impact will reduce to very small as views of the works become less obvious and lacking

definition. Overall, considering that receptors within the ZTV are of high sensitivity but the magnitude of the potential impact is small or very small and the impact will be temporary, the significance of the visual impact is predicted to be of minor adverse significance.

Mitigation and residual impact

9. Mitigation that should be employed is directly related to the methods of construction. The number of vessels deployed to complete the works must be limited to the most efficient in order to complete the work as safely and as quickly as possible. The construction of the devices themselves will be done off site which will minimise the time required for installation.

10. Overall, a residual impact of minor adverse significance is predicted.

13.5 Potential impacts during operation

Potential impact of the substation on visual amenity and landscape character

11. The new substation building and associated elements could potentially detract from the visual amenity and landscape character of the setting, particularly considering the likely high sensitivity of local residents, beach users, walkers and other recreationists within a 1km radius, and the sensitivity of the local landscape as indicated by designations such as Area of Great Landscape Value, and proposed Hayle Harbour World Heritage Site.

12. However, whilst the visual context of the site is highly sensitive, the site of the proposed building is well selected since the building would be concealed from the most sensitive public views by the surrounding sand dune topography. By locating the proposed building as close as possible to the existing substation, it will relate well to the character of its immediate built context. Given the mixed materials of other buildings in the vicinity, and the degree of visual concealment offered by the site, the selection of material is not considered a sensitive issue. It is, therefore, considered that the proposed single storey sub station site will not result in significant visual impact or change to local landscape character.

Mitigation and residual impact

13. No mitigation measures are required and there will be no residual impact.

Effect of cable on visual amenity

14. The cable across the beach could potentially be uncovered if beach material is scoured away due to normal beach processes and variations in beach level. This could potentially cause a significant adverse effect on the natural character and visual amenity of the beach.

15. However, the proposed burial depth of the cable beneath the beach (up to 3m) has been determined by the predicted variations in beach level anticipated. The cable across the beach is not expected to be exposed due to natural movement of beach material, and will therefore not cause any visual impact once laid.

Mitigation and residual impact

16. No mitigation measures are required and there will be no residual impact.

Potential impact of WEC devices during the day in views from land

17. Preliminary wire-line perspectives of the 3D models both for the most likely and the worst case scenario hypothetical layouts of WECs were obtained for two of the viewpoints agreed with consultees (Carn Naun, viewpoint 4, and Rosewall Hill, viewpoint 6 (see Appendix M)). These viewpoints were selected to represent the worst case being, respectively, the closest and highest viewpoints to the Wave Hub site.

18. The above preliminary results confirmed that the visibility of WECs in both hypothetical layouts would be inconspicuous or faint in good visibility conditions due to the size of the WECs when viewed at distances in excess of 15km. It was therefore considered unnecessary to create wire-line perspectives for all of the viewpoints considered for analysis as identified in Appendix M. This was because other viewpoints are further away, implying that the visual impact of WECs would be less.

19. The Rosewall Hill viewpoint has been assessed as it represents the worst case view along the section of coast between Cape Cornwall and St Ives. Views towards the Wave Hub site from this section of coast are of a similar high sensitivity due to the AONB designation, the South West Coast Path and the elevated, open, gently undulating landform facing the open sea. Rosewall Hill has a significantly high elevation and is easily accessed by the public, lying within the AONB just west of St Ives.

20. Navax Point has also been considered as a representative sensitive viewpoint for the section of coast between Godrevy Point and St Agnes Point. Its exposed setting on the cliffs over Godrevy and siting within the AONB and National Trust Land, as well as being one of the nearest receptors to the site for this section of coast, makes it an appropriate choice.

21. The third viewpoint that has been assessed is St Ives Head. It was chosen over Carn Naun because of the ability to accurately map a wire frame given the amount of reference features in the foreground of the photographs. Additionally, St Ives Head is probably the viewpoint that is experienced most often and from the most residential properties as well as demonstrating the likely impact at a lower elevation. Due to lack of foreground topography, it has not been possible to relate wireline perspectives to the existing view from Carn Naun.

22. With respect to Rosewall Hill, views from this elevated viewpoint are open, distant and panoramic. Wave Hub will be located 19.4km north of this viewpoint which itself is about 4km south west of St Ives. The view is likely to be experienced over a prolonged duration by walkers using the network of footpaths across the hill.

23. Figures 13.5 and 13.6 show the predicted visibility of the likely and worst case WEC layouts respectively. The devices appear as faint specks sitting below the line of the

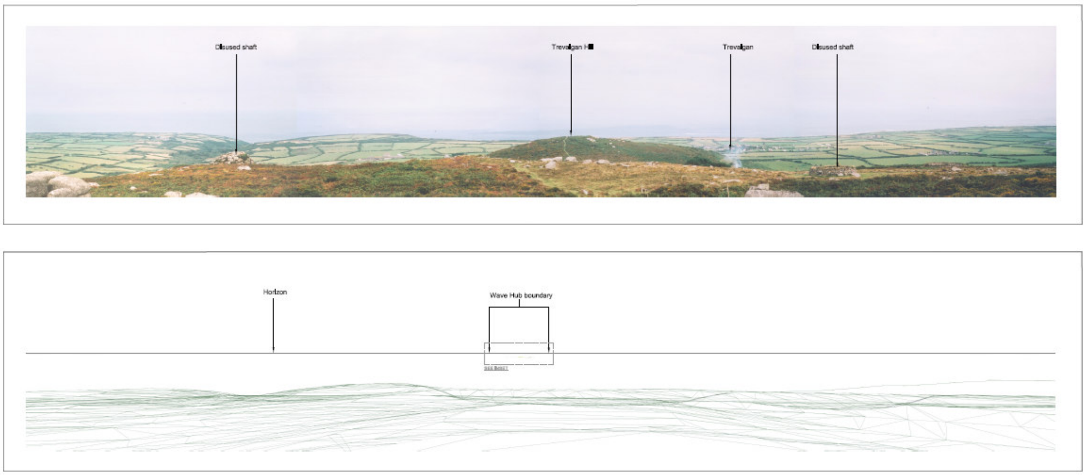
horizon. The proposed site makes up a fraction of the overall view and is barely discernible. As the devices and associated buoys are barely legible and near the limit of visibility of the human eye the magnitude of the impact is negligible. Given that the sensitivity of the landscape resource is high, the overall significance of the visual impact is of minor adverse significance for both potential device layouts.

24. Coastal views from St Ives Head are open, distant and panoramic. The direction of view is generally looking north to north-west and is dominated by the open sea with the rocky headland of Clodgy Point enclosing Porthmeor beach in the middle distance. The viewpoint is located north-east of St Ives and is popular with users of the South West Coast Path as well as tourists overlooking the well used sandy Porthmeor beach. The Wave Hub will be located 18.8km north-west of this viewpoint and at 29mAOD represents a relatively low elevation.

25. Figures 13.7 and 13.8 show the predicted visibility of the Wave Hub site for both the likely and worst case WEC layouts respectively. Both wire-line perspectives indicate that the magnitude of the visual impact would be negligible due to the Wave Hub site not being legible and near, if not at the limit of visibility of the human eye. The viewpoint is considered to be highly sensitive to visual change. As it is a popular headland offering panoramic views of the coast and the town, views are expected to be prolonged and therefore the sensitivity of the visual receptor is considered to be high. Considering all these factors and remembering that atmospheric conditions play a significant role in visibility, the Wave Hub WECs would have a minor adverse visual impact at worst.

26. Views from the high ground at Navax Point are open, distant and panoramic. The Wave Hub will be located 21.4km north-west of this viewpoint which sits to the east of St Ives Bay. St Ives Head and the west side of the bay can be seen in the distance and the rocky landform of Godrevy Point and Godrevy Island in the mid view. The foreground consists of relatively flat gorse covered cliff tops with the South West Coast Path in the centre of the view. The view is likely to be experienced over a prolonged duration by walkers using the South West Coast Path.

27. Figures 13.9 and 13.10 show the predicted visibility of the Wave Hub site for both the likely and worst case WEC layouts respectively. The sensitivity of the visual receptors represented by this viewpoint is considered to be high due to the rural landscape setting within the AONB and the well used South West Coast Path. The wire frame for both the likely and worst case WEC layouts indicate the magnitude of the visual impact as being negligible. The Wave Hub site observed just below the horizon is faint in the view and hardly legible. Considering all these factors and remembering that atmospheric conditions play a significant role in visibility, the Wave Hub site would have a minor adverse visual impact at worst.



Viewpoint No.	Description	NGR SW	Approximate Elevation	Distance To Centre of Wave Hub Site	Reasons For Selection of Viewpoint
6	Looking north west out towards the sea from a public footpath on one of the highest points around	48799 E 39182 N	227mAOD	19.4km	- AONB - Public footpath - One of the highest points within 20km radius of site

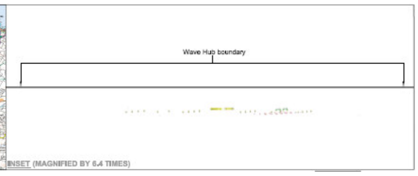
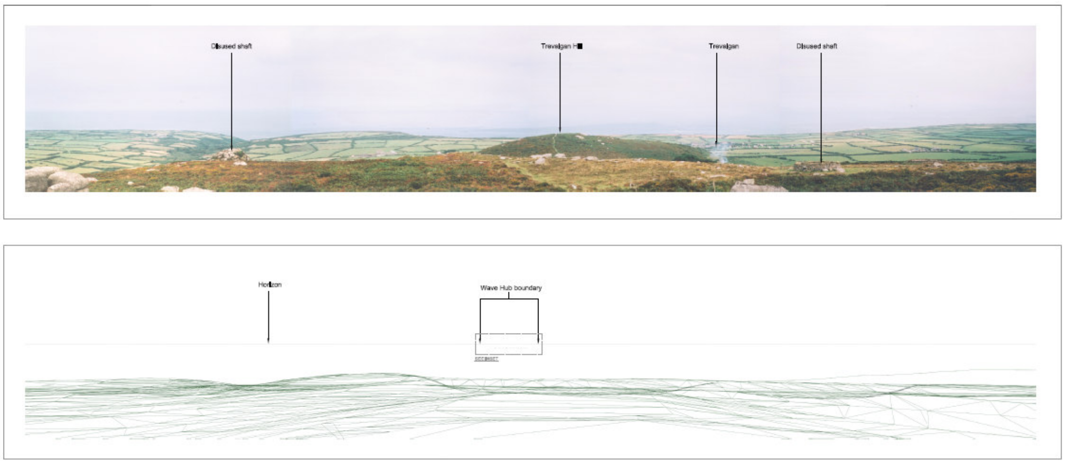


Figure 13.5 Existing view from Rosewall Hill (top) with likely WEC layout (bottom)



Viewpoint No.	Description	NGR SW	Approximate Elevation	Distance To Centre of Wave Hub Site	Reasons For Selection of Viewpoint
6	Looking north west out towards the sea from a public footpath on one of the highest points around	48799 E 39182 N	227mAOD	19.4km	- AONB - Public footpath - One of the highest points within 20km radius of site

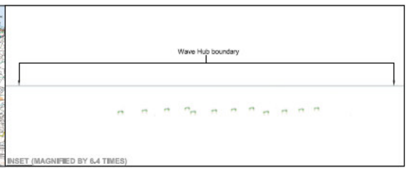


Figure 13.6 Existing view from Rosewall Hill (top) with worst case WEC layout (bottom)

Viewpoint No.	Description	NGR SW	Approximate Elevation	Distance To Centre of Wave Hub Site	Reasons For Selection of Viewpoint
1a	Looking north west out to sea from the headland with Clodgy Point in the middle distance	51968 E 41145 N	29mAOD	18.8km	- Nearest settlement to site - Popular viewpoint - On South West Coast Path

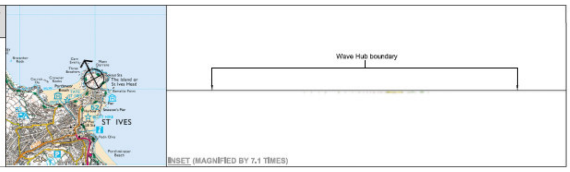


Figure 13.7 Existing view (top) from St Ives Head with likely WEC layout (bottom)

Viewpoint No.	Description	NGR SW	Approximate Elevation	Distance To Centre of Wave Hub Site	Reasons For Selection of Viewpoint
1a	Looking north west out to sea from the headland with Clodgy Point in the middle distance	51968 E 41145 N	29mAOD	18.8km	- Nearest settlement to site - Popular viewpoint - On South West Coast Path

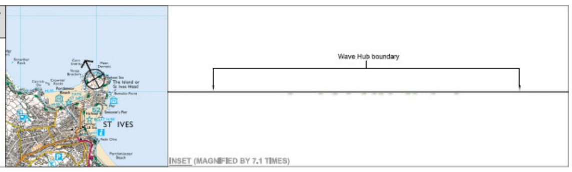
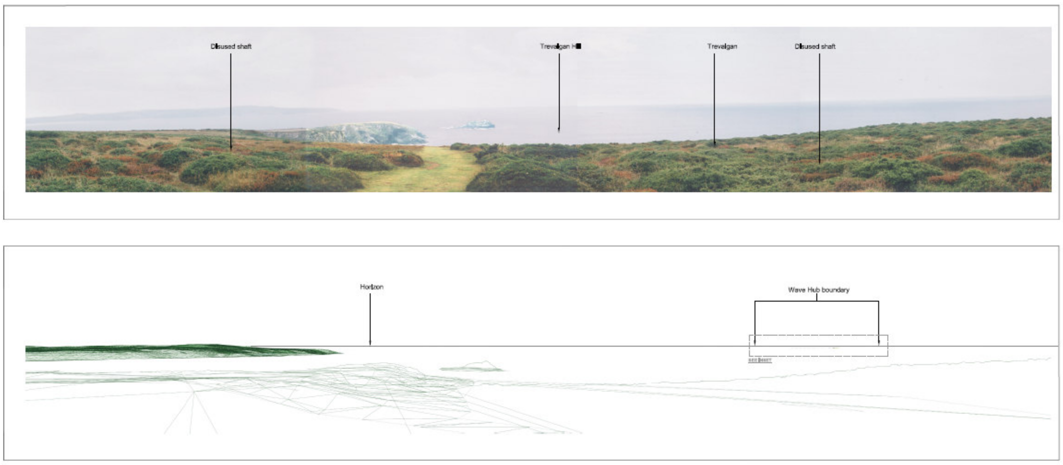


Figure 13.8 Existing view from St Ives Head (top) with worst case WEC layout (bottom)



Viewpoint No.	Description	NGR SW	Approximate Elevation	Distance To Centre of Wave Hub Site	Reasons For Selection of Viewpoint
7	Looking north from Navax Point at Trig Point towards Godrevy Point with St. Ives Bay in distance	*59164 E 43432 N*	*78mAOD*	*21.4km*	*- AONB - Public footpath near SW Coast Path - National Trust land*

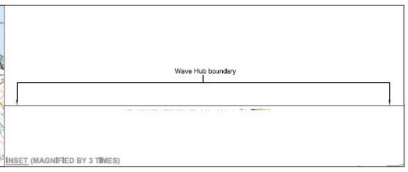
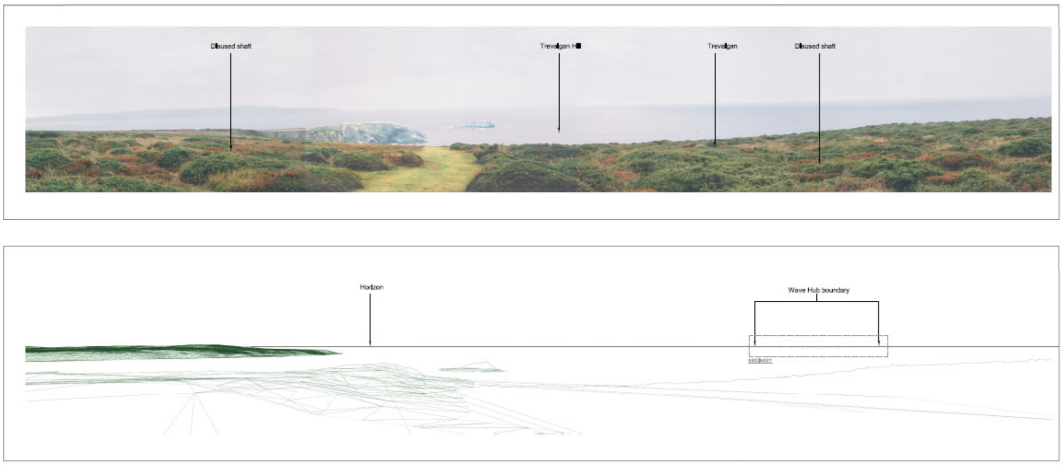


Figure 13.9 Existing view from Navax Point (top) with likely WEC layout (bottom)



Viewpoint No.	Description	NGR SW	Approximate Elevation	Distance To Centre of Wave Hub Site	Reasons For Selection of Viewpoint
7	Looking north from Navax Point at Trig Point towards Godrevy Point with St. Ives Bay in distance	*59164 E 43432 N*	*78mAOD*	*21.4km*	*- AONB - Public footpath near SW Coast Path - National Trust land*

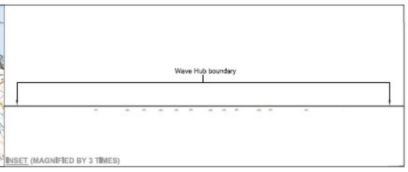


Figure 13.10 Existing view from Navax Point (top) with worst case WEC layout (bottom)

Mitigation and residual impact

28. There is no scope to change the colour of the devices from yellow, as this is understood to be a safety requirement. A pale grey colour and matt finish for devices would potentially reduce their prominence and reflectiveness at closer range, but colour of devices will not be a significant factor influencing visual impacts in views from land.

29. The inclusion of the various sizes of different WEC currently on the market indicates that the size and shape of WEC makes no significant difference to their visibility at the distances considered. However, should other devices of a significantly larger scale be considered in future, this may change the nature of visual impact experienced from the coast.

30. There is limited scope to influence the layout of the devices since this is driven by the dominant wave direction, and need to be aligned roughly north-south to catch the prevailing westerly wave direction. This means that the extent of visibility of WEC layouts will be least from areas of coast perpendicular to this north-south alignment, that is, the coast to the west of St Ives. The coast further east between Godrevy Point and St Agnes Head will see a wider angle of devices however. But since the visibility of the devices from these more distant coasts is likely to be negligible in any case, the alignment of the WECs would not significantly affect their visual impact unless the size of WECs was significantly larger.

Effect of navigation lighting on night-time views from land

31. Without having a quantifiable baseline for existing night skies out to sea, and without knowing what lighting intensities would be required, it has not been possible to accurately assess the likely visual impact of proposed lighting on night skies. However, considering the distance of the Wave Hub site off the coast, and the scale of the development highlighted on the wire frame models, it is possible to estimate the impact as follows.

32. Rosewall Hill and Navax Point are high sensitive receptors due to the landscape designations, the quieter, more rural, setting and existing low light level of night skies. The magnitude of the potential impact is likely to be small as it is possible the light sources will be evident in the view under clear conditions. Overall the likely significance of the visual impact due to the light sources is predicted to be of minor to moderate adverse significance, but there is some uncertainty in this impact prediction.

33. Locations around St Ives Bay are less sensitive since they currently experience a degree of light pollution from coastal settlements. The magnitude of the potential impact from St Ives Head is likely to be small as the light sources may be evident in the view on the horizon. Overall the likely visual impact due to the light sources would be of minor adverse significance.

Mitigation and residual impact

34. There is no suitable mitigation for the possible visual impact experienced from the

light sources associated with the buoys. The proposals for the required lighted buoys are governed by the guidelines set out within the IALA Buoyage system. The significance of the residual impact will, therefore, be a stated above (i.e. varying from minor to moderate adverse significance depending on location).

14 Cultural heritage and archaeology

14.1 Introduction

35. This section of the Environmental Statement assesses the potential impacts on cultural heritage and archaeology that were identified by the Wave Hub *Environmental Scoping Study* (Halcrow, 2005), consultation and the *Archaeological Assessment* (HES, 2006). The key potential impacts are:

- Impact on visual setting and historical context of designated areas;
- Impact on known and potential sites of cultural heritage and archaeological importance; and
- Impact on coastal archaeological sites due to changes in coastal processes.

36. The information included within this section is derived largely from the *Archaeological Assessment* that was undertaken specifically to inform the EIA process. The *Archaeological Assessment* was undertaken by the Historic Environment Service (Projects) (HES) of Cornwall County Council. This assessment covers the terrestrial, intertidal and marine cultural heritage and archaeology that is of relevance to the proposed Wave Hub development. The complete *Archaeological Ass*essment (HES, 2006) is included at Appendix N.

14.2 Methodology

Geophysical survey

1. A geophysical survey of the study area was undertaken by EGS. This survey comprised sub-bottom profiling, sidescan sonar and magnetometer surveys. In order to inform the *Archaeological Assessment*, the results of the geophysical surveys were interpreted by HES. Further archaeological interpretation of this data is provided in Appendix N.

2. Although the geophysical survey was undertaken to inform the design of the Wave Hub, consultation with English Heritage and HES lead to the following addition to the survey to inform the *Archaeological Assessment*:

- Side scan sonar (giving 100% coverage)
- Magnetometry; and,
- Additional survey lines along the cable route.

Archaeological Assessment

3. A full description of the methodology followed for the *Archaeological Assessment* is provided in Appendix N. In summary, the *Archaeological Assessment* involved five main phases of study:

- Research and desk-based study including searches of historical databases and archives;

- Walkover survey to visually examine terrestrial and intertidal areas and to appraise the potential visual impact of the Wave Hub proposals on designated cultural heritage and archaeological sites;

- Collation, collection, interpretation and presentation of archaeological and historical data using database records and GIS mapping to produce distribution maps and sea-level models, to identify areas of likely archaeological potential and to cross-reference marine geophysical data against marine archaeological sites and wrecks;

- Assessment of marine geophysical survey data, including sub-bottom profiling, sidescan sonar, magnetometer and video data; and

- Report production to present the above including an assessment of potentially significant impacts and to recommend mitigation measures.

4. The *Archaeological Assessment* was undertaken according to:

- The Institute of Field Archaeologists' *Standards and Guidance for Archaeological Desk-based Assessments and Evaluations* (IFA, 1999);

- The principles and precepts set out in *Planning Policy Guidance Note 16 (PPG16): Archaeology and Planning* (DoE, 1990); and

- The Joint Nautical Archaeology Policy Committee's *Code of Practices for Seabed Developers* (Hampshire & Isle of Wight Trust for Maritime Archaeology, 2005).

Worst case scenario

5. The worst case scenario for the impact assessments only concerns impacts relating to seabed sediment disturbance and known / unknown archaeology. Accordingly, no worst case scenarios are applied to impacts on terrestrial and intertidal archaeology and impacts on historic settings of designated areas.

6. The worst case scenario for seabed disturbance is considered to be the WEC layout that provides the greatest numbers of anchors for moorings. Accordingly, the worst case scenario is a maximum of 264 anchors for WECs based on connection of 30 PowerBuoy devices to each of the four PCUs, and assuming 66 anchors per array of 30 devices.

7. The worst case WEC layout scenario for impacts on coastal archaeology is based on a WEC layout comprising four Wave Dragon devices. Four Wave Dragons were chosen to represent worst case scenario because they have the largest effect on waves and currents, and therefore also have the largest effect on sediment regime at the coast.

14.3 Baseline conditions

1. For a full description of the baseline conditions the reader is referred to Sections 4, 5 and 6 of the *Archaeological Assessment* in

Appendix N. The following paragraphs provide a summary of the baseline conditions. Figure 14.1 presents the locations of terrestrial archaeological sites.

Geology

8. Onshore, superficial deposits of windblown sand and alluvium overlie Devonian sedimentary bedrock. Offshore, an intermittent cover of reworked Quaternary sediment overlies bedrock comprising slates, siltstones, sandstones and limestones.

Historic Landscape Character

9. The historic landscape character (HLC) of the study area falls under the Recreation HLC zone because of the presence of the chalet park on Riviere Towans, but is considered to be more characteristic of the Dunes HLC zone for the purposes of the assessment.

Proposed World Heritage Site

10. The terrestrial part of the study area lies adjacent to the proposed Cornish Mining World Heritage Site (Area A2, the Port of Hayle) and its key management issues, notably that of protecting the visual setting and historical context of the site (issue 6) which requires that *"Developments outside of the Site that will affect its outstanding universal value will be resisted (Policy 6)"* (World Heritage Site Bid Partnership, 2005).

Scheduled Monuments

11. There are no Scheduled Monuments within the study area.

Listed Buildings

12. There are no Listed Buildings or structures within the study area.

Protected wreck sites

13. There are no wreck sites within the study area that are designated either under the Protection of Wrecks Act 1973 or under the Protection of Military Remains Act 1986.

National Heritage Act Sites

14. The *Archaeological Assessment* has identified a number of sites, or potential sites, in the maritime section of the study area. In total, 60 magnetic anomalies were identified (one is a large iron wreck, possibly the Helene, sunk by a U-boat in 1918; two other anomalies may represent debris on the seabed). In addition, the following features were also recorded; 19 sidescan sonar targets, 27 recorded wrecks within 2km of the original Wave Hub and site to shore cable route and one palaeo-channel.

15. It should be noted that since the geophysical surveys were undertaken, the proposed deployment area has been relocated. There is some geophysical data covering the revised deployment area, but the surveys of this location were undertaken at a lower intensity that for the original proposed deployment area. Therefore, the revised deployment area has approximately 50% coverage.

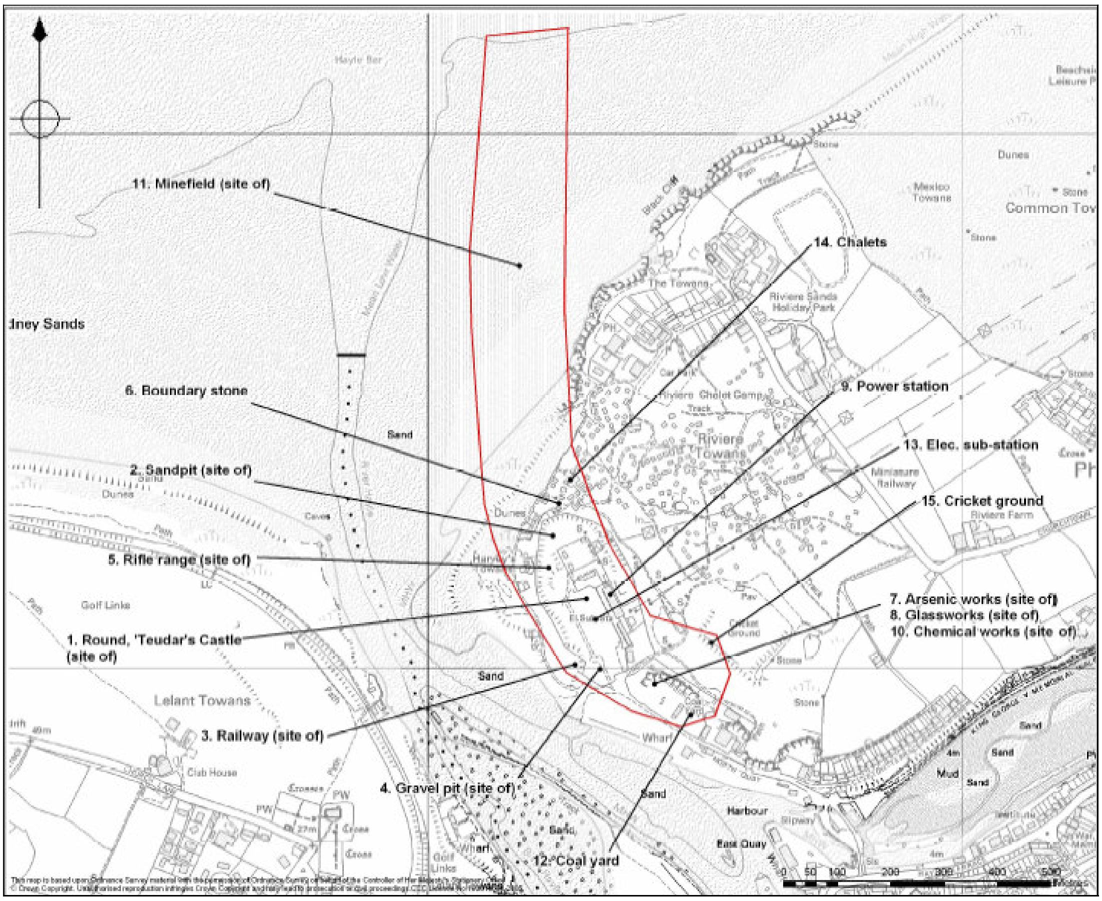


Figure 14.1 Locations of terrestrial archaeological sites

16. Given that there is partial geophysical survey coverage of the relocated deployment area, there is some uncertainty in the assessment of potential impact relating to unknown archaeological sites. This uncertainty is taken into account in the impact assessment and recommendations are made as to the approach to dealing with this uncertainty.

Conservation Areas

17. The study area lies outside the Hayle Conservation Area.

Planning Policy Guidance

18. PPG16 applies to terrestrial sites. However, for the purposes of this assessment, the principles embodied in PPG16 apply equally to marine sites.

Local Plans

19. The study area lies within the remit of the following plans with policies relevant to cultural heritage and archaeology:

- Cornwall County Structure Plan 1997;
- Penwith Local Plan Deposit Draft 1998 incorporating proposed modifications 2003; and
- Hayle Estuary Management Plan.

Known and potential terrestrial archaeology

20. The Hayle-Gwithian Towans sand dune complex is the second largest in Cornwall and is recognised as having an extremely archaeological and historical dimension. For example, two excavations at Gwithian have revealed a Bronze Age site with three major occupation horizons.

21. The following terrestrial archaeological / historical sites exist within the study area:

- Site of Riviere Castle, 5th to 6th century stronghold of Teudar;
- 19th century sand extraction pit site;
- 19th century railway line site;
- 19th century gravel pit site;
- 19th century rifle range site;
- Six boundary stones dating to 1867;
- Site of Pentowan Calcining Works (arsenic works), then site of Pentowan Glass Bottle Works (1917-9125), then part site of bromine producing works (1939/40-1973);
- Hayle power station site (1910-1977); and
- Modern coal yard, electricity station, holiday chalets (1930s onwards) and cricket ground.

22. In addition, there is the potential for buried palaeo-environmental and archaeological material below the dunes, including remnants of World War II defences.

Known and potential intertidal archaeology

23. A submerged forest lies in the Hayle estuary at Trewinnard indicating that marine transgression created the estuary over an area of previously dry land. Isolated finds (Bronze Age razor and Carthaginian coin) were made in the intertidal zone adjacent to the study area.

24. There are no known in situ or derived sites or artefacts of prehistoric date within the study area although there is potential for palaeo-environmental material or evidence of prehistoric human activity to survive below the sands. A World War II minefield was cleared following the war, although some mines are reputed to be unaccounted for. Other war debris may be buried below the sands.

Known and potential maritime archaeology

25. The marine area has an archaeological and historical background covering the prehistoric to medieval periods, the Tudor period, and the 17th, 18th, 19th and 20th centuries.

26. There are a number of known wrecks within the vicinity of the proposed Wave Hub and cable route. Only six wrecks are within 1km or the cable route (the *Alster, Dageid, Dux, Gemini, St Charmond* and *War Baron*), and no wrecks are at less than 0.5km distance from the cable route. The geophysical survey identified the large iron wreck of a steamer (possibly the *Helene*; see Figure 14.2) torpedoed by a U-boat in 1918 and a number of smaller targets that may be of archaeological interest.

27. There is a palaeo-channel offshore with the potential for palaeo-environmental material or evidence of prehistoric activity below the seabed.

Figure 14.2 Diving on the wreck believed to be the Helene

14.4 Potential impacts during construction and decommissioning

Potential for impact on known and potential sites of cultural heritage and archaeological importance

1. The deployment of the offshore infrastructure and the WEC devices (including their moorings) and ploughing and laying for the cable could damage completely submerged marine structures and deposits, some of which have been identified by the geophysical surveys and others that have not.

2. It is recognised that there may be features of archaeological interest in the relocated deployment area that were not identified during the geophysical survey due to the lower intensity of the survey in this area.

However, the assessment of the potential impact can be undertaken given that it is recognised in archaeological assessment that there is always the potential for features of archaeological potential to be present as they cannot be detected by surveys, or, if detected, they cannot be positively identified at the survey stage. However, due to the lower intensity of the survey in this area, there is a greater level of uncertainty as to the presence of features of potential importance in this area.

3. With respect to the intertidal zone, the ploughing along the route of the site to shore cable across the beach could affect potential archaeological sites present within the intertidal zone. The directional drilling for the cable through the dunes, and limited excavation for the construction of onshore infrastructure such as the new substation building, could destroy buried terrestrial archaeological remains.

4. Although the site to shore cable route has been planned to avoid known wreck sites and has allowed a 500m buffer zone, the geophysical survey indicates that the types of maritime sites along the cable route that could be affected ranges from a large iron wreck (originally marked on a chart in a different position) to smaller iron objects, including a number of small anomalies are too large to be fishing debris and may represent material of archaeological interest. Therefore, known and unknown archaeological sites could be affected by seabed disturbance associated with cable laying and deployment of the Wave Hub's offshore infrastructure, WEC devices, buoys and moorings.

5. In both the marine and intertidal zones there is the potential for currently unidentified buried palaeo-environmental material and for chance finds. Although the WWII minefield on the beach was cleared after the war, thirty mines are reputed to be unaccounted for. Other remnants of WWII defences could also be affected by directional drilling and cable laying.

6. The main type of terrestrial sites which might be affected are 19th or 20th century industrial sites, which are of local importance, but which are contaminated and decrepit. Other sites which existed historically are no longer extant and are unlikely to have any surviving remains. The new substation will be built within the old power station and existing access roads will be used so the development will not have an impact on terrestrial archaeological sites.

7. The area of seabed that will be disturbed during the construction phase is relatively small and localised to the site of the works. The greatest potential for effect relates to the works required for the burial of the cable in St Ives Bay; elsewhere, the cable will be laid on the surface of the seabed and the installation of the offshore infrastructure will affect a relatively small area of seabed.

8. The worst case scenario for seabed disturbance at the deployment area relates to 264 anchors for WECs based on connection of 30 PowerBuoy devices to each of the four PCUs, and assuming 66 anchors per array of 30 devices. However, the scale of seabed disturbance by the anchors is much smaller ($467m^2$) compared to disturbance by the cable

($40,000m^2$) (based on calculations described in Section 7.4).

9. However, should features of archaeological interest (that are currently unknown) be present, they could be of variable value, ranging from low to very high depending on the nature of the feature. The lower intensity geophysical survey that was undertaken of the relocated deployment area (compared with the original site) adds to the uncertainty of the nature of potential archaeological features that may be present.

10. The magnitude of the potential impact could also vary depending on the nature of the archaeological feature that may be encountered, from total loss of the feature (potentially of major negative magnitude) to minor damage. The consequence of this uncertainty is that the potential impact could range from no significant impact to major adverse significance depending on the nature of the archaeological feature and the extent of disturbance/damage caused by the construction works. It should be noted that the design of the scheme has taken into account the potential for impact on the known archaeological resource as far as possible (i.e. the presence of known wreck sites).

Mitigation and residual impact

11. As described above, careful planning of the cable route has been undertaken to avoid identified maritime sites such as the iron wreck identified in the geophysical survey and to leave a 500m buffer zone around such sites. This measure has been used to plan the proposed cable route and will continue as far as the design progresses.

12. In order to minimise the potential for impact on the unknown archaeological resource, the area of seabed that is disturbed during the construction and decommissioning works should be kept to the minimum required to undertake the works.

13. A geophysical and/or metal detector survey of the beach and dunes should be undertaken to detect any buried WWII ordnance or other defences. It is recognised that this measure is likely to be included under the performance specification for the construction works which will mean that the decision to undertake a pre-construction survey will be taken by the appointed contractor

14. The proposed use of directional drilling to route the cable through the dunes (rather than trenching) will ensure that any archaeological remains are avoided.

15. An agreed programme of archaeological recording should be put in place and a Written Scheme of Investigation (WSI) approved by the Historic Environment Planning Advice Manager of Cornwall County Council and the Inspector of Ancient Monuments, English Heritage. This should include the following:

- Provision for archaeological assessment of any further geophysical survey of geotechnical investigations that are undertaken of the deployment area;
- Provision for further archaeological investigation in the event of any disturbance to the seabed in the

vicinity of smaller geophysical targets;

- Provision for archaeological involvement in subsequent diver investigations;
- Provision for monitoring the cable laying process either by recovering sediment samples or close video inspection by ROV; and,
- Contingency for sampling and specialist analysis of identified submarine or intertidal palaeo-environmental deposits.

16. The implementation of the above recommended mitigation measures will mean that all practicable measures have been put in place to minimise the potential adverse impacts on the known and potential archaeological resource and will enable the unknown resource that may be impacted to be described and assessed. As a consequence, and given the nature of the proposed works, highly significant impacts should be avoided and it is predicted that the residual impact on unknown archaeology, should it occur, is likely to be of minor adverse significance.

14.5 Potential impacts during operation

Potential for impact on the visual setting and historical context of designated areas

1. It is considered that the proposed development has the potential to impact on the historical context of designate sites in the following ways:

- The development could affect the visual setting and historical context of the proposed World Heritage Site (Area A2 - The Port of Hayle);
- The development could affect the visual setting and historical context of Hayle Harbour Conservation Area;
- The development could affect the visual setting and historical context of Scheduled Monuments in the vicinity; and,
- Re-use of the disused power station site could contribute to the erosion of the character and setting of the harbour, the town, listed buildings and structures.

2. The former power station site is situated in an old sand pit screened by high dunes to the north and west. The new substation will be built within the dunes and will not be visible from the proposed World Heritage Site or the Hayle Harbour Conservation Area and will not affect its setting within the disused power station site.

3. The nearest Scheduled Monuments are the early Christian crosses and inscribed stone in and around Phillack churchyard, approximately 1km east of the study area and the Cunaide Stone at Carnsew, approximately 1km south of the study area. About 1.4km south-east of the study area are two scheduled bridges, the 1811 road bridge across Copperhouse Creek (‘the Black Bridge’) and the early railway bridge which carried the Hayle Railway (1837) across the same creek. The proposed development is not inter-visible

with any Scheduled Monuments and will not impact on their settings.

4. Overall, it is concluded that there will be no significant impacts on the visual setting and historical context of designated areas.

Mitigation and residual impact

5. Development proposals should take into account the setting of the project area in relation to the historic character of proposed World Heritage Site and the Conservation Area; this should involve retention of historic fabric where possible and design proposals that minimise visual impact and are of a high quality that respect the setting. However, it is recognised that the new substation will be built adjacent to the existing substation complex operated by WPD and will be designed in accordance with its functional requirements. Visually, this is likely to mean that the substation building will be a modern structure surrounded by the same type of palisade fencing that surrounds the existing substation in order to provide the necessary level of security and health and safety. Also, it is likely that site clearance will be limited to removing some scrub vegetation and tipped rubble, and it is unlikely that this will reveal any historic fabric.

6. Providing the suggested mitigation measures are fulfilled the development will have a residual impact of minor beneficial significance on the historic setting of the harbour and town by improving the environment.

Potential impact on coastal archaeological sites due to potential changes to coastal processes

7. Changes to coastal processes and/or the wave climate at the coast have the potential to give rise to a range of impacts on archaeological and historical sites during the operational phase. In particular, changes can affect sand deposition/erosion around these sites. Of particular concern would be a change in sediment dynamics leading to the burial / exposure of archaeological and historical sites.

8. A coastal processes study was undertaken to support various aspects of the Wave Hub project, including the EIA process. Impacts on coastal processes are covered in Section 6 of this Environmental Statement and the *Coastal Processes Study Report* (see Appendix A). The worst case scenario WEC device layout is predicted to change the wave climate and currents to the extent that it will not result in a discernable effect on sediment transport and beach levels along the north Cornish coast; that is, a change of less than 0.2m in beach levels during extreme storm events. This change is minimal when compared to current typical seasonal and temporal changes to the level of the beach, which can reduce by up to 1.8m in places following severe storms, removing material from the upper beach to create an intertidal bar some distance offshore. During less severe wave conditions this material is returned to the beach from the intertidal bar.

9. Given the seabed deployment of the Wave Hub's offshore infrastructure, WEC device moorings and the cable, the relatively

small area of sea to be covered by the deployment area, and the fact that the deployment area is a considerable distance offshore, it is considered unlikely that the operational Wave Hub will have an impact on coastal processes, waves or currents that could affected coastal archaeological sites.

10. The *Coastal Processes Study Report* supports the conclusions drawn above. Therefore, no significant impacts are predicted on coastal archaeological sites as a consequence of effects on coastal processes.

Mitigation and residual impact

11. No mitigation measures are required and no significant residual impacts are predicted.

15 Road traffic and access

15.1 Introduction

1. This section assesses the potential impacts on road traffic associated with the proposed Wave Hub development and addresses issues associated with access in the vicinity of the land-based infrastructure. Issues related to sea traffic are addressed in Section 12 on navigation.

2. The *Environmental Scoping Report* (Halcrow, 2005) did not identify any potentially significant impacts associated with the proposed development on transport and road traffic. However, a number of issues have been identified during the EIA process and these issues are addressed in this section. These issues comprise the following:

- Disruption to local traffic during the construction of the onshore components of the Wave Hub development;
- Damage to local roads during construction;
- Disruption to public rights of way and Sustrans cycle routes
- Disruption to local traffic during the operational phase of the Wave Hub development.

15.2 Methodology

Data collection

1. Baseline information on road traffic and access within the study area was obtained through desk based research. In addition, road traffic count data were purchased from Cornwall County Council to establish baseline traffic flows for the local road network.

Impact assessment methodology

2. The criteria for classifying the value or sensitivity of environmental resources or receptors with respect to road traffic and transport are set out in Table 15.1.

Table 15.1 Criteria for classifying the sensitivity of receptors with respect to road traffic

Value	Criteria
Very High	Motorway route with very high volume of traffic
High	Primary route with high volume of traffic
Medium	Main road with medium volume of traffic
Low	Secondary road with low volume of traffic
Negligible	Path/other road of no importance

Worst case scenario

3. No worst case scenario applies to road traffic and access since all potential impacts are unrelated to different layouts of WECs, anchors, buoys and safety zones.

15.3 Baseline conditions

Road transport

1. Hayle can be accessed via the A30 from the east or west. The A30 is the major 'A' road in North Cornwall and it links Cornwall with the M5, the nearest motorway, at Exeter.

2. Traffic flows were obtained for Loggans Mill Roundabout and Griggs Hill/The Causeway junction as these provide a good indication of traffic coming off the A30 at St. Erth Roundabout and Loggans Roundabout into Hayle.

3. For the Griggs Hill/The Causeway junction it was found that most of the traffic from St. Erth Roundabout was travelling towards Hayle and very few vehicles travelling to St. Ives. The majority of vehicles travelling from Hayle travelled to St. Ives from this junction with fewer vehicles travelling to St Erth Roundabout.

4. Traffic flows for Loggans Mill Roundabout showed that all routes to and from Hayle had the busiest flows of traffic. Lowest counts were recorded on all routes to and from Wheal Alfred.

5. Traffic flows for the Copper Terrace/Lethlean Junction provide information for traffic movements along the proposed access route to the development site. All routes to and from Lethlean Lane had the lowest recorded traffic movements. Fore Street had the highest movements in both from both Loggans Roundabout and Lethlean Lane.

6. From the counts, it is evident that the peak flow of traffic along all routes occurs around 11.00 and 17.00 daily. Car and taxis accounted for the highest proportion of vehicles by type that use the surveyed junctions.

Public rights of way

7. The South West Coast Path is a National Trail which runs to the west of the study area. The path also follows the coast north along the dunes and east towards Gwithian. There is a short length of public footpath near Mexico Towans and Beachside Leisure Park. There is also wider public access along the beach and the local road network.

Sustrans cycle routes

8. A Sustrans cycle route runs to the south of the study area, travelling along Hayle Estuary before travelling inland along the Kings Memorial Road.

Railway

9. Hayle has a railway station and is serviced by trains linking Penzance with Plymouth.

15.4 Potential impacts during construction and decommissioning

Potential for disruption to local traffic during the construction and decommissioning phase

1. It is proposed that the site compound will be located at the end of North Quay Road.

The site will be accessed by the Kings Memorial Road.

2. The construction will require delivery of plant and material in loads, with the numbers of road vehicles involved shown in Table 15.2.

Table 15.2 Predicted number of road vehicles during the construction phase

Work	Number of road vehicles*	Duration of works (days)
Offshore	0	n/a
Cable-laying (beach)	1 plough 2 excavators 1 crane 6 staff vehicles (daily)	20
Directional drill	1 drill (and equipment) Duct delivery (1 HGV) 6 staff vehicles (daily)	
Substation works	50 x trucks (delivery of materials) 10 staff vehicles (daily)	55
Waste removal	12-15 x trucks (site debris and excavated material)	20

* One-off vehicle movements unless otherwise indicated

3. In light of the above, it is predicted that the impact magnitude will be minor negative given the low volumes of construction traffic and the short-term nature of the construction works. The sensitivity of the receptor is considered to be medium resulting in a potential impact of minor adverse significance.

4. For the decommissioning phase, the substation structure may be demolished and removed, along with the substation equipment. It is predicted that this will require a similar level of road traffic movements as described above and, therefore, the potential impact on the road traffic network will be of a similar magnitude. On this basis it is concluded that the potential impact associated with decommissioning will be of minor adverse significance.

Mitigation and residual impact

5. Access routes will be agreed with Cornwall County Council and/or the Highways Agency in advance of the construction and decommissioning works and the local community will be notified of the works, access arrangements and any restrictions being applied.

6. Overall, it is concluded that there will be no significant residual impact on the local road network during the construction and decommissioning phases.

Potential for damage to local roads

7. There is the potential for damage to local road networks during the construction and decommissioning phases, although it is considered that damage is highly unlikely to occur given that a limited amount of plant is required and the plant required is typical of that required for works of this nature.

Nevertheless, assuming a precautionary approach, it is assumed that should damage to roads occur it would be of moderate magnitude, with the sensitivity of the receptor being of medium sensitivity. On this basis, it is concluded that there is the potential for a worst case impact of minor to moderate adverse significance.

Mitigation and residual impact

8. It is proposed that a pre- and post-construction and decommissioning phase surveys should be undertaken on those routes at risk of damage from the movement of vehicles. Any damage that can be attributed to the proposed works should be made good.

9. Assuming the adoption of these mitigation measures, no significant residual impact is predicted.

Potential for disruption to public rights of way and Sustrans cycle routes

10. During the mobilisation of vehicles and materials to and from the substation and foreshore during the construction and decommissioning phases, there will be some temporary disruption to public footpaths. As a consequence, during the works it will be necessary to temporarily restrict access and/or create a diversion on the South West Coast Path which runs to the west of the substation area and along the ridge of the sand dunes through which the cable will be drilled. In addition, the Sustrans cycle route will be affected by traffic accessing the site via Kings Memorial Road during the construction phase.

11. Given the high importance of the South West Coast Path and the Sustrans cycle route, it is considered that this potential impact is of moderate negative magnitude; the sensitivity of the receptor is considered to be high. Overall, it is concluded, therefore, that the potential impact will be of moderate adverse significance.

12. The construction and decommissioning works do not have the potential to impact on as this route does not run through the development site.

Mitigation and residual impact

13. It is considered likely that there will be a requirement to temporarily divert or close either, or both, the South West Coast Path and Sustrans cycle route for safety reasons. In this case, it will be necessary to apply for formal diversion orders from the local authority.

14. It will also be beneficial to erect signs and information boards to briefly describe the proposed scheme as many members of the public will find the details of the scheme of interest; this can serve to minimise disruption/conflict with members of the public.

15. Following mitigation, it is concluded that the residual impact will be of short-term minor adverse significance.

15.5 Potential impacts during operation

Potential for increase in the level of traffic on the local road network during the operational phase

1. During the operational phase there is no routine requirement for access to the substation as the operational system is intended to be relatively autonomous. All the Wave Hub functions will be monitored and controlled remotely. However, there will be some requirement for occasional routine maintenance and minor repairs as needed; these are likely to be undertaken via service contracts.

2. In light of the above, no significant impacts are predicted on road traffic and access during the operational phase.

Mitigation and residual impact

3. No mitigation measures are required and no significant residual impacts are predicted.

16 Tourism and recreation

16.1 Introduction

1. The north Cornish coast is a highly attractive destination for tourists and recreational visitors. Its appeal includes high quality scenery, rich cultural heritage, the natural environment, and a clean healthy image associated with outdoor recreation.

2. The *Environmental Scoping Report* (Halcrow, 2005) identified that Wave Hub could have the following potential impacts on tourism and recreation:

- Disturbance to recreational users of beaches at Hayle and around St. Ives Bay during cable laying.

16.2 Methodology

Data collection

1. Information on tourism and recreation in the study area was obtained through web-based research, a review of OS maps and aerial photographs, and a site visit to observe and record services related to tourism and recreation. Penwith DC provided information on beach user numbers.

2. Consultation was undertaken with representatives from the Cornish tourism sector, namely:

- Cornwall Tourist Board;
- Cornwall Enterprise;
- Surfers Against Sewage;
- British Surfing Association; and,
- Royal Yachting Association.

3. In addition, baseline conditions have been informed by data collected and reported in the Wave Hub Coastal Processes Study Report (Halcrow, 2006; see Appendix A) and the Wave Hub Navigation Risk Assessment (Anatec, 2006; see Appendix L).

Assessment of impacts

4. Impacts on surfing and navigation have been informed by the Wave Hub Coastal Processes Study Report and the Navigation Risk Assessment.

3. The significance of the effects on tourism and recreation were established through identification of sensitivity or value, assessment of magnitude and assessment of significance using Table 4.3.

Worst case scenario

4. The worst case WEC layout scenario for impacts on tourism and recreation is limited to the impact on surfing waves and is based on a WEC layout comprising four Wave Dragon devices. Four Wave Dragons were chosen to represent worst case scenario because they have the largest effect on waves and, therefore, also have the largest effect on the surfing waves at the coast.

16.3 Baseline conditions

Tourism

1. Cornwall is one of Britain's most popular tourism destinations, and forms an important part of the Cornish economy and employment sector. Tourists make a huge contribution to the economic welfare of the region, spending money in shops, restaurants, hotels and cafes, thus increasing the turnover of local businesses

2. A study on the economic impact of tourism in Cornwall and its districts (South West Tourism, 2003) revealed that 7,109 jobs in Penwith are related to tourism spend and 27% of total employment is supplied by tourism.

Accommodation

3. Within St. Ives Bay a large number of campsites and holiday chalets are concentrated around the Hayle to Gwithian dune system. There are ten campsites within a 5km radius of the proposed substation area. The Riviere Towans Chalet Camp is located directly adjacent to the proposed substation site and some on the chalets are situated directly on top of the dunes through which the cable will be drilled.

Beach recreation

4. Hayle and the surrounding beaches are an important attraction for local visitors and tourists. A series of beaches extend eastwards from Hayle's river mouth in a crescent shape for approximately three miles eastwards. The beaches join up at low tide. The first beach along this stretch is known as Hayle Towans. The beaches continue as far as Godrevy Point. In addition to general sun-bathing, the beaches are used for activities including surfing (see below) and sand yachting, etc. West of Hayle are the beaches around Carbis Bay and St Ives.

5. Table 16.1 details beach counts for the area for 2004 and 2005.

Table 16.1 Visitor counts for Penwith beaches

Beach	2004	2005
Godrevy	82,175	67,990
Gwithian	158,700	182,900
Peters Pint	22,500	15,978
Upton Towans	102,930	76,365
Beachview	15,764	30,990
Mexico Towans	14,415	19,330
Hayle Towans	201,270	84,872
Carbis Bay	-	38,060
Porthkidney	5,370	10,260
Porthminister	203,720	97,450
Porthmeor	229,322	143,500
Porthcurno	45,300	44,881
Sennen Cove	289,000	165,320
Gwenver	70,000	43,895
Marazion	34,700	89,709

Surfing

6. Surfing is a popular and important recreational activity along the Cornish coast.

7. There are a number of surfing breaks within St Ives Bay including in front of the caravan site at Hayle Towans (The Site), Gwithian, Godrevy and around St Ives (Porthminster, Porthmeor). Further along the north Cornish coast are other surfing spots including Portreath, Porthtowan, St Agnes, Droskyn, Perranporth, Crantock and the breaks around Newquay.

8. There are a number of BSA approved surf schools based at and/or using these beaches. A review of the BSA surf schools identified on the BSA's website suggests that no surf school is based at Hayle (the nearest surf school operates out of Gwithian), however, this does not necessarily imply that Hayle Towans or the other beaches near to Hayle are not used by surf schools.

Offshore recreation

9. A number of recreational activities take place within St Ives Bay and further offshore including sea angling and sailing.

10. The *Marine Traffic Survey* (Anatec, 2005) recorded 98 recreational vessels (including 70 yachts) during two 14 day surveys. Only one vessel track (identified to be a yacht) passed through the Wave Hub's deployment area. The survey revealed that the majority of the other vessels passed between the deployment site and the coast.

11. The nearest recreational vessel facilities are at St. Ives and Hayle harbours. There are no general sailing areas or racing areas identified in the area. Medium use recreational routes (defined as popular routes on which some recreational craft will be seen at most times during summer daylight hours) are identified inshore close to St Ives Head and offshore outside the 12 nautical mile limit (i.e. well away from the Wave Hub deployment area).

16.4 Potential impacts during construction and decommissioning

Disruption to recreation

1. During construction of the Wave Hub, it will be necessary to install the cable connecting the onshore and offshore power generating infrastructure. The cable route extends from the sub-station to the sea via the sand dunes and beach at Hayle Towans. Therefore, cable installation has the potential to disrupt the recreational use of the beach and dunes at Hayle Towans and the adjacent water area for bathing, surfing and other activities. A similar impact can be anticipated for decommissioning the cable.

2. Hayle Towans is a popular area used by locals, tourists and recreational users with 84,872 visitors in 2005 and 201,270 visitors in 2004. The disruption impact will depend on the timing, duration, location and scale of the works related to the recreational use of the beach and water.

3. According to the construction schedule, it is likely that construction will be

timed to take place sometime over the late spring and summer months to make the most of favourable weather and sea conditions. This means that the construction could coincide with busy recreational and tourist times including May bank holidays and the early summer, and possibly the peak summer season of late July and August associated with school holidays and August bank holiday.

4. It is estimated that 20 days will be required for the following construction works:

- Directional drilling through the sand dunes;
- Pulling cable through the sand dunes;
- Cable laying across the beach; and
- Cable laying in bathing and surfing water areas.

5. During the cable laying operations in the intertidal area, a public exclusion area will need to be created to enable a safe working area. The size of this exclusion area will be dependent on methodology used to lay the cable, but it is anticipated that a 100m wide working corridor across the beach and the sand dune will be required. This will result in a minor negative impact due to the small and temporary scale of disruption. Given the high importance of the beach to tourism during the summer season (when the cable will be laid) the impact is predicted to be of minor adverse significance.

Mitigation and residual impact

6. The working area required for cable laying on the beach should be kept to a minimum to ensure only a small part of the beach is rendered unusable for the short duration of the works in the intertidal area. The area should be securely cordoned off to prevent the public from entering the construction area. Adequate signage and notices should be provided to ensure beach users are fully informed of the nature and timing of the works which are due to take place. Access to other sections of the beach should not be compromised by the works, and if necessary alternative access routes should be provided to divert beach users around the excluded area.

7. Following mitigation, there will be no significant impact on tourism and recreation on the beach.

Disruption to offshore recreation

8. The proposed offshore works have the potential to impact on the recreational use of the sea during the cable laying and deployment of the Wave Hub and WECs. During the works, it will be necessary to restrict access from the vicinity of the works for safety reasons.

9. The cable laying works in the near-shore waters, where bathing and surfing take place, it expected to be a very short term activity and will take approximately one or two days.

10. The works at the proposed deployment area will also require a restricted area to be established for safety reasons. This only has the potential to affect sailing given the location of the proposed deployment area.

11. Overall, it is predicted that the magnitude of the potential impact is minor negative due to the limited duration of the works in the near-shore area and the low level of recreational use of the deployment area itself. The receptor value is of medium sensitivity as although recreation and tourism is important to the area, the level of use of the study area and the limited duration of the works means that the predicted impact is of minor adverse significance.

Mitigation and residual impact

12. In order to minimise disturbance to recreational activity during the offshore construction period information on the programme for these works must be made available through site notices and a Notice to Mariners.

13. Overall, no significant residual impact on recreational boat users is predicted.

16.5 Potential impacts during operation

Impacts to tourism and recreational use of the beach

1. During the operational phase of the proposed development, there is no potential for disturbance to beach recreation and tourism in the local areas since the only equipment in this area – the cable – should not require maintenance. Therefore, no significant impacts are predicted.

Mitigation and residual impact

2. No mitigation measures are required and there will remain no residual significant impact is predicted.

Changes to surf conditions

3. As described in detail in Section 6, the proposed Wave Hub is predicted to affect the near-shore wave climate and consequently has the potential to effect on surf conditions. The nature of the effect on surf conditions is dependant on the details of the WEC arrays (e.g. physical form, number, arrangement of devices, etc).

4. For the purposes of assessment, a number of possible scenarios have been assumed, including a likely worst case WEC layout scenario (i.e. four Wave Dragon devices) and example conditions for offshore waves generating small (H 1m, Ts 7s) and big (H 4m, Ts 16s) surfing waves at the coast.

5. The results of the *Coastal Processes Study Report* (see Appendix A) identify reductions in the height of surfing waves at the coast of the following magnitudes for the worst case WEC layout scenario (see Figures 6.6, 6.8 and 6.9:

- Up to 13% reduction during mean wave conditions;
- Up to 11% reduction during small wave surfing conditions (offshore Hs 1m, Ts 7s) at breaks at St Agnes, Droskyn and Penhale; and

- Up to 11% reduction during big wave surfing conditions (offshore Hs 4m, Ts 16s) at breaks at Portreath, Portowan and Chapel Porth.

6. The results of the *Coastal Processes Study Report* identify reductions in the height of surfing waves at the coast of the following magnitudes for the typical case WEC layout scenario (various WEC devices) (see Figures 6.7, 6.10 and 6.11):

- Up to 5% reduction during mean wave conditions;

- Up to 5% reduction during small wave surfing conditions (offshore H 1m, Ts 7s) at breaks at St Agnes, Droskyn and Penhale; and

- Up to 5% reduction during big wave surfing conditions (offshore H 4m, Ts 16s) at breaks at Portreath, Portowan and Chapel Porth.

7. Given the popularity of surfing in Cornwall and its contribution to the socio-economy, the sensitivity of a change in surfing wave heights is potentially high, particularly at the most popular surfing locations around coastal towns particularly Newquay. The sensitivity of surfing impacts at other locations is considered to be medium given that the scale of surfing is less.

8. Commentary concerning the predicted change in wave heights has been provided by SAS: "Under most conditions, it is doubtful that the effect will be noticeable by surfers at all, given the small magnitude of the height reductions in question and the fact that wave height is only one factor in determining the quality of a surfable wave." For example, in addition to wave height, surfers will choose a particular wave of a set based on criteria such as their position relative to the breaking section of the wave and other surfers, the wave in relation to the other waves in a set, the cleanliness of the wave and its breaking characteristics, etc. It is these factors, more than wave height, which will influence a surfer's wave choice since they determine the quality of the surfable wave and the surfing experience.

9. Overall, a worst case scenario reduction in wave height of up to 13% will have a minor adverse impact on surfing conditions at a limited number of breaks along the north Cornish coast between Portreath and Penhale. The breaks around Newquay will be unaffected.

10. A wave height reduction of up to 5% is much more likely to result from Wave Hub's operation and will have a minor adverse impact on surfing conditions at the same breaks.

Mitigation and residual impact

11. No mitigation measures are required and there will remain a minor adverse residual impact at the breaks affected.

Navigation of recreational vessels

12. The risk of collision between recreational vessels and the Wave Hub infrastructure is assessed under Section 12, and is informed by the *Navigation Risk Assessment* (see Appendix L). In summary,

the main risk relates to either a vessel becoming becalmed and drifting into the Wave Hub site or due to watch-keeping failure or navigational error and routeing through the Wave Hub site, particularly in bad weather. Given the ready availability of weather forecasts, the growing use of GPS and the navigation aids in place, the risk of a vessel being in proximity to the Wave Hub in bad weather and therefore the risk of collision is considered to be low. Accordingly, a potential impact of minor adverse significance is predicted.

Mitigation and residual impact

1. Various navigation control measures will be in place and apply to recreational vessels. Trinity House will consider the needs of small leisure craft by taking into account the likely traffic type and density when determining the correct level of marking for the site. Notification of the Wave Hub to the recreational craft community will be widespread and information will be promulgated to yacht clubs, marinas, harbour masters, etc.

2. With the implementation of the above mitigation measures, it is concluded that the frequency of vessel infringements will be reduced, and potentially avoided entirely. Consequently, it is predicted that there will be no significant residual impact.

17 Noise and air quality

17.1 Introduction

1. This section addresses the potential noise and air quality impacts that are predicted to result from the construction, operational and decommissioning phases of the scheme. This section focuses on the potential impacts on sensitive receptors with the exception of ecological receptors and fish resources; these aspects are addressed in Sections 10 and 11.

2. The *Environmental Scoping Report* (Halcrow, 2005) identified the potential impacts to be the effects of noise and dust generated during the construction works.

17.2 Methodology

Guidance

1. Construction (and decommissioning) work involves various activities, undertaken by different types of plant, at different locations and at varying times. As a consequence, construction noise levels at noise-sensitive locations vary with time as the noise sources move progressively closer or further away from a property, and as the activities themselves change.

2. With respect to the proposed construction works, the main activities are likely to be excavation works in designated working areas within the onshore study area (i.e. location of proposed substation and ancillary buildings and access road track) and directional drilling for the cable.

3. There are no national criteria for limiting noise levels from construction sites/activities; the Control of Pollution Act 1974, the Act that pertains to such activities, leaves it to local authorities to recommend criteria appropriate to their area of jurisdiction.

Worst case scenario

4. No worst case scenario applies to noise and air quality since all potential impacts are unrelated to different layouts of WECs, anchors, buoys and safety zones.

17.3 Baseline conditions

Background onshore and offshore noise

1. No information was available from CCC or Penwith District Council on background noise levels at the onshore site in Hayle.

2. Typical background noise is likely to be associated with low level noise from human activity, cars and beach users.

3. Offshore sources of noise are dominated by the sea and wind.

Onshore construction works

4. The main onshore construction activities are the improvement of the access road, construction of the substation building and ancillary building, supply of services, and directional drilling of the cable. The nearest receptors to noise generated during the construction and decommissioning phases are

residents of Riviere Towans Holiday Homes and beach users.

17.4 Potential impacts during construction and decommissioning

Noise disturbance to sensitive receptors

1. During construction of the onshore infrastructure there is likely to be generation of some noise and vibration. This will largely be localised to the area of the proposed substation, although there is likely to be some noise generated during the laying of the cable in the intertidal area and the directional drilling of the cable through the dunes. In addition, there will be increased noise associated with the transportation of material to the site by road.

2. The construction works are predicted to last for a period of about 55 days in total and, therefore, the works are short term. The noise generated by construction will vary depending on the nature of the activity being undertaken and noise generation is likely to be intermittent. Construction noise sources are likely to be associated with typical construction plant such as excavators, lorries, drilling equipment, etc, with similar plant required for the decommissioning phases. The majority of the noise impact from increases in traffic flow would occur at the beginning and the end of the works period when plant would be mobilised/demobilised to and from the site. A full description of the construction and decommissioning works is provided in Section

3. With respect to sensitive receptors, the nearest residential area is Riviere Towans Chalet Camp and Riviere Towans itself. However, there are isolated houses overlooking the site of the proposed sub-station. Other receptors comprise users of the beach and walkers on the South West Coast Path.

4. It is concluded that the magnitude of the potential impact will be minor negative given the short duration of the works and the fact that the construction and decommissioning works do not require the use of significant quantities of plant. In terms of sensitive receptors, there are a limited number of dwellings that will be exposed to noise generated during construction and decommissioning and, therefore, a very small population will be affected by the short term, intermittent noise generated. In light of the above, the receptor is evaluated to be of medium sensitivity.

5. Overall, the impact is predicted to be of minor adverse significance.

Mitigation and residual impact

6. It is proposed that the following measures will be implemented to mitigate against noise disturbance to the local community:

- All local residents will be informed of the nature, timing and duration of particular construction and decommissioning activities that might give rise to noise and vibration through information notices and leaflets where appropriate; and,
- The contractor and the Environmental Health Officer for Penwith District Council

will agree details of the construction works prior to commencement. Particular attention should be paid to scheduling those activities that have the potential to generate the highest levels of noise within the hours between 08:00 to 18:00.

7. Although the implementation of the above mitigation measures should avoid complaints arising from local residents, the generation of noise during the construction and decommissioning phases is unavoidable and a residual impact of minor adverse significance is predicted.

Dust nuisance during onshore construction

8. It is likely that there will be localised increases in dust generation as a result of increased vehicle movements, the use of plant associated with the construction phase and excavation. This would result in a minor negative impact on air quality as the effect will be intermittent and highly localised to the construction works.

9. In light of the above, it is concluded that there is a low potential for the limited dust that will be generated during construction to result in a significant nuisance to local residents. Consequently, no significant impact is predicted.

Mitigation and residual impact

10. No mitigation measures are required and there will remain no significant residual impact is predicted.

17.5 Potential impacts during operation

Noise disturbance during operation of the substation

1. Although the equipment within the sub-station is likely to generate some noise, this will be of a very low level and is unlikely to be detectable beyond the immediate vicinity of the substation. In particular, no noise from the substation is likely to be detectable at the nearest residential properties. Therefore, no impact is predicted.

Mitigation and residual impact

11. No mitigation measures are required and there will remain no significant residual impact is predicted.

18 Socio-economics

18.1 Introduction

1. This section of the Environmental Statement assesses the potential impacts of the proposed Wave Hub development on socio-economic conditions.

2. The *Environmental Scoping Report* (Halcrow, 2005) did not identify any adverse socio-economic impacts on Hayle or the wider area. However, SWRDA's objectives behind the Wave Hub's concept are such that the project should bring a variety of direct and indirect socio-economic benefits to the South West region. Such benefits include the potential creation of a number of new jobs and new industry and the expansion of existing industry capable of manufacturing, deploying, maintaining, inspecting, repairing and decommissioning the potentially wide range of devices likely to be deployed.

3. The overall economic impact of the proposed Wave Hub development are identified and analysed in a *Wider Economic Impact Assessment Report* prepared by Arthur D Little (ADL) Ltd (2005). That report describes the various potential direct and indirect impacts of the proposed development and forms the basis for the information provided in this section. ADL Ltd (2005) also provides an overview of the existing socio-economic baseline of the region.

18.2 Methodology

Data collection

1. Information on the existing socio-economic character of the study area has been gathered from the *Wider Economic Impact Assessment Report*, web-based research and information sources including CCC, Penwith DC and the National Statistics Office.

Impact assessment

2. The significance of the socio-economic impacts was established through the identification of sensitivity of value using the methodology detailed in Table 4.3.

3. With respect to the potential socio-economic impacts associated with the proposed development, it is appropriate to adopt a different approach to the presentation of potential impacts from that adopted for the other sections of the Environmental Statement.

4. Rather than describing the potential impacts associated with the construction/decommissioning phases and the operational phases, it is more appropriate to describe the potential direct and indirect impacts.

5. Direct impacts are associated with the Wave Hub facility WECs and can arise as a consequence of its construction and operation.

6. Indirect impacts are those that may arise as a consequence of the Wave Hub, but which are not directly related to the development considered under the consent

applications this Environmental Statement supports. For example, beyond the deployment of WECs at Wave Hub, WEC developers may construct and operate WECs at new wave farms in other parts of the Cornwall and the South West, subject to other consent applications.

7. Figure 18.1 summarises the predicted direct and indirect impacts of the proposed development.

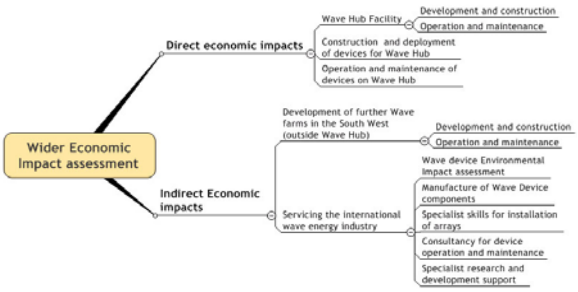


Figure 18.1 Predicted direct and indirect economic impacts associated with the proposed Wave Hub (ADL, 2005)

8. Potential indirect impacts on the socio-economic environment are excluded from this impact assessment. The primary reason for this is that they are not of direct relevance to the consent application for Wave Hub and are thus outside the scope of this Environmental Statement. In addition, it is not possible to assess the potential indirect impacts of other possible developments on other environmental parameters (e.g. fisheries resources, marine ecology, archaeology, etc) given that there are no current plans for any other developments and, therefore, the inclusion of potential socio-economic effects would be inappropriate.

Worst case scenario

9. No worst case scenario applies to socio-economics since all potential impacts are unrelated to different layouts of WECs, anchors, buoys and safety zones.

18.3 Baseline conditions

Overview of the Cornish economy

1. The largest sectors of the Cornish economy are food and drink and tourism and leisure; these sectors are central to the South West Regional Economic Strategy (RES). Other important sectors in Cornwall include agriculture, fishing and creative industries.

2. These important sectors are, in some cases, fragile; tourism and leisure is subject to severe competition and the natural resources sector has been affected by the Common Agricultural and Fisheries Policies and the loss of markets.

3. Despite some progress made over the recent years, average wages and productivity in Cornwall are substantially behind the rest of the region. Cornwall struggles to attract major investment in high value added manufacturing sectors and there are limited employment opportunities.

4. Small businesses dominate the Cornish economy. About 70% of 18,000 businesses employ less than five people and over 30% have an annual turnover of less than

£100,000. In addition, over 44,000 people are self-employed.

5. Cornwall has one of the highest proportions of low paid workers in England with average earnings lower than any other English county. Furthermore, unemployment levels rise during the winter period, with pockets of particularly high unemployment and deprivation in West Cornwall. This reflects the importance of tourism and other seasonal jobs to the local economy.

6. Overall, Cornwall qualifies for the highest possible level of support from the European Union (EU) under its Objective One programme, as GDP per head is around 71.6% of EU25 GDP. The EU Objective One funding has been fundamental for the development and regeneration of the urban centres.

7. Emphasis is being put on sustainability of development while building on Cornwall's unique culture, heritage and traditions, alongside its outstanding natural environment. CCC has highlighted economic development and regeneration as one of its top priorities in order to address three interlinked issues:

- The lack of good quality job opportunities to meet local demand;
- Insufficient and inappropriate skills amongst local people; and,
- The need to improve the competitive position of local businesses.

8. About 30% of employers in Cornwall experience skills gaps in their workforce. The generic skills most frequently mentioned as lacking are basic IT skills/use of computer packages/software programming, customer care and sales and marketing skills. Nevertheless Cornwall has skills in the design and construction of boats, notably for the recreational sector. These skills could be adapted to support activities in the wave energy industry.

9. Cornwall has a dispersed settlement pattern with implications for travel modes and planning economic development. Cornwall's larger urban centres that have a concentration of people, jobs and facilities include Penzance, Falmouth-Penryn, Newquay, St. Austell, Bodmin, Truro and Camborne-Pool-Redruth.

10. Among the major reasons for the comparatively weak economic performance of Cornwall are undoubtedly the lack of major conurbations, real and perceived low quality of transportation links, gaps in skills profile, distance from higher education institutions and related unfavourable industry structure. Although other types of manufacturing are relatively under-represented, the region has a strong specialisation in marine technologies, as measured by proportion of employees in the sector compared to the UK average.

Economic context of Hayle

11. Hayle is one of the most deprived wards (both in terms of individual income and provision of services) of Penwith District and Cornwall. This is despite the fact that Hayle and the St. Ives Bay is noted for its 'three miles of golden sand', which attract thousands of

tourists each year. Levels of unemployment are high compared to other parts of Cornwall with many of the jobs being seasonal.

12. Hayle harbour, home to a small fishing fleet and a commercial port, has a long history of problems caused by sand being washed into it from St Ives Bay and difficulties in securing further development of the area. The last change of the harbour ownership occurred in early 2004 and the new owners are a UK subsidiary of a Dutch real estate development company (ING). It is working on plans for a twelve-year £150m redevelopment of the site. This development fits with a wider 2001-2016 development plan for Penwith District, that anticipate 3,300 new dwellings to be built during the period in the district, and that underlines the need for improved employment opportunities in the locality and economic diversification.

13. The Hayle Area Forum (regeneration group) is driving a steering group known as 'Revitalise! Hayle Coast and Country'. The top priorities of the local people's vision are:

- A revitalised harbour;
- More and better quality shops, restaurants and cafes;
- Improved town buildings; and,
- A town centre and better focal point for the town.

Transport infrastructure in Cornwall and the South West

10. The main road network connecting Cornwall with the rest of the UK is based on the M5/A38/A30 axis (Figure 18.2).

11. Network Rail operates a number of rail services within Cornwall, the main line being from Penzance to Exeter St. David's and on to London. There are also a number of branch lines connecting the main line to towns such as St Ives and Newquay.

12. The main airports in the South West are at Bristol, Bournemouth and Exeter. The nearest airport to the proposed Wave Hub landfall at Hayle is Newquay, which has daily flights to Gatwick, Bristol, Dublin and Leeds/Bradford.

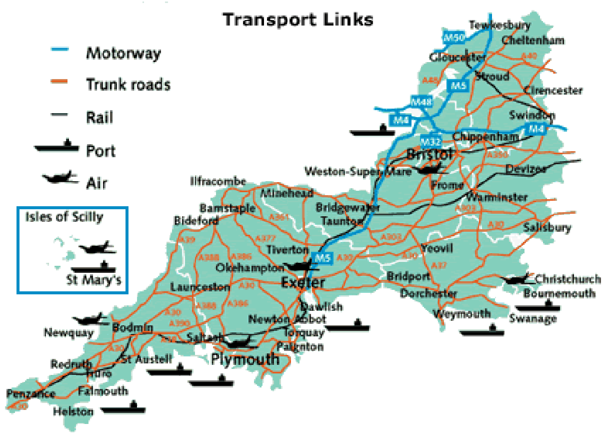


Figure 18.2 Transport infrastructure in Cornwall and the South West (source: www.southwestrda.org.uk)

Population

13. The 2001 Census indicates that the population figure is 7844 for Hayle out of a total of 499,114 for Cornwall (www.cornwall.gov.uk). Like much of Cornwall, the population of Hayle varies significantly throughout the year, increasing with the influx of tourists during the holiday periods at Easter and in the summer (July and August).

Marine and shipbuilding sector in Cornwall and the South West

14. Cornwall is home to a number of shipyards and harbours, which play a crucial role in ensuring economic prosperity of the region. Falmouth, the largest shipyard in Cornwall, hosts a substantial number of small enterprises specialising in building and refitting luxury boats and yachts in dry and wet docks. The shipyard provides immediate access to deep, sheltered waters ideal for sailing trials as well as many excellent local services and facilities as one would expect from a town with a prestigious maritime heritage.

15. The Falmouth/Penryn area provides employment opportunities for about 3,000 people and counts amongst its strengths Falmouth Marine School, a major source of skilled workers for the industry.

16. There are several marine centres across the South West and Cornwall containing a skills base, which will be of direct relevance to the Wave Hub project. These include centres such as Falmouth, Plymouth and Poole.

17. The region's major marine centre is Plymouth, which accounts for over half the marine technologies sector Gross Value Added (GVA) in the region. Apart from an increasing number of companies specialising in higher added value products and services, Plymouth boasts a wide variety of marine related education, training and research undertaken within the University of Plymouth and the marine science institutes. Over 6,000 people are directly employed in the marine technologies sector.

18.4 Potential direct impacts of the construction and operation of Wave Hub

Direct economic impacts of the Wave Hub and WEC manufacture and deployment

1. ADL Ltd (2005) predicted the number of direct Full Time Equivalents (FTE) arising from £1million investment using Econ-i (a software tool). In addition, the direct GVA per £1 expenditure was determined and Type II multipliers (i.e. the sum of direct, indirect and induced effects, including the changes in output induced by income spending and indirect demands for output within the regional economy) for the different expenditure distributions were estimated. As a result, it is possible to estimate the direct, indirect and induced jobs and GVA arising from Wave Hub construction and operation.

2. For example, for every £1 million of direct expenditure in the region under the 'best case' scenario (i.e. if all possible items were incurred in the South west), 17.5 direct jobs would be created (but would only last for the duration of construction). The associated Type

ll employment multiplier also suggests that a further 6.5 indirect and induced jobs would be created in the region as a result of the investment. This brings the overall impact of the expenditure in the region associated with the Wave Hub itself to about 24 jobs per £1 million expended.

3. The overall impact of the development, construction and operation of Wave Hub is illustrated in Figures 18.3 (jobs arising) and 18.4 (GVA) for the South West.

4. As shown in Figure 18.3, during the construction and development phase total employment peaks at over 140 jobs during 2006. Of these about 30 would be based within Cornwall.

5. During the operational phase, Wave Hub will consist of a full time staff of two directors and one office manager. It is estimated that the project will spend over £420,000 per annum for ongoing Wave Hub operations and maintenance. The difference between the different scenarios depends on the ability of local companies to provide the services required.

6. In addition to the above, WEC developers will manufacture, deploy, operate and maintain WECs to be connected to Wave Hub. Many of these activities will increase GVA and create jobs in Cornwall and the South West.

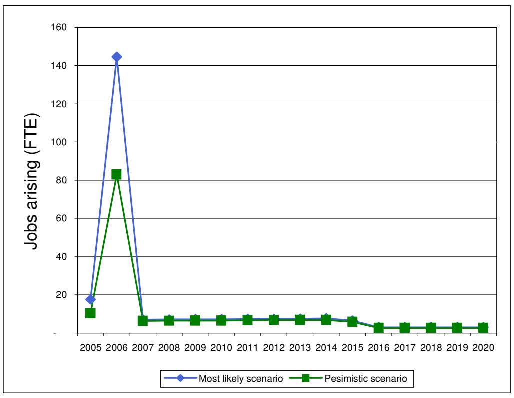


Figure 18.3 Employment impact on South West economy resulting from development, construction and operation of Wave Hub

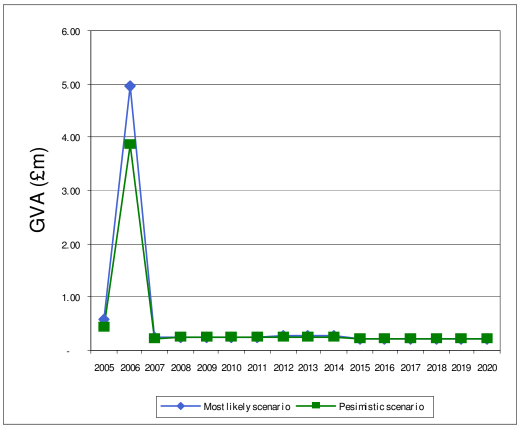


Figure 18.4 GVA impact on South West economy resulting from development, construction and operation of Wave Hub

7. Figures 18.5 and 18.6 illustrate the total number of jobs and GVA created through construction and operation of WECs on Wave Hub and includes both indirect and induced jobs.

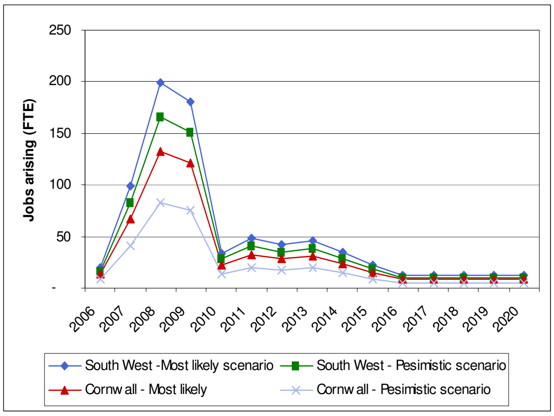


Figure 18.5 Direct, indirect, and induced jobs (FTE) created through the construction and operation of WECs on Wave Hub

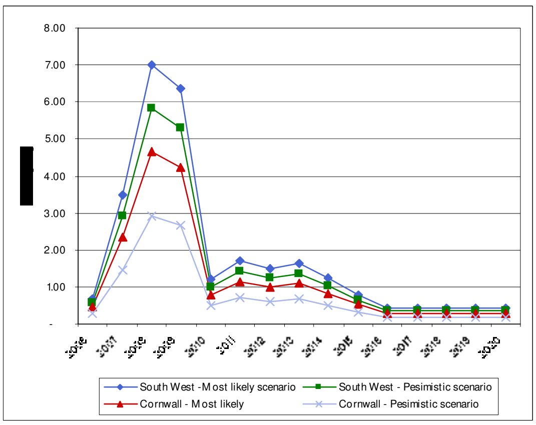


Figure 18.6 GVA (£m) created through the construction and operation of WECs on Wave Hub

8. This assessment has assumed that displacement impacts – where the project draws scarce skills from other sectors – are negligible. Most of the jobs are within the declining marine services, and it is assumed that activities related to activities such as electrical engineering are not sourced locally. Indeed, the project may have positive substitution effects, where there is a switch of labour from related sectors that are currently underperforming, into an area where market growth is potentially high and specialised.

9. The magnitude of the direct socio-economic impacts is considered to be of moderate positive magnitude overall, with the most beneficial effects arising during the construction and development phase. The value of the receptor (i.e. the regional economy) is high and it is concluded that the proposed Wave Hub represents an overall impact of moderate beneficial significance to the socio-economic environment.

Mitigation and residual impact

10. No mitigation measures are required and a residual impact of moderate beneficial significance is predicted.

19 Conclusions

19.1 Introduction

1. This section summarises the potential impacts, proposed mitigation measures and residual impacts associated with the proposed Wave Hub development during the construction, operational and decommissioning phases (Tables 19.1 to 19.3). The tables also indicate the level of uncertainty that applies to the assessment of the significance of the potential impact where appropriate.

2. The following notation has been used throughout Tables 19.1 and 19.2 when describing significance and uncertainty.

Significance

XXX	Major negative impact
XX	Negative impact
X	Minor negative impact
0	Impact considered to be not significant
+	Minor benefit
++	Moderate benefit
+++	Major benefit
?	Impact of unknown significance

Uncertainty

*	Some uncertainty, but outcome is sufficiently clear to enable a decision
**	An area of substantial uncertainty
***	True impacts are unknown, and prediction is currently little more than an educated estimate

Table 19.1 Summary of potential impacts, mitigation measures and residual impacts during the construction and decommissioning phases

Receptor	Predicted effect / potential impact	Significance	Uncertainty	Mitigation	Residual significance
Coastal processes	The potential effects of Wave Hub on coastal hydrodynamics and geomorphology arise on completion of the scheme and are, therefore, addressed in Table 19.2.				
Water, sediment and soil quality	Impact on water quality due to pollution	No impact is predicted under normal conditions, but there is the potential for accidental pollution	-	All contractors should have precautionary preventative mitigation measures in place (e.g. contingency plan, emergency contacts, suitable spill kits and absorbents and staff training to deal with pollution incidents)	No impact is predicted under normal conditions, but there is the potential for accidental pollution
	Impact on water quality due to turbidity from sediment disturbance	0	-	None required	0
	Impact on water quality due to contaminated sediment disturbance	0	-	None required	0
	Impact on water quality due to contaminated ground disturbance	0	-	None required	0
Terrestrial ecology	Potential for effect on designated sites	0	-	None required	0
	Potential for effect on habitats and flora	X	*	• Identification and fencing of clear working areas • Transplanting of balm-leaved figwort • Pre-construction survey for invasive plants	X (short term), 0 (longer term)

Receptor	Predicted effect / potential impact	Significance	Uncertainty	Mitigation	Residual significance
	Potential for effect on protected and notable species	X (birds and reptiles), 0 (invertebrates)	*	• Vegetation to be cleared between September and February • Works to be halted if breeding birds suspected to be present, and assessment by ecologist • Identification and fencing of clear working areas • Reptile translocation prior to works	X (short term on birds), 0 on other features
Ornithology	Potential for effect in intertidal birds	0	*	• Ideally, works to take place outside the winter (October-March) • If winter working in unavoidable, work should not take place for 2 hours after high tide where high tide occurs early in the morning • Duration and extent of work should be kept to a minimum • Best working practice to be followed and adherence to EA PPGs	0
	Potential for effect on offshore birds	0	*	None required	0
Marine ecology	Disturbance to intertidal communities during construction and decommissioning of the cable	X	-	• Clear definition and fencing of working area	X
	Disturbance to subtidal benthic communities	X	-	None possible	X

Receptor	Predicted effect / potential impact	Significance	Uncertainty	Mitigation	Residual significance
	Disturbance to marine mammals due to the generation of underwater noise	X	*	If piling is required for the installation of the moorings, the following measures are applicable: • Ensure that the correct specification of pile and pile driver is used • Use of 'soft' start up procedure	X
Fish resources and commercial fisheries	Potential for conflict between commercial fishing activity and construction works	X	-	• Notification via Notice to Mariners • Appointment of a fisheries liaison officer	X
	Potential effects of underwater noise generated during the construction phase on fish resources	X	*	If piling is required for the installation of the moorings, the following measures are applicable: • Ensure that the correct specification of pile and pile driver is used • Use of 'soft' start up procedure	X
	Potential for effect on the food resource for fish	0	-	None required	0
	Potential effects on fishing activity during decommissioning	0	-	None required	0
Navigation	Potential for conflict between construction activities and navigation	0	*	Device specific-risk assessments will be required and this will lead to the identification of mitigation measures to attempt to minimise the risk to navigation to a level that is as low as reasonably practicable	0
Landscape and views	Potential impact of cable laying on the visual amenity of the beach	XX	-	Notification of the works at beach entrance points	X
	Potential impact of cable laying on landscape features, particularly sand dunes	0	-	None required	0

Receptor	Predicted effect / potential impact	Significance	Uncertainty	Mitigation	Residual significance
	Potential impact of offshore construction in views from land	X	-	• Number of vessels needed should be limited to the minimum number required	X
Cultural heritage and archaeology	Potential for impact on known and potential sites of cultural heritage and archaeological importance	0 – XXX depending on the nature of archaeological features that may be present and the extent of disturbance./damage	**	• The area of seabed that is disturbed should be kept to a minimum • Geophysical survey of the beach and dunes to detect any buried WWII ordnance • Agreed programme of archaeological recording • Approval of a Written Scheme of Investigation	The recommended mitigation measures will minimise potential adverse impacts and also the level of uncertainty regarding impact prediction. Highly significant impacts should be avoided and the residual impact is likely to be of minor adverse significance (X)
Road traffic and access	Potential for disruption to local traffic	X	-	• Access routes to be agreed with the Highways Agency • Inform local community of the works, access arrangements and restrictions	0
	Potential for damage to local roads	X / XX	*	• Pre- and post-construction and decommissioning phase surveys to be undertaken • Damage attributable to the works should be made good	0

Receptor	Predicted effect / potential impact	Significance	Uncertainty	Mitigation	Residual significance
	Potential for disruption to public rights of way and Sustrans cycle routes	XX	*	• If there is a need to close or divert part of the South West Coast Path, a footpath diversion order will be needed • Information boards and signs to be erected	X
Tourism and recreation	Disruption to recreation	X	-	• Working area on the beach to be kept to a minimum • Construction area cordoned off • Signage and notices • Alternative access routes to divert beach users around the excluded area	0
	Disruption to offshore recreation	X	-	• The construction programme should be made available via Notice to Mariners	0
Noise and air quality	Noise disturbance to sensitive receptors	X	-	• Local residents to be informed of the nature, timing and duration of works • Contractor and the Penwith DC Environmental Health Officer to agree timing of construction works	X
	Dust nuisance during onshore construction	0	-	None required	0
Socio-economy	Direct economic impacts of the Wave Hub and WEC manufacture and deployment	++	-	None required	++

Table 19.2 Summary of potential impacts, mitigation measures and residual impacts during the operational phase

Receptor	Predicted effect / potential impact	Significance	Uncertainty	Mitigation	Residual significance
Coastal processes	With respect to **general wave height** the modelling predicts up to a 5% magnitude reduction in wave heights at the coast during a 1 in 1 year return period storm for the worst case WEC layout. For the typical case WEC layout the modelling predicts up to a 3% reduction in wave height at the coast				
	With respect to **surfing waves**, under the worst case WEC layout, during mean wave conditions a reduction in wave heights at the coast of up to 13% is predicted. For small and big surfing wave conditions, a reduction in wave heights at the coast of up to 11% is predicted. Under the typical case WEC layout, the impact of the various WEC types during mean, small and big wave conditions will be a reduction in wave heights at the coast of up to 5%.				
	With respect to **sediment transport, t**he WECs are predicted to have a very small effect in localised areas near the coast. The Wave Hub infrastructure is predicted to result in very localised effects on sediment movements in the immediate vicinity of the infrastructure				
Water, sediment and soil quality	Impact on water quality due to pollution	No impact is predicted under normal conditions, but there is the potential for accidental pollution	-	All contractors should have precautionary preventative mitigation measures in place (e.g. contingency plan, emergency contacts, suitable spill kits and absorbents and staff training to deal with pollution incidents)	No impact is predicted under normal conditions, but there is the potential for accidental pollution
	Impact on water quality due to turbidity from sediment disturbance	0	-	• Sub-sea infrastructure should be founded on bedrock to prevent undermining through scouring and anchored or weighed down to prevent flow-induced vibration • Cables will need to be weighted or anchored to prevent uplift and abrasion against exposed rock outcrops	0
Terrestrial ecology	No significant impacts are anticipated				

Receptor	Predicted effect / potential impact	Significance	Uncertainty	Mitigation	Residual significance
Ornithology	Potential for effect on intertidal birds	0	*	In the event that maintenance work is required, the following measures should be implemented: • Ideally, works to take place outside the winter (October-March) • If winter working is unavoidable, work should not take place for 2 hours after high tide where high tide occurs early in the morning • Duration and extent of work should be kept to a minimum • Best working practice to be followed and adherence to EA PPGs	0
	Potential for effect on offshore birds	0	*	• Best working practices must be employed and method statements produced activities where there is a risk of pollution. • Lighting at night time should only be permitted where required for safety and navigational purposes	
Marine ecology	Potential for effect on marine mammals due to the generation of underwater noise	0	**	• In view of the level of uncertainty associated with the prediction of this impact, a programme of monitoring of operational noise is recommended	0
	Potential effects of electromagnetic fields on sensitive marine organisms	X (elasmobranchs), 0 (cetaceans)	*	No mitigation measures are possible	X (elasmobranchs), 0 (cetaceans)
	Potential for the proposed development to act as a physical barrier to movement	0	-	None required	0

Receptor	**Predicted effect / potential impact**	**Significance**	**Uncertainty**	**Mitigation**	**Residual significance**
	Potential for impact on benthic communities as a result of predicted effects on the sediment regime	0	-	None required	0
Fish resources and commercial fisheries	Potential interference with fishing activity due to the presence of the sub-sea cable	X	-	Other than the post-installation survey of the cable route, no further mitigation is required	X
	Exclusion of fishing activity from the Wave Hub deployment area	X / XX	*	No mitigation measures are possible particularly if safety zones around the WECs are declared under the Energy Act 2004	X / XX
Navigation	Potential for a commercial effect on shipping as a consequence of re-routeing	0	-	None required	0
	Potential for a vessel to come into proximity with the deployment area as a consequence of having to deviate course due to interaction with other vessels	0	-	None required	0
	Assessment of risk of vessel-to-vessels collisions	+	-	None required	+
	Assessment of the potential for ship collision with WEC devices	X (powered ship collision), 0 (drifting ship collision). This assessment relates to the *risk* of collision; under each scenario, the significance of a collision (should it occur) could be significant	-	Mitigation measures are proposed to minimise the potential for collision/interaction, such as: • Marking of the Wave Hub deployment area • Marking of individual structures • Designation of an area to be avoided • Designation of safety zones	0

Receptor	Predicted effect / potential impact	Significance	Uncertainty	Mitigation	Residual significance
	Risk of fishing vessel collision	X; this assessment relates to the *risk* of collision; the significance of a collision (should it occur) could be significant	-	The mitigation measures described above are applicable here	0
	Risk of collision between recreational vessels and the Wave Hub infrastructure	X; this assessment relates to the *risk* of collision; the significance of a collision (should it occur) could be significant	-	The mitigation measures described above are applicable here	0
	Potential for interaction between the site to shore cable and anchoring/trawling	X	-	• Survey of the cable route following installation • Regular post-installation surveys to ensure cable remains buried • As-laid position of cable to marked on Admiralty Charts • Best practice offshore cable installation liaison and notification procedures applied	0
	Potential for interactions between Wave Hub and the MoD Danger Area	0	-	None required	0
Landscape and visual	Potential impact of the substation on visual amenity and landscape character	0	-	None required	0
	Effect of cable on visual amenity	0	-	None required	0
	Potential impact of WEC devices during the day in views from land	X (Rosewall Hill); X (at worst; St Ives Head); X (at worst; Navax Point)	-	No mitigation measures are possible	X (Rosewall Hill); X (at worst; St Ives Head); X (at worst; Navax Point)

Receptor	Predicted effect / potential impact	Significance	Uncertainty	Mitigation	Residual significance
	Effect of navigation lighting on night-time views from land	X - XX (Rosewall Hill and Navax Point); X (St Ives Head)	*	No mitigation measures are possible	X - XX (Rosewall Hill and Navax Point); X (St Ives Head)
Cultural heritage and archaeology	Potential for impact on the visual setting and historical context of designated areas	0	-	• Development proposals to take into account the setting of the project area in relation to the proposed World Heritage Site and Conservation Area	0
	Potential impact on coastal archaeological sites due to potential changes to coastal processes	0	-	None required	0
Road traffic and access	Potential for increase in the level of traffic on the local road network	0	-	None required	0
Tourism and recreation	Impacts to tourism and recreational use of the beach	0	-	None required	0
	Changes to surf conditions	X	-	None required	X
	Navigation of recreational vessels	X	-	• Needs of small leisure craft to be taken into account when determining appropriate marking for the site • Wave Hub will be notified to recreational craft community via marinas, harbour masters, etc	0
Noise and air quality	Noise disturbance during operation of the substation	0	-	None required	0

20 Monitoring

20.1 Introduction

1. This section makes recommendations for environmental monitoring during the construction and operational phases of the proposed Wave Hub development. The need for monitoring has been defined on the basis of the nature of the potential impacts that are predicted to arise as a consequence of the proposed development.

2. When defining the requirements for monitoring it is important to focus on those areas where significant potential impacts may arise, or where there is a relatively high degree of uncertainty as to the nature of the potential impact.

3. This section is not intended to provide a specification for monitoring, but sets out those areas where monitoring is proposed. It is proposed that such detailed monitoring specifications will be developed through consultation and it will be necessary to achieve agreement to the detailed monitoring programme prior to its implementation.

20.2 Offshore seabirds

1. The impact assessment has concluded that there are unlikely to be any significant impacts on offshore seabirds during the life of the proposed development. However, given that the project is likely to be the first of its kind in the UK, it is recommended that post-construction monitoring is undertaken in order that the findings of the EIA process can be verified. Such monitoring would have value in informing the assessment of any future wave energy developments.

2. The detail of the monitoring programme should be agreed with the relevant statutory consultees prior to its implementation. It is suggested that it should follow the Before-After-Control-Impact (BACI) methodology.

20.3 Underwater noise and cetaceans

1. The aim of underwater noise and cetacean monitoring is to:

- Verify the findings of the Environmental Statement with respect to the level of noise generated during the construction works (this is only recommended if piling is required for the installation of the moorings for the WECs);

- Define the level of noise generated by the WECs during the operational phase; and

- Verify the predictions made in the Environmental Statement with respect to the potential impacts on fish and cetaceans.

2. The definition of the level of noise generated by the WECs during the operational phase is considered particularly important given that there is a lack of information on underwater noise generation due to the fact that this is an emerging technology.

3. The definition of the level of noise generated by the WECs during the operational phase is considered particularly important given that there is a lack of information on underwater noise generation due to the fact that this is an emerging technology.

4. Monitoring of noise generated during both the construction and operational phases requires a description of the baseline noise environment to be made and, therefore, a baseline noise survey will also be required against which the effects of the proposed development can be assessed. A specialist acoustic consultant will need to be commissioned to undertake the noise monitoring and to interpret the findings with respect to its likely implications for fish and cetaceans (see below).

5. It is necessary to undertake monitoring of cetacean activity in parallel with the noise monitoring referred to above. This monitoring could be undertaken following the same approach to the survey work that was undertaken to inform the baseline conditions for the EIA process (i.e. the use of a T-POD deployed on a wave rider buoy) and analysis of the data.

6. The details of the noise and cetacean monitoring programme will be developed and agreed with the relevant consultees prior to the implementation of the project.

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