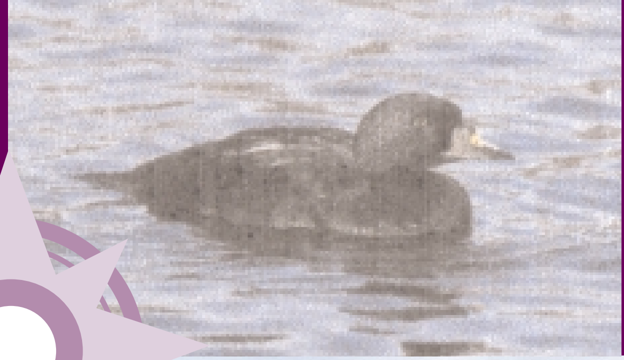

ENVIRONMENTAL STATEMENT

SUPPORTING APPLICATIONS FOR AN OFFSHORE WINDFARM AT ROBIN RIGG

SCOTLAND	PRIVATE BILL ELECTRICITY ACT 1989 (SCOTLAND) COASTAL PROTECTION ACT 1949 FOOD AND ENVIRONMENT PROTECTION ACT 1985
ENGLAND	COASTAL PROTECTION ACT 1949

Produced by natural power for OERL TXU

Preface

This Environmental Statement has been prepared for the Scottish Executive Energy Division under Section 36 of the Electricity Act (Scotland) 1989; a Private Bill for the Scottish Parliament; the Scottish Executive - Transport Division under Section 34 of the Coastal Protection Act 1949 and the Scottish Executive – Rural Affairs Department under the Food and Environment Protection Act 1985; and in accordance with the statutory procedures set out in The Environmental Assessment (Scotland) Regulations 1988 and the Environmental Impact Assessment (Scotland) Regulations 1999, in support of an application for an offshore wind farm at Robin Rigg in the Solway Firth.

A further application will be submitted to the DTI under Section 34 of the Coastal Protection Act 1949.

This Environmental Statement and application maps may be viewed at the following addresses:

Environment and Infrastructure
Dumfries & Galloway Council
Council Offices
4 Market Street
Castle Douglas
DG7 1BE

Tel: 01556 502351

Ewart Library
Catherine Street
Dumfries
DG1 1JB

Tel: 01387 253820

Planning Department
Allerdale Borough Council
Allerdale House
New Bridge Road
Workington
CA14 3YJ

Tel: 01900 326333

Maryport Library
Lawson Street
Maryport
Cumbria
CA15 6ND

Tel: 01900 812384

Dalbeattie Library
23 High Street
Dalbeattie
DG5 4AD

Tel: 01556 610898

Stranraer Library
2-10 North Strand Street
Stranraer
DG9 7LD

Tel: 01776 707400

This is the full Environmental Statement, which contains the full environmental assessments that have been undertaken including maps, visualisations, diagrams and plates. A separate Non-Technical Summary is also available.

Copies of the full Environmental Statement or the Non-Technical Summary can be obtained from the Natural Power Offices, *The Green House, Forrest Estate, Dalry, Castle Douglas, DG7 3XS. Tel: (01644) 430008.*

Volume 1:	Environmental Statement	£250
Volume 2:	Non-Technical Summary	Free
Volume 3:	Appendix	P.O.A

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Section 1

Project Overview

1.1 INTRODUCTION

This Environmental Statement and accompanying documents describe the construction, operation and decommissioning of a proposed offshore wind farm at Robin Rigg in the Solway Firth, describes the physical and natural environment of the area within which the wind farm would be situated, and assesses the potential effects that the construction, operation and decommissioning of the development would have on the physical, natural and human environment. It also describes the need for renewable energy development within the UK in the context of international agreements on reduction in the emission of climate change gases and the EU, UK and Scottish targets for contribution of renewables to overall energy and electricity production.

This volume presents the main Environmental Statement. The detail of this volume is summarised in a separate Non-Technical Summary. These documents are accompanied by a number of detailed technical documents and appendices referred to in the main text which should be read in conjunction with this Statement.

The main Environmental Statement presented here is divided up as follows:

Section 1, this section, provides a brief overview of the project and the developer.

Section 2 outlines the need for the development. Within that section, part 2.8 describes the permissions required for the various components of the proposed development for which this Environmental Statement has been prepared.

Section 3 outlines the environmental assessment methodology and the means by which environmental mitigation was incorporated into the development of the proposals from the very beginning at the site selection stage.

Section 4 of this Statement gives a detailed description of the proposed development including details of the construction and decommissioning operations on and offshore, while Section 3 outlines the alternative sites, development design and construction operations considered in the development of the final proposal.

Section 5 presents a methodology for reducing the environmental impacts of the project beginning with site selection and continuing through incorporation of mitigation measures into the design of the proposal. It describes the general methodology for the assessment of residual environmental and human effects of the proposal.

Sections 6 to 8 describe the physical, environmental and human baseline conditions of the Solway Firth relevant to the subsequent assessment of the proposal.

Section 9 presents the detailed assessments of effects

Section 10 summarises the residual impacts and mitigation measures incorporated into the design and outlines monitoring proposals for environmental resources before, during and after construction of the proposal should the project be given all the relevant building permissions.

1.2 PROJECT DESCRIPTION

The proposal is for a 60 turbine offshore wind farm located on a sub-tidal sand flat known as Robin Rigg in Scottish waters in the mid area of the Solway Firth, an anemometry mast, on-site 33 kV cabling, an on-site substation platform and a 132 kV seabed cabling between the substation platform and the landfall south of Flimby on the Cumbrian coast. The turbines would be situated some 9 km from the Dumfries and Galloway shoreline within Scotland, and 12 km from the Cumbrian coastline at their nearest points. Figure 1.1 shows the position of the layout in relation to the coast lines.

The 60 turbines would be arrayed in a grid pattern with the overall layout in the approximate form of a trapezium thinning towards the north east. The layout would comprise 10 northwest/southeast lying rows of between 2 and 8 turbines, separated by 450 m. Turbines within rows would also be separated by approximately 450 m. Rows are given letters A to K (I is left out to avoid confusion for turbine numbering). The north-easternmost row, Row A, would contain 2 turbines, increasing to 8 turbines within the central 3 rows (Rows E, F and G) and decreasing to 3 turbines for the south-westernmost row (Row K). This is illustrated in Figure 1.2.

Each turbine would contain a transformer within the tower base or housed on top of the nacelle, transforming electricity produced by the turbine generator at 690 volts to 33 kV. Communication and 33 kV electricity cables would be laid along each turbine row. These would be gathered along the south eastern edge of the wind farm and finally connected to the on-site substation platform at the eastern end of Row F. All cables would be buried within the seabed. The turbine positions and cable routes are shown on Figure 1.2.

The 33 kV cables will be gathered and metered at the substation platform and stepped up to 132 kV. From the substation platform two 132 kV cables will be laid on the seabed south eastwards for a distance of 12 km with landfall south of Flimby on the Cumbrian coast. From the landfall site the cables would be carried underground to a new switchyard at the existing transmission system which lies 1.5 km from the landfall site at the nearest point.

The turbines would all be of one type. They would be three bladed with a horizontal axis nacelle positioned on a tubular tower. The rotor axis would have a maximum height of 80 m above Mean Sea Level (MSL). The turbines would have an installed capacity of 2-3.6 MW with a maximum blade length of 50 m, giving a maximum height from MSL to blade tip of 130 m.

The turbine foundations would be either monopile or mulitpile foundations. A monopile foundation would comprise a single steel pile up to 5.5 m diameter buried up to 35 m into the seabed. A multipile foundation would comprise circular central column, with steel leg structures supported by 3 or more piles with individual diameters between 1.2 m to 1.8 m, and buried up to 35 m into the seabed. The top of the foundation would end in a platform that would provide access to the turbine base. The turbine base would be bolted to the foundation platform.

The majority of the turbine tower, nacelle and blades and the substation platform would be finished in a mid grey with a matt finish which is considered by to be the colour with least contrast to backdrops to the wind farm when viewed from potential viewpoints on land under the most prevalent meteorological conditions found at the site. Four navigation buoys would be positioned on the outside of the wind farm with yellow flashing lights and reflector beacons. The towers of the outside turbines on all edges of the wind farm would be painted with a metre deep yellow ring above the astronomical high tide level. A single foghorn with a nominal audible range of 2 miles will be placed on the central turbine of the site.

1.3 SITE LOCATION

The site where the turbines and substation platform would be situated lies within the central part of the Solway Firth, immediately to the north of the English/Scottish boundary which roughly bisect the firth. The centre of the turbine layout would lie some 11 km from the Dumfries and Galloway coastline within Scotland and 13.5 km from the Cumbrian coastline in England. The closest towns in Scotland and England are Dalbeattie situated some 21 km to the north-northwest and Maryport situated 14 km to the south east of the site centre respectively. The site location is shown on Figure 1.1.

A Ministry of Defence firing range which lies on the coast south of the A71 between Kirdkudbright and Dundrennan lies some 14 km to the west of the site. The danger area of the firing range extends out in a fan shape some 25 km southwards into the Solway and lies some 10 km southwest of the wind farm site at its nearest point.

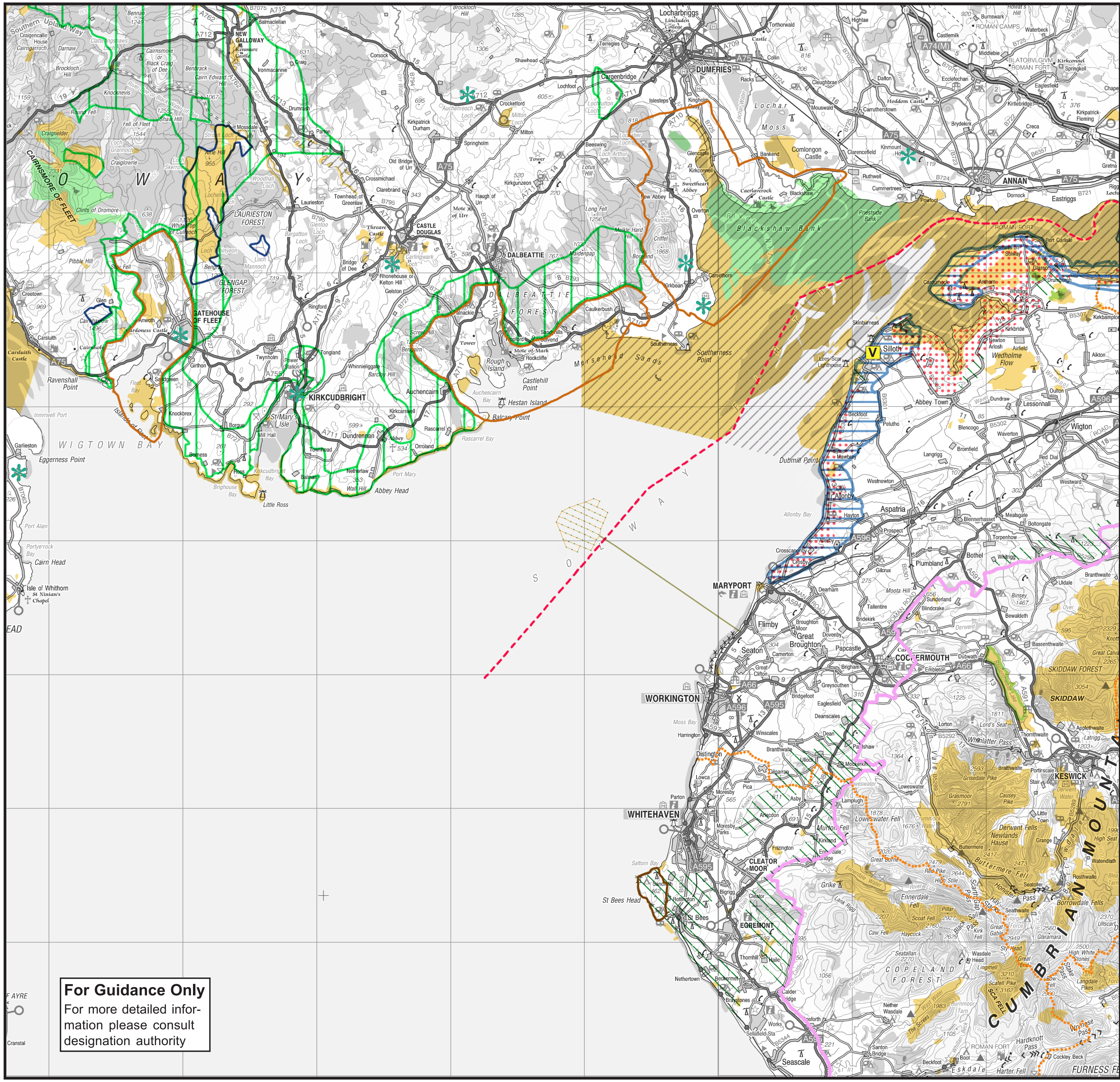
There is no offshore sand or gravel or oil or gas extraction in this part of the Solway Firth. There are no underwater cables or pipelines in the vicinity of the wind farm site. The closest turbine foundation would lie some 28 km from the nearest pipeline/cable which is a gas interconnector pipeline running between Kirkcudbright and Ireland. Three fixed link microwave corridors pass through the general area of the site between transmitters and receivers on the Scottish and English coasts. The layout has been designed to avoid any impacts on these links. This is described in detail in Section 9.18 of this Environmental Statement.

The area on which the turbines would be located is a sub tidal bank composed of reasonably homogenous fine to medium sand with some shell fragments. The sediments overlie a layer of stiff clay with cobbles and boulders lying at depths of 8 m to at least 29 m below the seabed, depending on location. The area of sand bank with depths of less than 10 m in depth below mean sea level is roughly wedge shaped measuring some 4.5 km southeast to northwest and 7 km northeast to southwest. The thinner end of the wedge is situated to the northeastern end of the sand bank, with the bank broadening towards the southwest. The turbines would be positioned in depths of water between 4 and 13 m below Mean Sea Level. A navigation channel, known as Middle Channel lies immediately to the north of the bank. The channel passes east to west and ranges from 10 - 18 m in depth below Mean Sea Level in the vicinity of the site. A further non-navigable channel lies in the more mobile area to the south of the bank currently ranging from 9 to 18 m below MSL. The spring tidal range is 7.4 m in this part of the Solway. The Middle Channel is part of a navigation route for yachts and fishing boats between the inner and outer Solway, but is not navigable for commercial traffic. Commercial shipping within the Solway passing between the main ports of Silloth and Workington and shipping lanes beyond the Outer Solway, uses the English Channel which passes some 7 km southeast of the proposed turbine positions at the closest point.

There is some sporadic fishing in the vicinity of the site currently comprising up to 10 locally owned boats trawling the channels to the north and south of the bank for shrimps during the winter period with the shrimps moving further into the Inner Solway during the summer. The inshore area to the north of the site contain cockle beds. However, all cockle fishing in the Solway by boat, tractor or hand gathering is currently banned awaiting a management plan and Regulatory order following a documented fall in stocks. There is some trawling of the deeper channels between sand banks by trawlers operating from Maryort fishing for sole and plaice, especially the areas of the chart known as Maryport Roads to the south east, and Scotch Deep to the north of the Robin Rigg site.

The site lies outside any area protected for scenic, ecological, archaeological or navigational reasons. The inner Solway is protected as a European Marine site which is designated as a Special Protection Area under the 1979 Birds Directive for internationally important populations of individual species and assemblages of over-wintering water fowl, and is a Candidate Special Areas of Conservation submitted for designation under the 1992 Habitats Directive for its estuarine, saltmarsh, intertidal mudflats and sandflats and subtidal sandbank habitats. The Solway Firth European Marine Site is an area covered by a management plan which has been designed principally to protect and promote the integrity of the SPA and candidate SAC. The proposed wind farm site lies some 7 km south of the boundary of the Marine Site at its closest point.

The coast line to the north-northwest of the site has been designated as the East Stewartry Coast National Scenic Area. This area comprises the inlets of Auchencairn, Orchardton Bay and Rough Firth and the surrounding hills and a strip of coastline extending eastwards to Caulkerbush. The closest point of the NSA lies some 9 km from the closest turbine within the layout. Further north and east beyond the promontory of Southerness Point lies the Nith Estuary NSA. The southern boundary of this NSA lies some 15 km from the closest turbine. The remainder of the coastline between Annan and Kirdcudbright lies within the Solway Coast Regional Scenic Area.



Project:

Proposed Offshore Wind Farm, Solway Firth

Title:

Figure 1.1: Designations & Sites of Interest

Key

- Proposed Wind Farm Site
- Candidate Special Area of Conservation
- Special Protection Area
- Site of Specific Scientific Interest
- Archaelogically Sensitive Areas
- National Scenic Area
- National Nature Reserve
- Area of Outstanding Natural Beauty
- Heritage Coast
- County Landscape
- Regional Scenic Area
- National Park Boundary
- Historic Gardens & Designed Landscapes (Scotland)
- RAMSAR site
- Borough Council Boundaries
- Scotland - England border
- Centreline of 132kV Cable Corridor
- Hadrian's Wall
- Hadrian's Wall World Heritage Site Setting Area
- V Area of Outstanding Natural Beauty (AONB) Visitors Centre

Scale: 1: 250,000 (reduced)

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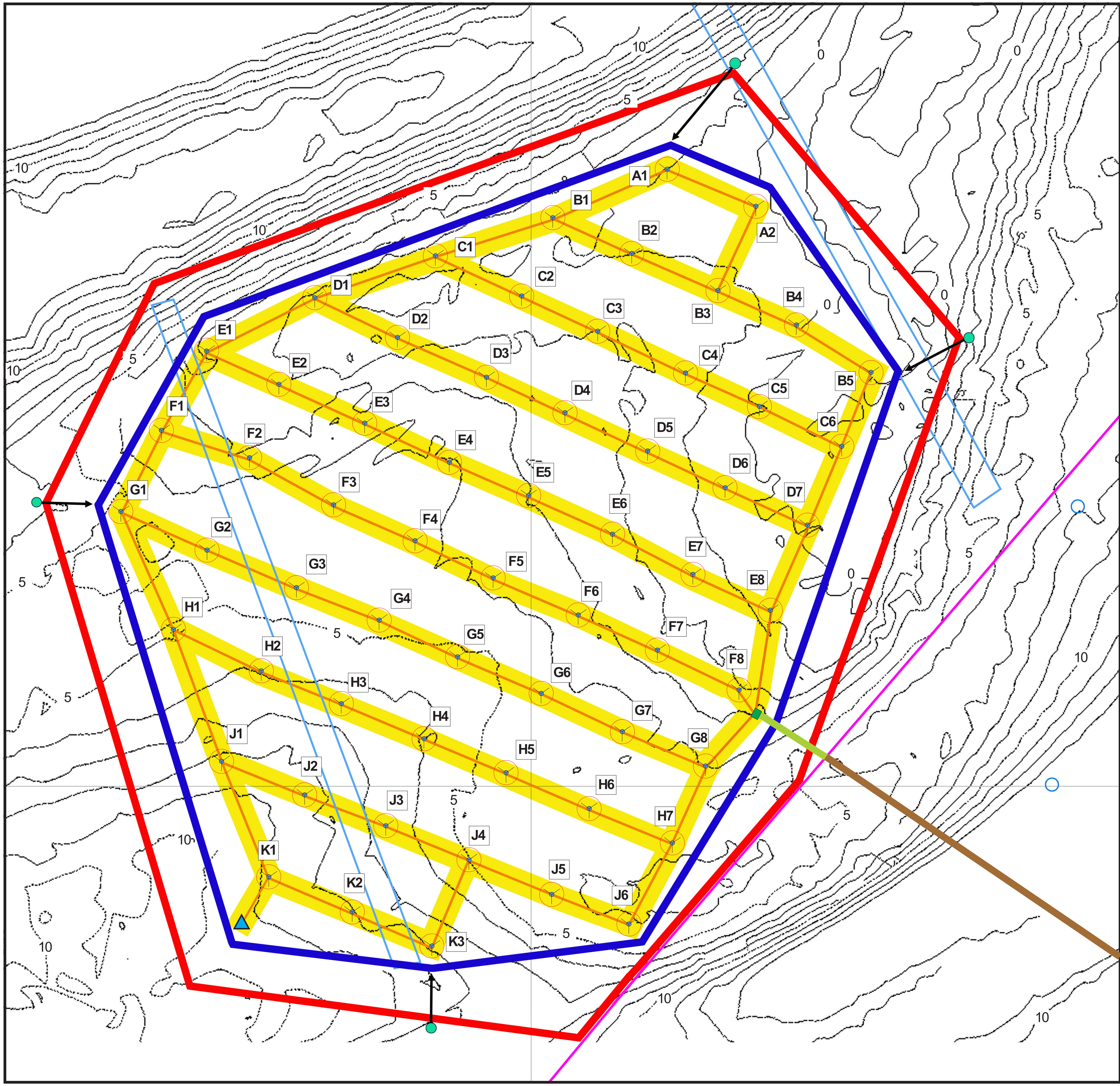
natural power

Client:

Solway Offshore Ltd
A TXU Europe Company
and
Offshore Energy Resources Ltd.

TXU

Offshore Energy Resources Limited



Project:

Proposed Offshore Wind Farm, Solway Firth

Title:

Figure 1.2: Site Layout

Key:

- Wind Turbine
- 33 kV Cable Route
- 125m Cable Corridor (including variance)
- Turbine Exclusion Zone surrounding Microwave Links
- Offshore Mounted Substation & Helipad
- Centreline of 132 kV Cable Route (2 cables)
- Centreline of Indicative 132 kV Cable Route Corridor
- Scotland - England border
- Depth of Seabed below Chart Datum
  Chart datum approx. 4.45m below MSL. Hydrographic Survey Aug/Sep 2001.
- Site of Underwater Wreck or Other Anomaly
- Anemometry Mast
- Boundary for Exclusion of Vessels during Construction
- Operational Period Trawl Exclusion Zone
- Proposed Location of New Buoys during Construction Phase
  Arrows indicate repositioning of buoys upon completion of construction

Scale: 1: 20,000

Metres: 0, 400, 800
Centimetres: 0, 1, 2, 3, 4
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Client:
Solway Offshore Ltd
A TXU Europe Company
and
Offshore Energy Resources Ltd.

TXU
Offshore Energy Resources Limited

The Cumbrian coast between Bank End north of Maryport and Wolsty Hall south of Silloth is designated as part of the Solway Coast Area of Outstanding Natural Beauty. This lies some 13 km west of the nearest turbine at its closest point. This overlaps with part of the Hadrian's Wall Military Zone which extends as far south as Maryport, and is associated with the Hadrian's Wall World Heritage Site.

1.4 THE DEVELOPERS

The Robin Rigg wind farm consent applications which are supported by this Statement, are being submitted jointly by Solway Offshore Ltd. and Offshore Energy Resources Ltd.

1.4.1 Solway Offshore Ltd

Solway Offshore Limited is a wholly owned subsidiary of TXU Europe Group Plc. Through its retail brand TXU Energi, it is the third largest domestic energy supplier in the UK with 5.5 million customers. TXU is the leading energy trader in the UK and its energy portfolio includes coal-fired power stations, combined heat and power and renewable energy generation.

Globally TXU is one of the most influential energy services companies. TXU sells more than 330 million megawatt hours of electricity and 2.8 trillion cubic feet of natural gas annually, serving 11 million customers worldwide, primarily in the US, Europe and Australia.

1.4.2 Offshore Energy Resources Ltd.

The Offshore Energy Resources Ltd. consortium comprises Babcock and Brown and UPC International Partnership**.**

Babcock & Brown

Babcock & Brown is an independent worldwide firm which specialises in originating, structuring, investing in, arranging and managing large asset-based financings and acquisition. The company was founded in 1977 and currently employs more than 350 people in 17 offices. Among its other interests, Babcock & Brown is a leading exponent of wind energy financing worldwide. Over the last 12 years Babcock & Brown has worked on nine projects in the US and Europe totalling 855MW. These projects are listed in table 1.4.1. below.

Table 1.4.1 Wind energy projects with involvement of Babcock & Brown

Project	Development Date	Technology	Size
Mojave Wind (USA)	1989/90	MHI	85+75MW
P&L Windfarm (UK)	1993	MHI	31MW
RYG Windfarm (UK)	1993	Bonus	7MW
Paxareiras I & IIa (Spain)	1998	Bonus	40MW
IVPC (Italy)	1998	Vestas	169MW
Vicedo (Spain)	1999	Bazan/Bonus	25MW
IVPC4 (Italy)	2000	Vestas	283MW
Paxareiras II C&F (Spain)	2000	Bazan/Bonus	44MW
TAPD (Greece)	2001*	Bonus	96MW
TOTAL			855MW

A further 290MW of wind energy projects are currently being developed by Babcock & Brown Windpower in Australia. Babcock & Brown's involvement in these projects includes project development and commercial structuring, as well as financing. Babcock & Brown takes active involvement in negotiating commercial arrangements with manufacturers, suppliers and contractors, dealing with land, permission and interconnection issues and liaising, where appropriate, with large domestic utilities.

UPC International Partnership

UPC International Partnership, has extensive experience in developing, financing, constructing, owning and operating wind energy projects. UPC began pursuing wind energy projects in southern Italy in 1993, resulting in the successful development of a portfolio of projects with a total capacity in excess of 450MW. The first phase of projects have a capacity of 169.2MW (the "169.2MW Project") utilising Vestas V-42 and V-44 turbines, and are in commercial operation. The 169.2MW Project is one of the largest wind energy projects ever constructed and has reached a high operating availability. The total operating availability was over 99.1% for 2000, which approaches the maximum theoretical limit of a wind farm.

Projects totalling an additional 76.8MW entered operation in 1998 and the remaining 33MW covered under the 169.2MW project financing entered operation in early 2000.

UPC subsidiaries have project managed, under contract, all aspects of the development, construction, administration, operation and maintenance of the 169.2MW Project. UPC has therefore acquired extensive experience and know-how which has been fully utilised on UPC's subsequent wind energy projects. Following the success of the 169.2MW Project, UPC began the process of developing, financing, constructing, owning and operating a further 11 wind energy projects, totalling 283.1MW, located across five regions in Italy (the "283.1MW Project").

1.5 PROJECT DEVELOPMENT CONSULTANTS

The project has been designed and assessed by the joint developers in association with two lead consultants: Kirk McClure Morton (KMM) and Natural Power Consultants Ltd (Natural Power).

KMM is a UK and Ireland based civil, structural and environmental engineering consultancy with expertise in a number of areas including coastal and maritime project design from project concept to handover. KMM has been involved in the planning, engineering design and contract supervision of a variety of port and harbour schemes, ranging from small berthing structures to large quay facilities to accept vessels up to 500,000 DWT. KMM are lead consultant engineers in the Robin Rigg project with responsibility for carrying out bathimetric, hydrographic, seismic and borehole surveys and hydrographic and sediment transport modelling, to define the physical environment, and the design of the engineering elements of the project from turbine foundations to specifications for construction vessels. KMM have also contributed to the Environmental Impact Assessment through modelling of impacts of the construction and operation of the project on sediment movement, morphology and tidal flows.

Natural Power is a renewable energy consultant and developer based in Dumfries and Galloway. As consultants the staff have worked on over forty planning applications for wind farms in the UK and Ireland, including five onshore wind farms in Scotland which are either operating, under construction or have full planning consent. These include the Windy Standard wind farm in Dumfries and Galloway. In addition Natural Power have been involved in the site selection, development and management of six other operational wind farms in England and Wales. Natural Power have been lead consultant in the Robin Rigg project in areas of site selection, wind resource assessment and layout design, and have also coordinated the Environmental Impact Assessment process.

LEAD WIND ENERGY AND PLANNING CONSULTANT:		
Natural Power Consultants Ltd	The Green House Forrest Estates Dalry Castle Douglas Dumfries & Galloway DG7 3XF	Tel: 01644 430008 Fax: 01644 430009 *Contact: Jeremy Sainsbury*
LEAD ENGINEERING CONSULTANT:		
Kirk McClure Morton	74 Boucher Rd Belfast BT12 6RZ	Tel: 02890 667914 Fax: 02890 668286 *Contact: Dr. Michael Shaw*

The following consultants were commissioned to provide professional skills for specific assessments.

MARINE BIOLOGICAL CONSULTANCIES:		
Solenvo Marine Environmental Consultants	1A Woodbine Road Gosforth Newcastle NE4 3DD	Tel: 0191 284 8652 Fax: 0191 284 8652 *Contact: Dr. Jane Lancaster*
Centre for Marine and Coastal Studies	Liverpool University Vanguard Way Birkenhead Merseyside CH41 9HX	Tel: 0151 650 2275 Fax: 0151 650 2274 *Contact: Dr. Andrew Hough*
MARENCO Ltd.	74 Boucher Road Belfast BT12 6RZ	Tel: 02890 682275 Fax: 02890 682276 *Contact: Dr. Eric Huston*
ORNITHOLOGICAL CONSULTANCY:		
Dr. Steve Percival	71 Park Avenue Coxhoe Co. Durham DH6 4JJ	Tel: 0191 377 3160 Fax: 0191 377 3160 *Contact: Dr. Steve Percival*
LANDSCAPE & SEASCAPE CONSULTANCY:		
Enviros Aspinwalls	61 The Shore Leith Edinburgh EH6 6RA	Tel: 0131 555 9500 Fax: 0131 555 9501 *Contact: Lindsey Guthrie*
MARINE ARCHAEOLOGICAL CONSULTANCY:		
Wessex Archaeology Ltd.	Lintrathen Rectory Hill Salisbury SP5 1JL	Tel: 01794 342 343 Fax: 01794 342 344 *Contact: Andy McKenzie*
NOISE CONSULTANCY:		
Hayes McKenzie Partnership	Portway House Old Sarum Park Salisbury SP4 6EB	Tel: 01722 326867 Fax: 01722 337562 *Contact: Antony Firth*
LEGAL CONSULTANCY:		
Bond Pearce Ltd.	22 Kings Park Road Southampton SO15 2UF	Tel: 02380 632211 Fax: 02380 720700 *Contact: Marcus Trinick*

Section 2

Policy Background

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Section 2

Policy Background

2.1 INTRODUCTION

The positive policy environment for wind energy and other forms of renewable energy in the UK are largely motivated by the UK's commitment to international agreements on reductions in the emissions of climate change gases. While this undoubtedly has been the primary motivation there are a number of other important benefits of renewable energy which have been recognised by policy makers including the reduction in the 'mining' of valuable and scarce global fossil fuel supplies, curbing in the emission of other transboundary pollutants such as nitrous oxides and sulphur dioxide, greater self sufficiency in energy supply, and advantages in decentralised embedded generation including reduction in transmission losses and power supply failures. While these other advantages are important and may have been the initial motivation for the funding of renewable energy research in the 1970s and 1980s, rising international concern over the phenomena of climate change has dominated renewable energy policy over the last decade.

2.2 CLIMATE CHANGE: EVIDENCE AND CONSEQUENCES

2.2.1 CLIMATE CHANGE OBSERVATION AND MODELLING

The phenomena of 'climate change' is widely regarded as the most pressing environmental concern of the coming century. Even if the causes of climate change are successfully tackled over this century, the consequences of emissions outputs already released are generally accepted as causing environmental and economic problems extending many centuries into the future[1].

Change in global and regional temperatures and precipitation patterns is a natural phenomena and there have been a number of cooling and warming periods recorded over the last millenium. However in late 1980s a growing concern emerged that the climate was being influenced by human activity beyond these normal fluctuations. The issue of 'climate change' is normally used to mean that of anthropogenic forcing of mean global temperatures through emissions to the atmosphere and land use changes.

The study into the evidence for and implications of climate change has been largely coordinated by the Intergovernmental Panel on Climate Change (IPCC) which was established in 1988 by the World Meteorological Organisation and the United Nations Environmental Programme. Its remit is to study historical evidence for climate change up to the present, modelling climatic processes and future climate change scenarios, identifying regional variations in climate change, quantifying the risk of potential global and regional effects of climate change and recommending mitigation and adaptation measures for the international community and individual governments.

The IPCC has had 3 report stages so far, 1990, 1996 and 2001. Evidence that climate change is occurring and that it is outside the fluctuations of natural changes has become stronger with each report, and the IPCC now states that it is '*unequivocal*' that it is occurring. Evidence from various sources of global temperatures over the past millennium indicate that

> '*the rate and duration of warming in the northern hemisphere in the 20th Century appears to be unprecedented during the millennium and cannot simply be considered to be a recovery from the Little Ice Age of the 15th to 19th centuries.'*

According to the IPCC's 2001 report

> '*the 1990s are likely to have been the warmest decade of the millennium in the northern hemisphere'*

and further

> *'the warmth of the decade is outside the 95% confidence interval of temperature uncertainty.* [2]

i.e. outside the natural temperature fluctuations of the past millennium.

The evidence is very strong that the effect is being driven by anthropogenic factors. The factors include industrial and agricultural emissions of the so-called 'greenhouse gases' into the atmosphere and other effects such as land use changes which reduce the ability of the natural environment to recycle these gases. Currently carbon dioxide emissions are judged by the current models to represent about half of the warming effect of anthropogenic factors. This proportion is predicted to increase to 75% by 2100 [3].

Carbon dioxide levels in the atmosphere have increased by about 30% since the pre-industrial period from about 280 parts per million to today's level of 365 ppm. Increases in concentration have arisen from two factors: deforestation and the resulting losses of carbon stored in the biosphere to the atmosphere and carbon mined from beneath the earth's surface and released into atmosphere through the burning of fossil fuels. The former factor is modelled as having a small effect compared to burning of fossil fuels and its contribution is set to decrease further in the future.

Future carbon dioxide levels in the atmosphere been modelled under a number of different global economic and demographic scenarios for the 21st century. The 2100 carbon dioxide concentration predictions for these scenarios ranges from about 550 ppm to 950 ppm, i.e. between 2 and 3.4 times pre-industrial levels. The IPCC predict that reforestation of the globe to pre-industrial levels would only reduce CO2 levels by between 40 and 70 ppm[4]. Therefore if carbon dioxide concentrations in the atmosphere are to be stabilised then primary focus needs to be made on reducing emissions from fossil fuels.

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1 IPCC (2001a) The Third Assessment Report of Working Group 1 of the Intergovernmental Panel on Climate Change

2 IPCC (2001a) The Third Assessment Report of Working Group 1 of the Intergovernmental Panel on Climate Change

3 IPCC (2001a) The Third Assessment Report of Working Group 1 of the Intergovernmental Panel on Climate Change

4 IPCC (2001a) The Third Assessment Report of Working Group 1 of the Intergovernmental Panel on Climate Change

Global mean temperatures are predicted to increase by between 1.7 and 4.2 deg C by 2100 for the range of global development scenarios. One effect of climate change and increases in mean global temperatures is a corresponding rise in sea levels. Global sea level is expected to rise between 0.11 and 0.77 metres by 2100 for the various global development scenarios, taking into account uncertainties in the speed of melting of polar ice caps. Due to the very long term cycle of mixing in the oceans, there is a long time delay between increases in atmospheric and surface temperatures and thermal expansion of the oceans. For C02 concentration stabilisation at twice pre-industrial levels i.e. 560 ppm, eventual sea level rise is predicted to be between 0.5 and 2 m [5].

2.2.2 IMPACTS OF CLIMATE CHANGE

Likely impacts of expected climate change on human and natural systems are more difficult to predict than temperature, precipitation and sea level changes. Severity of the impacts on human and natural systems depends very much on adaptability of systems to change. Natural ecosystems ability to adapt will in many cases be severely inhibited by biogeographical fragmentation and other current existing pressures on ecosystems. Migration of whole ecosystems will be impossible in many areas, due to human barriers to movement such as agriculturally intensive areas and urban development. In addition to effects of climatic changes many coastal ecosystems will also be affected by sea level rises. According to the IPCC,

> '*many coastal areas will experience increased levels of flooding, loss of wetlands and mangroves, and seawater infusion into freshwater sources. The extent and severity of storm impacts, including storm surge floods and shore erosion will increase as a result of climate change.*[6]

Human impacts are likely to be greatest in those countries with fewer resources to prepare themselves for adaptation. Developing countries will be most affected especially those reliant on primary production as a major source of income, and the overall impact is likely to be a widening in the wealth gap between the industrialised and developing countries.

One predicted effect of increased concentrations of 'greenhouse' gases in the atmosphere is predicted to be an increased frequency and intensity of extreme weather events particularly rainfall. According to the IPCC '*the most widespread direct risk to human settlements from climate change is flooding and landslides, driven by projected increases in rainfall intensity and, in coastal areas, sea level rise.'* Impacts on the economy of developing countries hit by extreme weather events can be catastrophic with recorded economic losses of half of a state's GDP in a single event. In the developed world insurance costs are likely to increase along with increases in risk. Global economic losses from catastrophic events increased by 10 fold in real terms between 1950s and the 1990s, from $3.9 billion to $40 billion at 1999 values[7].

The IPCC recommends a two pronged approach to reducing the effects of climate change. Firstly, the reduction of human influences in climate, primarily through reductions in the use of fossil fuels and emissions of other greenhouse gases, and to a lesser extent reforestation projects, and secondly through measures to allow natural and human systems to adapt as far as possible to expected changes. The earlier that greenhouse gas emissions can be reduced, the lower the costs of adaptation and human costs of failure to adapt. According to the IPCC stabilising carbon dioxide concentrations at 450 ppm (that is 85 ppm above today's levels and 170 ppm above pre-industrial levels) in the long term would require dropping of emissions worldwide to below 1990 levels within a few decades[8].

2.3 INTERNATIONAL AGREEMENTS ON CLIMATE CHANGE EMISSIONS

The United Nations took up the issue of climate change in 1988 and adopted a resolution on the "Protection of global climate for present and future generations of mankind". When in 1990, the IPCC issued its First Assessment Report, confirming that climate change was indeed a threat and calling for a global treaty to address the problem, the UN General Assembly formally launched negotiations on a framework convention on climate change and established an Intergovernmental Negotiating Committee (INC) to conduct those negotiations. On 9 May 1992, the INC adopted the United Nations Framework Convention on Climate Change. The Convention was opened for signature at the "Earth Summit", in Rio de Janeiro, Brazil, on 4 June 1992, and came into force on 21 March 1994. Currently 186 governments and the European Community are parties to the Convention. The ultimate long-term objective of the Convention is to stabilise atmospheric concentrations of greenhouse gases at so-called 'safe' levels. These levels, which the Convention does not quantify, should be achieved within a time frame sufficient to allow ecosystems to adapt naturally to climate change and to enable economic development to proceed in a sustainable manner

The Convention divides countries into two groups: those listed in its Annex I which are the industrialised countries who have historically contributed the most to climate change; and those that are not so listed, comprising the developing countries. The per capita emissions of Annex I Parties are higher than those of most developing countries and they have greater financial and institutional capacity to address climate change. The Convention therefore require these Parties to take the lead in modifying longer-term trends in emissions. To this end, Annex I Parties are committed to adopting national policies and measures with the non-legally binding aim of returning their greenhouse gas emissions to 1990 levels by the year 2000.

When governments adopted the Convention, it was understood that its commitments would not be sufficient to achieve its ultimate long-term objective. They therefore included a series of review mechanisms in the Convention to ensure that its commitments could be tightened in the future. The first of these, the Kyoto Protocol was adopted 11 December 1997. The Kyoto Protocol commits Annex I Parties to individual, legally-binding targets to limit or reduce their greenhouse gas emissions, adding up to a total cut of at least 5% from 1990 levels in the "commitment period" 2008-2012. The individual targets range from an 8% cut for the EU to a 10% increase for Iceland. Under the terms of the Protocol, the EU may redistribute its target among its 15 member states.

[5] IPCC (2001a) The Third Assessment Report of Working Group 1 of the Intergovernmental Panel on Climate Change
[6] IPCC (2001b) Climate Change 2001: Impacts, Adaption and Vulnerability. Third Assessment of Working Group 2
[7] IPCC (2001b) Climate Change 2001: Impacts, Adaption and Vulnerability. Third Assessment of Working Group 2
[8] IPCC (2001b) Climate Change 2001: Impacts, Adaption and Vulnerability. Third Assessment of Working Group 2

The targets cover emissions of the six main greenhouse gases, namely: carbon dioxide (CO2); methane (CH4); nitrous oxide (N2O); hydrofluorocarbons (HFCs); perfluorocarbons (PFCs); and sulphur hexafluoride (SF6).

Some specified activities in the land use, land-use change and forestry (LULUCF) sector, including afforestation, deforestation and reforestation, which emit or remove carbon dioxide from the atmosphere, are also covered. The Protocol establishes three innovative "mechanisms", known as joint implementation, emissions trading and the clean development mechanism, which are designed to help Annex I Parties reduce the costs of meeting their emission targets by achieving or acquiring reductions more cheaply in other countries than at home.

The Protocol also includes provisions for the review of its commitments. Negotiations on targets for the second commitment period are due to start in 2005, by which time Annex I Parties must have made "demonstrable progress" in meeting their commitments under the Protocol.

The Kyoto Protocol was open for signature between 16 March 1998 and 15 March 1999. 84 countries signed the Protocol during that period, including all but two Annex I Parties. In order to enter into force, the Protocol must now be ratified. Although nearly 40 countries have already ratified or acceded to the Protocol, only one Annex I Party has yet done so. Many Parties, however, have indicated a wish to bring the Protocol into force by 2002, in time for the World Summit on Sustainable Development (Johannesburg, September 2002)[9].

2.4 EUROPEAN UNION CLIMATE CHANGE AND RENEWABLES POLICY

The European Union has been the driving force of international agreement on climate change policy since the conception of the Framework Convention on Climate Change a decade ago. It has played a particularly key role in negotiations following the signing of the Kyoto Protocol in 1997, on mechanisms, monitoring and reporting for implementation of the Protocol, which culminated in November 2001 in Marrakech[10]. It is therefore strongly motivated to ensuring that its Member States collectively meet the EU's commitments to the Kyoto Protocol. The means by which the EU will enable this is currently being developed by the European Climate Change Programme which was launched in March 2000.

The last monitoring data indicate that the EU has fulfilled its earlier obligation to the FCCC to ensure its greenhouse gas emissions by 2000 were no greater than 1990 levels. It is clear, however, that action by both Member States and the Community needs to be reinforced if the EU is to succeed in achieving the 8% cut in emissions by 2008-2012 as agreed at Kyoto. The ECCP, launched in June 2000, was tasked with identifying this action in the form of additional policies and measures as well as an emissions trading scheme[11].

[9] United Nations Framework Convention on Climate Change web site resource http://unfccc.int/resource/process/components/response
[10] European Commission website resource http://europa.eu.int/comm/environment/climat
[11] European Commission (2001) European Climate Change Programme Report 2001

The work focussed on the energy, transport, industry and agricultural sectors, with energy supply and energy demand as the subjects of two separate working groups. The ECCP strategy is that each sector should contribute to the reduction in greenhouse gas emissions but with emphasis on most cost effective measures between and within the action areas. 40 cost effective measures were identified which could reduce the greenhouse gas emissions of the EU by 664-765 Mega-tonnes of CO2 equivalent, as compared to the estimate by the European Environment Agency of a required 336 Mt CO2 equivalent to meet the –8% target[12].

The 40 measures were divided into three categories being 1) those at an advanced stage of preparation 2) those in the pipeline and 3) those for which more work is needed. Category 1 contains 8 measures. One of these that lies within the Energy Supply working group area is a target for 12% of gross inland energy consumption to come from renewable sources by 2010. This target was drawn from existing EU renewable energy policy given in the EU's 1997 White Paper on Renewable Energy Sources[13].

At the Kyoto summit in 1997, it was agreed that the European Union would have the freedom to decide the contribution of the individual Member States to the overall –8% commitment of the EU as a whole. These have been set in the range between Denmark and Germany at reductions of 21% and Portugual with an allowed increase in emissions of 27%. The UK's contribution has been set at reducing greenhouse gases to 12.5% below 1990 levels by 2008-2012. By 2000, EU member States emission inventories showed that the overall basket of emissions had been reduced by 4% over 1990 levels i.e. half way towards the 2008-12 target[14].

It was understood that each measure identified within the ECCP would vary in its application to each Member State, both with regard to compatibility with the Member State's individual greenhouse gas reduction target but also the current conditions in the energy, transport, industry or agricultural sector as appropriate, within that Member State. This strategy was also the case with regard to the renewable energy target as it applied to individual States.

The measure was to be the subject of an EU Renewable Energy Directive[15]. This Directive was issued by the European Council in September 2001. The Directive commits Member States to the setting of national targets for consumption of energy from renewable sources in terms of a proportion of total electricity consumption. The first target shall be issued in a report not later than October 2002 and further targets need to be set every five years thereafter.

The Directive gives indicative first targets for each Member State in an Annex to the Directive. These vary from 78.1% for Austria over a 1997 proportion of 70.0%, to 5.7% for Luxembourg over a 2.1% 1997 proportion[16]. The UK's indicative target is set at 10.0%. The UK had the lowest 1997 figure of all the

[12] European Commission (2001) European Climate Change Programme Report 2001
[13] European Commission (1997) Energy for the Future: Renewable Sources of Energy White Paper for a Community Strategy and Action Plan com(97)599
[14] European Environment Agency press release 20/04/2001: EU greenhouse gas emissions down 4%, more cuts needed – EEA, Copenhagen.
[15] European Council (2001) Directive 2001/77/EC on the Promotion of Electricity Produced from Renewable Energy Sources in the Internal Energy Market
[16] European Council (2001) Directive 2001/77/EC on the Promotion of Electricity Produced from Renewable Energy Sources in the Internal Energy Market

member States, at 1.7% of electricity consumption coming from renewable sources in the UK. If the 2010 targets are achieved the UK would move up to the third lowest user of renewable energy in the EU.

2.5 UK CLIMATE CHANGE AND RENEWABLES POLICY

2.5.1 THE UK CLIMATE CHANGE PROGRAMME

Much of the direction of the UK policy on renewables is guided by its commitments to international and European climate change instruments. The UK Government warns in its Climate Change Programme that:

> *'Climate change brings with it huge costs to the economy, environment and society.'*

And according to the Environment Minister, Michael Meacher:

> *'we cannot deny climate change, ignore it or hope it will go away...There is no question that climate change needs to be addressed urgently.'*

In 1998 the UK Government set itself a domestic target for reduction of carbon dioxide emissions beyond its commitment to the Framework Convention on Climate Change, which was set by the EU as a reduction in a specified basket of greenhouse gases of 12.5% by 2008-2012. The UK Government's new domestic target was to carbon dioxide emissions to 20% below 1990 levels by 2010.

In November 2000, the Government published the UK Climate Change Programme which outlines the target areas and policies through which it aims to achieve this domestic target. Importantly, the UK Climate Change Programme recognises that the domestic goal for a 20% reduction in carbon dioxide emissions by 2010 over 1990 levels is only '*a first stage towards what will be needed in the longer term.'* The recent Energy Review by the Performance and Innovation Unit published in February 2002, recognises that a cut in carbon dioxide emissions by 60% by 2050 can be achieved at a bearable cost but would require large changes to energy systems and to society[17].

The target areas identified in the UK Climate Change Programme include energy generation, transportation and domestic and business energy efficiency. Energy use including transportation currently accounts for 80% of all greenhouse gas emissions and 90% of all CO2 emission in the UK[18]. Expansion of the proportion of electricity produced by renewables is seen within the programme as a major contributor to greenhouse gas emission reductions within the energy sector, alongside promotion of combined heat and power plant, subject to the cost to consumers being acceptable.

2.5.2 UK RENEWABLE ENERGY TARGETS

In the Department of Trade and Industry review of renewable energy, '*New and Renewable Energy: Prospects for the 21st Century-Conclusions in Response to the Public Consultation*', published in 2000, Helen Liddle the then UK Minister for Energy stated:

> '*Renewable sources of energy are an essential ingredient of the Government's climate change programme and are set to make an increasingly important contribution to the provision of secure, diverse, competitive and sustainable energy supplies.'*

Accordingly in the same document and also within the Climate Change Programme, the Government states that its main objective in the energy sector is to work towards the aim of obtaining 10 per cent of the UK's electricity supply from renewable sources by 2010. In the shorter term the Government aims to achieve 5 per cent of UK's electricity supply from renewables by 2003. The 2010 target set in 2000, is equivalent to the UK's indicative target given in the later European Commission Directive on Renewable Energy issued in 2001, and it is expected that it will meet with the approval of the Commission following submission of the target to the Commission under the requirements of the Directive later this year.

The recent Energy Review by the Performance and Innovation Unit recommends a further target of 20% of UK electricity demand coming from renewable sources by 2020[19]. However, according to the twelfth report of the House of Lords Select Committee on the European Communities, 'Electricity from Renewables':

> *'It is inconceivable that UK targets for electricity from renewables can be met without much fuller development of onshore and particularly offshore wind energy – though we are concerned that this will not be achieved within the present arrangements. If the UK targets for renewable energy are to be met, the contribution from wind energy in each year of the next decade needs to grow at about 5 times the best annual rate achieved in recent years.'*

To date, government support for new renewable energy has come through the Non Fossil Fuel Obligation in England and Wales and its equivalent in Scotland, the Scottish Renewable Order. Under these contracts wind farm operators are guaranteed the sale of electricity produced by the wind farms at a fixed price equal to the operators bid price, for a set number of years following the commissioning of the project. Contracts were awarded to the lowest bid prices, the idea being to encourage the most efficient production of renewable electricity. Prior to the superseding of the NFFO and SRO by the Renewables Obligation this year, there were 4 consecutive rounds of NFFO and 3 of SRO. Contracted prices for wind energy under succeeding NFFO Orders and under SRO Orders reduced significantly from 11 p/kWh under NFFO2 [20] to an average of 2 p/kWh under SRO 3 [21]. This has largely been as a result of continuing improvements in the efficiency of the technology and cost savings implemented as a result of operational experience.

The NFFO and SRO mechanisms were replaced in early 2002 by the Renewables Obligation in England and Wales and the Renewables Obligation (Scotland) within Scotland. These set regional targets for renewable energy electricity to be supplied by electricity supply companies. The targets which will increase

17 Performance and Innovation Unit (2002) Energy Review
18 Performance and Innovation Unit (2002) Energy Review

19 Performance and Innovation Unit (2002) Energy Review
20 The Electricity (Non-Fossil Fuel Sources) (England and Wales) Order 1994(4)
21 The Electricity (Non-Fossil Fuel Sources) (Scotland) Order 1999(9)

year on year from 2002 to 2010, are intended to collectively achieve the national target of 10% electricity to come from renewables by 2010.

In addition to the market for renewables created by the Renewables Obligation as described below, the government have recognised that the first offshore wind farms in the UK will need some direct support. This is being provided through capital grants awarded through the Department of Trade and Industry.

2.5.3 THE RENEWABLE OBLIGATION (SCOTLAND)

The first consultation paper for the Renewable Obligation (Scotland) (ROS) issued in October 2000, explained that the ROS would:

> '*oblige all licensed electricity suppliers in Scotland to obtain renewables obligation certificates sufficient to cover a specified proportion of the electricity supplied to their customers in Scotland'*.

The power to set the ROS has been granted to the Scottish Executive by the 2000 Utility Act. Following the initial consultation period a further final statutory consultation was launched in August 2001 and the ROS made into law through a Statutory Instrument in April 2002.

Renewable Obligation Certificates (SROCs in Scotland) will be granted to the owners of qualifying renewable energy electricity generation plant according to the amount of electricity they produce. These will be traded on an open market within the UK as a whole, thus those suppliers with a deficit of SROCs from their own generation plant may buy SROCs from those suppliers with a surplus of SROCs, until they meet the renewables obligation for the region they are supplying to. The Statutory Instrument sets the obligation for suppliers supplying in Scotland for each year i.e. the proportion of electricity supplied that should come from renewable sources. The Obligation will rise year on year until 2011. As defined in Schedule 1 of the Statutory Instrument, the first Obligation is set between 1st April 2002 and 31st March 2003 at 3% of all electricity supplied by all suppliers in Scotland coming from *qualifying* renewable generating plant, which the Scottish Executive hope will be achieved predominantly through the commissioning of renewable energy plant given contracts under the old Scottish Renewable Order. The RO (Scotland) will rise by increments year on year reaching 10.4% in the final year of 1st April 2010 to 31st March 2011.

The Statutory Instrument allows suppliers to meet their obligation by making a 'buy out' payment to the Gas and Electricity Markets Authority to cover their deficit of SROCs for any given year, should they not have sufficient SROCs to meet their obligation. The buy out price has been set at £30 per MWh (equivalent to 3p per kWh). This buy out price will effectively set the market price for the trading of SROCs.

Those plant which will qualify for SROCs are set down within Article 8 of the Statutory Instrument. They exclude large scale hydro projects (net capacity >20 MW) commissioned before April 2002, and certain types of energy from waste projects. Electricity generated by new wind energy developments including offshore wind energy schemes would qualify for SROCs provided that the electricity is supplied directly to customers within Great Britain.

Currently, over 11%, of electricity supplied in Scotland comes from large scale hydro projects with over 2% being sourced from already commissioned SRO projects and other generation plant that would qualify for ROCs, estimated to rise to 3% by 2003. Therefore the RO (Scotland) targets should act to increase the proportion of electricity supplied in Scotland from renewable sources to around 18%.

There are indications that Scotland may be asked to increase its 2010 obligation target if the UK's 10% target for electricity coming from renewables is to be met. In March 2000 the UK government asked the English regions to assess their renewables resource and establish corresponding regional targets. The resulting targets are lower than had been hoped, leading to only 21.2 to 24.9 TWh per year in England of the 39 TWh per year required across the country as a whole by 2010 and would require Wales and Scotland to exceed their current targets for the UK to meet its overall target[22].

The current annual supply of electricity in Scotland is approximately 33 TWh. A further 7.4% of supply in Scotland coming from renewables between March 21st 2003 and March 21st 2011 to allow the 10.4% obligation to be fulfilled, would mean an annual output of 2.44 TWh coming from renewable energy developments *commissioned* during those years. It is expected that the majority of the new renewable generation in Scotland will come from wind energy schemes.

> The wind farm at Robin Rigg is estimated to produce around 417 to 750 GWh of electricity per year depending on the final turbine selected for the site (2 MW to 3.6 MW machines). It would generate an amount of renewable electricity equivalent to meet between 17% and 30% of the total new output needed under the Scottish Renewables Obligation to meet the 2010 target. The proposed wind farm at Robin Rigg would therefore represent a very significant contribution to the UK renewables and CO2 emissions reduction targets.

2.6 WIND ENERGY IN THE UK

The UK has been estimated as having around 40% of the total wind resource in Europe. Of this 40% about 25% is in Scotland.

By the end of 2001 the total installed wind capacity in the UK had reached approximately 473.6 MW giving an annual production of 1.24 TWh[23]. In Britain the highest wind speeds and therefore the greatest potential for energy production from wind energy are found mainly along the coastlines and in the upland areas of Scotland, England and Wales. However, while the potential for offshore wind energy has been estimated by the ETSU to be 98.6 TWh per year[24], all but two turbines currently operating in the UK have been built onshore.

With a single exception, all operating wind farms in the UK have been built under competitive tendering contracts issued under the NFFO and SRO schemes.

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22 ENDS Report (2002) Unambitious English Regions Place Onus on Scottish Renewables. ENDS Report no. 325 February 2002.
23 British Wind Energy Association web site http://www.bwea.com
24 Matthies HG et al. (1995) Study of Offshore Wind Energy in the EC. ETSU Report w/35/00250

Although wind energy is growing more quickly in the UK in recent years with just under 200MW due for installation during 2002 MW[25], the take up of wind power in the UK has been slow compared to a number of other countries in Europe and around the world. Wind energy is the world's fastest growing and most popular energy technology with over 22,500 MW now installed worldwide[26]. In 2000, 4251 MW were installed worldwide compared to just over 3,500 MW in 1999[27]. However, of the capacity installed in 2000, 3095 MW were installed in three countries, Germany, Denmark and Spain which at the end of 200 had over 60% of worldwide wind energy capacity. The table below shows installed capacity at the start and end of 2000, by region and for the top ten countries within Europe.

Table 2.6.1 Installed wind farm capacity worldwide

Region	Capacity at the Start 2000 (MW)	Capacity at the End 2000 (MW)	% Increase
Europe	9,307	12,972	39.4
South and Central America	87	103	18.4
Asia	1,287	1,574	22.3
Pacific Region	116	221	90.5
Middle East & Africa	39	141	261.5
North America	2,619	2,695	2.9
Total	**13,455**	**17,706**	**31.6**
Germany	*4445*	*6113*	*37.5*
Spain	*1530*	*2402*	*57.0*
Denmark	*1742*	*2297*	*31.9*
Netherlands	*410*	*448*	*9.3*
UK	*356*	*409*	*14.9*
Italy	*211*	*389*	*84.5*
Sweden	*220*	*231*	*5.0*
Greece	*87*	*189*	*17.2*
Ireland	*73*	*118*	*61.6*
Portugal	*60*	*100*	*66.7*

As the global growth of the wind energy industry has continued, technological advances have occurred with respect to wind turbines. One of the main areas where wind turbines have evolved is in their dimensions. The advantage in using larger wind turbines is the increased power output of large turbines. Power output is proportional to the swept area of the turbine blade i.e. a turbine with twice the blade diameter will have four times the power output. In addition the higher the rotor height the higher the average wind speed across the rotor area leading to a further increase in electricity generation per turbine.

The trend in using larger wind turbines in wind energy projects is particularly apparent in the Northern Europe, where land-based constraints are more pertinent. Planners in Northern Europe are therefore commonly opting for smaller numbers of larger wind turbines in order to generate a given quantity of wind-sourced electricity. In Germany in 1999, over 1,500 MW of wind energy capacity was installed, with an average wind turbine capacity of nearly 1.2 MW.

[25] British Wind Energy Association web site http://www.bwea.com
[26] Wind Power Monthly, the Windicator 2002.
[27] Wind Power Monthly, the Windicator 2001.

The first wind farm to be constructed in the UK with +1MW turbines was the Lambrigg wind farm in Cumbria in September 2000. Since then a number of wind farms have been commissioned or are due for commissioning in 2002 with +1MW turbines including the 9 x 1.65 MW Deucheran Hill and 24 x 1.3 MW Bowbeat wind farms in Scotland.

Although it is recognised that wind energy is inherently an intermittent source of electricity, its variable nature poses no special problems for power system operation. Indeed the Renewable Energy Advisory Group (REAG) Report shows that the national grid can readily accommodate more than 10% to 20% of its input from intermittent sources[28].

Wind turbines in the UK typically have a capacity factor in the order of 25-40% (i.e. the percentage of their maximum power output that they produce over the course of a year) and generate electricity for 60-85% of the time, in a year of average winds.

2.7 OFFSHORE WIND

2.7.1 OFFSHORE WIND IN EUROPE

Vindeby, the world's first offshore wind farm was constructed in the Baltic Sea some 1.5 km off the west coast of the island of Lolland, Denmark, in 1991. The wind farm comprises eleven 450 kW turbines in two rows, installed on gravity foundations and was developed as an experimental pilot project. The small size of turbine and therefore high costs of foundations per installed MW have meant that the electricity costs were significantly higher than for an equivalent sized onshore wind farm, with development costs 85% higher and electricity production only 20% greater[29]. Energy costs have been approximately 0.08 ECU/kWh[30]. Nevertheless the project has been a success, and has producing around 12 GWh per year since installation. Vindeby has paved the way for a number of subsequent offshore wind farms and individual installations in Denmark, Sweden, the Netherlands and the UK with increasing turbine size. The latest and the largest to date is the single row of 20 x 2MW turbines installed at Middelgrund, approximately 2 km offshore east of Copenhagen. Photographs of this wind farm as seen from Amager towards the south of Copenhagen, and Charlottenlund in the north are presented in Figures 2.7.1 and 2.7.2.

[28] Department of Trade and Industry (1992) "*Renewable Energy Advisory Group: Report to the President of the Board of Trade*" (London: HMSO).
[29] Krohn, S. (1997): "Off-shore Wind Energy: Full Steam Ahead", 1 September, Danish Wind Turbine Manufacturers Association Web page, www.windpower.dk
[30] Institute for Wind Energy - Research Projects: Opti-OWECS Final Report Volume 0. http://www.ct.tudelft.nl/windenergy/owecs/paragraph44.htm

Figure 2.7.1: Middelgrund offshore wind farm, Copenhagen, as seen from Amager at a distance of 2km

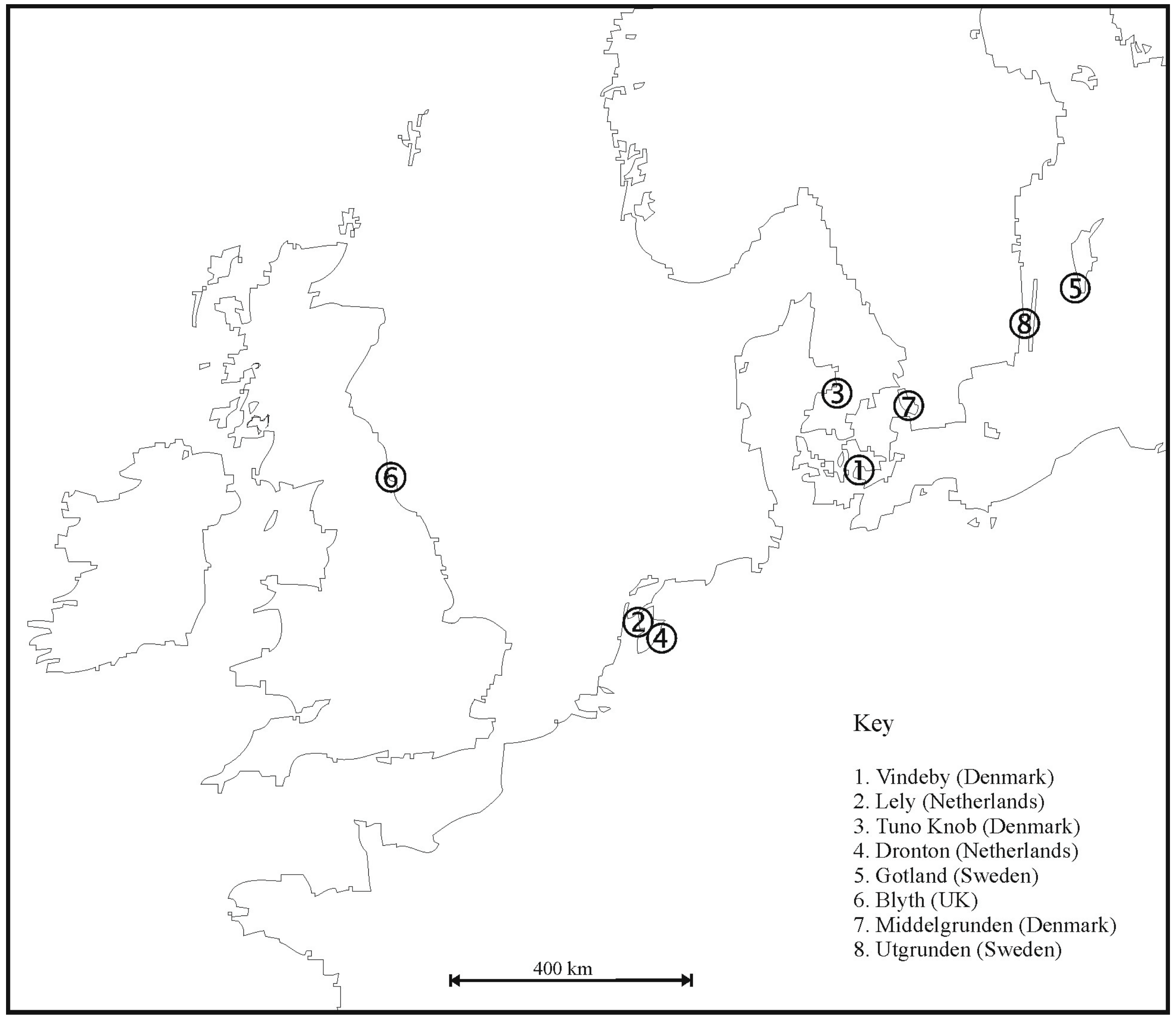
Figure 2.7.2: Middelgrund offshore wind farm, Copenhagen, as seen from Charlottenlund at a distance of 6 km

The total world installed power to date for offshore wind farms stands at 80.6 MW. The installations are summarised in Table 2.7.1 below and their positions are shown in Figure 2.7.3. Availability for offshore wind energy (the proportion of time that collectively the turbines have been fully operational and ready to generate electricity when the wind speeds lie within the operative range) has proved to be higher than previously expected with the availability at Tunø Knob installation for example exceeding 98%[31] and this figure is likely to be increased further for larger offshore wind installations[32].

Table 2.7.1 Existing offshore wind installations

Figure 2.7.3 ref. number	Site	Country	Year built	Turbines
1	Vindeby	Denmark	1991	11 x 450 kW
2	Lely	Netherlands	1994	4 x 500 kW
3	Tunø Knob	Denmark	1995	10 x 500 kW
4	Dronten	Netherlands	1996	19 x 600 kW
5	Bockstigen	Gotland, Sweden	1997	5 x 550 kW
6	Blyth	England	2000	2 x 2MW
7	Middelgrund	Denmark	2000	20 x 2MW
8	Utgrund	Sweden	2000	7 x 1.5 MW

Figure 2.7.3 Locations of existing offshore wind installations



[31] David Taylor (1999) Wind Energy. Open University Website www.openuniversity.edu/StudentWeb/t265/update/wind.htm

[32] P. Christensen and G. Giebel (2001) Availability of Wind Turbines in Remote Places: a Statistical and Real Tome View. Paper presented at EWEC Conference Copenhagen 2001.

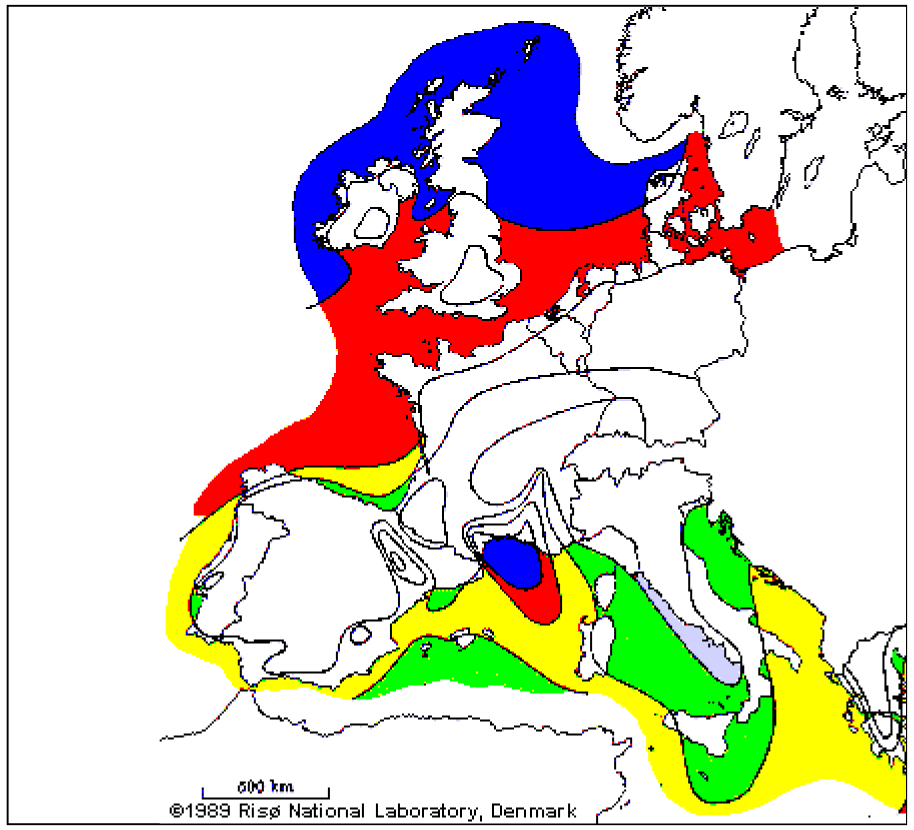
While currently operating offshore wind installations have been relatively moderate developments, there is now a drive for further larger offshore wind installations in Germany, Denmark and the UK. The Danish plans are furthest advanced with construction having begun on the first of two 100-plus MW turbine developments off the west coast of Jutland at Horns Rev and south of the island of Lolland at Rødsand.

The experience gained in the construction of the offshore wind farms installed since 1992 has allowed significant improvement in foundation and structural design and in the design of turbines for offshore use to reduce the need for unplanned maintenance. In addition the environmental effects of the current installations have been monitored to a greater or lesser extent for environmental effects, although far more comprehensive monitoring regimes are planned for the Horns Rev and Rødsand projects. The outcome of the existing monitoring programmes have allowed greater confidence in defining the scope of environmental impacts for planned projects and provided data to aid in the prediction of ecological effects.

2.7.2 OFFSHORE WIND IN THE UK

Offshore wind speeds off the coast of the UK and especially Scotland are high in relation to the rest of Europe as shown in Figure 2.7.4 below and the accompanying table.

Figure 2.7.4 Offshore wind speeds in Europe



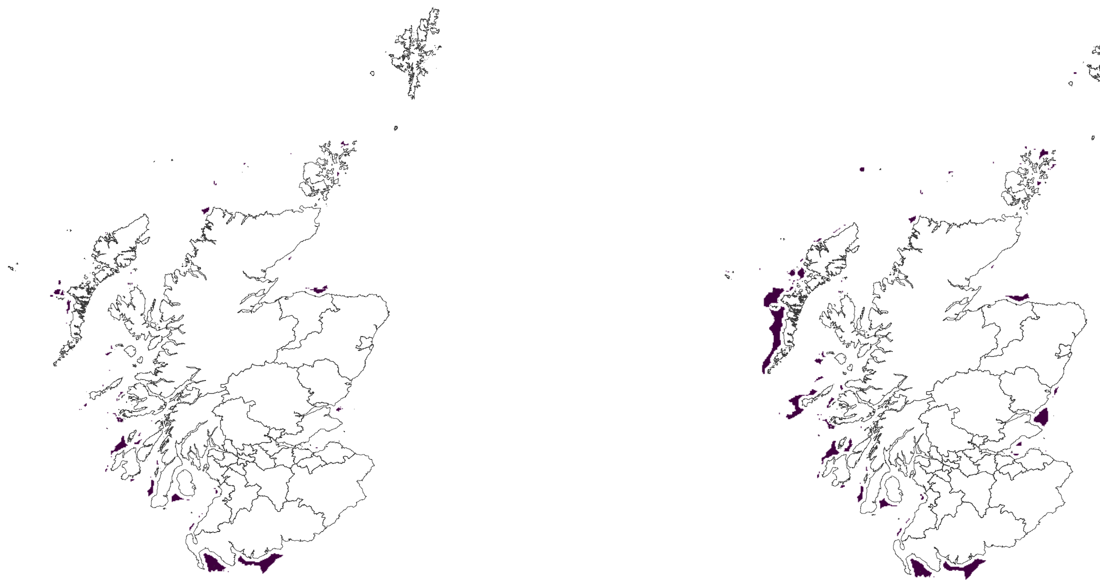
	Wind resources over open sea (more than 10 km offshore) for five standard heights				
	10m ms^{-1}/Wm^{-2}	25m ms^{-1}/Wm^{-2}	50m ms^{-1}/Wm^{-2}	100m ms^{-1}/Wm^{-2}	200m ms^{-1}/Wm^{-2}
	> 8.0 > 600	> 8.5 > 700	> 9.0 > 800	> 10.0 > 1100	> 11.0 > 1500
	7.0-8.0 350-600	7.5-8.5 450-700	8.0-9.0 600-800	8.5-10.0 650-1100	9.5-11.0 900-1500
	6.0-7.0 250-300	6.5-7.5 300-450	7.0-8.0 400-600	7.5-8.5 450-650	8.0-9.5 600-900
	4.5-6.0 100-250	5.0-6.5 150-300	5.5-7.0 200-400	6.0-7.5 250-450	6.5-8.0 300-600
	< 4.5 < 100	< 5.0 < 150	< 5.5 < 200	< 6.0 < 250	< 6.5 < 300

ETSU produced a resource assessment for offshore wind in the coastal waters of the UK as part of a European study in 1995 that estimated a potential total resource of 98.6 TWh annual electricity output from offshore wind farms[33]. This is estimated to represent 33% of Europe total offshore potential[34].

The Scottish offshore wind resource has been estimated in a report commissioned by the Scottish Executive published in December 2001. The results were published in December 2001 in the comprehensive report 'Scotland's Renewable Resource 2001'[35]. The report examined achievable resources for offshore wind technology for electricity production costs in the years 2010 and 2025 of 7p/kWh and 5p/kWh. The total base resource at 7p/kWh for offshore wind energy in Scotland was estimated at 25 GW of installed capacity. Maps are shown in Figures 2.7.5 of the location of the available resource for the 7p/kWh and 5p/kWh production costs.

33 Matthies HG et al. (1995) Study of Offshore Wind Energy in the EC. ETSU Report w/35/00250
34 BWEA Website: http://www.offshorewindfarms.co.uk/info.html
35 Garrad Hassan (2001) Scotland's Renewable Resource 2001'. Report for the Scottish Executive.

Figure 2.7.5 Offshore wind resource locations at 5p/kWh and 7p/kWh production costs



5p/kWh resource **7p/kWh resource**

The first potential government support for private initiative in offshore wind took place in 1996 when 2 offshore sites at Gunfleet off the coast of Essex, and Blyth harbour in Northumberland were awarded contracts under the 4^{th} Round of the Non-Fossil Fuel Obligation although under the 5^{th} round of NFFO, offshore wind projects were not allowed. The Blyth Harbour project which added two near-shore 2 MW turbines to the existing onshore wind farm, became the first offshore wind installation in the UK when the turbines were erected in 2000. The larger wholly offshore Gunfleet project and a further project at Scroby Sands off the Norfolk coast near Yarmouth, that failed to win a NFFO contract, have more recently been submitted for construction permits. The Scroby Sands project received permission to build in April 2002.

While the Blyth Harbour project was been constructed and commissioned through the NFFO scheme the British Wind Energy Association recognised towards the end of the 1990s that the UK would need a more focussed approach to offshore wind if any significant contribution was to be made from offshore projects to electricity supply by 2010. By 1998 BWEA had set up offshore groups and had begun negotiations with the Department of Trade and Industry and the Crown Estates, who own 96% of all land within 12 nautical miles of the coast in the UK. They also commissioned a number of research projects to further the understanding of the technical and environmental characteristics of offshore wind developments including a study by Metoc Plc for ETSU which has provided a scope and description of environmental issues which need to be considered within the Environmental Impact Assessment for an offshore wind project[36].

The objective of the BWEA and later the DTi was to create a new industry in the offshore sector so that the UK could strengthen and re-skill its offshore oil and gas industry and become a world leader in offshore wind energy design and installation. At the same time the government began to recognise offshore wind as an essential contribution to achieve the ambitious renewables targets for 2010.

In early 2001 the DTI announced the decision to support a number of demonstration projects and under what would be the first round of competitive tendering for offshore projects in the UK. The aim was to provide some economic support for 6-10 projects developed using a range of methods, locations and companies, to allow a broad development of offshore wind experience within the existing offshore energy and wind energy industries. To achieve this a size restriction of 30 turbines within 10 square km was set for individual projects to be submitted by competent consortia. The consortia were able to choose sites around the UK within the 12 mile limit.

In 1998 the Crown Estates permitted potential developers to erect offshore masts on a pre tender basis with no guarantee of lease, under a licence to take scientific research data. Three masts were erected as a result, one of these being the mast erected on the Robin Rigg bank. In December 2000 the Crown Estates issued invitations to competent consortia to bid for and register on sites in Round 1 of Offshore UK. In April 2001 successful consortia were announced. 18 consortia qualified and were offered option leases. Due to duplication of the more favourable sites, the consortia actually registered only 13 different sites with up to 3 consortia registering in a single area at Shell Flats in the Irish Sea near Blackpool. Two consortia, Solway Offshore Ltd. and Offshore Energy Resources Ltd. registered in the mid Solway area and agreed to progress and design the two developments as a single wind farm on two areas of immediately adjacent sea bed. This allowed for a maximum of 60 turbines but in a single array to reduce cumulative visual and ecological impacts. It also allowed the potential impacts to be assessed of a single block rather than 2 blocks interacting with one another.

2.8 REGULATORY AND PLANNING CONTEXT

2.8.1 INTRODUCTION

The boundary between Scotland and England is defined on a map basis under the Scotland Act 1998 and is shown on Figure 1.1 in Section 1 of this ES. The territorial seas of Scotland and England extend respectively to meet at the boundary between the two countries.

The 60 wind turbines proposed would be in Scottish waters together with an anemometer mast, offshore sub-station, cables linking the wind turbines to the offshore sub-station, and 12km stretch of the cable which would take power from the wind farm to an onshore grid connection. Most of the cable run to this grid connection would be in English waters, the landfall being at Flimby in England as shown on Figure 4.13.1 in Section 4.13 of this ES.

Above mean low water springs in England the export power cables would be laid underground through the intertidal area, under sea defences and from there inland to a new 132kV switchyard where the power cables from the wind farm would connect with the existing 132kV overhead line distribution network.

[36] ETSU (2000) An Assessment of the Environmental Effects of Offshore Wind Farms. ETSU Report W/35/00543/REP

Section 2.8.2 below discusses the consents and authorisation for which applications are now or very shortly being made. Section 2.8.3 discusses the need for environmental impact assessment (EIA) in the context of these applications. Some later consents will additionally be required, but these are not development consents for the purposes of EIA, and in any case the works to which they relate will have already been assessed in the context of the applications discussed in 2.8.2.

2.8.2 APPLICATIONS FOR CONSENTS AND AUTHORISATION

It is proposed to seek consents and authorisation for Robin Rigg Wind Farm through the following applications.

Section 36 of the Electricity Act 1989 provides for consent (Section 36 consent) to be required from the Scottish Ministers for the construction, extension or operation of a generating station where the intended capacity exceeds 1MW. In the case of Robin Rigg Wind Farm, Offshore Energy Resources Limited and Solway Offshore Limited are seeking Section 36 consent for the construction and operation of the wind turbines and their foundations (60 wind turbines), an offshore 33kV/132kV sub-station, 33 kV cables buried in the seabed between the wind turbines and the substation and that part of the 132 kV cable run from the offshore substation to the onshore grid connection that lies within Scottish waters. These elements of the project are shown on the Figure 4.5.1 in Section 4.5 of this ES.

Under Section 5 Food and Environment Protection Act 1985 a licence ("a FEPA licence") is required from the Scottish Ministers for the deposit of articles either in the sea or under the seabed. For the proposed Robin Rigg Wind Farm a FEPA licence will be required for the placement of the foundations of the wind turbines in the seabed. It is likely that two FEPA licences will be sought from the Scottish Ministers to enable the placement of either monopile or multi-pile foundations or perhaps a mix of the two types of foundations (see the discussion of foundations in Section 4.7 of this ES).

However, under the provisions of the Deposits in the Sea (Exemptions) Order 1985 no FEPA licence can be required for the laying of cables in the seabed. These cables will be dealt with under the Section 36 consent in Scotland and under Section 34 Coast Protection Act 1949 in Scotland and England.

The public has the right to navigate in tidal waters, and this right extends to fishing. By reason of the works for which a Section 36 consent is being sought there may be an interference with this right of navigation. In addition, for safety reasons, it is appropriate to seek to exclude rights of navigation in construction areas and for certain purposes during the operation of the wind farm. For these purposes a Private Bill is being promoted in the Scottish Parliament.

Under Section 34 Coast Protection Act 1949 consent is required from the Scottish Ministers or within English waters from the Secretary of State (Department of Transport Local Government and the Regions) for the construction of any works or the deposit of any object or materials on, under or over any part of the seashore under the level of mean high water springs which would cause or would be likely to result in an obstruction or danger to navigation. Consent under Section 34 of the 1949 Act will be sought for the laying of export power cables from the Scotland/England boundary through English waters as far as mean high water springs, taking a precautionary approach to the issue of the public right of navigation. Consent will also be sought from the Scottish Ministers for all proposed cables in Scottish waters under Section 34 of the Coast Protection Act.

Under Section 57 Town & Country Planning Act 1990 (applicable in England and Wales) planning permission is required for building and engineering operations which are material development for the purposes of the Act. The developers will be making an application for planning permission for the open trenchwork required to lay cables inland from mean low water and for the proposed new 132kV switchyard at the connection point to the existing distribution network.

Under Section 37 Electricity Act 1989 the consent of the Secretary of State at the Department for Trade and Industry is required for new overhead power lines and their supporting poles or pylons within England and Wales. The Overhead Lines (Exemption) Regulations 1990 prescribe circumstances in which consent under Section 37 may be required for improvements to existing overhead lines. At the date of this environmental statement Norweb Plc, as owner of the electricity distribution system to which Robin Rigg Wind Farm will connect, is investigating what will be required to connect the wind farm to its system. If an application under Section 37 Electricity Act 1989 is required that will be made by Norweb with supporting environmental information as required.

2.8.3 NEED FOR ENVIRONMENTAL IMPACT ASSESSMENT

EIA is a process which seeks to identify any significant environmental effects (both positive and negative) of development proposals. It aims to prevent, reduce and mitigate and offset against any adverse environmental impacts, and at the same time to allow the public, decision making authorities, government agencies and NGOs, access to sufficient data and information relating to a proposal to make objective judgments as to its acceptability within the context of national, regional and local planning and environmental policy.

Legislation on environmental assessment was implemented in the UK following the adoption of the 1985 EC Directive (No. 85/337/EEC) 'on the assessment of the effects of certain public and private projects on the environment'. This Directive was amended in 1997 by EC Directive 97/11/EC. The Directives have been implemented through various statutory instruments in the UK.

The need for EIA for electricity generation projects requiring consent under Section 36 Electricity Act 1989 is provided for in Scotland by The Electricity Works (Environmental Impact Assessment) (Scotland) Regulations 2000. These set out the statutory process and minimum requirements for environmental impact assessment of those projects which require such assessment. They also set out criteria for the screening of projects for the need for environmental assessment. Schedule 1 to the Regulations describes projects for which EIA is a mandatory. Schedule 2 to the Regulations lists projects for which EIA may be required depending on factors described in the Regulations.

Robin Rigg Offshore Wind Farm is a Schedule 2 development under the 2000 Scottish Regulations. For such developments the Scottish Executive can be asked for a decision on whether a full Environmental

Statement is required, or alternatively the developer can voluntarily submit an ES. The Guidance Notes that accompany the Regulations state with regard to offshore wind farms that

> *'on the basis of sites presently identified.....the likelihood is that most Section 36 applications in territorial waters that come under Schedule 2 will require EIA'*

In this case the promoters have elected to carry out EIA of the Robin Rigg project under the 2000 Regulations

While no regulations implement the EC Directives on EIA for the purposes of the Food and Environment Protection Act 1985 Section 8 of that Act enables the Scottish Executive to call for such environmental information as it sees fit in support of applications under Section 5 of the Act. This environmental statement contains such information.

No regulations have been made under Section 34 Coast Protection Act 1949 requiring EIA of projects except within harbour areas. The proposed cable within Scottish waters is not within a harbour area. However, EIA of the cable route is being provided in this case under the 2000 Regulations which apply to applications under Section 36 Electricity Act 1989.

Turning to the Private Bill in the Scottish Parliament Standing Orders of the Parliament have implemented the EC Directives, so that EIA of those elements of the project relevant to the Private Bill is required (and has been provided in this environmental statement).

Within English waters, and on the English mainland, 132 kV cables are proposed to link the wind farm to a grid connection with the existing 132 kV network. Above mean low water in England the proposed cables and new switchyard will be subject to EIA under the Town & Country Planning (Environmental Impact Assessment) (England and Wales) Regulations 1999. Environmental information will be provided under these Regulations to accompany the application for planning permission when made.

As to the cables within English waters no Regulations have been made under the Coast Protection Act 1949 to implement the EC Directives except within harbour areas. The proposed cables within English waters are not within a harbour area. Nevertheless the promoters of Robin Rigg wind farm have taken the view that environmental information should be provided to accord with the requirements of the EC Directives, and such will be the case when the Section 34 application for the cables within English waters is made.

Finally, it was noted above that an application under Section 37 Electricity Act 1989 may be required. If this is the case, then EIA of those works may be required and if so will be undertaken through the application to be made by Norweb Plc.

This environmental statement contains all the information provided for in the scoping opinions given by decision makers and specifically that which Annex 4 of the 1985 Directive requires to be provided. It contains sufficient information to enable the likely significant effects of the project on the environment to be taken into account when decisions are made. It will inevitably be the case that some information will reach decision makers after the publication of this document, and after applications for development consents have been made. While that information will doubtless be helpful to the decision makers it is not essential in the sense that it is required to enable the likely significant effects of the development to be isolated and analysed. Decisions on the proposed development consents can be made, taking into account the requirements of the Directives, on the basis of information in this document. Information which follows the submission of this document will assist, but is not essential.

2.8.4 PLANNING POLICY FRAMEWORK

The need for the proposed Robin Rigg wind farm in energy policy terms has been discussed earlier in this Section. Turning to planning control only limited parts of what is proposed will fall within town and country planning jurisdiction. No part of the development in Scottish waters would be subject to this jurisdiction. Within England the elements of the development above mean low water springs (the boundary of jurisdiction for this project under the Town & Country Planning Act 1990) would comprise:

- Export power cables above mean low water; and
- A new 132kV switchyard at the connection point with the existing 132 kV network.

The consenting route for these works is discussed under Section 2.8.2 above. Only in respect of these onshore works do the policies and explanatory text of development plans (within England and Wales) have direct application. However, policy documents, including development plans, within Scotland, England and Wales may usefully inform the interests which local authorities seek to protect within their areas for the purposes of other chapters in this environmental statement.

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As to the onshore elements of the development an application for planning permission will be made in due course. Environmental information will accompany the planning application (see section 2.8.3) and therefore the topic will not be further explored in this environmental statement.

As to the effects of the offshore elements of the development on onshore interests these will be limited to visual amenity and to landscape issues. The landscape and visual assessment incorporates a seascape assessment, a landscape appraisal, and an assessment of the effects of the development on visual amenity.

There are no policies within development plans or at a national level on effects of development on seascape. Again, for the limited purposes of this policy assessment it seems sensible to concentrate on landscape interests because these are advised on at a national and local level in terms of development outside designated areas which may impact on the interests of those areas. Effects on visual amenity, related to such landscape designations, can also be discussed in the context of advice on developments which may affect designated areas.

It must be stressed that no planning advice at a national or local level has direct application to what is proposed at Robin Rigg. Nevertheless such policy advice is briefly explored in the succeeding paragraphs so as to inform decision makers of the onshore interests which policy seeks to protect, and which may to some degree be affected by the offshore wind farm.

2.8.4.1 Scotland

The seascape, landscape and visual assessment identifies that the offshore wind farm will affect the interests protected by the following designations: the Nith Estuary, East Stewartry Coast and Fleet Valley National Scenic Areas and the Solway Coast Regional Scenic Area.

However, significant effects are only identified on the East Stewartry Coast NSA. For the limited purposes of this discussion it is intended to address only that identified effect, which is noted in the landscape and visual assessment as capable of being viewed as positive or negative.

Paragraph 5 of NPPG 14 discusses national designations and advises that

'*development which would affect a designated area of national importance should only be permitted where:*

- *the objectives of designation and the overall integrity of the area will not be compromised; or*
- *any significant adverse effects on the qualities for which the area has been designated are clearly outweighed by social or economic effects of national importance.'*

Although the landscape and visual assessment within this environmental statement identifies a significant effect on the East Stewartry Coast NSA the conclusions to the assessment make it clear that the proposed development can be seen as acceptable. The assessment does not identify that the objectives of the designation or the overall integrity of the area of the NSA would be compromised. Therefore the advice in paragraph 25 of NPPG is positively satisfied in this case. Paragraph 26 of the NPPG contains further advice on development in or adjacent to NSAs. However, it is not thought that this advice adds anything material to that in paragraph 25.

At a local level policy E1 in the Dumfries and Galloway Structure Plan 1999 advises on development in or affecting NSAs: "The siting and design of developments should respect the special nature of the area. Development within, or which would have a significant impact on national scenic areas (NSAs), will only be permitted where it can be demonstrated that either:

1. the proposed development will not compromise the area's scenic and landscape character, and overall integrity; or
2. any significant adverse effects on the scenic interests and integrity of the area are clearly outweighed by social or economic benefits of national importance."

It can be seen that the policy test in E1 mirrors that in paragraph 25 of NPPG 14, and thus adds no further issues for consideration.

At this level of discussion it is not thought necessary to discuss policies within the Stewartry Local Plan 1991 or its proposed replacement which is at a consultation draft stage.

2.8.4.2 England

The landscape and visual assessment identifies effects on the following designated areas: the Lake District National Park, the Solway Coast Area of Outstanding Natural Beauty (AONB) and on the Allerdale landscape of county importance. There is also a discussion of the effects of what is proposed on the Hadrian's Wall World Heritage site.

Since conclusions are reached that the development would not be likely to have a significant effect on any of these areas it is not felt necessary to explore policy issues relating to such effects further.

It must be emphasised that, if Robin Rigg wind farm was proposed onshore this section of the environmental statement would be much more substantial and would devote space to a discussion of local policies. However, since planning controls do not extend to what is proposed offshore it is felt sufficient to provide the briefest of explorations of onshore policy issues.

Section 3

Site Selection, Site Design and Alternatives Considered

Contents Page

Section 3

Site Selection, Site Design and Alternatives Considered

3.1 'DO NOTHING' SCENARIO

3.1.1 CONSEQUENCES OF THE 'DO NOTHING' SCENARIO

The most simple alternative that should be considered to the development at Robin Rigg is to leave things as they currently stand. That is, that the renewable electricity that would have been produced by the Robin Rigg wind farm during its 25 year lifetime is sources instead from generators representing the current UK electricity generation mix, or rather the generation source that the wind farm would displaced when it was producing electricity.

Section 2 described the issue of climate change and the consequences of taking no action to reduce global emissions of greenhouse gases. The greenhouse gases displaced by the Robin Rigg wind farm will contribute significantly to greenhouse gas emission reduction at the regional level through the production of an estimated 17-30% (depending on turbine size installed in the range from 2 - 3.6 MW) of the new renewable electricity generation required in Scotland between 2003 and 2010 to meet the 2010 Scottish renewable target. The target is an important contribution to the UK Climate Change Programme.

Subsidiarity, that is the division of global responsibility down to the national and regional scales, is a key principle of the Framework Convention on Climate Change. For the aims of the Convention to be met each signatory state and each region within that state needs to meet its share of the overall emissions reduction target. Therefore, any development that contributes significantly to the regional renewable energy targets is playing a significant role in moving towards mitigating against the environmental and social impacts of climate change that would occur under a global do nothing scenario

These impacts are broadly described in Section 2.2 earlier in this ES.

3.1.2 GREENHOUSE GAS AND OTHER EMISSIONS OFFSET BY ROBIN RIGG

It is worth calculating the emissions that will be output by electricity generators should neither the Robin Rigg wind farm nor any alternative renewable generator of the same annual electricity output, be developed. These emissions will comprise carbon dioxide (the main gas contributing to climate change) and sulphur dioxide and nitrous oxides which together are the main cause of acid rain.

Each kWh that the wind farm at Robin Rigg would generate would offset the generation of 1 kWh by load following power stations which in the UK are powered by fossil fuels. Planning Policy Guidance Note 22: Renewable Energy which guides decisions on planning applications for renewable energy proposals in England and Wales, gives the following figures that should be assumed in calculating emissions offset by each kWh generated by a wind farm: 850g carbon dioxide, 11g sulphur dioxide, 2g nitrogen oxides.

In order to use the above figures it is first necessary to calculate the electricity output of the wind farm proposal i.e. the electricity output of the wind farm over its proposed lifetime, less the energy used for the construction, installation and maintenance etc. of the wind farm. These are calculated below.

3.1.3 ELECTRICITY OUTPUT OF THE ROBIN RIGG WIND FARM

The wind farm proposal would have a total installed capacity of between 120 MW and 216 MW depending on the final turbine size used (between 2 MW and 3.6 MW per turbine).

The capacity factor for the site, that is the net annual output as a proportion of the maximum annual output for constant ideal wind conditions, has been calculated from the on-site wind data, correlated with long term data from the nearest meteorological station. The capacity factor has been estimated at 39.6%. This factor includes availability figures (predicted at greater than 98% for large offshore wind farms[37]) and losses in electrical cabling up to the point of connection with the existing transmission network.

Assuming a 25 year life, the total electricity output over the lifetime of the Robin Rigg wind farm should it be constructed would be between 10.4 and 18.7 TWh (1 TWh = 1 billion kWh).

This would be sufficient to meet the electricity demand of between 99,000 and 178,000 average households during the lifetime of the wind farm, depending on the size of turbine used.

3.1.4 ENERGY COST OF THE PROPOSED WIND FARM

To accurately estimate the pollution savings of the wind farm proposal, or conversely the emissions that would be released during its proposed lifetime should it *not* be constructed, the electricity output of the wind farm needs to be balanced against the energy cost of the proposal i.e. energy inputs into the wind farm over its lifetime. This comprises any fossil fuel used in the construction of the turbine components, the construction of the site including turbine foundations, turbine delivery and erection, cable construction and laying and grid connection, energy used in maintenance operations during the operating life of the wind farm and finally fossil fuel used in the decommissioning of the development.

37 P. Christensen and G. Giebel (2001) Availability of Wind Turbines in Remote Places: a Statistical and Real Tome View. Paper presneted at EWEC Conference Copenhagen 2001.

The energy costs of onshore wind farms in Europe have been assessed in detail by the Danish Wind Turbine Manufacturers Association in 1997[38]. The findings are consistent with earlier independent studies by the Risoe National Laboratory in Roskilde, Denmark[39]. The Danish Wind Manufacturers Association paper estimates the global direct and indirect energy use for manufacture, installation, operation, maintenance and decommissioning of 600 kW wind turbines to be about 450,000 kWh. Adjustments for offshore larger turbines of the type being considered for Robin Rigg have been calculated in a study for the Rødsand offshore wind farm in Denmark, which is of a similar size to the Robin Rigg project. The study concluded that the net energy *use* per kWh of electricity *produced* by the wind farm would be approximately 30% of that for an onshore 600 kW machine[40].

Using these figures the total energy *used* over the lifetime of the Robin Rigg wind farm has been estimated to come to less than 0.5% of the total electricity *output* of the wind farm over it's 25 year lifetime.

3.1.5 NET EXTRA GREENHOUSE GAS AND OTHER POLLUTANTS EMITTED IN THE DO NOTHING SCENARIO

Taking into account the energy use as described above as well as the energy output of the wind farm, the proposal at Robin Rigg would achieve the net pollution savings shown in the table 3.1.1 over a 25 year lifetime for the minimum and maximum installed capacities of 120 MW and 218 MW. The table gives the additional emissions that would be output should the wind farm at Robin Rigg *not* be constructed.

Table 3.1.1 Total additional emissions output from UK generators over the 25 year proposed operational life span, for the Do Nothing Scenario i.e. the case that neither the Robin Rigg wind farm nor an equivalent renewable energy development is constructed.

Emission Type	Installed Capacity of 120 MW (60 x 2MW turbines)	Installed Capacity of 218 MW (60 x 3.6 MW turbines)
Carbon Dioxide	8.8 million tonnes	15.9 million tonnes
Sulphur Dioxide	114,000 tonnes	206,000 tonnes
Nitrogen Oxides	21,000	37,000

[38] Danish Wind Turbine Manufacturers Association (1997) 'The Energy Balance of Wind Turbines' Web address www.windpower.org/publ/enbal.pdf
[39] H. Meyer, P.E. Morthorst, L. Schleisner, N.I. Meyer, P.S.Nielsen and V. Nielsen (1994) Omkostningsopgoerelse for miljoeeksternaliteter i Forbindelse med Energiproduktion'. Risoe National Laboratory.
[40] S. Properzi, H. Herk-Hansen and H. L. Borg (2001) Life Cycle Assessment of a 150 MW Offshore Wind Farm at Rødsand, Denmark. Paper presented at European Wind Energy Conference Copenhagen 2001.

3.2 TECHNICAL REQUIREMENTS FOR OFFSHORE WIND

Technical requirements for offshore wind farms are largely guided by economic considerations. Increasing water depth, increasing distance of the wind farm from land and therefore increased grid connection length increase costs while reduced wind speeds and turbine size decrease revenue and therefore also reduce the viability of offshore wind projects.

Certain technical requirements define favoured physical and geographical environments for offshore wind and guide in the site selection process. Other technical considerations guide the design and layout of the components of offshore wind farm developments. These two sets of factors are outlined below.

3.2.1 TECHNICAL CONSIDERATIONS IN SITE SELECTION

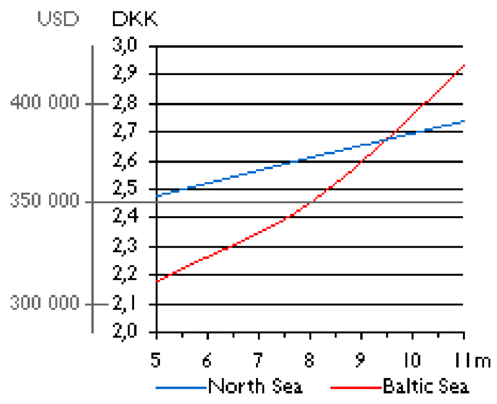
3.2.1.1 Turbine Foundations and Water Depths

Turbine foundations for offshore projects contribute a significantly larger proportion of overall development costs than for onshore wind farm developments. For onshore wind developments foundations costs comprise typically 6% of overall development costs, while for offshore projects foundation costs typically represent 25% of development costs in shallow waters (3-5m) with proportions increasing with increasing depth[41]. In the seas around the UK waves, as well as turbine size, will be an important factor in determining the required weight and strength of foundations as wave height can be significant. In other areas such as the Baltic Sea, foundations need to cope with pack ice and the weight and dimensions of the foundation will be significantly more sensitive to depth. Nevertheless, for UK marine conditions, turbine foundation costs for steel monopile foundations can increase by about 2% per metre of increasing water depth from a base depth of 5 metres[42] (see Figure 3.2.1). Therefore there are clear economic advantages in situating offshore wind farms in shallow waters of depths of less than 10 m although water depths of up to 30 m are technically possible.

The size and nature of foundations will also be affected by the nature of the bed and sub-bed geology. However, there is a technical solution to almost all geological conditions from hard bedrock to loose sediments. Current foundation types include gravity foundations, which rely on weight of sediment above a heavy plate of large circumference buried at relatively shallow depth, monopile foundations that are single piles penetrating the substrate to depths which depend on the stiffness of the substrate and the risk of movement of the upper levels of substrate, to multipile foundations which are supported by a number of piles penetrating the substrate. Piles are suited to both bedrock close to the surface or deep sediments. While gravity foundations are appropriate for stiff sediments, they would be problematic in areas of high sediment movement as removal of layers of sediment covering the plate would destabilise the foundation.

[41] Krohn, Soren (1997): "Off-shore Wind Energy: Full Steam Ahead", 1 September, Danish Wind Turbine Manufacturers Association Web page, www.windpower.dk
[42] Krohn, Soren (1997): "Off-shore Wind Energy: Full Steam Ahead", 1 September, Danish Wind Turbine Manufacturers Association Web page, www.windpower.dk

Figure 3.2.1 Increasing Cost (US$) of Monopile Foundation With Water Depth (m)[43]



3.2.1.2 Grid Connection Distance and Wind Farm Size

A large cost element which is sensitive to location is the grid connection cabling between the site and the existing transmission system. For a viable wind farm onshore or offshore, grid connection costs would typically not exceed 10% of total development costs. Marine power cable construction and installation is significantly greater than for onshore connection. There is therefore a critical relationship for offshore wind farms between wind farm size and distance to shore and onward distance to the nearest onshore grid connection. Although the viability of an offshore wind farm is dependent on a complex set of variables, an economically viable offshore wind farm of greater than 100 MW installed capacity should typically be sited within 10-15 km of the shore and within 20 km of the existing 132/275 kV grid network.

3.2.1.3 Wind Speed

On the revenue side of the accounts sheet, wind capture is the key factor in site selection and site design. Due to longer wind fetches and lower surface 'roughness' at sea, wind capture is approximately 30% higher at sea than on adjacent land lying at sea level. This partially compensates for increased turbine foundation and grid connection costs. Wind energy capture varies as the cube of wind speed, for a given turbine rotor size. That means that a 5% increase in average wind speeds gives an approximate 16% increase in wind energy capture (depending on the shape of the wind speed distribution about that average). The economic viability of a wind development is therefore very sensitive to small differences in average wind speed.

[43] Danish Wind Turbine Manufacturers Association Web page www.windpower.dk

3.2.2 TECHNICAL CONSIDERATIONS IN SITE DESIGN

3.2.2.1 Turbine Size

Since foundation costs are not solely dependent on turbine size and are a significant part of overall project cost, there are advantages in using large turbines, to increase wind capture per foundation. Offshore wind farms in the UK are likely to utilise the largest wind turbines in production that are currently in the order of 2 to 2.5 MW but will increase to 3 to 3.6 MW by 2003/2004. This compares to onshore development where turbines installed in the UK have typically been in the order of 600 kW installed capacity, although more recently a number of wind farms have been installed with 1.3 MW turbines and a wind farm on Kintyre commissioned in 2001 comprises 8 x 1.75 MW turbines.

3.2.2.2 Separation Distances and Layouts

Because of low surface 'roughness' and therefore low wind turbulence at sea, wind turbines have a greater wake effect associated with them at sea then when installed on land. Wake effects are losses of energy capture of a wind turbine lying in the wind shadow of an upwind turbine. Greater advantages in overall yield of a group of wind turbines are gained from increasing separation distances between turbines at sea than onshore. Increasing separation distances between adjacent turbines running parallel to the prevailing wind direction increases wind yield more than increasing separation distances perpendicular to the prevailing wind direction. Conversely, as separation distances between turbines increases, so does the overall length of power cables between turbines, and at some point the increased capital cost will offset the increased energy yield of the wind farm. This requires a fine balance.

There may also be landscape and visual preferences in density and layout of turbines that may partially override these other considerations. Similarly, while a single long row of turbines spaced perpendicular to the prevailing wind direction would give the greatest wind capture, there may be visual advantages to placing turbines in a more compact group with breadth and depth of the layout being of similar lengths to reduce the extent of the horizon broken by the wind farm when viewed from various positions. Landscape and visual considerations are discussed in more detail later in this section and also in Section 9.10 of this Statement.

3.3 BROAD SITE SELECTION

In 1998 Solway Offshore Ltd. Fred Olsen Energy began a search for potential offshore wind sites in the UK in response to the beginning of negotiations between the DTi, the Crown Estates and the British Wind Energy Association that had the aim of initiating an offshore wind industry in the UK (see Section 2.7.2). Fred Olsen Energy later merged in 2000 with Natural Power Consultants Ltd.

The aim of the broad site selection process was to identify a suitable site for erection of a wind monitoring mast. A thorough site selection process was developed that considered all aspects of a site that would have a bearing on the economic viability and the technical and environmental acceptability of an eventual wind energy development in that area.

The whole of the coastline of the UK was considered in the initial stages of the search. Chief criteria forming a framework for the search were the technical criteria described above from which a minimum wind speed, a maximum water depth, a maximum distance from potential grid connection, and a minimum area of continuous low water were defined. The limits and sources of data included in the search were as follows:

- **wind speed:** the European wind energy atlas was used to give indicative average annual wind speeds at various heights around the coast line of Britain. A minimum indicative wind speed of 8.5 m/s at 50 m above sea level was selected as the cut off for a potentially viable offshore wind farm.
- **water depth:** a maximum water depth of 10 m below Mean Sea Level was considered as being preferred for a potentially viable offshore wind farm, with favourable cost factors in other areas. Indicative water depths were derived from admiralty charts for inshore areas. While it was understood that charts may not present current conditions, it was considered that they would give sufficient indication of approximate locations and areas of shallow water for the purposes of broad site selection.
- **continuous shallow water:** The early indications were that the DTi and Crown Estates would be defining intermediate sized wind farms for the first round of offshore wind projects in the UK of the order of thirty turbines. For current large scale turbines this would require a minimum area of around 5 square km of continuous or adjacent shallow water of a depth no greater than 10 m. For the search to give some flexibility in design for a given site a minimum area of 10 square km was set as the limit.
- **grid connection:** A distance of 20 km was defined as the maximum distance of a potential site from the nearest 132/275 kV distribution/transmission network. The UK network layout was drawn from 7-year plans of the various network operators in the UK. In addition Ordnance Survey 1:50,000 Landranger maps show the position of all overhead lines within the current network.

The first round of offshore wind development centres on leases from the Crown Estates. The Crown Estates include the majority of inshore waters out to 12 nautical miles from the high water mark. This was defined as the absolute outer limit for the search. At the same time, to reduce the impacts of offshore wind farms on onshore landscapes and visual receptors, a minimum distance of 5 km from the high water mark was set for potential sites.

The above search criteria led to the selection of a number of areas that were considered to be technically acceptable, and were applicable for further consideration. The next stage of site selection required consideration of these areas against a number of other marine based factors. These included the following:

- Identification and avoidance of internationally important marine wildlife designations including marine Candidate Special Areas of Conservation to be designated under the EU Habitats Directive, Special Protection Areas designated under the EU Birds Directive and Ramsar designated intertidal areas.
- Initial consultations with the Ministry of Defence, the Civil Aviation Authority and the National Air Traffic Service to highlight any issues with radar or low flying aircraft.
- Identification of busy shipping lanes in the vicinity of the sites. While the water on potential sites would be too shallow to allow the passage of merchant vessels under normal conditions, risks of collision during storm conditions and high seas would be increased with reduced distance to nearest shipping lanes.
- Distance of sites from ports with the ability to service construction vessels and with cranes capable of lifting turbine and foundation components.
- Potential for other resource use that might be sterilised by the presence of a wind farm including mineral reserves and oil and gas reservoirs.

The mid Solway Firth emerged as one of the sites which met with all the identified criteria. The site contains a number of areas of shallow water of sufficient size for a medium to large wind farm, is well represented with electricity transmission corridors on the English side, has an indicative wind speed of greater than 9 ms^{-1} at 50 m above sea level, has limited shipping traffic, has no recognised mineral, gas or oil resource and is in reach of a number of ports with facilities appropriate for offshore wind farm construction including Maryport, Workington, Barrow-in-Furness and Silloth. While the Inner Solway is protected by a number of national and international wildlife designations, there are a number of technically suitable areas for offshore wind within the mid Solway which, following initial studies of the use by wintering and breeding birds in the area, were considered far enough from the designated areas to avoid significant impacts. This would need to be confirmed by detailed environmental assessment should the Solway be selected as the preferred site. Similarly, while an MOD firing range danger area extended into the sea south of Kirkcudbright, there was potential to avoid this area during finer site selection. No military or civil aviation issues were raised by the relevant consultees.

Following selection of the Solway, an anemometer was erected in the mid Solway area with the agreement of the Crown Estates.

3.4 FINER SITE SELECTION: ALTERNATIVE SITES AND CONSTRAINTS IN THE SOLWAY

3.4.1 IDENTIFICATION OF CONSTRAINTS IN THE SOLWAY

Wind Speed

The 54 metre high anemometer was installed by the developer in the Solway in November 1999 and has been recording wind speeds and direction continuously since that date. The short term data from the anemometer is correlated with a 10 year data set from the Dundrennan Meteorological Station on the southern coast of Dumfries and Galloway to provide longer term estimates for the wind resource in the vicinity of the anemometer site. The most widely used wind modelling tool, the Wind Atlas Analysis and Application Programme (WAsP) is used to predict the variation of wind speeds in the wider area based on the correlated anemometry data. Key inputs into the WAsP analysis are a digital terrain map for the area, and selection of appropriate roughness lengths of the coastal and marine areas. This analysis provides an accurate assessment of the variation of wind energy at differing heights within the Solway Firth.

Average annual wind speeds within the Solway have been found to generally exceed the threshold for a potentially viable offshore wind farm. Wind speeds increase towards the west south-west and also increase marginally as one moves away from the immediate coast lines to the north and south of the anemometer position. These increases were not considered to be critical and could potentially be overridden by other constraints.

Water Depths

The Solway is exposed to a number of powerful storms in the average year and the sediments of the Solway are known to be fairly mobile. However, some indication of the more general areas with shallow lying sediments could be gained from existing hydrographic maps from surveys carried out in 1885 and 1932. Continuous or closely adjacent areas of greater than 10 square kms in size, with water depths of less than 10 metres below Mean Sea Level in 1932 are shown in Figure 3.4.1. These areas gave an indication of where a potentially viable wind farm might be located.

Areas with depths less than 10 m below Mean Sea Level outside of the European Marine Site (see below) are found immediately adjacent to the Cumbrian and Dumfries and Galloway coastlines, widening significantly in the area south of Silloth, and also on the extensive sandbanks within the mid Solway area between the English Channel (main shipping navigation channel) and Auchencairn Bay in Dumfries and Galloway.

Grid Connection

Existing 132/275 kV lines in the Solway area are shown on Figure 3.4.1. The only such line in the western part of Dumfries and Galloway is a loop running as far south as Tongland some 3 km north east of Kirkcudbright at which point it is at its closest to the Solway Firth. To the east, in the vicinity of the Inner Solway area, a number of transmission lines originate from the Chapelcross power station. One of these runs west north west and follows the railway line between Annan and Dumfries. This lies some 1.5 km from the coast at its closest point which is near Powfoot in the Inner Solway. Two further transmission lines pass eastwards, the southernmost of these following the coast line as far as the end of the Solway Firth at Gretna before continuing south beyond Carlisle. On the English side of the Solway, 3 parallel transmission lines run from the Chapelcross power station southwest before dividing at Seaton some 4 km north of Workington and some 2 km east of the coast at Flimby. One of these lines continues to Workington and a further one passes east of Workington and returns to the coast at Lowca some 6 km south, before passing eastwards of Whitehaven.

The various lines provide a number of potential opportunities for grid connection for the Solway with the two most potentially favourable areas in terms of shortest distances, being the Inner Solway between Gretna and Powfoot, and in the mid Solway between Allonby and Whitehaven. West of Powfoot, grid connection opportunities in Scotland are limited to a single potential but unlikely connection possibility at Kirkcudbright.

If boundaries are drawn some 20 km from the principle potential connection areas, these cover the entire area of the inner and mid Solway as far west as Workington.

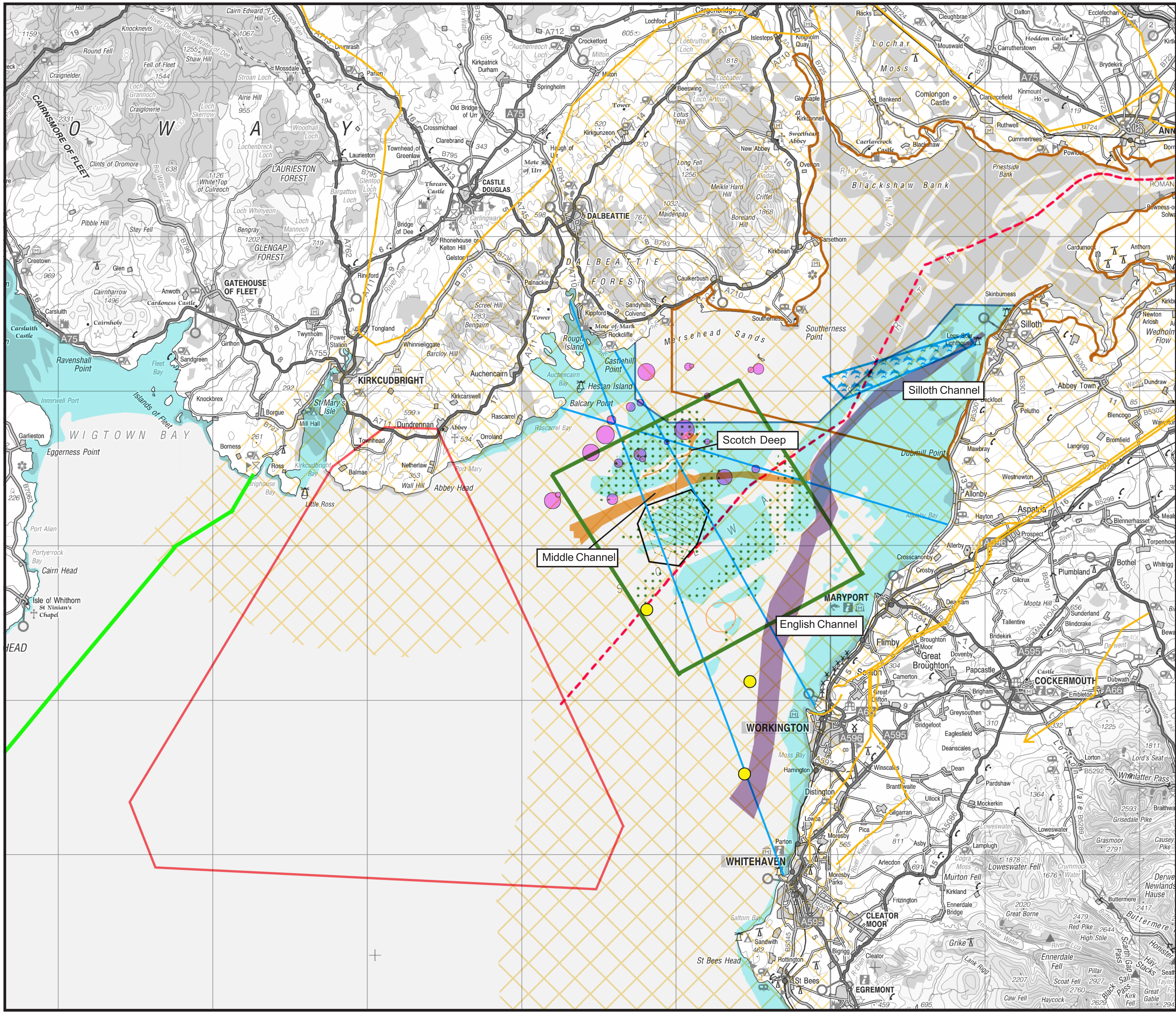
Ecological Constraints

The area of the Inner Solway that lies east of a dogleg line extending between the eastern edge of Sandyhills Bay in Dumfries and Galloway and Dubmill Point in Cumbria.is protected partially or wholly by a number of national and international designations. The entire area is designated a Special Protection Areas for the protection of important overwintering waterfowl populations, designated under the 1979 EC Birds Directive**,** and is a Candidate Special Area of Conservation, submitted for designation for its estuarine habitats including saltmarsh, intertidal sand and mud flats, and subtidal sandbanks, under the 1992 EC Habitats Directive and as a Ramsar site. The coastal areas on both sides of the estuary within this area down to the low tide mark are designated as a Sites of Special Scientific Interest. The area also contains an area west of Silloth used annually as a pupping ground for harbour porpoise.

It was considered that the whole of this area as shown on Figure 3.4.1 should be avoided to avoid any adverse impacts on the protected habitats and bird species, and pupping porpoises during the construction and operation period of the wind farm, and was not considered further in the site selection process.

MOD Firing Range

To the west of the Mid Solway area lies a MoD firing range. This lies on the coast between Kirdcudbright and Abbey Head and the Danger Area associated with the range extends in a fan shape from the firing range some 25 km out into the Solway. This area was not considered further in the site selection process.



Project:

Proposed Offshore Wind Farm, Solway Firth

Title:

Figure 3.4.1: Constraints to Site Selection

Key

- Proposed Wind Farm Site
- European Marine Site
- Harbour Porpoise pupping ground (2001)
- Main Shipping Channels
- Leisure/Fishing Vessel Navigation Route
- MOD Firing Range Danger Area
- Scotland - England border
- Spoil Ground
- Existing 132/275kV Distribution/Transmission Network
- Areas within 20km of Existing 132/275kV Network
- Gas Interconnector Pipeline
- Survey area boundary 1932 (UK Hydrographic Office)
- Seabed depth less than 10m below mean sea level
  British Government Surveys 1932 UK Hydrographic Office
- Survey Area Boundary 2001 (Kirk McClure Morton)
- Seabed depth less than 10m below mean sea level
  Independent Survey 2001 Kirk McClure Morton
- Common Scoter Main Distribution Areas
- Microwave Links
- Cardinal Buoys

Scale: 1: 250,000

Kilometres: 0 5 10 15

Centimetres: 0 1 2 3 4 5 6

N

Date: 20-05-02	Prepared by: DH
Drawing No: SOL_M2_Constraints.tif	Checked by: DW

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Client:

Solway Offshore Ltd
A TXU Europe Company
and
Offshore Energy Resources Ltd.

TXU
Offshore Energy Resources Limited

Microwave Links

Three fixed link microwave corridors were found to cross the Solway outside of the European Marine Site area. These were considered not to have significant implications for site selection as suitable exclusion corridors could be placed around the links during the layout design stage that would assure avoidance of disruption to the services, although these would to a certain extent constrain layout design possibilities.

Navigation Channels and Fishing Areas

A number of navigation channels exist within the Solway. The channels are shown on Figure 3.4.1. These follow channels that have depths greater than the maximum considered by the study for an offshore wind farm. The main merchant shipping routes are from Workington and Whitehaven southwards and westwards (these routes can be seen in Figure 8.2.1 in Section 8 of this ES). From Workington, the route follows the English Channel southwestwards. The English Channel which continues into the Silloth Channel further up the Solway, lies some 3-8 km off the Cumbrian coast, lying at its furthest from the coast between the lesser used ports of Maryport and Silloth. No other channels within this area of the Solway are suitable for merchant vessels. The channels on the Scottish side, Middle Channel and Scotch Deep are used by local fishing vessels and yachts.

3.4.2 SUMMARY OF CONSTRAINTS

All the constraints to offshore development described above are shown in Figure 3.4.1.

The outer area of the Solway was excluded from further consideration due to water depths exceeding the 10 m below MSL search criteria except immediately adjacent to the coast. The MOD firing range Danger Area was a further constraint in the outer area of the Solway.

The Inner Solway was excluded from further consideration due to the European Marine Site designated area.

The remaining areas of potentially suitable shallow water lie in the mid Solway, between the English Channel navigation channel and Orchardton Bay on the Dumfries and Galloway coast, and the area south west of Silloth between the coast line and the Silloth Channel. Grid connection distances and wind speeds were both acceptable within these areas of the mid Solway, and therefore did not lead to further constraint.

Further constraint was subsequently imposed by the developer in terms of proximity to the coast. The area of shallow water to the south west of Silloth was considered less preferred than the sand banks in the middle of the Solway due to its proximity to the Solway Area of Outstanding Natural Beauty. Thus the mid Solway area around the Robin Rigg and Two Foot Bank and the sand banks to either side emerged as the most preferred potential sites within the Solway. The combined areas of these banks far exceeded the area of shallow water required for an offshore wind farm proposal. However, prior to finer selection between the sand banks within this area, a geophysical survey was commissioned to allow the current shape of the sand banks to be mapped.

3.4.3 GEOPHYSICAL SURVEY AND FINAL SITE SELECTION

The geophysical survey, carried out in late 2001, covered a rectangle in the mid Solway up to 3-4 km from either coast. The area is shown in Figure 3.4.1 earlier. The survey included hydrographic survey, shallow seismic, sidescan sonar and magnetometry.

The hydrographic survey showed some movement of the sandbanks since the last complete hydrographic survey of 1932. The extent of the banks with depths less than 10 m below Mean Sea Level in 2001 are shown in Figure 3.4.1 superimposed over the 1932 survey results. Comparison shows:

- A new channel has opened up along the English/Scottish Border.
- The bank to the south of the border, the Two Foot Bank, has narrowed significantly but has extended further east.
- The north-eastern area of the Robin Rigg bank, the bank lying on the Scottish side of the border, has been removed, although the south western area is largely unchanged.
- The bank to the north of the Middle Channel is largely unchanged.

These three banks were considered further following the field survey, against technical and environmental criteria.

The primary factor in the choice between the three otherwise suitable banks is that both the Cumbrian and Dumfries and Galloway coastlines in the Solway are designated at the National or Regional level for their scenic value. Although the Two Foot Bank has shorter potential grid connection than the other two banks its main disadvantage is the shape of the bank. This would constrain a wind farm placed on it to a long strip of turbines running parallel to the Cumbrian shoreline. This would both reduce energy yield since the bank also lies parallel to the prevailing wind direction, and also significantly increase the horizontal extent of the wind farm when viewed from the majority of viewpoints on both sides of the Solway, increasing the degree of visual impact from both coasts. Both the bank to the north of the Middle Channel and the Robin Rigg bank are wider perpendicular to the shoreline and would allow significantly more compact layouts when viewed from either shore.

The bank to the north of the Middle Channel has two main disadvantages. Firstly, it is closer to the Dumfries and Galloway shoreline which is designated as a National Scenic Area at this point. Secondly, marine bird surveys begun in May 2001 in the area outside of the European Marine Site, identified nationally important numbers of Common Scoter within the area extending some 5 km south and east of Hestan Island, which includes this sandbank. Continuing twice monthly surveys found that the birds did not congregate in similar numbers over the Robin Rigg bank further to the southeast.

The Robin Rigg bank situated as it is in the centre of the Solway is further from the nearest shore than either of the other two banks reducing visual and landscape impacts of a wind farm placed on that bank.

After careful consideration the Robin Rigg bank was considered to be the most environmentally advantageous of the technically acceptable sites. At the same time the developer was satisfied that the site had good economic potential for a viable offshore wind energy installation.

3.5 ALTERNATIVE LAYOUTS

Once the site had been identified at Robin Rigg, further baseline studies were initiated to allow a thorough description of the physical and natural and human environment and to identify any constraints to layout design. These included the installation of tidal stream and wave energy monitors, benthos flora and fauna sampling and analysis, sediment composition sampling and analysis, monthly epibenthic trawl surveys and continued monthly bird surveys. Further consultations were also made with private companies, NGOs and government agencies, over existing human infrastructure, potential ship wrecks and navigation interests. A number of consultee groups were also set up to identify further sensitivities in the area of Robin Rigg as described in Section 5 of this Statement. The results of all these surveys and consultations are described in detail in Sections 7 and 8 of this ES.

A number of constraints were identified in the vicinity of Robin Rigg. These included the three microwave corridors mentioned earlier. Suitable exclusion zones were identified around these in consultation with the Radiocommunications Agency and with the link operators as described in detail in Section 9.18 of this Statement. These are shown on the relevant alternative layout diagrams presented in Figures 3.5.1 to 3.5.4 and 3.5.5 to 3.5.6.

The firm boundaries to the site layout were the deeper water to the south, and the Middle Channel, navigation channel, to the north. While to the east and west the rough boundaries were defined by water depths increasing beyond 10 m below MSL, the more shallow waters would be preferred where possible for turbine positions.

A number of anomalies were identified in the vicinity of the site during the magnetometer and sidescan sonar surveys. Three of these were identified as potential ship wrecks as described in detail in Section 7.8 of this Statement. An exclusion zone of 200 metres radius was placed around each of these sites during layout design, for both turbine positions and cable routes. These are shown in the alternative layout maps in Figures 3.5.1 to 3.5.4 and 3.5.5 to 3.5.6.

The area some 2-7 km beyond the Middle Channel to the north of the site was identified as being an important area for nationally significant numbers of Common Scoter. The harbour porpoise pupping area some 12 km to the north-east of the site centre was identified as having potential sensitivity to construction noise during the pupping season.

No further physical or environmental constraints were identified on the Robin Rigg bank.

Turbine layout design outside of these constraints was guided principally by two considerations: wind energy capture and visual and landscape effects.

Wind energy yield was modelled in a wind farm design computer package using the WAsP correlated wind data described earlier. The design package calculated the yield of each potential turbine position within a given layout based on the predicted average annual wind speed at that point as moderated by the effect of wind shadow from all other turbines within the layout for the predicted annual wind direction distribution.

Visual design was principally approached through the definition of layout characteristics that would give the wind farm an intrinsically balanced and pleasing design regardless of viewing position. However, a number of key viewpoints were selected by the landscape consultant in consultation with the landscape consultees and working group from which to assess the relative merits of a number of alternative layouts and to allow draft principals of good visual design to be confirmed or otherwise. 33 key viewpoints were selected within landscape designations lying on the English and Scottish coastlines, tourist attractions, residential areas and transport corridors. A finer set of 16 viewpoints were selected as being of most sensitivity to visual design. The selection process is outlined in Section 7.7.5 of this ES.

30 turbines was the maximum number of turbines allowed by the Crown Estates following consultation with the Department of Trade and Industry for any single lease. Since the Robin Rigg wind farm is in fact the combination of two Crown Estate leases a maximum of 60 turbines was allowed. This number was selected for the initial site design. Similarly due to the economics of offshore wind energy development as discussed in Section 3.2, large turbines were selected for the site, with a maximum hub height of 80 metres and maximum rotor diameter of 100 m.

Once turbine numbers and sizes had been selected, layout design was considered to be subject to a number of key variables including: length and breadth ratio; average separation distances between turbines and therefore turbine density and total extent; layout pattern; orientation of layout pattern with prevailing wind direction and coastline; and flexibility of computer optimisation of layout for wind yield.

As discussed earlier in Section 3.2, each of these variables has implications for energy yield and visual and landscape effects. In some cases such as length and breadth ratio, a layout which gives energy yield will in the particular case of the Robin Rigg site also give visual advantages in terms of reduced horizontal extent when viewed from most potential viewpoints. Other variables such as average separation distance may require a balancing act between energy yield and visual considerations. A further economic consideration is cable length. Increases in turbine separation distances to improve energy yield will have a detrimental cost implication for total cable lengths.

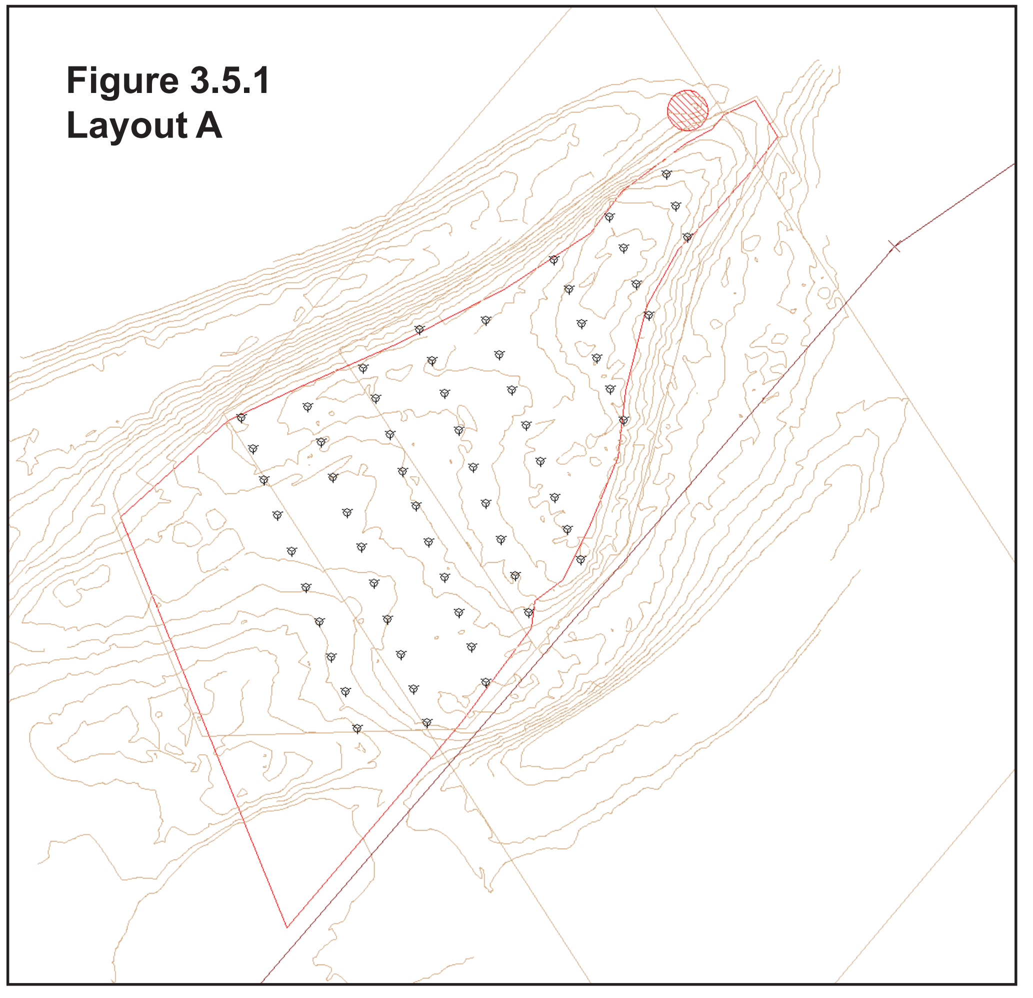


Figure 3.5.1
Layout A

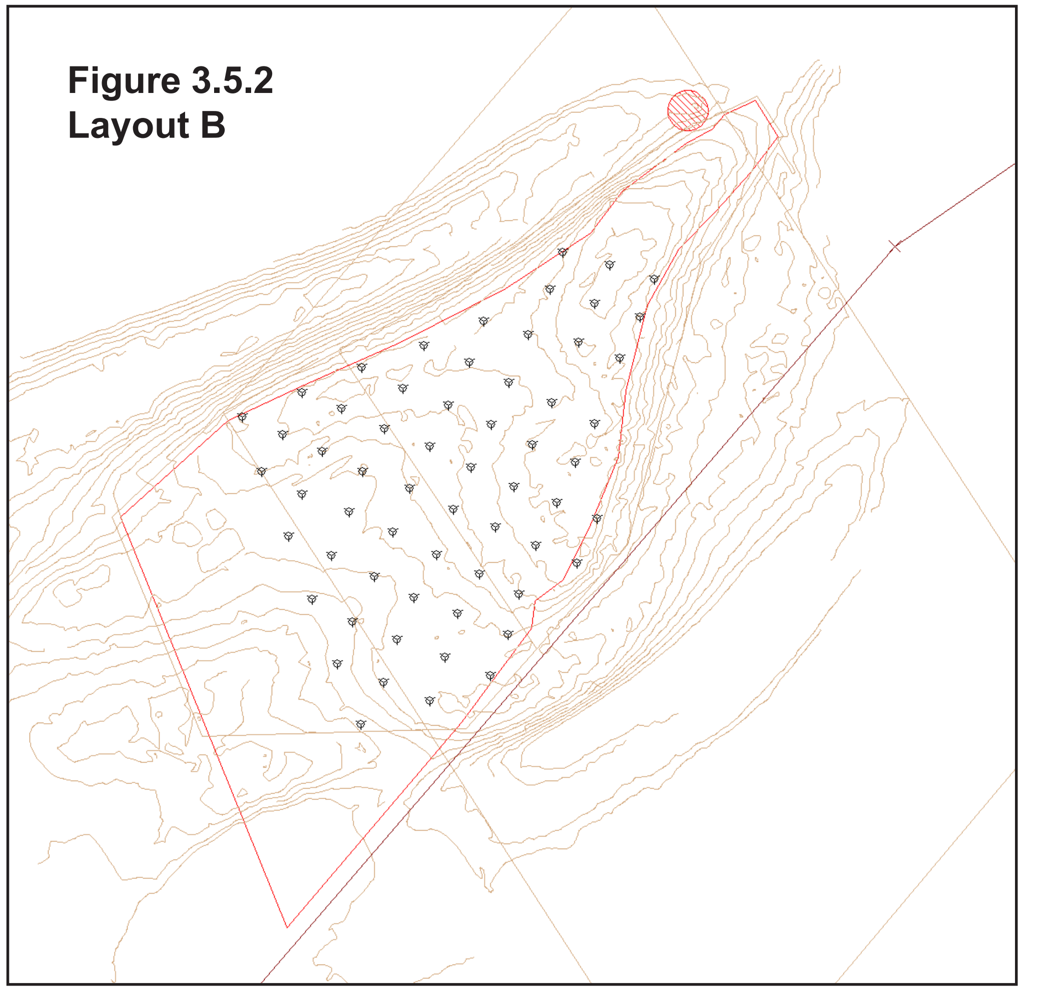


Figure 3.5.2
Layout B

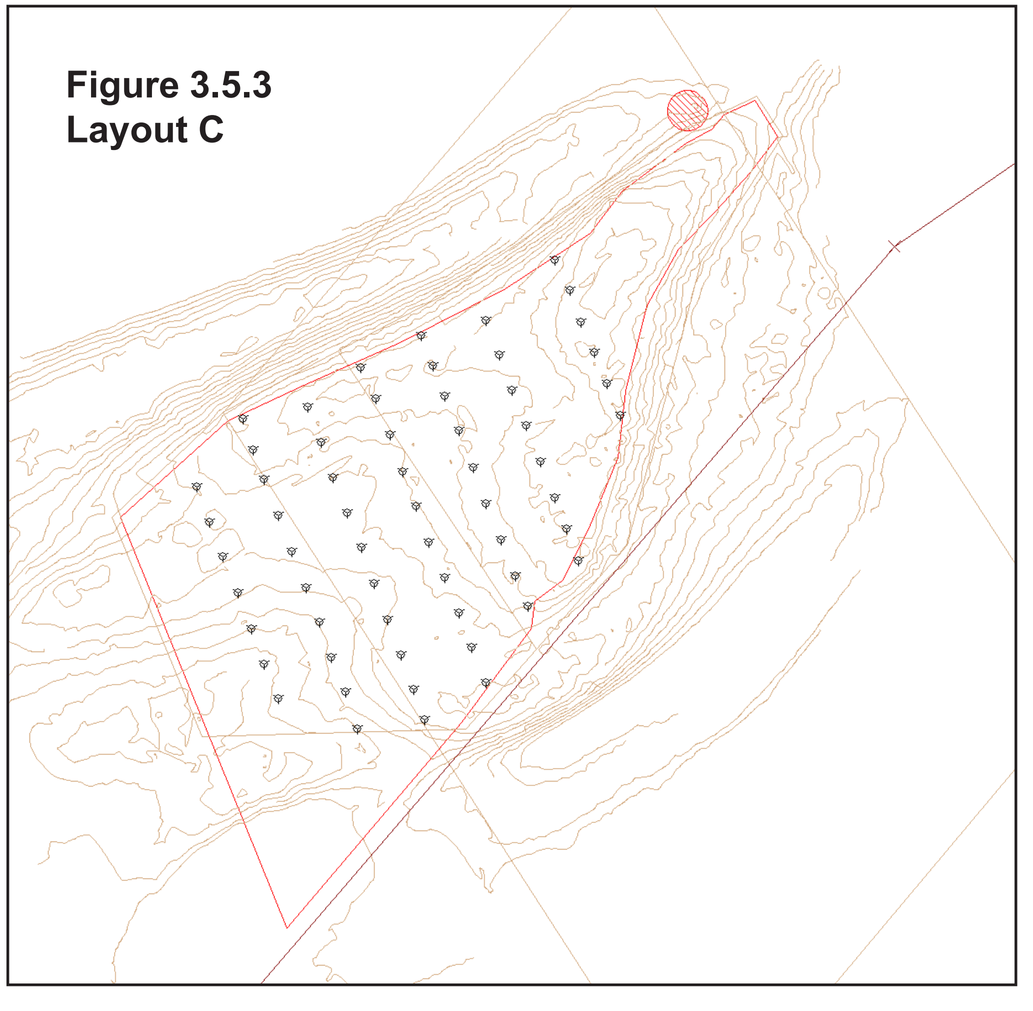


Figure 3.5.3
Layout C

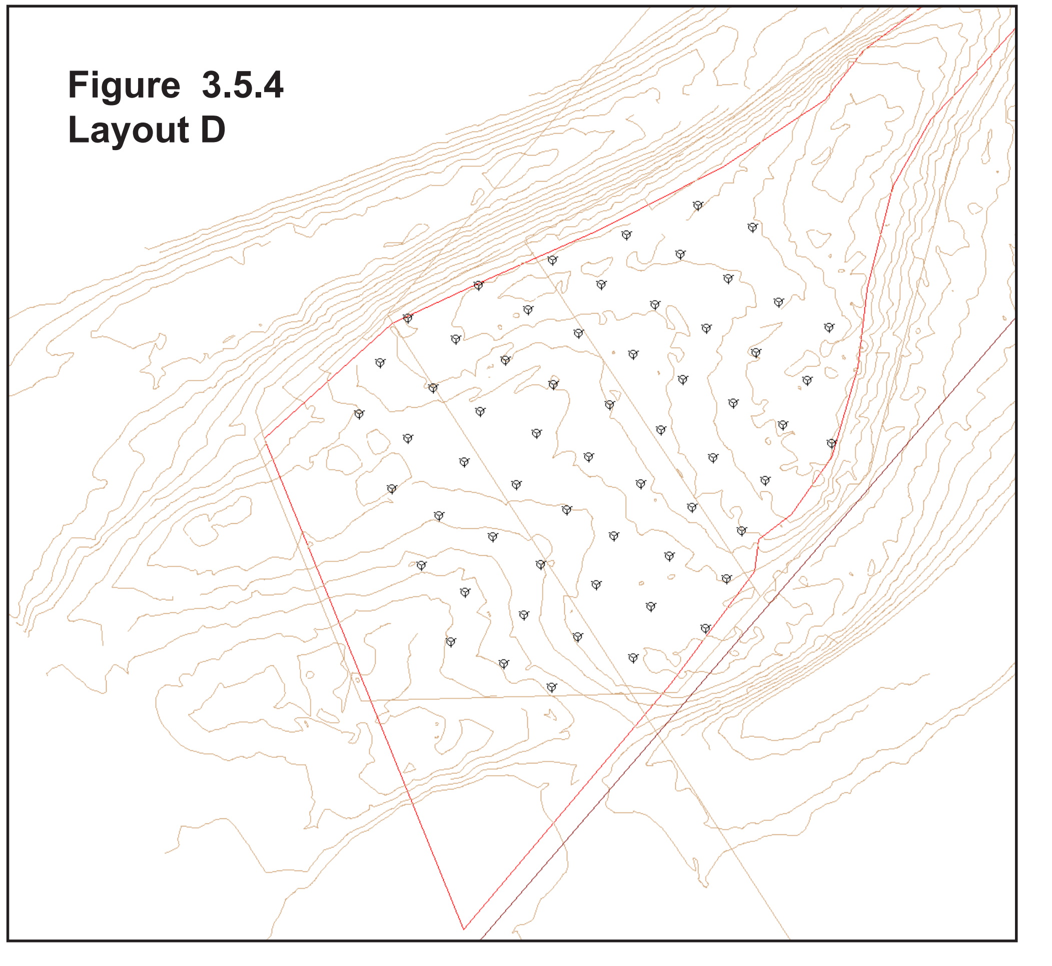


Figure 3.5.4
Layout D

Four initial generic layout types were designed using a range of variable combinations. These are illustrated in Figures 3.5.1 to 3.5.4

- ***Layout A*** has turbines arranged in an offset grid with 7 diameter separation distance between turbines downwind and 4 diameter separations cross wind to reduce wind shadow effects on downwind turbines. The layout sits to the eastern side of the shallow water area using the eastern narrowing tail of the bank.
- ***Layout B*** is a purely computer optimised layout. In this layout the computer design programme is given freedom to place turbines anywhere within the constrained site boundaries which were set as the western site boundary and the western side of the central microwave link exclusion zone. The design programme places turbines randomly within the site boundary. It then continues through iteration after iteration shifting turbines by increasingly smaller distances to maximise energy yield for the layout as a whole.
- ***Layout C*** is a variation on Layout A with the same offset pattern and downwind and crosswind separation distances, but using the western rather than the eastern extreme of the site. Due to the fan shape of the site, a single added column on the western edge allowed the removal of two columns along the eastern edge reducing the northeast/southwest extent by 12%.
- ***Layout D*** is a more uniform grid pattern with a 5 diameter separation distance between closest turbines in both directions. This produces a more compact layout than layout A and C, further reducing northeast/southwest extent by 8% with all turbines positioned between the western boundary and the western edge of the central microwave exclusion zone as with the optimised Layout B.

Layout B had as expected the highest predicted energy yield, with layout A and C following and layout D with the lowest energy yield some 1.3% lower than the energy yield for Layout B. Cable corridor lengths varied by no more than 3.3 % and were as follows:

Layout A	29.3 km
Layout B	28.9 km
Layout C	28.4 km
Layout D	29.1 km

The landscape consultant was presented with wireframes from each of the 33 viewpoints for all 4 layouts. The consultant carried out an assessment of the layouts with respect to the following criteria:

- horizontal extent of the layout;
- composition in terms of balance and harmony of the layout as represented by the wireframes; and
- composition of the layout in conjunction with the backdrop of land mass, or land mass and sea, as represented by the wireframes.
- This was followed by:
- an initial comparison of wireframes from all viewpoints; and
- a detailed comparison of wireframes from key viewpoints.
- Having established the criteria, the layouts were compared, as follows:
- Name and number of viewpoint;
- Distance to the nearest turbine;
- Height above Ordnance Datum;
- Likely receptors (residents, road users, walkers on national trails or public footpaths, visitors);
- Landscape designation (National Park, Area of Outstanding Natural Beauty, National Scenic Area, Regional Scenic Area;
- Notes on horizontal extent and composition;
- Composition of turbines against landscape and/or sea; and

Layouts A and C were generally considered to have too large separations between rows of turbines when viewed from the north or south where the wind farms were characterised by open views to the horizon between rows towards the centre of the site disintegrating into more disjointed dense turbine groups to either side. The greater horizontal extent of these layouts, particularly Layout A, when viewed from the closest coastlines to the northwest and southeast were seen as disadvantages. Conversely the greater openness of these layouts was not viewed as a visual advantage contrary to expectation.

Layout B, meanwhile, while having a lower horizontal extent was considered to be difficult to read and presented an unbalanced and disharmonious layout when viewed from a number of viewpoints particularly those with a higher elevation. In particular the line of turbines placed along the western boundary was considered to lead to disturbing groupings of turbines particularly when viewed from points on either coast line lying on or close to the line of view along this boundary.

Layout D was seen as having distinct visual advantages over the other three layouts when seen from the majority of viewpoints. This was considered to be a result of the compact ordered nature of the layout with higher numbers of lines of symmetry than layouts A and C, leading to the avoidance of the juxtaposition of large open gaps and adjacent dense groups of disordered turbines, and also a smaller horizontal extent. A table summarising the findings of the assessment from the 33 viewpoints is given below.

Layout No.	Preferred layout for number of viewpoints
Layout A	0
Layout B	5
Layout C	6
Layout D	21
No clear preference *	1
Total viewpoints	33

* Note : No clear preference denotes that there was little obvious difference between the layouts, or that the distance to the turbines was so extensive that it was not possible to discern the differences.

A further environmental advantage of Layouts B and D over layouts A and C was the increased separation distance of nearest turbines from the harbour porpoise pupping area and from the boundary of the Solway European Marine Site.

Following the comparison of these four layouts, a further area to the south of the western part of the site was identified as having potential for turbine placement despite having deeper waters. It was considered that the extra energy yield resulting from moving into this higher wind energy area with greater numbers of potential turbines with unbroken wind reach might offset increased costs of turbine foundations in this area.

Two layouts were designed for the new boundaries following the lessons learnt from the previous four layouts. These comprised:

- Layout E, an energy optimised layout but with the first set of turbines confined to two rows of offset turbines following the pattern of Layout D. This then forced the computer design package to incorporate some order into the design and avoided the unbalanced clumping of turbines along the western boundary as was seen with Layout B

- Layout F, which used the new area and followed the offset grid pattern of Layout D but with greater separation distances between turbines.

The energy yields of both these layouts was higher than all four previous layouts with Layout E having a yield of some 2.2% higher than Layout D. Cable lengths meanwhile were approximately 31% greater than for Layout D. The energy yields and cable lengths did not differ significantly between E and F although E had a higher energy yield and slightly lower cable length.

The landscape consultant was asked to compare the new layouts from the 33 viewpoints. The results are given in the table below:

Layout No.	Preferred layout for number of viewpoints
Layout E	7
Layout F	22
No clear preference	4
Total	33

Since Layout E had only moderately greater predicted energy yields than F, F was considered the preferred of these two layouts.

Finally Layout F was compared by the landscape consultant to Layout D the previously preferred layout.

The landscape consultant considered that the order in Layouts D and F translated at most of the viewpoints into a more balanced and harmonious composition of turbines in the seascape or when read against the land mass on the opposite side of the Solway Firth than any of the other layouts. At several key viewpoint locations this pattern related better to the backdrop of land, or land and water than all other layout options. From nearly all elevated locations, both Layouts D and F were considered to create a legible pattern, with the off set rows of turbines becoming apparent against the sea surface. It was considered that the order of this pattern created by a man-made construction in the sea was more satisfactory than the apparently haphazard and randomised effect produced by the optimised Layouts B and E.

Figure 3.5.5 Layout E

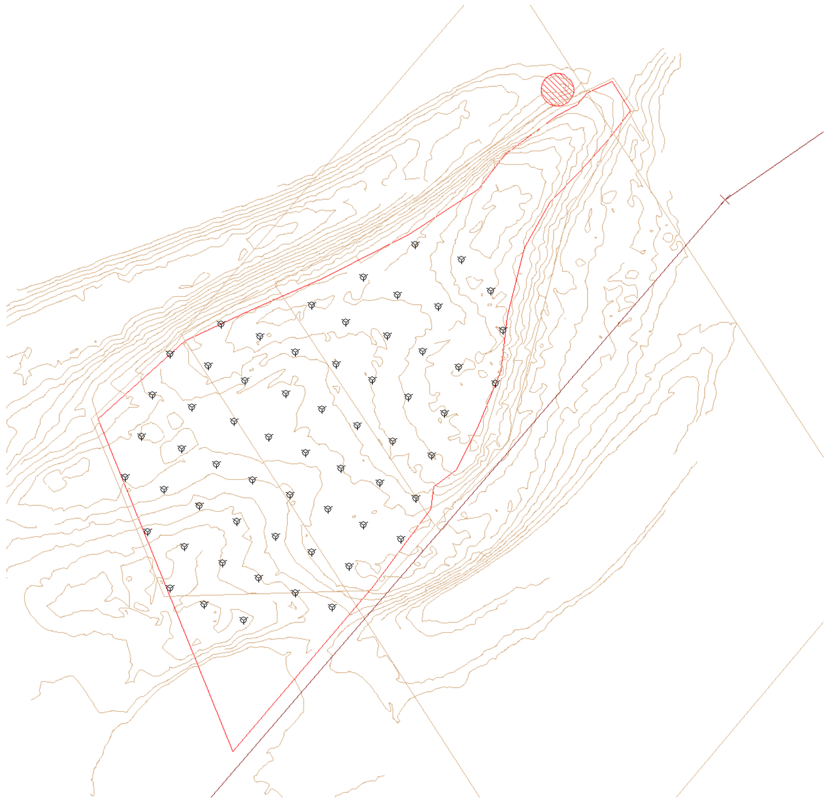
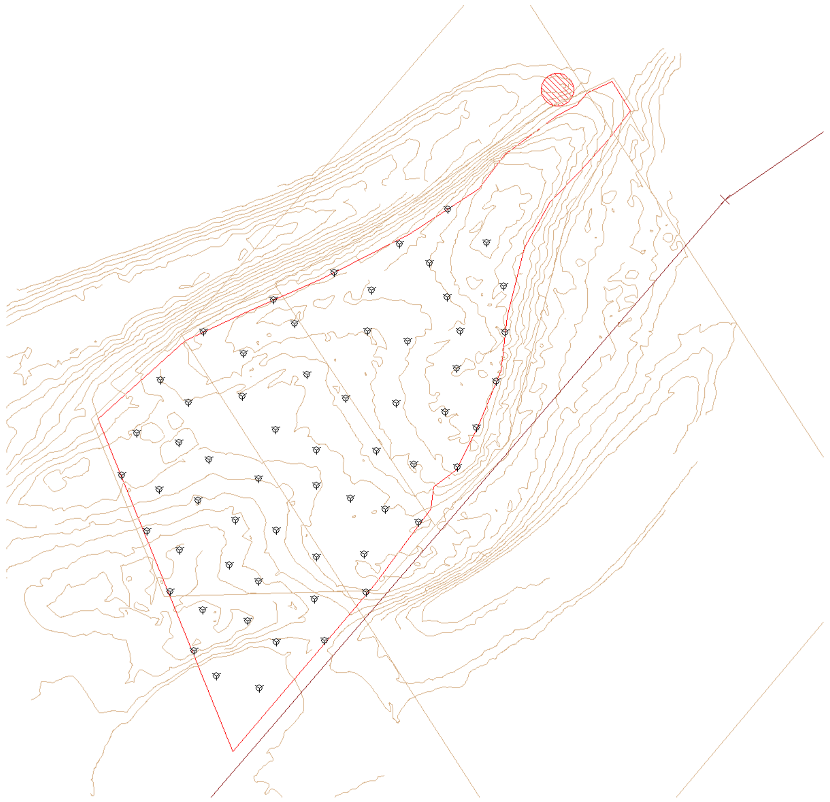


Figure 3.5.6 Layout F



Nevertheless, comparison between the two off set row layouts represented in Layout D and Layout F, indicated that Layout D was preferred at most viewpoint locations. This was in almost all instances as a result of the more compact layout and resulting composition of the array, as well as the relationship with the seascape and landmass backdrop. Layouts D and F were both based on off set grids of turbines, the main difference between these two layouts being that the grid of Layout F extended over a greater area, with a larger separation distance between the rows and the rows extending further to the south west of the site area, as summarised below:

	Layout D	Layout F
Down wind extent of layout	3.9 km	5.2 km
Cross wind extent of layout	3.4 km	4.1 km

Although there were some variations in the composition of the turbines across the array, the determining factor in preference between the layouts was, in almost all instances, the reduced horizontal extent of turbines. This related to the composition of the turbines when viewed as an array and the relationship between the array of turbines and the backdrop of sea and land. The resulting visual preferences from the 33 viewpoints are summarised in the following table.

Layout	Preferred layout for number of viewpoints
Layout D	23
Layout F	5
No clear preference	5
Total	33

After careful consideration, despite the 2.2% higher energy yield of Layout F over Layout D, the landscape and visual advantages of Layout D over Layout F were considered important enough given the landscape designations on both the English and Scottish coasts.

Layout D was therefore selected as the final layout with the adjustment of a single turbine that had appeared as an outlier from viewpoints to the north-northwest of the site. This turbine was moved to a point on the end of the south-eastern most diagonal. The result is a layout that appears balanced and harmonious from the majority of viewpoints both those at sea level and elevated, and meets all the identified environmental and technical constraints.

3.6 ALTERNATIVE TURBINE TYPES

The only generic turbine type currently under production that is suitable for offshore installation is the two or three bladed horizontal axis type. The motion of three bladed turbines is considered to be more aesthetically pleasing than for two bladed machines. This is the type that would be used for the Robin Rigg wind farm. Although no specific turbine manufacturer or model of turbine has been selected for use at the site, it is considered that the turbines for the site will be selected from the larger 3 bladed horizontal axis wind turbines in production at the time of construction, that is in the region of 2 to 3.6 MW.

While smaller turbines could technically be used i.e. sub 2 MW machines, an important characteristic of offshore wind development is that foundation costs are largely independent of turbine size, foundation specifications being more dependent on wave energy and water depths. Moreover turbine foundations represent a high proportion of total development costs. Therefore electricity costs are significantly reduced by placing larger turbines on each foundation.

3.7 ALTERNATIVE TURBINE FOUNDATIONS

3.7.1 KEY FACTORS IN FOUNDATION DESIGN

Considerable experience has been gained in the support of offshore structures in the oil and gas industry in recent decades. Whilst this experience is useful in the design of offshore wind turbines, this relatively new field has placed unique demands on the design of foundation structures, since wind turbine foundation designers are faced with several problems not normally encountered by traditional oil and gas offshore structures.

The choice of foundation concept for an offshore wind turbine is governed by a number of factors. These factors are primarily the soil condition, water depth, possible erosion and loading conditions. With particular relevance to loading conditions, the relatively light weight of turbine structures and the fact that the majority of loads are generated at the rotor hub (creating large overturning moments) lead to specific problems in the design of foundations. Selection from a number of technically feasible foundation types is dependent on a number of further factors including but not restricted to differences in environmental impacts associated with the different types, contractors preferences, available construction equipment and overall materials and construction cost

3.7.2 FOUNDATION TYPES

Three main types of offshore turbine foundation have been considered. These are:-

- **Monopile**
- **Multi-pile**
- **Gravity**

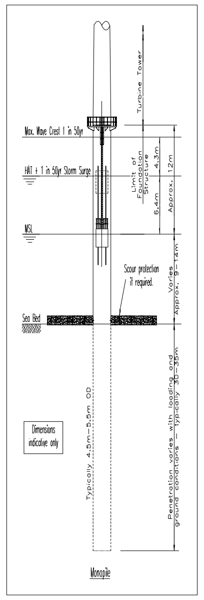
These are described in more detail below.

3.7.2.1 Monopile Foundations

Monopile foundations have been used at Lely (1994) and Dronten (1996) off shore wind parks in the Netherlands, at Bockstigen-Valar (1997) and Utgrunden (2000) in Sweden and the two offshore turbines at Blythe Harbour in the UK.

he monopile foundation, Figure 3.7.1, constitutes a large circular cross section steel pile which is driven or vibrated into the seabed, or placed in a pre- drilled hole in case of very hard deposits of clay or rock. The length of the pile varies depending on the actual soil/rock conditions and water depths.

Figure 3.7.1 Monopile Foundation



Sites which contain large boulders can be problematic during installation of the pile, although monopiles have been successfully installed in the past by drilling or water jetting to the obstruction which was then removed.

A monopile foundation typically consists of a large diameter steel cylinder of up to 5.5 m diameter, with a wall thickness of 60 to 80 mm, and is installed 15 to 40 m into the sea bed depending on soil conditions. The mass of a pile is typically in the range of 350 to 500 tonnes, depending on the water depth. Heavy duty equipment, normally cranes operating from a jack-up platform or floating barge, is necessary to install the piles into the sea bed.

Levelling and fine adjustment may be accommodated by the introduction of a larger diameter transition sleeve above water level. This is connected to the pile, usually by a grouted connection.

The connection between the turbine and the foundation will be approximately 12 m above mean sea level, and an access platform will be located at this level. The tower is bolted on to a flange on top of the monopile.

Monopiles can be constructed at almost any near shore location, e.g., a shipyard or factory, and be towed by tug or carried on barges for transportation to the construction site. They are relatively simple and inexpensive to produce compared to concrete gravity foundations.

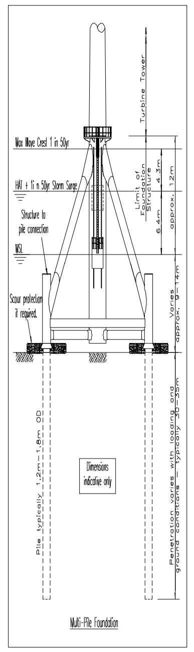
This type of foundation is sensitive to scour in that any loss of material from around the pile may lead to a loss of restraint and thus increased stresses in the pile. In some cases local scour protection will be adequate. However, for the Robin Rigg site the pile would need to be designed to accommodate the loss of bed material to a specified depth as global movements of the sand can be expected, based on historical evidence, and therefore local scour protection would be ineffective.

3.7.2.2 Multi Pile Foundations

Foundations on multiple piles have not yet been applied to offshore wind turbines. However structures supported on multiple piles have been used for off shore oil and gas installations.

The multi-pile foundation constitutes a circular central column, with steel leg structures supported on piles. The height and width of the structure will depend on site conditions. The supporting piles will have diameters in the order of 1.2 m to 1.8 m, which will be driven or vibrated into the sea bed, depending on sediment conditions.

Figure 3.7.2 Multipile Foundation



This type of foundation will be sensitive to scour/global bed movements for those reasons previously stated for the monopile foundation.

The central column will be in the range 4.5– 5.5m in diameter with the material thickness in the range 40m to 80mm. The leg bracing elements will likely be fabricated from steel tubes in the order of 1.2m to 2.0m in diameter with wall thickness in the range 20mm to 40mm. The mass of such a foundation will typically be in the range of 250 to 350 tonnes. The weight of the piles will be in the order of 20 - 30 tonnes each. High stress concentrations will be experienced at the connections between the various tube elements and the central tower and stiffening may be required at these locations.

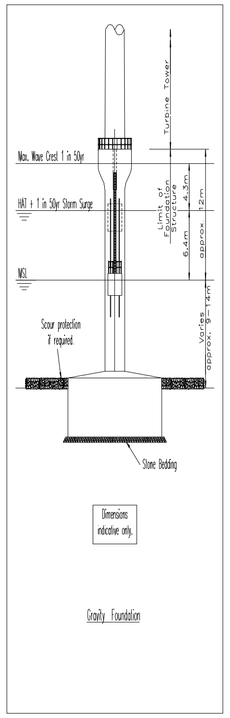
Multi-pile foundations would be constructed onshore and would be transported to the site on barges. Minimal preparation of the sea bed is necessary, this likely to comprise only the clearing of obstacles and basic levelling to receive a piling template. The piles can be installed by cranes, operating from a jack- up or a floating barge and will be driven or vibrated into place.

Ground conditions which contain large boulders may be problematic although obstructions can often be removed or drilled through. To control the exact location of the piles, a template is used to keep the piles in position during installation. Following the installation of the piles, the base structure is installed, directly on top of the piles. There are several methods of achieving adequate structural connection between structure and pile including propriety mechanical latching systems, pile swaging (controlled expansion of the pile towards the sleeve) and grouting of the annulus between the pile and sleeve. The precise method to be used at Robin Rigg should multipile foundations be selected, would be determined at the detailed design stage.

3.7.2.3 Gravity Foundations

Gravity-type foundations have been used for the construction of almost all onshore wind farms. Gravity foundations have also been successfully used since the early stages of offshore wind park development. Vindeby (1991), Tunø Knob (1995), and Middelgrunden (2000) offshore wind parks in Denmark all feature concrete gravity foundations.

Figure 3.7.3 Gravity Foundation



Such bases may take many different shapes but will generally comprise a base with a large plan area and a central tower. This type of base relies on its mass to resist overturning forces. The foundation will generally comprise a hollow concrete or steel structure which is filled with a high density material once the base has been placed in position.

A high degree of site preparation is required for this type of foundation as the base relies on good comprehensive contact with the underlying stratum, which must be strong enough to resist the high comprehensive forces experienced. The foundation is placed on a pre-prepared bed of compacted, crushed stone, which is usually placed in a shallow excavated area to provide embedment of the structure into the bed.

The foundation would usually be built in dry dock, or at a land location in close proximity to a suitable harbour, and would be floated or transported by barge to the site. Concrete caissons will generally have a high weight and thus, a relatively large crane will be required for installation. Water and compressed air jets are used to bed the structure into its final position.

Gravity foundations are very sensitive to scour. Following detailed sediment and hydrographic surveys, and a study of historical changes in bed level it has been determined global movement of the sand banks can be expected beyond the level at which gravity foundation could be afforded suitable protection. Therefore gravity foundations have been ruled out as technically unsuitable for the particular sediment and hydrographic conditions found at the site

3.7.3 FOUNDATION CHOICE

Of the three generic foundation types described above, only the pile based foundation types were determined to be technically suitable for the site given the historical evidence of significant variations in bed level.

Both the multipile and monopile generic designs would be technically suitable to the Robin Rigg physical environment. The decision between using multipile and monopile foundations will depend largely on cost, construction timetable constraints and contractor choice and available equipment. These decisions cannot be made at the time of submission of this Environmental Statement.

The decision will be guided by the following comparisons:

Piling Time

Piling all the piles for a multipile foundation is likely to take less than half the time as for a monopile foundation, in the order of 3 days compared to 7 days per turbine foundation. This piling time will be the critical path in construction timetables for the wind farm as a whole, particularly in consideration of the scarcity of monopile piling equipment available (see below).

Available Equipment

The availability of jack up barges with piling equipment capable of handling the sizes of piles required for multipile foundations is reasonably good. However piling equipment capable of piling the monopile foundation of the dimensions required for the Robin Rigg turbines is significantly scarcer.

Environmental Characteristics

Environmental advantages of monopile compared to multipile include a reduced take up of the sea floor, of approximately 20 – 30 sq. m compared to up to 750 sq. m for multipile foundations. This reduces direct impacts on benthic flora and fauna and reduces the obstruction of water flow by the foundations. However, the Environmental Effects predicted in Section 9 of this Statement show that all these effects would be negligible for both foundation types. Environmental advantages of multipile foundations over monopile foundations include potentially lower sound output levels of piling hammers depending on the method of installation chosen. In addition if augering is required to bore out pile shafts the amount of material released will be lower for multipile foundations. The difference is approximately 450 m^3 assuming auguring is required for 35 metres of both pile types. Finally constraints in timetable imposed by monopile foundation driving and equipment availability may reduce the potential to avoid any sensitive periods for sea mammals and birds.

The worst case characteristic for the two foundation types has been assumed in each of the environmental assessments presented in Section 9 of this Statement i.e. monopile piling noise has been assumed in predicting construction effects on sea mammals, while multipile sea floor footprints have been assumed for predicting direct effects on benthic communities. In no case is the construction or presence of turbine foundations predicted to have a significant environmental impact. Therefore, there are no overriding environmental reasons for selection of either foundation type.

Table 3.7.1 Comparison table for monopile and multiple foundation types

	Foundation Type	
	Monopile	**Multipile**
Characteristic		
Piling time per foundation	7 days	3 days
Piling equipment availability	limited	Reasonable
Foundation footprint	20 –30 m^2	Up to 750 m^2
Foundation weight	350 – 500 tonnes	250 –350 tonnes
Obstruction of water flow	Negligible	Negligible

Section 4

Detailed Project Description

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Section 4

Detailed Project Description

4.1 SITE LOCATION

The site lies within the central part of the Solway Firth, immediately to the north of the English/Scottish boundary which roughly bisect the firth. The centre of the site lies 11 km from the Dumfries and Galloway shoreline within Scotland and 13.5 km from the Cumbrian coastline. The closest towns in Scotland and England are Dalbeattie situated some 21 km to the north-northwest and Maryport situated 14 km to the south east respectively. The site location with respect to the coastlines is shown on Figure 1.1 in Section 1 of this ES.

The area on which the turbines would be located is a sub tidal bank composed of reasonably homogenous fine to medium sand with some shell fragments. The sediments overlie a layer of stiff clay with cobbles and boulders lying at depths of 8 m to at least 29 m below the seabed, depending on location. The area of sand bank with depths of less than 10 m in depth below mean sea level is roughly wedge shaped measuring some 4.5 km southeast to northwest and 7 km northeast to southwest. The thinner end of the wedge is situated to the north eastern end of the sand bank, with the bank broadening towards the southwest. The turbines would be positioned in depths of water between 4 and 13 m below Mean Sea Level. A navigation channel, known as Middle Channel lies immediately to the north of the bank. The channel passes east-west and ranges from 10 - 18 m in depth below Mean Sea Level in the vicinity of the site. A further channel which is not a recognised navigation channel, lies in the more mobile area to the south of the bank currently ranging from 9 to 18 m below MSL. The spring tidal range is 7.4 m in this part of the Solway. The Middle Channel is part of a navigation route for yachts and fishing boats between the inner and outer Solway. Commercial shipping within the Solway passing between the main ports of Silloth and Workington and shipping lanes beyond the Outer Solway, uses the English Channel which passes some 7 km southeast of the proposed turbine positions at the closest point.

4.2 PROJECT OVERVIEW

The proposal is for a 60 turbine offshore wind farm located on a sub-tidal sand flat known as Robin Rigg in Scottish waters in the mid area of the Solway Firth, an anemometry mast, on-site 33 kV cabling, an on-site substation platform and a 132 kV seabed cabling between the substation platform and the landfall south of Flimby on the Cumbrian coast. The turbines would be situated some 9 km from the Dumfries and Galloway shoreline within Scotland, and 12 km from the Cumbrian coastline at their nearest points.

The 60 turbines would be arrayed in a grid pattern comprising 10 northwest/southeast lying rows of between 2 and 8 turbines, separated by 450 m. Each turbine would contain a transformer within the tower base or housed on top of the nacelle, transforming electricity produced by the turbine to 33 kV. Communication and 33 kV electricity cables would be laid along each turbine row. These would be gathered along the south eastern edge of the wind farm and finally connected to the on-site substation platform.

The 33 kV cables would be gathered and metered at the substation platform and stepped up to 132 kV. From the substation platform two 132 kV cables would be laid on the seabed south eastwards for a distance of 12 km with landfall south of Flimby. From the landfall site the cables would be carried underground to a new switchyard at the existing transmission system which lies 1.5 km from the landfall site at the nearest point.

The turbines would all be of one type. They would be three bladed with a horizontal axis nacelle positioned on a tubular tower. The turbines would have an installed capacity of 2-3.6 MW with a maximum height from Mean Sea Level to blade tip of 130 m. The turbine foundations would be either monopile or mulitpile foundations buried up to 35 m into the sea bed.

Four navigation buoys would be positioned on the outside of the wind farm with yellow flashing lights and reflector beacons. The towers of the outside turbines on all edges of the wind farm would be painted with a metre deep yellow ring above high tide. A single foghorn would be placed on the central turbine of the site.

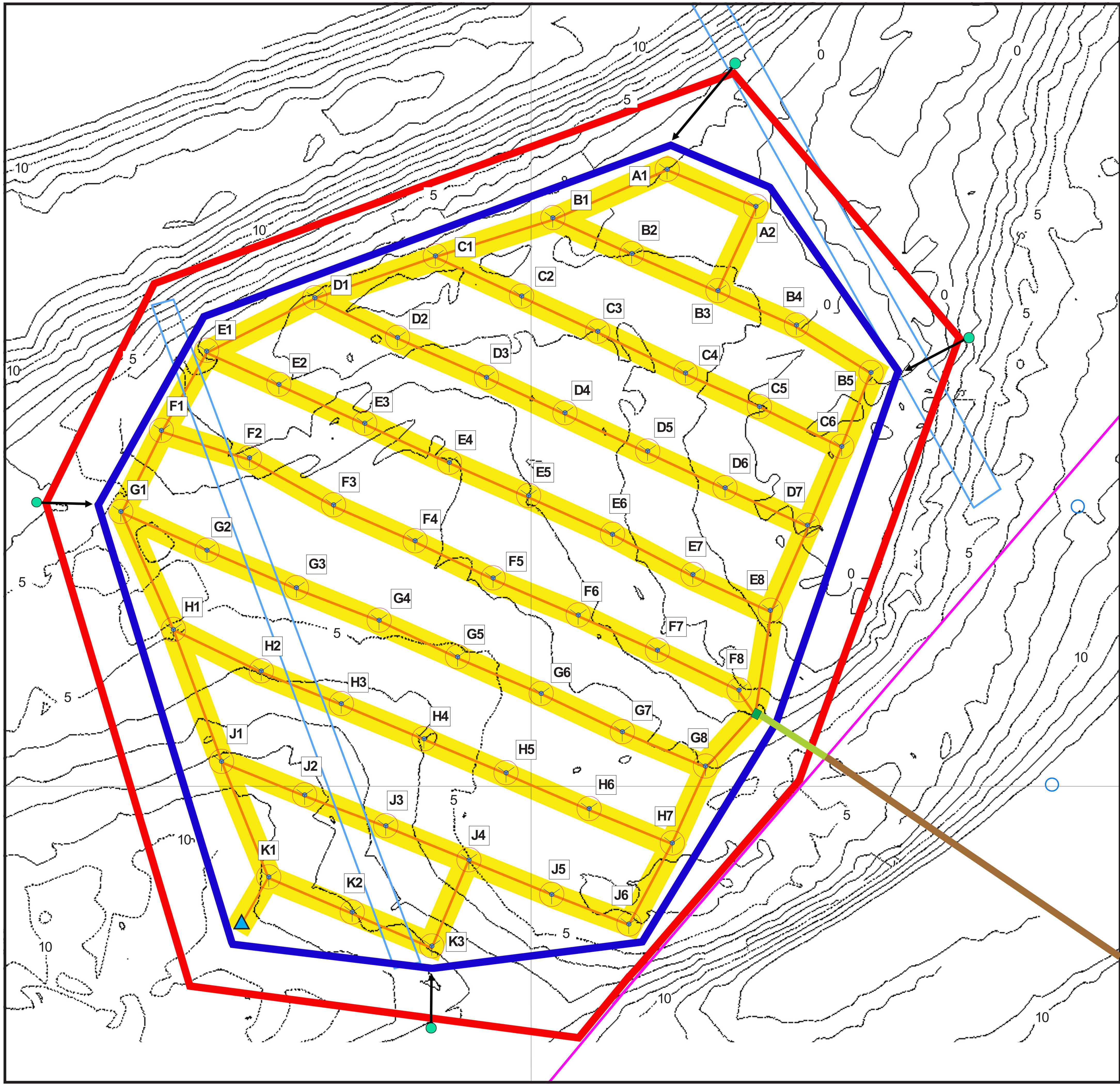
4.3 WIND RESOURCE

A 54 metre high anemometer was installed by the developer in the Solway in November 1999 and has been recording wind speeds and direction continuously since that date. The short term data from the anemometer has been correlated with a 10 year data set from the Dundrennan Meteorological Station on the southern coast of Dumfries and Galloway to provide longer term estimates for the wind resource in the vicinity of the anemometer site. The most widely used wind modelling tool, the Wind Atlas Analysis and Application Programme (WAsP) has been used to predict the variation of wind speeds in the wider area based on the correlated anemometry data. Key inputs into the WAsP analysis are a digital terrain map for the area, and selection of appropriate roughness lengths of the coastal and marine areas. This analysis provides an accurate assessment of the variation of wind energy at differing heights within the Solway Firth.

Average annual wind speeds at the site was found to meet the developers preferred minimum which was set at 9.0 m/s at hub height for the Solway project. Wind speeds increase gradually towards the west-southwest of the site and also decrease marginally as one moves towards either coastline.

The wind rose (frequency of wind speed with direction around the compass) for the short term data recorded at the site is similar to the long term wind rose for Dundrennan. The long term wind rose shows that the most wind energy comes from the southwest, with the south-westerly 30 degree sector representing the peak 30 degree sector. The short-term data on site shows the main peak wind frequency spread more evenly between 195 and 285 degrees centring on the southwest, with a secondary peak for winds coming from the northeast. This means that for the great majority of the time turbine rotor would be facing in a general southwesterly or northeasterly direction i.e. up or down the Solway. The rotors would thus be turned away from the nearest coastline.

Figure 4.5.1 Site Layout (Same as Figure 1.2) will sit here instead of this pagexxxxxxx



Project:

Proposed Offshore Wind Farm, Solway Firth

Title:

Figure 4.5.1: Site Layout

Key:

- Wind Turbine
- 33 kV Cable Route
- 125m Cable Corridor (including variance)
- Turbine Exclusion Zone surrounding Microwave Links
- Offshore Mounted Substation & Helipad
- Centreline of 132 kV Cable Route (2 cables)
- Centreline of Indicative 132 kV Cable Route Corridor
- Scotland - England border
- Depth of Seabed below Chart Datum
  Chart datum approx. 4.45m below MSL. Hydrographic Survey Aug/Sep 2001.
- Site of Underwater Wreck or Other Anomaly
- Anemometry Mast
- Boundary for Exclusion of Vessels during Construction
- Operational Period Trawl Exclusion Zone
- Proposed Location of New Buoys during Construction Phase
  Arrows indicate repositioning of buoys upon completion of construction

Scale: 1: 20,000

Metres: 0, 400, 800

Centimetres: 0, 1, 2, 3, 4

N

Date: 28-05-02	Prepared by: DH
Drawing No: SOL_LayoutDDDD.tif	Checked by: JS

Drawing by:
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Client:
Solway Offshore Ltd
A TXU Europe Company
and
Offshore Energy Resources Ltd.

The highest 3 second gust recorded on site was 48.4 m/s at a height of 54 m on 7 Feb 2002.

The data showed that wind speeds would lie within the operating range for the wind turbines being considered for the site for 94% of the time during the average year, although this would reduce to around 90% once wake effects within the proposed layout are considered (i.e. turbines lying in the wind shadow of turbines upwind).

4.4 WATER DEPTHS

The results of the surveys indicate the depth of water to Mean Sea Level (MSL) across the wind turbine area is generally in the range of 4 m to 9 m. Over a small area at the southwestern corner the depth increases to a maximum of 13 m.

4.5 SITE LAYOUT

The proposed turbine layout for the site is shown in Figure 4.5.1. The development of the layout is described in detail in Sections 3.4 and 3.5 of this ES. In the final selected design the 60 turbines would be arrayed in an offset grid pattern with the overall layout in the form of a trapezium thinning towards the north east.

The layout would comprise 10 northwest/southeast lying rows of between 2 and 8 turbines, separated by 450 m. Turbines within rows would also be separated by 450 m. Rows are given letters A to K (I is left out as is common practice with alphanumerical sequences to avoid confusion) with turbines numbered along each row from the northwest. The north-easternmost row, Row A, would contain 2 turbines, increasing to 8 turbines within the central 3 rows (Rows E, F and G) and decreasing to 3 turbines for the south-westernmost row (Row J). This is illustrated in Figure 4.5.1. Turbines within rows would also be separated by approximately 450 m. This represents a separation distance of 5 diameters for the largest turbine type considered for the development, which is close to the technical limit recommended by turbine manufacturers. The layout is therefore compact both in distance between turbines and in overall shape, which was considered to give landscape and visual advantages over more largely spaced turbines or layouts with greater numbers of turbines in fewer rows which in both cases would otherwise give greater overall wind yields (see Section 3.5 of this ES). The layout would cover a total area of 10.3 square km.

The turbines would be positioned in current depths of water between 4 and 13 m below Mean Sea Level although the sand bank on which the turbines would be positioned is mobile and water depths may vary at each turbine during the 25 year lifetime of the project.

Average annual wind energy yield would be greatest for turbines on the western edge of the site with yields falling off towards the centre of the layout where turbines lie in a partial wind shadow of other turbines in all directions.

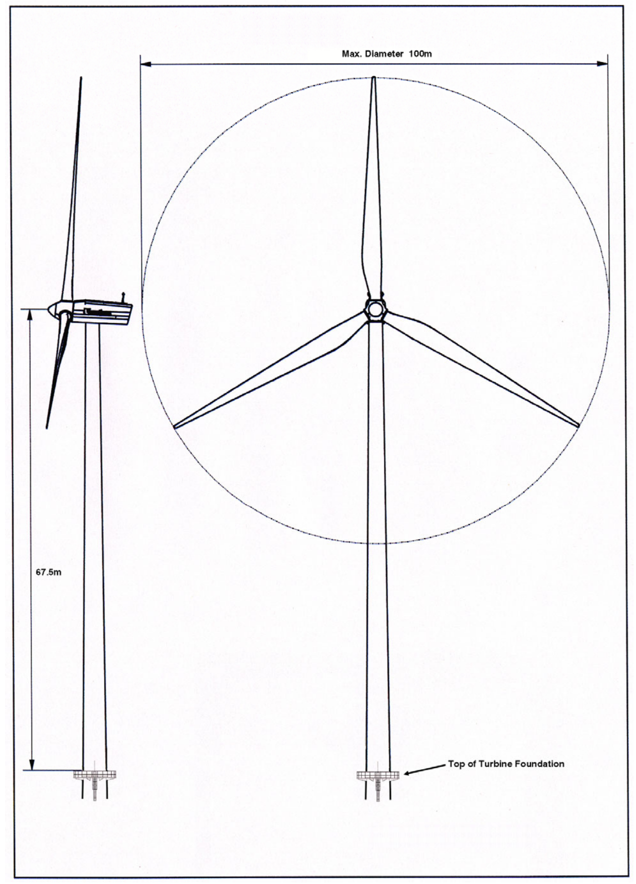
4.6 TURBINE DESCRIPTION

The final turbine model would not be selected until after the permission process but would have an installed capacity of 2 - 3.6 MW. The turbines would all be of one type. They would be three bladed with a horizontal axis nacelle positioned on a tubular tower. A drawing of this turbine type with maximum dimensions is shown in Figure 4.6.2**.** The larger plus 3MW turbines are not yet in production but are expected to be by the time that the Robin Rigg site was constructed.

A photograph of a 2MW production turbine is given in Figure 4.6.1

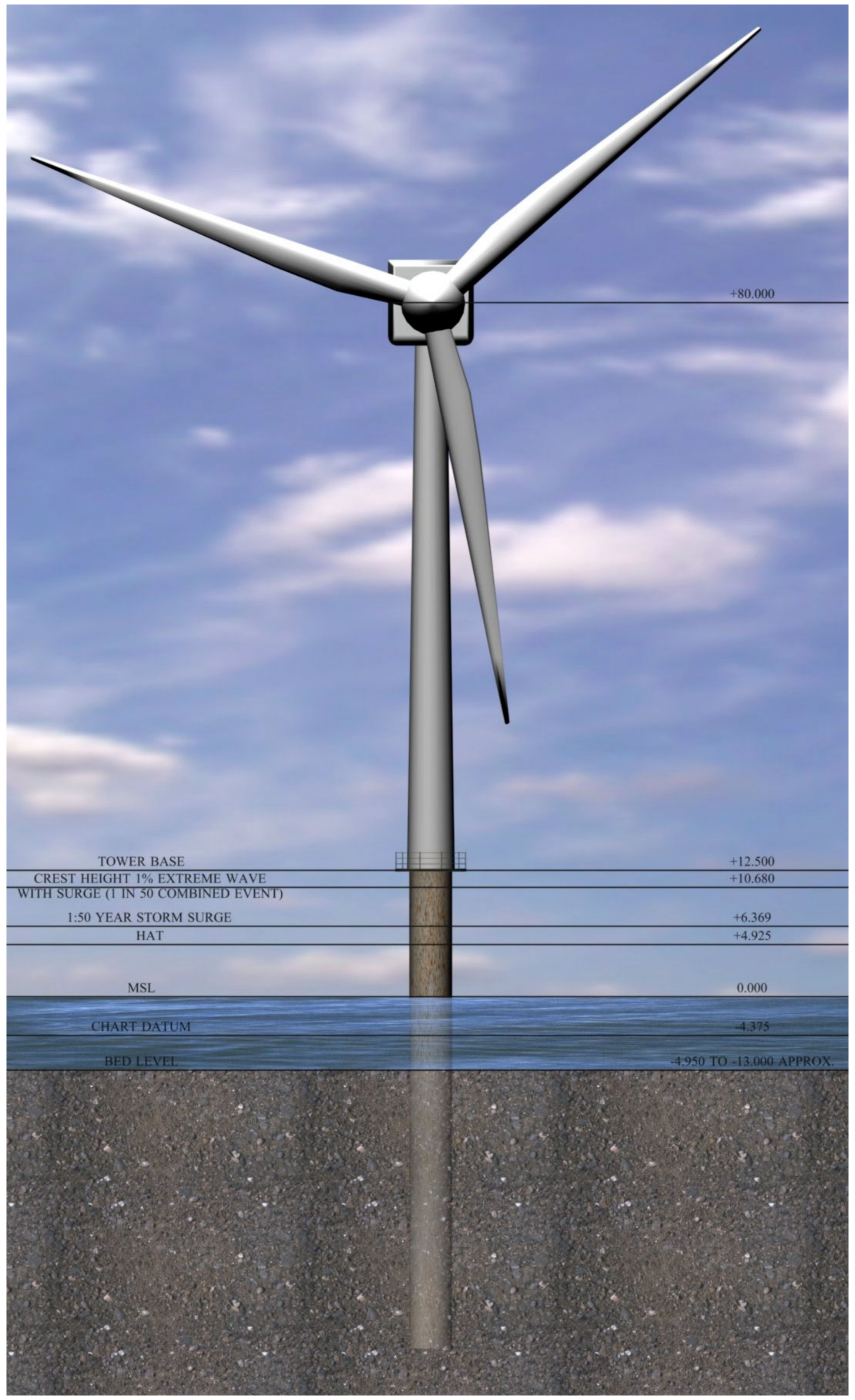
Figure 4.6.1 2 MW V80 Turbine (Courtesy of Vestas wind Systems A/S)

Figure 4.6.2 Indicative specification of turbine for use at Robin Rigg



Heights of turbine and foundation components above mean, high and extreme sea levels is shown in the diagram in Figure 4.6.3. The dimensions given here relate to the largest turbine size considered for the site.

Figure 4.6.3 Maximum heights of foundations, turbine tower and nacelle above Mean Sea Level



The rotor axis would have a maximum height of 67.5 m over the top of the foundation, which itself would lie approximately 12.5 m above Mean Sea Level (MSL). The turbines would have a maximum blade length of 50 m, giving a maximum height from MSL to blade tip in the highest position of 130 m. The spring tidal range in this part of the Solway is 7.4 m giving a normal minimum blade tip height above the sea surface (for the lowest blade tip position) of 26.3 m at spring high tides, decreasing to 19.3 m for the extreme conditions of the highest astronomical tide combined with a 1 in 50 year surge and a 1 in 50 year wave.

These extreme conditions would give a wave crest height of 10.7 m above MSL. The interface between the base of top of the turbine and the foundation would be positioned above this level.

The turbine models being considered would begin generating electricity at wind speeds of approximately 3-5 metres per second (m/s) rising to their maximum output at velocities of 12-18 m/s. The design of the turbines would be such that should wind speeds reach 25 m/s they automatically shut down for safety reasons. The turbine models being considered are of variable speed output, with the speed of rotation varying from around 8 rpm at low wind speeds and increasing to a maximum of 21 rpm at the higher wind speeds (for the smallest turbine being considered). All rotor blades on the wind turbines within the wind farm would rotate in the same direction, i.e. clockwise when viewed from the windward direction.

The turbines would have tubular steel towers assembled from two to three sections. The nacelle placed on top of the tower would contain a variable speed gearbox, a brake, and a generator generating electricity at 690 V. There would be a transformer stepping this up to 33 kV located either within the base of the tower or on top of the nacelle.

The total weight of the turbine would be between 220 and 280 tonnes.

The final turbine colour would be decided in consultation with the regulatory authorities. However, following consideration of the most frequent weather conditions, the backdrop to turbines from the closest viewpoints and the direction of views to the wind farm the landscape consultant has recommended a matt pale grey. Some navigation markings would be required for the outermost turbines in the form of a single yellow stripe at the base of each turbine. This is detailed later in Section 4.9.

The turbines would be of a modern quiet design. The source noise of the turbines at a wind speed of 8 m/s at a height of 10 m (standard noise measurement) would be no greater than 108 dB(A) at 1 metre from source (assuming a point source). The noise received at closest locations on land is modelled in Section 9.19 and would be well below background noise levels.

4.7 FOUNDATION AND SCOUR PROTECTION

4.7.1 FOUNDATION DESIGN

It is not possible at this stage to specify the particular type of foundation which would eventually be used, this being dependent on a number of factors including but not restricted to contractors specific choice, available construction equipment, site conditions and cost.

Two types of foundation, however, are considered suitable for the proposed site.

Monopile Foundations

A monopile foundation for a modern multi-mega watt turbine would comprise a large diameter steel cylinder of up to 5.5 m diameter, with a wall thickness of 60 to 80 mm. The mass of a pile would be in the range of 350 to 500 tonnes.

Levelling and fine adjustment would be accommodated by the introduction of a larger diameter transition sleeve above water level. This would be connected to the pile, usually by a grouted connection after final adjustments.

The turbine tower would be bolted on to a flange on top of the monopile at a level above which the water/wave level is expected to reach. An access/work platform would be provided at that level.

Multi Pile Foundations

The multi-pile foundation would likely comprise a circular central column, with steel leg structures. The foundation would be supported by piles with diameters in the order of 1.2 m to 1.8 m, which are driven or vibrated up to 35 m into the sea bed, depending on soil conditions. The height and width of the structure would also depend on site conditions.

The central column would be in the range 4.5 – 5.5m in diameter with the material thickness in the range 60m to 80mm. The leg bracing elements would likely be fabricated from steel tubes in the order of 1.2m to 2.0m in diameter with wall thickness in the range 20mm to 40mm. The mass of such a foundation would typically be in the range of 250 to 350 tonnes. The weight of the piles would be in the order of 20 - 30 tonnes each. High stress concentrations would be experienced at the connections between the various tube elements and the central tower and stiffening would be required at these locations. The whole foundation structure would have a diameter of 30-35m.

Figure 4.7.1 Typical Monopile Foundation

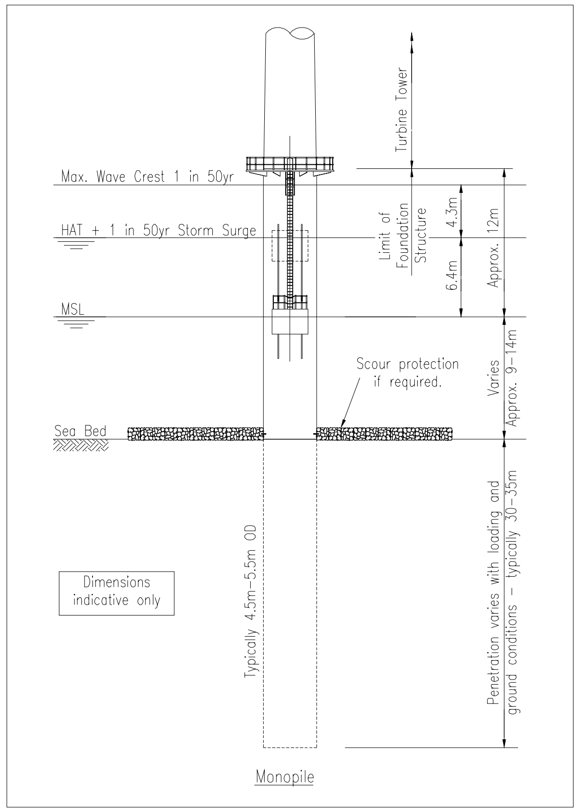
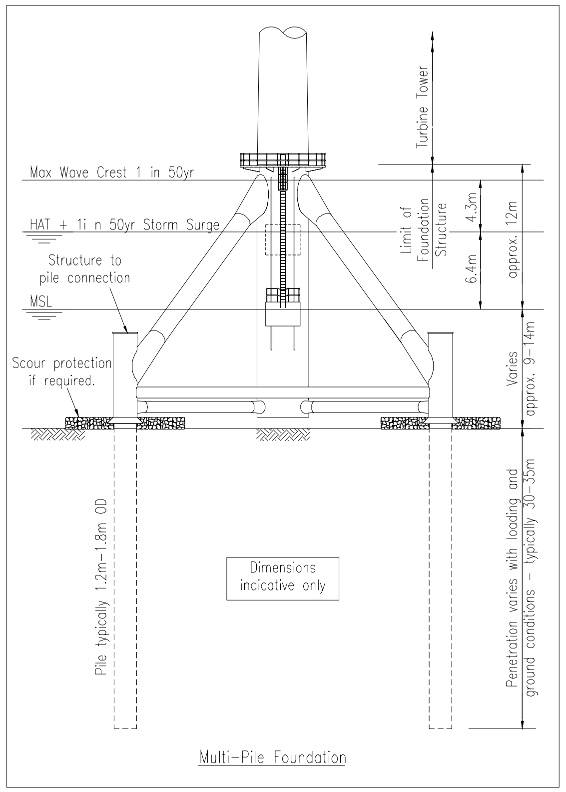


Figure 4.7.2 Typical Multipile



4.7.2 SCOUR PROTECTION

Marine structures can be susceptible to erosion of the bed sediment in the vicinity of their foundations due to the action of waves, currents and tides. This is commonly referred to as scour.

Scour can be classified as detailed below and as illustrated in Figure 4.7.3.

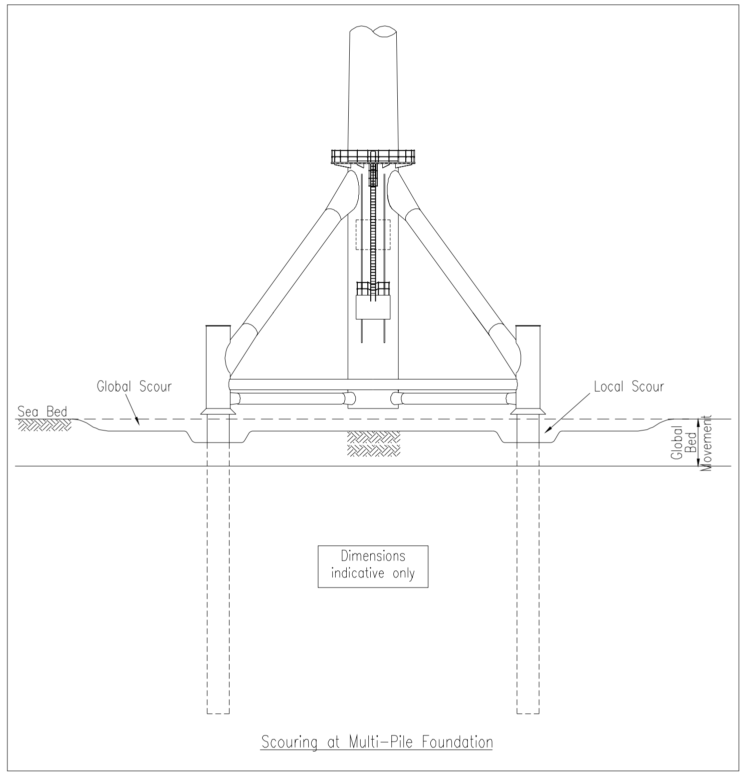
1. local scour - deep localised pits around single piles
2. global scour - shallow wide spread depressions around individual installations
3. overall seabed movement.

Local scour can result from the disturbance of the flow pattern by the introduction of a structure on the seabed. Of particular interest is the effect of a single vertical pile installed in the bed. The presence of a vertical pile leads to an increase in the speed of flow in the vicinity of the pile with a resultant increase in shear stress at bed level, which can cause erosion (scour) of the sediment. In general terms the extent of such erosion would be confined to with 1.5-2 pile diameters of the pile and to a depth in the order of 1 pile diameter.

Global scour is a similar phenomenon that can be experienced over the full area of a multi-piled structure i.e. in the case of the Robin Rigg turbines, an area of approximately 30 - 40 m in diameter at each turbine base if multipile foundations are used. The effects of such scour are generally shallower than local scour.

Overall seabed movement can occur over large areas as a result of the action of tides, currents and waves and is not related to the presence of structures on the seabed. The extent of movements and changes in depth would vary with location and the nature of the seabed material.

Figure 4.7.3 Scour around a multipile foundation



In the case of Solway Firth, historical evidence has shown that overall seabed movement is likely to predominate, although local and global scour may occur around the individual installations and piles in the periods between events that cause more global movement of the banks.

Local and global scour can be prevented by the introduction of scour protection measures such as stone filled mats, rock armour, grout filled bags and soil improvement. However events which cause global movement are likely to occur frequently enough to cause local/global scour to be insignificant in relation to the design of the structure and would likely be of magnitudes that would damage/negate any local scour protection measures which may be installed.

It is therefore considered unlikely that localised scour protection measures would be installed at Robin Rigg unless monitoring during the operational phase of the wind farm showed that such scour protection was necessary at any particular location in the wind farm.

The effects of overall seabed movement will be considered in the design of the foundation structure and piles by predicting the likely minimum level of the seabed and designing the foundations on the assumption that the seabed would be reduced to this level during the lifetime of structure. All ancillary items such as J-tubes and cabling will be designed to accommodate predicted variations in the level of the seabed.

Scour and global bed movement can be unpredictable and therefore regular inspections of the foundations would be undertaken to determine the extent of any scour or global bed movements. The results of these inspections would be compared with the design criteria of the foundations to ensure adequate performance.

Should at some time in the future the bed level be reduced to a level where any further reduction may have structural implications then it may become necessary to introduce protective measures to avoid further lowering of the bed level by additional local scour. It would be expected that such measures would likely involve the introduction of rock filled mattresses or grout filled bags, etc, fixed to the structure/pile which would allow the scour protection to accommodate variations in the seabed without a loss of structural integrity of the protection. The likely extent of such measures would be approximately 15m radius around monopiles and a 5-10m radius around individual smaller piles.

4.8 ANEMOMETRY MAST

An anemometry mast would be installed on the southwestern edge of the wind farm as shown in the layout map in Figure 4.5.1. The mast would carry a number of anemometers wind vanes at varying heights for measuring wind speed and direction. The mast would be of steel lattice construction similar to the existing one positioned on the site with a height of 80 m from Mean Sea Level, and would be positioned on a single pile buried in the seabed using similar techniques to the piles used for the turbine foundations. The anemometer would be linked to the wind farm by a communications cable laid on the seabed or by a microwave link. In the case of a cable connection, the proposed route is shown in Figure 4.5.1 and the cable would be laid using similar techniques to the laying of power cables within the wind farm area.

4.9 NAVIGATION AIDS FOR SEA TRAFFIC

4.9.1 OPERATIONAL PERIOD

To warn commercial shipping, fishing vessels and recreational yachtsmen of the existence of the wind farm during its operational period, a system of yellow special marker buoys is proposed for the development along with a foghorn. The four buoys would be positioned at four points on the outside of the wind farm as shown in Figure 4.5.1. They would be painted yellow and be fitted with flashing yellow lights visible over three nautical miles. Buoys A and B would be marked with a yellow multiplication cross and would have a light flashing yellow every five seconds. Buoys C and D would also be marked with a yellow multiplication cross and carry a light flashing yellow four times every 12 seconds, with a visible range of 3 nautical miles as requested by Northern Lighthouse. The markings as described would allow vessels to pass along the channels to the north and south of the wind farm area avoiding the development. The characteristics of the buoys are given in Table 4.9.1 below along with proposed positions. The final detail of positions will be agreed with Northern Lighthouse who have responsibility for navigation markings in Scottish waters.

Table 4.9.1 Characteristics of marker buoys around the wind farm during the operational period

Shape	Colour	Mark	Latitude	Longitude	Characteristics
Conical	Yellow	X	54deg 45.19N	03deg 44.38W	Fl Y 5s
Conical	Yellow	X	54deg 46.21N	03deg 41.57W	Fl Y 5s
Can	Yellow	X	54deg 45.45N	03deg 40.50W	Fl (4) Y 12s
Can	Yellow	X	54deg 44.04N	03deg 42.59W	Fl (4) Y 12s

Each buoy would also be fitted with a radar reflector.

An existing beacon positioned at 54deg 45.428N, 03deg 40.096W would be discontinued on establishment of the new-lit buoys.

For low visibility conditions an audible fog signal is also required in the approximate centre of the array. The ‘nominal’ audible range would be at least two miles and omni-directional. This signal would have a character of Morse “U” sounding every 30s.

In addition to the above navigational markings and lights requested by Northern Lighthouse, the developer has agreed at the request of local yacht clubs to include a yellow band around the base of the outermost turbine towers on all sides of the development. The band would be a metre deep and would be positioned above the foundation/turbine base interface which would lie some 12.5 m above Mean Sea Level. The band would allow yachtsmen in bad visibility to identify if they were on the outside of the development or within the wind farm on seeing a turbine tower.

Navigation restrictions during the operational period of the wind farm are given in Section 4.18.3.

4.9.2 CONSTRUCTION PERIOD

During the construction period non-wind farm vessels would be excluded from the wind farm as described in Section 4.17.1. The area would be marked with the same four buoys as described above for the operational period, placed at the following positions:

Table 4.9.2 Characteristics of marker buoys around the construction exclusion zone during the construction period of the wind farm

Shape	Colour	Mark	Latitude	Longitude	Characteristics*
Conical	Yellow	X	54deg 45.19N	03deg 44.53W	Fl Y 5s
Conical	Yellow	X	54deg 46.34N	03deg 41.32W	Fl Y 5s
Can	Yellow	X	54deg 45.50N	03deg 40.32W	Fl (4) Y 12s
Can	Yellow	X	54deg 43.53N	03deg 42.83W	Fl (4) Y 12s

These positions are also shown on the layout map shown in Figure 4.5.1.

If the construction timetable as given in Section 4.15 is followed, with up to 20 turbines constructed in the first year and the remainder in the second year, there may be an opportunity to reduce the construction exclusion zones for each year to surround only those turbines to be built in that construction year. If so the positions of navigation buoys during the construction period will be adjusted as appropriate in accordance with the International Association of Marine Aids to Navigation and Lighthouse Authorities (IALA) maritime voyage system (MVS) in consultation with Northern Lighthouse.

4.10 LIGHTING FOR AIR TRAFFIC

The Ministry of Defence, the Civil Aviation Authority and the National Air Traffic Service have all been consulted regarding the project. None of these bodies has requested any lighting placed on the turbines for air traffic purposes. None is therefore envisaged for the project.

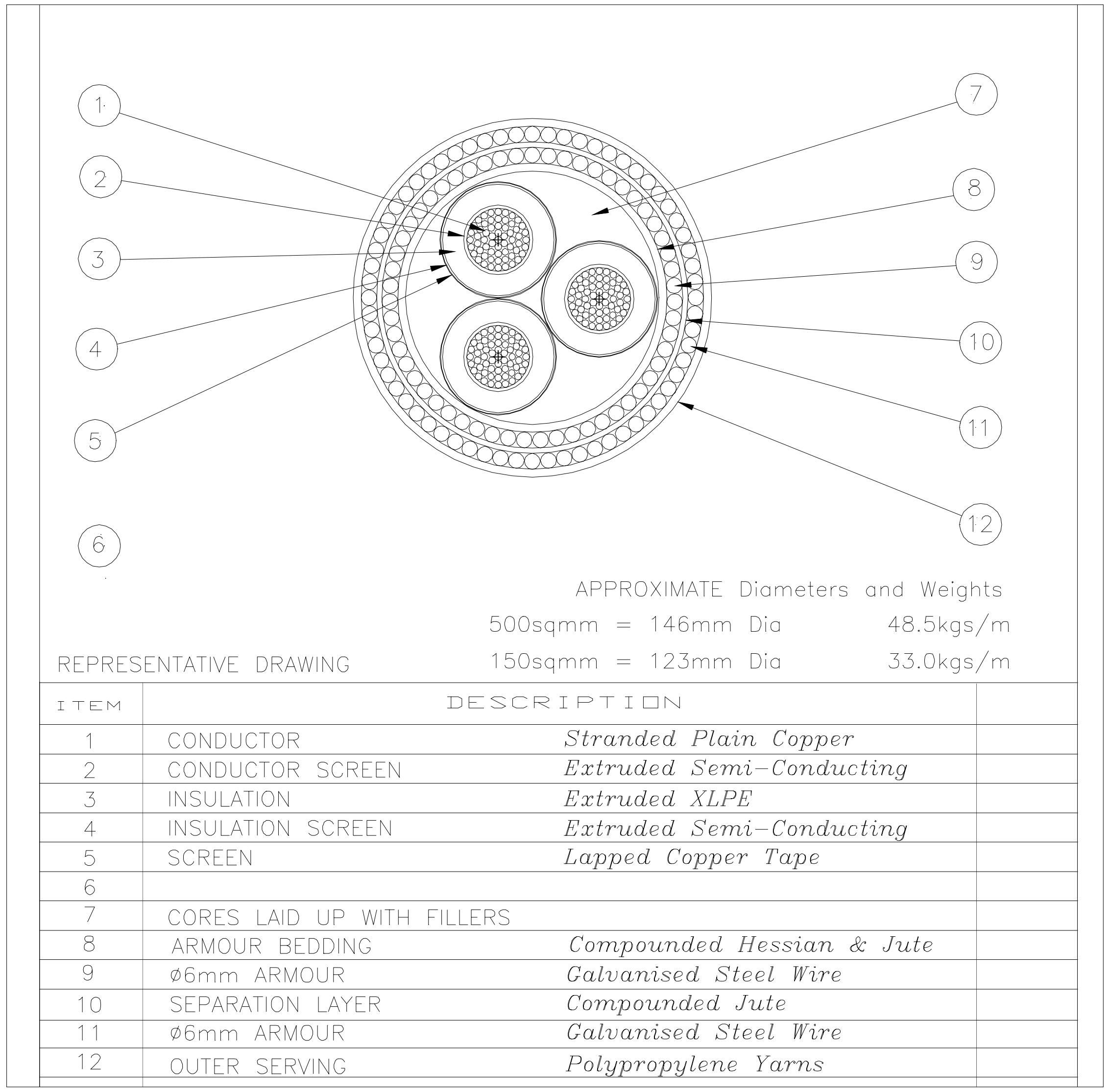
4.11 TURBINE TO OFFSHORE SUBSTATION CABLING

The turbines in the wind farm would be connected to transformers located in the offshore substation platform through 33 kV sea floor cabling. The cable routes between the 60 turbines and the offshore substation are shown in Figure 4.5.1. The routes would follow the turbine rows running northwest/southeast and collect along the southeastern edge of the layout and from there pass directly to the substation platform positioned in the middle of this line. While there would be a single 33 kV cable laid along each turbine row a maximum of 10 turbines could feed into each 33 kV cable of the type that would be used at the site. Therefore, with 30 turbines on each side of the substation position, a minimum of 3 cables would run along the cable corridors immediately to the southwest and northeast of the substation lying within the same trench.

The total length of on-site cable *corridor* would be 29 km, with the total length of 33 kV cable laid within these corridors being up to 40 km. The cable type used for the onsite cabling has not been finally selected but would not be oil filled - either using EPR (Ethylene Propylene Rubber) insulation or more likely XLPE (Cross-Linked Polyethylene), in order to eliminate risks of oil leakage from cable in the event of a breach.

A typical cross section of a 33 kV cable is shown in Figure 4.11.1. The cable would contain 3 cores of copper conductor, operating under 3 phase AC, with each core insulated by EPR or XLPE and incorporating a copper screen. To provide mechanical protection the cable would contain two layers of galvanised steel wire armouring, with the armouring layer being earthed for safety and to minimise electric fields external to the cable. The cable diameter would be approximately 150mm.

Figure 4.11.1 3 Core Copper XLPE Armoured 33 kV Subsea Cable



A number of possibilities have been investigated for installation of the on-site cabling. It is usual practice to bury submarine cables for two main reasons:-

- for cable protection
- to prevent cables presenting a physical obstacle to anchors and fishing equipment.

Depths of embedment vary but in sands cables are usually embedded at depths in the order of 1 m by ploughing or jetting. However, particular problems could occur at the Robin Rigg site as global movements of the seabed are expected which may significantly vary the level of the seabed. This presents two problems:-

- The buried cable may be exposed and thus may be susceptible to physical damage
- Should the seabed level fall significantly the cable may end up suspended above the seabed which would induce unwanted stress in the cable.

The precise method of cable installation and protection would be determined at a later date by the project designer, the main contractor and the cable installation specialist. However the following two methods are considered most likely.

Trenching with Excess Cable Length

This method would comprise installation of the cable using the standard method of burying in a shallow trench, probably excavated by fluidising the sand or by ploughing but with the provision of loops of spare cable length which would allow the cable to fall with seabed level without 'hanging up'. There is however the possibility therefore of the cable being uncovered and exposed on the bed surface. To ensure no physical damage should the cable be exposed, anchoring and trawling be prohibited within the wind farm area (does not include 132 kV wind far to shore cable). Given the heavy weight of cables it is expected that the cables would tend to 'self bury' as the bed sediments are subjected to movement.

Ancillary items such as J-tubes (steel tubes on the structure into which the cables are inserted to carry the cable to the internal connection point) would be installed to a specified depth below the seabed to allow for any likely/predicted fall in seabed level over the lifetime of the wind farm. Other protection measures such as sleeving of the cable may also be used locally at the connection to the J-tubes/structures to avoid damage caused by movement of the exposed section of the cable due to current and tidal action.

Directional Drilling

Alternatively the cables between turbines and transformers may be installed by the use of directional drilling. This technique involves the drilling of a pilot hole to a predetermined depth and profile along which a hole is bored to the required diameter. The cable is then installed by pulling through the bored hole. Using this technique cables can be installed in the deeper more stable strata well below the mobile sediment zone, thus ensuring the cable would not be exposed.

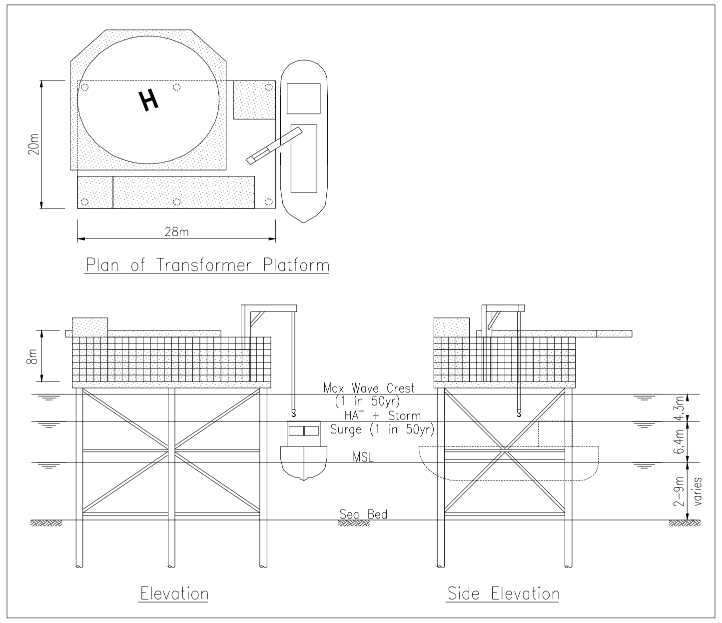
The construction techniques for both these methods are discussed later under 4.17.4.

4.12 OFFSHORE SUBSTATION PLATFORM

The offshore substation platform would be situated in the middle of the southeastern edge of the wind farm some 80 m southeast of the turbine at the end of row F (see Figure 4.5.1). All 33 kV cables would be collected at the substation where the voltage would be stepped up to 132 kV. Two 132 kV sea floor cables would connect the substation to the shore.

The offshore transformer would be supported on a steel platform structure at a height of approximately 10-12m above mean sea level. The area required to accommodate the required equipment would be in the order of 500-900m^2.and is expected to have approximate dimensions of 20m by 20 m with a height of 10 m (as shown in visualisations of the wind farm in Section 9.10 of this ES), although a 30 m by 30 m platform area might be required depending on final facilities needed. Boat access points would be required and in addition a helicopter landing platform may be provided on the upper level of the substation. The final design of the substation platform has not been completed, but it is likely to be similar to that shown in Figure 4.12.1.

Figure 4.12.1 Indicative Diagram of On-site Substation Platform



The weight of the electrical installations and other ancillary equipment supported on the platform would be in the order of 300-400 tonnes and the tallest components would be approximately 8m in height.

The main items of electrical equipment provided would be.

- 33/132 KV transformers
- 33 KV Switchboard
- 132 KV Switch gear
- Diesel generator and tank

In addition the substation would include lifesaving / safety equipment and may also include limited maintenance and welfare facilities.
The two transformers would each contain approximately 30,000 – 40,000 litres of cooling fluid and the diesel tank would have a capacity of approximately 100,000 litres of diesel fuel.

All equipment that contains any significant quantity of oil (e.g. the transformers, diesel generator and diesel oil tank) would be bunded with an open steel bund around the base of each transformer and the diesel generator and fuel tank, each bund being capable of holding more than the complete volume of fluid. This would ensure that even in the unlikely event of a major rupture, all fluid would be contained and can be dealt with safely. Other items of equipment would only contain small amounts of oil.

It is most likely that the equipment and helicopter deck would be supported on a steel superstructure on 4 to 6 steel tubular legs which would be supported on steel tubular piles. The form of construction would be similar to that of a traditional offshore oil installation with the superstructure being fabricated from standard structural steel box and I sections, probably with open mesh decking. Similar construction techniques are likely to be employed. The helicopter deck would also be of steel construction and would likely be positioned above the main elements of plant and electrical equipment.

4.13 TRANSFORMER TO LAND CABLE

From the substation platform two 132 kV cables would carry the power ashore. The route would be approximately 12 km long and would lie within the corridor shown on Figure 4.13.1 with landfall just south of Flimby on the Cumbrian coast. The exact offshore route will be finalised once the route of the cables on shore is finalised as described in Section 4.14 below, in order to avoid excessive cable length and dog legs in the cable route close to the shore. Benthic, sediment and geophysical surveys have been carried out over this corridor and resulting impact assessments are given in Section 9 of this ES.

The final specification for the 132 kV cables is yet to be finalised but they would be similar in design and cross section to the on-site 33kV cables described in Section 4.11 and shown in Figure 4.11.1. The need for greater insulation at 132kV would result in a slightly larger cable diameter of approximately 160mm.

Like the 33 kV cables, the 132 kV would not contain oil, but would be insulated by EPR or XLPE. The armouring layer would also be earthed minimising electric fields external to the cable.

It is important that the land connection cable be protected from damage by vessels or by the action of waves and currents. It is known that the sand banks in the Solway Firth are very mobile and this would cause problems for the protection of cables.

Unlike the situation within the wind farm on-site cabling, where cable runs are shorter and where it is possible to place restrictions on anchoring etc, the cable to land would be in open waters and as such it would be necessary to take measures to ensure the cable does not become exposed on the seabed. For the sections of the cable on the banks it is likely that directional drilling as described in Section 4.11 would be used to install the cable at such a depth as to ensure that they are not exposed by movement of the bed sediments
In the areas remote from the sand banks where the bed is more stable it is likely that the cable would be installed in a shallow trench by fluidising the sand or by plough/excavation in harder bed materials. Such trenches are generally allowed to backfill naturally, particularly if the sediment is sand.

Using these methods exposure of the 132 kV cable at any point along its route is extremely unlikely. There would therefore be no anchoring or trawling restrictions in the vicinity of the 132 kV cable to shore.

4.14 GRID CONNECTION ONSHORE

The wind farm would be connected into United Utilities 132kV distribution system, due to the close proximity of existing 132kV overhead lines to the coast. This would allow underground routing avoiding the need for new overhead lines.

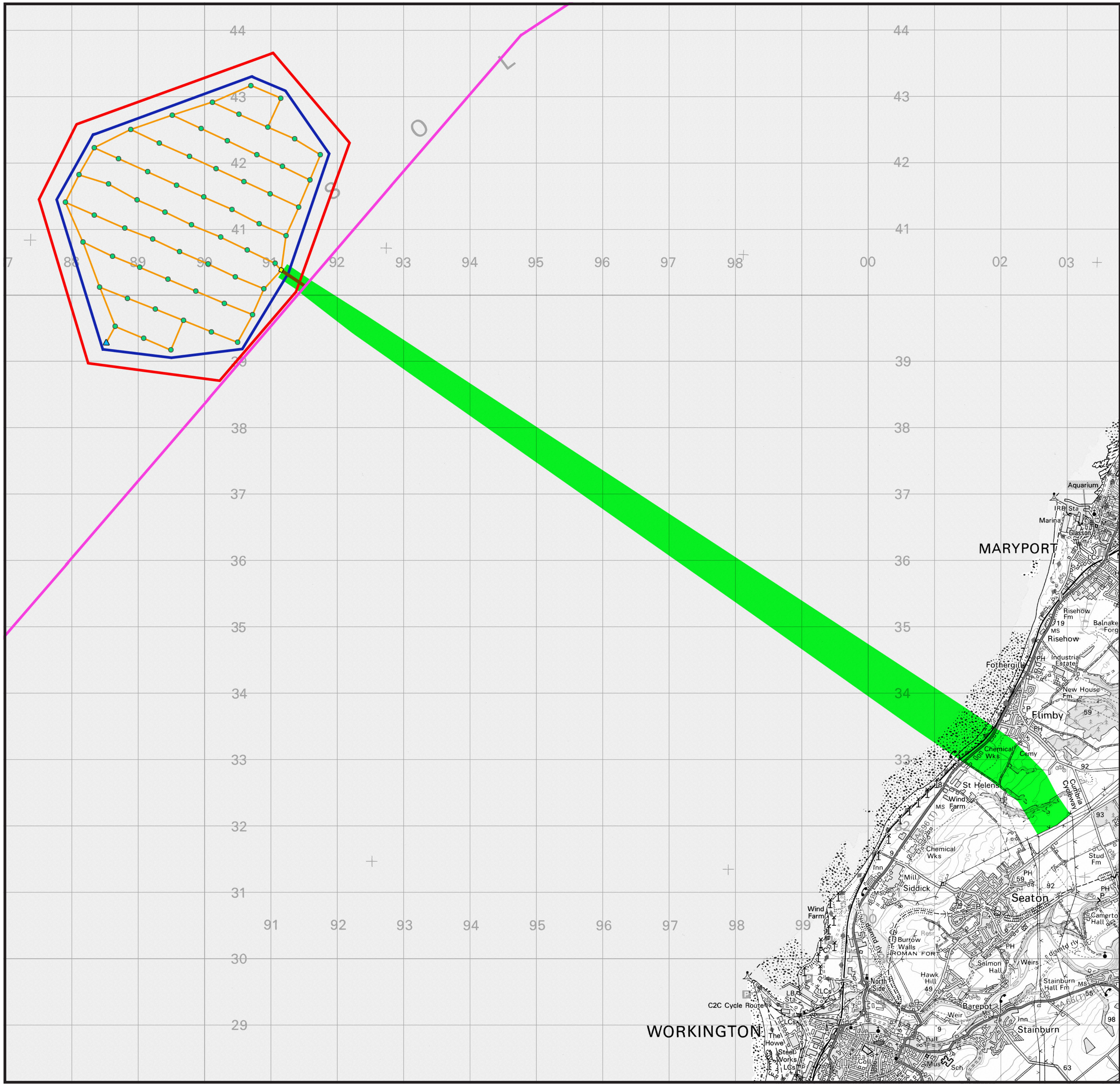
The two 132 kV cables would come ashore just south of Flimby, Cumbria as shown in Figure 4.13.1. The cables would then continue underground to the connection point with the existing 132 kV overhead line that lies some 2 km east of the landfall point, at its closest point. The final route of the underground cable is yet to be determined but the route would lie within the corridor shown in Figure 4.13.1.

The onshore switchyard would be positioned close to United Utilities' existing overhead line, into which the wind farm will connect. Equipment in the substation would include:

- 132kV switchgear
- Air insulated busbars
- Cable sealing ends
- Small building housing metering and protection relays
- Down droppers from the overhead line down into the substation

The switchyard would be fenced to prevent unauthorised access and ensure the safety of the public. The final position and design of switchyard at the connection point is also yet to be determined. Both the underground inland cabling and the switchyard will be the subject of planning applications to Cumbria County Council under the Town & County Planning Act. Supplementary environmental information will be submitted along with the applications covering any on-shore environmental impacts of the 132 kV cable and switchyard

United Utilities are studying the impact that the wind farm would have on their system. In order to accept the output from the wind farm, it is likely that the conductors on the existing 132kV overhead line would need to be replaced which could require some modifications to the existing towers. Should these modifications require a consent under Section 37 of the Electricity Act 1990, this would be subject to a separate consents application.



Project:

Proposed Offshore Wind Farm, Solway Firth

Title:

Figure 4.13.1: Wind Farm to Shore Cable Route

Key

- Wind Turbine
- Cable route
- 132kV Cable Corridor
- Substation
- Anemometry Mast
- Trawling Exclusion Zone
- Construction Exclusion Zone
- Scotland - England border

Scale: 1: 50,000 (reduced)

Kilometres 0 1 2

Centimetres 0 1 2 3 4

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4.15 CONSTRUCTION TIMETABLE

Should all permissions be received by January 2003 (date of Notice to Proceed), construction of the wind farm would begin in June 2003 and due to requirements for good weather conditions for offshore operations would be split between two "construction seasons": June-October 2003, and April-October 2004. To allow some production of electricity in the first year, the wind farm construction would be slit into two separate stages in each of which groups of turbines would be fully erected from installation of foundations to commissioning. In the first season up to twenty turbines would be fully installed and commissioned with accompanying cabling. The remainder would be constructed in the second construction season.

The construction programme would consist of the following elements:

Pre-Construction Design and Fabrication

Activities during this period include design and off-site fabrication of components for foundations, towers, turbines, and cabling. This period would begin at Notice to Proceed, and would continue for approximately 18 months.

On-Shore Mobilisation

These activities include delivery of materials and components to port locations, some degree of assembly within dedicated port areas, and loading of materials and assembled components onto vessels for delivery to site.

These activities would commence in month [6] following NTP, and would continue throughout each construction season. They would be suspended during the period between the two construction seasons.

Seabed Preparation

Minimal preparation of the seabed would be required for the monopile type foundation, this being restricted to the removal of any obstacles from the footprint of the pile. Multi-piled foundations would require the clearing of obstacles from an area up to approximately a 15-20m radius from the central tower location. Levelling of the site would also be required in order to accommodate the placement of a temporary piling template.

This activity would commence in month [6] following NTP and would continue throughout each construction season, with a suspension between the two construction seasons.

Installation of Foundations

The pre-assembled elements of each foundation (whether mono-pile or multi-pile) would be transported from port to site on the vessel to be used for installation of the foundation. The piles would be fixed into the seabed using a combination of hammering and augering. Mono-pile foundations are likely to take [7] days each to install. Multi-pile foundations are likely take [3] days to install per turbine

Installation of foundations would commence in month [7] following NTP. Up to [20] foundations would be installed during the 2003 construction season. The remaining foundations would be installed during the 2004 construction season.

Installation of Towers, Nacelles, Blades

The erection of towers, nacelles and blades would be carried out using vessels similar to those used for installation of foundations. These vessels would move the components from shore to the site, and would then be fixed in place over each foundation. The erection of each tower, nacelle and blade set would take approximately [3] days.

Erection of towers, nacelles and blades would commence in month [7] following NTP. Up to [20] sets would be installed and commissioned during the 2003 construction season. The remaining sets would be installed during the 2004 construction season.

Installation of Array Cabling

The array cabling would connect the turbines to the on-site sub-station. The cables would be buried approximately 1 metre below the seabed, and would be laid with sufficient slack to allow for possible lowering of the seabed due to natural mobility of the sand.

This activity, including the laying of cable, connection to the turbines, and connection to the sub-station for those turbines erected during each construction season, would be carried out during the last [60] days of that construction season.

Installation of Sub-Station

A 33/132kV sub-station would be installed on a platform to be erected on the site. The platform would be installed on a mono-pile or multi-pile foundation similar to those used for the turbines. The foundation and the platform would be installed during month [7] following NTP in the first construction season. The sub-station would be delivered to the site and installed during month [8]. Connection of the sub-station to the on-site cable array would be carried out during the last [60] days of the 2003 construction season.

Installation of Site-to-Shore Cable

The sub-station would be connected to the English shore by two 132 kV cables, which would be buried beneath the seabed.

At least the first of the two 132 kV cables would be installed during the last [60] days of the 2003 construction season. The second cable may require installation during the last [60] days of the 2004 construction season although it would be preferred both from an environmental and cost perspective to install both cables at the same time. This would occur if manufacturers are able to supply all the appropriate cabling in the 2003 season.

Installation of On-Shore Interconnection Facilities

At the point of landfall, the two 132kV cables would be buried and extended 2 km inland to the interconnection point adjacent to the 132 kV distribution system belonging to United Utilities. At the interconnection point, a switch-yard would be installed.

Installation of these on-shore facilities would be carried out during the last [60] days of the 2003 construction season.

4.16 CONSTRUCTION PHASE ONSHORE

4.16.1 TEMPORARY HARBOUR AREA AND FACILITIES

Harbour facilities and working areas would be required before and during the course of the construction to provide facilities for:-

- Berthing for construction and service vessels
- Transport and lifting equipment
- Fabrication and assembly areas
- Temporary storage areas
- Berths, offices, canteen and amenity facilities for the construction crew
- Fuel storage.

The precise facilities required would depend on the contractors chosen method of working and construction schedule.

It is highly unlikely that gravity foundations would be used on site and as such there would not likely be a requirement for dry dock facilities. The foundations are likely to comprise either monopile or tripod arrangements in steel construction.

The initial fabrication/rolling of steel elements would likely be carried out at a specialist rolling mill/fabrication yard remote from the harbour area. Monopiles may be fabricated completely at this location and be shipped directly to the site. However given the size of multi-pile foundations, final assembly would be required to be carried out at the harbour in close proximity to the quay area to facilitate easier transport and handling. A covered area would be required for final fabrication and a large hardstanding area would be required for temporary storage, plant and offices, etc. In addition, an area would be required for the storage/assembly of the turbines. These would be manufactured at a remote facility and the component parts would be transported to the harbour area for final assembly prior to transport to the site. Double handling of items should be prevented as this reduces the required storage area for nacelles, hubs, blades and towers. Tower sections would either be assembled onshore at the quay or on a barge next to the quay prior to shipment. The nacelles would be mounted and fully tested prior to leaving the factory, but some mounting works would be carried out in the harbour for transport reasons.

Onshore working space would therefore be required for the last mountings of the nacelle and the pre-assembling of the tower sections. Additional are offices for the completion of the project and facilities for the crew are required. Based on experience from other offshore wind farms in Denmark, turbine manufacturers have estimated the following approximate space requirements for Robin Rigg assuming a maximum of 20 turbines to be stored at any given time:

- 300 m2 for pre-mounting of nacelles
- 2.500 m2 storm-safe storage area for nacelles
- 20.000 m2 storage area for towers, blades and hubs

The final working space will be dependent on the installation method and the grade of pre-assembling. In the case of a complete assembled rotor or a semi pre-assembled turbine, additional working space would be needed.

It is estimated that for a development of 60 plus-2MW turbines on monopile or tripod bases, an overall area of approximately 30,000 m^2 would be required for fabrication, assembly and storage. Of this approximately 4,000 m^2 would be required to be covered for dry working.

In addition to hardstanding areas, a significant amount of quay space/berthing would be required to service the construction vessels and to allow for the loading of construction materials, etc. In periods of poor weather sufficient space would be required to accommodate all of the construction vessels which would include work boats, jack-up platforms, barges and cable laying vessels.

Specific locations have yet to be chosen and would be chosen/determined by the installation contractor, however they would need to be reasonably close to the site and as such the following are considered most likely to be used along with Maryport for which data isn't available:-

Workington:	770m quay frontage; vessels up to 12,000 dwt, 137m length and 20.4m beam; rail terminal; 1500m^2 warehousing; open storage area with flood lighting.
Silloth:	590m quay length; vessels up to 3,000 dwt, 90m length, 13m beam and 5.5m draught; 30,000m^2 in port; 75,000m^2 adjacent to port; 1800m^2 covered warehousing.
Barrow:	2,690m quay length, vessels up to 230m length, 35m beam; 10m draught; 6,000m^2 warehousing; 100,000m^2 storage areas

It is possible that construction/fabrication facilities may be located at more than one harbour. All of the harbours above have planning permission required to carry out the operations required for the wind farm construction although depending on the final harbour used, some improvements may be required to accomodate temporary cranes. There would be a requirement for cranes to operate, both in the temporary storage/fabrication area and on the quayside. Cranes with a large lifting capacity would be required for the movement/loading of the finished foundations and for the turbine components. Depending on the harbour used some local preparation/improvement works may be required to accommodate larger cranes. Smaller mobile cranes would also be required for general lifting during fabrication, although these are unlikely to require any significant preparatory works.

4.16.2 CONSTRUCTION OPERATIONS ONSHORE

During the construction of the wind farm, a number of certain elements of the work would be carried out on shore.

The construction activities onshore would by necessity, take place at or in the vicinity of a port. The construction methodology, yet to be confirmed in detail, would determine to a large degree the facilities that are required onshore.

As described previously the foundation structure would comprise either a monopile or a multi-pile structure, both in steel construction.

It can therefore be assumed that the majority of construction operations onshore would be associated with steel fabrication with very little if any concrete construction being required.

Monopiles and tripod foundations comprise large section steel tubes which, due to the specialist equipment required to produce the tubes, would likely be manufactured at a steel mill remote from the site. In the case of monopiles, where the construction is relatively simple, it may be the case that most of the steel fabrication would be carried out at a remote site, with the finished product either being transported directly to the site or to the construction port for storage.

Figure 4.16.1 Assembly of Rotors Onshore

The constituent parts of a multi-pile foundation may also be fabricated remotely and transported to the part fabrication area. It is likely that final assembly of multi-piles foundations would be carried out at the port. The main operations at the site would therefore involve the cutting, grinding and welding of steelwork.

Completed foundation units would be craned onto transport barges directly from the assembly/storage area. Construction operations onshore would also involve the assembly of the turbine sub-units.

Requirements for onshore storage and construction areas are described in Section 4.16.1.

The turbines and associated equipment are very large items of equipment and would likely be transported by sea from the manufacturing location. Tower sections would either be assembled onshore at the quay or on a barge next to the quay prior to shipment. The nacelles would be mounted and fully tested prior to leaving the factory, but some mounting works would be carried out in the harbour for transport reasons. Rotors may be assembled fully onshore or alternatively mounted individually onto the rotor axis at each turbine location offshore. In either case the mechanical and support elements would be manufactured to high tolerances and thus it is not envisaged that any work other than final assembly would be required at the onshore yard.

Cabling would likely be transported directly to the site by sea and as such no onshore works in respect of cable handling, etc are envisaged.

During construction of the wind farm there would be a requirement for storage facilities onshore close to the load out area.

4.16.3 MATERIAL REQUIREMENTS

The precise onshore material requirements for foundations would be very much dependent on the type of foundation structure to be adopted. The quantities in Table 4.16.1 below are estimates based on either a tripod multipile or a monopile foundation, assuming the construction and installation of 60 turbines.

Table 4.16.1: Estimated material requirements for foundations

	Monopile	Tripod
Steel	21,000 – 30,000 tonnes	18,000 – 24,000 tonnes
Aluminium (Anodes)	50 – 70 tonnes	180 – 240 tonnes

It is unlikely that any significant amounts of materials other than steel would be used in the construction of the foundations.

Turbine towers, nacelles and blades would likely be manufactured at a remote location and be transported to the site for installation.

It is considered likely that cables would be transported directly to the site by sea.

4.17 CONSTRUCTION PHASE OFFSHORE

4.17.1 CONSTRUCTION AREA AND RESTRICTIONS ON SEA TRAFFIC

An area surrounding the whole of the wind farm area out to a distance of 350 m from the outside turbines would be required for construction works and movement of vessels between turbines during the

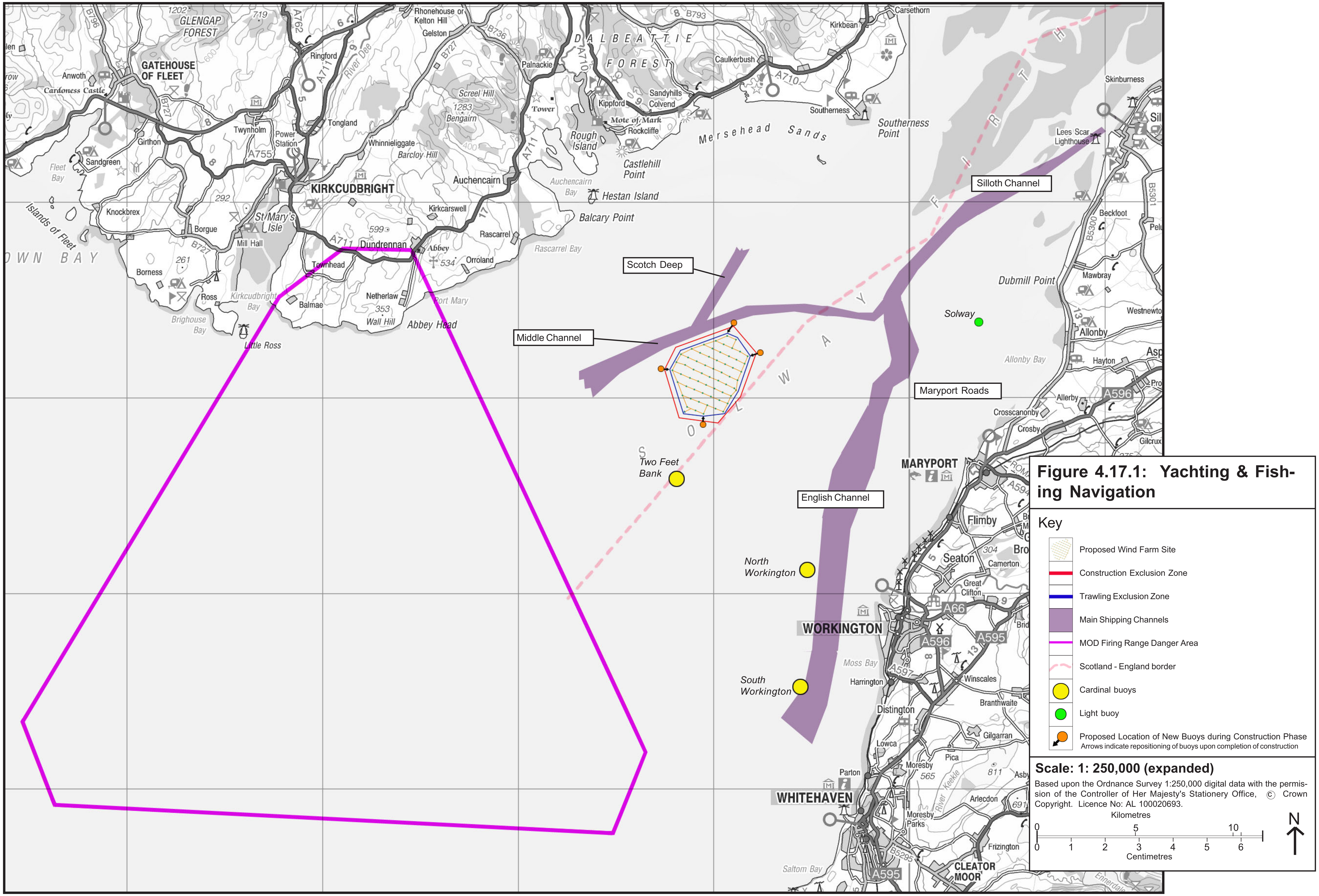

Figure 4.17.1: Yachting & Fishing Navigation

construction period. While most of the construction operations would take place at turbine positions, there would also be construction vessel movements along cable routes between turbines during the clearing of obstructions and the laying of cables. The construction area is shown in Figure 4.5.1.

During construction, all vessels except those involved in the construction of the wind farm would be excluded from the area shown in Figure 4.5.1. This area is shown in relation to navigation channels in Figure 4.17.1.

If the two stage, two year construction schedule outlined in Section 4.15 is used, then there may be a possibility of having two reduced construction and navigation exclusion areas during the two consecutive years of construction since in year 1 of construction Stage 1 of the wind farm would be completed to a point where turbines would be generating electricity. This area could then be free from the navigation exclusion while Stage 2 was being constructed in Year 2. Should that be the case, detailed planning of construction works by the civil contractor would be required, following award of construction permits, to identify the extent of Stage 1.

The construction area would be established and marked in accordance with the International Association of Marine Aids to Navigation and Lighthouse Authorities (IALA) maritime voyage system (MVS). Local radio navigation warnings would be given in advance of and during the construction of the offshore wind farm and the laying of power cables to the shore. Proposed markings are given in Section 4.9.2 earlier in this section.

4.17.2 CONSTRUCTION VESSELS

The final construction vessels to be used at the site would be decided by the civil contractor contracted to construct the wind farm should it receive building permission. However, it is likely that most of the construction work would be carried out from either jack-up platforms or from floating vessels.

The heavy weight of both the foundations and the turbines would require large cranes which would operate from either crane barges or large jack-up platforms.

Before piling and the placing of foundations it would be necessary to prepare the bed. This would likely be carried out using a backhoe, or crane with grabline, probably operating from a floating barge.

The installation of small piles would require only medium sized platforms and cranes. However for the installation of monopiles a larger jack-up platform would be required. Working platforms would likely be self sufficient in power and consumables, but would require the attendance of service vessels to transport men and equipment. Tugs would also be required to move the platforms and barges between the proposed turbine locations.

During the piling stage at least one flat topped barge would be required to transport piles to the site as there would be limited storage space available on the working platforms, especially if monopiles are to be used.

For the laying of cables, specialist equipment would be required. If the cables are to be installed by directional drilling then drilling rigs would be required. These would operate from jack-up platforms. For sections of cables to be laid in trenches, either water jetting equipment or a plough would be required. In addition a specialist cable laying vessel would be required for the transport and handling of the cables.

In addition to the major items of plant mentioned above, other ancillary plant items such as welders, grinders, compressors, grout pumps, mixes etc would be required during the construction and installation processes.

The amount of plant required on site at any one time would be dependant on the contractors chosen method of working and the construction programme.

Figure 4.17.2 Jack-up barge
(Courtesy Seacore Ltd)

Figure 4.17.3 Floating crane vessel.
(Courtesy Vestas Wind Systems A/S)

4.17.3 CONSTRUCTION OPERATIONS OFFSHORE

Most of the main construction elements would be, where possible prefabricated on land and would be shipped to the site from suitable local ports. The precise vessel requirements would be determined by the installation contractor, however it can be expected that those vessels used may include barges, jack-up platforms, tugs and work boats/service vessels. For more information on possible construction vessels/plant refer to Section 4.17.2.

The following major activities would take place offshore: -

- Preparation of the seabed, i.e. for multi-pile and tripod foundations, removal of large boulders, and any other obstruction and levelling to receive a piling template.
- Installation of turbine tower, nacelle and rotors

- Installation of site substation
- Jetting or ploughing of trenches for cables
- Directional drilling for cables
- Placing of cables .
- Installation of cables through J-tubes and connection to turbines
- Commissioning

4.17.3.1 Preparation of Seabed

Minimal preparation of the seabed would be required for the monopile type foundation, this being restricted to the removal of any obstacles from the footprint of the pile. It is highly unlikely that any significant obstacles would be encountered on the proposed site.

Multi-piled foundations would require the clearing of obstacles from a much wider area, up to approximately a 15-20m radius from the central tower location. Levelling of the site would also be required in order to accommodate the placement of a temporary piling template. In relatively shallow water this work could be performed by hydraulic machinery operating from a jack-up platform. In deeper water and in areas with a high tidal range such as the Solway the use of cranes and grablines may be required.

4.17.3.2 Piling Techniques

The method of installing piles would be determined generally by the ground conditions on the site. The site under consideration generally comprises dense sand of varying depth overlying a stiff clay containing some cobbles and boulders. It is therefore likely that piles would be either driven or augured/drilled and driven to the required depth.

Both of these operations can be carried out from a jack-up platform. Driving of piles has very little impact on the surrounding environment other than noise. However, it does have some disadvantages including:-:-

1. The act of driving will sometimes damage the pile head and the pile may not be driven truly vertical. In order to connect the tower, this could entail cutting the head level and true and prepping it for either welding on of a flange or direct welding of the tower. This problem was overcome at Utgrunden by using a sleeve, incorporating the tower connection flange that slid over the pile and could be adjusted to grade and level. Once in position the annulus between the pile and sleeve was grouted.

2. During pile driving, both lateral and vertical accelerations will be experienced. Any attachments to the pile will need to be designed for these forces or be retrofitted after completion of driving. This would include access ladders and walkways, anodes and J-tubes etc

If augering/drilling and driving then there is less likelihood of damage to the pile as the required driving energies are smaller. However, this method has the disadvantage of producing arisings from the drilling (see Section 4.17.4 below).

Figure 4.17.4 Drilling for installation of monopile foundation (Courtesy SeacoreLtd)

Should a particularly hard stratum be encountered at a relatively shallow depth then, particularly in the case of the monopile, it may be necessary to drill a hole into the hard stratum and to grout the pile into the hole. This method is more controlled than driving and it is usually possible to achieve the necessary construction tolerances in the one single operation. Very little damage would be caused to the pile as no driving is required and it is therefore possible to install the pile with all the necessary ladders and boat landings, etc already fitted.

4.17.3.3 Installation of Foundations

The installation of the remainder of the foundation structure would follow completion of the piling phase.

In the case of a monopile the extent of works required would depend on the accuracy of piling. It is likely that levelling would be required to achieve the tolerances necessary for installation of the turbine and tower. In the past this adjustment for tolerance has been achieved by providing a larger diameter sleeve around the upper ‘dry’ section of the monopile. Once this sleeve is in position the annulus between pile and sleeve is grouted to form a structural connection.

This method has the advantages of working completely above water and of a small construction weight thus minimising craneage requirements.

In the case of the multi-piled foundation a more complex operation is required. Most problematic is the fact that the connection to the piles must be made underwater. Underwater connections of this type have been used successfully in the offshore oil and gas industry and can be achieved by either the provision of a mechanical latching device, swaging or grouting.

It is anticipated that the foundation structure would be prefabricated on land and would be lifted into position as a single unit by a crane on a jack-up platform or ship. The unit weight is anticipated to be in the region of 250-350 tonnes and thus large cranes and barge would be required. The base would be lifted onto the piles and would be supported by temporary pile grippers or other temporary means. Once final levelling has been completed, the connection would then be made.

In the case of swaging or latching there are no potential impacts as these are mechanical fixing methods. If grouting, there is a possibility of some spillage of the grout material which would likely be of a cementitious nature (see Section 4.20).

4.17.3.4 Installation of Turbine Towers

Offshore wind turbines are most likely to be installed from either a jack-up barge or a floating crane vessel. The choice would depend on the water depth, the crane capability and vessel availability. The crane must be capable of lifting the structures with hook heights greater than the level of the nacelle to enable the tower and turbine assembly to be installed. Existing crane vessels have not been specifically designed for installing offshore wind turbines.

Usually turbines are erected as on land, i.e. first the tower in segments and then the nacelle and the rotor.

Figure 4.17.5 Installation of Rotor (Courtesy Seacore Ltd)

All installation methods have advantages and disadvantages. The decision will depend on assembly design, foundation structure, and site conditions and to some part on the approach adopted for maintaining the structures.

4.17.3.5 Cable Installation

The method chosen for cable installation is usually determined by the bed material present on the site and the degree of protection required. As stated in Sections 4.11 and 4.13 two possible methods of cable installation/protection are considered likely on the site under consideration.

1. Burying the cable in a shallow trench in the seabed sand sediments and providing adequate slack to accommodate changes in seabed level.
2. Installation of the cable to a greater depth by the use of directional drilling techniques.

Cable Burial

The method used to excavate trenches in which to bury cables would vary depending on the bed material. In the sands which are present on the proposed site this work would likely be carried out by fluidising the sand or by the use of a plough.

Both of these methods would cause minimal localised disruption to the seabed environment. Fluidising would raise some of the sediment into suspension, whilst ploughing would displace the sediment, position the cable and place the displaced material back into the original position. In both instances the amount of material excavated would be small (see Section 4.17.4 below).

Directional Drilling

Cables may be installed by the use of directional drilling techniques. This technique involves the drilling of a pilot hole to a predetermined depth and profile along which a hole is bored to the required diameter. The cable is then installed by pulling through the bored hole. Using this technique cables can be installed in the deeper more stable strata well below the mobile sediment zone, thus ensuring the cable would not be exposed.

4.17.4 SEDIMENT DISTURBANCE

The disturbance of sediment from the seabed would be limited to a few construction operations, namely:-

1. Bed preparation
2. Piling/augering
3. Cable laying.

4.17.4.1 Bed Preparation

Bed preparation would generally entail only minor levelling of the proposed turbine location to remove any sand ripples or sand waves that may be present. This work would be limited to a small area no greater than approx 1,200m^2 per multi-pile foundation and 100m^2 for monopile foundation and would likely be carried out by hydraulic excavators or cranes operating from floating plant. Sediment disturbance in this operation would be small as no excavation would be carried out, just local movement of the material on the seabed, to provide a level surface. The amount of sediment raised into suspension would be insignificant given the high degree of natural movement of bed sediments on the site.

4.17.4.2 Piling/Augering

The installation of piles would be likely to create sediment disturbance as it may be necessary to auger the piles in the dense sands and underlying stiff clays. The augering process would raise to the surface both the sands and clays. Quantities of material augered would vary depending on the type of foundation, but would probably be in the order of 150m^3 for multi-pile foundations and 550m^3 for monopile foundations. The relative quantities of sand and clay would depend on the sub-bed strata at each individual turbine location.

It is anticipated that the augered material would be allowed to deposit on the seabed in the vicinity of the turbine foundation.

It is likely that the clay arisings would settle very rapidly in close proximity to the pile position. Sands may stay in suspension for a longer period and settle over a somewhat wider area.

4.17.4.3 Cable Laying

Sediment disturbance would be almost nil in cable laying if the cables are laid by directional drilling techniques.

However if the cables are laid in trenches in the bed then there would be a greater likelihood of sediment disturbance. It is unlikely that trenches would be any deeper than 1.0-1.5m and thus the amount of sediment disturbed would be minimal. The amount of material raised into suspension would depend on the method of excavation but it is estimated that this is not likely to exceed approximately 0.3 m^3 per metre length of cable. This equates to approximately 8700 m^3 within the wind farm site and approximately 3600 m^3 on the cable route to shore.

4.17.5 OFFSHORE NOISE

Construction activities offshore would generate noise to varying degrees. Generally noise generated would be limited to engine noise and low level mechanical operations, with the exception of piles installation which would produce a higher level of noise above the sea surface.

The level of noise produced by pile installation would depend on the method of installation. Piles would be likely to be driven although some augering may be carried out to aid driving. The precise technique used would depend on the contractors method of working, the size and type of pile and the subsurface conditions.

Given the site conditions of dense sand overlying stiff clays the likely range of piling equipment which might be used is estimated as described below.

Foundation Type	Hammer Weight (tonnes)	Max Net Impact Energy Above Water (kNm)
Monopile	55	550
Mulitipile	25	220

Data from piling hammer contractors indicates that the piling operation may have a source sound power level of 137 – 165 dB L_{AmaxI} using the 'impulse' measurement time weighting, equivalent to approximately 121 – 149 dB L_{Aeq} , equivalent continuous sound level, depending on the net energy used, the type of ground condition and the pile size. The highest noise level would be for driving of monopiles without augering into the clay layer of the substrate where this is close to the seabed surface. Received noise levels at closest locations on land are predicted in Section 9.19 of this ES.

4.18 OPERATIONAL PHASE

4.18.1 LIFETIME OF PROJECT

The lifetime of the project would be 25 years from receiving building permissions to decommissioning. The foundations will be designed for this lifetime in terms of wall thickness of piles to take account of corrosive processes. Turbines are generally designed with a warranty life of 25 years for use on land, and similar 20-25 year warranties will be sought for turbines to be used at Robin Rigg. In order to ensure that the turbines continue to operate with acceptable availability (i.e. >95% online per turbine on average), regular maintenance and overhaul operations would be carried out at the site. In addition foundations would require monitoring and maintenance during the operational period to ensure that scour around the foundations is not greater than expected, and to check foundations for corrosion. Replacement of anti-corrosion anodes would also be required. These maintenance operations are outlined below.

4.18.2 MAINTENANCE OPERATIONS

The following maintenance operations would be carried out:

Foundations

- Replacement of sacrificial anodes. This would occur as and when required but would be approximately replacement at each turbine once every 15 - 20 years.

- Painting of the sections of foundation above water. Frequency of this would depend on the results of inspections during the operation and cannot be specified at this stage
- Inspection of seabed levels around foundation locations. This would be likely to occur annually following the winter. Should bed levels have reduced below a critical level, scour protection would need to be installed which itself would need periodic inspections.

Turbines

As offshore wind turbines, the turbines are designed to operate under minimal supervisory input. The turbines are monitored and controlled automatically by control systems within the turbine. should a fault develop in a turbine, the turbine would be automatically shut down. All information relating to on-site conditions, turbine status and generated output is held within a central Supervisory Control and Data Acquisition (SCADA) system linked to each individual turbine control system. The SCADA system would be downloaded, monitored and controlled remotely. Therefore the only requirement for visits to the turbines will be for planned maintenance visits and unplanned maintenance for repair of faults.

Turbines used at the site would be designed as offshore turbines. These would therefore require reduced planned maintenance visits of approximately one per year for each turbine. The maintenance operations would operate from a local port, most likely Workington or Silloth and planned maintenance visits would be spread over the months of good weather.

Substation

The switchgear within the substation may require a 10 yearly maintenance. The fuel tank for the diesel generator would need to be refilled following use, but use of the generator would be unusual.

While there will therefore be only minimal need for maintenance visits to the substation, it is likely to would be used as a facility to support maintenance on the turbines and foundations.

4.18.3 NAVIGATION RESTRICTIONS DURING OPERATIONAL PERIOD

Once the wind farm is operational, trawling and anchoring would be prohibited from the wind farm area for non-wind farm vessels. The exclusion area for trawling and anchoring is given in Figure 4.5.1 and is shown with reference to navigation channels in this area of the Solway in Figure 4.17.1 earlier.

In both cases, this would be to ensure that 33 kV cables within the wind farm area that have potential for periodic exposure during movement of the bank, would not be snagged and vessels or gear damaged. There would be a 50m exclusion zone around each structure for all non-wind farm vessels to ensure that unauthorised vessels do not make fast to the structures, which could be hazardous at certain states of the tide, currents and weather conditions. Signs on the turbine bases would make it clear that unauthorised boats may not tie up to the turbines. In addition information boards showing the layout, latitudes and longitudes of the turbines and exclusion zones for trawling and around turbines would be placed at all ports and slipways in the Solway. The same information would be given to local sailing clubs and fishermen's groups for distribution to members.

The 132 kV cable to shore would directional drilled under mobile banks and trenched in areas of stable sediment removing the risk of any exposure of the cable. There would therefore be no restrictions on anchoring or trawling in the vicinity of the substation to shore cable.

4.19 DECOMMISSIONING PHASE

It is likely that the proposed facility would have a lifespan of at least 20-25 years, although this may be extended should the turbines be upgraded or replaced.

The Oslo and Paris Convention (OSPAR) covers the North East Atlantic and North Sea and deals with the disposal at sea of any installations, full or in part, which are removed. The section of OSPAR that governs the disposal of offshore installations was reviewed in 1998, leading to a new regulatory framework, Decision 98/3, known as the Sintra Statement. This statement not longer permits the disposal of offshore structures at sea. Topsides of all structures and substructures and jackets of structures less than 10,000 tonnes are required to be completely removed and returned to shore.

It is impossible to know what regulations may be in place at the time of decommissioning and thus this discussion is based on current regulations. Similarly, accepted best practice methods of decommissioning will have been developed by the decommissioning date. These cannot be predicted in detail at this stage. In addition the detailed methodology of decommissioning and removal would be very much dependent on a number of factors such as availability of plant and vessels, working conditions, programme and the Contractors chosen method of working. However, it can be safely assumed that the decommissioning process would broadly approximate to the reverse of the installation procedure.

With regard to the foundation structures, it is likely that the turbine would be removed either in one operation for subsequent disassembly on shore, or in sections at the offshore site for ease of transportation. If the turbine were to be disassembled on shore then a foundation structure would be constructed on the quayside to temporarily support the structure during the dismantling process.

The foundation structures would be removed after disconnecting and pulling out the electrical cables. In the case of a monopile foundation it may be possible to remove the pile in one operation by the use of heavy lift cranes and a large vibrating hammer. One other option, subject to legislation in place at the time may be to cut off the pile below bed level to remove the upper section off site and leave the lower section in-situ below the level that could be uncovered by sediment transport movements. Leaving the lower portions in-situ may have environmental as well as cost advantages. All anti-corrosion anodes would be removed. Anemometers would be removed through similar methods to monopile turbines.

In the case of a multi-pile turbine foundation it would be necessary to remove the super structure before removing the piles. In this case the piles would be removed by crane and transported to land. The piles would then be dealt with as for a monopile.
The transformer platform would likely be dealt with in a similar manner to the multi-pile foundation, once the main items of electrical equipment are removed.

The method of dealing with the removal of cable would depend on the method used for installations. If the cables are buried at a shallow depth in sand they may be reeled out after excavation of the sediment, most likely by water jetting. Removal of the cables by this method would release some sediment into suspension but the amount would be small and would not have any significant impact. If however the cables were installed at a greater depth by directional drilling or have been buried by the natural sediment transport processes then removal would be very difficult without extensive and expensive works. In this case it is considered that the preferred option would be to cut the cables off below bed level and to leave them in-situ.

All materials removed to land from the site would be re-used, recycled or disposed of in accordance with the appropriate regulations and best practice in force at the time.

4.20 POTENTIALLY POLLUTING SUBSTANCES

The construction and operational phases of the wind farm development would involve the use of potentially polluting substances. These are described below.

4.20.1 CEMENTITIOUS MATERIALS

In the case of both multi-pile and monopile foundations it is possible that cementitous grout would be used to form the connection between the piles and the main structure. This technology is well developed, however when grouting, especially underwater, the possibility of spillage exists. The volume of grout required to make connections would vary depending on the base type. For a single foundation, the quantity required would be in the range of $3.5m^3$ (multi-pile) to $12m^3$ (monopile). Grouting operations can generally be accurately controlled and as such potential spillage volumes would be small.

4.20.2 CORROSION PROTECTION

It is likely that the sections of foundations projecting above water level would be provided with a coating in order to protect against corrosion. This would likely be epoxy or polyurethane, would be applied onshore and would be allowed to harden prior to installation.

In the case of a multi-pile foundation, which would be fabricated on land prior to installation, the underwater sections of the structure would most likely be protected by the provision of sacrificial aluminium anodes.

Aluminium anodes comprise approx 94.9% to 99.2% aluminium which is emitted over the lifetime of the anode. The amount of emissions would depend on the number of anodes used, the precise composition and the lifetime of the structure. For a multi-pile foundation structure for an offshore turbine the total weight of anodes used would likely be in the order of 3000kg –4000 kg which would be active for a period of between 15 to 25 years. Therefore for a single foundation the rate of emission of aluminium would be in the range 120 kg/yr to 260 kg/yr. For the total wind farm development the rate of emission would be in the order of 7200 kg/yr to 15600 kg/yr.

In the case of a monopile foundation, the provision of anodes is not always the preferred solution as forces generated during pile driving can damage anodes fixed to the structure before installation. In this case corrosion protection may be achieved by providing an additional thickness of steel over that required for structural strength. This sacrificial layer would corrode over the lifetime of the structure and would lead to emission of steel into the surrounding environment. The amount of emissions would depend on the rate of corrosion and the lifetime of the structure, but would be insignificant. Should anodes be attached to monopile foundations following piling the approximate weight required per foundation over a 15-25 year lifetime would be 1000 kg giving an annual release of aluminium from the whole wind farm of 2400 kg to 4000 kg per year.

4.20.3 ANTI-FOULING

Toxic anti-fouling paints containing TBT have been widely used to prevent marine growth on ship hulls and marine structures. However, these paints have been found to cause environmental damage to non-target organisms. It is not envisaged that any anti-fouling measures would be employed on the proposed foundation structures.

4.20.4 OILS AND LUBRICANTS

Potentially polluting substances would also be used by construction plant of particular relevance being oils and hydraulic fluids. Measures would be taken on working platforms such as barges and jack-up platforms to ensure that spillages are contained and that no such material is allowed to discharge into the sea Biodegradable mineral oil would be used in hydraulic machinery.

During the operational phase of the wind farm significant amounts of oil would be present on the transformer platform both in the transformers (60,000 to 80,000 litres) and in a storage tank for the diesel generator. These and other oil receptacles would be fully bunded to ensure the containment of any spillages. Oils from spillages would be removed to land for disposal in accordance with relevant regulations.

4.20.5 GENERAL REFUGE/SEWAGE

General refuge, waste water and sewage would be generated on working platforms and service vessels, etc. All such material would be removed to land for disposal.

4.21 EMPLOYMENT PROFILE

Construction Period

A contractor who recently prepared a detailed bid for another UK offshore wind farm, in which the program envisages construction and commissioning of a 30 turbines, cables and an offshore sub-station during a single 6 month construction season, have estimated peak employment at around 100-120. They estimate that about half these workers would be hired locally.

The Robin Rigg project would therefore be likely to employ similar numbers during two construction seasons working from the construction port which is likely to be Maryport, Silloth, Workington or Barrow-in-Furness.

Operational Period

During the operational lifetime of the wind farm there would be a need for a permanent staff of 5 equivalent full time technicians and administration staff. The technicians would be stationed onshore in close proximity to the wind farm and close to a harbour. The administration staff would be likely to operate from the same office.

During planned maintenance and servicing operations on the turbines, foundations and offshore substation there would be a need for an additional maintenance crew of around 10 personnel to support the core technical team. These would be most likely to be brought in from further afield but housed in the vicinity for the planned maintenance periods.

Section 5

EIA Methodology

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Section 5

EIA Methodology

5.1 OVERVIEW

Essentially two separate assessments have been carried out in the process of site selection and design of the Robin Rigg wind farm. The first of these was a very broad assessment of potential sites around the coast of the UK for offshore wind farms for the first round of applications to the Crown Estates for erection of wind monitoring masts. This continued during the monitoring period to confirm whether or not the general site was potentially suitable for wind energy should the wind monitoring demonstrate a high enough wind speed. This process has been described in Section 3.3 of this ES. Following confirmation that this broader area of the Solway was potentially technically suitable for a wind energy development that could have acceptable environmental effects, the main EIA process was begun, running hand in hand with the finer site selection and design process. The full EIA followed a methodology based on a number of guidance documents including in particular Planning Advice Note 58: Environmental Impact Assessment.

The process of environmental assessment was as follows:

1. ***Development Characteristics*** initial description of broad construction and operational characteristics of an offshore wind farm
2. ***Scoping of EIA*** initial scoping process to identify sensitive environmental and human receptors that could potentially be affected by the characteristics identified in stage 1.
3. ***Gathering of Existing Data:*** collection and collation of existing literature and data for the general site area
4. ***Baseline Surveys*** identification and consultation on nature and extent of further baseline study to gather data to identify/confirm the technical constraints of the site and attributes of the environment that may be potentially affected by the proposal. Carrying out the agreed surveys.
5. ***System Understanding and Developing Assessment Processes*** development of understanding of interactive physical and ecological systems. Consultation and determination of methodology and models for prediction of negative and positive effects within each study area taking into account interactions within systems.
6. ***Site Design and Mitigation:*** identification of preferred site layout and initial site design; initial assessment of effects and where necessary, further design iterations and assessment of mitigation measures to avoid, minimise and mitigate against adverse effects arising from the proposal.
7. ***Determination of Significance of Residual Impacts*** estimation of the magnitude of any residual effects following inclusion of all mitigation measures into the site design and choice of construction operations, and assessment of the "significance" of these residual effects.

The scoping exercise in Stage 2 of the process, was an ongoing process that was continued during Stages 3 to 5, being further expanded or refined following the findings of those stages.

The EIA process for the wind farm proposal outlined above will now be described in more detail.

5.2 STAGE 1 - DEVELOPMENT CHARACTERISTICS

The important characteristics of the development including construction and operation were defined through a knowledge of existing operational onshore and offshore wind farms, expected turbine technology improvements by the predicted time of construction, and construction experience from older offshore technologies including undersea cables and oil technology.

Important characteristics of the development were considered to be:

- Turbine size and number
- Foundation type and installation requirements
- On-site cabling type and installation
- Offshore substation size, materials use and installation
- Wind farm to shore cabling design and installation
- Onshore grid connection
- Time scale of construction and decommissioning periods
- Lifetime of wind farm

Alternative foundations, turbine types, turbine layout and other characteristics of the development are described in more detail in Section 3 of this Statement. These were all considered as potential characteristics of the development for the purposes of the initial scoping stage.

5.3 STAGE 2 - SCOPING OF EIA

The nature of environmental and social effects can be divided into a number of different categories. Firstly there are categories of environmental and human receptors i.e. marine plant and animal communities above and below the seabed surface, migratory fish, wintering bird populations, tourists, coastal settlements, fishermen etc. that may be affected. Then there are the various stages and components of the wind farm proposal which may have differing characteristics with relation to the environment i.e. the construction, operation and decommissioning stages, and the turbines, power cables, transformer etc. as separate components of the proposed development.

Scoping exercises were undertaken to identify the environmental effects that could result from a development with the characteristics defined during Stage 1 of the process, with reference to the environmental receptors specific to the area in the vicinity of the proposal. An essential part of this involved ascertaining what these sensitive environmental receptors were for the site and its surroundings.

Research commissioned by the DTi and guidance documents issued for the assessment of offshore wind energy developments in the UK by government agencies and NGOs, provided the core elements of the scope of EIA for the Robin Rigg wind farm proposal. The following documents were used as guidance for the types of effects associated with offshore wind farm development:

- ***Metoc Plc (2000)*** An Assessment of the Environmental Effects of Offshore Wind Farms. ETSU W/35/00543/REP
- ***Countryside Agency (under review)*** Model Scoping for an Offshore Wind Farm Environmental Statement
- ***SNH (pers. comm.)*** Solway Firth Potential Offshore Wind Farm Environmental Statement Content
- ***Greenpeace (2000)*** North Sea Offshore Wind – A Powerhouse for Europe. Technical and Ecological Considerations.
- ***Countryside Council for Wales (2001)*** Best Practice Guidance on Seascape Assessment. CCW/University College Dublin
- ***ETSU (2001)*** Assessment of the Effects of Noise and Vibration from Offshore Wind Farms on Marine Wildlife. ETSU W/13/00566/REP. Centre for Marine and Coastal Studies. Liverpool University.

In order to identify the environmental receptors specific to the Solway Firth, a number of specialist pre-consultation groups were set up by Natural Power which engaged in regular scoping and later survey methodology discussion meetings. The four separate groups covered the following theme areas: landscape, ecology, commercial fishing and economic development and tourism. 40 stakeholders were invited to form these groups of which 25 attended meetings. A list of theme group stakeholders are included in Appendix A in the volume of appendices. Theme group meetings were invaluable in informing the detail of the scope in the particular theme areas.

In addition to the theme group meetings, a wider group of government agencies, NGOs and private companies providing important services and owning infrastructure that might be present in the Solway were consulted in writing with an overview of the area of interest and the type of development proposed. A full list of those consulted in this process is given in Appendix B in the volume of appendices. Planning documents from Dumfries & Galloway and Cumbria Councils were also examined for sensitive receptors in the coastal areas of the Solway that were assigned a degree of sensitivity through policy i.e. National Scenic Areas, Regional Scenic Areas, SSSIs etc.

Further sources for the scoping exercise were the Environmental Statements for the Horns Rev and Rødsand offshore wind farm proposals in Danish waters and monitoring data and experience from existing small offshore wind farms at Vindeby and Tunø Knob in Denmark and individual offshore turbines in Sweden.

A scoping document giving the scope of the EIA and the content of the planned Environmental Statement based on the findings of the activities and research described in the paragraphs above, was drawn up and submitted to the Scottish Executive. The Scottish Executive subsequently circulated the scope to consultees that it considered relevant. Comments from these consultees led to revision of the scope of the EIA where appropriate.

The scoping exercise continued throughout the EIA process, particularly during the collection of baseline data as outlined below. The baseline surveys informed on the process firstly through collection of environmental data that providing greater knowledge of the environmental and social receptors present in the area, and secondly through geophysical and hydrographic surveys providing the detail of the physical environment and allowing a better understanding of the necessary characteristics of the development in terms of foundation design and construction techniques, cable laying option and sediment dispersal.

5.4 STAGE 3 - GATHERING OF EXISTING DATA

A number of existing data sources were collected and reviewed prior to the initiation of survey work targeted directly on gathering data for the EIA of the proposal. It was understood that existing data sources would in most cases be unlikely to provide sufficient data alone to use in the EIA but would provide a valuable initial stage with which to form methodologies for further survey.

Existing data sources that were reviewed included:

- The Solway Firth Review (1996) by the Solway Firth Partnership documenting and summarising all information available on the state of resource use throughout the Firth
- Historical bathimetric charts from 1887 and 1932
- Aerial photographs of the Solway Firth at a scale of 1:25000 (1997)
- Borehole data from 3 boreholes carried out prior to the erection of the wind anemometry mast in 1999
- Several studies of intertidal and shallow subtidal habitats in the Solway Firth including qualifying habitats in the Solway European Marine Site Monthly
- Trawl surveys carried out in the Solway area during the 1970s
- PhD fish surveys in the Irish Sea and Solway Firth in the 1990s
- General Irish Sea fish surveys
- Data on salmonids from various sources including Eden Rivers Trust, the West Galloway Fisheries Trust and the Cumbrian Sea Fisheries Committee
- The Solway Shark Watch and Sea Mammal Survey (SSW&SMS) sightings program, which holds data between 1938 and 2002 with the majority of data relating to the last few years
- Sea Watch Foundation 'abundance' plots for sea mammals in the northern Irish Sea
- The JNCC Coastal Directories Project, Region 13 report providing a comprehensive description of the coastal margin, its habitats, species and human activities from Colwyn Bay to Stranraer.
- The Wetland Bird Survey 1999-2000 Wildfowl and Wader Counts published by the British Trust for Ornithology, the RSPB and the JNCC
- JNCC's Seabird Colony register. This work was initiated as Operation Seafarer in 1969-70, and has been updated on annual basis since 1984, the most recent summary published in 1991
- High tide waterfowl counts from 2000/01 and 2001/02, low tide waterfowl counts from 2000/01 and 2001/02, and additional offshore bird records extracted from the reserve log for the RSPB reserve at Mersehead.
- Data from seabird observations carried out in the mid Solway by Peter Ullrich of the Cumbria Bird Club from 1990 through to 2001
- A landscape character assessment of the Dumfries and Galloway region carried out in 1998 by Scottish Natural Heritage, in partnership with the local authority and other agencies

- A landscape character assessment of the Cumbria region carried out in 1995 by Cumbria County Council
- The Sites and Monuments Record (SMR) maintained by Cumbria County Council
- The National Monuments Record (NMR) (including the maritime section of the NMR) maintained by English Heritage
- The UK Hydrographic Office (UKHO) wrecks record
- historic maps and general information on the history of the Solway obtained from Record Offices in Carlisle and Dumfries.
- The Local Studies Collections in Maryport and Dumfries giving information on Solway shipwrecks within the Solway, and the general maritime history of the area.
- Information on seabed cables from the UK Cable Protection Committee
- A list of all microwave links starting or ending within 50 km of the proposal from the Radiocommunications Agency, with transmitter and receiver grid coordinates and broadcast frequencies.

Detail of the existing data sources and coverage are presented within the baseline conditions Sections 6 to 8 of this ES.

5.5 STAGE 4 - BASELINE SURVEYS

Baseline surveys were carried out by specialist consultants in a number of different study areas following methodologies agreed with independent stakeholders. These were aimed at gathering sufficient data to form a picture of the current status of environmental, social and physical elements in the vicinity of the proposal, filling in any gaps in existing historical data. The ultimate aim was to allow the prediction of the potential effects of a subsequent detailed development proposal upon these physical, environmental and social elements.

Methodologies and extent of studies were developed in consultation with theme groups and individual stakeholders to ensure the most appropriate techniques. The baseline studies and surveys have been coordinated to ensure that where they study separate elements of interacting systems, the methodologies and extent are compatible with one another and provide common data that allow the description and understanding of those systems. This then allows the prediction of second or third stage indirect effects of the wind farm development on sensitive receptors as well as direct ones. This has been particularly important in studies of the marine ecology where separate studies have been carried out on individual system elements including benthic and epibenthic communities, wintering and breeding birds, and resident and visiting sea mammals. Each of these communities interact within the ecosystem and therefore study areas covering these elements overlapped both within the immediate area of the wind farm and also in areas outside where for example, there were important populations of wintering birds.

Baseline survey methodolgies and coverage are described in detail in Sections 6 to 8 of this Statement.

Baseline surveys carried out specifically for the Robin Rigg wind farm design and environmental assessment have included:

- Multibeam echo sounder bathymetry (water depth) surveys in August and September 2001 across the full extent of the licence area and extending beyond into the surrounding area. Repetition of these surveys in the wind farm potential area between 26th March and 4th April 2002
- Borehole surveys at 11 sites on the Robin Rigg subtidal bank giving information on subsurface sediment to a depth of over 30 m
- Bathimetric surveys along the proposed cable route to land in March 2002
- Shallow seismic survey across the wind farm site giving an indication of sediment patterns down to 83 m.
- Sidescan sonar and magnetometer survey giving information on obstacles and potential boat remains of archaeological interest on the seabed and metallic features buried beneath the sea bed
- Wave energy recordings at two fixed points measuring wave energies and directions for three weeks in Oct/Nov 2001
- Recording of current flow within the proposed development area and in the surrounding waters by two recording current meters and by direct current metering at two further locations over various periods between November 2001 and March 2002
- Surface sediment analysis of grab samples in 1113 sample sites within the potential wind farm area and in control areas outside of the wind farm area at Robin Rigg and Two Foot Bank, and along the 132 kV cable route corridor
- Comprehensive benthic flora and fauna sampling at the same sampling points as the surface sediment sampling positions
- Benthic trawl sampling along transects to the north to northwest of the wind farm site within the area with consistently high populations of common scoter in March 2002, analysed for biomass of bivalves and other food sources for Common scoter
- An intertidal Phase 2 habitat walkover survey in February 2002 along a transect from high water springs to low water springs at the landfall site for the 132 kV wind farm to shore cable.
- Monthly fish trawl surveys within the wind farm site, in control areas and within the common scoter area since October 2001
- Boat based twice-monthly bird surveys across a wider survey area containing most of the mid Solway area, since May 2001
- Aerial monthly bird surveys along transect lines 2 km, across the same area as the boat based surveys from November 2001 to April 2002 (January and February impossible due to weather conditions)
- A landscape and seascape character assessment of the area within 35 km of the site using the published Scottish Natural Heritages Landscape Character Assessments for Dumfries & Galloway and Cumbria County Council's Landscae Character Assessment for Cumbria supplemented by site visits by the specialist landscape assessor for the landscape assessment, and full field survey for the seascape assessment

The coverage of the biological survey areas, sample points and transects are shown in Figure 7.2.1 in Section 7 of this ES.

5.6 STAGE 5 - SYSTEM UNDERSTANDING AND DEVELOPING ASSESSMENT PROCESSES

Following the analysis of baseline studies and surveys a better understanding was gained of the interaction of physical and marine biological elements. The corresponding need for an integrated approach to prediction of effects of the wind farm was recognised from the beginning and was initiated through the coordination of integrated baseline surveys. It was continued into the impact assessment stage starting with an initial meeting between the various specialist assessment consultants covering the different interacting physical and biological elements.

At this meeting and during following correspondence each specialist defined what they would require from the other specialists both in terms of baseline analysis and prediction of effects. It was understood that physical impact assessments had no requirement for data from the biological specialists. The physical processes including sediment transport and suspended sediment modelling required only physical baseline data including hydrographic processes, sediment analysis and construction processes and description of the elements of the wind turbine foundations. The biological assessments, however, required the predictions of sediment transport and effects as a primary input. Similarly the fish and the ornithological assessments required predictions of the direct and indirect effects of the development on the benthic communities, while the sea mammal impact assessment had the findings of the fish assessment as an input. Potential secondary and tertiary indirect impacts arising from interactions between systems during the construction and operational period of the wind farm are given along with the direct potential primary impacts in Section 9.2 and 9.3 of this ES.

5.7 STAGE 6 - SITE DESIGN AND MITIGATION OF IMPACTS

The baseline studies and surveys and initial impact assessments identified technical constraints and more sensitive environmental receptors within the environs of the Robin Rigg bank. The goal of site design was to design a wind farm within the boundaries of technical and economic constraints that would avoid any unacceptable environmental impacts. The initial process of site selection took account of broad environmental and technical constraints in the early stage of the project, both around the coastline of the UK and within the environs of the Solway Firth. This is described in Section 3 of this Statement. Following acceptance by the Crown Estate of the lease area bid for the Robin Rigg wind farm, there remained an allowance of movement of the boundary area by 50%. This allowed room for movement of elements of the wind farm to take account of technical and environmental considerations, two principle technical considerations being water depth and wind capture. Project design comprised a process of identification of preferred areas within the allowed wind farm area, selection of turbine layout patterns from a number of considered options, and selection of the most appropriate construction techniques for the various elements of the development from the various options available. Selection of these broad and more detailed options was principally guided by the technical and environmental considerations and constraints identified by the baseline studies, and by economic considerations, and in some cases required a balance between these considerations. An example of this balance is described in Section 3.5 of this ES. Following initial visual assessment of a number of alternative layouts, the layout considered to be most visually acceptable was selected for the development, despite having a lower energy output and therefore economic return than the other alternatives considered.

Further mitigation measures were incorporated into the design as environmental assessments were developed, and the more significant impacts were identified. The design process continued until it was considered by the developer and specialist consultants that the most appropriate wind farm design had been developed. The results of further consultation with the Scottish Executive, written consultation with statutory and non-statutory consultees, and specific theme consultation group meetings guided the design process. In this way the proposal presented here can be seen to have incorporated mitigation measures directly into the design process and the findings and conclusions of the environmental assessments reflect the incorporation of those measures.

The site design process, including a description of the technical and environmental considerations for the site and a description of the design alternatives that preceded the final proposal, are described in Section 3 of this Statement.

5.8 STAGE 7 - DETERMINATION OF SIGNIFICANCE OF RESIDUAL IMPACTS

Once a final design had been adopted which mitigated against environmental impacts of the proposal through design and definition of construction techniques, the specialist consultants assessed the residual environmental impacts of the proposal through the integrated analysis described earlier. When undertaking these assessments a common outline methodology was adopted wherever possible, in order to come to a view on whether or not specific potential effects were “significant” with reference to the Electricity Works (Environmental Impact Assessment) (Scotland) Regulations 2000.

While some of the individual assessments evaluated significance of impacts using the exact definitions given in the outline methodology, a number of key assessments adapted the outline methodology to suit the environmental and social receptor being assessed. This occurred in some cases, for example, the benthic assessment where ‘recoverability’ was considered to be a key factor that needed inclusion within the evaluation of significance.

The basic outline methodology for assessing significance was developed after consideration of:

- The Department of the Environment Planning Research Programme’s *Preparation of Environmental Statements for Planning Projects that Require Environmental Assessment - A Good Practice Guide* (HMSO, 1995);
- *Planning Advice Notes 58: Environmental Impact Assessment:* the Scottish Executive (1999);
- *Guidelines for Landscape and Visual Impact Assessment*: The Institute of Environmental Assessment and the Landscape Institute: (E & FN Spon, 1995).

- *Interim Landscape Character Assessment Guidance* – Countryside Agency / Scottish Natural Heritage (1999) updated and published in April 2002.

In determining the significance of a potential residual effect, the magnitude of the change arising from the proposal is correlated with the 'sensitivity' of the particular environmental attribute under consideration. Magnitude of change is evaluated in accordance with the definitions set out in Table 5.8.1 below.

Table 5.8.1: Definitions of "Magnitude" of Effect

HIGH	Total loss or major alteration to key elements/features of the baseline (i.e. pre-development) conditions
MEDIUM	Partial loss or alteration to one or more key elements/features of the baseline (i.e. pre-development) conditions
LOW	Minor shift away from baseline (i.e. pre-development) conditions
NEGLIGIBLE	Very slight change from baseline (i.e. pre-development) conditions

Where applicable in carrying out individual assessments, a scale of increasing 'sensitivity' of the environmental or social receptor is defined. This may be defined in terms of quality, value, rarity or importance to other elements and be classed as "Low", "Medium", or "High". For certain assessment areas, guidance can be taken from value attributed to elements through designation or protection under law i.e. landscapes or ecological resources given various levels of protection under planning law. Where assessment of this nature has taken place, the correlation of magnitude against 'sensitivity' determines a qualitative expression for the significance of the effect. This is demonstrated in the following matrix.

Table 5.8.2: Significance Matrix

MAGNITUDE OF EFFECT			
HIGH	Moderate	**Moderate/Major**	**Major**
MEDIUM	Low/Moderate	Moderate	**Moderate/Major**
LOW	Low	Low/Moderate	Moderate
NEGLIGIBLE	Negligible/Low	Low	Low/Moderate
	LOW	**MEDIUM**	**HIGH**
	'SENSITIVITY' OF RECEIVING ELEMENT		

Although significance is usually assessed in terms of varying degrees, those effects indicated as major and moderate/major are likely to be regarded as being equivalent to *"**significant effects**"* when discussed in terms of The Electricity Works (Environmental Impact Assessment) (Scotland) Regulations 2000. Following the iterative design process identified earlier, the significance of each effect would be confirmed or reassessed.

The significance of the effect may also need to be qualified with respect to the scale over which it may be felt; for example International, National, Regional or Local. The significance of an effect may also be affected by its duration, for example the length of the construction period, and by its reversibility i.e. the degree to which a site could be returned to its baseline conditions following decommissioning.

Where possible, each of the key impact assessments in Section 9 of this Statement has been formulated in this way, giving an evaluation of the magnitude, 'sensitivity' and significance of residual impacts following the implementation of stated mitigation measures.

Section 6

Baseline Conditions – Physical Environment

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6.1 BATHYMETRY

6.1.1 EXISTING DATA

Current and historical admiralty charts were available for the Solway Firth area and these were used to determine historic changes in seabed level. Three relevant charts were used for the years 1887, 1932 and 2001.

The 2001 admiralty chart used (scale 1:100000) shows the depths of the seabed in meters reduced to Chart Datum, which is approximately the level of the Lowest Astronomical Tide. The chart did not include the Inner Solway area. The 2001 chart is based on historical surveys with some corrections using limited recent measurement. For this reason it was considered that further bathimetric survey of the area of interest would be needed.

The 1932 admiralty chart contained soundings in the vicinity of Workington Spoil Ground. The soundings were reduced to 13.0 feet below Ordnance Datum (Newlyn), which is the land levelling system for Great Britain. The soundings were in Fathoms (~ 1.83 metres).

The charts for 1932 and 2001 are referenced to a co-ordinate system. They also contain important data about current streams for different locations for neap tide and spring tide for one tidal cycle (6 hours before and after High Water) and for specific current directions.

The 1887 chart contained no coordinates. Three reference points were chosen in order to compare this chart with others, these were:

6 Maryport – Saint Mary Church - 3°30'0''W °42'54''N
7 Aird's Hill - 3°50'54''W 54°49'11''N
8 Southerness Point - 3°36'6''W 54°52'16''N

Aerial photographs of Solway Firth were also available at a scale of 1:25000 (1997).

6.1.2 SURVEY METHODOLOGY

Bathymetry (water depth) readings were taken in August and September 2001 across the full extent of the licence area and extending beyond into the surrounding area as indicated in Figure 6.1.1. Limited surveys were also undertaken in the Inner Solway Area in December 2001 for the purposes of hydrodanamic modelling of the Solway. Surveys were carried out along the proposed cable route to land in March 2002.

In addition the area proposed to be used for the siting of turbines was re-surveyed between 26th March and 4th April 2002 in order to determine changes in bathymetry over the intervening period of winter storm activity. The extent of all surveys are indicated on Figure 6.1.1 below.

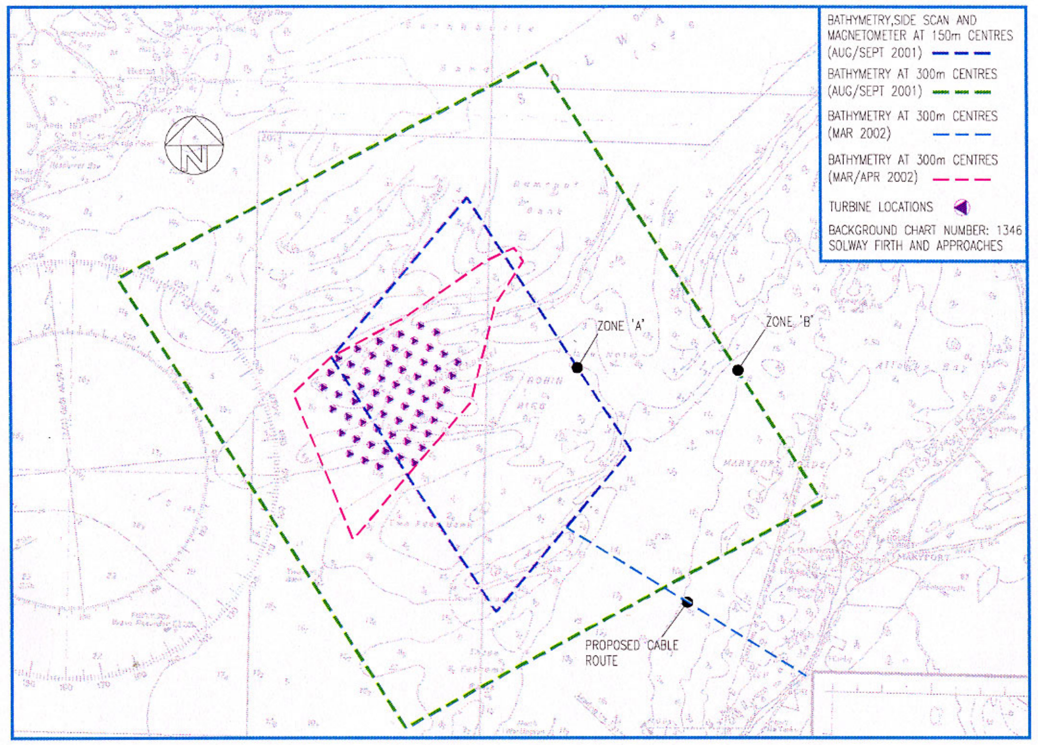


Figure 6.1.1 Extent of bathymetric surveys

Soundings were recorded in lines in two orthogonal directions at 150 m spacings in area A. Readings were recorded in orthogonal lines at 300m in spacings in Area B. The survey of the Inner Solway area comprised transects at regular intervals across the estuary and also along the main channels. The cable route survey comprised three longitudinal survey lines along the length of the proposed route. The re-survey of the development area was undertaken in lines in one duration only (N-S) at 300m spacings. Cross runs (E-W) were recorded at 900m centres for checking purposes.

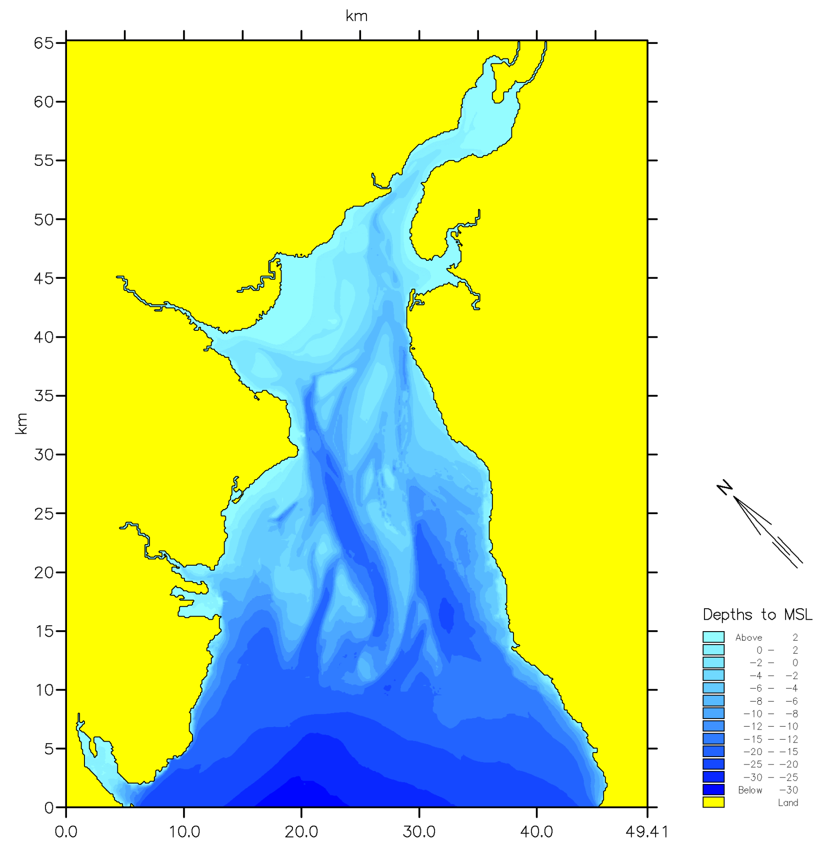
Depths were obtained by digital Raytheon DE719 echo sounder, which was calibrated by the bar check method. Depths were logged to Hypack survey software in tandem with position. All bathymetric measurements have been given in figures as distances below Mean Sea Level (MSL).

Tides were measured at Workington, using a Valeport 740-model tide gauge. Tidal height was recorded at intervals of 5 minutes. A Temporary Benchmark (TBM) alongside the tide gauge was used as a reference point to carry out regular calibration checks of the tide-gauge. This TBM was located just outside Workington lock gate at a level of 6.66 m OD.

6.1.3 SURVEY RESULTS

The survey results for the three survey areas are illustrated in Figure 6.1.2 below.

Figure 6.1.2 Results of bathymetric surveys



The results of the first wind farm area survey indicates the depth of water to Chart Datum (CD) across the proposed wind farm development area is generally in the range of 0 m to 5 m. At the south-western corner the depth does increase to a maximum of 9 m although this is only over a small area.

6.2 HYDROGRAPHY

6.2.1 WAVE ENVIRONMENT

6.2.1.1 Offshore Wave Data

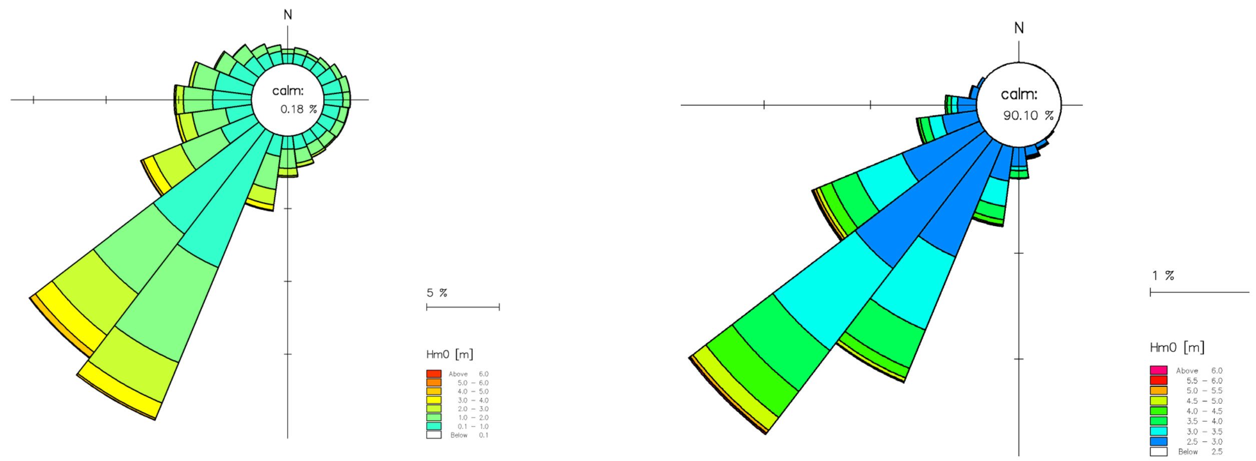
There was no significant data set of waves recorded previously on site. Thus, offshore wave data from the United Kingdom Meteorological Office Western European wave model was used for this project.

The UK Meteorological Office wave model, which covers the whole of the Atlantic and Coastal waters of Western Europe, was used as a source for 3 hourly annual wave and wind records. The 3 hourly data includes wind wave and swell wave components in the form of the Significant Wave Height, Mean Wave Period and Mean Wave Directions. Wind speeds and directions are also included in the data set.

10 years of data for the period 1992 until 2001 for a point 54.50°N, 4.06°W was used as an offshore data set.

This data set is shown in the form of wave climate roses which show the frequency of waves coming from a particular direction for different ranges of wave heights. The wave rose shown in Figure 6.2.1 reflects the distribution of all the waves during an average year. Figure 6.2.1 also shows the wave for larger wave events where wave heights above 2.5 meters. This rose shows that the larger waves come mainly from the southwest directions.

Figure 6.2.1: Wave roses



Annual Average Wave Rose – All Waves

Annual Average Wave Rose – Hs.2.5m

The offshore wave data was also used to calculate the annual variation in the significant average wave height for every year from 1992 to 2001 as shown in Table 6.2.1.

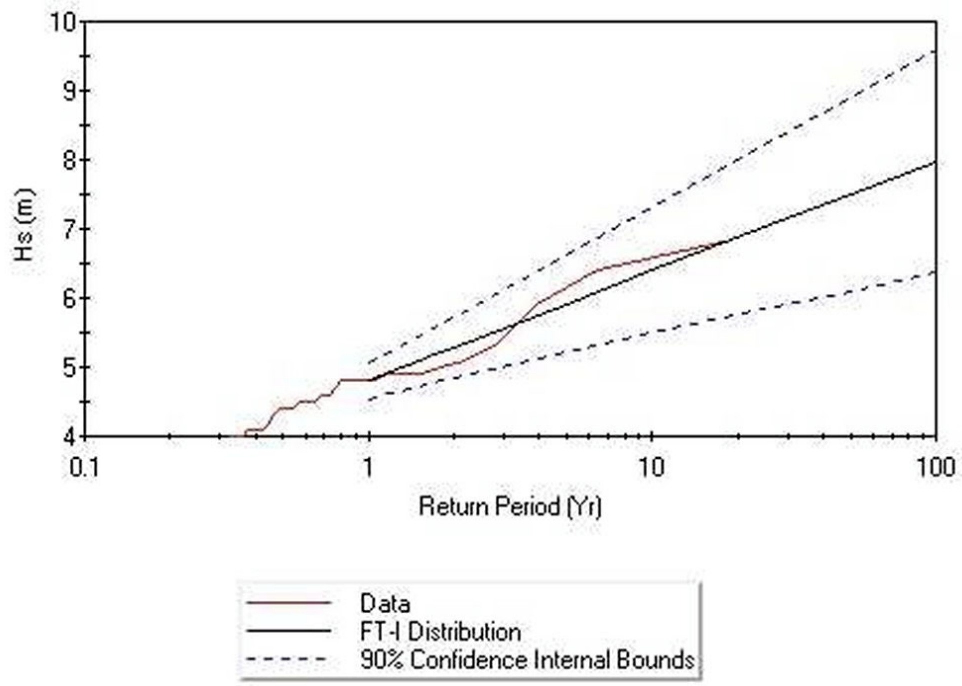
Table 6.2.1: Mean yearly significant wave height

Year	Mean Significant Wave Height (m)
1992	1.26
1993	1.23
1994	1.35
1995	1.2
1996	1.11
1997	1.16
1998	1.27
1999	1.27
2000	1.24
2001	1.00
Total year	**1.21**

The 10 year data set of 3 hourly wave data was used to estimate the extreme wave conditions for a variety of storm return periods. The analysis was undertaken using both Fisher-Tippet and Weibull distributions.

Extreme wave heights were calculated for waves coming from compass directions 226° and 255° for return periods up to 100 years. In this case Fisher-Tippet I distribution provided the best fit for the data as illustrated in Figure 6.2.2

Figure 6.2.2: Results of extreme wave analysis
Extreme Wave Analysis 226° – 255°



As the coastal processes are strongly influenced by wave height, an analysis was carried out on winter periods when wave conditions are more likely to occur.

Figure 6.2.3 shows the average significant wave height for every winter period from year 1992 to year 2002. The graph shows that the wave height average is reasonably constant over the winters (around 1.6 metres). The winter 2001-2002 did not differ significantly from the previous winters.

Figure 6.2.4 shows the time series of the wave height, period and mean wave direction for year 1994-95 (stormy winter), year 1995-96 (calm winter) and year 2001-2002 (period during which bathymetric surveys were undertaken).

Figure 6.2.3: Average Significant wave height 1992 to 2002

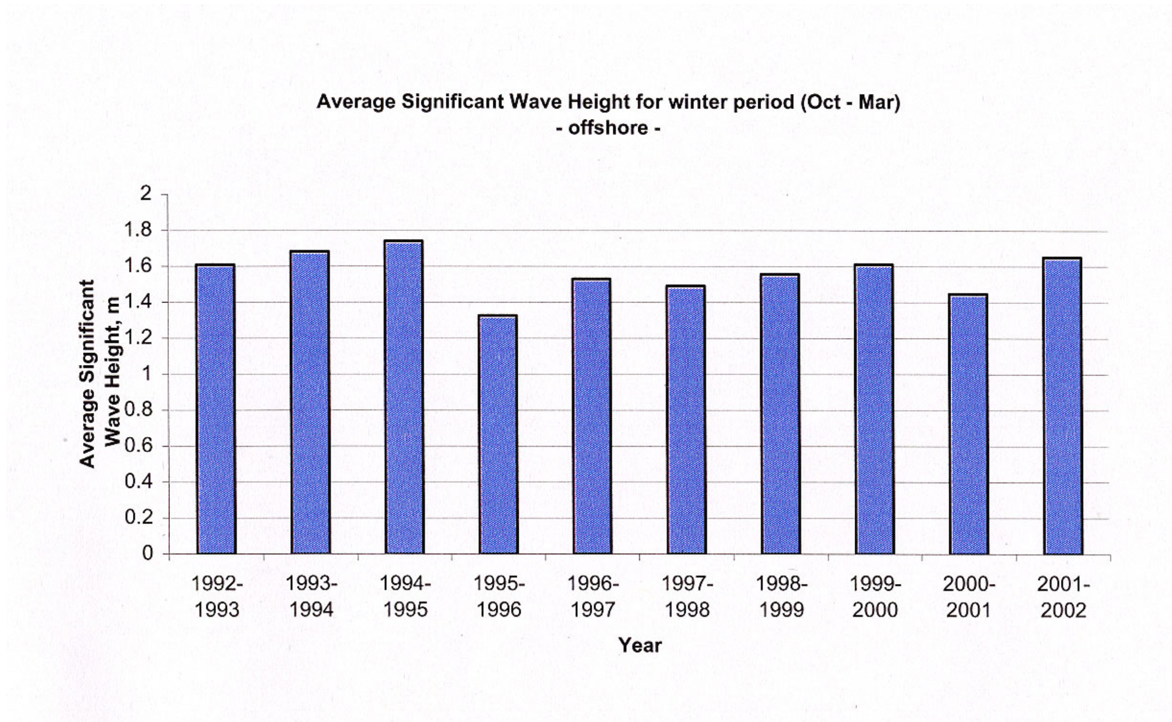


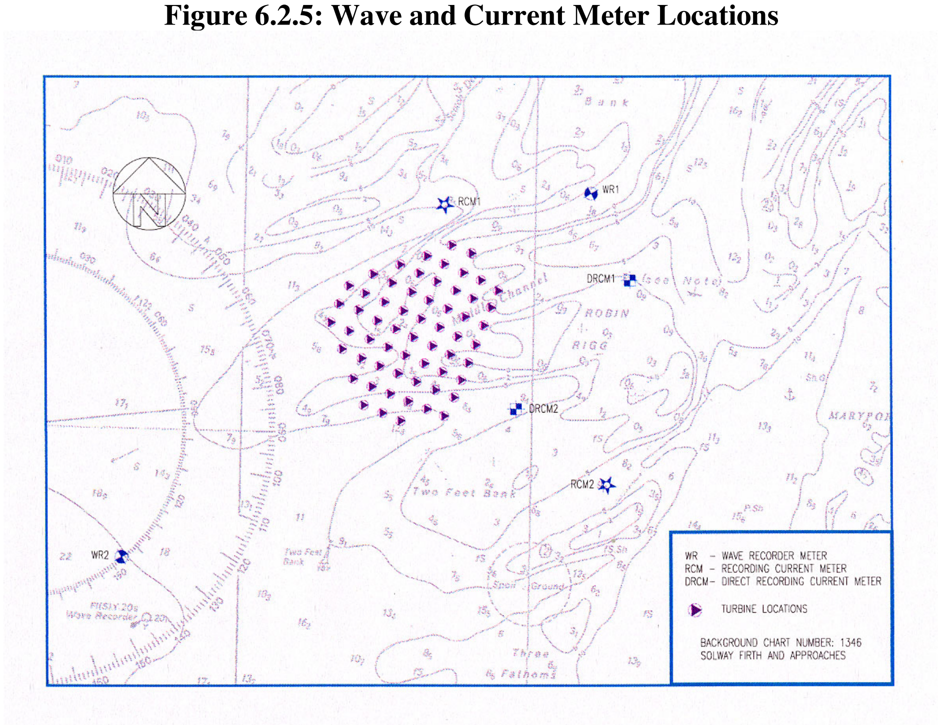
Figure 6.2.4: Time series of wave height, period and mean direction 1994-1995, 1995-96 and 2001-2002

Offshore wave data time series (winter 94/95) | **Offshore wave data time series (winter 95/96)** | **Offshore wave data time series (winter 01/02)**

6.2.1.3 On-Site Wave Measurement

Two Valeport 730W wave meters were deployed on the seabed at the positions indicated on figure 6.2.5 and as detailed below. The recorders were on the SW and NE sides of the banks in order to determine the attenuation of the major storm waves across the bank.

Figure 6.2.5: Wave and Current Meter Locations



The wave recorder positions and recording periods were as follows:

Station: WR1	
Location:	293790E, 544400N
Recording Periods:	24 Oct 2001 to 16 Nov 2001
Station: WR2	
Location:	283018E, 536123N
Recording Periods:	24 Oct 2001 to 14 Nov 2001
	15 Nov 2001 to 12 Dec 2001
	14 Dec 2001 to 15 Feb 2002

Unfortunately the inshore recorder (WR1) became buried in the bed sands and was lost after the first recording period had elapsed. A short dataset of three weeks only is therefore available for this recorder. Although no major storms occurred during this period, wave height measurements did indicate a strong tidal dependency and current influence.

6.2.1.4 Wave Climate on Site

Figure 6.2.6 shows a comparison of wave heights and wave periods recorded at the two recording locations and offshore. The distribution is similar for the two data sets.

The data recorded on site indicates a high degree of variability in wave height across the site due to variations in water depth and current flows. Computational modelling techniques were therefore employed to determine the wave climate across the whole of the site.

The modelling was undertaken using the Mike 21 NSW model to determine the wave transformation from offshore to the site. This model is a spectral wave model, which describes the propagation, growth and decay of waves in near shore areas. The model takes into account of the effects of refraction, shoaling, local wind generation and energy dissipation due to bottom friction and wave breaking. The input of the model includes directional distribution of wave energy at the offshore boundary.

The wave climate modelling was undertaken for both extreme wave conditions and for gale conditions. The latter included simulations of the propagation of waves into the area from the Irish Sea and locally generated waves across the Solway Firth itself.

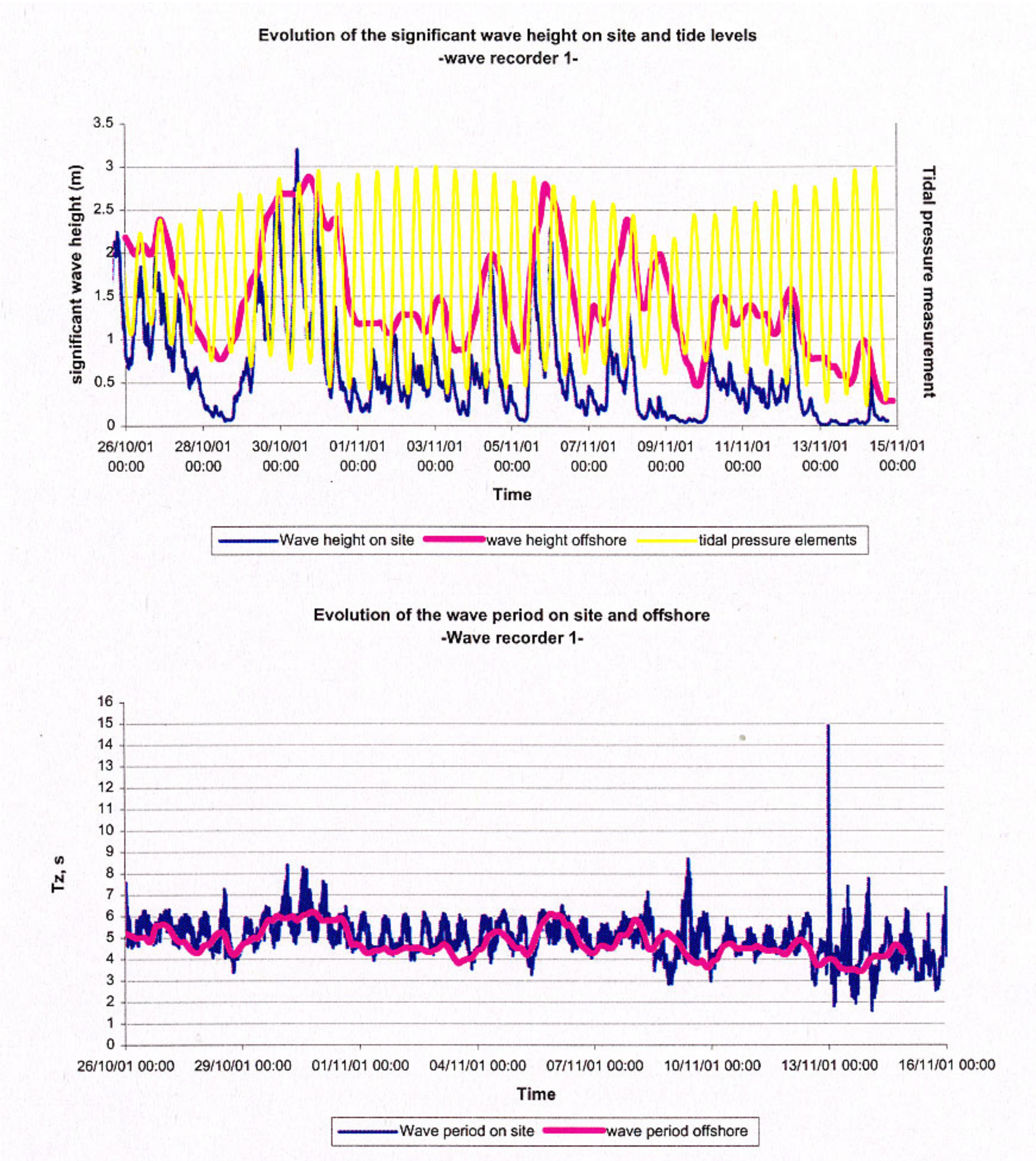
Extreme wave modelling was used to determine the maximum wave climate on the site for a 50 year return period. Extreme wave models were run at high tide with storm surge in order to determine the worst possible conditions. Figure 6.2.7 illustrates the extreme wave heights and mean wave directions for 1 in 50 year storm events from 200^{o} and 240^{o}.

While the extreme wave data is required for the design of the wind turbines and foundations, the sediment transport on the site will be more strongly influenced by the frequently occuring gale events. The gale wave climate was modelled during a full spring tidal cycle. Figure 6.2.9 indicates the results of wave modelling for gales from 210° and 240° for high and low tidal conditions.

Waves in gale conditions are predicted to be in the order of 3.0 – 3.25 m with periods in the range 6.17 s to 6.24 s.

Local wind generated waves were also modelled for NW and SE gales. These models were run at high tide during which period the waves will be at their most significant. The results of these models are illustrated in figure 6.2.10. It can be seen that these locally generated waves have smaller wave heights (between 1.2 and 1.3 m) and shorter wave periods (3.3 – 3.7 seconds) at the wind farm site due to the much shorter fetch across the Solway Firth.

Figure 6.2.6 Comparison of wave heights and periods offshore and on site



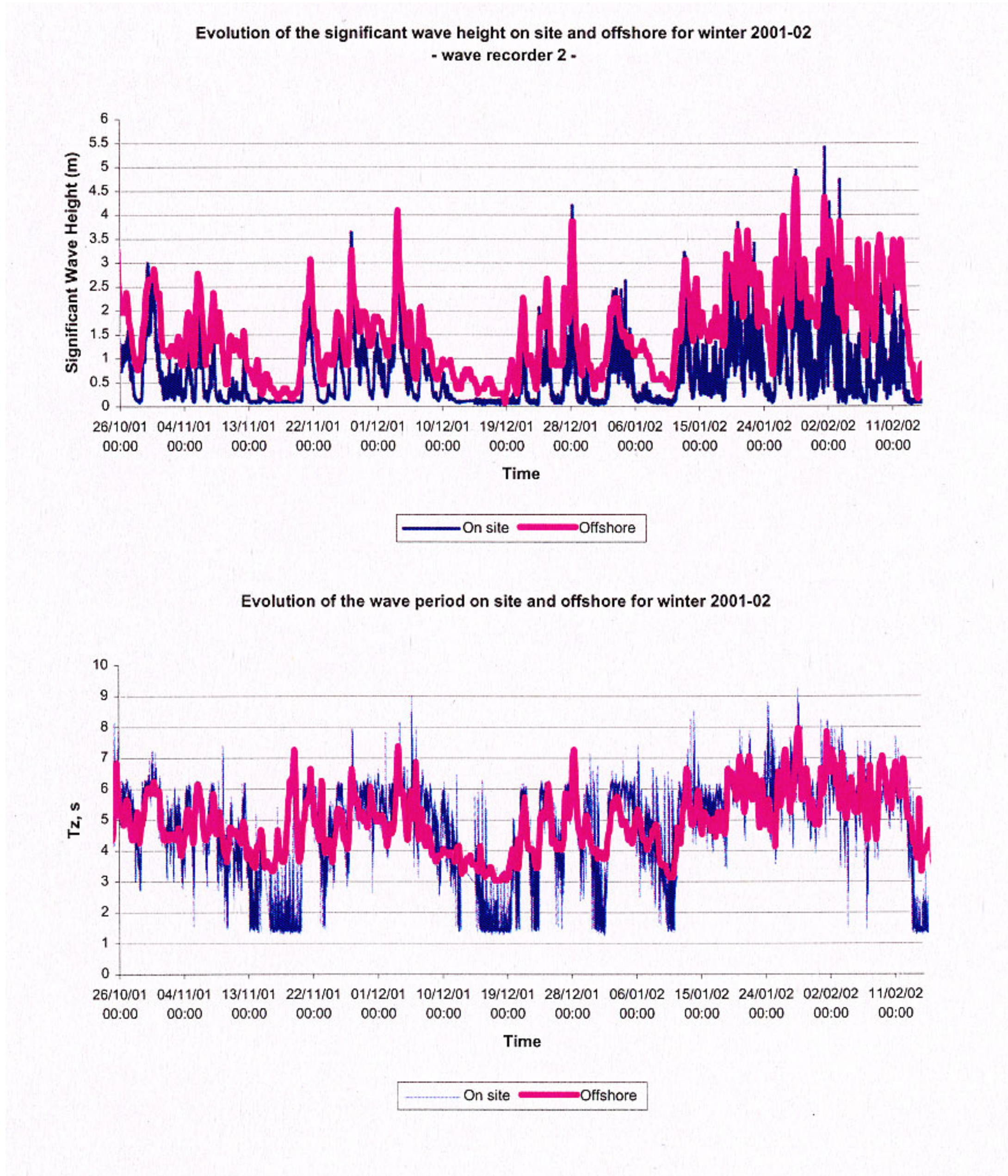
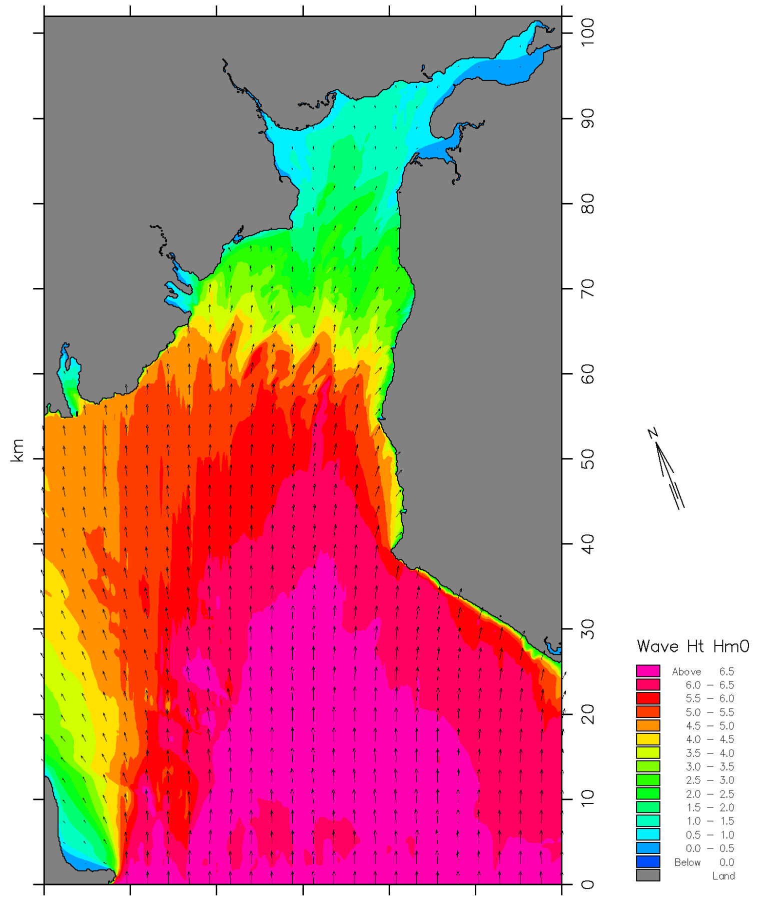


Figure 6.2.7 Wave height and direction – 1 in 50 year storm from 200° and 240°

Significant wave height and direction – 1:50 yr storm from 200°



Significant wave height and direction – 1:50 yr storm from 240°

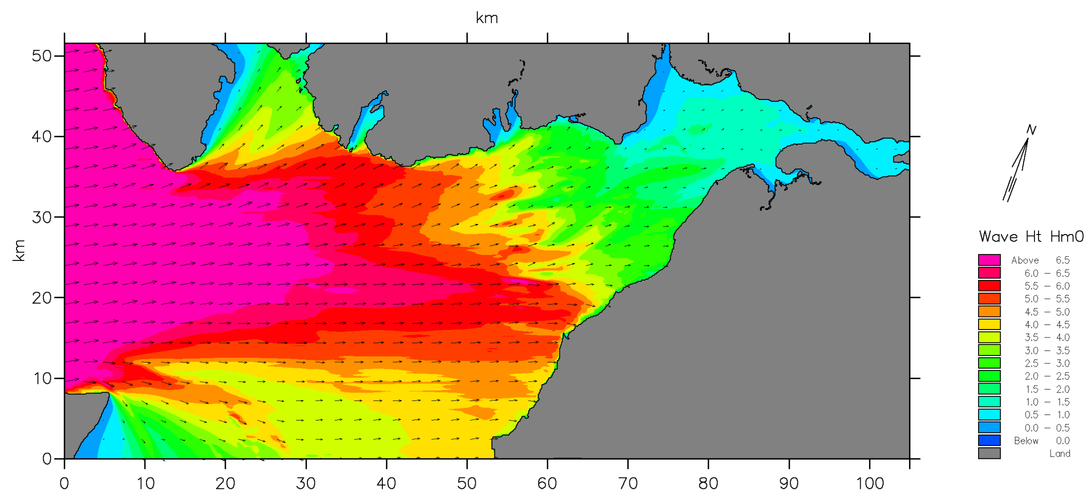
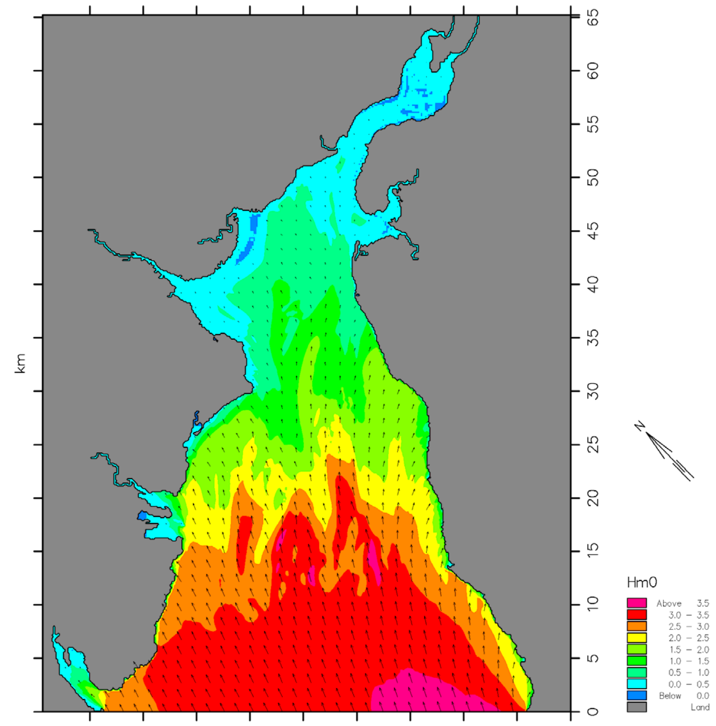


Figure 6.2.8 Wave height and direction – gale from 200° - High and low tides

Significant wave height and direction – gale from 200° at HW



Significant wave height and direction – gale from 200° at LW

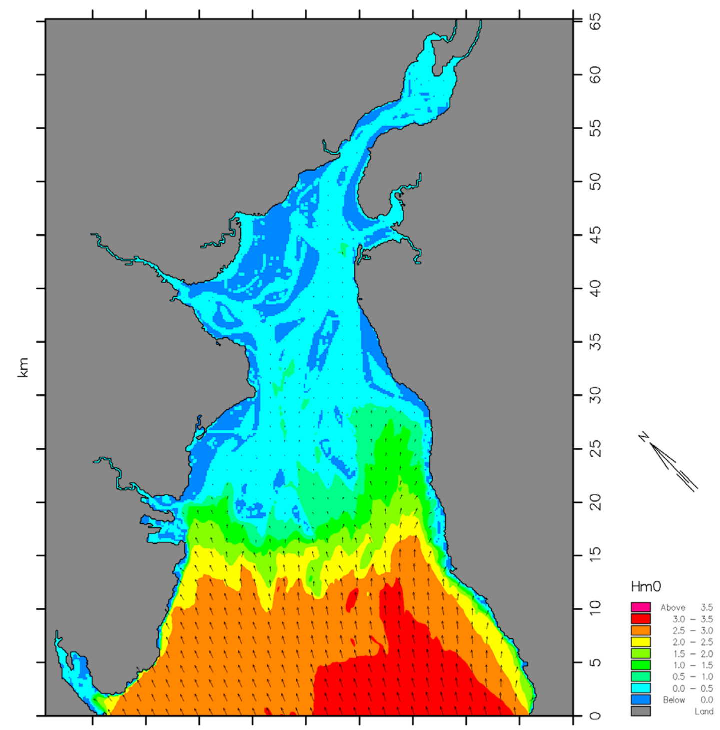
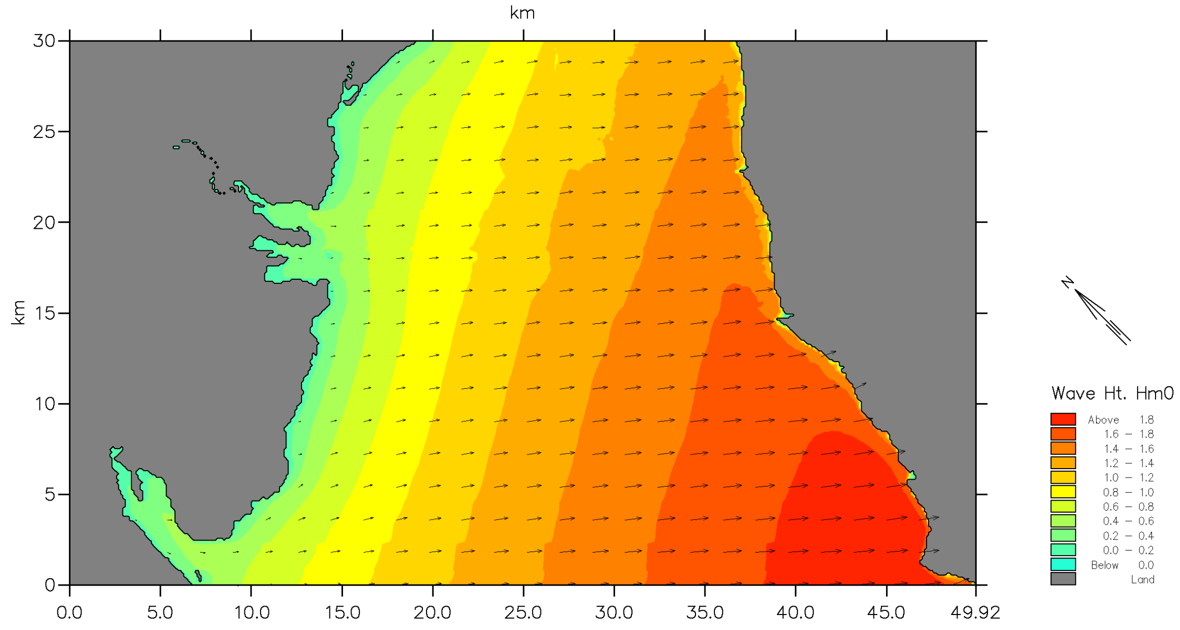
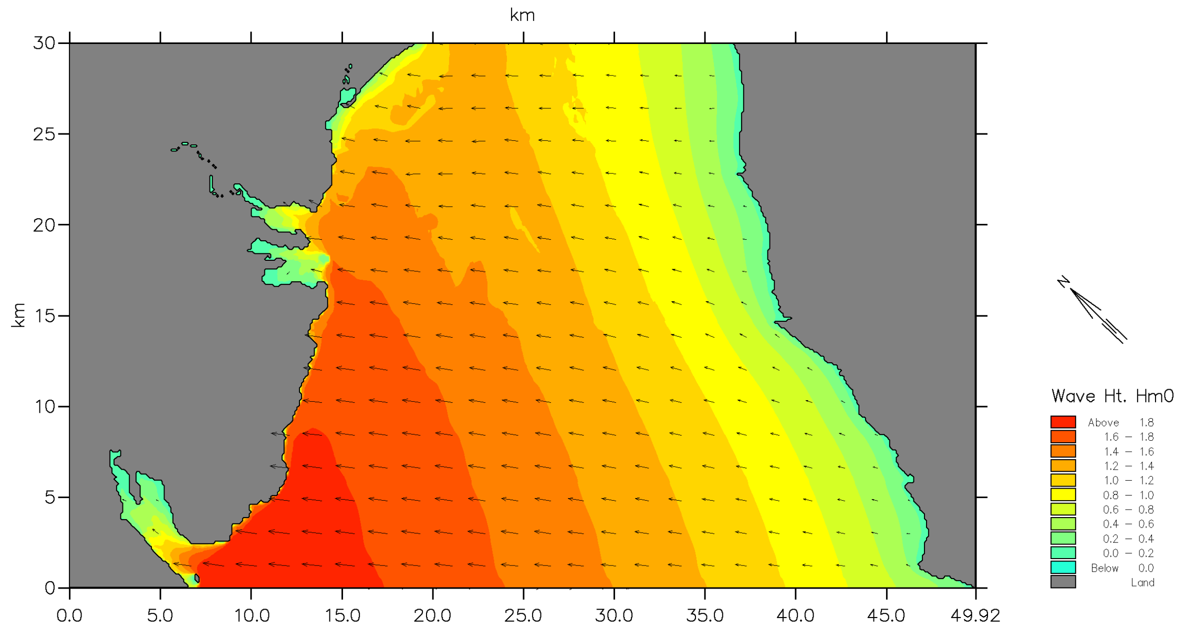


Figure 6.2.9 Locally wind generated waves – NW and SE gales

Significant wave height and direction – NW gale



Significant wave height and direction – SE gale



6.2.2 TIDAL AMPLITUDE

6.2.2.1 Existing Data

Information on tidal levels to Chart Datum is available in the Admiralty Tide Tables for United Kingdom and Ireland

The tide levels for the various secondary ports around Solway Firth are as illustrated in Table 6.2.2.

Table 6.2.2 Tidal levels for ports in the Solway Firth

Tide levels	Chart Datum			OD Newlyn		
	Workington	Hestan Islet	Maryport	Workington	Hestan Islet	Maryport
MHWS	+8.10 m	+8.30 m	+8.60 m	+3.90 m	+4.29 m	+4.30m
MHWN	+6.30 m	+6.30 m	+6.60 m	+2.10 m	+2.29 m	+2.30 m
MLWN	+2.60 m	+2.40 m	+2.50 m	-1.60 m	-1.61 m	-1.80 m
MLWS	+0.90 m	+0.90 m	+0.90 m	-3.30 m	-3.11 m	-3.40 m

Note: MHWS means Mean High Water Spring tide; MHWN means Mean High Water Neap tide; MLWS means Mean Low Water Spring tide; MLWN means Mean Low Water Neap tide;

6.2.2.2 Site Measurement

Tidal amplitude measurements are continuously measured in the primary port of Barrow-in-Furness. A tidal gauge was set up at Workington when the bathymetric surveys were being carried out.

Comparisons were made between Barrow and Workington to confirm the difference in tidal levels for the two locations. Tidal levels in Workington were also compared with the tidal predictions from the admiralty tide tables.

6.2.3 TIDAL FLOWS

6.2.3.1 Existing Data

The admiralty tidal stream atlas for the Irish Sea and Bristol Channel provided information on tidal flows in the area in question. These documents show tidal streams at hourly intervals commencing 6 hours before High Water (HW) Dover and ending 6 hours after HW Dover. On the charts, the direction of the tidal streams are shown by arrows which are graded in weight, and if possible, in length to indicate the approximate rate of the tidal stream.

Information about tidal streams in Solway Firth for specific directions was also available on the Admiralty chart. The two relevant Admiralty tidal diamonds show the data at hourly intervals 6 hours before and after HW at Liverpool for spring and neap tides

6.2.3.2 On-Site Measurement

Current flow within the proposed development area and in the surrounding waters was recorded by the deployment of two recording current meters and by direct current metering at two further locations. Recording locations are indicated on figure 6.2.5**.**

Recording Meters

The location and measurement period of the two recording current meters were as follows;

Station: RCM 1
Location: 290485E, 544155N
Recording Period: 13 Dec 2001 – 06 Feb 2002
Station: RCM 2
Location: 294100E, 544155N
Recording Period: 15 Nov 2001 – 12 Dec 2001

Direct Current Readings

In addition to the recording current meter data, flow measurements were also taken at three depths at 15 min intervals over both a full neaps and full spring tidal cycle as noted below.

Station: DCRM1		
Location:	54°45.973'N 3°38.139'W	
Recording Periods:	Spring	17 Nov 2001 – 18 Nov 2001
	Neaps	24 Mar 2002
Station: DCRM2:		
Location:	54°44.415'N 3°40.469'W	
Recording Periods:	Spring	18 Nov 2001
	Neaps	25 Mar 2002

The results of the current meter recording indicate a maximum current velocity of 1.0 m/s measured at station DCRM1. Generally the readings appear to be reasonably consistent although one erroneous reading was noted on recorder DCRM 1 on 18/11/2001 when the current velocity recorded was significantly lower than both the proceeding and following readings. This could possibly have been caused by a foreign body (weed etc) interfering with the meter.

6.2.3.3 Tidal Model

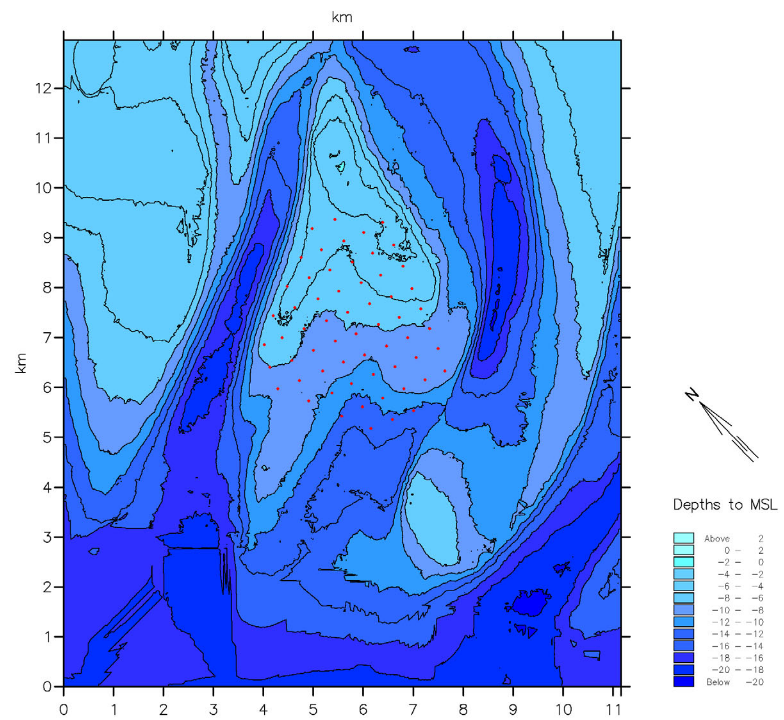
Computational modelling techniques were used to assess the impact of the wind farm on the tidal conditions throughout the Solway Estuary.

The tidal flows characteristics of the coastal study were determined using a suite of two-dimensional depth integrated hydrodynamic models, Mike21 HD developed at DHI, Denmark. These models are capable of both conserving mass at flooding and at drying cells, that is essential in areas where beaches and banks are exposed at low water. The model thus takes into account the presence of banks in the Solway Firth.

The tidal model of the Solway Firth was set up as a sub model of an Irish Sea Model, the bathymetry of which included data from the hydrographic surveys, aerial photographic contours and Admiralty Chart data. In order to correctly model the water exchange between the study area and the Irish Sea, it was necessary to ensure that the boundary conditions to the Solway Firth model were sufficiently far offshore as not to influence the area of interest. A 405m grid hydrodynamic model of the Irish Sea was therefore used to form the boundary conditions for progressively finer grid models of the Solway Firth and adjoining sea areas. The Irish Sea model was calibrated by using tidal height information for primary and secondary ports and tidal diamond current velocities shown on the Admiralty Chart.

The tidal conditions in the Solway Estuary were modelled using as series of progressively finer grid models. Initially a 135 m grid model was set up for the whole of the estuary with a boundary between Barrow Head and Selker Rocks. To provide more detailed information for tides around the wind farm site, a set of nested 135 m, 45 m and 15 m grid models were set up. This nested grid model system was calibrated using the DRCM site readings noted above. The bathymetry of the 15 m nested grid model is shown in Figure 6.2.10

Figure 6.2.10 15 m grid tidal model bathymetry



The fluvial input to the Firth of Solway was obtained from the National River Flow Archive Data Retrieval Service. Rivers entering the Firth of Solway were identified and the information for the relevant gauging station on these rivers was then extrapolated based on the additional area drained between the gauging station and the mouth of the respective rivers. Where the river was not included on the archive, nearby guaged catchments were used to derive a representative flow.

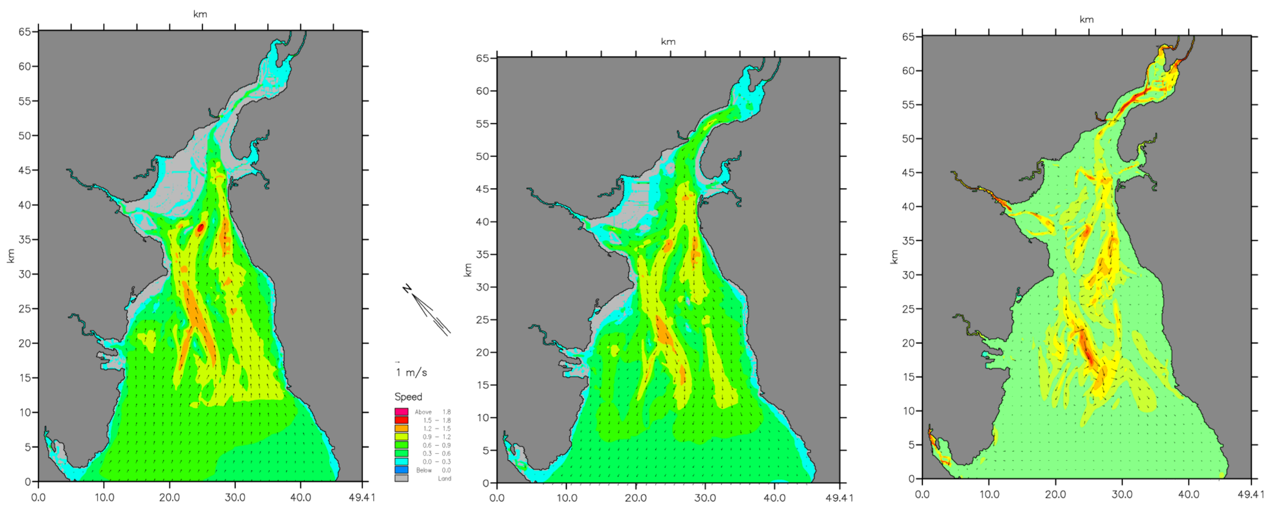
Figure 6.2.11 shows the tidal vectors and speeds for typical flood and ebb tides as well as the residual tidal velocity.

Approximated volume flows were also calculated through the wind farm site at neap and spring tides. The calculations were made using the recording current meter data and the area chosen was 4125 meters wide (corresponding to the width of the wind farm site) and an average 10 metres depth at Mean Sea Level.

The results show that the average volume flow in and out of the wind farm site is around 16000 m^3/s.

Figure 6.2.11 Tidal vectors and speed – Flood and Ebb tides

Flood tidal flow – Spring tide **Ebb tidal flow – Spring tide** **Residual tidal velocity–Spring tide**



6.3 SEDIMENTOLOGY AND COASTAL MORPHOLOGY

6.3.1 EXISTING DATA

The nature of the seabed in the Solway Firth is indicated on the Admiralty Chart for Solway Firth and its adjoining area. The data on the chart shows that the seabed is mainly composed of sand with local presence of mud and shells.

Previous research describes a top layer of approximately 40m thickness covering most of the area. The area has also been described as structurally complicated with a variability that suggests the presence of glacial deposits that include sands, gravels and boulder clay (Institute of Geological Sciences – Irish Sea Investigations 1969-1970, report No. 71/19). Information from the Solway Firth Review (Solway Firth Partnership 1996) also suggests the presence of broken rocks, clays, sands and gravels.

6.3.2 SURVEY METHODOLOGY

Surveys to determine the bed and sub-surface geological conditions comprised the following works:

- Borehole investigations
- Seismic surveys by sub-bottom profiler
- Bed Sediment sampling
- Laboratory testing of materials from boreholes

6.3.2.1 Borehole Investigations

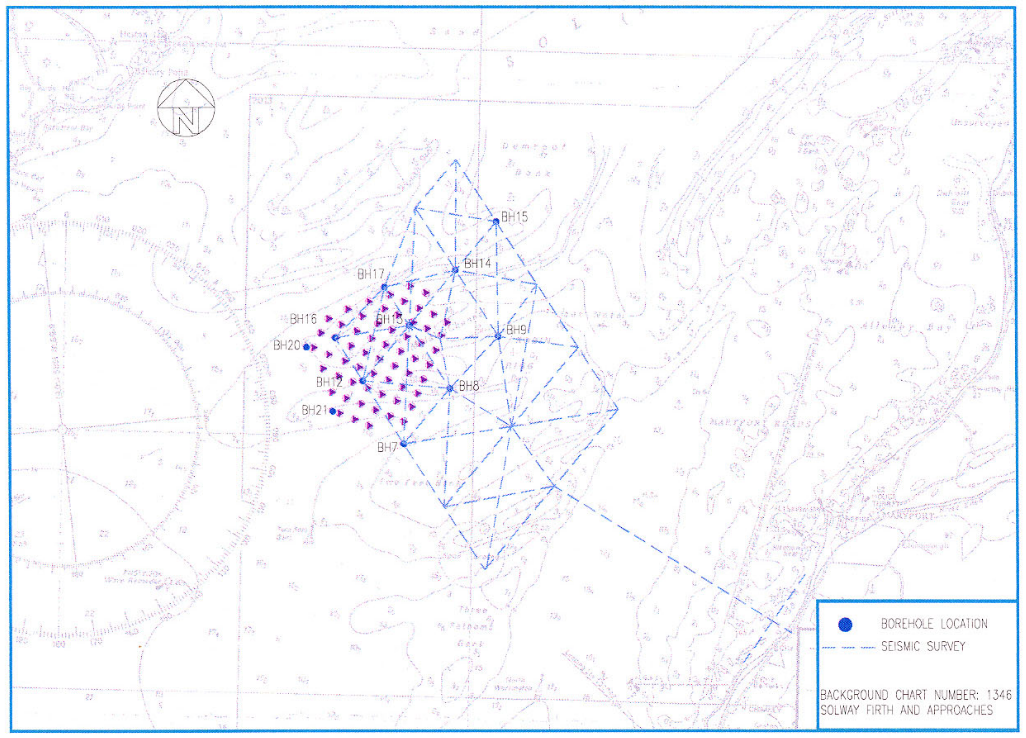
Borehole investigations were carried out at a number of locations in and surrounding the proposed turbine development area and along the proposed cable route to land. The positions of the boreholes are indicated in Figure 6.3.1.

All works were carried out from a jack-up barge. Boreholes were advanced through the upper sediments by shell and auger drilling in 200 mm diameter using light cable percussion techniques. The boreholes were drilled to a depth where either a) the casing would not penetrate due to friction causing 'binding' of the casing or b) were a combination of friction and the presence of boulders caused refusal. Beyond the depth of penetration by shell and auger the boreholes were advanced by rotary drilling. A high-pressure pneumatic compressor, 850cfm at 170 psi was used as a flushing medium.

Small disturbed samples were taken at each change of strata and at regular intervals within thick strata. Undisturbed samples were taken in cohesive layers and standard or cone penetration tests were carried out in the non cohesive layers. All works were carried out in accordance with the requirements of BS 5930 the Code of Practice for Site Investigation

The results of the boreholes within the main development area generally indicate the presence of medium dense to dense fine to medium sands overlying stiff to very stiff clay with cobbles and boulders. The depths of the upper sediments vary from 8 m to at least 29 m depending on location. Clay was encountered to a depth of 31 m beyond which it was not possible to advance the boreholes. Typical borehole logs are illustrated in Figure 6.3.2.

Figure 6.3.1: Borehole and Seismic Survey Locations



6.3.2.2 Seismic Surveys

Geophysical surveys were undertaken on both the main development area and along the proposed cable route.

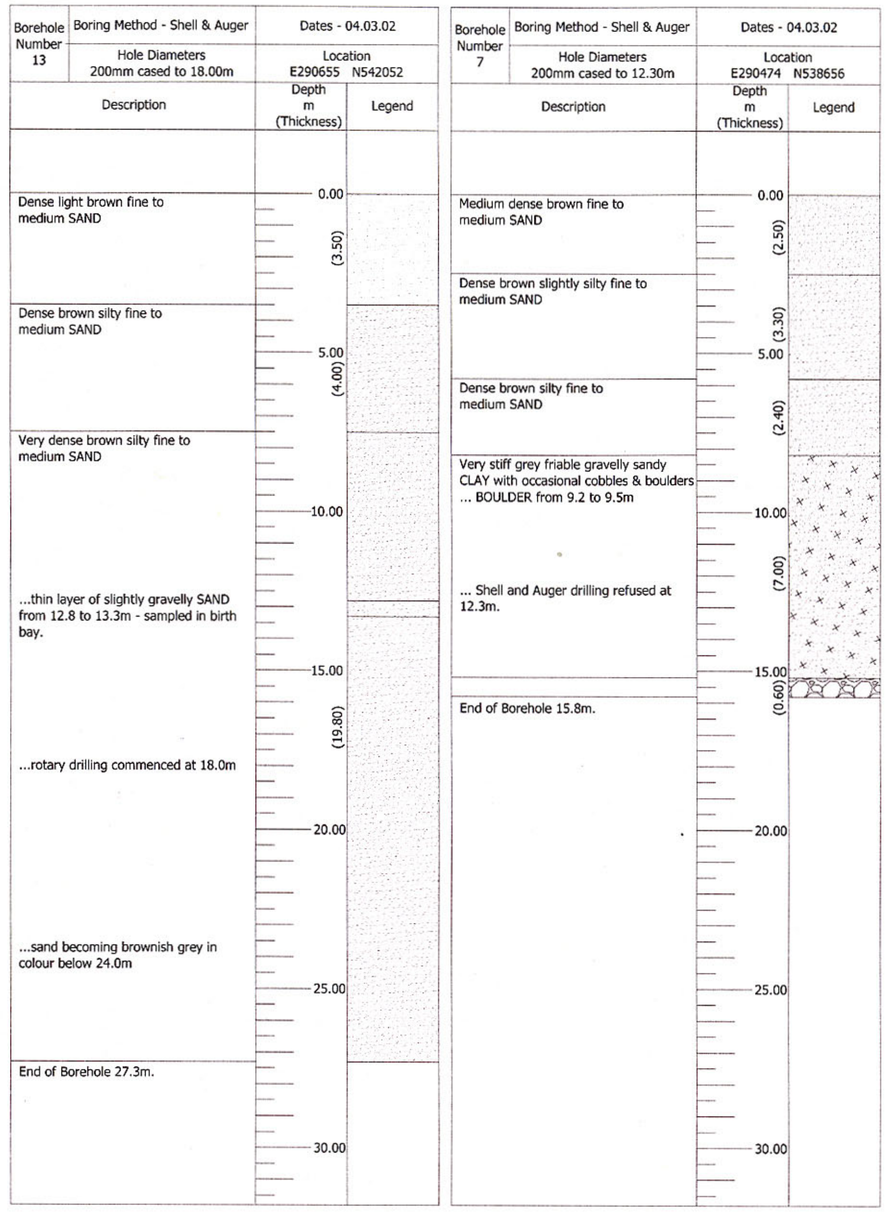
The surveys involved the collection of subsurface information using a sub-bottom profiling system. A GeoAcoustics Model 5420Asub bottom profiler was used. Survey lines were run to ensure maximum coverage, particularly at areas where borehole positions were proposed. A sweep of 100mSecs was used when collecting sub-bottom data. This allows for a maximum achievable depth of penetration of approximately 83m, thereby ensuring that any reflectors present within this limit should be picked up by the profiling system.

On the main development site the sub-bottom profiler runs were carried out between proposed borehole positions in order to allow for calibration of the survey with borehole data. The locations of seismic survey runs are indicated on Figure 6.3.1.

Overall the sub-bottom records reveal a very complex and sometimes chaotic arrangement of reflectors. There were two main reflectors that could be clearly identified. The first main reflector was characterised by a very strong acoustic signature and was consistently identified over a significant portion of the survey area. Depths to this reflector were measured at approximately 1.5m down to approximately 36m below the seabed. It displays characteristics generally thought to be typical of boulder clay or sediment with a significant clay component.

The second reflector has a much more chaotic and jumbled acoustic signature. As a result of this, it is not always possible to clearly identify this second reflector. Measured depths to this reflector ranged from approximately 3m to approximately 38m. The characteristics of this reflector seem to suggest the possible presence of bedrock and/or weathered rock, however this reflector was not clearly identified during the borehole investigations.

Figure 6.3.2 Typical borehole logs



Other important features identified from the records were the presence of internal reflectors occurring above and between the two main reflectors. These generally occurred at approximately 1m intervals and suggest the possible presence of material such as shell fragments, gravels, stones etc within the sediment.

A number of seismic survey lines were also run parallel to the shoreline and extending from the shoreline to the development area, along the proposed cable route. The average measured depth to the most clearly identified reflector was between 10-12m. The deepest measured depth was 25m.

Overall, the results of the proposed route survey suggest that the subsurface is generally comprised of soft sediments with the possible presence of coarse materials such as gravels, shell fragments etc.

6.3.2.3 Bed Sediment Sampling

Samples of the bed sediment material were taken at various locations across the proposed development site as indicated on Figure 6.3.3**.** Samples were obtained by day grab deployed from a work boat. All samples obtained thus were sieved to determine the sediment grading curve for the material.

In the development area the bed sediment generally comprises a light brown fine to medium sand with some shell fragments. The material is reasonably homogenous within the proposed wind farm site.

The bed material along the proposed cable route is more varied. Generally the material on the portion of the cable route on the banks is similar to that described earlier, however on the section of the cable route closer to land, the material gradually changes to a combination of gravel and cobbles before eventually returning to sand within the nearshore (intertidal) area.

6.3.2.4 Laboratory Testing of Materials from Boreholes

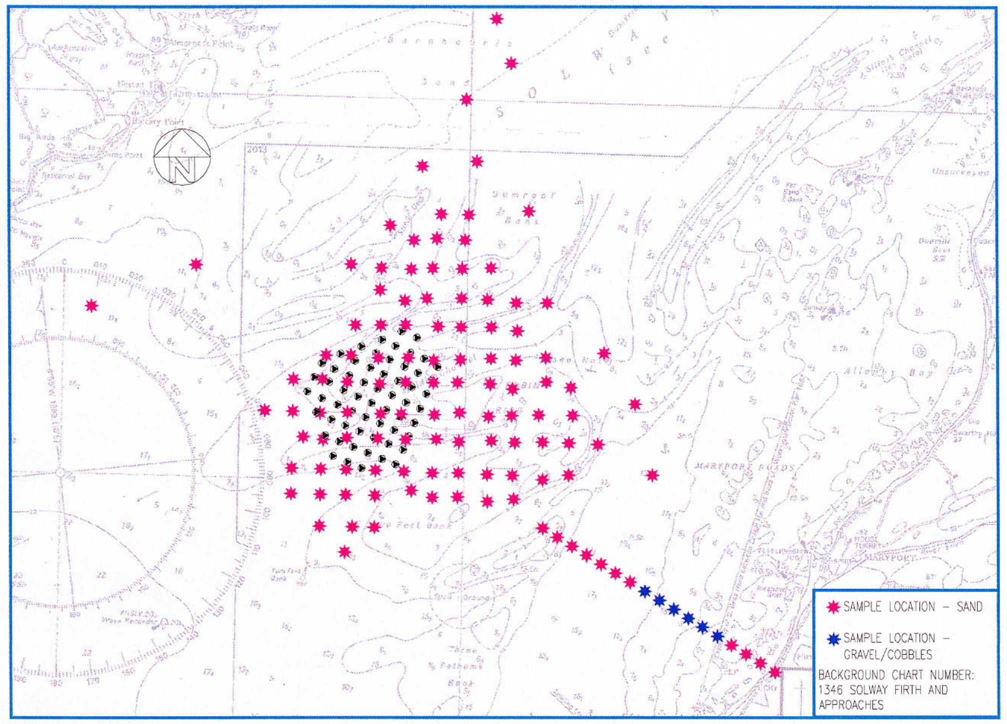
Samples of materials obtained from the boreholes were tested in the laboratory to determine relevant characteristics.

For granular materials (sands) this generally comprises grading of the material. The material in the upper layers of sand is reasonably homogenous and is generally graded fine to medium.

Clays and other cohesive materials were tested to determine the shear strength of the material.

6.3.3 SEDIMENT DISTRIBUTION

Figure 6.3.3 Results of bed sediment sampling



From the site works it is evident that the sediments across the proposed development site are reasonably homogeneous, comprising a fine sand. Only a short section of the cable route was found to differ, this comprising gravel and cobbles over a length of approximately 3-4 km.

6.3.4 SEDIMENT TRANSPORT

The MIKE 21 Sediment Transport modules were used for the determination of the sediment transport patterns on the Solway Firth. This model takes the output from both the hydrodynamic model and the wave propagation model as input, as well as using information on sediment sizes and gradation to determine bed level changes and sediment transport rates.

In this study, net rates of sediment transport, which summarise the movement of sediment over the complete tidal cycle in the Robin Rigg area, were simulated both during a spring tide and no waves and as well as with southwest gales from 200° and 250°. During a spring tide with no gales, the net rate of sediment transport is up to 4000 m3/year/m over a full tidal cycle, as illustrated in Fig. 6.3.4.

During southwest gales, the net rate of sediment transport increases significantly as shown in Fig. 6.3.4, where the maximum net rate is around 12000 m^3/year/m over a full tidal cycle.

Due to wave refraction, the sediment transport pattern around the area of the site is quite similar with gales from either 200° and 250°. However, the net sediment transport regime is slightly different close to the shorelines. Indeed, for the 200° gales, the net sediment pattern is more important on the west coast than the east coast and conversely.

Instantaneous rates of sediment transport were also simulated during a tidal cycle with no wave as shown in Fig.6.3.5. The peak sediment transport rate is at its highest during the flood tides with a value of around 0.0005 m^3/s, which is equivalent to 15700 m^3/year/m.

The effect of the sediment transport during spring tide will result in suspended sediment concentration up to 50 mg/l around the wind farm site area.

Simulations also include the instantaneous sediment transport rates throughout tidal cycle during southwest gales. Ebb and Flood rates are in illustrated in Fig. 6.3.5. The sediment movement are mainly orientated southeast during the ebb tide and north-northwest during the flood tide.

The peak rates of sediment transport for 200° gales are up to 0.0020 $m^3/s/m$ during the flood tide, which is equivalent to 63000 m^3/year/m.

As predicted, the movements of sediments in the Robin Rigg area are very high during southwest gale conditions with suspended sediment concentration up to 270 mg/l around the wind farm site.

Figure 6.3.4 Net rate of sediment transport through tidal cycle

Spring tide – no waves **Spring tide with gale from 200°** **Spring tide with gale from 250°**

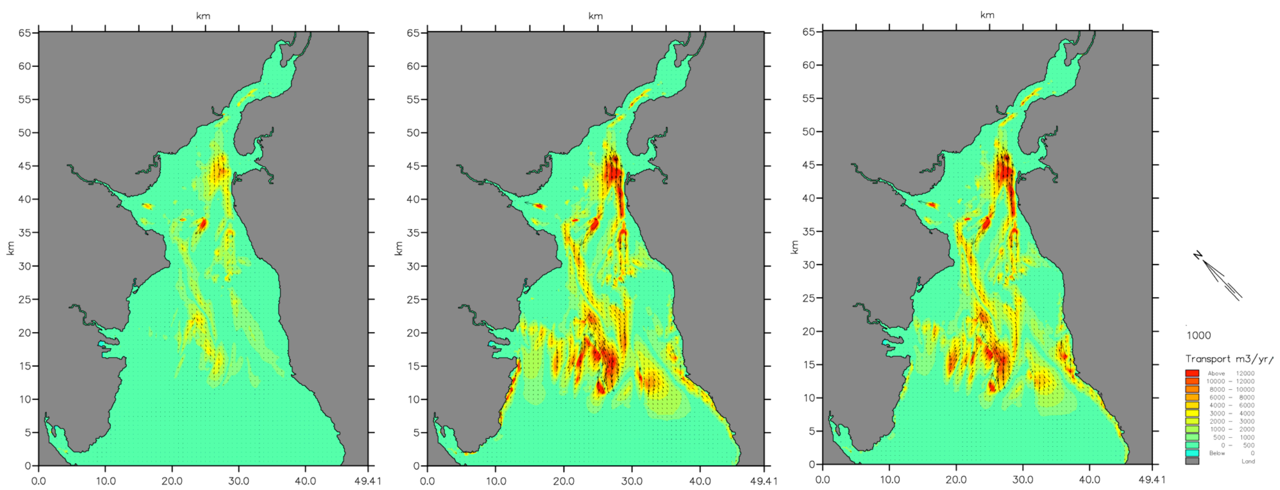
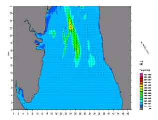
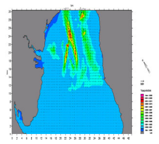


Figure 6.3.5

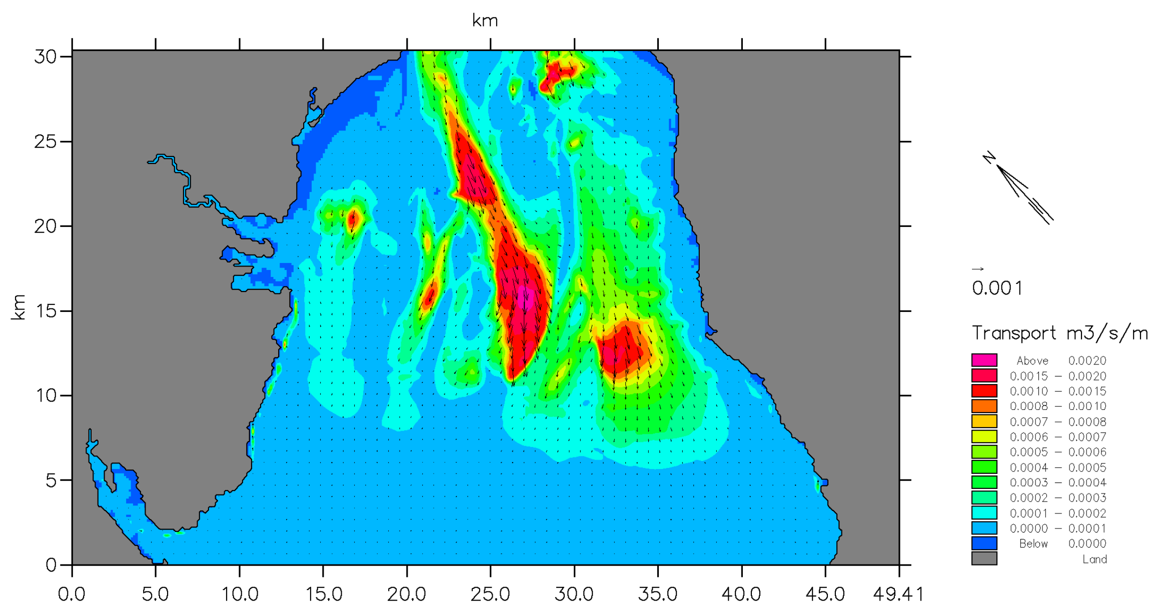
Sediment transport rate – Ebb tide with no waves



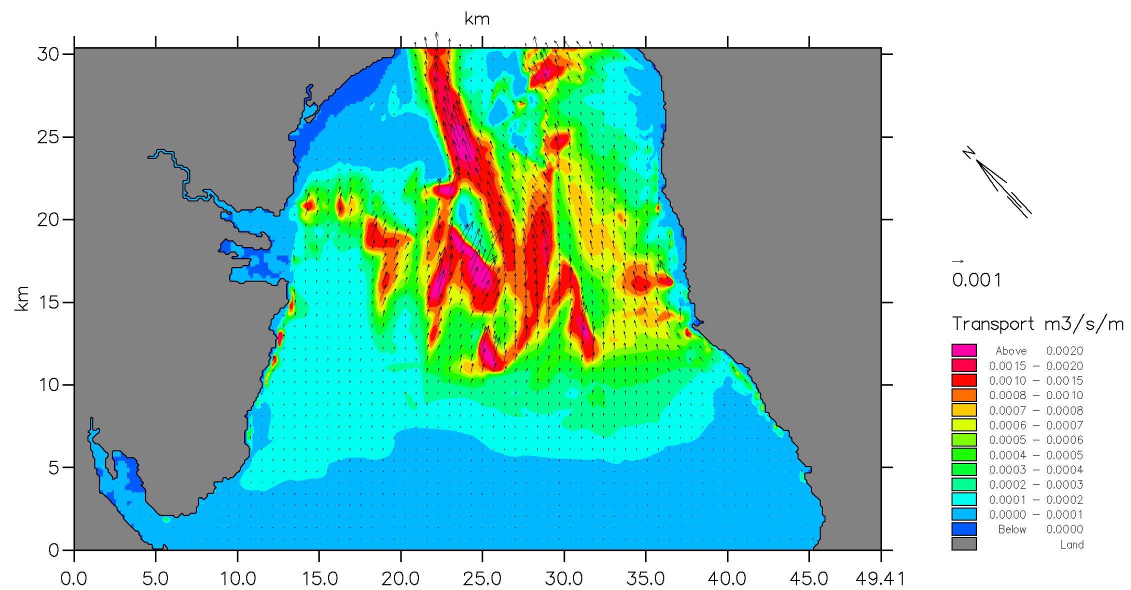
Sediment transport rate – Flood tide with no waves



Sediment transport rate – Ebb tide with gale from 200°



Sediment transport rate – Flood tide with gale from 200°



6.3.5 MORPHOLOGY AND DEVELOPMENT

The combination of the bathymetric surveys, the 2001 Admiralty Chart and the aerial photographs of the site were used to determine the current levels of the seabed in Solway Firth and Inner Solway in recent years.

The source data for the admiralty charts from 1887 and 1932 was used to provide an indication of historical bed levels. These provide a comparison between the historical data and current (2001) seabed levels (see Figure 6.3.6). It is apparent that the site is a dynamic area and these drawings present relevant information on the historic movement of the banks and channels.

Three main zones are identified as indicated in Figure 6.3.6. Zone 1 seems to be a stable area over the years with no major channel migrations. The seabed level has remained generally constant. The channel in zone 2 appears to have moved southwards and eastwards. The migration of this channel has led to the development of a more shallow area. The channel in zone 3 has clearly moved eastwards and northwards over the years.

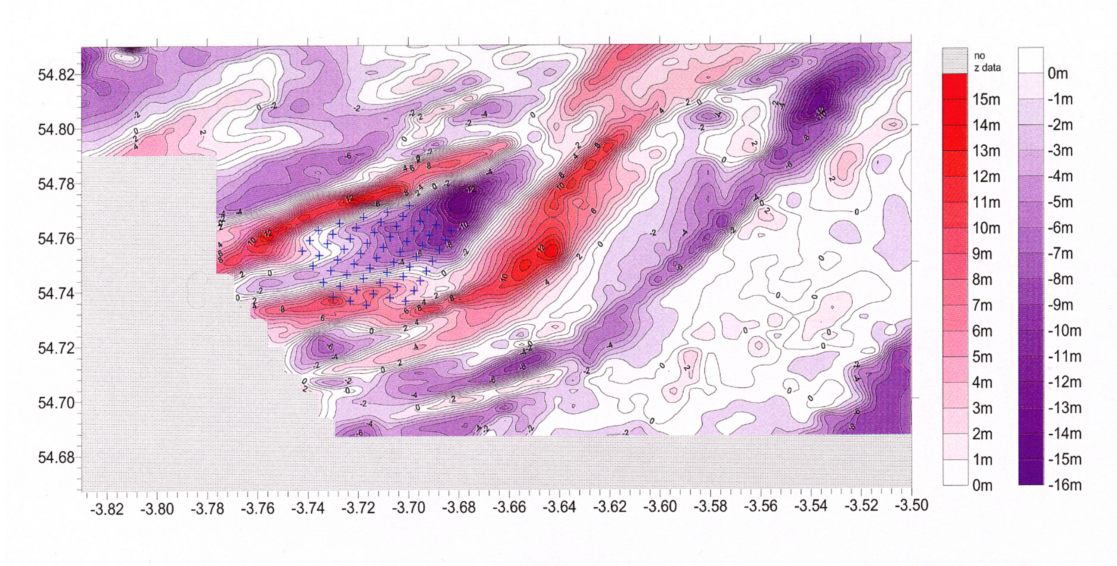
The comparison of the historical charts with current bed levels provides an indication of changes in bed level over significant time periods. However it uncertain what happened between the dates for which data is available (1887, 1932 and 2001), and whether the changes happened gradually or in response to extreme events.

A second bathymetric survey was therefore carried out on the site 7 months after the original survey in order to determine changes in bed level over a single winter period for which weather records are available.

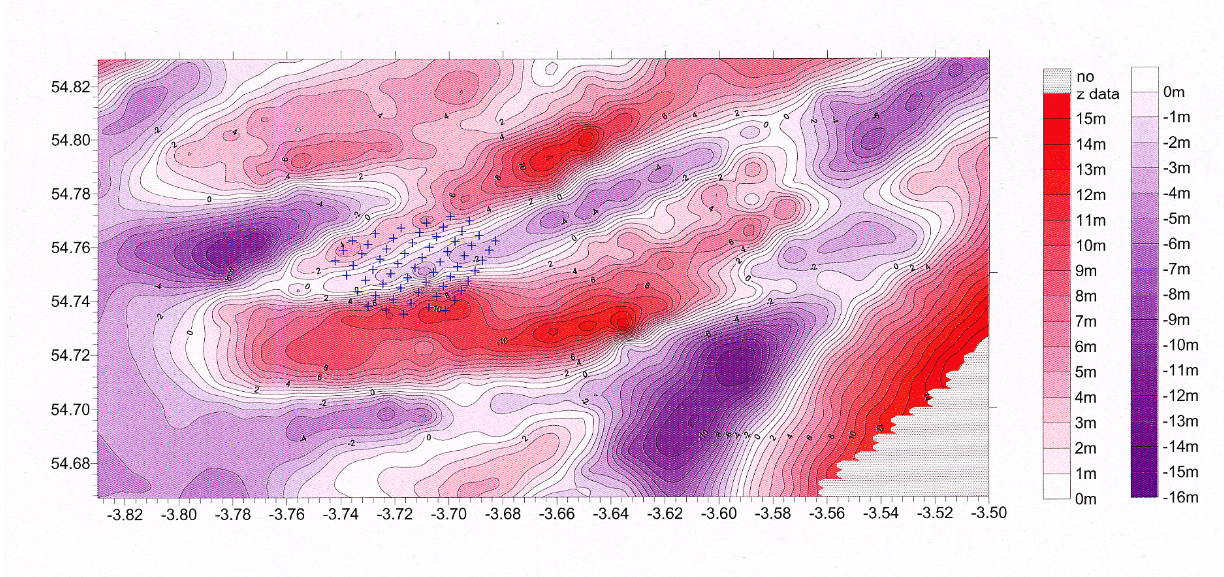
The results in Figure 6.3.7 show that there was some redistribution of the bed sediments with localised changes in seabed level between –2 m and 3.5 m. However the overall position of the bank remained largely unchanged. This would tend to indicate that global movement of the banks is caused by the cumulative effects of many storm events over many years, rather than as a result of a single event.

Figure 6.3.6 Bathymetric Information for years 1887, 1932 and 2001.

Comparison of the seabed levels beween 1887 and 2001



Comparison of the seabed levels between 1932 and 2001



Seabed zones

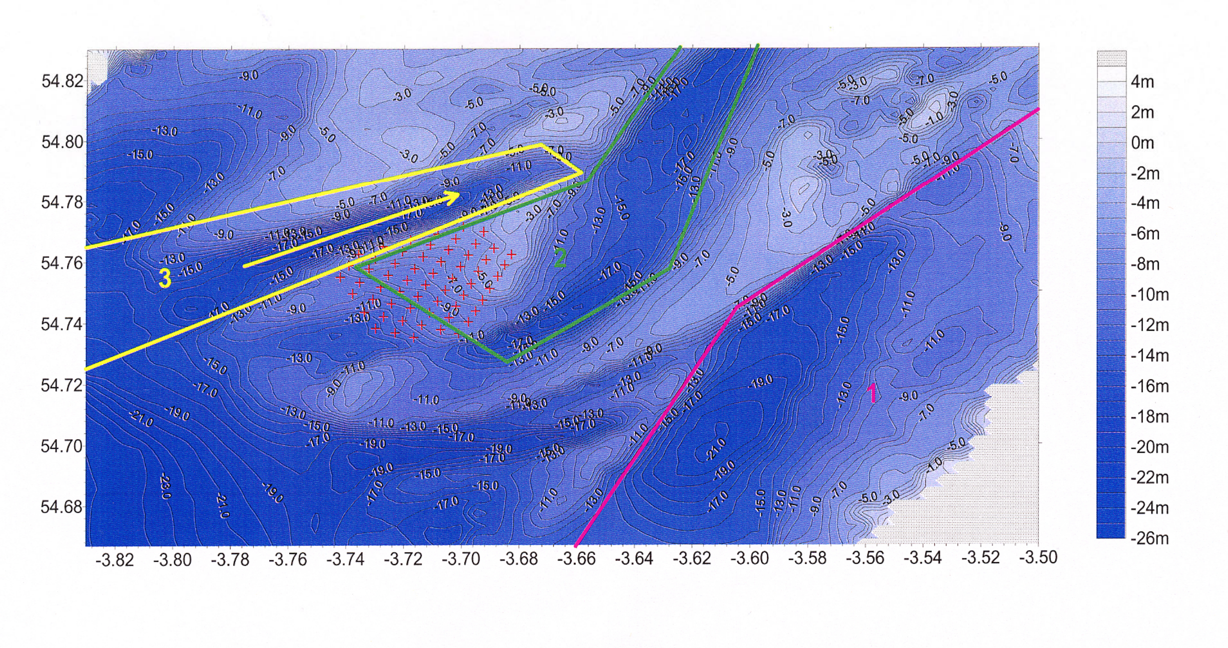
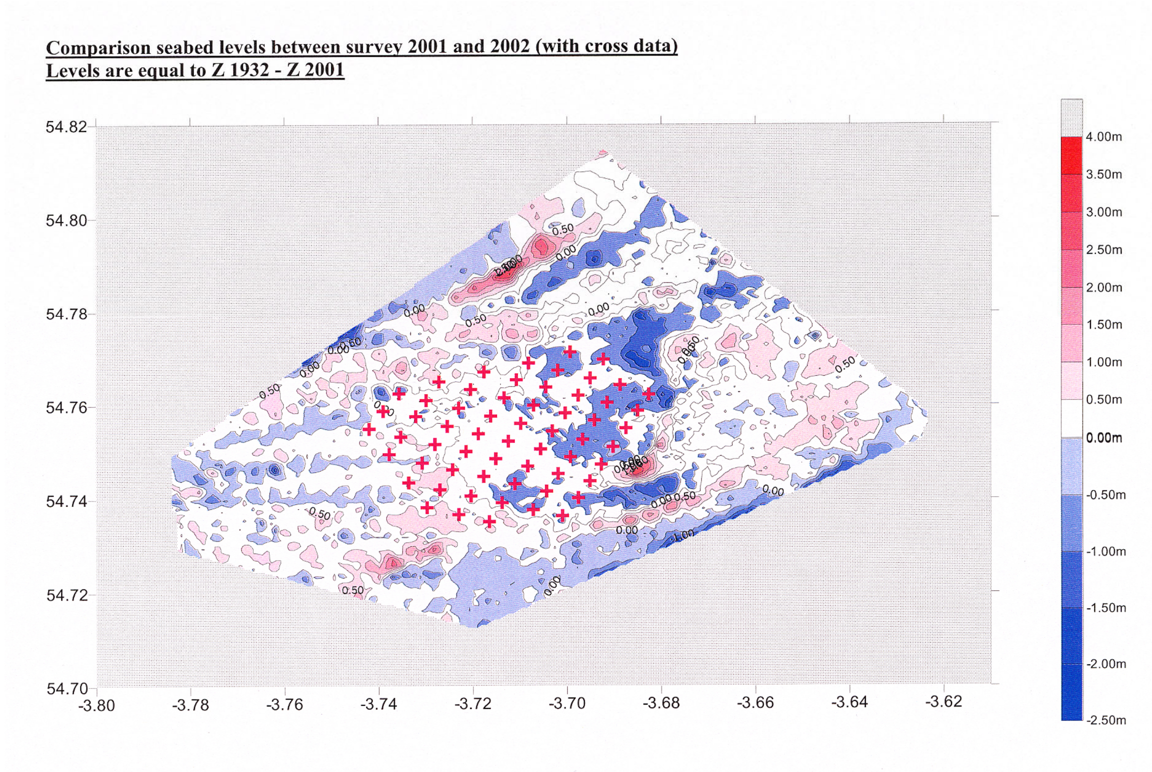


Figure 6.3.7 Comparison of 2001 and 2002 surveys



Section 7

Baseline Conditions – Environmental Resources

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Baseline Conditions – Environmental Resources

7.1 SOLWAY FIRTH EUROPEAN MARINE SITE OVERVIEW

7.1.1 INTRODUCTION

The Inner Solway eastwards of a dogleg line extending between the eastern edge of Sandyhills Bay in Dumfries and Galloway and Dubmill Point in Cumbria between Sandyhills Bay and Dubmill Point north of Allonby is designated internationally for its birds and marine/shoreline habitats.

While the Robin Riogg proposal lies more than 7 km outside of this area known as the Solway Firth European Marine Site, its importance is such that its interests and sensitivities have been summarised in this section. The position and design of the wind farm has been selected carefully to avoid impacts on this site, as described in detail in the various assessments in Section 9 of this ES.

The 44,000 hectare extent of the European Marine Site is internationally designated as a Special Protection Area under the 1979 EU Birds Directive and selected as a candidate for designation as a Special Area of Conservation under the 1992 EU Habitats Directive. The broad area covered by the designations is shown in Figure 1.1 in Section 1 of this ES. Both Directives have been implemented under UK law by the Conservation (Natural Habitats) Regulations 1994 (The Habitat Regulations) which requires Scottish Natural Heritage, English Nature and the respective Secretaries of State in Scotland and England to exercise their duties with relationship to designated sites to secure compliance with the requirements of the Directives.

For the Solway site which lies within both regions, English Nature and SNH have jointly published a Management Plan[44] which outlines the reasons for designation, sensitivities to existing operations and development pressure and an Action Plan for protection and enhancement of the key elements of conservation interest within the broader site. The main aim of an SPA and SAC designation is to provide a stronghold for habitats and associated species through appropriate management measures achieved by cooperation between the regulatory authorities, land owners, industries and the public. They are not intended to be ‘no go’ areas.

In addition to the SPA and SAC designations the coastal elements down to the low water line are nationally designated as Special Sites of Scientific Interest.

[44] English Nature and Scottish Natural Heritage (1992) Solway Firth European Marine Site Management Scheme

7.1.2 REASONS FOR DESIGNATION

7.1.2.1 Candidate SAC

The Habitats Directive was adopted by the EU in May 1992. The overall aim of the Directive is to encourage the conservation of biodiversity in Europe, including both terrestrial and marine biodiversity, by requiring Member States to take measures to maintain or restore certain natural habitats and wild species at a favourable conservation status in the EU, giving effect to both site and species protection objectives. The Directive also aims to ensure that any development of the site is sustainable. Annex I of the Habitats Directive lists a number of habitat types that are considered to be under pressure or rare enough or important enough to justify protection. Member States are required to designate particularly extensive or high quality examples of Annex I habitats that lie within their territories as Special areas of Conservation. The Inner Solway has been selected as a Candidate SAC because it holds five different Annex I habitats. These are described below and there extent within the European Marine Site shown in Figures 7.1.1 to 7.1.7.

Estuaries

The Solway Firth is one of the largest, least industrialised and sandy estuaries in Europe. At low water the Inner Solway area almost completely dries out exposing extensive mud flats and sand flats. These form one of the largest continuous areas of sedimentary habitats in the UK. The estuary is also important for migratory fish including salmon and sea trout as they pass through the esturay into the rivers Nith, Sark, Kirtle water, Esk, Eden and Wampool. The mudflats also provide important nurseries and feeding grounds for commercial and recreation fish as well as significant food sources for birds. Intertidal and subtidal scar ground is a characteristic feature of the Firth. The scar areas which remain clear of sand support rich and well developed animal and plant communities typical of rocky areas. The scars support seaweeds, mussels, crabs and reef building honeycomb worm.

Pioneer Saltmarsh

Pioneer saltmarsh on the Solway Firth is part of a complex sequence of saltmarsh types which range from pioneer communities through to mid and high saltmarsh and tidal grazing marsh. The distribution of pioneer saltmarsh varies inresponse to changine river channels and erosion and accretion of existing marsh.

Saltmarsh

The Inner Solway contains some 13% of the UK’s resource of a saltmarsh type which is uninterrupted in transition from saltwater to freshwater habitats. 3,800 hectares of these habitats are found in the Inner Solway. Unlike more southerly saltmarshes, those of the Inner solway develop on sediments with a high sand content. Furthermore some of the plants they support such as sea purslane, common sea lavender and lax-flowered sea lavender are at the northern limits of their range in the UK. The marshes are important as feeding grounds for many species of birds and also provide breeding pools and food sources for the rare natterjack toad.

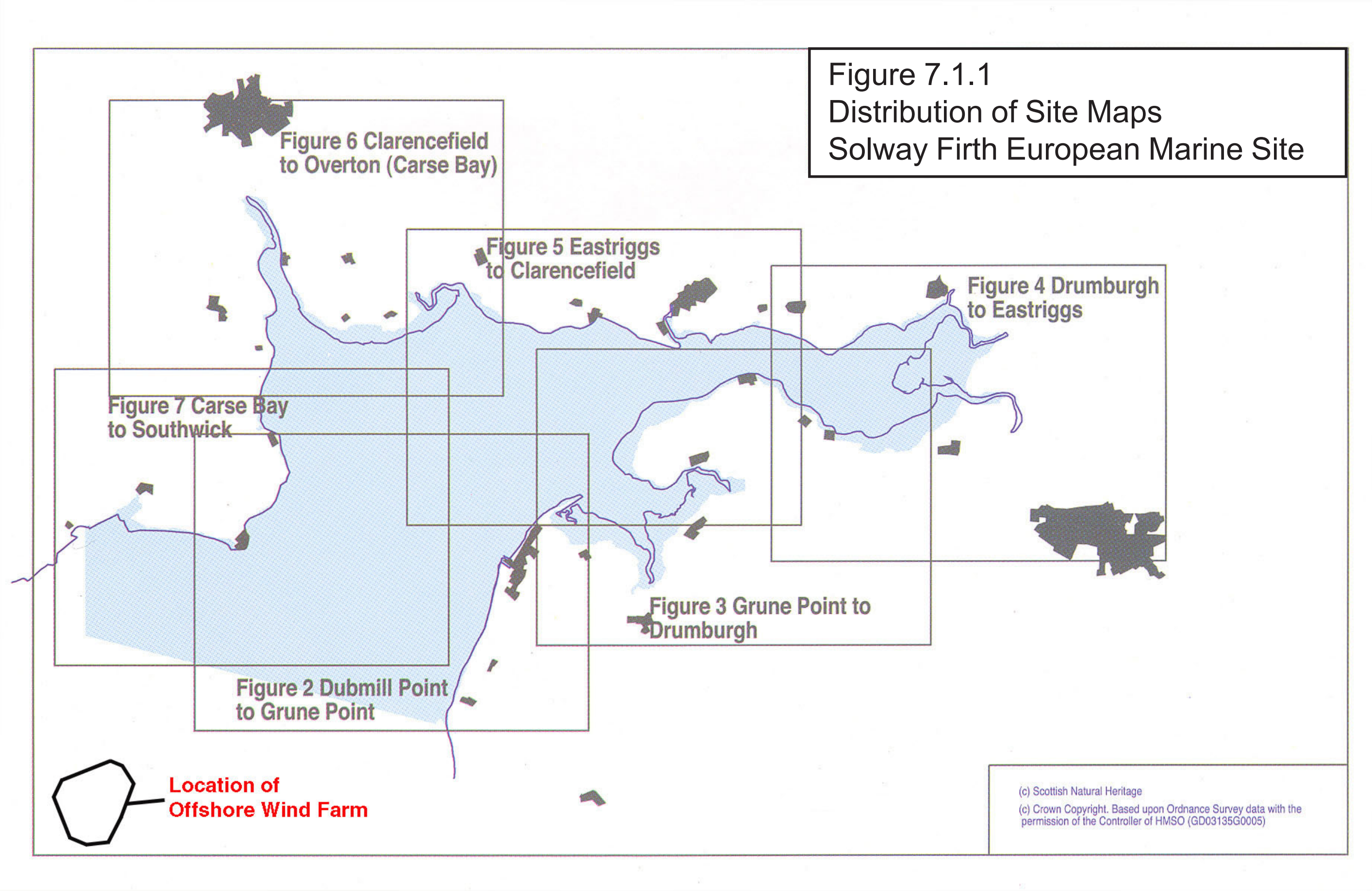


Figure 7.1.1
Distribution of Site Maps
Solway Firth European Marine Site

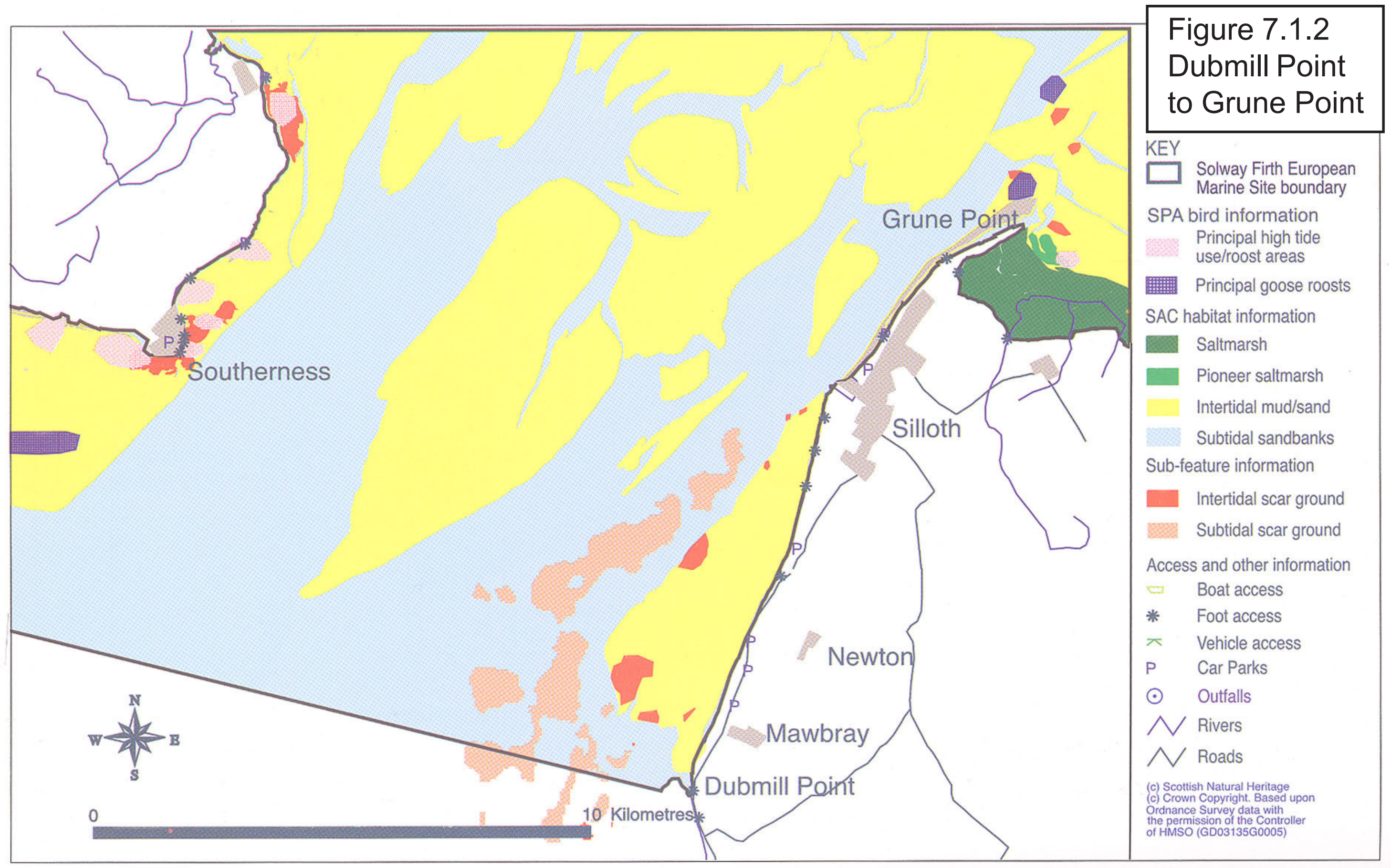


Figure 7.1.2
Dubmill Point
to Grune Point

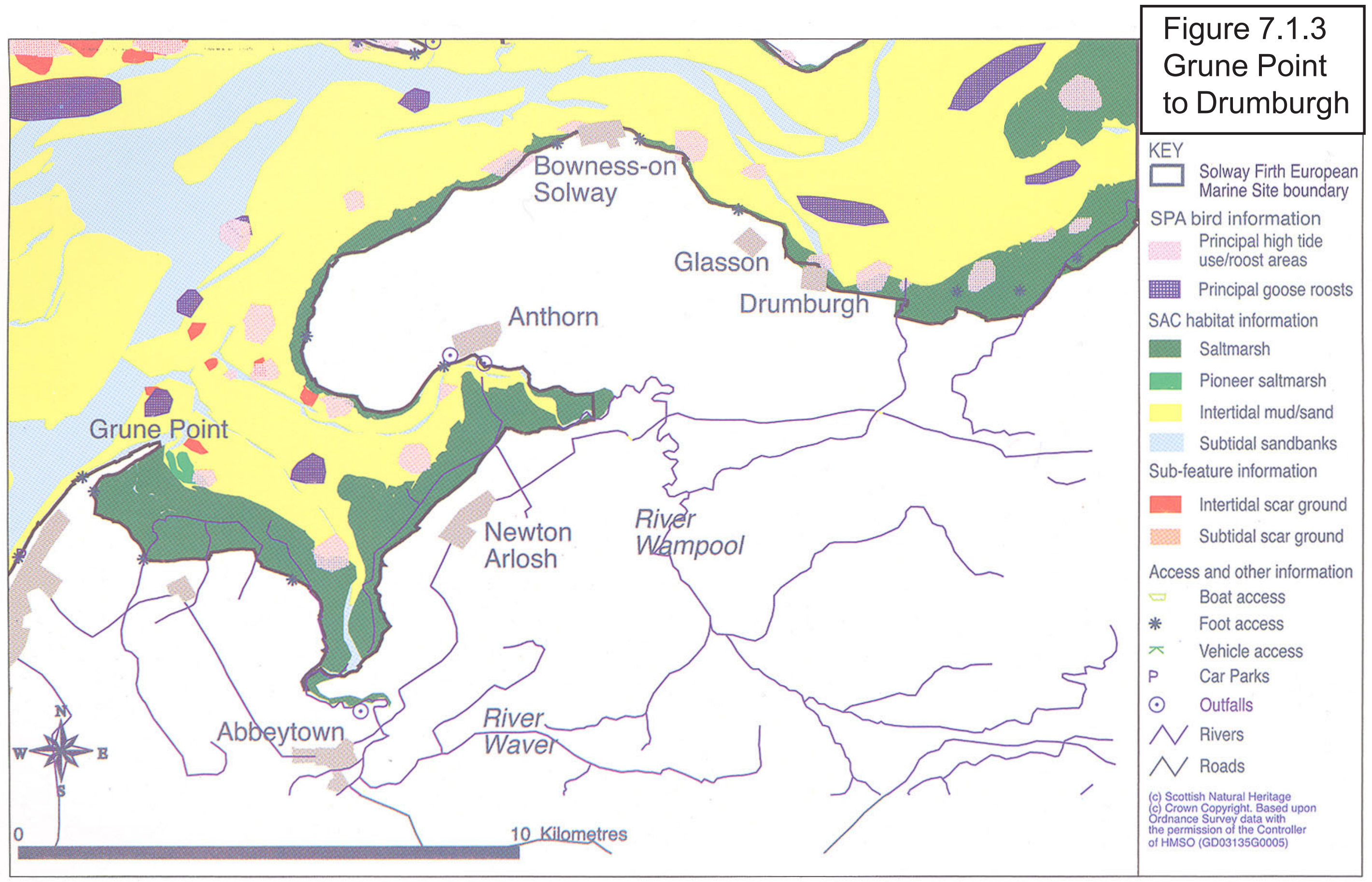


Figure 7.1.3
Grune Point
to Drumburgh

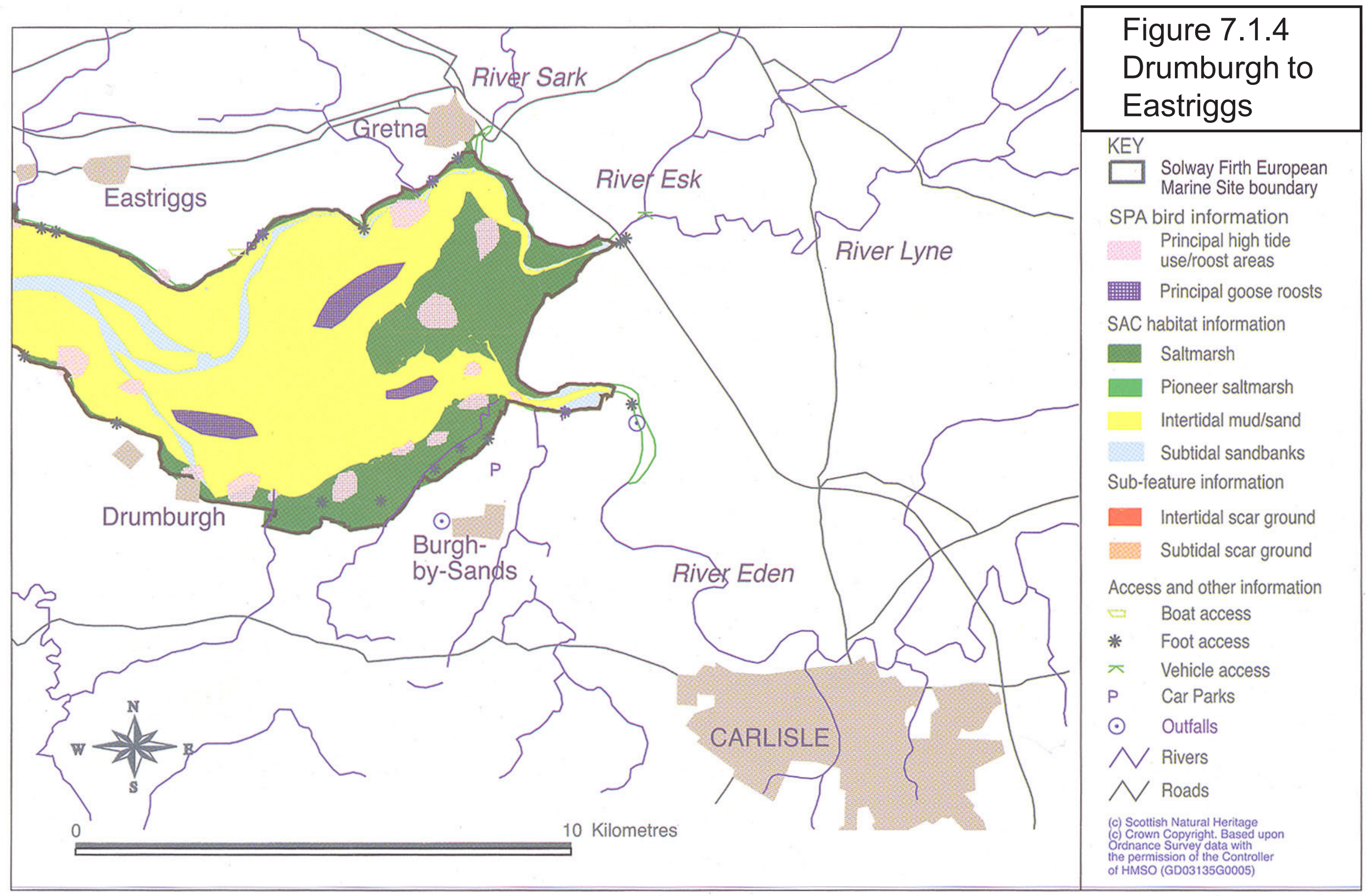


Figure 7.1.4
Drumburgh to
Eastriggs

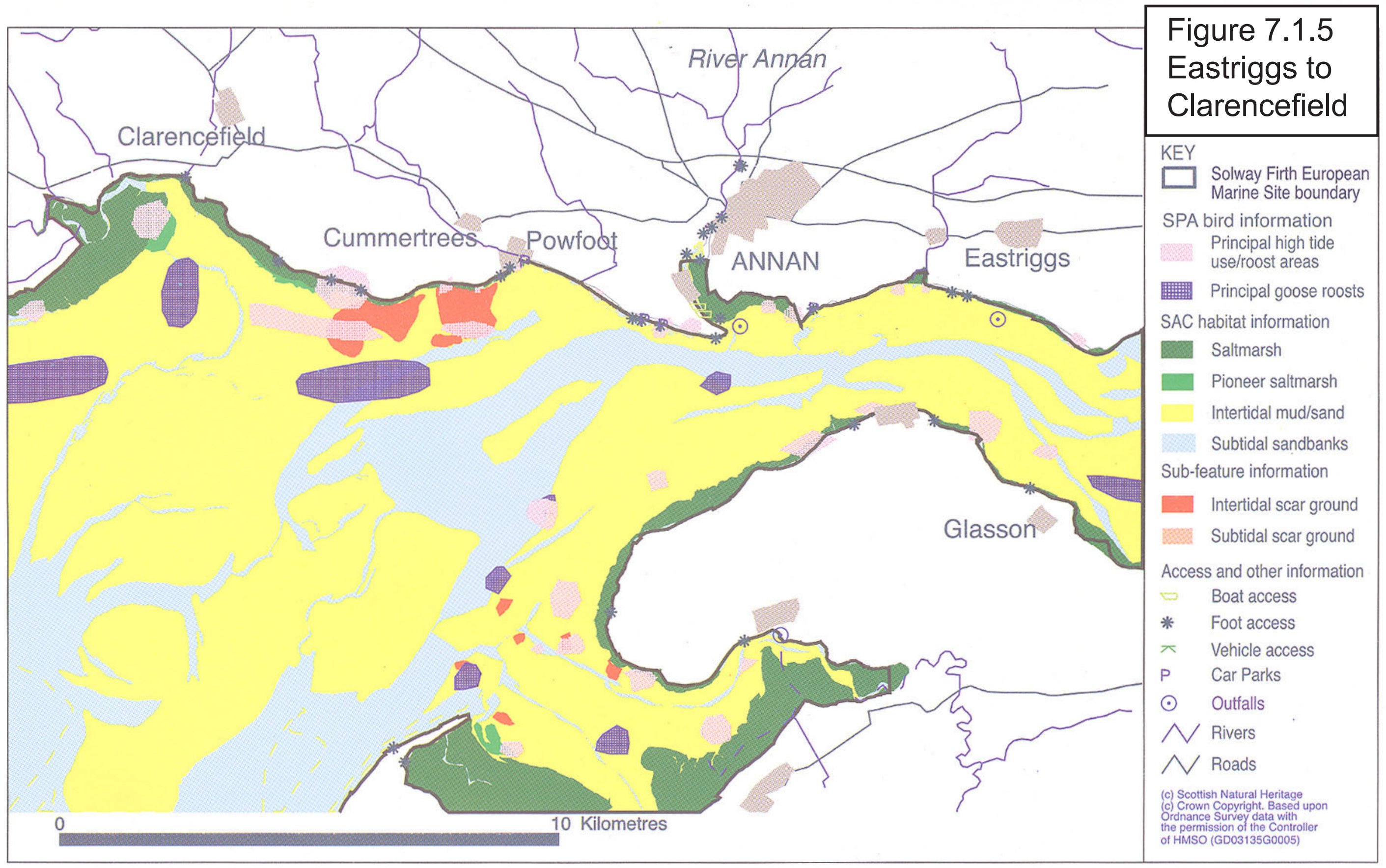


Figure 7.1.5 Eastriggs to Clarencefield

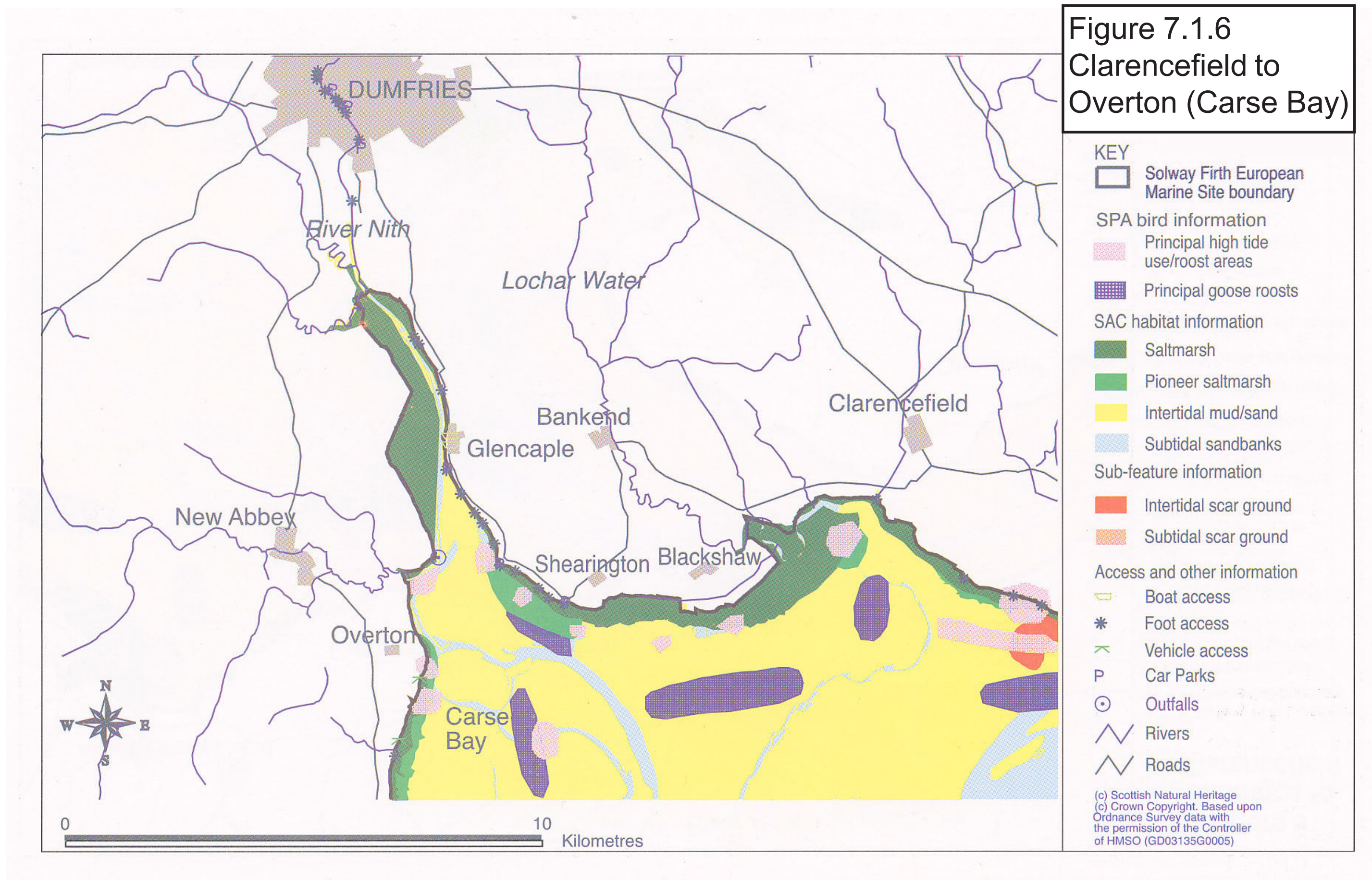


Figure 7.1.6 Clarencefield to Overton (Carse Bay)

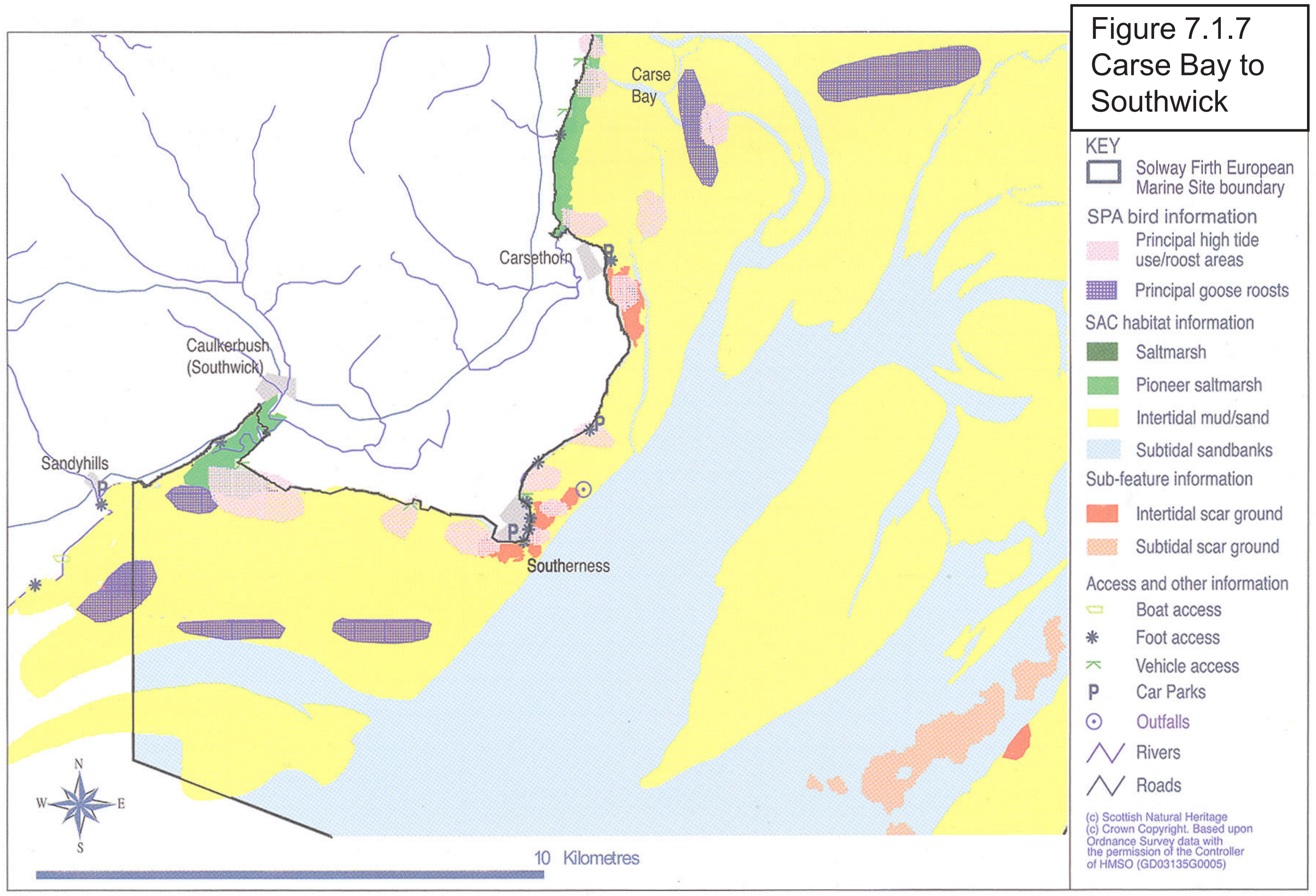


Figure 7.1.7 Carse Bay to Southwick

Intertidal Mud and Sandflats

The intertidal mudflats and sandflats of the Solway are the third largest in the UK following the Wash and Morecambe Bay they contribute significantly to the habitat diversity of the site and to its international importance. The flats are highly mobile and consist primarily of fine sands and silt. Finer sandy sediments occur in the inner estuary with coarser sediments becoming more predominant as one moves in the outer estuary. The flats, which are exposed in low tide and covered at high tide, support a typical estuarine fauna, providing a valuable food source for birds and fish and provide refuge for roosting birds at lower tides. A range of factors including salinity, sediment grain size, organic content and wave exposure influence the benthic communities of the varying areas of flats. The cockle beds found in the intertidal flats play a crucial role in the health of the estuary acting as filter feeders taking phytoplankton out of the system and providing pathways for nutrient recycling.

Subtidal Sandbanks

The subtidal sediment banks are separated by six main river channels, which continually change position. They play an important role in maintaining a sediment balance within the estuary, acting as both source and sink for sediments. The sub littoral sediment communities of the inner estuary are typically sparse in the inner estuary but become richer towards the outer estuary due to a more varied substrate including patches of mud, silt, stone and outcrops of underlying hard bedrock amongst sand. Those sediments provide spawning grounds and nursery grounds for fish, invertebrates and brown shrimps.

7.1.2.2 Special Protection Area

The EC Birds Directive applies to birds, their eggs and their habitats. It provides for the protection and management of naturally occurring wild birds within member States. The Directive requires Member States to take necessary measures to preserve a sufficient diversity of habitats for all species of wild birds naturally occurring within their territories in order to maintain populations at sustainable levels. Moreover it requires Member States to take special measures to conserve the habitats of certain rare and migratory species that are listed under Annex 1 of the Directive.

The Solway SPA has been designated for its internationally important wintering populations of rare species listed under Annex I of the Directive, internationally important individual populations of regularly occuring water fowl and lastly for internationally important assemblages of water fowl. With the third largest continuous area of intertidal habitat in the UK, the Solway Firth is a vital resting and over wintering area for birds migrating along the eastern Atlantic seaboard. While the whole of the Inner Solway is designated an SPA to provide an integrated approach to management of the area, there are distinct more localised areas within this area that are key habitats for the individual species and assemblages. Nevertheless, the important bird populations require a broad functional estuarine regime that is capable of supporting the various intertidal habitats of importance for feeding as well as areas above high tide for roosting. The habitats and main areas used by the Annex 1 species are shown in Figures 7.1.2 to 7.1.7.

The Annex 1 species supported by the area in internationally important populations comprise:

- *Barnacle Goose:* the Inner Solway supports a wintering population of around 12,000 barnacle geese following their arrival from their artic summer habitats in September. The barnacle geese feed within the saltmarsh areas and adjacent farmland of the Inner Solway, and roost in particular at Mersehead sands, Blackshaw Bank south of Caerlaveroch and the sand flats fronting Rockcliffe Saltmarsh which lies at the easternmost edge of the Solway between the mouths of the Esk and Eden. The roost areas vary according to the tide.
- *Golden Plover:* the Inner Solway supports a winter population of around 3,400 golden plover. They feed on small shellfish and worms and roost on intertidal mudflats. Their distribution within the site is variable, with a strong autumn passage on the north shore and numbers on the south shore increasing sharply in October and remaining high until February.
- *Whooper Swan:* over 200 whooper swans over winter in the area, mainly at Caerlaveroch and Moricambe Bay, arriving from Iceland in early-mid October. They feed on saltmarsh and adjacent farmland and roost on the waters of the estuary.

Other non Annex 1 species that winter in internationally important populations within the area include bar tailed goldwit, curlew, knot, oystercatcher, pink-footed goose, pintail, redshank and scaup.

The third category for which the Solway is designated an SPA is for its internationally important assemblage of over-wintering water fowl. Over 120,000 birds roost and feed in the Inner Solway during the winter months of which over 20,000 are over-wintering water fowl. Wildfowl and waders feed and roost on the intertidal habitats. As noted above, particular areas will be favoured by different species, and moreover these areas will vary from year to year according to natural fluctuations in food availability.

7.1.3 SENSITIVITIES OF THE EUROPEAN MARINE SITE

The Management Plan for the site published in 2000 identifies a number of potential operations that have could negative effects on some or all of the 5 Annex I habitats, the Annex I bird species, the internationally important populations of other migratory water fowl and the internationally important assemblage of water fowl. These categories and examples of current operations are given in the table 7.1.1 below. Importantly these operations are not prohibitions but operations that require management. Shaded boxes indicate those of the 8 designated elements that are considered to be highly or moderately vulnerable to the effects of the operations.

Table 7.1.1 Operations that may cause detioration or diturbance to the Solway Firth European Marine Site (shaded boxes show potential impacts)

Categories of Operation		Estuaries	Saltmarsh	Pioneer Saltmarsh	Intertidal mudflats	Subtidal sandbanks	SPA Annex I	SPA other species	SPA waterfowl assembly
Physical loss									
Removal	Coastal development	■	■	■	■	■	■	■	■
	Aggregate extraction	■	■	■	■	■	■	■	■
	Dredging	■	■	■	■	■	■	■	■
	Shrimp trawling	■	■	■	■	■	■	■	■
Smothering	Disposal of dredge material								
Physical damage									
Siltation	Dredging	■		■	■	■			
Abrasion	Benthic fishing	■	■	■	■	■	■	■	■
	Tractor dredging for shellfish	■	■	■	■	■	■	■	■
	Coastal development	■	■	■	■	■	■	■	■
	Mussel harvesting	■	■	■	■	■	■	■	■
Selective extraction	Aggregate extraction	■		■	■			■	■
Non physical disturbance									
Noise	Wild fowling						■	■	■
	Jet skiing						■	■	■
	Low flying aircraft						■	■	■
Visual	Recreational activity						■	■	■
	Bait collection						■	■	■
Toxic Contamination									
Introduction of synthetic compounds	Industrial effluent discharges	■	■	■	■	■	■	■	■
Introduction of non synthetic compounds	Industrial and sewage discharges	■	■	■	■	■	■	■	■
Introduction of radionuclides	Power station discharge (i.e. Chapel Cross, Sellafield)	■	■	■	■	■	■	■	■
Non Toxic Contamination									
Nutrient enrichment	Industrial and sewage discharges	■	■	■	■	■	■	■	■
	Agricultural run off	■	■	■	■	■	■	■	■
Organic enrichment	Industrial and sewage discharge	■	■	■	■	■	■	■	■
Changes in thermal regime	Disharge of warm water from power stations								
Changes in turbidity	Suction or tractor dredging								
Changes in salinity	Water abstraction from in-flowing rivers								
Biological Disturbance									
Introduction of pathogens	Industrial and sewage discharge								
Introduction of non-native species	Introduction of *spartina anglica*	■	■	■	■		■	■	■
Selective abstraction of species	Bait collection	■		■	■		■	■	■
	Mussel harvesting	■		■	■		■	■	■
	Cockle harvesting	■		■	■		■	■	■

7.1.3.1 Potential Sensitivities to Offshore Wind Development

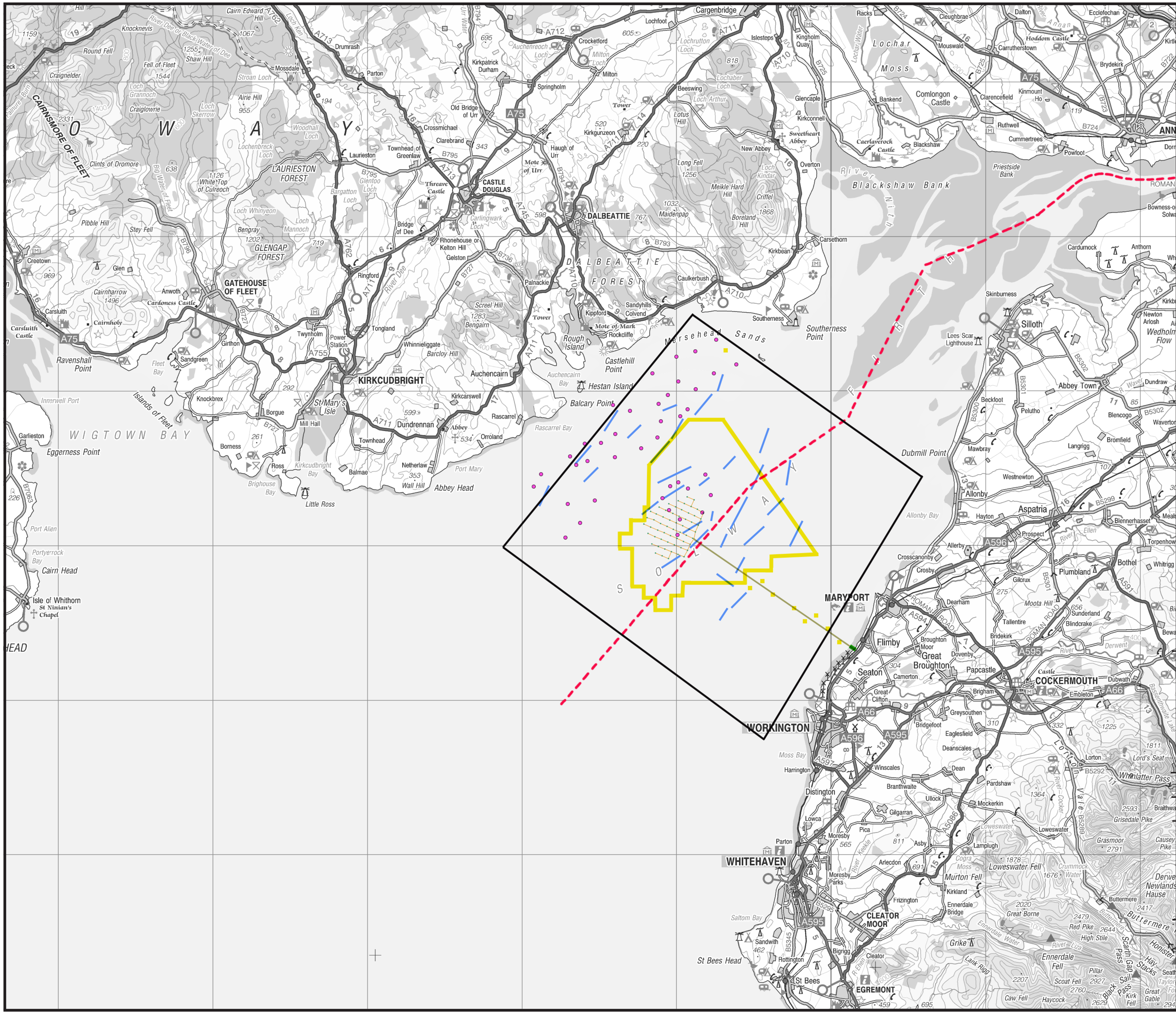
Of the operations given in Table 7.1.1 above, those that could potentially be associated with wind energy development are as follows:

- Physical Loss: some physical loss of habitat could result from the construction of wind turbines directly within one of the protected habitats although this would be a very small loss in comparison to the extent of habitats. Some loss through smothering could also occur if material is removed from foundations and deposited on a protected habitat. The wind farm would need to be constructed within a protected habitat for this damage to occur.
- Physical Damage: some minimal damage could occur of habitat within a wind farm area through the construction period from ploughing of cables into to the seabed, and from the feet of jackup barges resting on the sea bed. The wind farm would need to be constructed within a protected habitat for this damage to occur.
- Non-Physical Disturbance: construction and to a lesser extent operation of a wind farm will have noise and visual effects on Annex 1 birds and over-wintering water fowl depending on the distance of the elements of the wind farm from roosting and feeding areas within the SPA.
- Toxic Contamination: toxic contamination in small amounts could potentially occur during accidents in the construction period i.e. leaks of hydraulic fluids from cranes, jack-up barges etc. In addition, leaks of transformer fluids could occur if transformers were not bunded securely during operation of the wind farm. The risk of contamination in the event of a leak would depend on the toxicity and quantity of the fluids used and the distance of the wind farm from the protected areas but would be unlikely to be significant.
- Non-Toxic Contamination: the only means by which this could occur is through increases in turbidity from the disturbance of sediments during construction or from seabed scour. Due to the high mobility and therefore turbidity of the Solway the habitats within the SAC are not moderately or highly vulnerable to increases in turbidity.

The Robin Rigg wind farm development is positioned some 7 km south of the European Marine Site at its closest point. The relative position of the proposed development to the SPA and SAC is shown in Figure 7.1.1. The effects of the Robin Rigg wind farm construction and operation on the European Marine Site is given in Section 9 of the ES.

7.2 OUTLINE OF ECOLOGICAL SURVEYS

Following broad site selection, initial scoping exercises and reveiws of existing data on the ecological resource of the Robin Rigg area and the middle area of the Solway in which it lies, a number of surveys were initiated to fill in gaps in knowledge of the area and give sufficient data to carry out impact assessments on the various ecological elements including the the marine benthos flora and fauna, benthic/demersal or pelagic fish including species which utilise the Solway Firth as a spawning/nursery ground, seabirds and water fowl and marine mammals. Survey areas and methodologies are discussed in detail in the releant sections that follow. The survey areas, methodologies and survey periods were coordinated to ensure that the results of each survey could be read in the context of other surveys. In some cases such as the benthic trawl, surveys were carried out specifically to provide data for other assessments in this case for the ornithological assessment.



Project:

Proposed Offshore Wind Farm, Solway Firth

Title:

Figure 7.2.1 Biological Survey Areas

Key

- Proposed Wind Farm Site
- Site to shore 132kV cable
- Bird survey area (May 2001 - April 2002)
- Fish trawl transect lines (November 2001 - April 2002)
- Bird food source benthic trawls (March 2002)
- Benthic grab sample area (October 2001 & February 2002)
- Benthic grab sample point (March 2002)
- Littoral Benthic Survey (February 2002)
- Scotland - England border

Scale: 1: 250,000

Kilometres: 0 5 10 15

Centimetres: 0 1 2 3 4 5 6

N

Date: 28-05-02	Prepared by: DH
Drawing No: SOL_SurveyAreas.tif	Checked by: DW

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Offshore Energy Resources Ltd.

TXU
Offshore Energy Resources Limited

Ecological surveys carried out specifically for the Robin Rigg wind farm environmental assessment included:

- Comprehensive benthic flora and fauna sampling at the same sampling points as the surface sediment sampling positions
- Benthic trawl sampling along transects to the north to northwest of the wind farm site within the area with consistently high populations of common scoter in March 2002, analysed for biomass of bivalves and other food sources for Common scoter
- An intertidal Phase 2 habitat walkover survey in February 2002 along a transect from high water springs to low water springs at the landfall site for the 132 kV wind farm to shore cable.
- Monthly fish trawl surveys within the wind farm site, in control areas and within the common scoter area since October 2001
- Boat based twice-monthly bird surveys across a wider survey area containing most of the mid Solway area, since May 2001
- Aerial monthly bird surveys along transect lines 2 km, across the same area as the boat based surveys from November 2001 to April 2002 (January and February impossible due to weather conditions)

The survey areas, transects and sample points for these surveys are given in Figure 7.2.1. The baseline surveys and the results of the surveys are described in detail in the following sections.

7.3 MARINE BENTHOS

7.3.1 INTRODUCTION

Marenco Ltd. were commissioned by Solway Offshore Ltd. and Offshore Energy Resources to assess the likely construction, operational and decommissioning impacts of the proposed Robin Rigg offshore wind development on benthic flora and fauna, that is marine life lying within the upper sediment layers of the sea bottom. This work comprised the following elements:

1. A literature review of existing studies of the benthic ecology and biotopes within the Solway, including the Robin Rigg sandbank.
2. An analysis of the need for field survey
3. Defining survey areas and a suitable survey methodology that would yield data sufficient for analysis of impacts, including indirect impacts on birds and fish feeding on benthic flora and fauna,
4. An analysis of the sensitivity and recoverability of the communities present in the vicinity of the wind farm and substation to shore cable, to potential impacts associated with the development
5. A full impact assessment of impacts of construction, operation and decommissioning of the wind farm and substation to shore cable on benthic communities, including consideration of mitigation measures.

Parts 1 to 3 are contained in this baseline section of the ES. Parts 4 and 5 are reported on in Section 9.6 of the ES.

In addition to the benthic surveys carried out by Marenco for the benthic impact assessment process, further benthic trawl surveys were carried out by Dr. Jane Lancaster for the purposes of assessment of impacts on bird populations. The surveys were required to map out available shellfish food resources for Common Scoter to give an understanding of the underlying reasons for the observed distribution of these birds in the vicinity of the wind farm site. As such a much more simplified survey methodology and laboratory analysis were required. The methodology and results for that survey are detailed in Appendix C in the separate volume of appendices and is described in relation to Common Scoter populations in Section 7.6.4 of this ES.

7.3.2 EXISTING DATA

The Solway Firth is a shallow estuary and at low water the area of the Inner Solway (further east than the wind farm area) almost completely dries out exposing extensive fringing beaches and sandbanks. The sand and mudflats form one of the largest continuous areas of intertidal habitat in Great Britain, surpassed in area by only Morecambe Bay and the Wash[45]. These shifting sediments of fine muddy sand dominate both the intertidal and sublittoral.

7.3.2.1 Previous Studies

Due to the status of the Inner Solway as European Marine Site there have been a number of studies undertaken describing the marine flora and fauna of the qualifying habitats. However, the intertidal and subtidal areas outside the European Marine Site have been less well studied and information on marine biology of the area around Robin Rigg is scarce.

There have been several surveys on the intertidal sediments within the Solway. Perkins (1973) described the marine fauna and flora of the Solway Firth[46]. The Marine Nature Conservation Review (MNCR) has carried out intertidal surveys throughout most of the Solway Firth[47 48 49]. More recently Hull University was contracted to undertake a broad scale mapping study of the intertidal habitats on the Scottish side of the Firth[50]. All of these studies have however concentrated on the intertidal areas adjacent to the coast and have not included offshore sandbanks.

Several studies of shallow subtidal habitats have been undertaken in the Solway Firth and these have been reviewed by Barnes *et. al.* (1995)[51], Mills (1991; 1998)[52 53] and Covey (1998)[54]. However given the difficulty in

45 Davidson, N. C., Laffoley, D. d'A., Doody, J. P. Way, L. S., Gorden, J., Key, R., Drake, C. M., Pienkowski, M. W., Mitchell, R. M. and Duff, K. L. (1991) *Nature conservation and estuaries in Great Britain*. Peterborough, Nature Conservancy Council.

46 Perkins, E. J. (1973) The marine fauna and flora of the Solway Firth. *Dumfries and Galloway Natural History and Antiquarian Society*.

47 Covey, R. (1990) Littoral survey of the north coast of the outer Solway (Mull of Galloway to Auchencairn). *Chief Scientist Directorate Report* No. **1074**. Nature Conservancy Council, Peterborough.

48 Covey, R. and Emblow, C.S. (1992) Littoral survey of the Inner Solway Firth and additional sites in Dumfries and Galloway. *Joint Nature Conservancy Committee*, *JNCC Report* No. **33** (MNCR Report No. MNCR/SR/20).

49 Covey, R. (1998) Marine Nature Conservation Review Series 11. Liverpool Bay and Solway Firth: area summaries. Peterborough, JNCC, (Coast and seas of the united Kingdom. MNCR series.)

50 Cutts, N. and Hemmingway, K. (1996) The Solway Firth broad scale habitat mapping. Report to SNH by the Institute of Esturine and Coastal Studies, University of Hull.

51 Barnes, J. H., Robson, C. F., Kaznowska, S.S., Davidson, N.C., Doody, J.P. (1995) The British coasts and seas. Region 13. Northern Irish Sea; Colwyn Bay to Stranraer. Coastal Directories regional reports Series. JNCC, Peterborough.

52 Mills D.J.L. (1991) Benthic marine ecosystems in Great Britain. A review of current Knowledge – Cardigan Bay, North Wales, Liverpool bay and the Solway (MNCR Coastal Sector 10 & 11). NCC, CSD Report No. 1174 (MNCR Report No. MNCR/OR/O0101.

surveying subtidal habitats, their nature and the extensive areas which they cover, existing information for these areas is limited[55]. Some information is provided by Perkins (1973; 1981)[56 57] on the marine fauna and flora. Perkins and Williams (1966) studied the distribution the distribution of sediments and benthos[58]. Surveys of the shallow sublittoral have also been carried out by the MNCR[59].

7.3.2.2 Intertidal Mudflats and Sandflats

Intertidal flats cover over 35,000 ha in the Solway Firth and cover 50% of the total area of the Inner Solway[60]. Intertidal mudflats and sandflats are also Annex I SAC features as described in Section 7.1. These sand and mud flats are very mobile due to the changing erosion and deposition patterns resulting from strong tides, wave action and the changing course of river channels. The sediments of the Solway generally support rich marine and estuarine communities.

The majority of the Inner Solway is dominated by fine sands rather than muds[61], which is unusual in intertidal flats in the low salinity of an estuary. Within the estuaries the middle-channel banks tend to be less species rich than stable outlying the more stable nearshore banks.

The Marine Nature Conservation Review classifies characteristic and recurring species for different sediment types[62]. These different sediment communities, known as biotopes are summarised for the Solway Firth in Table 7.3.1

While there have been many surveys on the infauna of the intertidal flats of the Solway Firth most of these have concentrated on the coastal flats, and specific data for offshore subtidal banks such as Robin Rigg is limited. This is primarily due to the difficulty of accessing and sampling these areas. Information from Perkins and Williams (1966)[63] and Perkins (1973)[64] reveals the fauna of the littoral sediments in the outer Solway to include *Corophium voluntator*, the polychaetes *Arenicola marina* and *Owenia fusiformis*, and the bivalve *Scrobicularia plana*, *Macoma balthica*, *Cerasterderma edule*, *Angulus tenuis*, *Fabulina fabula*, *Abra alba*, *Nucula sulcata* and *Donax vittatus.*

An indication of what may be found on the outer Solway sandbanks comes from Cutts and Hemmingway (1996), however their survey did not extend as far south as Robin Rigg. In areas of high wave exposure they found the sediments to be coarse and the fauna to be dominated by burrowing amphipods, mainly *Bathyporeia* species[65]. Clean medium sands to fine sands in moderately exposed reaches of the firth were dominated by polychaetes such as *Nephtys cirrosa* and *Nephtys hombergii* and the bivalves *Angulus tenuis* and *Donax vittrus.* In areas of fine or very fine sand in normal salinity, typical species included polychaetes such as *Nephtys* species, *Scoloplos armiger*, the lugworm *Arenicola marina* and the amphipod *Bathyporeia pelagica*. Transitional communities occurred with changes in grain size[66].

53 Mills, J.L. (1998) Liverpool Bay to the Solway (Rhos-on Sea to the Mull of Galloway) (MNCR Sector 11). In: *Marine Nature Conservation Review. Benthic marine ecosystems of Great Britain and the north-east Atlantic*. Ed. K. Hiscock, 315-338. Peterborough, JNCC. (Coast and Seas of the United kingdom. MNCR series.)

54 Covey, R. (1998) Marine Nature Conservation Review Series 11. Liverpool Bay and Solway Firth: area summaries. Peterborough, JNCC, (Coast and seas of the united Kingdom. MNCR series.)

55 Solway Firth Partnership (1996) *The Solway Firth Review*. The Solway Firth Partnership.

56 Perkins, E. J. (1973) The marine fauna and flora of the Solway Firth. *Dumfries and Galloway Natural History and Antiquarian Society*.

57 Perkins, E. J. (1981) Studies in the distribution and biological impact of the effluent released by Thames Board Mills Ltd., Siddick. The bottom fauna of Maryport Roads and Allonby Bay 1962-1978. Unpublished report to the Cumbria Sea Fisheries Committee (*CSFC Scientific Report*, No. **81/3**).

58 Perkins, E. J. and Williams, B. R. H. (1966) The biology of the Solway Firth in relation to the movement and accumulation of radioactive materials. Part II. The distribution of sediment and benthos. Chapelcross, United Kingdom Energy Authority. (*UKEA Production Group Report*, **587**).

59 Covey, R. (1992) Sublittoral survey of the north coast of the outer Solway (Mull of Galloway to Auchencairn). *Chief Scientist Directorate Report* No. **1193**. Nature Conservancy Council, Peterborough.

60 Solway Firth Partnership (1996) *The Solway Firth Review*. The Solway Firth Partnership.

61 Marshal, J.R. (1962) Morphology of the Upper Solway saltmarshes. *Scottish Geological Magazine* No. **78**, pp. 81-99.

62 Connor, D. W., Brazier, D. P., Hill, T. O. and Northen, K. O. (1997) Marine Nature Conservation Review: marine biotope classification for Britain and Ireland. Volume 1. Littoral biotopes. Version 97.06. *Joint Nature Conservation Committee Report*, No. **229**.

63 Perkins, E. J. and Williams, B. R. H. (1966) The biology of the Solway Firth in relation to the movement and accumulation of radioactive materials. Part II. The distribution of sediment and benthos. Chapelcross, United Kingdom Energy Authority. (*UKEA Production Group Report*, **587**).

64 Perkins, E. J. (1973) The marine fauna and flora of the Solway Firth. *Dumfries and Galloway Natural History and Antiquarian Society*.

65 Cutts, N. and Hemmingway, K. (1996) The Solway Firth broad scale habitat mapping. Report to SNH by the Institute of Esturine and Coastal Studies, University of Hull.

66 Covey, R. and Emblow, C.S. (1992) Littoral survey of the Inner Solway Firth and additional sites in Dumfries and Galloway. *Joint Nature Conservancy Committee*, *JNCC Report* No. **33** (MNCR Report No. MNCR/SR/20).

Table 7.3.1 MNCR biotopes (97.06) from various sediment types in the Solway Firth [67 68 69 70].

MNCR Biotope code	Habitat description	Characteristic species
LGS.S.Tal	Extreme upper shore strand line	Talitrid amphipods in decomposing seaweed: *Talitrus saltator* (sand hopper)
LGS.Sh.bar.sh	Barren shingle or gravel	Barren
LGS.S.Bar.Snd	Barren course sand shore	Low abundance of *Bathyporeia* sp. and *Pontocrates* sp.
LGS.S.AP	Clean sand shores	Burrowing amphipods and polychaetes
LGS.S.AP.P	Clean sand shores	Burrowing amphipods and polychaetes; often *Arenicola marina*
LGS.S.AP.Pon	Lower shore clean sands	Burrowing amphipods *Pontocrates* sp. and *Bathyporeia* spp.
LGS.Est.Ol	Fresh water influenced sands	Oligochaetes
LMS.MS.BatCor	Uppershore slightly muddy fine sands	*Bathyporeia* sp. and *Corophium* spp.
LMS.MS.Pcer	Fine sands and muddy sand shores	Polychaetes and *Cerastoderma edule*
LMS.MS.MacAre	Muddy sandy shores	*Macoma balthica* and *Arenicola marina*
LMU.HedScr	Sheltered fine muddy sands, with reduced salinity	*Scrobicularia plana, Hediste diversicolor, Cerastoderma edule*
LMS.Pcer	Fine/muddy sands, mid to lower shore	Polychaetes and *Cerastoderma edule* and *Macoma balthica*
LMU.SMu.HedMac	Sandy mud shores	*Hediste diversicolor* and *Macoma balthica*
LMU.SMu.HedMac.Pyg	Sandy mud shores	*Hediste diversicolor, Macoma balthica* and *Pygospio elegans*
LMU.SMu.HedMac.Are	Muddy sand/sandy mud shores	*Hediste diversicolor, Macoma balthica* and *Arenicola marina*
LMU.SMu.HedMac.mare	Sandy mud shores	*Hediste diversicolor, Macoma balthica* and *Mya arenaria*
IMS.Zmar	Sheltered lower shore, fine mud	Eel grass *Zostera marina*
LMU.Sm	Saltmarsh	Salt marsh vegetation
LMU.MU.HedOl	Low salinity soft mud shores	*Hediste diversicolor* and oliochaetes

67 Covey, R. (1990) Littoral survey of the north coast of the outer Solway (Mull of Galloway to Auchencairn). *Chief Scientist Directorate Report* No. **1074**. Nature Conservancy Council, Peterborough.

68 Covey, R. and Emblow, C.S. (1992) Littoral survey of the Inner Solway Firth and additional sites in Dumfries and Galloway. *Joint Nature Conservancy Committee*, *JNCC Report* No. **33** (MNCR Report No. MNCR/SR/20).

69 Cutts, N. and Hemmingway, K. (1996) The Solway Firth broad scale habitat mapping. Report to SNH by the Institute of Esturine and Coastal Studies, University of Hull.

70 Connor, D. W., Brazier, D. P., Hill, T. O. and Northen, K. O. (1997) Marine Nature Conservation Review: marine biotope classification for Britain and Ireland. Volume 1. Littoral biotopes. Version 97.06. *Joint Nature Conservation Committee Report*, No. **229**.

7.3.2.3 Sub-tidal Sediment Communities

This habitat primarily consists of soft sediment types that are permanently covered by shallow sea water (<20m) and is also an Annex I SAC feature. The subtidal channels of the Solway experience shallow water at low tide and fast tidal velocities, up to six knots in the Inner Solway[71]. These areas are characterised by an absence of infauna. The number of species increases towards the outer estuary as conditions become less extreme and sediment types become more varied.

Over much of the Inner Solway the sediments are dominated by a sparse community of mobile opportunistic species such as the amphipods *Bathyporeia pelagica*, *Bathyporeia pilosa* and *Haustorius arenarius*, with some sites also having the Baltic tellin *Macoma balthica* and the polychaetes *Eteone longa* and *Pygospio elegans* (biotope code: MobRS;Ncir). These communities are likely to extend over the whole subtidal area of the Inner Solway where tide swept mobile sediments are present[72].

To the west and head of the Firth there are predominantly fine to medium sands, supporting rich and diverse communities dominated by the polychaete worm *Nephtys cirrosa* and the amphipod *Bathyporeia elegans* [73]. Other species include the polychaete *Magelona mirabilis*, the bivalve *Angulus tenuis*, horse mussels (*Modiolus modiolus*) and edible mussels in the Silloth channel. Towards the middle channel and the east, the banks are mainly clean sands with low species diversity, the key species being *Nephtys cirrosa* in clean sands and *Microthalamus similis* in areas of gravel and pebbles.

The southern Solway sub-tidal zone is less well studied, but existing data suggests that the shallow inshore zone is composed of fine mobile sands with sparse infauna and epifauna (biotope codes: FaS and Mob:Ncirbat)[74] with the species richness increasing towards the Irish Sea. The sublittoral zone of the outer Solway is reportedly richer than the barren channels of the Inner Solway[75]. With increased depth sediments become more stable and are characterised by brittle stars (biotope code: AfilEcor) and a richer infauna of polychaetes and bivalves (biotope code: FaMS)[76]. Accoding to Perkins and Williams (1966)[77] and Perkins (1973)[78] in silty areas the polychaete *Nephtys cirrosa* and the bivalves *Nucula sulcata*, *Abra abra* and *Fabula tenuis* reach maximum abundance. These communities are found in Allonby Bay, between Castlehill Point and Wigtown Bay, and the area between Workington and Abbeyhead. In areas of fine sand the bivalves *Mactra corallina* and *Donax vittatus* tend to be more common, while in medium sands it is the bivalve *Spisula solida* that dominates the infauna.

71 Puxley, C. J. (1997) The Solway Firth: its past and present maritime usage with special reference to Silloth. In: *Coastal Zone Topics Process Ecology and Management* (Eds. P. D. Jones and R. G. Chambers), **2** *The Solway and Cumbrian Coasts,* (Eds. A. L. Buck and J. R. Pomfret). pp. 1-6.

72 Covey, R. (1998) Marine Nature Conservation Review Series 11. Liverpool Bay and Solway Firth: area summaries. Peterborough, JNCC, (Coast and seas of the united Kingdom. MNCR series.)

73 Cutts, N. and Hemmingway, K. (1996) The Solway Firth broad scale habitat mapping. Report to SNH by the Institute of Esturine and Coastal Studies, University of Hull.

74 Covey, R. (1998) Marine Nature Conservation Review Series 11. Liverpool Bay and Solway Firth: area summaries. Peterborough, JNCC, (Coast and seas of the united Kingdom. MNCR series.)

75 Perkins, E. J. and Williams, B. R. H. (1966) The biology of the Solway Firth in relation to the movement and accumulation of radioactive materials. Part II. The distribution of sediment and benthos. Chapelcross, United Kingdom Energy Authority. (*UKEA Production Group Report*, **587**).

76 Covey, R. (1998) Marine Nature Conservation Review Series 11. Liverpool Bay and Solway Firth: area summaries. Peterborough, JNCC, (Coast and seas of the united Kingdom. MNCR series.)

77 Perkins, E. J. and Williams, B. R. H. (1966) The biology of the Solway Firth in relation to the movement and accumulation of radioactive materials. Part II. The distribution of sediment and benthos. Chapelcross, United Kingdom Energy Authority. (*UKEA Production Group Report*, **587**).

78 Perkins, E. J. (1973) The marine fauna and flora of the Solway Firth. *Dumfries and Galloway Natural History and Antiquarian Society*.

Table 7.3.2 Characteristic species of the Solway sublittoral sand flats[79]

Characteristic Species	Sediment type
Mactra corallina	Fine sediments
Donax vittatus	Fine sediments
Nephtys spp.	Medium sands
Nucula sulcata	Muddy sands
Abra alkbida	Muddy sands
Angulus tenuis	Muddy sands

The most dominant mobile epifaunal species in the Solway is the brown shrimp (*Crangon crangon*), which migrates from the outer Solway to the Inner Solway each summer[80 81]. Shrimps are found at Robin Rigg in the winter months, lowest numbers occurring between June and August when the shrimps migrate back up the estuary to feed. Evidence suggests that during the 1970's the area around Robin Rigg was used as a spawning ground by *C. crangon*.

Other epifaunal species that have been found in the area around Robin Rigg are the shore crab (*Carcinus manaus*), hermit crabs (*Eupagurus bernhardus*), spider crabs (*Macropodia rostrata* and *Hyas areneus*), swimming crabs (*Portunus depurator* and *Portunus holsatus*), the common starfish (*Asterius rubens*) and large brittle star (*Ophiura ophiura*). Many of these species migrate into the Solway in the summer when the salinity is higher[82].

7.3.2.4 Intertidal Scar Grounds

In addition to mud and sandflats the Solway also contains areas of coarser sediment such as pebbles, cobbles and boulders, which are raised above the level of the sand. These are known locally as 'scars' and arise due to the exposure of boulder clay. Once exposed, the clay is usually eroded from the boulder interstices, leaving extensive areas of boulder shores[83]. Outcrops of bedrock are very localised. In some areas, the movement of sediment means that scar exposures may appear suddenly, only to be smothered shortly afterwards. Most scar ground is found on the English side of the Firth.

79 Perkins, E. J. and Williams, B. R. H. (1966) The biology of the Solway Firth in relation to the movement and accumulation of radioactive materials. Part II. The distribution of sediment and benthos. Chapelcross, United Kingdom Energy Authority. (*UKEA Production Group Report*, **587**).
80 Perkins, E. J. (1981) Studies in the distribution and biological impact of the effluent released by Thames Board Mills Ltd., Siddick. The bottom fauna of Maryport Roads and Allonby Bay 1962-1978. Unpublished report to the Cumbria Sea Fisheries Committee (*CSFC Scientific Report*, No. **81/3**).
81 Lancaster, J. (1999a) Ecological studies on the brown shrimp (Crangon crangon) fishey in the Solway Firth. PhD thesis. University of Newcastle upon Tyne.
82 Perkins, E. J. (1978) The Solway Firth – its hydrology and biology. Report to the NCC, south-west Scotland Region, Balloch.
83 Anon (1999) English Nature's and Scottish Natural Heritage's advice for the Solway European marine site given in compliance with Regulation 33(2) and in support of the implementation of the Conservation (Natural Habitats &c) Regulation 1994. Consultation Draft

Perkins (1986) found the species richness of a scar depends on the frequency of sand inundation[84]. A succession of colonising species has been recorded on scars. During the early stages of colonisation the species richness of communities is very low[85] and many species present are typical of sedimentary shores, simply living as infauna within the boulder clay (e.g. *Lanice conchilega*). In low lying scar the grounds can only be briefly colonised by species prior to sand scouring, hence pioneer species predominate, such as opportunistic green algaes (*Enteromorpha* species and *Ulva lactuce*) and laver (*Porphyra umbicalis*).

On larger, more permanent scars when they are not covered in sand for long periods of time the biota recorded is similar to that of rocky shore including periwinkles (*Littorina littoria*) and fucoid seaweeds[86]. Later in the succession the hard substrate may be colonised by breadcrumb sponge (*Halichondria panicea*), edible mussels (*Mytilus edulis*) and the reef building honeycomb worm (*Sabellaria alveolata*). The honeycomb worm is a priority (national) BAP species and is important in stabilising scars, for bird and fish food and the establishment of mussel beds.

Once established mussels can take over a scar, smothering *Sabellaria* reefs and further stabilising the scar, thus creating a mussel bed[87]. Around the low water mark these scars can support dense mussel beds in quantities sufficient for commercial exploitation. Large mussel beds are found on the English side of the Firth between Dubmill Point and Silloth, at Skinburness, in patches on the Cardurnock flats and at Southerness on the Scottish side of the Firth[88 89].

7.3.2.5 Sublittoral Scar Grounds

The communities recorded on sublittoral scar grounds have been found to be essentially similar to those normally found in sublittoral rocky areas with rich and well developed epifaunal communities. These are characterised by the breadcrumb sponge *Halichondria panicea*, the hydriod *Abietinaria abietina*, the polychaete *Sabellaria spinulosa*, the gastropod *Buccinum undatum*, the horse mussel *Modiolus modiolus*, the bryozoan *Flustra foliacea* and the ascidian *Dendrodoa grossularia* in areas where the boulder clay has remained free from sand inundation for an extended period[90]. Subtidal scar grounds were considered by Perkins (1981; 1986) to be important for the presence of commercially important species such as the edible crab *Cancer pagurus* and lobster *Homarus gammerus*, and for the fish that use them as feeding grounds[91 92]. The biomass per unit area recorded from scars was generally one or two orders of magnitude greater than recorded from adjacent sands.

84 Perkins, E. J. (1986) The ecology of the scar grounds in the Solway Firth. *Transactions of the Dumfriesshire and Galloway Natural History and Antiquarian Society*, **61**:4-19.
85 Perkins, E. J. (1977) The influence of sediment morphology. In: Problems of a Small Estuary. *Proceedings of the Symposium on the Burry Inlet (South Wales)*, (Eds. A. Nelson Smith & E. M. Bridges). University College of Swansea, September 1976. **7**:1-19.
86 Perkins, E. J. (1986) The ecology of the scar grounds in the Solway Firth. *Transactions of the Dumfriesshire and Galloway Natural History and Antiquarian Society*, **61**:4-19.
87 Solway Firth Partnership (1996) *The Solway Firth Review*. The Solway Firth Partnership.
88 Lancaster, J. (1993) An ecological Survey of the Cumbrian Coast. Cumbria Sea Fisheries Committee report.
89 Lancaster, J. (1999b) Appraisal of the Solway Firth Littoral Mussel (*Mytilus edulis*) Stocks in the Solway Firth. Cumbria Sea Fisheries Committee report 1999.
90 Perkins, E. J. (1981) Studies in the distribution and biological impact of the effluent released by Thames Board Mills Ltd., Siddick. The bottom fauna of Maryport Roads and Allonby Bay 1962-1978. Unpublished report to the Cumbria Sea Fisheries Committee (*CSFC Scientific Report*, No. **81/3**).
91 Perkins, E. J. (1981) Studies in the distribution and biological impact of the effluent released by Thames Board Mills Ltd., Siddick. The bottom fauna of Maryport Roads and Allonby Bay 1962-1978. Unpublished report to the Cumbria Sea Fisheries Committee (*CSFC Scientific Report*, No. **81/3**).
92 Perkins, E. J. (1986) The ecology of the scar grounds in the Solway Firth. *Transactions of the Dumfriesshire and Galloway Natural History and Antiquarian Society*, **61**:4-19.

7.3.3 SURVEY METHODOLOGY

Benthic sampling was undertaken during October 2001, February 2002 and March 2002. All stations were sampled using a 0.1m^2 stainless steel Day Grab (Plate 7.3.1), with the exception of a number of stations along the cable route which were sampled with a 0.1m^2 Hamon Grab (Plate 7.3.2) due to the harder nature of encountered sediment. Sampling locations are detailed in Figure 7.3.1. Full survey information for each sample location is presented in Appendix D1 in the separate volume of appendices.

Plate 7.3.1: Day Grab

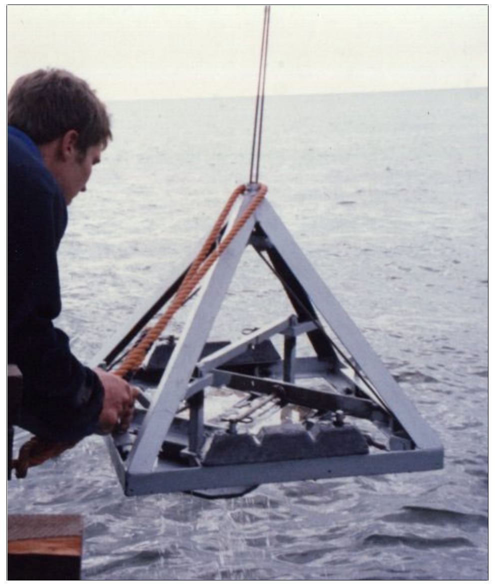


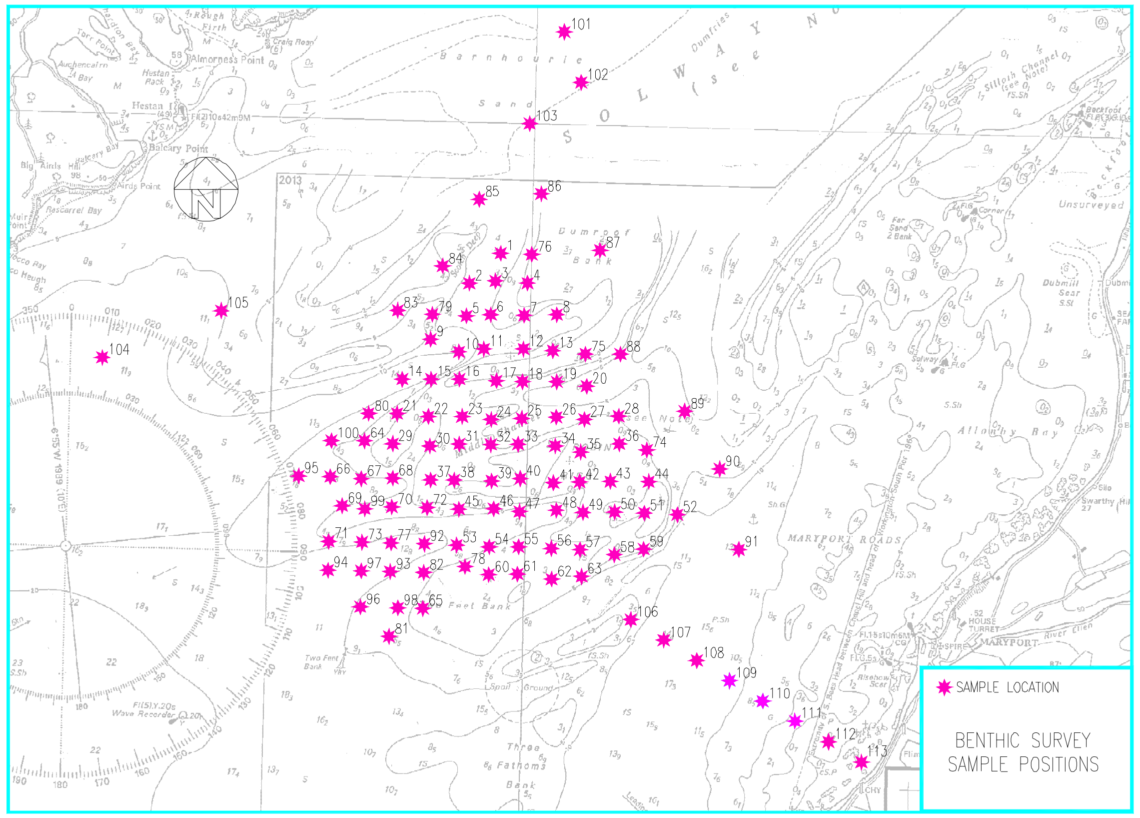
Plate 7.3.2: Hamon Grab

7.3.3.1 Sub-tidal Methodology

Day grab samples were collected from a total of 100 stations, within and adjacent to the perimeter of the proposed wind farm development area during October 2001 and February 2002. The sampling programme was initially based upon a systematic sampling array distributed on both the Scottish and English sides of the Solway Firth with 80 sites situated within the proposed development area and 20 sites located within 0-2 km of the site perimeter. A total of 18 sites on the English side were later relocated to the west of the original proposed development area after a final decision to build the wind farm completely on the Scottish side.

Day grab samples were also collected at five additional sites to the north and north west of the main development area during February 2002, in order to provide benthic information on possible Common Scoter feeding grounds (Figure 7.3.1).

Figure 7.3.1 Benthic sampling positions within the wind farm area, along the 132 kV route and in the Common Scoter feeding ground to the north



Grab samples were collected at eight sites along the proposed cable route. Samples were taken using a Hamon grab at those sites where harder sediment caused the day grab to fail.

Station positions were accurately determined using a Geographical Positioning System. The water depth was recorded at each site. At each site, three replicate samples were taken for macrofaunal analysis and a single sample taken for particle size analysis and total organic carbon analysis. The depth of sediment collected in each grab was measured and recorded. Samples less than 5 cm deep were rejected. Macrofaunal samples were sieved through a 1.0 mm mesh and the residue fixed in 4% formaldehyde solution.

Specimens were identified to species level, if possible, otherwise, to the lowest possible taxonomic level. Blotted wet biomass (to 0.0001 g) was calculated on enumerated fauna, with the extraction and assignment of major fragments to the appropriate group where possible. All extracted material was stored in 70% industrial methylated spirits (IMS). To ensure consistent identification throughout the survey, multiple reference specimens of each taxa recorded in the survey were selected and retained as a reference collection.

Particle size analysis on sediment from each site was conducted by laser diffraction. The organic carbon content of the sediments was analysed by using a Carlo Erba model 1108 Elemental Analyser.

7.3.3.2 Intertidal Methodology

Habitat characteristics of the shore were assessed on the 26 February 2002 using accepted Phase 2 survey methods by a walkover survey on the 26 February 2002.

The survey consisted of an expert-eye appraisal along a transect from high water springs to low water springs. Habitat and species details were recorded for each distinct habitat within the site Species present were identified and information recorded for any physiographic features. Species *in situ* were recorded using a 'percentage cover' or 'density of individuals' abundance scale, which uses the SACFOR (Superabundant, Abundant, Common, Frequent, Occasional, Rare) notations. Identified biotopes were classified according to Connor *et al*, 1997[93].

Intertidal sediment samples were taken for macrofaunal and sediment analysis in order to supplement the information provided from the walkover survey. Five replicate core samples were taken at five sites set at 100 m intervals along the shore transect using a corer of 0.01 m^2 internal circular section forced into the sediment to a depth of 15 cm. A 1 m^2 area was also be marked out within an undisturbed section of each site and a record taken of obvious mounds, casts and algal cover and the area forked through to identify larger macrofaunal samples which may not have been recorded in the core samples. Sediment for macrofaunal analysis was sieved on a 0.5 mm mesh and macrofauna identified to species level. Samples were processed to the same methodology outlined above for the sub-tidal macrofauna samples.

7.3.3.3 Data Analysis and Community Representation

A range of univariate and multivariate data analyses were performed. These were in accordance with accepted practice in the UK for the definition of marine faunal assemblages.

Univariate analyses included number of taxa, numbers of individuals (abundance), Margalef Richness (D), Shannon-Weiner diversity (H') and evenness (I). Multivariate analysis will include Bray Curtis similarity analysis, in combination with a hierarchical clustering procedure and ordination by Multidimensional Scaling (MDS).

Each site was assigned a biotope, according to Connor *et al*, 1997, on the basis of the species recorded and other habitat information. A biotope map for the main development area and the cable route was prepared, using biotope information, bathymetry data and substrate information.

7.3.4 BENTHIC SURVEY RESULTS

The results from the main benthic survey of the wider proposed development area were treated as a separate data set from the results of the cable route benthic survey. However, some comparative analysis of both data sets was undertaken in order to assess differences between the benthic communities identified within each survey area.

The results data for the sample stations within the actual boundary of the proposed windfarm are also presented as a separate subset in order to highlight the benthic community specific to the development area.

93 Connor, D. W., Brazier, D. P., Hill, T. O. and Northen, K. O. (1997) Marine Nature Conservation Review: marine biotope classification for Britain and Ireland. Volume 1. Littoral biotopes. Version 97.06. *Joint Nature Conservation Committee Report*, No. **229**.

7.3.4.1 Sediment Analysis

Robin Rigg Survey

The sediment analysis results for the Robin Rigg survey are presented in full in Appendix D2 in the separate appendices volume. The results for the sample stations located within the boundary of the proposed windfarm are presented below in Table 7.3.3.

Table 7.3.3 Sediment analysis results for stations within the boundary of the proposed windfarm

Site	Median particle diameter (PHI)	Mean particle diameter (PHI)	Sorting coefficient	Skewness (SKI)	Total organic carbon (%)
15	1.92 Medium sand	1.82 Medium sand	0.44 Well sorted	0.022 Symmetrical	<0.40
21	2.41 Fine sand	2.23 Fine sand	0.46 Well sorted	-0.061 Symmetrical	<0.40
22	2.51 Fine sand	2.35 Fine sand	0.46 Well sorted	-0.019 Symmetrical	<0.40
23	2.55 Fine sand	2.3 Fine sand	0.45 Well sorted	-0.057 Symmetrical	<0.40
24	2.2 Fine sand	2 Fine sand	0.46 Well sorted	-0.054 Symmetrical	<0.40
29	2.56 Fine sand	2.4 Fine sand	0.48 Well sorted	0.008 Symmetrical	<0.40
30	2.41 Fine sand	2.21 Fine sand	0.48 Well sorted	-0.036 Symmetrical	<0.40
31	2.47 Fine sand	2.26 Fine sand	0.47 Well sorted	-0.061 Symmetrical	<0.40
32	2.2 Fine sand	1.9 Medium sand	0.49 Well sorted	-0.089 Symmetrical	<0.40
37	2.53 Fine sand	2.22 Fine sand	0.49 Well sorted	-0.064 Symmetrical	<0.40
38	2.51 Fine sand	2.28 Fine sand	0.46 Well sorted	-0.058 Symmetrical	<0.40
45	2.46 Fine sand	2.22 Fine sand	0.46 Well sorted	-0.05 Symmetrical	<0.40
64	2.08 Fine sand	2.01 Fine sand	0.46 Well sorted	0.001 Symmetrical	<0.40
67	2.37 Fine sand	2.12 Medium sand	0.49 Well sorted	-0.055 Symmetrical	<0.40
68	2.48 Fine sand	2.25 Fine sand	0.46 Well sorted	-0.053 Symmetrical	<0.40
70	2.51 Fine sand	2.07 Fine sand	0.7 Moderately well sorted	-0.278 Coarse skew	<0.40
72	2.27 Fine sand	2.18 Fine sand	0.52 Moderately well sorted	0.001 Symmetrical	<0.40
77	2.71 Fine sand	2.4 Fine sand	0.44 Well sorted	-0.049 Symmetrical	<0.40
80	1.8 Medium sand	1.74 Medium sand	0.43 Well sorted	0.006 Symmetrical	<0.40
92	2.39 Fine sand	2.13 Fine sand	0.53 Moderately well sorted	-0.052 Symmetrical	<0.40
99	2.44 Fine sand	2.27 Fine sand	0.51 Well sorted	0.038 Symmetrical	<0.40

Sediments within the main survey area are identified as predominately well sorted to moderately well sorted fine to medium sands. Perfectly sorted sediment could theoretically consist of particles of one size only. However in most natural conditions there is a range in particle sizes created by fluctuations in current velocity, transport and the density and shape of grains. Well sorted fine sand, which reflects high sediment mobility, dominates the sandbank area with a band of medium sands found to the north of the site.

The amount of organic carbon in marine sediments is often used as an index of the amount of food available to benthic organisms or as an indication of the amount and type of food settling to the sediments from the water column. Sub-tidal sandbanks typically have low organic matter levels and this is reflected by total organic carbon contents in sampled sediments from the survey area which were found to be consistently lower than the detection limit of 0.4%.

Cable Route

Sediment analysis results for the sub-tidal and intertidal cable route sample stations are presented in Table 7.3.4 and Table 7.3.5 respectively.

Table 7.3.4 Sediment analysis results for the Sub-tidal cable route sample stations

Station	Median particle diameter (PHI)	Mean particle diameter (PHI)	Sorting coefficient	Skewness (SKI)	Total organic carbon (%)	Grain Size Fraction > 2000 µm	Solids < 63 µm
106	2.09 Fine sand	2.02 Fine sand	0.44 Well sorted	-0.021 Symmetrical	<0.40	0%	0%
107	4.29 Very coarse silt	3.7 Very Fine Sand	1.61 Poorly sorted	0.102 Fine skew	<0.40	0%	54.30%
108	3.04 Very fine sand	2.43 Fine sand	1.91 Poorly sorted	0.327 Fine skew	<0.40	22.01%	27.85%
109	-0.49 Very coarse sand	-0.17 Very Coarse Sand	1.93 Poorly sorted	0.82 Fine skew	1.21	78.26%	10.55%
110	5.94 Coarse silt	3.35 Very Fine Sand	1.65 Poorly sorted	-0.652 Coarse skew	0.4	88.98%	82.85%
111	4.41 Very coarse silt	1.99 Medium sand	2.58 Poorly sorted	-0.346 Coarse skew	1.17	97.99%	56.43%
112	0.73 Coarse sand	0.71 Coarse sand	2.42 Poorly sorted	0.668 Fine skew	1.39	71%	20.15%
113	2.46 Fine sand	2.17 Fine sand	0.5 Well sorted	-0.125 Fine skew	<0.40	0%	0.87%

Table 7.3.5 Sediment analysis results for the intertidal cable route sample stations

Station	Median particle diameter (PHI)	Mean particle diameter (PHI)	Sorting coefficient	Skewness (SKI)	Total organic carbon (%)	Grain Size Fraction > 2000 µm	Solids < 63 µm
S1	1.87 Medium sand	1.65 Medium sand	0.59 Poorly sorted	-0.103 Coarse skew	0.59	0%	0%
S2	2.3 Fine sand	2.01 Fine sand	0.49 Well sorted	-0.152 Coarse skew	<0.4	0%	0%
S3	2.39 Fine sand	2.16 Fine sand	0.46 Well sorted	-0.108 Coarse skew	<0.4	0%	0%
S4	2.26 Fine sand	1.59 Medium sand	0.86 Poorly sorted	-0.395 Coarse skew	<0.4	0%	1.24%
S5	2.48 Fine sand	2.21 Fine sand	0.47 Well sorted	-0.119 Coarse skew	<0.4	0%	0.75%

The proposed cable route crosses a deeper channel between the shallower Robin Rigg sandbank and the shallow sub-tidal at the cables landfall south of Flimby.

The sediment on the Robin Rigg side of the proposed cable route is identified as fine well-sorted sand. Sediment in the deeper channel is siltier but is mixed with an increasing gravel and cobble fraction as the cable route moves across the channel towards the shore. Sediments in the channel also demonstrated a higher, but still relatively low total organic carbon content than adjacent sandier sediments on Robin Rigg. Sub-tidal sediments on the shoreward side of the channel were similar in composition to the generally well sorted fine sand sediments of the intertidal at the cable route landfall. The total organic carbon content of intertidal sediments was low or below detection limits.

7.3.4.2 Benthic Survey

Robin Rigg Survey

A full species list and abundance and biomass data for the 100 stations sampled throughout Robin Rigg is presented in Appendix D3. The results for the stations located within the boundary of the proposed windfarm are presented below in Table 7.3.7.

A total of 61 species or higher taxa were recorded for all stations. However, the number of species and individuals recorded for each sample station was generally low with five stations recording no species at all.

The number of species recorded ranged from 0 to 12 per grab sample (0.1m^2) and the number of individuals between 0 and 40 per grab sample.

The ten most dominant species recorded in the survey are presented below in Table 7.3.6.

Table 7.3.6: Ten most dominant species

Species	Total number recorded for all sample stations	Description
Nepthtys cirrosa	261	Bristleworm
Bathyporeia elegans	207	Amphipod
Gastrosaccus spinifer	86	Mysid
Magelona johnstoni	43	Bristleworm
Pontocrates altamarinus	31	Amphipod
Nepthtys (juv.)	24	Bristleworm
Echinocardium (juv.)	19	Sea potato
Fabulina fabula	17	Tellin shell
Urothoe brevicornis	16	Amphipod
Haustorius arenarius	16	Amphipod

Sample stations throughout the Robin Rigg survey area were consistently represented by a low number of species and individuals. In many cases only one individual of each species was recorded for each sample. Sand eels (*Ammodytes tobianus)* and juvenile sea potato (*Echinocardium caudatum*) were also occasionally observed. Biomass was very low at all sites.

Table 7.3.7: Abundance and Biomass data/0.1m^2 for sampling stations located within the wind farm site (P = present)

TaxonName	S15	S21	S22	S23	S24	S29	S30	S31	S32	S45
Lagotia viridis	-	-	-	-	-	-	-	-	-	-
Phialella quadrata	-	-	-	-	-	-	-	-	-	-
Nephtys (juv.)	-	-	-	-	-	-	-	-	-	-
Nephtys cirrosa	5	3	5	3	-	4	3	3	-	1
Magelona johnstoni	-	-	-	-	-	-	-	-	-	-
Gastrosaccus spinifer	-	-	-	-	-	-	2	1	1	-
Pontocrates altamarinus	-	1	-	1	-	-	-	1	-	-1
Schistomysis (juv.)	-	-	-	-	-	-	-	1	-	1
Urothoe brevicornis	-	1	-	-	2	-	-	1	-	-
Bathyporeia elegans	1	-	1	-	-	-	-	-	-	-
Haustorius arenarius	-	-	-	-	1	-	-	-	-	-
Idotea linearis	-	-	-	1	-	-	-	-	-	-
Pinnotheres pisum	-	-	-	-	-	-	-	-	-	-
Polinices pulchellus	-	-	-	-	-	-	-	-	-	-
Tellimya ferruginosa	-	-	-	-	-	-	-	1	-	-
Mactra stultorum	-	-	-	-	-	-	-	-	-	-
Fabulina fabula	-	-	-	1	-	-	-	1	-	-
Echinocardium (juv.)	-	-	1	2	-	1	-	-	-	-
Ammodytes tobianus	-	1	-	-	-	-	-	-	-	-
Total Number Taxa	2	4	3	5	2	2	2	7	1	2
Total Number Individuals	6	6	7	8	3	5	5	9	1	2
Biomass (g)	0.0483	0.4217	0.0617	0.0333	0.006	0.1009	0.0384	0.1224	0.0167	1.2453
TaxonName	**S64**	**S67**	**S68**	**S70**	**S72**	**S77**	**S80**	**S92**	**S99**	**Total for all Samples**
Lagotia viridis	-	P	P	-	-	-	-	-	-	P
Phialella quadrata	-	-	P	P	-	-	-	-	P	P
Nephtys (juv.)	-	2	-	1	-	-	-	-	1	4
Nephtys cirrosa	3	-	3	1	-	2	1	2	1	40
Magelona johnstoni	1	-	-	3	-	2	1	2	8	17
Gastrosaccus spinifer	-	-	-	-	7	-	-	-	-	11
Pontocrates altamarinus	-	1	-	-	-	1	-	-	-	5
Schistomysis (juv.)	-	-	-	-	-	-	-	-	-	2
Urothoe brevicornis	-	-	-	-	-	-	-	-	-	4
Bathyporeia elegans	-	-	-	3	4	2	-	1	1	15
Haustorius arenarius	-	-	-	-	-	-	-	-	-	1
Idotea linearis	-	-	-	-	-	-	-	-	-	1
Pinnotheres pisum	-	-	-	-	-	-	-	-	3	3
Polinices pulchellus	-	-	-	-	-	-	-	-	1	1
Tellimya ferruginosa	-	-	-	-	-	-	-	-	-	1
Mactra stultorum	-	-	-	-	-	-	-	-	1	1
Fabulina fabula	-	-	-	-	-	1	-	1	-	4
Echinocardium (juv.)	-	-	-	-	-	-	-	-	-	4
Ammodytes tobianus	-	-	-	2	-	-	1	-	-	4
Total Number Taxa	2	3	3	6	2	5	3	4	8	
Total Number Individuals	4	4	5	11	11	8	3	6	17	
Biomass (g)	0.1015	0.0641	0.058	0.0051	0.0108	0.0125	0.6752	0.0165	4.6212	

This low level of biodiversity is shaped by sediment characteristics and the instability of the mobile sandbank habitat. The fauna present is characterized by the presence of short-lived benthic species, tolerant to sediment disturbance. Fairly robust infaunal polychaete, amphipod and bivalve species are typical. The fauna is dominated by the polychaete, *Nephtys cirrosa* and the amphipod, *Bathyporeia elegans* and is reflective of the biotope, IGS.NcirBat (see Section 7.3.5)

Cable Route Survey - Sub-tidal

A full species list and abundance and biomass data for each of the eight cable route sites is presented in Appendix D4 in the seperate volume of appendices.

A total of 86 species or higher taxa were recorded at the eight stations along the sub-tidal section of the cable route. The majority of the species were associated with the mixed cobble, gravel and silt sediments of the deeper channel. The number of species and individuals recorded per grab sample ranged from just two 'single individual' amphipod species *Gastrosaccus spinifer* and *Pontocrates altamarinus* recorded at sample Station 106 adjacent to the sandbank to a total of 44 species and 204 individuals recorded at Station 109 in the deeper channel.

The shallow sandier sample stations adjacent to the sandbank and on the shoreward side of the cable route were impoverished with a low diversity polychaete or amphipod communitiy similar to that found within the main survey area at Robin Rigg. Middle cable route sediment had a muddy sand faunal community reflective of the biotope IMS.FaMS.

The deeper channel community is similar to that described for subtidal 'scar' grounds (exposed boulder clay) which remain clear of the sand and support a rich and well developed fauna typical of subtidal rocky areas[94].

The presence of hard substrata (shells and stones) within the mixed sediment habitat of the deeper channel enables the presence of an epifaunal (surface dwelling) community. This community was represented by populations of the encrusting bryozoan *Flustra foliacea* with a variety of slightly scour/silt-tolerant species which formed a turf on cobbles and boulders including the hydroid *Hydrallmania falcata* and the calcareous tube dwelling polychaete *Pomatoceros* sp. This habitat is characteristic of the biotope MCR.ByH represented by sand-influenced bryozoan/hydroid turfs on moderately exposed circalittoral rock or mixed substrata. Siltier associated sediments and more stable under stone and crevice environments supported a wider range of polychaete and amphipod species than adjacent sand bank areas but overall species richness of sediments was still low with species represented by only a few individuals. Other epibenthic species recorded within the channel included the brittlestar *Ophiothrix fragilis* and the sea squirt *Dendrodoa grossularia*.

The species occurring in the highest numbers in the cable route survey stations are presented below in Table 7.3.8.

[94] Solway Firth Partnership (1996) *The Solway Firth Review*. The Solway Firth Partnership.

Table 7.3.8: Species occurring in the highest numbers in cable route benthic survey

Species	Total number	Species description
Cliona	PRESENT	Sponge
Phialella quadrata	PRESENT	Hydroid
Hydrallmania falcata	PRESENT	Hydroid
Cerinathus lloydii	PRESENT	Sea anenome
Dendrodoa grossularia	PRESENT	Sea squirt
Flustra foliacea	PRESENT	Bryozoan; Hornwrack
Pomatoceros lamarcki	153	Polychaete worm living in calcareous tube on rocks
Pomatoceros sp.	51	Polychaete worm living in calcareous tube on rocks
Dodecaceria	19	Polychaete worm found in old shells
Nemertea	18	Unsegmented worm found under stones in sand, mud and rock crevices
Mysella bidentata	15	Bivalve shell found in muddy sand or fine gravel or tubes of *Golfingia*
Abra alba	10	Bivalve shell found in soft substrata
Phoronis	10	Horseshoe worm
Golfingia elongata	9	Unsegmented worm in muddy sand or gravel
Pholoe minuta	9	Polychaete scale worm
Emida bahusiensis	9	Polychaete scale worm
Sabellaria spinulosa	9	Polychaete worm found on rocks adjacent to sand
Polycirrus	8	Polychaete worm found in tube amongst hydroids and old shells
Nematoda	7	Threadworms - meiofauna
Syllida armata	7	Polychaete worm found amongst colonial sedentary animals
Polydora ciliata (agg.)	7	Polychaete worm found in U-shaped tube in limestone rock or shells
Pomatorceros triqueter	7	Polychaete worm living in calcareous tube on rocks
Tanaopsis graciloides	7	Crustacean found in burrows in sand under stones and in crevices
Nephtys (juv.)	6	Polychaete 'cat worm' burrowing in sand
Mya truncata (juv.)	6	Bivalve 'blunt gaper' found in mixed sandy substrata

The tube-building polychaete *Sabellaria spinulosa* was found at some of the deeper channel sample stations. *Sabellaria spinulosa* forms crusts on silty turbid circalittoral rock and is related to the 'reef-building' worm *Sabellaria aveolata* which was recorded in the lower intertidal of the cable route landfall.

Cable Route Survey Inter-tidal

GENERAL DESCRIPTION

Covey, R 1998 describes the coastline between Maryport and Whitehaven as predominately rocky, with areas of bound shingle, boulders or mobile blast-furnace waste. The shores are rugged, with the typical zonation of fucoid shore communities interrupted by ridges or gullies. Communities present include spiral wrack *Fucus spiralis* (Fspi), particularly on the upper shore, bladder wrack *Fucus vesiculos*us (Fves) and, less commonly, serrated wrack *Fucus serratus* (Fser.Fser) in zones down the shore. Mid- and lower shores often support *Mytilus edul*is (MytFves; MytFR) with barnacle communities (Bpat.Sem) present on some shores. In places, where mobile mixed substrata are adjacent to bedrock, scoured communities occur characterised by mussels and sparse algae (MytX).

INTERTIDAL PHASE 2 SURVEY

An intertidal Phase 2 survey was conducted along a transect from high water to low water at the location of the central line of proposed cable route landfall corridor immediately south of the town of Flimby.

The shoreline is identified as moderately exposed to prevailing westerly winds but probably experiences a degree of shelter due to the shallowness of the water offshore.

The shoreline is predominately sandy with areas of cobble scar and extends for approximately 500 m from the top of the shore to low water springs (Plate 7.3.3).

Plate 7.3.3: Intertidal survey area (looking west from upper shore)

The top of the shore is fringed by approximately 5m of small sand dunes (<1 m in height) followed by 43 m of steep coarse barren shingle and sand (BarSh). A cobble scar (approximately 55 m wide) lines this shingle bank on the upper shore for most of the length of the shore from Workington to Maryport. The cobble scar is interrupted in places by slagcrete reef.

The upper shore cobble scar area was made up of easily displaced cobbles. Species diversity was low with an impoverished under stone community represented by amphipod species and the mussel, *Mytilus edulis*. The seaweeds, laver *Porphra umbilicalis* and gut-weed *Entermorpha intestinalis* were occasional as attached species (Ent). Species diversity on the solid slagcrete was greater than on adjacent cobble scar. Bladder wrack and spiral wrack were frequent on slagcrete with the limpet *Patella vulgata* occasional beneath the fronds (Fspi).

Middle shore areas of cobble scar were more embedded into underlying sediment creating a more stable environment and higher linked species diversity. Mussels were common in the interstitial space between cobbles along with the periwinkle *Littorina littorea*. Attached species included bladder wrack and the barnacle *Semibalanus balanoides* (Fves).

A large area of cobble scar was located at lower shore level approximately 100 m from low water springs. Mussels were frequent observed and periwinkles were common. The mussels added to the stability of the lower middle shore scar areas. Attached species included barnacles, bladder wrack and serrated wrack (MytFves; MytFR).

The low water spring mark coincided with another scar area dominated by storm-damaged colonies of the honeycomb worm *Sabellaria alveolata* (Salv) (Plate 7.3.4).

Plate 7.3.4: Sabellaria reef on lower shore scar ground

Extensive *Sabellaria* reefs are found along much of the Cumbria coast, including within the Solway Firth and are features of national nature conservation importance[95]. Pools of water between the *Sabellaria* provide habitats for algae including *Ceramium* sp. and abundant mussel spat. Interstitial species include periwinkles and the dog whelk, *Nucella lapillus*. Attached species include barnacles and serrated wrack with the kelp *Laminaria digitata* observed at the extreme low water mark (Ldig).

SEDIMENT CORE SAMPLING

Intertidal sediment core samples were taken of sediment at 5 sample stations (S1 - S5) located at 100 m intervals along the survey transect from high water to low water using a corer of 0.01 m^2 internal circular section forced into the sediment to a depth of 15 cm. The results of the core sampling survey, as data for pooled replicates, are presented in Table 7.3.9. Full survey abundance and biomass data for all intertidal station replicates and field observations are presented in Appendix D4 in the appendices volume.

The sandy sediments at the cable route landfall are dominated by the amphipod *Bathporeia sarsi* and the polychaetes *Scolelepis squamata* and *Capitella* sp. (AP.P). The lugworm *Arenicola marina* was also observed at middle to lower shore sample stations. Juvenile mussels were present in lower shore sediment. Species richness and diversity was generally low and is reflective of a mobile fine sand environment.

Table 7.3.9: Results of intertidal core survey (P = Present)

Species	Species description	Pooled Abundance				
		IT1	IT2	IT3	IT4	IT5
NEMERTEA	unsegmented worm found under stones	1				
NEMATODA	'thread worms'				2	
Pholoe minuta	Polychaete 'scale worm' - at low water under stones		1			
Eteone longa (agg.)	Polychaete worm low water in clean sand	1	2		4	
Anaitides mucosa	Polychaete worm				6	
Glycera tridactyla	Polychaete worm burrowing in clean or muddy sand				3	
Hediste diversicolor	Polychaete 'ragworm' - burrowing in black muddy sand	1	2			
Nephtys cirrosa	Polychaete worm		1			2
Nephtys hombergii	Polychaete worm - common and widespread					1
Scoloplos armiger	Polychaete worm in fine muddy sand		3	3	2	2
Aricidea minuta	Polychaete worm					3
Paradoneis lyra	Polychaete worm			1		
Paraonis fulgens	Polychaete worm	1				
Malacoceros tetracerus	Polychaete worm at LW in muddy sand or under stones	1				
Scolelepis squamata	Polychaete worm, mid-low shore, clean/slight mud. sand	2	2	11	1	2
Capitella	Polychaete worm - very common widespread	7	11	4	28	3
Bathyporeia elegans	Amphipod			1		
Bathyporeia pelagica	Amphipod		1		1	1
Bathyporeia pilosa	Amphipod	10	1			
Bathyporeia sarsi	Amphipod	21	72	8	3	
Cumopsis goodsiri	Cumacean - fine sand, mid-tidal level to shallow subtidal					2
Portumnus latipes	Pennant's swimming crab				1	
Nucula nitidosa	'Nut shell' - on silt and fine sand, common				1	2
Mytilus edulis	Mussel				10	
Mytilus edulis (juv.)	Mussel		2		50	17
Mysella bidentata	Bivalve shell- in muddy sand				1	1
Spisula (juv.)	Elliptical trough shell - mixed soft substrata					1
Arenicola marina (juv.)	Lugworm		P			
Arenicola marina	Lugworm			P	P	P

[95] Solway Firth Partnership (1996) *The Solway Firth Review*. The Solway Firth Partnership.

7.3.4.3 Statistical Analysis

Univariate and multivariate analysis was performed on the results data for the main survey area and the sub-tidal section of the cable route to identify differences between sites.

Statistical analysis has not been performed on the results data for the intertidal section of the cable route. This is because of the high degree of spatial variability that is already expected between sample stations due to the effects of physical factors such as immersion and exposure times, which influence zonation within the intertidal environment. It is however recommended that samples are taken at the same locations as part of a post-development monitoring programme and statistical analysis performed to identify recolonisation success and any temporal variations in community structure as a result of the cable laying process

Univariate Analyses

Univariate methods reduce the full set of species counts for a sample into a single coefficient e.g. diversity index. Univariate statistics for the main survey area and sub-tidal cable route data are presented in Appendix D5.

It is generally accepted that increasing levels of environmental stress e.g. sediment disturbance, decreases biodiversity species richness and evenness, thereby increasing dominance of individual species adapted to the particular type of stress.

MARGALEF RICHNESS

Margalef richness (D) is a measure related to the total number of taxa present for a given number of individuals.

Richness was generally low on Robin Rigg and ranged from 0 at stations with only one recorded species to a value of 4.42 at Station 78 which was outside the boundary of the proposed windfarm. Richness could not be calculated for the five Robin Rigg stations where a zero species count was recorded. Richness was highest at the cable route survey stations located in the deeper channel with a value of 8.08 calculated for Station 109.

PIELOU'S EVENESS

Pielou's Eveness relates how evenly the individuals are distributed among the different taxa. Where communities are dominated by one or two species, the evenness values are low, indicating a stressed environment. However, although many of the stations throughout the survey area had a low species count evenness values were generally high at individual stations due to the spread of a low number of individuals across a narrow species range. When numbers are pooled for all of the stations it can however be seen that there is definitely an uneven spread of individuals across the total species range with the survey dominated by two species i.e. *Nepthtys cirros*a and *Bathyporeia elegans*. Eveness was generally high for cable route survey stations.

SHANNON-WEINER DIVERSITY

Shannon-Weiner diversity incorporates both the number of species (species richness) and evenness. The diversity was lowest at those stations with only one recorded species and was highest at Robin Rigg survey station 78 which was outside the boundary of the proposed wind farm The overall diversity on Robin Rigg was very low. Diversity was highest at cable route survey station 109.

The univaritate statistics results tables for the above analyses are given in Appendix D5 to this ES.

Multivariate Analysis

Multivariate analyses are believed to be more sensitive in detecting community differences than univariate methods. Large data matrices are reduced to pictorial representations. Multivariate analysis was performed on the combined data set for Robin Rigg and the cable route.

CLUSTER ANALYSIS

Cluster analysis of the combined data set was performed to demonstrate the degree of similarity between the faunal composition of each of the samples. A square root transformation was performed on the data and a Bray-Curtis similarity index derived. The clustering technique compares, for each taxon, the abundance of the taxon in a sample, with the abundance in each of the other samples. The result is a matrix of similarity indices comparing each sample with all other samples. The similarity matrix resulting from the analysis is presented diagrammatically as a dendogram (Figure 7.3.2). Samples that are similar link towards the bottom of the figure (high % similarity). Those that are less similar, link towards the top of the diagram (low % similarity). The scale is an index from 0% to 100% and should be viewed as a relative indicator of similarity: it does not indicate the proportion of families in common. Interpretation of the dendogram is subjective and involves the recognition of groups, or clusters, of samples, which are linked at higher levels of similarity on the basis of a similar faunal assemblage.

The cluster analysis of the full data set demonstrates a distinct separation of the Robin Rigg survey area stations from five of the cable route stations at a very low similarity level i.e. the cable route sites have a distinct community assemblage from that of the main survey area at Robin Rigg. This is already obvious from analysis of the species which are present in the cable route samples but cluster analysis provides a visual confirmation of the difference between the two areas. The remaining survey stations are separated into a number of clusters at a higher similarity level with the majority of the main survey stations showing an average similarity of approximately 30%. While this level of similarity may seem low it is important to note that sample stations throughout the main survey area are generally represented by very low numbers of species and individuals. It therefore only takes the presence of one or two extra individuals or an additional species to separate a site as different from another site. The sample stations within Robin Rigg are therefore dominated by varying degrees of low diversity impoverished sediment.

MULTI-DIMENSIONAL SCALING

The two-dimensional Multi-Dimensional Scaling (MDS) configuration for the macro-fauna of all replicates is illustrated in Figure 7.3.3. MDS provides a visual representation of differences between sites by constructing a "map" or configuration of the samples in a specifed number of dimensions based on a similarity matrix. The MDS plot represented has a stress value of 0.18, indicating a 'reasonable representation of the sites in a two-dimensional picture' and shows clearly that the cable route sites C3, C4, C5, C6 and C7 are separated from the main grouping.

SIMPER

Having established that there were differences between stations, the data was subjected to Similarity Percentage Analysis (SIMPER) to elucidate which species were responsible. The results, showing the top ten rank order species found at each station are presented in Appendix D6. The SIMPER analyses demonstrated that the average dissimilarity between the cable route sites and the main survey sites is over 90%. The species noted for the dissimilarity between the two areas are the higher abundance of *Nephtys cirrosa* and *Bathyporeia elegans* within samples from the main survey area and the high abundance of *Pomatocerous lamarcki* (Keel worm) at several of the cable route sites.

Figure 7.3.2 Bray-Curtis Similarity Dendogram Combined Data Set

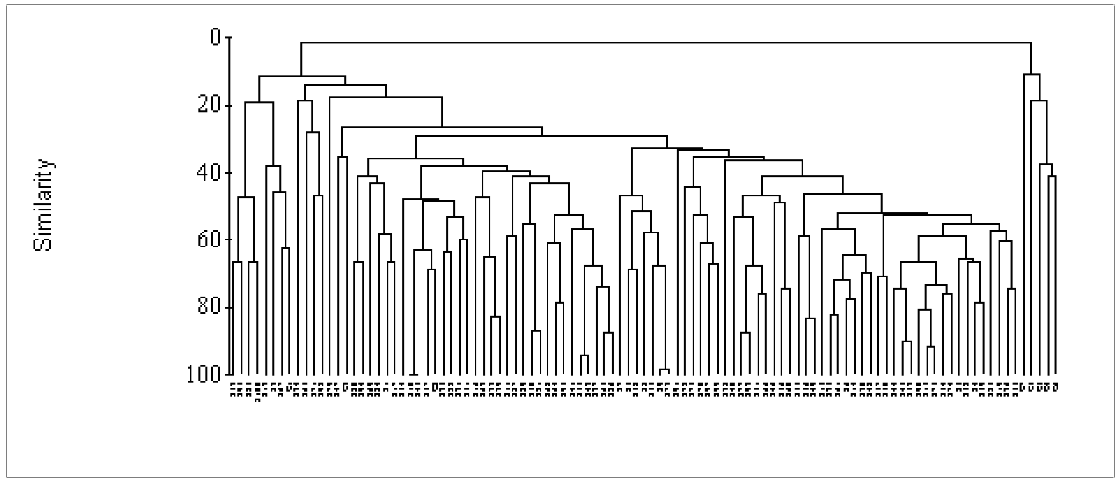
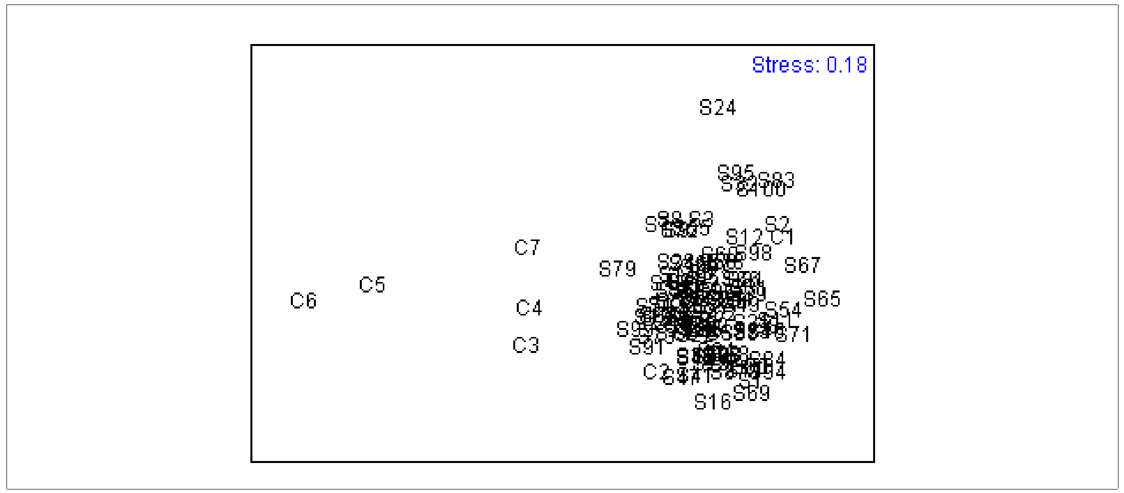


Figure 7.3.3: MDS Plot Combined Data Set



7.3.5 BIOTOPE DISTRIBUTION

A biotope is defined as the habitat (i.e. the environment's physical and chemical characteristics) together with its recurring associated community of species[96]. Biotopes identified for the main benthic survey area and the sub-tidal and intertidal elements of the cable route benthic survey are presented below in Table 7.3.10. Figures 7.3.4 to 7.3.6 also provide an indicative distribution of the main biotopes in identified in the benthic surveys.

Table 7.3.10: Biotope descriptions for sub-tidal and intertidal survey areas[97]

SUBLITTORAL BIOTOPES
1. Higher code IGS.FaS Shallow sand faunal communities
Biotope description Clean sands which occur in shallow water, either on the open coast or in tide-swept channels of marine inlets. The habitat typically lacks a significant seaweed component and is characterised by robust fauna, particularly venerid bivalves, amphipods and robust polychaetes.
Loctation This is the predominate biotope present throughout the Robin Rigg survey area and along the shallower elements of the cable route and can be sub-divided into IGS.NcirBat for the whole of the Robin Rigg survey area. May grade into IGS.Mob in areas of high sediment disturbance.
1a. Biotope code IGS.NcirBat ***Nephtys cirrosa* and *Bathyporeia* spp. in infralittoral sand**
Biotope description Well sorted medium and fine sands characterized by *Nephtys cirrosa* and *Bathyporeia* spp. (and sometimes *Pontocrates* spp.) which occur in the shallow sublittoral to at least 30 m depth. This biotope occurs in sediments subject to physical disturbance, as a result of strong tidal streams or wave action and may be closely allied to the intertidal biotopes LGS.Aeur and LGS.AP.Pon and intermediate in the degree of disturbance between the subtidal biotopes IGS.Mob and IGS.Sell. The faunal diversity of this biotope is considerably reduced compared to less disturbed biotopes and for the most part consists of the more actively-swimming amphipods. Sand eels *Ammodytes* sp. may occasionally be observed in association with this biotope (and others). The range in wave exposure and tidal streams are responsible for the level of physical disturbance that yields this biotope. This biotope is very similar to IGS.Ncir which occurs in reduced / variable salinities with additional reduced salinity fauna. Stochastic recruitment events in the *Nephtys cirrosa* populations may be very important to the population size of other polychaetes present and may therefore create a degree of variation in community composition (Bamber, 1994).
1b. Biotope code IGS.Mob Sparse fauna in infralittoral mobile clean sand
Biotope description Coarse sandy sediment in shallow water, often duned on exposed or tide-swept coasts often contains very little infauna due to the mobility of the substratum. Some opportunistic populations of infaunal amphipods may occur, particularly in less mobile examples. Sand eels *Ammodytes* sp. may occasionally be observed in association with this biotope (and others). This biotope is more mobile than IGS.NcirBat and may be closely related to LGS.BarSnd on the shore.

SUBLITTORAL BIOTOPES (CONTINUED)
2. Higher code MCR.ByH Bryozoan/hydroid turfs (sand influenced)
Biotope description Circalittoral rock or mixed substrata in moderately exposed conditions which typically support a prominent turf of bryozoans and hydroids. The habitat has weak or moderate tidal currents which, with sand nearby, leads to some sand in suspension and influence on the fauna present. Also included here are habitats of missed rock and coarse sediment, where the latter significantly abrades or periodically covers the rock (MCR.Urt). *Flustra foliacea* and to a lesser extent *Securiflustra securifrons* (or in the south *Chartella papyracea*), often form the bulk of the turf. In some cases other bryozoans, such as *Alcyonidium diaphanum* and *Eucratea loricata* may be prominent. The hydroids *Sertularia* spp. And *Hydrallmania falcata* are particularly characteristic of this habitat (and may dominate), although others also occur.
Location This is the predominate biotope associated with the gravel and cobble fraction of the deeper channel area of the cable route.
Biotope code MCR.Flu ***Flustra foliacea* and other hydroid/bryozoan** **turf species on slightly scoured circalittoral rock or mixed substrata**
A widespread biotope which has been split into several related entities. The biotope is characterised by silt- and scour-tolerant species which occur in varying proportions around the country, but *Flustra foliacea* tends to dominate. This biotope is characteristic of silty rocks habitats, tending to be moderately exposed to wave action and with a moderate tidal flow which create the slight scour conditions (compared to silted rocky habitats in sheltered conditions). The species associated with and therefore characterising the different *Flustra* biotopes vary from region to region, ranging from the relatively low species-rich Flu.Flu found on North Sea coasts to the similar but far richer biotopes with sponges and hydroids on the west of Britain and Irish Sea coasts (Flu.HbyS). there are also several other related biotopes: these include the *Urticina* (Urt.Urt) and *Ciocalypta* (Urt.Cio) biotopes which occur at rock-sediment interfaces; ascidian-dominated biotopes with *Flustra* (StoPaur) and several other biotopes characterised by other slight scour-tolerant or turbid-water species such as *Sabellaria spinulosa* which include *Flustra* (Sspi and MolPol.Sab) and *Alcyonidium diaphanum* (SnemAdia). Only use this biotope if records do not fit into other categories.
3. Higher code IMS. FaMS Shallow muddy sand faunal communities
Biotope description Muddy sand habitats in the infralittoral zone extending from the extreme lower shore down to more stable circalittoral zone at about 15 –20 m. The habitat supports a variety of animal-dominated communities, particularly of polychaetes, bivalves and the urchin *Echinocardium cordatum*.
Location This biotope is associated with siltier sediments along the cable route

[96] Connor, D. W., Brazier, D. P., Hill, T. O. and Northen, K. O. (1997) Marine Nature Conservation Review: marine biotope classification for Britain and Ireland. Volume 1. Littoral biotopes. Version 97.06. *Joint Nature Conservation Committee Report*, No. **229**

[97] Connor, D. W., Brazier, D. P., Hill, T. O. and Northen, K. O. (1997) Marine Nature Conservation Review: marine biotope classification for Britain and Ireland. Volume 1. Littoral biotopes. Version 97.06. *Joint Nature Conservation Committee Report*, No. **229**

LITTORAL BIOTOPES

1. Biotope code LGS. BarSh Barren shingle or gravel shores

Biotope description
Shingle or gravel shores, typically with sediment particle size 4-256 mm, are normally only found on exposed open coasts in fully marine conditions. Such shores tend to have little associated finer sediment and due to their high degree of mobility support virtually no macrofauna. Coarse sand, the next grade of sediment smaller than this size range is also found on exposed open coasts andhas no distinct macrofaunal community. The shingle shore and mobile sand biotopes are therefore distinguished soley on the basis of their substratum (i.e. particle size). Macrofauna are present of extremely sparse in this very mobile an freely draining substratum. Trial excavations are unlikely to reveal macroscopic infauna. However, the few species that may be found are those washed into the habitat by the ebbing tide, including the occasional amphipod or small polychaete. There may be temporary cover of the green algae *Enteromorpha* or *Ulva* during periods of stability in the summer.

Location Extreme upper shore at landfall of cable route

2. Higher code MLR.Eph Ephemeral green or red seaweeds (freshwater or sand-influenced)

Biotope description
Ephemeral algae often colonise disturbed littoral rock. On moderately exposed shores this can occur as Enteromorpha spp. On freshwater-influenced or unstable upper shore rock (MLR.Ent)

2a. Biotope code MLR.Ent
Enteromorpha spp. on freshwater-influenced or unstable upper eulittoral rock
Upper shore hard substrata that is relatively unstable (e.g. soft rock) or subject to considerable freshwater runoff is typically characterised by a dense mat of the green filamentous algae *Enteromorpha intestinalis* and *Enteromorpha prolifera*, often found together with the red algae *Porphyra umbilicalis*. This band of *Enteromorpha spp*. is usually found above the *Fucus spirallis* zone (Fspi) and may replace the *Pelvetia canaliculata* zone (PelB).

3. Biotope code SLR.Fspi
***Fucus spiralis* on moderately exposed to very sheltered upper eulittoral rock**

Biotope description
Moderately exposed to very sheltered upper eulittoral bedrock and boulders are typically characterised by a band of the spiral wrack *Fucus spiralis* overlying the black lichens *Verrucaria maura* and *V. mucosa*. Limpets *Patella vulgata,* winkles *Littorina* spp. and barnacles *Semibalanus balanoides* are usually present under the fucoid fronds and on open rock. During the summer months ephemeral green algae such as *Entermorpha* spp. and *Ulva lactuca* may also be present. This zone usually lies below a *Pelvetia canaliculata* zone (Pel or PelB); occasional clumps of *Pelvetia* may be present (usually less than common) amongst the *F. spiralis*. In areas of extreme shelter, such as in Scottish sealochs, the *Pelvetia* and *F. spiralis* zones often merge together forming a very narrow band. Fspi occurs above the *Ascophyllum nodosum* (Asc) and/or *Fucus vesiculosus* (Fves) zones and these tow fucoids may also occur, although *Fucus spiralis* always dominates. Vertical surfaces in this zone, especially on moderately exposed shores, often lack the fucoids and are characterised by a barnacle- *Patella* community (Bpat.Sem).

Location On upper shore cobble scar and slagcrete at cable route landfall

LITTORAL BIOTOPES (CONTINUED)

4. Biotope code SLR.Fves
***Fucus vesiculosus* on sheltered mid eulittoral rock**

Biotope description
Moderately exposed to sheltered mid eulittoral rock characterised by a dense canopy of large *Fucus vesiculosus* plants (typically abundant to superabundant). Beneath the algal canopy the rock surface has a sparse covering of barnacles (typically rare-frequent) and limpets, with mussels confined to pits and crevices. *Littorina littorea* and *Nucella lapillus* are also found beneath the algae, whilst *Littorina obtusata* and *Littorina mariae* graze on the fucoid fronds. The fronds may be epiphytised by the filamentous brown alga *Elachista fucicola* and the small calcareous tubeworm *Spirobis spirorbis*. In areas of localised shelter, *Ascophyllum nodosum* may also occur, though never at high abundance (typically rare to occasional) – (compare with Asc). Damp cracks and crevices often contain patches of the red seaweeds *Osmundea (Laurencia) pinnatifida, Mastocarpus stellatus* and encrusting coralline algae. This biotope usually occurs between the *Fucus spiralis* (Fspi) and the *Fucus serratus* (Fser) zones; both of these fucoids may be present in this biotope, though never at high abundance (typically less than frequent). In some sheltered areas *Fucus vesiculosus* forms a narrow zone above the *A. nodosum* zone (Asc). Where freshwater run-off occurs on more gradually sloping shores *F. vesiculosus* may be replaced by *Fucus ceranoides* (Fcer).

Location On upper-middle shore cobble scar at cable route landfall

5. Biotope code MLR.MytFves
***Mytilus edulis* and *Fucus vesiculosus* on moderately exposed mid eulittoral rock**

Biotope description
Mid eulittoral exposed to moderately exposed bedrock, often with nearby sediment, may be covered by dense large *Mytilus edulis* which form a band or large patches and support scattered *Fucus vesiculosus* and occasional red algae. This differs from mussels in the lower eulittoral (MytFR) which occur with a wider range of red algae (often in higher abundance than the mid eulittoral). Ephemeral green algae such as *Enteromorpha* spp. and *Ulva lactuca* commonly occur on the shells of the mussels. The barnacle *Semibalanus balanoides* is common on both the mussel valves and on patches of bare rock, where the limpet *Patella vulgata* is also found, often at high abundance. The dog whelk *Nucella lapillus* and a range of littorinids also occur within the mussel bed.

Location On middle to lower shore cobble scar at cable route landfall

6. Biotope code MLR.MytFR
***Mytilus edulis, Fucus serratus* and red seaweeds on moderately exposed lower eulittoral rock**

Biotope Description
Lower eulittoral moderately exposed bedrock, often with nearby sediment covered by dense, large *Mytilus edulis* with a covering of scattered *Fucus serratus* and red algae. The algae include *Porphyra umbilicalis, Rhodothamniella floridula, Palmaria palmate, Mastocarpus stellatus* and *Ceramium nodulosum*. Ephemeral green algae such as *Enteromorpha* spp. and *Ulva lactuca* commonly occur on the shells of the mussels. The barnacle *Semibalanus balanoides* is common on both the mussel valves and on patches of bare rock, where the limpet *Patella vulgata* is also found, often at high abundance. The dog whelk *Nucella lapillus* and a range of littorinids also occur within the mussel bed. This biotope differs from MytFves which has far fewer red algae present and scattered *Fucus vesiculosus,* indicative of the mid eulittoral zone.

Location On lower shore cobble scar at cable route landfall

LITTORAL BIOTOPES (CONTINUED)

7a. Higher code MLR.Sab Littoral *Sabellaria* (honeycomb worm) reefs

The sedentary polychaete worm Sablellaria alveolata builds tubes from sand and shell. On moderately exposed shores, where there is a plentiful supply of sediment, Sabellaria can from honeycomb reefs on boulders and low-lying bedrock on the mid to lower shore. These Sabellaria reefs are quite distinct from the mosaic of seaweeds and barnacles or red seaweeds generally associated with moderately exposed rocky shores. Although these reefs may be susceptible to storm damage in the winter, they can regenerate remarkably quickly in a season.

Location On extreme lower shore cobble scar at cable route landfall

7b. Biotope code MLR.Salv
***Sabellaria alveolata* reefs on sand-abraded eulittoral rock**

Biotope description
Many wave-exposed boulder scar grounds in the eastern basin of the Irish Sea (and as far south as Cornwall), are characterised by reefs of *Sabellaria alveolata* which build tubes from the mobile sand surrounding the boulders and cobbles. The tubes formed by *Sabellaria alveolata* form large reef-like hummocks, which serve to further stabilise the boulders. Other species in this biotope include the barnacles *Semibalanus balanoides, Balanus crenatus* and *Elminius modestus* and the molluscs *Patella vulgata, Littorina Littorea, Nucella lapillus* and *Mytilus edulis*. Low abundances of algae tend to occur in areas of eroded reef. The main algal species include *Porphyra* spp., *Mastocarpus stellatus, Ceramium* spp., *Fucus vesiculosus, Fucus serratus, Enteromorpha* spp. and *Ulva* spp. On exposed surf beaches in the southwest *Sabellaria* forms a crust on the rocks, rather than the classic honeycomb reef, and may be accompanied by the barnacle. *Balanus perforatus* (typically common to abundant). On wave-exposed shores in Ireland, the brown alga *Himanthalia elongata* can also occur.

8. Biotope code MIR.Ldig
***Laminaria digitata* on moderately exposed or tide-swept sublittoral fringe rock**

Exposed to sheltered sublittoral fringe rock with a canopy of the kelp *Laminaria digitata*. Several variants of this biotope are described for moderately exposed, sheltered, tide-swept and boulder shores.

9. Biotope code LGS. AP.P
Burrowing amphipods and polychaetes (often *Arenicola marina*) in clean sand shores

Biotope description
Mid and lower shore clean sand on wave-exposed or moderately wave-exposed coasts support a community of burrowing amphipods and polychaetes. Amphipods *Bathyporeia pelagica*, B. pilosa, B. sarsi, *Pontocrates arenarius* and the isopod *Eurydice pulchra* are typically present. Polychaetes make the greater part of the commuity in terms of species richness and are dominated by *Nephtys cirrosa*, *Scolelepsis squamata* and *Arenicola marina*. The medium nad fine sand remains damp throughout the tidal cycle and contains little organic matter. The lugworm *Arenicaola marina* present are usually as temporary recruitment that are likely to be washed out during storms.

Figure 7.3.4 Biotopes identified during subtidal benthic surveys

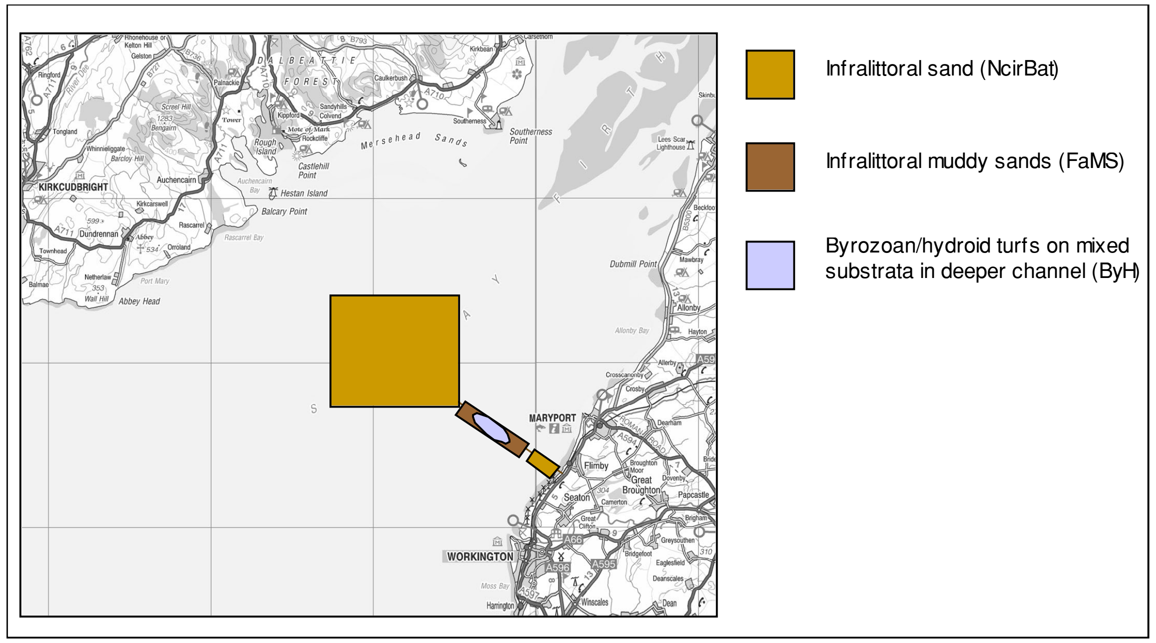


Figure 7.3.5 Biotopes identified in the intertidal survey on the 132 kV corridor

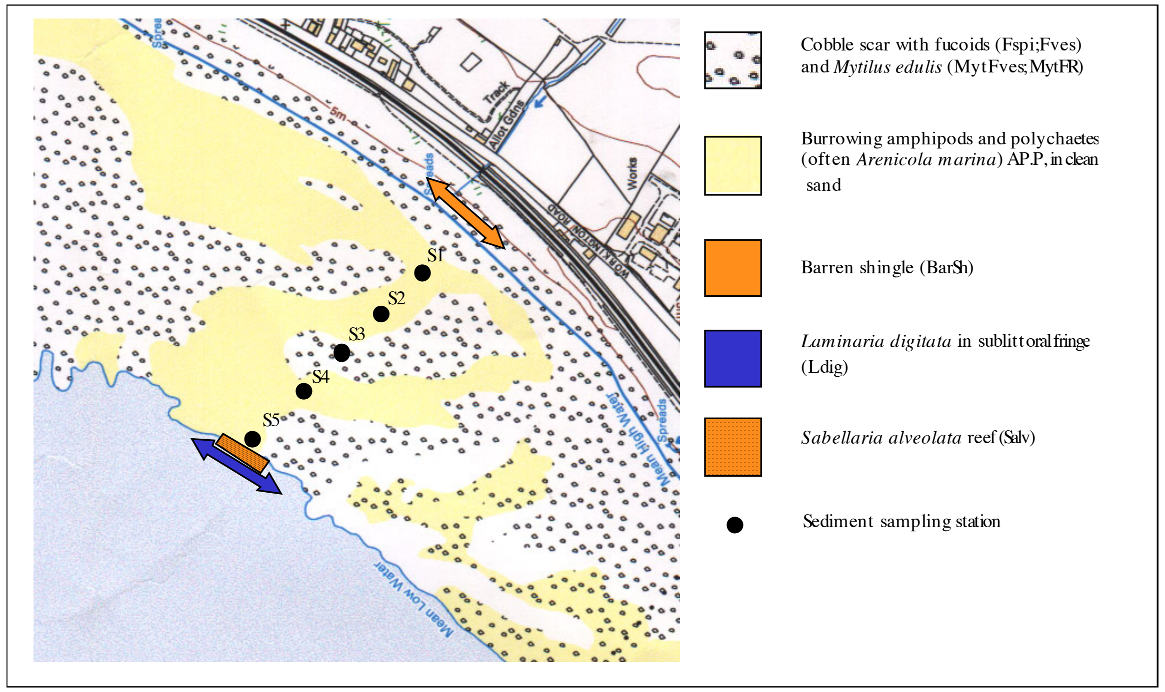
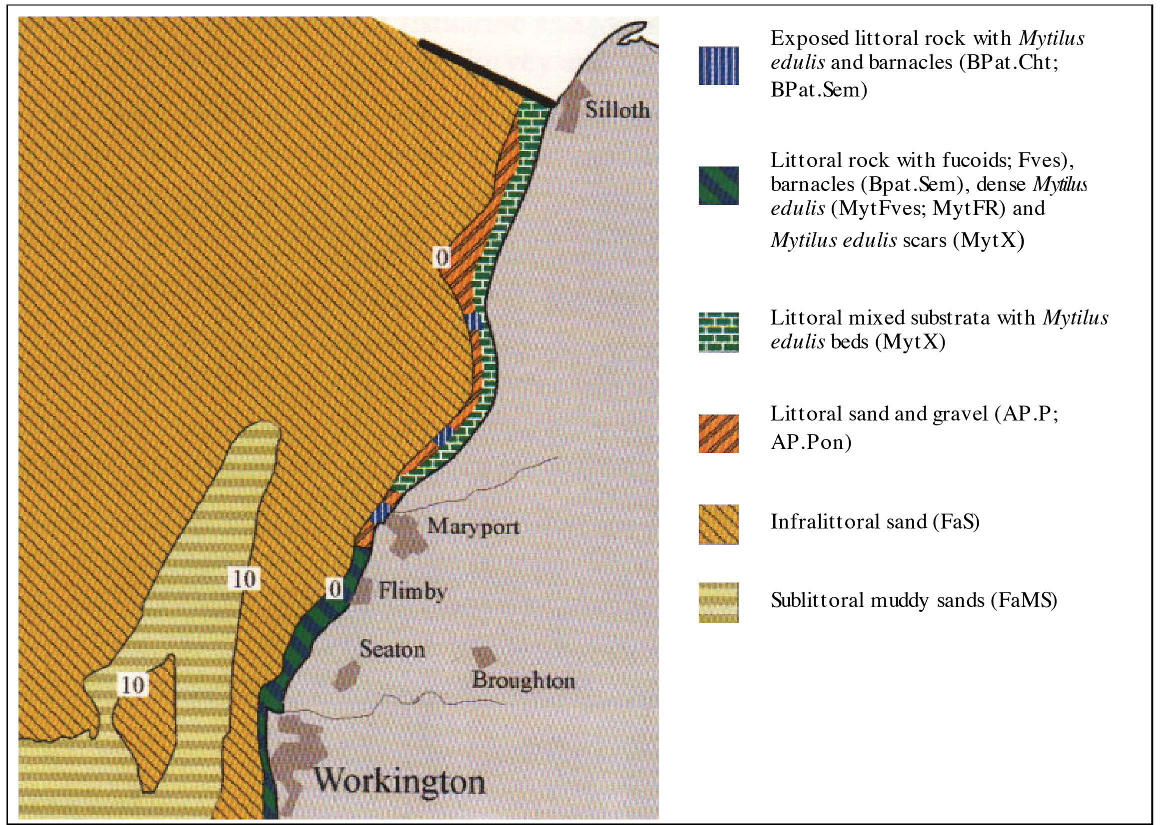


Figure 7.3.6 Indicative distribution of the main biotopes adjacent to the 132 kV cable route landfall at Flimby (adapted from Covey, R. 1998).



7.4 FISH

7.4.1 INTRODUCTION

There is a great deal of information relating to fish species in the Irish Sea and various studies have also been carried out specifically in the Solway Firth over the last 30 years, including surveys in 2001/2002 for this assessment. Survey data has been considered for monthly trawls between November 2001 and April 2002 (with the exception of January that was cancelled due to bad weather conditions). Monthly trawl surveys are ongoing until late summer 2002.

Information for this assessment has been compiled from the following sources:

- Monthly trawl surveys in an area surrounding the proposed Robin Rigg offshore wind farm from November 2001 to April 2002
- Monthly trawl surveys carried out in the Solway area during the 1970s
- PhD fish surveys in the Irish Sea and Solway Firth in the 1990s
- General Irish Sea fish surveys
- General Irish Sea and Solway Firth reviews
- Consultation with relevant parties as part of this EIA

7.4.2 CONSULTATION

As part of the baseline assessment various interested parties were contacted in order to obtain information relevant to the species considered and ensure that due consideration was given to existing concerns.

The following bodies were consulted:

- Eden Rivers Trust
- Scottish Natural Heritage
- English Nature
- Environment Agency
- West Galloway Fisheries Trust
- Cumbrian Sea Fisheries Committee
- Annan Fishermen's Association
- Solway Shellfish Mangement Association
- Scottish Fisheries Protection Agency
- Solway Shark Watch and Sea Mammal Survey

7.4.3 TRAWL SURVEYS

Baseline data on fishes in the Solway were provided primarily by Lancaster (unpubl.) from work undertaken for a PhD thesis and site-specific surveys for the proposed Robin Rigg development carried out from November 2001 onwards as outlind below. Sampling was undertaken with a light-weight 1.5m beam trawl with a 22mm mesh cod-end.

The trawl locations for monthly surveys carried out from November 2001 are shown in Figure 7.4.1.

The majority of fish surveys carried out in the Solway Firth (including surveys for the proposed Robin Rigg development) have used beam trawls. The beam trawl is the standard gear for sampling benthic and demersal fish populations on course substrata[98]. This method is recommended in the *JNCC Marine Monitoring Handbook* and has been used in several studies of the epibenthic population of the Solway Firth[99] [100]. This is the most suitable sampling method for benthic and demersal (bottom-living) fish species but is, as a result, highly biased towards such species. As a result, more pelagic species (free-swimming throughout the water column) may be severely under-represented in samples, particularly as these tend to swim up and over the net.

Nevertheless, general surveys of the Irish Sea have found the most abundant fish species of shallow soft sediment habitats such as those of the Solway Firth to be benthic or demersal species. These fish communities tend to be dominated by juvenile flatfish such as plaice, dab, turbot, brill, sole and solenette, and sand eels. Sand gobies, lesser weevers and sand-smelt are also associated with this fish community, with common gobies and flounder present in reduced salinity environments[101]. The use of beam trawl techniques is therefore considered to be the most appropriate to the Robin Rigg area.

From November 2001, monthly surveys were undertaken using a beam trawl deployed from a local fishing vessel. 31 sampling sites were identified as shown in Figure 7.4.1. The sampling sites were identified after consultation with the other parties undertaking surveying in the area of the proposed wind farm and with the vessel's skipper. The most intensive sampling occured within the original potential wind farm area, an area of approximately 6 x 8.5km (48.45km^2 as the area is not rectangular). This area was divided into 12 equal sampling squares of approximately 4km^2. An additional 4 squares of 4km^2 were identified 'up tide' (north east) of the area of the proposed wind farm, as this is where the greatest impact on the sediment and therefore mobile epibenthic species is predicted to occur. Outside of this central area larger sampling rectangles were identified (of approximately 8km^2). These larger sampling rectangles surround the central sampling area. Additional sampling rectangles were identified to the west of the proposed wind farm site to collect data on the epibenthos of the areas identified as most important to birds (especially the common scoter) in the ongoing bird survey.

These sites were surveyed over two consecutive days on tides midway between neap and spring. One 15 minute tow was undertaken on sampling station per survey. Samples were collected using a 2m steel beam trawl with approximately 1.1m steel shoes and fitted with an iron tickler chain. The mesh size of the main body of the net was 22 mm, with a 22 mm mesh cod-end. At the GPS position and time was recorded at the beginning and the end of the tow in order to calculate the length of the tow and tow speed. Water temperature, air temperature, depth, ambient weather conditions, wind direction and tidal state were all be recorded at the beginning and end of each tow. Water samples were taken to measure salinity.

After each tow the total contents of the cod-end was weighed. Large fish (over 30cm in length) were identified, weighed and their length recorded, before being returned to the sea. The catch was then separated into three components; shrimps (*Crangon crangon*), fish and epibenthic invertebrates. Each component of the catch was then weighed before a one kilo sample of each component was then taken. The samples were stored in a cool box and then immediately frozen on return to shore.

In the laboratory the samples were defrosted and their weight recorded. With the fish and epibenthic invertebrate samples all fish and invertebrates were identified to species and their length, or carapace length in the case of crustacea, recorded. The total weight of each species present was also recorded. With the shrimp samples the carapace length and the sex of 100 *C. crangon* from each sample were determined. The sex of *C. crangon* was identified according to the characters of the first and second pleopod[102] [103]. The proportion of berried females and proportion of post-spawners (females that have recently lost their eggs, but not yet moulted to a 'clean' carapace) was also recorded. Berried females were examined and the stage of development of their embryo's eggs recorded according to the method of Abbot and Perkins (1977)[104]. The ovigers can be divided into four groups indicative of their state of development (Table 7.4.1), dependant on the visibility of the eye and it's length in relation to the length of the egg.

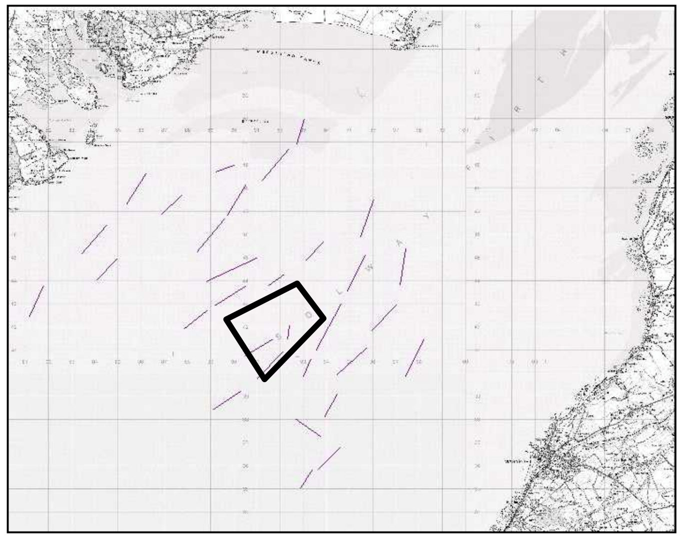
Table 7.4.1 State of development of eggs on berried female *C. crangon*

Stage of development	Eye Visible	Ratio of long axis eye/egg	Colour
Stage 1	No	no visible eyes	white
Stage 2	Yes	< $^1/_{10}$	creamy pink
Stage 3	Yes	between $^1/_{10}$ and $^1/_6$	pink to brown
Stage 4	Yes	> $^1/_6$	brown to purple

The number of individuals in each sample was then raised to the weight of each component in the haul. This data was then standardised to a 15 minute tow. For statistical analysis, sampling stations were clustered according to their Bray Curtis Similarity (Ranked), from which distinct areas were identified. Correlations between abundance and physical parameters were examined using regression analysis. Differences between areas, seasons and years were assessed by the ANOVA General linear model on normalised (log or arsine) transformed data.

[98] Wilding, T.A., Gibson, R.N. and Sayer, D.J. (2000) Procedural Guideline No. 4-3: Sampling benthic and demersal fish populations on sediments. *JNCC Marine Monitoring Handbook*.
[99] Lancaster, J., (1999) *Ecological studies in the brown shrimp fishery in the Solway Firt*h. University of Newcastle upon Tyne. PhD thesis.
[100] Abbott, O. J. and Perkins, E. J. (1977) The biology of the Brown shrimp *Crangon crangon* in the Solway Firth. *Cumbria Sea Fisheries Scientific Report* **77/4**. Published by Cumbria Sea Fisheries Committee, The Courts, Carlisle.
[101] Nash, R.D.M. (1990). Fish assemblages in the Irish Sea. In: Irish Sea Study Group Report. Part 1 Nature Conservation, 325-333. University of Liverpool; Liverpool.
[102] Meredith, S. S., (1952) A study of Crangon vulgaris in the Liverpool Bay area. Prococeedings and Transactions of the. Liverpool Biological Society, **58**: 75-109.
[103] Tiews, K. (1967) The use of plastic tags for tagging small shrimps (brown shrimps, *Crangon vulgaris* Fabricius) and the problems of tagging experiments of this species of shrimp. *Symposium Series Marine biology Association India*, **2** (4): 1296-1300.
[104] Abbott, O. J. and Perkins, E. J. (1977) The biology of the Brown shrimp *Crangon crangon* in the Solway Firth. *Cumbria Sea Fisheries Scientific Report* **77/4**. Published by Cumbria Sea Fisheries Committee, The Courts, Carlisle.

Figure 7.4.1: Location of beam trawls in relation to the Licence Area



7.4.4 SUMMARY OF FISH SPECIES AND COMMUNITIES IN THE SOLWAY FIRTH

The detailed trawl survey results are presented in Appendix E in the separate appendices volume. From this and previous surveys carried out in the Solway Firth, it is evident that the area is important to a wide variety of fish, over 130 species of fish having been recorded in the Solway[105]. These include a number of highly abundant species (which may be of ecological or commercial importance) and several species that are classed as rare or endangered.

7.4.4.1 Main Species

The most common fish and epibenthic (free-swimming) shellfish species recorded between November 2001 and April 2002 in sampling sites at Robin Rigg were (in order of abundance):

- brown shrimp (*Crangon crangon*)
- plaice (*Pleuronectes platessa*)
- dab (*Limanda limanda*)
- whiting (*Merlangius merlangus*)
- Dover sole (*Solea solea*).

The most abundant of these, the brown shrimp (*Crangon crangon*), is of particular commercial importance within the Solway Firth and is also of importance as a source of food for a wide variety of fish, birds and sea mammals.

[105] Solway Firth Partnership. (1996). Solway Firth Review. June 1996. Solway Firth Partnership.

Plaice, Dover sole and whiting which area all important commercial species were caught in large numbers in the 2001-2002 beam trawl surveys. Other non-target species that were caught in smaller numbers but may be landed as commercial by-catch include the flounder (*Platichthys flesus*), brill (*Scophthalmus rhombus*) and turbot (*Psetta maxima*). Solenette (*Buglossidium luteum*) and scaldfish (*Arnoglossus laterna*) are not landed commercially but were caught in reasonable numbers in beam trawl surveys.

7.4.4.2 Other Regularly Recorded Species

A number of numerous, but non-commercial species are also present in the Robin Rigg area. These species represent prey sources for larger fish, birds and some sea mammals and so may be important components of the estuarine ecosystem. Species taken in the 2001-2002 beam trawls included the sand goby (*Pomatoschistus minutus*), lesser weever (*Echiichtys vipera*) and pogge (*Agonus cataphractus*). Beam trawl surveys between 1995 and 1998 (Lancaster unpubl.) show these species to have considerable seasonal and interannual variation in abundance and spatial distribution within the Solway Firth.

7.4.4.3 Elasmobranchs (sharks, skates and rays)

The elasmobranchs (or cartilaginous fish) are considered separately due to their sensitivity to electric fields. Species which have been recorded within the Solway Firth[106] are:

Skates and rays:

- *Raja clavata* – formerly common in all British waters, most of the year, but is seriously declining in the Irish Sea due to overfishing, especially in the case of juveniles.
- *Dasyatis pastinaca* - the stingray tends to be a seasonal visitor typically in the waters off the south coast of the British Isles. It favours soft sandy or muddy substrata in 2-40m particularly in sheltered estuaries.
- *Torpedo* spp. - the torpedo (electric) ray is also a species that is relatively uncommon in British Waters. Like the other rays it inhabits areas of sand and mud from 3-70m water depth.

Sharks and dogfish:

- *Scyliorhinus canicula* - the most common shark in British waters all year round. The lesser-spotted dogfish is anecdotally reported to be increasing in number possibly as a result of decreased competition from other species, which have been reduced through fishing.
- *Galeorhinus galeus* – the tope uses inshore areas for pupping and nursery grounds and is a UK Biodiversity 'species of concern'.
- *Cetorhinus maximus* - the basking shark is found in the surface waters during the summer months and is especially prevalent in the Irish Sea. This species is legally protected and has vulnerable status in the IUCN Red List.

[106] Hammond, N & Lewis, M. (2002) Unpublished Data. Solway Shark Watch and Sea Mammal Survey.

- *Lamna nasus* - the porbeagle shark can be found all year round and is a valuable species for commercial and recreational fisheries. The IUCN status is that the NE Atlantic population is more threatened that the global population.
- *Alopias vulpinus* - the thresher shark tends to be a southern resident of the UK waters, rarely venturing north of the Welsh coast.
- *Prionace glauca* – the blue shark is a seasonal species typically found in the waters off the south coasts of England and Ireland.

7.4.4.4 Pelagic Species

Pelagic species have been less well studied (see above). However, from various surveys it is apparent that the most abundant pelagic species in the Solway Firth include herring, mackerel and sprat. Sprats (*Sprattus sprattus*) are distributed widely throughout the Irish Sea and throughout the Solway Firth but are not exploited as a commercial fishery[107]. They were commonly found in the 2001-2002 beam trawls.

7.4.4.5 Migratory Species

In addition the Solway Firth is important to migratory fish (Lancaster, unpubl.), including the sea trout and salmon, allis and twaite shad, smelt, sea lampreys and eel with fish migrating into the Rivers Nith, Annan, Sark, Kirtle water, Esk, Eden and Derwent (Lancaster, unpubl.). Several of these species are protected. The routes taken by migratory species moving past the Robin Rigg area are, however, uncertain.

7.4.5 FISH COMMUNITY CHARACTERISATION

Demersal fish assemblages in the Irish Sea have been categorised by Ellis *et al.* (2000)[108]. According to data collected from beam trawl surveys, the communities recorded at Robin Rigg are typical of general communities within the Solway Firth and throughout much of the shallow eastern Irish Sea. Ellis *et al* included eight sites in the Solway Firth, all of which corresponded to their *Pleuronectes-Limanda* (plaice – dab) assemblage. The discriminating fish species in this assemblage are plaice (*Pleuronectes platessa*), dab (*Limanda limada*) and sole (*Solea solea*), with other important fish species including solenette (*Bugolossidium luteum*), dragonet (*Callionymus lyra*), tub gurnard (*Trigla lucerna*), grey gurnard (*Eutrigla gurnardus*), whiting (*Merlangius merlangus*) and dogfish (*Scyliorhinus canicula*)[109]. The sand eel *Ammodytes tobianus*, an extremely common inshore species, is also common in this type of environment and, as expected, large shoals have been noted near the coast of the Solway[110].

107 Solway Firth Partnership. (1996). Solway Firth Review. June 1996. Solway Firth Partnership.
108 Ellis, J.R., Rogers, S.I. & Freeman S.M. (2000). Demersal assemblages in the Irish Sea, St. George's Channel and Bristol Channel. Est. Coast. Sh. Sci. 51: 299-315.
109 Ellis, J.R., Rogers, S.I. & Freeman S.M. (2000). Demersal assemblages in the Irish Sea, St. George's Channel and Bristol Channel. Est. Coast. Sh. Sci. 51: 299-315.
110 Solway Firth Partnership. (1996). Solway Firth Review. June 1996. Solway Firth Partnership.

The communities present are therefore generally typical of much of the eastern Irish Sea. In addition, surveys carried out in 2001 found similar fish assemblages to those recorded in surveys carried out in the 1970s (Lancaster, unpubl.), suggesting an overall stability in fish community composition.

7.4.6 NURSERY AND SPAWNING GROUNDS

For a number of species the Solway Firth is important as a nursery ground for juveniles. Nursery grounds are widespread along the coast of northwest England including the Solway Firth[111], with estuaries such as the Solway providing a particularly important nursery resource to coastal fish populations[112].

Few marine species spawn in estuarine waters, although sole, flounder, dab and whiting are known to spawn in areas including the mouth of the Solway Firth[113]. In particular, the outer Solway Estuary is one of two sole spawning areas in the eastern Irish Sea.

Juvenile fish enter estuaries a short time after spawning as predator numbers tend to be low and waters are productive and sheltered[114]. Many flatfish species spend at least six months in coastal nursery grounds following metamorphosis, moving offshore as they grow[115], the larger fish generally living further offshore[116]. However, movement to and from spawning grounds can cause major changes in distribution of adult fish[117].

Therefore, although Robin Rigg is not known to be an area coinciding with spawning grounds, it is undoubtedly a nursery ground for a number of commercial demersal fish species e.g. plaice (*Pleuronectes platessa*), dab (*Limanda limanda*), flounder (*Platichthys flesus*), sole (*Solea solea*), herring and whiting (*Merlangius merlangus*).

7.4.7 IDENTIFICATION OF KEY SPECIES

Of the fish species recorded within the Solway Firth, many can be regarded as being of particular importance, or *sensitivity*. Sensitive species may be benthic/demersal or pelagic but will include species which utilise the Solway Firth as a spawning/nursery ground. This sensitivity may derive from:

- Commercial importance
- Rarity and, in many cases, protected status
- Importance in the local ecosystem (e.g. 'keystone' species)

111 Pawson, M.G. & Robson, C.F. (1996b). Chapter 5.7 Fish: exploited sea fish. In: Coasts and Seas of the United Kingdon. Region 13 Northern Irish Sea: Colwyn Bay to Stranraer, includig the Isle of Man, ed.s J.H. Barne, C.F. Robson, S.S. Kaznowska, J.P. Doody & N.C. Davidson, 120-124. Joint Nature Conservation Committee; Peterborough.
112 Potts, G.W. & Swaby, S.E. (1993). Review of the status of estuarine fishes. English Nature Research Reports No. 34. English Nature; Peterborough.
113 Fox, C.J., Dickey-Collas, M., Winpenny, A.J. (1997). Spring plankton surveys of the Irish Sea in 1995: The distribution of fish eggs and larvae. Science series technical report No:104. CEFAS.
114 Blaber, S.J.M. & Blaber, T.G. (1980). Factors affecting the distribution of juvenile estuarine and inshore fish. J. Fish. Biol. 17: 143-162.
115 Amezcua Martinez, F. (2000). Distribution and biology of the order Pleuronectiformes in the north Irish Sea in relation to sediment type. PhD Thesis. University of Liverpool; Port Erin Marine Laboratory, Isle of Man.
116 Nash, R.D.M. (1990). Fish assemblages in the Irish Sea. In: Irish Sea Study Group Report. Part 1 Nature Conservation, 325-333. University of Liverpool; Liverpool.
117 Amezcua Martinez, F. (2000). Distribution and biology of the order Pleuronectiformes in the north Irish Sea in relation to sediment type. PhD Thesis. University of Liverpool; Port Erin Marine Laboratory, Isle of Man.

The degree of sensitivity afforded a species has been based on the following criteria, and also takes into account the occurrence (or likely occurrence) of a species within the Solway Firth:

HIGH sensitivity
Recognised Rare, Protected or Nationally Uncommon species
Species recognised to be uncommon within the Irish Sea
Species which are target species for fisheries in the Solway Firth OR by-catch species which contribute roughly equally with target species to the income of fishermen dependent upon the waters of the Solway Firth
Species which use the study area as spawning or nursery grounds and whose spawning or nursery grounds are limited within the Irish Sea
Species whose loss or depletion would cause trophic cascades, by virtue of the numbers or position in the local food web

MEDIUM sensitivity
Species whose numbers have declined (nationally or within the Irish Sea), but which are not yet regarded as being rare or uncommon
Commercially important by-catch species regularly taken by local fishing boats
Species which depend on the habitats present in the study area for spawning or nursery grounds but which use such habitats throughout the Irish Sea
Species whose loss or depletion would cause disruption of the local food web

LOW sensitivity
Species common and widely distributed throughout the Irish Sea
Species with little or no commercial value
Species which spawn widely with little or no habitat requirements (e.g. mackerel)
Species whose loss or depletion would not cause trophic effects

Based on these criteria, fish species which are considered to be of high or medium sensitivity have been discussed separately below.

7.4.7.1 Brown Shrimp

The brown shrimp *Crangon crangon* is abundant in sandy estuaries around the Irish Sea, including the Solway Firth[118], where it supports a small, but valuable fishery[119]. The main fishing areas occur to the north and east of the Robin Rigg survey area throughout the year (see Section 8.1 of this ES) although there is considerable variability in the distribution and abundance of shrimp over spatial and temporal scales.

The brown shrimp can tolerate a wide temperature range and can, therefore, spawn in the summer or winter. However, in the vicinity of Robin Rigg, berried (egg-carrying) *C. crangon* tend to occur in the winter and spring throughout the area to the north and east of the Robin Rigg area just prior to release of the larvae in the spring.

Brown shrimp are considered to be of **high** sensitivity due their importance as a commercial fishery and in the estuary ecosystem.

7.4.7.2 Plaice

Plaice are caught commercially in the greatest abundance on inshore fishing grounds of the north east Irish Sea[120]. Plots of plaice distribution, from surveys carried out between 1995 and 1998, show high densities of plaice to be present in the Inner Solway to the south-east of Southerness Point. This area falls to the north-east of the Robin Rigg site (see Section 8.1 of this ES) although the distribution is highly seasonal, with contour plots of plaice demonstrating that fishes will move up and down through the estuary on a seasonal basis, but with the major densities tending to be either inshore or offshore of the Robin Rigg area.

Plaice spawning grounds are known to occur throughout the eastern Irish Sea including the St. Bees Head area. Spawning takes place in the early months of the year with larvae migrating to nursery grounds[121] lying inshore along the coast from Anglesey to the Mull of Galloway[122], arriving in May to July. Nursery grounds almost certainly coincide with the Robin Rigg area. Juvenile plaice feed heavily on shellfish and juvenile polychaete worms, migrating in early autumn to spawning areas off St. Bees Head[123].

Plaice are considered to be of **high** sensitivity due to their importance as a commercially exploited species and the presence of nursery grounds in the Solway Firth.

7.4.7.3 Dab

118 Pawson, M.G. & Robson, C.F. (1996). Chapter 5.7 Fish: exploited sea fish. In: Coasts and Seas of the United Kingdon. Region 13 Northern Irish Sea: Colwyn Bay to Stranraer, includig the Isle of Man, ed.s J.H. Barne, C.F. Robson, S.S. Kaznowska, J.P. Doody & N.C. Davidson, 120-124. Joint Nature Conservation Committee; Peterborough.
119 Potts, G.W. & Swaby, S.E. (1993). Review of the status of estuarine fishes. English Nature Research Reports No. 34. English Nature; Peterborough.
120 Amezcua Martinez, F. (2000). Distribution and biology of the order Pleuronectiformes in the north Irish Sea in relation to sediment type. PhD Thesis. University of Liverpool; Port Erin Marine Laboratory, Isle of Man.
121 Potts, G.W. & Swaby, S.E. (1993). Review of the status of estuarine fishes. English Nature Research Reports No. 34. English Nature; Peterborough.
122 Pawson, M.G. & Robson, C.F. (1996). Chapter 5.7 Fish: exploited sea fish. In: Coasts and Seas of the United Kingdon. Region 13 Northern Irish Sea: Colwyn Bay to Stranraer, includig the Isle of Man, ed.s J.H. Barne, C.F. Robson, S.S. Kaznowska, J.P. Doody & N.C. Davidson, 120-124. Joint Nature Conservation Committee; Peterborough.
123 Potts, G.W. & Swaby, S.E. (1993). Review of the status of estuarine fishes. English Nature Research Reports No. 34. English Nature; Peterborough.

Dab (*Limanda limanda*) is one of the most common species recorded throughout the Solway Firth[124]. Spawning in this species takes place from February to April although there is no evidence that spawning takes place within the Solway Firth.

Dab are considered to be of **medium** sensitivity due to their abundance and so likely importance in ecosystem functioning.

7.4.7.4 Dover Sole

Dover sole (*Solea solea*) occur seasonally throughout the Solway Firth[125]. During the winter Dover sole inhabit deeper offshore waters, migrating inshore during April to spawn. Following spawning, adult fish remain inshore until autumn.

Spawning grounds are present in the Outer Solway to the south-west of Robin Rigg, although nursery grounds are present in areas inshore of a line between Burrow Head and Workington, coincident with the Robin Rigg area[126].

Dover sole are considered to be of **high** sensitivity due to their commercial importance in the Solway Firth.

7.4.7.5 Flounder

Flounder (*Platichthys platessa*) are common throughout the Solway Firth, particularly the Upper Solway[127]. Particularly large individuals have been reported from within the Estuary which are an important attraction for anglers[128]. Flounder are therefore considered to be of **medium** sensitivity as a commercial species.

7.4.7.6 Herring

Herring are recorded in the Solway Firth and in the past were targeted as a commercial fishery. The Irish Sea herring fishery has now, however, been closed on spawning stocks, except for a small area between Ireland and the Isle of Man.

Herring spawning grounds lie outwith the Solway Firth, mainly to the south-east of Isle of Man, although nursery grounds occur throughout the eastern Irish Sea from Colwyn Bay (N. Wales) to the Mull of Galloway, and including the Solway Firth. Spawning occurs in September and October with juveniles reaching nursery grounds from November onwards. Juveniles and adults have similar diets feeding mainly on invertebrates and small fish, particularly sandeels.

[124] Solway Firth Partnership. (1996). Solway Firth Review. June 1996. Solway Firth Partnership.
[125] Solway Firth Partnership. (1996). Solway Firth Review. June 1996. Solway Firth Partnership.
[126] Solway Firth Partnership. (1996). Solway Firth Review. June 1996. Solway Firth Partnership.
[127] Solway Firth Partnership. (1996). Solway Firth Review. June 1996. Solway Firth Partnership.
[128] J. Lancaster, pers. Comm

Herring are considered to be of **medium** sensitivity due to the expected presence of sizeable nursery grounds in the Solway Firth.

7.4.7.7 Whiting

Whiting (*Merlagius merlangus*) is common throughout the Irish Sea and Solway Firth, being one of the most commonly caught species in fish trawl surveys carried out between November 2001 and April 2002 (see Appendix E). It is most common in the Solway Firth during the winter, feeding on benthic invertebrates and small fish including sandeels and gobies. Whiting is considered to be of **high** sensitivity due to its importance as a commercial species.

7.4.7.8 Sandeel

Sandeel are widely distributed in the Irish Sea[129] and are reported in shoals close inshore in the Solway Firth[130]. They are not fished commercially but are an important food for mackerel and herring and other fish species[131] and bird species[132]. Sandeel is considered to be a of **high** sensitivity species due to it's importance in the food web and the potential for trophic cascades in the result of loss or depletion of the population.

7.4.7.9 Sprat

Sprats are distributed widely throughout the Irish Sea and throughout the Solway Firth although not a commercial fishery within the Firth. Sprat can be abundant in the Solway Firth at certain times of year[133]. Spawning of pelagic eggs occurs at sea in spring and summer. Larvae drift inshore where the young live in shoals, often with first-year herring. The young fish feed on plankton and invertebrate eggs and young, while adults feed mainly on planktonic Crustacea[134].

The sprat is considered to be a **high** sensitivity species due to its importance in the food web and the potential for trophic cascades as a result of significant loss or depletion of the population.

7.4.7.10 Gobies (sand goby and common goby)

Up to eleven species of goby occur in the Irish Sea[135]. They are a diverse group of mainly inshore fish closely associated with the seabed[136] producing benthic eggs. The sand goby occurs on shallow sand or muddy

[129] Pawson, M.G. & Robson, C.F. (1996). Chapter 5.7 Fish: exploited sea fish. In: Coasts and Seas of the United Kingdom. Region 13 Northern Irish Sea: Colwyn Bay to Stranraer, includig the Isle of Man, ed.s J.H. Barne, C.F. Robson, S.S. Kaznowska, J.P. Doody & N.C. Davidson, 120-124. Joint Nature Conservation Committee; Peterborough.
[130] Solway Firth Partnership. (1996). Solway Firth Review. June 1996. Solway Firth Partnership.
[131] Solway Firth Partnership. (1996). Solway Firth Review. June 1996. Solway Firth Partnership.
[132] Wheeler, A. (1969). The Fishes of the British Isles and N. W. Europe. Macmillan; London.
[133] Solway Firth Partnership. (1996). Solway Firth Review. June 1996. Solway Firth Partnership.
[134] Wheeler, A. (1969). The Fishes of the British Isles and N. W. Europe. Macmillan; London.
[135] Fox, C.J., Dickey-Collas, M., Winpenny, A.J. (1997). Spring plankton surveys of the Irish Sea in 1995: The distribution of fish eggs and larvae. Science series technical report No:104. CEFAS.
[136] Wheeler, A. (1969). The Fishes of the British Isles and N. W. Europe. Macmillan; London.

bottoms and usually lives in deeper water than common goby, although juveniles penetrate estuaries. The common goby is abundant in shore pools, saltmarsh creeks and estuaries[137].

Both species, however, are very abundant in the UK[138] and are described as frequent (sand goby) and abundant (common goby) in UK waters[139]. CEFAS surveys of egg and larvae distributions of Irish Sea fish species in 1995 showed goby larvae to be widespread throughout the eastern Irish Sea[140]. Within the Solway the sand goby can occur abundantly in beam trawls taken in the winter months. During the summer months it tends to migrate inshore where it may mix with the common goby[141].

Gobies, although not a directly valuable species, are an important prey item to many species of fish (common gobies are predated particularly by eels and flounders, while sand gobies are preyed on by bottom-living fish, flatfishes, codling and bass). Being present in high densities, both of these species make considerable contributions to the ecosystem[142].

In addition, both the common goby (*Pomatoschistus microps*) and sand goby (*Pomatoschistus minutus*) goby are protected under the Bern Convention Annex III. Both species are therefore considered to be of **high** sensitivity.

7.4.7.11 River Lamprey

The river lamprey or lampern (*Lampetra fluviatilis*) is found in Western Europe from the Mediterranean to southern Norway and is the most abundant migratory lamprey in west European rivers[143], occurring in many UK rivers.

The river lamprey exists in a number of Solway rivers, with the River Derwent in particular thought to be of significance for this species[144]. They are also known to be present in the River Eden which is designated a cSAC on account of the presence of the river lamprey and the lampern spawns at several sites along the River Eden[145]. Distribution records on the British Marine Fishes Database records lampern in Wigtown Bay and to the southwest of Southerness Point near the NW corner of the development area[146].

The river lamprey grows to maturity in estuaries and then migrates into clean rivers and streams usually between August and October (although this varies significantly between rivers). Here they spawn between March and June[147] and die following spawning. Larvae spend several years in freshwater before migrating to estuarine waters for a further 1-2 years. It is thought that the river lamprey tends to stay in coastal waters, especially those of low salinity. The main diet of the river lamprey in estuarine habitats is a variety of fish including herring, sprat and flounder.

Populations of migratory species of the lamprey have declined, mainly due to pollution and construction of physical barriers on rivers[148] [149] as well as canalisation and dredging, increased water abstraction and land drainage[150]. The lamprey is listed under Annex II and V of the EC Habitats Directive as a species of Community Interest whose conservation requires the designation of Special Areas of Conservation, and is listed in Annex III of the Bern Convention on the Conservation on the Conservation of European Wildlife and Natural Habitats. The river lamprey is therefore considered to be of **high** sensitivity due to its protected status.

7.4.7.12 Sea Lamprey

The sea lamprey is uncommon around the UK, although larvae can be locally common in suitable streams, including the Rivers Eden and Derwent, which are both designated cSAC's on account of the presence of sea lampreys.

The sea lamprey (*Petromyzon marinus*) breeds in freshwater and spends most of its time here in the larval stage. Breeding occurs in May-June in British waters after which the adults die[151]. Downstream migration occurs after metamorphosis (winter-early spring) where lamprey prey on shad, cod, haddock, salmon, basking sharks, sturgeon, eels and cetaceans. Little information is available of the life-history of sea lampreys at sea[152] [153], although it appears to be found in both coastal and deep offshore waters, similar to the distribution of salmon, one of their prey species[154].

The sea lamprey is protected under the Bern Convention Annex III and Habitats Directive Annex II and V. Like the river lamprey, sea lamprey are thought to have declined due to pollution and presence of weirs[155]. The species is considered to be **high** sensitivity due to its protected status.

7.4.7.13 Smelt

The anadramous (upstream spawning migrant) smelt *Osmerus eperlanus* occurs in a number of river systems throughout the UK, although the population of the River Cree is the only one thought to remain in the Solway Firth. Smelt had previously been present in nine rivers along this coast including the Rivers Nith and

137 Hayward, P., Nelson-Smith, T. & Shields, C. (1996). Collins Pocket Guide to the Seashore of Britain & Europe. Harper Collins; London.
138 Potts, G.W. & Swaby, S.E. (1996). Chapter 5.9 Fish: other species. In: Coasts and Seas of the United Kingdom. Region 13 Northern Irish Sea: Colwyn Bay to Stranraer, includig the Isle of Man, ed.s J.H. Barne, C.F. Robson, S.S. Kaznowska, J.P. Doody & N.C. Davidson, 128-130. Joint Nature Conservation Committee; Peterborough.
139 Hayward, P.J. & Ryland, J.S. (1990). The Marine Fauna of the British Isles and North-West Europe. Oxford University Press; Oxford.
140 Fox, C.J., Dickey-Collas, M., Winpenny, A.J. (1997). Spring plankton surveys of the Irish Sea in 1995: The distribution of fish eggs and larvae. Science series technical report No:104. CEFAS.
141 Potts, G.W. & Swaby, S.E. (1993). Review of the status of estuarine fishes. English Nature Research Reports No. 34. English Nature; Peterborough.
142 Wheeler, A. (1969). The Fishes of the British Isles and N. W. Europe. Macmillan; London.
143 Maitland, P.S. (1980). Review of the ecology of lampreys in Northern Europe. Can. J. Fish. Aquat. Sci. 37 (11): 1944-1952.
144 Solway Firth Partnership. (1996). Solway Firth Review. June 1996. Solway Firth Partnership.
145 Keith Hendry, pers. comm
146 Pawson, M.G. & Robson, C.F. (1996). Chapter 5.7 Fish: exploited sea fish. In: Coasts and Seas of the United Kingdom. Region 13 Northern Irish Sea: Colwyn Bay to Stranraer, includig the Isle of Man, ed.s J.H. Barne, C.F. Robson, S.S. Kaznowska, J.P. Doody & N.C. Davidson, 120-124. Joint Nature Conservation Committee; Peterborough.
147 Maitland, P.S. (1980). Review of the ecology of lampreys in Northern Europe. Can. J. Fish. Aquat. Sci. 37 (11): 1944-1952.
148 Maitland, P.S. (1980). Review of the ecology of lampreys in Northern Europe. Can. J. Fish. Aquat. Sci. 37 (11): 1944-1952.
149 Edinburgh Biodiversity Partnership (2000). http://www.edinburgh.gov.uk/CEC/City_Development/Environment/Biodiversity_Action_Plan/Biodiversity.html.
150 Edinburgh Biodiversity Partnership (2000). http://www.edinburgh.gov.uk/CEC/City_Development/Environment/Biodiversity_Action_Plan/Biodiversity.html.
151 Maitland, P.S. (1980). Review of the ecology of lampreys in Northern Europe. Can. J. Fish. Aquat. Sci. 37 (11): 1944-1952.
152 Maitland, P.S. (1980). Review of the ecology of lampreys in Northern Europe. Can. J. Fish. Aquat. Sci. 37 (11): 1944-1952.
153 Wheeler, A. (1969). The Fishes of the British Isles and N. W. Europe. Macmillan; London.
154 Keith Hendry, pers. comm
155 Wheeler, A. (1969). The Fishes of the British Isles and N. W. Europe. Macmillan; London.

Annan[156]. There is now concern over the smelt populations of the River Cree, which is one of only three populations throughout Scotland and the only one on the west coast of Scotland[157].

Adult smelt will congregate around river mouths in winter before entering rivers in early spring[158]. These aggregations prior to migration make smelt populations vulnerable to impacts[159]. Smelt initially appear in the lower reaches of the River Cree in January with spawning occurring during the 1st high tides in March[160]. Eggs are incubated in the spawning area for 20-35 day after which juveniles are swept downstream to estuarine feeding grounds[161]. A study of smelt feeding in the River Cree found the diet to be comprised mainly of fish, particularly juvenile smelt and brown shrimp[162].

Smelt has been identified as a species under threat in Scotland[163] and it is a Local Biodiversity Action Plan species (LBAP). The species is therefore considered to be **high** sensitivity both due to its rarity in the Irish Sea and the use of the estuary as a feeding ground for juveniles.

7.4.7.14 Shad

Both the allis and twaite shad are present in only low numbers around the British Isles with known spawning populations confined to relatively few rivers[164]. Both species were classed by as scarce (i.e. a species with significantly less than average population level)[165].

The rarer species of shad, the allis shad, are caught regularly in small numbers in the Wigtown Bay area during May and early June[166]. Considerable evidence also exists to suggest one or more of the rivers draining into the Solway Firth, possibly the River Cree, may support a spawning population of allis shad[167] [168] [169]. Radio tracking studies involving shad have been undertaken by the West Galloway Fisheries Trust, although results of the study are unavailable at this time

Twaite shad are more common that the allis shad, although it has been suggested that a recent decline in numbers will result in a deterioration in populations as already seen in the allis shad[170]. The habitat requirements for the twaite shad are not fully understood although spawning stocks are known to occur in only a few rivers in Wales and along the Welsh-English border with possible populations also in rivers flowing into the Solway[171].

The allis shad (*Alosa alosa*) and the twaite shad (*Alosa fallax*) are both anadramous species. Studies in the Severn Estuary have shown shad to migrate upstream in the Severn during late April-May, probably spawning in mid-June[172] with juveniles returning to the sea in late summer or autumn.

Allis and twaite shad are both protected under Annex III of the Bern Convention on the Conservation of European Wildlife and Natural Habitats (1979), Annexes II and V of the EC Habitats Directive and Schedule V of the Wildlife and Countryside Act 1981. Twaite and allis shad are both considered to be of **high** sensitivity due their rarity and protected status.

7.4.7.15 Salmon

Salmon are widely distributed throughout the UK[173] including the Solway region with populations in many of the rivers feeding the Solway Firth. Of the main rivers a number are designated as salmonid fisheries, including Piltanton Burn, River Bladnoch, River Cree, Water of Fleet, Urr Water, River Nith, River Annan, River Sark, River Eden, River Ellen, and River Derwent (SFP). The River Bladnoch is also designated as a cSAC for Atlantic salmon.

Information on numbers of salmon is inferred here from rod and net catches (although landings will also depend upon fishing effort). Populations of salmon fluctuate according to many factors including sea temperature and food availability[174] and catches in local rivers have risen and fallen highly with no clear trend over recent years. The River Eden, suggested as being the fourth best salmon river in the country[175], had shown a general increase in rod catches of salmon between 1980 and the early 1990's. In the last decade catches have fallen from a maximum of approximately 2500 annual rod catch to below 1000[176]. However, other rivers such as the Rivers Derwent and Esk have shown a recent increase in rod catches. The River Ellen has had variable catches of very small number of salmon (average of <30 fish per year over last 20 years). Salmon net catches in the Solway between 1980-2000 have been highly variable. Catches have shown a general decline, with numbers lower than those of the early 1990s, although again recent figures (1999-2000) indicate that catches may be increasing.

The Atlantic salmon is present in the Solway all year through either as adults, kelts or smolt. Upstream spawning migrations occur throughout the year[177] and timings may vary for specific rivers, such as the River Eden where spring run numbers have dwindled and the autumn run has become more important[178]. Salmon

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156 Lyle, A.A. & Maitland, P.S. (1997). The spawning migration and conservation of smelt *Osmerus eperlanus* in the River Cree, southwest Scotland. Biol. Conserv. 80: 303-311.
157 Lyle, A.A. & Maitland, P.S. (1997). The spawning migration and conservation of smelt *Osmerus eperlanus* in the River Cree, southwest Scotland. Biol. Conserv. 80: 303-311.
158 Wheeler, A. (1969). The Fishes of the British Isles and N. W. Europe. Macmillan; London.
159 Solway Firth Partnership. (1996). Solway Firth Review. June 1996. Solway Firth Partnership.
160 Lyle, A.A. & Maitland, P.S. (1997). The spawning migration and conservation of smelt *Osmerus eperlanus* in the River Cree, southwest Scotland. Biol. Conserv. 80: 303-311.
161 Sinclair, C.A., Crossland, A.R., Ribberns, J. (2000). Sparling (smelt), *Osmerus eperlanus*, Conservaiton on the River Cree. A Report to SNH. West Galloway Fisheries Trust.
162 Hutchinson, P. (1983). The ecology of smelt *Osmerus eperlanus* (L.) from the River Thames anf the River Cree. PhD Thesis, University of Edinburgh.
163 Lyle, A.A. & Maitland, P.S. (1997). The spawning migration and conservation of smelt *Osmerus eperlanus* in the River Cree, southwest Scotland. Biol. Conserv. 80: 303-311.
164 JNCC (2001). SAC feature information. http://www.jncc.gov.uk/idt/sac/data.
165 Swaby, S.E. & Potts, G.W. (1990). Rare British marine fishes – identification and conservation. J. Fish. Biol. 37 (Supplement A): 133-143.
166 Potts, G.W. & Swaby, S.E. (1993). Review of the status of estuarine fishes. English Nature Research Reports No. 34. English Nature; Peterborough.
167 Aprahamian, M.W. & Aprahamian, C.D. (1990). Status of the genus *Alosa* in the British Isles; past and present. J. Fish. Biol. 37 (Supplement A): 257-258.
168 Solway Firth Partnership. (1996). Solway Firth Review. June 1996. Solway Firth Partnership.
169 Maitland, P.S. & Lyle, A.A. (1990). Practical conservation of British fishes: current action on six declining species. J. Fish. Biol. 37 (Supplement A): 255-256.
170 Aprahamian, M.W. & Aprahamian, C.D. (1990). Status of the genus *Alosa* in the British Isles; past and present. J. Fish. Biol. 37 (Supplement A): 257-258.
171 JNCC (2001). SAC feature information. http://www.jncc.gov.uk/idt/sac/data.
172 Claridge, P.N. & Gardner, D.C. (1978) Growth and movements of the twaite shad, Alosa fallax (Lacepede), in the Severn Estuary. J.Fish. Biol. 12 (3) : 203-211.
173 Aprahamian, M. W. & Robson, C.F. (1996). Chapter 5.8 Fish: salmon, sea trout and eels. In: Coasts and Seas of the United Kingdom. Region 13 Northern Irish Sea: Colwyn Bay to Stranraer, includig the Isle of Man, ed.s J.H. Barne, C.F. Robson, S.S. Kaznowska, J.P. Doody & N.C. Davidson, 125-127. Joint Nature Conservation Committee; Peterborough.
174 Solway Firth Partnership. (1996). Solway Firth Review. June 1996. Solway Firth Partnership.
175 Alistair Maltby, pers.comm
176 Environment Agency (2000). North West Fisheries Annual Report 2000. 2000 Annual Report on Fisheries in the North West. Environmental Agency; Warrington.
177 J. Ribbens, pers. comm
178 Environment Agency (2000). North West Fisheries Annual Report 2000. 2000 Annual Report on Fisheries in the North West. Environmental Agency; Warrington.

will drift back and forth on the tides within river mouths waiting for appropriate conditions for upstream migrations (high freshwater runoff). However, details of their movements in coastal waters are not fully understood[179]. It is often assumed that they will remain close to the coast when migrating in nearshore waters in order to be able to detect the smell of their home river system and that if they do move offshore in the Solway then they are most likely to use the deeper channels. Although moving past the Robin Rigg area, salmon will therefore not be expected to pass over the Robin Rigg area in large numbers.

The peak of the (downstream) smolt run is strongly limited to late spring (May) in most areas, usually with little movement after June. As a result it is thought that downstream migration of smolt is likely to be relatively minor during the summer[180]. This is reflected by surveys of the River Bladnoch[181]. It is thought that salmon smolts move extremely rapidly once they enter saline waters and within a few weeks are likely to be hundreds of miles away in the north Atlantic[182] and microtagging work has suggested that Eden river salmon are often caught off North West Ireland[183]. Previous studies have also shown that during migration through estuaries to coastal waters, salmonid smolts tend to remain in the top 30% of the water column[184] and will orientate themselves within the main flow of the channel where water velocities are highest[185].

The salmon, *Salmo salar* is protected under the EC Habitats Directive and Annex III of the Bern Convention on the Conservation of European Wildlife and Natural Habitats (although in freshwaters only) and is a local biodiversity action plan (LBAP) priority species. Due to its protected status and commercial value, salmon is considered to be of **high** sensitivity.

7.4.7.16 Sea Trout

Sea trout are widely distributed throughout the UK[186] with similar distribution to salmon in the Solway Firth. Sea trout, however, remain in coastal waters. As a result sea trout are less likely to leave the Irish Sea and, possibly, many may not leave the Solway Firth area and would be expected to use the Solway Firth area for feeding[187]. Sea trout tend to return to their home rivers to spawn, but less consistently than salmon. They also return to sea following spawning, and repeat spawn much more commonly than salmon.

Numbers of sea trout are again inferred from rod and net catches which are likely to show variation according to effort as well as salmon numbers. Catches show sea trout numbers in rivers feeding the Solway Firth to have been highly variable over the last 20 years[188]. The Solway Firth Review (1996) reported a decline in sea trout numbers over the previous 5 years although this also indicated that a recovery may be underway[189]. This concurs with reported sea trout net catches which showed an overall decline from the mid-1980s, with figures for 1999-2000 indicating an increase may be occurring[190].

Although movements of sea trout are not well known as they migrate through estuaries to coastal waters[191] [192] it is thought that they tend to remain in surface waters within the main channel where water velocities are highest[193].

Sea trout is considered to be of **high** sensitivity due to its high economic importance.

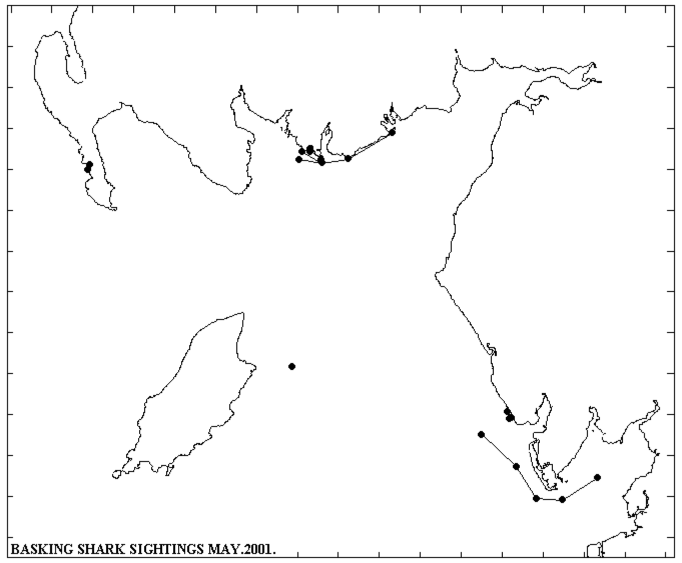
7.4.7.17 Basking Shark

The basking shark (*Cetorhinus maximus*) is a large filter-feeding shark (growing up to approximately 10 m long, making it the second-largest shark species). Basking sharks travel alone, in pairs, or in groups of up to 100 individuals. The basking shark is protected in UK waters under the Wildlife and Countryside Act (1981).

The basking shark is a seasonal visitor to the Irish Sea. Knowledge of the geographical and temporal distributions of the basking shark in the Irish Sea is based mainly on records of sightings provided by the general public, fishermen and other users of the sea with occasional data from dedicated searches. This data is collated by the Basking Shark Society, based on the Isle of Man, which holds records for the last 17 years. In addition to this, the basking shark is one of the species included in the sightings database of the Solway Shark Watch & Sea Mammal Survey[194] (SSW&SMS). Basking sharks are most commonly observed in the Irish Sea during the summer months when water temperatures increase. Most commonly, sightings are made in the inshore waters (<10km from the coast) to the south and south west of the Isle of Man. In these areas, sightings may number many hundreds per year[195]. Sightings of basking shark in the inshore waters of the north eastern Irish Sea are few in number. However, they are regularly seen each year particularly around May. Figure 7.4.2 below describes sightings of basking shark and their probable movements in the north eastern Irish Sea, made during May 2001. Thus, whilst the Solway Firth does not appear to be as important an area for basking sharks when compared to the deep water to the west of the Isle of Man, they are nevertheless present each year in the general area of the proposed wind farm.

Figure 7.4.2: Sightings of basking shark in the north eastern Irish Sea during May 2001 reported to the Solway Shark Watch & Sea Mammal Survey[196]

[179] Keith Kendall, pers. comm
[180] Ian Russell, pers. comm
[181] West Galloway Fisheries Trust, unpubl.).
[182] Ian Russell, pers. comm
[183] Keith Kendall pers. comm
[184] Moore, A. & Potter, E.C.E. (1994). The movements of sea trout (*Salmo trutta* L.) through the estuary of the Rive Avon, Southern England. Fisheries Management & Ecology. 1: 1-14.
[185] Moore, A., Ives, M., Scott, M. & Bamber, S. (1998). The migratory behaviour of wild sea trout (*Salmo trutta* L.) smolts in the estuary of the River Conwy, North Wales. Aquaculture. 168: 57-68.
[186] Aprahamian, M. W. & Robson, C.F. (1996). Chapter 5.8 Fish: salmon, sea trout and eels. In: Coasts and Seas of the United Kingdom. Region 13 Northern Irish Sea: Colwyn Bay to Stranraer, includig the Isle of Man, ed.s J.H. Barne, C.F. Robson, S.S. Kaznowska, J.P. Doody & N.C. Davidson, 125-127. Joint Nature Conservation Committee; Peterborough.
[187] Jamie Ribbens, pers. comm
[188] Environment Agency (2000). North West Fisheries Annual Report 2000. 2000 Annual Report on Fisheries in the North West. Environmental Agency; Warrington.
[189] Solway Firth Partnership. (1996). Solway Firth Review. June 1996. Solway Firth Partnership.
[190] Environment Agency (2000). North West Fisheries Annual Report 2000. 2000 Annual Report on Fisheries in the North West. Environmental Agency; Warrington.
[191] Moore, A. & Potter, E.C.E. (1994). The movements of sea trout (*Salmo trutta* L.) through the estuary of the Rive Avon, Southern England. Fisheries Management & Ecology. 1: 1-14.
[192] Keith Kendall, pers. comm
[193] Moore, A., Ives, M., Scott, M. & Bamber, S. (1998). The migratory behaviour of wild sea trout (*Salmo trutta* L.) smolts in the estuary of the River Conwy, North Wales. Aquaculture. 168: 57-68.
[194] Hammond, N & Lewis, M. (2002) Unpublished Data. Solway Shark Watch and Sea Mammal Survey.
[195] CMACS. (1998). Records of Basking Sharks *Cetorhinus maximus* in the North Eastern Irish Sea.
[196] Hammond, N & Lewis, M. (2002) Unpublished Data. Solway Shark Watch and Sea Mammal Survey.



The basking shark, as a protected species, is considered to be of **high** sensitivity.

7.4.7.18 Rays

Rays, and the thornback ray (*Raja clavata*) in particular, are targeted by commercial fishing vessels in the Irish Sea and the Solway Firth, particularly in the spring and early summer when the females aggregate on areas of rough ground to lay their eggs ("mermaids' purses") and possibly to mate. The adults arrive in the Allonby Bay area during early spring (Feb/March)[197] but no information exists on which routes taken. The females will lay approximately 20 mermaids purse eggs inshore from March through to August. The eggs will hatch 4-5 months later with the juveniles occupying the shallow inshore waters for a number of months before moving into deeper water. Hence the area close to the wind farm is likely to be used for most of the year by electroreceptive fish of different life stages.

The stingray (*Dasyatis pastinaca*) is also found occasionally in shallow water mud/sand environments around much of the UK.

It is noteworthy that over the past few decades, elasmobranch species in general have suffered dramatic reductions in their numbers due to unregulated fishing and habitat degradation[198]. Life history constraints mean that elasmobranch populations cannot recruit individuals fast enough to replace those lost to fishing and pollution. Nationally, there are a number of anecdotal accounts from the sea fishing industry of rapid declines in stocks of rays and there are several investigations currently underway into the possible causes of these declines[199].

Ray and skate populations, represented by the most common species, the thornback ray, are considered to be of **high** sensitivity due to their breeding population in the area, overall population declines and susceptibility to electrical fields. Other electrosensitive species (sharks and dogfish) would not be expected to use the Robin Rigg area nor to be as common or susceptible to electrical fields (being more pelagic) as the rays.

7.5 MARINE MAMMALS

7.5.1 INTRODUCTION

Marine mammals present in UK waters comprise cetaceans (whales and dolphins), pinnipeds (true seals, eared seals and walrus) and sea otter.

The order cetacea is divided into two sub-orders; the mysticetes and the odontocetes. The mysticetes, or baleen whales, are large oceanic whales that have adapted to the use of low-frequency sounds to communicate over long distances. Members of this sub-order include the long-finned pilot whale (*Globicephala melas*) and the humpback whale (*Megaptera novaengliae*).

The odontocete or toothed whales is the sub-order to which the dolphin and porpoise belong. These animals are generally much smaller than the mysticetes and have adapted the use of very high frequency sounds such as echolocation in communication, orientation and feeding. Odontocete cetaceans are generally more common in shallow coastal waters.

Of the marine mammal groups, cetaceans and pinnipeds and found within the general area of the proposed development, and thus are considered below. The European otter (*Lutra lutra*) is also found in the Solway Firth, however, this species rarely ventures out of near-shore waters, and thus, it is very unlikely that otters would be seen in the area of the proposed development. For this reason, otters are not considered any further.

7.5.2 DATA AVAILABILITY AND INFORMATION SOURCES USED

The northern Irish Sea and the Solway Firth are not rich areas for marine mammals compared with other areas of Britain. Indeed, the SCANS project, an International investigation co-ordinated by the Sea Mammal Research Unit (SMRU) to estimate small cetacean abundance in the North Sea and waters around the UK in 1994, did not survey the northern Irish Sea due to the fact that numbers are considered so low. As a result of this, there is very little quantitative data as to the population sizes for cetaceans that do visit the Irish Sea. A similar picture exists for pinniped numbers in the Irish Sea.

Some qualitative, rather than quantitative data does exist for the general area of the northeastern Irish Sea in the form of Sightings databases. Data from sightings programs is inevitably difficult to interpret, but does provide a good indication of the species that are present in, or visit an area.

Sightings in the Solway Firth and general northeastern Irish Sea are generally reported to the Solway Shark Watch and Sea Mammal Survey (SSW&SMS). This sightings program holds data between 1938 and 2002

[197] Lancaster, unpubl.
[198] Camhi, M., Fowler, S., Musick, J., Bräutigam, A. and Fordham, S. (1998) Sharks and their relatives. Ecology and Conservation, IUCN/SSC Occassional Paper
[199] *Shark Trus (2002). Website of the UK Shark Trust (http://ds.dial.pipex.com/sharktrust/index.shtml)*

with the majority of data relating to the last few years[200]. However, this database is only in a 'working-format' at this time, and the information it can provide is therefore limited. Data is available, however, for the species that are sighted more commonly. This data has been considered together with Sea Watch Foundation 'abundance' plots for the northern Irish Sea.

7.5.3 SPECIES RECORDED AND THEIR CONSERVATION STATUS

The cetacean and pinniped species recorded in the Solway Firth and regional northern Irish Sea, and their conservation status, are given below.

7.5.3.1 Cetaceans

Fifteen species of cetaceans have been recorded since 1975 in nearshore waters of the Irish Sea (within 60 km of the coast)[201]. These include the following six species that are either present throughout the year or recorded annually as seasonal visitors:

Odontocetes

- harbour porpoise *Phocoena phocoena*
- bottlenose dolphin *Tursiops truncatus*
- common dolphin *Delphinus delphis*
- Risso's dolphin *Grampus griseus*

Mysticetes

- long-finned pilot whale *Globicephala melas*
- minke whale *Balaenoptera acutorostrata*

Other cetacean species that have been recorded only casually in the region include:

Odontocetes

- northern bottlenose whale *Hyperoodon ampullatus*,
- Sowerby's beaked whale *Mesoplodon bidens*,
- white-beaked dolphin *Lagenorhynchus albirostris*,
- Atlantic white-sided dolphin *Lagenorhynchus acutus*,
- striped dolphin *Stenella coeruleoalba*, and
- killer whale *Orcinus orca*

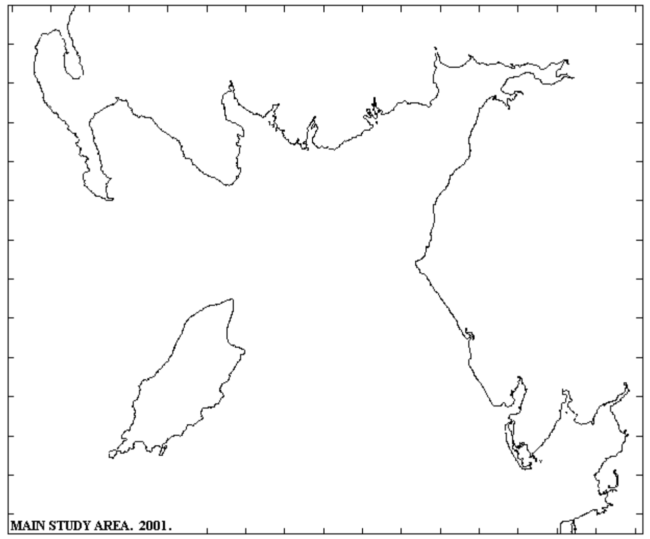
[200] Hammond, N & Lewis, M. (2002) Unpublished Data. Solway Shark Watch and Sea Mammal Survey.
[201] Evans, P.G.H. (1998b) Biology of cetaceans of the north-east Atlantic (in relation to seismic energy). In: Tasker, M.L. ; Weir, C., (eds.) Proceedings of the Seismic and Marine Mammal Workshop, London, 23-25 June 1998.

Mysticetes

- fin whale *Balaenoptera physalus*,
- sei whale *Balaenoptera borealis*,
- sperm whale *Physeter macrocephalus*,

Of the species listed above, the harbour porpoise and bottlenose dolphin (odontocete cetaceans) are most commonly observed in the Study Area of the Solway Shark Watch & Sea Mammal Survey (Figure 7.5.1).

Figure 7.5.1: Study Area of the Solway Shark Watch & Sea Mammal Survey[202]



In UK waters, protection is given to all cetaceans species through Section 9 of the Wildlife and Countryside Act 1981, which prohibits the deliberate killing, injuring or disturbance of any cetacean and Article 12 of the EC Habitats Directive (92/43/EEC), implemented by The Conservation (Natural Habitats, etc.) Regulations 1994. The UK is also a signatory to the Agreement on the Conservation of Small Cetaceans of the Baltic and North Seas and has applied its provisions in all UK waters. These include the requirement that the signatories "*work towards....the prevention of...disturbance, especially of an acoustic nature*". The National and International legislation affecting the most commonly observed odontocetes and mysticetes in the Solway Firth is given in Table 7.5.1 below.

7.5.3.2 Pinnipeds

Two species of seal (pinnipeds) are found along the coast of the Solway; the common/harbour seal (*Phoca vitulina*) and the grey seal *(Halichoerus grypus)*.

The common and grey seals are protected under Annex II of the E.C. Habitats Directive (1992/43/EEC) and the UK's Conservation of Seals Act (1970). The Conservation of Seals Act provides for a close season during which it is an offence to take or kill any seal except under licence. The close season for grey seals is 1 September to 31 December inclusive and for common seals, 1 June to 31 August inclusive, coinciding with the pupping season. The act provides an exception, which makes it lawful to kill a seal to prevent it from

[202] Hammond, N & Lewis, M. (2002) Unpublished Data. Solway Shark Watch and Sea Mammal Survey

causing damage to a fishing net or tackle, or to any fish in the net, providing the seal is in the vicinity of the net or tackle at the time.

All whales, dolphins and seals found in UK waters are considered to be of **high sensitivity** due to the National and International protection afforded to each species.

Table 7.5.1: National and international Legislation affecting the most regularly observed Cetaceans in the Solway Firth/north eastern Irish Sea

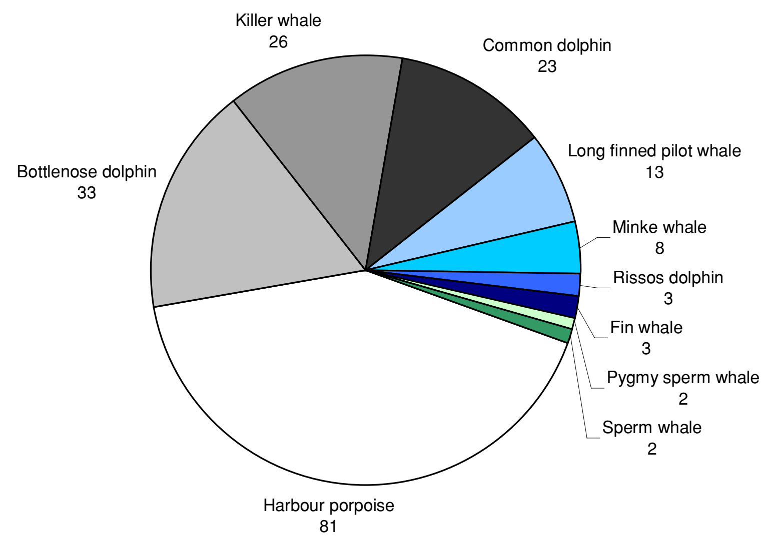
Legislation	Cetacean species			
	Odontocetes			Mysticete
	Harbour porpoise	Bottlenose dolphin	Common dolphin	Long-finned pilot whale
[203] BONN - Appendix II	●	●	●	●
[204] BERN - Appendix II	●	●	●	
[205] BERN - Appendix III				●
[206] Habitats Directive - (A. II)	●	●		
[207] Habitats Directive - (A. IV)	●	●	●	●
CITES [208]	●	●	●	●
ASCOBANS Agreement [209]	●	●	●	
Wildlife & Countryside Act [210]	●	●	●	●
IUCN Status [211]	*Unknown*	*Unknown*	*Unknown*	*Vulnerable*

7.5.4 DISTRIBUTION AND ECOLOGY OF CETACEANS (WHALES AND DOLPHINS)

Figure 7.5.2 below compares the numbers of groups or individuals of different cetacean species sighted in the Study Area of the SSW&SMS between August 2000 and August 2001. The harbour porpoise and bottlenose dolphin are by far the most commonly sighted. However, it should be noted that whilst Figure 7.5.2 describes cetaceans sighted in the SSW&SMS Study Area (NE Irish Sea), not all of these species are regularly seen in the shallow water of the Solway Firth. For examples, sightings of orca, fin and sperm whales are typically in the west of the SSW&SMS Study Area around the Mull of Galloway. These are, however, considered as they may enter the Solway Firth at times.

[203] Appendix II of CMS Agreement on the Conservation of Migratory Species of Wild Animals (BONN Convention, 1983)
[204] Appendix II of BERN Convention on the Conservation of European Wildlife and Natural Habitats
[205] Appendix II of BERN Convention on the Conservation of European Wildlife and Natural Habitats
[206] Annex II of the EU Habitats Directive (1992) (prohibiting all forms of deliberate capture, killing or disturbance, especially during breeding, rearing or migration; banning the keeping, sale, or exchange of such species; and requiring that member states monitor the incidental capture and killing of all cetaceans, and carries out research on conservation measures to prevent such accidents)
[207] Annex IV Animal and Plant Species of Community Interest in Need of Strict Protection of the EC Habitats Directive (1992)
[208] It is listed on List C1 of Council Regulation and, since 1985, has been treated by the European Community as if it is on CITES Appendix II (trade controlled to prevent overexploitation).
[209] The Agreement on the Conservation of Small Cetaceans in the Baltic and North Seas (ASCOBANS) (1992), applies.
[210] In the UK, it receives special protection in respect of particular methods of killing or taking under The Wildlife & Countryside Act (1981) and the Wildlife (Northern Ireland) Order (1985).
[211] Status listed by IUCN (1991) as insufficiently known

Figure 7.5.2: The frequency of sightings of cetacean species in the Solway Shark Watch and Sea Mammal Survey Area between August 2000 and August 2001[212]



The seasonal occurrence and ecology of the harbour porpoise, bottlenose and common dolphin in the north eastern Irish Sea are considered below. The long-finned pilot whale, an occasional visitor to the north eastern Irish Sea, has also been considered due to the fact that it is the most regularly observed mysticete whale in the Solway area and so it is considered so as to represent this group of cetaceans.

7.5.4.1 Harbour Porpoise (*Phocoena phocoena*)

The harbour porpoise, a small cetacean that feeds on a number of fish species including dab, flounder, sole, and cod, is widely distributed on the continental shelf in the eastern North Atlantic. Around the UK and Ireland it is the most commonly observed species, particularly along the south and west coasts of Ireland, Scottish waters and Northeast England. It is also the most common cetacean species recorded in the Solway Firth and the wider Irish Sea.

The results of the SCANS project calculated the harbour porpoise population of the North Sea (including the Baltic Sea) and UK waters at between 260,000-450,000 individuals[213]. Although the size of the northern Irish Sea population is unknown, the species is widely distributed throughout the Irish Sea, with clusters of sightings around the Isle of Man, off the Mull of Galloway and Solway Firth, and off the north coast of Anglesey and the Lleyn Peninsula in North Wales. The species appears to be resident throughout the year, although peak numbers are recorded between July and September. The Irish Sea is used both for feeding and breeding.

The occurrence and distribution of the harbour porpoise is classed as *'regular'* throughout the Irish Sea[214]. Eighty-one porpoise were sighted between August 2000 and August 2001 in the SSW&SMS Study Area

[212] Hammond, N & Lewis, M. (2002) Unpublished Data. Solway Shark Watch and Sea Mammal Survey.
[213] SMRU (2002a). Website of the Sea Mammal Research Unit. Small Cetaceans - Small cetacean abundance in the North Sea. Web site address: http://smub.st-and.ac.uk/small_cetaceans.htm
[214] Evans, P.G.H. (1998b) Biology of cetaceans of the north-east Atlantic (in relation to seismic energy). In: Tasker, M.L. ; Weir, C., (eds.) Proceedings of the Seismic and Marine Mammal Workshop, London, 23-25 June 1998.

which accounts for 41% of sightings of all species[215]. As shown in Figure 7.5.3, there were a large number of sightings made, particularly in the area of the Inner Solway, between Southerness Point and Silloth, several kilometres north west of the proposed development site. Sightings are recorded throughout the year, but largest numbers occur between May and September. This, however, this may correlate with the increased number of observers available outside of the winter months.

In particular, the area between Southerness Point and Silloth is thought to be used by porpoise for calving around September each year (see Figure 7.5.4). Certainly, dead porpoise calves are often found in the intertidal zone between Wokington and Silloth each year in September[216]. The significance of possibly porpoise breeding in the Solway Firth is unknown as there is little available information on the numbers and extent of areas used for breeding by small cetaceans. However, Evans[217] reports that harbour porpoise may regularly calve in nearshore waters.

Harbour porpoise are therefore, regularly observed in the Solway Firth, which suggests that this is an important location for the species, possibly both in terms of its food resources and as an area that provides shelter and security during breeding

Figure 7.5.3: All sightings of harbour porpoise reported to the Solway Shark Watch & Sea Mammal Survey between 2000 and 2001[218]

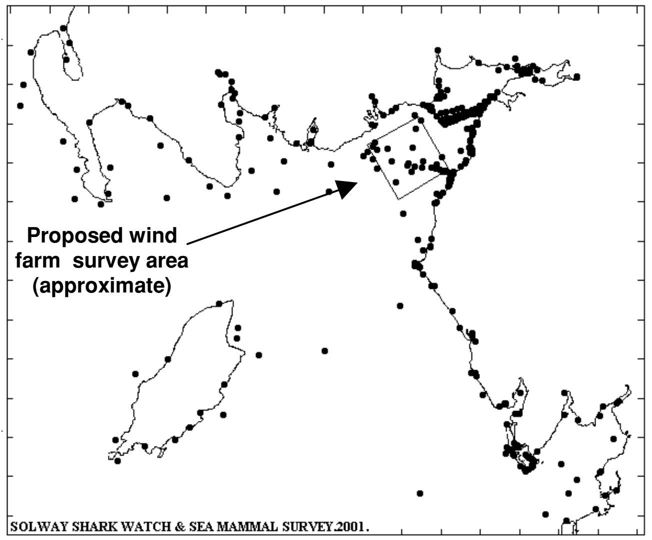
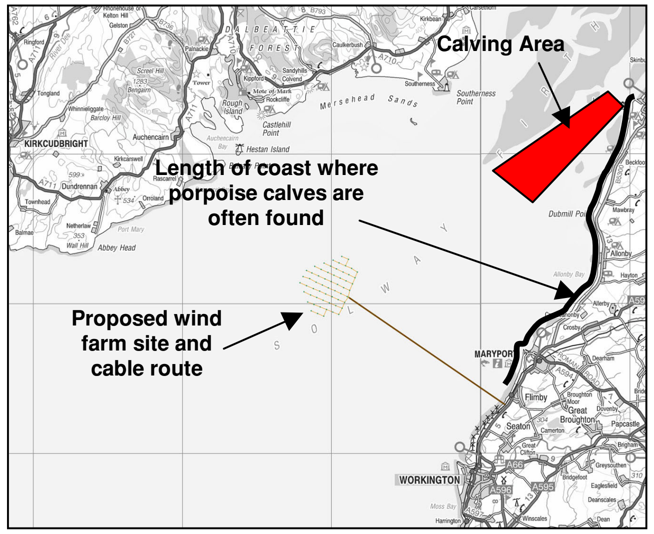


Figure 7.5.4: Possible porpoise calving area in the Solway Firth



7.5.4.2 Bottlenose Dolphin (*Tursiops truncatus*)

In the Irish Sea, bottlenose dolphins are seen in greatest abundance in and around Cardigan Bay, where a population of between one and three hundred occurs[219 220 221]. Although reported throughout the northern Irish Sea, the species is generally uncommon here, with clusters of sightings occurring along the north coast of Anglesey, the south and southwest coasts of the Isle of Man, and in Morecambe Bay. Their presence to the south west of the Isle of Man is classed as *'regular'*, whilst the area to the north east of the Isle of Man, including the Solway Firth is classed as *'occasional*[222]. However, this species represents the second most commonly sighted cetacean in the SSW&SMS Study Area comprising 17% of sightings between August 2001 and August 2001, which refers to 33 individuals sighted[223].

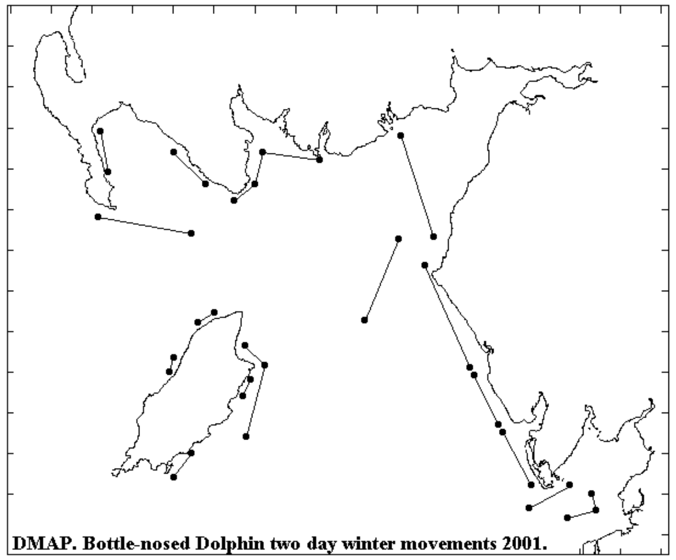
Bottlenose dolphins are seen in the northern Irish Sea during all months of the year, with most sightings in April and between July and September. Sightings are commonly of groups that vary between two and ten individuals including young. In the Solway Firth, bottlenose dolphins are only occasionally seen. When they are seen however, they are usually observed in large groups moving through the area over a period of a few days. One such sighting of groups of bottlenose dolphins moving up into the Solway Firth and out towards the Mull of Galloway is shown in Figure 7.5.5. This movement may describe a foraging migration from Cardigan Bay. This species feeds on a variety of benthic and pelagic fish including eels, flounder, dab, sole, salmon and trout, all of which are found in the Solway Firth.

In the context of the wider Irish Sea and British waters, the numbers of bottlenose dolphins present in the Solway Firth are of minor importance, established resident populations being located in Cardigan Bay and the Moray Firth.

215 Hammond, N & Lewis, M. (2002) Unpublished Data. Solway Shark Watch and Sea Mammal Survey.
216 Hammond, N & Lewis, M. (2002) Unpublished Data. Solway Shark Watch and Sea Mammal Survey.
217 Evans, P.G.H. (1998b) Biology of cetaceans of the north-east Atlantic (in relation to seismic energy). In: Tasker, M.L. ; Weir, C., (eds.) Proceedings of the Seismic and Marine Mammal Workshop, London, 23-25 June 1998.
218 Hammond, N & Lewis, M. (2002) Unpublished Data. Solway Shark Watch and Sea Mammal Survey.

219 Lewis, E.J. (1992) *Social cohesion and residency of bottle-nosed dolphins (Tursiops truncatus) in west Wales. An analysis of photographic data*. BSc Thesis, University of Leeds. 31pp.
220 Arnold, H., Bartels, B., Wilson, B., and Thompson, P. (1997) *The bottlenose dolphins of Cardigan Bay: Selected biographies of individual bottlenose dolphins recorded in Cardigan Bay, Wales*. Report to Countryside Council for Wales. CCW Science Report No. 209.
221 Sea Watch, unpublished data. Sea Watch Foundation, Oxford University.
222 Evans, P.G.H. (1998b) Biology of cetaceans of the north-east Atlantic (in relation to seismic energy). In: Tasker, M.L. ; Weir, C., (eds.) Proceedings of the Seismic and Marine Mammal Workshop, London, 23-25 June 1998.
223 Hammond, N & Lewis, M. (2002) Unpublished Data. Solway Shark Watch and Sea Mammal Survey.

Figure 7.5.5: Sightings of bottlenose dolphins over a two-day period reported to the Solway Shark Watch & Sea Mammal Survey[224]



7.5.4.3 Common Dolphin (*Delphinus delphis)*

The common dolphin is found mainly in deeper waters from the Iberian Peninsula north to west Scotland. In the northern Irish Sea, common dolphins have been recorded over a wide area with no particular locality apparently being preferred. Their presence is classed as *'regular'* to the south west of the Isle of Man and *'scarce/casual'* for the north east of the Isle of Man and Liverpool Bay[225] [226]. This corresponds with the SSW&SMS records in which the common dolphin was only sighted 23 times between August 200 and August 2001[227].

Most sightings in the Irish Sea occur between June and September, with group sizes numbering usually between one and twenty animals and occasionally up to fifty individuals or more are seen. As with the bottlenoses dolphin, there is no data as to the number of individuals found in the northern Irish Sea or UK in general. However, in the context of the wider Irish Sea and British waters, the numbers of common dolphins present in the Solway Firth are of minor importance, this species being more common to the west of Scotland and Ireland and the south west of England.

The diet of this species includes a wide variety of fish and squid of which pelagic fish species are most common. This species include blue whiting, mackerel, poor cod, hake, sardine, anchovy, silvery pout, scad, hake, and whiting, the majority of which are not found in high numbers in the Solway Firth.

224 Hammond, N & Lewis, M. (2002) Unpublished Data. Solway Shark Watch and Sea Mammal Survey.
225 Evans, P.G.H. (1998a) Distribution of harbour porpoise (*Phocoena phocoena*). In: United Kingdom Digital Marine Atlas (UKDMAP), Third Edition July 1998. Natural Environment Research Council.
226 Evans, P.G.H. (1998b) Biology of cetaceans of the north-east Atlantic (in relation to seismic energy). In: Tasker, M.L. ; Weir, C., (eds.) Proceedings of the Seismic and Marine Mammal Workshop, London, 23-25 June 1998.
227 Hammond, N & Lewis, M. (2002) Unpublished Data. Solway Shark Watch and Sea Mammal Survey.

7.5.4.4 Long-finned Pilot Whale (*Globicephala melas*)

The long-finned pilot whale is the most commonly recorded mysticete whale within the SSW&SMS Study Area. It is common and widely distributed in deep North Atlantic waters, but seasonally enters coastal areas such as the Faroes, northern Scotland, western Ireland and the south-west Channel Approaches. In the northern Irish Sea, the long-finned pilot whale is reported mainly from the vicinity of the Isle of Man where it occurs more or less annually in small numbers. The nearest sightings to the Solway Firth are from Morecambe Bay.

Sightings surveys in the eastern North Atlantic in the late 1980's[228] estimate the population at 778,000. However, between August 2000 and August 2001, only thirteen individuals (groups of individuals) were recorded within the SWS&SMS Study Area. This follows its distribution classification for the eastern Irish Sea of *'casual/absent'*[229], and thus, the Solway Firth does not appear to be an important area for this species in comparison to its distribution around Scotland, the west of Ireland and south west of England.

7.5.5 THE DISTRIBUTION AND ECOLOGY OF PINNIPEDS (SEALS)

Two species of seal occur along the coasts of the Irish Sea; the common/harbour seal (*Phoca vitulina*) and the grey seal *(Halichoerus grypus)*. Both are present in relatively low numbers in the Irish Sea and do not make an important contribution to overall UK populations[230].

7.5.5.1 Common Seal (*Phoca vitulina*)

Britain holds approximately 5% of the world population of common seals and about 40% of the European sub-species *Phoca vitulina vitulina*. Distribution of the common seal in the Irish Sea is mainly along the coasts of Ireland and Scotland, however, small numbers are also seen at various sites in Morecambe Bay, along the Cumbrian Coasts and around the Calf of Man at the southern tip of the Isle of Man. Small numbers are also recorded in the Solway Firth where they haul out of the water onto sandbanks and mudflats. There are no records of common seals breeding in the Solway Firth.

The Sea Mammal Research Unit (SMRU), which surveys common seal numbers on a five-year basis around the UK, surveyed the Solway Firth in 1992 and 1996 (Table 7.5.2). The number of common seals recorded within the general area of the Solway Firth is very low, with some eight individuals recorded in 1992 and six individuals in 1996. These surveys are carried out by thermal imaging from helicopter in August when seals haul out of the water for extended periods to moult. Of course, some individuals may be in the water at the time of the survey, but studies around Orkney, the Moray Firth and the Wadden Sea suggest that August counts represent between 60 and 70% of the total population present in the area[231].

228 Buckland, S.T., Bloch, D., Cattanach, K.L., Gunnlaugsson, T., Hoydal, K., Lens, S., and Sigurjónsson, J. (1993) Distribution and abundance of long-finned pilot whales in the North Atlantic, estimated from NASS-87 and NASS-89 data. *Rep. Int. Whal. Commn*, (special issue 14), 33-49.
229 Evans, P.G.H. (1998b) Biology of cetaceans of the north-east Atlantic (in relation to seismic energy). In: Tasker, M.L. ; Weir, C., (eds.) Proceedings of the Seismic and Marine Mammal Workshop, London, 23-25 June 1998.
230 Duck, C.D. (1996). 5.14 Seals In: Coasts and Seas of the United Kingdom - Region 13, Norethern Irish Sea Colwyn Bay to Sranraer including the Isle of Man Eds: Barnes, J.H, Robson, C.F, Kaznowska, S.S, Doody, J.P, Davidson, N.C. Joint Nature Conservation Committee, Peterborough.
231 SMRU (2002b). Website of the Sea Mammal Research Unit. Seals in Great Britain. Web site address: http://smub.st-and.ac.uk/seals_in_gb.htm

Duck (1996)[232] reports that the total number of seals present in the Irish Sea was less than 1% of the British total and only six sightings of common seals were reported to the Solway Shark Watch & Sea Mammal Survey (SSW&SMS) between August 2000 and August 2001[233]. The Solway Firth is therefore not an important location for common seals.

Table 7.5.2: Sea Mammal Research Unit (SMRU) Seal Survey Data: August 1992 and 1996

Species	Year	Location (with National Grid Refs.)	Number
Common Seal (*Phoca vitulina*)	1992	Inner Solway (308300558700)	1
		Mull of Galloway (196700750400)	7
	1996	Outer Solway (270700543500)	1
		Mull of Galloway (196700573500)	5
Grey seal	1992	Mull of Galloway (195900564000)	4
(Halichoerus grypus)	1996	Mull of Galloway (197000571600)	2
		Luce Bay (225800533200)	5
		Luce Bay (226200545200)	32
		Inner Solway (301300550000)	36

7.5.5.2 Grey Seal (*Halichoerus grypus*)

The grey seal is the more abundant of the two species found around the UK. Approximately 40% of the world population breeds at sites in Britain between August and December. The main breeding sites are in the Inner and Outer Hebrides, Orkney, the mainland coast of the far north and north-east of Scotland, the Isle of May, south-west Wales, the Farne Islands and Shetland (SMRU, 2002b). The majority of these pupping sites are surveyed annually by SMRU during the seals autumn breeding season using conventional aerial photography. These sites collectively produce over 85% of the pups born in Great Britain.

Grey seals were surveyed concurrently with common seals in the Solway Firth by SMRU in 1992 and 1996. Only four seals were recorded in 1992 (see Table 7.5.2). However, in 1996 two groups of 32 and 36 individuals were recorded in Luce Bay and on the sandbank between Southerness Point and Beckfoot respectively.

It should be noted however, that the numbers of grey seals that use the Solway Firth may be much greater. Certainly, Hammond (pers. comm.) reports that up to 300 seals were reported on the sandbank between Southerness Point and Beckfoot around the same time as the 1996 SMRU survey took place, 356 individuals were reported between August 2000-2001[234] and there have been an increasing number of complaints to the Cumbrian Sea Fisheries Committee regarding grey seal bulls attacking fishing nets[235].

However, the size of the Irish Sea population is considered insignificant compared to the British population of over 110,000 animals[236].

[232] Duck, C.D. (1996). 5.14 Seals In: Coasts and Seas of the United Kingdom - Region 13, Northern Irish Sea Colwyn Bay to Sranraer including the Isle of Man Eds: Barnes, J.H, Robson, C.F, Kaznowska, S.S, Doody, J.P, Davidson, N.C. Joint Nature Conservation Committee, Peterborough.
[233] Hammond, N & Lewis, M. (2002) Unpublished Data. Solway Shark Watch and Sea Mammal Survey.
[234] Hammond, N & Lewis, M. (2002) Unpublished Data. Solway Shark Watch and Sea Mammal Survey.
[235] Dobbson, D. Cumbrian Sea Fisheries Committee. Personal communication
[236] Duck, C.D. (1996). 5.14 Seals In: Coasts and Seas of the United Kingdom - Region 13, Northern Irish Sea Colwyn Bay to Sranraer including the Isle of Man Eds: Barnes, J.H, Robson, C.F, Kaznowska, S.S, Doody, J.P, Davidson, N.C. Joint Nature Conservation Committee, Peterborough.

7.5.6 FORAGING BEHAVIOUR OF THE COMMON AND GREY SEAL

There is no information available as to specific areas where seals forage within the Solway Firth. However, seal tracking studies by the SMRU has shown that seals may forage over a very large area, particularly grey seals. In a recent study of seal movements and foraging behaviour in the general area of the proposed Rødsand wind farm in Denmark, the average home range (the area in which a seal regularly forages for food) was established as 3,980km^2 for grey seals and 215km^2 for common seals[237]. Thus, grey seals that haul out on the sandbanks in the Solway Firth may forage throughout the whole area between the Solway Firth and the northern tip of the Isle of Man.

Both grey and common seals are opportunistic hunters that feed on a variety of fish and invertebrates. Prey items include small flat fish and gadoids (cod and whiting) and invertebrates such as squid and octopus.

7.6 ORNITHOLOGICAL BASELINE STUDY

7.6.1 INTRODUCTION

This study was commissioned to Dr. Steve Percival by Natural Power Consultants Ltd to undertake an assessment of the potential ornithological impacts of a proposed offshore wind farm in the Solway Firth. The work sought to evaluate whether the proposed wind farm may have any adverse effects on the ornithological nature conservation interests of this area, and determine whether any such effects may be significant.

The aims of the ornithological assessment are as follows:

1. To establish the importance of the proposed wind farm area and its surrounds for birds, including breeding, migratory and wintering populations;
2. To predict the potential ornithological impacts of the construction, operation and de-commissioning of the wind farm and predict the significance of the impact;
3. To develop mitigation measures to reduce potential ornithological impacts;
4. To assess the residual impacts following mitigation and the significance of these.

The potential for cumulative effects will form a component of the assessment where appropriate (to be determined through discussions with consultees).

This Section gives the results of the first part of the assessment, i.e. a description and assessment of the importance of the use of the wind farm area and its environs for breeding, migratory and over-wintering populations. The remaining three components of the assessment are presented in Section 9.8 of this ES.

[237] Dietz, R; Teilmann, J; Henricksen, O.D.; Laidre, K. (2001) Satellite tracking as a tool to study potential effects of offshore wind farms on seals at Rødsand - Technical Report. Ministry of the Environment and Energy, Denmark (*in english*) pp.43.

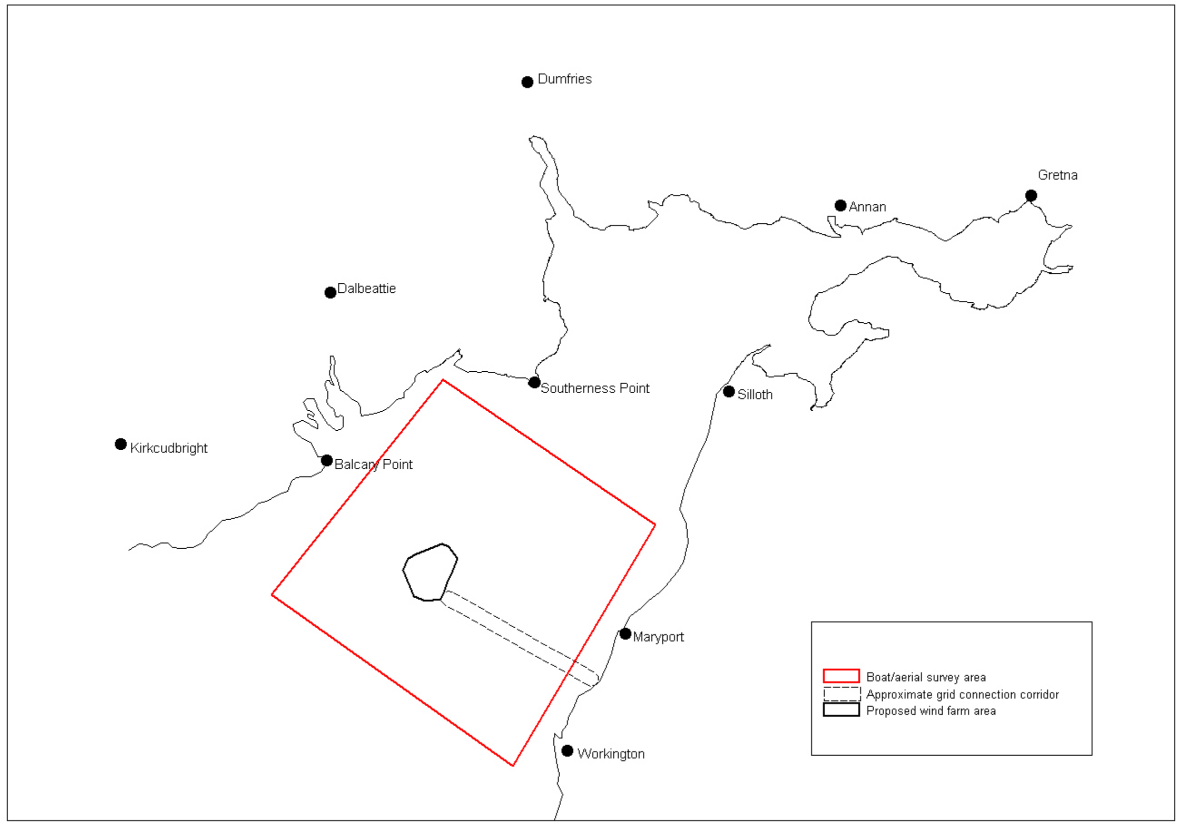
7.6.1.2 Definition of the Study Area

The main study area for this assessment was defined to include all the areas that could possibly be affected by the proposed offshore wind farm, and an additional zone around this to investigate the importance of the proposed wind farm site in relation to the region as a whole. For the field studies, this buffer zone included at least 5km around the possible wind farm locations that were being considered at the start of the study.

The location of the main study area is shown in Figure 7.6.1, which also shows the proposed location of the wind farm and the approximate route that the grid connection cable will follow.

The area surrounding the main study has also been considered in this assessment, in order to out that study area into a wider context and ensure that all possible impacts are assessed. All the important ornithological sites in the Solway Firth have all been considered, including all the statutory and non-statutory nature conservation designations of ornithological importance. The terrestrial habitat that could be affected by the development, including the grid connection cable route, has also been included.

Figure 7.6.1 – Study area and proposed wind farm location



7.6.1.3 Description of the Proposal

The proposed wind farm location is shown in Figure 7.6.1. The development will include 60 turbines an offshore substation platform, two anemometer masts, and undersea cabling between turbines and the substation and between the substation and the shore. Details of the development are given in Section 4 of this ES. The area in which the turbines will be sited covers 10.3 km^2.

The grid connection will be made to the south-east of the wind farm in England. The approximate corridor through which this will pass to its landfall is shown in Figure 7.6.1. The cable will be trenched and drilled into the seabed, then it will run underground when it reaches the shore to the grid connection point.

7.6.1.4 Consultations

Consultations have been undertaken with a range of statutory and non-statutory environmental bodies, including Scottish Natural Heritage (SNH), English Nature (EN), the Royal Society for the Protection of Birds (RSPB) and the Cumbria Wildlife Trust (CWT). Regular meetings of a focus group have been and are continuing to be held to discuss ornithological and other ecological issues.

7.6.1.5 Field Studies

The details of the field study methodology are described fully below. A comprehensive year-round programme of field bird surveys has been undertaken, which has provided a detailed picture of how bird populations are using the proposed wind farm area and its surrounds (up to 5km from the proposed wind farm site). This has included boat-based surveys twice per month and four supplementary aerial surveys.

7.6.1.6 Supplementary Data

Further data have been obtained from RSPB, the Cumbria Bird Club, the Solway Review, the Wetland Bird Survey, the JNCC Seabird Colony Register and the JNCC Seabirds at Sea Atlas (and any other relevant sources) to supplement the field survey data, in particular to explore longer-term trends and for conditions where marine survey is not possible (e.g. high winds).

7.6.1.7 Integration and Analysis of Data on Birds' Ecological Resources

As part of the environmental statement, a study of the birds and the ecological resources that they use has been undertaken. Analyses of the marine ecological survey data are being carried out, in order to better understand the ecological resource that the proposed wind farm area provides, and to determine how it is affected by the development. The aim is to understand the factors affecting the key bird species' distributions in the area, including substrate type and prey distribution (using survey data from the benthic and trawl surveys). This enables potential effects to be more fully evaluated, and any effects of the proposed wind farm to be more fully determined.

7.6.1.8 Impact Assessment

The information collected and evaluated during the determination of the baseline ornithological status of the study area has been used as the basis for identifying and predicting potential ornithological impacts associated with the proposed development. The full range of impacts has been assessed, including direct, indirect and secondary impacts, both temporary and long term and adverse and beneficial. The level of significance of any identified impacts has been addressed, across all phases of the project lifecycle. The assessment methodology follows that developed specifically for bird impacts on wind farms by the British Wind Energy Association (BWEA) and SNH.

The available information on the impacts of existing offshore (and relevant onshore) has been collated to update knowledge on the effects of wind farm developments on coastal birds.

Once the potential environmental impacts were evaluated, feasible and cost-effective measures to prevent significant adverse impacts or reduce them to acceptable levels (should they be likely to occur), and enhance the significant positive benefits are being developed where possible, with the results feeding back into the project design.

7.6.2 DESK STUDY

7.6.2.1 Designated Nature Conservation Areas (Ornithology)

There are numerous important bird areas in the region that are protected though a variety of both statutory and non-statutory designations. Those designations are shown in Figure 7.6.2, and the details of the important species that they support are given in Table 7.6.1. The locations of the other main nature conservation sites in the region are shown in Figure 7.6.3.

Figure 7.6.2 International/national Designations

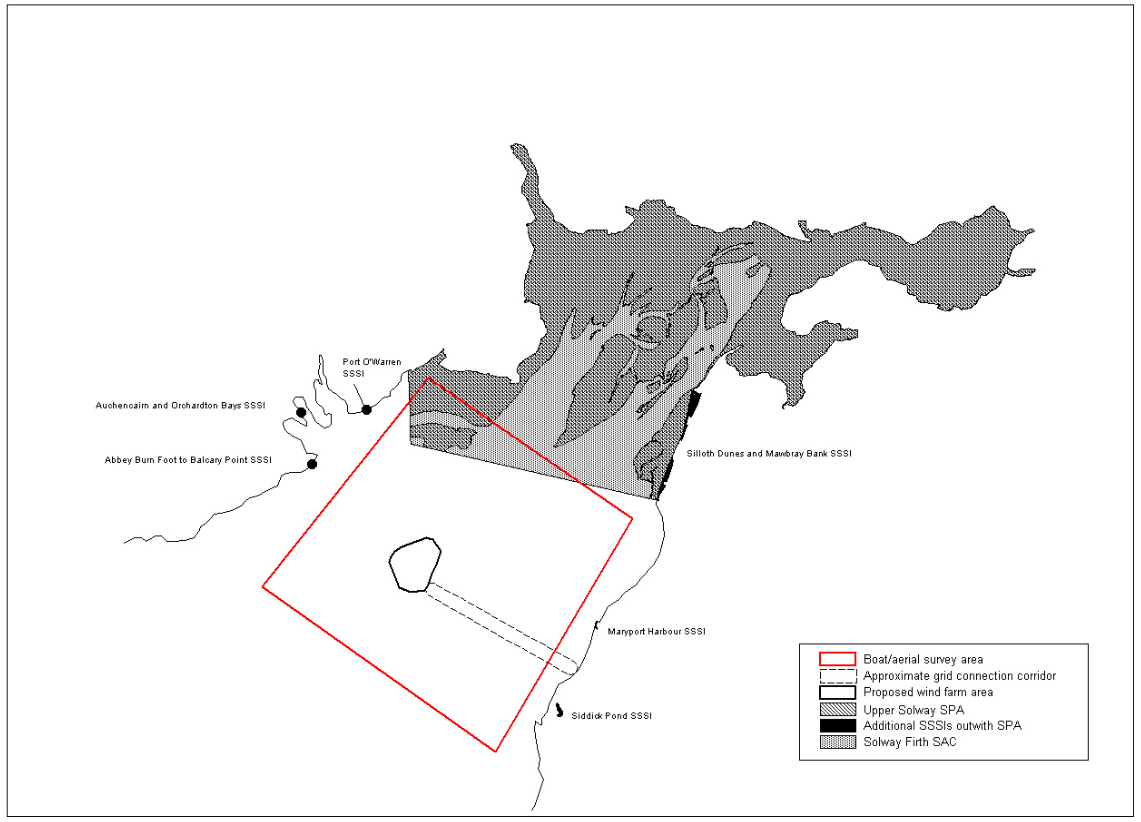


Figure 7.6.3 Other conservation sites

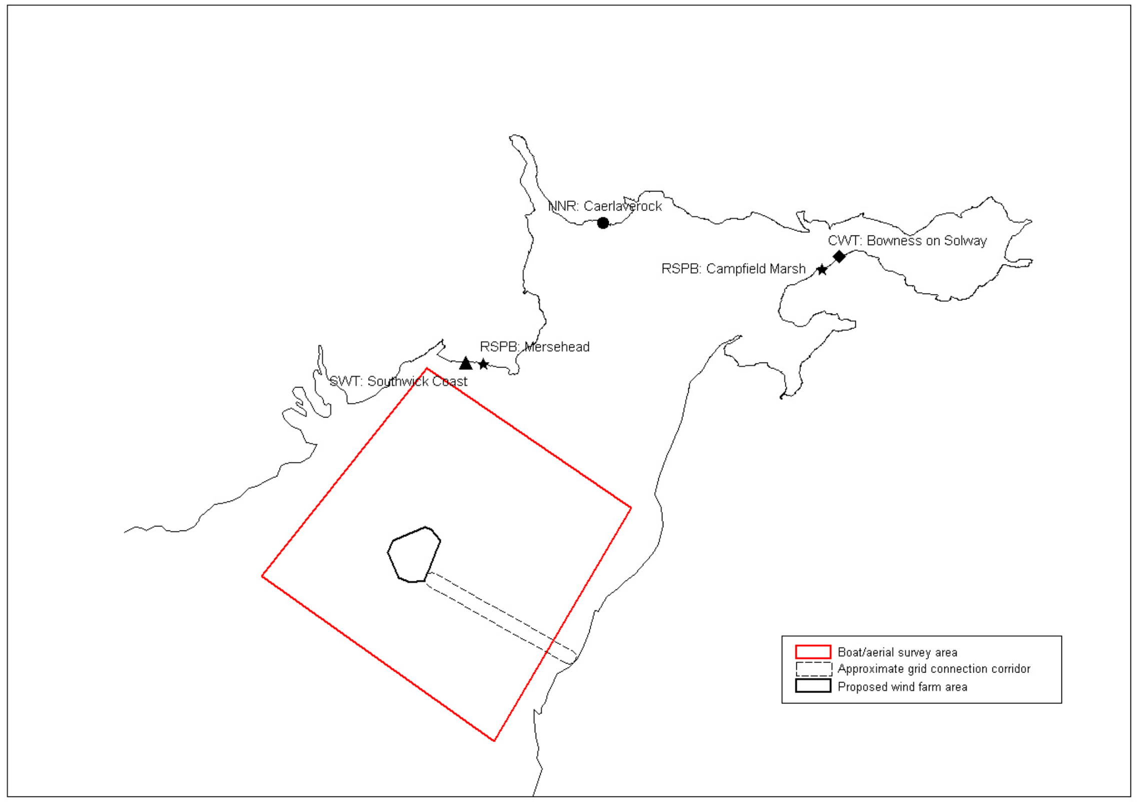


Table 7.6.1 Coastal protected sites of ornithological importance within the study area.

Site	Status	Distance from wind farm (km)	Area (ha)	Main conservation interest
Upper Solway Flats and Marshes	SPA, RAMSAR, SSSI	6.4 at closest point extending to 38 km at furtherst point	28,053 (SPA); 29,951 (SSSI/ RAMSAR)	Internationally important numbers of 11 wintering waterfowl species (whooper swan, pink-footed goose, barnacle goose, shelduck, pintail, oystercatcher, knot, dunlin, bar-tailed godwit, curlew and redshank); nationally important numbers of 8 further wintering waterfowl species (inc. scaup).
Caerlaverock (part of Upper Solway Flats and Marshes).	BIO, NNR, WWT (contained within SPA)	25	5,469 (BIO), 7,706 (NNR), 726 (WWT)	Saltmarshes, mudflats, netral grasslands, reedbeds and freshwater marsh. Key site for wintering barnacle geese and whooper swans.
Rockliffe Marshes (part of Upper Solway flats and Marshes)	SPA, SSSI, CWT (contained within SPA)	38	1,897, 1120 (CWT)	Internationally important numbers of nine wintering waterfowl species; nationally important numbers of six further wintering waterfowl species
Maryport Harbour	SSSI	12 (2.7km from grid connection route)	4	Small area of saltmarsh and mudflats
Port O'Warren	SSSI	10	6	Breeding birds
Auchencairn and Orchardton Bays	SSSI	9.6	179	Saltmarsh, mudflats.
Abbey Burn Foot to Balcary Point	SSSI	8.5	186	Coastal habitats, flowering plants, seabirds.
Mersehead (part of Upper Solway flats and Marshes)	RSPB (contained within SPA)	6.4	743	Saltmarsh and other wetland habitats. Breeding and wintering birds.
Campfield Marsh (part of Upper Solway flats and Marshes)	RSPB (contained within SPA)	34	221	Saltmarsh, breeding and wintering birds.
Bowness-on-Solway (part of Upper Solway flats and Marshes)	CWT (contained within SPA)	36	6	Saltmarsh

***Key**:to Table 7.6.1*

International Statutory Designation:

- SPA/pSPA is a site designated under the EU Birds Directive to protect rare/vulnerable species and regularly occurring migratory birds.

National Statutory Designations:

- SSSI (Site of Special Scientific Interest) - sites protected under the Wildlife and Countryside Act, 1981 and subsequent amendments as of national nature conservation or geological importance.
- LNR- local nature reserves - established by local authorities (under Section 21 of the National Parks and Access to the Countryside Act 1949), to protect natural features of special interest to the local area.

Other designations/protected areas:

- Ramsar Site - designated under the Ramsar Convention to protect internationally important wetlands. All in the UK are also SSSIs and most are SPAs.
- NNR - declared under the National Parks and Access to the Countryside Act (1949) or Wildlife and Countryside Act (1981). They are owned or leased by the statutory conservation agencies and managed to benefit wildlife and their habitats.
- BIO – designated to promote the understanding of the changes affecting the environment and man's influence on them. They are an international designation made by UNESCO and form part of a world-wide chain of protected sites.
- CWT/SWT – Cumbria/Scottish Wildlife Trust reserves - established to promote non-statutory nature conservation at a local level.
- RSPB – reserve managed by RSPB for its bird populations.
- WWT – Wildfowl and Wetlands trust reserve

Site	Status	Distance from wind farm (km)	Area (ha)	Main conservation interest
Southwick Coast	SWT	12	3	Saltmarsh
Siddick Pond	SSSI	13 (2.3km from grid connection route)		
Silloth Dunes and Mawbray Bank	SSSI	16	188	Sand dunes, dune heath, flowering plants, natterjack toads.

7.6.2.2 Information Available for Desk Study

JNCC Coastal Directories Project

The Coastal Directories Project was established by JNCC, as a national project to compile all the available information to produce a comprehensive description of the coastal margin, its habitats, species and human activities. The publication relevant to this study is Region 13, the Northern Irish Sea from Colwyn Bay to Stranrae[238]. This provides a detailed description of the areas and species of nature conservation interest within the region, and all the relevant conservation designations.

The Solway Review

The Solway Review was produced by the Solway Firth Partnership to document the information available on the current state of resource use throughout the Solway Firth. It includes comprehensive sections on the marine environment, coastal and intertidal habitats, sub-tidal habitats and communities, fish and bird populations and the current conservation designations in the area[239].

JNCC Seabirds At Sea Team Surveys/ Atlases

In 1979 the then Nature Conservancy Council started a research programme on Seabirds at Sea. This was designed primarily to survey Britain's inshore and offshore waters, to identify areas of particular importance to seabirds. Numerous reports have been produced during the project (which is still ongoing as the Offshore Animals branch of JNCC) but those of particular relevance to this study are Webb *et al.* (1990)[240], Webb *et al.* (1995)[241] and Stone *et al.* (1995)[242]. Supplementary information for inshore waters has been taken from the most recently published results from the national waterfowl monitoring scheme (Wetlands Birds Survey, WeBS) counts[243].

Breeding Seabirds

All of Britain's seabird colonies are monitored regularly as part of JNCC's Seabird Colony register. This work was initiated as Operation Seafarer in 1969-70[244], and has been updated on annual basis since 1984. Lloyd *et al*. produced the most recently published summary in 1991.

Wintering/passage waterfowl

The wintering and passage waterfowl populations in the Solway have been counted regularly as part of the national Wetland Bird Survey (WeBS) since the 1960s. Data on the key species in the region (i.e. those present in nationally/internationally important numbers) are presented below, as the standard 5-year mean peak counts for 1995/96-1999/2000 (the five most recent years' data available[245]).

These data are particularly relevant to the assessment of the grid connection cable. The data for the relevant count sector through which this passes have been obtained from WWT and are presented below.

RSPB Data from Mersehead Reserve

Dave Fairlamb, site manager for the RSPB reserve at Mersehead has kindly extracted data from his reserve records relevant to this assessment. These data include high tide waterfowl counts from 2000/01 and 2001/02, low tide waterfowl counts from 2000/01 and 2001/02, and additional offshore bird records extracted from the reserve log.

These data are very useful to provide a comparison of land-based counts with the numbers recorded during the boat and aerial surveys. Though the land-based counts do not cover the extent of the wind farm area, they do provide additional information on bird numbers in the area generally, including in weather conditions when it is not possible to carry out boat/aerial surveys. These data also provide information on the bird numbers on the nearest area of extensive inter-tidal area to the proposed wind farm site.

Seabird Data from Cumbria Bird Club

Peter Ullrich of the Cumbria Bird Club has been observing seabirds in and around the proposed wind farm site over a number of years. Sea trips were made up to 4 times per year from 1990 through to 2001 (15 trips in total), and all notable bird records were noted (including numbers and location). All visits were made between May and September. These data enabled the results from the detailed monitoring carried out in 2001/02 to be put into a longer-term context. The data were used particularly to determine whether the numbers and distribution of seabirds showed any major differences between years.

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238 Barne, J.H., Robson, C.F., Kaznowska, S.S., Doody, J.P. and Davidson, N.C., *eds*. 1996. *Coasts and seas of the United Kingdom. Region 13 Northern Irish Sea: Colwyn Bay to Stranraer, including the Isle of Man*. Peterborough, Joint Nature Conservation Committee.
239 Solway Firth Partnership. 1996. Solway Firth Review.
240 Webb, A., Harrison, N.M., Leaper, G.M., Steele, R.D., Tasker, M.L. and Pienkowski, M.W. 1990. *Seabird distribution west of Britain*. Peterborough, Nature Conservancy Council.
241 Webb, A., Stronach, A., Tasker, M.L. and Stone, C.J. 1995. *Vulnerable concentrations of seabirds south and west of Britain*. Peterborough, Nature Conservancy Council.
242 Stone, C.J., Webb, A., Barton, C., Ratcliffe, N., Reed, T.C., Tasker, M.L., Camphuysen, C.J. and Pienkowski, M.W. 1995. *An atlas of seabird distribution in north-east European water*. Peterborough, Joint Nature Conservation Committee.
243 Musgrove, A., Pollitt, M., Hall, C., Hearn, R., Holloway, S., Marshall, P., Robinson, J. and Cranswick, P. 2001. *The Wetland Bird Survey 1999-2000 Wildfowl and Wader Counts*. BTO/WWT/RSPB/JNCC, Slimbridge.
244 Cramp, S., Bourne, W.R.P. and Saunders, D. 1974. *The Seabirds of Britain and Ireland*. Collins, London.
245 Musgrove, A., Pollitt, M., Hall, C., Hearn, R., Holloway, S., Marshall, P., Robinson, J. and Cranswick, P. 2001. *The Wetland Bird Survey 1999-2000 Wildfowl and Wader Counts*. BTO/WWT/RSPB/JNCC, Slimbridge.

7.6.2.3 Breeding Seabird Populations

The nationally and regionally important seabird breeding colonies in the study area is shown in Table 7.6.2 (no seabird species breeds in this area in internationally important numbers). All data are derived from the Seabird Colony Register[246] or more recent information, if available. Their locations are shown on Figure 7.6.4.

Figure 7.6.4 Seabird colonies

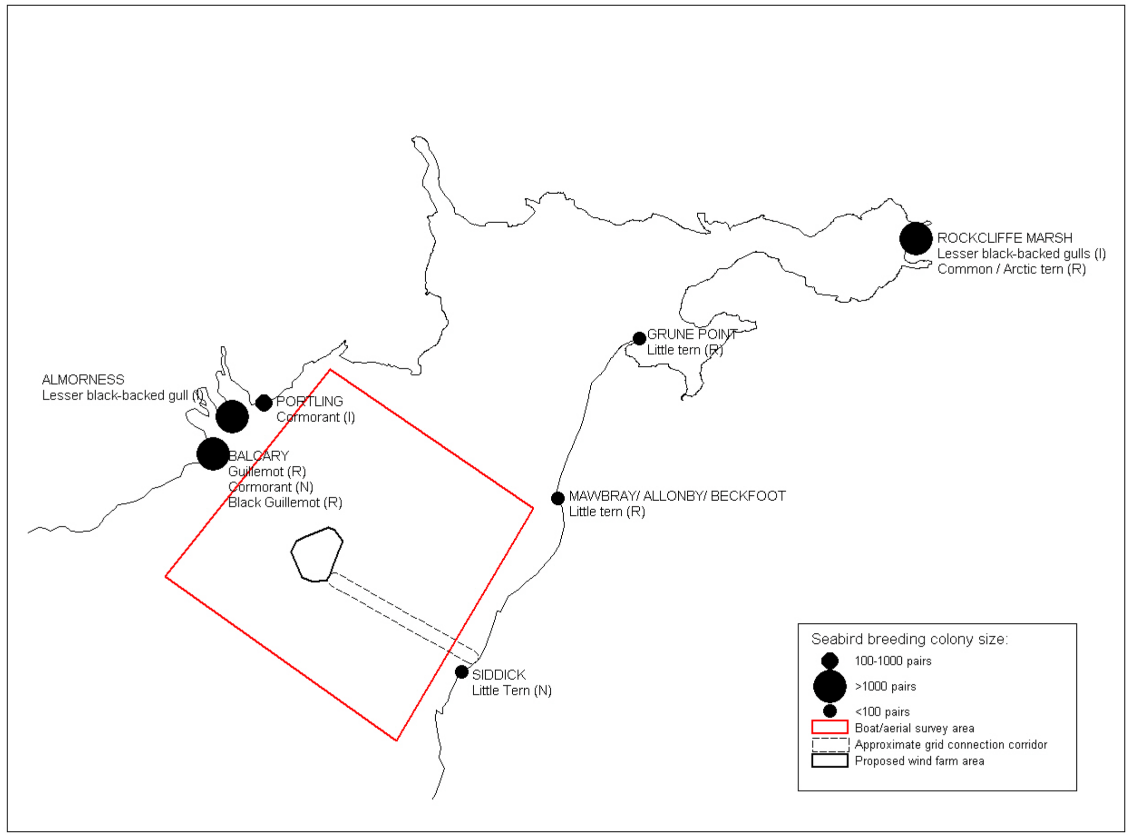


Table 7.6.2. Seabird breeding colonies in the study area (nationally/ regionally important numbers)

Species	Colony	Number of breeding pairs
Little tern	Siddick (adjacent to existing wind farm)	30 pairs N (1)
Lesser black-backed gull	Rockcliffe Marsh	7,644 pairs I
Common/arctic tern	Rockcliffe Marsh	62 pairs R
Cormorant	Portling	192 pairs I
Lesser black-backed gull	Almorness	1,500 pairs I
Guillemot	Balcary	1,000 pairs R
Cormorant	Balcary	140 pairs N
Black Guillemot	Balcary	6 pairs R
Little Tern	Grune Point	< 10 pairs R
Little Tern	Mawbray/ Allonby/ Beckfoot	< 10 pairs R

Key: *I = numbers of international importance, N = nationally important numbers, R = regionally important numbers, where importance has been defined as >1% of resource at each scale.*
(1) This population has declined in more recent years, with no birds at all breeding in 2001 (Source: John Callion, Cumbria Bird Club).

7.6.2.4 Offshore Seabird Densities

Table 3 shows the densities of seabirds counted offshore by the Seabirds at Sea team. These are based on both aerial and ship-based surveys reported in Webb *et al.* (1990)[247] and Stone *et al.* (1995)[248]. Where these reports differ in the densities given, the higher has been used here in preference. Additional counts of seabirds in inshore waters counted by the WeBS scheme have also been noted where appropriate.

246 Lloyd, C., Tasker, M.L. and Partridge, K. 1991. *The status of seabirds in Britain and Ireland*. T. and A.D. Poyser, London.

247 Webb, A., Harrison, N.M., Leaper, G.M., Steele, R.D., Tasker, M.L. and Pienkowski, M.W. 1990. *Seabird distribution west of Britain*. Peterborough, Nature Conservancy Council.

248 Stone, C.J., Webb, A., Barton, C., Ratcliffe, N., Reed, T.C., Tasker, M.L., Camphuysen, C.J. and Pienkowski, M.W. 1995. *An atlas of seabird distribution in north-east European water*. Peterborough, Joint Nature Conservation Committee.

Table 7.6.3: Densities of seabirds within and around the study area, from the JNCC seabirds at sea Atlas and the Wetland Bird Survey[249]

Species	Density (no per km^2)	Period / comment
Divers	0.1 – 0.49	March – April (most likely to be red throated or great northern)
Fulmar	0.01 – 0.99	March – April, August – November
Manx Shearwater	0.01 – 0.99	September – October
Gannet	0.01 – 0.99	May – October
Cormorant	0.1 – 0.99	All year. 588 [N] winter peak WeBS count
Scaup	0	5,400 [I] winter peak WeBS count (Quinn *et al.* 1993) Inner Solway is most important area in Britain: principal area around Nith estuary.
Common Scoter	0.01 – 0.99	January – April. 5,000 [N] winter peak WeBS count.
	1 – 4.99	July – September.
Eider	0.01 – 0.99	May – September
Herring Gull	0.01 – 0.99	July – February
Great Black-backed Gull	0.01 – 0.99	August – October
Kittiwake	1 – 1.99	April – May
	0.01 – 0.99	August –March
Guillemot	0.01 – 0.99	August
	1.0 – 1.99	November- February

Key: *[I] = internationally important numbers, [N] = nationally important numbers, where importance has been defined as >1% of resource at each scale.*

7.6.2.5 Wetland Bird Survey (WeBS) Data

The results of the Solway Estuary WeBS counts are summarised in Table 7.6.4. In line with standard assessment practice[250] these have been presented as average peak counts for the most recent 5 years for which data were available. The importance of those populations has been determined using the standard 1% criterion, using the threshold values given in Musgrove *et al.* (2001)[251].

249 Musgrove, A., Pollitt, M., Hall, C., Hearn, R., Holloway, S., Marshall, P., Robinson, J. and Cranswick, P. 2001. *The Wetland Bird Survey 1999-2000 Wildfowl and Wader Counts*. BTO/WWT/RSPB/JNCC, Slimbridge.

250 Musgrove, A., Pollitt, M., Hall, C., Hearn, R., Holloway, S., Marshall, P., Robinson, J. and Cranswick, P. 2001. *The Wetland Bird Survey 1999-2000 Wildfowl and Wader Counts*. BTO/WWT/RSPB/JNCC, Slimbridge.

251 Musgrove, A., Pollitt, M., Hall, C., Hearn, R., Holloway, S., Marshall, P., Robinson, J. and Cranswick, P. 2001. *The Wetland Bird Survey 1999-2000 Wildfowl and Wader Counts*. BTO/WWT/RSPB/JNCC, Slimbridge.

Table 7.6.4: Waterfowl counts for the Solway Estuary, from the WeBS monitoring scheme (Musgrove et al. 2001). All species occurring in nationally (N) or internationally (I) important numbers are given.

Species	5-year mean peak count 95/6-99/00	GB threshold for national importance	Threshold for international important	Importance (N=national, I=international)
Red-throated diver	51	50	750	N
Great crested grebe	324	100	1500	N
Cormorant	564	130	1200	N
Whooper swan	240	55	160	I
Pink-footed goose	14045	2250	2250	I
Barnacle goose	23471	120	120	I
Shelduck	3486	750	3000	I
Mallard	2083	5000	20000	R
Pintail	3610	280	600	I
Scaup	2970	110	3100	N
Common scoter	5000	275	16000	N
Goldeneye	175	170	3000	N
Red-breasted merganser	109	100	1250	N
Oystercatcher	38399	3600	9000	I
Ringed plover	388	290	500	N
Golden plover	5719	2500	18000	N
Grey plover	1055	430	1500	N
Lapwing	9616	20000	20000	R
Knot	8521	2900	3500	I
Sanderling	237	230	1000	N
Dunlin	15266	2000	14000	I
Black-tailed godwit	108	70	700	N
Bar-tailed godwit	2524	530	1000	I
Curlew	5258	1200	3500	I
Redshank	3509	1100	1500	I
Lesser black-backed gull	697	500	4500	N
Herring gull	4854	4500	13000	N

Key: *[I] = numbers of international importance, [N] = nationally important numbers, [R] = regionally important numbers, where importance has been defined as >1% of resource at each scale.*

Data for the estuarine area through which the grid connection route passes are summarised in Table 7.6.5. No species is found in this sector in internationally or nationally important numbers, but ten do occur in regionally important numbers. These birds use a wide area of mudflats for feeding but roost on the beach adjacent to and within the Siddick wind farm[252].

252 John Callion and Percival, unpublished data

Table 7.6.5: Five-year mean annual peak counts of waders 1995/6 – 1999/2000 from the Wetland Bird Survey count sector through which the grid connection cable will pass (Outer Solway: Workington to Flimby sector).

Species	Mean peak count	Species	Mean peak count
Oystercatcher [R]	854	Ringed Plover [R]	92
Grey Plover	24	Golden Plover [R]	820
Lapwing [R]	820	Sanderling [R]	198
Knot [R]	105	Dunlin	159
Curlew [R]	466	Whimbrel	1
Black-tailed Godwit	<1	Bar-tailed Godwit [R]	235
Purple Sandpiper	11	Common Sandpiper	<1
Redshank [R]	152	Turnstone [R]	176

Key: *R = regionally important numbers; no species in internationally or nationally important numbers, where importance has been defined as >1% of resource at each scale.*

7.6.2.6 RSPB Mersehead

The RSPB Mersehead high tide waterfowl counts are included in full in Appendix F1 in the separate volume of appendices. These birds roost on the RSPB reserve at high tide and forage mainly over the adjacent inter-tidal areas at low tide. The main ornithological interest is the wintering wader populations, notably oystercatcher (peak 6,600, nationally important), and curlew (peak 920, regionally important).

The RSPB Mersehead low tide waterfowl counts are included in full in Appendix F2. These further illustrate the importance of the inter-tidal area of Mersehead Sands, particularly for oystercatcher. Numbers were generally similar in 2000/01 and 2001/02. In terms of species that may extend their distribution offshore, two species, great crested grebe and scaup, were recorded in nationally important numbers during these land-based counts.

Additional information on seabirds and other important species that may over-fly the wind farm site are included in Appendix [x]. The key points are summarised here:

- Divers: predominantly red-throated (no black-throated seen, and 2 great northerns in 2001 were the first record for the reserve), peak count (106) reached national importance.
- Great crested grebe: wintering population reached national importance, peak 194.
- Manx shearwater: small numbers recorded during May-September, peak 54. Mainly noted during strong westerly winds.
- Gannet: regularly seen during May-September. Generally in small numbers, but with occasional much larger peaks. Peak count of 480 passing in an hour in June 2000 was during strong south-westerly wind.
- Cormorant: seen in regionally important numbers (peak 68 in autumn).
- Scaup: nationally important numbers seen offshore (peak 360).
- Common [Black] scoter: records from April through to December but mostly in May/June, with peak numbers seen in June 2001 (1,050).
- Skuas: only occasional records of arctic, great and pomarine.
- Kittiwake: occasional records only (May-September) but sometimes in large numbers. Exceptional total of 744 flew past in an hour in strong south-westerly winds on 23 June 2000, daily peak 860.
- Sandwich tern: reserve used mainly as a post-breeding site, peak 220 in August.
- Guillemot and razorbill: only very small numbers recorded.

7.6.2.7 Cumbria Bird Club seabirds at sea data

The raw data supplied by Peter Ullrich from his trips out by boat into the Outer Solway are included in full in Appendix F3 in the separate olume of appendices. The key points are summarised below:

- Red-throated diver: seen regularly across the area, peak 50. Single black-throated record.
- Manx shearwater: up to 70 seen regularly, mainly July-August.
- Storm petrel: small numbers (peak 30) seen regularly during July and August 5-10km off St Bee's Head and, on one date, on the southern edge of the Solway Offshore study area.
- Gannet: up to 50 regularly seen, numbers highest in May.
- Common scoter: only small numbers encountered (peak 20).
- Skuas: occasional records of small numbers (max. 5) of arctic, great and pomarine.
- Kittiwake: frequently seen.
- Sandwich tern: only small numbers seen (peak 10), May-September.
- Common/arctic tern: few records, but 50 seen in May 2001.
- Guillemot and razobill: generally small numbers, though hundreds seen in September 1993.

7.6.2.8 Bird Migration Routes

No bird migration routes have been specifically documented in the region. Any concentrations, if they occur at all, are likely to be close inshore, well away from the proposed wind farm site. Migration over the sea is more likely to occur over broad front[253], which would mean that the risk of collision between birds and the turbines would be negligible.

The Upper Solway SPA holds over 100,000 wintering/passage waterfowl, including several internationally important populations. These birds will make migratory movements into and out from the SPA each year, though again there are no features to concentrate these birds through the wind farm.

Seabird movements are more likely to occur regularly through the wind farm site. The RSPB data above suggest that such movements may be particularly frequent in strong westerly/south-westerly winds.

In order to quantify the rates of bird movement through the study area, all bird flights during field surveys have been recorded (see field studies below).

[253] Alerstam, T. 1990. *Bird Migration*. Cambridge University Press, Cambridge.

7.6.2.9 Conclusions of Desk Study

It is clear from the desk study that the main bird interest in the region lies further up the estuary in the Upper Solway Flats and Marshes SPA. This area holds a range of internationally and nationally important bird populations, and is protected by a range of international and national designations. The SPA lies 6.4km from the proposed wind farm at its nearest point.

There are a number of nationally and regionally important breeding seabird colonies in the region, and it is likely that at least some of these species may use the wind farm area for foraging.

The JNCC Seabirds at Sea data provided an initial indication of the likely importance of the general area around the wind farm for seabirds. These showed that most species were only found in this area at low density, and no major concentrations were reported. This conclusion is further supported by seabirds at sea data from the Cumbria Bird Club.

Numbers of some seabirds may be higher in certain weather conditions. In particular RSPB at Mersehead have recorded higher numbers of gannets and kittiwakes in stronger westerly or southwesterly winds.

Though the available data were useful in providing an indication of the likely bird interest in the wind farm area, it was clear that field surveys would be required to quantify the bird populations using this area more fully. The desk study, and consultations made through the focus group meetings, also suggested that the bird interest could be potentially year-round, so these field studies would need to cover a 12-month period. The field studies provided the data to determine better the numbers that might be affected by the proposal, and provided a more detailed baseline that could be used in the wind farm site design process, to ensure that any important concentrations of birds were avoided. Due to necessary timing of submission of the Statement and the Section 36 application, this baseline study includes only data collected in field surveys between May 2001 and April 2002. However, the data from the May 2002 survey will be reported in a supplementary report following analysis later in the summer.

7.6.3 FIELD STUDIES

7.6.3.1 Overview of overall strategy/aims

The main aim of this work was to determine the distribution and abundance of seabirds using the Solway offshore wind farm site and its surrounds. The survey methods need to be suited to all of the main bird groups that are being surveyed, so a combination of boat-based and aerial surveys was used. Standard methodologies were used, following Komdeur *et al*. 1992[254], though these were tailored to suit the local surveying conditions, and recent methodological improvements that have been developed were also be incorporated. In particular the spatial resolution of the data collection were more precise than these standard survey techniques. The study area included the 8 x 8 km area in which the wind farm could have been located, plus an area 5km around this. The total area was 380km^2 with the wind farm area comprising 10.3km^2 of this. Following design of the wind farm layout, the data has been analysed to give figures for populations lying within the wind farm area itself as well as the wider study area (see 7.6.5.2 later).

[254] Komdeur, J., Bertelsen, J. and Cracknell, G. 1992. *Manual for Aeroplane and Ship Surveys of Waterfowl and Seabirds*. IWRB Special Publication No 19: 37pp. NERI, Kalø, Denmark.

7.6.3.2 Methods

Boat-based surveys

The survey vessel used for the boat surveys was a Fisheries Protection Vessel (16m length, 18 tonne displacement). This vessel provided an excellent viewing platform and had the combination of speed (to be able to survey across the range of tidal conditions) and the ability to operate in relatively shallow water. Its viewing platform gives a 4m viewing height above the sea surface. Though this was slightly below the JNCC recommended 5m, it gave a very suitable viewing platform, especially when taking into account the site constraints on a larger boat (which would not have been able to navigate the sandbanks that run through much of the study area). The maximum wind force for observations was reduced from force 5 to force 4 to further ensure that viewing conditions were optimal and were not compromised by the slightly lower viewing height.

The survey route was designed to provide a 2 km interval between transects; a total of 10 transects were surveyed, each of about 18km length. This separation distance was chosen to ensure that a good sample of the study area was covered for all species, whilst minimising the likelihood that birds may be displaced from one transect to the adjacent one (and hence double-counted).

Two surveys were completed each month from May 2001 (with the exception of May and October 2001 when only one survey was completed). The same route was used for all the surveys, though restricted hours of daylight, weather and tidal conditions meant that it was not always possible to cover the whole survey area in a single day. Where complete surveys were not possible the second survey each month was designed to ensure that the whole study area was covered at least once per month and that the potential wind farm area twice per month whenever possible. A GPS record of the precise route was taken on each trip, so that the location at all times was known.

The observation team included Clive Hartley and Dave Shackleton, who were both involved in observation and recording. The team are experienced ornithologists, well able to identify all the species encountered accurately. Both observers also had a good knowledge of the area and its ornithological interests.

All birds encountered, their behaviour, flight height and approximate distance from the boat were recorded. Following the JNCC Seabirds at Sea recommendations, birds were recorded into five distance bands (0-50m, 50-100m, 100-200m, 200-300m and 300+m). Birds were recorded continuously, at a steady speed of approximately 12 knots, with the precise time of each observation recorded where possible to give as accurate a position as possible (linking to the GPS position information being recorded simultaneously). A range-finder was used to estimate distances of the birds from the ship. All records of birds observed flying as well as those on the sea were recorded.

Surveys were carried out twice-monthly for a full year (though poor weather activity conditions have meant that one scheduled surveys during May and one during October were not carried out). Alternate surveys covered the high tide and the low tide periods. This baseline assessment presents the results of the first 22 surveys carried out between 10 May 2001 and 25 April 2002 , with a total of 2,045 kms surveyed whilst on transect . The remaining surveys from May and June 2002 will be reported in a supplementary report following analysis later in the summer.

Aerial Surveys

These were needed primarily to verify the distribution and abundance of seaduck (particularly common scoter) in the study area, but were also used to collect additional information on other species encountered as well (particularly in areas too shallow to reach at certain states of the tide). Methods for surveying common scoter have been refined since the publication of Komdeur *et al.* (1992)[255], so the precise methodology followed that developed the National Environmental Research Institute in Denmark[256], who have a large amount of experience surveying birds by air and specifically collecting such data for the assessment of offshore wind farms.

Flights were conducted at 80m altitude cruising at approximately 185 km.h-1, and transect lines were 2 km apart. Transects were routed on a north-south line to allow for observations to be made on both sides of the plane even in bright sunlight (minimising possible effects of glare). Two surveyors were used on each survey, so that numbers could be recorded up to 500m each side of the transect lines simultaneously. All the survey paths were recorded using a GPS. The plane used for the aerial surveys was twin-engined (for safety reasons) and was high-winged to allow unobstructed views.

The aerial survey work started in November 2001, with further surveys through the winter and spring at monthly intervals when weather conditions permitted. Further surveys have been undertaken in December 2001 and March and April 2002 (though the data from the last visit are not yet available).

7.6.4 ADDITIONAL ECOLOGICAL/ENVIRONMENTAL DATA

Additional data have been collated in order to characterise the ecological conditions and resource availability in the wind farm area, and to compare it with other parts of the study area. The main question addressed here was to determine how important a resource the wind farm area provides; this provided essential information to facilitate the determination of the magnitude of disturbance impacts on birds. If any birds were displaced, this would enable the ecological consequences of that displacement to be better understood. This information is also useful to inform the longer-term aspects of the possible impacts. A single year's data inevitably provide only a snapshot of the birds' distribution, but the ecological conditions on the wind farm site and its surrounds can provide an insight into the resources available to the birds and their likely longer-term patterns of site use.

Data on bird food availability

The study area holds two main bird feeding resources, benthic invertebrates living in and on the seabed, and marine fish populations. In terms of the key bird species found in the study area (i.e those occurring regularly in nationally important numbers), one of these, common scoter, is a benthic feeder, and the other, divers (predominatly red-throated) is a fish-feeder.

(a) Common scoter

Common scoter diet has been studied mainly through the examination of gut contents of shot birds. They feed primarily on bivalves, including *Macoma balthica*, *Cardium edule, Mytilus edulis, Mya arenaria, Spisula subtruncata, Cyprina islandica, Donax vittatus, Tellina tenuis* and *Venus corallina*. They will also feed on gastropod molluscs, crustaceans (isopods, amphipods and small crabs), annelids and echinoderms (all generally typical of sandy substrates), but bivalves typically predominate in their diet. They are not thought to be particularly selective amongst bivalves, with the species composition usually reflecting the more common species in the benthos.

Specific work was commissioned as part of the ornithological impact assessment to quantify the distribution and abundance of potential scoter food resources. The bird surveys indicated that scoter distribution was mainly restricted to the north-western part of the study area, with few recorded in the proposed wind farm area (see below). The aim of this part of the study was therefore to compare the benthic invertebrates, particularly bivalves, found on the site of the proposed wind farm with the adjacent area to the north west of the site (see Figure 7.2.1 earlier in this ES), which has been shown to be important for common scoter. The information produced by this survey was used to determine whether the food sources available to the common scoter in their preferred feeding areas are also available in the wind farm site and therefore identify the potential value of the proposed wind farm site as a food resource for the scoter.

The survey was undertaken in March 2002, using the fishing vessel Joleto. As this survey only required data on the types of benthic invertebrates available to bird predators, i.e. in the top 10cm layers of sediment, a pipe dredge was used. This method was considered more suitable than a day grab for this particular survey as the pipe dredge takes a larger sample of sediment and is easier to operate. At each sampling station the depth and GPS position was recorded. When the pipe dredge was brought to the surface the volume of sediment it contained was recorded, prior to the sediment being sieved through a 0.5 mm sieve. All animals retained in the sieve were preserved in 10% a formaldehyde solution and returned to the laboratory for identification.

The survey revealed a large difference in the number and types of benthic invertebrates found in the samples taken on the proposed wind farm and in the areas used by the common scoter as feeding grounds. The benthic fauna of the area of the proposed wind farm (see Appendix D4, sampling stations 1-10 in the appendices volume) was impoverished and dominated by polychaete worms (particularly *Nephtys* species). The samples taken from the area important to the common scoter (see Appendix D4, sampling stations 11-40), conversely were dominated by bivalves (particularly *Nucula sulcata*). Thus it would appear clear that the area in which the scoter are mainly found holds a substantial food resource, but that the wind farm area supports very little, if any, food resources that they could exploit.

[255] Komdeur, J., Bertelsen, J. and Cracknell, G. 1992. *Manual for Aeroplane and Ship Surveys of Waterfowl and Seabirds*. IWRB Special Publication No 19: 37pp. NERI, Kalø, Denmark.
[256] Clausauger et al 2001.

(b) Divers:

Divers are generalist fish-feeders, taking a range of species including cod *Gadus morhua*, herrings *Clupea harengus* (van Damme 1968), and sprats *Sprattus sprattus*, gobies Gobiidae, sticklebacks *Gasterosteus* and *Spinachia*, sand-eels Ammodytidae, flounders *Platichthys*, coalfish *Pollachius virens*, and butterfish *Pholis gunellus*, These are usually taken as small few, but wih a few up to 25cm long[257]. The trawl surveys (see section 7.4.3 of this ES for further details) indicated that such species are widespread across the study area, reflecting the widespread and scattered distribution of the divers. Neither the wind farm nor any other part of the study area supports any particularly notable food resources for these species.

Sediment characteristics

The sediment charactereistics were noted at each of the benthic sampling stations, to provide additional information on the conditions in each area. There was a major difference in the sediment type found in the area used by the scoter compared with that in the proposed wind farm site. The sediment found in the samples taken from the proposed wind farm was made up of course sand, while the sediment in the common scoter areas were dominatged by rather muddier sand.

Weather data

Data on wind speed and direction have been examined to determine the typicalness of the year during which baseline data have been collected. In particular this aimed to determine the longer-term frequency of occurrence of higher collision risk conditions such as storms.

The general wind pattern in 2001-02 was similar to the long-term trends with respect to both direction and speed. There was a period of particularly strong winds in winter 2002 though the overall mean windspeed was very close to the long-term average.

7.6.5 EVALUATION OF BASELINE CONDITIONS

7.6.5.1 Methodology for evaluation

The principal method used to evaluate the conservation importance of the bird populations in the wind farm area and its surrounds was the standard 1% criterion[258]. The population was considered to be Internationally important if it exceeded 1% of the whole biogeographic population, Nationally important if it exceeded 1% of the GB populations. Threshold levels were taken from Musgrove *et al*. (2001)[259] and JNCC (1993).

Further categories of Regional and Local importance were used for species that did not reach national importance. The first of these was defined as more than 1% of the regional resource, whilst the latter included all species on the red or amber lists of the RSPB *et al*'s 'Birds of Conservation Concern' (1996)[260] that did not reach at least regional importance in the study area. As a comprehensive data set has been gathered, the mean counts have been used as the main basis for this evaluation (as the counts most representative of the overall use that the birds made of the site), though the peak counts have also been taken into account in this process.

The overall strategy in the presentation of the results was firstly to establish the bird populations present within the study area. These data were then used to identify the species present in important numbers, and for these, each of the following are presented:

- Count totals for each visit, to show their seasonality of occurrence and the variability in the counts.
- Map of the overall distribution within the study area.
- A plot of the species' distribution in relation to distance from wind farm. This includes the numbers in the proposed wind farm area itself, and in a range of buffer zones around this (500m to 5km). The rationale behind this was that the disturbance effect on the wind farm is likely to be different for different species, so a full range of distances has been presented.

In addition the rates of flight movement recorded through the study area are reported for each species. Flight height histograms showing the proportions of flights at rotor height are given for each of the key species, and for all the species overall. The frequencies of flights of all species at rotor height were then further examined, to determine the numbers at risk of collision.

7.6.5.2 Results

Boat-based Surveys

The mean (using data taking coverage and distance from transect into account) and the peak counts recorded in the study area as a whole and within the wind farm area are shown in Table 7.6.6. Birds for which full specific identification was not possible have been included to the species group. Where a range of species and an 'unidentified' component were used within a major group the overall total for that group is also given, e.g. for divers the birds identified to species are given, plus a 'diver sp.' category for the birds that could only be identified as divers.

[257] Cramp, S. 1998. Handbook of the Birds of Europe, the Middle East and North Africa. CD-ROM. Oxford University Press, Oxford.
[258] JNCC 1995. Guidelines for the selection of biological SSSIs. JNCC, Peterborough.
[259] Musgrove, A., Pollitt, M., Hall, C., Hearn, R., Holloway, S., Marshall, P., Robinson, J. and Cranswick, P. 2001. *The Wetland Bird Survey 1999-2000 Wildfowl and Wader Counts*. BTO/WWT/RSPB/JNCC, Slimbridge.
[260] Royal Society for the Protection of Birds, BirdLife International, British Trust for Ornithology, Game Conservancy Trust, Hawk and Owl Trust, National Trust, Wildfowl and Wetlands Trust and the Wildlife Trusts. 1996. Birds of Conservation Concern. RSPB, Sandy.

Table 7.6.6 Mean and peak bird counts in the wind farm and whole study area (source: Boat survey 2001/02) and the conservation importance of populations.

Species	Mean count:		Peak count:		Importance:	
	Wind farm	*Study area*	*Wind farm*	*Study area*	*Wind farm*	*Study area*
Red-throated Diver	0.1	29.3	2	83	L	N
Black-throated Diver		0.8		6		L
Great Northern Diver		2.4		16		L
Diver sp	2.2	52.4	5	128	L	N
TOTAL DIVERS	2.3	84.9	8	231	L	N
Great Crested Grebe	0.1	25.6	1	77		
Fulmar	0.1	2.6	1	16		
Manx Shearwater	3.0	35.7	39	404	L	R
Storm Petrel		4.5		37		R
Gannet	0.4	16.5	4	74	L	R
Cormorant	0.1	9.7	1	56		R
Cormorant/Shag		0.2		3		
Shelduck		*0.7*		*8*		
Teal		*0.1*		*1*		
Scaup		67.1		758		R/N
Common Scoter	0.8	3358.1	6	5880	L	N
Velvet Scoter		0.1		1		
Goldeneye		0.1		2		
Red-breasted Merganser		4.3		15		
Osprey		*0.1*		*2*		
Kestrel		*0.1*		*1*		
Oystercatcher		*1.0*		*8*		
Sanderling		*4.2*		*50*		
Dunlin		*9.0*		*50*		
Curlew		*0.5*		*6*		
Arctic Skua		0.7		7		
Great Skua		0.4		2		
Pomarine Skua		0.1		2		
Great/Pom Skua		0.3		2		
Little Gull		0.4		3		
Black-headed Gull	0.7	21.5	9	107		
Common Gull	1.1	85.1	9	236	L	L
Herring Gull	0.9	128.2	3	736	L	L
LBB Gull	0.2	9.7	3	44	L	L
Herring/LBB Gull		1.0		8		
GBB Gull	0.1	38.1	1	253		
Kittiwake	4.5	123.1	46	704	L	R
Gull sp	0.1	10.4	1	75		
Gull sp (large)		34.2		223		
TOTAL GULLS	7.7	451.6	73	2389		
Common/arctic Tern		2.7		32		L
Sandwich Tern		1.1		3		
Little Tern				7		
Tern sp	0.1	0.5	1	4		
TOTAL TERNS	0.1	4.3	1	46		L
Guillemot	7.9	326.9	39	2292	L	R
Razorbill	2.0	44.1	18	227	L	R
Puffin		1.1		10		
Auk sp	0.4	32.5	3	302		
TOTAL AUKS	10.4	404.7	61	2831		R
Skylark		*0.6*		*10*		
Meadow Pipit		*0.1*		*10*		
Pipit sp		*0.6*		*1*		
Pied Wagtail		*0.1*		*1*		
Swallow		*0.7*		*8*		

Note: species in italics are those seen flying over the study area only and not making any use of its ecological resources. N = nationally important numbers, R = regionally important, L = locally important.

The key species selected for detailed assessment were those determined to be present in the wider study area in at least regionally important numbers. These comprised: red-throated diver (and divers generally), Manx shearwater, storm petrel, gannet, cormorant, scaup, common scoter, kittiwake, guillemot and razorbill (and auks generally). Two of these, divers and common scoter, were present in the wider study area in numbers regularly exceeding national importance. The others reached only regional importance (apart from Scaup that reached national importance in two surveys). Each of these species is now considered in turn later.

Aerial Surveys

The numbers of birds counted during the November, December and March aerial surveys are shown in Table 7.6.7. They generally showed a similar pattern to the data from the boat-based counts (taking into account the time of year at which these surveys were undertaken), with very few birds at all recorded within the proposed wind farm area. None of the conclusions with regard to the conservation importance of the bird populations recorded within the study area differed from those reached from the boat-based survey data, and the distribution patterns recorded were also very similar.

Table 7.6.7 Bird counts in the proposed wind farm area and the whole study area recorded during the November, December and March aerial surveys. Note blank cells indicate a zero count.

Species	November 2001		December 2001		March 2002	
	Wind farm	*Study area*	*Wind farm*	*Study area*	*Wind farm*	*Study area*
Red-throated Diver			1	54		1
Great Northern Diver				2		
Diver sp		4	1	138		12
Great Crested Grebe				25		
Grebe sp				14		
Fulmar		9				
Cormorant		12		12		3
Scaup		290		492		43
Eider				5		55
Common Scoter		330		1039		329
Red-breasted Merganser				1		1
Duck sp				14		
Oystercatcher				77		
Black-headed Gull				7		
Common Gull		18		1		2
Herring Gull	3	58		148		32
Lesser Black-backed Gull		2				5
Great Black-backed Gull		1		9		4
Kittiwake	1	57		6		6
Gull sp		25	25	531	1	643
Auk sp		6	2	92		25

Species Present in Nationally Important Numbers

DIVERS

Divers are primarily winter and spring visitors to the Solway. About one third of the birds seen were identified to species; of these 90% were red-throated, 2% black-throated and 8% great northern. Figure 7.6.5 shows the total number of divers recorded during each boat surveys (adjusted to take into account lower detectability of birds at greater distance from the observer). Peak numbers were recorded in December 2001, with few birds present between June and October.

The distribution of divers within the study area is shown in Figure 7.6.6. These birds were scattered over the whole of the study area, with no particular concentrations in any part of it. This even scatter of birds is also shown in relation to the distance from the wind farm (Figure 7.6.7). The numbers found in each zone closely reflected the proportion that each zone made of the study area, with no selection or avoidance of any particular part. Though numbers within the study are as a whole exceeded the threshold for national importance, the numbers within 5km of the wind farm were below this, reaching only regional importance.

There was a tendency for Red-throated Divers to occur in relatively shallow water (5 to10m depth), moving out with the ebb tide so as to maintain this depth. The smaller numbers of Black-throated and Great Northern Divers were found in somewhat deeper water, with the former mainly occurring in Scottish waters to the east of Hestan Island and the latter in English waters off Workington.

Figure 7.6.5 – Diver count totals

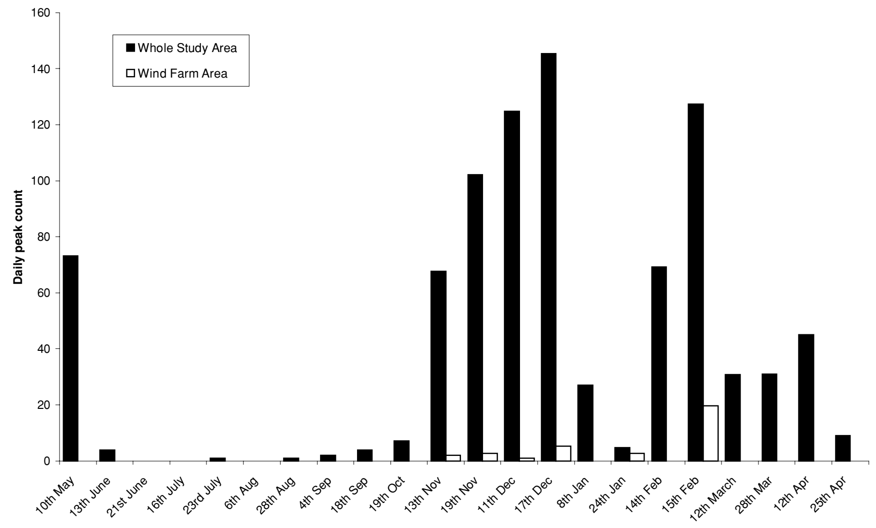


Figure 7.6.6 Diver distribution map

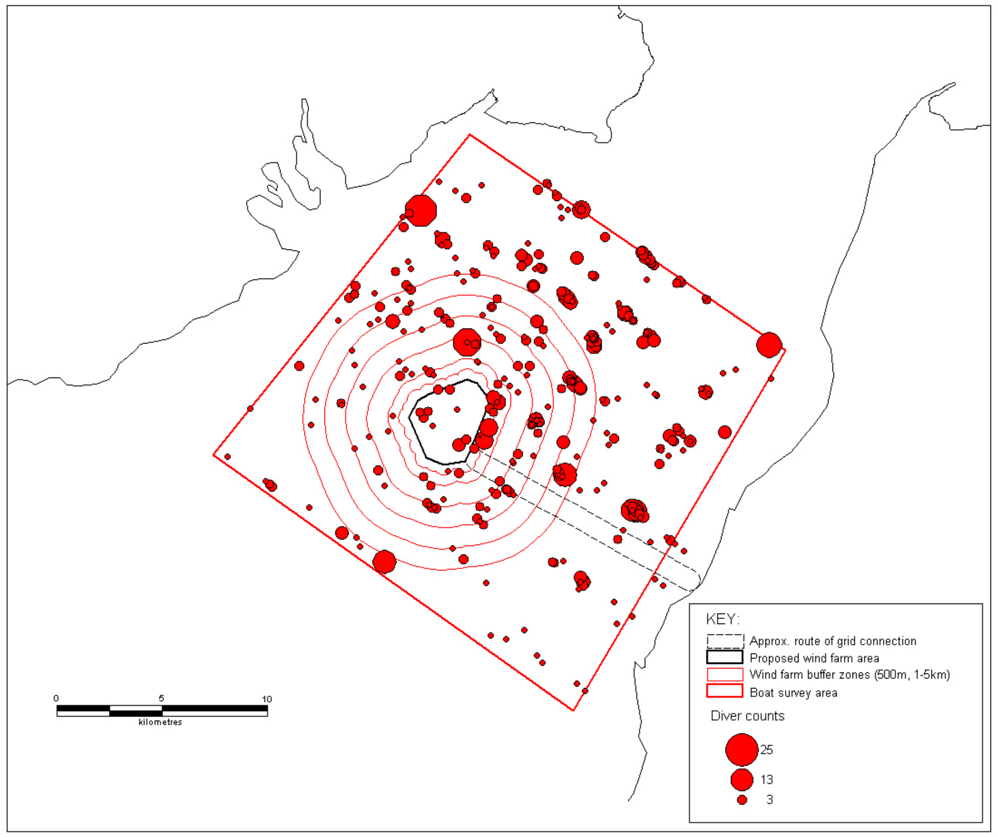


Figure 7.6.7 Diver distribution in relation to distance from wind farm

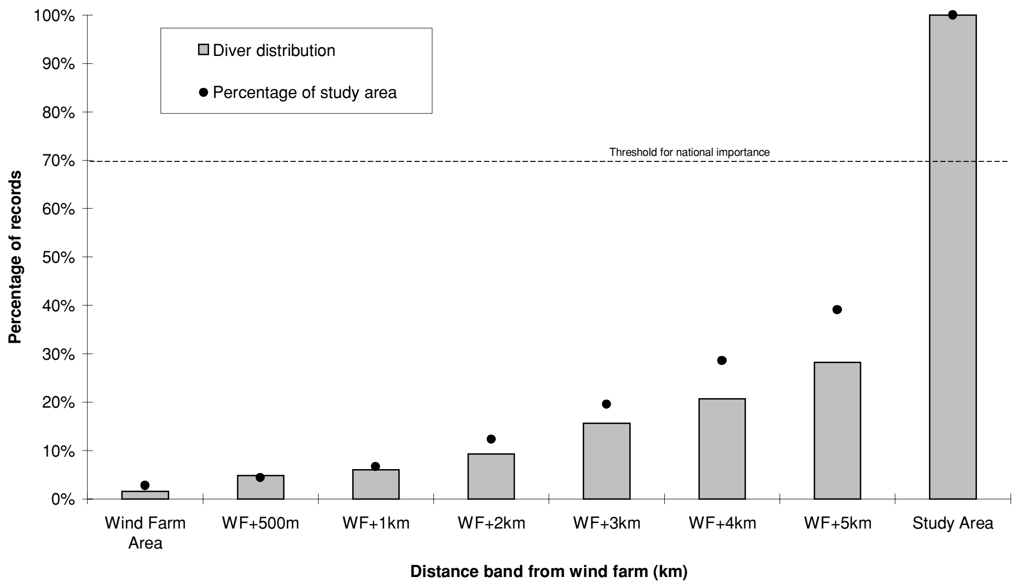


Figure 7.6.8 Common scoter count totals

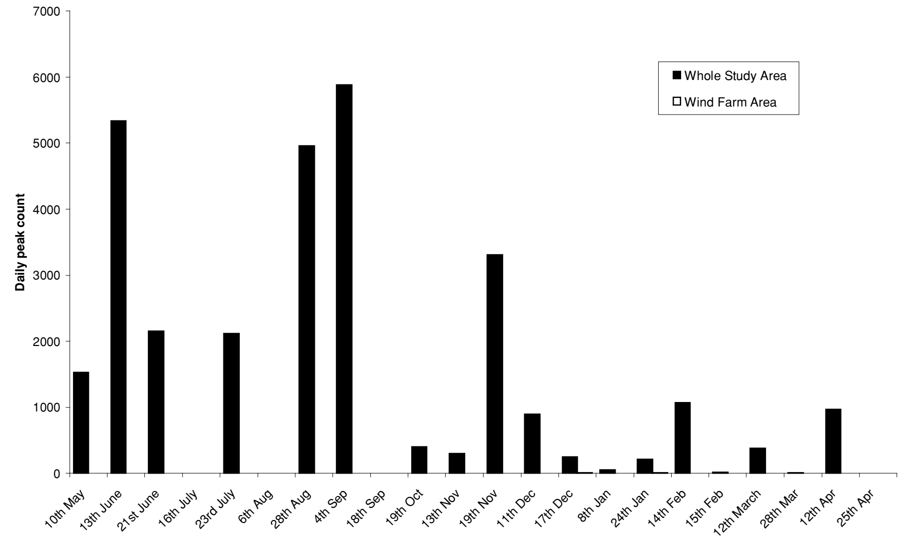
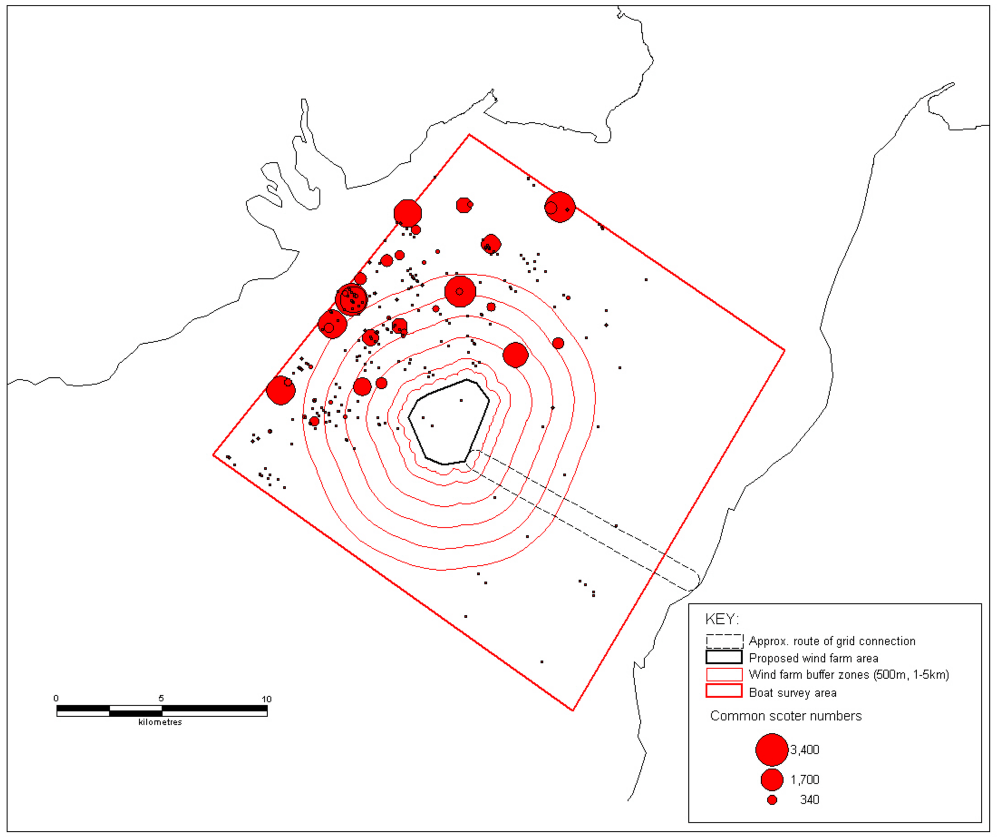


Figure 7.6.9 Common scoter distribution map



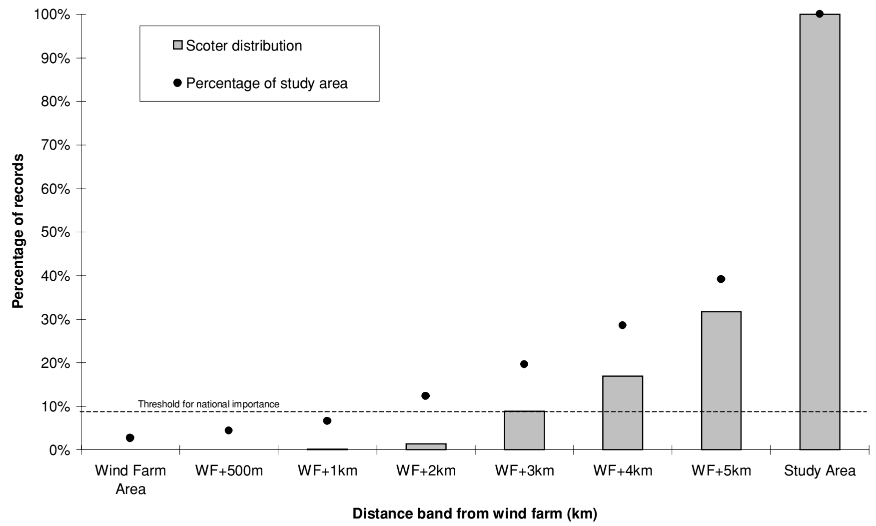
COMMON SCOTER

Nationally important numbers of common scoter were found within the wider study area year-round, though numbers were lower during the winter (Figure 7.6.8). Peak numbers (5,800) were recorded in late August/September, during the pre-moult build–up, and similar numbers were also present in May/June. Numbers were also variable between visits, reflecting the birds' changing distribution through the tidal cycle.

In contrast to the divers, the scoter distribution was very much concentrated in one part of the study area (Figure 7.6.9). Observations of this species were found mainly on the north-western edge of the study area; this area was consistently the one used by the scoter. Figure 7.6.9 also shows several flocks recorded further south and east; almost all of these were recorded on one survey on 4th September, when the survey started on the westernmost transect. As a result the scoter flocks were observed to move progressively further east during the survey, as they were flushed by the survey vessel. Notwithstanding this all of these data have been included in all of the analyses.

The scoter distribution in relation to the wind farm is shown in Figure 7.6.10. Very low numbers indeed were recorded within 2km of the wind farm site; on average less than 10 birds. Numbers reached national importance 2-3km from the site.

Figure 7.6.10 Common scoter distribution in relation to distance from wind farm



Species Present in Regionally Important Numbers

MANX SHEARWATER

Manx shearwaters were only found in the study area during the summer months (Figure 7.6.11). Few birds were recorded until late June. Numbers had declined by early August, and none were seen after that.

The shearwaters were seen mainly to the south and west of the wider study area over relatively deep water, with almost no birds at all seen in the northern and eastern parts of the area (Figure 7.6.12). The largest gatherings were present around high water on the Spring Tides of 22 June and 23 July. Birds were noted leaving the study area as the tide ebbed. Slightly more birds were seen in the wind farm site than would be expected from the area that it occupied, but the main concentrations were found in the 3-5km buffer zones (Figure 7.6.13). Overall numbers in the wind farm area were low (average 3).

Figure 7.6.11 Manx shearwater count totals

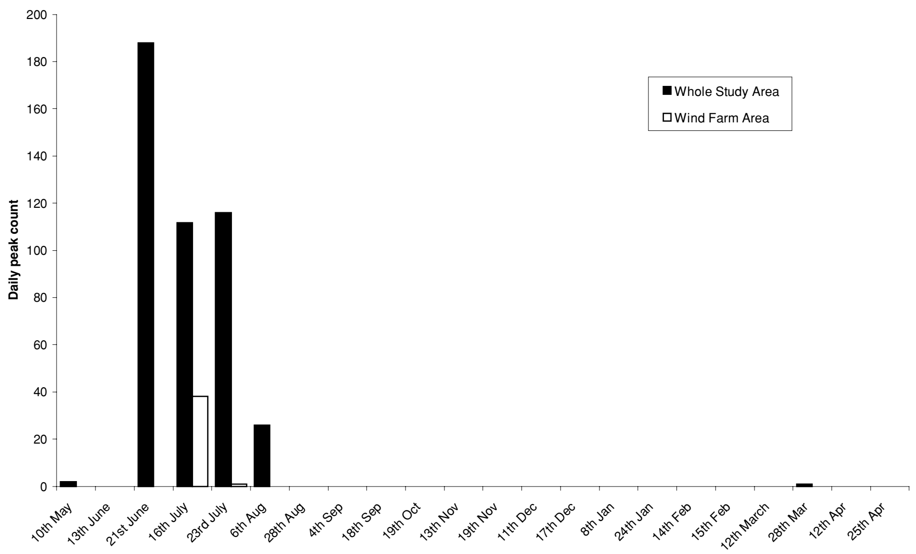


Figure 7.6.12 Manx shearwater distribution map

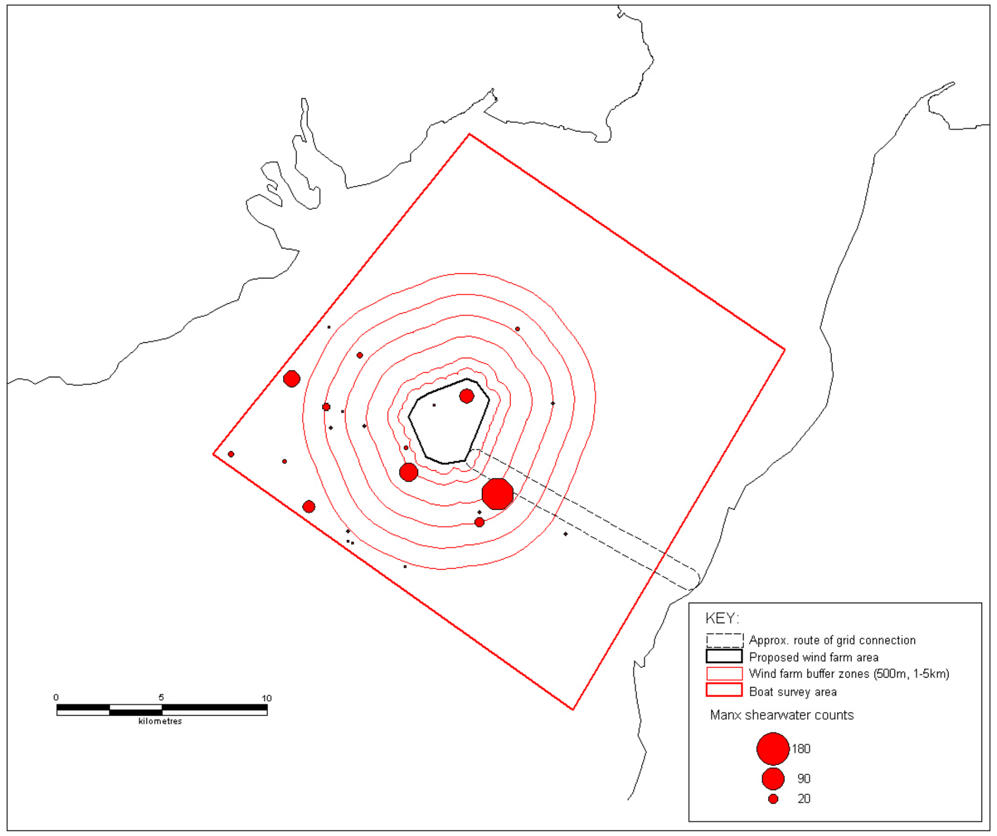
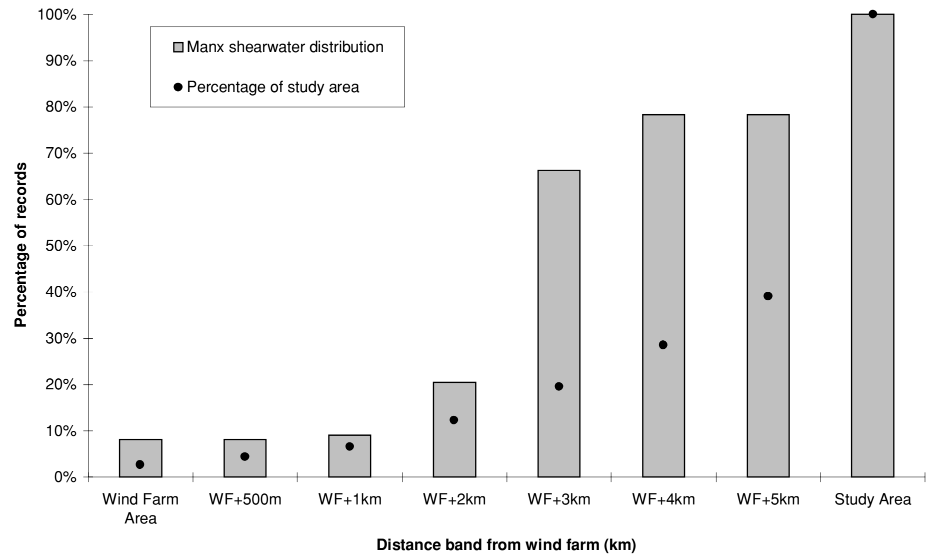


Figure 7.6.13 Manx shearwater distribution in relation to distance from wind farm



STORM PETREL

All except one of the storm petrels were recorded on a single survey visit (16th July). On this date a total of 37 were seen to the south and east of the wind farm site. Apart from that the only other record was of a single bird on the following visit (23rd July). All were more than 5km from the wind farm site.

GANNET

Gannets were most abundant through the summer, with a peak in late August (Figure 7.6.14). There were only sporadic records from October through to March.

Gannets were found fairly evenly distributed through most of the study area, apart from the shallower waters to the north-west (Figure 7.6.16). Numbers in the wind farm area were low, with more found 2-5km from the site (Figure 7.6.15).

Figure 7.6.14 Gannet count totals

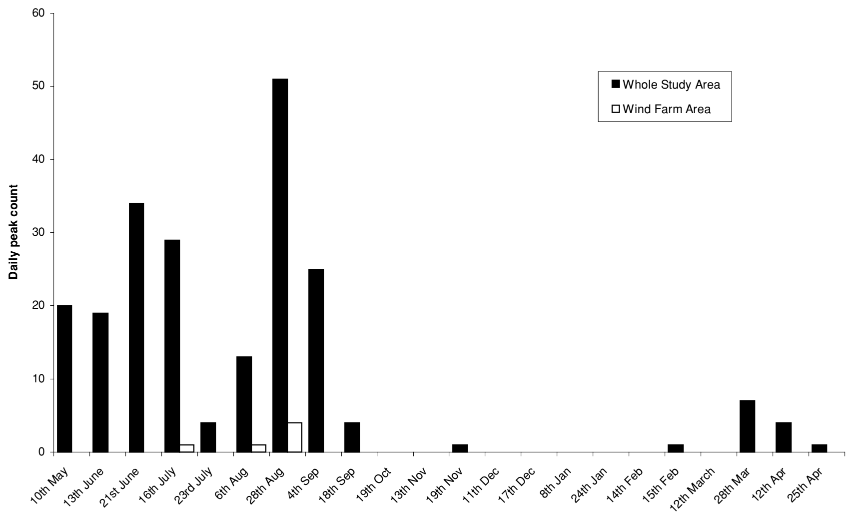


Figure 7.6.15 Gannet distribution in relation to distance from wind farm

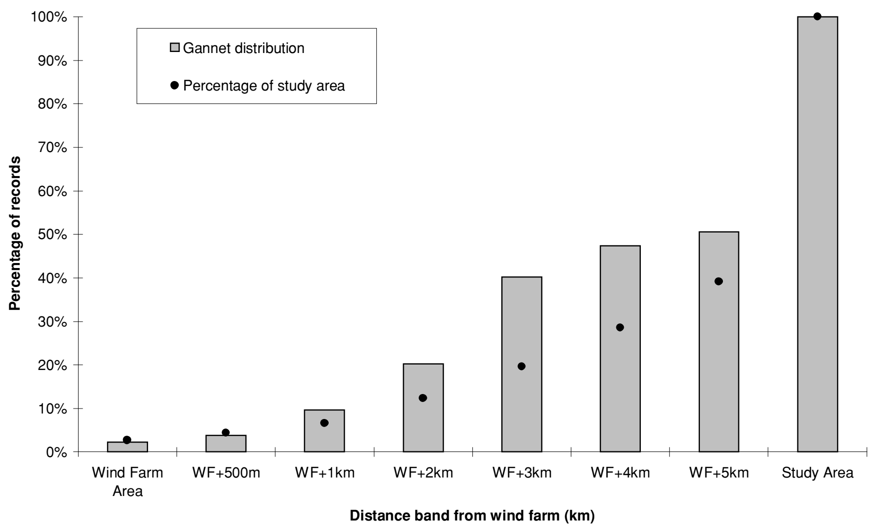
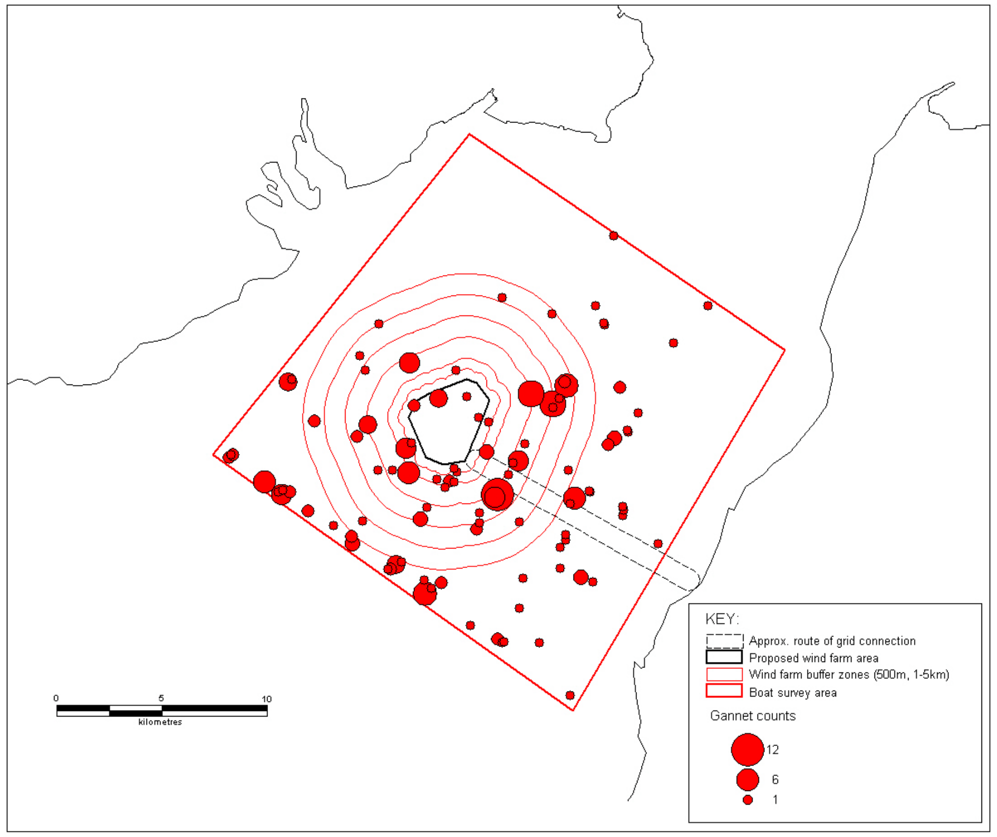


Figure 7.6.16 Gannet distribution map



CORMORANT

Cormorant numbers in the study area were generally low, though were higher during the summer than in the winter (Figure 7.6.17). It is likely that the study area forms part of the foraging range of the breeding colonies between Port o'Warren and Balcary Point

The distribution of cormorants (Figure 7.6.18) followed the locations of the main breeding colony, with greatest numbers in the north-western part of the study area. There was a small concentration adjacent to the wind farm; this was mainly a result of birds using the wind farm anemometer mast as a roost site. Generally though the wind farm area and its surrounds did not form an important part of this species' range (Figure 7.6.19).

Figure 7.6.17 Cormorant count totals

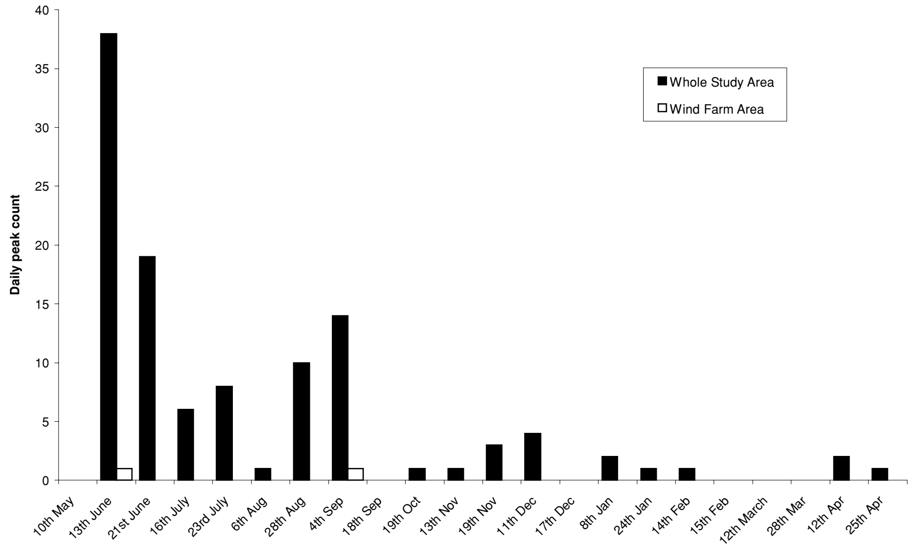


Figure 7.6.18 Cormorant distribution map

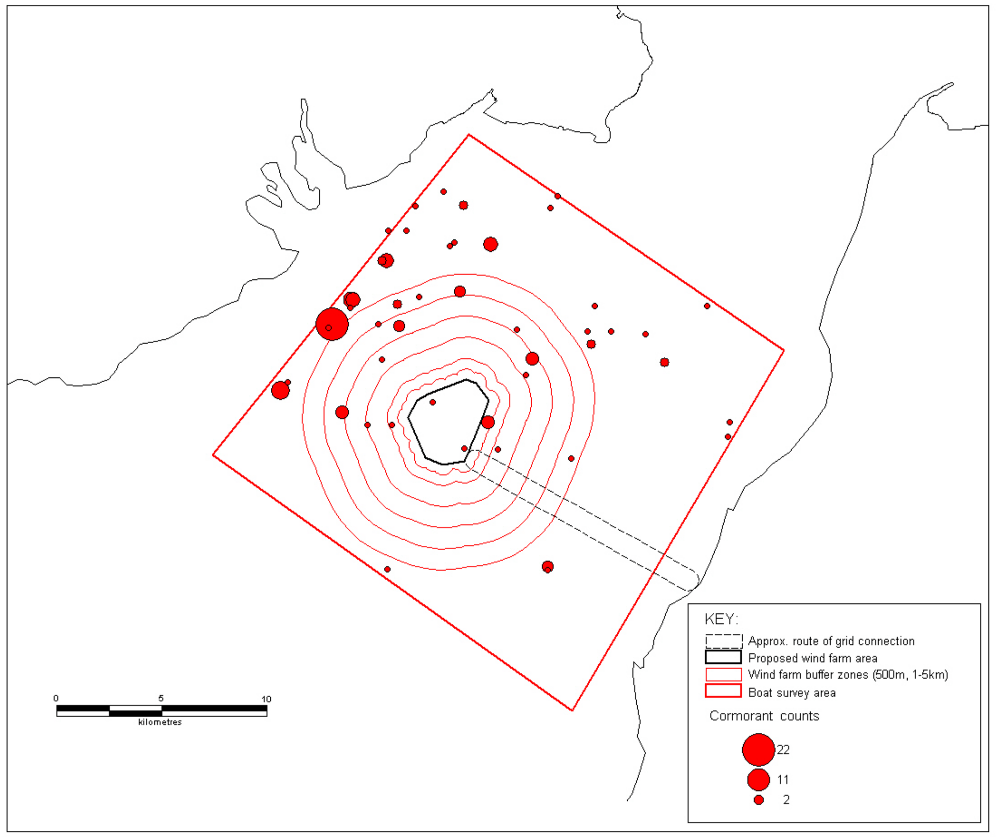
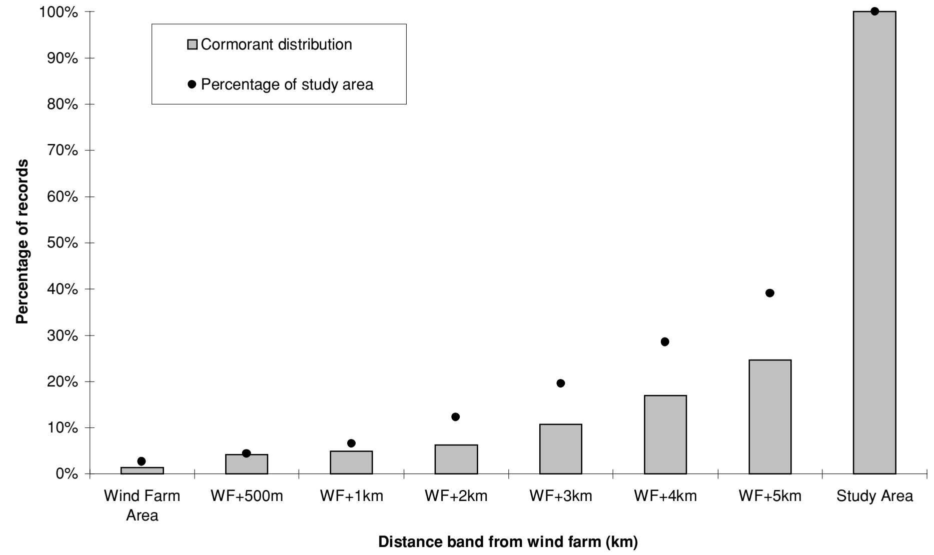


Figure 7.6.19 Cormorant distribution in relation to distance from wind farm



SCAUP

Scaup were only recorded occasionally within the study area: nationally important numbers were found on two dates in November and December (Figure 7.6.20). The main area that this species uses in the Solway lies to the north of the study area, around the mouth of the River Nith (Quinn *et al.*1993) and in shallow water depths on the southern edge of Blackshaw Bank (C.Hartley, pers. comm.). Occasional winter flocks do however sometimes come into the study area. The birds within the study area were all to the north of the wind farm site (Figure 7.6.21). None were seen within 500m of the wind farm area, with only a single flock within 2km (Figure 7.6.22). The wind farm area was not an important area for this species.

Figure 7.6.20 Scaup count totals

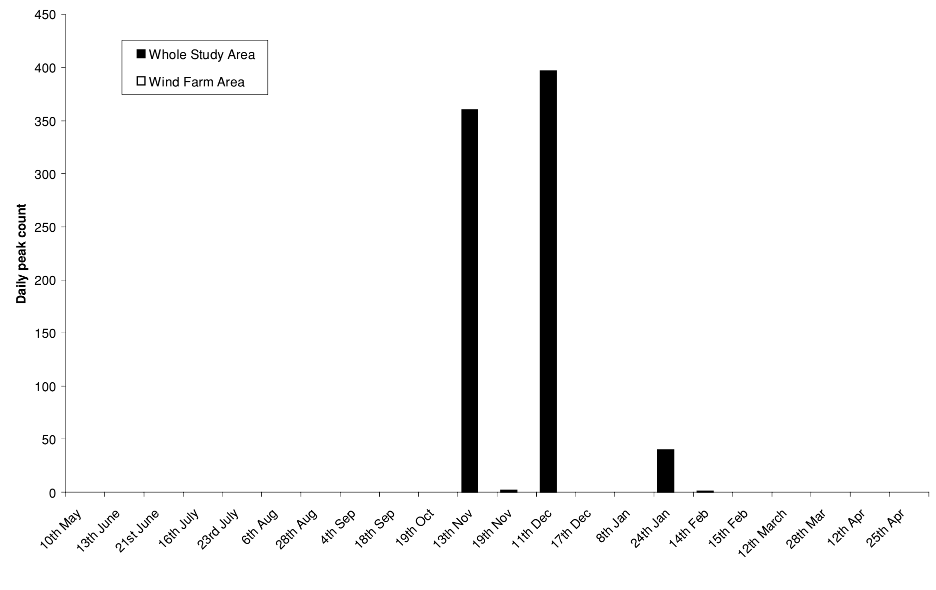


Figure 7.6.21 Scaup distribution map

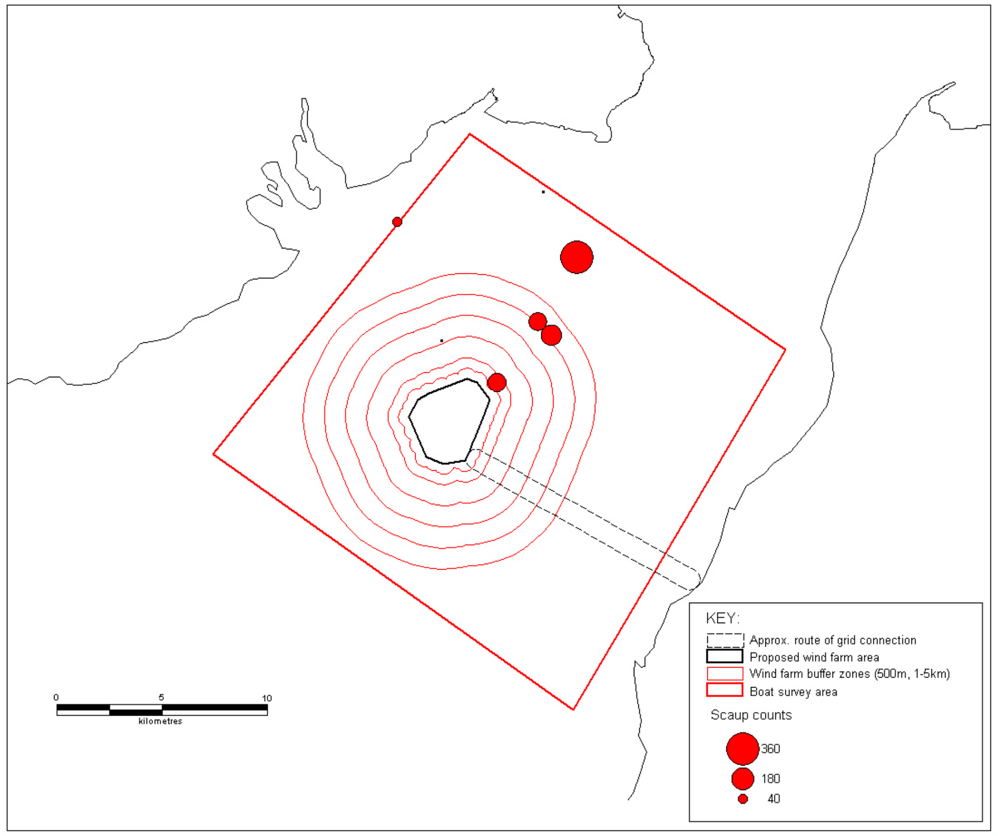
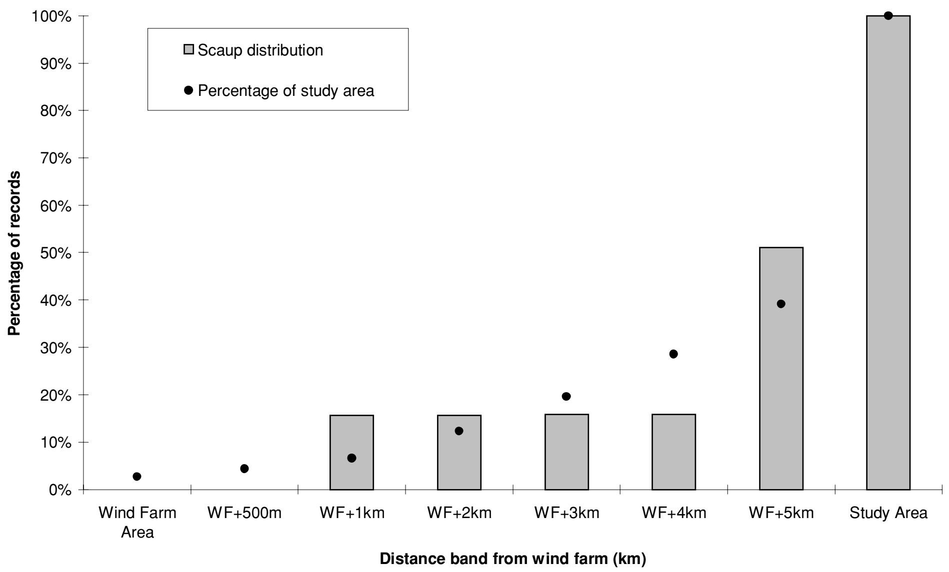


Figure 7.6.22 Scaup distribution in relation to distance from wind farm



KITTIWAKE

Kittiwake numbers in the study area were high through the spring and summer, but dropped to much lower levels through the winter months (Figure 7.6.23). The absence of birds at sea between the beginning of January and late March is notable, because land-based observations picked up large movements of Kittiwakes (of up to 800 birds per hour) passing through the Inner Solway in winds of between Force 5 and 7 during this period (C.Hartley pers. obs). Kittiwake distribution was fairly even across the study area, with no particular concentrations (Figure 7.6.25). The use of the wind farm area was as expected for its extent, though numbers in the buffer zones were slightly higher, with birds selecting the 1-4 km bands in particular (Figure 7.6.24). Overall however this species was widely distributed across the whole study area.

Figure 7.6.23 Kittiwake count totals

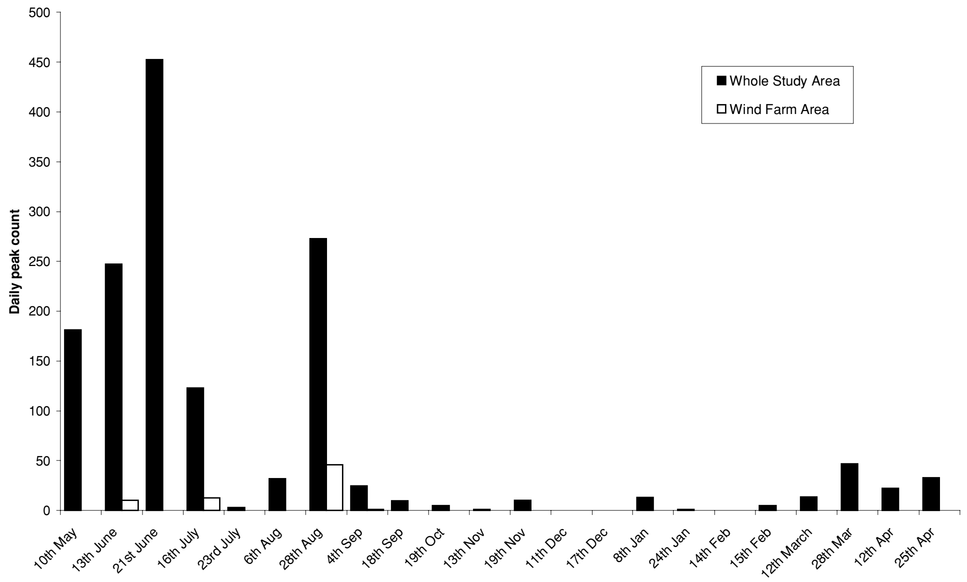


Figure 7.6.24 Kittiwake distribution in relation to distance from wind farm

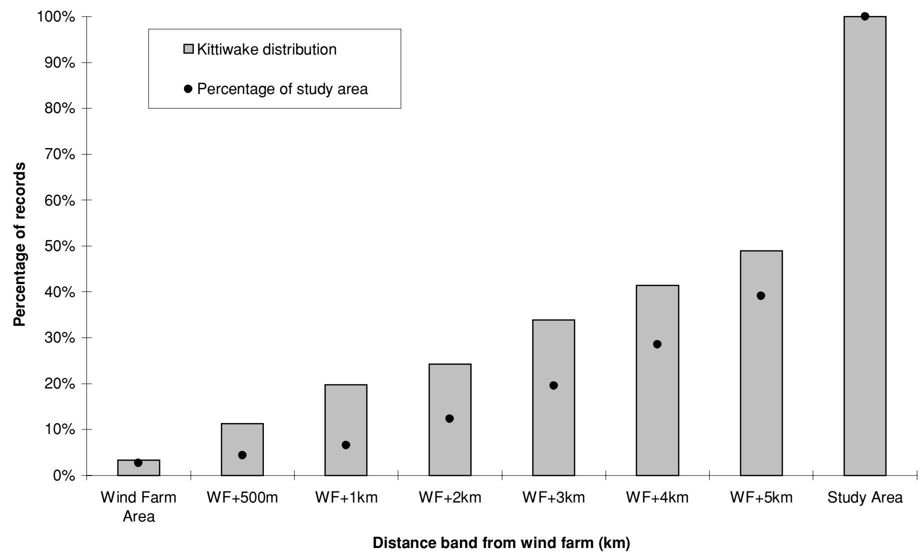


Figure 7.6.25 Kittiwake distribution map

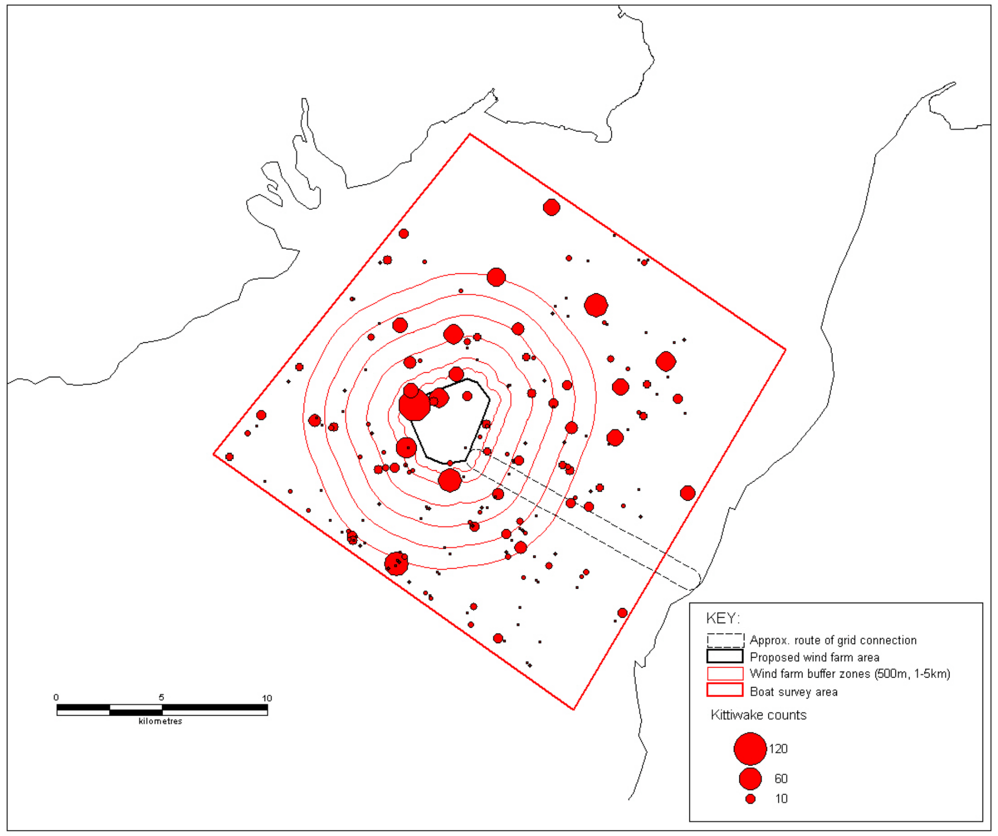


Figure 7.6.26 Guillemot count totals

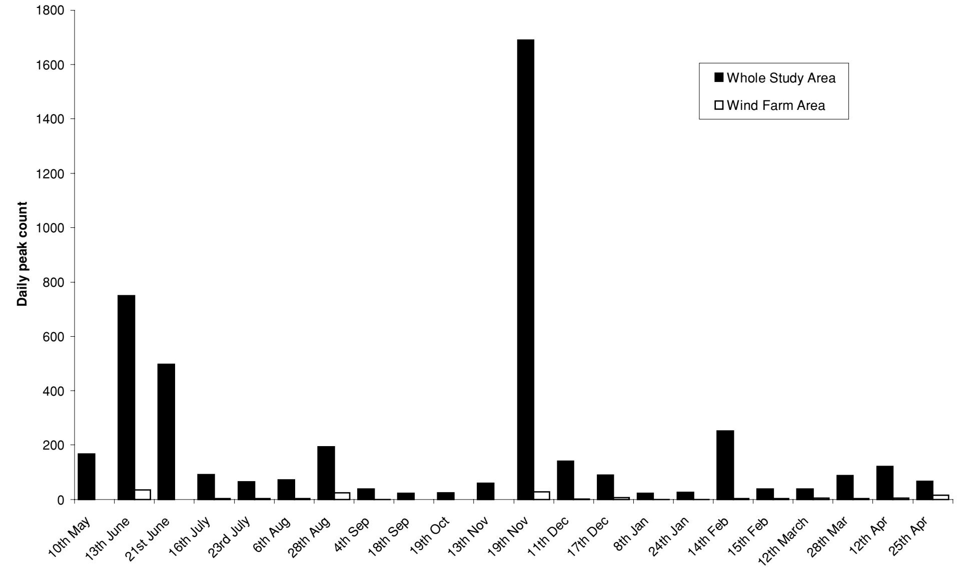
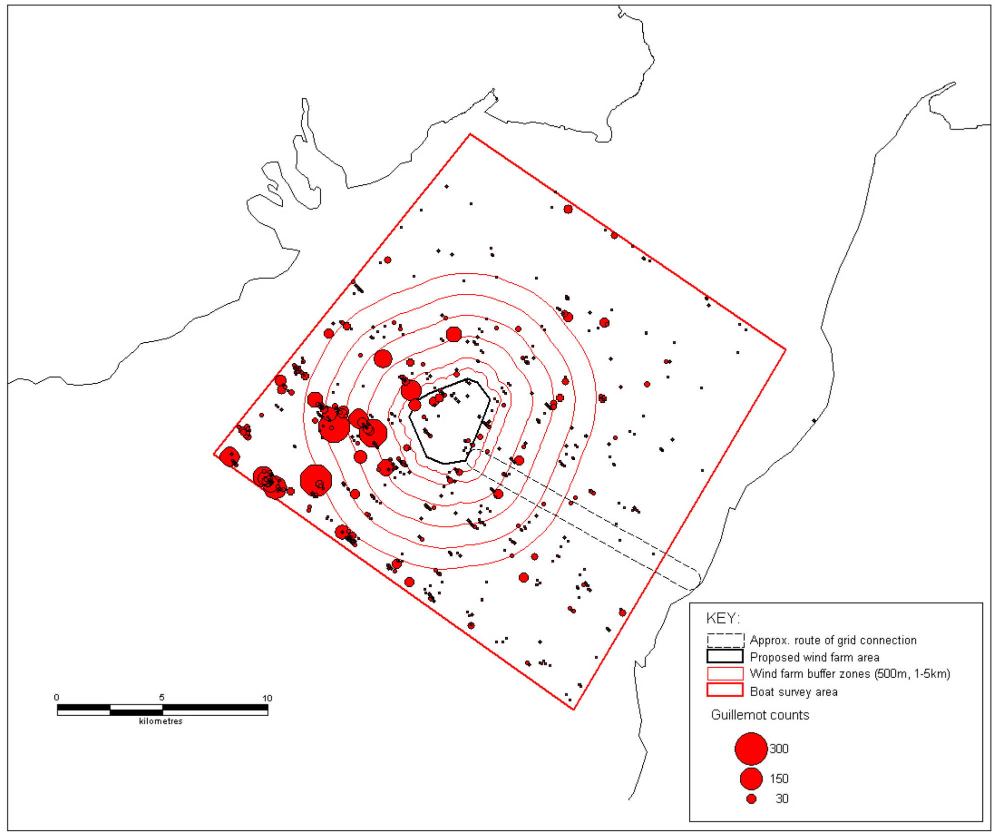


Figure 7.6.27 Guillemot distribution map

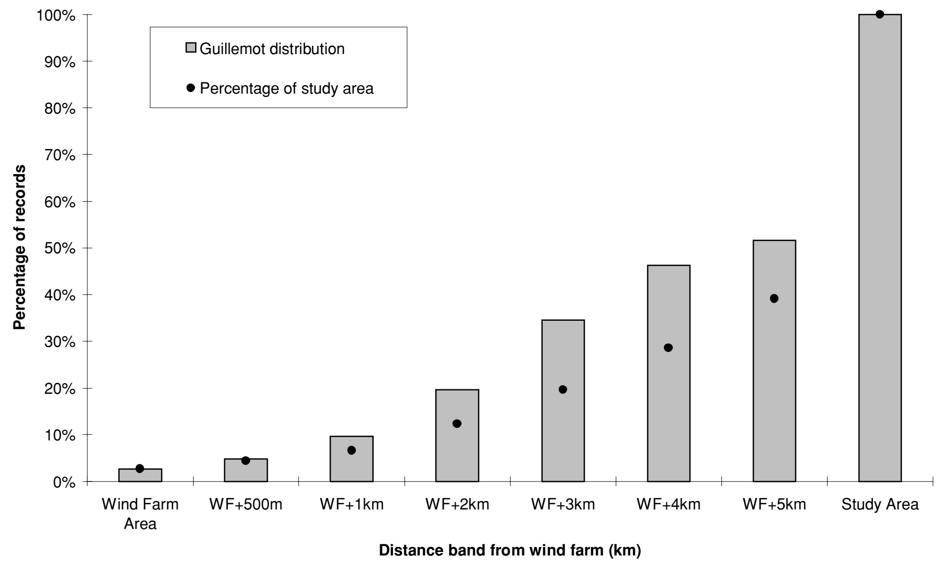


GUILLEMOT

Guillemot numbers in the study area were high in the spring/early summer, then declined from July onwards following the abandonment of nest sites (Figure 7.6.26). One major exception to this was a large influx of this species in November, when over 1,600 birds were recorded.

Guillemots were found throughout the study area, but the main concentration was found in the south-western corner (Figure 7.6.27), where relatively deep water (above 10 metres) occurs close to the Scottish nesting colonies. Numbers in the wind farm area and its close surrounds were low in comparison to the extent of those areas, but increased in the 2-5km bands (Figure 7.6.28).

Figure 7.6.28 Guillemot distribution in relation to distance from wind farm



RAZORBILL

Razorbills were less abundant overall than guillemot, but showed a similar pattern of occurrence, with high numbers in spring/summer and then a late autumn peak (Figure 7.6.29).

Their distribution was more even than that of the guillemot, with only the shallower waters on the northern edge of the study areas being less used (Figure 7.6.30). The wind farm area was used as expected from its extent, but the surrounding buffers were used proportionately more than the study area as a whole (Figure 7.6.31). There was a tendency for both the Razorbill and the Guillemot to move out of the study area on the ebb tide, which reflects their preference for water depths of 10 metres or more.

Figure 7.6.29 Razorbill count totals

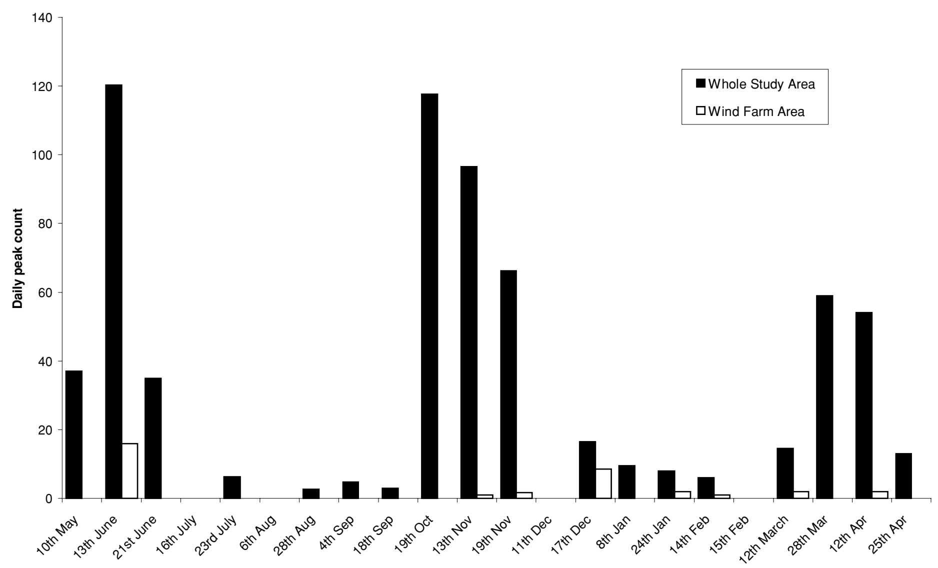


Figure 7.6.30 Razorbill distribution map

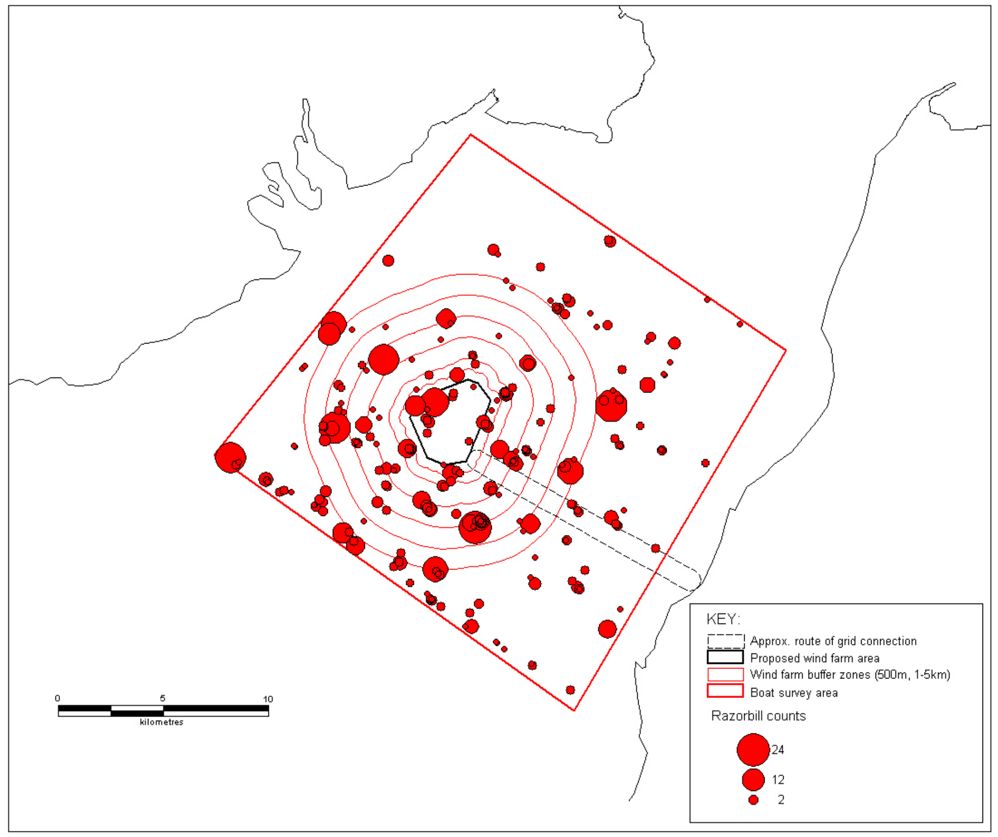
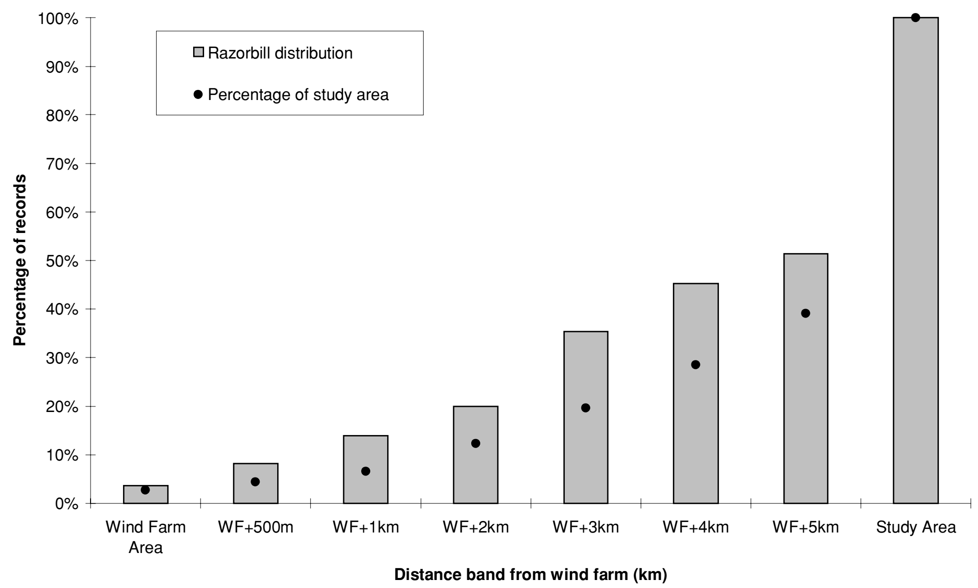


Figure 7.6.31 Razorbill distribution in relation to distance from wind farm



Upper Solway SPA species

The only use of the study area by the internationally important waterfowl populations on the Upper Solway SPA recorded during the surveys was a very low number of over-flying birds of the following species: shelduck, oystercatcher, dunlin and curlew.

Flight Movements

The rates of flight movement through the study area are summarised in Table 7.6.8. The rate has been expressed as the mean number of bird movements observed per hour survey in each of the survey zones.

Observed bird movement rates were generally quite low, and reflected the general bird abundance and distribution. Common scoter activity was low within 3km of the wind farm but much higher in the 3-5km zones and in the other parts of the study area (i.e. in their main area in which they were recorded – see above). Diver flight activity similarly followed their overall distribution, spread evenly across the study area. Much of the common scoter movement involved short, low-level flights, sometimes associated with feeding activity but also as a result of disturbance from the presence of the observation vessel. Diver flights were also partly associated with the presence of the boat, with birds often taking off a considerable distance from the boat.

Other seabird activity was quite low, with no species other than common scoter having overall mean observed movement rates in excess of 10 birds per hour. Other waterfowl flight rates were at very low levels, as were the flight rates of other bird species. Some movement of gulls flighting towards the shore was noted towards dusk, but this took place on a broad front.

Table 7.6.8. Rates of flight movement observed during the boat surveys. Numbers are the mean numbers observed per hour survey in each zone.

Species	Wind Farm	Buffer 500m	Buffer 1km	Buffer 2km	Buffer 3km	Buffer 4km	Buffer 5km	Rest of Study Area
Red-throated Diver			0.5	0.1	0.4	0.4	0.7	0.7
Black-throated Diver					0.1			0.0
Great Northern Diver				0.1	0.3		0.1	0.0
Diver sp	0.7	1.1	2.4	1.2	1.8	0.5	0.7	1.4
Great Crested Grebe	0.2							0.5
Fulmar	0.2		1.1	0.2	0.9	0.1	0.3	0.2
Manx Shearwater	2.7			0.1	1.3	1.3		1.1
Storm Petrel								0.6
Gannet	0.6	0.9	4.1	1.2	3.0	0.9	0.4	0.7
Cormorant	0.4			0.1	0.6	0.1	0.8	0.7
Cormorant/Shag						0.1		
Shelduck			3.3				0.1	0.0
Teal							0.1	
Scaup					0.1		11.4	
Common Scoter	0.5		9.1	48.3	12.2	69.9	85.4	66.6
Velvet Scoter						0.1		
Goldeneye								0.0
Red-breasted Merganser								0.1
Osprey					0.2			
Kestrel								0.0
Oystercatcher			0.4					0.1
Sanderling						3.3		
Dunlin								1.3
Curlew					0.5	0.1		
Arctic Skua		0.4						0.0
Great Skua							0.1	0.1
Pomarine Skua				0.1				
Little Gull			0.5					0.0
Black-headed Gull	1.9	0.5	1.5	0.5	0.4	1.4	1.0	1.1
Common Gull	1.9	6.5	6.2	1.3	3.1	2.1	2.8	4.9
Herring Gull	2.1	3.2	24.7	1.9	2.9	8.2	7.7	4.1
LBB Gull	0.2		0.5	0.4	0.6	0.5	0.8	0.6
Herring/LBB Gull				0.1				0.1
GBB Gull	0.4	3.6	1.6	0.6	0.6	0.7	0.5	0.9
Kittiwake	2.4	4.7	6.9	2.2	3.7	3.0	3.1	2.2
Gull sp	0.2			0.1	0.3	1.5	0.1	1.0
Gull sp (large)								4.7
Common/arctic Tern		3.0	7.0	0.1		0.4	0.3	0.0
Sandwich Tern								0.2
Tern sp	0.2							0.1
Guillemot	1.9	1.8	1.8	1.4	0.9	1.1	0.4	0.8
Razorbill	0.7	5.0	3.6	0.5	1.4	0.4		0.8
Puffin				0.1				0.0
Auk sp	0.9	0.4	1.6	1.5	0.9	0.3	1.0	0.7
Pied Wagtail					0.1			
Meadow Pipit				0.3	0.2	0.1		0.0
Pipit sp								0.0
Swallow					0.6			0.0
Skylark					0.4	0.3		

Flight Heights

The height above the sea surface was recorded for all flying birds seen during the boat surveys. The range of flight heights for all species is shown in Figure 7.6.32. As can be seen from that Figure, the very large majority of bird flights were below rotor height, reducing the risk of collision. The actual minimum height of the rotor blades above the sea will be just greater than 25 m (representing height above highest astronomical tide). Overall only 5% of observed flights were above 20m: details of these are given in Table 7.6.9.

Figure 7.6.32 All species flight heights

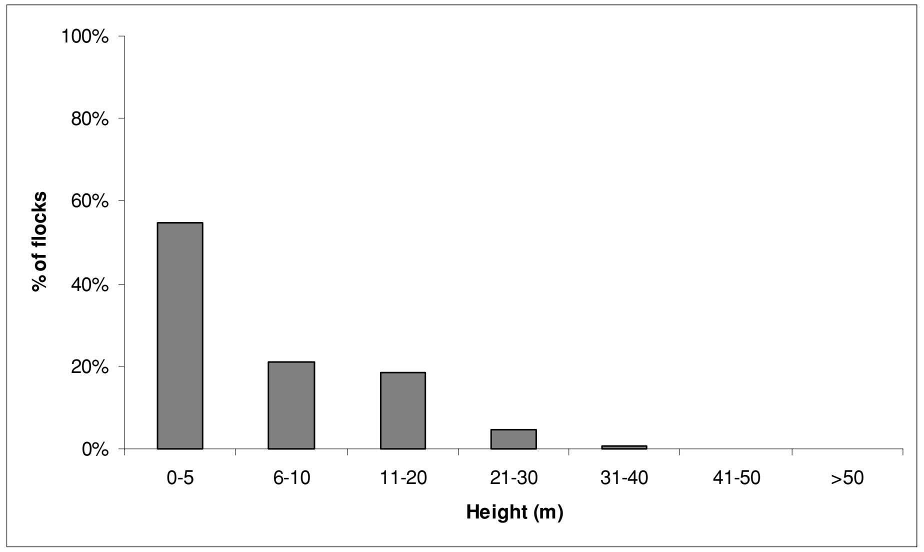


Table 7.6.9. Observed bird flight movements over 20m above the sea seen across the whole study area during the boat surveys

Species	Total number of observed movements above 20m	% of flights above 20m	Movement rate above 20m (flights per hour)
Red-throated Diver	2	3%	0.02
Diver sp	1	1%	0.01
Gannet	3	3%	0.03
Cormorant	3	5%	0.03
Common Scoter	4	<1%	0.04
Osprey	2	100%	0.02
Curlew	5	<1%	0.05
Black-headed Gull	1	1%	0.01
Common Gull	33	8%	0.33
Herring Gull	48	8%	0.48
LBB Gull	16	24%	0.16
Herring/LBB Gull	3	38%	0.03
GBB Gull	15	16%	0.15
Gull sp	1	1%	0.01
Kittiwake	1	<1%	0.01

The flight heights for the two species regularly occurring in the study area in nationally important numbers (divers and common scoter) are shown in Figures 7.6.33 and 7.6.34 respectively. Only 2% of the flights of each were above 20m, the height at which they may be at risk of collision with the wind turbine rotor blades.

Figure 7.6.33 Diver flight heights

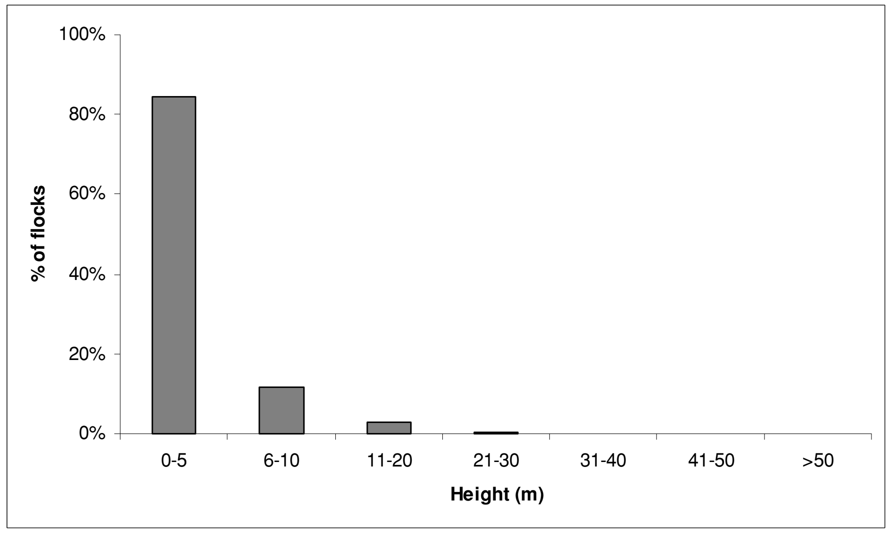
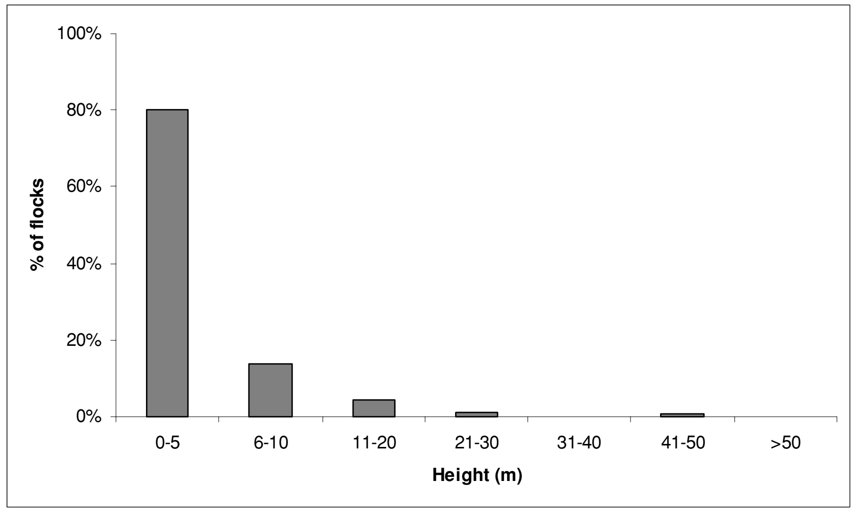


Figure 7.6.34 Common scoter flight heights



7.6.6 SUMMARY OF EXISTING ORNITHOLOGICAL CONDITIONS

- No species present in internationally important numbers within the study area
- Two species regularly counted in numbers exceeding national importance: divers (predominantly red-throated) and common scoter. None of these reached national importance within 2km of the wind farm area.
- Further 8 species determined to be regionally important within the study area: Manx shearwater, storm petrel, gannet, cormorant, scaup, kittiwake, guillemot and razorbill. None of these reached regional importance within 2km of the wind farm area.
- Negligible use of the area by Upper Solway SPA internationally important populations.
- Low rates of flight movement observed, other than in main common scoter area more than 3km to the west of the wind farm site.
- Very few (5%) of flights were at rotor height. Only 2% of diver and scoter flights at this height.
- All the above data were collected in reasonable weather conditions and from a single year. Data from the Cumbria Bird Club and RSPB, and land-based observations during storm conditions, suggest that they are generally typical, but that they underestimate the numbers of some seabirds (notably gannet and kittiwake) during windier conditions.

7.7 LANDSCAPE AND SEASCAPE CHARACTER ASSESSMENT AND VISUAL RECEPTORS

7.7.1 INTRODUCTION

This section provides a baseline landscape, seascape and visual assessment for the proposed Robin Rigg Offshore Wind Farm. It forms the first stage of a full landscape, seascape and visual impact assessment for the offshore wind farm, which consists of two stages as follows:

- Stage 1: Baseline landscape, seascape and visual assessment; and
- Stage 2: Landscape, seascape and visual impact assessment and optimised wind farm layout.

The assessment is based on a study area with a 35km radius from the centre of the proposed offshore wind farm.

The baseline assessment report includes the following sections:

Method of assessment – a brief summary of how the assessment has been carried out, with reference to Axis methodology[261] given in Appendix G1 and standard guidelines;
Landscape, seascape and visual context – a description of the regional context, infrastructure, tourist interest, designated areas and strategic policy guidance for the study area;
Baseline landscape and seascape assessment – a description, classification and evaluation of the existing landscape and seascape character of the study area;
Baseline visual assessment – a review of the visual context confirming visually sensitive receptors and appropriate viewpoint locations; and
Summary and conclusions – a summary of the assessment results and their significance for the impact assessment given in Section 9.10 of this Statement.

The assessment is illustrated in Figure 7.7.1 by a landscape and seascape character area map (including viewpoint locations). It is also supported by the seascape assessment methodology developed by Axis in Appendix G1 in the separate volume of appendices, and the inclusion of a seascape assessment field survey form in Appendix G2.

Stage 1 will provide a robust landscape, seascape and visual baseline from which the assessment of impacts and optimisation of the wind farm layout in stage 2 can be finalised.

[261] This methodology was prepared by Axis for use by the Natural Power Company (NPC), specifically for this project. It is included in appendix 1.

7.7.2 METHODOLOGY

The methodology for carrying out the landscape/seascape and visual impact assessment for Robin Rigg Offshore Wind Farm has been developed by Axis Consultants and applied by Enviros Aspinwall. The full methodology is included in Appendix G1 and has been based on guidelines provided in the following:

- Guidelines for Landscape and Visual Impact Assessment - The Landscape Institute and Institute of Environmental Assessment (1995) (GLVIA);
- Guide to Best Practice in Seascape Assessment - Countryside Council for Wales, Brady Shipman Martin and University College Dublin (2001).
- Interim Landscape Character Assessment Guidance – Countryside Agency / Scottish Natural Heritage (1999) updated and published in April 2002.

The detailed methodology for the baseline assessment is given in detail in Appendix G1 which included the original methodology developed by Axis Landscape Consultants in consultation Scottish Natural Heritage and the Countryside Commission along with agreed changes suggested by Enviros Aspinwalls based on experience gained from carrying out the assessment.

Stage 1 of the landscape/seascape and visual impact assessment is to review the existing landscape and visual resource. This process resulted in a baseline assessment, which is provided in this report. The data collected forms the basis against which to review the magnitude and the significance of the predicted landscape/seascape and visual impacts of the development in Stage 2 given in Section 9.10 of this ES.

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The assessment of existing landscape character, quality and sensitivity has concentrated on a 35km radius study area, centred on the proposed wind farm at Robin Rigg. The assessment required description, classification and evaluation of the landscape:

Description is the process of collecting and presenting information about landscape/seascape and visual resources in a systematic manner;

Classification is the more analytical activity whereby landscape/seascape resources, in particular, are refined into units of distinct and recognisable character;

Evaluation is the process of attributing a value to a given landscape/seascape or visual resource, by reference to specified criteria.

The baseline assessment comprised three stages: desk study, field survey and analysis. The methods used for desk study and field surveys are described in detail in the methodology given in Appendix G1.

7.7.2.1 Analysis

The sensitivity of the landscape/seascape resource and of the visual receptors/features were analysed on completion of the field survey. The sensitivity of the landscape and seascape resource to change of the nature associated with the proposed development has been described as high, medium, low or negligible for each landscape/seascape character area. This has been based on the professional interpretation of a combination of parameters. These include landscape designation, landscape quality, the scale of the landscape in which the proposed development is to be located, the nature of views and the extent to which views contribute to the character of the landscape. These are shown in the table below.

	Sensitivity of the Landscape			
Parameters	**High**	**Medium**	**Low**	**Negligible**
Landscape designation	National (e.g. designations National Park / NSA)	Regional designation (e.g. RSA)	No designation	No designation
Landscape scale	Small	Medium	Large	Vast
Landscape quality	Exceptional / High	Medium	Low	Low
Nature of views	Short distance	Medium distance	Long distance	Long distance

Likewise for the visual baseline, the sensitivity of each of the identified visual receptors/features has been determined. Viewpoint sensitivity is defined as high, medium, low or negligible based on an interpretation of a combination of parameters, as follows:

- Land use at the viewpoint;
- Landscape quality at the viewpoint;
- Landscape designation;
- Frequency of use; and
- Quality of the intervening landscape between the viewpoint and the proposed development.

These parameters were determined against the following criteria:

- High: Strategic recreational footpaths, areas or rights of way; important landscape features with physical, cultural or historic attributes; the principal views from residential buildings; popular beaches; beauty spots; picnic areas; and areas of in-shore recreational boating;
- Medium: Other footpaths; secondary views from residential buildings; roads and train lines; views from passenger ferries and cruisers;
- Low: Views from outdoor sports fields, commercial buildings or commercially engaged pedestrians;
- Negligible: Views from industrial areas and from commercial fishing or shipping.

The baseline study provides a robust description, classification and evaluation of the landscape, seascape and visual resource from which to advise, in landscape/seascape and visual terms, on the development's acceptability in principle and its preferred siting, layout and design. The baseline assessment contributed to influencing the scheme design and the development of mitigation measures.

7.7.3 LANDSCAPE AND SEASCAPE CONTEXT

7.7.3.1 Historic and Cultural Heritage

The Dumfries & Galloway Coast

The coast here has important links to the arrival of Christianity in Scotland, with an early monastery built at Whithorn. A network of abbeys and castles developed along the coast with the abbeys exerting a similar influence here as in Cumbria. Settlements such as Kirkcudbright grew up from the twelfth century. Kirkcudbright was an internationally important trading port at this time as it was the closest port to Spain and France for the medieval Scottish kingdom. Later it, and the other ports of Dumfries and Annan, had connections with the rest of the UK, Europe and the USA. Ships were built along this coast. There was little industrial development along this coast unlike the Cumbrian coast and as the railways were built there was a decline in shipping. The main activities have remained agriculture and forestry.

There is a long history of fishing along this coast. The poke netting and haaf netting methods have been used on the Scottish side of the Solway for many centuries and some of the ports, for example Kirkcudbright, have had a fishing fleet of various sizes over the years. Cockle and mussel collections were important but are currently forbidden. As with Cumbria, the area has been popular with artists over the years and also with tourists since Victorian times, who come to the area for the scenery and the attractive towns along the coast. As with the Cumbrian coast, sailing is popular with the coast used as a base for cruising to the Isle of Man and also up the west coast of Scotland. Because of the large numbers of bird species found in the inner firth, birdwatching is also popular.

The Cumbrian Coast

The Cumbrian coast has a long history of occupation and use. The Romans left the earliest traces of occupation. Hadrian's Wall extends as far as Bowness – on - Solway and defences in the form of forts, fortlets and towers continue south along the Cumbrian coast, for example at Maryport.

Historically, agriculture was mainly centred round the monasteries from the twelfth century. The Holme Cultram Abbey and the Priory at St Bees owned significant amounts of land and also encouraged salt production and the mining of iron ore.

Major changes occurred from the late eighteenth century when the industrial revolution began to have a major impact on the area. Coal and iron ore deposits were discovered close to Whitehaven, Workington and Maryport. This lead to the development of mining and the establishment of iron and steelmaking industries in these towns, which prospered as a result. The towns developed as ports and became important in exporting industrial products, mostly to Ireland but there were also connections to Europe and the USA, with the associated development of the ship building industry. Smuggling up the coast was common during this period.

Tourism began when the railways were built and the Victorians discovered towns such as Silloth and Allonby, which were made accessible by the development of the rail network. Tourism has become increasingly important for the area as the traditional industries have declined and today the regeneration of the three towns of Maryport, Whitehaven and Workington is associated with the development of tourism. Tourists are attracted by the scenic value of the area and the natural and cultural heritage. The remoteness of the coastal marshes and the sand dune coast are prized by tourists and artists. St Bees is the starting place of the coast to coast path, a national trail, while Workington and Whitehaven form the start of the coast to coast cycle path. Sailing and windsurfing are replacing the more traditional fishing industry, which is in decline here as on many other coasts. Traditional haaf netting is still practised in the Inner Solway estuary and is unique to the area.

7.7.3.2 Transport Routes

Transport routes of strategic importance within the study area are described below:

Road

In Dumfries and Galloway there are two roads of strategic importance, only one of which, the A75, falls within the study area. The A75 is the principal route between Galloway and the east of the region and forms part of the North Channel Sea route to Ireland. The Solway Coast Heritage Trail traverses the coast in Dumfries and Galloway. In Cumbria the principal route is the A66, linking Workington to the M6 in the East. Secondary routes include the A596 running between Workington and Carlisle and the A595 running between Carlisle and Barrow in Furness. Both of these routes lie close to the coast within the study area. The B5300 runs along a large part of the north western coast of Cumbria.

Just to the west of Annan, there is a scenic drive signposted along the B724, which follows the coast through Powfoot, Clarencefield and Glencaple to Dumfries. There are also viewpoints on the A711 from Dalbeattie to Kirkcudbright.

Rail

The Annan to Dumfries railway passes through the far northeastern part of the study area.

The Cumbria Coastal Railway links Whitehaven, Workington, Maryport with Barrow in Furness to the south and Carlisle to the north. The line passes close to the coast between Whitehaven and Maryport.

7.7.3.3 Recreation and Tourism

The Solway Firth area brings together a wide range of features that are of great interest for the purposes of recreation and tourism. A wide range of activities and attractions combined with the quality of the area's natural environment, form the basis for present and future expansion on the coastal strips of Cumbria and Dumfries and Galloway. Key recreational activities and centres are described below.

Walking

There are several walks from Balcary round to Mersehead and several more around Powfoot and Annan. Dumfries & Galloway Council has Ranger led walks and the National Trust at Rockcliffe has an organised programme of walks during the summer. The Cumbria Coastal Way, a national trail, runs from Silverdale, a village situated on the Cumbrian/Lancashire border, to Gretna on the border between England and Scotland. The coast to coast walk, also a national trail, starts at St. Bees Head and crosses the Lake District National Park (LDNP) on its journey to Robin Hoods Bay on the east coast. There are a number of national trails within the LDNP.

Cycling

National Cycle Route 7 passes through the Dumfries & Galloway Region and from Dumfries goes down to Glencaple and follows the B724 along the coast to Gretna. The Cumbria Cycle Way runs down the coast from Silloth to Maryport. Workington and Whitehaven are the starting point of the sea to sea cycle route.

Sailing

The main sailing club on the Dumfries and Galloway coast is the Solway Yacht Club at Kippford with both dinghy and yacht racing in the Solway. Yachts cruise across to Maryport, along the coast to Kirkcudbright, out to the Isle of Man, as well as further afield. Kirkcudbright has a smaller yacht club. On the Cumbrian Coast Maryport is becoming a popular area to cruise from; Kippford and Kirkcudbright being popular destinations. There are smaller marinas or yacht clubs at Workington, Harrington and Whitehaven. Allonby and Fleet Bay are noted as a good area for windsurfing.

Scuba Diving

Diving trips depart from Brighouse bay, Kirkcudbright, Workington and Whitehaven with popular wreck sites being located at St Bees Head and Abbey Head.

Sea Fishing

There are a number of popular sea fishing sites around the Solway Firth, including a number of competition sites, such as Brighouse Bay, Ross Bay, Rascarrel Bay, Skinburness, Allonby Bay, Workington and Harrington.

Bird Watching

There are a large number of areas where wildfowling and birdwatching are popular. These include the Inner Solway Marshes, St. Bees RSPB reserve, Balcary Heughs, Rockcliffe NTS, Rockcliffe to Sandyhills, Mersehead (RSPB), Southerness, Carsethorn, Glencaple, Caerlaverock National Nature Reserve (NNR), Powfoot and Seafield and Mull of Galloway.

Caravan Sites / Holiday Parks

There are a number of holiday/ caravan parks on the coastline within the study area including: Sangreen, Ross, Palnackie, Barnbarroch, West Barcloy, Sandyhills, Southerness, Gillfoot, Powfoot, East Cote, Silloth, Blitterlees, Allerdale, Beckfoot, Allonby and Maelo. There are several other camping/caravan parks within the LDNP.

Beaches

Designated bathing beaches on the Solway Firth are:

- Dumfries and Galloway: Rockcliffe, Sandy Hills, Southerness
- Cumbria: Skinburness, Silloth, Allonby

Golf

There are several golf courses along the Solway Coast, such as those located at The Torrs, Colvend and Southerness in Dumfries and Galloway, and Workington and Whitehaven in Cumbria.

National Trust for Scotland / Historic Scotland Properties

There are several properties in the area:

- National Trust for Scotland: Rockcliffe – various properties including Mote of Mark and Rough Island.
- Historic Scotland: Dundrennan Abbey, Orchardton Tower, Caerlaverock Castle, Ruthwell Cross

7.7.3.4 Landscape Designations

The application site is not within a designated landscape or area of nature conservation importance. However, outwith the application site, the landscape of the study area is subject to extensive landscape and nature conservation designations. The extent of landscape and nature conservation designations within the study area are illustrated in Figure 1.1 in Section 1 of this ES. Landscape designations are those areas designated on the basis of their inherent landscape qualities and scenic value, whereas nature conservation designations are those areas designated on the basis of their importance for the conservation of a particular plant or animal species.

There are a number of different landscape designations in the UK. Landscape designations in Scotland, which are present along the Dumfries and Galloway coast include:

Dumfries and Galloway

NATIONAL SCENIC AREAS (NSA)

There are 40 NSAs in Scotland comprising areas considered to be of '*national scenic significance….. which must be conserved as part of Scotland's national heritage'*, and cover approximately 13% of Scotland. The NSAs were selected as the best examples of the types of natural beauty for which Scotland is renowned, rather than representing the full range of Scotland's diverse landscapes. As a result they tend to focus on the mountainous north and west of the country and the islands, and less on the managed landscapes of the south and east. Scottish Natural Heritage have recently reviewed the selection of NSAs and advised the Scottish Executive on potential changes that may be desirable.

Three NSAs are designated within the study area, all of which are concentrated on coastal landscapes, and centred on the incised river estuaries and bays of the Nith Estuary, Stewartry Coast and Fleet Valley. These can be seen in figure 2 and are described as follows:

Nith Estuary NSA

This area includes Criffel and Kirkconnel Flow, the mouth of the River Nith south of Islesteps, Carse Sands and Caerlaverock. The River Nith and Lochar water flow into the Solway Firth to form a wide tidal estuary comprising the Carse Sands, Blackshaw Bank and Priestside Bank. These extensive sands, mudflats and saltings of an openness and horizontal scale unusual in Scotland, are complemented and enhanced by the presence of the gentle granite cone of Criffell and the long well wooded ridge extending back to Marthrown Hill. The eastern flank of the hill, has steep convex slopes with a mixture of woodland and moorland descending into the richer sylvan and pastoral landscape around New Abbey. By contrast Marthrown Hill is heavily wooded, but below it the riverside flats are a mixture of pasture and peat moss with associated birch trees. To the east of the tidal channel of the Nith relief is low, but the long valley is given emphasis by a long low ridge parallel with the river. The river at this point is broad and bordered by open fields, marshes and riverside trees in some places.

East Stewarty Coast NSA

This area comprises Auchencairn Bay, Orchardton, Bay, Rough Firth, Sandyhills Bay, the Mersehead sands and their immediate hinterlands. The wide tidal flats of Mershead Sands occur at a point where the saltings of Preston Merse meet the fossil cliffs and raised beaches of the rocky Sandyhills coast. Sandyhills Bay with its dunes and enclosing woodland is separated from Mershead Sands by the meandering intertidal stretch of the Southwick Water, which adds visual interest to the wide expanse of sand. Inland the containing hills are part wooded and part moorland, and at Caulkerbush there is a diverse pattern of hedgerow trees, parkland and wooded hillside. Westwards the hills become progressively more wooded in a way which strengthens the feeling of enclosure that they contribute to the inshore waters of Rough Firth, Orchardton Bay and Auchencairn Bay. Within the bays divided by the wooded promontories of Almorenesss Point and Torr Point, lie Heston Island and Rough Island which strengthen the character of enclosure and shelter that these inlets exhibit. The land use pattern of mixed farming and forestry and undulating relief around these bays underline the small scale of this landscape, which contrasts with the open character of the sand flats. The villages of Rockcliffe and Kippford add to the diversity of the scene and elsewhere buildings tend to be of a traditional character.

Fleet Valley NSA

This area includes Fleet Bay and the enclosing landforms on either side together with the valley of the River Fleet. Fleet Bay is dominated by the hill mass of Cairnharrow (456m) on its western side, of which Ben John and Mill Knock are outliers. On the east relief is not so pronounced but enclosure is given by the ridge which culminates in the well wooded Bar Hill just south of Gatehouse. Woodland contributes significantly to the Fleet bay landscape, with policy planting and hedgerow trees being dominant. The village of Gatehouse of Fleet provides a focus point for the valley, which changes character at the village from estuarial to upland. While there is greater amplitude of relief in the inner valley the landscape is also softer and more enclosed. There is a variety of woodlands from young plantations to mature broad-leaved woods clothing the valley sides, while above them extends the open moorland of the hills and below the riverside pasture. The pattern is one of rich, well managed, mixed land use farming in which the woods are particularly striking and where there is evidence of long established prosperity in the number of castles, churches, monuments and ancient remains.

REGIONAL SCENIC AREAS (RSA)

The first regional scenic designations in Dumfries and Galloway comprised AGLVs designated before the Local Government reorganisation in 1974. These placed the onus on the local planning authority to ‘safeguard the most outstanding natural beauty spots’ and encourage the provision of visitor facilities in these areas’. AGLVs were subsequently superseded by Areas of Regional Scenic Significance (ARSS) in the 1984 Structure Plan. The use, status, application and names of local landscape designations are varied and inconsistent throughout Scotland. Recent advice to government on landscape designations provided by SNH, recommended that ‘the opportunity should be taken to confirm and clarify the need for, status and use of other (than NSA) scenic designations’ while stressing the ‘continued need to recognise areas of landscape significance at a regional level’. The 1999 Dumfries and Galloway Structure Plan therefore identifies 10 Regional Scenic Areas (RSAs) to be protected. which supersede areas previously designated as AGLV or ARSS. They often incorporate NSAs and provide protection for the wider landscape around them. Together these provide protection to those areas of special scenic interest, which form the most valued landscapes in Dumfries and Galloway.

The 35km study area for the proposed development includes parts of three RSAs described below.

Solway Coast RSA

This area embraces the varied coastlines stretching from the Fleet Valley and the Galloway Hills RSA to Powfoot in the east. Most of the Solway Coast RSA is located within the 35km study area of the proposed development. It encompasses the estuaries of the Fleet, Dee, Rough Firth / Auchencairn Bay and Nith and the contrasting intervening rugged shores and associated coastal uplands. It also encompasses the Stewartry Coast and Nith Estuary NSAs. The area exhibits a diverse mixture of coastal landscape types. In the west there are rocky coastlines of cliffs, raised beaches and isolated coves backed by smooth undulating landscapes of improved pastures and gorsey peninsulas. There are also uplands of steep sided, rocky granite hills which contrast with areas of smoother topography and pasture but provide an important part of the setting of the coast. These uplands are juxtaposed with flat exposed coastal landscapes and estuaries to the east around the Nith Estuary. Views across the Solway to the Cumbrian Mountains and the Isle of Mann contribute to the scenic quality of the area.

Galloway Hills RSA

This area centres on the granite uplands of central Galloway, extending from the Ayrshire boundary south to where the hills meet the sea. Only the southern section of the Galloway Hills RSA is located within the study area of the proposed development. It mainly constitutes the valley of Loch Ken and the Fleet Estuary NSA. South of the Fleet Estuary the area merges into the Solway Coast RSA.

Terregles Ridge RSA

This area contains and forms the western setting to Dumfries, separating the Nith Valley from the drumlin landscapes stretching west to Castle Douglas. The designated area is based on the northern section of the Nith Estuary and Criffel Uplands, and extends slightly into the study area for the proposed development. The RSA is dissected by the Old Water and other tributaries of the Nith which create a very diverse landscape of transitional uplands and valleys concentrated in a small area.

HISTORIC GARDENS AND DESIGNED LANDSCAPES

There are several sites listed on the Register of Historic Gardens and Designed Landscapes in Scotland within the study area. These are described below.

Arbigland

Arbigland is situated on the western shore of the Nith Estuary on the Solway Firth, 1 mile south of Kirkbean, on a flat coastal plain with extensive views across the Solway Firth to the Lake District. The site includes 268 ha of designed landscape surrounding the main house. The present house was built in 1755, previously Arbigland Hall was built ~1500 on the site of a castle used from the Iron Age until that time. The earlier designed landscape of Arbigland Hall was incorporated into the more recent landscape set out when the present house was built.

The grounds consist of parkland, woodland policies and farmland. The sea views have been an important influence in landscape development. There are also woodland and ornamental gardens to the east and southeast of the house and a kitchen garden to the south. More recent gardens have been laid out surrounding the "House by the sea" closer to the shore.

The gardens are open to the public throughout the year and are considered to have high value as a work of art, historically, architecturally and horticulturally. The scenic value is considered to be outstanding and there is a high nature conservation value.

Barnhourie Mill

This property is situated in the hamlet of Sandyhills, 0.5km from the Solway Coast and 10km south of Dalbeattie on the A710. It includes a Mill and Millers House in 3.5ha of woodlands and gardens including Fairgirth Burn. The Mill dates from the 17th century. The garden was overgrown when bought by the present owners and has been cleared and developed by them since 1959. They specialise in growing dwarf species of Rhododendrons. The garden is open for one day every year and is considered to be of high value as a work of art and architecturally, and of outstanding horticultural value.

Brooklands

Situated in the lee of Brooklands Hill to the north of the study area, Brooklands lies 2km west of Crocketford and 12km north-east of Castle Douglas. The house overlooks the parkland with extensive views to the south to the sea and the Isle of Man can be seen on a clear day. There is open moorland beyond the parkland.

There is 52ha of designed landscape and the view south is a very important element in the design. The house was built c.1830 and the policies laid out after this. The gardens became dilapidated in the first part of the 20th century but were restored from 1947. The parkland to the south of the house forms the setting for the views. The estate also includes a woodland garden and a walled garden. It is open to the public for a few days every year and is considered of high value as a work of art and architecturally.

Broughton House

Broughton House is situated on the High Street of Kirkcudbright on the East Bank of the River Dee. The garden is 0.8ha and runs from the house down to the bank of the Dee.

The property was owned by Hornel in the early 20th century, who was an influential Scottish artist and one of the founders of the Glasgow School of Impressionist Painters. He remodelled the garden and added a gallery at the rear of the house. The house is now the Hornel Art Gallery and held by a trust set up by Hornel. The House is 18th Century Category A listed, as is the garden ornamentation. The garden and the gallery are open to the public throughout the year. The garden is considered of outstanding value as a work or art and an example of Hornel's art. It is of high historical and architectural value.

Cally

Cally Palace Hotel and Park is situated on the east side of the Water of Fleet and south of Gatehouse of Fleet, south of the A75. The park is a Victorian Designed Landscape although much has been lost to Forestry Commission plantations and the new A75(T) bypass which divides Cally Park into two.

The house was built in the late 17th century and was subsequently improved in the mid 19th century at which time the grounds were landscaped. It was sold to the Forestry Commission in 1939 who then sold it on as a hotel but kept much of the grounds and began planting commercial forestry. The house is currently a hotel although the original family still own the remainder of the estate. The house is Category A listed and some parkland remains although much has been lost. Most of the original design has been lost but the remaining parkland still forms an important setting for Cally Palace.

Threave Gardens

The gardens are situated 3km south west of Castle Douglas off the A75 overlooking the River Dee. There are long views north and south along the river from the gardens. Threave House is set in 42 ha of designed landscapes.

The house was built in 1872 and given to the National Trust in 1957. In 1960 the Threave School of gardening was set up which takes 8 students per year. The landscape was laid out by the original owner of the house and consisted of parkland, much of which has been converted into gardens created since 1960 which form demonstration borders for students and visitors. The gardens are open to the public all year round. They are considered of high value as a work of art and for architectural features and of outstanding horticultural value.

Cumbria

Landscape designations for England and Wales, which are present along the Cumbrian Coast are described below.

NATIONAL PARKS

A National Park is a large area of countryside that is specifically protected by law. There are ten areas designated as National Parks within England and Wales, created by the National Parks and Access to the Countryside Act 1949. The 1995 Environment Act restated and redefined the National Park rationale. The purpose of the designation is defined as follows:

- To secure and enhance the natural beauty, wildlife, and cultural heritage of such areas; and
- To promote opportunities for the understanding and enjoyment by the public of special qualities of these areas.

A National Park Authority for each National Park acts as the main authority for planning control and management, while the Countryside Agency / CCW perform important advisory roles.

Lake District National Park (LDNP)

The eastern part of the study area lies within the LDNP. It is the largest and most visited National Park in England, however only its western extremities are located within the 35km study area, including the areas around Bassenthwaite Lake near Skiddaw, Grassmoor and Ennerdale. The LDNP Authority defines the special qualities that give the area its distinctiveness as the:

- Combination of spectacular natural features and farmed landscapes;
- Opportunities for quiet enjoyment;
- Diversity of landscape;
- Open nature of fells;
- Lakes, tarns and rivers;
- Semi-natural woodlands;
- Character of settlements;
- Wide range of outdoor activities; and
- Social and cultural roots and rich legacy of the past.

AREA OF OUTSTANDING NATURAL BEAUTY (AONB)

AONBs are those areas that are not National Park but are considered amongst the most valuable in England and Wales and that are protected and managed by law to maintain their special character. They are selected and designated by the Countryside Agency under the Countryside and Rights of Way Act 2000 (CRoW) and at present over 20,000 square km of land in England and Wales designated as AONB. The primary purpose of the AONB designation is to conserve and enhance natural beauty, while taking account of the needs of agriculture, forestry, rural industry and the economic and social needs of local communities. Unlike National Parks, recreation is not an objective of designation, but demand for recreation is met so far as this is consistent with the conservation of natural beauty. The designation requires local authorities to devise strategies and plans for AONB management.

Solway Coast AONB

The Solway Coast AONB is located within the study area boundary, to the north east of the proposed development and follows 59km of the northern Cumbrian coast between Maryport and Rockcliffe. The AONB occupies an area of 115 sq. km, covering a large part of the English Solway coastline. The area is predominantly agricultural in character and, apart from the eastern section, is remote from large conurbations. The area has international importance for bird life, is valued for plant and animal habitats and natural features together with its wealth of important archaeological remains and historical features. The AONB contains a rich variety of habitats and landscapes including sand dunes between Maryport and Silloth, extensive salt marshes between Skinburness and Rockcliffe, inter-tidal mudflats, sand and shingle beaches and agricultural land. Coastal areas offer expansive views north over the Solway Firth to Scotland and views to the south Lake District mountains.

A management plan for the Solway Firth AONB was produced in 1998 by the Solway Rural Initiative, which aims to assist in co-ordinating all those involved in the management, use and enjoyment of the area. The distinctive landscape components of the AONB have been identified in four zones as follows:

- The Sand Dune Coast;
- The Salt Marsh Coast;
- Raised Mire Zone; and
- Agricultural Land.

Management proposals have been defined for each zone, which provide objectives for key issues such as landscape, nature conservation, trees and woodland, agriculture, settlement, cultural heritage and recreation.

HERITAGE COAST

The Heritage Coast classification scheme was initiated in 1972 to protect coastline of special scenic and environmental value from undesirable development. These areas of coastline exceed 1 mile in length and are selected for their exceptionally fine scenic quality and features of special interest. The National Trust owns much of the designated coastline. There are 43 designated Heritage Coasts in England and Wales. In England the Countryside Agency manages the Heritage Coasts. Some 31% of the coast in England and 42% in Wales is protected under the heritage coast scheme. Many of these coasts are part of larger National Parks or AONBs, and the protected area extends inland for an average of 1.5 miles.

St Bees Heritage Coast

The St Bees Heritage Coast is located within the study area boundary, approximately 26km to the south east of the proposed development. St. Bees is the only heritage coast between Anglesey and the Scottish border and is the only sea cliff in that area. The cliffs are dramatic, composed of striking red sandstone some 300 feet high, and afford excellent views north to Scotland and across to the Isle of Man. St. Bees is named after St. Bega, a 7th century Irish saint who founded a priory here. A national trail crosses the cliffs from Whitehaven to the beach at St. Bees. There is an RSPB nature reserve, which provides several viewing stations for observing nesting colonies of puffins, razorbills and the only British colony of black guillemots. There is a long stretch of beach, much of which has been designated a Site of Special Scientific Interest (SSSI), due in part to the variety of shellfish, crab, and mussels that occur. The Cumbria Coastal Path that runs between Carlisle and Milnthorpe passes along the Heritage Coast. The popular Coast to Coast long distance path also begins at St. Bees. Copeland District Council deal with planning applications and the RSPB own and manage a substantial length of the coastline at St. Bees.

COUNTY LANDSCAPE

County Landscapes are those areas designated by the local planning authority, under the Cumbria and Lake District Joint Structure Plan 1991 – 2006, as of county importance for their particular topographical, visual, cultural or historical characteristics. There are significant areas of County Landscape within the 35km study area for the proposed development, mainly situated around existing national landscape designations at St Bees Heritage Coast, the LDNP and Solway Coast AONB. County Landscapes replace Areas of Great Landscape Value defined in previous plans but tend to be more selective and cover fewer areas of the County. Their designation aims to conserve some of the most attractive landscape outside the National Parks and AONBs.

PARKS AND GARDENS OF SPECIAL HISTORIC INTEREST

Workington Hall

Situated to the east of Workington on the road to Stainburn. The hall was originally a mid 14th century fortified tower rebuilt in the eighteenth century at which time the grounds were extended and the estate planned and laid out. It is currently owned by Allerdale District Council. The estate includes areas of parkland, woodland and a walled kitchen garden to the south of the hall. The upper park is now farmed and has lost its parkland trees. There is a school and playing fields in the north-west corner and some housing development along the northern edge.

HADRIANS WALL WORLD HERITAGE SITE

Hadrians Wall extends as far west as Bowness-on-Solway, marking the westernmost fording point of the Solway. This end of the wall falls just outside the study area. Hadrians Wall has been designated as a World Heritage Site. This designation is continued to include the associated forts at Beckfoot, Maryport, Workington and Moresby (near Whitehaven). Between the end of the wall and the fort at Maryport, a series of smaller towers and milefortlets are interspersed between the main forts, although some have been lost to erosion in Allonby Bay. These smaller sites are designated as Scheduled Ancient Monuments and form part of the setting of the World Heritage Site. All the sites from Bowness Common, along the coast to Moresby, are within the study area. These sites form part of one of the most significant complexes of archaeological remains in the world and are an important part of the cultural heritage and landscape of the area. As such they are very important for tourism along this part of the Cumbrian coast. Most of the sites are situated within agricultural areas and the setting of the World Heritage Site along the Cumbrian coast incorporates many areas subject to other landscape or natural habitat designations. The management of the World Heritage Site has important links with supporting agriculture in the area and the conservation of important landscapes and habitats, as well as the conservation and investigation of the archaeological remains and the promotion of tourism and associated development.

7.7.3.5 Strategic Policy Guidance

Limited policy guidance exists for the development of offshore wind farms in the United Kingdom. This section summarises relevant national and local guidance on the effects of wind farm development on landscape and the coastline.

Scotland

NATIONAL PLANNING POLICY GUIDANCE (NPPG)

There is limited strategic policy guidance available on the siting of wind turbines offshore, because as noted in NPPG 6 'developments are likely to be below the low water mark and fall outwith the planning system for consideration.' Guidance considered to have some relevance to this section is summarised below:

- NPPG 6 Renewable Energy Developments
  '*The size and scale of the development and its relationship to the characteristics of the locality and landform in which it is to be built will be a relevant consideration. The visibility of a wind farm may in some circumstances raise concerns, although distance as well as landscape and topography will affect its prominence.'*

- NPPG 13 Coastal Planning
  'As the visibility of new development can be very pronounced on the coast, buildings and structures associated with the provision of renewable energy should be allowed on the undeveloped coast where they are primarily aimed at meeting local demand and, as far as is practicable, are sited in an unobtrusive location.'

- PAN 45 Renewable Energy Technologies
  'Scotland has a variety of landscapes. Some will be able to accommodate wind farms more easily than others, on account of their landform and relief and ability to limit visibility. Some are highly valued for their quality. There are no landscapes into which a wind farm will not introduce a new and distinctive feature. Given the Scottish Ministers' commitment to addressing the important issue of climate change and the contribution expected from renewable energy developments, particularly wind farms, it is important for society at large to accept them as a feature of many areas of Scotland for the foreseeable future.'

England and Wales

Planning Policy Guidance Note 20 (Coastal Planning) and Planning Policy Guidance Note 22 (Renewable Energy) do not provide any specific guidance on the effects of offshore wind farms on landscape.

7.7.3.6 Local Planning Guidance

Dumfries and Galloway Adopted Structure Plan 1999

The following policies are considered to have some indicative relevance to the landscape and seascape assessment, although it is important to note that the Robin Rigg development lies outside the jurisdiction of the local planning authorities and will therefore not be directly considered against local planning policy in either England or Scotland.

- Policy E1 *National Scenic Areas*

'The siting and design of development should respect the special nature of the area. Development within or which would have a significant impact on National Scenic Areas will only be permitted where it can be demonstrated that either:

1) The proposed development will not compromise the area's scenic and landscape character and overall integrity; or

2) Any significant adverse effects on the scenic interest and integrity of the area are clearly outweighed by social or economic benefits of national importance.'

- Policy E2 *Regional Scenic Areas*

  'The siting and design of development should respect the special nature of the area. Development within, or which would have a significant impact on Regional Scenic Areas, may be permitted where it can be demonstrated that:

  1) the landscape character and scenic interest for which the area has been designated would not be adversely affected; or

  2) there is a specific need for the development at that location which could not be located in a less sensitive area.'

- Policy E3 *Landscape character*

  'When assessing development proposal likely to have a significant impact on the landscape the Council will take into account the guidance set out in the Landscape Assessment.'

- Policy E7 *Coastal Development*

  'Development proposals will be assessed in relation to the developed and undeveloped coastal areas shown on map E5. These areas will be defined more clearly in local plans. When assessing coastal development proposals the Council will also consider the impact of natural heritage and coastal process, including discharges to air or water, any engineering works required and the design and layout of the scheme.'

Draft North West Regional Planning Guidance

The following policies are considered to be relevant to the landscape and seascape assessment:

- Policy ER1 *Landscape*

  'Development plans and environmental strategies should seek to conserve and wherever possible enhance the existing rich diversity of the landscapes in the North West, embracing coastal, rural and urban areas, underpinned by landscape character assessments that includes those produced by the regions local authorities. All policies should also afford the continued protection of those landscapes that are particularly sensitive due to their distinctive character and high landscape value, in particular protecting those areas and features of international and national importance from irreversible development.'

Cumbria and Lake District Structure Plan 2000

The following policies are considered to be relevant to the landscape and seascape assessment:

- Policy 2 *Conserving the Natural and Built Environment*

  'The County's scenic Beauty, natural resources and the quality of its built environment will be protected from inappropriate development, especially those areas and features of international or national importance where harmful development will not be permitted.'

- Policy 11 *Landscapes of national importance*

  'Development and other land use changes detrimental to the present characteristics and qualities of the landscape of the National Parks, AONBs and the Heritage Coast will not normally be permitted. Particular regard will be paid to the protection and enhancement of undeveloped open countryside and coast, the lakes and other sensitive locations, and in addition in National Parks the character of land identified on Section 3 Conservation maps. Development required to meet local infrastructure needs which cannot be located elsewhere, will normally be permitted provided it is sited to minimise environmental impacts and high standards of design.'

- Policy 12 *Landscapes of county importance*

  'Development and other land use changes detrimental to the distinctive character of designated County Landscapes, will not normally be permitted. Development required to meet local infrastructure needs which cannot be located elsewhere, will normally be permitted, provided it is sited to minimise environmental impacts and meets high standards of design.'

- Policy 54 Major Projects

  'Major developments which are more national than local in character and have significant environmental effects will only be permitted where:

  i. the sum of national, regional and local benefits is shown to clearly outweigh any harm or risks to the local or wider environment, and

  ii. the proposed scheme will be carried out in such a manner as to cause the least practicable harm, and

  iii. direct and indirect adverse impacts during construction and during operation (including those from the winning and working of construction materials, the disposal of waste and their transportation) are minimised, and

  iv. they do not harm areas or features of international or national conservation importance except where it can be demonstrated that the value of the benefits that would arise clearly outweigh the international or national conservation value of the interest affected, and in addition:

    - *in National Parks a case can be made in the national interest and all reasonable alternative locations and methods of satisfying the need have been explored and shown to be unacceptable;*
    - *in AONB's a case can be made in the national interest and all reasonable alternative locations have been explored and shown to be unacceptable.*

- Policy 56 Renewable Energy proposals

  Renewable energy developments which have no significant adverse impact on the environment, landscape or local communities will normally be permitted. Renewable energy developments which will have significant adverse impacts will only be permitted if this impact is outweighed by the energy *contribution and other benefits including reducing pollution. Large scale proposals for renewable energy developments within or affecting the National Parks and other areas and features of international or national conservation importance will be considered under policy 54.*'

7.7.4 BASELINE LANDSCAPE AND SEASCAPE ASSESSMENT

7.7.4.1 Seascape Character: Extent of Study Area

The study area for the landscape and seascape assessment is defined by the visual envelope of the proposed development. It is common practice for the potential effects of a proposed onshore wind farm to be assessed within a 25km radius study area. The study area for the seascape, landscape and visual assessment of the proposed offshore wind farm at Robin Rigg has been defined at 35km to ensure that the greatest potential extent of visibility has been considered in the assessment.

On this basis, the coastal extremities of the study area are defined by Fleet Bay to the west, the channel of the River Eden to the east and St. Bees Bay to the south.

Survey work established that the landward boundary of seascape units is not fixed and varies according to the extent of views from land to sea and views from sea to land, which are primarily influenced by topography and land cover. Field survey work and a ZVI have therefore been used to verify the extent of the landward boundary of seascape units. This confirmed that the landward boundary of seascape units in the study area varies between 2 to 10km.

Landscape character types have been identified and assessed beyond the landward boundary of the seascape character types, within the 35km radius study area.

Along the coast of the Solway Firth, theoretical seaward boundaries between adjacent units can only be defined in the distinct areas of indented coastline at the mouths of Kirkcudbright Bay and Auchencairn Bay. Elsewhere, the seaward extent of seascape character units can be based best on distance of views, as the sea has no variance in topography, landcover, geology etc, which define landscape character types. Such views would overlap to a large extent and are entirely dependent on prevailing weather conditions. The seaward boundaries and extent of views to sea have therefore been described in the assessment, rather than delineated according to a prescribed hypothetical drafting method.

7.7.4.2 Seascape Characterisation

Introduction

The methodology proposes that national seascape units should be defined as 'extensive sections of coast with an overriding defining characteristic such as coastal orientation or landform'. In general these units will be defined by major headlands of national significance and extend up to 24km offshore. Although no national seascape units have been identified, the CCW guidelines propose that Coastal Management Units (CMUs) could form the basis for the national units for the UK. It is considered that the coast between Fleet Bay and St. Bees Head falls within one national Solway Firth seascape unit.

The site for the proposed Robin Rigg offshore wind farm is situated roughly at the centre of this national unit, approximately 32km to the east of Fleet Bay and 27km north of St. Bees Head.

Regional Seascape Units within Study Area

The Solway Coastline within the Solway Firth national seascape unit can be sub – divided and assessed at the regional level. Regional units have been identified on the basis of visually distinct sections of coast, views from land to sea and sea to land, topography and seascape character. The assessment provides a description of the defining characteristics of each regional seascape unit, which have been derived from field and desk survey work. These include:

- the physical form of marine area, coastline and hinterland;
- the extent of landward and seaward boundaries;
- the nature of views from sea to land and the views from land to sea;
- activities and receptors;
- aesthetic factors;
- designated landscape; and
- scale of landscape.

The quality of each of the regional seascape units has been evaluated and negative / positive characteristics considered. The sensitivity of each of the identified regional seascape character units has also been evaluated in relation to the proposed development. This is considered as the vulnerability of a particular seascape unit to the anticipated change and is classified as high, medium, low or negligible.

The assessment has identified 13 regional seascape units within the study area as follows:

DUMFRIES AND GALLOWAY COAST:

- Fleet Bay;
- Kirkandrews Peninsula;
- Kirkcudbright Bay;
- Dundrennan Peninsula;
- East Stewartry Coast;
- Mersehead Sands; and
- Nith Estuary;

CUMBRIAN COAST:

- Moricambe Bay;
- Silloth Coast;
- Allonby Bay;
- Maryport Coast;
- Workington and Whitehaven Coast; and
- St. Bees.

These seascape units are shown in Figure 7.7.1 and described in detail in Appendix G4 in the separate volume of appendices. The assessment of seascape units is summarised in Table 7.7.1.

Table 7.7.1 Summary of Seascape Character Units

Seascape unit	Designations	Sensitive receptors	Views	Quality	Sensitivity to change to development outwith seascape unit
Dumfries and Galloway Coast					
Fleet Bay	Fleet Valley NSA	Residents Tourists Road users	Short distance across bay Long distance framed to sea	High	High
Kirkandrews Peninsula	Solway Coast RSA	Residents Tourists	Open, medium to long distance	Medium	Medium
Kirkcudbright Bay	Solway Coast RSA SSSIs	Residents Tourists Road users Walkers Angling Scuba diving Sailing	Closed, short to long distance	High	High
Dundrennan Peninsula	Solway Coast RSA SSSIs	Residents Road users Angling Beaches Walkers MOD activities	Open, medium to long distance	Medium	Medium
East Stewarty Bay / Coast	East Stewarty Coast NSA SSSIs	Residents Sailing Tourists Angling Walkers Bathing beaches Birdwatching Windsurfing Road users	Closed, short to long distance	Exceptional	High
Mersehead Sands	East Stewarty NSA Inner Solway Marshes SSSI, SPA, SAC, Ramsar Site	Residents Road users Golfers Walkers Tourists Bathing beach	Panoramic, long distance	High	High
Nith Estuary	Nith Estuary NSA Inner Solway Marshes SSSI, SAC, SPA, Ramsar Site	Residents Golfers Tourists Walkers Angling Road users	Open, long distance	High	High

Seascape unit	Designations	Sensitive receptors	Views	Quality	Sensitivity to change to development outwith seascape unit
Cumbrian Coast					
Moricambe Bay	Solway Coast AONB Inner Solway Marshes SSSI, SAC, SPA, Ramsar Site	Residents Walkers Birdwatchers Road users	Panoramic, long distance	High	Medium
Silloth Coast	Solway Coast AONB Inner Solway Coast SSSI, SPA, SAC, Ramsar Site	Residents Golfers Road users Walkers Tourists Bathing beaches	Open, long distance	High	High
Allonby Bay	Solway Coast AONB	Residents Walkers Golfers Bathing beach Windsurfing Angling Tourists Road users	Open, long distance	High	High
Maryport Coast	None	Residents Road users Rail route Walkers Tourists Industry	Short to long distance	Low	Low
Workington to Whitehaven Coast	None	Residents Road users Walkers Diving Sailing Golfers Tourists Cyclists	Short to long distance	Low	Low
St. Bees	St. Bees Heritage Coast County Landscape	Walkers Residents Tourists Road users Rail users	Panoramic, long distance	High	High

7.7.4.3 Landscape Characterisation

The assessment of landscape character and quality has concentrated on the area to the landward side of the boundaries of seascape units within the 35km radius study area, centred on the proposed offshore wind farm at Robin Rigg. A landscape character assessment of the Dumfries and Galloway region was carried out in 1998 by Scottish Natural Heritage, in partnership with the local authority and other agencies. A landscape character assessment of the Cumbria region was carried out in 1995 by Cumbria County Council. These studies provide a detailed assessment of the landscape character of the study area, consider the likely pressures and opportunities for change in the landscape, assess the sensitivity of the landscape to change and include guidelines indicating how landscape character may be observed, enhanced or restructured as appropriate. A field survey was also carried out to verify and amend as necessary the character types identified within the study area. By identifying areas of similar topography, landcover, landuse and landscape elements, the study area has been divided into 18 landscape character types. The boundaries of the character types identified within the Dumfries and Galloway and Cumbria landscape character assessments have been amended at their interface with seascape units. There is no existing landscape character assessment of the Lake District National Park, therefore desk analysis and fieldwork were required to identify landscape character types in this area. The character and quality of the landscape types are described and key landscape characteristics identified in order to provide a baseline against which the potential impact of the proposed wind farm on the landscape and visual amenity of the area can be judged. Landscape character types are identified in Figure 7.7.1 and are described as follows:

Dumfries and Galloway Coast:

- Coastal fringe;
- Coastal flats;
- Narrow wooded valley;
- Lower dale;
- Flooded valley;
- Drumlin pastures;
- Upland fringe;
- Foothills;
- Foothills with forest;
- Coastal granite uplands.

Cumbrian Coast:

- Coastal margins;
- Lowland;
- Lowland valley corridor;
- Intermediate moorland and plateau;
- Upland fringes;
- Higher limestone;
- Lakeland high fells;
- Lakeland lakes and valleys.

Figure 7.7.1 (landscape and seascape character areas as sent by Enviros) should sit here instead of this page

These landscape character types are described in detail in Appendix G4 of the volume of appendices and summarised in Table 7.7.2 below.

Table 7.7.2 Summary of Landscape Character Types

Landscape character type	Designations	Sensitive receptors	Views	Quality	Sensitivity to change to development outwith landscape type
Dumfries and Galloway Coast					
Coastal fringe	Galloway Hills RSA	Residents Road users	Medium distance	Medium	Medium
Coastal flats	Nith Estuary NSA NNR SSSI	Residents Road users	Open, long distance	High	High
Narrow wooded valley	Small parts within the East Stewart NSA Solway Coast RSA	Residents Road users	Short to medium distance corridor views	Medium	Low
Lower dale	Nith Estuary NSA Terregles Ridge RSA	Residents Road users	Open, medium to long distance	Medium	Low
Flooded valley	Galloway Hills RSA Loch Ken SPA and Ramsar Site Rive Dee SSSI	Residents Road users Walkers Birdwatchers	Open, long distance corridor views	High	Low
Drumlin pastures	Lock Ken SPA SSSIs	Residents Road users	Open, medium distance	Medium	Medium
Upland fringe	None	Residents Road users Walkers Visitors	Open, long distance	Medium	Medium
Foothills	None	Residents Road users Walkers	Open, medium distance	Medium	Medium
Foothills with forest	Woodhall Loch SSSI	Residents Road users Walkers Visitors	Short to medium distance	Medium	Low
Coastal granite uplands	East Stewarty Coast NSA Nith Estuary NSA Solway Coast RSA	Residents Road users Tourists Walkers	Panoramic, long distance views	High	High

Landscape character type	Designations	Sensitive receptors	Views	Quality	Sensitivity to change to development outwith landscape type
Cumbrian Coast					
Coastal Margins	Wedholme Flow SSSI	Residents Road users	Open, long distance	Medium	Medium
Lowland	SSSIs	Residents Road users Walkers Cyclists Tourists	Open, long distance	Medium	Medium
Lowland valley corridor	None	Residents Road users	Short to medium distance corridor views	Medium	Low
Intermediate moorland and plateau	County Landscape	Residents Road users	Open, long distance	Medium	Medium
Upland fringes	County Landscape SSSIs	Residents Walkers Road users	Short to long distance	High	High
Higher limestone	County Landscape LDNP	Residents Road users	Open, long distance	High	High
Cumbrian high fells	LDNP	Residents Road users Walkers	Panoramic, long distance	Exceptional	High
Cumbrian lakes and valleys	LDNP	Residents Road users Walkers	Short to medium distance corridor views	Exceptional	Low

7.7.5 SELECTION OF KEY VIEWPOINTS

A list of viewpoints was assembled following analysis of early Zone of Visual Influence maps for early layouts, from which key viewpoints for assessment and to aid in the design of the wind farm layout would be selected. A number of key concepts were used in the selection of the pool of viewpoints. These included:

1. Viewpoints within 35 km, the estimated limit of potential landscape and visual effects for a wind farm of this size and nature.
2. Viewpoints only selected where the ZVI map shows that views of the wind farm would theoretically be possible
3. Selection of viewpoints distributed as far as possible around the compass
4. Selection of viewpoints from a variety of character types i.e. inland and coastal, built up and remote
5. Inclusion of the closest points on land to the proposal on both sides of the Firth

6. Selection of viewpoints with a range of altitudes
7. Selection of representation of views from areas with a larger number of potential viewers:

   i) communities: In Scotland there are no large communities within 35 km with views of the proposal. The smaller communities that potentially had views included Southerness and Powfoot and villages along the A710 and A711. In England there are a number of larger communities along the coast with potential views of the proposal including Maryport, Workington and Whitehaven and a number of smaller communities along the coast including Silloth and Allonby and occasionally inland.

   ii) roads: trunk roads will have the largest number of travellers on them who might be exposed to views of the proposal. In Scotland, views of the proposal would not extend far inland and the only section of trunk road that might have a view of the proposal is a short raised section of the A75 half way between Annan and Dumfries. The only other A-roads in Scotland with a potential view of the proposal were the A710 and the A711. In England, both the A596 and A595 trunk roads would have potential views of the proposal both inland and on the coast, along generally localised short stretches. Other smaller coastal roads with potential views of the proposal would be the B5301 and the B5300.

   iii) railway lines: A short stretch of the railway line between Annan and Dumfries had potential distant views of the proposal. The only other railway line with potential views of the proposal was the Cumbrian west coast line between Whitehaven and Maryport.

   iv) places of leisure interest including: footpaths, both on the coast and inland on mountain and forest walks; popular beaches; coastal attractions and promontories, campsites and holiday villages, nature reserves with a large number of bird enthusiasts, and representative positions at sea in areas used for yachting..

9. Selection of views from within areas designated for their scenic value: In Scotland this included National Scenic Areas and Regional Scenic Areas along the coast. In England it included the Solway Firth Area of Outstanding Natural Beauty and the Lake District National Park.

From this pool of 33 viewpoints a shortlist of key viewpoints was chosen for detailed assessment as given in Section 9.10 of this statement. The selection was carried out in consultation with Scottish Natural Heritage, Dumfries & Galloway Council, the Lake District National Park Authority and Cumbria County Council. The list of viewpoints is provided below with commentary. Viewpoints which are shaded in the table have not been selected for detailed assessment for the reasons indicated. In Section 9.10 photomontages of the development have been prepared from primary viewpoints, with computer generated 'wireframes' of the development and panoramic photographs provided for secondary viewpoints.

Table 7.7.3: Review of Viewpoints

No	Name	Distance from site (km)	Grid reference	Receptors	Rationale / comment
1	A711, Auchencairn Topograph	12.8	278047 549818	Road users Residents	Chosen for final assessment. Provides representative views from the A711and marked viewpoint.
2	Rascarrel Bay	10.1	280152 548060	Walkers Visitors	Not chosen for detailed assessment as representative views from this are provided by viewpoint 1 and viewpoint 3.
3	Balcary Point	8.9	282821 549188	Walkers	Chosen for final assessment. Closest land based viewpoint to the proposed wind farm. East Stewartry Coast NSA.
4	A711, Torr House	13.4	280120 552760	Residents Road users	Not chosen for final assessment. More representative viewpoints elsewhere in Auhencairn Bay included.
5	Screel Hill, Forest Walk	16.2	278560 555158	Walkers	Chosen for final assessment. Provides representative views from coastal uplands over the East Stewartry Coast NSA and Solway Coast RSA.
6	Doach Wood Forest	17.8	279846 557852	Walkers	Not chosen for final assessment. Screel Hill chosen as representative viewpoint from coastal uplands.
7	Moyle Hill	15.3	284852 557351	Walkers	Not chosen for final assessment. Screel Hill chosen as representative from coastal uplands. No public footpath to summit.
8	Glen Isle	13.3	283400 554668	Walkers	Not chosen for final assessment. Representative viewpoints chosen elsewhere in Auchencairn Bay e.g. viewpoint 31.
9	Mote of Mark, Rockcliffe	12.3	284526 554006	Residents Tourists/ Visitors	Chosen for final assessment. Visitor / tourist attraction. Representative views from Rockcliffe residential area. Located in East Stewartry Coast NSA.
10	Castlehill Point	10.5	285448 552407	Walkers Tourists/ Visitors	Chosen for final assessment. Close land based viewpoint in East Stewartry Coast NSA. Accessible for tourists / visitors to Rockcliffe.
11	Torbay, approach to Rockcliffe	11.7	286267 554063	Residents Tourists	Not chosen for final assessment. Intermittent visibility to coast. Representative viewpoints chosen at Mote of Mark and Castlehill Point.
12	The Torrs, Portling	11.5	288796 554476	Walkers Tourists/ Visitors Golfers	Chosen for final assessment. Provides representative views from coastal walk between Rockcliffe and Sandyhills Bay.
13	Fairgirth Hill	13.7	289015 556751	Walkers	Not chosen for final assessment. Screel Hill chosen as representative from coastal uplands. No public footpath to summit.
14	A710, Mainriddle	14.4	295258 556855	Residents Road users	Chosen for final assessment. Provides representative views from the A710 running along the Dumfries and Galloway coast.

No	Name	Distance from site (km)	Grid reference	Receptors	Rationale / comment
15	Southerness Point	13.0	297750 554241	Residents Tourists / Visitors Caravan site Golfers	Chosen for final assessment. Prominent headland in the Solway Firth. Range of receptor types including holiday use, residential and recreation.
16	Criffel	19.4	295729 561866	Walkers	Chosen for final assessment. Most elevated viewpoint in Dumfries and Galloway. Footpath/accessible. Located within Nith Estuary NSA.
17	Ward Law overlooking Caerlaverock	26.2	302415 566651	Birdwatchers and visitors	Not chosen for final assessment. Over 25km from proposed development. No public footpath to summit.
18	A75 Kellhead Moss	34.8	313082 570046	Visitors / recreation Road users	Not chosen for final assessment. Over 30km from proposed development. Visibility from estate/wooded landscape.
19	Camp Site, Powfoot	32.0	314229 565214	Tourists – campers / caravans	Not chosen for final assessment. Over 30km from proposed development. Other closer viewpoints representative e.g. Southerness Point.
20	Sea Forth, Silloth	23.1	311283 554421	Residents Tourists – campers / caravans	Not chosen for final assessment. Over 20km from proposed development. Other residential settlements on Cumbrian Coast which are closer included.
21	Cumbria Coastal Way, Mawbray Bank	17.0	308099 546951	Walkers	Chosen for final assessment. Provides representative views from the Cumbria Coastal Way. Located within the Solway Coast AONB.
22	Allonby Sea Front	16.3	308091 542177	Residents Road users Recreation	Not chosen for final assessment. Representative views provided from Mawbray Bank and residential areas to the south.
23	A1596(T) Aspatria	21.7	313438 541503	Residents Road users	Not chosen for final assessment. Over 20km from proposed development. Intermittent visibility from settlement.
24	A595, Wharrels Hill, Bothel	25.8	317252 538030	Road users	Not chosen for final assessment. Over 25km from proposed development. Intermittent visibility from A595.
25	Maryport Marina	12.5	302870 536426	Residents Tourists/ Visitors	Chosen for assessment. Provides representative views from Maryport, urban area to the east of the site.
26	Watch Hill, Cockermouth	25.2	314760 531884	Walkers	Chosen for final assessment. One of the closest viewpoints in the LDNP. Accessible walk from Cockermouth. Located on National Trail.
27	Rail Route, Workington	12.8	299464 530133	Rail users Residents Road users	Chosen for final assessment. Provides representative views from Workington, large residential area.
28	Grassmoor, Lake District	32.9	317400 520400	Walkers	Not chosen for final assessment. Over 30km from the proposed development. Very limited visibility to coast.
29	Whitehaven Harbour	22.2	297004 518099	Residents Road users	Chosen for final assessment. Provides representative views from Whitehaven, large residential area.
30	Lighthouse, St Bees Head	24.9	293999 514609	Walkers Tourists / visitors	Chosen for final assessment. Provides representative views from Heritage Coast and National Trail from County Landscape.
31	Sea View, from due south	7.2	290000 532000		Not chosen for assessment.
32	Sea view from south west	6.0	284250 535500		Not chosen for assessment.
33	Sea view from due west	6.8	293000 541200		Chosen for assessment. Sea view closest to the NSAs on the Dumfries Coast and Kippford Sailing Club.

7.8 ARCHAEOLOGICAL BASELINE STUDY

7.8.1 OVERVIEW

7.8.1.1 Project Background

Wessex Archaeology were commissioned by Natural Power Consultants Ltd. to carry out a desktop baseline study of the marine and land-based archaeological heritage implicated by a proposed wind farm in the Solway Firth midway between the coasts of Dumfries and Galloway and Cumbria, including associated works on land.

Study Areas

Prior to the baseline study being initiated, a boundary had been identified within which the proposed wind farm would potentially be situated should surveys demonstrate it to be acceptable. In order to set data relating to the development in context, two ‘Study Areas’ (Outer Survey Area around the Development Area, and Cable Route and Coastal Study Area around the broad substation to shore cable corridor) were set out for collating information. The Study Areas comprised two boxes defined by the following NGRs:

Table 7.8.1 Outer Survey Area

Point	NGR_E	NGR_N
OSA 1	282000	545000
OSA 2	294000	551000
OSA 3	302000	538000
OSA 4	290000	532000
	Projection	*British National Grid*

Table 7.8.2 Cable Route and Coastal Study Area

Point	NGR_E	NGR_N
CSA 3	302000	538000
CSA 4	290000	532000
CSA 1	299000	526000
CSA 2	305000	539000
	Projection	*British National Grid*

Geophysical Survey Area

A geophysical survey comprising sidescan and magnetometer survey was commissioned previously by the client as described in detail in Section 6 of this ES. The extent of the Geophysical Survey Area was defined by a box as follows:

Table 7.8.3 Geophysical Survey Area

Point	NGR_E	NGR_N
F	288146	542275
X	292802	535042
Y	296664	539651
Z	292031	546810
	Projection	*British National Grid*

7.8.2 METHODOLOGY

7.8.2.1 Approach

This desktop baseline study is intended to inform the overall Environmental Impact Assessment of the Robin Rigg Offshore Wind Farm. It comprises a baseline description of known and potential archaeological resource, based on available sources.

The methodology adopted reflects best practice as codified in relevant sections the Institute of Field Archaeologists (IFA) *Standard and Guidance for Archaeological Desk-based Assessment* (IFA 1999).

The approach adopted also reflects the requirements of Environmental Assessment arising from Council Directive 85/337/EEC as amended by Council Directive 97/11/EC. However, there is little formal guidance in the UK on how the archaeological heritage should be addressed in carrying out Environmental Assessment.

7.8.2.2 Scope

The baseline study comprised the following elements:

- a broad overview of the maritime history of this part of the Solway;
- a brief background to UK policy and statutory protection given to wrecks in UK waters;
- a desktop study identifying any recorded wrecks and other features of maritime interest within the Outer Survey Area;
- a desktop examination of three potential wrecks sites found during geophysical surveys;
- an estimate of the historical importance of each recorded feature;
- definition of a suggested exclusion zone around each suspected wreck site.
- identification of any wrecks and other features of maritime interest within the Coastal Study Area (to cover possible cable routes);
- identification of features of archaeological interest in the foreshore zone and its immediate hinterland within the Cable Route and Coastal Study Area (to cover possible landfall infrastructure);
- consideration of the potential for deposits, former land surfaces and features of prehistoric date in the Outer Survey Area and Cable Route and Coastal Study Area (to cover possible impacts from piling/trenching on buried material).

7.8.2.3 Sources

Wessex Archaeology approached the principal sources of information relevant to desk-based assessment following organisations, as follows:

The Sites and Monuments Record (SMR) maintained by Cumbria County Council was approached on the 28th January 2002 for information within the Cable Route and Coastal Study Area. The SMR supplied 156 records on the 5th February 2002.

The National Monuments Record (NMR) (including the maritime section of the NMR) maintained by English Heritage was approached on the 28th January 2002 for information within the Coastal and Outer Study Areas. They responded on the 31st January 2002 with 104 land sites and 11 maritime sites.

Canmore (National Monuments Record of Scotland) was approached on the 28th January 2002 for information within the Coastal and Outer Study Areas. They responded on the 6th February 2002 stating they had no information within the two Study Areas.

UK Hydrographic Office (UKHO) was approached for information within the Coastal and Outer Study Area on the 31st January 2002. They responded on the 31st January 2002 with 7 maritime sites covering both the Coastal and Outer Study Area. The UKHO was also visited on the 7th February 2002 for cartographic and other navigational sources, including historic charts, surveys and sailing instructions.

The Receiver of Wreck (Maritime and Coastguard Agency) was approached on the 31st January 2002 for information within the Outer and Cable Route and Coastal Study Areas, but as yet has not responded.

The Naval Staff Directorate of the Ministry of Defence was approached on the 31st January 2002 for information within the Outer and Cable Route and Coastal Study Areas, but as yet has not responded.

Record Offices in Carlisle and Dumfries were visited on the 5th and 7th of February 2002. Historic maps and general information on the history of the Solway was obtained.

The Local Studies Collection for Maryport was visited on 6th and 7th February 2002, where local information was obtained on the history of the area. The Local Studies Collection in Dumfries was also consulted on the 7th February 2002, where information was obtained concerning Solway trade, shipwrecks within the Solway, and the general history of the area.

7.8.2.4 Geophysical Survey

Natural Power made available a report on the geophysical survey commissioned previously (see Appendix H inthe volume of appendices). The survey comprised a sidescan sonar survey a magnetometer survey, and a shallow seismic survey. The sidescan sonar was operated at a range setting of 100m on each channel, providing overlap between run lines. Because of the shallow nature of the area, the sidescan ‘fish’ was mounted at the bow of the survey vessel in a fixed position. A cesium magnetometer, model G881, was towed astern of the survey vessel. Data was logged in digital form in Magsea software on a separate laptop computer. In the course of the survey, five targets were found four of which were considered worthy of further investigation. These targets were investigated at a tighter line interval before the survey was completed. The results are discussed later

The shallow seismic surveys involved the collection of subsurface information using a sub-bottom profiling system. A GeoAcoustics Model 5420Asub bottom profiler was used with a sweep of 100mSecs. This allowed for a maximum achievable depth of penetration of approximately 83m, thereby ensuring that any reflectors present within this limit should be picked up by the profiling system.

7.8.2.5 Geotechnical Data

Natural Power made available logs of 13 boreholes. In addition, relevant BGS charts and reports were consulted.

7.8.2.6 Site Visit

A site visit was undertaken on 6th February 2002 to examine the foreshore area for proposed buried or overhead cables. The Study Area was viewed and digitally photographed from public land.

7.8.2.7 Methods

The known and potential archaeological resource was reviewed on the basis of the data collated above. The review has addressed all main archaeological periods and relevant themes, with an emphasis on maritime activity. Particular consideration has been given to the possible origin of the geophysical anomalies currently thought to be wrecks. Legislation, policy and guidance in respect of the protection of wrecks in UK waters has been reviewed and summarised. The study indicates the importance of the known and potential archaeological resource in its local, regional and national context. Exclusion zones are proposed around important sites that might potentially be affected by development of the wind farm.

7.8.2.8 Data and Mapping

Records from the principal sources have been collated using a bespoke MS Access-based database. Each site has been attributed a unique identification number, starting at 1001. Where records from several sources appear to refer to the same site, only a single site has been generated, cross-referenced to each of the relevant sources. The principle characteristics of each site are recorded in specific fields within the database. Summary data on each site will be produced as a gazetteer to accompany the assessment.

Documentary references to shipping losses (casualties) generally lack a specific location. The practice adopted by the NMR is to ascribe such casualties to a 'named location', i.e. a nominal but specific location corresponding to the place name given as the place of loss. Where Wessex Archaeology has identified additional casualties not previously recorded in the NMR, the same practice has been identified. Accordingly, Wessex Archaeology has created a series of named locations around the Solway to which documented losses have been ascribed.

Site data held in the database has been mapped using MapInfo. Both specific sites and totals of casualties are represented.

7.8.3 POLICY AND STATUTORY PROTECTION

7.8.3.1 Archaeological Sites

Ancient Monuments and Archaeological Areas Act 1979

Monuments that are of national importance can be protected by being added to the schedule (list) of monuments protected under the Ancient Monuments and Archaeological Areas Act 1979 (AMAA 1979). It is an offence to damage such a 'scheduled monument' or to carry out a range of specified activities, unless a licence for these activities has been obtained, in the form of 'scheduled monument consent'. Monument is a wide term that covers many types of archaeological site, including buildings, structures, works, caves, excavations and their sites. Monument can also mean the site of any vehicle, vessel, aircraft or other movable structure. As monuments that are situated in, on or under the seabed within UK territorial waters (referred to as a monument in territorial waters) can be scheduled, then it would be possible to schedule a historic wreck.

The AMAA 1979 is administered in England by English Heritage. Government policy in England is currently to use the Protection of Wrecks Act 1973 (see below) in preference to the AMAA 1979 in protecting wrecks.

In Scotland, the AMAA 1979 is administered by Historic Scotland. Historic Scotland has scheduled a group of wrecks from the German High Seas Fleet scuttled in 1919 in Scapa Flow under the AMAA 1979[262].

[262] Oxley, I. (in press) 'Scapa Flow and the protection and management of Scotland's historic military shipwrecks', *Antiquity*.

England's Coastal Heritage

England's Coastal Heritage: a statement on the management of coastal archaeology was published in 1996 by English Heritage and the Royal Commission on the Historical Monuments of England (RCHME). The statement set out a number of principles for managing coastal archaeology:

> *'The coastal zone of England includes a finite, irreplaceable, and, in many cases, highly fragile archaeological resource which by virtue of its value, variety, and vulnerability justifies a presumption in favour of the physical preservation* in situ *of the most important sites, buildings, and remains.*
>
> *'Although archaeological remains situated within inter-tidal and sub-tidal areas may be less visible and accessible than remains on dry land, this does not affect their relative importance and they should be managed in accordance with the principles which apply to terrestrial archaeological remains.*
>
> *'As historic landscapes can extend seamlessly from dry land, through the inter-tidal zone, and into sub-tidal areas, effective management of the coastal archaeological resource cannot be achieved without due consideration of marine as well as terrestrial archaeological remains.*
>
> *'Where economic development in the coastal zone is likely to impact on important archaeological remains, decisions should be taken with regard to the best available information and the precautionary approach should be adopted wherever possible.'*

The statement also included a number of detailed recommendations, which include the following:

Development control and environmental assessment	Coastal archaeological interests should be … consistently and comprehensively included in Environmental Assessment procedures for coastal and marine developments (including harbour works, mineral extraction, oil and gas related projects, capital dredging projects, cable projects, and waste water treatment and disposal) and other activities requiring sectoral consent.

Planning Policy Guidance

Planning law only applies within the territory of local authorities which, as a general rule, extends only to the low water mark. However, English Heritage and RCHME included the following statement in *England's Coastal Heritage*, referred to above:

> *'Although it remains government policy not to extend the Town and Country Planning system to the territorial sea, the principles set out in Planning policy guidance note 16: archaeology and planning should be applied to the treatment of sub-tidal archaeological remains in order to secure best practice.'*

Planning Policy Guidance: Archaeology and Planning (PPG 16) sets out the Secretary of State's policy on archaeological remains. It acknowledges the potentially fragile and finite or irreplaceable nature of such remains (para. 6), and states that the desirability of preservation of archaeological remains and their setting is a material consideration within the planning process (para. 18). PPG 16 provides that there is a presumption in favour of the physical preservation of nationally important archaeological remains (para. 8), and that where preservation *in situ* is not justified it is reasonable for planning authorities to require the developer to make appropriate and satisfactory provision for excavation and recording of remains (para. 25).

Paragraph 19 of PPG 16 suggests that it is in developers' own interests to include an initial assessment of whether the site is known or likely to contain archaeological remains as part of their research into the development potential of a site. Paragraph 22 adds: '*Local planning authorities can expect developers to provide the results of such assessments ... as part of their application for sites where there is good reason to believe there are remains of archaeological importance'*. PPG 16 also notes that in spite of the best pre-planning application research, there may be occasions when the presence of archaeological remains only becomes apparent once development has commenced (para. 31).

Planning Policy Guidance: Coastal Planning (PPG 20) notes that the coastal zone has a rich heritage both above and below low water mark, which includes buildings and areas of architectural or historic interest, industrial archaeology, scheduled and other ancient monuments and other archaeological sites (para. 2.8). PPG 20 also makes specific references to sites of archaeological and built heritage interest in the information required by local planning authorities in addressing coastal planning (para. 4.6).

Historic Scotland Operational Policy

Historic Scotland has published *Conserving the Underwater Heritage*, a Historic Scotland Operational Policy Paper[263]. The paper sets out a series of objectives and policies, which it summarises as follows:

> *'Underwater sites and terrestrial archaeological sites, areas and buildings which have underwater elements, or policy issues arising from our interest in these, should be afforded equal status in our activities, in particular in the areas of protection, management, training, archaeological fieldwork and research.*
>
> *'In promoting interest in and appreciation of Scotland's archaeological and built heritage, Historic Scotland will encourage others to operate similar principles of parity.'*

JNAPC Code of Practice for Seabed Developers

The Code of Practice for Seabed Developers, which was prepared by the Joint Nautical Archaeology Policy Committee (JNAPC), extends the principles of development-led archaeology on land to development at sea. It was endorsed by the Department of National Heritage (now DCMS) following discussion between archaeologists and many industry groups. The provisions of the Code are set out in Appendix H2 in the volume of appendices.

[263] Historic Scotland (1999) *Conserving the Underwater Cultural Heritage*, Historic Scotland Operational Policy Paper, HP6.

7.8.3.2 Wrecks

Protection of Wrecks Act 1973

Under the Protection of Wrecks 1973 (PWA 1973), wrecks and wreckage of historical, archaeological or artistic importance can be protected by way of designation. It is an offence to carry out certain activities in a defined area surrounding a wreck that has been designated unless a license for those activities has been obtained from the Government. Generally, the relevant Secretary of State must consult appropriate advisors prior to designation, though it is also possible to designate a wreck in an emergency without first seeking advice.

In England, the PWA 1973 is administered by the Department for Culture, Media and Sport (DCMS). In Scotland, the 1973 Act is administered by Historic Scotland. In both cases, specialist advice is sought from the Advisory Committee on Historic Wreck Sites (ACHWS) and a team of professional diving archaeologists employed on contract. Licenses can be obtained to carry out survey, excavation and other activities that would be otherwise prohibited.

There are no areas or sites subject to designation under the PWA 1973 within the Study Areas.

If a wreck of historical, archaeological or artistic importance is discovered in the course of the proposed works then there are means by which it can be designated under the PWA 1973 if considered necessary for its protection.

Merchant Shipping Act 1995

The ownership of underwater finds that turn out to be 'wreck' is decided according to procedures set out in the Merchant Shipping Act 1995 (MSA 1995). Finders should assume at the onset that all recovered wreck has an owner. Ownership of wreck lies in the original owner or their successor, unless they fail to make a claim to the Receiver of Wreck within one year of notification. Ownership of unclaimed wreck from within territorial waters lies in the Crown or in a person to whom rights of wreck have been granted; unclaimed wreck from beyond territorial waters is returned to the salvor.

The Receiver of Wreck has a duty to ensure that finders who report their finds as required receive an appropriate salvage payment. In the case of material considered to be of historic or archaeological importance, a suitable museum is asked to buy the material at the current valuation and the finder receives the net proceeds of the sale as a salvage payment. If the right to, or the amount of, salvage cannot be agreed, either between owner and finder or between competing salvors, the Receiver of Wreck will hold the wreck until the matter is settled, either through amicable agreement or by court judgement.

Protection of Military Remains Act 1986

Under the Protection of Military Remains Act 1986 (PMRA 1986) the Ministry of Defence has powers to protect vessels that were in military service when they were wrecked. The Ministry of Defence can designate named vessels as 'protected places' even if the position of the wreck is not known. In addition, the Ministry of Defence can designate 'controlled sites' around wrecks whose position is known. In the case of 'protected places', the vessel must have been lost after 4 August 1914, whereas in the case of a wreck protected as a 'controlled site' no more than 200 years must have elapsed since loss. In neither case is it necessary to demonstrate the presence of human remains. Diving is not prohibited at a 'protected place' but it is an offence to tamper with, damage, move or remove sensitive remains. However, diving, salvage and excavation are all prohibited on 'controlled sites', though licences for restricted activities can be sought from the Ministry of Defence.

In November 2001 the MoD reported on the Public Consultation on Military Maritime Graves and the Protection of Military Remains Act 1986 (MOD 2001). The report recommended that a rolling programme of identification and assessment be established to designate all other vessels, in military service when lost, as Protected Places. The assessment is to be carried out against criteria that include:

- Whether lives were lost;
- Evidence of sustained disturbance or looting;
- Likely effectiveness of designation;
- Public criticism or approval;
- Historical significance.

Under the PMRA 1986, all aircraft that have crashed in military service are protected automatically.

Additionally, it is an offence carry out unauthorised excavations for the purpose of discovering whether any place in UK waters comprises any remains of an aircraft or vessel which has crashed, sunk or been stranded while in military service.

7.8.4 BASELINE

7.8.4.1 Morphology, Geology and Seascape

The Development Area lies c. 12km off Maryport, Cumbria, and 9 km south of the Dumfries and Galloway coastline, and comprises the north west section of Robin Rigg sandbank, part of Middle Channel and a south west spur of Dumroof Bank. Admiralty Charts show that Robin Rigg dries to +0.9m Chart Datum (CD) and the spur of Dumroof Bank dries to +1.8m CD. Chart Datum, which is approximately the lowest astronomical tide is 4.375 m below <ean Sea Level in this area.

To the north of the Development Area, Middle Channel is charted between c. -0.6m CD and -10m CD, though the depth is changeable. On the English side of Robin Rigg, the seabed drops away into English Channel (to c. -15m CD) before rising gently to Maryport Roads between c. -2 and -10m CD. Tidal heights vary by 7.70 m between +8.6m CD (Mean High Water Springs) and +0.9m CD (Mean Low Water Springs) at Maryport (see Admiralty Chart 2013; 1346).

The admiralty charts from which the above has been taken have been superseded in the develoment area by surveys carried out in 2001 which are documented in Section 6 of this ES.
Current Admiralty Charts note that:

> *'All banks and channels in the entrance to the Solway are subject to frequent change. Mariners should not attempt to use the channels without local knowledge.'*

North of Dumroof Bank the Solway is charted as 'Unsurveyed'. Around Robin Rigg, current Admiralty Charts are largely based on surveys in 1932.

Sailing Directions of 1870 note that[264]:

> *'From abreast Maryport, and even to some distance below it, the whole body of the Solway firth is occupied by dangerous shifting sandbanks, many of which are dry at low water, while the foreshore north-east of Maryport gradually gains in breadth until it becomes an extensive outlying flat forming the south east boundary of the main navigable channel"*

The sailing directions comment of Robin Rigg that '*its form and extent is continually altering, and with its connected shoals is regarded as the most dangerous obstruction in the Solway'* (Bedford 1870: 208). Bedford reports that 'Middle Channel … is formed between the Robin spit and Dumroof … it is barred at the outer end, but within this narrow neck of 6 feet there is a breadth of deep water of a mile, which runs nearly straight into the Dumfries Channel'. He also remarks:

> *'The wrecks that have occurred within the Solway have generally been owing to errors in reckoning, due to vessels passing the Isle of Man without sighting it, and then mistaking the Solway for the Mersey, and in some instances for the Clyde.'*

The seabed comprises sand, with gravelly sand in the seaward approach to Middle Channel[265]. There is no section drawing for Solway, but a long section off the approaches to the Solway shows bedrock at depths of 50 to 60+m, covered by probable Devensian and undivided late Devensian and Holocene sediments. The section also indicates acoustic blanking attributed to gas-charged sediments, with sandy mud/muddy sand covered by sand.

Previous geotechnical site investigations for an Anemometer Tower erected by the developer at Robin Rigg in 1999, comprising two boreholes at 54º 45.35' N 03º 40.07' W (NGR 292680 541386) and 54º 44.74 N 03º 36.90' W (NGR 296053 540175), both show dense sand to 11.5m and 12.0m below seabed respectively.

The sub-bottom profiling survey carried out on 14-16 December 2001 revealed a complex and sometimes chaotic arrangement of reflectors (boundaries between layers). Two main reflectors were identified. The first main reflector was recorded at depths of 1.5m to 36m below seabed and displayed characteristics generally thought to be typical of a boulder clay or a sediment with a significant clay component. The second main reflector had a much more jumbled and chaotic signature and was recorded at depths of 3m to 38m below seabed. Its characteristics suggest the possible presence of bedrock and/or weathered rock. Additionally, internal reflectors were identified above and between the two main reflectors, generally occurring at 1m intervals and suggesting the presence of softer sediment such as sand or fine gravel.

[264] Bedford, E. J. (1870) Sailing Directions for the West Coast of England from Milford Haven to the Mull of Galloway, including the Isle of Man, London.
[265] BGS 1:250,000 Series, Lake District: Sea Bed Sediments and Quaternary Geology

Subsequent geotechnical investigations carried out in 2002, comprising 11 boreholes (see Section 6 of this ES), show dense sand from 8.2m to over 27.3m below seabed. Where observed, the ground underlying the sand comprises stiff friable gravelly sandy clay with occasional cobbles and boulders. There are no references to material indicative of former landsurfaces.

7.8.4.2 The Maritime History of the Solway

As discussed below, the Solway seems likely to have comprised dry land in the late Devensian and Early Holocene, to c. 6300 BC (Mesolithic). In the course of the Mesolithic and subsequent periods, the estuary would have developed its present form as a waterway linking the settlements around the coast to each other and to more distant ports, and providing marine resources such as fish. Direct evidence of Mesolithic seafaring is as yet rare in the UK, though slender Mesolithic logboats have been found in Denmark[266] and a wooden paddle dating to c. 7000 BC was discovered at Star Carr, Yorkshire[267]. It has been suggested that people hunted, fished and gathered shellfish along the shores of the Solway from well before 7500 BC[268], choosing habitation sites at the coast[269].

There is a range of Neolithic sites in Cumbria and Dumfries and Galloway, including megalithic monuments (stone circles, chambered tombs). The capacity for long distance contact – which presumably included seafaring – is evident from the distribution of Neolithic polished axes of Cumbrian origin to the isle of man, south-west Scotland, Yorkshire and southern England[270 271]. Equally, similarities between cultural material of Bronze Age date from Cumbria and Westmoreland and from Ireland suggest routine navigation of the Solway. Examples of Bronze Age craft capable of estuarine voyages have been excavated in the Humber, the Severn and at Dover, and other evidence of Bronze Age seafaring has been investigated outside Dover Harbour and off Salcombe[272].

Iron Age seafaring can be presumed but evidence in the UK generally is as yet rare. The inclusion of a series of coastal forts in the defensive system represented by Hadrian's Wall strongly suggests that the Romans' predecessors in the region were capable of seaborne raiding. The Roman fort at Maryport probably dates to AD 124 but may have been preceded by earlier structures in the vicinity, possibly closer to the river Ellen. The presence of Roman harbour installations at Maryport is suspected but firm evidence is currently lacking; the presence of the remains of Roman vessels in the Solway might similarly be suspected[273].

As in earlier periods, direct evidence of Early Medieval and Medieval seafaring in the Solway is scarce, though indirect archaeological evidence, place names and documentary accounts indicate the likely scale and scope. By way of example, Truckell[274 275] notes that:

> *'… in 1300, King Edward I had a fleet of 95 ships in the Solway…almost all the ships names are known- Annete, Blakebat, Blithe, Chevaler, Grace Dieu …most furnished by the Cinque Ports.'*

Heavy reliance on maritime activity in the Solway at local, regional, national and international scales is increasingly evident in the Post-medieval and Modern periods, perhaps reaching its peak in the 1840s but – with the exception of fishing – dwindling away by the 1930s[276 277 278].

According to Truckell, Dumfries and associated havens had strong trade connections with France (including Bordeaux, Rouen and Brittany) in the C15th and C16th, exporting woollen cloth. Imports to Dumfries included: coal from Cumberland; lime; brandy, wine, dried fruit etc. from France and Spain; tobacco from North America; and timber from Ireland and, later, Scandinavia. However, Truckell reports that 'by far the greatest volume of shipping was of a local nature, in and around the Solway'. Coal from Maryport was transported by sea to Carlisle until duties were imposed c. 1720, making it cheaper to carry coal by land. The passage by the river Eden to Carlisle became unworkable, leading to the construction of the Carlisle Canal by 1823, which assisted shipping and led to the introduction of a packet boat service beween Carlisle and Liverpool. Simper reports that Liverpool was the focal point of Solway trade right up until it ended abruptly at the end of the 1920s. Dalbeattie became a leading Solway port in the 1890s, where cargoes from the south were imported in order that granite sets could be taken back[279].

Maryport was created in the mid C18th, though the area was formerly occupied by a small settlement – Ellenfoot – whose occupants were engaged in fishing and farming. An Act for improving the harbour at Ellenfoot came into effect in 1749, and land was granted for building. The main focus of the port and town was the export of coal from local pits, with shipbuilding and other trades also. A local directory of 1811 notes that 'the coal trade was the chief staple of this part of the country and … the shipping has embarked much in the transport and timber trade. The work of an iron furnacer, shipbuilding, salt works … a pottery, a glass house, a cotton mill and extensive muslin manufactories … have added much to its population'[280]. Twenty boats were engaged in the herring fishery in 1813 and cod was abundant in winter. Red sandstone was exported from a freestone quarry, coal was exported to Ireland and timber, flax and iron was imported from the Baltic. In the late C19th, iron ore and grain were the main imports, with timber and general merchandise forming smaller proportions, the total being c. 88,000 tons in 1885. In the same year 196,201 tons of coal, 80,346 tons of pig iron and 3,398 tons of steel rails were exported[281]. Wood[282] notes:

> *'The origins of the coal trade are obscure but the first recorded coal shipments from Cumberland were made in 1604-5 when Workington exported 1,366 chaldrons of coal to Ireland and overseas.'*

To focus on the larger ports of the Solway is, however, misleading. The indented coast and the high tidal range meant that very many small settlements could be reached by sea, at least on high tides. Some settlements had small quays, but vessels could also take the ground to be loaded and unloaded at low water.

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266 Andersen, S.H. (1991) 'New Finds of Mesolithic Logboats in Denmark' in Westerdahl, C. (ed.) *Crossroads in Ancient Shipbuilding*, Oxbow Monograph 40, 1-10.
267 Marsden, P, 1997. *Ships and Shipwrecks*. B.T.Batsford Ltd.
268 Solway Firth Partnership (1996) *Solway Firth Review*.
269 Rollinson.W. (1978) A History of Cumberland and Westmorland.
270 Rollinson.W. (1978) A History of Cumberland and Westmorland.
271 Truckell.A.E. (n.d.) 'Solway Shipping', typescript.
272 Wright, E.V., Hedges, R.E.M., Bayliss, A. and Van der Noort, R. (2001) 'New AMS radiocarbon dates for the North Ferriby boats – a contribution to dating prehistoric seafaring in northwestern Europe', *Antiquity* 75: 726-734.
273 Wilson, R.J.A. (1997) 'Maryport from the First to Fourth Centuries: some current problems', in R.J.A. Wilson (ed.) *Roman Maryport and its Setting*.
274 Truckell.A.E. (1954-55) 'Early Shipping References in the Dumfries Burgh Records', *Transactions of the Dumfriesshire and Galloway Natural History and Antiquarian Society*. Vol. XXXIII.
275 Truckell.A.E. (n.d.) 'Solway Shipping', typescript.

276 Graham, A. and Truckell, A.E. (1976-7) 'Old Harbours in the Solway Firth', *Dumfriesshire and Galloway Natural History and Antiquarian Society*, vol. LII.
277 Cumbria County Council (n.d.) *Maryport Harbour Development Plan*.
278 Simper.R. (1974) Scottish Sail: a forgotten era.
279 Simper.R. (1974) Scottish Sail: a forgotten era.
280 Jackson, H. and Jackson, M. (1990) *Maryport in the 19th Century*.
281 Jackson, H. and Jackson, M. (1990) *Maryport in the 19th Century*.
282 Wood.O. (n.d.) *West Cumberland Coal 1600-1982/3*.

Graham and Truckell[283] provide the following quote by King-Webster: 'every available inlet had its quay, and elsewhere vessels used to dry out on any patch of sand firm enough for carts to come alongside when the tide was down'. Consequently, maritime traffic comprised both relatively small coasting schooners and ketches, and the larger ocean-going barques and brigs[284] [285].

In addition to licit trading there was a substantial smuggling trade, perhaps dating to 1670 but at its most virulent in the C18th, hence Prevost[286] notes that 'from about 1750 onwards the smuggling trade began to assume formidable proportions'. Smuggling of tea, tobacco and spirits into the Solway was carried out from Ireland and the Isle of Man, and carried on into the late 1780s[287].

As well as trade, maritime activity in the Solway encompassed shipbuilding and repair. Small clippers for the China trade were built at Annan and many Solway trading vessels were repaired at Kippford[288]. As noted above, many ships were built at Maryport[289].

7.8.4.3 Possible Wrecks identified by Geophysical Survey

A geophysical survey carried out by Hydrographic Surveys Ltd. located five anomalies that were considered in terms of their possible archaeological interest (Hydrographic Surveys November 2001). Hydrographic Surveys' findings can be summarised as follows:

Inventory No.	**Anomaly**	**Description**
1008	Anomaly A	Sidescan shows a definite feature 40m wide corresponding to a strong magnetic signature, though no interpretation is offered on basis of sidescan and magnetometer survey.
1009	Anomaly B	Feature 30m wide partially buried in seabed, but no significant magnetometer response. 'The dimensions and shape of this feature suggest the remains of a wreck'.
1010	Anomaly C	Positively identified as the weather monitoring station associated with the wind farm proposal shown on Admiralty Charts and visible above water.
1011	Anomaly D	Appears on the sidescan as a definite feature suggesting the partial remains of a wreck up to 80m wide and upstanding by up to 4m. Irregular shape suggests that the wreck is no longer intact. Strong magnetic signature suggests a metal hull.
1012-1013	Anomaly E	Interpreted as a trench or ridge.

As non-wreck interpretations are offered for anomalies C and E, the net effect is that the geophysical survey located three possible wreck sites: A (1008); B (1009); and D (1011). All three sites are outside the proposed Development Area. Site 1011 is on Dumroof Bank, site 1008 is on Two Feet Bank – an extension of Robin Rigg – and site 1009 is on Robin Rigg itself.

An anonymous typed list of shipping casualties from the Solway examined by Wessex Archaeology (see Appendix H2 and Figure 7.8.1) includes six wrecks lost on Robin Rigg, as follows:

Inventory No.	**Description**
2009	*Atlas* of Whitehaven, lost in Sept.-Dec. 1807.
2084	*Carn Trial*, a barque of Liverpool lost on 9th/10th October 1878. Nine saved by the Maryport Lifeboat; silver medal to coxswain. Possible that the ship was later salvaged.
2102	*Estrella de Chili* of Glasgow, lost 24th November 1888 with one life.
2136	*Topdal,* Borgue of Mandal lost on 6th October 1900. Lifeboat saved crew of eight.
2143	*Mary* of Dumfries lost on 9th August 1903 Capt. Edgar and crew lost.
2147	*S. S. Grayfield* of London lost on 2nd November 1905. Maryport lifeboat saved 21 lives.

The list includes a further 10 recorded casualties whose place of loss is not given, and seven whose loss is attributed only to the Solway. Twenty-six casualties are ascribed to Maryport, which might include ships lost in the general vicinity. As the source of the list of casualties is not known, it is difficult to gauge how systematic

[283] Graham, A. and Truckell, A.E. (1976-7) 'Old Harbours in the Solway Firth', *Dumfriesshire and Galloway Natural History and Antiquarian Society*, vol. LII.
[284] Graham, A. and Truckell, A.E. (1976-7) 'Old Harbours in the Solway Firth', *Dumfriesshire and Galloway Natural History and Antiquarian Society*, vol. LII.
[285] Simper.R. (1974) Scottish Sail: a forgotten era.
[286] Prevost..W.A. (1975) 'The Solway Smugglers and the Customs Port at Dumfries', *Dumfriesshire and Galloway Natural History and Antiquarian Society*, vol. LI.
[287] Graham, A. and Truckell, A.E. (1976-7) 'Old Harbours in the Solway Firth', *Dumfriesshire and Galloway Natural History and Antiquarian Society*, vol. LII.
[288] Simper.R. (1974) Scottish Sail: a forgotten era.
[289] HJackson, H. and Jackson, M. (1990) *Maryport in the 19th Century*.

its compilation may have been; it might be reasonably surmised that many more wrecks occurred than are listed.

Notwithstanding the deficiencies of the list, it is at least possible that the sites identified by geophysical survey may correspond to the remains of one or otherof the *Atlas*, *Carn Trial*, *Estrella de Chili*, *Topdal*, *Mary* or *Grayfield*. However, the list provides no additional information – such as construction or dimensions – that enable closer correlation. Similarly, neither the geophysical nor tentative documentary evidence provide sufficient data against which to gauge their possible historical importance.

It is possible that further detail of the named vessels might be sought from primary research in other documentary sources (e.g. shipping registers and newspapers). Physical evidence – in the form of archaeological observations by diver or ROV inspection of the anomalies – might corroborate additional documentary work, but as all three anomalies lie outside the proposed development area, no such further work is considered necessary.

7.8.4.4 Other Recorded Wrecks and Features in the Outer Survey Area

Other than the anomalies referred to above, there are three other recorded sites in the Outer Study Area. The *Rose of Sharon* (1004) was lost in 1970 after colliding with a submerged object, although sidescan surveys have failed to locate the wreck since 1983. Site 1002 is an unidentified, possible wreck charted as 'position approximate'. The remaining site within the Outer Study Area is a Post-medieval well (1277) recorded in the National Monuments Record whose position is clearly incorrect.

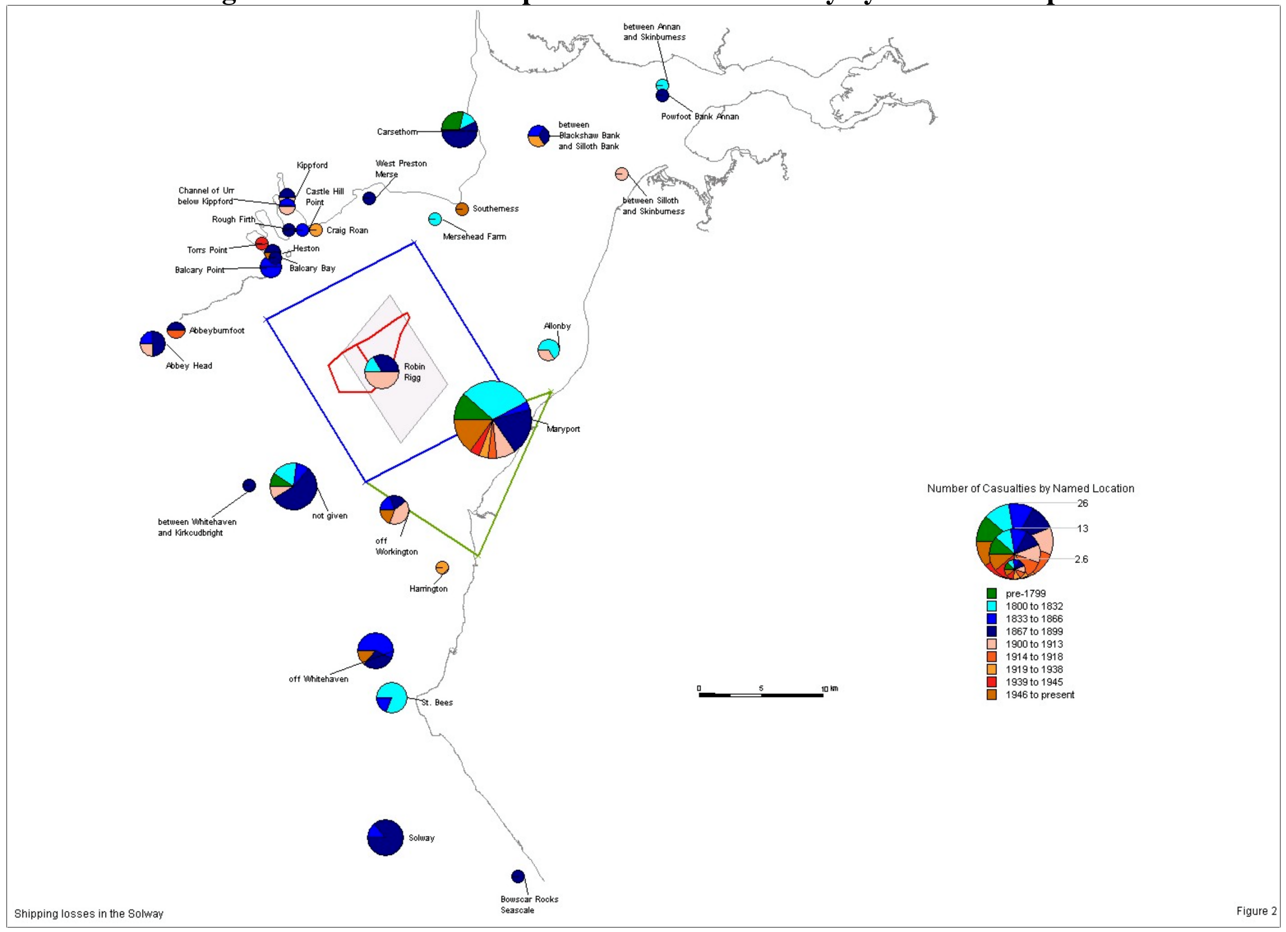
7.8.4.5 Wrecks and Other Features within the Cable Route and Coastal Study Area

The Cable Route and Coastal Study Area contains 14 maritime sites. Of these, 13 are reported wreck sites, ten of which (1022, 1021, 1020, 1019, 1018, 1017, 1016, 1015, 1014, 1023) are all from the same named location – Maryport – as follows:

- The *Crosby* (1014) was a wooden sailing vessel driven ashore and lost en route from Jamaica to Maryport in 1773.
- The *Nelly* (1015) was a wooden cargo vessel driven ashore and lost en route from Riga to Carlisle in 1773.
- The *Jane* (1016) was a Scottish wooden sailing vessel lost with all hands in 1815.
- The *Betsey* (1017) was a British sloop lost at Maryport en route from Cork in 1815.
- The *Ann* (1018) was a British wooden sailing vessel stranded at Maryport en route from Dumfries in 1821; only two lives were saved.
- The *James* (1019) was a British wooden sailing vessel lost near Maryport en route from Liverpool in 1822.
- The *Wilhelmina Scott* (1020) was a British wooden cargo vessel driven ashore near Maryport en route to Whitehaven in 1822.
- A wooden cargo vessel (1021) carrying oil was lost between Whitehaven and St. Bees Head in 1824.
- The *Sarah and Marianne* (1022) was a wooden cargo vessel that came ashore on the north side of Maryport harbour in 1835.
- The *Alma* (1023) was a Norwegian barque transporting cloth, stranded and lost in high winds en route from Dobo to Maryport in 1884.

As noted above, the typed list of shipwrecks in the Solway Firth examined by Wessex Archaeology includes 15 wrecks attributed to Maryport, and a further five off Workington (see Appendix H3 and Figure 7.8.1).

Figure 7.8.1 Recorded ship casualties in the Solway by location and period



The other three wrecks within the Cable Route and Coastal Study Area are as follows:

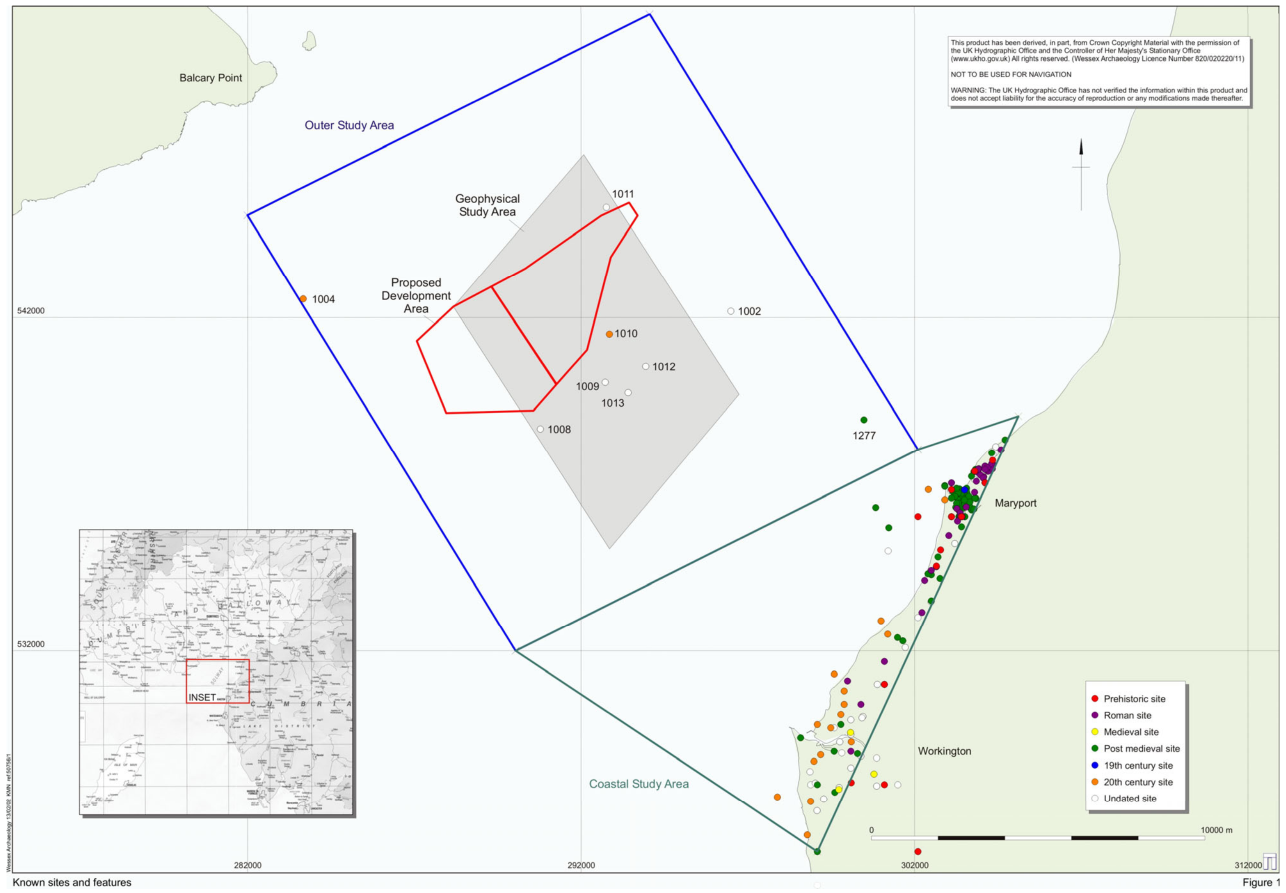
- *Hard Lines FD6* (1007) which drifted on to Maryport north beach and was pounded to pieces in 1973. The vessel was not found at low water springs.
- *Mary Queen II* (1005) was a Motorised Fishing Vessel taken in tow when its engine failed but was lost and went ashore at Workington in 1984.
- *Malin* (1006) was an ex-lifeboat that sank off shore in 1994. Three crew were saved but the vessel was not located in a 1994 search.

The remaining site in the Cable Route and Coastal Study Area is an obstruction (1024) reported by fishermen. First charted in 1976, it is now listed in the Kingfisher Charts Obstruction Book.

It should be noted that the geophysical survey did not cover the entire area of the proposed wind farm or the cable to shore (see Figure 7.8.2). It is anticipated that further geophysical survey would be undertaken if consent for the scheme is granted, prior to construction taking place. The further survey will cover those areas of the scheme not previously surveyed.

It is also worth noting that the line spacing (150m centres) adopted for the geophysical survey was tailored to sidescan survey rather than magnetometer survey. The effective lateral range of magnetometers is quite limited, so even within the Geophysical Survey Area any wrecks that are entirely buried and fall between survey lines may not have been identified. The further geophysical survey referred to above would adopt a suitably close line spacing in the immediate vicinity of elements of the proposed scheme (e.g. turbines, cables).

Figure 7.8.2 Archaeological sites and potential wrecks in the wind farm area and 132 kV cable route search areas



7.8.4.4 Features of Archaeological Interest in the Foreshore Zone and its Immediate Hinterland

Prehistoric

There are no recorded sites from the Lower Palaeolithic to the Mesolithic period (500,000-4000 BC) within the Cable Route and Coastal Study Area.

There are three records relating to the Neolithic (4000-2400 BC). An axe (1025, possibly duplicated as 1217) found near the Ellen might suggest maritime activity in the estuary. A flint flake (1184) found just outside the Cable Route and Coastal Study Area reinforces the case for Neolithic activity in the area. An inhumation near a Roman signal tower (1042) may be Neolithic in date.

There are seven Bronze Age (2400-700 BC) records, three of which lie just outside the Cable Route and Coastal Study Area but are again included as background information. The Bronze Age evidence comprises a halberd blade (1027, possibly duplicated as 1223), a palstave (1261), axes (1103 and 1190), an axe hammer (1193), and a perforated stone axe hammer (1191).

The records of Iron Age/Romano-British evidence (700 BC to AD 410) within the Cable Route and Coastal Study Area, mainly comprising carved stones. Records 1114, 1093, 1065 and 1066 are all carved stones related to the same location. Records 1113 and 1051 also refer to carved stones. Record 1098 is associated with an Iron Age barrow.

Roman

There are 37 Roman (AD43-410) sites recorded within the Cable Route and Coastal Study Area. This is hardly surprising given the presence of the fort (1102) at Maryport. Records 1036, 1037, 1038, 1043, 1044, 1130, 1166, 1176, 1177, 1178, 1182, 1183, 1221, 1232, 1241, 1242, 1248, 1250, 1251, 1252, 1256, 1272 and 1273 all relate to Roman infrastructure, such as towers, walls, buildings, roads and so on. Records, 1026, 1028, 1029, 1030, 1033, 1039, 1040, 1041 and all relate to religion, such as alters and temples. Numerous isolated finds have also been discovered: finds 1101 and 1110 are coins; record 1180 refers to finds found in the cliff face; record 1121 refers to horse trappings; 1181 is a carved head; 1031 is a quern and 1133 an incense jar.

Medieval

The only recorded Early Medieval (AD 410-1066) material is a Scandinavian sword (1047). Medieval (1066-1499) evidence comprises Seaton Priory (1045), Workington town (1187) documented between 1150 and 1308, and a twelfth century cross (1192) found in a niche in Cross House, Workington.

Post Medieval and Modern

There are eighty-two Post Medieval (1500-1799) sites within the Cable Route and Coastal Study Area. These mostly comprise industrial features such as mills, bridges and buildings (see Appendix H4 in the volume of appendices). Seventeen Modern sites are recorded. Of these, 10 are wartime pillboxes, batteries or other defences (1134, 1160, 1161, 1164, 1167, 1168, 1169, 1170, 1171, 1172), four are bombing decoys (1048, 1173, 1174, 1175), one is an ordnance factory (1163) and one a naval gunnery school (1280). The last is the home of Workington FC (1208).

7.8.4.5 The Potential for Deposits, Former Land Surfaces and Features of Prehistoric Date

During glacial periods, the Solway would have been covered by ice. Contemporary sea-level would have been low because of the volume of water locked up in the ice, and the weight of ice would have depressed the Earth's crust in the region. As the ice retreated, the Solway would have been subject to massive flows of meltwater and sediment, sea-level rose and the crust rebounded. Together with other local effects, these processes would have caused the coastline to change substantially in the region, just as it became inhabitable by humans once more. While evidence of human occupation preceding the last (Devensian) glacial period (i.e. archaeological material of Lower, Middle and Early Upper Palaeolithic date) is likely to have been removed by glacial and post-glacial processes, it is possible that material of late Devensian and Holocene date may survive. In particular, it is possible that the base of the Solway formed inhabitable land for a period between the climate ameliorating and sea-level reaching its current level.

Relative sea-level appears to have been lower than -60m OD at c. 11,000 BP (c. 11,000 BC, Loch Lomond Stadial at the end of the Devensian) rising to c. -34m OD by 9500 BP (8600 BC) (Devoy 1985: 50). Britain was re-occupied from c. 12,500 BP by Late Upper Palaeolithic hunter-gatherers, whose flint-working technologies developed as climate and available resources changed, becoming recognisable as Mesolithic cultures from c. 8500 BC. Rapid sea-level rise brought sea-level to c. -2m OD by 7500 BP (6300 BC) in the region (see Devoy 1985: 52). Today, the tide rises between -3.4m OD (MLWS) and +4.3m OD (MHWS) at Maryport.

The potential for prehistoric archaeological material to be present at levels affected by development is largely dependent on the geological processes affecting the area following the Devensian glacial maximum. In particular, potential depends on the following factors:

- whether there was an inhabitable landsurface within the vertical extent of the scheme;
- whether any such landsurface survived the massive processes taking place in the course of de-glaciation and marine transgression; and/or
- whether any such surviving landsurfaces are now buried by a great depth of marine-derived sediment that has been deposited since the area was inundated.

The two boreholes referred to above suggest the presence of a considerable thickness (8.2m to more than 27.3m) of sand, which seems likely to comprise post-inundation marine deposits that blanket any preceding relict landsurfaces.

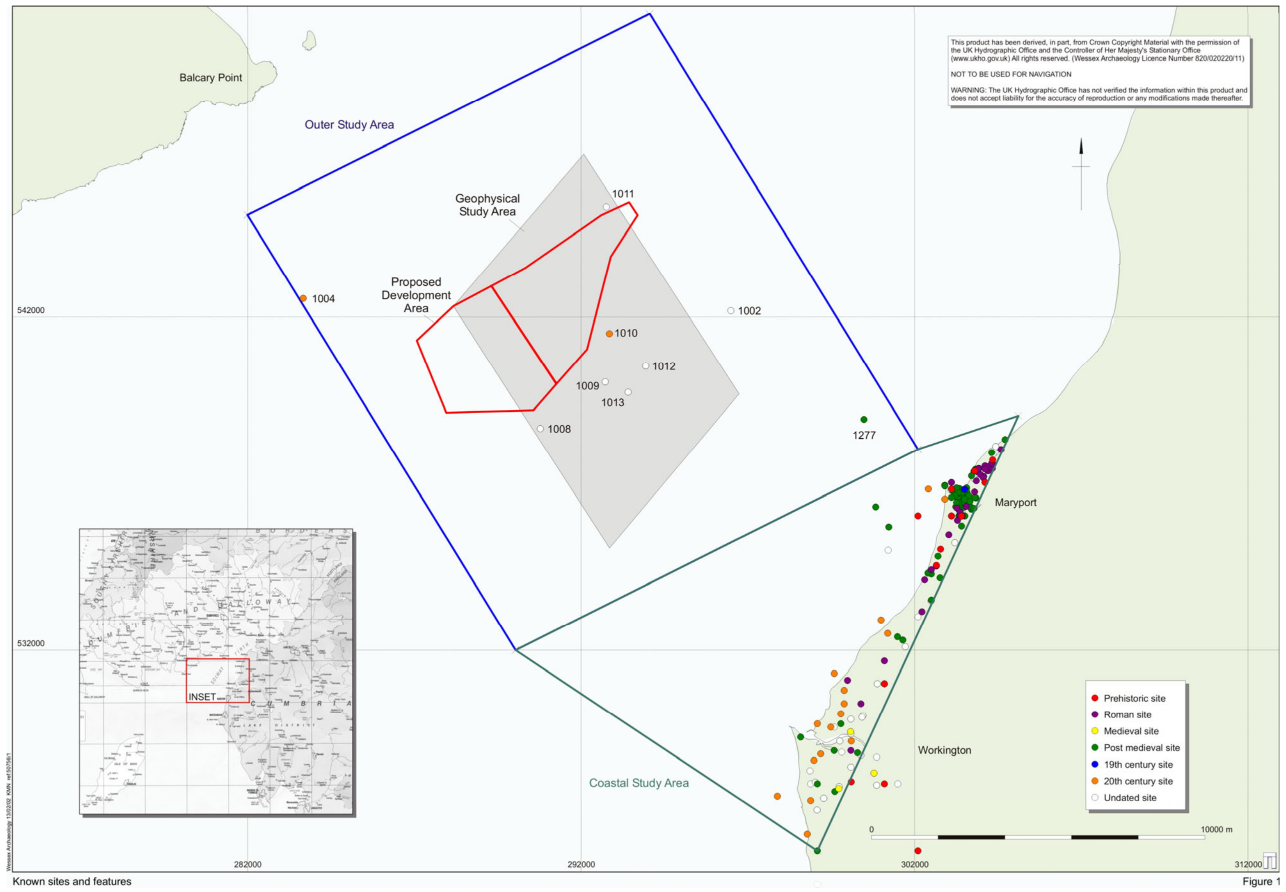
However, the sub-bottom survey suggests that in places, boulder clay or weathered rock are within 1-5m of the current bed, i.e. the marine-derived blanket of sand is less thick. Given both the relatively shallow depth of the seabed and apparent presence of a surface a few metres below the seabed, then it is possible that there would have been a surface exposed as inhabitable land in the Late Upper Palaeolithic/Mesolithic. The topography of this surface as indicated by the sub-bottom survey is quite marked, descending to c. 20-30m below seabed over a relatively short distance. These deeper points would have been inundated earlier, hence the Development Area may have comprised a mix of terrestrial, intertidal and marine environments in the Late Upper Palaeolithic/Mesolithic. However, the complete absence in the boreholes of material indicative of former landsurfaces suggests that any such surfaces did not stabilise prior to marine transgression, or have been reworked. The potential for the Development Area to include surfaces and deposits of palaeo-environmental and archaeological interest appears to be low

The route of the cable to shore has not yet been subject to geotechnical/geophysical investigation. It remains possible that the route may include survivals of former landsurfaces. If present, such survivals would be of regional and possibly national importance.

It should be noted that the geophysical survey did not cover the entire area of the proposed wind farm or the cable to shore (see Figure 7.8.2). It is anticipated that further geophysical survey would be undertaken if consent for the scheme is granted, prior to construction taking place. The further survey will cover those areas of the scheme not previously surveyed.

It is also worth noting that the line spacing (150m centres) adopted for the geophysical survey was tailored to sidescan survey rather than magnetometer survey. The effective lateral range of magnetometers is quite limited, so even within the Geophysical Survey Area any wrecks that are entirely buried and fall between survey lines may not have been identified. The further geophysical survey referred to above would adopt a suitably close line spacing in the immediate vicinity of elements of the proposed scheme (e.g. turbines, cables).

Figure 7.8.2 Archaeological sites and potential wrecks in the wind farm area and 132 kV cable route search areas



7.8.4.4 Features of Archaeological Interest in the Foreshore Zone and its Immediate Hinterland

Prehistoric

There are no recorded sites from the Lower Palaeolithic to the Mesolithic period (500,000-4000 BC) within the Cable Route and Coastal Study Area.

There are three records relating to the Neolithic (4000-2400 BC). An axe (1025, possibly duplicated as 1217) found near the Ellen might suggest maritime activity in the estuary. A flint flake (1184) found just outside the Cable Route and Coastal Study Area reinforces the case for Neolithic activity in the area. An inhumation near a Roman signal tower (1042) may be Neolithic in date.

There are seven Bronze Age (2400-700 BC) records, three of which lie just outside the Cable Route and Coastal Study Area but are again included as background information. The Bronze Age evidence comprises a halberd blade (1027, possibly duplicated as 1223), a palstave (1261), axes (1103 and 1190), an axe hammer (1193), and a perforated stone axe hammer (1191).

The records of Iron Age/Romano-British evidence (700 BC to AD 410) within the Cable Route and Coastal Study Area, mainly comprising carved stones. Records 1114, 1093, 1065 and 1066 are all carved stones related to the same location. Records 1113 and 1051 also refer to carved stones. Record 1098 is associated with an Iron Age barrow.

Roman

There are 37 Roman (AD43-410) sites recorded within the Cable Route and Coastal Study Area. This is hardly surprising given the presence of the fort (1102) at Maryport. Records 1036, 1037, 1038, 1043, 1044, 1130, 1166, 1176, 1177, 1178, 1182, 1183, 1221, 1232, 1241, 1242, 1248, 1250, 1251, 1252, 1256, 1272 and 1273 all relate to Roman infrastructure, such as towers, walls, buildings, roads and so on. Records, 1026, 1028, 1029, 1030, 1033, 1039, 1040, 1041 and all relate to religion, such as alters and temples. Numerous isolated finds have also been discovered: finds 1101 and 1110 are coins; record 1180 refers to finds found in the cliff face; record 1121 refers to horse trappings; 1181 is a carved head; 1031 is a quern and 1133 an incense jar.

Medieval

The only recorded Early Medieval (AD 410-1066) material is a Scandinavian sword (1047). Medieval (1066-1499) evidence comprises Seaton Priory (1045), Workington town (1187) documented between 1150 and 1308, and a twelfth century cross (1192) found in a niche in Cross House, Workington.

Post Medieval and Modern

There are eighty-two Post Medieval (1500-1799) sites within the Cable Route and Coastal Study Area. These mostly comprise industrial features such as mills, bridges and buildings (see Appendix H4 in the volume of appendices). Seventeen Modern sites are recorded. Of these, 10 are wartime pillboxes, batteries or other defences (1134, 1160, 1161, 1164, 1167, 1168, 1169, 1170, 1171, 1172), four are bombing decoys (1048, 1173, 1174, 1175), one is an ordnance factory (1163) and one a naval gunnery school (1280). The last is the home of Workington FC (1208).

7.8.4.5 The Potential for Deposits, Former Land Surfaces and Features of Prehistoric Date

During glacial periods, the Solway would have been covered by ice. Contemporary sea-level would have been low because of the volume of water locked up in the ice, and the weight of ice would have depressed the Earth's crust in the region. As the ice retreated, the Solway would have been subject to massive flows of meltwater and sediment, sea-level rose and the crust rebounded. Together with other local effects, these processes would have caused the coastline to change substantially in the region, just as it became inhabitable by humans once more. While evidence of human occupation preceding the last (Devensian) glacial period (i.e. archaeological material of Lower, Middle and Early Upper Palaeolithic date) is likely to have been removed by glacial and post-glacial processes, it is possible that material of late Devensian and Holocene date may survive. In particular, it is possible that the base of the Solway formed inhabitable land for a period between the climate ameliorating and sea-level reaching its current level.

Relative sea-level appears to have been lower than -60m OD at c. 11,000 BP (c. 11,000 BC, Loch Lomond Stadial at the end of the Devensian) rising to c. -34m OD by 9500 BP (8600 BC) (Devoy 1985: 50). Britain was re-occupied from c. 12,500 BP by Late Upper Palaeolithic hunter-gatherers, whose flint-working technologies developed as climate and available resources changed, becoming recognisable as Mesolithic cultures from c. 8500 BC. Rapid sea-level rise brought sea-level to c. -2m OD by 7500 BP (6300 BC) in the region (see Devoy 1985: 52). Today, the tide rises between -3.4m OD (MLWS) and +4.3m OD (MHWS) at Maryport.

The potential for prehistoric archaeological material to be present at levels affected by development is largely dependent on the geological processes affecting the area following the Devensian glacial maximum. In particular, potential depends on the following factors:

- whether there was an inhabitable landsurface within the vertical extent of the scheme;
- whether any such landsurface survived the massive processes taking place in the course of de-glaciation and marine transgression; and/or
- whether any such surviving landsurfaces are now buried by a great depth of marine-derived sediment that has been deposited since the area was inundated.

The two boreholes referred to above suggest the presence of a considerable thickness (8.2m to more than 27.3m) of sand, which seems likely to comprise post-inundation marine deposits that blanket any preceding relict landsurfaces.

However, the sub-bottom survey suggests that in places, boulder clay or weathered rock are within 1-5m of the current bed, i.e. the marine-derived blanket of sand is less thick. Given both the relatively shallow depth of the seabed and apparent presence of a surface a few metres below the seabed, then it is possible that there would have been a surface exposed as inhabitable land in the Late Upper Palaeolithic/Mesolithic. The topography of this surface as indicated by the sub-bottom survey is quite marked, descending to c. 20-30m below seabed over a relatively short distance. These deeper points would have been inundated earlier, hence the Development Area may have comprised a mix of terrestrial, intertidal and marine environments in the Late Upper Palaeolithic/Mesolithic. However, the complete absence in the boreholes of material indicative of former landsurfaces suggests that any such surfaces did not stabilise prior to marine transgression, or have been reworked. The potential for the Development Area to include surfaces and deposits of palaeo-environmental and archaeological interest appears to be low

The route of the cable to shore has not yet been subject to geotechnical/geophysical investigation. It remains possible that the route may include survivals of former landsurfaces. If present, such survivals would be of regional and possibly national importance.

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8.1 COMMERCIAL FISHERIES IN THE WIDER SOLWAY

The Solway has a long history of commercial full time and part time fisheries. While the fisheries have declined in recent years a number are still active, and these are worked mainly by fleets on the Cumbrian coast, although there are also boats working from Annan and Kirkcudbright in Dumfries and Galloway. The boats fish for a wide range of different species, and use a variety of methods for the catch. The fisheries include plaice, whiting, cod, skate, sole, ray and turbot. There are some lobster pots fishing for crab as well as lobster. Shellfish fisheries include queen scallops, cockles and shrimp which is the most important fishery in the Upper Solway which contains the wind farm proposal area. Finally, traditional haf net fishing is still practised in parts of the Solway, this being a fishing method used by individuals in shallow estuaries fishing for salmon and sea trout in the river mouths feeding into the Solway.

8.1.1 REGULATION OF FISHING IN THE SOLWAY

Fishing in the Solway is regulated locally by the Scottish Fisheries Protection Agency on the Scottish side of the border, and by the Cumbria Sea Fisheries Agency working under MAFF's Sea Fisheries Inspectorate on the English side.

Cockle fishing by boat, tractor and hand gathering is now banned on both sides of the border. Boat and tractor gathering in Scottish waters is banned under the Inshore Fishing (Prohibition of Fishing for Cockles) (Scotland) Order 1995. In English waters all gathering was banned in 1994 by the Cumbria Sea Fisheries Committee. The decision to ban hand gathering on the Scottish side was taken following a consultation period at the end of 2001, after the Fisheries Research Services annual survey of Solway cockles carried out in May 2001 showed that the overall Scottish biomass was down nearly 52%.

No further cockle gathering by any means will be allowed until the Solway Shellfish Management Association on the Scottish side and Cumbria Sea Fisheries Committee on the English side have drawn up management plans to protect the sustainability of the fishery. Once the management plans have been drawn up, both organisations will apply for a Regulating Order, which will set the rules for catches including the method of gathering and volumes that may be gathered.

Other restrictions on fisheries in the Solway includes limits on the use of beam trawls over 6m to the west of a line drawn from Maryport to Southerness Point and an EU minimum mesh size of 20mm on all trawl nets. Beam trawls employed are usually fitted with a piece of 30 - 65mm netting, called the 'veil', (also know as the 'sieve') which reduces the catch of juvenile fish by up to 80%[290].

[290] Lancaster, J. (1999) Ecological studies on the brown shrimp (*Crangon crangon*) fishery in the Solway Firth. PhD thesis. University of Newcastle upon Tyne.

8.1.2 FISHING FLEETS AND AREAS

8.1.2.1 English Ports

The largest harbour in the Solway Firth in terms of a fishing fleet is Whitehaven, where some 15 full time vessels operate. The majority of Whitehaven vessels fish outside of the Solway Firth, south of St. Bees head. Their main catch is *Nephrops* and white fish, the bulk of which is plaice, whiting and cod as well as smaller quantities of monk fish, brill, hake, and turbot. The *Nephrops* grounds are south east of St. Bees Head and are fished by Cumbrian and Northern Irish vessels, all of which land at Whitehaven. *Nephrops* now make the bulk of the landings in Whitehaven. There are an additional 5 or so under 10m, part time trawlers and a few other boats that set nets and lobster pots in the area between St. Bees and Workington.

Between Workington and Whitehaven there are several small boats (under 10m) working on a part time/hobby basis, setting nets all year round (for plaice, whiting, skate etc.) as well as a few lobster pots (for both crabs and lobsters). These boats are launched from Parton (approximately 2 boats) and Harrington (approximately 6 boats).

At Workington there are about 11 trawlers, but only 3 of these are over 10m in length. There are an additional 20 or so boats that set both trammel and gill nets all year round, especially in the inshore area between Workington and Maryport. These nets are set for thorn backed rays (migrating in the spring to their breeding rounds in Allonby Bay) as well as white fish species. With the exception of one boat at Workington most of the fishermen are part time or hobby fishermen.

Maryport recently had 16 full time large trawlers, however the number may have declined in the last few years. Maryport has its own fishing cooperative. Landings there tend to be mainly demersal fish, with sole and *Nephrops* taking a fair chunk of the value. Recently several Maryport trawlers have turned to fishing for scallops on the Scottish side of the Firth. Maryport trawlers tend to concentrate their efforts in the Solway Firth fishing for prime fish species. The Maryport trawlers use the deeper channels between the sand banks for otter trawling for sole and plaice, especially the area of the chart known as Maryport Roads and the Scotch Deep. Finally there are 3 shrimp vessels based at Maryport concentrating their efforts at Heston Island, the channels around Dumroof Bank and Robin Riggs, Beckfoot and around Silloth.

In Allonby Bay trammel nets are set for skate, plaice, sole and turbot, from up to 6 boats, one of which is full time. Beach nets are also set in this area. Allonby bay is considered a skate (thornback ray - *Raja clavata*) breeding ground[291 292 293].

[291] Nottage, A. S. and Perkins, E. J. (1978) Some observations on the general biology of the Thornback Ray, *Raja clavata* L in the Solway Firth. *Cumbria Sea Fisheries Committee Scientific report* No. **7819**. Published by Cumbria Sea Fisheries Committee, The Courts, Carlisle.

[292] Nottage, A. S. and Perkins, E. J. (1980) Observations on the general biology of the Thornback Ray, *Raja clavata* L in the Solway Firth 2. *Cumbria Sea Fisheries Committee Scientific report*. Published by Cumbria Sea Fisheries Committee, The Courts, Carlisle.

[293] Nottage, A. S. and Perkins, E. J. (1983) Growth and maturation of Roker, *Raja clavata* L in the Solway Firth. *Journal of fish Biology* 23; 43-48

Figure 8.1.1
Commercial Fishing Grounds of the Solway

Silloth is the most Northerly harbour on the English side of the firth with 5 shrimp boats. These may also fish for cockles (should the fishery open again) and mussels. Between Maryport and Silloth a hand gathering fishery for mussel exists on the outer reaches of the sand flats at Beckfoot and Mawbray.

8.1.2.2 Scottish Ports

On the Scottish side of the Firth, Annan used to be an important shrimp fishing port however the number of shrimp boats has declined in recent years. There are now only 2 shrimp boats operating from Annan. Shrimp and cockle vessels have been known to operate from Palnackie and Kipford harbours, however, there are no reports that they do so at the moment.

Kirkcudbright is the home of several scallop boats. These vessels fish the scallop grounds to the west of the Firth, (roughly a circle from the Isle of Whithorn to the Isle of Man and Luce Bay[294].

8.1.2.3 Fishing, Spawning and Nursery Grounds

The maps in Figure 8.1.1 show the fishing areas for main catch species in the Solway, and spawning and nursery areas where known. This data has been obtained from the Solway Firth Review.[295]

8.1.3 THE SOLWAY SHRIMP FISHERY

The brown shrimp (*Crangon crangon*) fishery is the most important in the mid and Inner Solway (North of Maryport and Balcary Point) and therefore in the vicinity of the wind farm development area. Information about this fleet and their landings is scarce. There is no statutory obligation for fishermen to disclose or report their landings of shrimps in England and DEFRA estimate the annual landings. Although landing figures are collected in Scotland by the Scottish Office, the figures are probably an under estimate. A study funded by CSFC and SOAEFD was conducted on the Solway shrimp fishery between 1995 and 1998 by Lancaster (1999)[296]. Prior to this study the last description of the Solway shrimp fishery was provided by Howard (1978)[297] and Mason (1968)[298].

The Solway has supported an artisanal fishery for brown shrimps for over a century. The brown shrimp fishery in the Solway Firth could, until recently, be regarded as a traditional cottage industry, but a degree of modernisation has occurred in the past 10 years. The Solway Firth is Britain's second largest shrimp fishery, after the Wash. According to Scottish office figures 146 tonnes were reported to be landed in 1993. During the period 1995 - 1997 up to 105 tonnes were landed per year[299].

Table 8.1.1: Brown shrimp landings in the UK (tonnes)

Area	1995	1996	1997	Source
Wash	740	389.2	175.6	Eastern Sea Fisheries Committee
Solway	104.1	87.0	52.1	Log Books (Lancaster 1999)
Humber	4	not available	not available	North Eastern Sea Fisheries Committee
Thames	24	<1	<1	Essex and Kent Sea Fisheries Committee
Lancashire coast	24	17.0	not available	North West and North Wales Sea Fisheries Committee

Shrimp vessels operate from Silloth and Maryport in Cumbria, and Annan and occasionally Palnackie in Dumfries and Galloway. The number of vessels involved in the shrimp fishery varies constantly with boats being frequently purchased, sold and even sunk. When catches and prices are good part time fishermen join the fleet, often using old boats that have been tied up for much of the year; when catches and prices have been poor fishermen have switched to different species (e.g. scallops, mussels or cockles), fished different areas (e.g. Grimsby, the Thames or the Wash) or even give up fishing altogether.

The largest fleet is located at Silloth in Cumbria, where up to 11 shrimp vessels have worked in recent years. At the present time there are 5 full time shrimp vessels operating from Silloth, however the numbers will rise if shrimp catches or prices are good. There are also three shrimp vessels based at Maryport. Up to 6 boats are based in Annan, however only two presently fish for shrimps. Shrimp vessels also occasionally operate from other ports around the Solway, such as Palnackie, although not at the moment. Tractors towing beam trawls may also be used to fish for shrimps and in the past up to two tractors operated on the Scottish side of the Firth, around the Southerness area. No tractors are currently involved in the shrimp fishery.

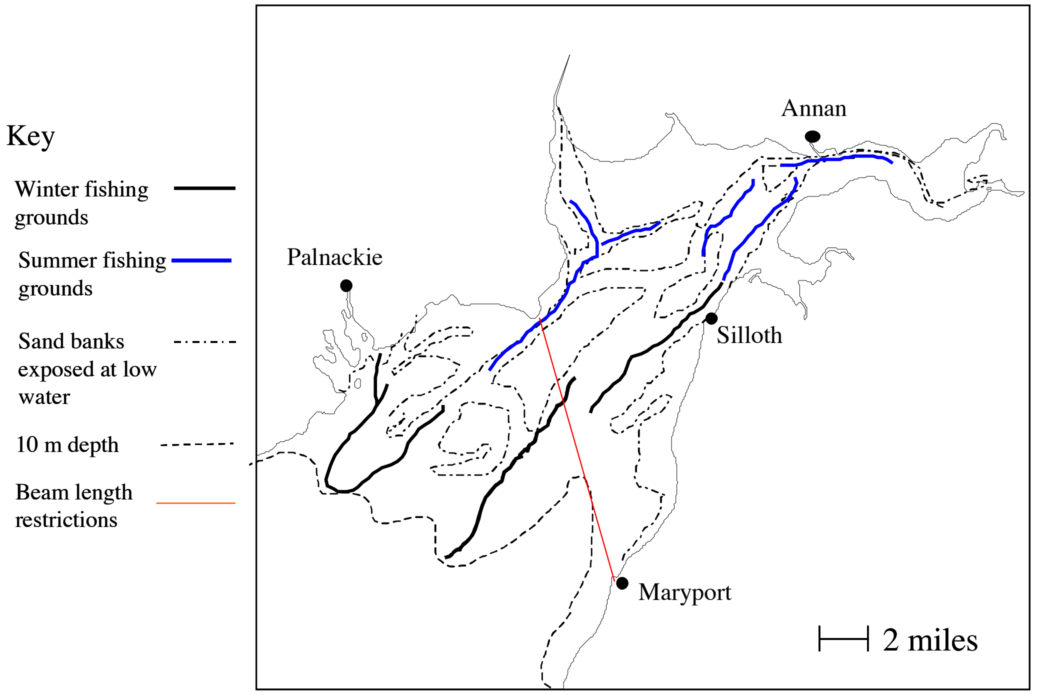
The Solway Firth shrimp fishery represents a half way house between the traditional fisheries such as the Lancashire coast and Morecambe Bay, and the most modern fishery the Wash, with some representatives of both type of vessels, twin beamers and smacks. The majority of vessels are under 10m with no vessels larger than 14m total length. Their engine size ranges from less than 75 kW to 250 kW.

The gear used in the Solway Firth *C. crangon* fishery usually consists of 6m beam trawls with a mesh size of 21-23mm, but trawl design varies considerably between vessels[300]. Restrictions limit the use of beams over 6m to the outer part of the Firth (offshore of a line drawn from Maryport to Southerness Point see Figure 8.1.2). This together with the EU minimum mesh size of 20mm are the only fishery restrictions in

294 Solway Firth Review (1996) *The Solway Firth Review*. The Solway Firth Partnership.
295 Solway Firth Partnership (1996) *The Solway Firth Review*. The Solway Firth Partnership.
296 Lancaster, J. (1999) Ecological studies on the brown shrimp (*Crangon crangon*) fishery in the Solway Firth. PhD thesis. University of Newcastle upon Tyne.
297 Howard, F.G. (1978) The Scottish shrimp fishery. *Scottish Fisheries Bulletin*, **44**: 34-38
298 Mason, J. (1968) The Scottish fishery for brown shrimps, *Crangon crangon* (L.), in the Solway Firth. *ICES, C.M. Shellfish and Benthos Committee*, K:**22**; 1-7.
299 Lancaster, J. (1999) Ecological studies on the brown shrimp (*Crangon crangon*) fishery in the Solway Firth. PhD thesis. University of Newcastle upon Tyne.
300 Lancaster, J. (1999) Ecological studies on the brown shrimp (*Crangon crangon*) fishery in the Solway Firth. PhD thesis. University of Newcastle upon Tyne.

force in the Solway. The beam trawls employed are usually fitted with a piece of 30 - 65mm netting, called the 'veil', (also know as the 'sieve') which reduces the catch of juvenile fish by up to 80%[301].

Figure 8.1.2 The location of the main brown shrimp fishing areas in the Solway Firth



Fishing activities attempt to mirror the distribution of the target species. *C. crangon*, however, is a highly mobile animal. *C. crangon* undergo daily tidal migrations entering the inter-tidal flats at high tide and retreating on the ebb tide, to bury in the sand[302]. In addition seasonal movements occur with populations migrating offshore in winter into deeper, more saline waters in order to avoid low salinities and temperatures and moving back into the shallow sub-tidal zone in spring[303 304].

Figure 8.1.2 shows the main shrimp fishing areas in the Inner and mid Solway. In recent years the majority of the shrimp fleet fish in the Inner and mid Solway Firth from April until November with the most intensive fishing taking place in the area between Silloth and Cardurnock, from south of Silloth to Beckfoot, around Southerness and in the Powfoot and Dumfries Channels. Landings tend to peak in May and September and the most effort is applied between May and November. A winter fishery for shrimps exists in the Mid Solway, mainly around Heston Island, Dumroof, Robin Riggs and Beckfoot, more suited to the larger vessels in the shrimp fleet[305]. As can be seen from Figure 8.1.2, the proposed wind farm area lies within the winter fishing area but lies further out into the Solway than the main summer and autumn fishing areas.

Shrimp fishing generally takes place in the channels on the edge of the banks. The fishing patterns frequently change in the Solway due to changes in the ever mobile sand banks and channels. The mobility of the distribution of shrimp fishing in the Solway is illustrated by comparing modern and past fishing locations. Fishing during the 1960's was reported by Mason[306] to usually occur in the shallow upper reaches of the Firth, in the Newbie - Southerness area, but also further west, in depths of 1.8m - 3.7m. Prior to 1967 the best fishing was off Newbie, but changes in the sand banks and channels resulted in movement of the shrimps, accompanied by a shift from Annan to Silloth as the chief port[307].

In the past after the shrimps having been boiled aboard the vessels, were landed, they were hand peeled or 'picked' by local women employed by the fishermen to remove the shells[308]. The shrimp meat was then forwarded to local factories where it would then be preserved or 'potted' in butter and sold to the local market as potted shrimp. From the 1970's it became increasingly difficult to recruit local women to work in the pickeries, hence limiting the amount of shrimps that could be landed. In the early 1990's an export market to the Netherlands began for 'rough' shrimp (shrimps with their shells on) and more fishermen and boats joined the Solway shrimp fishery[309]. In 1995 only one family (with two boats) was known to be picking their own shrimps, while all the other vessels were landing their shrimps to buyers for the Dutch processors. However since 1997 there has been a recovery in the picking industry and at the present time all the Silloth vessels land shrimps to be picked locally (either in Silloth or Flukebrough). Hence shrimp fishing provides many (up to 35) jobs on land in addition to the employment on the boats.

Many of the fishermen returned to picking their own shrimps as the price remains much more stable compared to the fluctuating price of rough shrimps. In 1997 the price for pealed shrimps was £12.12 per kilo of shrimp meat (with 0.410 kilo of shrimp meat per kilo of cooked shrimps once the shell is removed - which works out at £4.97 per kilo of unpeeled shrimp), while the price paid per kilo by the shrimp processors for rough shrimp fell from £2.50 per kilo to an all time low of 80p per kilo.

The values of the fishery in monetary term was estimated to be £254,920 in 1995, £209, 860 in 1996 and £189,290 in 1997. So despite the landings in 1997 being 50% down on the landings of 1995, the value of the fishery was only reduced by 26%, since the majority of the landings in 1995 were landed picked and therefore had a greater value, than shrimps landed rough.

The small mesh used by the shrimp fleet combined with the fact that the Solway is a fish nursery area results in the capture of many undersized juvenile fish. Lancaster found that the by-catch of the shrimp

301 Lancaster, J. (1999) Ecological studies on the brown shrimp (*Crangon crangon*) fishery in the Solway Firth. PhD thesis. University of Newcastle upon Tyne.
302 Al-Adhub, A. H. Y. and Naylor E. (1975) Emergence rhythms and tidal migrations in the brown shrimp, *Crangon crangon*. *Journal of the Marine biological Association of the United Kingdom*, **55**: 801-810.
303 Abbott, O. J. and Perkins, E. J. (1977) The biology of the Brown shrimp *Crangon crangon* in the Solway Firth. *Cumbria Sea Fisheries Scientific Report* **77/4**. Published by Cumbria Sea Fisheries Committee, The Courts, Carlisle.
304 Lancaster, J. (1999) Ecological studies on the brown shrimp (*Crangon crangon*) fishery in the Solway Firth. PhD thesis. University of Newcastle upon Tyne.
305 Lancaster, J. (1999) Ecological studies on the brown shrimp (*Crangon crangon*) fishery in the Solway Firth. PhD thesis. University of Newcastle upon Tyne.
306 Mason, J. (1968) The Scottish fishery for brown shrimps, *Crangon crangon* (L.), in the Solway Firth. *ICES, C.M. Shellfish and Benthos Committee*, K:**22**; 1-7
307 Mason, J. (1968) The Scottish fishery for brown shrimps, *Crangon crangon* (L.), in the Solway Firth. *ICES, C.M. Shellfish and Benthos Committee*, K:**22**; 1-7
308 Howard, F.G. (1978) The Scottish shrimp fishery. *Scottish Fisheries Bulletin*, **44**: 34-38
309 Lancaster, J. (1999) Ecological studies on the brown shrimp (*Crangon crangon*) fishery in the Solway Firth. PhD thesis. University of Newcastle upon Tyne.

vessels included twenty three species of fish and represented 18.5% by weight of the total catch[310]. Plaice, dab and whiting were the most commonly encountered species. Over the three-year period there were an estimated 33 plaice, 31 dab and 9 whiting caught as by-catch in shrimp trawls for every kilogram of shrimp cooked. However, the fishermen did not land any fish during the three years of the study period, as legal sized fish were rarely caught in sufficient numbers.

8.1.4 HAF NETTING AND ANGLING

Sea angling is popular from both the shore and from small boats throughout the Solway Firth. Cod and bass are popularly targeted species by sea anglers. Fishing competitions are a popular recreational pursuit for both tourists and locals alike in Dumfries and Galloway. Flounders are particularly important to these competitions and indeed there are several completions devoted to flounders. Solway flounders are particularly large (up to 40cm and above) and abundant during the spring and summer.

One additional method of fishing still practiced in the upper Solway is haf netting. This is the only legal method of netting migratory fish species and is practiced in the Eden channel in the Inner Solway, by up to 165 licensed haf netters.

Of the fisheries described above the only regular fishery in the immediate vicinity of the development area is the brown shrimp fishery of the Upper Solway which is currently fished by up to 10 boats operating from Maryport and Silloth on the Cumbrian coast and Annan on the Dumfries and Galloway coast, although this number can vary (see below). In addition, up to 16 trawlers in Maryport may occasionally fish the channels between the sand banks in the Robin Rigg area for sole and plaice although their main fishing area lies closer to the Cumbrian coast in English waters well away from the proposal wind farm area.

8.2 SEA NAVIGATION IN THE SOLWAY

8.2.1 COMMERCIAL SHIPPING

There are no through shipping movements within the Solway Firth. Commercial shipping is concentrated on the ports of Whitehaven, Workington, Maryport and Silloth, with the majority of shipping movements being generated at Workington and to a lesser extent Silloth. While having handled significant commercial traffic in the past, the harbours at Whitehaven and Maryport are now used more for fishing and leisure sailing. The cargo tonnage handled at Silloth and Workington between 1997 and 2000 is given in Table 8.2.1 below. To give these figures context, Liverpool, which is the busiest port in the Irish Sea, handles some 30 million tonnes per year on average i.e. 50 times that handled at Workington.

[310] Lancaster, J. (1999) Ecological studies on the brown shrimp (*Crangon crangon*) fishery in the Solway Firth. PhD thesis. University of Newcastle upon Tyne.

Table 8.2.1: Cargo tonnage handled at Workington and Sillioth 1997-2000

YEAR	PORT	
	WORKINGTON (Thousand tonnes)	SILLOTH (Thousand tonnes)
1997	565	147
1998	623	155
1999	563	231
2000	636	168

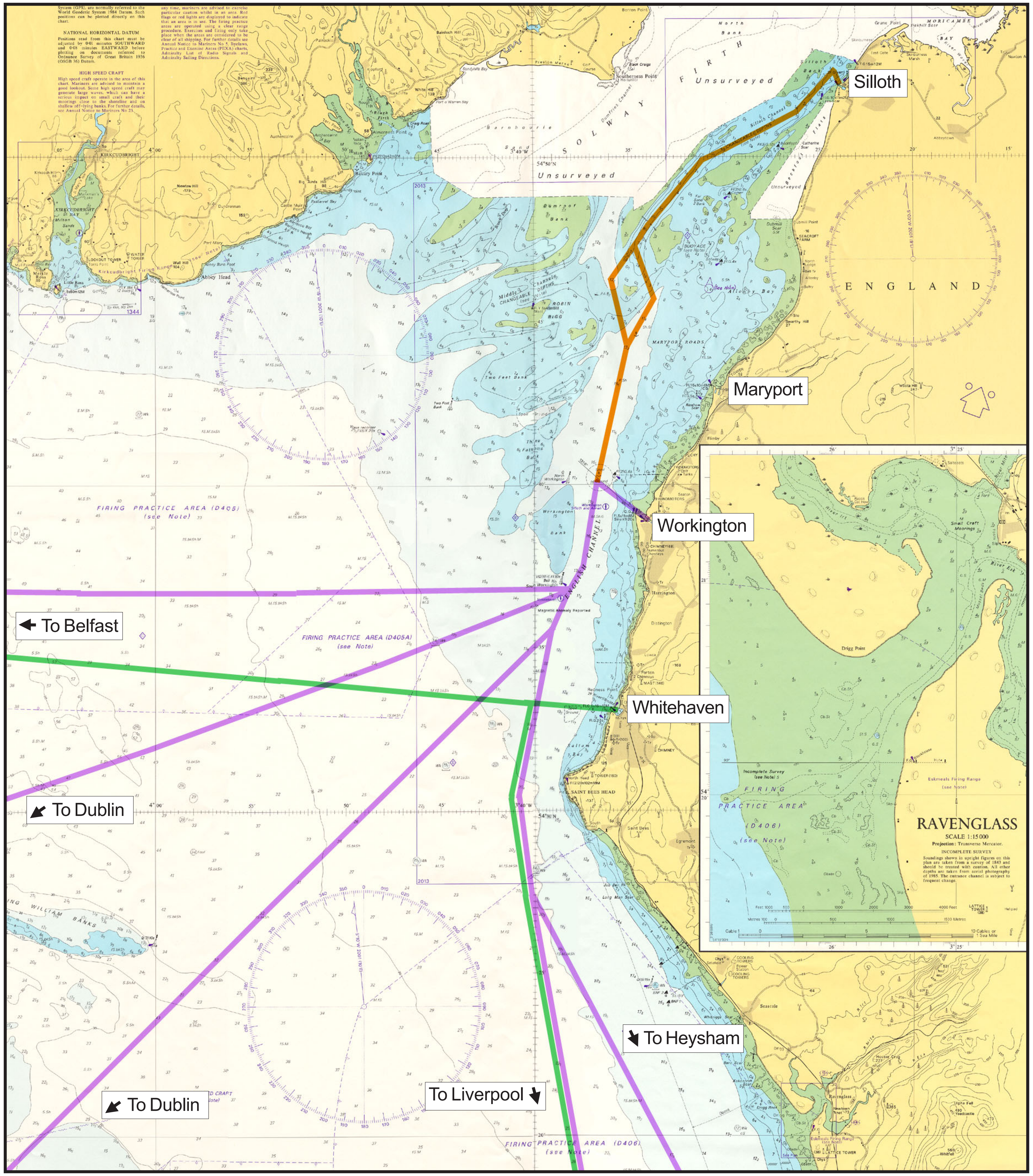
The main cargos handled are grain, fertilisers and animal feed at Silloth and phosphoric acid, timber, steel and petroleum products at Workington. The Port Authorities indicate that the vast majority of routing to and from Workington and Silloth is made to Liverpool, Ireland and other destinations further south. Most vessel movements are therefore on the Cumbrian coast following the routes south and westward shown in Figure 8.2.1. The exception are log cargos to Workington originating from the west coast of Scotland via the channels to the west of the Mull of Galloway. Within the Solway all merchant vessels use the English Channel and the Silloth Channel to reach the various ports on the Cumbrian Coast. These channels and there relationship to the Robin Rigg area are shown on Figure 8.2.1. Outside of these main channels water depths are too shallow or sediments too mobile for commercial shipping.

Of the ports on the Dumfries & Galloway side of the Solway, Kirkcudbright is the only one able to accommodate vessels larger than a cruising yacht as it can accommodate draughts of up to 5m at high water. A fleet of scallop vessels is based here. Two shrimp vessels operate out of Annan currently with both Palnackie and Kippford having been used by shrimp and cockle vessels in the past (see Section 8.1 above). Some trawling is carried out by the Maryport trawlers in the Maryport Roads, Middle Channel and Scotch Deep all of which are deeper channels between the subtidal sand banks. It is known that on occasion trawls are left out whilst going over the banks from one channel to another.

All the banks and channels of the Inner Solway are subject to frequent change and remain uncharted. One of the main reasons for the lack of any major commercial development at the head of the Solway is the difficulty in navigating the shallow uncharted waters. A combination of local knowledge and frequently repositioned marker buoys is needed to ensure safe navigation by fishing and leisure vessels along the lines of the deeper channels.

Accidents to fishing vessels and merchant ships are predominantly strandings and groundings. Although accidents show no apparent pattern there were a string of 7 accidents on the Cumbrian coast between Workinton and St. Bees during the period 1991 to 1994. During this period the total number of accidents involving merchant vessels in the whole of the Irish Sea was 23.

Figure 8.2.1
Commercial Shipping Routes



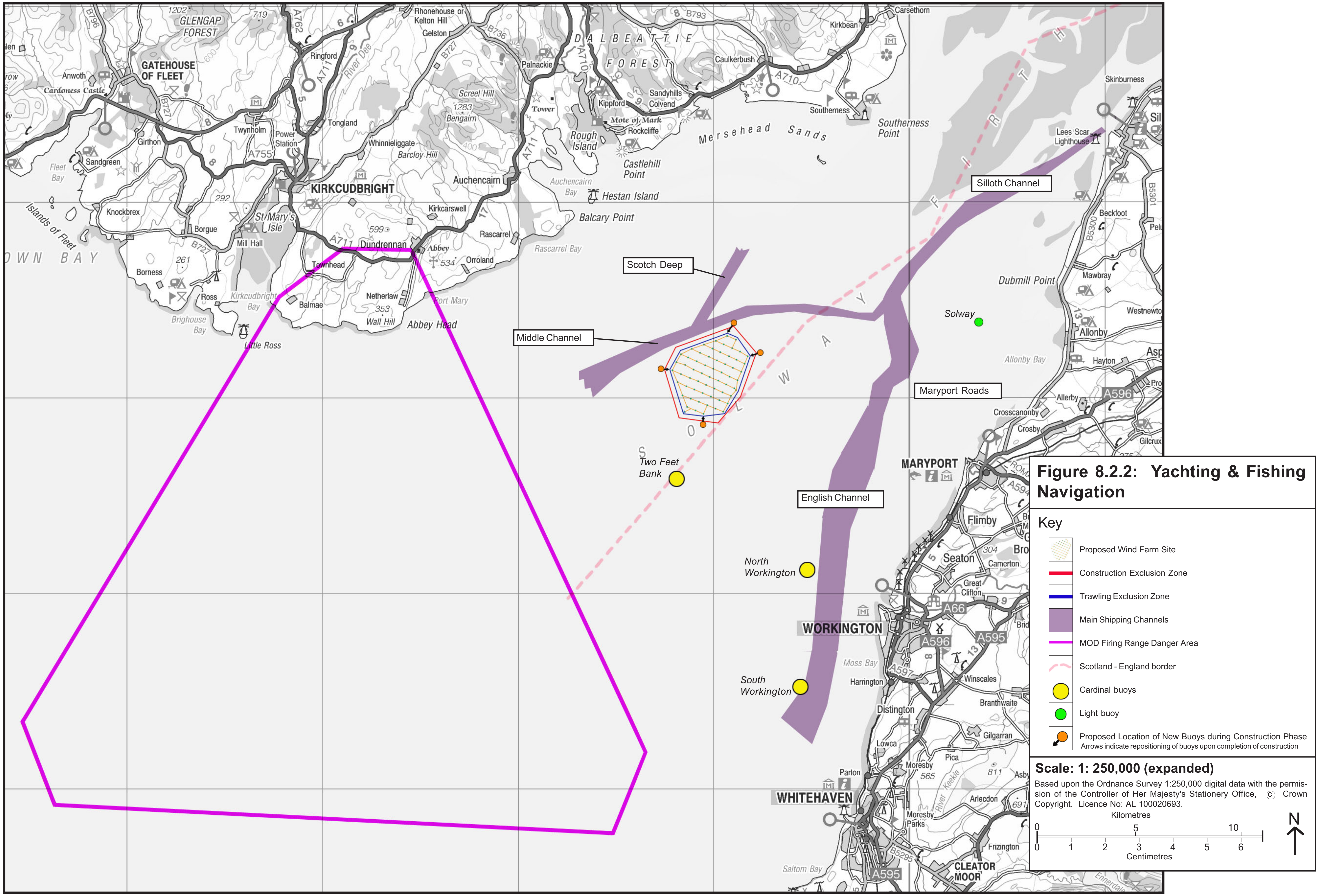


Figure 8.2.2: Yachting & Fishing Navigation

8.2.2 RECREATIONAL SAILING

The dominant sea users in the Inner and mid Solway are related to leisure and fishing activity. Typical numbers of yachts and fishing vessels observed to pass through the MOD danger area to the west of the Robin Rigg site are 25 per day with numbers rising on occasion to 50 [311].

There are nine sailing clubs in the Solway affiliated to the Royal Yachting Association with a combined membership in the region of 800. Table 8.2.2 below gives details of active sailing clubs in the vicinity of the Robin Rigg proposal.

Table 8.2.2 Active sailing clubs in the Solway

Location	Club	Approximate Number of Members
Kirkcudbright	Kirkcudbright Sailing Club	70
Kippford	Solway Yacht Club	300
Maryport	Maryport Yachting Association	60
Workington	Vanguard Sailing Club	-
Whitehaven	Whitehaven Sailing and Boating Association	50

Most sailing activity is restricted to waters within 5 km of the coast. The exception is a popular trans-Solway route between Maryport and Kippford.

Both Solway Yacht Club at Kippford and Maryport Yachting Association hold races during the season which use existing admiralty buoys as racing marks as shown in Figure 8.2.2. The course configuration and therefore the buoys used vary depending on weather.

The Solway Yacht Club which is positioned closest to the proposed development have inshore and offshore races. The inshore races use four marks which are laid out by the SYC each year at the positions given in Table 8.2.3 below.

Table 8.2.3: Racing marks for Solway Yacht Club Inshore Races

Mark	Latitude	Longitude
Firth	54deg50.00N	03deg47.00W
Balcary	54deg49.60N	03deg49.20W
Heston	54deg49.60N	03deg49.20W
Tor	54deg50.10N	03deg50.00W

The offshore race season generally lasts from May to September and comprises about 6 races per year. The offshore races use existing navigation buoys positioned at the points given in Table 8.2.4 below and begin and end at Heston Island.

Table 8.2.4: Navigation Buoys Used for Solway Yacht Club Offshore Races

Buoy	Latitude	Longitude
Two Foot Bank Buoy	52deg42.40N	03deg44.40W
Solway Light Buoy	54deg46.80N	03deg30.05W
North Workington Buoy	54deg40.10N	03deg38.10W
South Workington Buoy	54deg37.00N	03deg38.50W
King William Bank Buoy	54deg26.00N	04deg00.00W
Ross Island Mooring Buoy	54deg46.15N	04deg04.20W

The Solway Yacht Club also holds passage races between Heston and Whitehaven, Maryport and Ramsey in both directions. All offshore races are scheduled to take place during daylight hours but under exceptional circumstances night sailing may be required. Yachts in SYC races are required to carry VHF radio and most would be fitted with GPS navigation equipment. All races are run according to the International Racing Rules of Sailing, which are replaced by the International Rules for the Prevention of Collisions at Sea between official sunset and sunrise.

The Maryport yacht club races are mainly inshore and use the Solway light Buoy and the North & South Workington Cardinals. They make no use of the Robin Rigg area.

With the upgrading of facilities on both sides of the Solway especially at Kirkcudbright, Kippford, Maryport and Whitehaven, more yachts cruise between the ports and it is not unusual for 10 to 15 to cross the Solway at the weekend during the season.

Jet skis and windsurfers also have the capability to cross the Solway although this is not a common occurrence.

8.3 AIR TRAFFIC AND RADAR

The Civil Aviation Authority, the National Air Traffic Service (NATS) and the Ministry of Defence (MOD) were consulted regarding the air traffic interests in the vicinity of the Robin Rigg bank. While the majority of Dumfries and Galloway is included within MOD's LFA 20T Tactical Training Area, this does not extend southwards into the Solway.

Neither the MOD, CAA or NATS have radar or communication facilities that would be affected by structures within the Solway. The nearest CAA consultation zone for radar facilities lies in South

[311] Solway Firth Parnership (1996) The Solway Firth Review

Lanarkshire extending some 20 km south into Dumfries and Galloway. The zone lies some 40 km north of the mid Solway area at its closest point.

An MOD radar consultation zone centred just south of Stranraer lies more than 35 km west of the Robin Rigg site.

Neither the MOD, CAA nor NATS have concerns relating to the Robin Rigg proposal.

8.4 MINERAL, OIL AND GAS RESOURCES

Sand and Gravel

A number of coastal sand and gravel extraction sites have been worked in the past in the Solway, principally on the Cumbrian coast between Allonby and Workington. The largest extraction operation in recent times was the removal of shingle from the shore at Maryport between 1975 and 1994 for building use. This and all other coastal extraction sites on both sides of the Inner and mid Solway areas have now been abandoned. The only remaining coastal sand/gravel extraction sites in the Solway lie between Sandhead and Glenluce east of the Mull of Galloway.

A number of inland sand and gravel sites exist in Dumfries and Galloway, and these have increased production in recent years due to improved transport infrastructure. New reserves identified in the southern reaches of the Nith and Annan and in raised beaches along the coastal margins along with further reserves in the Wigtown area are likely to yield more than sufficient for domestic purposes in the near future.

All sand and gravel extraction to date in the Solway Firth has been located onshore or inland. No extraction has taken place below the low tide mark and the Crown Estates who have control over the licensing for any extraction in inshore waters have issued no licenses for mineral or aggregate extraction in the Solway. While the sand bank of Robin Rigg might potentially yield sand of use for building purposes, there has been no such interest shown in the area.

Oil and Gas

Oil and gas exploration has been fairly active in the outer Solway and Irish Sea in recent years, with a number of licenses having been given to oil companies for exploration in the area between the Isle of Man and a the Solway Bay Closing Line between Kirkcudbright and Whitehaven since the 14th round of licensing by the Department of Trade and Industry in 1993. All licence blocks for offshore oil and gas lie west of the Bay Closing Line. Waters to the east of the line would require onshore drilling licences.

A number of seismic surveys were carried out in the offshore licence blocks immediately to the west of the Baying Closing Line, which were followed in some cases by exploratory drilling in 1995/96. Eleven companies had held licenses in this area of the Irish Sea of which just over half have carried out exploratory drilling. It would appear that the drilling was not successful since none of the licence holders have applied for renewal of the licences which have since expired.

The nearest offshore reservoirs that are currently being exploited lie south of a line between the southern point of the Isle of Man and Barrow-in-Furness where there is a large gas field

No oil or gas exploration licenses have been issued east of the Bay Closing Line within the Solway itself although an onshore licence exists at Whitehaven which extends out two km into the Solway. According to the DTi estuarine areas such as the Solway are always removed from bidding maps as they are considered sensitive to impacts from oil and gas exploitation.

8.5 UNDERSEA PIPES AND CABLES

The UK Cable Protection Committee who have responsibility for administrating and protecting undersea cables and pipelines in UK waters have been consulted regarding the Solway area. The closest proposed or existing cable or pipeline to the site is the Gas Interconnector Pipeline between Scotland and Ireland which runs from Brighouse Bay south west of Kirkcudbright to Loughshinney in Ireland. This is shown in the constraints map, Figure 3.4.1, in Section 3 of this ES. It lies more than 20 km west of the Robin Rigg site at its closest point.

8.6 MILITARY USE OF THE AREA

There is a firing range on the Dumfries and Galloway coast on the peninsula between Kirkcudbright and Dundrennan. The danger area associated with the firing range extends in a fan shape some 25 km south into the Solway reaching a maximum breadth of about 30 km as shown on Figure 3.4.1 in Section 3 of this ES. The next nearest MOD Danger Areas are one at Spadeadam to the east of the Inner Solway and a further fanshaped danger area extending out into the Irish Sea south of Whitehaven. There are no other areas which are used for military purposes in the immediate vicinity of the Solway Firth.

8.7 TELECOMMUNICATIONS NETWORKS AND ELECTROMAGNETIC SIGNALS

All telecommunications and broadcasting network operators were consulted prior to the design process for the proposed development. The full list of consultees is given in Appendix B of the separate volume of appendices. The majority of consultees responded on the basis of whether the location for the wind farm was such that there was potential to cause problems to transmission or reception of electromagnetic signals. In this respect most consultants have responded with a declaration that no potential problems are envisaged without giving details of the operation and layout of networks within the vicinity of the Solway. The exception has been for fixed microwave links where the details of any network components in the vicinity of the proposed development site would have a strong bearing on the eventual design of the wind farm layout.

Fixed microwave links are direct line-of-site communication links between transmitting and receiving dishes placed on masts generally located on hilltops, that vary in length from a few km to over 70 km. They are used for the transmission of information to broadcasting masts for TV and radio and for mobile telephone networks.

The Radiocommunications Agency who act as the governmental advisory body and watchdog for the telecommunications and broadcast operators were contacted for details of any fixed microwave links starting or ending within 50km of the proposal. These links were analysed to identify any that crossed the Mid or Upper Solway and therefore could potentially be affected by the development. Three different corridors containing 9 microwave links were identified. These are as follows:

- M1: Cambret Hill, D&G (252400E 557800N) to Wharrels Hill,Cumbria (317200E 538200N), 7 links with RA Reference Codes 9952 9953 9954 9955 33351 33416 and 33421
- M2: BBC Whitehaven, Cumbria (299200E 512700N) to Baskeoch Hill, Dalbeattie, D&G (281000E 561500N), 1 link with RA Reference Code 25545
- M3: NTL Workington, Cumbria (300100E 527700N) to Baskeoch Hill, Dalbeattie, D&G (28100E 561600N), 1 link with RA Reference Code 28039

The corridors are shown in Figure 3.4.1 in Section 3 of this ES. The 7 links within the M1 corridor are operated by British Telecom. The links are 67.7 km long and range in frequency from 3.7 to 6.9 GHz. The link in the M2 corridor is operated by One2one, has a length of 52.1 km and a frequency range from 12.9 to 13.1 GHz. The final link in corridor M3 is also operated by One2one, has a length of 38.9 km and the same frequency range from 12.9 to 13.1 GHz. These links were taken into account in the layout design of the wind farm and the turbines have been placed to avoid interference with the links. This is described in Section 9.18 of this Statement.

8.8 TOURISM AND THE SOLWAY

Tourism is an important economic sector on both sides of the Solway.

In Dumfries & Galloway, the total number of visitors in 2000 was 1.2 million, with a total expenditure of £159 million, representing 6.3% of total visitors and 4.3% of all tourist expenditure in Scotland as a whole[312]. In the same year just over 7,000 people were employed in the Dumfries and Galloway in jobs relating to tourism, representing some 11.9% of the total work force, a proportion exceeded in Scotland only in Perthshire and the Highlands[313].

In Cumbria the value of tourism to the local economy was £967 million in 2000 (i.e. prior to the foot and mouth epidemic). Tourism is estimated to account for 39,500 direct jobs and 7,500 indirect jobs in the county representing some 20% of the work force, although significantly more than half of these jobs are within the Lake District National Park away from the Solway coast[314]. 75% of visitors to Cumbria come between April and October. 40% of all businesses in Cumbria are related to tourism[315] although again these will be concentrated in the Lake District National Park.

The Solway Firth itself, although not representing the chief focus for tourism in the area, has a number of different features that collectively provide potential for a growing tourist industry. On the Dumfries & Galloway coast, tourists are attracted by signposted heritage routes which include castles and gardens, as well as the scenery, wildlife reserves, harbours and beaches. The Cumbrian side of the Solway offers a diversity of scenery and environments, traditional villages and seaside towns, beaches, golf courses, and coastal walks through landscapes of local and national value, and historical interest.

The main reason why the Solway's tourist potential has not been fully realised to date has been the existence of nationally significant tourist destinations in fairly close proximity or further afield. In Cumbria, the majority of tourists are drawn to the Lake District National Park rather than the coastal area, while tourists travelling into Scotland from England will to a large extent bypass Dumfries & Galloway and continue on to the Central Belt and Highlands to the north[316]. Edinburgh, Glasgow and the Highlands region alone attract more than 65% of all visitors to Scotland[317]. However, once the Solway area has been discovered, repeat visits are high, particularly for those with specialist interests such as water sports, golf, sailing and angling.

8.8.1 VISITOR ACTIVITIES

Table 8.8.1 below gives figures for the proportion of tourists undertaking particular activities in Dumfries and Galloway taken from the Solway Firth Review from the years 1992-1994. The equivalent figures for Cumbrian are not available.

Table 8.8.1 Activities undertaken by tourists in Dumfries and Galloway 1992-94[318] and in Scotland as a whole in 2000[319]

Activity	Proportion of total activities on tourist trips in D&G	Proportion of total activities on tourist trips in Scotland
Visiting Castles, Monuments Churches	18%	27%
Hiking/Walking	17%	27%
Angling	12%	4%
Swimming	9%	-
Visiting Museums and Galleries	8%	10%
Golf	5%	5%
Wildlife/Birdwatching	5%	16%
Other	26%	11%

312 Visit Scotland (2001) *Tourism in Scotland 2000.* Research Department, Visit Scotland.
313 Visit Scotland (2001) *Tourism in Scotland 2000.* Research Department, Visit Scotland.
314 Cumbria County Council (2001) Memorandum Submitted to the Select Committee on Culture, Media and Sport, April 2001.
315 Cumbria County Council (2001) Memorandum Submitted to the Select Committee on Culture, Media and Sport, April 2001.
316 Solway Firth Partnership (1996) *The Solway Firth Review*. The Solway Firth Partnership.
317 Visit Scotland (2001) *Tourism in Scotland 2000.* Research Department, Visit Scotland.
318 Solway Firth Partnership (1996) *The Solway Firth Review*. The Solway Firth Partnership.
319 Visit Scotland (2001) *Tourism in Scotland 2000.* Research Department, Visit Scotland.

As can be seen from Table 8.8.1, hiking, visiting heritage sites and wildlife and birdwatching are less important in Dumfries & Galloway than in Scotland as a whole, while angling is of greater importance, although it is not clear whether the surveys used comparable questions and definitions.

The individual tourist activities on both sides of the Solway are summarised in the following paragraphs.

Walking and Cycling

Walking is one of the most popular activities that attracts visitors to the Solway. Footpaths include coastal walks and forest and hill walks inland on the edges of the Galloway Hills to the north and the foothills of the Lake District National Park to the south. In addition to networks of short footpaths there are a number of long distance footpaths in Cumbria. The principle of these with relevance to the site at Robin Rigg is the Cumbrian Coastal Way that runs 124 miles from Barrow in Furness to Carlisle. In the vicinity of the site the footpath runs along the western edge of the Solway Area of Outstanding Natural Beauty. Part of this route is shared by the Allerdale Ramble which runs 55 miles from Borrowdale in the Lake District to Maryport, and on to Skinburness. The Hadrian's Wall National Trail also follows the coastline in this area from Maryport northwards. Beginning at St. Bees Head further to the south on the edge of visual influence of the wind farm proposal, is the Coast to Coast long distance footpath. Impacts of the proposal on these footpaths are considered in the landscape impact assessment in Section 9.10 of this ES. The principle footpaths in the area are shown on Figure 8.8.1.

Cycle routes are also shown on the figure. These include the Cumbria Cycle Way which runs down the coast from Silloth to Maryport. Workington and Whitehaven are the starting point of the sea to sea long distance cycle route to Sunderland.

Coastal long distance cycle routes and footpaths are limited to the Cumbrian side of the Solway. On the Dumfries and Galloway side the coast is punctuated by many inlets which lend themselves more to short circular walks. These include walks on either side of Orchardton Bay taking in Balcary and Castlehill Points respectively. A long distance cycle route, National Cycle Route 7, does follow the coast of the Inner Solway between Carlisle and Dumfries but then turns inland.

Sea Fishing

There are 18 sea angling clubs in the Solway with over 600 members. In addition to this are a number of visiting fishermen. A number of operators cater for visiting anglers by providing boats and tackle. There are three types of sea fishing carried out in the Solway: deep sea fishing, inshore fishing from boats within 5 km of the shore and shoreline fishing. The main species caught at sea are codling and whiting with flounder, eels and bass caught by onshore anglers during the summer months. A number of annual fishing competitions are held along the coast including the Palnackie flounder trampling competition in which participants feel for flounder with their feet while wading in shallow water, catching them by hand.

Birdwatching

The Solway is a key destination for bird watching. There are a large number of areas where wildfowling and birdwatching are popular. These include the Inner Solway Marshes, St. Bees RSPB reserve, Balcary Heughs, Rockcliffe NTS, Rockcliffe to Sandyhills, Mersehead (RSPB), Southerness, Carsethorn, Glencaple, Caerlaverock National Nature Reserve (NNR), Powfoot and Seafield and Mull of Galloway.

The main attractions are the Wildfowl and Wetlands Trust reserve at Caerlaverock some 23 km to the north east of the Robin Rigg site and the Rockcliffe Marshes National Trust reserve at the head of the Solway, some 40 km to the east of the site. These attract some 16,000 and 60,000 visitors per annum respectively. Closest to the site is an RSPB reserve at Mersehead Sands lies on the western edge of the Upper Solway Special Protection Area for birds. The part accessible by birdwatchers lies some 10 km to the north of the site.

Sailing and Windsurfing

The sailing interest in the vicinity of the site has been described earlier in Section 8.2.2.

Principle windsurfing areas in the vicinity of the site are at Kippford in Dumfries and Galloway and Allonby Bay on the Cumbrian coast as shown in Figure 8.8.1. The total membership of windsurfing clubs was less than 100 in the late 1990s but may have increased in recent years. A national windsurfing event is held in Allonby Bay each year with up to 100 participants and spectators. Windsurfers occasionally cross the Solway from Allonby Bay to Kippford.

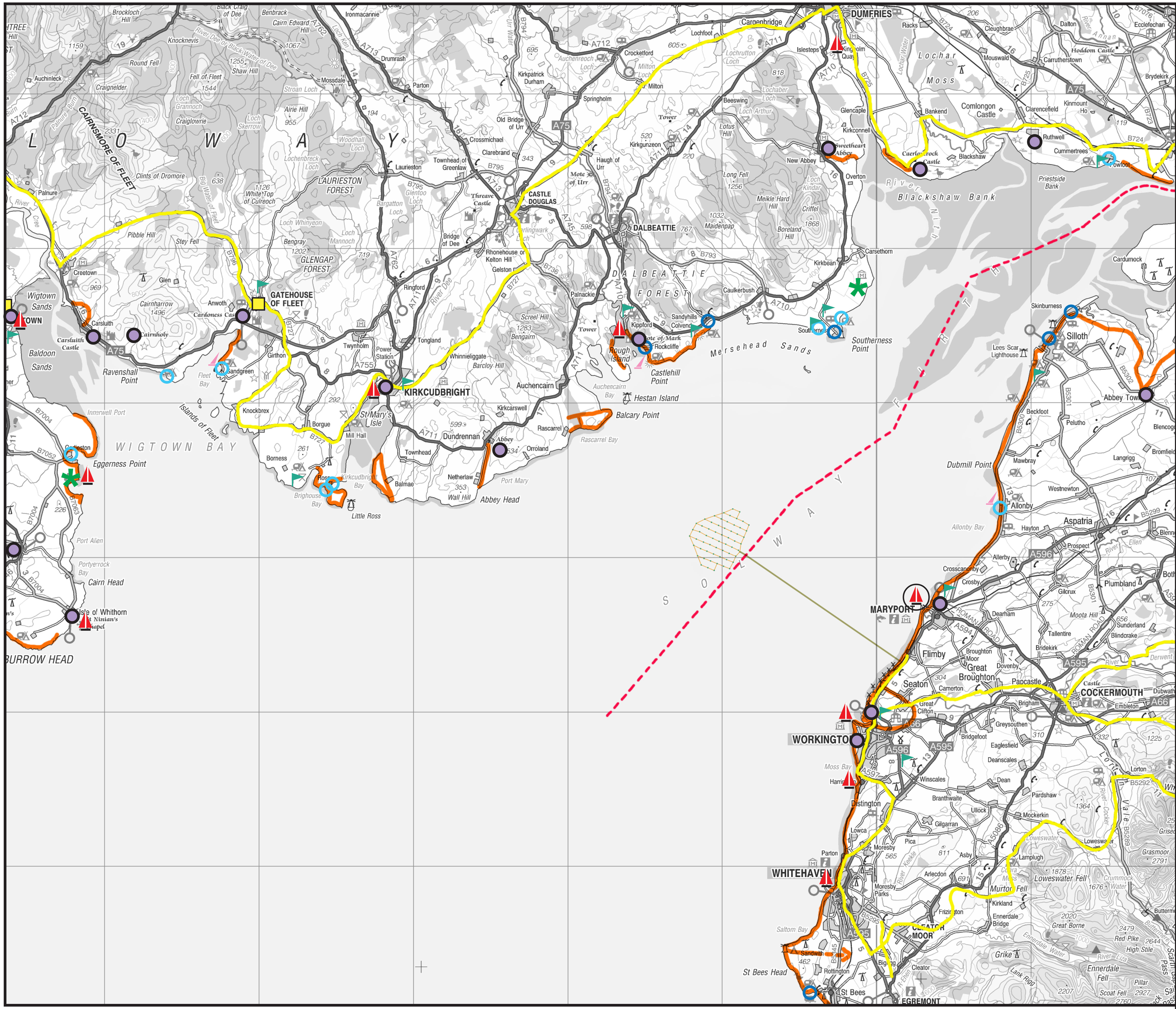
Beaches

The beaches around the Solway are a significant attraction to the Solway, particularly on the Cumbrian coast where the beaches are larger although comprising shingle as well as sand. A number of beaches have been designated as Bathing Beaches under the EC Bathing Waters Directive. Designated bathing beaches on the Solway Firth are:

- Dumfries and Galloway: Rockcliffe
Sandy Hills
Southerness
- Cumbria Skinburness
Silloth
Allonby

Golf

8 golf course lie in the vicinity of the site on both coasts at Siloth, Maryport and Workington on the Cumbrian coast and at Southerness and Kippford on the Dumfries & Galloway coast. Golf courses on the Solway coast are shown in Figure 8.8.1



Project:

Proposed Offshore Wind Farm, Solway Firth

Title:

Figure 8.8.1: Tourist & Leisure Map

Key

- Proposed Wind Farm Site
- Centre line of 132kV cable
- National Cycle Route
- Coastal Footpath Routes
- Designated Bathing Beach
- Bathing Beach
- Sailing Centre/Club
- Marina
- Windsurfing Area
- Golf Course
- Designed Landscapes/Gardens
- Visitor Centres
- Historic/Architectural Sites
- Scotland - England border

Scale: 1: 250,000

Based upon the Ordnance Survey 1:250,000 digital data with the permission of the Controller of Her Majesty's Stationery Office, © Crown Copyright. Licence No: AL 100020693.

Kilometres: 0 5 10 15

Centimetres: 0 1 2 3 4 5 6

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Date: 28-05-02	Prepared by: DH
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TXU

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Caravan Sites / Holiday Parks

There are a number of holiday/ caravan parks on the coastline within the study area including: Sangreen, Ross, Palnackie, Barnbarroch, West Barcloy, Sandyhills, Southerness, Gillfoot, Powfoot, East Cote, Silloth, Blitterlees, Allerdale, Beckfoot, Allonby and Maelo.

8.8.2 INDIVIDUAL VISITOR ATTRACTIONS

The general picture of the Solway area is one of a large number of small attractions with a significant number within 5 km of the coast. Many of these are heritage and museum based which provide an important resource for the local population as well as for tourists.

Table 8.8.2 below gives the visitor numbers in 1994 for the attractions in the Solway with over 10,000 visitors annually. More recent figures are not available.

Table 8.8.2 Top visitor numbers attractions in the Solway, 1994[320]

Visitor Attraction	Number of Visitors
Gretna Old Blacksmiths Shop	400,000
Tullie House, Carlisle	229,000
Carlisle Castle	71,600
National Trust, Rockcliffe	60,000
Creetown Gem Rock Museum	52,000
Logan Botanical Gardens	33,700
Mabie Forest	40,000
Mill on the Fleet, Gatehouse of Fleet	28,500
Dalbeattie Town Wood	26,000
Caerlaverock Castle	24,900
Whitehaven Museum and Art Gallery	16,800
Wildfowl and Wetlands Trust, Caerlaverock	16,000
Maryport Maritime Museum	11,700
Sweetheart Abbey, New Abbey	10,300
Tollbooth Art Centre Kirkcudbright	10,000

The impacts on tourism is assessed in Section 9.15.3, and under Section 9.10 with respect to visual effects of the wind farm proposal.

320 Solway Firth Partnership (1996) *The Solway Firth Review*. The Solway Firth Partnership.

Section 9
Environmental Effects

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Section 9
Environmental Effects

9.1 INTRODUCTION

The potential environmental effects of the wind farm including effects on humans, are assessed in detail in this section. While the initial scoping and consultation exercises gave an indication of the possible effects of the wind farm on environmental resources and human receptors in the vicinity of the site, these were revised further prior to detailed assessment, following detailed baseline studies of the existing physical, biological and human environment around the site and following initial design of the wind farm. The wind farm design including characteristics of construction, operation and decommissioning phases were further revised to include mitigation measures after detailed assessments had been carried out. The residual impacts of the scheme were then assessed. Section 4 of this ES describes the construction, operation and decommissioning phases in detail, incorporating all mitigation measures.

The tables in the following two sections outline the environmental effects of the scheme that were considered as potential prior to detailed assessment. The tables consider direct and indirect effects. The potential indirect effects emerged from development by the various consultants of a broad understanding of the interaction between physical and hydrographic processes and biological communities in the Solway following detailed baseline studies. The tables consider a hierarchy of primary, secondary and tertiary effects arising from a given development operation/characteristic. Primary effects result directly from the development characteristic for example introduction of sediment into the water column from augering turbine foundations. Secondary effects are indirect effects being caused directly by the primary effect, for example increased turbidity of water resulting from introduction of sediment. Tertiary effects are indirect effects caused directly by secondary effects i.e. behavioural effects on fish due to increased water turbidity.

The detailed assessments given in the remainder of this part of the ES assess these potential effects in detail and identify any which are considered by the specialist consultants to be significant. The majority of the potential effects listed in the table below emerge as being non-significant. The only non-significant effects are seascape, landscape and visual effects limited to the area of Dumfries and Galloway closest to the proposal. These effects are summarised in Section 9.10.7.

9.2 POTENTIAL ENVIRONMENTAL EFFECTS DURING CONSTRUCTION AND DECOMMISSIONING

Construction/decommissioning Operation/Event	Impact Tier (Direct-Indirect)	Potential Impact Requiring Assessment
Seabed preparation for foundations and cable routes	Primary	• Loss of benthic community in immediate vicinity of foundation and cable
	Secondary	o Loss of food source for fish
	Secondary	o Loss of food source for birds feeding on shellfish etc.
	Primary	• Damage to any ship wreck lying in immediate vicinity of foundations or cable route
Augering of pile shafts, trenching of cables	Primary	• Introduction of sediment into water column
	Secondary	o Increased turbidity
	Tertiary	◊ *Changing of physical environment for fish*
	Tertiary	◊ *Reduction in effectiveness of birds diving for shellfish*
	Secondary	o Increased deposition of sediment downstream
	Tertiary	◊ *Smothering of benthic community downstream*
Piling/removal of turbine foundations	Primary	• Physiological/behavioural effects on fish
	Primary	• Physiological/behavioural effects on sea mammals
	Primary	• Avoidance of piling site by birds
	Primary	• Potential noise intrusion for tourists/residents onshore
Navigation exclusion zone around construction/decommissioning area	Primary	• Reduction in fishing area for shrimp trawls
	Primary	• Exclusion on-site for leisure sailing/wind surfing/jet skiing across Firth in Robin Rigg area
Boat movements, construction/decommissioning activities above sea surface	Primary	• Visual intrusion for viewers on coast looking across Firth
	Primary	• Avoidance of immediate area by birds
	Primary	• Disturbance of seals on haul-out areas
Spillage of hydraulic fluids, fuel etc.	Primary	• Change in water quality
	Secondary	o Temporary effects on benthic/fish communities
	Secondary	o Potential fouling of bird feathers

9.3 POTENTIAL ENVIRONMENTAL EFFECTS DURING OPERATION

Development Characteristic	Impact Tier (Direct-Indirect)	Potential Impact requiring assessment
Physical presence of turbine foundations	Primary	• Replacement of sediment with hard substrate for benthic life at foundation
	Secondary	o New benthic community on foundation
	Tertiary	◊ *Change in food availability for fish in immediate area of foundation*
	Primary	• Reduction in tidal flow/wave energy
	Secondary	o Increased shelter for fish downstream of foundation
	Primary	• Change in sediment transport in vicinity of wind farm
	Secondary	o Change in turbidity/deposition
	Tertiary	◊ *Change in physical environment for fish/benthic communities*
	Secondary	o Change in coastal processes
Physical presence of turbines and substation platform	Primary	• Visual/landscape impacts on coastal landscapes and human receptors
	Secondary	o Effects on tourism
	Primary	• Avoidance of area by birds
	Primary	• Collision risk of birds in rotors
	Primary	• Collision risk for boats
	Secondary	o Risk of spillage of transformer coolants
	Primary	• Obstruction of fixed microwave communications links
	Primary	• Potential collision of low flying aircraft
	Primary	• Possible interference of TV reception
Navigation Lighting and foghorn	Primary	• Disturbance effect on birds
Presence of cables on sea bed	Primary	• Risk of exposure of cables through normal sediment transport
	Secondary	o Non-zero magnetic fields in immediate vicinity of exposed cable
	Tertiary	◊ *Disorientation effects on migratory fish*
	Secondary	o Non-zero electric fields around exposed cables
	Tertiary	◊ *Attractive/repulsive effects on elasmobranch fish*
	Primary	• Exclusion of trawling from site
	Secondary	o Loss of catch for fishermen
Noise of wind turbines	Primary	• Avoidance of area by marine mammals
	Primary	• Avoidance of immediate area by birds
	Primary	• Behavioural effects on noise sensitive fish
Presence of sacrificial anodes on foundations	Primary	• Loss of aluminium into water column
	Secondary	o Toxic effects on fish/benthic communities

9.4 EFFECTS ON HYDROGRAPHY, SEDIMENTS AND MORPHOLOGY

9.4.1 CONSTRUCTION

The effects on sediments during construction will generally be as a result of raising sediments into suspension during operations such as piling, bed preparation and cable laying.

Bed preparation on the proposed site will be minimal and will have no significant impact.

9.4.1.1 Piling

The most sediment likely to be raised in suspension will be from the augering of a monopile, the total volume of material being in the order of 700 – 800m^3 per monopile.

Any clay removed during the installation of the piles will be brought to the surface in lumps and will be deposited on the seabed in the vicinity of the foundations where the presence of this material may help to reduce the effects of local scour at these locations.

The depth at which clay is present varies across the site from 8 m to beyond 30 m. The average depth at which clay is encountered is in the order of 21 m. In the case where clay is present at a shallow depth (in the order of 8 m) the quantity of clay brought to the surface will be in the order of 600 m^3. It is envisaged that this material will be deposited over an area of approximately 30 m diameter around the pile, generating a layer of clay on the seabed in the order of 0.85 m in depth. In the case of clay at an average depth of 21 m the amount brought to the surface will be in the order of 330 m^3 producing a layer approximately 0.47 m in depth. With the installation of 60 turbines the total amount of clay deposited on the seabed will therefore be in the order of 19800 m^3.

The volume of clay which will be deposited as a result of pile installation has been compared to the annual amount of sediment movement which can be expected across the width of the deposited material, as determined by mathematical modelling. The average amount of clay at a single pile (330 m^3) constitutes only 0.1% of the annual expected movement with the worst case scenario (600 m^3) constituting only 0.18% of the expected movement.

The total area of bed affected by the deposition of clay arisings will be in the order of 42000m^2 which constitutes only 0.4% of the total windfarm area and as such the effects of depositing this material on the seabed will be negligible.

In the case of augering/drilling in sand, the sand will be pumped to the surface and will be deposited into the water at the surface. Figure 9.4.1 shows a typical sediment dispersal plume for the installation of a monopile foundation. The model assumes work extending over a 24 hr period with sediment release at the rate of 10kg/s. It can be seen from the plume diagram that the effects of sediment release are localised in the vicinity of the pile with levels dropping to a level of 0.01kg/m3 within approximately 600 m of the turbine location.

Figure 9.4.1 Typical suspended sediment plume (kg/m^3) during monopile installation

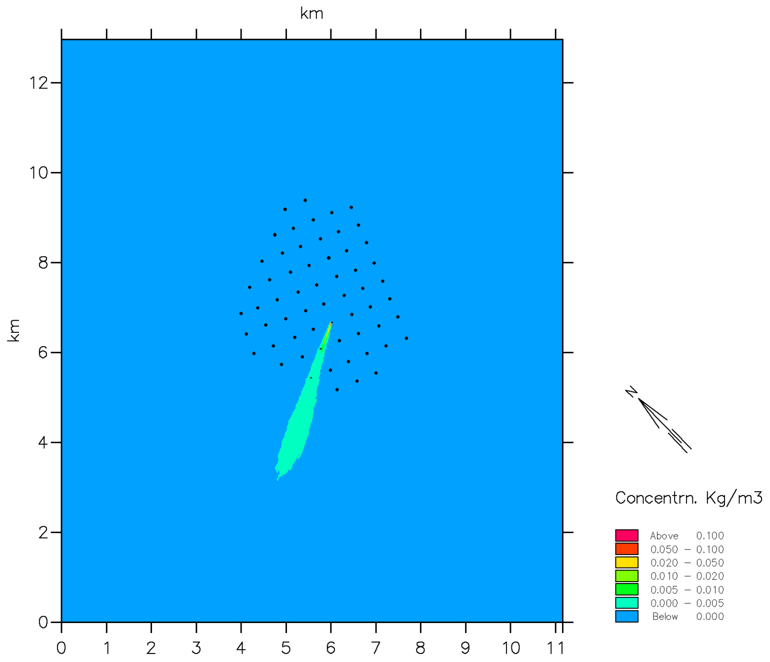
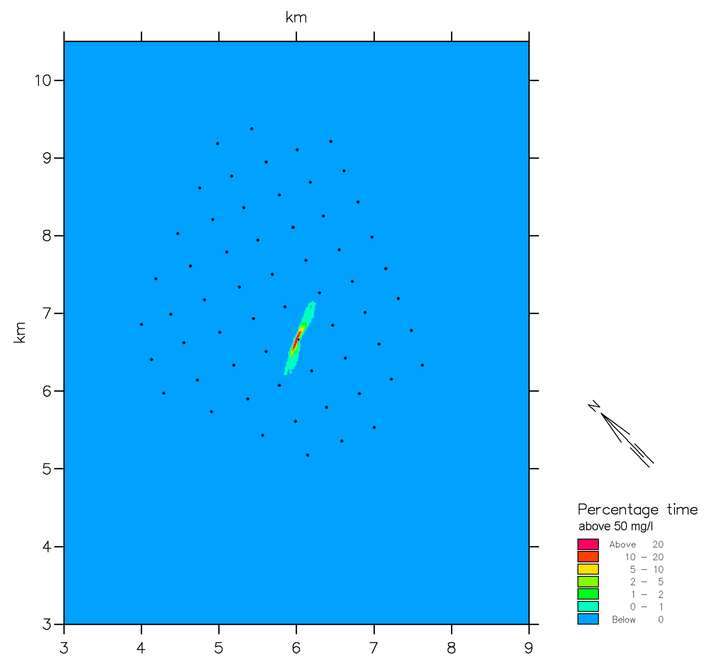


Figure 9.4.2 illustrates the percentage of time during which the sediment load in the water column is in excess of 50 mg/l which is the amount of sediment which is raised in suspension during normal tidal conditions on the site. It can be seen that this level is exceeded only within a distance of 900 m from the pile position and at this distance 5t 5s exceeded for only 1-2% of the installation time. Closer to the pile, within 300 m, the 50 mg/l level is exceeded for only 10-20% of the installation time.

Figure 9.4.2 Percentage of time during pile installation when suspended sediment > 50mg/l



It is apparent from the modelling that background levels of sediment load (50 mg/l under normal tidal conditions) are only exceeded for short periods of time and this only in close proximity of the pile position. The impacts from the pile installation operation are therefore negligible.

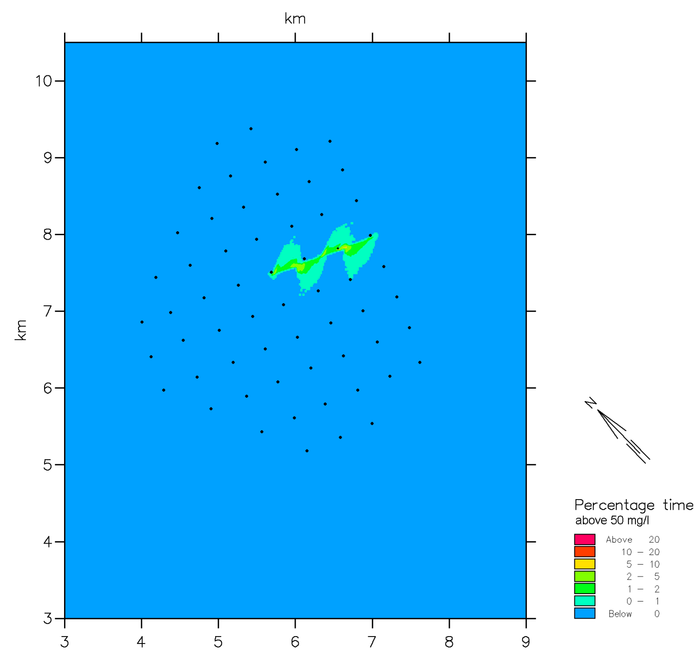
9.4.1.2 Cable Laying

As described in Section 4.11 it is considered that the cables within the wind farm area would be installed in shallow trenches by ploughing. The main cable to land would be likely to be installed by a combination of directional drilling and ploughing. Directional drilling would be used for the section of the cable on the banks, while ploughing would be restricted to the more stable bed sections in the main channel and closer to land.

For the cables between the turbines it is estimated that sediment release into suspension would be in the order of 0.15 m^3/m, whilst for the larger cables to land this figure would be in the order of 0.2 m^3/m. During directional drilling the arisings from the drilling operation would be captured for disposal off site and as such there would be no release of material into the water.

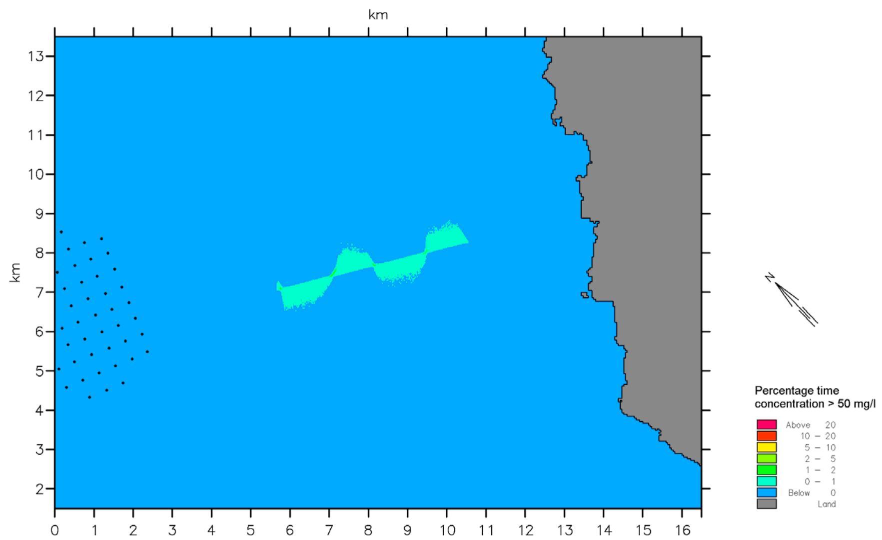
The installation of cables between turbines has been modelled assuming continuous laying of a cable between 4 turbine locations at a rate of 1 m/min which includes an allowance for delays/connections etc. The percentage time for sediment load in excess of 50 mg/l is illustrated in Figure 9.4.3. It can be seen that this level would only be exceeded for a maximum of 5 – 10% of the installation time and this only in close proximity to the cable position (less than 100 m). The level of 50 mg/l would never be exceeded beyond a distance of 700 m from the cable position and within 700 m the percentage time in excess of 50 mg/l would be less than 2%.

Figure 9.4.3 Percentage of time during on-site cable installation when suspended sediment > 50mg/l



For the main cable to land, ploughing only has been considered as directional drilling will not have the effect of raising sediment into suspension. The installation of this cable was modelled on the section between the banks and the areas where gravel was found to occur, as the gravel sediments are too heavy to be raised into suspension. The rate of installation was considered to be 2 m/min in continuous operation. The percentage time in excess of 50 mg/l is illustrated in Figure 9.4.4 which shows that this level is only exceeded within a distance of 700m of the cable position and for less than 5% of the installation time.

Figure 9.4.4 Percentage of time during substation to shore cable installation when suspended sediment > 50mg/l



9.4.2 OPERATION

The effects of the proposed development have been assessed by modelling the coastal processes at the development site and the surrounding area both before and after construction of the turbines.

9.4.2.1 Impact on Tides

The impact of the wind farm on the tides was assessed by comparing the tidal currents distribution and tidal height within the estuary with and without the presence of the wind farm.

The flow pattern showing the tidal speeds during ebb and flood spring tides was simulated with and without the presence of the wind farm and are shown in Figures 9.4.5 and 9.4.6. In this simulation the turbine base size was chosen to illustrate the 'worst case' i.e. a multiple pile foundation with an effective base size of 15x15m.

Figure 9.4.5 Comparison of ebb tidal velocities with and without wind farm installed

Ebb tidal velocities –spring tide without wind farm | **Ebb tidal velocities –spring tide with wind farm**

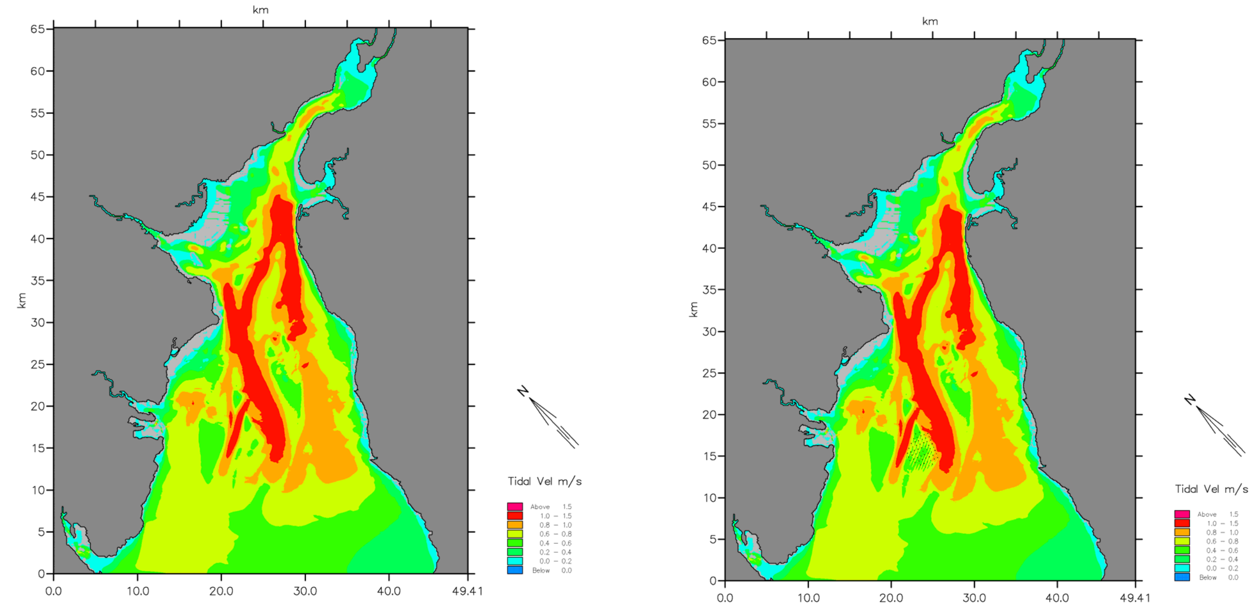


Figure 9.4.6 Comparison of flood tidal velocities with and without wind farm installed

Flood tidal velocities –spring tide without wind farm | **Flood tidal velocities –spring tide with wind farm**

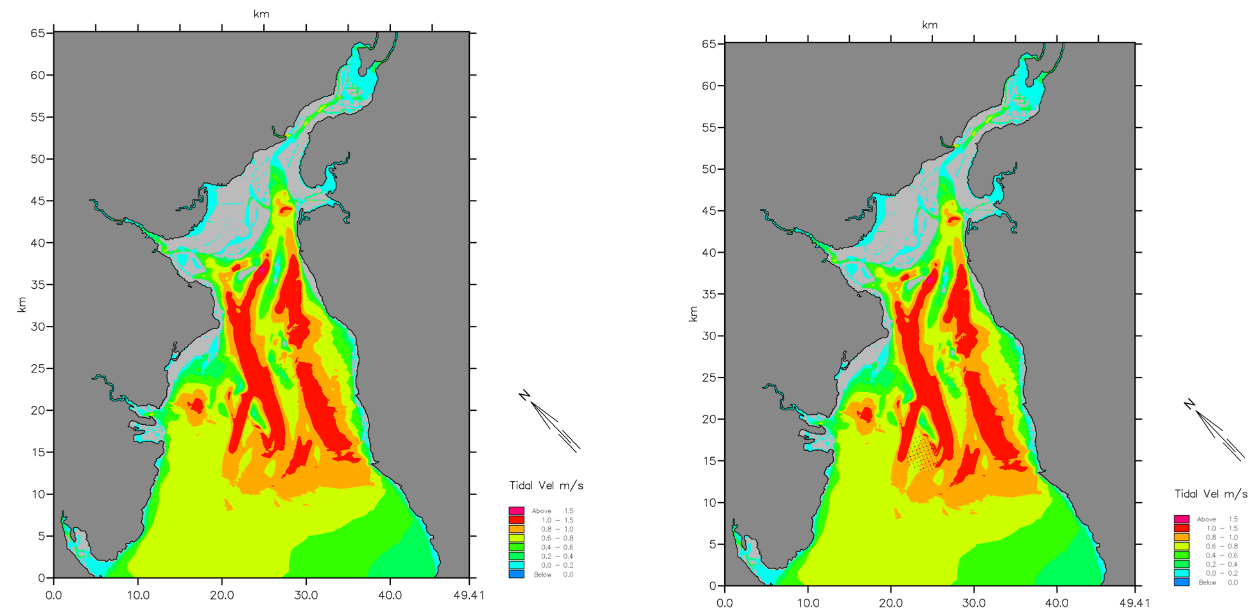
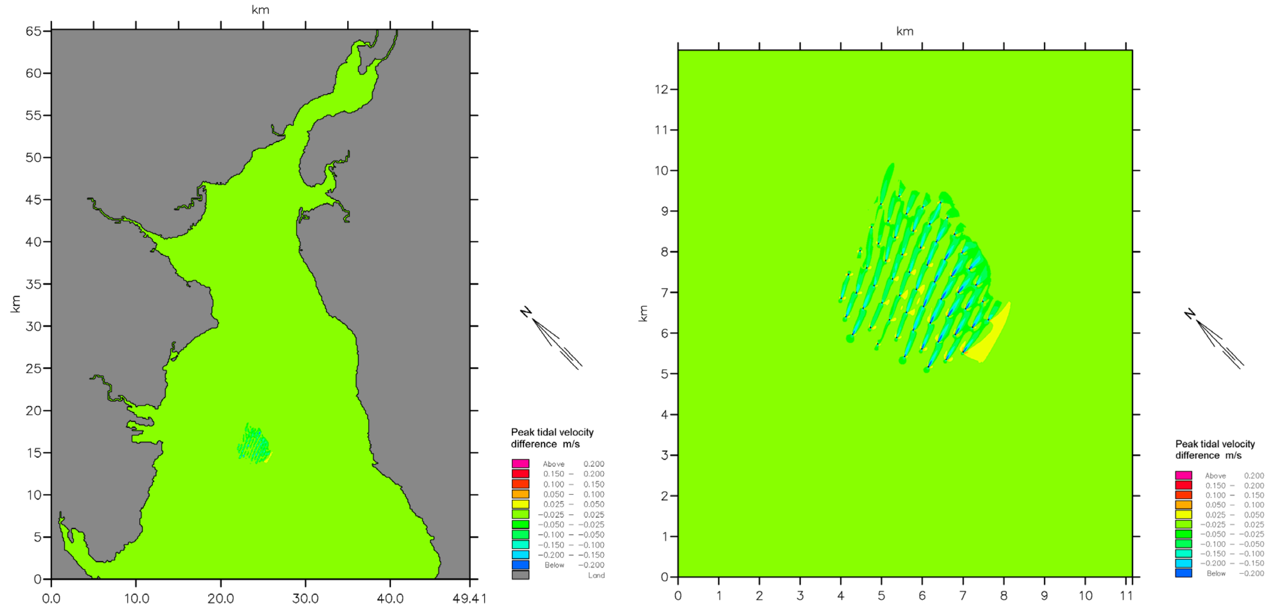


Fig. 9.4.7 show the difference of the peak tidal velocity within the Solway estuary with and without the existence of the wind farm for both the estuary as a whole and for the wind farm site itself. The presence of the turbines causes local disturbances that lead to small decelerations and accelerations of the tidal flow.

However, on a larger scale, the wind farm has no significant impact on the general tidal flow characteristics.

Figure 9.4.7 Difference in peak tidal velocities with and without wind farm installed

Peak Tidal Velocities without Wind Farm | **Peak Tidal Velocities with Wnd Farm**

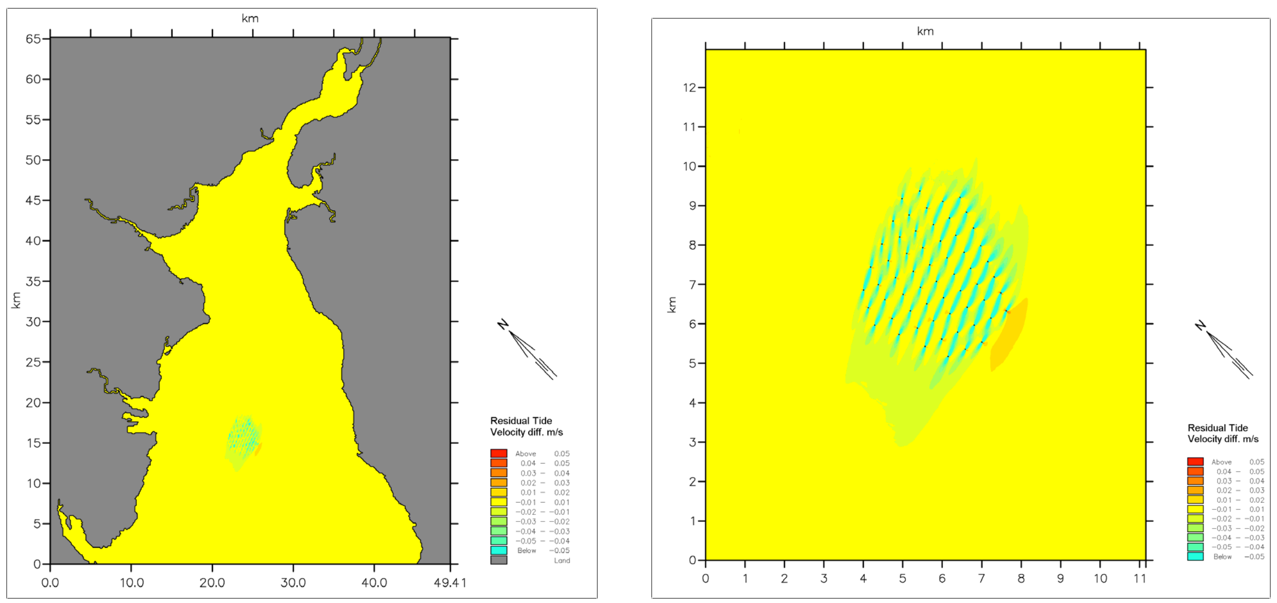


Similarly, Fig. 9.4.8 shows the residual tidal velocity differences in the estuary as a whole and within the wind farm site.

As can be seen in the figures above and below, the presence of the wind farm does not significantly affect the tidal height and flow characteristics in the Solway Firth away from the immediate are of the farm itself.

Figure 9.4.8 Difference in residual tidal velocity with and without wind farm installed

Residual Tide Velocity without Wind Farm | **Residual Tide Velocity with Wind Farm**



9.4.2.2 Impact on Waves

The major storm events, which most significantly affect the coastal process in the Solway Firth, are predominantly from the southwest.

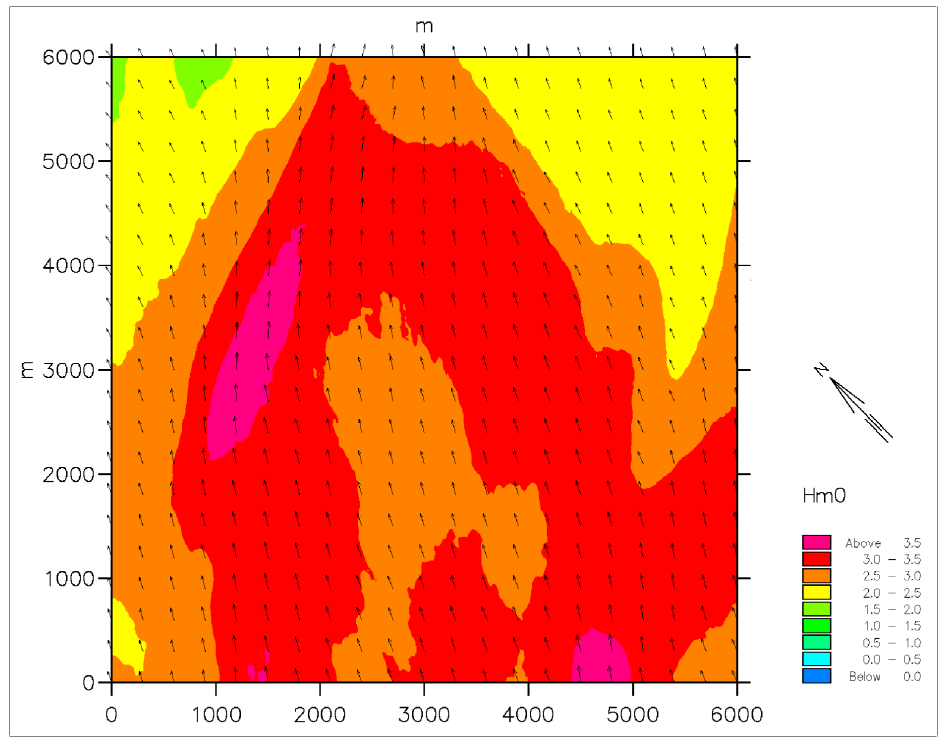
Wave climate was simulated for typical gales from the south-southwest to west-southwest directions with and without the presence of the wind farm. The waves generated during gales from this southwest sector propagate into the Firth from the Irish Sea and are of a sufficiently long wave period, in the order of 7.5s, that the turbine structures are transparent to the passing wave.

There is a small and local reduction in the wind speed within the wind farm site, in the order of 10%, that slightly changes the wave climate around and immediately downwind of the turbines, as illustrated in Fig. 9.4.9. However, as can be seen from Fig. 9.4.10, this has no significant impact on the wave climate in the Estuary as a whole.

Figure 9.4.9 Comparison of significant wave height and direction at site with and without turbines

Gale from 200° at High Water

Significant wave height and direction at site without wind farm



Significant wave height and direction at site with wind farm

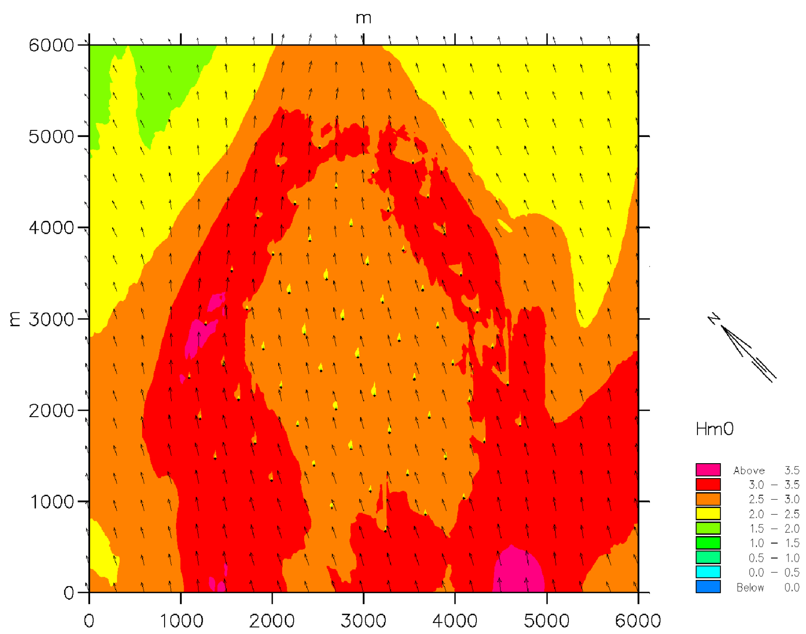
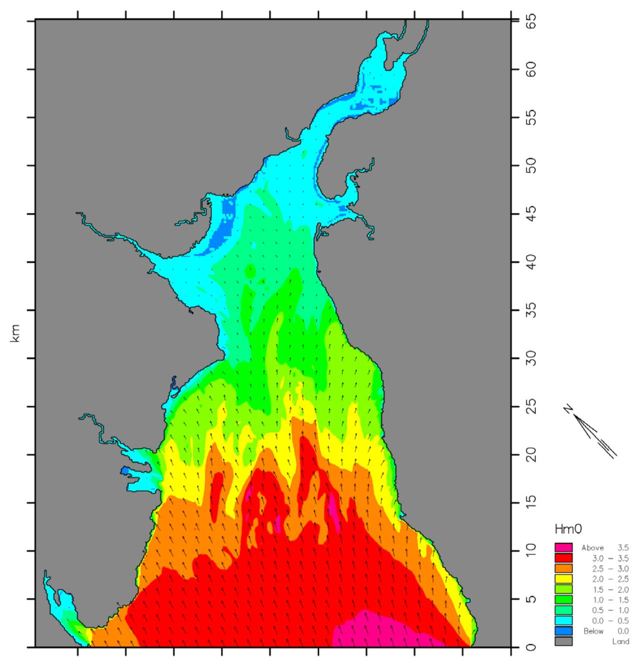


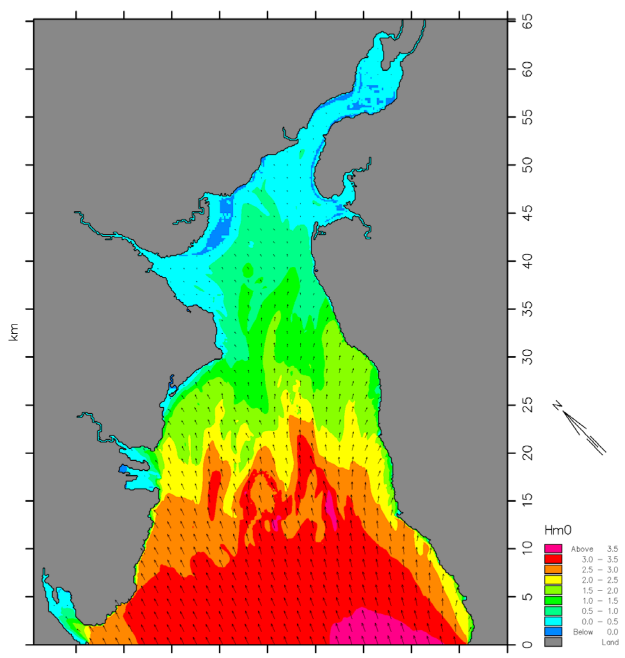
Figure 9.4.10 Comparison of significant wave height and direction in estuary with and without turbines

Gale from 200° at High Water

Significant wave height and direction without wind farm



Significant wave height and direction with wind farm

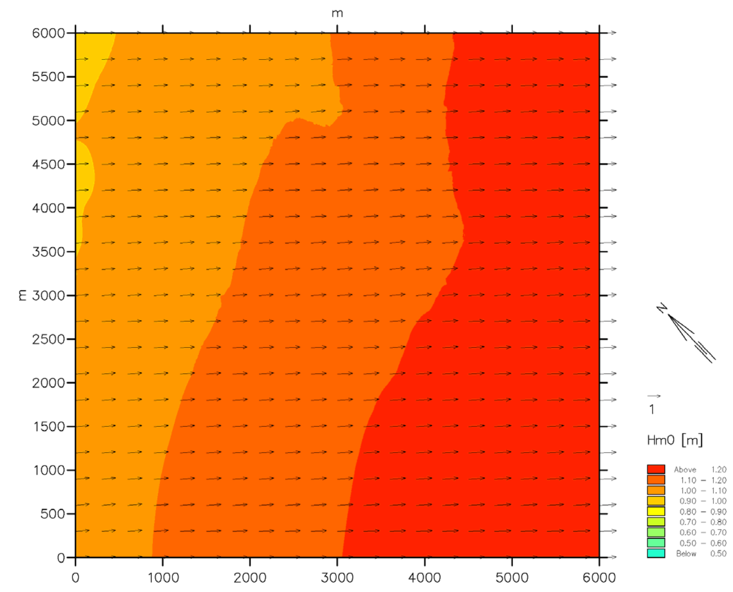


Wave climate was also simulated for Northwest and Southeast gales. These local winds generate short period waves across the Firth that are slightly affected by the presence of the turbines as well as a small reduction in the wind speed downwind of the wind farm. As shown in Fig. 9.4.11, there is a small local impact on the wave climate in the vicinity of the wind farm with a small decrease of the significant wave height around the turbines in the order of 5%. However the wind speed recovers downwind of the wind farm resulting in no significant impact on the wave climate along the downwind shoreline, as illustrated in Fig. 9.4.12, where the wave height will be within 5 mm in height of these occurring without the presence of the turbines.

Figure 9.4.11 Comparison of significant wave height and directions at site with and without turbines

Gale from NW direction at High Water

Significant wave height and direction at site without wind farm



Significant wave height and direction at site with wind farm

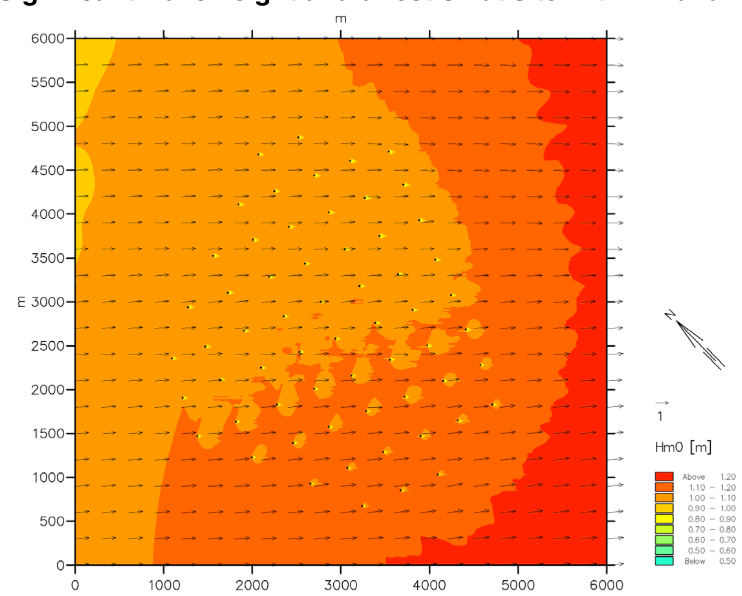
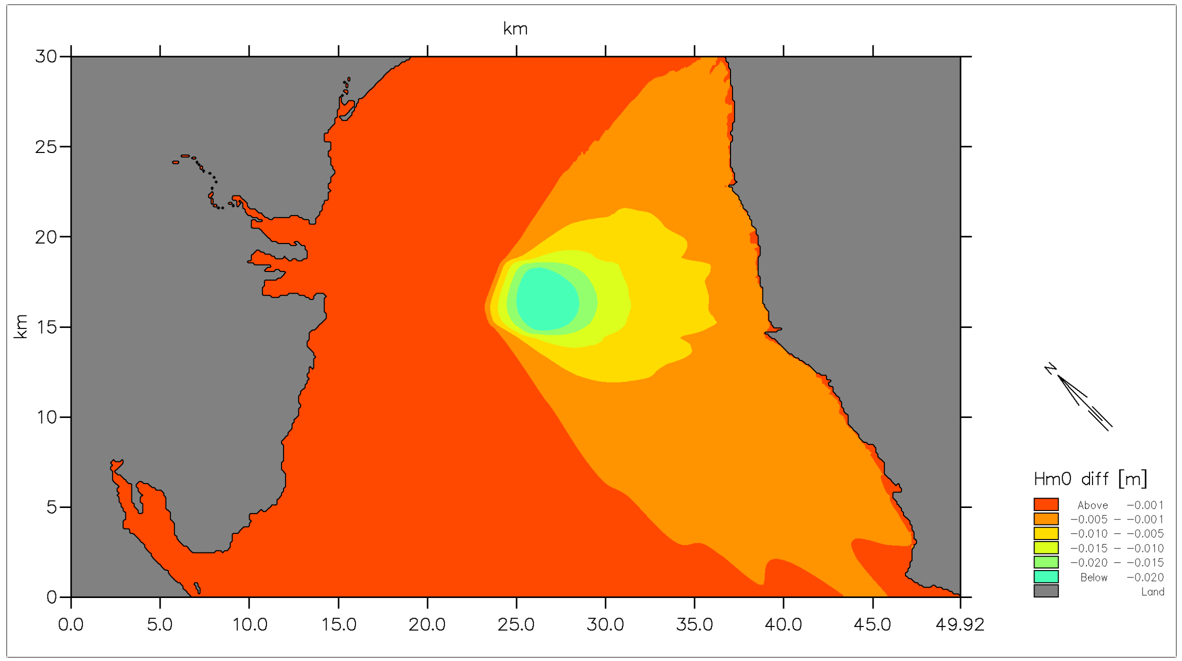


Figure 9.4.12 Wave height difference with and without wind farm

NW gale at high tide



9.4.2.3 Impact on Sediment Movement and Sediment Transport

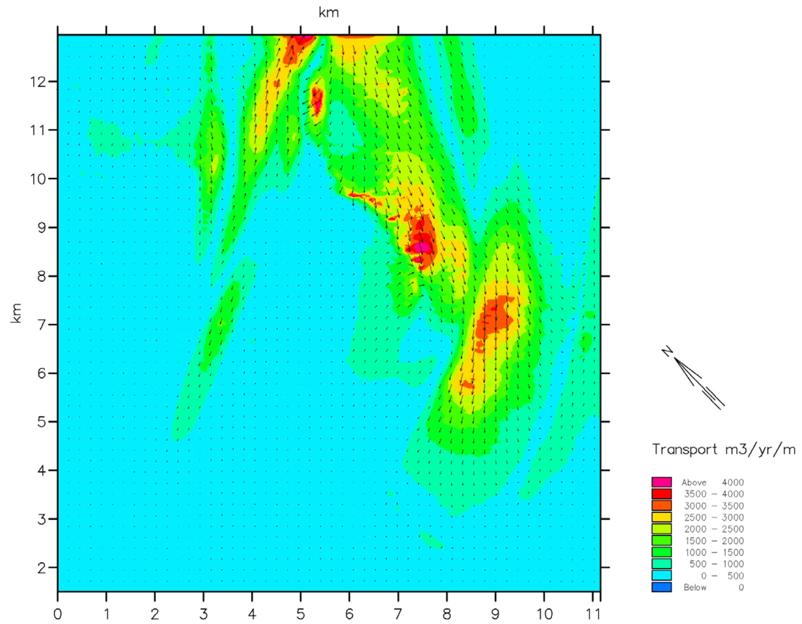
During calm weather the tidal currents are the main influence on the sediment transport process. Modeling of the sediment transport with and without the presence of the wind farm was undertaken to assess the impact of the wind farm during relatively calm conditions.

Fig. 9.4.13 shows the net sediment transport rate over a full tidal cycle during a spring tide with no waves with and without the presence of the wind farm. The transport patterns are similar in the two different situations, although there is a local reduction of the net sediment transport rate around the turbines on the eastern part of the site.

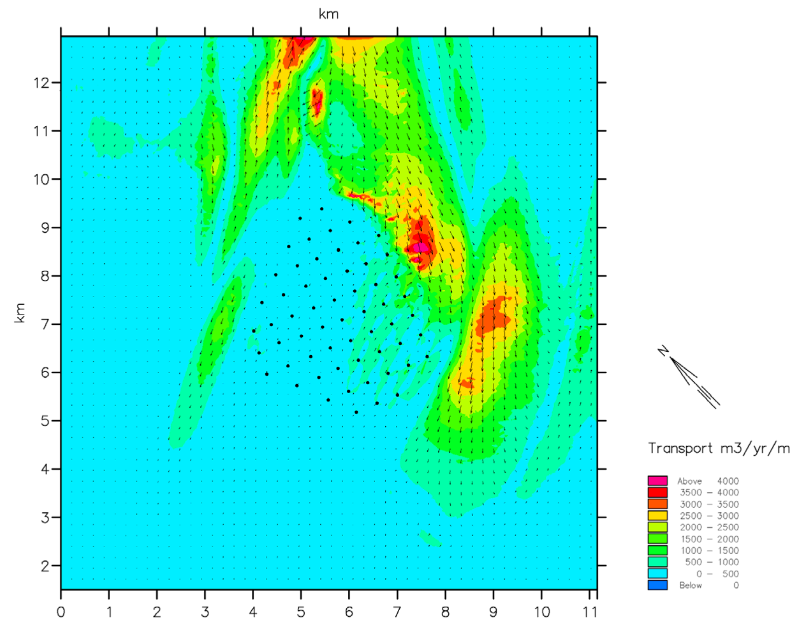
The residual tidal velocities represent the net movement of particles over the tidal cycle, so reflect the sediment transport pathways due to tidal currents in Solway Firth. As shown previously, the difference in the residual tidal velocity with and without the wind farm is negligible within the estuary as a whole. Thus apart from the area of the wind farm itself, the presence of the turbines will not have a significant effect on the sediment movement processes during relatively calm conditions.

Figure 9.4.13 Net sediment transport rates over full tidal cycle

Spring tide – no wave – without wind farm



Spring tide – no wave – with wind farm



As noted in Section 6 of this ES, the combination of tidal currents and large breaking waves results in significant sediment transport during southwesterly gales around the banks and in the estuary as a whole.

Fig. 9.4.14 and 9.4.15 show the rate of sediment transport during a flood and ebb tide with a southwest gale from 200° with and without the turbines installation. The simulations demonstrate that in these conditions, the impact on the sediment transport is locally situated within the wind farm and is different for ebb and flood tides.

Figure 9.4.14 Rate of sediment transport – Flood tide with gale from 200°

Without wind farm **With wind farm**

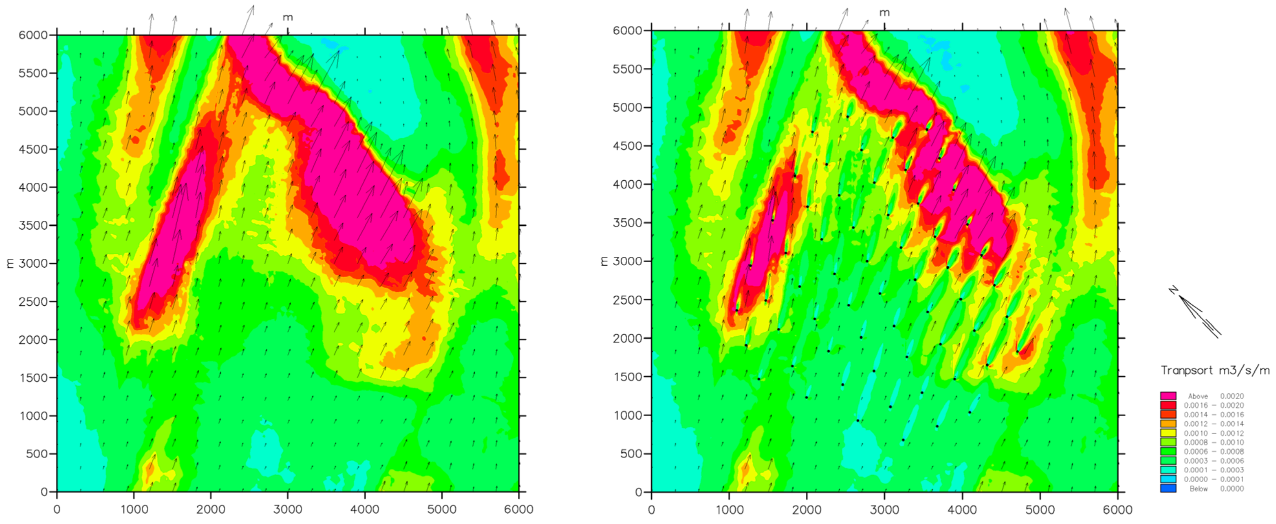
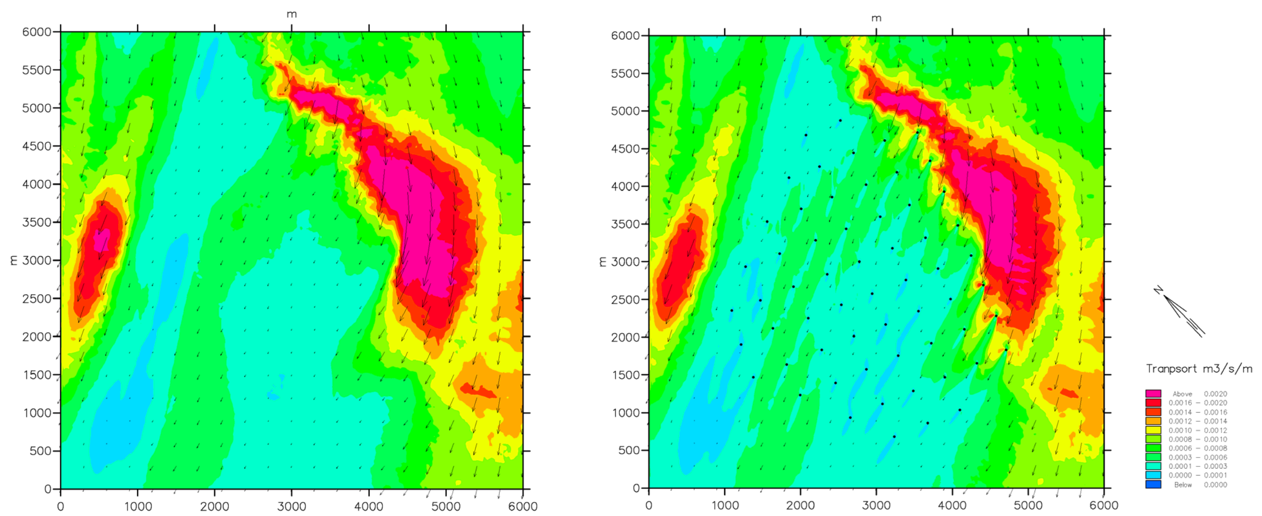


Figure 9.4.15 Rate of sediment transport – Ebb tide with gale from 200°

Without wind farm **With wind farm**

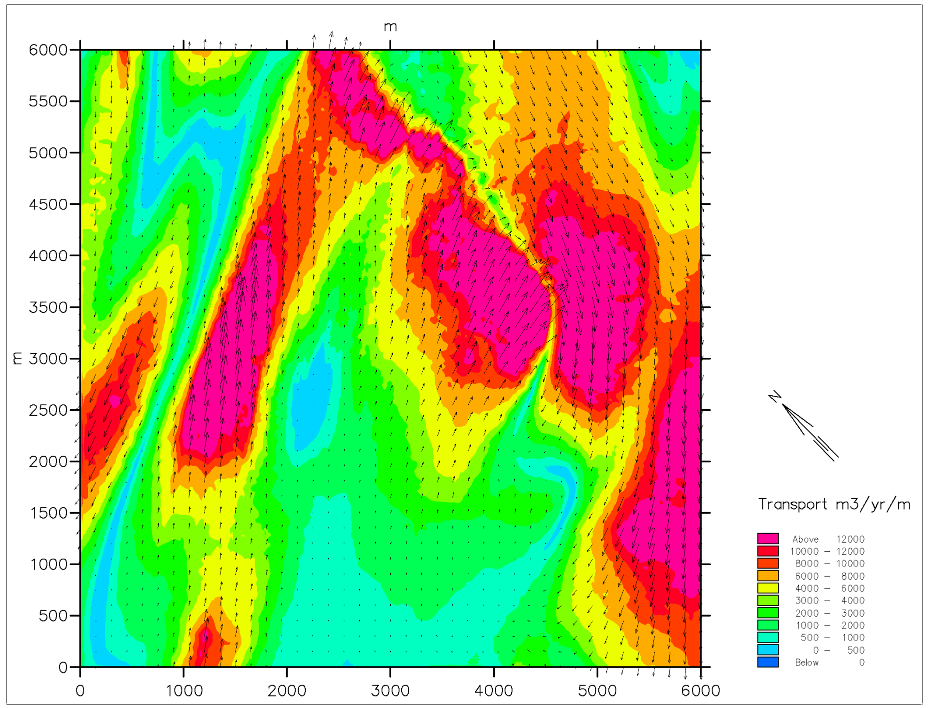


In the case of flooding, the sediment transport regime is locally altered at the turbines positions, particularly on the northeast part of the wind farm, where the sediment transport rate is naturally very high (above 0.0020 m^3/s/m, which is equivalent to 62000 m^3/year/m). In contrast, during an ebb tide, the impact on the sediment transport regime is in an area of the site with naturally lower sediment transport rates.

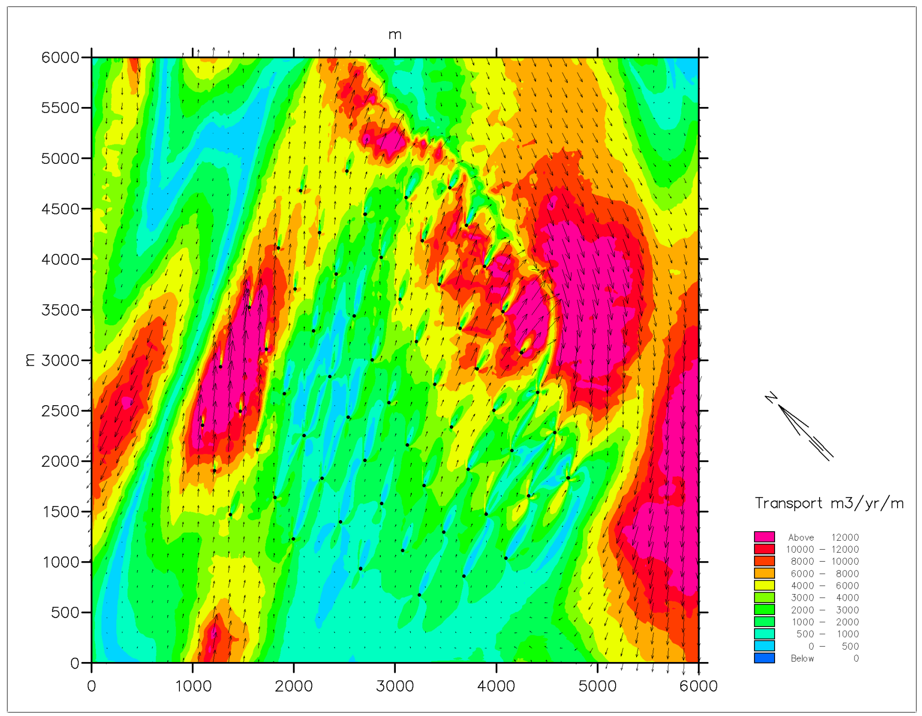
Figure 9.4.16 illustrates the net rates of sediment transport over a full tidal cycle for southwest gales with and without the wind farm. As with the peak sediment transport rates, the impact on the net sediment transport rates is restricted to local areas around the wind farm site.

Figure 9.4.16 Net rate of sediment transport over full tidal cycle – Gale from 200°

Without wind farm



With wind farm



The coastal processes along the Northwest and Southeast coasts of the Solway Firth are influenced by both the southwesterly gales and the locally generated waves across the estuary. As noted in Section 9.4.2.1 and 9.4.2.2 above related to tides and waves respectively, the wind farm site has no measurable impact on the waves and tidal flows along the shorelines during Southeast and Northwest winds. Thus the wind farm will have no significant impact on the coastal processes along the shorelines of the Solway Firth.

9.4.3 MITIGATION MEASURES

The effects of the construction operations on the sedimentology of the Solway Firth area will be insignificant and as such no mitigation measures are considered necessary.

The presence of the proposed turbine foundations will have no significant effects on the coastal processes and sediment transport regime and thus no mitigation measures are considered necessary.

9.5 EFFECTS ON WATER QUALITY

9.5.1 SEDIMENT DISTURBANCE

As outlined in Section 9.4 above, the changes in the volume of sediment transport due to the construction and operation of the wind farm are insignificant in relation to the volume of the natural sediment transport in the Solway Firth. Thus, the construction and operation of the wind farm will have no impact on the suspend sediment levels within the estuary.

It is possible that the preparation of the foundations for the wind turbines will involve augering of material in preparation for piling (as well as piling without augering). If material were extracted by augering it would likely remain in situ. If this is not the case and augered material needs to be transported elsewhere it may be disposed of in a spoil ground at sea under the terms of a licence granted under the Food and Environment Protection Act 1985.

However, no intrusive investigation has yet taken place to determine the presence of pollutants within the material that may be removed. If this material is polluted it may be necessary to take it to a licenced waste management site on land rather than to a spoil ground at sea.

It is proposed that prior to the commencement of any augering operations cores will be taken and analysed to determine the presence of pollutants. The results of the analysis will be sent to the Scottish Executive. If pollutants which preclude sea disposal are found on this analysis then the material augered will be taken to a licenced waste management site.

9.5.2 PRELIMINARY RISK ASSESSMENT OF OIL SUBSTANCE SPILLAGES FOR CONSTRUCTION PHASE

During construction there is a risk of the spillage of oils and other potentially contaminating substances such as hydraulic fluid from construction plant.

In addition the construction of grouted connections will entail a risk of spillage of cementitous substances.

The potential spillage quantities as outlined in Section 4.20 of this ES, would be small.

The average volume of water flow through the site is in the order of 16,000m^3 per second. This high rate of flow will cause a high degree of dilution of any spillages and for the volumes of spillage expected the effects are considered to be insignificant.

9.5.3 PRELIMINARY RISK ASSESSMENT OF OIL AND SUBSTANCE SPILLAGE FOR OPERATION PHASE

The risk of spillage of potentially polluting substances during operation will mainly be restricted to leakage of oils from the turbines and from transformers and storage tanks on the transformer platform.

It is anticipated that items of equipment containing substantial quantities of oil will be bunded to prevent spillage into surrounding waters in the event of leakage. The quantities of oil which could potentially leak from other items of equipment will be small and the effects of such potential spillage are not considered to be significant given the high volume of water passing the site with each tidal cycle, which will provide a high degree of dilution.

9.5.4 MITIGATION MEASURES

During the construction phase precautions will be taken to prevent pollution from oil spillage by the following methods:-

- Use of water based lubricants in hydraulic machinery
- Bunding of major oil containers to prevent spillage.

With respect to the spillage of cementitious materials all shuttering, etc will be efficiently sealed to prevent leakage and all grouting operations will be carefully monitored.

Regarding the operational phase, all items of equipment containing substantial quantities of oil will be bunded securely to prevent spillage/leakage. The power cables joining the turbines to the on-site substation platform and between the platform and the shore would be of a type that does not contain oil.

9.6 EFFECTS ON MARINE BENTHOS

9.6.1 IMPACT ASSESSMENT METHODOLOGY

9.6.1.1 Approach

An assessment method has been developed which allows a prediction of the probable significance of direct and indirect impacts on each identified benthic biotope. Natural Power have produced a generic matrices table which provide a structure for the assessment of the *magnitude* of each impact in accordance with the degree of 'shift' from the baseline condition. The *significance* of this impact, with respect to the EIA regulations, is then determined using a matrix, which factors the *magnitude* against the *sensitivity* of the environmental resource, where *sensitivity* is related to the importance and recoverability of the resource. MARENCO, the marine biologist consultancy contracted to carry out the benthic assessment, has adapted the Natural Power assessment model so that it takes account of current thinking for the assessment of sensitivity as it relates to the marine environment.

9.6.1.2 Sensitivity and Magnitude

Existing Approaches to Assessing Sensitivity

An appraisal was made of the techniques which are currently used to assess the sensitivity of marine life to environmental change. There has been considerable progress in recent years in the development of protocols which allow assessment of the sensitivity of species and biotopes to a range of natural and anthropogenic activities.

The current methods used by the Marine Life Information Network for Britain and Ireland (MarLIN) have been used as the basis for assessing species and biotope sensitivity. This research expands upon the work of Holt et al.[321] [322], which addressed many of the concepts relating to sensitivity, vulnerability, recoverability and intolerance. This assessment was undertaken primarily through interrogation of completed Biology and Sensitivity Key Information Reviews using the MarLIN website[323].

Definitions used in the assessment of magnitude and sensitivity are outlined below.

- **Recoverability** is the ability of a habitat, community or species to return to a state close to that which existed before the development, activity or event. Recovery may occur through re-growth, re-colonisation by migration or larval settlement from undamaged populations or re-establishment of viability where, for instance, reproductive organs or prop gules have been damaged by the event.

- **Importance** in the context of marine natural heritage: species or biotopes that are rare or very restricted in their distribution; species or biotopes that are in decline or have been; species or biotopes where a country has a high proportion of the regional or world population or extent; species that are keystone in a biotope by providing a habitat for other species; biotopes with a particularly high species richness; locations or biotopes that are particularly good or extensive representatives of their type. Species will also be 'important' if they are listed for protection on statutes, directives and conventions.

- **Biotope** is the physical 'habitat' with its biological 'community'; a term which refers to the combination of physical environment (habitat) and its distinctive assemblage of conspicuous species.

- **Environmental Factor** is a component of the physical, chemical, ecological or human environment that may be influenced by natural events or anthropogenic activity[324].

Definition of Sensitivity

The sensitivity of biotopes has been determined as 'High', 'Medium' or 'Low' following the general methodology given below. The sensitivity awarded a particular biotope is the HIGHEST level attained in a particular category.

HIGH	• Rare or very restricted in distribution • In decline or have been • A high proportion of the regional or world extent • Keystone in a biotope by providing a habitat for other species • Biotopes with a particularly high species richness • Recovery is not possible • Partial recovery is only likely to occur after about ten years and full recovery may take only 25 years • Only partial recovery is likely within ten years and full recovery is likely to take up to 25 years
MEDIUM	• Species or biotopes of local importance but not recognised as rare, protected or Nationally important examples • Only partial recovery is likely within ten years and full recovery is likely to take up to ten years. • Full recovery will occur but will take many months (or more likely years) but should be complete within about five years • Species whose loss or depletion would cause disruption of the local food web
LOW	• Common species or biotopes which are well represented in other areas • Full recovery is likely within a few weeks or at most six months.

[321] Holt, T.J., Jones, D.R., Hawkins, S.J & Hartnoll, R.G., 1995. The Sensitivity of marine communities to man-induced change – A scooping report. Countryside Council for Wales, Bangor, CCW Contract Science Report, no. 65.
[322] Holt, T.J., Hartnoll, R.G. & Hawkins, S.J., 1997b. The sensitivity and vulnerability to man-induced change of selected communities: intertidal brown algal shrubs, *Zostera* beds and *Sabellaria spinulosa* reefs. *English Nature, Peterborough, English Nature Research Report* No. 234.
[323] MARLIN (2001) Biology and Sensitivity Key Information Sub-programme [on-line]. Plymouth: Marine Biological Association of the United Kingdom. (http://www.marlin.ac.uk).

[324] Tyler-Walters, H., Hiscock, K., Lear, D.B & Jackson, A., 2001. Identifying species and ecosystem sensitivities. Report to the Department for Environment, Food and Rural Affairs from the Marine Life Information Network (MarLIN), Marine Biological Association of the United Kingdom, Plymouth. Contract CW0826. [Final Report].

Definition of Magnitude

Magnitude of impact is determined in accordance with the following table. Magnitude has been assessed based on the changes from the baseline extent and condition of each biotope within the study area.

HIGH	Keystone/dominant species throughout the wider biotope or habitat are likely to be killed/destroyed by the factor under consideration.
MEDIUM	The population(s) of keystone/dominant species in the wider biotope may be reduced/degraded by the factor under consideration, the habitat may be partially destroyed or the viability of a species population, diversity and function of a community may be reduced.
LOW	Keystone/dominant species in the wider biotope considered are unlikely to be killed/destroyed by the factor under consideration and the habitat is unlikely to be damaged. However, the viability of a species population or diversity / functionality in the immediate biotope community will be reduced.
NEGLIGIBLE	The factor does not have a detectable effect on structure and functioning of the wider biotope or the survival or viability of keystone/important species

The assessment of significance with regard to the EIA regulations has then been made by reference to the following matrix, which incorporates *magnitude* and *sensitivity*.

MAGNITUDE	**HIGH**	Moderate	**Moderate/Major**	**Major**
	MEDIUM	Low/Moderate	Moderate	**Moderate/Major**
	LOW	Low	Low/Moderate	Moderate
	NEGLIGABLE	Negligible	Negligible/Low	Low
		LOW	**MEDIUM**	**HIGH**
		SENSITIVITY		

As with the generic Natural Power assessment model only impacts with a significance of MOBERATE/MAJOR or MAJOR should be considered to be significant. Negligible, Negligible/Low, Low/Moderate and Moderate impacts should not be considered to be significant with respect to the Regulations.

9.6.2 CONSTRUCTION EFFECTS

9.6.2.1 Loss or Change of Habitat

Wind Farm Area

There would be permanent direct loss of available seabed habitat beneath the turbine bases and a temporary loss along strips cleared for cable trenches within the site. However, this would encompass a very small area of the total sandbank habitat and in the 'worst case' i.e. a multiple pile foundation, would be an area of only 15m x 15m for each turbine and a strip up to 1m wide along the 29 km of cable trench within the wind farm site connecting the turbines to the offshore substation. The total direct loss would represent a maximum of 0.4% of the total 10.3 square km extent of the NcirBat biotope within the wind farm area.

No other biotopes are found within the wind farm area. The biotope is considered to have a Low sensitivity and the direct loss of substrate is considered to be of negligible magnitude giving a negligible impact. The impact to the main NcirBat biotope in the wind farm area from loss of available habitat is therefore not significant.

However, substation platform and turbine foundations will provide a new habitat for colonisation by species which attach to hard surfaces and in turn provide an environment for colonisation by successive species. Colonising species will include seaweeds, the common mussel *Mytilus edulis*, barnacles and other encrusting species such as hydroids, ascidians and sponges.

Colonisation of turbine bases would begin immediately depending upon the recruitment times of various species and would be successional according to the colonisation success of different species. Colonisation rates would be influenced by the hydrodynamics of the sandbank area.

Localised scour protection measures around the turbine bases are considered unnecessary. However, should scour protection becomes necessary due to erosion around turbine bases during the lifetime of the project, it is proposed to use rock filled mattresses or grout filled bags to around 10-15 m radius around the piles. These areas of scour protection are likely to be covered and uncovered due to natural fluctuations in the bed level. The community that develops on areas of exposed scour protection is likely to be representative of the encrusting species which colonise the piles themselves.

132 kV Cable Route

The wind farm to shore cable will be directionally drilled along the sandbank and trenched from the edge of the sandbank to the landfall south of Flimby. No impacts are predicted to the NcirBat biotope due to directional drilling

There would however be direct mortality of some infaunal and epibenthic species impacted by trenching across the mixed substrata of the deeper channel section of the cable route due to substratum loss and sediment disturbance. Impacts would be limited to the 1 m wide strip cleared for trenching (see 9.6.3.2) or less if ploughing methods are used.

Recolonisation of the backfilled cable route trench would begin immediately by mobile polychaete and epibenthic species. Colonisation of harder substratum such as cobbles and boulder would occur through recruitment, although full recolonisation may take several years, with species recruiting from surrounding areas. This may be an important consideration for areas of *Sabellaria* reef which may be encountered at the shoreward end of the cable route especially in the lower part of the shoreline but also in the shallow sub-tidal. The species is fixed to the substratum so substratum removal would cause mortality. Variability in recruitment (dependent on suitable environmental conditions) means that full recovery could take several years. The sensitivity of Sabellaria reef to damage through trenching has therefore been assessed as medium. The magnitude of impact is however low given the overall presence of Sabellaia reef and the impact to the biotope should therefore not be of higher than Low/Moderate significance.

9.6.2.2 Sediment Disturbance

Wind Farm Area

The benthic community in the wind farm area is dominated by a single biotpe (Ncir.Bat) which is represented by low numbers of short-lived robust species such as polychaetes and amphipods. These species are highly adapted to life in mobile sediments, which are subject to regular disturbance and would be able to withstand a certain amount of physical disturbance as a result of the wind farm development.

Disturbance would include minor disturbances through bed preparation prior to turbine installation, disturbances from piling and augering, disturbances to sediment from the feet of jack up platforms and disturbances to sediment from cable laying.

Bed preparation would include only minor levelling of the proposed turbine location to remove any sand ripples or sand waves that may be present. Sediment disturbance would be small as no excavation would be carried out, just local movement of the material on the seabed and this would not impact the robust infaunal polychaete and amphipod population.

Trenching of cables within the turbine array by the use of a plough would cause the greatest levels of physical disturbance with complete displacement of the benthic community and smothering of adjacent areas.

Approximately 29 km of interconnecting cables will be trenched to a depth of 1 m throughout the turbine array area. Trench excavation for cable laying would be carried out by fluidising sand or by the use of a plough. Both methods would cause minimal localised disruption to the seabed environment. Fluidising would raise some of the sediment into suspension, whilst ploughing would tend to displace the sediment to either side of the trench. Mobile polychaete and amphipod species adjacent to the cable trenches would be resistant to shallow smothering and would be expected to relocate to favoured depths with no mortalities. Displaced individuals which survive physical damage to soft body parts should rapidly re-burrow back into the sandy sediment. However, displacement to the surface may increase the risk of predation by bottom feeding fish.

Recolonisation of disturbed sediments, primarily by polychaetes adapted to mobile sediments, amphipods and perhaps molluscs, would be achieved by the migration of individuals.

Recovery of the community would be rapid, as they are frequently exposed to such conditions, due to storm events.

The impact to the NcirBat biotope from physical disturbance is therefore insignificant given the occurrence of this biotope throughout the wider Robin Rigg area.

It is predicted that the construction phase would not significantly increase the amount of sediment that is available for re-distribution by hydrographic processes (see Section 9.4 earlier). The transport and settlement of re-suspended finer sediments by wave and tidal action and residual current movements, to other areas should therefore be insignificant and would not exceed that expected during average rough sea conditions experienced regularly on Robin Rigg.

The impact to the NcirBat biotope and surrounding biotopes within the Solway Firth from increased suspended sediments would therefore not be significant.

132 kV Cable Route

The wind farm to shore cable route passes through a deep channel community which is represented by a muddy sand community (FaS) and an encrusting community on cobbles and stones represented by bryozoans and hydroids (ByH).

Trenching of the cable route will cause the displacement of mixed substrata and smothering of adjacent communites. The majority of the species identified in the deeper channel are associated with the harder substrata either as attached colonial species, or live under stones or in crevices. Displaced colonies which remain attached to shell debris, cobbles or boulders will probably survive if moved to a similar aspect adjacent to the trench. Species like the tube dwelling polychaetes *Pomatoceros lamarcki* and *Polydora ciliata* will be vulnerable to crushing but will be able to survive shallow smothering. *Sabellaria* reef in the vicinity of the cable route is resistant to localised increases in suspended sediments and is tolerant to burial under sand for several weeks, although feeding and growth will be curtailed.

9.6.2.3 Water Quality Changes

Wind Farm Area

There may be potential for the release of grouting and cementing materials during installation of the wind farm turbines. Cementitious grout would be used to form the connection between the turbine piles and the main structure. However, grouting operations would be accurately controlled and as such potential spillage volumes would be small. Also given the high volume of water passing through the development area with each tidal cycle the dilution effects would be such that the impact of spillages would be insignificant.

Impacts to the benthic community in the wind farm area due to the release of cementitious materials are therefore negligible.

The potential for oil spillages from hydraulics and increased vessel activity during construction could have impacts on the benthic environment. However, due to the highly dynamic nature of the site, it is likely that small quantities of oil would be quickly dispersed (see Section 9.5 above). Unless oil is incorporated into the sediments, low inputs should not have significant impacts to identified benthic communities.

Cable Route

As with the wind farm area there may be some potential for oil spillages from hydraulics and vessels. The cables will not contain oil in order to remove any risk of oil leakage in the case of damage to the cable armoured wall.

Impacts to identified benthic communities should be insignificant assuming proper management of risk.

9.6.2.3 Noise and Vibration

The full impacts of noise on benthic communities is at present unknown. During the construction phase, noise pollution from drilling and piling may disturb the benthos by causing polychaete species to react by withdrawing to the bottom of their burrows or retracting their palps into their tubes. Bivalve species may withdraw siphons. The amphipod *Bathyporeia* sp. may respond by wriggling but is unlikely to be directly sensitive to noise.

These reactions to noise and vibration should not interfere with the ecological functioning of identified biotopes.

9.6.3 OPERATION EFFECTS

9.6.3.1 Sediment disturbance

It is predicted that there would be localised scour effects due to the diffraction and funnelling of waves around turbine foundation bases (1.5 – 2.0 m around each pile to 1 pile diameter depth).

This local erosion or deposition around the bases should not be significant and given the highly mobile nature of the sand bank and the high level of natural bed movement would not impact the already impoverished benthic community found on the wind farm site, which is adapted to extreme natural fluctuations in sediment stability.

It is predicted that there would be no changes to the hydrodynamic regime due to the cumulative effect of multiple turbines and therefore no effects to the wider benthic environment due to changes to hydrographic processes.

9.6.3.2 Water Quality Changes

Multi-pile foundations would be protected by the provision of sacrificial anodes which would lead to the emission of aluminium into the water in the range of 120 – 260 kg/yr per foundation and 7200 kg/yr to 15600 kg/yr for the wind farm as a whole. However, given the spacing of the structures and the high degree of water around the structures, particularly given the high currents and tidal range on the site, the impact on the site would be insignificant. No impacts to identified benthic communities are predicted.

Mono-pile foundations would use a sacrificial layer of steel, which would lead to the emission of steel into the surrounding environment. The amount of emissions would depend on the rate of corrosion and the lifetime of the structure, but would not be significant. No impacts to identified benthic communities are predicted.

9.6.3.3 Noise and Vibration

During operation the underwater noise generated from the wind turbines may be in a similar frequency range as shipping vessels, wind and waves, and would therefore contribute to the background low frequency noise.

As yet, little research has been conducted on the effects of noise and vibration on the benthic communities. It is however predicted that unless vibration of the wind turbines alters the physical composition of the seabed, there should be no significant impacts on benthic communities[325].

9.6.4 SUMMARY OF IMPACTS

The results of the benthic sensitivity assessment are presented below in Table 9.6.1. The assessment rationale for scoring each biotope is presented in Appendix D7 in the separate volume of appendices. The assessment was applied to the main biotopes identified in the benthic surveys as follows: -

Wind farm Area	IGS.NcirBat	*Nephtys cirrosa* and *Bathyporeia* spp. in infralittoral sand
Cable Route Sub-tidal	IMS. FaMS	Shallow muddy sand faunal communities
	MCR.ByH	Bryozoan/hydroid turfs (sand influenced)
Cable Route Intertidal	MLR.Salv	*Sabellaria alveolata* reefs on sand-abraded eulittoral rock
	MIR.Ldig	*Laminaria digitata* on moderately exposed or tide-swept sublittoral fringe rock
	LGS. AP.P	Burrowing amphipods and polychaetes (often *Arenicola marina*) in clean sand shores
	MLR.MytFves	*Mytilus edulis* and *Fucus vesiculosus* on moderately exposed mid eulittoral rock

No significant impacts have been identified resulting from the development.

Table 9.6.1 Summary Table of Impacts on Key Biotopes

325 Metoc (2000) An Assessment of the Environmental Effects of Offshore Wind Farms. Report No. ETSU W/35.00543/REP.

Biotope	Substratum Loss			Smothering			Physical Disturbance		
	Sensitivity	Magnitude	Impact	Sensitivity	Magnitude	Impact	Sensitivity	Magnitude	Impact
(NcirBat)	LOW	NEG	NEG	LOW	NEG.	NEG.	LOW	NEG.	NEG.
(FaMS)	MEDIUM	LOW	LOW/MOD	LOW	NEG.	NEG.	LOW	LOW	LOW
(ByH)	MEDIUM	LOW	LOW/MOD	MEDIUM	LOW	LOW/MOD	MEDIUM	LOW	LOW/MOD
(SalV)	MEDIUM	LOW	LOW/MOD	MEDIUM	LOW	LOW/MOD	MEDIUM	LOW	LOW/MOD
(Ldig)	MEDIUM	LOW	LOW/MOD	MEDIUM	LOW	LOW/MOD	MEDIUM	LOW	LOW/MOD
(AP.P)	MEDIUM	LOW	LOW/MOD	LOW	LOW	LOW	LOW	LOW	LOW
(MytFves)	MEDIUM	LOW	LOW/MOD	MEDIUM	LOW	LOW/MOD	MEDIUM	LOW	LOW/MOD

Biotope	Noise			Suspended Sediments			Contamination		
	Sensitivity	Magnitude	Impact	Sensitivity	Magnitude	Impact	Sensitivity	Magnitude	Impact
(NcirBat)	LOW	NEG.	NEG.	LOW	NEG.	NEG.	MEDIUM	LOW	LOW/MOD
(FaMS)	LOW	NEG.	NEG.	LOW	NEG.	NEG.	MEDIUM	LOW	LOW/MOD
(ByH)	LOW	NEG.	NEG.	LOW	NEG.	NEG.	MEDIUM	LOW	LOW/MOD
(SalV)	N/A	N/A	N/A	MEDIUM	LOW	MOD.	MEDIUM	LOW	LOW/MOD
(Ldig)	N/A	N/A	N/A	MEDIUM	LOW	LOW/MOD.	MEDIUM	LOW	LOW/MOD
(AP.P)	N/A	N/A	N/A	LOW	NEG.	NEG.	MEDIUM	LOW	LOW/MOD
(MytFves)	N/A	N/A	N/A	LOW	LOW	LOW	LOW	LOW	LOW/MOD

9.6.5 EFFECTS ON SHORELINE AND INTERTIDAL HABITATS

The intertidal section of the cable route crosses a 500 m area of mixed cobble scar and fine sand. The flora and fauna community, which consists of fucoid seaweeds on hard cobble substratum, and an impoverished polychaete and amphipod infaual sand community is well represented locally.

Some mobile polychaete and amphipod species may survive temporary displacement but mortality will affect the majority of identifed benthic species over a strip up to 3m wide along the cable route transect due to loss of substratum, smothering by displaced sediment and mechanical damage from trenching machinery which will have a track width of approximately 3m.

The *Sabellaria* reef at the lower intertidal would be vulnerable to mechanical damage from the cable trenching. However, *Sabellaria* is prone to damage and is especially susceptible to storm damage in the winter with regeneration occurring remarkably quickly within a season[326].

Fucus vesiculosus and other fucoid species attach permanently to the substratum, and would be removed upon substratum loss or killed by prolonged smothering by displaced sediment. However, recovery would be high due to the high fecundity of the species and there widespread distribution. For example, *Fucus vesiculosus* recruits readily to cleared areas of the shore and full recovery takes 1-3 years[327].

[326] Connor, D.W., Brazier, D.P., Hill, T.O., & Northen, K.O. 1997. Marine Nature Conservation Review: marine biotope classification for Britain and Ireland. Volume 1. Littoral biotopes. Version 97.06. *JNCC Report*, No. 299.

[327] Holt, T.J., Hartnoll, R.G. & Hawkins, S.J., 1997b. The sensitivity and vulnerability to man-induced change of selected communities: intertidal brown algal shrubs, *Zostera* beds and *Sabellaria spinulosa* reefs. *English Nature, Peterborough, English Nature Research Report* No. 234.

The lugworm *Arenicola mari*na should repopulate backfilled areas rapidly by migration from adjacent populated areas.

It is predicted that the effects on the intertidal habitat at the cable route landfall would be temporary with full recovery expected within 2-3 years. The sensitivity of identified intertidal biotopes to damage through trenching varies between low to medium depending on recovery rates with the sediments probably showing the highest levels of recovery. The magnitude of impact is low given the overall presence of the habitat in the area and the impact to the biotopes should not be significant.

The above assessment has been based on the intertidal communities identified in a Phase 2 habitat survey along a transect along the centre line of the 132 kV cable corridor. The precise location of the route in the intertidal shoreline area cannot be determined until the route on land has been finalised. At that stage a further littoral survey will be carried out along the selected route line and the impacts reassessed. The communities are not, however, expected to differ greatly from those identified in the Phase 2 survey along the corridor centre line.

Key Habitats

It is predicted that the impacts to benthic communities will be localised and consist of mortality to some species through substratum loss or physical disturbance.

The construction and operation of the wind farm would have no significant effects on the sedimentology and water quality of the Solway Firth area (see Section 9.5 earlier) and therefore no impacts are predicted to benthic communities outside the wind farm and cable route development area.

Therefore, no effects are predicted for Annex 1 habitats within the Solway Firth European Marine Site described in Section 7.1 of the ES.

9.6.6 MITIGATION AND MONITORING

The wind farm site selection has selected a site dominated by a biotope which is adapted to mobile and impoverished sediments. This selection is considered to lead to minimal damage to benthic interests.

A monitoring programme for the wind farm site is suggested, however, to confirm the findings of the assessment during and following construction. 10 sample sites are suggested located around/within the windfarm to measure effects of scour, and sediment disturbance, and also along the 132 kV cable route where it has been trenched rather than drilled.

The monitoring programme should continue for 3 years post construction.

Regarding the intertidal area, the final cable route would be microsited as far as possible so that trenching operations avoid damage to good examples of *Sabellaria* reef habitat which occurs in the shallow sub-tidal and lower intertidal part of the cable route landfall.

A monitoring programme should be developed to identify recolonisation success of *Sabellaria* reef and other biotopes in the intertidal area.

9.7 EFFECTS ON FISH

9.7.1 OVERVIEW

The fish impact assessment for the Robin Rigg proposal has been carried out by the Centre for Marine and Coastal Studies (CMACS) at Liverpool University.

The fish species and populations that make use of the Solway Firth were detailed in Section 7.4 of this ES, along with a description of the use of the Robin Rigg area by key species, defined in terms of their commercial value, rarity or key position in the ecosystem. In this section the potential effects of the construction, operation and decommissioning of the Robin Rigg wind farm on the populations of these key species and groups are assessed.

Potential effects include direct (those that are causally linked to the development without any intermediary factor) and indirect (those involving at least one intermediary process) short term and long term, and positive or negative effects. The final scope of potential impacts has been determined following the completion of baseline studies, field survey and consultation, and following initial specification for design, construction and operation of the wind farm. The potential effects on fish have been identified as follows.

Construction and Decommissioning Effects

- Physiological and behavioural effects of underwater noise and vibration resulting from construction operations on various groups of fish
- Direct effects on fish of water quality changes through suspension of sediment in the water column disturbed during construction
- Indirect effects of water quality changes through effects on benthic food sources

Operational Effects

- Physiological and behavioural effects of underwater noise and vibration resulting from turbine operation
- Effects of magnetic fields in the vicinity of power cables lying on or beneath the sea bed, particularly on migratory fish
- Effects of electric fields in the vicinity of power cables on electrosensitive fish groups, in particular elasmobranchs
- Indirect effects on fish of permanent changes in habitat through changes in wave exposure, and sediment transport

The evidence for impacts of offshore wind farm construction and operation is often relevant to groups of fish (with similar physiology), rather than being specific to all the sensitive species identified in the Robin Rigg area. For example, different groups of fish have different hearing capabilities.

The assessments of each of the above potential effects therefore may deal with impacts on such ‘groups’ of species. Impacts have been summarised, however, in a tabular form in relation to each ‘high’ or ‘medium’ sensitivity species identified in the area.

9.7.1.1 Determination of Significance of Impacts

In the determination of the impact of the wind farm proposal on fish populations, mitigation measures have been recommended wherever considered appropriate. Residual impacts of the proposal with the mitigation measures in place have then been determined. In order to ascertain the importance of these residual impacts and to allow them to be weighed up against the positive benefits of the proposal, a method for determination of the *significance* of the impacts has been developed from Natural Power’s general methodology (see Section 5.8 of this ES). This method requires a prior determination of the *sensitivity* of a species or group and an evaluation of the *magnitude* of the effect of the proposal on that species or group. In this case the magnitude of the impact includes a consideration of the timescale of the effect, i.e. short, medium or long term.

Sensitivity

In accordance with the Natural Power methodology, the sensitivity of taxa using the study area has been determined as either ‘High’, Medium’ or ‘Low’ following the general methodology given below. The sensitivity awarded a particular species is the HIGHEST level attained in any category.

HIGH sensitivity
Recognised Rare, Protected or Nationally Uncommon species
Species recognised to be uncommon within the Irish Sea
Species which are target species for fisheries in the Solway Firth OR by-catch species which contribute roughly equally with target species to the income of fishermen dependent upon the waters of the Solway Firth
Species which use the study area as spawning or nursery grounds and whose spawning or nursery grounds are limited within the Irish Sea
Species whose loss or depletion would cause trophic cascades, by virtue of the numbers or position in the local food web

MEDIUM sensitivity
Species whose numbers have declined (nationally or within the Irish Sea), but which are not yet regarded as being rare or uncommon
Commercially important by-catch species regularly taken by local fishing boats
Species which depend on the habitats present in the study area for spawning or nursery grounds but which use such habitats throughout the Irish Sea
Species whose loss or depletion would cause disruption of the local food web

LOW sensitivity
Species common and widely distributed throughout the Irish Sea
Species with little or no commercial value
Species which spawn widely with little or no habitat requirements (e.g. mackerel)
Species whose loss or depletion would not cause trophic effects

The sensitivity of each species recorded as using the area in the vicinity of Robin Rigg was assessed in the Baseline Fish section in Section 7.4 of this ES.

Magnitude

Assessments of magnitude have necessarily been carried out on a qualitative basis. Impacts may be negative OR positive. Magnitude would be assessed on the following basis.

Magnitude	Type and scale of effect
High	Major alteration to population levels (including through habitat availability or prey/predator levels)
	Impacts long-term (e.g. >5 years) and/or irreversible
Medium	Appreciable alteration to population levels
	Impacts medium-term (e.g. 1-5 years) and/or irreversible
Low	Minor alteration to population levels
	Impacts short-term (up to 1 year) and/or reversible through impact reduction or mitigation measures
Negligible	No measurable alteration to population levels
	Impacts short-term and/or reversible

In each case an assessment has also been made of how reliable/complete was the data used in making the evaluation.

Significance

Determinations of the significance of an impact combines evaluations of sensitivity and magnitude. Significance has been determined to the highest possible level, e.g. significance to salmon populations may be assessed at the Solway Firth, Irish Sea and UK level while significance to *Crangon* may only be assessed at the Solway Firth level.

Final significance is determined on the basis of Natural Power's standard matrix given in Table 5.8.2 in Section 5 of this ES. This would include the timescale over which impacts would extend, their reversibility and whether impacts are positive or negative.

9.7.2 CONSTRUCTION EFFECTS

9.7.2.1 Effects of Underwater Noise

Noise Generated by Construction Activities

The loudest noises produced during the construction period are likely to be associated with the installation of the turbine foundations, for which, three options are proposed: driven monopile, augered monopile or multipile foundations (Section 4.7). This assessment considers the impact of driving monopile foundations into the seabed. Should the construction timetable in Section 4.15 of this ES be followed, the piling would be carried out between July and October in the first year of construction and between April and October in the second. Piling may take place at up to two discrete locations at any one time. Of the three foundation options driven monopiles are expected to produce the most noise (the worst-case-scenario), and thus, the greatest potential impacts. Should the multipile or augered monopile option be progressed, impacts of noise and vibration would be reduced.

Intermittent noise associated with construction activities (vessel movements, seismic survey, piling etc) is generally low frequency in the range of several hertz (Hz) to 3000Hz [328]. For example, at a distance of 1km, peak sound levels (PSL) generated by pile driving has been measured at 105-115 decibels (dB) in the frequency range 50-200Hz [329]. This equates to source levels (at 1 meter from source) of 135-145dB re: 1 μPa-1m (sound levels are given with reference to 1 μPa-1m unless otherwise stated), although sound levels may be as high as 150dB at source.

For comparison, the noises produced by seismic air-gun surveys range from 10 to 1000Hz at source levels of 210dB for an average airgun array and 259dB for a large airgun array[330]. Boats and ships generate noises with source levels and dominant frequencies ranging from 152dB at 6300Hz for a 5m Zodiac with an off-board motor, 162dB at 630Hz for a tug/barge travelling at 18 km/hr, through to a large tanker with source level around 177dB at 100Hz [331]. The noise from a typical fishing vessel is reported to be 150-160dB at source[332].

[328] Vella, G., Rushforth, I., Mason, E., Hough, A., England, R., Styles, P., Holt, T., Thorne, P. (2001). Assessment of the Effects of noise and vibration from offshore wind farms on marine wildlife. Report to ETSU (Department of Trade and Industry). DTI/Pub URN 01/1341. Pp 71.
[329] Moore, A. & Potter, E.C.E. (1994). The movements of sea trout (*Salmo trutta* L.) through the estuary of the Rive Avon, Southern England. Fisheries Management & Ecology. 1: 1-14.
[330] Richardson, W.J; Greene, C.R; Malme, C.I; Thompson, H.H (1995). Marine Mammals and Noise. Academic Press, San Diego.
[331] Vella, G., Rushforth, I., Mason, E., Hough, A., England, R., Styles, P., Holt, T., Thorne, P. (2001). Assessment of the Effects of noise and vibration from offshore wind farms on marine wildlife. Report to ETSU (Department of Trade and Industry). DTI/Pub URN 01/1341. Pp 71.
[332] Gulland, J.A. & Walker, D.T. (1998)Marine Seismic Overview. In: Tasker, M.L. & Weir, C. (eds.). Proceedings of the Seismic and Marine Mammals Workshop, London

Physiological Mechanisms of Noise Perception in Fish

Fish perceive sound through the ears and lateral line (collectively referred to as the acoustico-lateralis system) and through the 'swimbladder', a gas filled sack located within the body. The acoustico-lateralis system is sensitive to the vibration or particle displacement component of a sound wave, whilst the swimbladder is sensitive to pressure (and the pressure component of a sound wave), which it resonates as a vibration signal that stimulates the ears[333].

The two stimulatory components of the sound signal (vibration and pressure) change significantly with distance from the source, the most marked change occurring when fish move across the near-field:far-field boundary. In the near-field, vibration (or particle displacement), akin to hydrodynamic flows is the stimulus detected by fish[334]. This field extends one wavelength of the sound frequency from its source and is of particular importance to fish as it is used to detect the motion of predators and prey. Taking the pile driving example given above, noise generated at frequencies between 50-200Hz[335] [336] would generate near-fields extending some 9 to 35m out from the noise source.

The far field extends from one wavelength outwards. Unlike the near-field, pressure is the prevailing component of the sound wave, and thus, fish species that can detect and process both pressure and vibration stimuli are generally considered to be more sensitive to underwater noise.

Sensitivity to noise and vibration differs among fish species, particularly with respect to the anatomy of the swimbladder and its proximity to the inner ear. Species that lack a swimbladder, such as the elasmobranchs (sharks and rays) and flatfish, are only generally sensitive in the near-field. Fish having a fully functional swimbladder tend to be much more sensitive to noise. These groups of fish, which include the clupeids (herring family) and the gadoids (cod fish), may have some form of close coupling between the swimbladder and the inner ear.

Fish are generally sensitive to noises within the frequency range of <1Hz to 3000Hz. Within this range however, fish only respond consistently to very low frequency, or very high frequency noises[337] [338] [339]. Mid-frequency sounds in the range of 50 to 2000Hz only produce short-term startle response at the outset of sound production with subsequent habituation to noise[340] [341] [342] such as that produced by pile driving[343], drilling and general marine construction sounds.

[333] Hawkins, A.D. (1993). Underwater sound and fish behaviour. In: Pitcher, T.J (ed), The Behaviour of Teleost Fish, Second Edition. *Groom Helm Ltd., Kent* 114-149
[334] Jobling, M. (1995) Gas bladder and sound detection (Chapter 2.8) In: Environmental Biology of Fish,
[335] Moore, S.E., Ljungblad, D.K.: (1984) Gray whales in the Beaufort, Chuckchi and Bearing Seas: Distribution and sound production. P. 543-559 In: Jones, M.L., Swartz, S.L, Leatherwood, S. (eds.), The gray whale *Eschrichtius robustus*. Academic Press, Orlando, Florida 600p.
[336] Richardson, W.J; Greene, C.R; Malme, C.I; Thompson, H.H (1995). Marine Mammals and Noise. Academic Press, San Diego.
[337] Knudsen, F. R., P. S. Enger And O. Sand. (1992) Awareness reactions and avoidance responses to sound in juvenile Atlantic salmon, *Salmo Salar* L. Journal of Fish Biology 40: 523-534.
[338] Knudsen, F. R., P. S. Enger And O. Sand. 1994. Avoidance responses to low-frequency sound in downstream migrating Atlantic salmon smolt, *Salmo Salar*. Journal of Fish Biology 45: 227-233.
[339] Nestler, J.M., Ploskey, G.R., Pickens, J., Menezes, J., Schilt, C. (1992) Response of blueback herring to high frequency sound and implications for reducing entrainment at hydropower dams. North American Journal of Fish Management 12 667-683
[340] Knudsen, F. R., P. S. Enger And O. Sand. (1992) Awareness reactions and avoidance responses to sound in juvenile Atlantic salmon, *Salmo Salar* L. Journal of Fish Biology 40: 523-534.
[341] Knudsen, F. R., P. S. Enger And O. Sand. 1994. Avoidance responses to low-frequency sound in downstream migrating Atlantic salmon smolt, *Salmo Salar*. Journal of Fish Biology 45: 227-233.
[342] Westerberg, H (1999) Impact Studies of Sea-Based Windpower in Sweden. "Technische Eingriffe in marine Lebensraume"
[343] Anderson, J.J. (1992) Assessment of the risk of pile driving to juvenile fish. Report by the Fisheries Research Institute, University of Washington, to the Deep Foundations Institute, Seattle, Washington. 11p.

Hearing thresholds are defined at three different levels[344];

- *Absolute hearing threshold* - the minimum sound levels required at a specific frequency for the sound to be heard. These thresholds are established under controlled laboratory conditions in the absence of any masking noises.
- *Awareness reaction threshold* - the sound level, in the present of masking sounds, at which there is a spontaneous, physiological response (such as an increase in heart rate). This threshold is usually considerably above the absolute hearing threshold.
- *Avoidance response threshold* - the threshold at which a fish first shows an avoidance reaction. Again, this is generally well above the absolute hearing threshold and above the awareness reaction threshold.

Noise and Vibration Effects on Species Recorded in the Licence Area

NOISE-SENSITIVE SPECIES

Several species of fish that may be regarded as 'hearing specialists' have been recorded in the Study Area. Notable are whiting, a gadoid, which were caught in large numbers during the baseline survey. Other 'hearing specialists' present in the area include the allis and twaite shad (herring-like fish) and smelt. The majority of construction activities, including piling, are likely to produce sounds with greatest energy in the mid-frequency range of fish (50 to 2000Hz). Noises within this range, generally elicit a simple startle response at the outset of noise production, to which fish quickly habituate. Certainly, many species classed as 'hearing specialists' are reported to show tolerance to anthropogenic noise sources such as oil drilling platforms[345] and it is reported that received noise levels of 180dB are required to produce a strong avoidance or alarm response in herring and cod[346]. Noise levels of 180dB are considerably louder than the maximum 150 dB sounds pile driving would to produce at any distance from the source. The magnitude of noise and vibration impacts is therefore considered to be 'negligible' to 'low', and so, impacts would not be significant.

OTHER SPECIES

Flatfish such as plaice (*Plueronectes platessa*), dab (*Limanda limanda*) and sole (*Solea solea*) are commercially important and occur in large numbers in and around the Licence Area. This group of fish lack a swimbladder, and thus, they are only likely to be sensitive in the near-field. Elasmobranches such as the commercially important (and declining) thornback ray and the Nationally protected basking shark, will show a similar reaction to flatfish. A worst-case-scenario assumes that these species will show short-term changes in behaviour and possible avoidance of the relatively small near-field area (up to 35m around the turbine foundation location(s) at which piling is taking place) over the duration of noise generation. Whilst some species within these groups are considered to be of 'high' *sensitivity* as a result of their commercial

[344] Knudsen, F. R., P. S. Enger And O. Sand. (1992) Awareness reactions and avoidance responses to sound in juvenile Atlantic salmon, *Salmo Salar* L. Journal of Fish Biology 40: 523-534.
[345] Valdemarsen JW (1979) Behaviour aspects of fish in relation to oil platforms in the North Sea. *ICES C.M., B:27*
[346] Pearson WH; Skalski JR; Malme CI (1992) Effects of sound from geophysical survey device on behaviour of captive rockfish (*Sebastes spp.*). Canadian Journal of Fisheries and Aquatic science 49 1343-1356

and conservation interests, the *magnitude* of impacts is 'negligible' as impacts are minor and short-term. Impacts would therefore not be significant.

MIGRATORY SPECIES

Consideration of any impacts on the migratory salmonids (salmon and sea trout) is important due to their commercial importance and their National and International protection. In addition to this, the timing of works between April and October would overlap with migration times as adult salmon move into the Solway Firth throughout the year (due to differences in spawning times for each river), whilst smolt runs from the rivers into the Solway tend to peak during May.

The impact of noise and vibration on salmonids would follow a similar pattern to that of flatfish. Salmonids are thought to be more sensitive to the vibration stimulus of a sound wave (near-field effects) rather than the pressure component[347] and are sensitive to noise between several hertz and approximately 300Hz [348]. The hearing threshold of salmon in the range of peak sound levels generated by piling (50 to 200Hz) is 100 to 110dB[349] with best sensitivity of 100dB at 150Hz. This represents the *absolute hearing threshold*, the lowest levels at which pure-tone sounds can be detected by the salmon in the absence of any other noise.

Investigations into the use of low-frequency sounds as a fish deterrent for species such as the salmon and trout, have established awareness reaction and avoidance response thresholds. In investigating the *awareness reaction threshold* under laboratory conditions, Knudsen et al.[350] [351]and Mueller, *et al.*[352] found that at 150Hz, sounds of 170-180dB were required to obtain a behavioural response in both salmon and trout (*Salmo trutta*). This is approximately 70 to 80dB above the *absolute hearing threshold* of the salmon at 150Hz. Knudsen et al. further report that the avoidance response threshold for salmon and trout investigated in the marine/freshwater environment, was not apparent at 150Hz, even at received sound levels of greater than 200dB[353]. Sand *et al.* report similar results in the riverine environment where salmon showed no observable reaction to received sound levels of 214dB at 150Hz[354]. These levels far exceed the noise that would be generated during piling.

Hawkins and Johnstone conclude that the swimbladder plays no part in the hearing of the salmon[355]. On this basis, the noise generated during construction would not act as a barrier to migrating salmonids other than in the small area occupied by the near-field (between 9 and 35m around the piling location). There is also some direct evidence of the reaction of salmonids to piling activities to support this; in the marine environment, Feist et al. have demonstrated that marine piling may affect, in some way, the behaviour of salmonids within a radius of 600 meters of the sound source[356]. Anderson reports similar results, but adds that apparent habituation to piling was observed almost immediately[357].

The Solway Firth is 26 km wide at the point of the Licence Area, and the deep water channels that salmonids migrate along are several kilometres to the north and south of the wind farm area, migration of either juveniles or adults would, therefore, not be restricted. While the sensitivity of salmonids is 'high' due to their protected status and commercial importance, the magnitude of these impacts would be 'negligible', and so would not be significant.

The European eel (*Anguila anguila*), another migratory species present in the Study has been shown to be relatively insensitive to the noise generated by offshore wind turbines[358] and thus, the magnitude of impacts is considered to be 'negligible'.

The Nationally protected sea and river lampreys are migratory species that spend a period of their lives in either the marine or freshwater environment. These species, however, lack a swimbladder and thus, they will only be susceptible to noise and vibration in the near-field. Considering that this is such a small area (9 to 35m) in comparison to the width of the estuary at the site of the proposed works, the magnitude of impacts is considered to be 'negligible'.

9.7.2.2 Suspended Sediment

Different fish species show considerable variation in their tolerance of suspended sediments. In more sensitive species, high levels of suspended sediment may exert effects through the reduction of food availability for predatory fish due to reduction of light levels and the clogging of gill rakers and gill filaments by particulate matter while in tolerant species, turbidity may provide protection from predators[359].

However, the area under consideration is shallow, sandy and exposed to significant wave action and tidal currents. As a result, the Solway is naturally very turbid and large areas of sandbanks are known to move over periods of days (see Section 6.4 of this ES). In addition, a number of local harbours require maintenance dredging. For example, the Port of Workington requires maintenance dredging to remove some 120,000 m^3 of spoil per year[360], which is disposed of at one of two licence sites. One of these license sites lies less than 5km to the south-east of the development area at the Solway Firth Spoil Ground (IS 240; Location 54° 42' 20" N 03° 40' 00"W; Radius 0.5nm). In 2001 a total of 52,088m^3 of dredge disposal material was deposited at this site (in July/September). According to Dave Dobson[361] this has no important effects on local fisheries, though changes to the nature of the seabed sediments can sometimes be detected for some time after dumping. Another site, lying further inshore is used at Workington Anchorage (IS 241; Location 54° 20' 20" N 03° 30' 50" W; Radius 0.4nm) had 70,524m^3 of dredged

347 Hawkins, A.D. (1993). Underwater sound and fish behaviour. In: Pitcher, T.J (ed), The Behaviour of Teleost Fish, Second Edition. *Groom Helm Ltd., Kent* 114-149
348 Hawkins A.D., Johnstone A.D.F. (1978) The hearing of the atlantic salmon *Salmo salar*. Journal of Fish Biology 13 655-673
349 Hawkins A.D., Johnstone A.D.F. (1978) The hearing of the atlantic salmon *Salmo salar*. Journal of Fish Biology 13 655-673
350 Knudsen, F. R., P. S. Enger And O. Sand. (1992) Awareness reactions and avoidance responses to sound in juvenile Atlantic salmon, *Salmo Salar* L. Journal of Fish Biology 40: 523-534.
351 Knudsen, F. R., C. B. Schreck, S. M. Knapp, P. S. Enger and O. Sand. 1997. Infrasound produces flight and avoidance responses in Pacific juvenile salmonids. Journal of Fish Biology 51: 824-829.
352 Muller, R.P., Neitzel, D.A., Mavros, W.V. (1998) Evaluation of low and high frequency sound for enhancing fish screening facilities to protect outmigrating salmonids. Report by Pacific Northwest National Laboratory, Richmond, Washington, US to US Dept Energy. 26p.
353 Knudsen, F. R., P. S. Enger And O. Sand. (1992) Awareness reactions and avoidance responses to sound in juvenile Atlantic salmon, *Salmo Salar* L. Journal of Fish Biology 40: 523-534.
354 Sand, O., Enger, P.S., Karlsen, H.E, Knudsen F.R. (2001) Detection of infrasound in fish and behavioural responses to intense infrasound in juvenile salmonids and European silver eels: A mini-review. American Fisheries Society Symposium 26: 183-193.
355 Hawkins A.D., Johnstone A.D.F. (1978) The hearing of the atlantic salmon *Salmo salar*. Journal of Fish Biology 13 655-673

356 Feist, B. E.; J. J. Anderson, and R. Miyamoto. 1996. Potential impacts of pile driving on juvenile pink (*Oncorhynchus gorbuscha*) and chum (*O. keta*) salmon behaviour and distribution. Report No. FRI-UW-9603. Fisheries Research Institute, School of Fisheries, Univ. of Washington, Seattle, WA. 58p
357 Anderson, J.J. (1992) Assessment of the risk of pile driving to juvenile fish. Report by the Fisheries Research Institute, University of Washington, to the Deep Foundations Institute, Seattle, Washington. 11p.
358 Westerberg, H (1999) Impact Studies of Sea-Based Windpower in Sweden. "Technische Eingriffe in marine Lebensraume"
359 Cole, S., Codling, I.D, Parr, W. & Zabel, T. (1999). Guidelines for managing water quality impacts within UK European marine sites. A Report to WRc. October 1999. Natura 2000. UK Marine SACs Project.
360 Solway Firth Partnership. (1996). Solway Firth Review. June 1996. Solway Firth Partnership
361 Cumbria Sea Fisheries Committee, pers. Comm.

material disposed in January 2001. The latter area cannot be used during summer as it interferes with a local lobster fishing ground.

Those species present in the Solway Firth, including the migratory species, are therefore those more tolerant of naturally varying levels of suspended sediments.

Construction of the proposed Robin Rigg wind farm would liberate suspended sediment through:

- Possible augering of pile support locations
- Piling of pile supports
- Cable laying operations

Of these, by far the greater amount of suspended sediment would arise from augering of holes for turbine supports. However, geophysical surveys have shown sediments throughout the area to be of coarse sand with areas of boulder clay at 8-29m depth below these upper sediments. Accordingly, this would contain only limited amounts of fine material (which would be easily transported in suspension) and so only local and relatively minor increases in suspended sediment would occur during construction.

Assuming the worst case scenario, that all turbine supports locations are augered, the result of temporary elevations of suspended sediment levels may therefore be that some fish species could move from the development area during temporarily increased suspended sediment levels. However, the individuals affected would rapidly return following the cessation of sediment disturbance. Impacts would be lower for pile driving and cable laying.

Assessment of effects on benthic invertebrate communities (Section 9.6) shows rapid recolonisation and natural tolerance of sediment movements. No effects on food sources for fish species would, therefore, occur.

The magnitude of impacts, for both resident and migratory species, would therefore be, at most, low. Accordingly, impacts would not be significant.

9.7.2.3 Potentially Polluting Substances

In the case of both multi-pile and monopile foundations it is possible that cementitious grout will be used to form the connection between the piles and the main structure (Section 4.20). For a single foundation the quantity required will be in the range of 3.5m^3 (multpile) to 12m^3 (monopile). Grouting operations may lead to a localised increase in pH but as operations are accurately controlled and there is a high volume of water passing through the development area with each tidal cycle, the dilution effects will be such that impacts on fish will not be significant.

9.7.3 OPERATIONAL EFFECTS

9.7.3.1 Electromagnetic Field Effects

Electromagnetic fields, produced by electrical cabling both between turbines and from the wind farm to the shore, may affect fish species through:

- the emittance of small electrical fields which are detected by particularly electrosensitive species
- disturbance to the Earth's natural magnetic field which is used for navigation by many migratory species such as salmon.

Electrosensitive organisms present in the Solway Firth are sharks, skates and rays (subclass Elasmobranchii) which are known to detect the electric outputs of their prey. These species and salmon etc. are also thought to use the Earth's magnetic field for navigation[362 363]. Elasmobranchs are therefore the group most likely to detect electric fields - via passive reception of low-frequency voltage gradients.

Although the electric fields produced by undersea cables are traditionally considered to be negligible it has subsequently been demonstrated that relatively small emissions can de detected by UK benthic elasmobranchs[364]. Anguillid eels are also receptive to electric fields although they are less sensitive[365].

Therefore, there exists the potential for electrosensitive species to detect and respond to the electromagnetic fields produced by offshore power installations. This potential is considered here in respect of cabling associated with the proposed Robin Rigg offshore wind farm.

Predicted Electromagnetic Fields (EMF)

The wind turbines would be connected together by 33kV triple core XPLE cable with a 132kV main conduit to the onshore connection in the Flimby area. This is a similar situation to the Horns Rev wind farm which is currently under construction in Denmark (which has been used as an example of the predicted EMF emissions)[366]. The cables networking the Horns Rev turbines will have a 33kV rating whilst the main conduit to shore is rated at 150kV. Finite element numerical analysis based on Maxwell's equations for electric fields and their mutual coupling was used to predict the electric fields emitted. Based on this modelling, it is predicted that the 132kV cable would produce the greatest electric field, with emission of 10µV/cm through an unburied 3-core cable.

Within the wind farm area, the 33 kV cables from turbines to the offshore substation would be trenched at depths of around 1m. However, the natural movement of channels in the Robin Rigg area could cause some lengths of cable to become exposed from time to time, although the weight of the cable would cause subsequent re-burial.

[362] Kalmijn, A.J. (1982) Electric and Magnetic Field Detection in Elasmobranch Fishes. Science 218, 916-918
[363] Bullock, T.H. (1973) Seeing the World through a New Sense: Electroreception in Fish. Am. Sci. 61, 316-325
[364] Gill, A.B. & Taylor, H. (2001) The potential effects of electromagnetic fields generated by cabling between offshore wind turbines upon elasmobranch fishes. CCW Contract Science Report No. 488.
[365] Bullock, T.H. (1973) Seeing the World through a New Sense: Electroreception in Fish. Am. Sci. 61, 316-325
[366] Hoffman E; Astrup J; Larsen F; Munch-Petersen S; Strottrup J (2000) The effects of marine wind farms on the distribution of fish, shellfish and marine mammals in the Horns Rev area. Baggrundsrapport nr. 24. Report to ELSAMPROJEKT A/S. Danish Institute for Fisheries Research.

The 132 kV cabling to land would be in open waters and as such it would be necessary to take measures to ensure the cable does not become exposed on the seabed. For the sections of the 132 kV cabling through the mobile sand banks directional drilling would be used to install the cable at such a depth as to ensure that they are not exposed by movement of the bed sediments. In the areas remote from the sand banks where the bed is more stable it is likely that the cable would be trenched at a depth of approximately 1 metre. For the directional drilled sections electric fields on the sea bed would be zero. In trenched areas burial would reduce the EMF field generated and exposure would be extremely unlikely.

Maximum cable emissions would therefore be 10µV/cm where lengths of the cable become exposed (applicable to 33 kV cables in the wind farm areas only).

Potential Impacts on Electrosensitive Species in the Solway Firth

The species most likely to detect the electromagnetic fields are those that typically inhabit the benthic zone either throughout, or at some stage in, their life history. Those pelagic species which are found in deeper waters and swim at higher levels in the water column (basking shark *Cetorhinus maximu,s,* porbeagle shark *Lamna nasus,* thresher shark *Alopias vulpinus* and the blue shark *Prionace glauca*) would not, therefore be affected by EMF as it would be very unlikely that they would move into the relatively shallow areas of the Solway Firth.

Benthic species present in the area are:

Batiodea (Skates and rays)
- thornback ray *Raja clavata*
- stingray *Dasyatis pastinaca* .
- torpedo (electric) ray *Torpedo* spp.

Selachii (Sharks and dogfish)
- lesser-spotted dogfish *Scyliorhinus canicula*
- tope *Galeorhinus galeus*

It is also likely that a number of other species of benthic elasmobranchs (particularly the eight other species of ray, the two *Mustelus* sp. of dogfish and the angelshark *Squatina squatina)* may use the shallow, finer sediment areas of the Irish Sea and the Scottish West coast at some point in their life history.

Of particular significance is the thornback ray (*Raja clavata)* breeding ground in the Allonby Bay area. Hence the area close to the wind farm is likely to be used for most of the year by electroreceptive fish at different life stages.

Following the cable specifications outlined above, we would predict that the maximum electric field of 10µV/cm would occur adjacent to the cable with significant dissipation either side over a distance of tens of metres of seabed. There are three main impacts that need to be considered:

1. Some benthic elasmobranchs may avoid electric fields at 10µV/cm. Recent studies have demonstrated that benthic elasmobranchs may actively avoid the electric fields predicted to emanate from undersea cables[367] at a distance of approximately 20cm from the source. Where cables become exposed, therefore, avoidance is likely to result. However, this is only likely to occur over limited sections of the cable length at any time, and not at all over the directionally drilled length.

2. Individuals may be attracted to electric fields of approximately 0.1µV/cm, which is consistent with the predicted bioelectric field emitted by prey species. Hence, the reduction in the magnitude of the electric field emitted, due to burial, may act as an attractant to some elasmobranchs over distances of tens of metres. There is, however, no evidence to suggest that attraction to electric fields would have a detrimental effect on fish at individual or population levels (e.g. following an initial attraction, individuals may then move away).

3. The migration route taken by rays moving into Allonby Bay is not known. It seems safe to assume, however, that some if not most individuals will move upstream in the area between Robin Rigg and the English shore. These individuals would therefore cross the path of the main cable and may be subject to either repulsion, in the very unlikely case of cable exposure, or attraction. As noted above, however, the significance of these effects are unknown at present and such impacts would be avoided along directionally drilled sections and reduced in deep water sections.

Impacts on electrosensitive species are therefore expected to be of Low magnitude and so this would be an impact of, at most, Moderate significance – not significant in terms of the EIA regulations. Some uncertainty remains, however, on the precise reaction of individuals when encountering electrical fields, particularly with respect to thornback rays. Ongoing monitoring is therefore recommended of populations of electrosensitive species, either through dedicated surveys or through statistical analysis of fishery catches in the area over time.

Effects of Magnetic Fields

The current industry standard cable specifications will reduce the potential magnetic fields to low levels. Although elasmobranchs and migratory teleosts, such as Salmonids and Anguillid eels, navigate by geomagnetic fields, the localisation and low level of the magnetic fields emitted would be below naturally occurring fields. Also, when entering coastal waters, salmonids navigate through olfaction (i.e. 'smelling' their destination river). No adverse effects on migration due to magnetic fields would therefore occur.

9.7.3.2 Noise and Vibration

Noise Generated by Production Activities

Until recently there has been very little data on the underwater noise and vibration generated by the turbines of an operating offshore wind farm. Henriksen et al., however, have measured underwater noise at the Middlegrunden and Vindeby Wind Farms in Denmark and the Bockstigen-Valar Wind Farm in

[367] Gill, A.B. & Taylor, H. (2001) The potential effects of electromagnetic fields generated by cabling between offshore wind turbines upon elasmobranch fishes. CCW Contract Science Report No. 488.

Sweden[368]. Measurements were collected whilst the turbines were both operating and idle, so that background noise levels could be established. In addition to this, measurements at Middlegrunden were carried out whilst the turbines were operating under two different wind speeds.

Table 9.7.4: Peak source levels and frequencies in underwater noise produced by turbines at Middlegrunden, Vindeby and Bockstigen-Valar[369]

Turbine Type	Wind speed (m/s)	source level (dB re: 1 $\mu Pa^2/Hz$)	* Noise frequency (Hz)
Eleven **0.45 MW** 'Bonus' turbine concrete foundation (Vindeby, Denmark)	13 13	113 **130**	125 25
Twenty **2 MW** 'Bonus' turbines concrete foundation (Middlegrunden, Denmark)	13 6 6	**115** 101 111	125 125 25
Five **0.55 MW** 'Windworld' turbines steel monopile turbine supports (Bockstigen-Valar, Sweden)	8 8	108 108	160 16

** Noise frequencies given are the centre frequencies of 1/3-octave bands.*

Table 9.7.4 above describes the peak source levels and frequencies of underwater noise produced by the three different wind farms. Maximum unweighted source level measured was 130dB re 1μPa^2/Hz at a frequency of 25Hz and 115 dB re 1μPa^2/Hz at 125Hz which is similar to, or considerably less than, the noise produced by ships (Section 9.7.1.1).

Of interest, the results show that the noise level at 125Hz produced by a 2MW 'Bonus' turbine on a concrete foundation (Middlegrunden) is only 2dB greater than the noise level produced at the same frequency by a turbine that is a quarter the power (Vindeby). This indicates that there is not a direct relationship between turbine power and noise levels produced.

The proposed Robin Rigg Wind Farm would employ 2-3.6MW turbines of a similar nature to those at Middlegrunden. We have therefore assumed that the noise produced by operating turbines at Robin Rigg would be similar in both intensity and frequency to Middlegrunden.

Noise and Vibration Effects on Species Recorded in the Licence Area

NOISE SENSITIVE SPECIES

Considering the fish species present in the general area of the proposed Robin Rigg Wind Farm, the gadoid fish such as whiting and cod are likely to be most sensitive to the noise generated by the operating turbines as they are considered to be 'hearing-specialists[370] as discussed in Section 9.7.2.1.

[368] Henriksen, O. D; Teilmann, J; Dietz, R; Miller, L. (2001) Does underwater noise from offshore wind farms potentially affect seals and harbour porpoises? Poster presented at the "14th biennial conference on the biology of marine mammals" Vancouver, Canada.

[369] Henriksen, O. D; Teilmann, J; Dietz, R; Miller, L. (2001) Does underwater noise from offshore wind farms potentially affect seals and harbour porpoises? Poster presented at the "14th biennial conference on the biology of marine mammals" Vancouver, Canada.

[370] Hawkins, A.D. (1993). Underwater sound and fish behaviour. In: Pitcher, T.J (ed), The Behaviour of Teleost Fish, Second Edition. *Groom Helm Ltd., Kent* 114-149

Whiting are assumed to have similar audible thresholds to the cod, which are most sensitive to sounds in the frequency range of 100-150Hz where the absolute hearing threshold is 75-80dB[371], and thus, the noise generated by operating turbines immediately adjacent to the turbines would be 35-40dB above their hearing sensitivity in this range (it can be assumed that the highest noise levels would be found immediately adjacent to turbine foundations and that the additional noise component from the other 59 turbines in the array would be negligible close to a turbine base). However, as discussed above, the hearing threshold at which fish show behavioural reactions is generally well above the absolute hearing threshold. Furthermore, most fish only show strong behavioural responses to frequencies below 50Hz and above 2000Hz. Certainly, gadoids have been documented to tolerate noisy underwater structures such as oil drilling platforms, which generate sound levels comparable to or greater than to offshore wind farms.

Investigations at the Svante Wind Farm, Sweden, have shown numbers of cod in close vicinity to an operating turbine to be greater than in the surrounding open waters, although lower than when the turbines are not operating[372]. This presumably reflects habituation to a continuous noise stimulus and/or tolerance in light of benefits provided by the turbine foundation. Therefore, whilst this suggests that hearing specialists such as the cod, whiting and shad's may show some behavioural reaction to the noise generated by the proposed wind farm, such species have been shown to readily habituate to/tolerate, and accumulate around such structures.

OTHER SPECIES

Of the other fish species present in the general area, the flatfish and elasmobranchs are only sensitive to underwater noise within the near-field (see section 9.7.2.1 earlier). For the peak sound intensity at Middlegrunden of 125Hz, this equates to a near-field of less than 15m from the source. Even within this 30m diameter zone around a turbine, it is unlikely that they would show a significant reaction to wind farm noise, which would only be 15-20dB over their absolute hearing threshold. The area within which the near field would be resent represents less than 0.5% of the overall wind farm area.

MIGRATORY SPECIES

As discussed in Section 9.7.2.1, salmonids will not be sensitive to construction-related noise and vibration. Due to the fact that operational noise would be considerably lower (130dB at 25Hz and 115dB at 125Hz) than the 145dB sound levels generated during pile driving, salmonids would not show any behavioural response to wind farm operation.

Within the near-field, wind farm turbines will produce noise and vibrations stimuli that will be perceived by fish as hydrodynamic motion. However, Hoffman et al. report that the low-frequency hydrodynamic/acoustic fields generated by turbines will be perceived very differently by fish from fields generated by other animals[373], and thus, fish in the near-field will not be impaired in their ability to detect and interpret fields from different sources such as predators or prey.

[371] Hawkins, A.D. (1993). Underwater sound and fish behaviour. In: Pitcher, T.J (ed), The Behaviour of Teleost Fish, Second Edition. *Groom Helm Ltd., Kent* 114-149

[372] Westerberg, H (1999) Impact Studies of Sea-Based Windpower in Sweden. "Technische Eingriffe in marine Lebensraume"

[373] Hoffman E; Astrup J; Larsen F; Munch-Petersen S; Strottrup J (2000) The effects of marine wind farms on the distribution of fish, shellfish and marine mammals in the Horns Rev area. Baggrundsrapport nr. 24. Report to ELSAMPROJEKT A/S. Danish Institute for Fisheries Research.

In summary, the impact of noise and vibration from the operating wind farm is likely to induce some startle responses in fish species with good hearing capabilities such as whiting and shad. This may be accompanied by some short-term avoidance reactions followed by general habituation to the continuous noise generated by the operating turbines. The hydrodynamic/acoustic fields generated within the near-field would not impair the ability of fish to detect and interpret fields from different sources. Furthermore, the near-fields (<15m at 125Hz) generated around each turbine, are sufficiently small that fish would be able to move unhindered through the wind farm, and thus, any migratory species moving through the wind farm would not be restricted.

The presence of species of commercial importance, and species that are protected under National and International legislation, gives an overall ‘high’ sensitivity for fish species. However, the magnitude of noise and vibration impacts is considered to be ‘negligible’ to ‘low’ and, so, any impacts would not be significant.

9.7.3.4 Habitat Modification

Permanent alteration of benthic habitat would arise from the replacement of existing sandy substrate with hard vertical surfaces of the turbine support structures. As described earlier in Section 4.7.2 scour protection around the turbine supports is not considered appropriate for this site.

As assessed in the benthic impact assessment in Section 9.6.2, the effects of direct habitat loss on the overall extent of the single biotope found within the wind farm area is considered to be negligible.

However, the construction of the proposed wind farm would result in the production of new habitat. The vertical nature and expected colonisation of such structures by invertebrate species would result in the turbines having an artificial reef or Fish Aggregating Device (FAD) effect. It has long been known that fish tend to aggregate around objects placed in the sea. As a result of this association, the phenomenon has been widely used in the development of Fish Aggregating Devices (FAD's). However, the attraction of fish to objects such as artificial reefs is poorly understood. It is postulated that fish are attracted to submerged objects because they provide shelter from currents and wave action, safety from predators and food resources associates with the organisms that colonise submerged objects.

Artificial reefs and FAD’s are currently being used in North America and extensively in the Far East as a fisheries technique for both fin and shell-fisheries[374] [375]. Several studies have demonstrated that biomass is greater on vertical artificial reefs than on natural reefs and it has been postulated that this difference is due to vertical structures being more attractive to fish for settlement and recruitment than moderately sloped natural reefs[376]. In addition, species diversity and possibly productivity are assumed to increase with reef complexity[377]. Increases in catch-per-unit-effort (CPUE) are documented for fish assemblages on artificial reefs in Southern California[378]. However, although it is possible that reef material may increase the production of non-commercial species, studies by Hoffman et al. at the Horns Rev wind farm site in Denmark suggest that the hard substrate provided by the addition of scour protection at the base of each turbine would not produce significant amounts of new production of commercially fished species as breeding takes place elsewhere and reef structure is not required by juveniles[379]. The absence of scour protection at the proposed Robin Rigg wind farm would not, therefore diminish its function as an ‘artificial reef’.

Different fish species have different affinities to submarine structures and these affinities may change during their lifecycle. Whilst the majority of the fish species present in the Solway are not true reef-dwelling species, some groups present are known to be attracted to such structures. These include the gadoids such as the cod and, in particular, whiting (which are found in very large numbers in the Solway). Flatfish such as plaice are also attracted to artificial reefs although it is believed that they visit reefs primarily to forage[380]. Studies have, however, shown flatfish such as plaice, dab and sole in and around gas platforms[381].

Thus, there is the possibility that fish may be attracted to the proposed wind farm, although the actual size of the total fish populations may not necessarily increase. It is much more likely that the congregations of fish around the proposed wind farm would represent a small redistribution of the existing populations in the area. The attraction of the wind farm to fish may be most apparent during stormy conditions as the turbines are likely to absorb and disperse the incident energy and create a relatively calme area within and immediately leeward of the wind farm. The wind farm is also likely to become more attractive following colonisation of turbine surfaces by colonising organisms such as sponges, anemones and the common mussel *Mytilus edulis.* This effect would continue despite retardation of community development due to regular removal of colonising communities.

The overall magnitude of such an impact would therefore be low to negligible, although some reef-dwelling species found in rocky substrate areas of the Solway may colonise these new structures, thereby increasing population sizes.

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374 Herrnkind, WF; Butler, MJ; Hunt, JH (1997) Can artificial habitats that mimic natural structures enhance recruitment of Caribbean spiny lobster?. *Fisheries* 22 24-27

375 Marine Conservation Society (MCS) (2000) Habitats factsheet: artificial reefs. *SP/08/00*

376 Rilov G; Benayahu. Y (2000) Fish assemblage on natural versus vertical artificial reefs: the rehabilitation perspective.. *Marine Biology* 136 5 931-942

377 Wickens, J. & Barker, G (1996). Quantifiying complexity in rock reefs. In Jensen, A.C. (ed.) Euopean artificial reef research. Proceedings of the 1st EARRN conference. Ancona, Italy. March 1996. Southampton Oceanography Centre. pp423-430.

378 Ambrose RF; Swarbrick SL (1989) Comparison of fish assemblages on artificial and natural reefs off the coast of southern California. *Bulletin of Marine Science* 44 718-733

379 Hoffman E; Astrup J; Larsen F; Munch-Petersen S; Strottrup J (2000) The effects of marine wind farms on the distribution of fish, shellfish and marine mammals in the Horns Rev area. Baggrundsrapport nr. 24. Report to ELSAMPROJEKT A/S. Danish Institute for Fisheries Research.

380 Hoffman E; Astrup J; Larsen F; Munch-Petersen S; Strottrup J (2000) The effects of marine wind farms on the distribution of fish, shellfish and marine mammals in the Horns Rev area. Baggrundsrapport nr. 24. Report to ELSAMPROJEKT A/S. Danish Institute for Fisheries Research.

381 Hoffman E; Astrup J; Larsen F; Munch-Petersen S; Strottrup J (2000) The effects of marine wind farms on the distribution of fish, shellfish and marine mammals in the Horns Rev area. Baggrundsrapport nr. 24. Report to ELSAMPROJEKT A/S. Danish Institute for Fisheries Research.

9.7.3.5 Water Quality Effects

Changes to water quality as a result of the wind farms presence and operation may arise due to:

- localised minor increase in suspended sediment as a result of sediment scour around the turbines
- Abrasion of copper slip rings located within the turbine nacelle (around 2 kg of copper per turbine) and loss of Aluminium from corrosion protection anodes
- Potential accidental release of oils, lubricants etc due to maintenance activities

Liberation of suspended sediment due to wave and current action within the Solway is a natural phenomenon. The additional effects of scour around turbine support structures would not have a discernible additional effect in relation to the Robin Rigg area.

Abrasion of copper slip rings may liberate, as an absolute worst-case situation, up to 480 kg of copper (based on 60 turbines with a five year slip-ring lifespan) over the lifetime of the wind farm. This equates to 0.065 g of copper per day. Liberated as extremely fine particles, this would rapidly disperse throughout the Solway Firth and would not be detectable in coastal waters.

There could be some very minor risk of spillage of small quantities of oils due to the required maintenance regime. These operations would, however be subject to strict control and the amounts involved in any possible spillage would be small and subject to rapid dispersal. Any impacts would therefore be negligible.

Aluminium anodes will be used to protect the multipile foundation structures for turbines, should this foundation option be progressed. The anodes will emit aluminium over there lifetime, some 15 to 25 years (Section 4.20.2). For the total wind farm developed, the amount of aluminium emitted will be in the range of 7200-15,600kg/yr, which equates to 19.7-42.7g/day. Liberated as extremely fine particles, the aluminium would rapidly disperse throughout the Solway Firth and would not be detectable in coastal waters.

Any water quality impacts on fish would therefore be negligible and so no significant impacts would result.

9.7.4 DECOMMISSIONING

The impacts associated with decommissioning would be similar to those of construction and would arise from the generation of local noise, vibration and disturbance. However, the noise levels generated are expected to be at a much lower level in the absence of noisy activities such as the piling. In addition to this, noise and disturbance would be confined to a very small area around the decommissioning works over a short-term period. Accordingly, the magnitude of the impact is considered to be ’negligible’ to ’low’ and would not be significant.

9.7.5 MONITORING AND MITIGATION MEASURES

9.7.5.1 Construction-related Noise

The construction period is likely to run from July through to October, and April to October in two consecutive years and may involve pile driving of more than one turbine at a time. Thus, to limit the size of the near-field within which fish are most likely to be effected, piling should be carried out in a restricted/localised area as defined by an Environmental Management Plan for the works. In addition to this, a ’soft-start’ methodology should be employed in a similar nature to current UK legislation concerning seismic surveys. This ’soft-start’ would allow any fish within the local area of a pile, to move out of range as the noise generated by pile driving increases.

Monitoring of fish populations during and after construction would provide confirmation of the predictions of the EIA. For fish, monitoring should address:

- The presence of electrosensitive species (particularly thornback ray) in the Solway Firth and particularly in the vicinity of the cable routes
- The utilisation of the wind farm area by fish species, including the importance of turbine support structures as FAD’s

Any monitoring programme is suggested to last three years post construction.

Catch data on salmonid populations in rivers entering the Solway Firth should be gathered over the construction and initial operational phases for trend analysis.

9.7.6 SUMMARY OF RESIDUAL IMPACTS MAGNITUDE AND SIGNIFICANCE

Table 9.7.5 summarises the magnitude and significance of impacts on the key species of medium or high sensitivity. The level of *significance* attributed to impacts on each species relates to the highest level of impact assessed for that species resulting from the construction, operation and decommissioning periods.

No significant impacts have been identified as resulting from the development proposal.

sloped natural reefs[376]. In addition, species diversity and possibly productivity are assumed to increase with reef complexity[377]. Increases in catch-per-unit-effort (CPUE) are documented for fish assemblages on artificial reefs in Southern California[378]. However, although it is possible that reef material may increase the production of non-commercial species, studies by Hoffman et al. at the Horns Rev wind farm site in Denmark suggest that the hard substrate provided by the addition of scour protection at the base of each turbine would not produce significant amounts of new production of commercially fished species as breeding takes place elsewhere and reef structure is not required by juveniles[379]. The absence of scour protection at the proposed Robin Rigg wind farm would not, therefore diminish its function as an 'artificial reef'.

Different fish species have different affinities to submarine structures and these affinities may change during their lifecycle. Whilst the majority of the fish species present in the Solway are not true reef-dwelling species, some groups present are known to be attracted to such structures. These include the gadoids such as the cod and, in particular, whiting (which are found in very large numbers in the Solway). Flatfish such as plaice are also attracted to artificial reefs although it is believed that they visit reefs primarily to forage[380]. Studies have, however, shown flatfish such as plaice, dab and sole in and around gas platforms[381].

Thus, there is the possibility that fish may be attracted to the proposed wind farm, although the actual size of the total fish populations may not necessarily increase. It is much more likely that the congregations of fish around the proposed wind farm would represent a small redistribution of the existing populations in the area. The attraction of the wind farm to fish may be most apparent during stormy conditions as the turbines are likely to absorb and disperse the incident energy and create a relatively calme area within and immediately leeward of the wind farm. The wind farm is also likely to become more attractive following colonisation of turbine surfaces by colonising organisms such as sponges, anemones and the common mussel *Mytilus edulis.* This effect would continue despite retardation of community development due to regular removal of colonising communities.

The overall magnitude of such an impact would therefore be low to negligible, although some reef-dwelling species found in rocky substrate areas of the Solway may colonise these new structures, thereby increasing population sizes.

376 Rilov G; Benayahu. Y (2000) Fish assemblage on natural versus vertical artificial reefs: the rehabilitation perspective.. *Marine Biology* 136 5 931-942

377 Wickens, J. & Barker, G (1996). Quantifiying complexity in rock reefs. In Jensen, A.C. (ed.) Euopean artificial reef research. Proceedings of the 1st EARRN conference. Ancona, Italy. March 1996. Southampton Oceanography Centre. pp423-430.

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Table 9.7.5 summarises the magnitude and significance of impacts on the key species of medium or high sensitivity. The level of *significance* attributed to impacts on each species relates to the highest level of impact assessed for that species resulting from the construction, operation and decommissioning periods.

No significant impacts have been identified as resulting from the development proposal.

Table 9.7.5 Summary of impact magnitude, species sensitivity and significance of effect for each fish species

SPECIES	SENSITIVITY	MAGNITUDE						SIGNIFICANCE
		Construction/Decommissioning		Operation				
		Noise	Increased Suspended Sediment	Noise	EMF	Habitat changes	Water Quality	
Brown shrimp	High	Negligible	Negligible	Negligible	Negligible	Negligible-Low	Negligible	Low-Moderate
Plaice	High	Negligible	Negligible	Negligible	Negligible	Negligible-Low	Negligible	Low-Moderate
Dab	High	Negligible	Negligible	Negligible	Negligible	Negligible-Low	Negligible	Low-Moderate
Sole	High	Negligible	Negligible	Negligible	Negligible	Negligible-Low	Negligible	Low-Moderate
Flounder	Medium	Negligible	Negligible	Negligible	Negligible	Negligible-Low	Negligible	Negligible-Low
Herring	Medium	Negligible-Low	Negligible	Negligible-Low	Negligible	Negligible-Low	Negligible	Negligible-Low
Whiting	High	Negligible-Low	Negligible	Negligible-Low	Negligible	Negligible-Low	Negligible	Low-Moderate
Sandeel	High	Negligible-Low	Negligible	Negligible-Low	Negligible	Negligible-Low	Negligible	Low-Moderate
Sprat	High	Negligible-Low	Negligible	Negligible-Low	Negligible	Negligible-Low	Negligible	Low-Moderate
Sand goby	High	Negligible-Low	Negligible	Negligible-Low	Negligible	Negligible-Low	Negligible	Low-Moderate
Common goby	High	Negligible-Low	Negligible	Negligible-Low	Negligible	Low	Negligible	Moderate
River Lamprey	High	Negligible	Negligible	Negligible	Negligible	Negligible	Negligible	Low
Sea Lamprey	High	Negligible	Negligible	Negligible	Negligible	Negligible	Negligible	Low
Smelt	High	Negligible	Negligible	Negligible	Negligible	Negligible	Negligible	Low
Allis Shad	High	Negligible-Low	Negligible	Negligible-Low	Negligible	Negligible-Low	Negligible	Low-Moderate
Twaite Shad	High	Negligible-Low	Negligible	Negligible-Low	Negligible	Negligible-Low	Negligible	Low-Moderate
Salmon	High	Negligible	Negligible	Negligible	Negligible	Negligible-Low	Negligible	Low
Sea Trout	High	Negligible	Negligible	Negligible	Negligible	Negligible	Negligible	Low
Basking Shark	High	Negligible	Negligible	Negligible	Negligible	Negligible	Negligible	Low
Thornback Ray	High	Negligible	Negligible	Negligible	Low	Negligible	Negligible	Moderate

Significance is taken to be the combination of Sensitivity with the highest magnitude impact recorded.
Levels of significance of Moderate-Major or above only are considered to be significant with respect to the EIA regulations.

9.8 ASSESSMENT OF EFFECTS ON BIRDS

9.8.1 INTRODUCTION

This study was commissioned by Natural Power Consultants Ltd to undertake an assessment of the potential ornithological impacts of a proposed offshore wind farm in the Solway Firth. The work sought to evaluate whether the proposed wind farm may have any adverse effects on the ornithological nature conservation interests of this area, and determine whether any such effects may be significant.

The aims of the ornithological assessment are as follows:

- To establish the importance of the proposed wind farm area and its surrounds for birds, including breeding, migratory and wintering populations;
- To predict the potential ornithological impacts of the construction, operation and de-commissioning of the wind farm and predict the significance of the impact;
- To develop mitigation measures to reduce potential ornithological impacts;
- To assess the residual impacts following mitigation and the significance of these.

The first stage has been documented in Section 7.6 of this ES. This section discusses the remaining three elements of the assessment.

9.8.2 ASSESSMENT METHODOLOGY

9.8.2.1 Introduction

It is important to define the terminology used and the precise methods used for the assessment of any ecological effects. The methodology used here is based on the Environmental Assessment Regulations 1999 and on the Institute of Environmental Assessment guidelines[382]. The EIA Regulations state that an impact should only be considered as material to the decision making process if it is considered to be significant.

Negative effects are defined as effects that are detrimental to the nature conservation value of any component of the ecosystem and anything that might reduce that component's viability at the site. Positive effects are defined as those that increase conservation value and which improve a component's viability.

Any effects have been further defined as direct (those that are causally linked to the development without any intermediary factor) or indirect (those involving at least one intermediary process).

The methodology used throughout the assessment process follows that developed by Scottish Natural Heritage (SNH) and the British Wind Energy Association (BWEA)[383]. It is described briefly below.

[382] Institute of Environment Assessment. 1995. Guidelines for Baseline Ecological Assessment. E. & F.N. Spon.
[383] Percival, S.M., Band, B. and Leeming, T. 1999. Assessing the ornithological effects of wind farms: developing a standard methodology. Proceedings of the 21st British Wind Energy Association Conference 161-166.

9.8.2.2 Determination of Significance

The criteria used for the determination of significance of ecological effects are summarised in Tables 9.8.1 and 9.8.2 below.

Table 9.8.1 Definition of terms relating to the sensitivity of the ecological components of the site.

Sensitivity	Definition
VERY HIGH	Cited interest of SPAs, SACs and SSSIs. Cited means mentioned in the citation text for the site as a species for which the site is designated (SPAs/SACs) or notified (SSSIs).
HIGH	Other species that contribute to the integrity of an SPA or SSSI. A local population that represents more than 1% of the national population of a species. An ecologically sensitive species, e.g. large birds of prey or rare birds (<300 breeding pairs in the UK).
MEDIUM	Regionally important population of a species, either because of population size or distributional context. EU Birds Directive Annex 1, EU Habitats Directive priority habitat/species and/or W&C Act Schedule 1 species (if not covered above). UK BAP priority species (if not covered above).
LOW	Any other species of conservation interest, e.g. species listed on the Birds of Conservation Concern not covered above.

Table 9.8.2: Definition of terms relating to the magnitude of ecological effects

Magnitude	Definition
VERY HIGH	Total loss or very major alteration to key elements/ features of the baseline conditions such that post development character/ composition/ attributes would be fundamentally changed and may be lost from the site altogether. >80% of population/habitat lost
HIGH	Major alteration to key elements/ features of the baseline (pre-development) conditions such that post development character/composition/attributes would be fundamentally changed. 20-80% of population/habitat lost
MEDIUM	Loss or alteration to one or more key elements/features of the baseline conditions such that post development character/ composition/ attributes of baseline would be partially changed. 5-20% of population/habitat lost
LOW	Minor shift away from baseline conditions. Change arising from the loss/ alteration would be discernible but underlying character/ composition/ attributes of baseline condition would be similar to pre-development circumstances/patterns. 1-5% of population/habitat lost
NEGLIGIBLE	Very slight change from baseline condition. Change barely distinguishable, approximating to the "no change" situation. <1% of population/habitat lost

The combined assessment of the magnitude of an effect and the sensitivity of the site (or any component of the ecosystem) have been used to determine whether or not an impact is significant with respect to the EIA Regulations. These two criteria have been cross-tabulated to assess the overall significance of that effect (Table 9.8.3). This matrix differs somewhat from the generic matrix given in Section 5.8.

Table 9.8.3: Matrix of magnitude of effect and sensitivity used to test the significance of effects. The significance category of each combination is shown in each cell.

MAGNITUDE OF EFFECT				
VERY HIGH	Medium	High	Very high	Very high
HIGH	Low	Medium	Very high	Very high
MEDIUM	Very low	Low	High	Very high
LOW	Very low	Low	Low	Medium
NEGLIGIBLE	Very low	Very low	Very low	Low
	LOW	MEDIUM	HIGH	VERY HIGH
	'SENSITIVITY' OF RECEIVING ELEMENT			

The interpretation of these significance categories is as follows:

- **Very low** and **low** are not normally of concern, though normal design care should be exercised to minimise impacts.
- **Very high** and **high** represent a significant impact on bird populations and could warrant refusal of a planning proposal.
- **Medium** represents a potentially significant impact that requires careful individual assessment. Such an impact could warrant planning refusal, but it may be of a scale that can be resolved by revised design or appropriate mitigation.

The impacts considered in the remainder of this assessment have been divided into impact types rather than stages of the development. Thus disturbance effects of construction noise and operation of wind turbines are both considered under the same subsection.

9.8.3 DIRECT EFFECTS (A): LOSS OF HABITAT FOR FEEDING AND ROOSTING

The direct loss of habitat resulting from the development through the construction of the turbine bases and cabling will be of such a small scale that they will clearly not be significant in terms of their impact on bird habitats (and their food). No significant impacts are predicted on the area's benthic invertebrate or fish populations.

9.8.4 DIRECT EFFECTS (B): COLLISION RISK

9.8.4.1 Introduction

The proposed Solway offshore wind farm may impact on the area's bird populations by causing additional mortality through bird collisions with the wind turbines. This section of the OIA addresses this risk, estimating the magnitude of the risks using a standardised modelling approach and hence the significance of the likely impacts.

Bird collisions have not been found to be a problem at any of the existing offshore wind farms[384 385]. Radar studies have shown that birds generally avoid flying in close proximity to offshore wind turbines, particularly in conditions of reduced visibility[386]. However, no detailed studies on collision rates of birds with offshore wind turbines have been carried out, so it is not possible to draw on specific offshore experience to determine the likely effects of the Solway development. However, there have been a number of onshore studies that do provide some relevant information on the likely collision rates that may be encountered at the site. This includes several studies at coastal wind farms where similar species to those at the Solway

384 Larsson A.K. 1994. The environmental impact from an offshore plant. Wind Engineering 18,213-219.
385 Van der Winden J., Dirksen S., van den Bergh L.M.J. and Spaans A.L. 1996. Nachtelijke vliegbewegingen van duikeenden bij het Windpark Lely in het Ijsselmeer. DLO rapport No. 96.34.
386 Van der Winden J., Dirksen S., van den Bergh L.M.J. and Spaans A.L. 1996. Nachtelijke vliegbewegingen van duikeenden bij het Windpark Lely in het Ijsselmeer. DLO rapport No. 96.34.

site occurred. The work carried out to date suggests that the numbers of such birds that would need to be passing regularly through a wind farm would need to be very high in order for significant mortality to occur. At Kreekrak in the Netherlands, for example, a coastal wind farm immediately adjacent to the Oosterschelde Special Protection Area (SPA), with a local population of 2-6,000 waterfowl only 1.9-4.6 collisions per turbine per year were estimated[387 388]. This study concluded that the level of mortality was not significant, and recommended that a further 15 turbines could be constructed without an adverse impact on the local bird populations. Very low collision rates have been reported from the Blyth Harbour wind farm, where 4,500 waterfowl regularly occur and which falls within the Northumberland coast SPA[389]. This study reported an average of 1.3 collisions per turbine per year, apparently declining in some species as birds habituated to the presence of the turbines[390].

Birds differ markedly in their demographic characteristics, and hence as a result also differ in their susceptibility to changes to mortality rates. Any additional mortality would be most likely to adversely affect species with high adult survival and low breeding rate, as they would be less able to replace any losses. The presence of would reduce the likelihood of any such effect. Populations regulated in a density-dependent way would be less susceptible to collision mortality, as any additional losses would result in a compensatory increase in survival and/or breeding success[391].

9.8.4.2 The Collision Risk Model

The collision risk model used in this assessment is the one developed by SNH and BWEA[392]. Details of the model are given in these two publications. The model runs as a two-stage process. Firstly the risk is calculated making the assumption that flight patterns are unaffected by the presence of the wind turbines, i.e. that no avoidance action is taken. This is essentially a mechanistic calculation, with the collision risk calculated as the product of (i) the probability of a bird flying through the rotor swept area, and (ii) the probability of a bird colliding if it does so. This probability is then multiplied by the estimated numbers of bird movements through the wind farm rotors at the risk height (i.e. the height of the rotating rotor blades) in order to estimate the theoretical numbers at risk of collision if they take no avoiding action.

The second stage then incorporates the probability that the birds, rather than flying blindly into the turbines, will actually take a degree of avoiding action (as has been shown to occur in all studies of birds at existing wind farms, with avoidance rates typically well in excess of 99%[393]). To determine the avoidance rate, a collision risk model is run for the parameters of an existing study wind farm, to estimate the number of collisions that would have occurred without avoidance. The collision rate is then calculated as the ratio of the actual number of collisions recorded at the study wind farm to the number predicted without avoidance, and the avoidance rate is simply the collision rate subtracted from one.

As such data are not available for any offshore wind farms, a worst-case approach has been taken, using the lowest avoidance rate reported for waterfowl species in any study. This has been taken as the collision rate reported at Blyth Harbour[394 395], where an avoidance rate of 99.62% was estimated using the same standard collision risk model.

9.8.4.3 Key Species

The collision risk assessment was carried out firstly for the two species that occurred regularly in the study area in nationally important numbers; common scoter and red-throated diver. Further consideration was then given to the additional possible collision issues raised by consultees, including waterfowl movements to/from the Upper Solway SPA. Lastly the other species found using the site during the baseline studies were considered to determine if any of these may possibly face a significant collision risk (including landbird migrants over-flying the site).

9.8.4.4 Input Data

Common Scoter

NUMBERS AT RISK – the numbers of scoter in the study area have been quantified by approximately twice-monthly boat surveys between May 2001 and April 2002, during which all flight movements observed were recorded. This has enabled the movement rate through the wind farm area and its surrounds to be determined. On average 0.5 scoter per hour were estimated to move through the wind farm area. Dawn/dusk survey observations did not show any indication that this may increase at night.

FLIGHT HEIGHTS – An important component of the collision risk is the height above the sea at which the birds fly. The turbines will be on towers with a hub height above Mean Sea Level of 80 m and will have a rotor diameter of up to 100m in an area with the greatest astronomical tidal range being just under 10 m, so the distance between blades at their lowest point and the sea surface will be between 25 m and 35 m above the sea. Only 4 birds (<1% of flock records) were recorded flying at rotor height. This would indicate that the collision risk for scoters would actually be very low. These flight height data, however, cover only lower wind speed (less than force 5) conditions and were only collected during daylight. It is possible (though unlikely) that their flight behaviour may differ at night and in windier conditions. Therefore a worst case analysis was carried out for the assessment modelling, assuming that all the birds were flying at rotor height.

OTHER INPUT DATA - The other input data for the scoter collision risk modelling were taken from the published literature. Body size was obtained from Cramp, using an average body length of 0.49m and an

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387 Musters, C.J.M., Noordervliet, M.A.W. and Ter Keurs, W.J. 1995. Bird casualties and wind turbines near the Kreekrak sluices of Zeeland. Report 28 pp

388 Musters, C.J.M., Noordervliet, M.A.W. and Ter Keurs, W.J. 1996. Bird casualties caused by a wind energy project in an estuary. *Bird Study* 43: 124-126

389 Still, D., Little, B. and Lawrence, S. 1996. The effect of wind turbines on the bird population at Blyth Harbour. Report to Border Wind Limited. 34 pp

390 Painter, A., Little, B. and Lawrence, S. 1999. Continuation of bird studies at Blyth Harbour wind farm and the implications for offshore wind farms. DTI ETSU report no W/13/00485/00/00.

391 Percival, S.M. 2000. Birds and wind turbines in Britain. *British Wildlife* 12: 8-15.

392 Percival, S.M., Band, B. and Leeming, T. 1999. Assessing the ornithological effects of wind farms: developing a standard methodology. Proceedings of the 21st British Wind Energy Association Conference 161-166.

393 Percival, S.M. 2000. Birds and wind turbines in Britain. *British Wildlife* 12: 8-15.

394 Still, D., Little, B. and Lawrence, S. 1996. The effect of wind turbines on the bird population at Blyth Harbour. Report to Border Wind Limited. 34 pp

395 Painter, A., Little, B. and Lawrence, S. 1999. Continuation of bird studies at Blyth Harbour wind farm and the implications for offshore wind farms. DTI ETSU report no W/13/00485/00/00.

average wingspan of 0.85m[396]. Flight speeds for scoter were not available, so instead the value for eider duck in Campbell and Lack[397] was used, 21 m.s^{-1}.

Divers

NUMBERS AT RISK – as for scoters, the numbers and movements of divers in the study area have been quantified by twice-monthly boat surveys, during which all flight movements observed were recorded. On average 0.9 divers per hour were estimated to move through the wind farm area. Dawn/dusk survey observations did not show any indication that this may increase at night.

FLIGHT HEIGHTS - only 2 divers (3% of flock records) were recorded flying at rotor height. This would indicate that the collision risk for divers would actually be very low. As stated above, however, these flight height data cover only lower wind speed (less than force 5) conditions and were only collected during daylight. It is possible (though unlikely) that their flight behaviour may differ at night and in windier conditions. Therefore a worst case analysis was carried out for the assessment modelling, assuming that all the birds were flying at rotor height.

OTHER INPUT DATA - the other input data for the diver collision risk modelling were taken from the published literature. Body size was obtained from Cramp[398] using an average body length of 0.61m and an average wingspan of 1.11m. Flight speed was taken from Campbell and Lack[399]; 17 m.s^{-1}.

Migrant Waterfowl

Consultees raised migrant waterfowl as another group of birds that could be a possible collision issue. The main concern was possible collision mortality affecting the internationally important estuarine populations wintering in the Upper Solway. Flocks from these important sites may potentially fly through the wind farm area whilst moving between the Solway and other wintering areas, and between wintering and breeding areas.

Studies of bird flight behaviour have shown that bird species such as those for which the SPA is important generally fly in close proximity (within 1km) of the coast during such movements[400]. Generally collision problems with such species are only likely to occur when a wind farm lies on a flight route that is used frequently by large numbers of birds, e.g. between a feeding and a roosting area[401]. The data from the field studies have shown that the proposed wind farm site does not lie on such a route, with very low numbers of these species recorded flying within the wind farm area.

However, these do not cover night time, nor high wind conditions, so no field data were available on the actual movements of such species through the site under these circumstances. Therefore a worst case collision risk analysis was carried out, assuming that these waterfowl populations hosted by the Upper Solway SPA, fly through the study area twice per year. Two species were selected for the modelling, one wildfowl (barnacle goose) and one wader (oystercatcher). Both occur on the Upper Solway in internationally important numbers, both are particularly numerous and both are particularly long-lived (making their populations potentially more susceptible to additional collision mortality).

In the absence of any nocturnal/high wind condition flight height data, the worst case assumption was made that all flew at rotor height (again extremely unlikely given general information on these species' flight behaviour[402]).

Other Species

There are two further groups of birds that might over-fly the proposed wind farm and hence be at risk of collision: other seabird species, and landbird migrants. Of the other seabird species, those most likely to occur in sufficient numbers to be at risk of collision impacts are cormorant, gulls and auks. Cormorants have been shown to have very high avoidance rates of wind turbines. For example at Blyth Harbour about 50-100 birds were flying through the wind farm on a daily basis and only a single collision was reported in a study lasting over 6 years[403]. Gulls have been reported as collision victims at many coastal wind farms[404], but this is generally a result of their high abundance at such sites, and there is no evidence that they are particularly susceptible to collisions. Kittiwake potential collision risk is likely to be greater in high winds at times of passage, but land-based observations suggest that birds tend to fly low over sea, particularly in strong winds, making use of troughs between waves (C. Hartley, pers. obs.). There is no such information for auks, as they have not been studies at any existing wind farms. Collision rates would however, be likely to be negligible given their flight behaviour (flying close to the sea surface and well below rotor height; none at all were seen flying above 20m during the boat surveys, see above).

Landbird migrants fly over the sea during long-distance migration, and it is likely that the Solway site would be over-flown by at least some of these birds. Studies at onshore coastal wind farms have reported collision rates of 0.01-0.02% of birds passing through the wind farm, equivalent to 1 in 5-10,000 individuals[405 406]. Collisions would therefore only result in a significant adverse effect if many tens of thousands of birds were regularly passing through the wind farm. Such an occurrence at the Solway would be very unlikely: migration over the sea occurs over a broad front[407], and there are no topographical features to concentrate birds through the wind farm. The only possible problems might occur if these birds were attracted to the wind farm, e.g. by bright continuous lighting. In order to ensure that this does not occur as a result of the navigational lighting on the wind turbines, use of such lighting will be avoided. The only navigational lighting will be yellow flashing lights mounted on four navigational buoys on the outside of the wind farm (see section 4.9.2 of this ES), which would not have such an attractant effect[408 409].

396 Cramp, S. 1998. Handbook of the Birds of Europe, the Middle East and North Africa. CD-ROM. Oxford University Press, Oxford.
397 Campbell, B. and Lack, E. 1985. *Dictionary of Birds*. T. and A.D. Poyser, London.
398 Cramp, S. 1998. Handbook of the Birds of Europe, the Middle East and North Africa. CD-ROM. Oxford University Press, Oxford.
399 Campbell, B. and Lack, E. 1985. *Dictionary of Birds*. T. and A.D. Poyser, London.
400 Dirksen, S., Spaans, A.L. and Winden, van der J. 1998. Nocturnal collision risks with wind turbines in tidal and semi-offshore areas. In *Wind Energy and Landscape*. Proc. 2nd European and African Conference on Wind Engineering, 1997. pp. 99-108.
401 Percival, S.M. 2001. Assessment of the effects of offshore wind farms on birds. ETSU report no W/13/00565.
402 Dirksen, S., Spaans, A.L. and Winden, van der J. 1998. Nocturnal collision risks with wind turbines in tidal and semi-offshore areas. In *Wind Energy and Landscape*. Proc. 2nd European and African Conference on Wind Engineering, 1997. pp. 99-108.
403 Painter, A., Little, B. and Lawrence, S. 1999. Continuation of bird studies at Blyth Harbour wind farm and the implications for offshore wind farms. DTI ETSU report no W/13/00485/00/00.
404 Percival, S.M. 2000. Birds and wind turbines in Britain. *British Wildlife* 12: 8-15.
405 Winkelman, J.E. 1992a. Impact of the Sep wind park near Oosterbierum (Fr.), the Netherlands, on birds, 1: Collision victims. DLO-Institut voor Bos-en Natuuronderzoek, Arnehem, RIN rapport 92/2.
406 Winkelman, J.E. 1992b. The impact of the Sep Wind park near Oosterbierum, The Netherlands, on birds, 2: nocturnal collision risks. RIN Report 92/3
407 Alerstam, T. 1990. *Bird Migration*. Cambridge University Press, Cambridge.
408 Percival, S.M. 2001. Assessment of the effects of offshore wind farms on birds. ETSU report no W/13/00565.

9.8.4.5 Model Predictions

The model predictions for the worst case collision risks are summarised in Table 9.8.4. Generally the collision prediction were very low, even though unrealistic worst case assumptions had been made, including that all the birds would fly at rotor height (which the field data show is clearly not the case). The Table also shows the annual mortality rate for each species, and the percentage that the additional predicted worst case wind farm would add to this. For most species the magnitude of the collision risk is clearly negligible (giving an increase, even in a worst case, of less than 1% on the baseline mortality rate). The only species to exceed this was red-throated diver, where the predicted worst case collision mortality was low (only 3.3 birds per year) but as the population within the study area is comparatively low (up to 230 birds) and the species is generally quite long-lived (annual survival rate c.90%), this was equivalent to a 22.8% increase in the annual mortality rate.

Table 9.8.4. Worst case collision risk predictions for key species at the Solway Offshore wind farm.

Species	Predicted annual collisions with wind farm (worst case)	Annual mortality rate	Collision mortality as % of overall annual mortality
Common scoter	3.4	23%	0.3%
Red-throated diver	3.3	10%	22.8%
Oystercatcher	10.9	7%	0.4%
Barnacle goose	11.0	10%	0.5%

Therefore the only species that requires further consideration beyond the worst case model with all birds flying at rotor height is the red-throated diver. If all the birds did indeed fly at rotor height, then a significant impact on the local population may occur. However, the field data available for this species from the boat surveys, suggest that this is a very unrealistic scenario. In fact 98% of the birds observed were flying below rotor height (25m above sea level); most were actually 10m or less above the sea. This suggests that the actual collision rate would be substantially less than this. In addition it should also be noted that the collision risk assessment was based on a worst case avoidance rate. Though no information is available for wintering divers, breeding divers have been reported in close proximity to wind turbines on Orkney, with regular feeding flights past the turbines without any collisions being noted[410]. No diver collisions have been reported from any existing wind farms.

The overall collision risks that would be likely to result from the proposed Solway offshore wind farm are summarised in Table 9.8.5, taking account revisions to the diver worst case model as discussed above. None of these would be deemed to be significant.

[409] Ogden, L.J.E. 1996. Collision Course: The Hazards of Lighted Structures and Windows to Migrating Birds. World Wildlife Fund Canada and the Fatal Light Awareness Program report, 52 pp.

[410] Meek, E.R., Ribbands, J.B., Christer, W.B., Davy, P.R. and Higginson, I. 1993. The effects of aero-generators on moorland bird populations in the Orkney Islands, Scotland. *Bird Study* 40: 140-143

Table 9.8.5: Summary of collision risks from the Solway offshore wind farm.

Species	Sensitivity of local population	Magnitude of effect	Significance	Significant impact?
Common scoter	High	Negligible	Very low	No
Red-throated diver	High	Low	Low	No
Migrant waterfowl	Very high	Negligible	Low	No
Other seabirds	Medium	Low/negligible	Low/Very low	No
Migrant landbirds	Low	Negligible	Very low	No

9.8.5 INDIRECT EFFECTS: HABITAT LOSS (DISTURBANCE)

The wind farm could potentially affect the local bird populations by disturbing them and displacing them from an area around the turbines. Such disturbing activities are likely to be greatest during construction but may continue through the operational phase as well. Wind farm disturbance to birds has been the subject of several studies on land, and the maximum distance at which birds have been displaced is 800m, though in many cases no effect at all has been found[411 412 413]. English Nature recommend that wind farms should be located at least 800m from areas of high ornithological interest[414], though this value does not have a strong scientific basis[415].

Studies at existing wind farms have found generally small-scale disturbance effects, with displacement distances ranging from several hundred metres to no measurable effect at all[416]. The maximum distance at which effects have been suggested is 800m [417], though in this study there were potentially confounding factors that could have influenced the results. Other studies have found displacement up to 500m from turbines. However, the only such study at an offshore wind farm has been carried out at Tunø Knob in the Danish Baltic[418 419]. This showed no significant impact on the eider duck population at this small (10 x 660kW turbine) wind farm. No studies have been carried out on other seabird species at offshore sites, nor at larger wind farms comparable to the size of that proposed for the Solway. Therefore, in the absence of such studies a precautionary approach has been taken in this assessment. It is likely that there would be some disturbance of the birds in/around the wind farm, but it is not possible to draw on published studies to determine the size of that zone. It is however, possible to draw on what is known about bird-wind farm interactions to get at least a general indication of the likely scale of impact.

The approach taken here assumes that there would potentially be displacement of birds from the wind farm itself and from an area surrounding it. The uncertainty as to the precise extent of this surrounding impact area has been incorporated by examining a range of possible and worst case scenarios that might occur.

[411] SGS Environment. 1996. A review of the impacts of wind farms on birds in the UK. ETSU report on contract W/13/00426/REP/3.

[412] Gill, J.P., Townsley, M. and Mudge, G.P. 1996. Review of the impacts of wind farms and other aerial structures upon birds. Scottish Natural Heritage Review 21. 68 pp.

[413] Percival, S.M. 2000. Birds and wind turbines in Britain. *British Wildlife* 12: 8-15.

[414] English Nature. 1994. Nature conservation guidelines for renewable energy projects. English Nature, Peterborough.

[415] Percival, S.M. 2000. Birds and wind turbines in Britain. *British Wildlife* 12: 8-15.

[416] Percival, S.M. 2000. Birds and wind turbines in Britain. *British Wildlife* 12: 8-15.

[417] Pedersen, M.B. and Poulsen, E. 1991. Impact of a 90m/2MW wind turbine on birds: Avian responses to the implementation of the Tjaereborg Wind Turbine at the Danish Wadden Sea. Danske Vildtundersogelser Haefte 47: 34-44 pp

[418] Guillemette M., Larsen J.K. and I. Clausager. 1998. Impact assessment of an off-shore wind park on sea ducks. NERI technical report no. 227.

[419] Guillemette, M., Larsen, J.K. and Clausager, I. 1999. Assessing the impact of the Tunø Knob wind park on sea ducks: the influence of food resources. NERI Technical Report No. 263. 21pp.

From existing studies, it is actually unlikely that this zone would extend to more than 1km from the turbines. However, as no detailed studies have been undertaken on the main species of conservation interest in this area, an alternative approach has also been taken. Bird numbers in bands around the wind farm have been quantified, and these data have been used to determine the disturbance zone that would be needed in order to potentially affect nationally important numbers (and to result in a significant impact).

Table 9.8.6 summarise the sensitivities of the bird populations in the wind farm area and its surrounds, the magnitude of the impact that would arise if birds were displaced from an area 1km around the wind farm, and what disturbance zone would be needed to result in a significant impact.

The magnitude of the impacts would be related to the importance of the wind farm area for each species. A hypothetical worst case would be where a species was completely dependent on that area and no alternative were available. In such a case displacement would be likely result in that species leaving the area altogether. Therefore the magnitude of the possible disturbance impacts has been assessed taking each species' distribution and ecological requirement into account.

Overall no significant disturbance impacts are predicted. Disturbance would affect at most regionally important numbers of any species, and the wind farm area does not provide any particularly important ecological resource for these bird populations. For the only two species to regularly occur in the study area in nationally important numbers, red-throated diver and common scoter, displacement zones of more than 5km and 3km respectively would be needed to affect nationally important numbers. Given that the maximum distance displacement that has been demonstrated at existing wind farms is 800m, it can be safely concluded that disturbance to these species over such large distances would be very unlikely. Even with the additional disturbance effects of offshore-specific activities including foghorns and piling for the turbine foundations, effects to this magnitude of distance would be very unlikely indeed.

Table 9.8.6: Summary of disturbance impact assessment from the Solway offshore wind farm.

Species	Sensitivity of local population	Buffer width (for national importance)	Magnitude of effect	Significance	Significant impact?
Common scoter	High	3km	Low	Low	No
Red-throated diver	High	>5km	Low	Low	No
Manx shearwater	Medium	-	Negligible	Very low	No
Storm petrel	Medium	-	Negligible	Very low	No
Gannet	Medium	-	Negligible	Very low	No
Cormorant	Medium	-	Low	Low	No
Scaup	Medium	-	Low	Low	No
Kittiwake	Medium	-	Low	Low	No
Guillemot	Medium	-	Low	Low	No
Razorbill	Medium	-	Low	Low	No
Other seabirds	Low	-	Low	Very low	No

The grid connection cable will have negligible magnitude impacts on the area's bird populations. It has been routed through an area of generally low bird density to the shore, and will affect only a small area of seabed. The landfall will be routed to avoid any protected areas, and to avoid the main wader roost and little tern breeding colony at Siddick, so impacts on these species too will be of negligible impact.

9.8.6 MITIGATION MEASURES

The key mitigation measure that has been undertaken is to ensure that the proposed site location is such that it contains no particularly important or sensitive species that could be affected by the development. Several criteria were used for this purpose:

- Maximise the distance from internationally and nationally important nature conservation sites. The site is over 7km from the nearest protected nature conservation area (Solway Firth cSAC).
- Maximise distance offshore. The site is over 7km from the shore at its nearest point.
- Avoid known bird concentrations, particularly of vulnerable or rare species (Annex 1 of EU Birds Directive).
- Maximise distance from nationally and regionally important seabird breeding colonies (taking into account species concerned and foraging ranges). The site is more than 8km from the nearest important seabird colony. Ensure the grid connection cable does not have a significant adverse effect on any significant ecological interest. Routed to avoid little tern colonies and regionally important wader roost sites. Underground.
- Route construction vessels away from more sensitive areas, particularly that used by the concentrations of common scoter.
- Use of navigational lighting minimised, with only lighting on four buoys outside the wind farm.

9.8.7 PROPOSED MONITORING PROGRAMME

The details of the bird monitoring programme would be agreed through consultation with RSPB, English Nature and SNH. The methodologies would generally follow those used in the baseline work for this ES, bit would also include the investigation of the use of infra-red video monitoring to measure collision rate. The developer has however agreed to implement the following:

Continuation of Baseline Monitoring prior to construction

- Further boat surveys (monthly), to provide a further baseline on bird use of the study area

Monitoring during construction

- Twice-monthly surveys by boat

Post-construction monitoring

- At least 3 years' boat surveys (monthly)
- Collision monitoring – infra-red video camera mounted on turbine (sample continuous day/night)

The survey area for this monitoring work would be the same throughout the study, though this would be reviewed through consultation with SNH, English Nature and RSPB. As this is extensive and covers much sea over 2km from the proposed wind farm, this will allow both a before/after/control/impact analysis and an analysis of bird distribution in relation to distance from the turbines to be made.

The data from the aerial surveys will be reviewed and an assessment made as to whether this would be a useful survey method to continue at this site in combination with the boat surveys.

9.9 EFFECTS ON MARINE MAMMALS

9.9.1 OVERVIEW

The marine mammal impact assessment for the Robin Rigg proposal has been carried out by the Centre for Marine and Coastal Studies (CMACS) at Liverpool University.

The marine mammals that make use of the Solway Firth were detailed in Section 7.5 of this ES, along with a description of the use of the Robin Rigg area. In this section the potential effects of the construction, operation and decommissioning of the Robin Rigg wind farm on these species and groups are assessed.

Potential effects include direct (those that are causally linked to the development without any intermediary factor) and indirect (those involving at least one intermediary process) short term and long term, and positive or negative effects. The final scope of potential impacts has been determined following the completion of baseline studies, field survey and consultation, and following initial specification for design, construction and operation of the wind farm.

As marine mammals forage for food over extensive areas and have highly adapted sensory abilities, localised effects of changes in water quality or prey availability would be easily detected and avoided with no impacts on individuals or populations.

The potential impacts of the proposed wind farm are, therefore, those associated with its construction (noise generated and disturbance due to construction activities. and its operation (noise and vibration and disturbance due to maintenance activities). In addition to this, the potential effect of the proposed wind farm on the general environment (e.g. artificial reef effect) may also have an impact on marine mammals. It should be noted that impacts might be positive or negative.

Behavioural Impacts

- Startle and alarm reactions
- Changes in swimming speeds and diving behaviour
- Attraction to/avoidance of the general area of the wind farm, either during construction or during the lifetime of the project. This may have an effect at the population level if impacts extend to changes in breeding or feeding behaviour (exclusion from breeding/feeding grounds or /attraction to the wind farm area for breeding/feeding).

Impacts on Communication and Perception

- Masking of communication between individuals
- Masking of other biologically important noises such as predators and prey
- adaptive shifting of vocalisations e.g. 'shouting' (this may also have possible efficiency and energetic consequences)

Physiological Impacts

- Stress reactions ranging from simple reactions like increases in heart rate to stress disorders, which may lead to secondary impacts
- Damage to the ears such as temporary or permanent shift in the hearing threshold

9.9.1.1 Data Sources of the Assessment of Impacts

The potential impacts have been assessed through two main areas of existing data.

Noise and Vibration

Data is available for the underwater noise and vibration generated from several different offshore wind farms. In addition to this, the noise and vibration generated by marine construction activities such as dredging, piling, drilling and seismic surveys is well known. This data has been compared against the audible sensitivity (the hearing sensitivity) of marine mammals to establish whether (i) marine mammals would be able to hear the noise produced by construction activities/operation of the wind farm, and (ii) whether the noise levels would be of a sufficient level to have an impact.

Behavioural Reactions of Marine Mammals to Anthropogenic Activities

A more useful insight into the likely impact of noise and vibration generated by the construction activities and operation of the proposed wind farm, are the documented reactions of marine to construction activities and other noisy anthropogenic sources of which there is a wealth of information.

9.9.1.2 Determination of Significance of Impacts

In the determination of the impact of the wind farm proposal on marine mammals, mitigation measures have been recommended wherever considered appropriate. Residual impacts of the proposal with the mitigation measures in place have then been determined. In order to ascertain the importance of these residual impacts and to allow them to be weighed up against the positive benefits of the proposal, a method for determination of the *significance* of the impacts has been developed from Natural Power's general methodology (see Section 5.8 of this ES). This method requires a prior determination of the *sensitivity* of a species or group and an evaluation of the *magnitude* of the effect of the proposal on that species or group. In this case the magnitude of the impact includes a consideration of the timescale of the effect, i.e. short, medium or long term.

Sensitivity

As defined is Section 7.5.3, all marine mammal species (cetaceans and pinnipeds) recorded in the Solway Firth are considered to be of high sensitivity.

Magnitude

Again, many assessments of magnitude would necessarily be carried out on a qualitative basis. Impacts may be negative OR positive. Magnitude would be assessed on the following basis.

Magnitude	Type and scale of effect
High	Permanent physiological effect. Gross interruption of normal behaviour. Long-term over the lifetime of the development (>5 years).
Medium	Temporary physiological effect Disruption to perception and communication (masking of communication between conspecifics, other biologically important noises and adaptive shifting of vocalisations - with possible efficiency and energetic consequences) Some modification of normal behaviour. Medium to long-term
Low	Low risk of physiological effects (e.g. short term and minor stress conditions, increase in heart rate) Minor and short-term changes in behaviour (up to 1 year)
Negligible	No measurable risk Slight or no obvious changes in behaviour

There would also be an assessment of the reliability and completeness of the data used in making the evaluation.

Significance

Determinations of the significance of an impact combine evaluations of sensitivity and magnitude, using Natural Power's matrix given in Table 5.8.2 in Section 5 of this ES. Significance is determined to be the highest potential level for a given impact. In considering the above, however, it must be borne in mind that precise figures of population sizes are not known at any level for many marine mammal species. This is particularly so for cetaceans where population sizes are only known for one or two species.

Final significance has been determined on the basis of the standard matrix approach. This includes factors for their reversibility and whether impacts are positive or negative.

9.9.2 CONSTRUCTION EFFECTS

9.9.2.1 Noise Generated by Construction Activities

The loudest noises produced during the construction period are likely to be associated with the installation of the turbine foundations, for which, three options are proposed: driven monopile, augered monopile or multipile foundations (Section 4.7). This assessment considers the impact of driving monopile foundations into the seabed, which would be carried out over a maximum seven month period between April and October over two consecutive years. Piling may take place at up to two discrete locations at any one time. Of the three -foundation options, driven monopiles are expected to produce the most noise (the worst-case-scenario), and thus, the greatest potential impacts. Should the multipile or augered monopile option be progressed, impacts of noise and vibration would be reduced.
The underwater noise and vibration generated by construction activities is discussed in Section 9.7.2.1. Briefly, the loudest noise sources generated during construction would be those associated with pile driving and seismic surveys. Pile driving noise may reach levels of 150dB at source, whilst seismic survey produce low frequency sounds with source levels of 210dB to 259dB [420]. The noise generated by seismic surveys is generally below 1000Hz, whilst several investigations into the sound generated during pile driving report that the majority of the sound energy generated is between 50-100Hz[421] and 50-200Hz[422]. All sound levels given in this section are levels at the source of sound generation unless otherwise stated.

In general, small cetaceans have poor hearing at low frequencies[423]. The hearing range of the harbour porpoise (the species most commonly sighted in the Solway Firth), ranges from 1kHz (1000Hz) to 150kHz with best sensitivity between 8kHz to 40kHz[424]. Theoretically, at 1kHz, a noise must be greater than 75dB for porpoise to hear it.

However, it should be noted that absolute hearing thresholds are developed under laboratory conditions in the absence of any background noise. Hearing thresholds in the relatively 'noisy' marine environment are, therefore, likely to be above those established in the laboratory for both cetaceans and seals. An example of this is given for the beluga, a small odontocete whale. A sound in the frequency range of 50 to 200Hz (as for pile driving) must exceed the beluga's absolute hearing threshold by approximately 17dB (the Critical Ratio) for it to be heard above background noise. Critical ratios for low frequency sounds have not been determined for any other small cetaceans, however, it is assumed that they are similar in the harbour porpoise as the absolute hearing sensitivity of the two species is similar[425].

The absolute hearing threshold of the common seal ranges from 1kHz to 50kHz with the hearing threshold ranging from 60 to 82dB [426]. At frequencies below 1kHz, where the noise from most construction activities

420 Richardson, W.J; Greene, C.R; Malme, C.I; Thompson, H.H (1995). Marine Mammals and Noise. Academic Press, San Diego.
421 Richardson, W.J; Greene, C.R; Malme, C.I; Thompson, H.H (1995). Marine Mammals and Noise. Academic Press, San Diego
422 Moore, S.E., Ljungblad, D.K.: (1984) Gray whales in the Beaufort, Chuckchi and Bearing Seas: Distribution and sound production. P. 543-559 In: Jones, M.L., Swartz, S.L, Leatherwood, S. (eds.), The gray whale *Eschrichtius robustus*. Academic Press, Orlando, Florida 600p.
423 Vella, G., Rushforth, I., Mason, E., Hough, A., England, R., Styles, P., Holt, T., Thorne, P. (2001). Assessment of the Effects of noise and vibration from offshore wind farms on marine wildlife. Report to ETSU (Department of Trade and Industry). DTI/Pub URN 01/1341. Pp 71.
424 Anderson, J.J. (1992) Assessment of the risk of pile driving to juvenile fish. Report by the Fisheries Research Institute, University of Washington, to the Deep Foundations Institute, Seattle, Washington. 11p.
425 Anderson, J.J. (1992) Assessment of the risk of pile driving to juvenile fish. Report by the Fisheries Research Institute, University of Washington, to the Deep Foundations Institute, Seattle, Washington. 11p.
426 Richardson, W.J; Greene, C.R; Malme, C.I; Thompson, H.H (1995). Marine Mammals and Noise. Academic Press, San Diego.

are found, data for the common seal showed an absolute hearing threshold at 100Hz of 96dB[427]. Absolute hearing thresholds have not been developed for behavioural responses in the grey seal. However, as the common and grey seal are both phocinid seals, their sensitivity is assumed to be similar.

9.9.2.2 Noise and Vibration Effects on Species Recorded in the Licence Area

Cetaceans

The harbour porpoise is the only cetacean species regularly observed in the Solway Firth. They are recorded throughout the year, with the largest number of sightings made between May and September. This species is also reported to birth (calve) within the Solway Firth (Hammond, 2002, pers com) with calving taking place during late summer/early autumn. Maximum presence and calving, therefore, coincides with the timing of works for the construction phase of the proposed project, which would run from approximately July to October in the first year of construction and April to October over the second year (see Section 4.15 of this ES)

Records of the effects of noise on cetaceans are primarily concerned with seismic surveys, which are considerably noisier than pile driving. The general reaction of cetaceans to seismic surveys is avoidance. As such, UK legislation requires that a safety zone with a radius of 500m is established around a seismic survey array[428]. The National Marine Fisheries Service of the United States identified conservative safety distances defined by the following *received* (i.e. noise level at the receiver not the source) low-frequency sound pressure levels[429]:

- **180**dB for the large mysticetes such as the long-finned pilot whale
- **210**dB for small cetaceans such as harbour porpoise.

The noise generated by pile driving is unlikely to exceed 150dB *at source*, which is considerably less that the 210dB *received* levels that mark the safety zone during seismic surveys for small cetaceans such as the harbour porpoise. Therefore even if a harbour porpoise was located immediately adjacent to a piling site it would still lie within an area considered to be safe by the NMFS.

In addition to this, it is not know whether small cetaceans can hear very low-frequency sounds in the range of those generated by pile driving activities. The theoretical sensitivity of harbour porpoise in this range of 50-200Hz, in the absence of background noise, is approximately 115-105 dB respectively (see Section 9.9.2.1). Assuming a source level generated by pile driving of 150dB, at 50Hz, and in the absence of background noise, porpoise would only be able to detect the pile driving within 1km. This is the 'zone of audibility'. Sounds generated by pile driving at 200Hz will be detectable for several kilometres (again, in the absence of background noise). However, the ocean is a noisy environment, and in the presence of background noise, these detection distances will decrease. Critical ratios of low-frequency sounds for the harbour porpoise are unknown, but assuming they are similar to the beluga whale (as discussed above) they will be approximately 17dB at frequencies below 1000Hz. This decreases porpoise sensitivity to sounds between 50 and 200Hz from 115 and 105dB respectively to 132 and 122dB respectively. Correspondingly, detection distances for pile driving noise will be much smaller (at 50Hz sound levels of 150dB at source will be detectable within approximately 64m and between 500 and 1000m for sounds at 200Hz).

The sound level generated by pile driving required to elicit a behavioural reaction ('zone of responsiveness') is likely to be very much smaller than the zone of audibility, and indeed, may be zero. However, assuming a worst-case-scenario where the zone of responsiveness is similar to the zone of audibility, porpoise would avoid an area around the construction site with a radius of up to 1-1.5km. Porpoise moving into the estuary would, therefore, only be excluded from travelling across approximately 12% of the estuary's width.

Porpoise are thought to calve mainly in September in the shallow water of the estuary. Whilst the exact area used for calving is unknown, it is thought to occur above the intersection of Southerness Point and Dubmill Point (Hammond, 2002 pers comm). This is more than 10km to the north east of the wind farm area. The zones of audibility and response discussed above for adult porpoise are very likely to apply to calves, as there appears to be no evidence to suggest that thresholds differ between calves and parents. Pile driving activities are, therefore, not expected to interfere with calving for the following reasons:

- There is sufficient room across the width of the estuary for porpoise to move past the construction site – more than 80% of the estuary's width would not be effected, including most or all of the deep water channels to the north and south of the Robin Rigg sand bank.
- The key area used for calving is beyond the zone of noise influence
- There is no data to suggest that calves would be any more sensitive to construction noise than adults

Porpoise seeing the construction works, however, may respond to (avoid) the visual stimulus as very few wild animals tolerate anthropogenic presence/activity prior to becoming sensitised to it.

In summary, the impact of construction work on small cetaceans is likely to be short-term avoidance of the local area of works based on visual and/or sound stimuli. Startle or alarm response is only likely to occur if individuals are in very close proximity to piling activities at their start up, which can be mitigated (see below). The noise generated from construction activities would not effect calving. The *magnitude* of the impact on small cetaceans is therefore considered to be 'low', and possible impacts are not significant.

The audible sensitivity of mysticete whales such as the long-finned pilot whale has not been measured. However, these large whales are thought to be sensitive to low frequency noise over considerable distances, based on the assumption that they are sensitive to noises in the same low-frequency range that they use for communication. Potter and Delroy suggest that the hearing sensitivity for mysticete whales may be centred in the vicinity of 100-200Hz[430]. If this is correct, then they would be able to hear the noise

[427] Kastak D; Schusterman RJ (1995) Aerial and underwater hearing thresholds for 100Hz pure tones in two pinniped species. In: Kastelein RA; Thomas JA; Nachtigall PE (eds.), Sensory systems of aquatic mammals. De Spil Publishers, Woerden, The Netherlands

[428] Pierson, M.O., Wagner, J.P.; Langford, V.; Birnie, P.; Tasker, M.L. (1998) Protection from and mitigation of the potential effects of seismic exploration on marine mammals. In: Proceedings of the Seismic and Marine Mammal Workshop, London June 1998. Eds.: Tasker, M.L. and Weir, C.

[429] National Marine Fisheries Service (NMFS) (1998) Small takes of marine mammals incidental to specified activities; seismic hazards investigations in Puget Sound/Notice of issuance of an Incidental Harassment Authorization. Federal Register 63: 2213-2216.

[430] Potter, J. and Delory, E (1998) Noise Sources in the Sea & the Impact for Those Who Live There. Acoustics & Vibration Asia 1998 Conference Proceedings 56-71

generated during construction, but it is not possible to predict their reaction. Certainly, many cetacean species show tolerance and habituation to loud anthropogenic noise (discussed by Vella *et al.*[431]), and the noise generated during construction would be considerably less than the 180dB received sound levels used to identify safety zones around seismic surveys. In addition to this, mysticetes such as the long-finned pilot whale are only occasionally sighted in the north eastern Irish Sea and most reports are of individuals off the Mull of Galloway, or between the Mull of Galloway/Luce Bay and the Isle of Man. Thus, it is unlikely that there would be very many individuals, if any at all, in the general area during construction that might be affected. The magnitude of possible impacts associated with the fairly short term construction activities would, therefore be, 'negligible' to 'low' and so, any impacts would not be significant.

Pinnipeds

Seals show both avoidance and attraction to anthropogenic noise sources, but generally show avoidance responses when sources of noise or activity are close and may be perceived as a threat. However, it is difficult to discriminate between a seal's avoidance of a noise source and avoidance of the presence of humans, which is the most probable cue. Furthermore, grey seals, the species that hauls out on the sand banks between Southerness Point and Silloth, a minimum of 10km north east of the wind farm area, seem to readily habituate to most anthropogenic sounds and activities[432].

The most common reaction of seals hauled out on land to construction noise and activity will be alarm behaviour. If a disturbance is sufficient, seals will leave their haul out area and enter the water. However, this behaviour is only generally triggered by very close approach by humans and other predators (tens to hundreds of metres, depending on frequency of exposure to human activity).

The reaction of seals to construction activities when they are already in the water, is generally avoidance, but again, this may be a reaction to visual cues rather than noise. Certainly, investigations of the impact of seismic surveys on grey seals showed that seals left an area where surveys producing source sounds of 214 to 224dB were being carried out, for the duration of the works. Following this, however, they returned soon after the survey ended[433]. As such, UK legislation requires that there are no seals within a 500m radius of seismic works before the survey can commence. In the United States, conservative safety distances for pinnipeds around seismic surveys are defined by *received* sound pressure levels of 210dB (NMFS, 1998), as for small cetaceans. This greatly exceeds the noise that would be generated by pile driving activities, and thus, it is considered unlikely that noise would impact on seals.

Seals may still, however, avoid the general area of the construction works due to the presence of human activity. A possible result of this avoidance behaviour may be exclusion from some feeding grounds in the wind farm area over all or part of the construction period. However, it is more likely that some seals would avoid the area whilst others would be indifferent to the presence of humans. Certainly, grey seal bulls (males) are known to approach fishing vessels in the Solway Firth (Dobson, 2002 pers comm). Also, during construction of the Näsrevet Wind Farm, Sweden (situated approximately 5km from a grey seal colony), seals rapidly habituated to construction activities[434]. Monitoring of these seals showed that they only became alarmed when support vessels moved with hundreds of meters of them. The closest seal haul out area to the site of the proposed works, is approximately 10km to the north east (between Southerness and Dubmill Points), and thus, seals hauled out at this location during low water would not be affected by construction activity or the movements of support vessels within the site area.

There would, therefore, only be a very low risk, if any, of any physiological effects on seals during the start up period of piling. Mitigation measures to avoid any such impacts due to close proximity of animals to piling are recommended below. There may be short-term changes in behaviour of seals in the water close to the site during the start of construction in April. However, seals are expected to quickly habituate to the day to day activities as has been demonstrated at Näsrevet and during other marine construction projects. The significance of any impact is therefore considered to be moderate, and would not be significant.

9.9.3 EFFECTS DURING OPERATION

9.9.3.1 Noise and Vibration

Noise Generated from Production Activities

Until recently there has been very little data on the underwater noise and vibration generated by an offshore wind farm. Henriksen *et al*. (2001), however, have measured underwater noise at the Middlegrunden and Vindeby Wind Farms in Denmark and the Bockstigen-Valar Wind Farm in Sweden (data given in Section 9.7.3.2). The maximum source levels found were 130dB (re:1μPa^2/Hz) at 25Hz and 115 dB (re:1μPa^2/Hz) at 125Hz. These sound levels are considerably less than the noise that would be produced during the construction period. Furthermore, they are far less than the received sound levels of 180 and 210dB, which define the safety zones around seismic surveys for mysticete and odontocete/pinnipeds respectively. However, unlike seismic survey and the majority of construction noises generated at sea, the noise generated by wind farms would be long-term in nature.

Noise and Vibration Effects on Species Recorded in the Wind Farm Area

CETACEANS

The only species commonly observed in the general area of the proposed wind farm is the harbour porpoise, however, it is not known whether porpoise can hear noises below 250Hz (wind farm peak sound level frequencies are 25 and 125Hz. In assessing the impact of offshore wind on the harbour porpoise, Henriksen *et al*. (2001)[435] extended the slope of the porpoise's absolute hearing threshold to below 250Hz (a worse-case-scenario). This theoretical sensitivity was then compared with underwater turbine noise and it was found that at 25 and 125Hz, sensitivity was very poor. The frequency at which they were most sensitive was 315Hz, where the noise generated by an offshore wind farm at source was 17dB above their

[431] Vella, G., Rushforth, I., Mason, E., Hough, A., England, R., Styles, P., Holt, T., Thorne, P. (2001). Assessment of the Effects of noise and vibration from offshore wind farms on marine wildlife. Report to ETSU (Department of Trade and Industry). DTI/Pub URN 01/1341. Pp 71.

[432] Vella, G., Rushforth, I., Mason, E., Hough, A., England, R., Styles, P., Holt, T., Thorne, P. (2001). Assessment of the Effects of noise and vibration from offshore wind farms on marine wildlife. Report to ETSU (Department of Trade and Industry). DTI/Pub URN 01/1341. Pp 71.

[433] Thompson, D., Duck, C.D., McConnell, B.J. (1998) Biology of seals of the north-east Atlantic in relation to seismic surveys.). In: Tasker, M.L. ; Weir, C., (eds.) Proceedings of the Seismic and Marine Mammal Workshop, London, 23-25 June 1998.

[434] Westerberg, H (1999) Impact Studies of Sea-Based Windpower in Sweden. "Technische Eingriffe in marine Lebensraume"

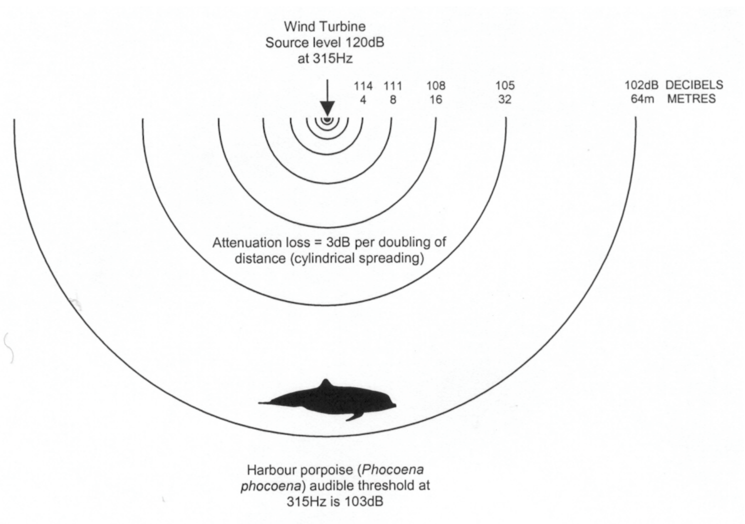
[435] Henriksen, O. D; Teilmann, J; Dietz, R; Miller, L. (2001) Does underwater noise from offshore wind farms potentially affect seals and harbour porpoises? Poster presented at the "14th biennial conference on the biology of marine mammals" Vancouver, Canada.

hearing threshold. This data allows the area in which porpoise would be able to hear the wind farm turbines ('zone of audibility') to be determined.

On the basis of the above noise levels at a maximum of 17dB above the hearing threshold of the porpoise and assuming cylindrical spreading of noise with a 3dB drop when the distance from the source is doubled, the Robin Rigg Wind Farm turbines would only be audible to porpoise within a distance of approximately 50m from the turbines (Figure 9.9.1). At greater distances, sound levels would be below their threshold.

The 'zone of responsiveness' (the area in which porpoise may show a behavioural response), is likely to be far less and indeed, may be as low as 0m.

Figure 9.9.1: Zone of audibility around a wind farm turbine for the harbour porpoise[436]



As the closest distance between turbines would be approximately 450m, porpoise would be able to move between turbines within the wind farm, without being adversely affected by noise generated. However, assuming a worst-case-scenario where the zone of responsiveness is similar to the zone of audibility, and porpoise avoid the wind farm area completely, then porpoise moving into the estuary would still only be excluded from travelling across 15% of the estuary's width.

Recently, it has come to light that harbour porpoise may use the Inner Solway Firth to calve during the late summer/early autumn (peak during September), as discussed earlier. There appears, however, to be no suggestion in the scientific literature that the absolute hearing threshold of calves differs in any way to adults, and thus, the zone of audibility for young is also assumed to also have a maximum radius of 50m. As porpoise would not be restricted from moving past the operating turbines, and considering that the area used for calving above the intersection of Southerness and Dubmill Points is more than 10km north east of the proposed wind farm site, no impacts of wind farm operation on calving are expected.

[436] Henriksen, O. D; Teilmann, J; Dietz, R; Miller, L. (2001) Does underwater noise from offshore wind farms potentially affect seals and harbour porpoises? Poster presented at the "14th biennial conference on the biology of marine mammals" Vancouver, Canada.

Even assuming a further worst-case-scenario, that the 'zone of audibility' is similar to a zone of exclusion, impacts on harbour porpoise, (and by extrapolation, other odontocete cetaceans) are considered to insignificant due the very small area from which they would be excluded. Following familiarisation with the physical presence of the wind farm, porpoise and other odontocete cetaceans such as the bottlenose dolphin, which are particularly opportunistic foragers, eating a very wide range of fish and other species, may exploit wind farm sites as feeding areas. The magnitude of noise and vibration impacts is therefore, 'negligible' to 'low', and so, impacts would not be significant.

The hearing sensitivity of the larger, mysticete cetaceans such as the long-finned pilot whales is not known, but they are expected to be able to hear the low-frequency noise generated by the proposed wind farm. Their reactions to wind farm noise, however, cannot be predicted in the absence of their hearing threshold. Certainly, there are many examples of mysticete whales continuing to migrate past oil and gas drilling platforms, which generate sound at frequencies and levels comparable to wind farms[437], and the noise generated by the proposed wind farm would be considerably less than the 180dB-received level by which seismic survey safety zones are established[438]. Thus, as long-finned pilot whales and other mysticete species are seldom seen in the shallow water of the Solway Firth, and considering that the sound levels generated during operation would not be at a level to injure animal, any impacts on behaviour would be of little significance for populations migrating through the Irish Sea.

PINNIPEDS

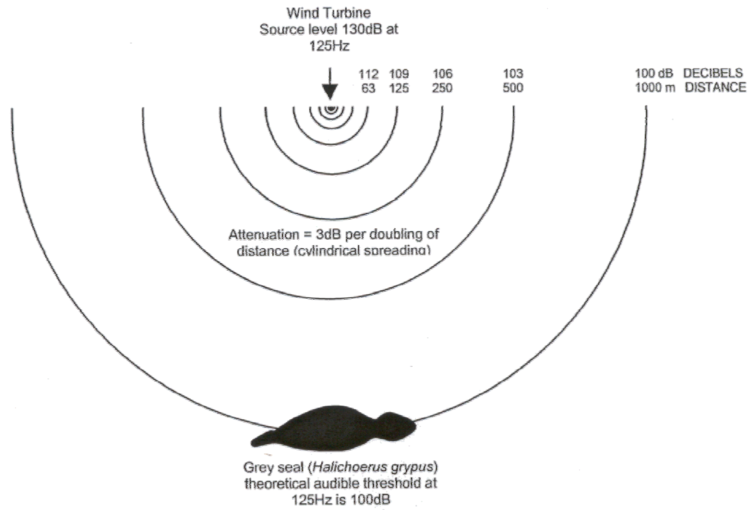
The absolute hearing sensitivity of common seals below 1kHz has only been determined for a single individual, due to the difficulty in training such animals to respond to specific sounds and frequencies under laboratory conditions. Henriksen *et al*. (2001)[439] adopted a worse-case-scenario (as for harbour porpoise) and extended the absolute hearing threshold of the common seal below 1kHz and into the frequency range of offshore wind turbine noise production. The maximum overlap between the two was 30dB above the hearing threshold at 125Hz. With cylindrical spreading of sound and a 3dB loss per doubling of distance from source, this gives the common seal a detection range 'zone of audibility' for wind farm noise of 1000m (Figure 9.9.2). It is assumed that grey seals (found most commonly in the Solway Firth) will have a similar zone of audibility.

[437] Vella, G., Rushforth, I., Mason, E., Hough, A., England, R., Styles, P., Holt, T., Thorne, P. (2001). Assessment of the Effects of noise and vibration from offshore wind farms on marine wildlife. Report to ETSU (Department of Trade and Industry). DTI/Pub URN 01/1341. Pp 71.

[438] National Marine Fisheries Service (NMFS) (1998) Small takes of marine mammals incidental to specified activities; seismic hazards investigations in Puget Sound/Notice of issuance of an Incidental Harassment Authorization. Federal Register 63: 2213-2216.

[439] Henriksen, O. D; Teilmann, J; Dietz, R; Miller, L. (2001) Does underwater noise from offshore wind farms potentially affect seals and harbour porpoises? Poster presented at the "14th biennial conference on the biology of marine mammals" Vancouver, Canada.

Figure 9.9.2: Zone of audibility around a wind farm turbine for the grey seal[440]



It should be noted that this zone of audibility above, is based on absolute hearing thresholds that are developed under laboratory conditions in the absence of any background noise. Hearing thresholds in the marine environment are likely to be above those established in the laboratory, and thus, the zone of audibility would be smaller.

Grey seals tend to forage over very large areas. Dietz et al. (2001)[441] established average 'home ranges' (the area in which grey seals foraged for food) of 3980 km^2. A similar investigation in the Baltic Sea revealed home ranges from 1088 to 6400 km^2 (Sjöberg & Ball 2000, cited in Dietz *et al.,* 2001). Assuming that the home range of grey seals is 3980 km^2 and that the 'zone of audibility' (1000m) is also a zone of exclusion, then grey seals would be excluded from an area of less than 36km^2 (area of proposed wind farm including a 1km boundary) or less than 1% of their home range. This is, however, a worse-case-scenario and assumes that that the 'zone of audibility' is equivalent to a zone of exclusion. It is much more likely that whilst seals may be able to hear the turbines within 1km, the area they are excluded from would be far smaller and indeed, exclusion may not occur at all. Certainly, there are many examples of pinnipeds approaching and tolerating noisy environments such as seismic surveys[442], airports and harbours, as discussed by Vella et al. (2001)[443].

The magnitude of noise and vibration impacts on the grey seal is therefore, considered to be 'negligible' to 'low' as they are, on balance, unlikely to show any reactions other than to the physical presence of the turbines, to which they are likely to habituate very quickly. In addition to this, it is possible that seals may use the wind farm as a feeding ground should fish assemblages be higher around turbine foundations (the 'reef-effect'/ FAD). Impacts would, therefore, not be significant.

9.9.3.2 Changes in Prey and Predator Populations

Harbour porpoise and grey seals are both opportunistic hunters that predate wide range of fish and invertebrates species over very wide areas. The proposed development and associated construction work are not expected to change overall populations densities of fish or invertebrates in the Solway Firth, but they may produce short-term changes in distributions through the 'artificial-reef' or FAD effect as discussed in Section 9.7.3.4. Both porpoise and seals would quickly adapt to any such changes.

Harbour porpoise and the grey seal have very few, if any, natural predators in the general area of the Solway Firth. The proposed development would not change this situation.

The magnitude of changes in prey and predator populations is considered to be 'negligible' and not significant.

9.9.4 IMPACTS DUE TO FUTURE DECOMMISSIONING

Cetaceans

The impacts associated with decommissioning would be similar to those of construction and would arise from the generation of noise and vibration. However, cetaceans in the area would have habituated to the noise, the physical presence of the turbines and occasional support vessels and thus, may perceive the decommissioning works as less disturbing than the construction works. Accordingly, the magnitude of the impact is considered to be 'negligible' to 'low' and would not be significant.

Pinnipeds

As for construction, direct impacts on seal populations in the area would be restricted to disturbance of any individuals active in the area and their possible exclusion during decommissioning activity. Any such impacts would therefore be short-term and would simply lead to movement of seals to other nearby areas. No impacts of decommissioning would therefore arise. An additional possible impact on seal populations, however, may be the loss of feeding areas created by the turbine structures. The magnitude of the impact is considered 'negligible' to 'low' and would not be significant.

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440 Henriksen, O. D; Teilmann, J; Dietz, R; Miller, L. (2001) Does underwater noise from offshore wind farms potentially affect seals and harbour porpoises? Poster presented at the "14th biennial conference on the biology of marine mammals" Vancouver, Canada.

441 Dietz, R; Teilmann, J; Henricksen, O.D.; Laidre, K. (2001) Satellite tracking as a tool to study potential effects of offshore wind farms on seals at Rødsand - Technical Report. Ministry of the Environment and Energy, Denmark (*in english*) pp.43.

442 Pierson, M.O., Wagner, J.P.; Langford, V.; Birnie, P.; Tasker, M.L. (1998) Protection from and mitigation of the potential effects of seismic exploration on marine mammals. In: Proceedings of the Seismic and Marine Mammal Workshop, London June 1998. Eds.: Tasker, M.L. and Weir, C.

443 Vella, G., Rushforth, I., Mason, E., Hough, A., England, R., Styles, P., Holt, T., Thorne, P. (2001). Assessment of the Effects of noise and vibration from offshore wind farms on marine wildlife. Report to ETSU (Department of Trade and Industry). DTI/Pub URN 01/1341. Pp 71.

9.9.5 MONITORING AND MITIGATION MEASURES

A soft-start procedure should be instigated so that any animals that are in very close proximity to the piling works are not subjected to maximum sound levels without warning. Furthermore, should piling involve installation of more than one turbine foundation at a time, piling should be carried out in the most restricted/localised area possible, as defined by an Environmental Management Plan for the works, to reduce the area from which marine mammals could be excluded.

Information from the Solway Shark watch and Sea Mammal Survey should continue to be collated to confirm that cetacean use of the Solway continues in a similar manner as previously.

9.10 LANDSCAPE, SEASCAPE AND VISUAL EFFECTS ASSESSMENT

9.10.1 INTRODUCTION

This section provides an assessment of landscape, seascape and visual effects for the proposed Robin Rigg Offshore Wind Farm as carried out by Enviros Aspinwall. The assessment includes the following sections:

Method of assessment – an explanation of how the assessment has been carried out, with reference to a methodology developed by Axis landscape consultants specifically for the Robin Rigg site* and standard guidelines;

Project description – a description of the aspects of the development with the potential to cause an effect on landscape, seascape or visual amenity in the study area and mitigation measures incorporated at the design stage aimed at reducing or minimising potential landscape, seascape and visual effects;

Assessment of residual effects – an assessment of the residual landscape, seascape and visual effects arising from the proposed wind farm during the operational phase having taken account of the inbuilt mitigation measures;

Summary – a summary of the effects on landscape/seascape quality, visual amenity and cumulative effects of the proposed offshore wind farm;

Conclusions – conclusions to the landscape, seascape and visual assessment of the proposed offshore wind farm.

The assessment is illustrated by photomontages/wireframes in Visualisations 1 to 33, Zone of Visual Influence maps in Figures 9.10.1 to 9.10.3 and a cumulative ZVI in Figure 9.10.4 all given at the end of this assessment.

* This methodology was prepared by Axis for use by the Natural Power Company (NPC), specifically for this project, however it could also be applied for landscape, seascape and visual assessments for other offshore wind farm sites, and has been developed from the Guide to Best Practice in Seascape Assessment (Counryside Council for Wales, Brady Shipman Martin, University College Dublin, March 2001). It is included in Appendix G1 in the separate volume of appendices.

9.10.2 METHODOLOGY

9.10.2.1 General Approach

The landscape, seascape and visual assessment for the proposed wind farm at Robin Rigg has been carried out in accordance with the methodology developed by Axis landscape consultants, which is included as Appendix G1 in the volume of appendices. The assessment has also drawn on information provided by consultations with Dumfries and Galloway Council and Scottish Natural Heritage Area Office.

The impact assessment aims to:

- identify systematically all the potential landscape, seascape and visual impacts of the development incorporating its proposed mitigation measures;
- predict and estimate their magnitude as accurately as possible; and
- assess their significance in a logical and well-reasoned fashion.

The assessment describes the changes in the character and quality of the landscape/seascape and visual resources that are expected to result from the proposed development. It covers both: landscape/seascape impacts, that is changes in the fabric, character and key defining characteristics of the landscape/seascape; and visual impacts, that is changes in available views of the seascape and the effect of those changes on people.

The landscape, seascape and visual assessment has involved a desk study, field work, data processing and analysis and interpretation using professional judgement.

A 35km radius study area has been chosen for the proposed development at Robin Rigg. This is recommended as an appropriate size of study area based on the nature of the development, accepted practice and in consultation with relevant agencies. A zone of visual influence (ZVI) was generated to identify the extent of the proposed wind farm's visibility over the 35km radius study area, which is shown in Figure 9.10.1 with expanded larger scale sections of the Dumfries and Galloway and Cumbrian coasts in Figures 9.10.2 and 9.10.3. The ZVI has been modelled using a computer based visibility analysis package compiled using Ordnance Survey digital height data, and a three dimensional digital model of the proposed wind farm.

A cumulative ZVI, Figure 9.10.4, was also generated to identify the extent of the proposed wind farm's visibility in relation to existing and known proposed wind farm developments within the study area. The cumulative ZVI extends the potential visibility of existing and proposed onshore wind farms to 25 km, as it is considered that significant cumulative effects would not occur beyond this distance.

A visibility assessment has been carried out to describe the general extent of visibility of the proposed wind farm within the study area. The visibility assessment has concentrated mainly on publicly accessible areas such as the road and public footpath network, residential and outdoor recreational areas, and has also considered offshore areas and sea based receptors, such as sailing and fishing activities.

A viewpoint analysis has been carried out to identify and evaluate the potential effects on landscape, seascape and visual amenity arising from the proposed wind farm at specific representative locations in the study area. The selection of viewpoints has been chosen in consultation with the Dumfries and Galloway Council, Scottish Natural Heritage, Cumbria County Council, the Lake District National Park Authority and the Countryside Commission. These viewpoints are considered to be representative of the spectrum of receptors in the study area, located at different distances, directions and heights relative to the proposed development. The viewpoint selection has been detailed in the baseline landscape, seascape and visual report presented in Section 7.7 of this ES

The assessment has involved the production of computer generated wireframes and photomontages (produced by Envision Ltd) to predict and illustrate the views of the proposed turbines from each of the agreed viewpoints. These are included as Visualisations 1 to 33 at the end of this assessment.

All height referred to in the assessment are above ordnance datum (AOD), which approximately equates to mean sea level.

9.10.2.2 Assessment Criteria

The aim of the environmental assessment is to identify, predict and evaluate potential key effects arising from a proposed development. Wherever possible identified effects are quantified, but the nature of landscape and visual assessment requires interpretation by professional judgement. In order to provide a level of consistency to the assessment, the prediction of magnitude and assessment of significance of the residual landscape and visual effects have been based on pre-defined criteria.

Landscape and Visual Sensitivity

The sensitivity of the landscape to changes associated with the proposed development is defined as *high, medium, low* or *negligible* based on professional interpretation of a combination of parameters, as follows:

- landscape designation;
- landscape scale;
- landscape quality; and
- the nature of views.

The weighting of visual receptor sensitivity is based on an interpretation of a combination of parameters as follows:

- the location of the viewpoint;
- the context of the view;
- the activity of the receptor; and
- frequency and duration of the view.

Visual receptor sensitivity is defined as *high, medium, low* or *negligible as follows:*

High
users of outdoor recreational facilities including strategic recreational footpaths, cycle routes or rights of way, whose attention may be focused on the landscape; important landscape features with physical, cultural or historic attributes; the principal views from residential buildings; popular beaches; beauty spots; picnic areas; and areas of in-shore recreational boating;
Medium
Other footpaths; secondary views from residential buildings; people travelling through or past the landscape on roads, train lines or other transport routes; views from passenger ferries and cruisers;
Low
People engaged in outdoor sports or recreation (other than appreciation of the landscape), commercial buildings or commercially engaged pedestrians, whose attention may be focused on their work or activity rather than the wider landscape.
Negligible
Views from industrial areas, ports or commercial fishing.

Magnitude of Change

The magnitude of change arising from the proposed development at any particular viewpoint is described as *substantial, moderate, slight* or *negligible* based on the interpretation of a combination of largely quantifiable parameters, as follows:

- distance of the viewpoint from the development;
- duration of effect;
- extent of the development in the view;
- angle of view in relation to main receptor activity;
- proportion of the field of view occupied by the development;
- background to the development; and
- extent of other built development visible, particularly vertical elements.

Significance of Effect

The effect of any identified landscape or visual effect has been assessed in terms of *major, moderate*, *minor* or *none*. These categories have been based on combining viewpoint or landscape sensitivity and predicted magnitude of change, as follows:

Table 9.10.1 Correlation of Sensitivity and Magnitude to Determine the Significance of Effect

	Magnitude of Change			
Landscape or Visual Sensitivity	**Substantial**	**Moderate**	**Slight**	**Negligible**
High	**Major**	**Major/ moderate**	Moderate	Moderate/ minor
Medium	**Major/ moderate**	Moderate	Moderate/ minor	Minor
Low	Moderate	Moderate/ minor	Minor	Minor/none
Negligible	Moderate/ minor	Minor	Minor/none	None

Where the landscape, seascape or visual effect has been classified as major or major/moderate, this is considered to be a significant effect. It should be noted that significant effects need not be unacceptable and may be reversible.

The matrix is not used as a prescriptive tool, and the methodology and analysis of potential effects on landscape and visual amenity at any particular location must make allowance for the exercise of professional judgement. Thus, in some instances a particular parameter maybe considered as having a determining effect on the analysis.

9.10.2.3 Cumulative Seascape, Landscape and Visual Assessment

The methodology prepared by Axis landscape consultants, did not specifically address the way in which potential cumulative landscape, seascape or visual effects should be evaluated. Although a Guide to Assessing the Cumulative Effects of Wind Energy Development has been produced (DTI Final Consultation Draft December 1999), there are no published guidelines in Britain defining a methodology for the assessment of cumulative effects on landscape, seascape and visual amenity that have been approved and endorsed by the Landscape Institute. The approach used is therefore based on the Guidelines for Landscape and Visual Impact Assessment (GLVIA)[444] as developed by Enviros Aspinwall to address cumulative effects.

Types of Cumulative Effect

Potential cumulative landscape, seascape and visual effects arise from the combined effects of additional wind farm developments. Combined effects may relate to the following:

[444] The Landscape Institute and Institute of Environmental Assessment (1995). This publication has been revised (April 2002) since the assessment for this project was carried out.

- Extending visibility of wind turbines over parts of the study area from where there are currently existing wind turbines visible, which may give rise to extended simultaneous visibility of wind turbines at particular locations in the landscape and seascape,
- Extending visibility of wind turbines over parts of the study area from where there are currently no wind farms visible, which may give rise to an extended sequential visibility of wind turbines across the landscape and seascape;
- Both simultaneous and sequential visibility of wind turbines.

In relation to the simultaneous visibility, cumulative effects occur where more than one wind farm is visible in the same direction from a particular place, as well as where wind farms become visible in more than one direction from that place.

Assessment of Cumulative Effects

The assessment of potential cumulative landscape, seascape and visual effects, is carried out in the same generic way as the potential of non-cumulative effects. Thus the viewpoint assessment is carried out in relation to the evaluation of the character, quality and sensitivity of the baseline landscape, seascape and visual amenity. This includes identification of any existing wind turbines in the landscape and the effect that they have on the character of the landscape or seascape units in which they are located.

In addition to the viewpoint assessment, potential cumulative effects are also considered in relation to the landscape and seascape units, and to receptors in these units, for example, main roads or National Trails, in order to identify sequential as well as simultaneous cumulative effects.

MAGNITUDE OF CUMULATIVE CHANGE

Cumulative landscape and visual effects may result from additional changes to the baseline landscape or visual amenity caused by the proposed Robin Rigg development in conjunction with other wind farm developments. The emphasis of the assessment is on the changes the proposal would bring to the existing landscape, which incorporates wind farm developments in Cumbria as part of its baseline landscape character and visual amenity. The assessment therefore identifies the cumulative magnitude of change relative to existing visual impacts of wind farms rather than the combined impact of all the wind farms visible. The magnitude of cumulative change arising from the proposed wind farm is assessed as *substantial, moderate, slight* or *negligible*, based on interpretation of the following largely quantifiable parameters:

- Number of existing wind farms visible;
- Number of proposed wind farms visible;
- Distance and direction to existing wind farms;
- Distance and direction to proposed wind farms;
- Horizontal angle subtended of visibility of existing wind farms; and
- Horizontal angle subtended of visibility of proposed wind farms.

The horizontal angle subtended is calculated by taking the bearing from the observer, or location in the landscape, to the left-hand visible turbine and counting degrees to the right-hand visible turbine in a wind farm. Where more than one wind farm is visible, the angles subtended by each wind farm are added together. This measure thus combines consideration of the number of turbines visible, since where more turbines are visible the corresponding angle will be greater. It also includes consideration of distance, since with increased distance from any wind farm, the corresponding angle will decrease.

On the basis of professional interpretation of the above parameters, the magnitude of cumulative change arising at each of the viewpoints from each of the existing wind farms and the proposed wind farm, both individually and in combination with each other, has been evaluated in the context of the proposed offshore wind farm at Robin Rigg.

SIGNIFICANCE OF EFFECT

The significance of any identified cumulative landscape, seascape or visual effect has been assessed as *major, moderate, minor* or *none*, in relation to the sensitivity of the receptor and the predicted magnitude of change. *As in the case of non-cumulative effects, the matrix which brings together receptor sensitivity and magnitude of change, is not used as a prescriptive tool.*

9.10.3 PROJECT DESCRIPTION

There are a number of project specific aspects of the development with the potential to cause an effect on landscape, seascape or visual amenity in the study area. These include activities associated with the construction phase, the structures and features present during the operational phase and the decommissioning of the proposed development. Mitigation measures incorporated at the design stage to avoid, reduce or remedy these effects are also identified and described below.

9.10.3.1 Construction Phase Description

Should the indicative construction timetable in Section 4.15 be followed, the construction phase would continue over two years. The construction stage includes an onshore construction phase and an offshore construction phase. The onshore construction activities and temporary features with the potential to cause an effect on the landscape and visual amenity of the area will be limited. Construction components will be delivered by sea, rail or road to existing working dock facilities in the study area. From here construction equipment and components will be transported by sea for installation at the offshore site.

The offshore activities and temporary features of the construction stage with the potential to cause an effect on landscape and visual amenity include:

- Pile installation;
- Installation and levelling of foundation structures;
- Installation of turbines;
- Installation of site substation;
- Jetting or ploughing of trenches for cables;
- Placing of cables for all foundation types;
- Installation of cable for all foundation types, and installation of the cable through the J-tube;
- Construction of backfilling and scour protection if required;
- Construction vessels; and
- Onshore cable laying and onshore switchyard.

The location and management of these features have been carefully considered, and various mitigation measures have been incorporated into the construction programme to limit the transitory effects of the construction phase, as described below.

Pile Installation

Piled foundations have been used throughout the world for supporting offshore oil and gas platforms and there exist well-established recommended practices and guidelines for the design and installation of piles. To date piled foundations for offshore wind turbines have generally comprised single monopiles installed using methods developed for marine construction. The method of installing piles will be determined by the ground conditions on the site and will probably be carried out from a jack-up platform.

Installation and Levelling of Foundation Structures

The installation of the remainder of the foundation structure will follow completion of the piling phase. It is likely that levelling will be required to achieve the tolerances necessary for installation of the turbine and tower. In the past this adjustment for tolerance has been achieved by providing a larger diameter sleeve around the upper ‘dry’ section of the monopile. Once this sleeve is in position the annulus between pile and sleeve is grouted to form a structural connection. This method has the advantages of working completely above water and of a small construction weight thus minimising craneage requirements and potential landscape and visual effects.

In the case of multi-piled foundation, the connection to the piles is made underwater and the foundation structure will be prefabricated on land and lifted into position as a single unit by a crane on a jack-up platform or barge, thus minimising the duration of potential visual effects.

Installation of Turbines

The offshore wind turbines are most likely to be installed from either a jack-up barge or a floating crane vessel. The crane will be capable of lifting hook heights greater than 80 metres to enable the tower and turbine assembly to be installed. Turbines will be erected as on land, first the tower in segments and then the nacelle and the rotor. Shore based construction activities would take place as part of existing dock facilities and would not effect the visual amenity of the area.

Construction Vessels

The precise vessel requirements are not known at this stage and will be determined by the installation contractor, however it can be expected that those vessels used may include barges, jack-up platforms, tugs and work boats/service vessels.

Potential Effects of Construction Phase

During the construction phase there will be a number of temporary visual impacts. These will be short duration and only affect a limited part of the overall application site. The main activities will take place at distances of over 8km from the coast, will be temporary in nature and are not considered to have a significant effect on the landscape or visual amenity of the study area. This phase has therefore not been considered in any further detail in the assessment.

9.10.3.2 Operational Phase

The operational phase of the wind farm will last a maximum of 25 years, and the elements of the development which could be visible from the surroundings are:

- Offshore wind turbines;
- Offshore anemometer masts;
- Offshore substation incorporating docking facility, heli-pad, switch gear; and
- Maintenance operations.
- Onshore switchyard

Offshore Wind Turbines

The proposed wind turbines will have a maximum hub height of 80m, with a maximum turbine rotor diameter of 100m, giving a total maximum blade tip height of 130m above mean sea level. The turbines will be three bladed horizontal axis wind turbines with tubular steel towers and nacelles.

It is recommended that the turbines should be a grey colour with a semi-matt finish to attenuate visibility from medium to long distance viewing locations. The turbines will be seen against a combination of sky, the sea and the backdrop of the landscape on the opposite coast or more commonly haze on days with normal visibility distances found on the Solway Firth, therefore the grey colour is considered appropriate for the conditions in which the turbines will be visible.

The design of the layout for the proposed offshore wind farm at Robin Rigg has been considered in great detail in respect of a number of constraints. Landscape and visual amenity were important considerations in the choice of layout for the proposed development and the process by which the layout was optimised in respect of the landscape and visual environment is a key mitigation measure. This process is described in detail in Section 3 of this ES. The Royal Fine Arts Commission (RFAC) was consulted during the design stage of the proposed development.

The process for the selection of a preferred layout of turbines was to establish the criteria to be used for the selection process and carry out a detailed comparison of wireframes from all the proposed viewpoints. The wireframes of the predicted view from each viewpoint for all layouts were compared as follows:

- name and number of viewpoint;
- distance to the nearest turbine;
- height above Ordnance Datum;
- likely receptors (residents, road users, walkers on national trails or public footpaths, visitors);
- landscape designation (National Park, Area of Outstanding Natural Beauty, National Scenic Area, Regional Scenic Area);
- notes on horizontal extent and composition;
- composition of turbines against landscape and/or sea; and
- preferred layout.

Initially four layouts were prepared by Natural Power, which comprised the following:

- Layout A: linear grid with all turbines to the east of the micro wave link at the west end of the site;
- Layout C: linear grid with one row of turbines to the west of the micro wave link at the west end of the site;
- Layout D: offset grid with two rows to the west of the micro wave link at the west end of the site; and
- Layout E: optimised for energy yield.

Subsequently, two further refined layouts were produced for consideration:

- Layout F: based on an off set grid; and
- Layout G: based on an optimised energy yield layout but with some order imposed on the computer modelling.

These layouts are illustrated in Figures 3.5.1 to 3.5.6 in Section 3 of this ES. Review of the initial layouts gave a clear preference in landscape and visual terms for Layout D, the off-set grid, which was the preferred layout at 21 of the 33 viewpoint locations. Of the two refined layouts, Layout F was preferred to layout G, optimised for energy yield.

Comparison between Layouts D and F indicated clearly that the main difference between the wireframes for the two layouts at nearly all viewpoint locations, resulted from the more compact nature of Layout D. Although there were some variations in the composition of the turbines across the array, the determining factor in preference between the layouts was, in almost all instances, the reduced horizontal extent of turbines.

Layouts D and F were based on a clearly discernible pattern created by a series of off-set rows of turbines. It was considered that the resulting order in Layouts D and F translate at most of the viewpoints into a more balanced and harmonious composition of turbines in the seascape or when read against the land mass on the opposite side of the Solway Firth. At several key viewpoint locations this pattern relates better to the backdrop of land, or land and water. It should be noted that this will vary with different weather conditions, but in terms of assessing the layouts, this was taken as a constant.

From nearly all elevated locations, Layouts D and F create a legible pattern, with the off set rows of turbines becoming apparent against the sea surface. It was considered that the order of this pattern created by a man-made construction in the sea is more satisfactory than the apparently haphazard and randomised layout options.

On the basis of the review of the various layout options for the Robin Rigg wind farm, and consideration of the potential effects arising from the six layouts at the chosen viewpoints in the study area, it was recommended that Layout D would generate the least potentially adverse landscape, seascape and visual effects. This layout was chosen as the final layout design for the proposed development.

Navigation Markings

To warn commercial shipping, fishing vessels and recreational yachtsmen of the existence of the wind farm during its operational period, a system of yellow special marker buoys is proposed for the development along with a foghorn. The four buoys would be positioned at four points on the outside of the wind farm as shown in Figure 8.2.2 in Section 8 of this ES and also at a larger scale in Figure 1.2 at the beginning of the ES. They would be painted yellow and fitted with flashing yellow lights visible over three nautical miles. The markings as described would allow vessels to pass along the channels to the north and south of the wind farm area avoiding the development**.**

In addition to the above navigational markings and lights requested by Northern Lighthouse, the developer has agreed at the request of local yacht clubs to include a yellow band around the base of the outermost turbine towers on all sides of the development. The band would be a metre deep and would be positioned above the astronomical high water mark.

Navigational markings are considered to have no effect on the landscape and visual amenity of the area due to the distance from which they will be viewed. The navigation lights are only visible from within 3 nautical miles therefore will not be seen from the coast within the study area during daylight hours.

Offshore Anemometer Mast

There will be one anemometer mast 80m high, consisting of a lattice tower. The mast will be retained throughout the operating life of the wind farm to monitor meteorological parameters such as wind speed and direction, as required for efficient operation of the wind farm.

Offshore Substation

The electricity produced by the turbines will be transmitted via underground cables to an offshore substation. The substation for the proposed development will be located at grid reference 292110E 541880N. This structure will be 20 metres wide by 20 metres breadth supported by a number of monopile foundation so that the base of the substation is 10-12 metres above mean sea level. The substation will incorporate a helipad situated 9 metres above the base level. This structure is likely to be a grey colour with a semi-matt finish, similar to that of the wind turbines.

Onshore Switchyard

This is likely to be a fenced area with dimensions up to 60 m by 60 m with a small building for metering equipment.

Site Access and Maintenance

Site access for maintenance will be by boat or helicopter.

Potential Effects of Operational Phase

It is not anticipated that the offshore substation, switchgear and maintenance visits will have any significant residual effects on the landscape and visual amenity of the area. Therefore, these elements have not been considered in any detail in this assessment. Accordingly, the assessment that follows has been based on the potential residual landscape, seascape and visual effects of the wind turbines. The substation will be visible from most slightly elevated location is from where the proposed development will be visible, and is shown on the wireframes and photomontages.

9.10.3.3 Decommissioning

The decommissioning of the proposed offshore wind farm at the end of the operational phase will involve the removal of towers and part or all of each pile. It is not envisaged that the activities associated with the decommissioning phase will be greater than for the construction phase and therefore not significant effects on the landscape, seascape and visual amenity of the study area are anticipated.

9.10.4 ASSESSMENT OF RESIDUAL EFFECTS

9.10.4.1 Introduction

This section comprises the assessment of the landscape, seascape and visual effects arising from the proposed wind farm during the operational period having taken account of the inbuilt mitigation measures discussed above.

The potential landscape, seascape and visual effects arising during the operational phase of the proposed wind farm have been assessed in the following ways:

- Analysis of the ZVI to provide a general overview of the visibility of the wind farm from different distances within the study area; and

- Consideration of the potential landscape, seascape and visual effects at 33 viewpoints proposed during consultation and detailed assessment of 16 key viewpoints.

9.10.4.2 ZVI Analysis

Introduction

The potential extent of visibility of the proposed off shore wind farm at Robin Rigg in the Solway Firth is illustrated by the Robin Rigg ZVIs and cumulative ZVI in Figures 9.10.1 to 9.10.4. The ZVIs assume a bare land surface taking no account of the screening effect of trees, hedgerows or buildings. They also assume clear viewing conditions. The ZVIs are based on blade tip visibility when positioned at the highest point and take earth curvature and atmospheric refraction into account in calculations of visibility. ZVIs for the Robin Rigg wind farm have been taken out to a distance of 35 km, and 25 km for the onshore existing and proposed wind farms to reflect the smaller size of turbines. These distances are considered to represent the outer limits of potential effects of the proposed offshore wind farm at Robin Rigg and existing onshore wind farms, and have been developed during consultation with Scottish Natural Heritage. Figures 9.10.1 to 9.10.3 are based on blade tip visibility, which means that they indicate all parts of the study area from where some part of one or more turbines may be visible (although visibility has been removed from the sea in the blow up ZVIs). Visibility has been separated into bands of numbers of turbines as follows:

- 1 - 15 turbines;
- 16 - 30 turbines;
- 31 - 45 turbines; and
- 46 - 60 turbines.

The potential extent of cumulative visibility of the proposed offshore wind farm and existing wind farms within the study area is illustrated in Figure 9.10.4. There are four existing wind farm developments within the study area as follows:

- Oldside: 9 turbines, tip height 61m;
- Siddick: 7 turbines, tip height 61m;
- Lowca: 7 turbines, tip height 63.5m; and
- Winscales: 3 turbines, tip height 66.5m.

All these wind farms lie within Cumbria and are close to the coast and their locations are shown in Figure 9.10.4 Visibility of all these wind farms has been shown as a single wind farm for clarity within the cumulative ZVI and given the notation of the Oldside Group.

In addition to the existing wind farms, there is a live planning application for a wind farm at Wharrels Hill, also in Cumbria for 8 turbines with a maximum blade tip height of 81m. Visibility of this proposal over a 25km radius, should it be constructed, is also shown in the cumulative ZVI.

Visibility has been grouped into cumulative visibility bands as follows:

- Robin Rigg only;
- Oldside Group only;
- Wharrels Hill only;
- Robin Rigg and Oldside Group;
- Wharrels Hill and Robin Rigg; and
- Oldside Group and Wharrels Hill;
- Robin Rigg, Oldside Group and Wharrels Hill.

Both the Robin Rigg ZVI and the cumulative ZVI are based on Ordnance Survey (OS) digital data at 50m interval resolution, and therefore do not take account of local landforms, buildings or vegetation. Where the ZVI indicates that there is no visibility of wind turbines, this may be considered accurate (within the normal tolerances of the OS data).

Robin Rigg ZVI

VISIBILITY FROM THE SEA: DUMFRIES AND GALLOWAY

The ZVI indicates that all of the turbines will be visible across nearly all of the sea area of the Solway Firth.

The proposed wind farm will not be visible from the western edge of the Nith Estuary seascape unit, and there will be visibility of between 1 - 15 turbines, on the north east side of the Estuary.

From Meikle Ross westwards to Fleet Bay in the Fleet Bay seascape unit, the wind farm will not be visible from an area up to approximately 3.5 km from the coast.

In the East Stewarty Coast seascape unit, visibility of the turbines varies due to the screening effects of Balcary Point, Hestan Island and Castlehilll Point. Thus on the south western side of Auchencairn Bay, the ZVI indicates that between 1 and 15 turbines would be visible from a narrow strip along the shore, with successively increasing visibility in a north eastwards direction across the Bay. In the lee of Hestan Island the wind farm will not be visible, with increasing visibility in a north westerly direction, and up to 31 - 45 turbines visible at the head of Orchardton Bay. In the immediate lee of Rough Island, visibility increases rapidly from 1 to 15 turbines to all 60 turbines.

VISIBILITY FROM THE LAND: DUMFRIES AND GALLOWAY

The most striking aspect of the ZVI, is the way in which visibility of the proposed turbines drops off rapidly onshore within a relatively short distance inland. This is particularly noticeable for areas adjacent to cliff coastline.

There will be almost no visibility of the proposed wind farm from the landward area to the west and north of Wall Hill and Netherlaw. There may be isolated, small areas on summit areas within Laurieston from where between 1 and 15 turbines may be visible. From isolated summits in Glengap Forest there may be visibility of between 1 and 60 turbines.

There may be visibility of up to 60 turbines from the area between Dundrennan and Abbey Head, as well as from an area extending approximately 7 km inland around Auchencairn Bay, including the summit of Screel Hill.

From Screel Hill northwards towards Dalbeattie, the ZVI indicates scattered areas from where up to 60 turbines may be visible. On the high ground around Kirkpatrick Durham and Springholm, the ZVI indicates that there maybe visibility of up to 60 turbines from isolated and fragmented areas.

In the area around Rockcliffe, there may be visibility of up to 60 turbines from an area to the south and west of the A711 and parts of Dalbeattie Forest to the north east of the A711. On high ground around Auchenhay Hill the ZVI indicates an area of visibility of up to 60 turbines.

Further east, there is a more extensive area from where the wind farm may be visible extending south-southeastwards from Long Fell and Criffel towards the coast and, extending along the coast from Douglas Hall in the west to Borron Point in the east.

Visibility of the wind farm from the Caerlaverock peninsula varies from between 1 and 15 turbines visible along the south west coast to all turbines being visible from the higher parts of the southern end of the peninsula.

Along the Mersehead sands, the ZVI indicates that all of the turbines may be visible from most of the coast line and extending inland for approximately 3 km.

Receptors: Dumfries and Galloway

SETTLEMENTS

The largest settlement in the Dumfries and Galloway section of the study area is Dumfries, which is located partially within the study area to the north. The ZVI indicates that there will be no visibility of the proposed development from Dumfries. Other main settlements include Gatehouse of Fleet, Kirkcudbright, Castle Douglas and Dalbeattie. The ZVI indicates that there will be no visibility of the proposed development from any of these settlements. There are numerous smaller settlements located within the Dumfries and Galloway section of the study area. The following table shows the main settlements and the number of turbines visible according to the ZVI.

Table 9.10.2: Visibility of proposed wind farm from settlements within Dumfries and Galloway

Settlement	Number of turbines visible	Settlement	Number of turbines visible
Dumfries	0	Kirkpatrick Durham	1-45
Gatehouse of Fleet	0	Rockcliffe	46-60
Kirkcudbright	0	Southerness	46-60
Castle Douglas	0	Hazelfield	46-60
Dalbeattie	0	Barlocco	46-60
Auchencairn	0	Clarencefield	46-60
Palnackie	0	Ruthwell	46-60
Dundrennan	0	Port of Warren	46-60
Kippford	0	Portling	46-60
New Abbey	0	Mainsriddle	46-60

The ZVI and above table show that the main settlements which will experience visibility of the proposed offshore wind farm are those near the coastal edge to the north of the proposed development, such as Rockcliffe, Southerness, Hazelfield and Portling. However, the larger settlements in the Dumfries and Galloway section of the study area, such as Dumfries, Castle Douglas and Dalbeattie have no visibility of the proposed development. Visibility of the proposed wind farm from residential settlements is therefore limited to relatively few, small settlements and hamlets along the coastal edge.

MAIN ROADS

The main roads within the Dumfries and Galloway section of the study area are the A75, A711, A710 and A713. These roads connect the major settlements in the study area and link to the strategic road network (A74M) to the east. Visibility on these roads provides a sequential experience of the proposed wind farm gained from driving around the study area. Viewpoints have been chosen at A710, Mainsriddle (VP14) and A711, Auchencarin Topograph (VP1) to represent views from these main roads and the sequential experience of travelling along the main coastal route through Dumfries and Galloway. The following table shows the main roads and the number of turbines visible according to the ZVI.

Table 9.10.3 Visibility of proposed wind farm from main roads within Dumfries and Galloway

Main road	Number of turbines visible
A75	Small section of distant visibility (over 35km) near Kelhead Moss, but predominantly no visibility.
A711	Intermittent visibility of 0-60 turbines from the west of Dundrennan to Palnackie No visibility from the west of Dundrennan and between Dalbeattie and Dumfries
A710	No visibility from Dalbeattie to Sandyhills and from Kirkbean to Dumfries 46-60 turbines visible between Sandyhills to Kirkbean
A713	No visibility

Generally, there is limited visibility of the proposed development from the major roads within the study area. The coastal routes along the A710 and A711 offer intermittent visibility of the proposed wind farm, but at a distance of over 11km, while the A75 and A713, located further inland, offer no visibility of the proposed development. Views from the A710 and A711 tend to be further reduced by intervening vegetation and buildings along the roadside. Furthermore, the direction of travel is usually east or west along the coast therefore the direction of views would be oblique to the proposed development and at speed.

MINOR ROADS

There a many minor roads within the Dumfries and Galloway section of the study area, often linking the major roads , connecting small settlements or extending to the coastal edge. The main 'B' roads include the B727, B736, B793 and B725. The following table shows the minor roads and the number of turbines visible according to the ZVI.

Table 9.10.4 Visibility of proposed wind farm from minor roads within Dumfries and Galloway

Minor road	Number of turbines visible
B727	No visibility
B736	No visibility
B793	Mainly no visibility, apart from area of 4-60 turbines around Auchenhay Hill
B725	No visibility between Dumfries and Glencaple 46-60 turbines visible between Locharwoods and Cummertrees

RAILWAYS

The ZVI indicates that from the Annan to Dumfries railway line 46-60 turbines of the proposed development may be visible over a 6km section to the north east of the study area. Potential visibility indicated on the ZVI will be at a distance of approximately 34.5km from the proposed development, at a speed and potentially screened by railside vegetation.

PUBLIC FOOTPATHS

There are several walks from Balcary around to Mersehead which are likely to have a range of views of the proposed wind farm, from 46-60 turbines along the coastal edge to more intermittent visibility in the hinterland of the East Stewartry Coast seascape unit. According to the ZVI, footpaths up the coastal granite uplands, such as Screel Hill and Criffel, offer views of 46-60 turbines, however these will often be restricted by the screening effect of intervening woodland vegetation along forest walks. Viewpoint 5 at Screel Hill, Viewpoint 9 at Mote of Mark and Viewpoint 16 at the summit of Criffel, are all representative of views from public footpaths in Dumfries and Galloway.

Visibility from Cumbria

Visibility of the proposed wind turbines from the Moricambe Bay seascape unit varies, with a narrow strip of no visibility gradually increasing in an easterly direction.

To the east and south of Silloth towards Maryport the ZVI indicates that there is an area of between approximately 5 and 7 km along the coast from where up to 60 turbines may be visible. The inland edge of this band of visibility is defined by the higher ground which borders the coast. It extends inland to Aspatria and then runs along the A596 to Maryport. There are isolated areas inland from where the ZVI shows that the wind farm may be visible including an area to the east of Aspatria, areas around and to the south of Gilcrux, and an area to the north of Bothel. The ZVI indicates that up to 60 turbines maybe visible from the coastal edge to the north of Maryport, and from an area of approximately 5 km width inland from Maryport including Broughton Moor, running south westwards through Flimby and Seaton to Workington. There may be visibility of up to 60 turbines in an area running between Workington and just to the north of Lowca, and a narrow band of less than 3 km width running south westwards from just to the north of Whitehaven towards St Bees Head. Inland the ZVI indicates that there may be fragmented visibility from the area around Cockermouth, and to the south along the east flank of Lorton Vale, as well as from scattered areas to either side of the A5086 including the settlements of Mockerin and Gilgarran.

Receptors: Cumbria

SETTLEMENTS

The largest settlements with the Cumbrian section of the study area are Maryport, Cockermouth, Workington and Whitehaven. The ZVI indicates that there will be intermittent visibility of between 0-60 turbines in Maryport, Workington and Whitehaven, however fieldwork has confirmed that this will be considerably less on the ground due to the screening effects of intervening urban structures. The ZVI indicates that there will be no visibility of the proposed wind farm in Cockermouth. There are numerous smaller settlements located within the Cumbrian section of the study area. The following table shows the main settlements and the number of turbines visible according to the ZVI.

Table 9.10.5 Visibility of proposed wind farm from settlements within Cumbria

Settlement	Visibility
Distington	0
Cleaton Moor	0
Egremont	0
Cockermouth	0
Great Broughton	0
Bothel	0
Abbey Town	1-30
Aspatria	Mainly no visibility Western side of town has visibility of 46-60
Whitehaven	46-60 along coastal front, B5439 and railway. No visibility to south of Bransty, north of Woodhouse and around Hensingham.
Workington	46-60 for most of urban area actual visibility very limited.
Maryport	46-60 along sea front and around Netherton and Ellenborough, dropping off to no visibility in valley of River Ellen.
Cardurnock	46-60
Skinburness	46-60
Silloth	46-60
Beckfoot	46-60
Mawbray	46-60
Flimby	46-60
Seaton	46-60
Broughton Moor	46-60
Gilgarron	46-60
Parton	46-60
Allonby	46-60

The ZVI and the above table therefore show that many of the settlements near the coastal edge in Cumbria may have visibility of the proposed development, however many of the larger settlements tend to have limited views of the development from within the urban area due to intervening buildings. Views of the proposed development are therefore likely to be confined to the edge of the settlements, or elevated loctions, which have open views over the SolwayFirth. There are several settlements that have no visibility of the proposed development, such as Cleaton Moor, Egremont and Cockermouth.

MAIN ROADS

The main roads within the Cumbrian section of the study area are the A66, A596, A595 and B5300. These roads connect the major settlements in the study area and link to the strategic road network (M6) to the east. Visibility on these roads provides a sequential experience of the proposed wind farm gained from driving around the study area. Viewpoints have been chosen at A595, Wharrels Hill, Bothel (VP24) , the A596, Aspatria (VP23), and Allonby Sea Front (VP22) to represent views from these main roads and the sequential experience of travelling along the main routes through Cumbria. The following table shows the main roads and the number of turbines visible according to the ZVI.

Table 9.10.6 Visibility of proposed wind farm from major roads in Cumbria

Major road	Number of turbines visible
A66	No visibility from the much of this route Area of 1-15 turbines visible around Great Clifton Area of 46-60 turbines visible around Stainburn
A596	46-60 turbines visible for much of this route between Crosby and Aspatria More intermittent visibility to the east of Aspatria
A595	46-60 turbines between Quarry Hill and Distington No visibility between Distington and Parton Intermittent visibility of 0-60 turbines through Whitehaven Mainly no visibility between Whitehaven and Egremont except for small area of 1-15 turbines visible at Bonnyrigg
B5300	46-60 turbines visible along most of this route between Maryport and Silloth at distances over 12.5km

The ZVI and above table show that the B5300 will experience greatest visibility for the proposed wind farm due to its route along the coastal edge between Maryport and Silloth, at distances of between 12.5 km and 22km from the proposed development. The A595 and A596 offer intermittent visibility of the proposed wind farm, from inland areas and at greater distance. There is no visibility for much of the A66 which links West Cumbria with the M6.

RAILWAYS

According to the ZVI the Cumbria Coastal Railway which links Whitehaven, Workington and Maryport to Barrow in Furness and Carlisle has 46-60 turbines visible during its journey between Whitehaven and Maryport. To the east of Maryport the line travels inland towards Carlisle and has no visibility of the proposed development for the majority of this section.

NATIONAL TRAILS

The Cumbria Coastal Way, a national trail, runs through the study area along the coast between St. Bees Head and Moricambe Bay at distances of between approximately 12km and 24km from the proposal. The ZVI indicates that 46-60 turbines of the proposed development will be visible along the majority of the length of the Cumbria Coastal Way in the study area.

The coast to coast walk and sea to sea cycle route start at St. Bees Head and cross the LDNP on their journey to Robin Hood Bay on the east coast. There will be 46-60 turbines visible from St. Bees to Maryport, between Dearham and Bridekirk and over Watch Hill, Cockermouth. There is no visibility of the proposed wind farm on the coast to coast walk to the east of Watch Hill through the LDNP.

Cumulative ZVI

VISIBILITY FROM THE SEA

It is not likely that the Oldside Group of turbines will be visible with the proposed off shore wind farm at Robin Rigg at distances of more than 25 km, except in very clear weather conditions. In such circumstances, the turbine of the Oldside Group would be discernible but would occupy a small portion of the overall field of view.

To the east of Abbey Head it would be possible to see the proposed off shore wind farm at Robin Rigg together with the Oldside Group and moving eastwards, the proposed wind farm at Wharrels Hill would become visible. Visibility of the Robin Rigg wind turbines together with either the Oldside Group or the proposed wind farm at Wharrels Hill, or both, will be dependent on clear weather conditions, as the distance between the proposed Robin Rigg turbines and the nearest turbine at the Oldside Group will be 12km, and the distance to the nearest turbine of the proposed Wharrels Hill turbines would be 24km.

VISIBILITY FROM THE LAND: DUMFRIES AND GALLOWAY

The most striking aspect of the ZVI, is the way in which visibility of the proposed wind farm at Robin Rigg alone drops off rapidly onshore within a relatively short distance inland. Given the distance between the Dumfries and Galloway coast and the nearest turbines in the Oldside Group (21.5km) and the nearest proposed turbine at Wharrels Hill (23.5km) it is not likely that there will be any cumulative effect on the Dumfires and Galloway Coast.

There are no existing wind farm developments in the Dumfries and Galloway section of the study area, therefore any potential cumulative visibility will be in long distance views across the Solway Firth to existing wind farms in Cumbria. Visibility of these existing wind farms is likely to be very limited due to the distance and prevailing weather conditions in the Solway Firth. The ZVI indicates that there may be cumulative visibility of the proposed wind farm and the Oldside Group from coastal locations such as around the viewpoints at Balcary Point, Castlehill Point, the Torrs and in the low lying area to the north of Southerness Point. From these areas the proposed wind farm will be at distances over 8.9km, and the Oldside Group at distances over 21.9km.

VISIBILITY FROM THE LAND: CUMBRIA

According to the cumulative ZVI visibility of the proposed developments at Robin Rigg and Wharrels Hill and the existing wind farm developments of the Oldside Group varies over the Cumbrian part of the study area.

There are bands of visibility shown where only the proposed wind farm at Robin Rigg may be visible. These are located to the west of Pelutho and Abbey town, and to the west of Aspatria extending south west to Maryport and Allonby Bay, and in a small area around Gilcrux.

There are many areas in which the proposed offshore wind farm and the Oldside Group may be seen simultaneously. This includes the coastal edge and hinterland up to 5km inland between St. Bees Head and Maryport, an area around Tallentine and from parts of the Lakeland high fells.

There are areas, mainly to the north of the Cumbrian section of the study area, in which the proposed offshore wind farm and the proposed Wharrels Hill wind farm may be seen simultaneously. These include the area to the east of Silloth, around Moricambe Bay and Wedholme Flow, and areas centred around Allonby, Aspatria and Plumbland.

There are small areas, mainly to the south of the Cumbrian section of the study area, in which the proposed offshore wind farm and both the Oldside Group and proposed Wharrels Hill wind farms may be seen simultaneously. These include areas around Pica, Gilgarron, to the east of Eaglesfield and Ullock, and from parts of the Lakeland high fells. There are also areas indicated next to the B595, the B596 near Aspatria, and a band near the coast between Silloth and Dubmill Point, from where the proposed Robin Rigg wind farm, the Oldside Group and Wharrels Hill wind farm may be visible.

Overall the Cumbrian section of the study area is more exposed to potential cumulative effects than the Dumfries and Galloway coast. The ZVI shows that theoretical views of existing or proposed wind farm developments cover most of the Cumbrian section of the study area. This is due to the presence of existing wind turbine developments in the Oldside Group and the proposed wind farm at Wharrels Hill. The pattern of cumulative visibility is complex and there are likely to be changing views of only the existing wind farms, only the proposed offshore wind farm and simultaneous views of existing and proposed wind farms when moving through the landscape. Generally, the majority of views to the south of the Cumbrian section of the study area will be of the proposed development and the Oldside Group, of the proposed development, Oldside and Wharrels Hill or of only the Oldside Group. The majority of views to the north of the Cumbrian section of the study area are of only Robin Rigg, Robin Rigg and Wharrels Hill or only Wharrels Hill.

Receptors

SETTLEMENTS

The proposed off shore wind farm at Robin Rigg may be seen together with the turbines of the Oldside Group from parts of Workington with clear visibility to the sea and to the north of the town. However field survey work has confirmed that there are very few parts of Workington where this would occur. From the few areas which do have such open views to the west and north of the town, the existing turbines and proposed turbines of the offshore site would be seen in the same general north westerly direction, with the turbines at Oldside being at distances of less than 1 km, and those of Robin Rigg being at distances over 12.8 km.

From parts of Maryport which have views westwards across the Solway Firth, and south south westwards along the Cumbrian coast, there may be visibility of both the Robin Rigg turbines and the Oldside Group which would occur in two separate quadrant sectors. The cumulative ZVI shown on Figure 9.10.4, also shows that at the northern edge of Maryport it may be possible to see the proposed wind turbines at Wharrels Hill, at a distance of over 11.5 km.

Parts of Whitehaven with views north north westwards across the Solway Firth, and along the coast to Workington, may have visibility of the Robin Rigg turbines at distances of over 22km, together with the Oldside Group.

From Allonby and most of Silloth, the cumulative ZVI indicates that the proposed turbines of the Robin Rigg wind farm and Wharrels Hill may be seen at distances of over 15 km and 10.3 km respectively. The offshore turbines would be seen in a west south west direction and the proposed turbines at Wharrels Hill in a south east direction.

In all of these settlements, actual cumulative visibility is likely to be very much less than that shown on the cumulative ZVI due to intervening buildings, and is therefore likely to be restricted to the settlement edges and elevated locations with unrestricted visibility.

MAIN AND MINOR ROADS

The cumulative ZVI indicates that there may be a complex mosaic of cumulative visibility of the Robin Rigg offshore turbines together with either the Oldside Group, the proposed Wharrels Hill turbines, or both, from the main road system in the Cumbrian part of the study area. Again, actual visibility on the ground is likely to be very much less extensive than that shown on the ZVI, due to local topography and vegetation. This has been verified during field survey work, which demonstrated that visibility of the existing turbines of the Oldside Group is less extensive than that shown on the cumulative ZVI.
Sequential views from main roads

The main road network in Cumbria provides a sequential experience of cumulative visibility of the existing wind farms in the Oldside Group, the proposed development at Wharrels Hill and the proposed offshore wind farm at Robin Rigg. From the A66, there are views of only Wharrels Hill near Bassenthwaite Lake and to the south west of Cockermouth. Between Brigham and Workington there are changing cumulative views of Oldside and Wharrels Hill, and only Wharrels Hill. Generally, there is little visibility of the proposed offshore wind farm. From the A596, between Maryport and Aspatria there are changing cumulative views of the existing turbines and proposed developments at Wharrels Hill and Robin Rigg. Between Aspatria and Wigton, only Wharrels Hill and Robin Rigg will be visible. On the A595, there are views of Robin Rigg and the Oldside Group near Whitehaven and Parton, but most of this road has views of just the Oldside Group between Parton and Winscales, with only a small section of visibility of all the existing and proposed wind farm developments. From the B5300, there will be views of just Robin Rigg between Maryport and Allonby. Between Allonby and Silloth, there will be cumulative views of Robin Rigg, Oldside and Wharrels Hill. Views towards Robin Rigg will be oblique to the direction of travel on the A596, A595 and B5300 and at speed therefore the duration of effect is short. Furthermore, actual visibility on the ground will be constrained by intervening roadside vegetation and buildings.

NATIONAL TRAILS

Between St. Bees Head and Maryport, Robin Rigg and the Oldside Group will be visible from the Cumbria Coastal Way and Coast to Coast Walk at varying distances, with Robin Rigg always over at least 11km offshore. Near Workington Steel Works along the raised area of the Howe, Wharrels Hill may also be visible at a distance of 19.5km. Between Maryport and Allonby on the Cumbria Coastal Way, just the proposed wind farm at Robin Rigg will be visible at a distance of approximately 12km to 15km. Between Maryport and Silloth the majority of the Coastal Way may have visibility of the proposed Robin Rigg wind farm and the Oldside Group. Around Moricambe Bay, the Coastal Way may have visibility of the proposed Robin Rigg wind farm and Wharrels Hill.

To the east of Maryport on the coast to coast walk, there is no visibility along the River Ellen, which opens out to an area where both Robin Rigg and the Oldside Group will be visible around Tallentine. To the east of Cockermouth on Watch Hill, Robin Rigg, Oldside and Wharrels Hill may be visible at long distances and between Watch Hill and Bassenthwaite Lake in the LDNP, only Wharrels Hill will be visible.

9.10.4.3 Viewpoint Analysis

A total of 33 viewpoints assembled during the consultation process were considered for the viewpoint analysis. All of the viewpoints were visited and considered in relation to the proposed development and the list reviewed to select 16 key viewpoints for detailed analysis. These viewpoint locations are considered to provide a representative sample of views from publicly accessible locations, from different distances, directions and heights, as well as from the various landscape character types identified in the study area from which the proposed wind farm would be visible

The predicted views from each of the 33 viewpoint locations are shown in the wireframes and photomontages in Visualisations 1 to 33. Detailed analysis of the 16 key viewpoints given in the boxes below includes a description of the existing and predicted view, and analysis on the magnitude of change, effects on landscape/seascape quality and effects on visual amenity. The cumulative magnitude of change, cumulative effects on landscape quality and visual amenity have also been assessed for the proposed development and existing wind farm developments in the study area.

Viewpoint 1: A711, Auchencairn Topograph

The viewpoint is located at Auchencairn Topograph, 89m AOD, at grid reference E278047 N549818, a marked viewpoint with interpretation in a layby on the A711 near Hazelfield. It has been chosen to provide representative views from the A711, one of the main trunk roads through the Dumfries and Galloway part of the study area, to the north west of the application site.

Existing view The existing view is long distance and panoramic. The view looking south east towards the application site consists mainly of gently undulating coastal pastureland in the foreground with a small section of seascape visible beyond Rascarrel Bay. The pastureland has regular, medium sized fields and stone wall boundaries. Scattered or linear belts of trees are present, and the coniferous woodland plantations at Auchencairn and Rascarrel Moss are particularly distinctive. The view has few built elements except for scattered farm buildings and the A711 corridor. There are views to the sea to the south west of Rascarrel Bay from this viewpoint, however the section of visible seascape occupies a small portion of the wider view. The wider view tends to be dominated by the coastal uplands to the north west with the distinct profile of Criffel and the headlands in the East Stewartry NSA providing the most striking aspect of the view rather than the coast.

Predicted view The wireframe indicates that 60 turbines will be visible on the horizon. Towers and rotor blades of all the turbines will be visible against a background of the landscape on the Cumbrian coast, however this will only occur in optimum visibility conditions. The wind farm layout consists of two turbines at the eastern end of the array, an opening followed by a row of turbines, a further opening and then a more concentrated grouping of turbines extending through the centre to the west end of the array. The composition of the turbines is compact and it has a balanced relationship with the landform on the north side of the Solway Firth that encloses the array in a small 'window' of sea. It also has an appropriate relationship to the land mass on the south side of the Solway Firth.

Magnitude of change The towers and rotors of 60 turbines will be visible from this location, with the closest visible turbine at a distance of 12.8km. The array of turbines covers a horizontal angle of 17.0°. The layout of the wind farm appears appropriate and balanced from this viewpoint in an enclosed window of sea. The horizontal angle occupied by the sea and the turbines in the view is relatively small, and the wider view tends to be dominated by the East Stewartry NSA and Criffel which provide the most striking aspect of available views rather than the coast. The associated magnitude of change is considered to be **moderate**.

Cumulative magnitude of change From this location the turbines at Siddick, Oldside, Lowca and Wharrels Hill are over 28km from the viewpoint on the opposite side of the Solway Firth. It is unlikely that they will be visible at all due to the effects of distance, therefore the magnitude of cumulative change is considered to be **negligible**.

Effects on landscape/seascape character and quality The viewpoint is located in the Dundrennan Peninsula seascape unit, which is of medium quality and has a medium sensitivity to change outwith its area. The key characteristics of the Dundrennan seascape unit are its coastline of rocky shores, sea cliffs and small sandy bays, and its hinterland of gently undulating pastureland. It is a relatively inaccessible stretch of coast, with only scattered properties and includes large areas of MOD owned land. The effect of the proposed offshore wind farm on landscape character and quality is considered to be **moderate / minor**.

Cumulative effects on landscape/seascape character and quality The existing wind turbines at Siddick, Oldside, Lowca and Wharrels Hill are over 28km from the Dundrennan Peninsula seascape unit, on the opposite side of the Solway Firth. It is unlikely that they will be visible or experienced at all in the Dundrennan seascape unit due to the effects of distance, therefore the cumulative effect on landscape character and quality is considered to be **minor / none**.

Effects on visual amenity The viewpoint is representative of views from road users on the A711 to the north west of the application site. The view from Auchencairn Topograph is located in a layby off the A711, where road users can pull in from the main road. Road users using this viewpoint are considered to be of **high** sensitivity. Although road users may use this location specifically to stop and view the surrounding landscape, views tend to be attracted to the East Stewartry NSA and Criffel rather than the small section of coast in which the proposed wind farm will be visible. The effect on visual amenity of the proposed wind farm on road users at the A711, Auchencairn Topograph will be **moderate**.

Cumulative effects on visual amenity The cumulative effect on visual amenity is considered to be **minor / none** for road users at the A711, Auchencairn Topograph. The proposed wind farm will not be seen simultaneously with other wind farm developments from this location.

Viewpoint 2: Rascarrel Bay

The viewpoint is located on the beach at Rascarrel Bay at grid reference E280152 N548060. It is reached via a minor road off the A711. The Rascarrel Bay viewpoint has not been chosen for detailed assessment as representative views from this area are provided by viewpoint 1, Auchencairn Topograph, to the north west and viewpoint 2, Balcary Point, to the east. The wireframe in Visualisation 2 show the predicted view from Rascarrel Bay.

Viewpoint 3: Balcary Point

The viewpoint is located on Balcary Point, 15m AOD, on the footpath along the coast at grid reference E 282821 N549188. It is reached from the car park at Balcary Bay along a circular footpath route round the headland. It is representative of views from the closest land to the proposed offshore wind farm and from the coast of the East Stewartry NSA.

Existing view The existing view to the application site is long distance and panoramic. The view looking south east towards the proposed development is dominated by open sea. The Cumbrian coast is visible in clear weather. The foreground consists of rough grassland and coastal rock outcrops. The photomontage shown in Visualisation 3 is part of a wider panoramic view from the coastal granite uplands to the north round to Big Airds Hill to the south west. Bengairn, Screel Hill and Criffel form distinctive profiles and the peninsulas and islands in the East Stewartry NSA are attractive features of the wider view. The panoramic sweep of view is long distance, consisting of diverse elements yet harmonious. It is remote, exposed and invigorating.

Predicted view The wireframe indicates that 60 turbines will be visible on the horizon. Towers and rotor blades of all the turbines will be visible against a background of the landscape on the Cumbrian coast, however this will only occur in optimum visibility conditions. The wind farm layout consists of regularly spaced turbines in an offset grid formation. The composition of the turbines is compact and the wind farm is seen mainly below the horizon of landscape on the opposite site of the Solway Firth, except for the turbines towards the south of the array which have blade tips just above the height of the landform backdrop.

Magnitude of change The towers and rotors of 60 turbines will be visible from this location, with the closest visible turbine at a distance of 8.8km. Balcary Point is the closest onshore viewpoint to the proposed wind farm and the array of turbines covers a horizontal angle of 22.7^{o}. Its horizontal extent has been minimised during the layout optimisation process. The view from this location is straight out to sea, however there is a wider view south west which includes the East Stewartry NSA and Criffel along the coast. The associated magnitude of change is considered to be **moderate**.

Cumulative magnitude of change From this location the turbines at Siddick, Oldside, and Lowca Wind Farms are likely to be visible, however at distances over 24.6km, on the opposite side of the Solway Firth. 9 turbines at Siddick will be visible, with the nearest at 24.6km, 9 turbines at Oldside will be visible, with the nearest distance at 24.8km and 8 turbines at Lowca will be visible, with the nearest at 30km form the viewpoint. The magnitude of cumulative change is considered to be **negligible** at such distances and the turbines will only be visible in clear weather conditions.

Effects on landscape/seascape character and quality The viewpoint is located within the East Stewartry Coast seascape unit, which is of exceptional quality and high sensitivity to change. The key characteristics of this landscape type are its incised bays and estuary, prominent headlands, peninsulas, islands and mudflats. The irregular, indented coastline and varied landcover from a landscape of great diversity and it is also a working, inhabited and much visited area. The landscape and seascape of the area will be experienced in relation to the proposed development from areas where views of the sea are available, which tend to be either suddenly revealed at the coast, raised areas of the surrounding hinterland or channelled along the orientation of the bay. The proposed offshore wind farm will introduce a new focal man-made element to the seascape unit. The effect of the proposed offshore wind farm on landscape character and quality is considered to be **major/moderate.**

Cumulative effects on landscape/seascape character and quality The nearest existing wind turbines are those at Siddick, over 24.6km from the viewpoint, on the opposite side of the Solway Firth. It is unlikely that they will be experienced in relation to this seascape unit due to the effects of distance, therefore the cumulative effects on landscape character and quality are considered to be **minor**.

Effects on visual amenity The viewpoint is representative of views for walkers on the footpath around Balcary Point to the north west of the application site. Walkers are the main receptors who will experience the wind farm from this location. The sensitivity of the viewpoint is therefore considered to be **high,** as walkers are likely to place a high value on the landscape and visit it specifically for its panoramic long distance views and dramatic coastal characteristics. Although there are features of interest in the wider view, the openness of views across the Solway Firth are the most striking aspect. The introduction of a group of turbines to the seascape is considered to be a **major / moderate** effect on the visual amenity at Balcary Point.

Cumulative effects on visual amenity The cumulative effect on visual amenity is considered to be **minor** for walkers at Balcary Point. The proposed wind farm will only be seen simultaneously with other wind farm developments at distances over 24.6km from this location.

Viewpoint 4: A711, Torr House

The viewpoint is located at Torr House on the A711, 20m AOD at grid reference E280120 N552760. The A711, Torr House viewpoint is representative of views from the elevated positions along the A711 in the East Stewartry Coast NSA. The wireframe in Visualisation 4 shows the predicted view from the A711, Torr House viewpoint.

Viewpoint 5: Screel Hill Forest Walk

The viewpoint is located at the summit of Screel Hill, 345m AOD at grid reference E278560 N555158. It is accessed via a 2km forest walk footpath from a car park off a minor road off the A711. The viewpoint is representative of views from the summit areas of the coastal granite uplands in the East Stewartry Coast NSA.

Existing view The existing view to the application site is long distance and panoramic. The view looking south east towards the proposed development consists of coastal granite uplands, coastal peninsulas, bays and open sea. The Cumbrian coast is visible in clear weather. Landcover is predominantly pastureland in lowland coastal areas with extensive coniferous woodland plantation, rough grazing and granite outcrops, mainly on the higher slopes. Built elements are subtle, but include settlements at Rockcliffe and Auchencairn, and scattered farmsteads and residential properties. The main element in the view that draws attention is the estuary at Rough Firth and Auchencairn Bay, which are enclosed by headlands at Castlehill Point and Balcary Point and divided by Almorness Peninsula and Glen Isle. Hestan Island and Rough Island are present in the view towards the proposed development. Overall the view is distant, panoramic, large scale, exposed, textured and colourful.

Predicted view The wireframe indicates that 60 turbines will be visible offshore. Towers and rotor blades of all the turbines will be visible against a background of the sea and landscape on the Cumbrian coast, however this will only occur in optimum visibility conditions. The view toward the proposed development is striking and diverse, with a distinctly incised coastal form, bays, peninsulas and islands. The layout will be seen in relation to these features in the foreground and in relation to the backdrop of the Cumbrian coast in very clear weather. Screel Hill is an elevated viewpoint, so the pattern of the off set grid is apparent in the layout as the height enables the layout of the turbines to be clearly read against the sea surface. The layout is compact, with clear rows in the centre of the array, appearing to fan out to the edges of the array.

Magnitude of change The towers and rotors of 60 turbines will be visible from this location, with the closest visible turbine at a distance of 16.2km. Screel Hill is the second most elevated viewpoint in the assessment and the array of turbines take on a different perspective when viewed from above. The turbines cover a horizontal angle of 13.4^{o} and appear quite compact. The horizontal extent of the wind turbines has been minimised during the layout optimisation process. The view incorporates particularly striking coastal features in the East Stewartry Coast NSA, so the turbines will be change the viewers perspective of the peninsulas, incised bays and islands in the foreground and will also be viewed against the elevated backdrop of the Cumbrian coast in clear weather conditions. The associated magnitude of change is considered to be **slight**.

Cumulative magnitude of change From this location the turbines at Siddick, Oldside, Lowca and Wharrels Hill are over 31.8km form the viewpoint, on the opposite side of the Solway Firth. It is unlikely that they will be visible at all due to the effects of distance, therefore the magnitude of cumulative change is considered to be **negligible**.

Effects on landscape/seascape character and quality The viewpoint is located within the coastal granite uplands landscape type, which is of high quality and medium sensitivity to change outwith its area. They key characteristics of this landscape type are its rugged granite hills, rising steeply from the coast to form a distinct upland profile on the landward side of the coast. Views from this landscape type tend to be panoramic and long distance. The vertical structures of the proposed offshore wind farm will be experienced at long distances but generally from elevated positions looking down onto the array of turbines. The effect of the proposed offshore wind farm on landscape character and quality is considered to be **moderate**.

Cumulative effects on landscape/seascape character and quality The existing wind turbines at Siddick, Oldside, Lowca and Wharrels Hill are over 31.8km from the viewpoint, on the opposite side of the Solway Firth. It is unlikely that they will be visible or experienced at all due to the effects of distance, therefore the cumulative effect on landscape character and quality is considered to be **minor / none**.

Effects on visual amenity The viewpoint is representative of views for walkers on the forest walk footpath at the summit of Screel Hill to the north west of the application site. Walkers are the main receptors who will experience the wind farm from this location. The sensitivity of the viewpoint is therefore considered to be **high,** as the walkers are likely to place a high value on the landscape and visit it specifically for its panoramic long distance views and dramatic coastal characteristics. However, the majority of the walk up Screel Hill is wooded and enclosed, and there are only views out to the coast from the area around the summit. Although there are features of interest in the wider view, such as the surrounding coastal uplands, the viewers attention is drawn to the coast due to the striking coastal form and features in the East Stewartry NSA. The effect on visual amenity of the proposed offshore wind farm on the Screel Hill viewpoint is considered to be **moderate**.

Cumulative effects on visual amenity The cumulative effect on visual amenity is considered to be **minor / none** for walkers at Screel Hill. The proposed wind farm will not be seen simultaneously with other wind farm developments from this location.

Viewpoint 6: Doach Wood Forest Walk

The viewpoint is located at the Solway Viewpoint in Doach Wood Forest at grid reference E279846 N557852. It is reached via way marked forest tracks from a car park off the B736. The Doach Wood Forest viewpoint has not been chosen for detailed assessment as representative views from the coastal granite uplands to the north west of the East Stewartry NSA are provided by viewpoint 5, Screel Hill Forest Walk. The wireframe in Visualisation 6 shows the existing and predicted view from Doach Wood Forest Walk.

Viewpoint 7: Moyle Hill

The viewpoint is located at the summit of Moyle Hill, in Dalbeattie Forest, at grid reference E284852 N55735. It is reached via forest tracks, waymarked as cycle routes, from a car park off the A710. There is no footpath or cycle route to the summit of Moyle Hill, which consists mainly of felled coniferous plantation woodland. The Moyle Hill viewpoint has not been chosen for detailed assessment as representative views from the coastal granite uplands are provided by viewpoint 5, Screel Hill Forest Walk. The wireframe in Visualisation 7 show the predicted view from Moyle Hill.

Viewpoint 8: Glen Isle

The viewpoint is located at the end of Glen Isle at grid reference E283400 N554668. It is relatively inaccessible but can be reached via forest tracks off a minor road near Palnackie. The Glen Isle viewpoint provides representative views from the upper reaches of the Rough Firth and the predicted views towards the proposed development are shown in the wireframe in Visualisation 8. The viewpoint has not been chosen for detailed assessment because of its inaccessibility and representative views from this area are provided by viewpoint 9, Mote of Mark, Rockcliffe.

Viewpoint 9: Mote of Mark, Rockcliffe

The viewpoint is located at the high point of the Mote of Mark in Rockcliffe, at grid reference E284526 N554006. It is reached by a waymarked footpath from the car park in Rockcliffe. It is representative of views from a key archaeological site and visitor attraction in Rockcliffe. It does not represent views from the majority of the residential area at Rockcliffe which is more enclosed with views toward the proposed development contained by Barcloy Hill.

Existing view The existing view to the application site is long distance and panoramic. The view looking south east towards the proposed development is dominated in the foreground by the intertidal estuary, headlands and islands of the East Stewartry Coast seascape unit. The flat, patterned mudflats of the Rough Firth are distinctive and dynamic, changing the character of the view according to the tidal state. These contrast with the rolling coastal landform and headlands of Barcloy Hill, Castlehill Point and Almorness Peninsula, which enclose the Rough Firth and channel views out to sea. Islands at Rough Island and Hestan Island are also important elements in the view, and their relationship and connection with the landscape change with tidal state. Rocky shores and small sandy bays are present around the coastline. Landcover is dominated by pasture land, rough grazing and deciduous woodland, and varies between the more tended pasture land to the north on Barcloy Hill to the rough grazing, gorse and woodland on Almorness Peninsula. Residential properties and the camping/caravan site at Rockcliffe form the main built elements in the view, but a fort at Castlehill Point and a lighthouse on Hestan Island are also present. The photomontage in Visualisation 9 is part of a wider panoramic view which extends from Mark Hill round to the coastal uplands of Bengairn and Screel Hill on the landward side of the East Stewartry seascape unit.

Predicted view The wireframe indicates that 60 turbines will be visible offshore. Towers and rotor blades of all the turbines will be visible against a background of landscape on the Cumbrian coast to the north of the layout and sky to the south of the layout, however views of the Cumbrian coast will only occur in optimum visibility conditions. The view toward the proposed development has a variety of landscape elements and interest. It is also a dynamic view with ever changing tidal states, and relationships between mudflats, islands and headlands. The layout of the proposed offshore wind farm will be seen in relation to these features in the foreground and in relation to the backdrop of the Cumbrian coast. The northern end of the layout appears above Castlehill Point, and most of the turbines break the horizon of landscape on the Cumbrian coast. The layout is compact, with clear lines of turbines in the centre appearing to spread into a more evenly spaced array of turbines toward the edges of the array.

Magnitude of change The towers and rotors of 60 turbines will be visible from this location, with the closest visible turbine at a distance of 12.3km. The turbines cover a horizontal angle of 16.7^{o}. The horizontal extent of the wind turbines has been minimised during the layout optimisation process. The view incorporates dynamic coastal features in the East Stewartry Coast NSA, so the turbines will change the viewers perspective of the peninsulas, bays and islands in the foreground and the turbines will also break the horizon of the Cumbrian coast in clear weather conditions. The associated magnitude of change is considered to be **moderate**.

Cumulative magnitude of change From this location the turbines at Siddick, Oldside, Lowca and Wharrels Hill are over 27.3km form the viewpoint, on the opposite side of the Solway Firth. It is unlikely that they will be visible at all due to the effects of distance, therefore the magnitude of cumulative change is considered to be **negligible**.

Effects on landscape/seascape character and quality The viewpoint is located within the East Stewartry Coast seascape unit, which is of exceptional quality and high sensitivity to change. The key characteristics of this landscape type are its incised bays and estuary, prominent headlands, peninsulas, islands and mudflats. The irregular, indented coastline and varied landcover form a landscape of great diversity and it is also a working, inhabited and much visited area. The landscape and seascape of the area will be experienced in relation to the proposed development from areas where views of the sea are offered, which tend to be either suddenly revealed at the coast, raised areas of the surrounding hinterland or channelled along the orientation of the bay. The proposed offshore wind farm will introduce a group of man made turbines to the seascape, at the eastern side of the mouth of the Rough Firth. The effect of the proposed offshore wind farm on landscape character and quality is considered to be **major / moderate.**

Cumulative effects on landscape/seascape character and quality The turbines at the Oldside Group and Wharrels Hill are over 27.3km from the viewpoint, on the opposite side of the Solway Firth. It is unlikely that they will be visible at all from this seascape unit due to the effects of distance, therefore the cumulative effects on landscape character and quality are considered to be **minor/none**.

Effects on visual amenity The viewpoint is representative of views for walkers and visitors using the footpath and visiting the Mote of Mark in Rockcliffe. The sensitivity of the viewpoint is therefore considered to be **high** as the receptors are likely to place a high value on the landscape and visit it specifically for its historical and archaeological value. The site bears evidence of human presence in the area since the 4th century AD and is managed by the National Trust for Scotland. The effect on visual amenity of the proposed offshore wind farm on the Mote of Mark viewpoint is considered to be **major / moderate**.

Cumulative effects on visual amenity The potential cumulative effect on visual amenity at this location will be **minor/none** due to the distance from the turbines in the Oldside Group and Wharrels Hill.

Viewpoint 10: Castlehill Point

The viewpoint is located at the topograph on Castlehill Point, 35m AOD, at grid reference E285448 N552407, which is reached by a footpath along the shores of the Rough Firth from the car park in Rockcliffe. The viewpoint has been chosen to provide representative views from a prominent headland and coastal walk in the East Stewartry NSA that is accessible from the settlement at Rockcliffe.

Existing view The existing view towards the proposed development site is south/south west out to sea and is long distance across the firth. The English coast is visible in clear weather. The photomontage shown in Visualisation 10 is part of a wider panoramic view which incorporates the coast and coastal uplands. The view is only partially enclosed to the north east by Barcloy Hill, but otherwise almost a full 360^{o} panorama is available. To the east, the view along the coast is dominated by steep sea cliffs, rocky shores and sandy beaches and to the south west the peninsulas and intertidal bays of the East Stewartry coast are particularly distinctive. Views inland are dominated by the coastal uplands including the summits of Bengairn and Screel Hill. There are very few built elements present in the view, with landcover being predominantly rough grazing, gorse, and patches of woodland. The view varies according to weather and viewing direction, but generally is harmonious, exposed, diverse, remote and invigorating.

Predicted view The wireframe indicates that 60 turbines will be visible on the horizon. Towers and rotor blades of all the turbines will be visible against a background of landscape on the Cumbrian coast to the north of the layout and sky to the south of the layout, however views of the Cumbrian coast will only occur in optimum visibility conditions. The wireframe indicates that the off set grid layout of the turbines is apparent, with five rows clearly discernible at the centre of the array. This results in a series of gaps openingup through the array and at the edges the layout tends to fan out to more evenly spaced turbines. Most of the turbines appear to break the skyline of the Cumbrian coast behind.

Magnitude of change The towers and rotors of 60 turbines will be visible from this location, with the closest visible turbine at a distance of 10.5km. Castlehill Point is one of the closest onshore viewpoints and the array of turbines covers a horizontal angle of 19.4^{o}. Its horizontal extent has been minimised during the layout optimisation process. The view from this location is straight out to sea due to its position next to the coast, however there is a wider view which includes the East Stewartry NSA. The associated magnitude of change is considered to be **moderate**.

Cumulative magnitude of change From this location the closest existing turbines are those at Siddick Wind Farm at a distance of 25.2km, on the opposite side of the Solway Firth. The nearest turbine at Oldside Wind Farm is at a distance of 25.7km, and the nearest at Lowca Wind Farm is 31.5km form the viewpoint. Wharrels Hill Wind Farm is even more distant at 35.1km. The magnitude of cumulative change is considered to be **negligible** at such distances when turbines will only be visible in clear weather conditions.

Effects on landscape/seascape character and quality The viewpoint is located within the East Stewartry Coast seascape unit, which is of exceptional quality and high sensitivity to change. The key characteristics of this landscape type are its incised bays and estuary, prominent headlands, peninsulas, islands and mudflats. The irregular, indented coastline and varied landcover form a landscape of great diversity and it is also a working, inhabited and much visited area. The landscape and seascape of the area will be experienced in relation to the proposed development from areas where views of the sea are available, which tend to be either suddenly revealed at the coast, raised areas of the surrounding hinterland or channelled along the orientation of the bay. The effect of the proposed offshore wind farm on landscape character and quality is considered to be **major / moderate.**

Cumulative effects on landscape/seascape character and quality The nearest existing wind turbines are those at the Siddick, over 25.2km from the viewpoint, on the opposite side of the Solway Firth. It is unlikely that they will be experienced in relation to this seascape unit due to the effects of distance, therefore the cumulative effects on landscape character and quality are considered to be **minor.**

Effects on visual amenity The viewpoint is representative of views for walkers on the footpath at Castlehill Point to the north west of the application site. The sensitivity of the viewpoint is therefore considered to be **high** as the walkers are likely to place a high value on the landscape and visit it specifically for its panoramic long distance views and dramatic coastal characteristics.

Although here are features of interest in the wider view, the openness of views across the Solway Firth are the most striking aspect. The effect on visual amenity of the proposed offshore wind farm on the Castlehill Point viewpoint is considered to be **major / moderate**.

Cumulative effects on visual amenity The cumulative effect on visual amenity is considered to be **minor** for walkers at Castlehill Point. The proposed wind farm will only be seen simultaneously with other wind farm developments at distances over 25.2km from this location, and on the opposite side of the Solway Firth.

Viewpoint 11: Torbay, Approach to Rockcliffe

The viewpoint is located at Torbay on the minor road that approaches Rockcliffe off the A710, at grid reference E286267 N554063. The viewpoint provides representative views from the coastal hinterland to the west of Rockcliffe and the predicted views towards the proposed development are shown in the wireframe in Visualisation 11. The viewpoint has not been chosen for detailed assessment because there is intermittent visibility of the coast from this area as shown in the Visualisation.

Viewpoint 12: The Torrs, Portling

The viewpoint is located at the topograph near the Torrs, 80m AOD, at grid reference E288796 N288796, on the coastal walk between Sandyhills Bay and Castlehill Point. It is representative of views from the coastal area due north of the application site.

Existing view Access to the viewpoint is by the waymarked footpath from the car park at Sandyhills Bay. The existing view towards the application site is due south. It is a long distance view across the open sea of the firth and the English coastline can be seen in clear weather. The foreground is formed by extensive intertidal areas that expose mudflats at low tide. The photomontage shown in Visualisation 12 is part of a wider panoramic view which extends along the coastline and inland. To the east the view extends to Southerness Point. This section of coast is varied and includes the distinctive Preston Merse to the east of Craigneuk Point. To the west of Craigneuk Point, high rocky sea cliffs covered in Gorse are predominant with an enclosed sandy beach at Sandyhills Bay. To the west the view along the coast is shorter and is confined by the headland near White Hill and Port of Warren. The hinterland is dominated by the granite mass of Bainloch Hill and Fairgirth Hill, which has coniferous plantation, deciduous woodland and extensive gorse cover. Scattered residential properties overlook the coast particularly at Portling, Port of Warren and Heughs of Laggan. The view is distant, panoramic, harmonious, large scale, exposed, diverse, peaceful and the in excellent condition.

Predicted view The wireframe indicates that 60 turbines will be visible on the horizon. Towers and rotor blades of all the turbines will be visible against a background of landscape on the Cumbrian coast to the east of the layout and sky to the west of the layout, however views of the Cumbrian coast will only occur in optimum visibility conditions. The layout consists of several single turbines at the eastern end of the array, a greater concentration of turbines at the centre and then three rows of turbines visible to the right of centre, with single turbines visible at the western edge. The overall composition is consistent and achieves a sense of balance. The turbines break the skyline of the Cumbrian coast to the west of the layout.

Magnitude of change The towers and rotors of 60 turbines will be visible from this location, with the closest visible turbine at a distance of 11.5km. The Torrs, Portling is one of the closest onshore viewpoints and the array of turbines covers a horizontal angle of 17.8°. Its horizontal extent has been minimised during the layout optimisation process. The view from this location is straight out to sea due to its position next to the coast, however there is a wider view which includes the varied coastline of the Mersehead Sands area to the east. The associated magnitude of change is considered to be **moderate**.

Cumulative magnitude of change From this location the closest existing turbines are those at Siddick Wind Farm at a distance of 25.1km, on the opposite side of the Solway Firth. The nearest turbine at Oldside Wind Farm is at a distance of 25.9km, and the nearest at Lowca Wind Farm is 32.3km form the viewpoint. Wharrels Hill Wind Farm is even more distant at 33.1km. The magnitude of cumulative change is considered to be **negligible** at such distances when the turbine will only be discernible in clear weather conditions.

Effects on landscape/seascape character and quality The viewpoint is located within the Mersehead Sands seascape character unit which is of high quality and high sensitivity to change outwith its area. The character and quality of this area is primarily derived from the wide tidal flats of the Mersehead Sands occurring at the point where the saltings of Preston Merse meet the fossil cliffs and raised beaches of the Sandyhills coast. The proposed offshore wind farm will be experienced from the landscape and seascape of this unit where views are available. These sea views tend to be open and unrestricted across the firth from the coastal edge and upland hinterlands but more intermittent from the flat coastal hinterland. The proposed wind farm will introduce a group of turbines to the seascape forming a distinctive focal element in the open sweep of sea. The effect of the proposed offshore wind farm on landscape character and quality is considered to be **moderate.**

Cumulative effects on landscape quality The nearest existing wind turbines are those at the Siddick, over 25.1km from the viewpoint, on the opposite side of the Solway Firth. At such distance, the cumulative effects on landscape character and quality are considered to be **negligible.**

Effects on visual amenity The viewpoint is representative of views for walkers on the coastal footpath between Sandyhills Bay and Castlehill Point, to the north of the application site. The sensitivity of the viewpoint is therefore considered to be **high** as walkers visit it specifically for its panoramic long distance views and dramatic coastal characteristics. Although there are features of interest in the wider view, the openness of views across the Solway Firth are the most striking aspect. The view is orientated toward the application site when walking south west toward Castlehill Point, but is oblique to the proposed development when walking north east toward Sandyhills Bay. The effect on visual amenity of the proposed offshore wind farm on the Castlehill Point viewpoint is considered to be **moderate**.

Cumulative effects on visual amenity The cumulative effect on visual amenity is considered to be **minor** for walkers at the Torrs, Portling. The proposed wind farm will only be seen simultaneously with other wind farm developments at distances over 25.1km from this location, and on the opposite side of the Solway Firth.

Viewpoint 13: Fairgirth Hill

The viewpoint is located at the summit of Fairgirth Hill, 230m AOD at grid reference E289015 N556751. It is relatively inaccessible with no marked footpath to the summit but can be reached through fields off the minor road between the A710 and the B793. The Fairgirth Hill viewpoint provides representative views from the upland area to the north of Mersehead Sands and the predicted views towards the proposed development are shown in the wireframe in Visualisation 13. The viewpoint has not been chosen for detailed assessment because of its inaccessibility and representative views from the coastal granite uplands area are provided by viewpoint 5, Screel Hill and viewpoint 16, Criffel.

Viewpoint 14: A710, Mainriddle

The viewpoint is located at a high point on the A710 to the east of Mainriddle at grid reference E295258 N556855. It has been chosen to represent views from the A710, one of the key routes through the Dumfries and Galloway part of the study area to the north of the application site.

Existing view The existing view towards the application site is open and long distance to the south, with views of the sea beyond Preston Merse. The foreground consists of undulating pasture land grazed by sheep, with discontinuous hedgerow field boundaries and linear tree belts. The view contains built elements such as scattered properties and farm buildings, and telegraph poles and wires. Beyond the pasture is an extensive area of Merse, which forms a fringe of flat, low lying salt marsh, which gives way to sand, mudflats and sea. There are wider views to the west to East Stewartry NSA and views inland consist of coastal uplands.

Predicted view The wireframe indicates that 60 turbines will be visible on the horizon. Towers and rotor blades of all the turbines will be visible against a background of

Sky. The layout consists of five clear offset rows of turbines to the west of the layout, with a greater concentration of turbines to the east of the array in a single cluster. The position of the turbines is central, with the land masses of both coasts framing the wider view south west down the Solway Firth. The proposed development will be seen beyond the context of the lowland coastal pasture land, merse and intertidial mudflats in the foreground.

Magnitude of change The towers and rotors of 60 turbines will be visible from this location, with the closest visible turbine at a distance of 14.4km. The array of turbines covers a horizontal angle of 12.4° . Its horizontal extent has been minimised during the layout optimisation process. The view from this location incorporates a variety of coastal hinterland elements and there are important wider views along the coast to the East Stewartry Coast NSA . The associated magnitude of change is considered to be **moderate**.

Cumulative magnitude of change From this location the closest existing turbines are those at Siddick Wind Farm at a distance of 24.9km, on the opposite side of the Solway Firth. The nearest turbine at Oldside Wind Farm is at a distance of 26.3km, and the nearest at Lowca Wind Farm is 33.4km form the viewpoint. Wharrels Hill Wind Farm is distant at 29.1km. The magnitude of cumulative change is considered to be **negligible** at such distances when turbines will only be visible in clear weather conditions.

Effects on landscape/seascape character and quality The viewpoint is located within the Mersehead Sands seascape character unit which is of high quality and high sensitivity to change outwith its area. The character and quality of this area is primarily derived from the wide tidal flats of the Mersehead Sands occurring at the point where the saltings of Preston Merse meet the fossil cliffs and raised beaches of the Sandyhills coast. The proposed offshore wind farm will be experienced from the landscape and seascape of this unit where views are available. These sea views tend to be open and unrestricted across the firth from the coastal edge and upland hinterlands but more intermittent from the flat coastal hinterland. The effect of the proposed offshore wind farm on landscape character and quality is considered to be **moderate.**

Cumulative effects on landscape/seascape character and quality The nearest existing wind turbines are those at the Siddick, over 24.9km from the viewpoint, on the opposite side of the Solway Firth. It is unlikely that they will be experienced in relation to this seascape unit due to the effects of distance, therefore the cumulative effects on landscape character and quality are considered to be **minor/none**.

Effects on visual amenity The viewpoint is represents views for road users on the A710 to the north of the application site. It is located on the A710 at a high point to the east of Mainriddle, where open views to the coast are available. Road users are considered to be of **medium** sensitivity, because travelling in vehicles at speed constrains the opportunity to view the surrounding landscape. There are no marked parking bays to pull in along this stretch of road near Mainriddle. The road is also undulating and only offers views of the coast from the high points. The effect on visual amenity of the proposed wind farm on road users at the A710, Mainriddle will be **moderate**.

Cumulative effects on visual amenity The cumulative effect on visual amenity is considered to be **minor/none** for road users on the A710. The nearest existing turbines are 24.9km away on the opposite side of the Solway Firth. The faint outline of these turbines will only be picked out in the clearest weather and with time to concentrate and locate them in the view.

Viewpoint 15: Southerness Point

The viewpoint is located on the rocky shores of Southerness Point, 5m AOD, at grid reference E297750 N554241. It has been chosen to provide representative views from this prominent headland in the Solway Firth to the north of the application site.

Existing view The existing view towards the application site is long distance across the rocky shores and pebble beach at Southerness Point and south down the Solway Firth. Physical features in the foreground include rock outcrops, sand and pebble beach, and mudflats at low tide. The view includes parts of the Dumfries and Galloway and Cumbrian coasts on either side of the central expanse of sea in the Solway Firth. The view south towards the application site shown in the photomontages in Visualisation 15 and 15A is part of a wider panoramic view that extends over long distances north east to Caerlaverock and the Inner Solway, east/south east to the Cumbrian Coast and west along the Dumfries and Galloway Coast. There are no built features shown in the photomontages, however the wider view incorporates residences, tourist accommodation and a lighthouse. Overall, the seaward view is distant, panoramic, large scale and simple. In addition to the photomontage presented in 15 two further photomontages have been presented inVisualisation 15A showing the predicted views at low and high tide at the request of Scottish Natural Heritage.

Predicted view The wireframe indicates that 60 turbines will be visible on the horizon. Towers and rotor blades of all the turbines will be visible against a background of
Sky. The layout consists of a row of turbines at the eastern end followed by a concentration of turbines across the centre of the array and individual turbines at the western end, which achieves an overall sense of balance, although no particular pattern of turbines is apparent. The position of the turbines is central, with the land masses of both coasts framing the wider view south west down the Solway Firth.

Magnitude of change The towers and rotors of 60 turbines will be visible from this location, with the closest visible turbine at a distance of 13.0km.The array of turbines covers a horizontal angle of 12.7°. Its horizontal extent has been minimised during the layout optimisation process. The view from this viewpoint is straight out to sea due to its exposed position at the end of Southerness Point, however there are wider views which extend over long distances to Caerlaverock, the Inner Solway, east/south east to the Cumbrian Coast and west along the Dumfries and Galloway Coast. The associated magnitude of change is considered to be **moderate**.

Cumulative magnitude of change From this location the closest existing turbines are those at Siddick Wind Farm at a distance of 21.9km, on the opposite side of the Solway Firth. The nearest turbine at Oldside Wind Farm is at a distance of 23.4km, and the nearest at Lowca Wind Farm is 30.6km from the viewpoint. Wharrels Hill Wind Farm is 25.5km away. The magnitude of cumulative change is considered to be **negligible** at such distance when the turbines will only be visible in clear weather conditions.

Effects on landscape/seascape character and quality The viewpoint is located within the Mersehead Sands seascape character unit which is of high quality and high sensitivity to change outwith its area. The character and quality of this area is primarily derived from the wide tidal flats of the Mersehead Sands occurring at the point where the saltings of Preston Merse meet the fossil cliffs and raised beaches of the Sandyhills coast. The proposed offshore wind farm will be experienced from the landscape and seascape of this unit where views are available. These sea views tend to be open and unrestricted across the firth from the coastal edge and upland hinterlands but more intermittent from the flat coastal hinterland. The effect of the proposed offshore wind farm on landscape character and quality is considered to be **moderate.**

Cumulative effects on landscape/seascape character and quality The nearest existing wind turbines are those at the Siddick, over 21.9km from the viewpoint, on the opposite side of the Solway Firth. It is unlikely that they will be experienced in relation to this

seascape unit due to the effects of distance, therefore the cumulative effects on landscape character and quality are considered to be **minor/none**.

Effects on visual amenity The viewpoint is representative of views for a variety of receptors including residents, tourists and golfers. Residents are considered to be of high sensitivity as they place a high value on the landscape and visual amenity associated with their primary place of residence. Tourists are also considered to be of high sensitivity as they place a high value on the visual amenity of the attraction to which they visit and golfers are considered to be of medium sensitivity as they are primarily involved in active recreation. The effect on visual amenity of the proposed wind farm on residents and tourists at Southerness will be **moderate** and on golfers will be **moderate / minor**.

Cumulative effects on visual amenity The cumulative effect on visual amenity is considered to be **minor** for residents and tourists at Southerness and **minor / none** for golfers. The nearest existing turbines are 21.9km away on the opposite side of the Solway Firth. The faint outline of these turbines will only be picked out in the clearest weather conditions.

Viewpoint 16: Criffel

The viewpoint is located at the summit of Criffel at 571m AOD at grid reference E295729 N561866. It is the most elevated viewpoint on the Dumfries and Galloway Coast and is reached via footpath to the north from a car park off the A710 near Loch Kindar. It is representative of views from the summits areas of the coastal granite uplands to the north of the application site and is located within the Nith Estuary NSA.

Existing view The viewpoint is located at the summit of Criffel at 571m AOD at grid reference E295729 N561866. It is the most elevated viewpoint on the Dumfries and Galloway Coast and is reached via footpath from a car park off the A710 near Loch Kindar. The existing view to the application site is long distance and panoramic. The view looking south towards the proposed development is dominated by the open expanse of sea in the Solway Firth. The open sea is enclosed to the east by the landform of the Cumbrian Coast and to the north by the Dumfries and Galloway Coast. The Cumbrian Coast is visible in clear weather. The foreground view consists of coastal granite uplands, Mersehead Sands seascape unit and the East Stewartry Coast seascape unit. Mersehead Sands forms a flat expanse of merse and intertidal mudflats, while East Stewartry Coast forms intertidal bays, with peninsula and islands. Overall the view is long distance, panoramic, large scale, diverse, exposed and invigorating.

Predicted view The wireframe indicates that 60 turbines will be visible in the Solway Firth. Towers and rotor blades of all the turbines will be visible against a background of sea. The proposed offshore wind farm will appear as a single group of man made turbines in the wider panoramic view and long distance view out to sea. The summit of Criffel is the highest viewpoint on the Dumfries and Galloway coast at 571m AOD. The view therefore looks down on the array of turbines, which enhances the viewers ability to interpret the pattern of the turbine layout and its relationship with both coastlines. The array consists of eight linear rows of turbines, with shorter rows to the west of the layout and longer rows in the centre. The offset grid pattern is clearly apparent and legible against the sea surface.

Magnitude of change The towers and rotors of 60 turbines will be visible from this location, with the closest visible turbine at a distance of 19.4km. Criffel is the most elevated viewpoint on the Dumfries and Galloway coast. The array of turbines is therefore legible and its relationship with wider seascape and landscape clearly discernible. The turbines cover a horizontal angle of 9.8° and appear as a compact group, with the 60 turbines forming an isolated, unified offshore element. The horizontal extent of the wind turbines has been minimised during the layout optimisation process. There are panoramic 360° views from the summit over coastal and inland areas of Dumfries and Galloway and to the Inner Solway and Cumbria, therefore the proposed development forms a relatively small element in the overall view. The associated magnitude of change is considered to be **slight**.

Cumulative magnitude of change From this location the closest existing turbines are those at Siddick Wind Farm at a distance of 29.8km, on the opposite side of the Solway Firth. The nearest turbine at Oldside Wind Farm is at a distance of 31.2km, and the nearest at Lowca Wind Farm is 38.3km from the viewpoint. Wharrels Hill Wind Farm is 32.3km away. The magnitude of cumulative change is considered to be **negligible** at such distances with the turbines only visible in clear weather conditions.

Effects on landscape/seascape character and quality The viewpoint is located at the boundary of the coastal granite uplands landscape type and the Nith Estuary seascape type. Although Criffel forms an important part of the setting of the Nith Estuary seascape unit, it is more relevant to discuss the effects on the landscape character and quality of the coastal granite uplands from this viewpoint. The coastal granite uplands landscape type is of high quality and high sensitivity to change outwith its area. They key characteristics of this landscape type are its rugged granite hills, rising steeply from the coast to form a distinct upland profile on the landward side of the coast. Views from this landscape type tend to be panoramic and long distance. The vertical structures of the proposed offshore wind farm will be experienced at long distances but generally from elevated positions looking down onto the array of turbines, which increases the viewers ability to interpret the turbine layout and its relationship with the surrounding seascape and landscape. The effect of the proposed offshore wind farm on landscape character and quality is considered to be **moderate**.

Cumulative effects on landscape/seascape character and quality The nearest existing wind turbines are those at the Siddick, over 29.8km from the viewpoint, on the opposite side of the Solway Firth. It is unlikely that they will be experienced in relation to this landscape type due to the effects of distance, therefore the cumulative effects on landscape character and quality are considered to be **minor/none**.

Effects on visual amenity The viewpoint is representative of views for walkers on the footpath at the summit of Criffel to the north west of the application site. The sensitivity of the viewpoint is therefore considered to be **high** as walkers are likely to place a high value on the landscape and visit it specifically for its panoramic long distance views and dramatic coastal characteristics. However, the majority of the walk up Criffel is to the north of the summit, and there are only views out to the coast from the area around the summit and to the south of it. Although there are features of interest in the wider view, such as the surrounding coastal uplands, the viewers attention is drawn to the coast due to the vastness of the open sea. The effect on visual amenity of the proposed offshore wind farm on the Criffel viewpoint is considered to be **moderate**.

Cumulative effects on visual amenity The cumulative effect on visual amenity is considered to be **minor/none** for walkers at the summit of Criffel. The nearest existing turbines are 29.8km away on the opposite side of the Solway Firth. The faint outline of these turbines may only be picked out in the clearest weather and with time to concentrate and locate them in the view.

Viewpoint 17: Ward law overlooking Caerlaverock

The viewpoint is located at Ward Law the site of a Roman Fort, overlooking Caerlaverock National Nature Reserve (NNR), 84m AOD at grid reference E302415 N566651. There is no public footpath to the summit but it can be reached across fields off the B725. The Caerlaverock viewpoint provides representative views from the Nith Estuary and the NNR at Caerlaverock and the predicted views towards the proposed development are shown in the wireframe in Visualisation 17.

Viewpoint 18: A75(T) Kelhead Moss

The viewpoint is located at a parking bay on the A75(T) near Kelhead Moss at grid reference E313082 N570046. The viewpoint provides representative views from the main road between Dumfries and the A74(M) and the predicted views towards the proposed development are shown in Visualisation 18. The viewpoint has not been chosen for detailed assessment because it is over 30km from the proposed development and there is only fleeting visibility of the coast from the A75, as shown in the visualisation.

Viewpoint 19: Campsite Powfoot

The viewpoint is located at the Campsite in Powfoot at grid reference E314229 N565214. It is situated on the coast and can be reached via a minor road off the B724. The viewpoint provides representative views from the start of the Inner Solway to the north east of the application site and the predicted views towards the proposed development are shown in Visualisation 19. The viewpoint has not been chosen for detailed assessment because it is over 30km from the proposed development.

Viewpoint 20: Silloth Sea Front

The viewpoint is located on the coastal path along Silloth sea front at grid reference E311283 N554421. The viewpoint provides representative views from Silloth to the north east of the application site and the predicted views towards the proposed development are shown in the wireframe in Visualisation 20. The viewpoint has not been chosen for detailed assessment because of it is over 20km from the proposed development and other residential settlements along the Cumbrian coast which are closer to the development have been assessed in detail.

Viewpoint 21: Cumbria Coastal Way, Mawbray Bank

The viewpoint is located on the Cumbria Coastal Way, at Mawbray Bank, 7m AOD at grid reference E308 N546951. It has been chosen to provide representative views from the Cumbria Coastal Way, a National Trail, to the north east of the application site.

Existing view The existing view south west towards the application site is long distance and panoramic. It is dominated by the flat open sea of the Solway Firth. The view extends to the Scottish coastline in fine weather, which can be seen as an undulating profile of coastal uplands to the north west. The foreground consists of sand dunes and shingle beach with the Cumbria Coastal Way footpath traversing the coast. Overall the view is long distance, open, balanced, unified and simple.

Predicted view The wireframe indicates that 60 turbines will be visible on the horizon. Towers and rotor blades of all the turbines will be visible against a background of sky. At this viewpoint, the layout consists of a series of rows at the western end of the array with a dense group of individual turbines at the eastern end of the array. There are no outstanding gaps and the spread of single and multiple turbines across the array achieves some balance, but is slightly weighted towards the east. The proposed offshore wind farm will introduce a group of turbines as a distinct element on the horizon in an otherwise regular and simple view.

Magnitude of change The towers and rotors of 60 turbines will be visible from this location, with the closest visible turbine at a distance of 17.0km. The array of turbines will be legible, although distant on the horizon because of the flatness of the open sea, the straightness of the horizon and the lack of other elements in the view. The turbines cover a horizontal angle of 11.6^{o} and appear compact, with the 60 turbines forming a isolated, unified offshore element. The horizontal extent of the wind turbines has been minimised during the layout optimisation process. The associated magnitude of change is considered to be **slight**.

Cumulative magnitude of change From this location the closest existing turbines are those at Siddick Wind Farm at a distance of 16.0km to the south. The nearest turbine at Oldside Wind Farm is at a distance of 18.2km. Turbines at Lowca and Wharrels Hill Wind Farms will not be seen at all from this viewpoint. Although the turbines at Siddick and Oldside may be seen to the south along the coast, they are distant and occupy only a very small angle of view (Siddick 1.0^{o} and Oldside 1.2^{o}). This is because the layouts of the wind farms are linear along the coast, therefore will the row of turbines will be viewed end on and occupy a small angle of view. The magnitude of cumulative change is considered to be **negligible**.

Effects on landscape quality The viewpoint is located within the Silloth Coast seascape unit, which is of high quality and medium sensitivity to change outwith its area. The character of this unit relies on its expansive views of the Scottish hills, the seascapes of the Solway Firth and on its largely unspoilt dune topography and vegetation. The landscape will be experienced in relation to the proposed development where views are available, which tend to be more open and longer distance from the coastal edge. The effect of the proposed offshore wind farm on landscape character and quality is considered to be **moderate**.

Cumulative effects on landscape quality The nearest existing wind turbines are those at the Siddick, over 16km to the south of the viewpoint. It is possible that they will be experienced in relation to this landscape type but they are distant and occupy a very small angle of the view. The cumulative effects on landscape character and quality are considered to be **minor**.

Effects on visual amenity The viewpoint is representative of views for walkers on the Cumbria Coastal Way at Mawbray Bank to the east of the application site. The sensitivity of the viewpoint is therefore considered to be **high** as the receptors place a high value on the amenity of the views and landscape along the duration of the walk. The Cumbria Coastal Way is also a national trail and of strategic importance for walking and rambling. Views of the proposed development will be offered when walking south along the coastal way, but there will be no views of the proposed development when walking north. The effect on visual amenity of the proposed offshore wind farm on the Mawbray Bank viewpoint is considered to be **moderate**.

Cumulative effects on visual amenity The cumulative effect on visual amenity is considered to be **minor** for walkers on the Cumbria Coastal Way at Mawbray Bank. The nearest existing turbines are 16.0km to the south at Siddick. The turbines can be picked out in the clearest weather and with time to concentrate and locate them in the view, but only when walking in a southerly direction along the footpath. Walkers moving north along the footpath will have no cumulative effects.

Viewpoint 22: Allonby Sea Front

The viewpoint in located in Allonby at the sea front at grid reference E308091 N542177. It is situated just off the main coastal road, the B5300 at the southern end of Allonby. The viewpoint provides representative views from Allonby Bay to the east of the application site and the predicted views towards the proposed development are shown in Visualisation 22. The viewpoint has not been chosen for detailed assessment because representative views from this area are provided by viewpoint 21, Mawbray Bank, to the north and viewpoint 25, Maryport Marina, to the south.

Viewpoint 23: A596(T) Aspatria

The viewpoint is located on the A596(T) to the west of Aspatria at grid reference E313438 N541503. The viewpoint provides representative views from Aspatria and the predicted views towards the proposed development are shown in the wireframe in Visualisation 23. The viewpoint has not been chosen for detailed assessment because there is fleeting, distant visibility toward the application site from Aspatria with views often contained by the settlement and by the screening effects of local topography.

Viewpoint 24: A595 Wharrels Hill, Bothel

The viewpoint is located on the A595 near Wharrels Hill, Bothel at grid reference E317252 N538030. The viewpoint provides representative views from the A595 near Bothel and the predicted views towards the proposed development are shown in the wireframe in Visualisation 24. The viewpoint has not been chosen for detailed assessment because of the fleeting, distant visibility towards the application site from this main road as shown in the visulaisation.

Viewpoint 25: Maryport Marina

The viewpoint is located at Maryport Marina near the sea wall, 15m AOD, at grid reference E302870 N536426. It has been chosen to represent views from the residential area and harbour at Maryport to the east of the application site.

Existing view The existing view is open and long distance. The view west towards the application site is dominated by the open sea of the Solway Firth. The Dumfries and Galloway coastline can be seen in fine weather, forming a distant elevated profile of coastal uplands. The foreground consists of the sea wall of Maryport Marina. Overall the view is distant, open, balanced, unified and simple.

Predicted view The wireframe indicates that 60 turbines will be visible on the horizon. Towers and rotor blades of all the turbines will be visible against a background of sky and landscape on the Dumfries and Galloway coast, although this will only be in clear weather conditions. At this viewpoint, the layout consists of a series of single turbines at the southern end of the array and rows apparent at the centre and to the right of centre, with two individual turbines at the northern end of the array. The proposed offshore wind farm will break the horizon of the landscape on the Scottish coast in optimum visibility conditions, and introduces a distinct element into an otherwise regular and simple view.

Magnitude of change The towers and rotors of 60 turbines will be visible from this location, with the closest visible turbine at a distance of 12.5km. The array of turbines will be viewed against the varied horizon of the Dumfries and Galloway coast and form a feature which is made apparent by the lack of other elements in the view. The turbines cover a horizontal angle of 18.0^{o}, which has been minimised during the layout optimisation process. The associated magnitude of change is considered to be **moderate**.

Cumulative magnitude of change From this location the closest existing turbines are those at Siddick Wind Farm at a distance of 4.3km to the south. The nearest turbine at Oldside Wind Farm is at a distance of 6.5km to the south, and the nearest at Lowca Wind Farm 13.5km to the south. The nearest visible turbine at Wharrels Hill is more distant at 14.5km to the east. A total of 16 turbines in the Oldside Group as a whole and 8 turbines at Wharrels Hill may be visible from this location. The turbines in the Oldside Group may be viewed as a linear feature along the coast therefore occupy a very small horizontal angle, of 3.4^{o} in the view. Maryport Marina is enclosed by buildings and sea walls and constrain views from the ground to the existing wind turbine developments. The magnitude of cumulative change is considered to be **moderate**.

Effects on landscape/seascape character and quality The viewpoint is located within the Maryport coast seascape unit which is of low quality and low sensitivity to change outwith its area. The character of the Maryport seascape unit is primarily determined by urban areas, industrial developments and existing wind farm developments at Siddick and Oldside. The proposed development will be experienced where views of the coast are available, which tend to be from within an urban context and often constrained by intervening development. The effect of the proposed offshore wind farm on landscape character and quality is considered to be **moderate / minor**.

Cumulative effects on landscape/seascape character and quality The nearest existing wind turbines are those at the Siddick, approximately 4.3km to the south of the viewpoint. The landscape of the Maryport coast seascape unit will be experienced predominantly with both the existing wind turbine developments at Siddick and Oldside and the proposed development simultaneously. The existing turbines, however, occupy only a small angle of the view. The cumulative effects on landscape character and quality are considered to be **moderate / minor**.

Effects on visual amenity The viewpoint is representative of views for residents in Maryport, especially the new flats around Maryport Marina, and boat users/fishing activities in the harbour. Residents are considered to be of high sensitivity as they place a high value on the landscape and visual amenity associated with their primary place of residence. Boat users/fishing activities at the harbour are considered to be of medium sensitivity. The effect on visual amenity of the proposed offshore wind farm on residents in Maryport is considered to be **moderate**, while the effect on boat users/fishing activity is considered to be **moderate / minor**.

Cumulative effects on visual amenity The cumulative effect on visual amenity is considered to be **moderate** for residents in Maryport and **moderate / minor** for boat users / fishing activities. The nearest existing turbine is 4.3km to the south at Siddick, and the majority of turbines at the Siddick and Oldside Wind farms will be seen simultaneously with the proposed development.

Viewpoint 26: Watch Hill, near Cockermouth

The viewpoint is located at the summit of Watch Hill, near Cockermouth, 218m AOD at grid reference E314760 N531884. It is reached by public footpath, which is a National Trail, and is accessible from a small parking area on the road. It has been chosen to provide representative views from the area of the Lake District National Park which is nearest to the proposed development.

Existing view The existing view to the application site is long distance and panoramic. The view looking west towards the proposed development is dominated by gently undulating lowland pastureland, with regular hedgerow field boundaries and patches of deciduous and coniferous woodland. Urban areas are situated within the agricultural backcloth, such as at Cockermouth, Seaton and Workington. Cockermouth is particularly apparent in the foreground. Other industrial and built elements are visible in the view, including wind turbines at Siddick, Oldside and Windscales. The coast and sea forms an important but distant element in the view, which extends long distances to the Dumfries and Galloway coastline in clear visibility conditions. The photomontage shown in Visualisation 26 is part of a wider panoramic view from the Lakeland Fells across coastal lowland and the sea round to Criffel on the Scottish coast. The wider view tends to be dominated by the Lakeland fells to the south west with the distinct jagged profiles of the higher fells providing the most striking aspect of the view rather than the coast. Overall the view is distant, panoramic, balanced, large scale, colourful and diverse.

Predicted view The wireframe indicates that 60 turbines will be visible on the horizon. Towers and rotor blades of all the turbines will be visible against a background of landscape on the Dumfries and Galloway coast, although this will only be in clear weather conditions. At this viewpoint, the layout consists of ten rows of turbines in an offset grid, with a greater number and concentration of turbines in the rows at the centre of the layout. It is situated in the horizon of sea, which is an important but distant element in the view, between the coastal lowland of West Cumbria and the distant Dumfries and Galloway coast. The proposed development will be seen in relation to the vast expanse of foreground in the view, which is diverse, patterned and contains a number of urban areas and built structures. The proposed development will also be seen in relation to existing wind turbines of the Oldside Group.

Magnitude of change The towers and rotors of 60 turbines will be visible from this location, with the closest visible turbine at a distance of 25.2km. Watch Hill is an elevated viewpoint, at 218m AOD so the view is down onto the wind farm, however it is very distant. The wireframe shows that the array of turbines is legible at this distance, forming a small, compact feature, with a horizontal angle of 9.3^{o}. The horizontal extent of the wind turbines has been minimised during the layout optimisation process. The wider view is a panoramic 360^{o} view over coastal and inland areas of Cumbria and to the Lakeland Fells, therefore the proposed development forms a relatively small element in the overall view. The associated magnitude of change is considered to be **negligible.**

Cumulative magnitude of change The turbines at Siddick and Oldside may be visible in the view towards the application site on the coast, at distances of 14.1km and 15.3km respectively. These turbines may be seen in the view in clear weather conditions, but are not immediately obvious and require scrutiny of the landscape to see them. The existing turbines are therefore nearer the viewpoint than the proposed development, which may be seen simultaneously, but only in exceptionally clear weather and at distances over 25km. The magnitude of cumulative change is considered to be **negligible**.

Effects on landscape/seascape character and quality The viewpoint is located within the Cumbrian upland fringe landscape type, which is of high quality and has a high sensitivity to change outwith its area. The character and quality of this landscape type derives from its elevated rolling landform that forms an upland fringe to the high fells of the Lake District. The proposed development may be experienced from long distances in areas where views of the coast are available, which tend to be the more exposed fell tops, such as Watch Hill. Nevertheless, the proposed development is located some 25.2km from the viewpoint. The effect of the proposed offshore wind farm on landscape character and quality is considered to be **minor / none**.

Cumulative effects on landscape/seascape character and quality The upland fringe landscape type will be experienced with both the existing wind turbine developments in the Oldside Group and the proposed development simultaneously. However, potential cumulative effects will be separated by large distances, with the existing turbines being nearer the character type than the proposed development. The cumulative effects on landscape character and quality are considered to be **minor**.

Effects on visual amenity The viewpoint is representative of views for walkers on the footpath up to the summit of Watch Hill to the east of the application site. The sensitivity of the viewpoint is considered to be **high** as the walkers are likely to place a high value on the landscape and visit it specifically for its panoramic long distance views over West Cumbria and the Lakeland Fells. The distinct profiles of the Lakeland Fells in the wider view tend to attract attention away from the coast, and the view to the coast contains a complex pattern of landscape elements in the foreground. The effect on visual amenity of the proposed offshore wind farm on the Watch Hill viewpoint is considered to be **minor**.

Cumulative effects on visual amenity The cumulative effect on visual amenity is considered to be **moderate / minor** for walkers at the Watch Hill, Cockermouth viewpoint.

Viewpoint 27: Rail route, Workington

The viewpoint is located in the car park at Oldside Wind Farm, 15m AOD, near to the rail route which runs along the coast to the north of Workington, at grid reference E299464 N530133. It has been chosen to provide representative views from the Workington coast to the south east of the proposed development. Is does not provide representative views from the residential area at Workington, where very few views to the coast are available.

Existing view The existing view to the application site is long distance and panoramic to the Dumfries and Galloway coastline in clear weather. The view looking north west to the proposed development consists of undulating improved grassland, golf course and rock outcrops next to a pebble and sand dune beach. The foreground view is dominated by the existing wind turbines at Oldside Wind Farm, car parking and amenities. The photomontage shown in Visualisation 27 is part of a wider view to the north and south along the coast. This tends to be dominated by built elements and urban features such as further wind turbines at Siddick, Siddick Chemical Works and Steel Works. Overall the view is long distance, open, discordant, active and interesting.

Predicted view The wireframe indicates that 60 turbines will be visible on the horizon. Towers and rotor blades of all the turbines will be visible against a background of landscape on the Dumfries and Galloway coast, although only be in clear weather conditions. At this viewpoint, the layout consists of a regular distribution of individual turbines and clustered or rows of turbines with consistent spacing. There tends to be more individual turbines to the north and south of the array and off set rows just to the right of centre. The proposed development is viewed against the distinct profile of coastal uplands around Bengairn and Screel Hill, with the turbines breaking the horizon of the landform. The proposed development will be seen through the existing turbines at Oldside Wind Farm in the foreground.

Magnitude of change The towers and rotors of 60 turbines will be visible from this location, with the closest visible turbine at a distance of 12.8km. The wireframe shows that the array of turbines is consistent and balanced with a horizontal angle of 16.7^{o}.
The horizontal extent of the wind turbines has been minimised during the layout optimisation process. The associated magnitude of change is considered to be **moderate.**

Cumulative magnitude of change From this location the closest existing turbines are those at Oldside Wind Farm at a distance of 57 metres to the west. The nearest turbine at Siddick Wind Farm is at a distance of 1.5km, and the nearest at Lowca Wind Farm 6.5km, although this is beyond the panorama of the view toward the application site. All of the turbines at Siddick and Oldside will visible from this location. The turbines in the Oldside Group will be viewed as prominent vertical features extending north along the coast, occupying 270° of the horizontal angle of the view. The turbines at Siddick will be viewed end on as a linear feature, occupying only 5.8 ° of the horizontal angle of the view. The magnitude of cumulative change is considered to be **moderate.**

Effects on landscape quality The viewpoint is located within the Maryport Coast seascape unit, which is of low quality and low sensitivity to change outwith its area. The character of the Maryport seascape unit is primarily determined by urban areas, industrial developments and existing wind farm developments at Siddick and Oldside. The proposed development will be experienced where views of the coast are available, which tend to be from within an urban context and often constrained by intervening development. The effect of the proposed offshore wind farm on landscape character and quality is considered to be **moderate / minor**.

Cumulative effects on landscape/seascape character and quality The landscape of the Maryport coast seascape unit will be experienced predominantly with both the existing wind turbine developments at Siddick and Oldside and the proposed development simultaneously. The existing turbines occupy a large angle of the view and the proposed development will be seen through gaps between turbines of the existing wind farms. The character of this seascape unit is currently strongly influenced by existing wind turbine developments. There are extensive industrial developments such as chemical works, and it is considered to be of low quality. The introduction of the offshore wind turbines as a single group located over 12.8km distant will increase the prominence of wind energy developments in the seascape unit and the cumulative effect on landscape character and quality is considered to be **moderate**.

Effects on visual amenity The viewpoint is representative of views for rail users on the rail line in Workington, golfers, and walkers/cyclists using the Cumbria Coastal Way. Rail users are considered to be of medium sensitivity due to the speed at which they pass through the landscape and subsequent duration of their viewing time. Golfers are considered to have a medium sensitivity as they are primarily involved in active recreation. Walkers and cyclists using the Cumbria Coastal Way are considered to have a high sensitivity as the receptors place a high value on the amenity of the views and landscape along the duration of the route. The effect on visual amenity of the proposed offshore wind farm on rail users in Workington and golfers is considered to be **moderate**. The effect on walkers and cyclists on the Cumbria Coastal Way and C2C cycle route is considered to be **moderate**.
Cumulative effects on visual amenity The cumulative effect on visual amenity is considered to be **moderate/minor** for rail users and golfers and **moderate** for walkers and cyclists on the Cumbria Coastal Way and C2C cycle route.

Viewpoint 28: Grassmoor

The viewpoint is located at the summit of Grassmoor, 841m AOD, at grid reference E317400 N520400. It is reached via footpath from a car park on the B5289 near Crummock Water the viewpoint provides representative views from the high fells at the western edge of the Lake District and the predicted views towards the proposed development are shown in the wireframe in Visualisation 28.. The viewpoint has not been chosen for detailed assessment because it is over 30km from the proposed development.

Viewpoint 29: Whitehaven Harbour

The viewpoint is located at the southern end of Whitehaven Harbour on a raised area near the Beacon, 30m AOD, at grid reference E297004 N518099. It has been chosen to provide representative views from the residential area and harbour at Whitehaven to the south east of the application site.

Existing view The existing view towards the application site is long distance to the Dumfries and Galloway coast in clear weather. The view looking north west to the proposed development is dominated by Whitehaven Harbour in the foreground, which has a sea lock and sea walls, which enclose the harbour. It is an active harbour with many yachts and fishing vessels. There is a combination of old industrial structures and newly constructed visitor facilities and features in the harbour. The view is enclosed and channelled out to sea by the steepness of the landform around the Harbour, although there are views along the coast to Workington to the north. Two turbines at Lowca Wind Farm can be seen near Cunning Point. From within the harbour, views to the sea tend to be foreshortened by the height of the harbour walls, but the higher areas around the bay offer longer distance sea views. The photomontage shown in Viosualisation 29 is part of a wider view which includes the urban area of Whitehaven to the east. Overall the view is distant, framed, medium scale, colourful, active and interesting.

Predicted view The wireframe indicates that 60 turbines will be visible on the horizon. Towers and rotor blades of all the turbines will be visible against a background of landscape on the Dumfries and Galloway coast, although this will only be in clear weather conditions. At this viewpoint, the layout consists of five distinct rows to the west of the layout, with turbines becoming more random and clustered in the layout to the centre and east. There is an individual turbine isolated to the east of the layout, however on the whole the array appears compact. The proposed development is viewed against the distinct profile of coastal uplands between Bengairn and Criffel, with the turbines just breaking the horizon of the landform, however this will only occur in optimum visibility conditions. The proposed development will be seen in relation to the harbour activities, vertical structures and industry in the foreground view.

Magnitude of change The towers and rotors of 60 turbines will be visible from this location, with the closest visible turbine at a distance of 22.2km. The wireframe shows that the array of turbines is compact with a horizontal angle of 9.2°. The horizontal extent of the wind turbines has been minimised during the layout optimisation process. The associated magnitude of change is considered to be **slight.**

Cumulative magnitude of change From this location the closest existing turbines are those at Lowca Wind Farm at a distance of 4.1km along the coast to the north. The nearest turbine at Oldside Wind Farm further north is at a distance of 11.8km. Only 4 of the turbines at Lowca will be visible, the remainder hidden behind the landform at Cunning Point. The turbines at Lowca occupy 4.1° of the horizontal angle of the view and those at Oldside just 1.6 °. The magnitude of cumulative change is considered to be **slight.**

Effects on landscape/seascape character and quality The viewpoint is located in the Workington and Whitehaven coast seascape unit, which is of low quality and low sensitivity to change outwith its area. Its character and quality is primarily determined by its almost entirely urban coastline, which is dominated by residential and industrial developments. The proposed development will be experienced from this character type where seaward views are available, which tends to be from elevated positions along the coastal cliffs, dropping off sharply inland. The proposed development will add to the man made influences which currently dominate this seascape unit. The effect of the proposed offshore wind farm on landscape character and quality is considered to be **minor**.

Cumulative effects on landscape/seascape character and quality The landscape of the Workington and Whitehaven coast seascape unit will be experienced predominantly with both the existing wind turbine developments at Lowca and Oldside and the proposed development simultaneously. The existing turbines however, occupy a small angle of the view and the proposed development is located at a considerable distance offshore. The character of this seascape unit is currently strongly influenced by existing wind turbine developments and industrial developments such as chemical works, and it is considered to be of low quality. The introduction of the offshore wind turbines as a single group located over 22.2km distant will increase the prominence of wind energy developments in the seascape unit, but the cumulative effect on landscape character and quality is considered to be **minor**.

Effects on visual amenity The viewpoint is representative of views primarily for residents of some areas of Whitehaven, sailing/fishing boat activity in the harbour and tourists visiting new harbour facilities built as part of the recent Millennium Project for the harbour. Residents are considered to be of high sensitivity as they place a high value on the amenity of their primary place of residence. Sailing/fishing boat activities are considered to be of medium sensitivity as they are often engaged in activity within the harbour walls, and tourists are considered to be of high sensitivity as they place a high value on the amenity of the attractions which they visit. The effect on visual amenity of the proposed offshore wind farm on residents and tourists in Whitehaven is considered to be **moderate**, while the effects on sailing/fishing boat activity within the harbour is considered to be **moderate / minor**.

Cumulative effects on visual amenity The cumulative effect on visual amenity for residents and tourists in Whitehaven is considered to be **moderate**, and for sailing/fishing boat activity within the harbour **moderate / minor**.

Viewpoint 30: Lighthouse, St. Bees Head

The viewpoint is located at the lighthouse on St. Bees Head, 81m AOD at grid reference E293999 N514609. It is accessible from a 3km walk along the National Trail footpath from the car park at St. Bees beach. It has been chosen to provide representative views from the National Trail and Heritage Coast at St. Bees Head to the south of the application site.

Existing view The existing view is long distance and panoramic. The existing view north towards the application site is dominated by the open sea of the Solway Firth. The Scottish coast is visible in clear weather, forming a distant backdrop of land. The foreground view consists of high sea cliffs, which descend steeply into the sea, and pastureland with stone wall and fence field boundaries. The national trail footpath is evident along the top of the sea cliffs. Overall the view is long distance, panoramic, harmonious, large scale, exposed and simple.

Predicted view The wireframe indicates that 60 turbines will be visible on the horizon. Towers and rotor blades of all the turbines will be visible against a background of landscape on the Dumfries and Galloway coast, although this will only be in clear weather conditions. At this viewpoint, the layout exhibits a tightly grouped, consistently spaced array of turbines. The layout forms a single isolated feature sitting below the horizon of the landform on the distant Scottish Coast, between the uplands of Bengairn and Criffel. The proposed offshore wind farm will introduce a single group of man made turbines on the horizon in an otherwise regular, flat and simple view with vast areas of open sea.

Magnitude of change The towers and rotors of 60 turbines will be visible from this location, with the closest visible turbine at a distance of 24.9km. The wireframe shows that the array of turbines is compact and distant with a horizontal angle of 8.3°. The horizontal extent of the wind turbines has been minimised during the layout optimisation process. The associated magnitude of change is considered to be **negligible.**

Cumulative magnitude of change From this location the closest existing turbines are those at Siddick and Oldside Wind Farm at a distance of 16.0km north along the coast. The turbines at Lowca and Wharrels Hill are not visible. The turbines at Siddick and Oldside both occupy 1.4° of the horizontal angle of the view. The magnitude of cumulative change is considered to be **slight.**
Effects on landscape/seascape character and quality The viewpoint is located within the St. Bees seascape unit, which is of high quality and high sensitivity to change outwith its area. The effect of the proposed offshore wind farm on landscape character and quality is considered to be **minor / none**.

Cumulative effects on landscape/seascape character and quality The cumulative effect of the proposed development on the landscape character and quality of the St. Bees seascape unit is considered to be **minor**.

Effects on visual amenity The viewpoint is representative of views for walkers using the Cumbria Coastal Way on St. Bees Head. Walkers using the footpath are considered to have a high sensitivity, as they are likely to place a high value on the amenity of the views and landscape along the duration of the route. The footpath from Sandyhills Bay along the coast offers no views to the proposed development until the area near the lighthouse where the view north suddenly opens out. The effect on visual amenity of the proposed offshore wind farm on walkers on the Cumbria Coastal Way at St. bees Head is considered to be **moderate / minor**.

Cumulative effects on visual amenity The cumulative effect on visual amenity for walkers using the Cumbria Coastal Way at St. Bees Head is considered to be **moderate / minor**.

Viewpoint 31: Sea View, Due South

The viewpoint is located offshore, due south of the proposed development at grid reference E290000 N532000 or latitude 54,40,3'N longitude 3,42,9'W. The viewpoint provides representative views from the offshore area to the south of the application site and the predicted views towards the proposed development are shown in the wireframe in Visualisation 31. The viewpoint has not been chosen for detailed assessment because of viewpoint 33, sea view from due west has been chosen to provide representative views from offshore.

Viewpoint 32: Sea View, South West

The viewpoint is located offshore, to the south west of the proposed development at grid reference E284250 N535500 or latitude 54,42,3'N longitude 3,48,2'W. The viewpoint provides representative views from the offshore area to the south west of the application site and the predicted views towards the proposed development are shown in the wireframe in Visualisation 32. The viewpoint has not been chosen for detailed assessment because of viewpoint 33, sea view from due west has been chosen to provide representative views from offshore.

Viewpoint 33: Sea View, Due West

The viewpoint is located offshore, due west of the proposed development at grid reference E281250 N542500 or latitude 54,45,5'N longitude 3,51,0'W. It has been chosen to represent views from offshore.

Existing view The existing view east towards the proposed development consists of an open panorama of seascape with the Cumbrian coastline visible in clear weather conditions.
Predicted view The wireframe indicates that 60 turbines will be visible on the horizon, against a background of landscape on the Cumbrian Coast in clear weather. The proposed offshore wind farm will introduce a single group of man made turbines on the horizon in an otherwise flat and simple view with vast areas of open sea.

Magnitude of change The towers and rotors of 60 turbines will be visible from this location, with the closest visible turbine at a distance of 6.8km. The layout of turbines has a horizontal angle of 26.6°. The horizontal extent of the wind turbines has been minimised during the layout optimisation process. This is the closest viewpoint to the proposed development. The associated magnitude of change is considered to be **substantial.**

Cumulative magnitude of change From this location the closest existing turbines are those at Oldside Wind Farm at a distance of 21.7km east. The turbines at Wharrels Hill are 36.4km distant and unlikely to be visible. The existing turbines in the Oldside Group comprise a small horizontal angle of the view, but may be visible in the distance through and to the south of the proposed offshore wind farm. The magnitude of cumulative change is considered to be **slight.**
Effects on landscape/seascape character and quality The viewpoint is located in the open sea of the Solway Firth, which is considered to be of high quality and high sensitivity to change. The proposed development will introduce a group of man made structures into the open sea and its effects on seascape quality is considered to be **major**.

Cumulative effects on landscape/seascape character and quality The cumulative effect of the proposed development on the landscape and seascape quality of the sea viewpoint is considered to be **minor**.

Effects on visual amenity The viewpoint is representative of views for boat users at sea, consisting mainly of recreational sailing and fishing. Boat users are considered to have a **medium** sensitivity, as they are likely to place a high value on the amenity of the views and seascape. The effect on visual amenity of the proposed offshore wind farm on boat users to the west of the application site is considered to be **major/moderate**.

Cumulative effects on visual amenity The cumulative effect on visual amenity for boat users to the west of the application site is considered to be **moderate / minor**.

The following table provides a summary of the assessment of the effects on landscape and visual amenity at the 16 key viewpoints chosen for the assessment.

Table 9.10.7 Summary of effects on landscape, seascape and visual amenity at the 16 Key Viewpoints

No.	Viewpoint Name	Horizontal Angle (°)	Nearest Visible (km)	Magnitude of change	Landscape/ seascape sensitivity	Effects on landscape/ seascape character and quality	Receptor sensitivity	Effects on visual amenity
1	A711, Auchencairn Topograph	17.0	12.8	Moderate	Medium	Moderate / minor	Road users – High	Moderate
3	Balcary Point	22.7	8.9	Moderate	High	**Major / moderate**	Walkers – High	**Major / moderate**
5	Screel Hill Forest Walk	13.4	16.2	Slight	High	Moderate	Walkers – High	Moderate
9	Mote of Mark, Rockcliffe	16.7	12.3	Moderate	High	**Major / moderate**	Walkers / Visitors – High	**Major / moderate**
10	Castlehill Point	19.4	10.5	Moderate	High	**Major / moderate**	Walkers – High	**Major / moderate**
12	The Torrs, Portling	17.8	11.5	Moderate	High	**Moderate**	Walkers – High	Moderate
14	A710, Mainriddle	12.4	14.4	Moderate	High	Moderate	Road users – Medium	Moderate
15	Southerness Point	12.7	13.0	Moderate	High	**Moderate**	Residents / Tourists – High Golfers – Medium	Moderate Moderate / minor
16	Criffel	9.8	19.4	Slight	High	Moderate	Walkers – High	Moderate
21	Cumbria Coastal Way, Mawbray Bank	11.6	17.0	Slight	High	Moderate	Walkers – High	Moderate
25	Maryport Marina	18.0	12.5	Moderate	Low	Moderate / minor	Residents – High Boat users / fishing – Medium	Moderate Moderate / minor
26	Watch Hill, near Cockermouth	9.3	25.2	Negligible	High	Minor / none	Walkers – High	Minor
27	Rail route, Workington	16.7	12.8	Moderate	Low	Moderate / minor	Rail users / Golfers – Medium Walkers / Cyclists - High	Moderate Moderate

No.	Viewpoint Name	Horizontal Angle (°)	Nearest Visible (km)	Magnitude of change	Landscape/ seascape sensitivity	Effects on landscape/ seascape character and quality	Receptor sensitivity	Effects on visual amenity
29	Whitehaven Harbour	9.2	22.2	Slight	Low	Minor	Residents / Tourists – High Boat users / fishers – Medium	Moderate Moderate / minor
30	Lighthouse, St. Bees Head	8.3	24.9	Negligible	High	Minor / none	Walkers – High	Moderate / minor
33	Sea View, Due West	26.6	6.8	Substantial	High	**Major**	Boats users / fishers – Medium	**Major / moderate**

The following table provides a summary of the cumulative assessment of the effects on landscape and visual amenity at the 16 key viewpoints chosen for assessment.

Table 9.10.8 Summary of cumulative changes on landscape, seascape and visual amenity at the 16 key viewpoints

No.	Viewpoint Name	Cumulative Magnitude of Change	Landscape /Seascape Sensitivity	Cumulative Effects on Landscape / Seascape Character and Quality	Receptor Sensitivity	Cumulative Effects on Visual Amenity
1	A711, Auchencairn Topograph	Negligible	Medium	Minor / none	Road users – High	Minor / none
3	Balcary Point	Negligible	High	Minor	Walkers – High	Minor
5	Screel Hill Forest Walk	Negligible	High	Minor / none	Walkers – High	Minor / none
9	Mote of Mark, Rockcliffe	Negligible	High	Minor / none	Walkers / Visitors – High	Minor / none
10	Castlehill Point	Negligible	High	Minor	Walkers – High	Minor
12	The Torrs, Portling	Negligible	High	Minor / none	Walkers – High	Minor
14	A710, Mainriddle	Negligible	High	Minor / none	Road users – Medium	Minor / none
15	Southerness Point	Negligible	High	Minor / none	Residents/ Tourists – High; Golfers – Medium	Minor Minor / none
16	Criffel	Negligible	High	Minor / none	Walkers – High	Minor / none
21	Cumbria Coastal Way, Mawbray Bank	Negligible	High	Minor	Walkers – High	Minor
25	Maryport Marina	Moderate	Low	Moderate / minor	Residents – High; Boat users / fishing – Medium	Moderate Moderate / minor
26	Watch Hill, near Cockermouth	Negligible	High	Minor	Walkers – High	Moderate / minor
27	Rail route, Workington	Moderate	Low	Moderate	Rail users / Golfers – Medium; Walkers / Cyclists - High	Moderate / minor Moderate
29	Whitehaven Harbour	Slight	Low	Minor	Residents / Tourists – High; Boat users / fishers – Medium	Moderate Moderate / minor
30	Lighthouse, St. Bees Head	Slight	High	Minor	Walkers – High	Moderate / minor
33	Sea View, Due West	Slight	High	Minor	Boats users / fishers – Medium	Moderate / minor

9.10.5 SUMMARY OF RESIDUAL EFFECTS

This section examines the significance of the landscape, seascape and visual effects arising from the proposed offshore wind farm development as follows:

- Effects on landscape and seascape quality - the effects of the proposed development on landscape and seascape quality in the landscape and seascape character types within the study area; and
- Effects on visual amenity - the effects of the proposed development on the visual amenity of the study area;

The effects of a proposed development on the seascape and landscape can be either direct or indirect. Direct effects occur where changes to the fabric of the landscape or seascape arise as the result of physical disturbance, for example the loss of landscape elements. These are limited to the offshore area within the application site boundary. Indirect effects on landscape and seascape quality are consequential changes that are separate from the source of the change in a temporal or spatial manner.

9.10.5.1 Construction Phase

The physical effects of the construction phase of the proposed wind farm on the seascape of the application site will be limited in extent and duration, being limited to the 2 year construction phase. The changes that will occur in the seascape will be the introduction of more human activity, increased movement of boats or barges and associated construction operations, such as pile installation, installation of turbine foundations, and erection of turbines. Construction components will be delivered by sea, road or rail to existing working dock facilities in the study area, therefore visual impacts will be temporary and minor.

These activities will affect a small part of the overall application site leaving the majority of the existing seascape unaffected. Furthermore, the change will be undertaken in such a way as to mitigate the extent of any unnecessary damage, or indirect effects.

For the above reasons, the construction phase of the proposed development is considered to have a minor effect on the seascape of the application site and does not therefore represent a significant effect.

9.10.5.2 Operational Phase Effects on Seascape Quality

The effects of the operational phase of the proposed offshore wind farm on the study area will constitute a change arising from the introduction of operating wind turbines in the open sea. The potential effects on landscape, seascape and visual amenity during the operational phase of the wind farm are summarised below.

Regional seascape units were identified along the coast of the Solway Firth national seascape unit in the 35km radius study area as part of the baseline assessment. Each unit occupies a visually distinct section of coast, with a landward boundary defined by coastal visibility and an undefined seaward boundary. The physical form, views, receptors and boundaries of these seascape units have been described and the quality and sensitivity to change in relation to the development considered. The extent of the seascape units are identified in Figure 7.7.1 in the landscape baseline section of the ES.

The seascape units along the Dumfries and Galloway coastline are of consistently medium to high quality. The coast consists of diverse areas of high sea cliffs, incised bays, sandy beaches, merse and intertidal mudflats. It is relatively unsettled with no major urban area along the coast, but is a working landscape and one which attracts tourists and visitors. The East Stewartry Coast seascape unit has an irregular, indented coastline with a landscape and seascape of great complexity and diversity, and is considered to be of exceptional quality. There are three NSAs along this stretch of coast covering areas around the Fleet Bay, East Stewartry Coast and the Nith Estuary.

Despite the consistently high quality of the seascape units along the Dumfries and Galloway coast, their sensitivity to change to the nature and scale of the proposed development varies considerably. Sensitivity is determined by seascape quality, scale and nature of views. There are incised enclosed bays and seascape units orientated at oblique angles to the coast which have no visibility to the open sea. Conversely there are open stretches of coast and incised bays with views towards the open sea.

The quality of the seascape units along the Cumbrian coast tends to be more variable. The coast consists of essentially a sand dune edge and agricultural hinterland to the north of Maryport and an urban coastline from Maryport to St. Bees Head. The seascape units to the north incorporate the Solway Coast AONB and are of high quality, while the seascape units to the south are dominated by urban, residential and industrial developments and are considered to be of low quality. The Cumbrian coastline exhibits a less varied coastal form than that of the Dumfries and Galloway Coast. It is regular and linear, with gently concave bays. As such, views towards the sea tend to be consistent along the length of the coast, varying with distance but with few areas offering enclosure or containment as in Dumfries and Galloway.

The resulting effects on seascape quality therefore vary according to the seascape quality, sensitivity and magnitude of change caused by the proposed development.

A summary of the potential effects of the proposed offshore wind farm on the seascape quality of the 13 seascape units identified within the study area is provided below:

Dumfries and Galloway Coast

FLEET BAY

Fleet Bay is located to the west of the study area approximately 29km from the proposed development. Its character and quality are predominantly determined by the incised estuary of Fleet Bay, the wooded valley sides of Fleet Valley and dominant upland hill mass of Cairnharrow and outliers on its western side. The quality of this seascape unit is considered to be **high** and the scale of the landscape is variable, with both short and long distance views, including open views to the sea. The sensitivity to change outwith the area is considered to be **high**. As there will be no visibility of the proposed development from Fleet Bay the magnitude of change to this seascape unit caused by the introduction of the proposed development offshore will be **none**. There will therefore be **no effect** arising from the proposed development on the seascape character and quality of the Fleet Bay seascape unit.

KIRKANDREWS PENINSULA

Kirkandrews Peninsula is located to the west of the study area at distances between approximately 22km to 29km from the proposed development. The character of this seascape unit is predominantly determined by its linear expanse of rocky shores, small incised bays and gently undulating hinterland. The quality of this seascape unit is considered to be **medium** and it is considered to have a **medium** sensitivity to change when considered in relation to the proposed development outwith its area. There is almost no visibility of the proposed wind farm to the west of Abbey Head and the associated magnitude of change of the Kirkandrews Peninsula seascape unit caused by the introduction of the proposed development offshore is considered to be **negligible** due principally to the lack of views of the development and intervening distance. The effect of the proposed development on the seascape character and quality of the Kirkandrews Peninsula seascape unit is considered to be **minor**/**none**.

KIRKCUDBRIGHT BAY

Kirkcudbright Bay is located to the west of the study area approximately 21km from the proposed development. The character of this seascape unit is predominantly determined by its distinctive incised coastal form, range of rocky shores, low islands and intertidal sand and mudflats. The quality of this seascape unit is considered to be **high**, and most of the land surrounding the Bay is included in a Regional Scenic Area. The scale of the landscape is varied with both short and long distance views, including views out to sea and it is considered to have a **high** sensitivity to change when considered in relation to the proposed development outwith its area. However the only views of the proposed development will be from the very outer parts of the headlands at the mouth of the bay, and the associated magnitude of change for the Kirkcudbright Bay seascape unit caused by the introduction of the proposed development offshore is considered to be **negligible**. The effect of the proposed development on the seascape character and quality of the Kirkcudbright Bay seascape unit is considered to be **minor** / **none.**

DUNDRENNAN PENINSULA

Dundrennan Peninsula is located approximately 11km to 21km to the north west of the proposed development. The character of this seascape unit is predominantly determined by the linear expanse of rocky shores, sea cliffs and convex sandy bays along the coast and its undulating hinterland. The unit incorporates a large area owned by the MOD that is used for munitions testing. The quality of this seascape unit is considered to be **medium** and it is considered to have a **medium** sensitivity to change when considered in relation to the proposed development outwith its area, primarily due to its existing land use, scale and intermittent nature of views to the coast. Views of the proposed offshore wind farm may be obtained from the area between Abbey Head and Balcary Point. The associated magnitude of change for the Dundrennan Penninsula seascape unit caused by the introduction of the proposed development offshore is considered to be **moderate**. The effect of the proposed development on the seascape character and quality of the Dundrennan seascape unit is considered to be **moderate**.

EAST STEWARTRY COAST

East Stewartry Coast is located approximately 9km to the north of the proposed development. The key characteristics of this landscape type are its incised bays and estuary, prominent headlands, peninsulas, islands and mudflats. The irregular, indented coastline and varied landcover form a landscape of great diversity and it is also a working, inhabited and much visited area. The quality of this seascape unit is considered to be **high** and it is designated as a National Scenic Area. It is considered to have a **high** sensitivity to change when considered in relation to the proposed development outwith its area, principally due its landscape quality and nature of views. The proposed development will be visible from areas where views of the sea are available, which tend to be either suddenly revealed at the coastal edge, elevated points of the surrounding hinterland or channelled along the orientation of the bay. The experience of the bay from the upper shores tends to be intimate, with views channelled along the orientation of the estuary and there are short distance views across the bays. The proposed offshore wind farm will introduce a new focal man-made element to the seascape unit, which will mainly be visible from elevated areas or parts of the coast with views out to the Firth. The associated magnitude of change for the whole of the East Stewartry seascape unit caused by the introduction of the proposed development offshore is considered to be **moderate**, and the effect on landscape and seascape character and quality for those parts of the seascape unit with visibility to the proposed development is considered to be **major**/**moderate.**

MERSEHEAD SANDS

Mersehead Sands is located approximately 11km to the north of the proposed development. The character and quality of this area is primarily derived from the wide tidal flats of the Mersehead Sands occurring at the point where the saltings of Preston Merse meet the fossil cliffs and raised beaches of the Sandyhills coast. The quality of this seascape unit is considered to be **high** and it is considered to have a **high** sensitivity to change when considered in relation to the proposed development outwith its area, principally due to the high quality and open nature of the coast. Sea views tend to be open and unrestricted across the firth from the coastal edge and upland hinterlands, but more intermittent from the flat coastal hinterland. The proposed wind farm will introduce a group of turbines to the seascape forming a distinctive focal element in the open sweep of sea. The associated magnitude of change for the Merseheads Sands seascape unit caused by the introduction of the proposed development offshore is considered to be **moderate**. The effect of the proposed offshore wind farm on landscape character and quality for those areas with visibility to the proposed development is considered to be **major** / **moderate.**

NITH ESTUARY

Nith Estuary is located approximately 13km to 35km to the north east of the proposed development. The character of this seascape unit is predominantly determined by the dramatically contrasting land, sea and sky elements that combine to contribute to a landscape of contrast and diversity. The quality of this seascape unit is considered to be **high**, mostly designated as a National Scenic Area. The landscape is generally large scale with open views and it is considered to have a **high** sensitivity to change when considered in relation to the proposed development outwith its area. However, views of the proposed offshore wind farm are distant and limited to the eastern section of the unit around Caerlaverock as the granite mass of Criffel screens views from much of the area. The proposed wind farm will be visible as a distant, man-made element in the open sea. The associated magnitude of change for the Nith Estuary seascape unit caused by the introduction of the proposed development offshore is considered to be **slight**.

The effect of the proposed development on the seascape character and quality of the Nith Estuary seascape unit is considered to be **moderate**.

Cumbrian Coast

MORICAMBE BAY

Moricambe Bay is located approximately 28km to 35km to the north east of the proposed development. The character of this seascape unit is predominantly determined by its incised coastal form, flat estuary, mudflats and coastal marshes. The quality of this seascape unit is considered to be **high** and most of it is designated as an Area of Outstanding Natural Beauty. The scale of the landscape is medium and views correspondingly of mainly short to medium distance, with limited visibility to adjacent areas. It is considered to have a **medium** sensitivity to change when considered in relation to the proposed development outwith its area. Views across the Firth tend to be open and long distance and orientated north west towards the Dumfries and Galloway coastline, and the vertical forms of the masts at Cardurnock are prominent throughout this seascape unit. The proposed offshore wind farm may be visible as a very distant element in very clear weather.. The associated magnitude of change for the Moricambe Bay seascape unit caused by the introduction of the proposed development offshore is considered to be **slight**. The effect of the proposed development on the seascape character and quality of the Moricambe Bay seascape unit is considered to be **moderate/minor**.

SILLOTH COAST

Silloth Coast is located approximately 18km to 28km to the north east of the proposed development. The character of this unit relies on its expansive views of the Scottish hills, the seascapes of the Solway Firth and on its largely unspoilt dune topography and vegetation. The quality of this seascape unit is considered to be **high** and it is considered to have a **high** sensitivity to change when considered in relation to the proposed development outwith its area, principally due to the openness of views to adjacent areas. Views of the proposed development tend to be more open and longer distance from the coastal edge. The associated magnitude of change for the Silloth Coast seascape unit caused by the introduction of the proposed development offshore is considered to be **slight** primarily due to the distance between the unit and the proposed development. The effect of the proposed offshore wind farm on the landscape character and quality of the Silloth Coast seascape unit is considered to be **moderate**.

ALLONBY BAY

Allonby Bay is located approximately 16km to the east of the proposed development. The character of this seascape unit is predominantly determined by its elongated concave bay, intertidal foreshore, scar ground, dune topography and associated vegetation. The landscape of this area is not designated, though the quality of this seascape unit is considered to be **high.** The scale of the landscape is generally medium to large and views are correspondingly medium to long distance**.** It is considered to have a **high** sensitivity to change when considered in relation to the proposed development outwith its area. There are expansive views of the Scottish hills and the seascape of the Solway Firth, however, the proposed offshore wind farm will be located at over 16km distance from the coastal edge, and greater distances inland. The associated magnitude of change for the Allonby Bay seascape unit caused by the introduction of the proposed development offshore is considered to be **moderate**. At such distances, the effect of the proposed development on the seascape character and quality of the Allonby seascape unit is considered to be **moderate**.

MARYPORT COAST

Maryport Coast is located from approximately 11km to the east of the proposed development. The character of the Maryport seascape unit is primarily determined by urban areas, which includes existing wind farm developments at Siddick and Oldside, and industrial developments. The quality of this seascape unit is considered to be **low** and it is considered to have a **low** sensitivity to change when considered in relation to the proposed development outwith its area, principally due to the existing landscape quality and nature of viewss. Views of the proposed development will tend to be from within an urban context, often constrained by intervening development and over 11km in distance. The associated magnitude of change for the Maryport Coast seascape unit caused by the introduction of the proposed development offshore is considered to be **moderate**. The effect of the proposed offshore wind farm on seascape character and quality is considered to be **moderate** / **minor**.

WORKINGTON AND WHITEHAVEN COAST

Workington and Whitehaven coast is located from approximately 14km to 26km to the south east of the proposed development. Its character and quality are primarily determined by its almost entirely urban coastline, which is dominated by residential and industrial developments. It is considered to be of **low** quality and **low** sensitivity to change when considered in relation to the proposed development outwith its area, principally due to its low quality and the nature of views. The proposed development will be seen from this seascape unit where seaward views are available, which tend to be from elevated positions along the coastal cliffs, dropping off sharply inland. The proposed development will add to the man made influences which currently dominate this seascape unit. The associated magnitude of change for the Workington and Whitehaven coast seascape unit caused by the introduction of the proposed development offshore is considered to be **moderate** mainly due to the distance between the unit and the proposed development**,** The effect of the proposed offshore wind farm on seascape character and quality is considered to be **moderate/minor.**

ST. BEES

St. Bees is located to the south of the study area approximately 24km from the proposed development. Its character and quality are primarily determined by dramatic sea cliffs composed of striking red sandstone over 100 metres high and extensive linear sandy beaches to the south. The quality of this seascape unit is considered to be **high** and the coastal edge is a Heritage Coast, and the hinterland formed part of a Landscape of County Imporatance. Views from the elevated cliffs towards the sea are long distance and open and it is of **high** sensitivity to change when considered in relation to the proposed development outwith its area. However, views of the proposed development are distant and restricted to the elevated areas on St. Bees Head, and there are no views of the proposed development from most of the area to the south of St. Bees Head. The associated magnitude of change of the St. Bees seascape unit caused by the introduction of the proposed development offshore is therefore considered to be **slight** mainly due to the limited area from which the wind farm will be visible and the intervening distance. The effect of the proposed development on the seascape character and quality of the St. Bees seascape unit is considered to be **minor.**

A summary table of the potential effects of the proposed offshore wind farm on the seascape quality of the seascape units identified within the study area is provided below:

Table 9.10.9: Summary of effects of proposed wind farm on seascape units

Seascape Unit	Quality	Sensitivity to change in relation to the proposed development	Magnitude of Change	Effect on seascape quality
Dumfries & Galloway Coast				
FLEET BAY	High	High	None	None
KIRKANDREWS PENINSULA	Medium	Medium	Negligible	Minor / none
KIRKCUDBRIGHT BAY	High	High	Negligible	Minor / none
DUNDRENNAN PENINSULA	Medium	Medium	Moderate	Moderate
EAST STEWARTRY COAST	High	High	Moderate	**Major / moderate**
MERSEHEAD SANDS	High	High	Moderate	**Major / moderate**
NITH ESTUARY	High	High	Slight	Moderate
Cumbrian Coast				
MORECAMBE BAY	High	Medium	Slight	Moderate / minor
SILLOTH COAST	High	High	Slight	Moderate
ALLONBY BAY	High	High	Moderate	Moderate
MARYPORT COAST	Low	Low	Moderate	Moderate / minor
WORKINGTON AND WHITEHAVEN COAST	Low	Low	Moderate	Moderate / minor
ST. BEES	High	High	Slight	Minor

9.10.5.2 Operational Effects on Landscape Character and Quality

Landscape character types were identified beyond the landward boundary of the seascape units in the 35km radius study area as part of the baseline assessment and are illustrated in Figure 7.7.1 in Section 7.7 of this ES. Having reviewed existing landscape character assessments completed by SNH and Cumbria County Council, and verified these assessments in the field, 18 landscape character types which occur within the study area have been used as the basis for describing the landscape. The topography, land-use, landcover, scale, views, and receptors of these landscape types have been described and the quality and sensitivity to change in relation to the development considered.

The landscape types in the Dumfries and Galloway section of the study area are of consistently medium to high quality. The landscape consists of a variety of lowland and upland landscape types, but the majority of the area consists of coastal granite uplands rising steeply from the coast and drumlin pastures at lower elevations to the north of the uplands. The sensitivity of the landscape types identified in the Dumfries and Galloway section of the coast tend to be low, mainly due to the lack of views to the coastal area and adjacent landscape and seascape units, which are often screened by intervening coastal granite uplands. The coastal granite uplands are the most sensitive landscape type due to their elevated position and proximity to the coast, with open views across the Solway Firth.

The landscape types in the Cumbrian section of the study area are also of consistently medium to high quality. The landscape consists of large areas of lowland agricultural land along the landward boundaries of the seascape units, which rises to upland fringes and eventually the high fells of the Lake District to the east of the study area. Valleys and lakes form important and distinctive features. The sensitivity of the landscape types tends to be medium to high, mainly due to the quality of the landscape, its scale and nature of views.

A summary of the potential effects of the proposed offshore wind farm on the landscape character and quality of the landscape types identified within the study area is provided below:

Dumfries and Galloway

COASTAL FRINGE

The coastal fringe is located approximately 14km to the north west of the proposed development. Its character and quality are primarily determined by its gently undulating topography, smooth hill pastures and gorsey knolls. It is considered to be of **medium** quality and has a **medium** sensitivity to change when considered in relation to the proposed development outwith its area. The proposed development will not be seen from most of this character type as there are only fleeting glimpses of the sea from this landscape character type. The associated magnitude of change of the coastal fringe landscape type caused by the introduction of the proposed development offshore is considered to be **slight**. The effect of the proposed offshore wind farm on landscape character and quality is considered to be **minor.**

COASTAL FLATS

The coastal flats landscape is located approximately 26km to the north east of the proposed development. Its character and quality are primarily determined by areas of farmed pasture and arable cultivation, and mosses with poor drainage, rushes and areas of low shrubs. This character type forms the landward boundary of seascape units along the Nith Coast and Inner Solway and is often experienced in relation to nearby coastal uplands, which rise steeply from the coastal flats. It is considered to be of **high** quality and has a **high** sensitivity to change when considered in relation to the proposed development outwith its area.

Views from this landscape type are open and long distance to the south across the coast and contained to the west by coastal uplands. The proposed development may be visible from areas to the south east of Lochar Moss but at distance of over 26km. The associated magnitude of change in the coastal flats landscape type caused by the introduction of the proposed development offshore is considered to be **slight**. The effect of the proposed offshore wind farm on landscape character and quality is considered to be **minor.**

NARROW WOODED VALLEY

The Narrow wooded valley landscape is located approximately 17km to the north and 32km to the north west of the proposed development. Its character and quality are primarily determined by the trough shaped river valley with pasture and arable valley floor enclosed by steep wooded slopes. It is considered to be of **medium** quality, of small to medium scale and with largely enclosed views affording almost no visibility to adjacent landscape areas. It is therefore considered to have a **low** sensitivity to change when considered in relation to the proposed development outwith its area. There will be very limited locations from where the proposed development will be visible due to the enclosed nature of the valley. The associated magnitude of change of the narrow wooded valley landscape type caused by the introduction of the proposed development offshore is therefore considered to be **negligible**. The effect of the proposed offshore wind farm on landscape character and quality is considered to be **minor**/**none.**

LOWER DALE

The lower dale landscape is located approximately 28km to the north east of the proposed development. Its character and quality are primarily determined by wide, flat, gently undulating valleys and nearby coastal flats. It is considered to be of **medium** quality and has a **low** sensitivity to change when considered in relation to the proposed development outwith its area, due to the limited visibility to adjacent landscapes. There are no views of the proposed development available in this landscape type, therefore there will be no change caused by the proposed development. The associated magnitude of change of the lower dale landscape type caused by the introduction of the proposed development offshore is therefore considered to be **negligible**. The effect of the proposed offshore wind farm on landscape character and quality is considered to be **none.**

FLOODED VALLEY

The flooded valley landscape is located approximately 30km to the north west of the proposed development. Its character and quality are primarily determined by the extensive water body lying in a generally shallow valley with a narrow valley floor. It is considered to be of **high** quality, of small to medium scale and with short to medium distance views, which are confined to the landscape unit affording limited visibility to adjacent landscape areas. It therefore has a **low** sensitivity to change when considered in relation to the proposed development outwith its area. Views are constrained by surrounding upland landscape types and there is almost no visibility of the proposed development some 30km outwith its area. The associated magnitude of change in the flooded valley landscape type caused by the introduction of the proposed development offshore is considered to be **negligible**. The effect of the proposed offshore wind farm on landscape character and quality is considered to be minor / **none.**

DRUMLIN PASTURES

The drumlin pastures landscape is located approximately 21km to the north west of the proposed development. Its character and quality are primarily determined by its smooth distinctive drumlin landform and improved pastures. It is considered to be of **medium** quality and has a **medium** sensitivity to change when considered in relation to the proposed development outwith its area. Views tend to be constrained by neighbouring upland landscape types and local topography, particularly by the coastal granite uplands which are situated between the drumlin pastures and the coast. There are patches of distant visibility from raised areas of this landscape type near Kirkpatrick Durham and Springholm. The associated magnitude of change of the drumlin pastures landscape type caused by the introduction of the proposed development offshore is considered to be **slight**. The effect of the proposed offshore wind farm on landscape character and quality is considered to be **minor**.

DUMFRIES AND GALLOWAY UPLAND FRINGE

The Dumfries and Galloway upland fringe is located approximately 30km to the north of the proposed development. Its character and quality are primarily determined by elevated rolling pastures, squared forest blocks and contrasting open and enclosed areas. It is considered to be of **medium** quality and has a **medium** sensitivity to change when considered in relation to the proposed development outwith its area. There is no visibility of the proposed development from this character type. There is therefore **no** magnitude of change to the upland fringe landscape type caused by the introduction of the proposed development offshore and there will be **no** effect on the landscape character and quality of the upland fringe**.**

FOOTHILLS

The foothills landscape is located approximately 30km to the north west and 32km to the north of the proposed development. Its character and quality are primarily determined by elevated upland topography with pastureland and some plantation woodland. It is considered to be of **medium** quality with medium to long distance views, but with limited views to adjacent landscape areas. It has a **medium** sensitivity to change when considered in relation to the proposed development outwith its area. There are isolated areas of visibility towards the application site from the highest parts of this landscape type, however the proposed development will be over 30km distant. The associated magnitude of change of the foothills landscape type caused by the introduction of the proposed development offshore is considered to be **slight**. The effect of the proposed offshore wind farm on landscape character and quality is considered to be **minor.**

FOOTHILLS WITH FOREST

The foothills with forest landscape is located approximately 28km to the north west of the proposed development. Its character and quality are primarily determined by blanket forest covering upland topography. It is considered to be of **medium** quality, with medium to long distance views, but limited visibility to adjacent landscape areas, largely due to the extensive forest cover. It has a **low** sensitivity to change when considered in relation to the proposed development outwith its area. There are small patches of visibility towards the proposed off shore wind farm indicated on the ZVI, however views from the ground are likely to be constrained by intervening woodland vegetation. The associated magnitude of change of the foothills with forest landscape type caused by the introduction of the proposed development offshore is considered to be **slight**. The effect of the proposed offshore wind farm on landscape character and quality is considered to be **minor.**

COASTAL GRANITE UPLANDS

The coastal granite uplands landscape is located approximately 13km to the north of the proposed development in a band along the Dumfries and Galloway coast. Its character and quality are primarily determined by rugged granite hills which rise steeply from flat coastal areas. Part of this landscape unit is a Regional Scenic Area, with long distance views and a large scale landscape. It is considered to be of **high** quality and has a **high** sensitivity to change when considered in relation to the proposed development outwith its area. There will be widespread visibility of the proposed development from elevated upland areas of this character type and the layout of proposed wind turbines will be visible against the sea surface.

The associated magnitude of change of the coastal granite uplands landscape type caused by the introduction of the proposed development offshore is considered to be **moderate**. The effect of the proposed offshore wind farm on landscape character and quality is considered to be **moderate,** primarily due to the intervening distance between the proposed off shore development and this landscape type**.**

Cumbria

LOWLAND

The lowland landscape is located approximately 15km to the east of the proposed development. Its character and quality are primarily determined by its gently rolling landform of pasture and arable land. It is considered to be of **medium** quality and has a **medium** sensitivity to change when considered in relation to the proposed development outwith its area. There are some open views over the Solway Firth and the proposed development is likely to be seen as a distant offshore element in some parts of this landscape type. The associated magnitude of change of the lowland landscape type caused by the introduction of the proposed development offshore is considered to be **moderate.** The effect of the proposed offshore wind farm on landscape character and quality is considered to be **moderate**.

LOWLAND VALLEY CORRIDOR

The lowland valley corridor landscape is located approximately 16km to the east of the proposed development. Its character and quality are primarily determined by its distinctive valley topography, intact river valley and range of urban and agricultural land uses. It is considered to be of **medium** quality and has a **low** sensitivity to change when considered in relation to the proposed development outwith its area, due primarily to the lack of visibility of adjacent landscape areas. Views from this landscape type are corridor views, often confined by the valley sides or contained by settlements or small woodlands. The associated magnitude of change of the lowland valley corridor landscape type caused by the introduction of the proposed development offshore is considered to be **slight.** The effect of the proposed offshore wind farm on landscape character and quality is considered to be **minor**.

INTERMEDIATE MOORLAND AND PLATEAU

The intermediate moorland and plateau landscape is located approximately 21km to the south east of the proposed development. Its character and quality is primarily determined by the open moorlands and ridges that link to higher limestone areas on the fringe of the Lake District National Park. Part of the area is a County Landscape, and it is considered to be of **medium** quality, of medium to large scale with open, long distance views, including views to the coast. It is considered to have **medium** sensitivity to change when considered in relation to the proposed development outwith its area. There are long distance views toward the application site from the ridges of this landscape type. The associated magnitude of change of the intermediate moorland and plateau landscape type caused by the introduction of the proposed development off shore is considered to be **sight,** largely due to the limited extent of visibility and the distance from the development. The effect on landscape character and quality is considered to be **moderate**/**minor**.

CUMBRIAN UPLAND FRINGE

The Cumbrian upland fringe landscape is located approximately 25 km to the south east of the proposed development. Its character and quality is primarily determined by its elevated rolling landform which forms an upland fringe to the high fells of the Lake District. It is considered to be of high quality with a **high** sensitivity to change when considered in relation to the proposed development outwith its area. There may be long distance views of the proposed development from the most elevated areas of this landscape type. The associated magnitude of change of the Cumbrian upland fringe landscape type caused by the introduction of the proposed development offshore is considered to be **slight**, primarily due to the limited extent of visibility and the intervening distance. The effect of the proposed offshore wind farm on landscape character and quality is considered to be **minor**.

HIGHER LIMESTONE

The higher limestone landscape is located approximately 21 km to the east/south east of the proposed development. Its character and quality are primarily determined by the rolling open pastures which links the rolling lowland, ridges and valleys to the high fells of the Lake District. It is considered to be of **high** quality and of **high** sensitivity to change when considered in relation to the proposed development outwith its area. There may be long distance views of the proposed development from the fell tops of this landscape type, but due to the intervening distance, the associated magnitude of change of the higher limestone landscape caused by the introduction of the proposed development offshore is considered to be **slight**. The effect of the proposed offshore wind farm on landscape character and quality is considered to be **minor**.

LAKELAND HIGH FELLS

The lakeland high fells are located approximately 26 km to the south east of the proposed development. Its character and quality are primarily determined by its spectacular and rugged mountain scenery of open fells with an expansive character and a mosaic of high craggy peaks. It is considered to be of **exceptional** quality, and is within the Lake District National Park, with long distance, open views to adjacent landscape and seascape units. It has a **high** sensitivity to change when considered in relation to the proposed development outwith its area. There may be long distance views of the proposed development from the summits of the fells in this landscape type.

However, due to the distance between this landscape and the proposed development, the associated magnitude of change of the Lakeland high fells landscape type caused by the introduction of the proposed development offshore is considered to be **slight.** The effect of the proposed offshore wind farm on landscape character and quality is considered to be **minor**.

LAKELAND LAKES AND VALLEYS

The Lakeland lakes and valleys are located approximately 24km to the east / south east of the proposed development. Its character and quality are primarily determined by its sheltered upland valleys and open water enclosed by the Lakeland Fells. It is considered to be of **exceptional** quality and lies within the Lake District National Park. Views tend to be contained and limited by the topography and there is therefore limited visibility to adjacent landscape or seascape units, and it therefore has a **low** sensitivity to change when considered in relation to the proposed development outwith its area. The proposed development is located offshore over 24km from this landscape type, which is generally contained by the high fells and offers limited visibility of the site. The associated magnitude of change of the Lakeland lakes and valleys landscape type caused by the introduction of the proposed development offshore is considered to be **negligible.** The effect of the proposed offshore wind farm on landscape character and quality is considered to be **minor**/**none.**

COASTAL MARGINS

The coastal margins landscape is located approximately 30km to the north east of the proposed development. Its character and quality are primarily determined by mosses and plain areas around Wedholme Flow, consisting of flat to undulating peat bogs or raised mires and areas of improved pasture divided into large square fields. It is considered to be of **medium** quality and has a**medium** sensitivity to change when considered in relation to the proposed development outwith its area. Views of the proposed development from this landscape type are distant and intermittent. The associated magnitude of change of the coastal margins landscape type caused by the introduction of the proposed development offshore is considered to be **slight.** The effect of the proposed offshore wind farm on landscape character and quality is considered to be **minor.**

A summary of the potential effects of the proposed offshore wind farm on the landscape quality of the landscape types identified within the study area is provided in the following table.

Table 9.10.10: Summary of potential effects of proposed wind farm on landscape quality

Landscape Character Type	Quality	Sensitivity to change in relation to the proposed development	Magnitude of Change	Effect on landscape quality
Dumfries & Galloway				
COASTAL FRINGE	Medium	Medium	Slight	Minor
COASTAL FLATS	High	High	Slight	Minor
NARROW WOODED VALLEY	Medium	Low	Negligible	Minor / none
LOWER DALE	Medium	Low	Negligible	None
FLOODED VALLEY	High	Low	Negligible	Minor / none
DRUMLIN PASTURES	Medium	Medium	Slight	Minor
UPLAND FRINGE	Medium	Medium	Negligible	None
FOOTHILLS	Medium	Medium	Slight	Minor
FOOTHILLS WITH FOREST	Medium	Low	Slight	Minor
COASTAL GRANITE UPLANDS	High	High	Moderate	Moderate
Cumbria				
LOWLAND	Medium	Medium	Moderate	Moderate
LOWLAND VALLEY CORRIDOR	Medium	Low	Slight	Minor
INTERMEDIATE MOORLAND AND PLATEAU	Medium	Medium	Slight	Moderate / minor
CUMBRIA UPLAND FRINGE	High	High	Slight	Minor
HIGHER LIMESTONE	High	High	Slight	Minor
LAKELAND HIGH FELLS	Exceptional	High	Slight	Minor
LAKELAND LAKES AND VALLEYS	Exceptional	Low	Negligible	Minor / none
COASTAL MARGINS	Medium	Medium	Slight	Minor

9.10.5.3 Summary of Effects on Landscape Designations

National Scenic Areas

NITH ESTUARY NSA

The Nith Estuary NSA is located approximately 17km to the north east of the proposed development. Its character and quality are predominantly determined by extensive sands, mudflats and saltings of an openness and horizontal scale unusual in Scotland, which are complemented and enhanced by the presence of the granite cone of Criffel. The Nith Estuary NSA is considered to be of high quality and the NSA has a **high** sensitivity to change when considered in relation to the proposed development mainly due to the high quality of the landscape, scale and nature of views in the NSA.. However, the proposed wind farm will not be visible from the western edge of the Nith Estuary seascape unit as views tend to be screened by Criffel. There may be varying long distance visibility of between 1 - 60 turbines, on the north east side of the Estuary. The associated magnitude of change of the Nith Estuary NSA caused by the introduction of the proposed development offshore is considered to be **slight.** The effect on landscape character and quality of the proposed wind farm on the Nith Estuary NSA is considered to be **moderate**.

EAST STEWARTRY COAST NSA

The East Stewartry Coast NSA is located approximately 9km to the north west of the proposed development. Its character and quality are predominantly determined by its incised bays and estuary, prominent headlands, peninsulas, islands and mudflats, contrasting with coastal granite uplands. The irregular, indented coastline and varied landcover form a landscape of great diversity and contributes to an intimate landscape with mainly short to medium length views. It is also a working, inhabited and much visited area. The East Stewartry Coast NSA is considered to be of **high** quality and has a **high** sensitivity to change when considered in relation to the proposed development outwith its area. The landscape and seascape of the area will be experienced in relation to the proposed development from areas where views of the sea are available, which tend to be either suddenly revealed at the coastal edge, elevated parts of the surrounding hinterland or channelled along the orientation of the bay. There are many areas of hinterland to the south of the A711 for example, which have a lower elevation than the raised coastal headlands, which screen views to the coast. Islands and peninsulas also enclose views. The proposed offshore wind farm will introduce a new focal man-made element to the seascape, which will mainly be visible from elevated areas or parts of the coast with views out to the Firth. The associated magnitude of change by the introduction of the proposed development offshore is considered to be **moderate.** The effect of the proposed offshore wind farm on the landscape and seascape quality of those parts of the NSA from where the development will be visible is considered to be **major/moderate.** From a large portion of the NSA, the proposed wind farm will not be visible and there will be no effect on the landscape character and quality.

FLEET VALLEY NSA

The Fleet Valley NSA is located from approximately 32km to the west / north west of the proposed development. Its character and quality are predominantly determined by the incised estuary of Fleet Bay, the wooded valley sides of fleet valley and dominant upland hill mass of Cairnharrow and outliers on its western side. The Fleet Valley NSA is considered to be of **high** quality and has a **high** sensitivity to change when considered in relation to the proposed development outwith its area. The coast forms an incised bay which is orientated to the south west and there are no views of the proposed development from the Fleet Valley NSA. The associated magnitude of change of the Fleet Valley NSA is considered to be **none**. Therefore, there will be **no effect** on the landscape character and quality arising from the proposed offshore wind farm on the Fleet Valley NSA**.**

Regional Scenic Areas

SOLWAY COAST RSA

The Solway Coast RSA embraces the varied coastlines stretching from the Fleet valley in the west to Powfoot in the east. At its closest the RSA around Dundrennan Peninsula, is approximately 11km to the north west of the proposed development. The designation links and includes the NSAs along the Dumfries and Galloway coast covering a wide area and diversity of coastal landscape types. For the purposes of this assessment, the potential effects on the landscape quality of the RSA are concentrated on the areas outside the NSA designations, because the latter are described above. The Solway Coast RSA is considered to be of **high** quality with a **high** sensitivity to change when considered in relation to the proposed development. However, there will be very few views available of the proposed development to the west of Abbey Head. In the stretch of the RSA between Abbey Head and Balcary Point, on the Dundrennan Peninsula, there will be visibility of the proposed development. From the coastal granite upland areas within the Solway Coast RSA there is long distance visibility from the summits of the hills. The associated magnitude of change of the Solway Coast RSA caused by the introduction of the proposed development offshore is considered to be **moderate.** Overall, the effect on landscape character and quality of the proposed wind farm on the Solway Coast RSA is considered to be **moderate.**

GALLOWAY HILLS RSA

The Galloway Hills RSA is located approximately 28km to the north west of the proposed development. Only the southern section of the RSA is situated within the study area, incorporating the valley of Loch Ken and the area around the Fleet Valley NSA. The Galloway Hills RSA is considered to be of **high** quality. It is a large scale landscape with medium to long distance views, although there are limited views of the coast and it therefore has a **medium** sensitivity to change when considered in relation to the proposed development outwith its area. There are very few available views of the proposed development from the Galloway Hills RSA therefore it will rarely be experienced in relation to the proposed development. The associated magnitude of change of the Galloway Hills RSA caused by the introduction of the proposed development offshore is considered to be **slight**. The effect on landscape character and quality of the proposed wind farm on the Galloway Hills RSA is considered to be **minor/none.**

TERREGLES RIDGE RSA

The Terregles Ridge RSA is located approximately 30km to the north of the proposed development. The area forms a diverse landscape of transitional uplands and valleys to the west of Dumfries. A small area of the RSA is located within the study area. The Terregles RSA is considered to be of **high** quality and has a **low** sensitivity to change when considered in relation to the proposed development outwith its area, primarily due to the nature of views, which restrict visibility to the coastal seascapes. There are no available views of the proposed development from the Terregles Ridge RSA therefore it will not be seen in relation to the proposed development. Consequently, there will be no magnitude of change and no effect on the landscape character and quality of the Terregles Ridge RSA.

The Lake District National Park

The western extremities of the Lake District National Park (LDNP) are located within the 35km study area, approximately 24km to the south east of the proposed development. The character and quality of the park are predominantly determined by its diversity of landscape, spectacular open high fells, lakes, tarns and rivers, and opportunities for quiet and active outdoor recreation. The LDNP is considered to be of **exceptional** quality and has a **high** sensitivity to change when considered in relation to the proposed development outwith its area. Views of the proposed development from the LDNP may be available in clear weather conditions, over very long distances from the summits of the fells. The view of the coast will be part of the wider panoramic view from the high fells, which include the dramatic profiles of the surrounding fells and areas of open water and valleys in the LDNP. As such, the coast and proposed offshore wind farm will form a minor element in the view and only visible in particularly clear weather conditions. The associated magnitude of change of the LDNP caused by the introduction of the proposed development offshore is considered to be **slight**. The effect on the landscape character and quality of the LDNP is considered to be **minor**.

The Solway Coast AONB

The Solway Coast AONB is located along the Cumbrian coast between Maryport and the Inner Solway at distances from approximately 13km east to over 35km north east of the proposed development. The area is predominantly agricultural in character and contains a rich variety of habitats and landscapes including sand dunes, salt marsh, intertidal mudflats and sand and shingle beaches. It is considered to be of **high** quality and has a **medium** sensitivity to change when considered in relation to the proposed development outwith its area. Coastal areas offer expansive views over the Solway Firth and it is likely that 46-60 turbines of the proposed development will be visible from the section of coast between Maryport and Silloth. Visibility to the offshore wind farm, becomes more distant and intermittent to the north east of Silloth around Moricambe Bay and Cardurnock. At such distances, the turbines will be distant elements and occupy a small portion of the overall field of view. Although the ZVI indicates that much of the AONB has visibility of the proposed development, the turbines will be at distances from 13km to 35km from this area. The associated magnitude of change of Solway Coast AONB caused by the introduction of the proposed development offshore is considered to be **moderate/slight.** The effect on the landscape character and quality of the AONB is therefore considered to be **moderate** in the southern section between Maryport and Silloth, and **moderate/minor** in the area to the north east of Silloth around Moricambe Bay.

St. Bees Heritage Coast

St. Bees Heritage Coast is located approximately 26km to the south east of the proposed development. Its character and quality is primarily determined by dramatic sea cliffs composed of striking red sandstone over 300 feet high. It is considered to be of **high** quality and has a **high** sensitivity to change when considered in relation to the proposed development outwith its area. Views of the proposed development are distant and restricted to the elevated areas on St. Bees Head, and there are no views of the proposed development most of the area to the south of St. Bees Head. The associated magnitude of change of the St. Bees Heritage Coast caused by the introduction of the proposed development offshore is therefore considered to be **slight.** The effect of the proposed development on the seascape character and quality of the St. Bees seascape unit is considered to be **minor**.

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Landscapes of County Importance

The area of County Landscape designation is located approximately 22km to the south east of the application site, mainly situated around existing national landscape designations at St. Bees Heritage Coast, the LDNP and the Solway Coast AONB. It is considered to be of **high** quality and has some of the most attractive Cumbrian landscape outside the nationally designated areas. There may be long distance views of the proposed development from the most elevated areas of this area. The County Landscape has a **medium to high** sensitivity to change when considered in relation to the proposed development due to the intervening distance. The associated magnitude of change of the Landscape of County Importance caused by the introduction of the proposed development offshore is considered to be **slight,** primarily due to the limited visibility of the development and the intervening distance**.** The effect on landscape quality of the proposed development on areas of County Landscape is considered to be **moderate** / **minor.**

The following table summarises the effects of the proposed wind farm on landscape designation within the study area.

Table 9.10.11 Summary of effect of proposed wind farm on landscape designations

Designated Landscape	Quality	Sensitivity to change in relation to the proposed development	Magnitude of change	Effect on landscape quality of designated area	Notes
National Scenic Areas in Scotland					
NITH ESTUARY NSA	High	High	Slight	Moderate	The proposed wind farm will not be visible from the western edge of the Nith Estuary seascape unit, and there will be visibility of between 1 - 15 turbines, on the north east side of the Estuary.
EAST STEWARTRY COAST NSA	High	High	Moderate	**Major / moderate**	The proposed wind farm will not be visible over a large part of the NSA.
FLEET VALLEY NSA	High	High	None	None	
Regional Scenic Areas in Scotland					
SOLWAY COAST RSA	High	High	Moderate	Moderate	
GALLOWAY HILLS RSA	High	Medium	Slight	Minor / none	
TERREGLES RIDGE RSA	High	Low	None	None	
National Parks in England					
THE LAKE DISTRICT NATIONAL PARK	Exceptional	High	Slight	Minor	
Heritage Coasts					
ST. BEES HERITAGE COAST	High	High	Slight	Minor	
Areas of Outstanding Natural Beauty in England					
THE SOLWAY COAST AONB	High	Medium	Moderate / slight	Moderate and moderate / minor	Effect on AONB quality considered to be major/moderate only in southern area between Maryport and Silloth – area to north around Moricambe Bay less effects
Landscapes of County Importance in England					
LCI	High	Low/medium	Slight	Moderate / minor	

Sites listed in the inventory of Historic Gardens and Designed Landscapes within Scotland

ARBIGLAND (Grid Ref NX 990 574)

Arbigland is located approximately 19km to the north east of the application site, situated on the western shore of the Nith estuary is within the area from where 46-60 turbines will be visible, however local topography, buildings and vegetation are likely to restrict full views of the proposed development.

BARNHOURIE MILL (Grid Ref NX 889 553)

Barnhourie Mill is located approximately 14.5km to the north of the proposed development. The grid reference given for Barnhourie Mill suggests that it may lie just outside of the ZVI, although exact property boundaries are not known. Woodland vegetation around Barnhourie Mill is likley to restrict full views of the proposed development.

BROOKLANDS (Grid Ref NX 811 731)

Brooklands is located approximately 34.5km to the north of the proposed development. It is further inland but elevated, in an area from where 46-60 turbines will be visible, however local topography, buildings and vegetation are likely to restrict full views of the proposed development, which if visible would only be seen in clear weather conditions.

BROUGHTON HOUSE (Grid Ref NX 685 510)

Broughton House is located approximately 24km to the north west of the proposed development. According to the ZVI there is no visibility of the proposed development from Broughton House.

CALLY PALACE (Grid Ref NX 600 550)

Cally Palace is located approximately 33km to the north of the proposed development. According to the ZVI there is no visibility of the proposed development from Cally Palace.

THREAVE GARDENS (Grid Ref NX 754 605)

Threave Gardens are located approximately 24.5km to the north of the proposed development According to the ZVI there is no visibility of the proposed development from Threave Gardens.

Register of Parks and Gardens of Special Historic Interest in England

WORKINGTON HALL (Grid Ref NY 008 287)

Workington Hall is located approximately 16km to the south east of the proposed development. According to the ZVI there is no visibility of the proposed development from Workington hall.

Due to the distance of the historic gardens and designed landscape in Dumfries and Galloway and the parks and gardens of special historic interest in Cumbria from the proposed development, there will be no significant effects on any of these sites.

Hadrian's Wall World Heritage Site

The Hadrian's Wall World Heritage Site (WHS) stretches 73 miles across England from Newcastle Upon Tyne to Carlisle. The World Heritage Site designation extends south west into Cumbria and the study area for the proposed development, however Hadrian's Wall itself is situated outside the study area, with only associated towers, forts and milefortlets extending along the Cumbrian coast down to Whitehaven. There are 25 sites identified in the Hadrian's Wall World Heritage Site Management Plan within the study area. The ZVI indicates that between 46-60 turbines of the proposed development may be seen at distances between 12km and 29km along the line of these sites. Actual visibility towards the sea from these sites varies with local topography, vegetation and buildings.

The Hadrian's Wall World Heritage site includes a World Heritage Setting Area, extending to Maryport, around some of the sites identified above. This Setting Area provides a buffer zone established to protect the Scheduled Monuments from visual intrusion for developments within the Setting Area. This Setting Area is approximately 2-3km wide, extending inland from the sites along the coast. The proposed development is outside the boundary of the Hadrian's Wall World Heritage Site Setting Area. In such cases, when a proposed large scale development is outside the setting area, policy 6.2.3 of the Hadrian's Wall Management Plan states that 'evaluation of major developments for their visual effect on the World Heritage Site is desirable' therefore the potential effect on the WHS itself is critical not the effect on the buffer zone.

The proposed offshore wind farm may be visible from some of the towers, forts and milefortlets of the Hadrian's Wall World Heritage Site from areas of coastal hinterland between Maryport and Cardurnock. However, the turbines will be located at distances of between 12km to 30km and whilst it may be possible to view some of the sites with the turbines visible in the same general direction, this will occur where there are expansive views across the Firth, and at such distances the turbines will form a minor element in the overall field of view. Fieldwork has confirmed that the majority of Scheduled Ancient Monuments associated with the WHS require scrutiny in the field in order to locate them and tend to be set in fields with no public access. Although the landscape sensitivity of the site is high due to its International Importance, its sensitivity as a visual receptor is low because the sites are small scale and require close scrutiny of small ground areas, in which the proposed offshore development will not constitute part of the setting. The magnitude of change caused by the proposed wind farm varies according to the location of the individual milefortlet or tower site, however it is considered to be slight to moderate due to the distance of the sites from the proposed development. The effect of the proposed offshore wind farm on the Hadrian's Wall World Heritage site is therefore considered to be **moderate/minor** due to the distance of the proposed wind farm offshore and its indirect relationship with relatively limited parts the World Heritage Site.

9.10.5.4 Effects on Visual Amenity

The computer visibility analyses and the viewpoint assessment, together with field observations, enables certain conclusions to be drawn about the predicted changes to the visual amenity baseline condition throughout the study area.

ZVI Analysis

The ZVI indicates that the turbines will be visible across nearly all the sea area of the study area. One of the most striking aspects of the ZVI is that visibility of turbines drops off rapidly onshore within short distances from the coast.

There is no visibility at all from several seascape units; Fleet Bay, Kirkandrews Peninsula, and most of St. Bees. The ZVI indicates most of the theoretical visibility of the proposed development on the Dumfries and Galloway coast is available from the Dundrennan Peninsula, East Stewartry Coast and Mersehead Sands seascape units and the Coastal Granite Uplands landscape type. There will be variable visibility within the East Stewartry Coast seascape unit due to screening effects of headlands, peninsulas and islands.

The ZVI indicates that most of the length of the Cumbrian coastline has theoretical visibility of the proposed development but beyond approximately 7km inland visibility drops off and becomes intermittent.

The visibility of the proposed wind farm from receptors within the study area can be summarised as follows:

SETTLEMENTS

- No visibility from major settlements in Dumfries and Galloway, including Dumfries, Castle Douglas and Dalbeattie.
- Main settlements in Cumbria such as Maryport, Workington and Whitehaven have visibility of up to 60 turbines shown on the ZVI, but visibility on the ground is much less due to intervening urban structures.

MAIN ROADS

- In Dumfries and Galloway, there will be intermittent visibility of the proposed development from the A710 and A711 coastal routes. There is a small section of visibility from the A75 but predominantly no visibility and no visibility from the A713 further inland.
- In Cumbria, ZVI indicates that the B5300 coastal route has full visibility of the proposed development and the A595 and A596 have fleeting visibility near the coast.
- In all cases, the effects of the proposed development are reduced by intervening roadside vegetation and the speed of travel on main roads.

RAILWAYS

- Very distant (34.5km) visibility of the proposed development may be gained from the Annan to Dumfries line
- Consistent visibility along the Cumbria Coastal Route, which drops away to no visibility inland of Maryport.

FOOTPATHS / NATIONAL TRAILS

- Views of 46-60 turbines from coastal walks in Dumfries and Galloway
- Views of 46-60 turbines for majority of the Cumbria Coastal Way. Coast to Coast Walk has full visibility near the coast but limited visibility on its route through the LDNP.

Viewpoint Assessment

Detailed analysis of 16 key viewpoints within the study area identified significant effects caused by the proposed development from 4 viewpoint locations. These are shown below:

Table 9.10.12 Summary of significant effects identified by viewpoint assessment

No.	Viewpoint Name	Magnitude of change	Landscape /seascape sensitivity	Effects on landscape /seascape quality	Receptor sensitivity	Effects on visual amenity
3	Balcary Point	Moderate	High	**Major / moderate**	Walkers – High	**Major / moderate**
9	Mote of Mark, Rockcliffe	Moderate	High	**Major / moderate**	Walkers / Visitors – High	**Major / moderate**
10	Castlehill Point	Moderate	High	**Major / moderate**	Walkers – High	**Major / moderate**
33	Sea View, Due West	Substantial	High	**Major**	Boats users / fishers – Medium	**Major / moderate**

The above table shows that significant landscape and visual effects are focused around the closest onshore viewpoints in the East Stewartry Coast NSA to the north-northwest of the application site (viewpoints 3, 9 and 10).

Cumulative Effects

There is very little cumulative visibility in the Dumfries and Galloway section of the study area, while in the Cumbrian section of the study area there may be a variety of distant cumulative views of existing wind farm developments and the proposed development at Robin Rigg. The cumulative ZVI shows that theoretical views of existing or proposed wind farm developments cover most of the Cumbrian section of the study area. This is due the presence of existing wind turbine developments in the Oldside Group (consisting of Siddick, Oldside, Lowca and Winscales wind farms) and the proposed wind farm at Wharrels Hill. Views of existing wind turbine developments are therefore a feature of the visual amenity of the area at present. The proposed development will increase the cumulative visibility of wind turbines in the area, however it only represents a moderate magnitude of change to the existing baseline conditions, as it is located over 11.5km off the Cumbrian coast.

Detailed analysis of 16 key viewpoints in the viewpoint assessment has identified no significant cumulative effects caused by the proposed development. Viewpoints at Maryport and Workington are likely to have most cumulative effects, however the impact of the existing wind turbines tends to be greater than the proposed development at Robin Rigg, due to their proximity to the viewpoint and the distance of the proposed development offshore. Cumulative views of the proposed development and the existing turbines in the Oldside Group are likely to be seen in the same direction view from the coastal and inland areas, due to the location of the Oldside Group along the coastal edge. Views of the proposed development and Wharrels Hill will not be in the same direction of view from the majority of the study area as the proposed Wharrels Hill development is located inland.

9.10.6 SUMMARY OF PUBLIC ATTITUDES TO WIND FARMS

This section briefly summarises the findings of public opinion surveys of attitudes to wind farms in the UK and is largely based on a recent summary by the British Wind Energy Association (2001) and 'A Summary of Research Conducted into Attitudes to Wind Power from 1990-1996'. A full summary of the public attitudes to wind farms is provided in Appendix G5 in the separate volume of appendices and focuses on landscape and visual issues.

Between 1990 and 1996 thirteen different research studies have been carried out by different research groups. In total, these surveys have canvassed the opinions of more than 3,500 people. The vast majority lived either close to a wind farm or a proposed wind farm.

Concerns regarding the visual impact of the wind farms have tended to follow the same pattern, with a decrease in the number of those concerned once the wind farms had been constructed. In the BBC Wales study[445], for example, 63% of those who could see a wind farm from their home still supported their wind farm.

[445] Love them or Loathe Them? Public Attitudes Towards Wind Farms in Wales. BBC Wales (1994).

Published research generally indicates that support for a wind farm project tends to increase once they have been built and commissioned [446, 447] and that perceived impacts, particularly relating to noise and visual impacts, often fail to materialise.

Recent research commissioned by the Scottish Executive examining the attitudes of local populations towards four operational wind farms in Scotland (Hagshaw Hill, South Lanarkshire; Windy Standard, Dumfries & Galloway; Novar, Highland and Beinn Glas, Argyll & Bute) produced, among others, the following findings:

- The proportion of respondents who had anticipated problems prior to the development (40%) was far higher than the proportion who actually experienced problems after the development (9%);

- In relation to the visual impact of the wind farm, a higher proportion of respondents said that they liked the look of the wind farm (21%) than the proportion who said the farm was unsightly or spoiled the view (10%).

Little published information exists on public attitudes to offshore wind farms in the UK, though the two offshore turbines off Blyth Harbour appear to have attracted relatively positive coverage in the press. A recent public opinion survey carried out at the public meeting for the proposed Kentish Flats Offshore Wind Farm, near Whitstable, Kent found that out of 78 respondents, 85% said they were in favour of the proposed wind farm and only 9% were against. In a separate independent study of local people's perceptions of the potential impacts, when asked how the view would be affected, 64% of respondents said that it would be either a positive change or no impact and only 33% felt it would be a negative change on the existing view.

A recent survey of opinion on energy issues in general[448] found that 47% of respondents thought offshore wind farms should be built in Britain and only 1% thought that they should not be built. Only 19% of respondents felts that offshore wind farms would spoil the landscape.

9.10.7 CONCLUSIONS

The landscape, seascape and visual assessment has established that the proposed development will change the landscape and visual baseline conditions during the construction and operational phases of the wind farm. The proposed offshore wind farm will introduce a group of 60 turbines and associated offshore substation into part of the Solway Firth at distances of over 8km from the coast of Dumfries and Galloway and Cumbria.

The onshore elements of the development will be subject of a separate study to be submitted with the application for planning permission under the Town and Country Planning Act 1990 in Cumbria.

[446] Scottish Executive (2000) 'Public attitudes towards wind farms in Scotland: results of a residents survey' System Three Social Research, The Scottish Executive Central Research Unit.
[447] RSPB (2001) 'The GB Public's views on energy issues'. RSPB market research project 0136.
[448] Renewable Energy World, Vol 4, No 1 (2001) 'Fundamentals of UK's first offshore wind turbines'.

The construction phase of the offshore wind farm is relatively short and will have only temporary, minor effects on the landscape, seascape and visual amenity of the study area.

The direct effects on seascape are not considered to be significant, as the offshore wind farm will occupy a small part of the overall area. Effects will be entirely reversible following the 25 year operational phase of the wind farm.

Considerable attention to landscape, seascape and visual amenity considerations has been given to the layout optimisation process. This has resulted in a wind farm design which is compact and, from nearly all viewpoints, forms a balanced group of turbines which are harmonious in composition, both as an array, and when viewed against the backdrop of land or sea.

Visibility of the turbines will vary with weather conditions on the Solway Firth. Analysis of data from meteorological stations in the study area, indicates that there is visibility of under 20km for approximately half the total number of days over the three years between 1999-2001 for which data was analysed. In clear weather conditions, it is likely that blade movement will be discernible at distances of up to 12km. For all locations beyond this distance, it is not likely that blade movement will be visible.

The landscape and seascape assessment of the proposed offshore wind farm at Robin Rigg has identified that out of the 31 character units identified in the study area, significant landscape or seascape effects will be confined to:

- Part of the East Stewartry Coast seascape unit; and
- Part of the Mersehead Sands seascape unit.

There are three NSAs in the Dumfries and Galloway part of the study area. There will be no effect on the Fleet Valley NSA and a moderate effect on those limited parts of the Nith Estuary NSA that have visibility of the offshore wind farm. The East Stewartry NSA will have visibility of the offshore development from elevated areas and the coastal edge with open views to the Solway Firth. There will be a major/moderate effect at those locations where there are views to the offshore wind farm, however for most of the East Stewartry NSA, there will not be a significant effect on seascape, landscape or visual amenity.

In the Cumbrian part of the study area designated landscapes include the LDNP, Solway Coast AONB, St Bees Heritage Coast and Landscapes of County Importance. There will be no significant seascape, landscape or visual effects on any of these designated landscapes.

There will be no effect on any of the historic gardens and designed landscapes in the Dumfries and Galloway part of the study area, and no effect on any Gardens of Historic Interest in Cumbria.

The assessment of visual amenity of the proposed wind farm has identified that out of the 16 viewpoints included in the detailed assessment, significant visual effects will be confined to three viewpoints on the Dumfries and Galloway coast and one viewpoint out at sea.

According to the ZVI, visibility drops off sharply inland with distance from the proposed development, particularly in Dumfries and Galloway. Views are available from the immediate coastline, but vary according to the coastal form and elevation of seascape units. In general, the Dumfries and Galloway coast is more irregular and varied with flat and upland topography, incised bays and open peninsulas. The Cumbrian coast tends to be regular and linear with elongated concave bays. Views are therefore sometimes enclosed or orientated away from the proposed development along the Dumfries and Galloway coast, while there are more open views towards the proposed wind farm of varying distance along the Cumbrian coast.

The significant effects arising from the offshore wind farm will be confined to those locations close to the coast with open views across the Solway Firth. Although there may be views of the turbines from more elevated areas inland, it is not considered that the development will cause a significant effect at these locations due to the intervening distance.

The overall trend identified in the cumulative assessment, is that cumulative visibility in the Dumfries and Galloway section of the study area will be limited and restricted to very clear weather conditions and therefore it is not considered that there will be any significant cumulative landscape, seascape or visual effects. In the Cumbrian section of the study area, the ZVI shows a complex pattern of distant cumulative views of existing wind farm developments, the proposed development at Wharrels Hill, together with the proposed wind farm at Robin Rigg. The assessment demonstrates that the additional effect arising from the proposed development at Robin Rigg is not anticipated to give rise to any significant cumulative effects on seascape, landscape or visual amenity.

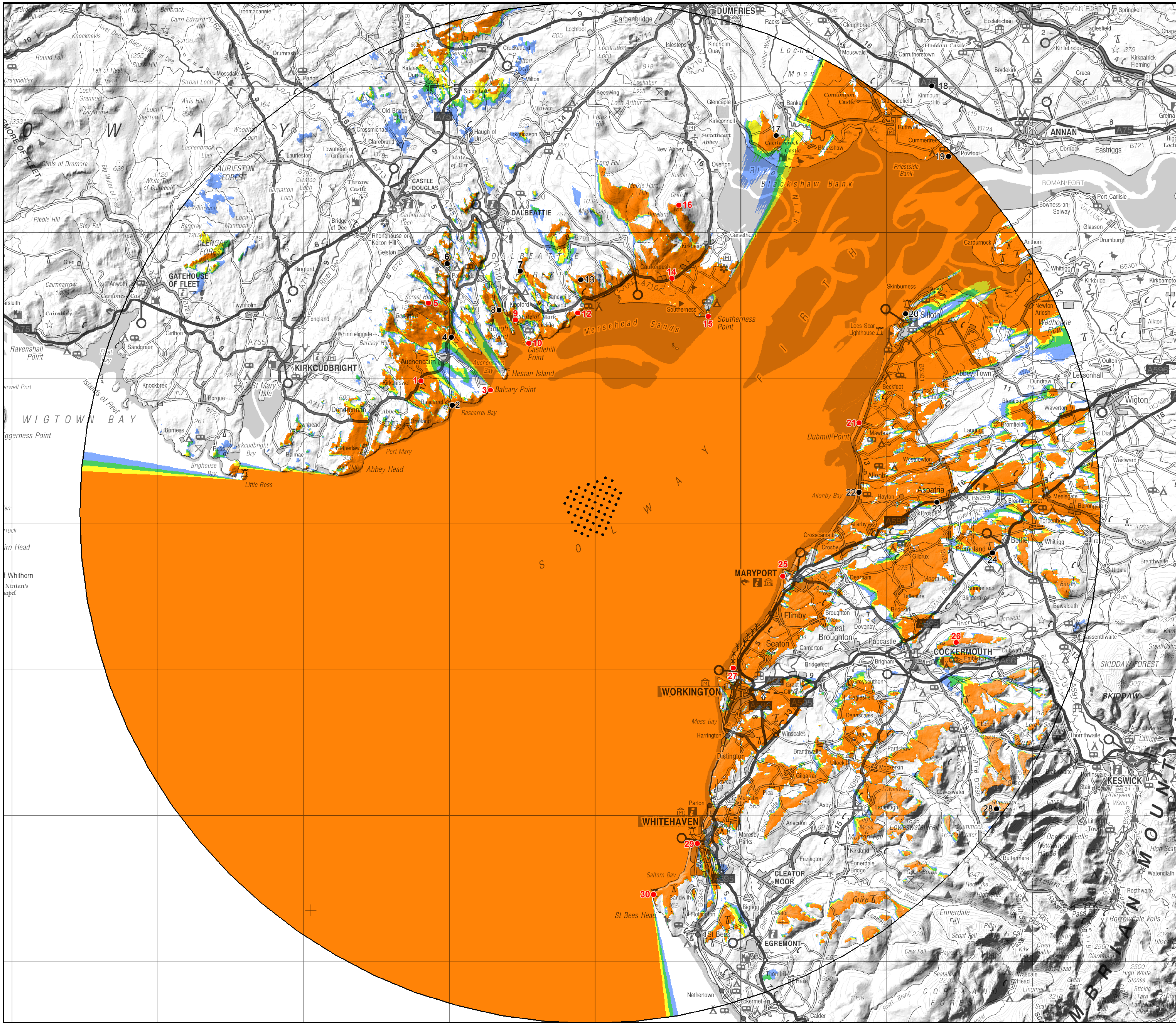
Any new wind farm development may result in potentially significant effects on the landscape quality and visual amenity of the locality. In the case of the Robin Rigg development, a 35km radius area has been assessed and significant effects identified in a relatively small area of the Solway Coast.

It should be noted that significant effects are not necessarily unacceptable. As discussed in Appendix G5 in the volume of appendices, surveys carried out in Wales, Cornwall, Cumbria and recently Scotland, indicate that the majority of people who live nearby, look favourably on the wind farms after they are constructed. The consistency of these surveys is notable.

The proposed development will introduce a group of man-made elements into the open seascape of the Solway Firth. Whilst the introduction of these large scale man made elements into the seascape will provide a noticeable feature, the turbines will be over 8km off the closest part of the coast, and the extent to which they will be visible from those locations with views to the Solway Firth will vary with weather conditions. Visibility of the wind farm will be largely restricted to the coastal edges and elevated inland areas of the study area.

The proposed wind farm is considered to be well designed and sited with due consideration to landscape, seascape and visual effects in relation to the other environmental constraints. From distant upland viewpoints the layout of the turbines will form a single isolated feature and will appear small in scale in relation to the vastness of the surrounding seascape. The wind farm will often be seen in relation to areas of seascape and coast in the wider view with a backcloth of landscape behind it on the opposite coast in clear weather. The layout shows a simple composition and has a balanced relationship with the surrounding landform. As the wind farm is sited over 8km offshore at the nearest point, consequently there are no sensitive landscape or visual receptors permanently located within the immediate vicinity of the site.

Having carefully examined the potential effects on landscape, seascape and visual amenity associated with the proposed wind farm, it is considered that the proposals are acceptable in this location.



Robin Rigg Wind Farm

Figure: 9.10.1: Zone of Visual Influence to Blade Tip Height

Key

(dots)	Wind turbine locations
(blue)	1-15
(green)	16-30
(yellow)	31-45
(orange)	46-60
1● (red)	Key viewpoints
2● (black)	Other viewpoints

Colours 1-15 to 46-60: Total number of turbines visible to blade tip height

Notes

- 60 turbines, blade tip height 130m
- Visibility takes earth curvature and atmospheric refraction into account.
- Visibility is removed outside 35km radius.

Scale: 1:250,000

Kilometres
0 1 2 3 4 5 6 7 8 9 10 11 12

North

Based upon the Ordnance Survey 1:250,000 Travelmaster map with the permission of the Controller of Her Majesty's Stationery Office.

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Client:

The Natural Power Consultants Ltd
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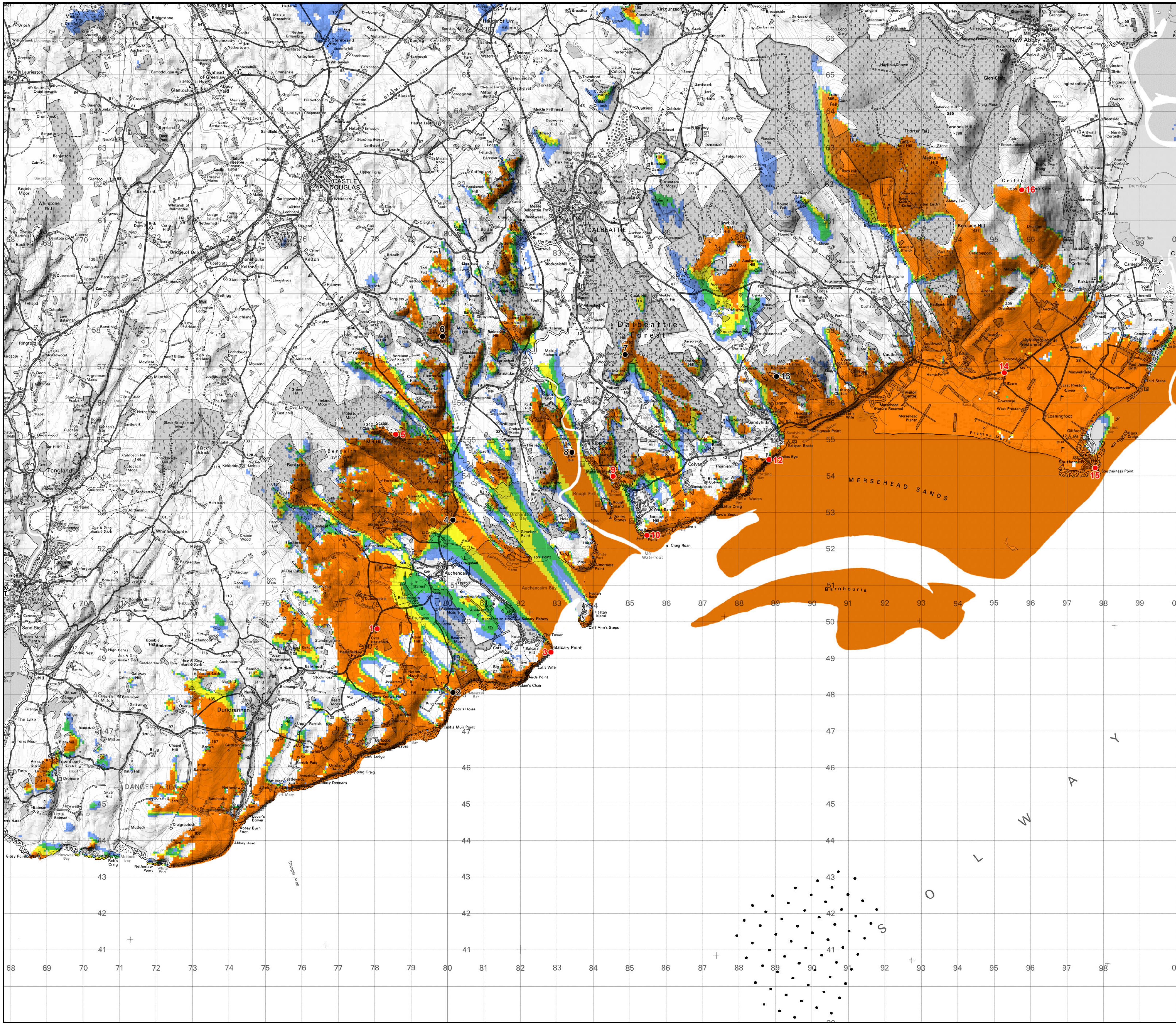

Robin Rigg Wind Farm

Figure 9.10.2: Zone of Visual Influence to Blade Tip Height

Key

Wind turbine locations	
1-15	Total number of turbines visible to blade tip height
16-30	
31-45	
46-60	
1●	Key viewpoints
2●	Other viewpoints

Notes

- 60 turbines, blade tip height 130m
- Visibility takes earth curvature and atmospheric refraction into account.
- Visibility is removed below low tide line.

Scale: 1:100,000

Kilometres

0 1 2 3 4 5

North

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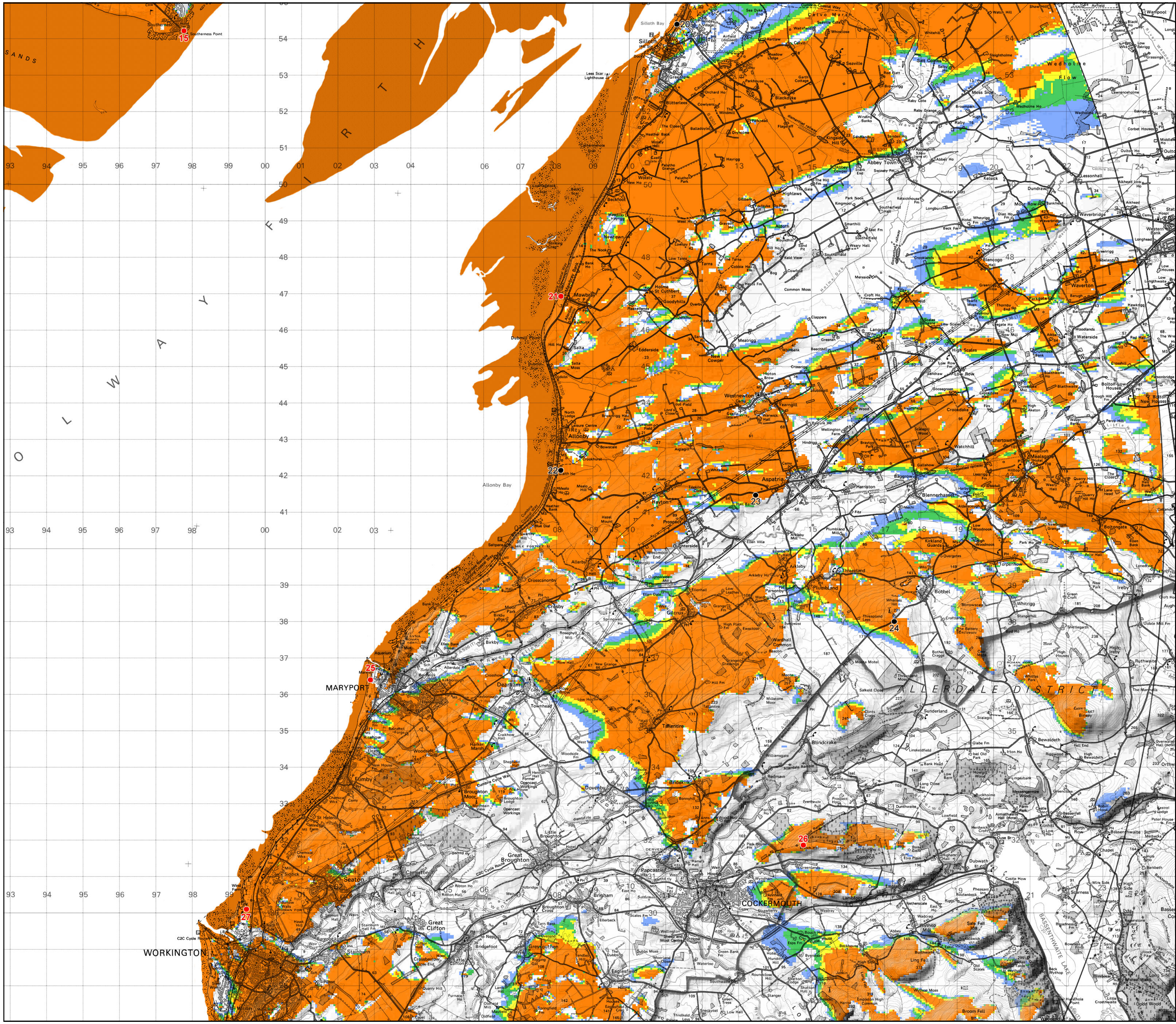

Robin Rigg Wind Farm

Figure 9.10.3: Zone of Visual Influence to Blade Tip Height

Key

Colour	Total number of turbines visible to blade tip height
Blue	1-15
Green	16-30
Yellow	31-45
Orange	46-60

21● Key viewpoints

22● Other viewpoints

Notes

- 60 turbines, blade tip height 130m
- Visibility takes earth curvature and atmospheric refraction into account.
- Visibility is removed outside 35km radius and below low tide line.

Scale: 1:100,000

Kilometres 0 1 2 3 4 5

North

Based upon the Ordnance Survey 1:250,000 and 1:50,000 raster data with the permission of the Controller of Her Majesty's Stationery Office.

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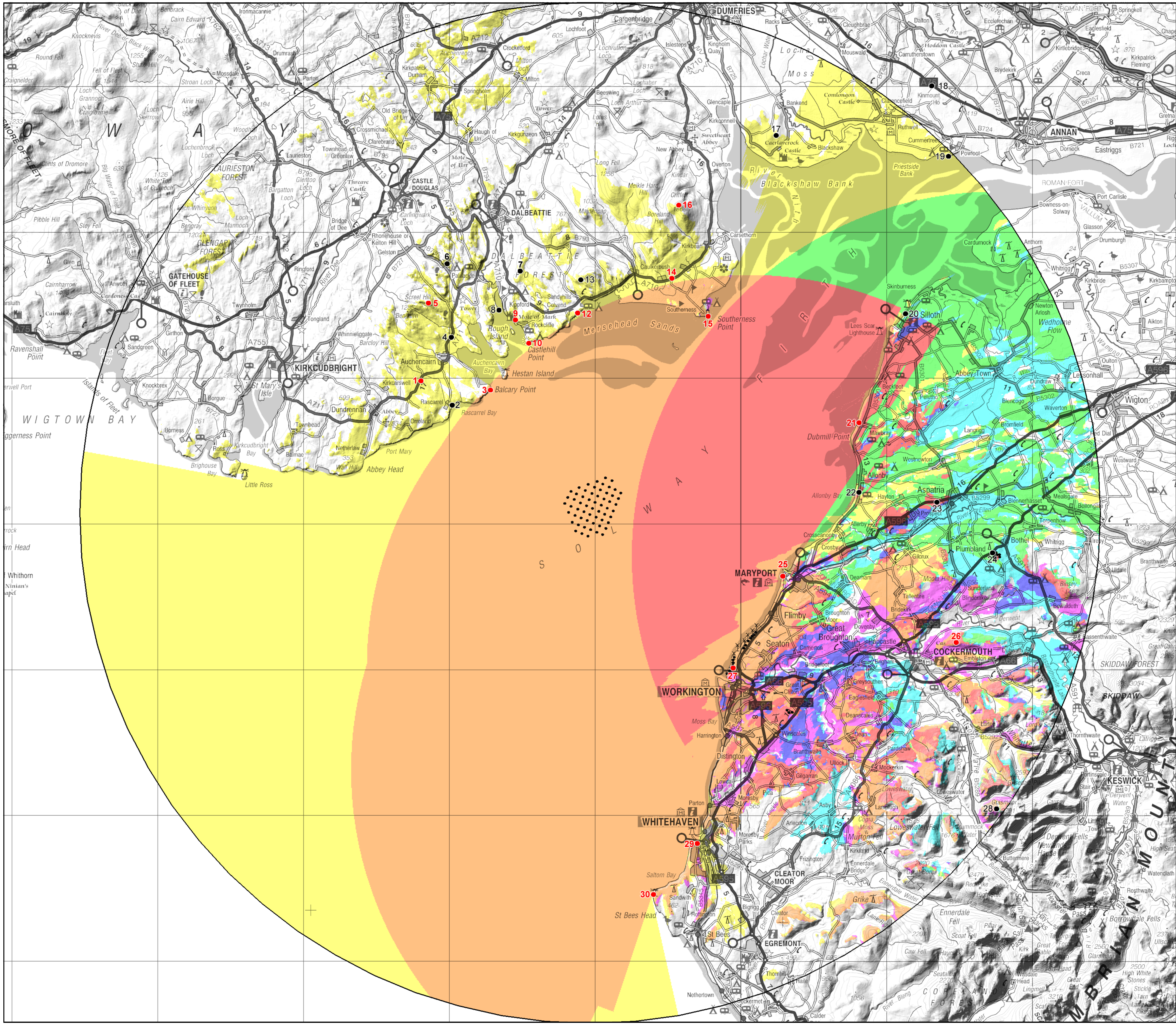
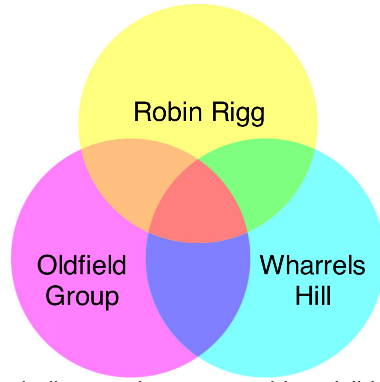


Robin Rigg Wind Farm

Figure 9.10.4: Cumulative Zone of Visual Influence to Blade Tip Height

Key



- Colours indicate at least one turbine visible.
- Overlap colours show areas from which more than one wind farm would be visible.

Wind turbine locations

1● Key viewpoints

2● Other viewpoints

Notes

- Robin Rigg: 60 turbines, tip height 130m
- Oldside group:
  Oldside: 9 turbines, tip height 61m
  Lowca: 7 turbines, tip height 63.5m
  Siddick: 7 turbines, tip height 61m
  Winscales: 3 turbines, tip height 66.5m
- Wharrels Hill: 8 turbines, tip height 81m
- Visibility takes earth curvature and atmospheric refraction into account.
- Visibility removed outside 35km radius from Robin Rigg and 25km from other wind farms.

Scale: 1:250,000

Kilometres

0 1 2 3 4 5 6 7 8 9 10 11 12

North

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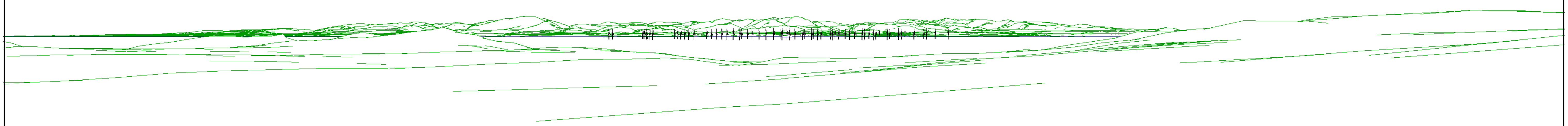
Photograph



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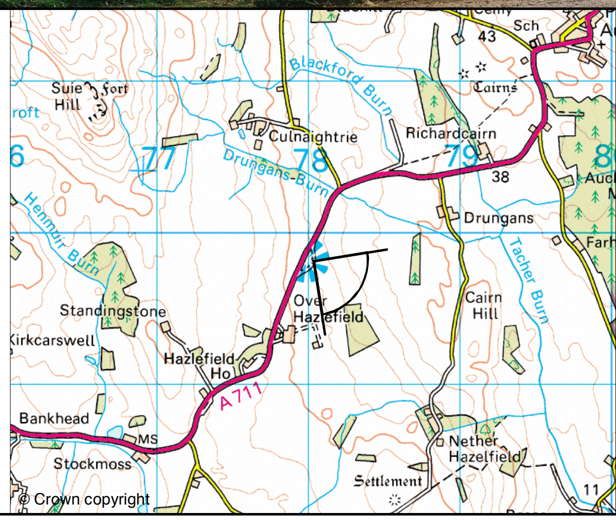
General notes

Wind farm layout:	14/03/02
Blade tip height:	130m
Camera lens:	50mm
Camera height:	1.65 m above ground
Arc of view	76 degrees
Correct viewing distance:	30 cm



Location notes:

Grid Ref:	278047 549818
Elevation:	89 m (above OS datum)
Bearing:	126 degrees (from grid north)
Distance:	Approx 12.8 km (to nearest turbine)

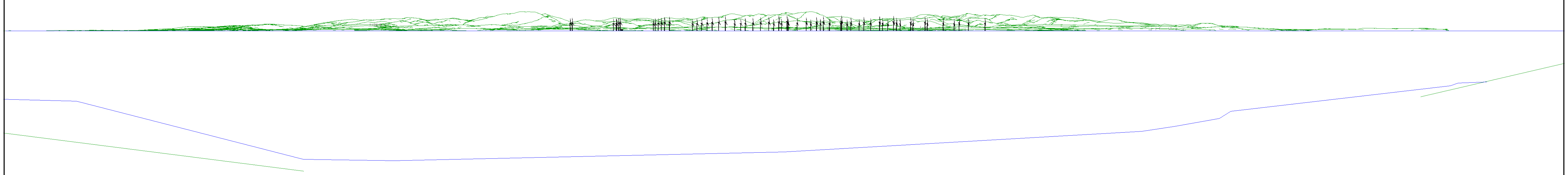
Robin Rigg Wind Farm

Visualisation No. 1

Location:

A711, Auchencairn Topograph

Photograph



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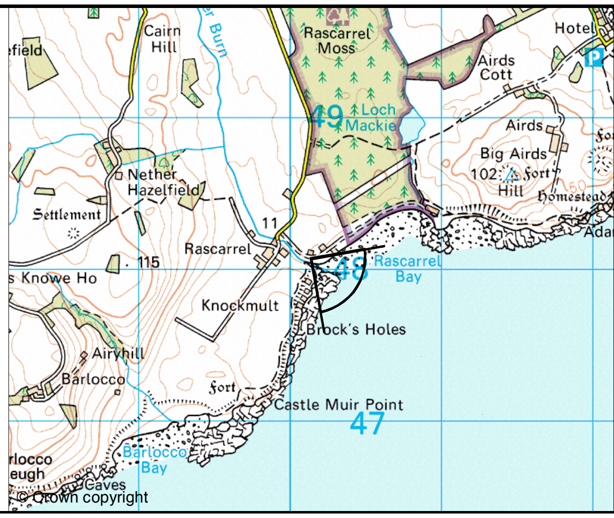
General notes

Wind farm layout:	14/03/02
Blade tip height:	130m
Camera lens:	50mm
Camera height:	1.65 m above ground
Arc of view	76 degrees
Correct viewing distance:	30 cm



Location notes:

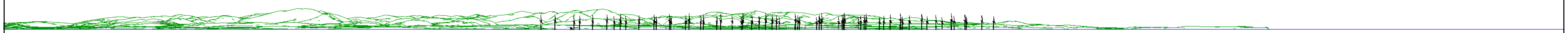
Grid Ref:	280152 548060
Elevation:	7 m (above OS datum)
Bearing:	125 degrees (from grid north)
Distance:	Approx 10.1 km (to nearest turbine)

Robin Rigg Wind Farm

Visualisation No. 2

Location:

Rascarrel Bay



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General notes

Wind farm layout:	14/03/02
Blade tip height:	130m
Camera lens:	50mm
Camera height:	1.65 m above ground
Arc of view	76 degrees
Correct viewing distance:	30 cm

Location notes:

Grid Ref:	282821 549188
Elevation:	15 m (above OS datum)
Bearing:	139 degrees (from grid north)
Distance:	Approx 8.9 km (to nearest turbine)

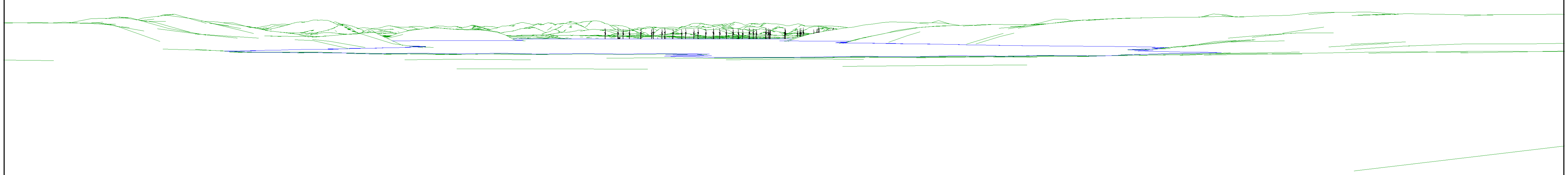
Robin Rigg Wind Farm

Visualisation No. 3

Location:

Balcary Point

Photograph



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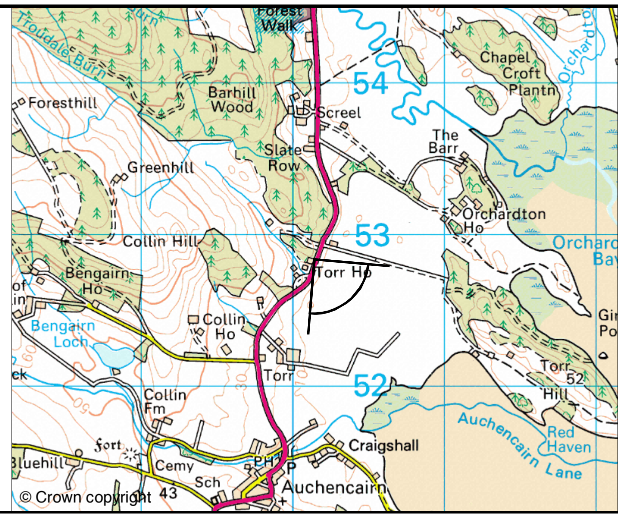
General notes

Wind farm layout:	14/03/02
Blade tip height:	130m
Camera lens:	50mm
Camera height:	1.65 m above ground
Arc of view	76 degrees
Correct viewing distance:	30 cm



Location notes:

Grid Ref:	280091 552692
Elevation:	16 m (above OS datum)
Bearing:	140 degrees (from grid north)
Distance:	Approx 13.4 km (to nearest turbine)

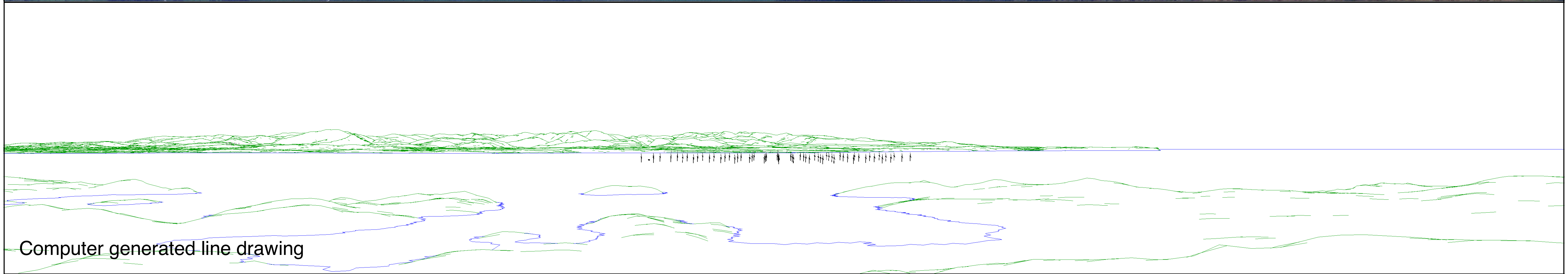
Robin Rigg Wind Farm

Visualisation No. 4

Location:

A711, Torr House

Photograph



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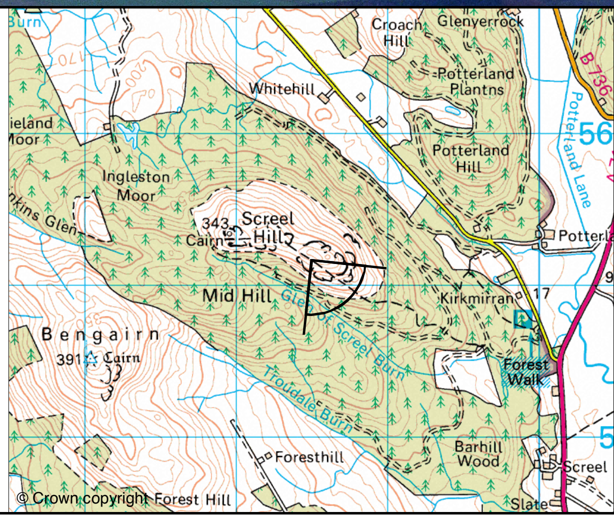
Fax: +44 (0)1644 430009
Email: post@naturalpower.com

General notes

Wind farm layout:	14/03/02
Blade tip height:	130m
Camera lens:	50mm
Camera height:	1.65 m above ground
Arc of view	76 degrees
Correct viewing distance:	30 cm



Location notes:

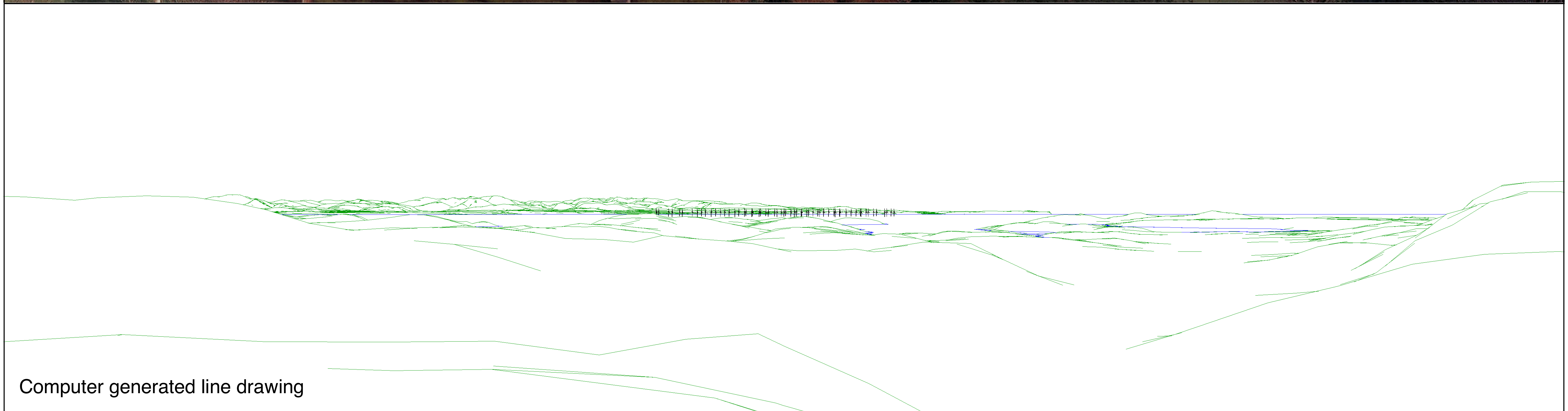
Grid Ref:	278560 555158
Elevation:	345 m (above OS datum)
Bearing:	141 degrees (from grid north)
Distance:	Approx 16.2 km (to nearest turbine)

Robin Rigg Wind Farm

Visualisation No. 5

Location:

Screel Hill Forest Walk



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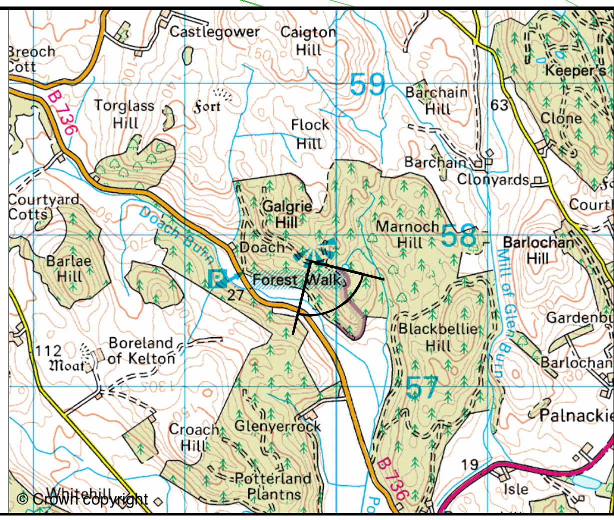
General notes

Wind farm layout:	14/03/02
Blade tip height:	130m
Camera lens:	50mm
Camera height:	1.65 m above ground
Arc of view	76 degrees
Correct viewing distance:	30 cm



Location notes:

Grid Ref:	279846 557852
Elevation:	120 m (above OS datum)
Bearing:	149 degrees (from grid north)
Distance:	Approx 17.8 km (to nearest turbine)

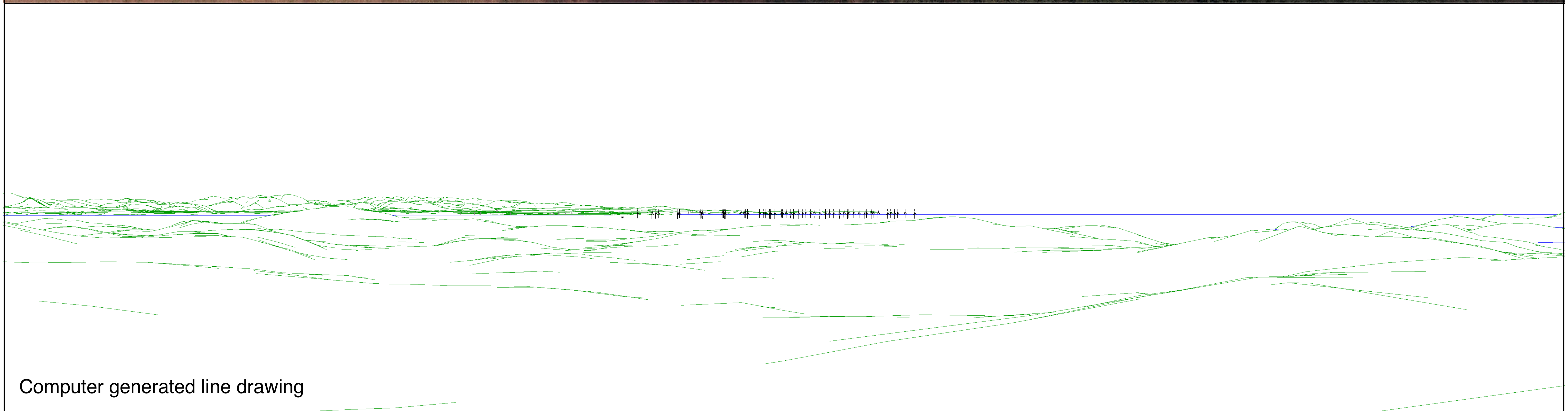
Robin Rigg Wind Farm

Visualisation No. 6

Location:

Doach Wood Forest Walk

Photograph



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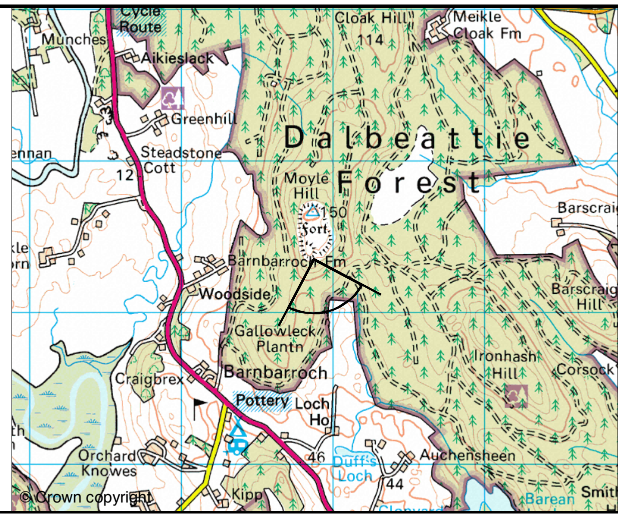
Fax: +44 (0)1644 430009
Email: post@naturalpower.com

General notes

Wind farm layout:	14/03/02
Blade tip height:	130m
Camera lens:	50mm
Camera height:	1.65 m above ground
Arc of view	76 degrees
Correct viewing distance:	30 cm



Location notes:

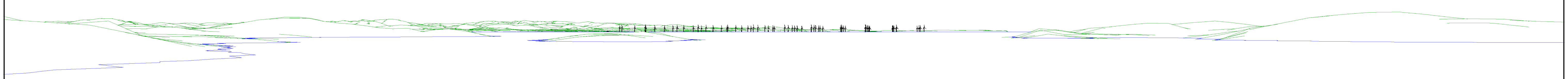
Grid Ref:	284852 557351
Elevation:	133 m (above OS datum)
Bearing:	163 degrees (from grid north)
Distance:	Approx 15.3 km (to nearest turbine)

Robin Rigg Wind Farm

Visualisation No. 7

Location:

Moyle Hill



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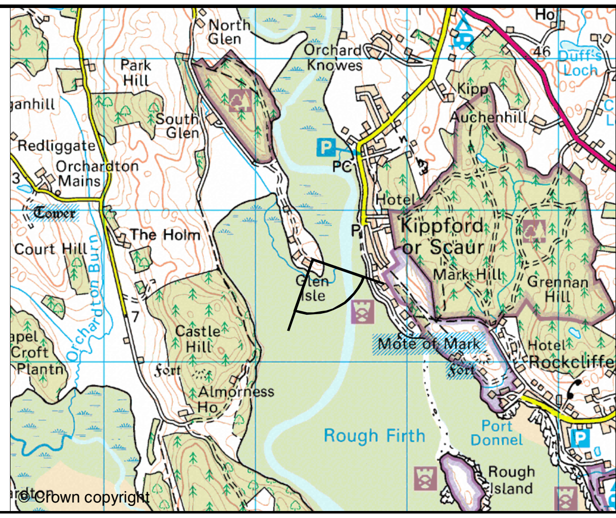
General notes

Wind farm layout:	14/03/02
Blade tip height:	130m
Camera lens:	50mm
Camera height:	1.65 m above ground
Arc of view	76 degrees
Correct viewing distance:	30 cm



Location notes:

Grid Ref:	283400 554668
Elevation:	25 m (above OS datum)
Bearing:	154 degrees (from grid north)
Distance:	Approx 13.3 km (to nearest turbine)

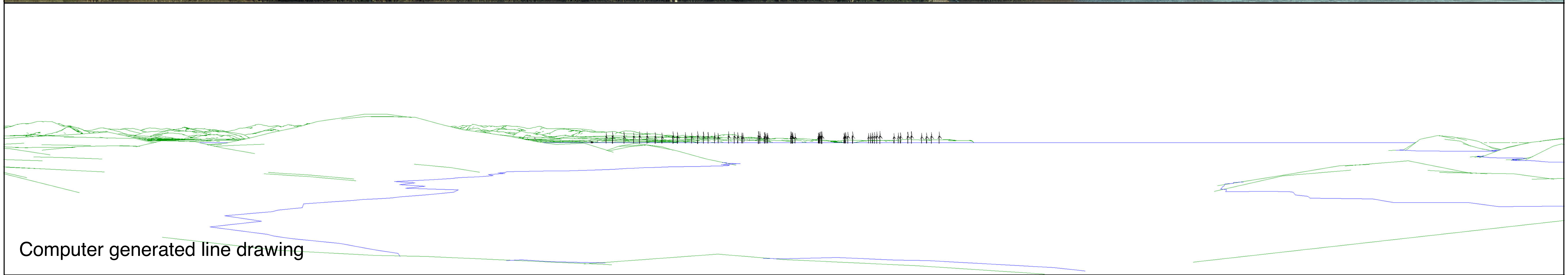
Robin Rigg Wind Farm

Visualisation No. 8

Location:

Glen Isle

Photograph



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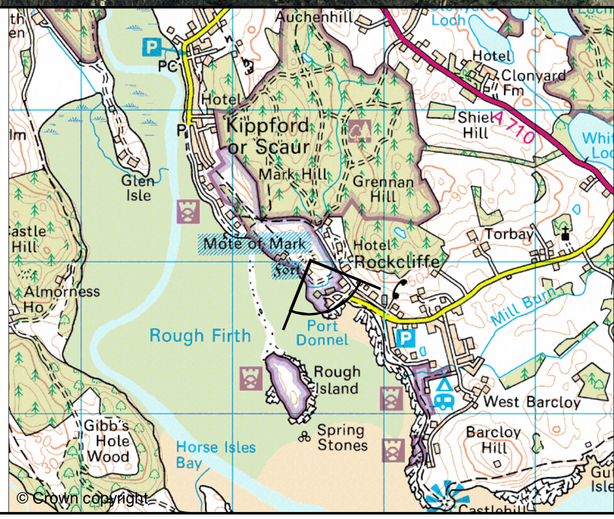
Fax: +44 (0)1644 430009
Email: post@naturalpower.com

General notes

Wind farm layout:	14/03/02
Blade tip height:	130m
Camera lens:	50mm
Camera height:	1.65 m above ground
Arc of view	76 degrees
Correct viewing distance:	30 cm



Location notes:

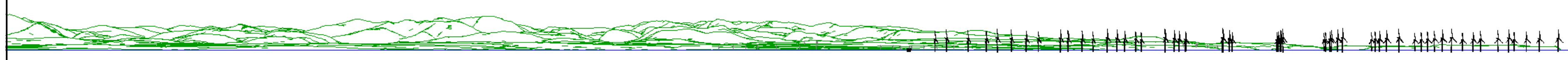
Grid Ref:	284526 554006
Elevation:	38 m (above OS datum)
Bearing:	157 degrees (from grid north)
Distance:	Approx 12.3 km (to nearest turbine)

Robin Rigg Wind Farm

Visualisation No. 9

Location:

Mote of Mark, Rockliffe



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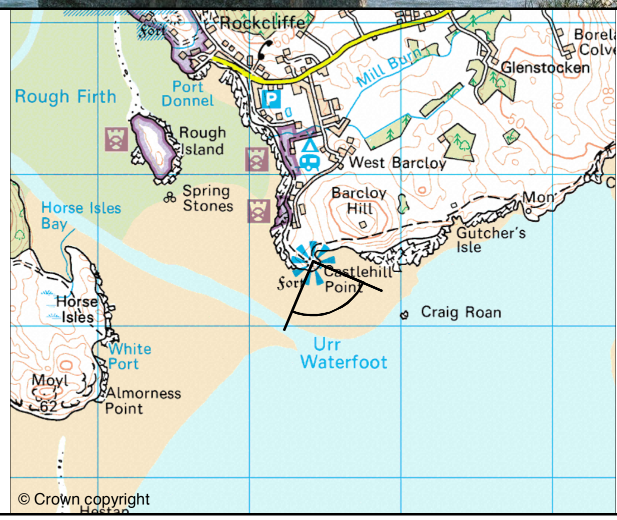
Email: post@naturalpower.com

General notes

Wind farm layout:	14/03/02
Blade tip height:	130m
Camera lens:	50mm
Camera height:	1.65 m above ground
Arc of view	76 degrees
Correct viewing distance:	30cm



Location notes:

Grid Ref:	285448 552407
Elevation:	35 m (above OS datum)
Bearing:	158 degrees (from grid north)
Distance:	Approx 10.5 km (to nearest turbine)

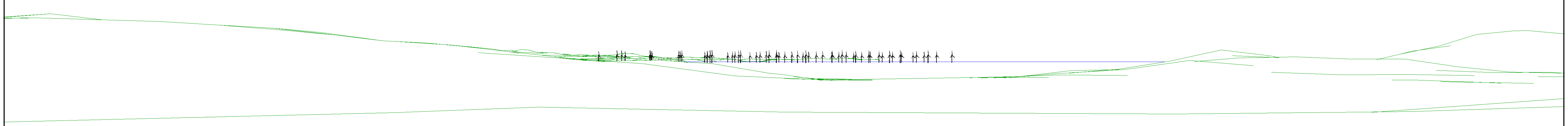
Robin Rigg Wind Farm

Visualisation No. 10

Location:

Castlehill Point

Photograph



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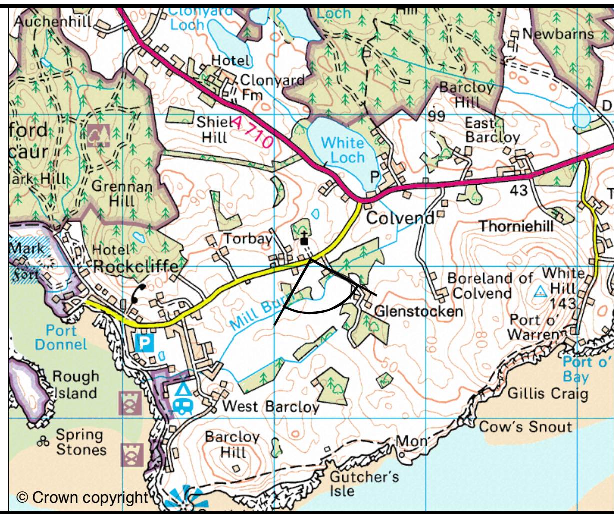
Email: post@naturalpower.com

General notes

Wind farm layout:	14/03/02
Blade tip height:	130m
Camera lens:	50mm
Camera height:	1.65 m above ground
Arc of view	76 degrees
Correct viewing distance:	30 cm



Location notes:

Grid Ref:	286267 554063
Elevation:	42 m (above OS datum)
Bearing:	164 degrees (from grid north)
Distance:	Approx 11.8 km (to nearest turbine)

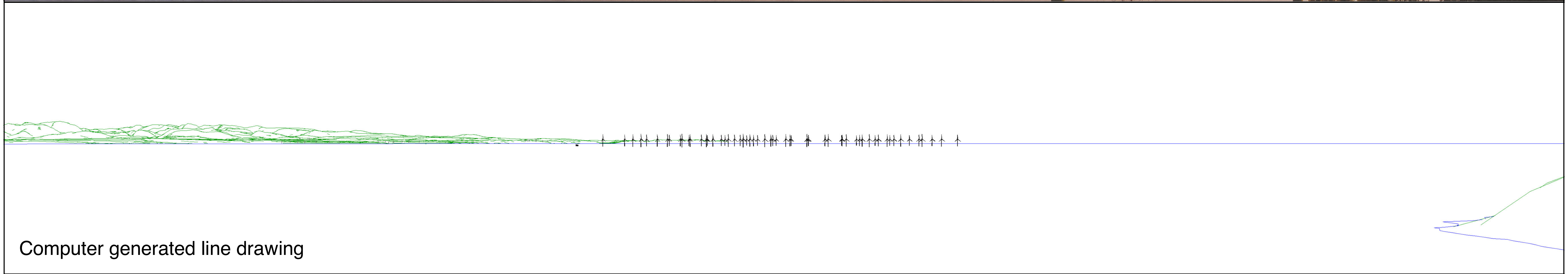
Robin Rigg Wind Farm

Visualisation No. 11

Location:

Torbay, Approach to Rockliffe

Photograph



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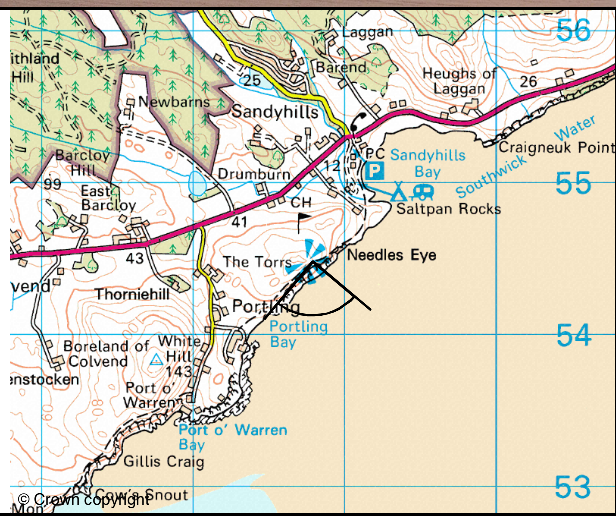
Email: post@naturalpower.com

General notes

Wind farm layout:	14/03/02
Blade tip height:	130m
Camera lens:	50mm
Camera height:	1.65 m above ground
Arc of view	76 degrees
Correct viewing distance:	30 cm



Location notes:

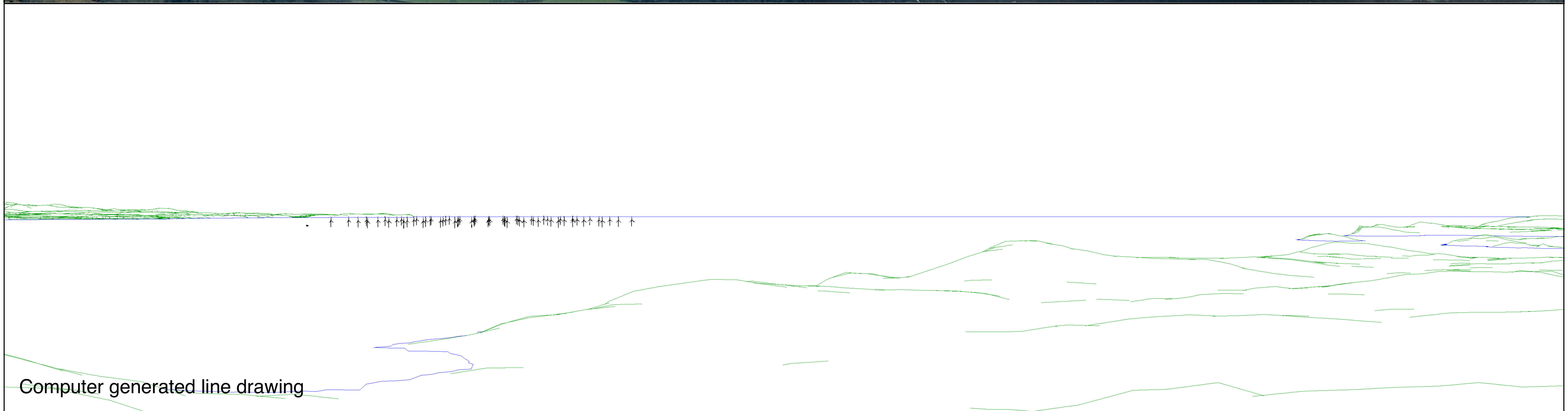
Grid Ref:	288796 554476
Elevation:	80 m (above OS datum)
Bearing:	175 degrees (from grid north)
Distance:	Approx 11.5 km (to nearest turbine)

Robin Rigg Wind Farm

Visualisation No. 12

Location:

The Torrs, Portling



Drawing by:

Envision
6 Darnaway Street
Edinburgh EH3 6BG
Scotland
Tel: +44 (0)131 226 3443
Fax: +44 (0)131 226 3553
Email: info@envision.ltd.uk

Client:

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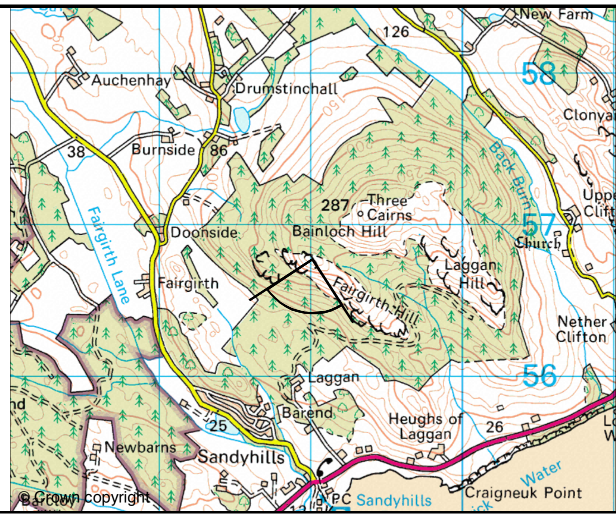
Dalry, Castle Douglas DG7 3XS
Scotland
Tel: +44 (0)1644 430008
Fax: +44 (0)1644 430009
Email: post@naturalpower.com

General notes

Wind farm layout:	14/03/02
Blade tip height:	130m
Camera lens:	50mm
Camera height:	1.65 m above ground
Arc of view	76 degrees
Correct viewing distance:	30 cm



Location notes:

Grid Ref:	289015 556751
Elevation:	230 m (above OS datum)
Bearing:	192 degrees (from grid north)
Distance:	Approx 13.7 km (to nearest turbine)

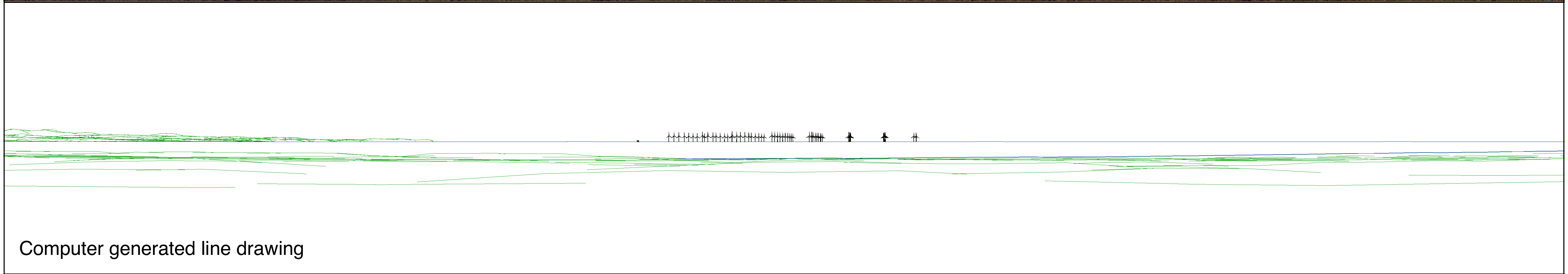
Robin Rigg Wind Farm

Visualisation No. 13

Location:

Fairgirth Hill

Photograph



Computer generated line drawing

Photomontage

Drawing by:

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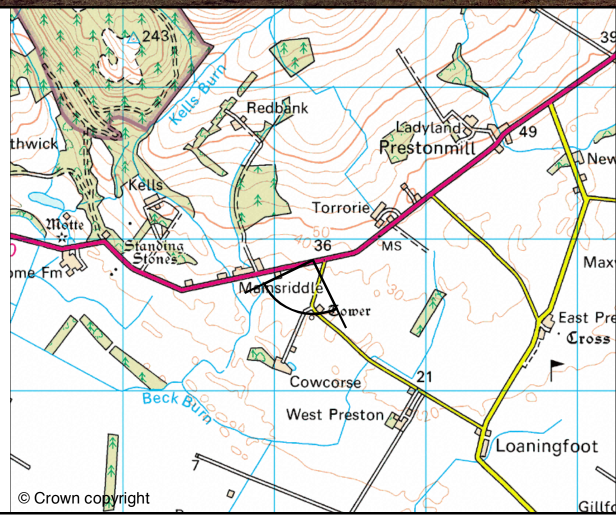
Fax: +44 (0)1644 430009
Email: post@naturalpower.com

General notes

Wind farm layout:	14/03/02
Blade tip height:	130m
Camera lens:	50mm
Camera height:	1.65 m above ground
Arc of view	76 degrees
Correct viewing distance:	30 cm



Location notes:

Grid Ref:	295258 556855
Elevation:	34 m (above OS datum)
Bearing:	199 degrees (from grid north)
Distance:	Approx 14.4 km (to nearest turbine)

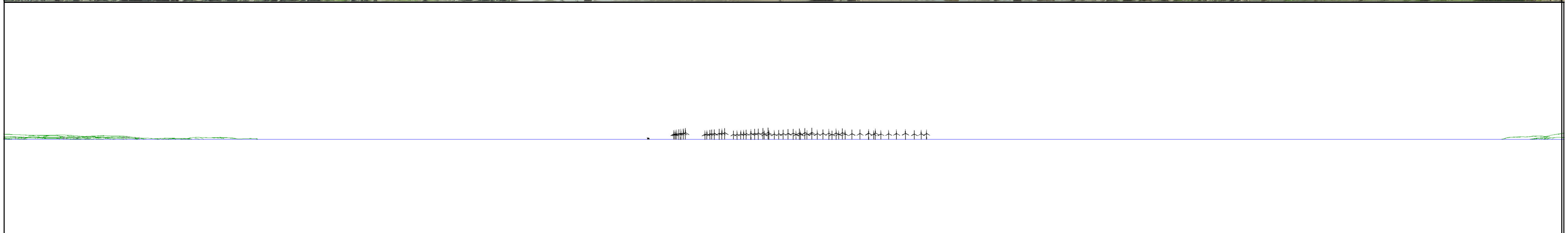
Robin Rigg Wind Farm

Visualisation No. 14

Location:

A710 Mainriddle


Photograph


Computer generated line drawing


Photomontage

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Fax: +44 (0)1644 430009
Email: post@naturalpower.com

General notes

Windfarm layout:	14/03/02
Blade tip height:	130m
Camera lens:	50mm
Camera height:	1.65 m above ground
Arc of view	76 degrees
Correct viewing distance:	30 cm

Location notes:

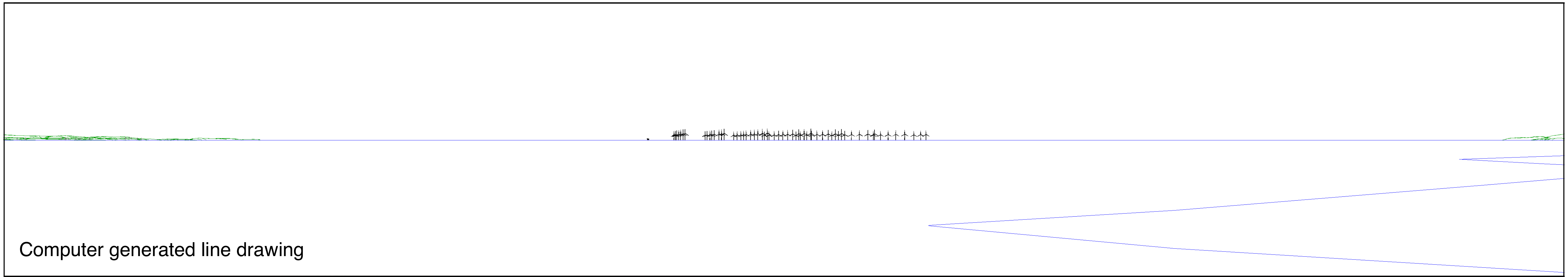
Grid Ref:	97750 554241
Elevation:	5 m (above OS datum)
Bearing:	211 degrees (from grid north)
Distance:	Approx 13 km (to nearest turbine)

Robin Rigg Wind Farm

Visualisation No. 15

Location:

Southerness Point



Computer generated line drawing

Photomontage (Low Tide)

Photomontage (High Tide)

Drawing by:

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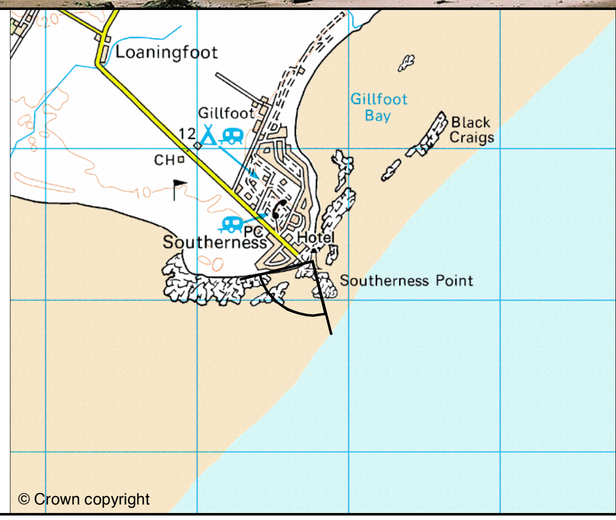
Email: post@naturalpower.com

General notes

Wind farm layout:	14/03/02
Blade tip height:	130m
Camera lens:	50mm
Camera height:	1.65 m above ground
Arc of view	76 degrees
Correct viewing distance:	30 cm



Location notes:

Grid Ref:	297729 554287
Elevation:	5 m (above OS datum)
Bearing:	211 degrees (from grid north)
Distance:	Approx 13.0 km (to nearest turbine)

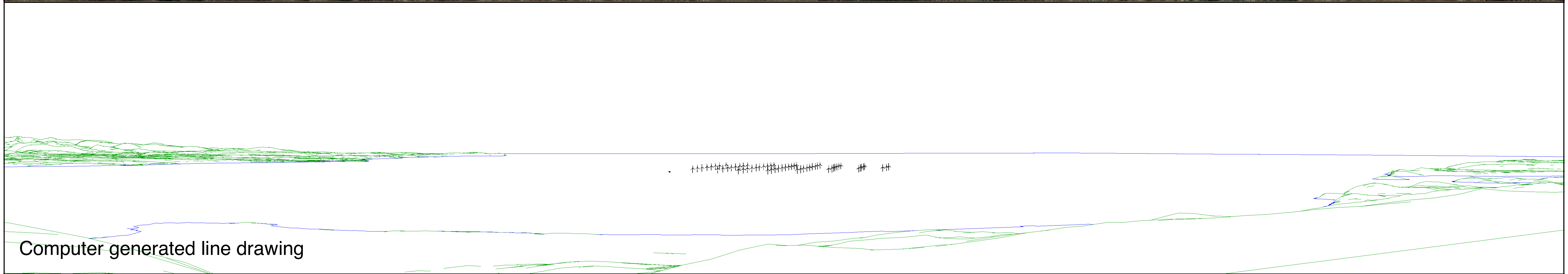
Robin Rigg Wind Farm

Visualisation No. 15a

Location:

Southerness Point at low and high tide. Approximately 50m from viewpoint used in Visualisation no. 15

Photograph



Computer generated line drawing

Photomontage

Drawing by:

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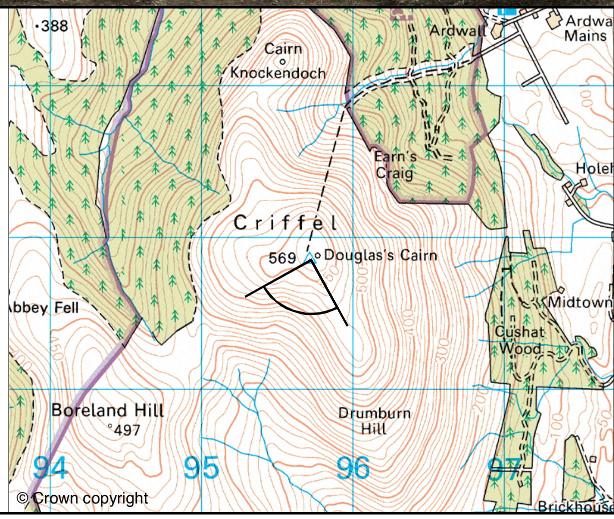
Email: post@naturalpower.com

General notes:

Windfarm layout:	14/03/02
Blade tip height:	130m
Camera lens:	50mm
Camera height:	1.65 m above ground
Arc of view	76 degrees
Correct viewing distance:	30 cm



Location notes:

Grid Ref:	295729 561866
Elevation:	571 m (above OS datum)
Bearing:	196 degrees (from grid north)
Distance:	Approx 19.4 km (to nearest turbine)

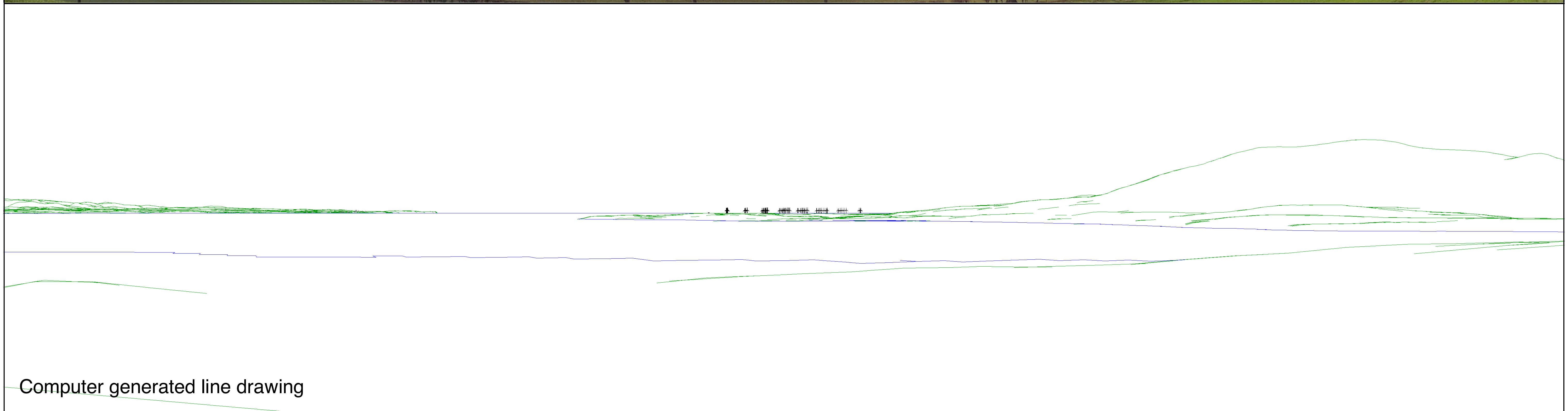
Robin Rigg Wind Farm

Visualisation No. 16

Location:

Summit of Criffel

Photograph



Computer generated line drawing

Drawing by:

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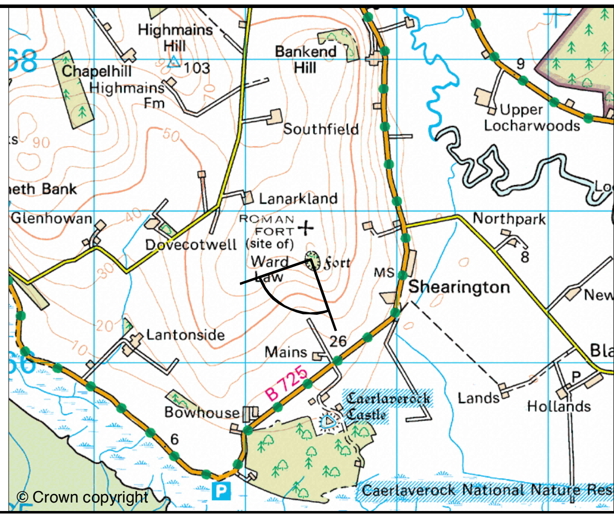
General notes

Wind farm layout:	14/03/02
Blade tip height:	130m
Camera lens:	50mm
Camera height:	1.65 m above ground
Arc of view	76 degrees
Correct viewing distance:	30 cm



Location notes:

Grid Ref:	302415 566651
Elevation:	84 m (above OS datum)
Bearing:	206 degrees (from grid north)
Distance:	Approx 26.2 km (to nearest turbine)

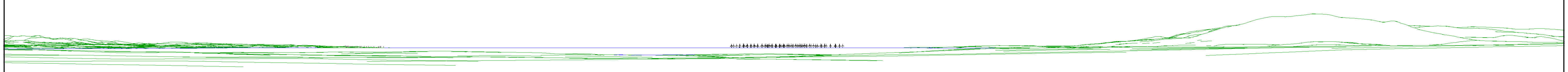
Robin Rigg Wind Farm

Visualisation No. 17

Location:

Ward Law overlooking Caerlaverock

Photograph



Computer generated line drawing

Drawing by:

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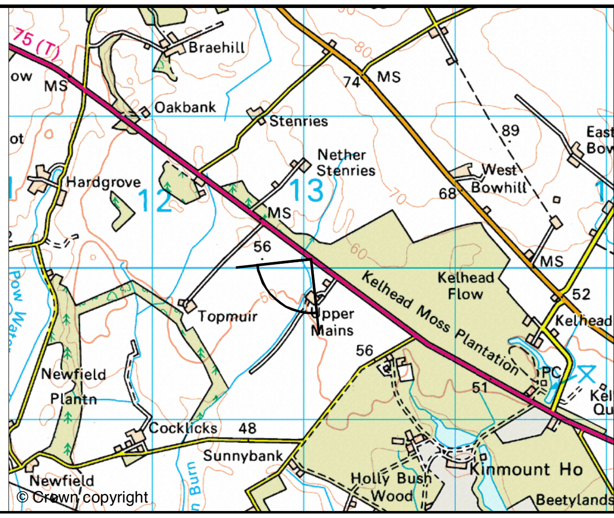
General notes

Wind farm layout:	14/03/02
Blade tip height:	130m
Camera lens:	50mm
Camera height:	1.65 m above ground
Arc of view	76 degrees
Correct viewing distance:	30 cm



Location notes:

Grid Ref:	313082 570046
Elevation:	54 m (above OS datum)
Bearing:	219 degrees (from grid north)
Distance:	Approx 34.8 km (to nearest turbine)

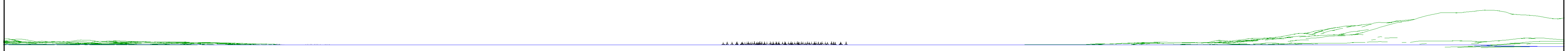
Robin Rigg Wind Farm

Visualisation No. 18

Location:

A75(T) Keyhead Moss

Photograph



Computer generated line drawing

Drawing by:

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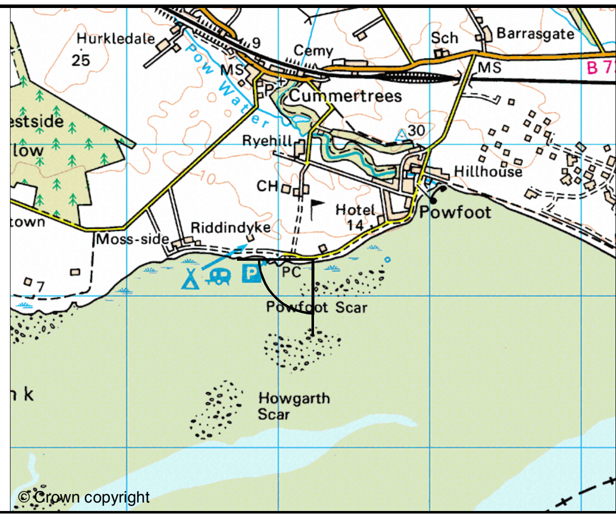
Email: post@naturalpower.com

General notes

Wind farm layout:	14/03/02
Blade tip height:	130m
Camera lens:	50mm
Camera height:	1.65 m above ground
Arc of view	76 degrees
Correct viewing distance:	30 cm



Location notes:

Grid Ref:	314229 565214
Elevation:	5 m (above OS datum)
Bearing:	225 degrees (from grid north)
Distance:	Approx 32 km (to nearest turbine)

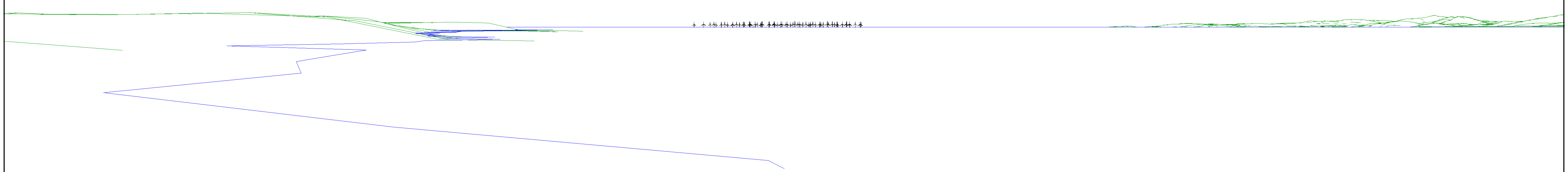
Robin Rigg Wind Farm

Visualisation No. 19

Location:

Campsite Powfoot

Photograph



Computer generated line drawing

Drawing by:

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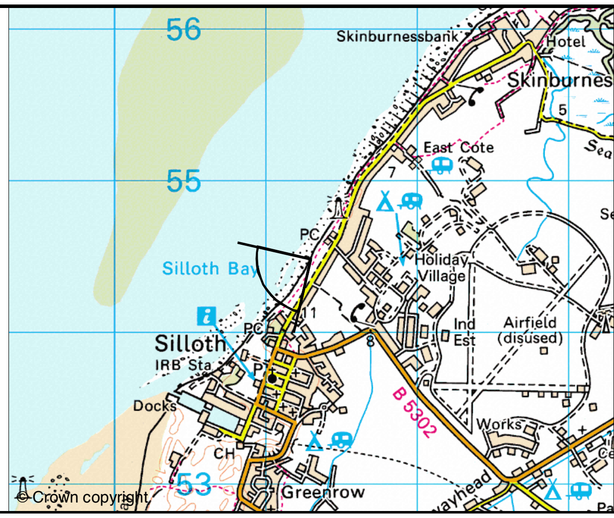
Email: post@naturalpower.com

General notes

Wind farm layout:	14/03/02
Blade tip height:	130m
Camera lens:	50mm
Camera height:	1.65 m above ground
Arc of view	76 degrees
Correct viewing distance:	30 cm



Location notes:

Grid Ref:	311283 554421
Elevation:	6 m (above OS datum)
Bearing:	238 degrees (from grid north)
Distance:	Approx 23.1 km (to nearest turbine)

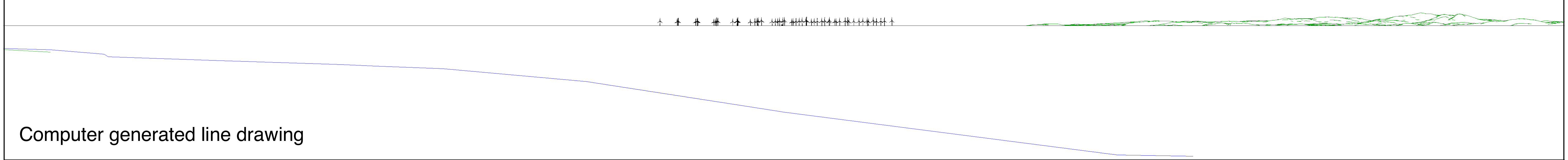
Robin Rigg Wind Farm

Visualisation No. 20

Location:

Silloth Sea Front

Photograph



Computer generated line drawing

Photomontage

Drawing by:

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Scotland
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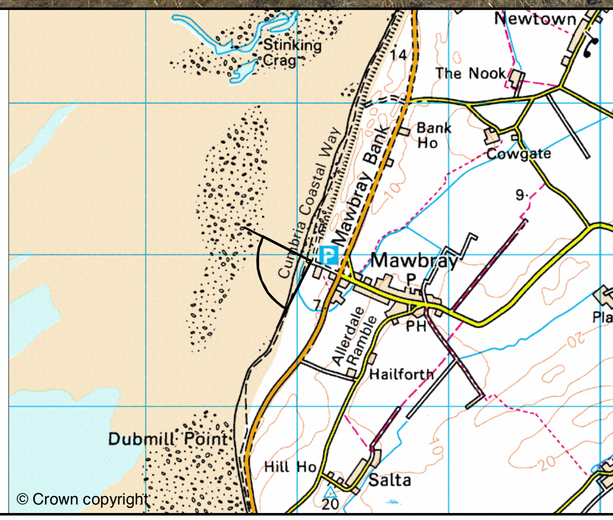
Fax: +44 (0)1644 430009
Email: post@naturalpower.com

General notes

Wind farm layout:	14/03/02
Blade tip height:	130m
Camera lens:	50mm
Camera height:	1.65 m above ground
Arc of view	76 degrees
Correct viewing distance:	30 cm



Location notes:

Grid Ref:	308099 546951
Elevation:	7 m (above OS datum)
Bearing:	252 degrees (from grid north)
Distance:	Approx 17 km (to nearest turbine)

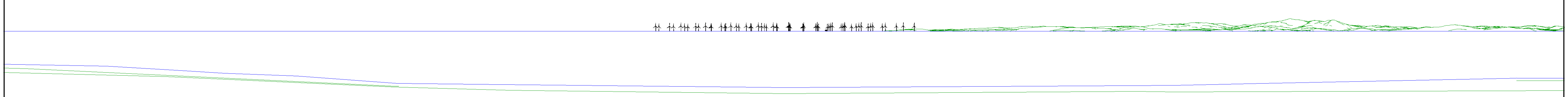
Robin Rigg Wind Farm

Visualisation No. 21

Location:

Cumbria Coastal Way,
Mawbray Bank

Photograph



Computer generated line drawing

Drawing by:

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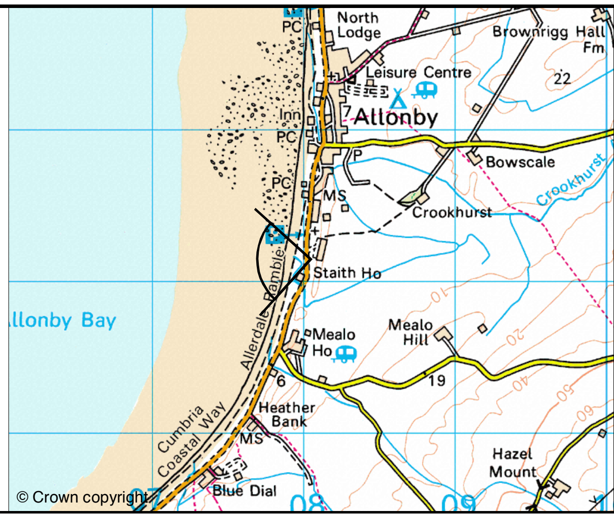
Dalry, Castle Douglas DG7 3XS
Scotland
Tel: +44 (0)1644 430008
Fax: +44 (0)1644 430009
Email: post@naturalpower.com

General notes

Wind farm layout:	14/03/02
Blade tip height:	130m
Camera lens:	50mm
Camera height:	1.65 m above ground
Arc of view	76 degrees
Correct viewing distance:	30 cm



Location notes:

Grid Ref:	308091 542177
Elevation:	11 m (above OS datum)
Bearing:	267 degrees (from grid north)
Distance:	Approx 16.3 km (to nearest turbine)

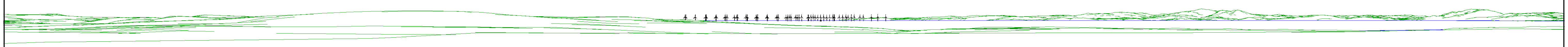
Robin Rigg Wind Farm

Visualisation No. 22

Location:

Allonby Sea Front


Photograph


Computer generated line drawing

Drawing by:

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Email: info@envision.ltd.uk

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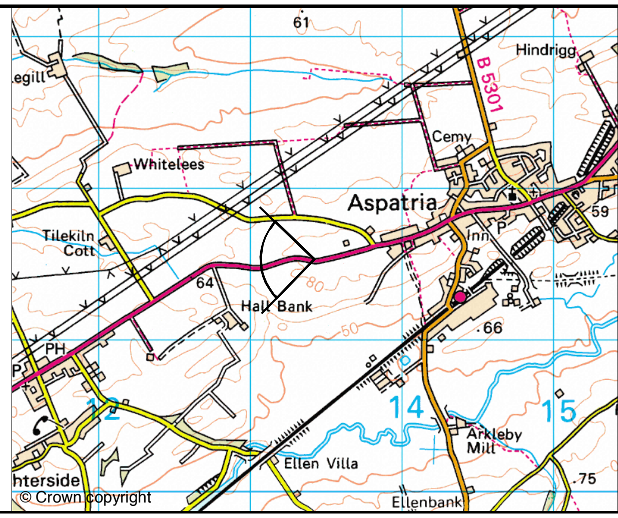
Dalry, Castle Douglas DG7 3XS
Scotland
Tel: +44 (0)1644 430008
Fax: +44 (0)1644 430009
Email: post@naturalpower.com

General notes

Wind farm layout:	14/03/02
Blade tip height:	130m
Camera lens:	50mm
Camera height:	1.65 m above ground
Arc of view	76 degrees
Correct viewing distance:	30 cm



Location notes:

Grid Ref:	313438 541503
Elevation:	83 m (above OS datum)
Bearing:	269 degrees (from grid north)
Distance:	Approx 21.7 km (to nearest turbine)

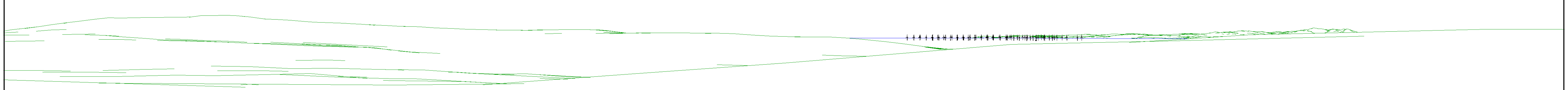
Robin Rigg Wind Farm

Visualisation No. 23

Location:

A596(T) Aspatria


Photograph


Computer generated line drawing

Drawing by:

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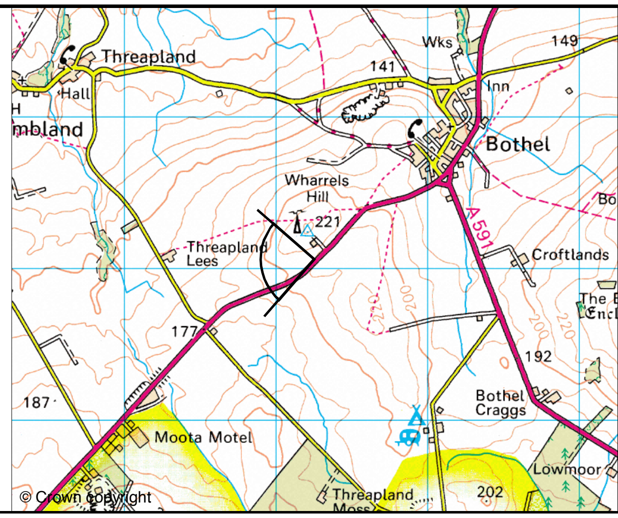
Email: post@naturalpower.com

General notes

Wind farm layout:	14/03/02
Blade tip height:	130m
Camera lens:	50mm
Camera height:	1.65 m above ground
Arc of view	76 degrees
Correct viewing distance:	30 cm



Location notes:

Grid Ref:	317252 538030
Elevation:	211 m (above OS datum)
Bearing:	266 degrees (from grid north)
Distance:	Approx 25.8 km (to nearest turbine)

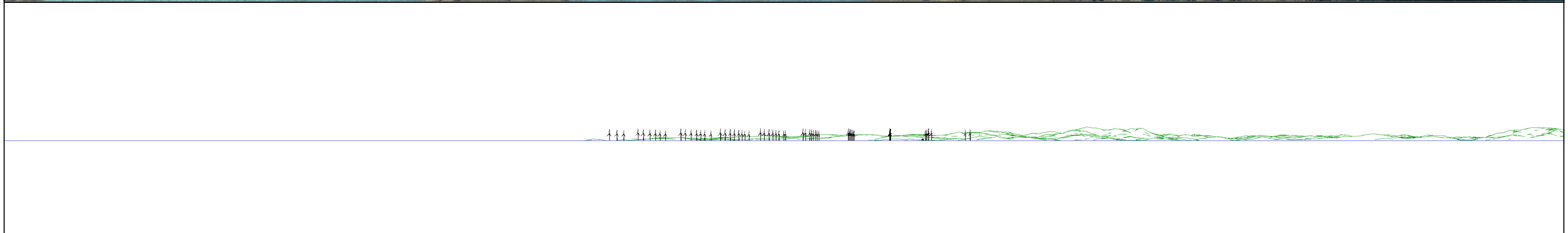
Robin Rigg Wind Farm

Visualisation No. 24

Location:

A595, Wharrels Hill, Bothel


Photograph


Computer generated line drawing


Photomontage

Drawing by:

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Scotland
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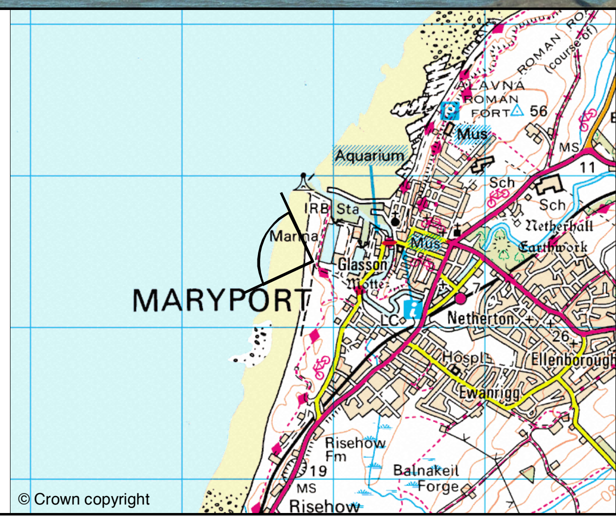
Fax: +44 (0)1644 430009
Email: post@naturalpower.com

General notes

Wind farm layout:	14/03/02
Blade tip height:	130m
Camera lens:	50mm
Camera height:	1.65 m above ground
Arc of view	76 degrees
Correct viewing distance:	30 cm



Location notes:

Grid Ref:	302870 536426
Elevation:	15 m (above OS datum)
Bearing:	290 degrees (from grid north)
Distance:	Approx 12.5 km (to nearest turbine)

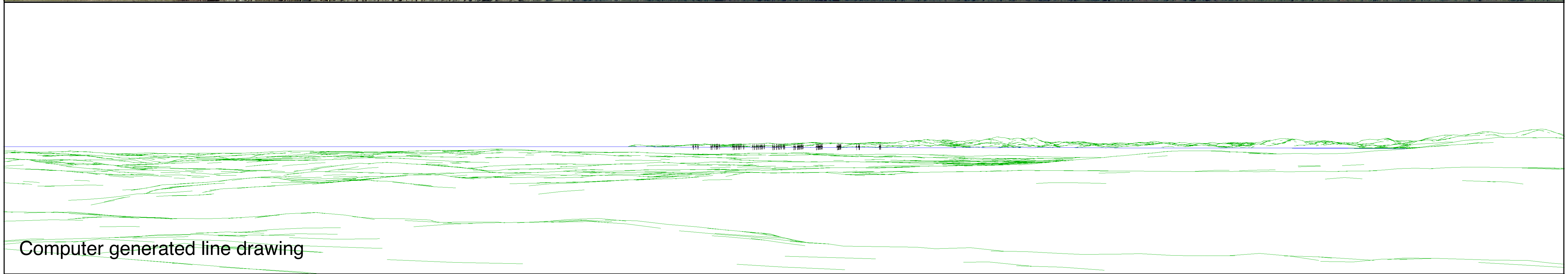
Robin Rigg Wind Farm

Visualisation No. 25

Location:

Maryport Marina

Photograph



Computer generated line drawing

Photomontage

Drawing by:

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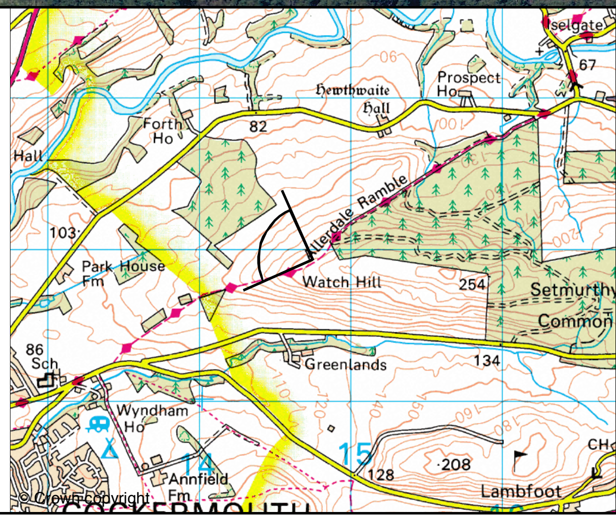
Tel: +44 (0)1644 430008
Fax: +44 (0)1644 430009
Email: post@naturalpower.com

General notes

Wind farm layout:	14/03/02
Blade tip height:	130m
Camera lens:	50mm
Camera height:	1.65 m above ground
Arc of view	76 degrees
Correct viewing distance:	30 cm



Location notes:

Grid Ref:	314760 531884
Elevation:	218 m (above OS datum)
Bearing:	291 degrees (from grid north)
Distance:	Approx 25.2 km (to nearest turbine)

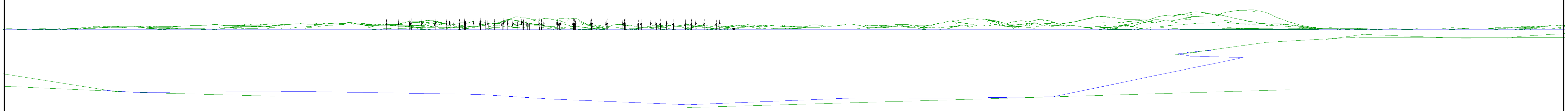
Robin Rigg Wind Farm

Visualisation No. 26

Location:

Watch Hill, near Cockermouth

Photograph



Computer generated line drawing

Photomontage

Drawing by:

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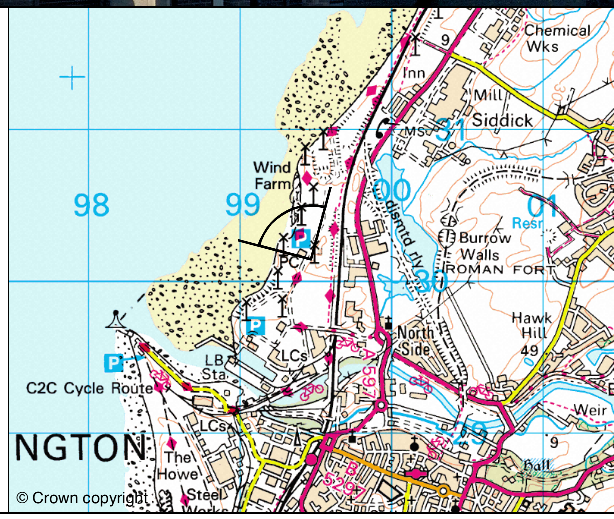
Fax: +44 (0)1644 430009
Email: mail@naturalpower.com

General notes

Windfarm layout:	14/03/02
Blade tip height:	130m
Camera lens:	50mm
Camera height:	1.65 m above ground
Arc of view	76 degrees
Correct viewing distance:	300 mm



Location notes:

Grid Ref:	299464 530133
Elevation:	15m (above OS datum)
Bearing:	330 degrees (from grid north)
Distance:	Approx 12.8 km (to nearest turbine)

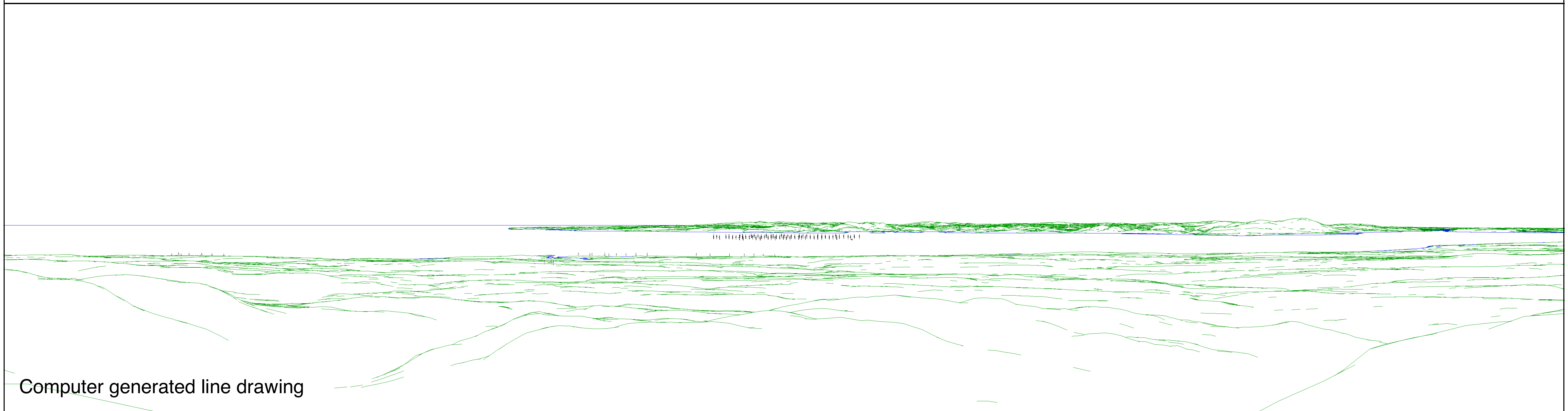
Robin Rigg Wind Farm

Visualisation No. 27

Location:

Rail route, Workington

Photograph not available



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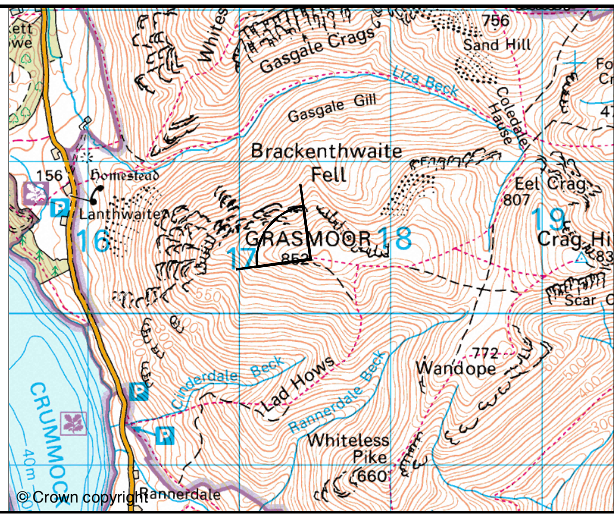
General notes

Wind farm layout:	14/03/02
Blade tip height:	130m
Camera lens:	50mm
Camera height:	1.65 m above ground
Arc of view	76 degrees
Correct viewing distance:	30 cm



Location notes:

Grid Ref:	317400 520400
Elevation:	841 m (above OS datum)
Bearing:	307 degrees (from grid north)
Distance:	Approx 32.9 km (to nearest turbine)

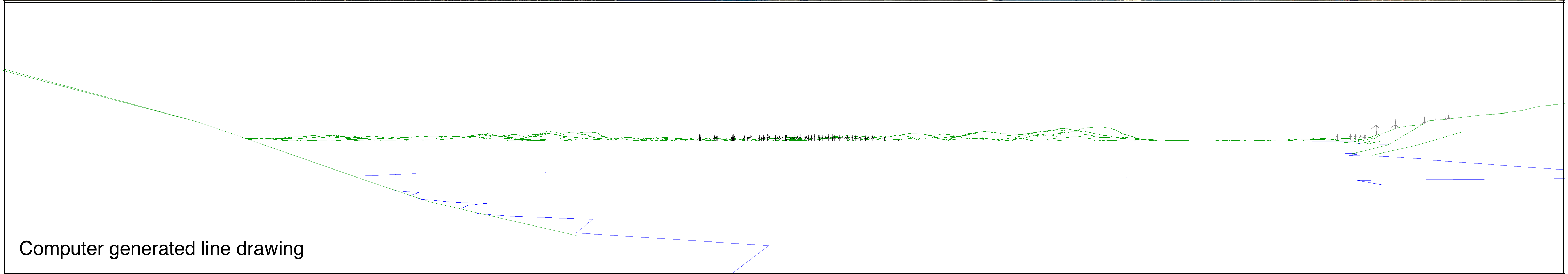
Robin Rigg Wind Farm

Visualisation No. 28

Location:

Grasmoor

Photograph


Computer generated line drawing

Photomontage

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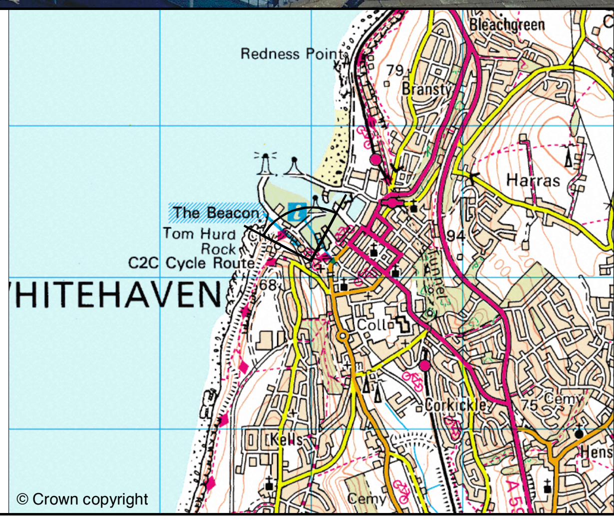
General notes

Wind farm layout:	14/03/02
Blade tip height:	130m
Camera lens:	50mm
Camera height:	1.65 m above ground
Arc of view	76 degrees
Correct viewing distance:	30 cm



Location notes:

Grid Ref:	297004 518099
Elevation:	20 m (above OS datum)
Bearing:	343 degrees (from grid north)
Distance:	Approx 22.2 km (to nearest turbine)

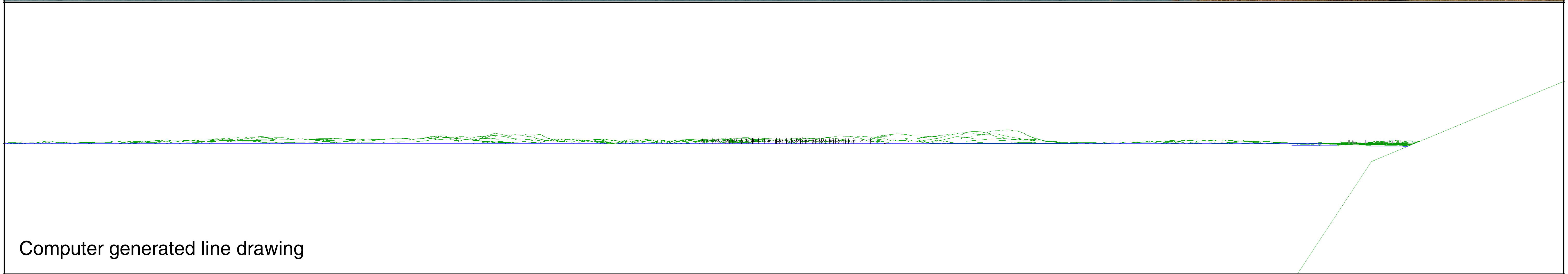
Robin Rigg Wind Farm

Visualisation No. 29

Location:

Whitehaven Harbour


Photograph


Computer generated line drawing


Photomontage

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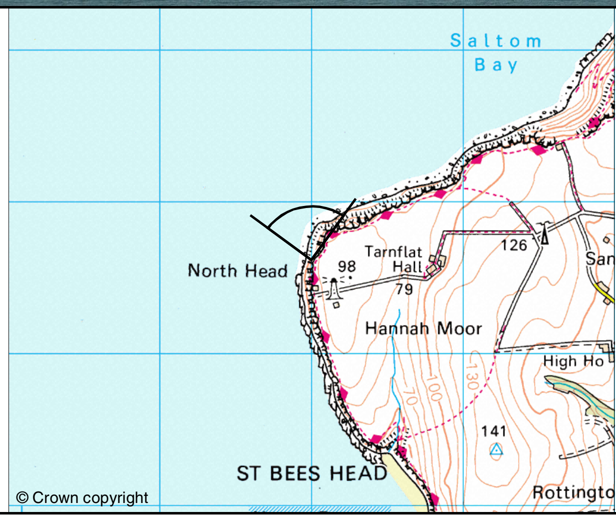
General notes

Wind farm layout:	14/03/02
Blade tip height:	130m
Camera lens:	50mm
Camera height:	1.65 m above ground
Arc of view	76 degrees
Correct viewing distance:	30 cm



Location notes:

Grid Ref:	293999 514609
Elevation:	81 m (above OS datum)
Bearing:	351 degrees (from grid north)
Distance:	Approx 24.9 km (to nearest turbine)

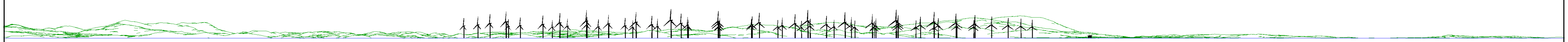
Robin Rigg Wind Farm

Visualisation No. 30

Location:

Lighthouse, St Bees Head

Photograph not available



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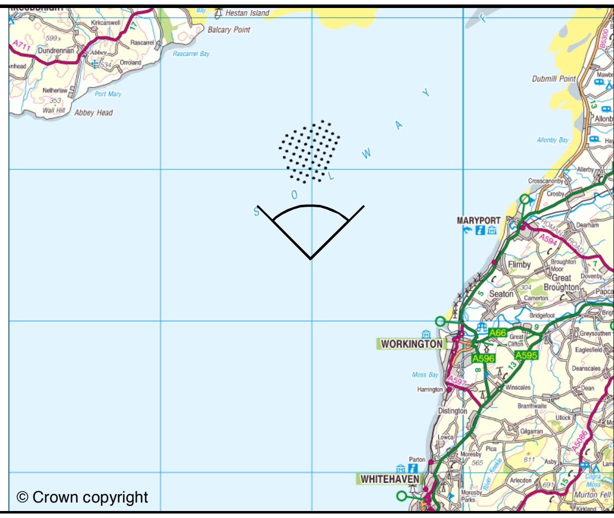
General notes

Wind farm layout:	14/03/02
Blade tip height:	130m
Camera lens:	50mm
Camera height:	1.65 m above ground
Arc of view	76 degrees
Correct viewing distance:	30 cm



Location notes:

Grid Ref:	290000 534000
Elevation:	5 m (above OS datum)
Bearing:	0 degrees (from grid north)
Distance:	Approx 5.2 km (to nearest turbine)

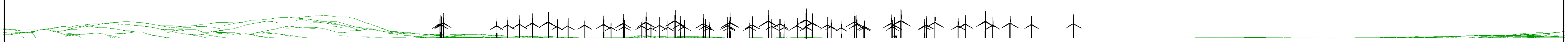
Robin Rigg Wind Farm

Visualisation No. 31

Location:

Sea View, Due South

Photograph not available



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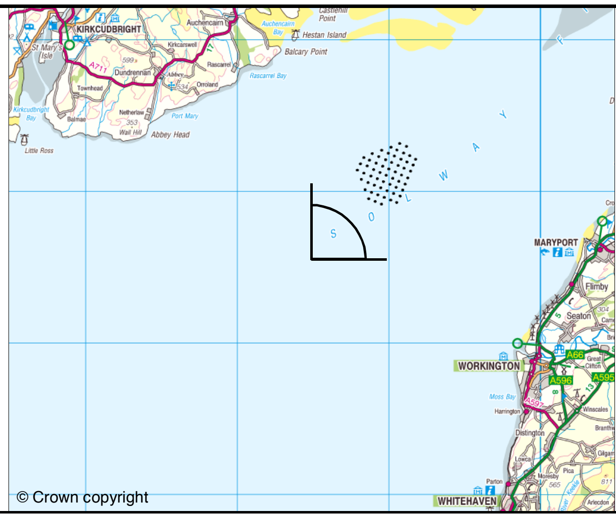
General notes

Wind farm layout:	14/03/02
Blade tip height:	130m
Camera lens:	50mm
Camera height:	1.65 m above ground
Arc of view	76 degrees
Correct viewing distance:	30 cm



Location notes:

Grid Ref:	285000 536000
Elevation:	5 m (above OS datum)
Bearing:	45 degrees (from grid north)
Distance:	Approx 5.1 km (to nearest turbine)

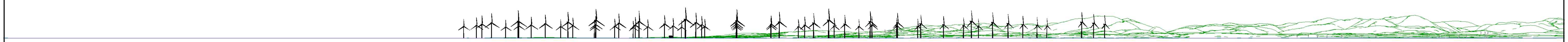
Robin Rigg Wind Farm

Visualisation No. 32

Location:

Sea View, South West

Photograph not available



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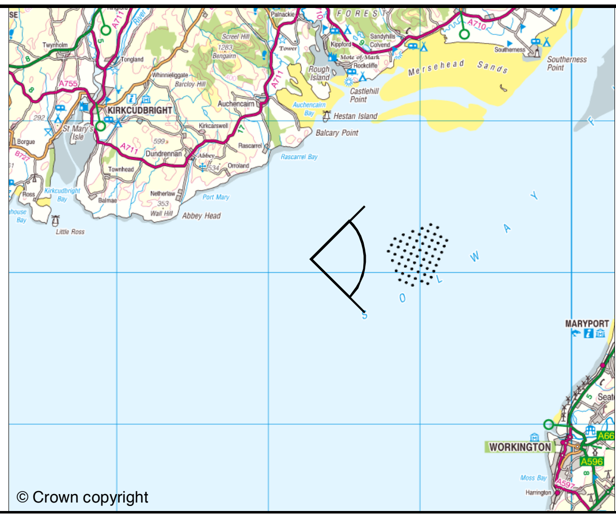
General notes

Wind farm layout:	14/03/02
Blade tip height:	130m
Camera lens:	50mm
Camera height:	1.65 m above ground
Arc of view	76 degrees
Correct viewing distance:	30 cm



Location notes:

Grid Ref:	283000 541000
Elevation:	5 m (above OS datum)
Bearing:	90 degrees (from grid north)
Distance:	Approx 4.9 km (to nearest turbine)

Robin Rigg Wind Farm

Visualisation No. 33

Location:

Sea View, Due West

9.11 IMPACTS ON ARCHAEOLOGICAL INTERESTS

9.11.1 ASSESSMENT METHODOLOGY

9.11.1.1 Outline

A methodology for the assessment has been provided by Natural Power. In essence, the methodology correlates the Sensitivity of each environmental factor with the Magnitude of Impact likely to be caused by the proposed scheme to that factor, in order to arrive at a value for the Significance of the effect. Only the higher values for Significance are regarded as a 'significant effect' for the purpose of the Environmental Assessment regulations. Details of the methodology are set out below.

9.11.1.2 Sensitivity

The Sensitivity of the environmental interest is determined in judging the impact of each issue. Sensitivity is gauged by reference to the importance of the individual feature being addressed, and its susceptibility to damage, being Low, Medium or High. The assessment of sensitivity is necessarily qualitative, but reference can be made to statutory or planning designations as an indicator of importance (e.g. Scheduled Monuments are of national importance and therefore having a high sensitivity), and to survival, condition and robustness in considering susceptibility to damage.

9.11.1.3 Magnitude and Significance

For the purposes of this assessment the Magnitude of an impact has been defined by the generic definitions given in Table 5.8.1 in Section 5.8 of this ES.

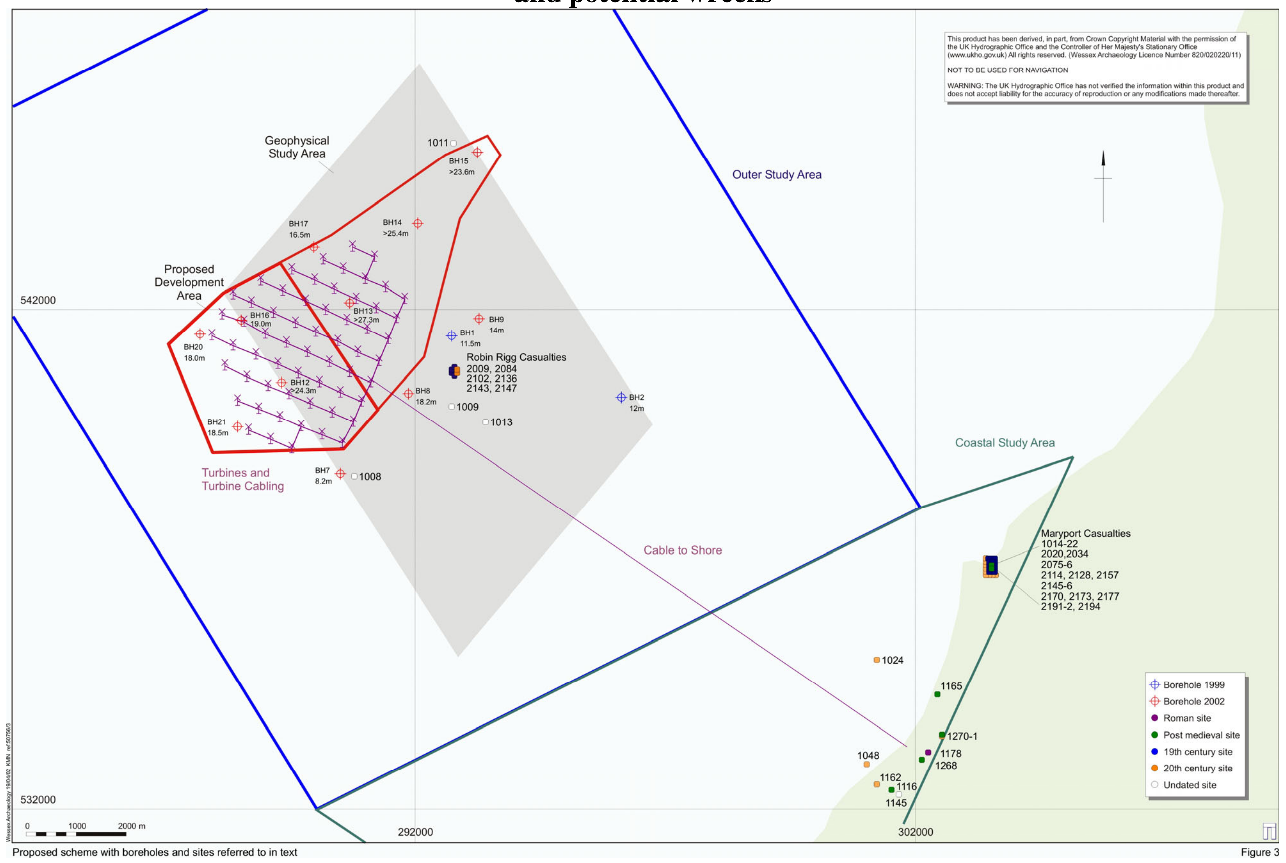
The significance of the effect of the proposed scheme on a specific site is established by correlating Sensitivity with Magnitude of Impact, using the generic matrix given by Natural Power in Table 5.8.2 also presented in Section 5.8.

Only effects considered to be of Moderate/Major or Major significance are considered to constitute significant effects. Negligible, Negligible/Low, Low, Low/Moderate and Moderate effects are not considered to be significant with respect to the Regulations.

9.11.2 SCHEME IMPACTS RELEVANT TO ARCHAEOLOGY

The scheme comprises 60 turbines of up to 100m rotor diameter on towers of up to 80m in height. The proposed positions of turbines is shown on Figure 9.11.1. The towers would have either monopile or multi-pile foundations. Monopile foundations typically consist of a steel cylinder up to 5.5m in diameter driven or augered 15 to 40m into the seabed, installed using cranes operating from a jack-up platform or floating barge. Multi-pile foundations comprise a central column braced by steel legs that are supported by piles with diameters of 1.0 to 1.5m, driven or vibrated up to 30m into the seabed. The footprint of multi-piles comprises a number of points within a circle up to 35 m diameter centred on each turbine. Both monopiles and multi-piles are sensitive to scour, though the conditions of the Solway site are such that foundations would be designed to accommodate the loss of bed material. For archaeological purposes, the primary impact of the turbines is the footprint of the foundation. Secondary impacts attributable to construction vessel anchors and jack-up spuds might be expected to occur over a wider area. As the seabed is known to be highly mobile, indirect impacts attributable to scour are considered to be of negligible archaeological effect.

Figure 9.11.1 Components of the Robin Rigg development in relation to identified archaeological sites and potential wrecks



If piles are augered in whole or in part, then augered material – sand and clay – may be disposed of on the seabed. The current mobility of the seabed is such that local disposal of arisings is unlikely to have an archaeological effect.

The turbines would be interconnected by cables as indicated on Figure 9.11.1. Interconnecting cables would be trenched to a depth of around 1m by fluidising the sand or by ploughing. For archaeological purposes the primary impact of the cables is the footprint of cable corridors though, as above, secondary impacts attributable to anchors/jack-up spuds may occur over a wider area.

The wind farm would be connected to the shore by a cable as shown on Figure 9.11.1. The route shown is the centre line of a corridor which is shown in Figure 4.13.1 in Section 4 of this ES. The corridor widens towards the shore where it reaches a maximum width of 680 m. The final route of the cable within this corridor, cannot be selected until the onshore cable. It is anticipated that the cable would be installed by a combination of shallow trenching to a depth of 1m with directional drilling under mobile banks. For archaeological purposes the primary impact of the cable to shore is the footprint of the cable corridor. Secondary impacts attributable to anchors/jack-up spuds may occur over a wider area.

Once landed, the cable would be laid underground to existing power lines. The onshore cable will be subject to a separate assessment under the Town and Country Planning Act.

9.11.3 ARCHAEOLOGICAL ASSESSMENT

9.11.3.1 Overview

Site 1011 is an anomaly interpreted as a wreck 2.7km from the nearest element of the proposed wind farm. It has not been assessed further on account of the distance from the proposed scheme.

Site 1008 is an anomaly *c.* 700m from the nearest element of the proposed wind farm. Site 1009 is an anomaly interpreted as a wreck *c.* 450m from the cable to shore. Both sites are assessed below.

Site 1013 is one end of a ridge or scar *c.* 580m from the cable. It has not been assessed as it is unlikely to be of archaeological interest. Site 1024 is an obstruction reported by fishermen *c.* 1km from the cable. No further details are available. It has not been assessed further on account of the distance from the proposed scheme.

Site 1268 is based on an NMR reference to a saltworking site. However, this record is most likely to be equivalent to site 1165 recorded in the SMR (NGR 302300 534300, *c.* 1.2km up the coast) corresponding to salt pans marked on the OS 6" first edition of 1864 (Cumberland XLIV SE). Accordingly, site 1268 has not been assessed.

Site 1178 is a Romano-British trackway recorded in the SMR *c.* 420m from the landing point of the cable. No further details are currently available. It is assessed below.

Sites 1048/1162 both refer to bombing decoys, though 1048 – on the foreshore *c.* 750m from the cable – may be a duplicate of 1162, which is in an area shown as a disused brickworks OS 6" provisional edition of 1947 (Cumberland XLIV SE). The remains of Allanby House (1270) and Flimby Hall (1271, Listed Building) are in the centre of Flimby, over 700m from the cable landing point. St. Helen's Colliery (1116), tramway 1145 and airshaft 1144 are at least 800m from the landing point of the cable. None of these sites have been assessed further on account of their distance from the proposed scheme.

The following casualties are recorded for the Named Locations Robin Rigg and Maryport respectively. No physical remains are currently associated with these casualties, so they must be regarded as potential rather than actual sites, for which sensitivity and magnitude of impact cannot be determined. Although they are not assessed further below, if physical remains of any of these casualties were to be impacted by the scheme, then the effect may be significant. While geophysical surveys to date have found none of these as wrecks within the proposed development areas further geophysical surveys would be carried out prior to construction as outlined in the mitigation section below. Any identified remains at that stage would be subject to further assessment.

Table 9.11.1 Recorded Casualties on Robin Rigg and at Maryport

Robin Rigg		Maryport	
2009	*Atlas*, 1807	1014	*Crosby*, 1773
2084	*Carn Trial*, 1878	1015	*Nelly*, 1773
2102	*Estrella de Chili*, 1888	1016	*Jane*, 1815
2136	*Topdal,* 1900	1017	*Betsey*, 1815
2143	*Mary*, 1903	1018	*Ann*, 1821
2147	*S. S. Grayfield*, 1905	1019	*James*, 1822
		1020	*Wilhelmina Scott*, 1822
		1021	wooden cargo vessel, 1824
		1022	*Sarah and Marianne*, 1835
		1023	*Alma*, 1884
		2020	*Hebe, 1822*
		2034	*Unknown vessel, 1882*
		2075	*Wanderer, 1871*

There is potential for other wrecks for which there is presently no record to have occurred within the footprint of the proposed scheme. As above, the sensitivity and magnitude of impact cannot be determined and they are not assessed below, but if physical remains were to be impacted then the effect may be significant.

The potential for prehistoric material dating to periods of lower sea-level within the footprint of the scheme currently appears to be low. The factors affecting this potential are, however, poorly understood in the region. In the absence of firm evidence of their presence, they have not been assessed. In addition only piling associated with turbines and the substation, and directional drilling of cables would impact on earlier land surfaces beneath the development areas. The actual area of the clay surface below the mobile sand layer that would be punctuated, assuming a worse case where each foundation pile punctuates this surface, and the whole area under a multipile foundation is effected, this would represent less than 0.06% of the area within the wind farm boundary. Therefore, even if important remains were present within the prehistoric land horizon the likelihood of any impacts on these is extremely small. However, in the event that new information indicated that prehistoric material was likely to be impacted, then the effect may be significant.

Although there are no recorded sites within the footprint of the proposed scheme sites on land, it is possible that as yet unrecorded sites exist. While the sensitivity and magnitude of impact on as yet unknown sites on land cannot be determined, the impact on any such sites that are present may be significant.

9.11.3.2 Assessment

Anomaly 1008 comprises a sidescan contact *c.* 40m wide corresponding to a strong magnetic signature, suggesting the presence of a wreck. The age and character of the wreck are not known. The latest date for any of the known casualties associated with Robin Rigg is 1905, which might be regarded as a latest date for the possible wreck. The wreck may be considerably older. Subject to the character of the site and its condition, the wreck might prove to be important archaeologically. As a result, its Sensitivity is best considered to be high until proven otherwise. Anomaly 1008 is *c.* 700m from the nearest element of the scheme and is consequently unlikely to sustain primary impacts. However, in the absence of mitigation (see below) it is conceivable that secondary impacts could occur, such as anchor damage attributable to vessels involved in construction. Occasional anchor damage would be discernible but is unlikely to change substantially the archaeological character of the site. Given the distance from scheme elements, even such secondary impacts are unlikely to occur. As a result, the magnitude of impact on Anomaly 1008 is considered to be Low or Negligible. Consequently, and notwithstanding the possible High sensitivity of the site, the overall significance is Low/Moderate, i.e. not a significant effect.

Anomaly 1009 is a 30m wide feature with no significant magnetometer response, interpreted as a wreck. The age and character of the wreck are not known but the lack of apparent magnetometer signature might suggest that the vessel was largely built of wood and not equipped with boilers/engines. As in the case of Anomaly 1008, the date of the last known casualty (1905) might be regarded as a latest date for Anomaly 1009, though it could be considerably older. Again, the wreck might prove to be important archaeologically and its Sensitivity is best considered to be high until proven otherwise. Anomaly 1009 is *c.* 450m from the nearest scheme element so primary impacts are unlikely. Secondary impact such as anchor damage is conceivable in the absence of mitigation (see below) and would be discernable, but if only occurring occasionally it is unlikely to change substantially the archaeological character of the site. The magnitude of impact is therefore Low or Negligible and, notwithstanding the possible High sensitivity of the site, the overall significance is Low/Moderate, i.e. not a significant effect.

Trackway 1178 is dated to the Romano-British period. The Sensitivity of the trackway and any other associated structures and deposits is best considered High, particularly given the importance of Roman remains to the archaeology of the region. Trackway 1178 is *c.* 420m from the centre line of the cable and therefore lies some 80-90m outside the potential cable corridor, therefore there should be no primary impacts. On land, construction activity tends to be more localised than at sea so it is very unlikely that any secondary impacts would affect Trackway 1178 even if the final cable route was selected on the northern edge of the corridor. Consequently, the magnitude is Low or Negligible. Despite the sensitivity being High therefore, the overall significance is Low/Moderate, i.e. not a significant effect. The cable route on land will be subject to a separate Town and Country Planning Act application which would be accompanied by supplementray environmental information that should confirm that the construction route would not cross this trackway. A field survey will be carried out along the selected route to identify any other remains. This would be reported on in the supplementary information to accompany the Town and Country Planning Act application.

Table 9.11.2: Summary of Potential Impacts

Site	Description	Sensitivity	Magnitude	Significance of Effect
1008	Anomaly	High	Low/Negligible*	Low/Moderate
1009	Anomaly/wreck	High	Low/Negligible*	Low/Moderate
1178	Trackway	High	Low/Negligible	Low/Moderate

NB: * Subject to mitigation (exclusion zone), see below.

9.11.4 PROPOSED MITIGATION AND MONITORING

9.11.4.1 Pre-construction

Additional marine geophysical survey would be carried out of the proposed wind farm and cable route prior to construction should the development be given building permission. This would be carried out for construction purposes i.e. identifying surface and subsurface obstacles to piles etc., however the data would also be made available for archaeological interpretation.

An archaeological assessment will be carried out of the cable route on land, using desk based (archaeological, documentary, cartographic and air photographic) sources as well as field survey, relating to the cable route corridor to accompany any planning application for this cable route under the Town and Country Planning Act

There is scope for minor scheme redesign through micrositing of elements of the development to avoid significant effects on sensitive sites revealed either by marine geophysical survey or by desk-based assessment of the cable route on land.

A written scheme of investigation to accompany construction would be prepared in the course of detailed design work, in consultation with archaeological curators.

9.11.4.2 Construction

The written scheme of investigation would provide for exclusion zones to be established around known sites of archaeological interest. The exclusion zones would be included in construction contract documents and on scheme drawings.

The written scheme of investigation would include a protocol for reporting archaeological material discovered in the course of construction, both during marine works and on land.

Implementation of the written scheme of investigation would be monitored by the archaeological curators.

9.11.4.3 Post-construction

Any archaeological archive arising from the project would be deposited in a suitable repository. Deposition of the archive would include arrangements for the stabilisation and disposition of any archaeological material recovered in the course of construction.

In the event that important archaeological material is recovered, recorded or otherwise investigated, summary results would be published in suitable regional/thematic journals.

9.12 CONSTRUCTION EFFECTS ON LAND

9.12.1 CONSTRUCTION TRAFFIC

Since either monopiles or multipile foundations are to be used with no scour protection around the foundations, there would be no requirement for transport of aggregates, or minerals to or from the wind farm site during the construction phase. The material requirements for the wind farm have been listed in Section 4.16.3. These comprise steel components for the foundations, turbine components, components for the substation and cabling.

The major components for, foundations, turbines and substation would be likely to be constructed elsewhere either in the UK or abroad and transported direct to the site or to the construction port for assembly. The substation is likely to be assembled in the port prior to transportation in nearly complete form to the site for installation onto monopile supports. The turbine components are likely to be stored in the construction port prior to assembly on site, although transportation may be direct to the site by ship from the fabrication plant. In either case transportation of turbine components is likely to be entirely by sea, even in the case that components are constructed in the UK. The main possibility for sourcing of turbine components in the UK, the new Vestas fabrication plant in Scotland which currently assembles nacelles for smaller turbines, lies in Macrihanish on the Mull of Kintyre with easy access to port facilities.

Cabling is also likely to be carried by sea to the construction port.

Should any components, such as foundation components, be carried over land to the construction port, of the ports that have been considered as having potential as the construction port (Workington, Silloth, Barrow-in-Furness and Maryport) only Silloth is not directly served by both rail and trunk roads. No significant traffic impacts would be expected should any of the other three ports be used. Selection of the construction port by the civil contractor contracted to construct the development would be dependent on the need for transport links. Should it emerge that large components would require overland transportation Silloth's suitability would need to be considered against its transport connections.

9.12.2 NOISE, DUST AND OTHER EMISSIONS FROM THE HARBOUR AREA

Since no aggregates or mineral would be required for the construction of the wind farm no dust emissions are expected at the construction port.

Noise of unloading, loading and assembly at the construction port is not expected to be greater than the noise from existing port operations at the ports considered as having potential for use, and would not require any special permissions. Impact of construction noise within the port would therefore not be significant.

9.13 MARINE NAVIGATION EFFECTS

9.13.1 COLLISION RISK ASSESSMENT

Construction Period

All non-construction vessels will be excluded from the construction area during the construction periods as described in Section 4.17.1. There would therefore be no risk of collision with foundations under construction.

Operational Period

Commercial vessels do not cross this part of the Solway due to the continually shifting sandbanks and lack of depth even at high water. The main destinations for commercial vessels being Silloth, Maryport, Workington and Whitehaven on the Cumbrian coast with the navigable routes being to follow the English and Silloth Channels and the Maryport Roads. There would therefore be a very low risk of collision of commercial shipping with any components of the wind farm.

Local fishermen trawl the channels around the banks and occasionally over the Robin Rigg bank rather than lift and reset their gear. There is therefore a higher risk of either collision or their gear becoming fast on either foundation structures (especially if multi-pile) or cables.

Local shrimp vessels work the banks during the winter months. These are small and manoeuvrable enough that there shouldn't be a collision risk. There is however a medium risk that their gear could become caught on the cabling.

Recreational sailors are currently recommended to stay to the west of the Two Feet Bank buoy (52deg 42'.40N 03deg 44'.40W) and therefore away from the banks. At high water however, some yachts will cut across on their way to and from Kippford and Maryport. Solway Yacht Club and Maryport Yachting Association also use the Solway buoy (54deg 46'. 80N 03deg 30'.05W), the North Workington buoy (54deg 40'.10N 03deg 38'.10W) and the South Workington buoy (54deg 37'. 00N 03deg 38'.50W) as marks for their races. Depending on weather, yachts may cross the area to reach the next racing mark. The minimum distance between blade tip and water at the astronomical high tide would be just over 25m; this will be in excess of the likely height of the top of the mast on a yacht using this area. There will be disturbed air but the dispersal pattern is such that it shouldn't cause problems for a yacht under sail. With the strong currents and tides in the area, there is a small risk of collision if a yacht was becalmed and unable to use an engine to get out of the area.

Although it is felt that the risk of collision is low, a comprehensive collision risk assessment has been commissioned. The results of this assessment will be submitted as a supplementary report to the environmental statement.

9.13.1.1 Mitigation against Collision

Trawlers would be prohibited from trawling within the wind farm area. In addition all vessels would be prohibited from approaching within 50 m of turbines during the lifetime of the wind farm and prohibited from mooring to turbine foundations and notices to this effect would be placed within all sailing harbours and mariners in the vicinity of the wind farm.

As described in Section 4.9.1 discussions with the Northern Lighthouse Board and Trinity House have resulted in the following proposals for buoying to mark the wind farm area during the operational period.

Shape	Colour	Mark	Latitude	Longitude	Characteristics*
Conical	Yellow	X	54deg 45.19N	03deg 44.38W	Fl Y 5s
Conical	Yellow	X	54deg 46.21N	03deg 41.57W	Fl Y 5s
Can	Yellow	X	54deg 45.45N	03deg 40.50W	Fl (4) Y 12s
Can	Yellow	X	54deg 44.04N	03deg 42.59W	Fl (4) Y 12s

*All lights to have a visible range of 3 nautical miles.

All buoys would be fitted with a radar reflector.

An audible fog signal would also be installed in the approximate centre of the array. The audible range is to be at least two miles and omni-directional. This signal shall have a character of Morse "U" sounding every 30s marking the position of the wind farm in conditions of poor visibility

Further consultation with Solway Yacht Club has highlighted that some form of visual marking would be useful for recreational sailors who are unlikely to have radar and will be reliant on charts and hand held GPS. It was requested that some form of localised visible mark be applied to the outer turbines e.g. a 1m wide yellow band. This would allow sailors to distinguish whether they were within the array or outside the array in poor visibility. The developers have agreed to a visible yellow band at the base of each turbine tower 1 metre deep, positioned over the tower/foundation interface.

Northern Lighthouse Board, Trinity House and the UK Hydrographic Office would be supplied with the locations of all the structures and the cabling patterns between the structures and exclusion zones around turbines to mark on admiralty charts. The cable route from the sub-station to shore would also be given.

Information boards showing the layout, latitudes and longitudes of the turbines and the cable route; cabling between structures; buoy and foghorn positions and characteristics would be placed at all major ports and slipways. The same information to be given to local sailing clubs and fishermen's groups for distribution to members.

There are several types of software around that work with a vessel's GPS, which gives audible and visual alarms of approaching danger. The appropriate information will be given to the database collator.

Up to date hydrographic information will be supplied to the UK Hydrographic Office for inclusion on updated charts. Local sailing clubs and fishermen's groups would also be supplied with this.

These measures should ensure a very low risk of collision with turbine structures.

9.13.2 EFFECTS ON SHIPPING AND LEISURE USE FROM EXCLUSION ZONES DURING CONSTRUCTION AND OPERATION

9.13.2.1 Construction

During construction, all vessels except those involved in construction will be excluded from the area. Construction is likely to take place between April and October. The exclusion zone is described in section 4.17.1.

This would have no effect on the commercial vessels (including scallop vessels) that operate to and from Kirkcudbright, Silloth, Maryport, Workington and Whitehaven since they do not use this area.

Shrimp vessels tend to work in the Inner Solway during this period. Effects on fishing vessels are considered in Section 9.15 below.

Both Solway Yacht Club and Maryport Yachting Association hold regattas in June / July. Race organisers will need to take account of the exclusion zone as well as weather when setting courses. The effect on Maryport Yacht Club will be negligible as they use the Solway, North and South Workington and Two Feet Bank buoys all of which are to the east and south of the exclusion zone and therefore the race course would not cross the exclusion zone.

Cruising yachts sailing from Kippford to Maryport and vice versa will need to follow the sailing directions and keep west of the Two Feet Bank buoy. This may have an effect on the routing of a small number of races during the one to two years of construction, but it is not considered to be a significant effect.

9.13.2.2 Operation

During operation, it is intended that the only vessels, which shall be excluded from the site will be trawlers with their gear out. In addition no unauthorised vessels would be allowed to anchor within the wind farm area. Effects on the available fishing resource resulting from these exclusions is assessed in Section 9.15 below.

Leisure vessels will be free to cross the area during the operational phase although there would be an exclusion area of 50m around each turbine and vessels will be strictly prohibited from making fast to the turbines. These 50 m exclusion zones comprise only 4.5% of the wind farm area. Effects on leisure vessels are therefore considered to be minimal.

As described in Section 8.2.1 commercial vessels never navigate through the Robin Rigg area. No effects are therefore expected for commercial vessels from exclusion zones.

9.14 AVIATION AND MILITARY IMPACTS

Defence Estates who have responsibility for military danger areas, military radar and communications and protection of low flying areas have been consulted with regard to the Robin Rigg proposals. They have responded with no objections to the proposed development provided that the development does not impinge into the nearby Danger Areas as described in Section 8.6 of this ES. The development would not impinge on this area and therefore there are considered to be no impacts on military use of the Solway. Defence Estates have requested further details of the exact position and dimensions of the development should it be constructed for use by military aircrew to avoid direct overflight of the site.

The Civil Aviation Authority Safety Regulation Group and National Air Traffic Services have been consulted with regard to effects on civil aviation. The CAA have responded with no objection since there are no Aeronautical Radio stations within 30 km of the site. NATS are satisfied that the proposals would not conflict with their safeguarding criteria and have no objections to the development.

9.15 EFFECTS ON SOCIO ECONOMICS

9.15.1 EMPLOYMENT AND INVESTMENT

Positive impacts on the local, regional and UK economy would result from the construction, operation and decommissioning of the Robin Rigg wind farm. These would include but would not be limited to:

- ***Construction*** – the investment value of the Robin Rigg wind farm through design, construction and commissioning would be at least £150 million and would involve a diverse range of businesses including civil engineering design, specialist plant hire, shipping and transportation, rental of port facilities, turbine and electrical components and civil and marine engineering contractors etc.
- ***Operation*** – the operational period would involve direct employment of a number of technicians and management staff in the local area during the lifetime of the wind farm. In addition there would be investment related to monitoring of the marine environment, including the periodic hire of local fishing boats for trawl and benthic grab surveys during the first few years of the operation of the wind farm.
- ***Decommissioning*** – this would result in significant contracts to civil engineering contractors over the year of decommissioning
- ***Indirect effects*** – there would be indirect positive effects on the local economy particularly in the vicinity of the construction port through accommodation and services required by the construction workers.

9.15.1.1 Construction and Commissioning

The capital cost of construction and commissioning of the Robin Rigg development will be upwards of £150 million depending largely on the size of turbine chosen for the site, this value including all design and development, civil engineering and construction, materials, turbines, foundations structures, cabling, transformers etc. and all commissioning and testing activities.

The wind farm would be constructed as a turnkey project, that is, a single contractor would lead the whole project which would be transferred to the investor immediately following commissioning. There would be likely to be three main subcontractors one of which would lead the turnkey project. These subcontractors would have the broad expertise areas of marine civil engineering, turbine assembly and erection and electrical engineering. A large number of smaller contractors in specialist areas would be sub-contracted.

Tendering for contracts has not begun and therefore it is not possible to say where the contractors and subcontractors would be based or where components and materials for the wind farm would be sourced. The turbines would represent in the region of 50% of the total capital investment. The only turbine manufacturing company with a facility in the UK is Vestas, who have recently set up a facility on the Mull of Kintyre for the assembly of nacelles of sub 1MW machines employing around 100 skilled workers. This facility is planned to expand in the future to include tower construction and the company currently manufactures 2MW turbines for offshore use and is developing larger turbines. A further company in Wales (Cambrian) manufactures turbine towers. There is therefore some potential for sourcing of components in the UK.

There would be many other contracts in electrical engineering, transportation, civil engineering etc. available for tender by locally based companies, i.e. companies located in the southwest of Scotland and the northwest of England.

Discussions have been held with economic development agencies on both sides of the border on appropriate methods of attracting tenders from businesses in the area. Two business seminars will be held, one in Dumfries & Galloway and the other in Cumbria prior to tendering to introduce local businesses to the project. Local contracts are expected to result from this process. Typically around 20-25 % of onshore wind farm contracts have gone to companies based in the region of onshore wind farms constructed in the UK. If the Robin Rigg wind farm project follows this pattern, upwards of £30 million will be invested into the economies of southwest Scotland and northwest England during construction.

The works will also lead to a major investment in a local port or ports likely to include Silloth, Maryport, Workington or Barrow-in-Furness. This period of intensive use of port facilities is expected to last for two construction seasons.

Up to 120 skilled and non-skilled workers will be employed for the construction period both onshore and offshore for the construction season(s). A number of these workers are likely to be sourced locally.

Other workers coming in from elsewhere will require accommodation in the vicinity of the construction port(s). They would also contribute indirectly to the locally economy through payment for goods and services during their stay in the area.

9.15.1.2 Operational Period

The operational period of the wind farm would last 20-25 years. During this time there would be a need for a permanent staff of 5 equivalent full time technicians and administration staff. The technicians would be stationed onshore in close proximity to the wind farm and close to a harbour. The administration staff would be likely to operate from the same office.

Experience elsewhere suggests that the majority of these staff would be recruited locally.

During planned maintenance and servicing operations on the turbines, foundations and offshore substation there would be a need for an additional maintenance crew of around 10 personnel to support the core technical team. These would be most likely to be brought in from further afield but housed in the vicinity for the planned maintenance periods.

In addition to the above employees, employed by the wind farm company or turbine suppliers, the operations crew would need a boat and crew for transportation to and from the wind farm. This would require daily visits to the wind farm during planned maintenance visits and the boat and crew would need to be on permanent call at other times. The boat and crew would be hired locally, at the harbour from which the operations team would operate.

Monitoring of the marine environment during construction and for the first three years of operation of the wind farm will also lead to local part-time employment. The baseline survey work that has been carried out already and is ongoing employs a number of locals including ornithological experts and fishermen on a part time contract basis. The construction and post-construction monitoring would provide similar opportunities for local contracts.

9.15.2 EFFECTS ON COMMERCIAL FISHERIES

As can be seen from Figure 8.1.1 given in Section 8.1, the majority of fisheries in the Solway are found in the outer Solway west of the Robin Rigg site. The main fishing activities carried out within the area of the sand banks in the vicinity of Robin Rigg are Maryport vessels trawling for demersal species, and smaller boats from Maryport, Silloth and Annan trawling for brown shrimp. Maryport recently had 16 full time large trawlers, however the number has been declining in the last few years. The Maryport trawlers fish the deeper channels (mainly Maryport Roads and Scotch Deep), between the sand banks for sole, plaice and other bottom living species, using an otter trawl.

The fish impact assessment presented in Section 9.7 of this ES predicted that the wind farm would not have a significant adverse impact on the fish resource in these areas, either during the construction or operational periods.

The only impact on fisheries would therefore result from restrictions to fishing within the wind farm during the construction and operation periods. As described in Section 4.17.1 and 4.18.3 all vessels would be excluded from an area extending 350m beyond the wind farm during the construction period, and once commissioned trawling would be prohibited vessels within the area extending 100m beyond the outer turbines in the layout. Finally an exclusion zone of 350m around the outside of the wind farm would be imposed for the decommissioning of the site, which would take place in a single season.

The exclusion zones are given in Figure 4.4.1 in Section 4 of this ES and in the context of the Solway as a whole in Section 8.2.2, and are identified from the following points on the perimeter.

Table 9.15.1 Construction and Decommissioning Exclusion Zone Perimeter

Point	Latitude	Longitude
C1	54deg 46’.34 N	03deg 41’.39 W
C2	54deg 45’.50 N	03deg 40’.32 W
C3	54deg 44’.37 N	03deg 41’.14 W
C4	54deg 43’.53 N	03deg 42’.17 W
C5	54deg 43’.59 N	03deg 44’.08 W
C6	54deg 45’.19 N	03deg 44’.53 W
C7	54drg 45’.56 N	03deg 44’.24 W

Table 9.15.2 Operational Period Trawling Exclusion Zone Perimeter

Point	Latitude	Longitude
T1	54deg 46'.21 N	03deg 41'.57 W
T2	54deg 46'.14 N	03deg 41'.28 W
T3	54deg 45'.45 N	03deg 40'.50 W
T4	54deg 44'.45 N	03deg 41'.22 W
T5	54deg 44'.08 N	03deg 41'.59 W
T6	54deg 44'.04 N	03deg 42'.59 W
T7	54deg 44'.07 N	03deg 43'.57 W
T8	54deg 45'.19 N	03deg 44'.38 W
T9	54deg 45'.51 N	03deg 44'.09 W

Both the Maryport Roads and the Scotch Deep are outside the above exclusion zones. One potential impact would be where trawlers leave their gear down when moving over the banks from channel to channel. If they were in the vicinity of the exclusion zone, they would have to lift their gear or go around it. This would not affect their ability to fish the area, but may have an effect on their operational fishing procedures.

The Middle Channel is not fished as heavily as the Scotch Deep and the Maryport Roads. It is the most mobile of the channels. Over the lifetime of the wind farm it is possible that there will be occasions where the channel will edge into the northern part of the operational trawling exclusion zone for the wind farm. It is intended to survey the bank to monitor its movement on a regular basis. This information will be passed to fishing bodies in England and Scotland, together with local fishermen known to use the area adjacent to the wind farm.

Fishing for Shrimp tends to concentrate around the edges of the banks in the Outer Solway during the winter months (November to April) this includes Robin Rigg. The three shrimp vessels based at Maryport plus on occasion an additional two from Silloth tend to concentrate on the area around Robin Rigg during these months. The boats generally use 6m beam trawls. Again, as the fishing is concentrated on the edges of the banks, the majority of the fishing area will be unaffected, apart from where there is movement of the Middle Channel as described above.

The bank is a nursery area for a number of species fished in and around the Solway including Plaice Sole, Dab and Whiting. The area over the bank is not fished as a result of this. As assessed in Section 9.7, the development, operation and decommissioning of this proposal will not have an adverse impact on the nursery species, or on the annual migration of species across it.

There has been a fishing special interest group set up to discuss the Robin Rigg proposal, including fishing bodies and representatives from both sides of the border. The group has met 3 times during the twelve months leading up to this submission, covering all aspects of the development, its operation, the surveys carried out, and the issues of compensation. The developers have agreed to compensate fishing interests which are directly affected by the construction, operation and decommissioning of the proposal. This compensation would be based on information gleaned from the vessels' log-books and annual accounts. The discussions would be conducted through a group representing both Scottish and English interests, which could be an extension of the specialist group's remit. Once the timetable for the project is known, including which turbines will be developed first and the speed of the progression of the project; the mechanism and sums of compensation can be fine-tuned and agreed.

During construction, operation and decommisioning the wind farm would pay annual sums into a fund agreed by the above mentioned cross border group that would then be responsible for the distribution of the money to individuals.

There will be a need for experienced boatmen both during the construction and operational phases of the wind farm and it may be that alternative stable employment can be provided which would mitigate the requirement to pay compensation.

9.15.3 EFFECTS ON TOURISM

The only direct effects on tourism would result from exclusion of vessels from the construction area during the construction period that would include exclusions on sea angling boats, yachts and wind surfers. Most of these activities take place inshore. For those crossing the Solway from, for example, Kippford to Allonby Bay, there would be a need to divert east or west of the construction exclusion zone increasing trip length somewhat, but this would not have a significant effect on tourists in the area.

The main effect of the proposal on tourism on the Solway would be the indirect effects of changes to the landscape and seascape through the introduction of a new visual feature into the Firth which would be visible from much of the coastline, though visibility would fall off rapidly as one moved inland particularly on the Scottish side of the Firth.

Although, hiking is not as popular to tourists visiting Dumfries & Galloway, as in Scotland as a whole, it is still one of the more popular activities for visitors to the area. On both the Dumfries & Galloway and Cumbrian coasts there are a number of coastal footpaths including in particular the Cumbrian Coastal way long distance footpath and the new Hadrian's Wall National Trail, from which one would obtain clear views of the wind farm along much of the routes. Additional attractions which are popular to tourists visiting the area and from which the wind farm proposal would be seen, are coastal golf courses, beaches, in particular Southerness, Sandyhills and beaches in Allonby Bay, and wildlife reserves, the closest being Mersehead Sands RSPB Reserve. These activities along with walking and hiking represent just over a third of all activities carried out by tourists in Dumfries & Galloway and are likely to be similar on the west Cumbrian coast.

The visual effects of the wind farm on visual receptors on the Dumfries & Galloway coast and the Cumbrian coast on the vicinity of the wind farm have been assessed in detail in Section 9.10 earlier. Significant visual effects have only been predicted for areas on the East Stewartry coast closest to the proposal and where open views of the turbines could be obtained looking out across the Firth towards Cumbria. This area would include the area of coastline between Balcary Point and Castlehill Point and and area eastwards as far as Mersehead Sands. No significant effects are predicted for areas further to the east at Southerness for example. No significant visual effects have been predicted anywhere on the

Cumbrian coast. The only tourists who would experience a significant effect would therefore be those walking on footpaths on the East Sewartry Coast, playing on the golf course at Torrs, those visiting the Mott of Mark at Kippford, birdwatchers at the RSPB reserve at Mersehead Sands and tourists sailing, wind surfing and angling at sea closer in to the wind farm.

As noted in the visual assessment, a significant effect does not imply a negative effect. Since the first onshore wind farm was built at Delabole in Cornwall in 1991, there have been a large number of opinion surveys collected from both residents and tourists collecting their opinions on wind farms constructed in England, Wales and Scotland. The vast majority have shown that residents and tourists alike view wind farms positively. According to a 1997 review of all opinion surveys:

'To date, every survey of public opinion taken after construction has shown a considerable majority in favour of the wind farm.[449]

A review of opinion surveys is given in Appendix G5. Typical examples of the findings of opinion surveys are the following. In 1993, the Department of Trade and Industry survey of opinion before and after construction of the Delabole wind farm over 84% either approved strongly or very strongly of wind energy when questioned after construction. This compares with 4% who expressed disapproval or strong disapproval.[450] The British Wind Energy Association reported in 1994 that at Taff Ely wind farm in Wales a study by East Midlands Electricity revealed that 6 months after start-up only 2% strongly opposed the development of wind farms in the area while 75% said that either they could not think of any disadvantages of wind power or there were no disadvantages.[451]

There is also anecdotal evidence that wind farms attract tourists and visitors to an area rather than discouraging them. A public attitude survey in Wales of the Taff Ely wind farm has shown that the vast majority of people with a view on tourism feel that visitor numbers to the area have increased since the wind farm was built. The Delabole wind farm has a visitor centre which attracts some 14,000 paying visitors each year.

As one of the first offshore wind farms in the UK, and the first in Scotland, the Robin Rigg wind farm would be likely to have an attractive effect for tourists. A survey of local businesses in the area of the proposed North Hoyle offshore wind farm off the coast of north Wales, many connected to the tourist industry, showed that more than 50% of businesses believed that the wind farm would encourage more visitors, while only 3% felt that tourists and day-trippers would be discouraged from visiting the area[452].

The developers have carried out their own public consultation (in addition to the specialist groups and other consultation work) on this proposal through 2 open events held at Workington on 19th/20th April and Kirkcudbright on the 26th/27th of April. The events were organised to give all interest parties an opportunity to see the proposed wind farm layout and associated survey work; and make comments to or ask questions of the project team prior to an application being made. Every body was given the opportunity to fill in a form (copy Appendix I in the separate volume of appendices), which asked a number of questions about the proposal. The results of the two main questions asked are represented below: -

[449] Revie, C., & Stein, G., *Planning for Renewables*, Friends of the Earth Scotland, 1997 p49
[450] Young, Dr. B, Attitudes Towards Wind Power - A Survey of Cornwall and Devon, ETSU-DTI; 1993
[451] BWEA, *Public Support for Wind Power*', Press Release; British Wind Energy Association; 30 March 1994
[452] National Wind Power (2001) North Hoyle Offshore Wind Farm Environmental Impact Assessment.

In each case the questions asked were identical.

Q 1. Do you approve of wind energy being used to generate electricity?

Tick boxes gave the options of: Yes / No / Neither approve or disapprove.

Q 2. What were your initial thoughts on hearing about an offshore wind farm in the Solway ?

Tick boxes gave the option of: In favour / Not in favour / No firm view either way.

WORKINGTON 71 forms filled in over two days.

Q.1	Yes	46 = 65%	**Q.2**	In favour	41 = 58%
	No	13 = 18%		Not in favour	24 = 34%
	Undecided	12 = 17%		Undecided	12 = 17%

KIRKCUDBRIGHT 247 forms filled in over two days.

Q.1	Yes	214 = 86%	**Q.2**	In favour	158 = 64%
	No	21= 64%		Not in favour	57 = 23%
	Undecided	12 = 5%		Undecided	32 = 13%

Both events were well advertised in local papers, radio and TV, prior to the actual open days, with locations chosen in consultation with local planning officers, to allow easy access (including disabled) and plenty of room for people to view displays.

It was estimated that about 50% of people who came to look filled in forms. The events show similar results to many earlier surveys in the industry, with more people in favour of the technology than the actual proposal being considered. In addition there is a clear majority of people both in favour of the technology and the proposal.

Information boards on the wind farm would be provided at mariners on both sides of the Solway and further discussions are taking place on the provision of space in visitor centres covering the wind farm and renewable energy.

9.16 EFFECTS ON MINERAL, GAS AND OIL RESOURCES

As outlined in Section 8.4 in the baseline section of this ES, there are no licences for oil and gas exploration nor extraction of sand or gravel from the area in the vicinity of the wind farm, nor have the DTi or the Crown Estates received applications for such licences in the area of the wind farm or the 132 kV cable route to shore. The development is therefore not considered to have an effect on the exploitation of these resources.

9.17 EFFECTS ON UNDERSEA PIPES AND CABLES

Consultation has confirmed that there are no proposed or existing undersea pipes and cables in the vicinity of the proposed wind farm including the substation to shore power cable route. The development would therefore have no impacts on undersea cables or pipelines.

9.18 ELECTROMAGNETIC EFFECTS

9.18.1 MICROWAVE FIXED LINKS

9.18.1.1 Background

Microwave links are direct straight line radiowave paths between an antenna and a receiver. As described in Section 8.7 of this ES, three microwave corridors were identified prior to sire design, crossing the Solway in the vicinity of the proposed wind farm site. These are identified as:

- M1: Cambret Hill, D&G (252400E 557800N) to Wharrels Hill,Cumbria (317200E 538200N), 7 links with RA Reference Codes 9952 9953 9954 9955 33351 33416 and 33421
- M2: BBC Whitehaven, Cumbria (299200E 512700N) to Baskeoch Hill, Dalbeattie, D&G (281000E 561500N), 1 link with RA Reference Code 25545
- M3: NTL Workington, Cumbria (300100E 527700N) to Baskeoch Hill, Dalbeattie, D&G (28100E 561600N), 1 link with RA Reference Code 28039

and are shown on Figure 3.4.1 in Section 3 of this ES and the two closest of these M2 and M3 are shown at a larger scale in relationship to turbine positions on Figure 4.5.1 in Section 4.

Of these the M1 corridor lies a distance of more than 3 km from the nearest turbine, well beyond the area of potential interference and has not been considered further in this assessment.

Wind farms have been known to cause interference or degradation to fixed link microwave signals through a number of different mechanisms. While there is no officially accepted criteria for establishing safe separation distances between wind turbines and fixed link microwave corridors, the Radiocommunications Agency, the government agency with responsibility for telecommunications planning and licensing are working towards such criteria and have produced a draft report entitled Fixed Link Wind Turbine Exclusion Zone Method[453].

The paper examines the three mechanisms by which turbines can interfere with microwave fixed links. These are:

Near-field Effects

A transmitting or receiving antenna has a near field zone where local inductive fields are significant and within which complex calculations are required to predict the effects of objects. This field should therefore be avoided by the placing of large objects such as wind turbines. The near field zone around either antenna typically extends a few tens of metres from the antenna and even the most conservative protective exclusion zones extend no further than 500 m from antennas.

[453] D. Bacon (draft) Fixed Link Wind Turbine Exclusion Zone Method. Radiocommunications Agency Working Paper FLCC (02-01)/004.

Diffraction

Diffraction occurs where an object such as a wind turbine obstructs and reflects or absorbs part of an advancing wave front. Avoidance of diffraction effects can normally be avoided by keeping obstructions outside of Fresnel zones around the direct path of the microwave link. The shape of a Fresnel zone is a 3 dimensional ellipsoid with the antenna and receiver acting as the focal points of the ellipsoid at either end i.e. the 3 dimensional form created by rotating an ellipse around an axis represented by the direct line of the corridor. The zone is thus widest at the central point of the microwave link tapering off towards both ends.

Reflection or Scattering

If a radio link transmitter 'illuminates' a wind turbine which then reflects or scatters the wave onwards to the receiver from one or more points on the surface of the turbine a multi-path situation is created which may involve in destructive or constructive interference in the wave as the longer (and therefore delayed) reflected path interferes with the direct line path signal from the transmitter. The pattern and extent of the zone which would need to be avoided around the microwave direct line path is a function of characteristics of the transmitting and receiving dishes and the radar cross section of the turbine. However, the zone is dumbbell shaped, normally falling off to zero within 5 km or less of the transmitting and receiving antennas.

9.18.1.1 Impact of the Robin Rigg Proposal on the Microwave Corridors

With regard to the near-field interference, the closest distance between turbines and the closest antenna of corridors M2 and M3 is 19 km. This is well beyond the distance at which there could be any near field effects from the turbines on the microwave links.

The calculations of suitable exclusion zones for avoidance of reflection or scattering effects are extremely complex and require a thorough understanding of the properties of the turbines as reflectors as well as the characteristics of the antenna dishes. However, according to David Bacon the Radiocommunications Agency expert on interference of wind farms on microwave links, within the central third of the microwave link exclusion zones for protection against reflection or scattering effects will be near zero and will be significantly smaller than the zones required for the protection from diffraction effects.

Therefore, if adequate protection is given for the microwave links against diffraction effects on the links within corridors M2 and M3 then the Robin Rigg proposal would have no impacts on microwave links within the vicinity of the proposal.

Protection from diffraction effects is normally secured by avoidance of part of the first Fresnel zone, the ellipsoid 3 dimensional shape around the microwave link as described earlier. The n-th Fresnel zone for a particular radio wave frequency is the locus of all the points for which if the radio signal travelled in a straight line from the transmitter to the point and then from the point to the receiver, the path lengths would be n wavelengths greater than the direct line route.

For large static obstructions diffraction can be avoided by leaving 60% of the 1st Fresnel zone unobstructed. For moving wind turbines a more conservative approach may be required. The Radiocommuncations Agency draft paper suggests that the 2nd Fresnel zone should be avoided. During the design of the wind farm an even more conservative approach was used in agreement with One2one the operators of the links in corridors M2 and M3, and a 3rd Fresnel zone avoidance policy was adopted by all parts of wind turbines.

The 3rd Fresnel zone has been calculated for both links M2 and M3 in the vicinity of the wind farm based on the following approximate equation which is adequate for this kind of assessment:

$$R = \sqrt{((n \times 600 d1 d2)/f(d1+d2))}$$

where R is the radius of the 3rd Fresnel zone from the straight line microwave path in metres
d1 and d2 are the distances of the wind farm from either antenna
f is the frequency in GHz of the lowest signal in the microwave link

The maximum radius of the 3rd Fresnel zone for the link in corridor M2 is 29.4 m. The equivalent for the link in corridor M3 is 26.1 m.

The wind farm has been designed so that all turbine tower positions avoid this zone plus a distance representing the maximum blade length for the turbines of 50 m plus a further 50 m safety zone to take account of any uncertainties in the exact position of transmitters and receivers supplied by the Radiocommunications Agency and for any micrositing of turbine foundations to avoid any obstacles revealed by further geophysical surveys at each foundation position. The contractor contracted to construct the wind farm would be made aware of these restrictions in movement of turbine positions to safeguard these safety zones.

On the basis of the above exclusion and buffer zones the operator of the links, One2one, is satisfied that the wind farm proposal would not impact on their microwave links in the vicinity of the wind farm.

9.18.2 INTERFERENCE TO TV AND RADIO RECEPTION

Both the BBC and the Independent Television Commission have been consulted with regard to the wind farm proposal at Robin Rigg. The BBC and the ITC split the country into areas of responsibillity for watching brief over new developments. The Robin Rigg site falls into the ITC's watching brief area which is further subcontracted to NTL the private transmission company. NTL have responded to the proposal.

According to NTL, households in the vicinity of the Solway Firth receive their signals from the Caldbeck and Sandale main transmitters in Cumbria some 30 km due east of the site. NTL state that it is commonly accepted that significant interference to reception is unlikely beyond a distance of 10 km from a wind farm where the wind farm lies directly between the receiving household and the transmitter, decreasing to 500 m in other directions around the wind farm. While households in the Dundrennan and Kirkcudbright area would lie on the other side of the wind farm to the transmitters at Caldbeck and Sandale, the wind farm lies just over 10 km from the nearest coastline in the direction lying directly away from the transmitters. It is therefore very unlikely that the wind farm would have any effects on TV reception at households in this area or any other area.

Nevertheless, the developer would be committed to investigating and rectifying any problems that may arise to domestic television if they can be shown to be caused directly by the development.

Similarly to television reception, no negative effects are anticipated for radio reception on land.

9.18.3 MOBILE PHONE NETWORKS

British Telecom, Cable & Wireless, O2 (formerly known as BT Cellnet), Orange, One2one and Vodaphone have all been consulted with regard to the development. None of these consultees have raised any objections to the proposals.

9.19 EFFECTS OF NOISE ON HUMAN RECIEVERS

9.19.1 CONSTRUCTION NOISE

Offshore construction noise will comprise ships engines, noise of piling hammers and augering operations etc. The only operation that would be likely to be heard onshore and would not be part of the ordinary noise environment in the Firth would be the noise of piling operations for turbine foundations.

Hayes McKenzie Partnership have been asked to carry out an assessment of the potential noise impact on residential properties in the nearest coastal areas, from the piling operations required as part of the construction process.

British Standard BS 5228, Noise and Vibration on Construction and Open Sites contains a methodology for noise level predictions from construction sites and provides some assessment guidance.

9.19.1.1 Source Noise Data & Assumptions

There are a number of available solutions for forming the foundations for the turbine towers. The worst case of these in terms of the noise impact would be to use monopiles driven, rather than augered and vibrated into the stiff to very stiff clay found under the sand layers at Robin Rigg.

A piling contractor with piling hammers of the type required for this operation have provided some noise data for the piling hammers required for driving this size of pile into the sea bed. The noise data is expressed in terms of the measured maximum ‘A’ weighted sound level using the ‘impulse’ measurement time weighting (L_{AmaxI}). This index is not commonly used in the UK for noise assessment but lies between the maximum sound pressure level using the ‘fast’ measurement weighting (L_{AmaxF}) and the peak measured sound pressure (L_{peak}).

The measured data indicates that the piling operation may have a source sound power level of 137 – 165 dB L_{AmaxI} depending on the energy delivered by each hammer blow, the type of ground condition and the size of the pile. Information from other sources suggest that the highest levels are not atypical for piling hammers used for piles of this size.

Measurements of piling on other sites, together with theoretical considerations, suggest that the L_{AmaxF} would lie about 6 dB below the L_{AmaxI} and in turn the L_{Aeq} for a 2 second repetition rate would lie around 10 dB below the L_{AmaxF}.

The prediction methodology for sound propagation in air, described in BS5228 for hard ground (water counts as acoustically hard ground) is based solely on attenuation by hemispherical spreading. Whilst this may be appropriate for the short propagation distances relevant to land based construction sites, atmospheric attenuation becomes increasingly important at distances over 500m. Assumptions have therefore have been made as to spectrum shape and likely atmospheric attenuation to allow this factor to be taken into account.

In converting measured data at distance from the source as provided by the piling hammer supplier, to source sound power level as described above, and in carrying out the predictions described below, a uniform power spectral density was assumed across the frequency range at source (ie. increasing at 3 dB per octave band) in the absence of any measured data. This produces an ‘A’ weighted equivalent atmospheric attenuation factor of 0.002 dB/m at 10,000 metres assuming atmospheric conditions of 15 degrees C and 70% RH.

9.19.1.2 Predicted Noise Levels

Calculations have been carried out based on the smallest separation distance between residencies and piling locations. This has been found to be at housing in Balcary Bay on the Scottish side with a separation distance of 9320 metres for piling foundations for Turbine E1, and at Flimby on the English side with a separation distance of 13100 metres for piling foundations for Turbine J6. The housing at Balcary Point is also approximately equivalent to the nearest point on land to the piling hammer locations. In addition the situation has been considered where two piling hammers would be employed simultaneously at the two closest turbine locations to these points on either side of the Firth, although it is unlikely that more than one hammer would be employed at the site, especially for the larger hammers needed for monopile foundations which are scarce in Europe.

The predicted level at this location for piling taking place at the closest turbine location, based on hemispherical spreading and atmospheric attenuation factors derived as described above, gives a predicted level of 57 dB L_{AmaxI} on the Scottish side equivalent to 51 dB L_{AmaxF} and 41 dB L_{Aeq} based on the assumptions derived above. On the English side the equivalent predicted level would be 52 dB L_{AmaxI}; equivalent to 46 dB L_{AmaxF} and 36 dB L_{Aeq}. Two piling hammers working simultaneously at the two nearest turbine locations would not affect the maximum levels unless the hammers were operating in sequence but would increase the L_{Aeq} by 3dB.

The noise levels have been modelled for downwind noise propagation. The noise level above would therefore only occur for wind blowing on shore from the piling rig, ie. south-easterly which site wind data shows is the least frequent wind direction. The wind was recorded as blowing from the 30 degree sector between 135 deg. and 165 deg. for no more than 7% of the time. For other wind directions, noise levels will be lower and for north-westerly directions it could be expected to be about 10 dB lower.

For piling the foundations for turbines further from the shore, the noise level will reduce due to the increased separation distance with levels of 52 dB L_{AmaxI}, equivalent to 46 dB L_{AmaxF} and 36 dB L_{Aeq}, occurring for the furthest turbine foundations on the Scottish side and 49 dB L_{AmaxI}, equivalent to 43 dB L_{AmaxF} and 33 dB L_{Aeq} on the English side.

9.19.1.3 Assessment

If the suggested construction timetable outlined under Section 4.15 of this ES is used the piling would take place over two periods; from July to October during the first year of construction and from April to October of the second year. It is anticipated that piling will be fairly continuous during the daytime hours. Piling may need to be continued during night-time hours although this would be a decision for the construction contractor.

BS5228 does not contain any guidance on noise levels considered acceptable for daytime noise levels from construction activities. The most relevant guidance is contained in MPG11, The Control of Noise at Surface Mineral Workings which considers similar noise sources to those found in the construction industry and is relevant for working over limited time periods. This document states that in exceptionally quiet rural areas a limit of 45 dB L_{Aeq} should prove tolerable to most people during the daytime. The night time nominal limit given in this document is 42 dB L_{Aeq} although BS5228 quotes a limit of 40 dB L_{Aeq} for night-time working. It is noted that a consultation paper on a revision to MPG11 is currently under review.

Based on the guidance given above, it is considered that the predicted L_{Aeq} noise levels (assumed to be equivalent to 16 dB less than the predicted L_{AmaxI} noise level), for the worst case of driven piles at the closest location to residential properties under down-wind conditions, is below the most relevant recommended day-time noise limit.

For night-time working, the predicted noise level is between the limit values in BS5228 and MPG11. Because the noise produced consists of highly impulsive repetitive noise, it is considered that the lower limit referred to above of 40dB L_{Aeq} would be the appropriate starting point for a condition. On the basis of defining night-time as 2300-0700 a noise limit of this level would limit night-time piling at turbine locations closer than 9800m to the nearest dwellings. The night-time limit might need to be extended to cover the later evening period in particularly quiet residential locations.

Because of the desirability of completing off-shore piling work within a predictable time frame, taking account of unpredictable weather conditions which could disrupt operations, it is proposed that there should be some degree of flexibility in the application of noise limits in relation to night-time (as possibly late evening) piling. Again, in controlling noise from piling it seems appropriate to strike a balance between the loudness of the noise received at dwellings and the period during which piling will continue. Therefore a flexible approach to noise control is proposed which will enable noise levels higher than 40dB L_{Aeq} to be received at any dwelling for a limited period, and following a defined process of agreement with the Scottish Ministers.

9.19.1.4 Conclusion

Predictions of noise of from piling operations have been carried out based on source power level data for the type and size of piling hammers likely to be used on the site, assumptions as to noise propagation and conversion between different measurement indices and worst case conditions for noise generation and propagation.

It was shown that piling noise would be below the limits for daytime working given in the relevant standards. For night time work, piling would be not be carried out on turbine foundations within 9.8 km to the closest residential properties on the Scottish side unless it can be shown that such work would meet the relevant noise limits in agreement with the Scottish Minsters.

9.19.2 OPERATIONAL NOISE

9.19.2.1 Guidance on Assessment of Noise from Wind Turbines

The only noise source originating at the wind farm during the operational lifetime will be noise generated by the wind turbines.

In the absence of any guidelines for assessment of the impact of offshore wind farms on human receptors, guidelines for onshore wind farms have been used.

The preferred methodology used for the assessment of wind farm noise on land in the UK are those recommended by the Working Group on Noise from Wind Turbines (WGNWT). In 1993 the Department of Trade and Industry set up the WGNWT as a result of difficulties experienced in applying the guidelines existing at the time to wind farm noise assessments. The WGNWT comprised independent experts on wind turbine noise, wind farm developers, DTI personnel and local authority Environmental Health Officers. In September 1996 the Working Group published its findings by way of report ETSU-R-97, The Assessment and Rating of Noise from Wind Farms[454]. This document describes a framework for the measurement of wind farm noise and contains suggested noise limits which were derived with reference to existing standards and guidance relating to noise emission from various sources

[454] ETSU-R-97 The assessment and rating of noise from wind farms. ETSU for the Department of Trade and Industry 1996

The suggested noise limits are 35-40 dB(A) or 5dB(A) above the prevailing background, whichever is the greater, for quiet day-time periods. For night-time periods the recommended noise limit is 43 dB(A) or 5dB(A) above the prevailing background, whichever is the greater. Where the occupier of a property has some financial involvement with the wind farm, the day and night-time lower noise limits can be increased to 45 dB(A) and consideration should be given to increasing the permissible margin above background. These limits are applicable up to a wind speed of 12m/s measured at 10m height on the site.

Where predicted noise levels are low at the nearest residential properties, a simplified noise limit is suggested such that noise is restricted to an L_{A90} level of 35 dB(A) for wind speeds up to 10 m/s at 10m height. This removes the need for extensive background noise measurements for smaller or more remote schemes and would normally be applicable for onshore wind farms for closest properties at greater than 1 km from the nearest turbine.

9.19.2.2 Wind Turbines as Noise Sources

Noise emissions generally associated with wind turbines are from two sources, aerodynamic and mechanical. Aerodynamic noise is the sound generated due to air passing over the blades of the turbine as they rotate. Mechanical emissions are those associated with the engineering components of the turbine such as the gearbox, the generator and the directional equipment that rotates the blade housing, or nacelle, with respect to the wind to optimise energy capture.

Although the larger turbines being considered for the site are not under production as yet, and therefore noise characteristics have not been measured, manufacturers predict that they will have a noise output of no greater than 108 dB at a wind speed of 8 ms-1 at a height of 10 metres above ground level. This noise level is considered to represent a worst case scenario for the turbines being considered for use on this site.

Generally speaking, turbines of the type being considered for use on the site will have a broadband noise spectrum i.e. the noise emitted from the turbine would not be expected to have a tonal content.

9.19.2.3 Noise Prediction Assumptions

The model used to predict noise emissions from the proposed site is the noise propagation model recommended by the Ministry of the Environment, Denmark in document "Statutory Order from the Ministry of the Environment No.304 of May 14, 1991, Noise from Wind Mills". There is no equivalent UK statutory instrument for the prediction of noise from wind farms.

In using the model the following assumptions have been made.

Propagation of Noise from its Source

Each turbine on the site is considered as a point noise source. The propagation of noise from its source varies depending on whether the receiving position is located upwind or downwind of that source. Where a receiver position is downwind of the source the noise level at that point is, in most circumstances, higher than if it were upwind. Therefore, for the purposes of this assessment, downwind propagation has been assumed at all times as this represents the worst case scenario.

Attenuation with Distance from the Source

Attenuation in a hemispherical spreading noise model, as used in this assessment, is normally calculated at a rate of 6bB per doubling of distance away from the source as recommended in the Danish Guidelines identified above.

Absorption in air of the noise at distance from the source is assumed in the Danish guidelines to be 0.005 dB(A) per m.

Surface Attenuation

Since the majority of separation area between the turbines and the closest properties would be over water, a perfect reflector has been assumed, i.e. zero absorption.

Topographic Effects

Where a noise source is not visible at a receiver position noise levels can reduce significantly. Studies have shown that accounting for topographic features in computer models are unreliable and they have therefore not been included in this model. The model used in this assessment assumes that all points around the noise source are in line of sight of all 60 turbines within the site.

9.19.2.3 Predicted Noise Levels from the Robin Rigg Proposal

As outlined in Section 9.19.1 above, the nearest properties to wind turbines are given as 9.3 km on the Dumfries & Galloway coast and 13.2 km on the Cumbrian coast.

Noise levels were predicted for the 60 turbine layout described in Section 4 of this ES using the largest turbines that could potentially be used at the site.

For the noise level model used with the assumptions given above the noise level would drop off to less than 20 dB(A) L_{Aeq} at sea within 5 km of the wind farm at a wind speed of 10 m/s at 10 m above sea level. This is below normal background noise levels in quiet rural areas under most conditions. At a distance of 9.3 km at the nearest coast the noise levels from the wind farm would be considerably lower and would be well below likely background noise levels under all conditions.

The predicted noise levels would be well below the lower noise limit suggested by the WGNWT at even 5 km from the site, and therefore noise from wind turbines is considered to have no significant effects on the amenity of local residences nor on those using amenities such as footpaths, beaches or golf courses on either coast.

Section 10

Summary of Residual Effects, Mitigation Measures and Monitoring

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Section 10

Summary of Residual Effects, Mitigation Measures and Monitoring

10.1 INTRODUCTION

This section summarises the findings of the environmental impact assessments given in Section 9 of this ES. Firstly, in 10.2 below the residual effects following the implementation of mitigation measures are summarised for all impact areas covering physical, environmental and human receptors. Section 10.3 then lists the mitigation measures that have been incorporated into the design of the proposal and into construction and decommissioning procedures. Finally 10.4 presents suggested pre- mid and post-monitoring regimes for ecological resources in the Robin Rigg area.

10.2 SUMMARY OF RESIDUAL EFFECTS

10.2.1 BENEFITS OF THE WIND FARM PROPOSAL

10.2.1.1 Environmental Benefits

Use of renewable energy plays an important part in the strategies to reduce the threat of climate change arising from atmospheric pollution which is widely regarded as the most critical environmental problem of this century. The displacement of pollution from fossil fuel power stations also helps combat acid rain and conserves fossil fuel reserves.

The need to address climate change has been recognised at a global, European and national level, via legally binding targets for the reduction in the emissions of carbon dioxide. The UK Government has a target for 20% reduction in carbon dioxide emissions levels from all sources by 2010. A key contribution of the energy sector is a target to produce 10% of all electricity from renewable energy sources by 2010. The Utility Act and Renewable Obligations in England and Scotland place an obligation on electricity suppliers to purchase 3% of all power sold by them in the UK from renewable energy sources by 2003, rising to 10.4% in 2010.

The wind farm at Robin Rigg is estimated to produce between 417 and 750 GWh of electricity per year depending on the final turbine selected for the site (2 MW to 3.6 MW machines). This would be sufficient to meet the annual electricity demand of between 99,000 and 178,000 average households, and would be equivalent to between 17% and 30% of the *total* new output needed to meet the 2010 Scottish renewables target. The proposed wind farm at Robin Rigg would therefore represent a very significant contribution to the UK renewables and CO2 emissions reduction targets.

Subsidiarity, that is the division of global responsibility down to the national and regional scales, is a key principle of the United Nations Framework Convention on Climate Change. For the aims of the Convention to be met each signatory state and each region within that state needs to meet its share of the overall emissions reduction target. Therefore, any development that contributes significantly to the regional renewable energy targets is playing a significant role in mitigating against the environmental and social impacts of climate change that would occur under a global do nothing scenario.

Assuming a 25 year life, the total electricity output over the lifetime of the Robin Rigg wind farm should it be constructed would be between 10.4 and 18.7 TWh (1 TWh = 1 billion kWh). Taking into account the energy use of the wind farm as well as the energy output, the proposal at Robin Rigg would achieve the following net pollution savings over the lifetime for the minimum and maximum installed capacities of 120 MW and 218 MW. .

Emission Type	Installed Capacity of 120 MW (60 x 2MW turbines)	Installed Capacity of 218 MW (60 x 3.6 MW turbines)
Carbon Dioxide	8.8 million tonnes	15.9 million tonnes
Sulphur Dioxide	114,000 tonnes	206,000 tonnes
Nitrogen Oxides	21,000	37,000

10.2.1.2 Economic Benefits

Construction – the investment value of the Robin Rigg wind farm through design, construction and commissioning would be at least £150 million. If the Robin Rigg wind farm project follows the pattern of onshore wind farms, upwards of £30 million will be invested into the economies of southwest Scotland and northwest England during construction. The works will also lead to a major investment in a local port or ports likely to include Silloth, Maryport, Workington or Barrow-in-Furness. This period of intensive use of port facilities is expected to last for two construction seasons. Up to 120 skilled and non-skilled workers will be employed for the construction period both onshore and offshore for the construction season(s). A number of these workers are likely to be sourced locally.

Operation – the operational period would involve direct employment of approximately 5 technicians and management staff in the local area during the lifetime of the wind farm with additional staff of 10 during planned maintenance periods. Experience elsewhere suggests that the majority of the permanent staff would be recruited locally.

10.2.2 EFFECTS ON HYDROGRAPHY, SEDIMENTS AND MORPHOLOGY

10.2.2.1 Construction

Piling The total area of bed affected by the deposition of clay arisings from augering, should piles be augered, would be in the order of 42000m^2 which constitutes only 0.4% of the total wind farm area and as such the effects of depositing this material on the seabed would be negligible. In the case of augering/drilling in sand, the sand will be pumped to the surface and will be deposited into the water at the surface. Background levels of sediment load would only be exceeded for short periods of time and this only in close proximity of the pile position. The impacts from the pile installation operation are therefore negligible.

Cable Laying The background level of suspended sediment would never be exceeded beyond a distance of 700 m from any cable position being ploughed, and within this distance, the percentage time in excess of the background level would be less than 2% for on site cables and 5% for the 132 kV cable to land on ploughed sections (directional drilling would raise no sediments).

10.2.2.2 Operation

Impact on Tides The presence of the wind farm would not significantly affect the tidal height and flow characteristics in the Solway Firth away from the immediate are of the farm itself.

Impact on Waves There would be a small local impact on the wave climate in the vicinity of the wind farm with a small decrease of the significant wave height around the turbines in the order of 5%. However the wind speed would recover downwind of the wind farm resulting in no significant impact on the wave climate along the downwind shoreline.

Impact on Sediment Movement and Sediment Transport Apart from the area of the wind farm itself, the presence of the turbines will not have a significant effect on the sediment movement processes during relatively calm conditions. The impact on the net sediment transport rates during southwesterly gales is restricted to local areas around the wind farm site. The coastal processes along the northwest and southeast coasts of the Solway Firth are influenced by both the southwesterly gales and the locally generated waves across the estuary. The wind farm site would have no measurable impact on the waves and tidal flows along the shorelines during southeast and northwest winds. Thus the wind farm will have no significant impact on the coastal processes along the shorelines of the Solway Firth.

10.2.3 EFFECTS ON WATER QUALITY

Sediment disturbance The changes in the volume of sediment transport due to the construction and operation of the wind farm are insignificant in relation to the volume of the natural sediment transport in the Solway Firth. Thus, the construction and operation of the wind farm will have no impact on the suspend sediment levels within the estuary.

Oil substance spillages for construction phase During construction there is a risk of the spillage of oils and other potentially contaminating substances such as hydraulic fluid from construction plant. In addition the construction of grouted connections will entail a risk of spillage of cementitous substances. The potential spillage quantities would be small. The average volume of water flow through the site is in the order of 16,000m^3 per second. This high rate of flow will cause a high degree of dilution of any spillages and for the volumes of spillage expected the effects are considered to be insignificant.

Oil substance spillages for operational phase The quantities of oil which could potentially leak from other items of equipment will be small and the effects of such potential spillage are not considered to be significant given the high volume of water passing the site with each tidal cycle, which will provide a high degree of dilution.

10.2.4 EFFECTS ON MARINE BENTHOS

10.2.4.1 Construction Impacts

Loss or Change of Habitat There would be permanent direct loss of available seabed habitat beneath the turbine bases and a temporary loss along strips cleared for cable trenches within the wind farm area. The worst case total direct loss would represent 0.4% of the total 10.3 square km extent of the NcirBat biotope within the wind farm area. The biotope is considered to have a Low sensitivity and the direct loss of substrate is considered to be of negligible magnitude giving an impact of negligible significance. There would be direct mortality of some infaunal and epibenthic species impacted by trenching of the 132 kV cable to shore, across the mixed substrata of the deeper channel section of the cable route. Impacts would be limited to the 1 m wide strip cleared for trenching. *Sabellaria* reef which may be encountered at the shoreward end of the cable route is fixed to the substratum so substratum removal would cause mortality. Full recovery could take several years. The sensitivity of *Sabellaria* reef to damage through trenching has therefore been assessed as medium. The magnitude of impact is low given the overall presence of *Sabellaria* reef and the impact to the biotope should therefore not be of higher than Low/Moderate and therefore not significant.

Sediment Disturbance Trenching of cables within the turbine array by the use of a plough would cause the greatest levels of physical disturbance with complete displacement of the benthic community and smothering of adjacent areas. Recovery of the community would be rapid, as they are frequently exposed to such conditions, due to storm events. The transport and settlement of re-suspended finer sediments by wave and tidal action and residual current movements, to other areas would be insignificant and would not exceed that expected during average rough sea conditions experienced regularly on Robin Rigg. The impact to the NcirBat biotope and surrounding biotopes within the Solway Firth from increased suspended sediments would not be significant. Trenching of the wind farm to shore cable route will cause the displacement of mixed substrata and smothering of adjacent communities. *Sabellaria* reef in the vicinity of the cable route is resistant to localised increases in suspended sediments and is tolerant to burial under sand for several weeks.

Water Quality Changes Unless oil is incorporated into the sediments, low inputs should not have significant impacts to identified benthic communities. Impacts to identified benthic communities should be insignificant assuming proper management of risk.

Noise and Vibration Noise and vibration should not interfere with the ecological functioning of identified biotopes.

10.2.4.2 Operational Impacts

Sediment disturbance It is predicted that there would be no changes to the hydrodynamic regime due to the cumulative effect of multiple turbines and therefore no effects to the wider benthic environment due to changes to hydrographic processes.

Water Quality Changes Given the spacing of the structures and the high degree of water around the structures, particularly given the high currents and tidal range on the site, the impact on the site would be insignificant. No impacts to identified benthic communities are predicted.

Noise and Vibration Unless vibration of the wind turbines alters the physical composition of the seabed, there should be no significant impacts on benthic communities.

No significant impacts have been identified resulting from the development.

10.2.4.3 Effects on Shoreline and Intertidal Habitats

It is predicted that the impacts to benthic communities will be localised and consist of mortality to some species through substratum loss or physical disturbance.

The construction and operation of the wind farm would have no significant effects on the sedimentology and water quality of the Solway Firth area (see Chapter 9.4) and therefore no impacts are predicted to benthic communities outside the wind farm and cable route development area.

Therefore, no effects are predicted for Annex 1 habitats within the Solway Firth European Marine Site.

10.2.5 EFFECTS ON FISH

10.2.5.1 Construction Effects

Effects of Underwater Noise Several species of fish that may be regarded as 'hearing specialists' have been recorded in the Study Area. Many of these species are reported to show tolerance to anthropogenic noise sources such as oil drilling platforms and it is reported that received noise levels of 180dB are required to produce a strong avoidance or alarm response. Noise levels of 180dB are considerably louder than the maximum 150 dB sounds pile driving would produce at any distance from the source. The magnitude of noise and vibration impacts is therefore considered to be 'negligible' to 'low', and so, impacts would not be significant.

The noise generated during construction would not act as a barrier to migrating salmonids or sea and river lampreys other than in the small area occupied by the near-field (between 9 and 35m around the piling location). The Solway Firth is 26 km wide in the area of Robin Rigg, and the deep water channels that salmonids migrate along are several kilometres to the north and south of the wind farm area, migration of either juveniles or adults would, therefore, not be restricted. The magnitude of these impacts would be 'negligible', and so would not be significant.

Suspended Sediment Those species present in the Solway Firth, including the migratory species, are those more tolerant of naturally varying levels of suspended sediments. The magnitude of impacts, for both resident and migratory species, would therefore be, at most, low. Accordingly, impacts would not be significant.

Potentially Polluting Substances Given the small volume of potentially polluting substances that could be released and the high volume of water passing through the development area with each tidal cycle, the dilution effects will be such that impacts on fish will not be significant.

10.2.5.2 Operational Effects

Electric Field Effects Maximum cable emissions would be 10μV/cm where lengths of the cable become exposed (applicable to 33 kV cables in the wind farm areas only). The species most likely to detect the electromagnetic fields are those that typically inhabit the benthic zone either throughout, or at some stage in, their life history. Elasmobranchs are the group most likely to detect electric fields - via passive reception of low-frequency voltage gradients. Elasmobranchs may actively avoid the electric fields predicted to emanate from undersea cables at a distance of approximately 20cm from the source. These individuals would therefore cross the path of the main cable and may be subject to either repulsion, in the very unlikely case of cable exposure, or attraction. Impacts would be avoided along directionally drilled sections and reduced in deep water sections. Impacts on electrosensitive species are therefore expected to be of Low magnitude and so this would be an impact of, at most, Moderate significance – i.e. not significant in terms of the EIA regulations.

Effects of Magnetic Fields Although salmonids are thought to use the earth's magnetic field to navigate back to their spawning river when in the wider ocean, when entering coastal waters, salmonids navigate through olfaction (i.e. 'smelling' their destination river). No adverse effects on migration due to magnetic fields within the estuary would therefore occur from the very low magnetic fields found immediately around any exposed cable within the wind farm area. The 132 kV cable to shore will remain buried at all times.

Noise and Vibration The impact of noise and vibration from the operating wind farm is likely to cause some short-term avoidance reactions followed by general habituation to the continuous noise generated by the operating turbines. The hydrodynamic/acoustic fields generated within the near-field would not impair the ability of fish to detect and interpret fields from different sources. Furthermore, the near-fields (<15m at 125Hz) generated around each turbine, are sufficiently small that fish would be able to move unhindered through the wind farm, and thus, any migratory species moving through the wind farm would not be restricted. The presence of species of commercial importance, and species that are protected under National and International legislation, gives an overall 'high' sensitivity for fish species. However, the magnitude of noise and vibration impacts is considered to be 'negligible' to 'low' and, so, any impacts would not be significant.

Habitat Modification As assessed in the benthic impact assessment, the effects of direct habitat loss on the overall extent of the single biotope found within the wind farm area is considered to be negligible. There is the possibility that fish may be attracted to the proposed wind farm through the presence of the turbine foundations acting as Fish Aggregating Devices through provision of shelter, although the actual size of the total fish populations may not necessarily increase. It is much more likely that the congregations of fish around the proposed wind farm would represent a small redistribution of the existing populations in the area. The overall magnitude of such an impact would therefore be low to negligible, although some reef-dwelling species found in rocky substrate areas of the Solway may colonise these new structures, thereby increasing population sizes.

Water Quality Effects Any water quality impacts on fish would therefore be negligible and so no significant impacts would result.

No significant impacts have been identified on fish resulting from the development proposal.

10.2.6 ASSESSMENT OF EFFECTS ON BIRDS

Loss of Habitat for Feeding and Roosting The direct loss of habitat resulting from the development through the construction of the turbine bases and cabling will be of such a small scale that they will clearly not be significant in terms of their impact on bird habitats (and their food). No significant impacts are predicted on the area's benthic invertebrate or fish populations and therefore on any bird species feeding resource.

Collision Risk with Turbines For most species the magnitude of the collision risk is negligible (giving an increase, even in a worst case, of less than 1% on the baseline mortality rate). The only species to exceed this level for the worst case collision risk where all birds are modelled as flying at rotor height, was red-throated diver. However, the field data available for this species from the boat surveys, found that in reality 98% of divers were observed flying below rotor height (25m above sea level); most were actually 10m or less above the sea. This suggests that the actual collision rate would be substantially less than the worst case. The magnitude of collision risk is considered to be Low for this High sensitivity species, giving a non significant effect.

Habitat Loss (disturbance) Disturbance would affect at most regionally important numbers of any species, and the wind farm area does not provide any particularly important ecological resource for these bird populations. No significant disturbance impacts are predicted.

No significant impacts have been identified on resulting from the development proposal on any bird populations wintering or breeding within the Solway Firth.

10.2.7 EFFECTS ON MARINE MAMMALS

10.2.7.1 Construction Effects

Noise and Vibration Effects on Cetaceans The sound level generated by pile driving required to elicit a behavioural reaction ('zone of responsiveness') is likely to be very much smaller than the zone of audibility, and indeed, may be zero. However, assuming a worst-case-scenario where the zone of responsiveness is similar to the zone of audibility, porpoise would avoid an area around the construction site with a radius of up to 1-1.5km. Porpoise moving into the estuary would, therefore, only be excluded from travelling across approximately 12% of the estuary's width. Pile driving activities are not expected to interfere with calving as the key area used for calving is beyond the zone of noise influence. The impact of construction work on small cetaceans is likely to be short-term avoidance of the local area of works based on visual and/or sound stimuli. Startle or alarm response is only likely to occur if individuals are in very close proximity to piling activities at their start up, which will be mitigated through soft starts (see mitigation). The *magnitude* of the impact on small cetaceans is therefore considered to be 'low', and possible impacts are not significant.

The audible sensitivity of mysticete whales such as the long-finned pilot whale has not been measured. Certainly, many cetacean species show tolerance and habituation to loud anthropogenic noise. It is unlikely that there would be very many individuals, if any at all, in the general area during construction that might be affected. The magnitude of possible impacts associated with the fairly short term construction activities would, therefore be, 'negligible' to 'low' and so, any impacts would not be significant.

Noise and Vibration Effects on Pinnipeds There would only be a very low risk, if any, of any physiological effects on seals during the start up period of piling particularly given the soft start procedure to be used. There may be short-term changes in behaviour of seals in the water close to the site during the start of construction in April. However, seals are expected to quickly habituate to the day to day. The significance of any impact is therefore considered to be moderate, and would not be significant.

10.2.7.2 Effects During Operation

Noise and Vibration Effects on Cetaceans The 'zone of responsiveness' (the area in which porpoise may show a behavioural response), is likely to be very low and indeed, may be as low as 0m. Even assuming a further worst-case-scenario, that the 'zone of audibility' is similar to a zone of exclusion, impacts on harbour porpoise, (and by extrapolation, other odontocete cetaceans) are considered to insignificant due the very small area from which they would be excluded. Following familiarisation with the physical presence of the wind farm, porpoise and other odontocete cetaceans such as the bottlenose dolphin, which are particularly opportunistic foragers, eating a very wide range of fish and other species, may exploit wind farm sites as feeding areas. The magnitude of noise and vibration impacts is therefore, 'negligible' to 'low', and so, impacts would not be significant. As long-finned pilot whales and other mysticete species are seldom seen in the shallow water of the Solway Firth, and considering that the sound levels generated during operation would not be at a level to injure animal, any impacts on behaviour would be of little significance for populations migrating through the Irish Sea.

Noise and Vibration Effects on Pinnipeds The magnitude of noise and vibration impacts on the grey seal is considered to be 'negligible' to 'low' as they are, on balance, unlikely to show any reactions other than to the physical presence of the turbines, to which they are likely to habituate very quickly. In addition to this, it is possible that seals may use the wind farm as a feeding ground should fish assemblages be higher around turbine foundations (the 'reef-effect'/ FAD). Impacts would, therefore, not be significant.

Changes in Prey and Predator Populations Harbour porpoise and grey seals are both opportunistic hunters that predate wide range of fish and invertebrates species over very wide areas. The proposed development and associated construction work are not expected to change overall populations densities of fish or invertebrates in the Solway Firth.

The magnitude of changes in prey and predator populations is considered to be 'negligible' and not significant.

10.2.8 LANDSCAPE, SEASCAPE AND VISUAL EFFECTS

Construction Phase

The construction phase of the offshore wind farm is relatively short and will have only temporary, minor effects on the landscape, seascape and visual amenity of the study area.

Operational Phase

The direct effects on seascape are not considered to be significant, as the offshore wind farm will occupy a small part of the overall area. Effects will be entirely reversible following the 25 year operational phase of the wind farm.

Considerable attention to landscape, seascape and visual amenity considerations has been given to the layout optimisation process. This has resulted in a wind farm design which is compact and, from nearly all viewpoints, forms a balanced group of turbines which are harmonious in composition, both as an array, and when viewed against the backdrop of land or sea.

Visibility of the turbines will vary with weather conditions on the Solway Firth. Analysis of data from meteorological stations in the study area, indicates that there is visibility of under 20km for approximately half the total number of days over the three years between 1999-2001 for which data was analysed. In clear weather conditions, it is likely that blade movement will be discernible at distances of up to 12km. For all locations beyond this distance, it is not likely that blade movement will be visible.

The landscape and seascape assessment of the proposed offshore wind farm at Robin Rigg has identified that out of the 31 character units identified in the study area, significant landscape or seascape effects will be confined to:

- Part of the East Stewartry Coast seascape unit; and
- Part of the Mersehead Sands seascape unit.

Of the three National Scenic Areas in the Dumfries and Galloway part of the study area, there will be no effect on the Fleet Valley NSA and a moderate effect on those limited parts of the Nith Estuary NSA that have visibility of the offshore wind farm. The East Stewartry NSA will have visibility of the offshore development from elevated areas and the coastal edge with open views to the Solway Firth. There will be a major/moderate and therefore significant effect at those locations where there are views to the offshore wind farm. However, for most of the East Stewartry NSA there will not be a significant effect on seascape, landscape or visual amenity.

In the Cumbrian part of the study area designated landscapes include the LDNP, Solway Coast AONB, St Bees Heritage Coast and Landscapes of County Importance. There will be no significant seascape, landscape or visual effects on any of these designated landscapes.

There will be no effect on any of the historic gardens and designed landscapes in the Dumfries and Galloway part of the study area, and no effect on any Gardens of Historic Interest in Cumbria.

The assessment of visual amenity of the proposed wind farm has identified that out of the 16 viewpoints included in the detailed assessment, significant visual effects will be confined to three viewpoints on the Dumfries and Galloway East Stewartry coast and one viewpoint out at sea.

According to the ZVI, visibility drops off sharply inland with distance from the proposed development, particularly in Dumfries and Galloway. Views are available from the immediate coastline, but vary according to the coastal form and elevation of seascape units.

The significant effects arising from the offshore wind farm will be confined to those locations close to the coast with open views across the Solway Firth. Although there may be views of the turbines from more elevated areas inland, it is not considered that the development will cause a significant effect at these locations due to the intervening distance.

The Robin Rigg proposal is not anticipated to give rise to any significant cumulative effects on seascape, landscape or visual amenity.

It should be noted that significant effects are not necessarily unacceptable. Surveys carried out in Wales, Cornwall, Cumbria and recently Scotland, indicate that the majority of people who live nearby, look favourably on the wind farms after they are constructed. The consistency of these surveys is notable.

The proposed wind farm is considered to be well designed and sited with due consideration to landscape, seascape and visual effects in relation to the other environmental constraints. From distant upland viewpoints the layout of the turbines will form a single isolated feature and will appear small in scale in relation to the vastness of the surrounding seascape. The wind farm will often be seen in relation to areas of seascape and coast in the wider view with a backcloth of landscape behind it on the opposite coast in clear weather. The layout shows a simple composition and has a balanced relationship with the surrounding landform. As the wind farm is sited over 8km offshore at the nearest point, there are no sensitive landscape or visual receptors permanently located within the immediate vicinity of the site.

Having carefully examined the potential effects on landscape, seascape and visual amenity associated with the proposed wind farm, it is considered that the proposals are acceptable in this location.

10.2.9 ARCHAEOLOGICAL EFFECTS

Five anomalies were identified by sidescan and magnetometer surveys of the area around the wind farm. Three of these are suspected wrecks. The sites are unidentified and therefore their sensitivity is considered High without further information. The closest of these lies 450 m from any offshore element of the wind farm therefore primary impacts are unlikely. Secondary impact such as anchor damage is conceivable in the absence of mitigation but unlikely to change substantially the archaeological character of even the nearest site. The magnitude of impact is therefore at most Low or Negligible and overall significance is at most Low/Moderate, i.e. not a significant effect.

A Romano-British trackway lies in the vicinity of the landfall of the 132 kV cable. The Sensitivity of the trackway is best considered High without detailed fieldwork. The trackway lies some 80-90m outside the potential cable corridor, therefore there should be no primary impacts. On land, construction activity tends to be localised so it is very unlikely that any secondary impacts would affect the trackway even if the final cable route was selected on the northern edge of the corridor. Consequently, the magnitude is Low or Negligible. Despite the sensitivity being High therefore, the overall effect is Low/Moderate, i.e. not significant..

6 and 13 ship casualties are recorded for the Named Locations Robin Rigg and Maryport respectively. While geophysical surveys to date have found none of these as wrecks within the proposed development areas further geophysical surveys would be carried out prior to construction along cable corridors and at turbine positions.

The potential for prehistoric material dating to periods of lower sea-level within the footprint of the scheme currently appears to be low. Only piling associated with turbines and the substation, and directional drilling of cables would impact on earlier land surfaces beneath the development areas. The actual area of the clay surface below the mobile sand layer that would be effected, would represent less than 0.06% of the area within the wind farm boundary. Therefore, even if important remains were present within the prehistoric land horizon the likelihood of any impacts on these is extremely small.

An archaeological assessment will be carried out of the cable route on land, using desk based (archaeological, documentary, cartographic and air photographic) sources as well as field survey, relating to the cable route corridor to accompany any planning application for this cable route under the Town and Country Planning Act. There is scope for minor scheme redesign through micrositing of elements of the development to avoid significant effects on sensitive sites revealed either by marine geophysical survey or by desk-based assessment of the cable route on land.

10.2.10 CONSTRUCTION EFFECTS ON LAND

There would be no requirement for transport of aggregates, or minerals to or from the wind farm site during the construction phase.

While most components are expected to be transported by sea, should any components, such as foundation components, be carried over land to the construction port, of the potential construction ports (Workington, Silloth, Barrow-in-Furness and Maryport) only Silloth is not directly served by both rail and trunk roads. No significant traffic impacts would be expected should any of the other three ports be used.

Noise of unloading, loading and assembly at the construction port is not expected to be greater than the noise from existing port operations at the ports considered as having potential for use, and would not require any special permissions. Impact of construction noise within the port would therefore not be significant.

10.2.11 MARINE NAVIGATION EFFECTS

10.2.11.1 Collision Risk Assessment

Construction Period All non-construction vessels will be excluded from the construction area during the construction periods. There would therefore be a very risk of collision with foundations under construction.

Operational Period Commercial vessels do not cross this part of the Solway due to the continually shifting sandbanks and lack of depth even at high water. There would therefore be a very low risk of collision of commercial shipping with any components of the wind farm. Recreational sailors are currently recommended to stay to the west of the banks. At high water however, some yachts will cut across on their way to and from Kippford and Maryport. The minimum distance between blade tip and water at the astronomical high tide would be just over 25m; this will be in excess of the likely height of the top of the mast on a yacht using this area. With the strong currents and tides in the area, there is a small risk of collision if a yacht was becalmed and unable to use an engine to get out of the area.

Although the collision risk is considered small through preliminary analysis, a full collision risk assessment has been commissioned. This will be provided in a supplementary report to the ES.

10.2.11.2 Effects on Shipping and Leisure Use from Exclusion Zones during Construction and Operation

Construction Period There would be no effect on the commercial vessels (including scallop vessels) that operate to and from Kirkcudbright, Silloth, Maryport, Workington and Whitehaven since they do not use the Robin Rigg area. Cruising yachts sailing from Kippford to Maryport and vice versa will need to follow the sailing directions and keep west of the Two Feet Bank buoy. This may have an effect on the routing of a small number of races during the one to two years of construction, but it is not considered to be a significant effect.

Operational Period Leisure vessels will be free to cross the area during the operational phase although there would be an exclusion area of 50m around each turbine and vessels will be strictly prohibited from making fast to the turbines. These 50 m exclusion zones comprise only 4.5% of the wind farm area. Effects on leisure vessels are therefore considered to be minimal.

10.2.12 AVIATION AND MILITARY IMPACTS

The Defence Estates, Civil Aviation Authority Safety Regulation Group and National Air Traffic Services have been consulted with regard to effects on aviation. All have responded with no objection.

10.2.13 EFFECTS ON SOCIO ECONOMICS

10.2.13.1 Effects on Commercial Fisheries

The majority of fisheries in the Solway are found in the outer Solway west of the Robin Rigg site. The main fishing activities carried out within the area of the sand banks in the vicinity of Robin Rigg are Maryport vessels trawling for demersal species, and smaller boats from Maryport, Silloth and Annan trawling for brown shrimp.

The bank is a nursery area for a number of species fished in and around the Solway including Plaice Sole, Dab and Whiting. The area over the bank is not fished as a result of this. The development, operation and decommissioning of this proposal will not have an adverse impact on the nursery species, or on the annual migration of species across it.

The only impact on fisheries would result from restrictions to fishing within the wind farm during the construction and operation periods. Two of the most trawled channels the Maryport Roads and the Scotch Deep are outside the exclusion zones and would therefore not be affected.

Fishing for shrimp tends to concentrate around the edges of the banks including Robin Rigg during the winter months (November to April). This winter fishing may be affected marginally by the operational restrictions and less so by the construction constructions since the construction seasons will lie outside of the winter months.

10.2.13.2 Effects on Tourism

The main effect of the proposal on tourism on the Solway would be the indirect effects of changes to the landscape and seascape through the introduction of a new visual feature into the Firth which would be visible from much of the coastline, though visibility would fall off rapidly as one moved inland particularly on the Scottish side of the Firth. Tourists who would experience a significant visual effect would be those walking on footpaths on the East Sewartry Coast, playing on the golf course at Torrs, those visiting the Mott of Mark at Kippford, birdwatchers at the RSPB reserve at Mersehead Sands and tourists sailing, wind surfing and angling at sea closer in to the wind farm.

A significant effect does not imply a negative effect. Of the large number of opinion surveys collected from both residents and tourists collecting their opinions on wind farms operating in the UK, the vast majority have shown that residents and tourists alike view wind farms positively.

There is also anecdotal evidence that wind farms attract tourists and visitors to an area rather than discouraging them. As one of the first offshore wind farms in the UK, and the first in Scotland, the Robin Rigg wind farm would be likely to have an attractive effect for tourists

10.2.14 EFFECTS ON MINERAL, GAS AND OIL RESOURCES

There are no licences for oil and gas exploration nor extraction of sand or gravel from the area in the vicinity of the wind farm, nor have the DTi or the Crown Estates received applications for such licences in the area of the wind farm or the 132 kV cable route to shore. The development is therefore not considered to have an effect on the exploitation of these resources.

10.2.15 EFFECTS ON UNDERSEA PIPES AND CABLES

Consultation has confirmed that there are no proposed or existing undersea pipes and cables in the vicinity of the proposed wind farm including the substation to shore power cable route. The development would therefore have no impacts on undersea cables or pipelines.

10.2.16 ELECTROMAGNETIC EFFECTS

10.2.16.1 Microwave Fixed Links

Three microwave corridors were identified prior to site design, crossing the Solway in the vicinity of the proposed wind farm site. Of these one corridor lies a distance of more than 3 km from the nearest turbine, well beyond the area of potential interference.

There are three mechanisms by which turbines can interfere with microwave fixed links. These are near field effects, diffraction and reflection and scattering

With regard to the near-field interference, the closest distance between turbines and the closest antenna of the two remaining corridors is 19 km. This is well beyond the distance at which there could be any near field effects from the turbines on the microwave links. Regarding diffraction effects the Radiocommuncations Agency suggests that the 2nd Fresnel zone around the links should be avoided.

During the design of the wind farm a more conservative approach was used in agreement with One2one the operators of the links in corridors M2 and M3, and a 3rd Fresnel zone avoidance policy was adopted by all parts of wind turbines. Since the wind farm lies in the central third of the links, the separation zone required to protect from reflection and scattering effects would be much smaller than the 3rd Fresnel Zone. On the basis of the avoidance of the 3rd Fresnel Zone, the operator of the links, One2one, is satisfied that the wind farm proposal would not impact on their microwave links in the vicinity of the wind farm.

10.2.16.2 Interference to TV and Radio Reception

It is commonly accepted that significant interference to reception is unlikely beyond a distance of 10 km from a wind farm where the wind farm lies directly between the receiving household and the transmitter, decreasing to 500 m in other directions around the wind farm. While households in the Dundrennan and Kirkcudbright area would lie on the other side of the wind farm to the transmitters at Caldbeck and Sandale, the wind farm lies just over 10 km from the nearest coastline in the direction lying directly away from the transmitters. It is therefore very unlikely that the wind farm would have any effects on TV reception at households in this area or any other area.

10.2.16.3 Mobile Phone Networks

British Telecom, Cable & Wireless, BT Cellnet, Orange, One2one and Vodaphone have all been consulted with regard to the development. None of these consultees have raised any objections to the proposals.

10.2.17 EFFECTS OF NOISE ON HUMAN RECEIVERS

10.2.17.1 Construction Noise

The only operation that would be likely to be heard onshore and would not be part of the ordinary noise environment in the Firth would be the noise of piling operations for turbine foundations.

The worst case noise impact would be to use monopiles driven, rather than augered and vibrated into the stiff to very stiff clay found under the sand layers at Robin Rigg.

Housing in Balcary Bay on the Scottish side is the closest housing to a piling position, with a separation distance of 9320 metres. The closest housing on the English side is at Flimby, 13100 metres from the nearest foundation.

It was shown that piling noise at the closest housing would be below the limits for daytime working given in the relevant standards. For night time work, piling would be not be carried out on turbine foundations within 9.8 km to the closest residential properties on the Scottish side unless it could be shown that such work would meet the relevant noise limits in agreement with the Scottish Ministers. On the basis of this construction noise impacts would not be significant.

10.2.17.2 Operational Noise

The predicted noise levels from the wind turbines would be well below the lower noise limit suggested by the most relevant guidelines at even 5 km from the site, and therefore noise from wind turbines is considered to have no significant effects on the amenity of local residences nor on those using amenities such as footpaths, beaches or golf courses on either coast which lie more than 9 km from the nearest turbine.

10.3 SUMMARY OF MITIGATION MEASURES

The following table summarises the mitigation measures incorporated into the design of the wind farm from site selection through design of the layout of the turbines and the design of the individual components of the wind farm, and finally the selection of construction and decommissioning techniques. Each mitigation measure is listed against the environmental or human receptor for which impacts have been reduced.

Principal Area of Effects	Mitigation Measure	Reasons for and Benefit of Measure
Water Quality Effects	***Bunding of major oil containers to prevent spillage during construction***	In the event of a leakage, bunding of all oil tanks on and offshore during the construction and operation period with bunding capable of accepting more than the maximum capacity of oil and fuel tanks would minimise risks of leakage into the marine environment.
	Use of water based lubricants in hydraulic machinery	Although no significant effects have been anticipated on water quality, using oil based lubricants, use of water based lubricants on hydraulic equipment used on the construction vessels and equipment will minimise the polluting effects of any leakage of these fluids during the construction period.
	Bunding of transformers in the offshore substation	The two transformers required for stepping up the voltage on cables collected from turbines from 33 kV to 132 kV would require a cooling system. The two transformers would each contain approximately 30,000 – 40,000 litres of cooling fluid. In order to minimise risks of this fluid leaking into the marine environment, bunding capable of containing the maximum amount of cooling fluid would be provided around each transformer.
	Using power cables containing non- oil based insulators	While anchoring and trawling will be prohibited within the wind farm during the operational period, and the 132 kV cable to land will be directionally drilled and trenched to minimise the risk of exposure of the cable, the prohibition within the wind farm could potentially be broken. In this case there is a risk of damage to the casing and armouring of the 33 kV cables within the wind farm. Most types of offshore cable contain oil for insulation and protection of the cores. The amount of oil contained within the 40 km of 33 kV cabling within the wind farm would be considerable. Therefore to remove any effects of spillage of oil on the marine environment in the case of damage to the cabling, the cabling will not contain oil but instead will use EPR (Ethylene Propylene Rubber) insulation or more likely XLPE (Cross-Linked Polyethylene.
	No use of TBT paints or other ant-fouling paints on foundations	Toxic anti-fouling paints containing TBT have been widely used to prevent marine growth on ship hulls and marine structures. However, these paints have been found to cause environmental damage to non-target organisms. It is not envisaged that any anti-fouling measures would be employed on the proposed foundation structures.
	With respect to the spillage of cementitious materials all shuttering, etc will be efficiently sealed to prevent leakage and all grouting operations will be carefully monitored.	This will reduce the amount of grouting material leaked to the marine environment during the installation of foundations should grouting be employed.
Benthic Community Effects	***Selection of site away from the Inner Solway European Marine Site.***	The site has been selected as far as possible from the European Marine Site and its important estuarine habitats within the limits of acceptable water depths and the MOD Danger Area to the west. The resulting separation distance is such that the construction and operation of the wind farm will have negligible effects on water quality and wave and tidal flows in the confines of the European Marine Site.
	Use of piled not gravity foundation with piles of sufficient depth to avoid scour protection	Piled foundations will be employed at the site rather than gravity foundations. In addition the depths of piles will be such that local and global scour of the seabed sediments around turbines will not have a destabilising effect on the foundations. Scour protection is therefore considered unlikely to be needed reducing direct impacts on the benthic community within the wind farm.
	Micrositing final 132 kV in the shallow sub-tidal and lower intertidal section of cable route to avoid good examples of Sabellaria reef habitat.	Once the route of the shoreward section of the 132 kV cable as been selected further littoral surveys will be undertaken of the intertidal and immediate subtidal area. The cable route will then be microsited further to avoid damage to good examples of *Sabellaria* reef as far as possible. This is considered to be the benthic community of most value that could potentially be affected by the Robin Rigg proposal.
Effects on Fish	***Use of earthed armouring and shielding for cables to reduce electric fields.***	Electric fields external to the power cables within the wind farm and the cable to shore will be reduced as far as possible through earthed shielding of the cables. While the cables within the wind farm will be trenched there is a risk that global sediment movements will expose lengths of cable from time to time. Providing extra loops of cable along the cable lengths will allow the weight of cables to lead to reburying over time. Both these measures will reduce the strength of electric fields to which electro-sensitive fish species would be exposed within the wind farm and therefore reduce and attractive or repulsive effects. The 132 kV cable to shore meanwhile would be trenched through stable sediment areas and directionally drilled under mobile banks, thus minimising any risk of exposure of the cable. The permanent burying of the cable will minimise electric field strengths on the seabed and the water column immediately above in the vicinity of the cable route, and therefore any effects on electro-sensitive fish.
	Burying of cables within wind farm and use of excess cable length in loops along length of cable	
	Directional drilling of 132 kV cable under mobile banks	
	Use of three core AC cables to reduce magnetic fields	Salmon and other migratory fish use the earth's magnetic field to navigate back to their spawning rivers. It is considered that once these fish reach the estuary to which the spawning river flows they use their olfactory sense rather than magnetic fields to find the river mouths. Nevertheless, to further reduce any risk of disturbance to migratory fish, the use of 3 core AC cables will provide a near zero net electric current in the cables and thus minimise magnetic fields external to the cables.
Marine Mammals	***Soft start piling***	At the beginning of piling at any foundation the piling will begin with a low piling energy and therefore low piling noise, increasing gradually to the required piling energy. This will be timed to allow any marine mammals and fish to move away from the immediate vicinity of the piling position and therefore avoid any physiological effects of piling noise.
	Avoidance of harbour porpoise calving area	An area known to have been used in recent years for calving of harbour porpoises east of the above the intersection of Southerness Point and Dubmill Point in the Inner Solway. the Robin Rigg site has selected so that it lies more than 10km west of this sensitive area. At this distance the effects of construction and operational noise on the calving of harbour porpoise is not considered to be significant.
Ornithological Effects	***Avoidance of protected nature conservation area including bird colonies***	The site has been sel3ected at over 7km from the nearest protected area (the European Marine Site with its Special Protection Areas for birds) and is over 8 km from the nearest important seabird colony, thus reducing disturbance effects and collision risks.
	Avoidance of Common Scoter feeding areas	Hydrographic data and surveys of the Solway revealed a belt of potentially suitable shallow water between the English Channel north west of Maryport and the Auchencairn Bay/Rough Firth inlet in Dumfries and Galloway. The northern part of this area was found from bird surveying beginning in May 2001 to provide feeding grounds for Common scoter in nationally important numbers. This area was therefore avoided through selection of the Robin Rigg site further to the south more than 3km from observed numbers of feeding Common Scoter in nationally important numbers.
	Route construction vessels away from more sensitive areas, particularly that used by the concentrations of common scoter.	The construction vessel routes will be from the southwest or southeast thus avoiding the Common Scoter feeding area.

Principal Area of Effects	Mitigation Measure	Reasons for and Benefit of Measure
Landscape, Seascape and Visual Effects	***Selection of site in central area of Solway furthest from land of suitable sand banks in the Solway.***	Review of hydrographic data and subsequent bathymetric surveys showed that the outer area of permanent subtidal banks of sufficiently shallow water depths in the Solway, lay between the English Channel northwest of Maryport and the Auchencairn Bay/Rough Firth inlets of Dumfries and Galloway. As both sides of the Solway are designated variously at the local and national level, selection of the Robin Rigg bank in the central part of this line of banks furthest from the coast on either side would reduce the significance of landscape and visual effects on the closest coastline to the proposal.
	Regularly spaced turbines layout rather than 'random' wind optimised layout	layouts with regularly placed turbines were compared with irregularly and semi-irregularly placed turbine layouts which had been optimised to maximise energy yield from the proposal. The landscape consultants concluded that the regularly placed turbine layouts had aesthetic advantages over the optimised layouts, were more balanced and were easier to read visually. A regularly placed layout was therefore selected as the final layout despite reduced energy yields.
	Compact turbine layout	While initially it was considered that an open widely spaced layout may have some aesthetic advantages over more compact layouts, comprehensive assessment and review of visualisations of a number of alternative layouts from key viewpoints concluded that a more compact layout had distinct advantages, principally in reducing the horizontal extent of the layout in views but also in reducing the effects of the juxtaposition of wide gaps between turbines and more dense groups immediately to one side when viewing the layout from viewpoints looking down turbine rows. The coast of this was an energy yield reduction when compared to wider spaced layouts.
	Reduction of horizontal extent of layout when viewed from closest viewpoints	The closest coastline to the Robin Rigg site on either coast lies to the northwest of the proposals, on the Stewartry Coast of Dumfries and Galloway, and to the southeast in the Maryport area. The magnitude of effects was therefore likely to be greatest from these locations. Following analysis of a number of different layouts the landscape consultant concluded that the magnitude of visual effects would be reduced from these viewpoints through reducing the northeast to southwest extent of the layout. Selection of the Robin Rigg subtidal bank over the Two Foot Bank to the southeast was key in this since the latter is significantly narrower from northwest to southeast, leading to a larger northeast to southwest extent for the same number of turbines. Following the selection of the Robin Rigg sandbank, the northeast to southwest extent of the sandbank was reduced as far as possible within the confines of the bank. An area of deeper water on the southern edge of the bank was used for turbine positions to reduce this further despite the associated potential need for deeper and therefore more expensive foundations in this area.
	Use of single model three bladed machines rotating in the same direction	Three bladed turbines are widely considered to have aesthetic advantages over two bladed machines, although two bladed machines can be more cost effective. three bladed machines were selected for the proposal. Having the same type of machine for all turbine positions with the same tower heights and rotational direction of blades was also considered to lead to a more harmonious layout.
	Grey semi-matt finish for turbines and offshore substation	It was recommended that the turbines should be a grey colour with a semi-matt finish to attenuate visibility from medium to long distance viewing locations. The turbines will be seen against a combination of sky, the sea and the backdrop of the landscape on the opposite coast or more commonly haze on days with normal visibility distances found on the Solway Firth, therefore the grey colour is considered most appropriate for the conditions in which the turbines will be visible.
	Burying of cable onshore	Burying of cables along the approximately 2 km of cable route between the landfall and the switchyard at the existing 132 kV distribution network east of Flimby, rather than overhead lines removes any visual effects of the power cable route onshore. This option was selected despite the considerable cost of undergrounding.
Archaeological Effects	***Exclusion zones to be established around known sites of archaeological interest offshore. The exclusion zones would be included in construction contracts***	This would ensure that the known sites were not damaged by construction works including anchoring of construction vessels
	Further geophysical survey prior to construction	This would take place along cable corridors within the wind farm site and at the turbine and substation positions to ensure that no further potential wrecks lie within the holes in the coverage of the previous surveys. Any such anomalies would be investigated and wind farm components microsited if necessary to avoid significant impacts.
Effects on Sea Navigation	***Avoidance of main commercial shipping channel***	The commercial shipping channels, the English Channel and the Silloth channel lie several km to the south of the site thus avoiding collision risks with commercial traffic. A possible site on Two Foot Bank, which lies closer to the channels, was not selected partly for this reason.
	Exclusion zone around construction area	All these measures act to reduce risks of collision of leisure vessels with construction vessels and equipment during the construction period and with the turbines and offshore substation during the operational period.
	Provision of sea navigation lit and marked buoys	
	Provision of radar reflectors on navigation buoys	
	Provision of a foghorn in the centre of the site	
	Provision of a yellow band on the outer turbines to increase visibility of turbines in poor conditions	
	A 50 m exclusion zone placed around turbines during the operational lifetime	
	Prohibiting mooring of any non-wind farm vessels to turbines during the operational lifetime	
	Provision of the position of all elements of the wind farm to the UK Hydrographic Office and sailing clubs.	
Effects on Fisheries	***Directional drilling of 132 kV cable under mobile banks***	The 132 kV cable to shore would be trenched through stable sediment areas and directionally drilled under mobile banks, thus minimising any risk of exposure of the cable. This will minimise the risk of fouling of any trawl nets or anchors used by fishing vessels in the vicinity of the cable route to shore.
Effects on Existing Infrastructure	***Site design to avoid interference on microwave links***	The turbine positions have been selected to avoid interference to the two microwave fixed link corridors crossing the site, to the satisfaction of the operators using avoidance zones beyond the minimum suggested by the Radiocommunications Agency
	Avoidance of existing cable routes, pipelines	Avoidance of any existing pipelines or cables on the seabed by at least 20 km through site selection has removed any risk of damage to this infrastructure.
Noise Effects on Humans	***Avoidance of piling on closest foundation positions to land at night unless it can be shown that noise levels for rural areas NPG11, the Control of Noise at Surface Mineral Workings (considered to be the most relevant guidance) are not exceeded***	Night-time piling at turbine locations closer than 9800m to the nearest dwellings would only be carried out if it could be shown that noise levels would be less than an agreed limit based on the limits for rural; areas found in NPG11, the Control of Noise at Surface Mineral Workings which is considered to be the most appropriate guidance unless otherwise agreed with the Scottish Executive. Because of the desirability of completing off-shore piling work within a predictable time frame, taking account of unpredictable weather conditions which could disrupt operations, it is proposed that there should be some degree of flexibility in the application of noise limits in relation to night-time (as possibly late evening) piling. Again, in controlling noise from piling it seems appropriate to strike a balance between the loudness of the noise received at dwellings and the period during which piling will continue. Therefore a flexible approach to noise control is proposed which will enable noise levels higher than 40dB L_{Aeq} to be received at any dwelling for a limited period, and following a defined process of agreement with the Scottish Ministers.

10.4 SUMMMARY OF MONITORING PROPOSALS

Monitoring is proposed for a number of ecological elements around the wind farm marine components including the 132 kV cable to shore. These monitoring proposals are suggested despite there being no predicted significant impacts of the proposals on any ecological receptor. The monitoring proposals are targeted at confirming the findings of non-significant construction and operational effects on birds, fish, sea mammals and benthic communities and also to increase the knowledge of the impacts of offshore wind energy development on marine receptors.

10.4.1 Marine Benthos

The wind farm site selection has selected a site dominated by a biotope which is adapted to mobile and impoverished sediments. This selection is considered to lead to minimal damage to benthic interests.

A monitoring programme for the wind farm site is proposed, however, to confirm the findings of the assessment during and following construction. 10 sample sites are suggested located around/within the wind farm to measure effects of scour, and sediment disturbance, and also along the 132 kV cable route where it has been trenched rather than drilled.

The monitoring programme should continue for the construction period and for 3 years post construction.

A monitoring programme should be developed to identify recolonisation success of *Sabellaria* reef and other biotopes in the intertidal area. It is recommended that the recovery success of intertidal *S. alveolata* reef habitat, damaged directly by cable route trenching, is investigated annually for a period of three years. This should be undertaken using Marine Nature Conservation Review Phase II habitat mapping techniques. Ongoing consultation should be maintained with English Nature and Scottish Natural Heritage to allow an assessment of the current and future extent of *S. alveolata* reef within the Solway Firth and accepted monitoring and surveillance techniques. Recovery rates of *S. alveolata* reef habitat damaged by the cable route should be assessed in relation to natural or anthropogenic influenced fluctuations in examples of wider Solway Firth reef habitat, as identified by broad scale mapping or other surveys carried out by Government agencies as part of ongoing monitoring programmes.

The detail of monitoring proposals would be subject to further consultation with English Nature and Scottish Natural Heritage should the Robin Rigg proposal be given permission to proceed.

10.4.2 Fish

A monitoring regime for fish populations during and after construction would provide confirmation of the predictions of the EIA. The monitoring regime should address:

- The presence of electrosensitive species (particularly thornback ray) in the Solway Firth and particularly in the vicinity of the cable routes
- The utilisation of the wind farm area by fish species, including the importance of turbine support structures as FAD's

Any monitoring programme is suggested to last during the construction period and for three years post construction. Details of the methodologies for monitoring would be agreed in consultation with English Nature and Scottish Natural Heritage should the Robin Rigg proposal be given permission to proceed.

Catch data on salmonid populations in rivers entering the Solway Firth should also be gathered over the construction and initial operational phases for trend analysis.

10.4.3 Marine Mammals

The developers would give support to the Solway Shark Watch and Sea Mammal Survey to continue to collect observations to confirm that cetacean use of the Solway continues in a similar manner as previously.

10.4.4 Birds

The details of the bird monitoring programme would be agreed through consultation with RSPB, English Nature and Scottish Natural Heritage. The methodologies would generally follow those used in the baseline work for this ES, but would also include the investigation of the use of infra-red video monitoring to measure collision rate. The developer has however agreed to implement the following:

Continuation of Baseline Monitoring prior to construction
- Boat surveys (monthly), to provide a further baseline on bird use of the study area

Monitoring during construction
- Twice-monthly surveys by boat

Post-construction monitoring
- At least 3 years' boat surveys (monthly)
- Collision monitoring – infra-red video camera mounted on turbine (sample continuous day/night)

The survey area for this monitoring work would be the same throughout the study, though this would be reviewed through consultation with SNH, English Nature and RSPB. As this is extensive and covers much sea over 2km from the proposed wind farm, this will allow both a before/after/control/impact analysis and an analysis of bird distribution in relation to distance from the turbines to be made.

The data from the aerial surveys will be reviewed and an assessment made as to whether this would be a useful survey method to continue at this site in combination with the boat surveys.