Alternative Landfall Cable Installation Method Marine Licence Application – Environmental Report

December 2016

Beatrice Offshore Windfarm Ltd

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Project Title	Beatrice Offshore Wind Farm
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Glossary

Term	Definition
Back of the berm	Landward edge of the shingle berm, where the limit of the storm shingle washover fans meet the vegetation edge of the hinterland as measured by BOWL's 2016 topographic survey.
Cable	Beatrice Offshore Wind Farm's transmission high voltage (HV) alternating current (AC) 220 kV subsea export cable.
Direct Pipe	Direct Pipe® is a pipeline installation methodology pioneered by Herrenknecht which combines the advantages of micro tunnelling and HDD technology. This technique excavates the borehole using a micro tunnelling machine, pushed by the prefabricated final pipeline in one single step. The necessary thrust force is provided by the Pipe Thruster which pushes the micro tunnelling machine forward (or pulls it backward) together with the pipe – with a thrust force of up to 750 tonnes in increments of 5 metres. The push force is transferred to the Direct Pipe through the Pipe Thruster's clamping unit and then to the tunnelling machine's cutterhead.
EC1	Beatrice OWF's transmission subsea Export Cable 1 (Easterly cable)
EC2	Beatrice OWF's transmission subsea Export Cable 2 (Westerly cable)
Entry point	The onshore entry point for the pipe on completion of the Direct Pipe installation activities and after the pipeline has been cut to the required length. Typically the final pipe entry point corresponds to the front wall of the Pipe Thruster Pit.
Final exit point	The offshore seabed pipe exit point, once the pipeline has been pulled back in to the seabed to achieve the required depth of burial. It is also the point at which the polyethylene (PE) pipe attaches to the Direct Pipe.
Horizontal Directional Drilling (HDD)	A steerable, trenchless, method of installing an underground pipe, conduit or cable in a shallow area along a prescribed bore path by using surface-launched drilling equipment, with minimal impact on the surrounding area.
Landward transgression	A term used to describe the geomorphological behaviour of a landform under processes which lead to its landward movement over time.
Landward translation	A term used to describe an analytical process whereby a survey transect is displaced in the horizontal plane by a defined distance (in this case the 'set back distance')

Term	Definition
MHWS	Mean high water spring tide mark is located part-way along the seaward face of the shingle berm. BOWL's 2016 topographical survey established the distance from MHWS to 'back of berm' was variable but approximately 25m.
OWF	Offshore Wind Farm
Pipe Thruster Pit	The onshore location of the Pipe Thruster Unit. The Pipe Thruster Pit (sometimes known as the launch pit) is a temporary pit structure which provides the necessary structural anchorage for the Pipe Thruster Unit and is configured to allow the required ground entry angle for the pipe. The Pipe Thruster Pit is usually constructed from sheet piles and concrete which is fully removed on completion of the pipeline installation.
Pipe Thruster Unit	The unit which is used to provide up to 750 tonnes of thrust or pull force to the pipeline string being installed.
Set back distance	The distance by which landfall infrastructure will be set back from the shore so that projected future coastal erosion over the next 25 years can be accommodated without compromising the infrastructure. The set back distance is measured from the back of the berm. It has been established as a distance of 50m.
Shingle Berm	The wave-built, gently sloping, often sizable shingle or gravel barrier, between the seaward foreshore and landward backshore plane or hinterland. The barrier is usually characterised with a series of storm ridges on its seaward face and shingle wash over fans landward of its ridge.
Vegetation edge	This is the edge of the hinterland vegetation where it meets the marine influenced beach topography. It is typically where shingle storm wash over fans meet the vegetation edge of the hinterland. It is otherwise referred to as the 'erosion edge' or 'back of the berm'.

1 Introduction

1.1 Background

The Beatrice Offshore Wind Farm (the Beatrice Project) received consent under Section 36 of the Electricity Act 1989 from the Scottish Ministers on 19 March 2014 (the S.36 Consent) and was granted two Marine Licences from the Scottish Ministers, one for the Offshore Wind Farm (OWF) and one for the Offshore Transmission Works (OfTW) on 2 September 2014, both varied on 26 April 2016 (the Marine Licences). Planning permission for the Onshore Transmission Works (OnTW) was received from The Moray Council on 3 November 2015.

The OWF is located in the Moray Firth approximately 13.5 km from the Caithness coastline at its nearest point (Figure 1.1). The OWF consists of 84 x 7 megawatt (MW) wind turbine generators (WTGs) on piled jacket foundations, inter-array cables and two Offshore Transformer Modules (OTMs) also on piled jacket foundations. The OfTW cable corridor makes landfall west of Portgordon, Moray. Onshore construction of the cable landfall is scheduled to commence with onshore site set-up in December 2016. Site set-up for the installation of the cable ducts is currently programmed for January 2017, with onshore to offshore drilling scheduled to commence in March 2017. The OWF is scheduled to become fully operational by October 2019.

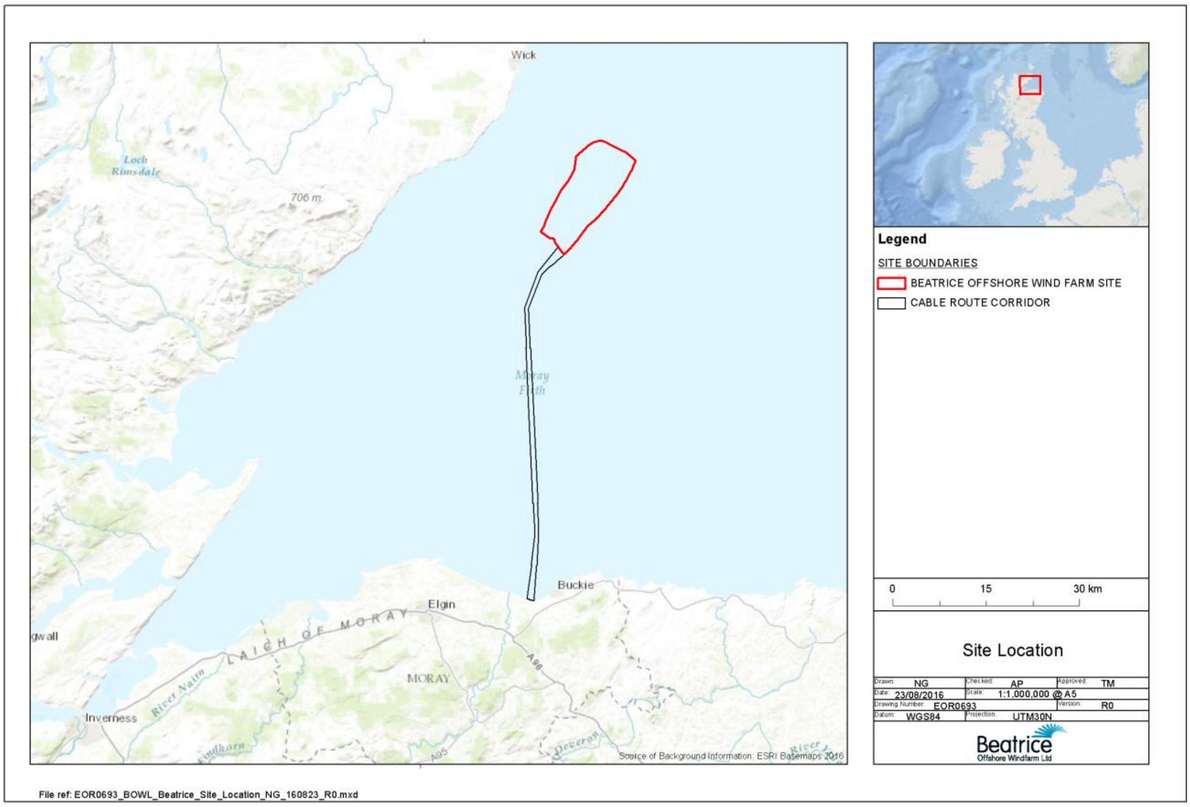


Figure 1.1: Beatrice OWF and OfTW Location.

The existing OfTW Marine Licence permits the installation of two transmission cables via two preinstalled horizontal ducts using horizontal directional drilling (HDD) at the landfall location. As a prudent project risk management measure, Beatrice Offshore Windfarm Limited (BOWL) wishes to apply for consent for an alternative installation methodology to be implemented in the event that the Direct Pipe (the preferred form of HDD installation) methodology proves unsuccessful in the field. This alternative method is for open trenching, between the original proposed landward pipe entry points and offshore final exit points of the original Direct Pipe profile, which extends underneath four zones namely: the shallow subtidal; the intertidal beach; the shingle berm; and the area immediately landward of the shingle berm (termed "the hinterland"), with some of the trenching works falling within the designated Spey Bay Site of Special Scientific Interest (SSSI).

Under the Marine (Scotland) Act 2010, a Marine Licence is required if a person or organisation intends to carry out marine construction works within the Scottish marine area seaward of Mean High Water Springs (MHWS) and therefore a Marine Licence is required for the alternative cable installation methodology up to the point of MHWS.

This Environmental Report has been prepared in support of the Marine Licence application only. The works landward of MHWS is being discussed separately with The Moray Council. However, for completeness, this document describes the full extent of the alternative methodology (i.e. from the onshore Direct Pipe entry points to a position approximately 420 metres (m) to 450 m seaward of these points), before focusing on the section of those works falling under the Marine Licensing regime (i.e. from below MHWS only). It should be noted at this point that a range of distances has now been included within this environmental report for which the alternative installation method applies. This is a refinement of the approximation given in the Consenting Approach document submitted on 4 October 2016 (BOWL, 2016b).

1.2 Consultation

Marine Scotland Licensing Operations Team (MS-LOT) was notified of the need for and intention to submit a Marine Licence application for the alternative (contingency) methodology during a meeting on 20 May 2016. Given the location of the works within the SSSI, consultation with Scottish Natural Heritage (SNH) took place during both an initial meeting on 31 May 2016 and a focused meeting on 15 September 2016, to determine SNH requirements for the application based on the initial draft geomorphological assessment (BOWL, 2016a). BOWL also held meetings with SNH on 31 August and 8 September 2016 when discussions touched on the alternative methodology, particularly in relation to erosion rates.

In October 2016, BOWL undertook consultation with MS-LOT on the approach to gaining consent for the alternative landfall cable installation method through the Consenting Approach document (BOWL, 2016b) which was submitted on 4 October 2016. The Consenting Approach document set out the scope of the Marine Licence application, including this Environmental Report. Following submission of the Consenting Approach document a meeting was held with MS-LOT and Marine Scotland Science (MSS) on 14 October 2016 to agree and further refine the approach in support of the Marine Licence application. The Consenting Approach document and the overall approach to undertaking the licence application was discussed and agreed with MS-LOT during the meeting. In particular, it was agreed that the scope of the Environmental Report presented in the Consenting Approach document was appropriate; that the application did not require an Environmental Impact Assessment (EIA) under The Marine Works (Environmental Impact Assessment) Regulations 2007; and that Pre-Application Consultation under the Marine Licensing (Pre-application Consultation) (Scotland) Regulations 2013 was not required.

2 Project Description

2.1 Alternative methodology

The export cable landfall location is located approximately 1.5 km west of Portgordon harbour, directly within Spey Bay, Moray, and towards the eastern limit of the Spey Bay SSSI. BOWL's preferred approach for cable installation remains installation via a form of HDD, called Direct Pipe®. This is a pipe installation methodology pioneered by Herrenknecht which combines the advantages of micro tunnelling and HDD technology. This technique excavates the borehole using a micro tunnelling machine, pushed by the prefabricated final pipeline in one single step. Direct Pipe is a micro tunnelling process and not reliant on drill muds to maintain the drill bore prior to the final pipe/duct installation. Once the pre-installed ducts are in place the cable is subsequently pulled through them.

BOWL is confident that installation of horizontal ducts by the Direct Pipe method will be possible, and further engineering assessments are underway to provide further reassurance that this is the case. The installation of two pre-installed cable ducts (between 420 m and 450 m in length), using the Direct Pipe method, at the landfall at Portgordon is currently programmed to commence with site set-up in January 2017. Installation using the Direct Pipe methodology is scheduled for completion by June 2017.

However, during design development, the installation of preinstalled ducts by HDD (Direct Pipe methodology) was identified as a potential single source project risk for which there is currently no alternative consented option. BOWL therefore wishes to consent an alternative approach that would be implemented only in the event that the preferred approach fails[1]. The alternative methodology is required to demonstrate appropriate project risk management.

The alternative methodology has been developed by Nexans Norway, who has been commissioned to deliver and install the export cables (Nexans Norway, 2016). Under the alternative methodology, it is proposed that the two cables would make landfall approximately 350 m to the west of the Burn of Tynet, with each cable separated by a distance of approximately 180 m (Figure 2.1). Open trenching is proposed to replace the Direct Pipe aspects of the works from the onshore Direct Pipe entry points (set back a minimum 50 m from current back of the shingle berm) to a position approximately 420 m to 450 m seaward of these locations (the locations of the offshore Direct Pipe final exit points). The open trenching will cover four distinct zones (Figure 2.1), namely the hinterland (landward of MHWS, covered by terrestrial planning consents), the shingle berm (seaward of MHWS however an integral part of the intertidal system, to be covered by this Marine Licence application), the intertidal zone (covered by both terrestrial planning consents and this Marine Licence application) and the subtidal zone out to 420 m to 450 m seaward of the onshore Direct Pipe entry points (also covered by this Marine Licence application). From that point, the trenching will continue offshore under the existing OfTW Marine Licence[2].

[1] BOWL may seek to adopt the alternative methodology in the event that BOWL's assessment is that it is not reasonably practicable to install the preinstalled pipe on the required profile to facilitate the export cable's safe pull-in from a final exit point offshore, underneath the designated SSSI area, to the designated onshore entry point. The required drill profile has to satisfy the 25 year design life requirements of the current assessed coastal processes with an agreed safety margin.

[2] To allow for the transition between the alternative method of installation to the installation method consented under the existing OfTW Marine Licence, the boundary of the Marine Licence application extends slightly beyond the location of the Direct Pipe final exit points.

The alternative cable landfall installation methodology has been designed to take into account the landward migration of the shingle berm over the 25 year planned lifetime of the Beatrice Project. A conservative set-back distance for the onshore Direct Pipe entry points of 50 m from the back of the shingle berm (the "erosion line") has been adopted for the purposes of the construction works, to account for a predicted long term erosion of the shingle berm. This set-back distance also applies to the Direct Pipe entry points for the existing consented Direct Pipe works, and is further explained in the Beatrice Offshore Wind Farm Consent Plan OfTW Cable Plan (BOWL, 2016c). Cable burial depth has also been designed to allow for 'rollback' (landward migration) of the shingle berm over a 25 year period. The proposed depths of burial currently proposed for each of the zones (see Table 2.1) reflect the predicted changes in beach levels, so that in 25 years' time the landfall cable will have from 1 m to 2.3 m cover (Nexans Norway, 2016).

Table 2.1 to Table 2.3 consider the full extent of the alternative methodology. Section 2.2 then considers which of these activities are licensable under the Marine (Scotland) Act 2010 and hence the subject of the Marine Licence application.

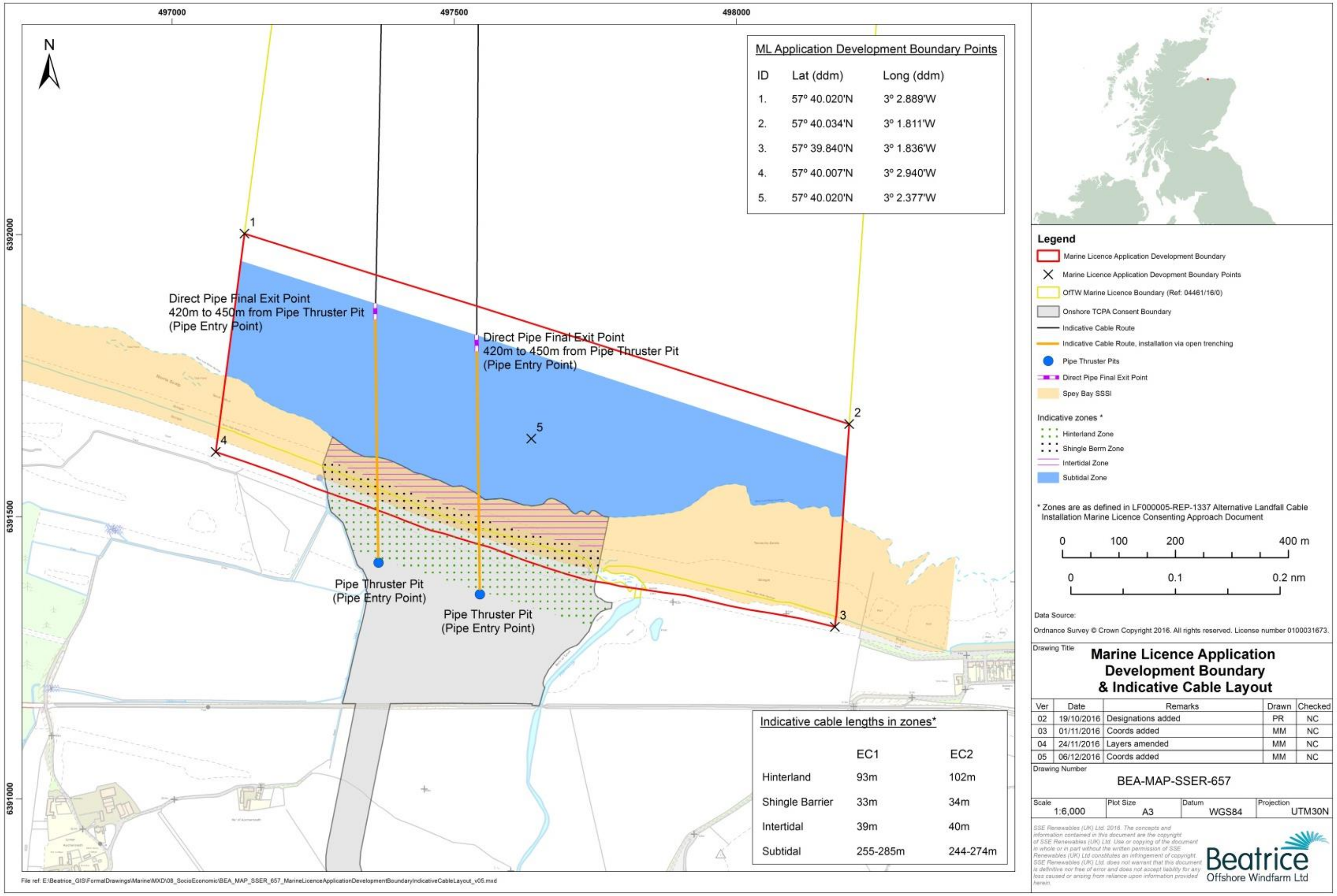


Figure 2.1: Indicative cable layout and the four zones.

Table 2.1: Alternative cable landfall installation methodology.

Activity	Description
Topographical survey	Topographical surveys will be carried out to identify and map the contours of the ground and existing features on the surface. This survey will provide the baseline for comparison with the post-installation and reinstatement survey (see below).
Open trenching from the onshore Direct Pipe entry points to a position approximately 420 m to 450 m seaward of this location (Direct Pipe final exit points)	**Temporary removal and deposit of material:** • During excavation of the two cable trenches, to aid successful reinstatement of the as found sediment layers, each layer of material within each zone will be removed and stored in a designated area, marked and kept separate from other layers. Tarpaulin or similar cover will be laid down prior to storing material. • Two temporary storage areas will be located landward of the SSSI boundary and MHWS, with preliminary estimated dimensions of 30 m x 30 m per area (1,800 m^2 total area). The temporary storage areas will be used to maintain the as found natural layers of excavated material to aid reinstatement, and will be sized dependant on the sediment profiles found during excavation. • Working areas of up to 30 m width will be established running parallel to each cable trench, from the Direct Pipe entry point to Mean Low Water Springs (MLWS), including vehicle access and storage areas. • Sheet piling will be installed to provide trench shuttering to minimise the extent of the excavation works and provide safe trench support from the seaward side of the shingle berm to the onshore Direct Pipe entry point (e.g. above MHWS). Across the shingle berm, sheet piles will reduce the working area to 30 m (including 4 m width between sheet piles; and transport and storage area along one side of the trench). • Tracked vehicles will access the beach via the working areas across the shingle berm. There may be a requirement to temporarily alter the gradient of the bank within the working area to facilitate safe access to the beach by vehicles. Any changes to the shingle berm will be carefully reinstated post-works. Onshore (behind the shingle berm) there may be a requirement to mitigate ground compaction caused by plant/vehicles by placing bog mats or similar within the construction site. Placement of bog mats will be considered based on the localised ground conditions encountered and the type of plant/vehicles accessing the site. Any changes will be carefully reinstated post works.

Activity	Description
	Trench depths and methods across the different zones: • Hinterland (onshore Pipe Thruster Pits to the back of the shingle berm, approximately 100 m length section): depth of cable trenches 8 m to allow for landward transgression of the shingle berm, tapering to ~1.3 m depth where the cable will align with the land cable. Cable to be laid directly in the open trench. • Shingle berm (approximately 30 m to 35 m length section): the cable will be pulled through a polyethylene (PE) pipe (around 500 mm in diameter) which is filled with thermal protective mass. Trench depth of 8 m (Note: worst case trench depth at peak of shingle berm). Water pumps will be used where excavation is below sea level. • Intertidal (approximately 40 m length section): the cable will be pulled through a PE pipe (around 500 mm in diameter) which is filled with thermal protective mass. Excavation and installation activities will be carried out during low water. A picker will be used to dig a trench for the cable in the sandstone bedrock. Alternatively, although very unlikely, concrete bags/clamps or rock nets may be installed on top of the PE pipe before sediment is backfilled into the trench. This measure will ensure the cable remains in position and buried at the correct depth at the bottom of the trench. Trench depth of 3 m. • Subtidal (approximately 244 and 285 m length section): the cable will be installed via cooperation between the Menzi Muck and a barge mounted backhoe excavator. Trench depth of 2 m. Cable to be laid directly in trench. Water depths at the final exit point (furthest seaward point of the works) are approximately 1.1 m (relative to LAT) for EC1; and approximately 1.0 m (relative to LAT) for EC2.
Cable depth survey	In order to record the backfilling depth, a survey of the cable and PE pipe depth where the PE pipe is installed, will be carried out prior to backfilling of the trench being carried out. The purpose of the survey is to verify that the cable has been installed at the required depth. This then gives the depth of the backfilling. .
Backfilling	Backfilling will commence immediately following installation of the PE pipe in the intertidal and shingle berm zones. The cable trench will be backfilled with material in reverse order to which it was removed. In the hinterland zone, the cable will be surrounded with predefined quality sand wrapped in geotextile, with the trench then backfilled with each layer in reverse order. For each layer or for each 0.5 m depth, the material will be compacted in order to reduce subsidence. Reinstated sediments on the shingle berm will not be compacted, which will contribute to ensuring that the porosity of the structure is not

Activity	Description
	unduly affected by the reinstatement works and that the ridge retains its percolation properties. In the subtidal zone, the trench will be allowed to backfill naturally.
Topographical survey	Following reinstatement, a topographical survey will be carried out to identify and map the contours of the ground and ensure that the landscape is similar to the baseline profile.

Table 2.2: Worst case parameters (Source, BOWL, 2016a).

Description	Details	Comments
Number of trenches	2	Export Cable 1 (EC1) and Export Cable 2 (EC2)
Separation of trenches	Approximately 180 m	-
Dimensions of trenches	Hinterland: rectangular trench EC1: 93 m x 4 m x 8 m EC2: 102 m x 4 m x 8 m Shingle berm: rectangular trench EC1: 33 m x 4 m x 8 m EC2: 34 m x 4 m x 8 m Intertidal: trapezoidal trench EC1: 39 m x 4 m x 3 m EC2: 40 m x 4 m x 3 m Subtidal: trapezoidal trench EC1 (min): 255 m x 4 m x 2 m EC1 (max): 285 m x 4 m x 2 m EC2 (min): 244 m x 4 m x 2 m EC2 (max): 274 m x 4 m x 2 m	Length x Width (at base) x Depth (max target depth contractor required to achieve) All values rounded to nearest whole metre. Hinterland: assumes steel sheet pile supported trench walls Shingle berm: assumes steel sheet pile supported trench walls

Description	Details	Comments
Plan area of trenches	Hinterland: EC1: 372 m^2 EC2: 408 m^2 Shingle berm: EC1: 132 m^2 EC2: 136 m^2 Intertidal: EC1: 156 m^2 EC2: 160 m^2 Subtidal: EC1 (min): 1,020 m^2 EC1 (max): 1,140 m^2 EC2 (min): 976 m^2 EC2 (max): 1,096 m^2	Values for intertidal and subtidal (trapezoidal trenches) will be slightly greater as width at surface will be greater than width at base, however the differences will not be significant due to the shallow depths of these trenches. All values rounded to nearest whole square metre. Total area affected from Direct Pipe entry points to MLWS = 1,364 m^2, of which 586 m^2 is within the SSSI, representing only 0.013% of the designated site. If only the 'sub-unit' of SSSI between Spey Mouth and Portgordon is considered (covering 44 hectare (ha)), then the total area represents only 0.13% of this 'sub-unit' of the SSSI.
Volume of sediment extracted	Hinterland: EC1: 2,976 m^3 EC2: 3,264 m^3 Shingle berm: EC1: 1,056 m^3 EC2: 1,088 m^3 Intertidal: EC1: 468 m^3 EC2: 480 m^3 Subtidal: EC1 (min): 2,040 m^3 EC1 (max): 2,280 m^3	All values rounded to nearest whole cubic metre. Total volume of material excavated from the Direct Pipe entry points to MLWS = 9,332 m^3, of which 3,097 m^3 is within the SSSI.

Description	Details	Comments
	EC2 (min): 1,952 m^3 EC2 (max): 2,192 m^3	
Working areas	30 m width (including trench width)	Conservative estimate, with working area running parallel to the trench, from the Direct Pipe entry points to MLWS.
Storage areas	Two 30 m x 30 m (approx.) areas	Located landward of the SSSI boundary and MHWS.

Table 2.3: Vessels and plant.

Type	Description
Excavators, dumpers and cranes/winches (shingle berm, intertidal)	Whilst the exact detail will not be known until subcontractors have been appointed, it is likely that a number of excavators (approx. 31 tonnes), dumpers and cranes/winches would be required.
Menzi Muck (intertidal, subtidal)	A Menzi Muck would likely be used in preference to an excavator in the areas closest to MLWS. A Menzi Muck is more manoeuvrable and has the ability to work in 1 m to 2 m water depth. Selection of appropriate plant would reduce the potential for over-excavation and reduce delays during construction. The image below shows a Menzi Muck similar to that proposed for the alternative installation method (BOWL, 2016a).  Photo courtesy of Nexans Norway
Barge mounted excavator (subtidal)	In the subtidal zone there would be cooperation between the Menzi Muck and a backhoe excavator. A barge mounted excavator would be used in greater water depths. The image below shows an example of an excavator and a backhoe barge (Nexans Norway, 2016).

Type	Description
	 Photo courtesy of Nexans Norway

2.2 Licensable activities

The alternative cable landfall installation activities taking place below MHWS which are licensable under the Marine (Scotland) Act 2010 are summarised in Table 2.4. These activities form the focus of the assessment presented in Section 3 of this Environmental Report. However as certain non-licensable activities can increase the duration and extent of the impact (e.g. use of vessels/plant and presence of human activity during surveys leading to disturbance effects), these wider activities are also considered in the overall assessment where relevant.

Table 2.4: Licensable activities.

Activity	Description
Temporary removal and deposit of material (shingle berm and intertidal zone)	• During excavation of the two cable trenches, each layer of material within the shingle berm and intertidal zones will be removed and stored in designated storage areas, marked and kept separate from other layers. Tarpaulin or similar cover will be laid down prior to storing material.
Creation of working areas (shingle berm and intertidal zone)	• Working areas of up to 30 m width will be established running parallel to each cable trench, to include vehicle access and storage area; • Sheet piling will be installed in the shingle berm zone to minimise excavation works and provide safe deep trench support. Sheet piles will reduce the working area to 30 m (including 4 m width between sheet piles; and transport and storage area along one side). It should be noted that the width between sheet piles is a refinement of the approximation given in the Consenting Approach document submitted on 4 October 2016 (BOWL, 2016b); and • Tracked vehicles will access the beach via the working areas across the shingle berm. There may be a requirement to temporarily alter the gradient of the bank within the working area to facilitate safe access to the beach by vehicles. Any changes to the gravel bank will be carefully reinstated post-works.
Open trenching	• Shingle berm (approximately 30 m to 35 m length section): the cable will be pulled through a PE pipe (around 500 mm in diameter) which is filled with thermal protective mass. Trench depth of 8 m (Note: worst case trench depth at peak of shingle berm). Water pumps will be used where excavation is below sea level; • Intertidal (approximately 40 m length section): the cable will be pulled through a PE pipe (around 500 mm in diameter) which is filled with thermal protective mass. Excavation and installation activities will be carried out during low water. A picker will be used to dig a trench for the cable in the sandstone bedrock. Alternatively, although very unlikely, concrete bags/clamps or

Activity	Description
	rock nets may be installed on top of the PE pipe before sediment is backfilled into the trench. This measure will ensure the cable remains in position and buried at the correct depth at the bottom of the trench. Trench depth of 3 m; and • Subtidal (approximately 244 to 285 m length section): the cable will be installed via cooperation between the Menzi Muck and a barge mounted backhoe excavator. Trench depth of 2 m. Cable to be laid directly in trench.
Backfilling	• Backfilling will commence immediately following installation of the PE pipe in the intertidal and shingle berm zones. The cable trench will be backfilled with material in reverse order to which it was removed; • In the intertidal zone, the material will be compacted in order to reduce subsidence; • Reinstated sediments on the shingle berm will not be compacted, which will contribute to ensuring that the porosity of the structure is not unduly affected by the reinstatement works and that the ridge retains its percolation properties; and • In the subtidal zone, the trench will be allowed to backfill naturally.
Decommissioning	• After the 25 year operational life of the Beatrice Project, the cable will then either be left in situ (in which case there will be no decommissioning impact) or replaced/removed. In the latter event, the potential impacts of decommissioning will be of a similar nature and magnitude to those discussed above for cable installation. In the event that the cables are removed or replaced a new Marine Licence will need to be applied for to allow the decommissioning works to take place.

2.3 Timescales and duration

Onshore installation of the two export cables is expected to commence in 2016. The Direct Pipe works are currently programmed to commence in January 2017 with site set-up, and be completed by June 2017. In the event that the first Direct Pipe fails, preparation for open trenching is anticipated to commence in March 2017.

There are two installation scenarios for the alternative methodology. Option 1 involves a phased approach, whereby the first export cable (EC1) would be installed in 2017, with the second cable (EC2) installed in 2018. Option 2 involves a simultaneous approach, whereby the landfall works for EC1 and EC2 are installed in 2017, the EC1 pull in and nearshore burial works is completed in late 2017, with the EC2 cable pull in and nearshore burial works taking place in early 2018. (Note: Each cable pull-in is tied to the cable manufacturing and OWF energisation programme) An indicative installation programme is provided in Figure 2.2, which indicates construction windows for each activity. Within these construction windows, works may be continuous or intermittent, depending on weather and tidal restrictions. Under Option 1, the total duration for the installation of the export cables is 9 months (EC1) and 7 months (EC2) across two years. Under Option 2, the landfall works would predominantly take place during 2017 over 9 months (EC1 and EC2), with the remaining EC2 works taking place over 4 months in 2018.

Option selection will be confirmed following appointment of the installation subcontractor.

OPTION 1 (phased approach)

	2017												2018											
Activity	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D
EC1 & EC2 sheet piling* & EC1 prep for trenching			■	■	■	■																		
EC1 trench excavation and PE pipe installation							■	■																
EC1 cable pull in and closure**, with site reinstatement								■	■															
EC1 nearshore cable burial works (to original Direct Pipe exit point)***								■	■	■	■													
EC2 prep for trenching													■	■										
EC2 trench excavation and PE pipe installation															■	■								
EC2 cable pull in and closure**, with site reinstatement																■	■							
EC2 nearshore cable burial works (to original Direct Pipe exit point)***																■	■	■	■					

OPTION 2 (simultaneous approach)

	2017												2018											
Activity	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D
EC1 & EC2 sheet piling* & prep for trenching			■	■	■	■																		
EC1 & EC2 trenching and laying PE pipe (& EC2 closure)							■	■																
EC1 cable pull in and closure**, with site reinstatement								■	■															
EC1 nearshore cable burial works (to original Direct Pipe exit point)***								■	■	■	■													
EC2 cable pull in and closure**, with site reinstatement																■	■							
EC2 nearshore cable burial works (to original Direct Pipe exit point)***																■	■	■	■					

*sheet piling both trench sides from shingle ridge to Direct Pipe entry point, ~20 days per cable, to depth of ~ 8 m
**closure: closing trench after duct installed
***via diver assisted burial dredge pump, small excavator

Figure 2.2: Indicative installation programme.

3 Existing Environment

3.1 Overview

A detailed description of the baseline environment for each environmental parameter is available from the Beatrice Project Environmental Statement (ES) and ES Addendum (BOWL, 2012; BOWL, 2013). The following sections provide an overview of the key receptors that may be potentially affected by the alternative cable landfall installation method. The receptors included in this section have been discussed and agreed with MS-LOT and MSS at the meeting on 14 October 2016. The information utilised to provide details of the key receptors has been drawn from the Beatrice Project ES and ES Addendum (BOWL, 2012; BOWL, 2013), the results of more recent post-consent/pre-construction surveys, and other publically available information, as set out in the Consenting Approach document (BOWL, 2016b).

3.2 Designated Sites

A summary of the designated sites that have been screened into the assessment as having the potential to interact with the licensable activities is provided in Table 3.1 and Figure 3.1.

The alternative cable landfall installation works are located within the Spey Bay SSSI, designated for geomorphology (Coastal Geomorphology of Scotland), fens (hydromorphological mire range), coastal habitats (shingle and saltmarsh), woodlands (wet woodland), flora (vascular plant assemblage) and butterflies (small blue *Cupido minimus*, and dingy skipper *Erynnis tages*).

The marine section of the works is also located within the Moray Firth proposed Special Protection Area (pSPA), designated for non-breeding populations of great northern diver (*Gavia immer*), red-throated diver (*G. stellata*), and Slavonian grebe (*Podiceps auritus*) and also designated by regularly supporting populations of migratory bird species.

Other designated sites in the vicinity of the works include the Moray Firth Special Area of Conservation (SAC) designated for bottlenose dolphin (*Tursiops truncatus*), the Dornoch Firth and Morrich More SAC designated for harbour seal (*Phoca vitulina*), the River Spey SAC designated for otter (*lutra lutra*), freshwater pearl mussel (*margaritifera margaritifera*), sea lamprey (*Petromyzon marinus*) and Atlantic salmon (*Salmo salar*) and the Lower River Spey – Spey Bay SAC designated for alder woodland on floodplains and coastal shingle vegetation outside the reach of waves.

Consideration of Likely Significant Effect (LSE) on those Natura 2000 sites with the potential to interact with the licensable activities is provided in Section 7.

Table 3.1: Summary of the designated sites and specific features that have been screened in as having the potential to interact with the licensable activities.

Designated site	Distance from Marine Licence Application Development Boundary	Qualifying features	Conservation objectives
Spey Bay SSSI	0 km (overlaps)	• Geomorphology: Coastal geomorphology of Scotland • Fens: Hydromorphological mire range • Coastlands: shingle and saltmarsh • Woodlands: west woodland • Vascular plants: vascular plant assemblage • Butterflies: small blue *Cupido minimus* and dingy skipper *Erynnis tages*	• To maintain the extent, diversity and quality of habitats within the site; • To ensure the continuation of natural coastal and river processes as far as practical unless there is a threat to life or avoidable damage to property; • To maintain the physical and visual integrity of the land-forms, including the ancient shingle berms; and • To promote public understanding and enjoyment of Spey Bay where appropriate and to manage visitor pressure sensitively.
Moray Firth pSPA	0 km (overlaps)	Regularly supporting non-breeding populations of the following Annex 1 species: • Great northern diver *Gavia immer* • Red-throated diver *Gavia stellata* • Slavonian grebe *Podiceps auritus* Regularly supporting populations of European importance of the following migratory species: • Great scaup *Aythua marila*	To avoid deterioration of the habitats of the qualifying species or significant disturbance to the qualifying species, subject to natural change, thus ensuring that the integrity of the site is maintained in the long-term and it continues to make an appropriate contribution to achieving the aims of the Birds Directive for each of the qualifying species. This will be achieved as follows: • Avoid significant mortality, injury and

Designated site	Distance from Marine Licence Application Development Boundary	Qualifying features	Conservation objectives
		• Common eider *Somateria mollissima* • Long-tailed duck *Clangula hyemalis* • Common scoter *Melanitta nigra* • Velvet scoter *Melanitta fusca* • Common goldeneye *Bucephala clangula* • Red-breasted merganser *Mergus serrator* • European shag *Phalacrocorax aristotelis*	disturbance of the qualifying features, so that the distribution of the species and ability to use the site are maintained in the long-term; • Maintain the habitats and food resources of the qualifying features in favourable condition.
River Spey SAC	2.5 km	• Otter *Lutra lutra* • Freshwater pearl mussel *Margaritifera margaritifera* • Sea lamprey *Petromyzon marinus* • Atlantic salmon *Salmo salar*	• To avoid deterioration of the habitats of the qualifying species or significant disturbance to the qualifying species, thus ensuring that the integrity of the site is maintained and the site makes an appropriate contribution to achieving favourable conservation status for each of the qualifying features; and • To ensure for the qualifying species that the following are maintained in the long term: ○ Population of the species, including range of genetic types for salmon, as a viable component of the site; ○ Distribution of the species within site; ○ Distribution and extent of habitats

Designated site	Distance from Marine Licence Application Development Boundary	Qualifying features	Conservation objectives
			supporting the species; ○ Structure, function and supporting processes of habitats supporting the species; ○ No significant disturbance of the species; ○ Distribution and viability of freshwater pearl mussel host species; and ○ Structure, function and supporting processes of habitats supporting freshwater pearl mussel host species.
Low River Spey – Spey Bay SAC	2.5 km	• Alder woodland on floodplains • Coastal shingle vegetation outside the reach of waves	• To avoid deterioration of the qualifying habitats thus ensuring that the integrity of the site is maintained and the site makes an appropriate contribution to achieving favourable conservation status for each of the qualifying features; and • To ensure for the qualifying habitats that the following are maintained in the long term: ○ Extent of the habitat on site; ○ Distribution of the habitat within site; ○ Structure and function of the habitat; ○ Processes supporting the habitat; ○ Distribution of typical species of the habitat; ○ Viability of typical species as components

Designated site	Distance from Marine Licence Application Development Boundary	Qualifying features	Conservation objectives
			of the habitat; and ○ No significant disturbance of typical species of the habitat.
Moray Firth SAC	15 km	• Bottlenose dolphin *Tursiops truncatus*	• To avoid deterioration of the habitats of the qualifying species or significant disturbance to the qualifying species, thus ensuring that the integrity of the site is maintained and the site makes an appropriate contribution to achieving favourable conservation status for each of the qualifying features; and • To ensure for the qualifying species that the following are established then maintained in the long term: ○ Population of the species as a viable component of the site; ○ Distribution of the species within site; ○ Distribution and extent of habitats supporting the species; ○ Structure, function and supporting processes of habitats supporting the species; and ○ No significant disturbance of the species.
Dornoch Firth and Morrich More SAC	51.2 km	• Harbour seal *Phoca vitulina*	• To avoid deterioration of the habitats of the qualifying species or significant disturbance

Designated site	Distance from Marine Licence Application Development Boundary	Qualifying features	Conservation objectives
			to the qualifying species, thus ensuring that the integrity of the site is maintained and the site makes an appropriate contribution to achieving favourable conservation status for each of the qualifying features; and • To ensure for the qualifying species that the following are established then maintained in the long term: o Population of the species as a viable component of the site; o Distribution of the species within site; o Distribution and extent of habitats supporting the species; o Structure, function and supporting processes of habitats supporting the species; and o No significant disturbance of the species.

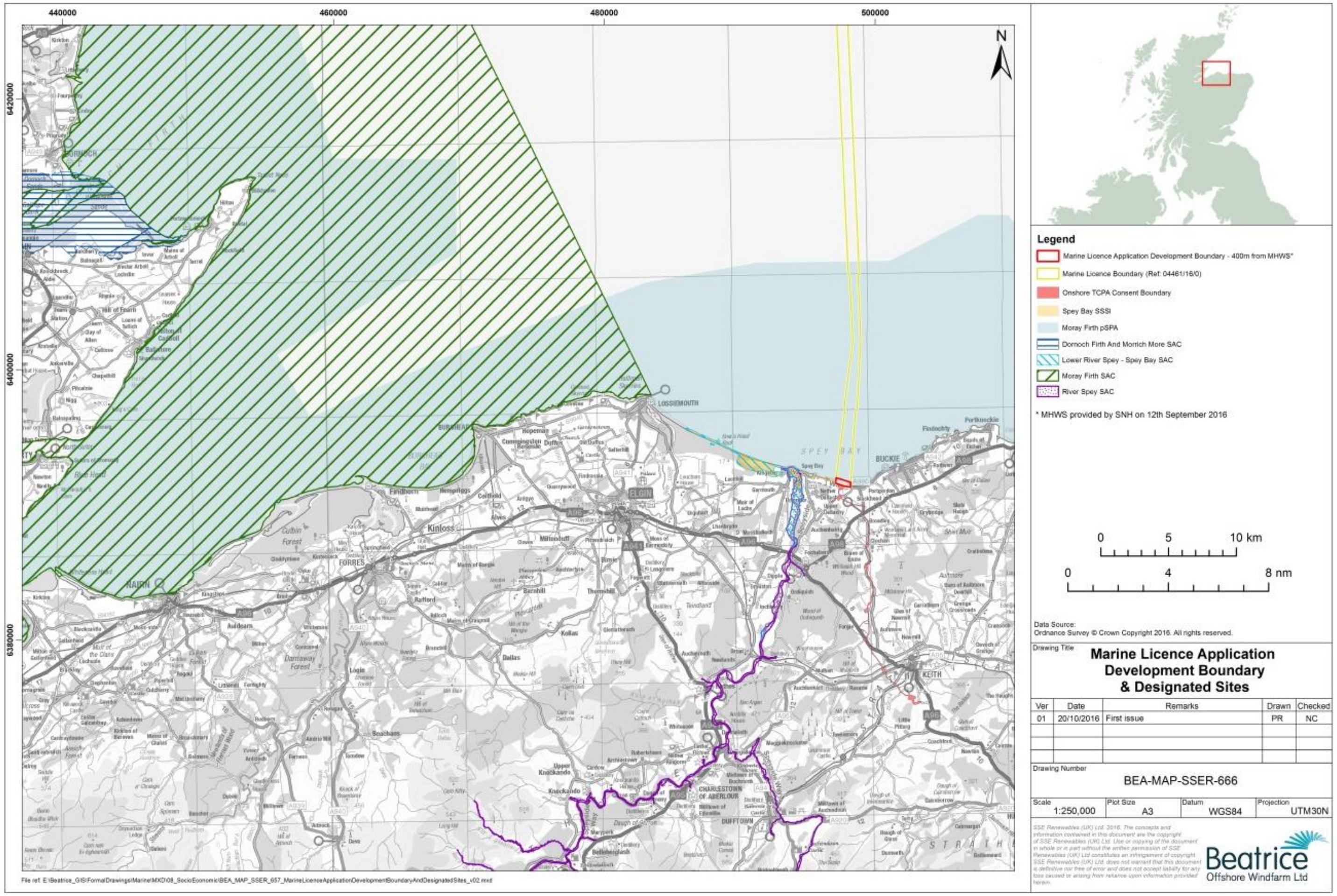


Figure 3.1: Marine Licence Application Development Boundary and Designated Sites.

3.3 Physical Processes

The study area considered for the potential geomorphological effects of the proposed alternative landfall installation method is from Portgordon Harbour in the east to Spey Mouth in the west. Extensive work has previously been undertaken to characterise the baseline physical processes and coastal geomorphology within the study area as part of the Beatrice Project ES and ES Addendum (BOWL, 2012; 2013), and this has been enhanced for the purpose of this application by an additional geomorphology study and site visit. This study is presented in **Appendix A** and presents a detailed technical account of the baseline physical processes in this location. The key elements of the previous studies were as follows:

- The shingle berm first emerges at Porttannachy and extends westwards from here to Spey Mouth, becoming progressively higher and wider with distance to the west.
- At Porttannachy, the beach is characterised by a relatively wide intertidal area named Tannachy Sands. This is composed of patchy sand overlying a conglomerate rock base. The active shingle berm is a low angled feature at this location, backed by a grassed bank which shows evidence of erosion and overtopping.
- At Tugnet, towards Spey Mouth, the sandy foreshore is entirely replaced by gravel and the coastline is characterised by a high shingle berm.
- The shingle berm has characteristic storm ridges on its seaward face and overwash fans landward of its crest along its length.
- Spey Bay is intersected by the outflow of the Burn of Tynet, located approximately 500m west of the eastern end of Tannachy Sands.
- The net longshore drift direction is westerly, with a modelled potential annual transport rate of approximately 3,000 m^3. Waves tend to dominate in driving sediment transport processes as currents are generally too weak to exert much influence.
- However, the magnitude and direction of transport can vary considerably depending on wave climate, indicating the dynamism of the coastal system.
- Historic shoreline evolution, based on mapping of mean high water and mean low water marks from historic Ordnance Survey maps shows that the coastline to the east of the Spey has experienced net recession over the past century.
- Based on analysis of historic maps and charts, an average annual erosion rate of 0.64m per year was calculated.
- The beach closure depth (the seaward limit beyond which the sea bed does not form part of the ‘active’ beach profile for sediment transport) was calculated to be at a water depth of 5.8m below lowest astronomical tide (LAT).

A site visit was undertaken on 24 August 2016. The findings of the previous baseline assessment were corroborated, other than the morphology of the Burn of Tynet had changed from a braided channel with an initial westerly alignment before straightening and discharging to flowing for a short distance in an easterly direction before straightening at its exit to the beach. This was due to a new ‘cut’ being artificially created by the landowner. It is considered that the landfall locations (starting around 350 m to the west of the burn) will not be affected, nor will installation at the landfall, affect this dynamism.

The site visit also suggested that storm waves, many of which approach normal (or near-normal) to the shore profile were important processes to consider. Most waves will generally move sediment along an onshore-offshore axis, rather than alongshore, explaining why the potential net longshore drift rates defined by previous modelling of the characteristic wave climate are relatively low at approximately 3,000m^3 per annum (in many other areas in the UK dominated by sediment transport, net annual littoral drift can easily be one or two orders of magnitude greater). This understanding also helps explain the processes of storm-driven 'washover' at the crest of the shingle berm which leads to washover fans on the backshore (Figure 3.2) and the series of storm ridges which have formed at distinct levels on the seaward face of the shingle berm itself (Figure 3.3).

Figure 3.2: Washover fans to the rear of the shingle berm barrier (Photo courtesy of Haskoning DHV)

Figure 3.3: Storm ridges on the seaward face of the shingle berm (Note the rack marks to help distinguish the different storm ridges in the photograph) (Photo courtesy of Haskoning DHV)

The morphology and sediments at a series of points along a transect in the general vicinity of the proposed landfall were observed and recorded during the site visit (**see Annex A in Appendix A**). This clearly shows the shingle berm being a high and steep but relatively narrow feature sitting on top of a mid-beach characterised by a mixed shingle and sand matrix, with a sandy lower foreshore and nearshore environment (Figure 3.4). This is in contrast to the shingle berm near Spey Mouth, where the feature is a much wider structure, with shingle occupying the entire intertidal zone (Figure 3.5). In addition, the gravel clasts on the crest of the barrier at the landfall location are slightly smaller in general than those on the crest at Spey Mouth, although in both cases the clasts are relatively large gravel sizes and are well-rounded, indicating a relatively long residence time and having been part of an active transport system in the littoral zone. It should be noted, however, that some of the gravels on the delta deposits and barrier at Spey Mouth may have been transported down river by fluvial flows in addition to the marine-derived sediments which undoubtedly are present in significant volumes.

Figure 3.4: Narrow shingle berm at the landfall location (Photo courtesy of Haskoning DHV)

Figure 3.5: Wide shingle berm near Spey Mouth (Photo courtesy of Haskoning DHV)

With progression westwards along the study area from Porttannachy to Spey Mouth, it becomes apparent that the landfall location represents the approximate start of the shingle berm because the height, width and hence volume of pebbles and cobbles increases markedly towards Tugent and Spey Mouth.

The Scottish Government (SG) is currently undertaking a *National Coastal Change Assessment* for Scotland (Rennie *et al.* 2016). SNH has provided BOWL with interim outputs from this study which were intended to inform BOWL about past and projected future coastal change at the landfall site. The key findings arising from Rennie *et al*. (2016) are as follows:

- The long term erosion rate for the landfall site is around 0.6 m/year (1903 – 2014), measured as the change in MHWS[3].
- If these most recent data are combined with data from 1990 to 2003, the average rates over the past quarter-century (actually 26 years) are 1.35 m/year at EC1 and 1.05 m/year at EC2.

A nearshore ground investigation undertaken along the proposed OfTW route (BOWL, 2015a) involved the drilling of seven boreholes in water depths of between 2.59 m to 9.20 m to a depth of between 18.0 m and 35.5 m below sea bed level. The location of the boreholes is shown in Figure 3.6 (reproduced from BOWL, 2015a). The ground investigation identified conditions which comprise discontinuous deposits of Holocene sand, gravels and silts, over Quaternary Glacial Tills and Outwash Deposits which rest on Devonian Old Red Sandstone (BOWL, 2015b). The particle size analysis of soil samples from the borehole logs, at the sea bed and at depth, resulted in soil descriptions mostly of ‘sands’ and ‘gravels’ with varying quantities of silts or cobbles, but there were also some gravelly and/or sandy ‘silts’ and some gravelly ‘cobbles’.

[3] MHWS is located part-way along the seaward face of the shingle berm. The distance from MHWS to the ‘back of berm’ is variable but approximately 25 m.

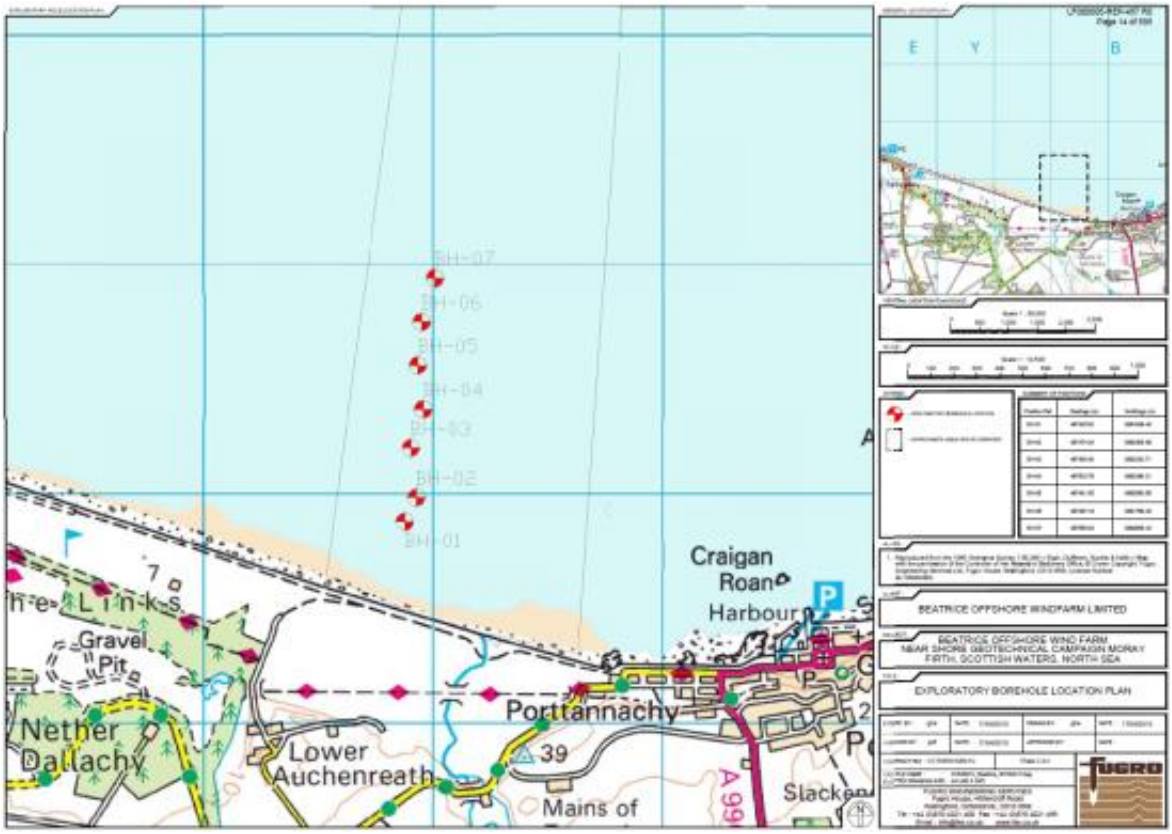


Figure 3.6: A reproduction of Fugro's Exploratory Borehole Location Map (source: BOWL, 2015a)

3.4 Benthic Ecology (including Annex I habitats)

The Beatrice Project ES (BOWL, 2012) described the benthic habitats around Spey Bay as fine-medium sands and gravels with small patches of hard substratum, such as cobbles, pebbles overlying sand further inshore. Hard substratum, classed as cobble reef, is colonised by encrusting epifauna and epiflora including tubeworms, barnacles, bryozoans, hydroids and algae (BOWL, 2012). This community is ascribed to the biotope SS.SCS.CCS.Pomb *Pomatoceros triqueter* with barnacles, coralline algae and bryozoan crusts on unstable circalittoral cobbles and pebbles (but with slightly richer biological community than usually associated with this biotope). The OfTW pre-construction Annex 1 Habitat Survey undertaken in 2015 by APEM (APEM, 2015) shows that the majority of the habitats within the OfTW corridor correspond to Low to Medium resemblance to Annex 1 cobble reef (based on Irving, 2009).

Inshore sublittoral habitats were composed of very clean fine sand with no visible epifauna (BOWL, 2012). This suggests an unstable sediment community, which may be colonised by fast growing ephemeral species such as the tube worm *Spirobranchus triqueter* and bryozoans and coralline algal crusts. Moving higher up the shore, the intertidal area of the cable landfall is characterised by sand and gravel with low cobble content and local silty patches (BOWL, 2016a). Typically, intertidal shores of gravel and cobbles are species poor and are likely to be dominated by amphipods, which inhabit the interstitial spaces between the sediment particles. The upper shore beyond the intertidal zone is backed by a steep, but relatively narrow, active shingle berm which is characterised by pioneer shingle communities of grassland, scrub or sand dune vegetation. Active shingle berms are a feature of the Spey Bay SSSI, and the ridges in Spey Bay are considered to be the finest example in Scotland (SNH, 2012). Species-rich dry heath and grassland occurs on the ridges, while in wetter hollows there is species-rich wet heath and transition to a vegetation type that is comparable to that of dune slacks. The Lower River Spey – Spey Bay SAC, which lies 2.5 km to the west of the cable landfall, is designated for the Annex I habitat: Coastal shingle vegetation outside the reach of waves (scientific name: Perennial vegetation of stony banks) (SNH, 2015).

Priority Marine Features (PMFs) identified within the OfTW, and which could occur in Spey Bay, include sublittoral sands and gravels and potential Annex 1 cobble reef (as described above).

3.5 Fish and Shellfish

Species of conservation concern, which may occur in the vicinity of Spey Bay include Atlantic salmon, sea lamprey and freshwater pearl mussel, all of which are primary citation features of the River Spey SAC, 2.5 km to the west of the cable landfall site (see Table 3.1). Other species of conservation concern identified in the Beatrice Project ES include the diadromous migratory fish species European eel (*Anguilla anguilla*), allis shad (*Alosa alosa*), twaite shad (*A. fallax*), river lamprey (*Lampetra fluviatilis*), smelt (*Osmerus eperlanus*), and sea trout (*Salmo trutta*) (BOWL, 2012). Elasmobranch species have slow growth rates and low reproductive output and are therefore of conservation concern when present.

Commercially important fish and shellfish species occur throughout the Moray Firth and for some the Moray Firth is a key spawning or nursery area. For example, Spey Bay is included in the area mapped as a spawning/nursery habitat for cod, lemon sole, herring (nursery only), *nephrops*, plaice, sandeel, sprat and whiting (Coull *et al.*, 1998; Ellis *et al.*, 2010). Surveys undertaken by BOWL in February and March 2014 confirmed the presence of cod spawning activity within the OWF site (BOWL, 2015c). However, data from these surveys and Coull *et al.* (1998) and Ellis *et al.* (2010) suggest spawning activity does not take place in the vicinity of the cable landfall. Results from herring larval surveys undertaken by BOWL (BOWL, 2014a, 2016d, 2016e) demonstrate that the majority of herring spawning activity occurs around Orkney and Shetland and not within Moray Firth or the vicinity of the cable landfall. Relatively low sandeel catches recorded in the sandeel survey conducted in 2014 suggest that there are not extensive areas supporting important sandeel populations (BOWL, 2014b).

Key shellfish species in the area include Norway lobster (*Nephrops norvegicus*), king scallop (*Pecten maximus*), squid (*Loligo forbesi*) edible crab (*Cancer pagurus*), velvet crab (*Necora puber*), mussel (*Mytilus edulis*), whelk, (*Buccinum undatum*), and lobster (*Homarus gammarus*).

3.6 Marine Mammals

Baseline data gathered for the Beatrice OfTW shows that the marine mammal species most likely to occur in the vicinity of Spey Bay are bottlenose dolphin (*Tursiops truncates)*, harbour porpoise (*Phocoena phocoena*), minke whale (*Balaenoptera acutorostrata*), harbour seal (*Phoca vitulina*) and grey seal (*Halichoerus grypus*) (BOWL, 2012).

The resident Moray Firth bottlenose dolphin population generally occur in coastal areas with most sightings within the Moray Firth SAC and along the south coast of the Moray Firth. In Spey Bay, near the OfTW landfall site, seasonal peaks in sightings occur during summer and early winter. Analyses of the site-specific data collected for the BOWL OWF and OfTW found that there was a 56% probability that bottlenose dolphin will be in the Spey Bay area (Thompson and Brookes, 2011). Harbour porpoise is widespread throughout the Moray Firth and this species accounted for 60% of all cetacean sightings along the south coast, although encounter rate decreased moving closer to the shore (Robinson *et al*., 2007). Habitat association modelling showed that the number of harbour porpoise within a 4x4 km grid cell in the vicinity of Spey Bay was just 1 or less (Thompson and Brookes, 2011). Minke whales commonly occur along the southern coastline of the Moray Firth during the summer months, coinciding with the emergence of sandeels (*Ammodytes* spp.) into the water column (Robinson *et al*., 2009). As with harbour porpoise, the encounter rate of animals is higher in deeper waters compared with inshore shallower waters (Robinson *et al*., 2007). Density estimates for minke whale in SCANS Block J, which includes the Moray Firth, is 0.022 animals km^{-2} (Hammond *et al*., 2013).

Both harbour seal and grey seal are widely distributed and abundant within the Moray Firth. The highest densities of both species are towards the inner Moray and Dornoch Firth and in the northern half of the outer Moray Firth (Thompson and Brookes, 2011). Telemetry studies of harbour seal found that the area around Spey Bay may be used for foraging by some of the animals tagged in the Dornoch Firth and Loch Fleet. Grey seal usage maps for the Moray Firth suggest that grey seal do not favour the area around Spey Bay (<1 animal per 4x4 km grid cell) and usage is higher in the inner Moray Firth and in the northern half of the outer Moray Firth. Findhorn, located approximately 40 km to the west of the cable landfall, towards the inner Moray, is the main haul-out along the southern Moray coastline for both grey and harbour seals.

3.7 Birds

Spey Bay forms part of the Moray Firth pSPA, which has been selected for classification on the basis of wintering aggregations of divers, grebes and seaducks as well as populations of shag present during both the breeding and nonbreeding seasons (see Table 3.1). The survey data which underpin the pSPA classification (SNH, 2016) represent the most comprehensive site specific data available for these species. Therefore, the species descriptions provided in SNH (2016) are summarised here to describe the baseline, with a focus on the area of Spey Bay where the alternative landfall cable installation works would be undertaken.

The boundary of the Moray Firth pSPA has been drawn to encompass the overlapping species-specific distributions of each species included in the proposed designation. However, each species has its own, smaller, distribution within the overall site boundary. Thus, only those species which have distributions which include the eastern half of Spey Bay (i.e. the location of the alternative landfall cable installation works) are discussed here. This is considered appropriate due to the short-term and localised nature of the works for the alternative landfall cable, which means that disturbance will be confined to a small area in the immediate vicinity. Further discussion in support of this is provided in the Assessment of Effects (Section 5.6).These species are great northern diver (*Gavia immer*), red-throated diver (*Gavia stellata*), Slavonian grebe (*Podiceps auritus*), common eider (*Somateria mollissima*), long-tailed duck (*Clangula hyemalis*), common scoter (*Melanitta nigra*), velvet scoter (*Melanitta fusca*), common goldeneye (*Bucephala clangula*) and red-breasted merganser (*Mergus serrator*). All of these species have been identified for inclusion in the pSPA on the basis of their presence during the nonbreeding season.

The combined diver density (note: surveys were not able to distinguish between great northern diver and red-throated diver) for the landfall area was 0.2-0.4 birds/km^2. This density was the lowest level included in the species-specific distributions (SNH, 2016). The main concentrations of divers within the Moray Firth are found in the western half of Spey Bay and also between Golspie and Dornoch.

Slavonian grebes were not recorded as far east as the landfall location. However, individuals of this species were found in low numbers along the rest of the coastline in the pSPA so it is probable that this species would also be present near the landfall works, albeit only in small numbers (e.g. 1 or 2 individuals).

Common eiders were distributed along most of the Moray Coast. In the vicinity of the alternative landfall cable installation works the density was estimated at 1-4 birds/km^2, the lowest density used to define the species-specific distribution (SNH, 2016). The main concentration was found further to the west, from Lossiemouth to Burghead. Long-tailed ducks had a similar distribution to common eider, with most observations made along the Moray coast. The landfall is located outside the main species-specific distribution in a region where the estimated density was up to 2 birds/km^2. The main concentration was found further west off Burghead.

Common scoter and velvet scoter had less widespread distributions than the other seaducks, with concentrations along the Moray coast between Lossiemouth and Nairn, but also including Spey Bay. These species were surveyed from shore and abundance was reported in large sectors of coastline. Thus, it is not possible from the pSPA documentation to estimate the density or abundance at a spatial resolution any finer than Spey Bay (as a whole). The Spey Bay abundance of common scoter was given as 300-900, while that for velvet scoter was given as 21 or greater.

Common goldeneye was one of the least abundant species. The main concentrations were in the Inverness Firth, with the estimate for the whole of Spey Bay 10 birds or less. Red-breasted merganser was also found in low numbers, with the only large aggregation recorded in the Beauly Firth. The Spey Bay abundance estimate was 7-14 birds.

3.8 Commercial Fisheries

The landfall location is located within ICES Rectangle 44E6 and closely borders ICES Rectangle 44E7. These two rectangles cover key fishing areas for nephrops and scallops and closer inshore for squid, crabs and lobsters. The majority of vessels operating within 44E7 are over 15 m in length. However, significant landings are made by vessels under 10 m in length that operate closer to shore (within 6 nautical miles (NM)) and target crab, lobsters, mackerel and squid, depending on the season (BOWL, 2012). Vessels under 10 m in length are most likely to operate in close proximity to the shore and the alternative cable landfall installation works (BOWL, 2012, Marine Scotland, 2016). The proposed installation activity in the subtidal area will take place within a distance of approximately 250 m from the shoreline, where smaller inshore vessels predominate. Based on the data available from BOWL (2012) and Marine Scotland (2016) the principal grounds close to shore are fished by small inshore vessels using creels to target crabs and lobsters but may also be occasionally visited by trawl vessels targeting squid. However, within Spey Bay and close to the alternative cable landfall installation area in Figure 2.1, it is most likely that creel vessels will operate as the shallow water depths and ground conditions are not suitable for trawl vessels. Creel vessels may also handline for mackerel (if they have quota to do so) during the summer months, although this activity seems to be towards the eastern portion of the southern coast of the Moray Firth (Marine Scotland, 2016).

Gear types utilised depend on the target species. Most vessels operating close to shore vessels use static gear such as pots/creels to target crabs and lobsters but may also use handlines to target mackerel. Bottom otter trawlers often using protective gear, such as rockhoppers to target squid on rough ground. Pots may also be used to target whelks, although this is generally centred around areas further offshore.

Peak activity for lobster and crab is between June and September. The peak in lobster and crab fishing activity is determined by the size of vessels and weather conditions are a significant factor in determining levels of activity in the winter months. In addition to full time vessels, there are also a number of part time vessels that will set a small number of creels in inshore areas during the summer months, increasing the activity levels in the summer. Peak landings for squid occur in August and September, although fishermen have reported the fishing season to be lengthening, with vessels beginning to target the species in June and continuing into February.

According to Marine Scotland (2016) there are around 12 vessels targeting crab and lobsters operating in the inshore area close to the alternative landfall location, although the monetary value of landings compared to the rest of the east coast is relatively low. There are also around 8 vessels using trawl gear close to shore in the area, with around 6 or 7 vessels targeting nephrops with trawls (Marine Scotland, 2016). However, in general these vessels are unlikely to be operating very close to shore in shallow water (Marine Scotland, 2016). Overall the monetary value of fisheries in the landfall area is low when compared to the remainder of the Moray Firth and the east coast of Scotland (Marine Scotland, 2016).

3.9 Shipping and Navigation

Navigational features in the vicinity of the landfall include the Binn Hill rifle range Practice and Exercise Area (PEXA X5702), located approximately 3 NM west of the OfTW cable route corridor, and a number of anchorage areas. In the Spey Bay anchorage area, which intersects the OfTW corridor, mariners are advised to remain in depths of not less than 10 m.

Maritime traffic surveys carried out in 2010 and 2011 (BOWL, 2012) indicated that the number of vessels within 10 NM of the OfTW averaged approximately nine vessels per day. The majority of vessel tracks were associated with vessels heading east/west into Inverness and Cromarty Firth. In general, merchant shipping on this route keeps at least 1.3 NM to 2.5 NM north of the Moray and Aberdeenshire coastlines, mainly due to sea depth restrictions. The Marine Scotland National Marine Plan Interactive Tool (Marine Scotland, 2016) indicates that shipping density is zero within the alternative cable landfall installation method application area (AIS Shipping Traffic Average Weekly Density 2012-2014).

During the surveys an average of one vessel every two days was recorded anchoring in the Spey Bay area. Offshore drilling rigs often moor in the general area whilst ‘waiting for orders’ and/or prior to being moored in the Cromarty Firth for maintenance.

The surveys tracked 48 fishing vessels intersecting the entire OfTW cable corridor (an average of approximately one fishing vessel per day). The majority of fishing tracks were recorded headed in and out of the fishing port of Buckie and with fishing vessels intersecting the OfTW cable corridor approximately 10 NM north of the OfTW landfall.

3.10 Marine Archaeology

There are no designated archaeological or cultural heritage assets within the OfTW corridor, or within a 1 km buffer, including the landfall. The marine geophysical survey carried out in 2011 identified eight unidentified targets within the OfTW which were considered to be of medium archaeological potential, and two wrecks charted by the UKHO within a 1 km buffer of the OfTW (BOWL, 2016f). Six archaeological assets and targets have been ascribed Archaeological Exclusion Zones (AEZs) with a 100 m radius which are located within a 1 km buffer of the OfTW corridor (i.e. outside of the OfTW corridor) as they have been assessed to be of high archaeological potential, including five wrecks charted by the UKHO and a single geophysical anomaly (BOWL, 2016f). Of these only HA1008, a wreck with high archaeological potential, is in the vicinity of the landfall activity approximately 615m from the nearest cable route (EC2).

In July 2015, BOWL commissioned a ground truthing survey of AEZs because these targets could potentially impact on the design and construction of the OWF. Following this survey it was recommended that a number of AEZs be removed (BOWL, 2015e), including four close to the landfall (HA17, HA20, HA28 and HA33) which were investigated using a Remotely Operated Vehicle (ROV) and were found to be of no archaeological interest.

3.11 Infrastructure and Other Users

Infrastructure and other users in the vicinity of the application area include other cable installation projects and recreational activity. The Caithness to Moray transmission cable makes landfall in the vicinity of the BOWL landfall, running along the eastern edge of the BOWL OfTW corridor. This cable will be installed by HDD at the landfall (Scottish Hydro Electric Transmission Plc, 2015).

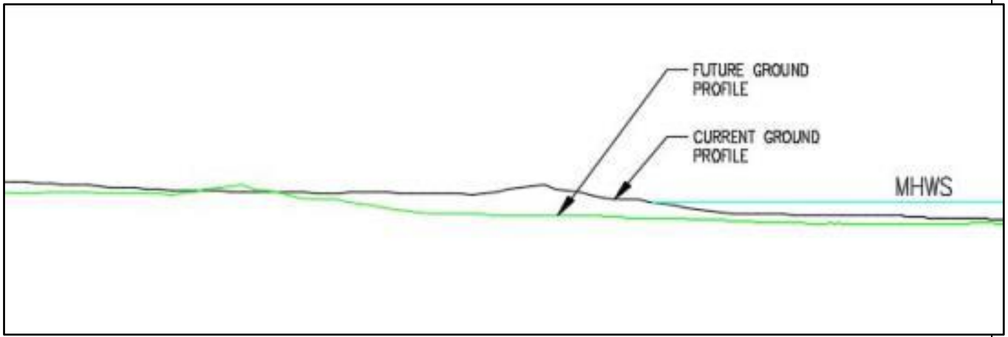
In terms of recreational activity, the nearest marina is located at Portgordon approximately 0.54 NM from the OfTW corridor, and the nearest clubs are located at Lossiemouth and Findochty (BOWL, 2012). Medium use recreational cruising routes intersect the OfTW corridor further to the north of the landfall application area. Spey Bay is also a general sailing area and extends 3.7 NM from the OfTW landfall. During the maritime traffic survey (BOWL, 2012) a small number of recreational vessels were recorded sailing off the Moray coastline to Lossiemouth.

4 Designed-in mitigation measures

There are a number of mitigation measures which have been designed into the alternative landfall cable installation methodology to reduce the impact on the environment. In addition, BOWL will implement a number of industry standard measures during the installation activities and the wider Beatrice Project as a whole, which reduce the potential for certain impacts. These measures are listed in Table 4.1 below and are referred to in the individual assessments where relevant.

Table 4.1: Mitigation Measures.

Measure	Description
Designed-in mitigation measures	
Minimising working and stockpile areas and locating stockpile areas outside SSSI boundary	Use of steel sheet piles to support trench walls throughout the shingle berm where the depth of cable burial needs to be up to 8 m allows for a rectangular and not trapezoidal trench. Not only does this reduce the area of disturbance but it also significantly reduces the volume of material that will need to be excavated, temporarily stored and then replaced. The length of the sheet piles will extend across the hinterland and shingle berm, but terminate at the toe of the shingle berm. The sheet piles would stand proud of the land surface across the hinterland and shingle berm.
	Working and stockpiling areas would be kept to a minimum size during the construction phase. A preliminary estimate is that a stockpiling area for each of the two cables would need to be approximately 30 m by 30 m in area, with these temporary stockpile areas being located well inland of the SSSI boundary. The working area for transport/access would be 30 m wide (including the trench width), running parallel to the trench.
Selection of appropriate trenching methodology	The use of steel sheet piles to support trench walls will minimise the overall width of each trench. The use of supported walls helps to minimise the extent of excavation that is needed in the loose and unconsolidated sediments, where the depth of cable burial needs to be considerably greater (up to 8 m) than for the intertidal or shallow nearshore zones. Not only would this reduce the plan area of disturbance but it would also significantly reduce the volume of material that will need to be excavated, temporarily stored and then replaced. As the depth of burial in the inter-tidal and shallow nearshore areas is not so great, there are no such advantages in the use of steel sheet piles to support trench walls and hence they will be unsupported.
Cable burial depth and landward setback to allow for rollback of the shingle berm	The maximum target cable burial depth that BOWL will require their contractor to achieve has been designed to accommodate anticipated erosion over the 25 year lifetime of the development to account for long term lowering of the seabed and landward regression of the shingle berm (see Section 4.5 in **Appendix A**). The cable burial depths below MHWS (3 m across the intertidal, 2 m across the nearshore subtidal) are considerably lower than the maximum theoretical depth of sediment disturbance at these locations (0.63 m at EC1 and 0.62 m at EC2) (see

Measure	Description
	Appendix A). A suitable factor of safety therefore exists between the theoretical maximum depth of seabed disturbance and the depth of cable burial. This should ensure that the cable remains buried throughout the 25 year operational life of the development in respect of storm wave action. The cable is also designed to be buried at a sufficient depth (8 m) below the hinterland and shingle berm to ensure that the longer term landward transgression of the shingle berm does not result in re-exposure of the cable during the lifetime of the project (25 years) (Figure 4.1) (for further details see Section 4.5 of **Appendix A).**  **Figure 4.1: Landward translation of the shingle berm by a setback distance of 50 m.**
Selection of appropriate construction plant	Use of a Menzi Muck in preference to an excavator in the areas closest to MLWS, which is more manoeuvrable and has the ability to work in 1 m to 2 m water depth. Selection of appropriate plant would reduce the potential for over-excavation and reduce delays during construction.
Excavation and reinstatement on a 'layer by layer' basis	Excavation of material along each trench would be undertaken in separate sediment layers and material of different grades would be stored separately within the temporary stockpile area for the respective cables.
	Reinstatement in the shingle berm and intertidal zone will be undertaken on a 'layer by layer' basis in reverse order to the excavation sequence. This reduces potential for adverse effects on the sediment structure of the shingle berm within the affected area. Reinstated sediments on the shingle berm portion of the cable route will not be compacted in order to retain the structure of the sediments within the shingle berm including their naturally sorted structure and high porosity.
Communications and awareness	
Advisory Safety Distances	During cable installation works, working areas in the intertidal zone will be marked off to prevent public access, and advisory safety zones (of up to 500 m radius) will be recommended around the cable installation works in the subtidal zone. Advisory safety zones will be notified via issue of a Notice to Mariners.

Measure	Description
Notices to Mariners	BOWL will issue Notices to Mariners in advance of installation activities to alert vessels and other interests of the timing and location of the works.
Fisheries Liaison	The BOWL Fisheries Liaison Officer (FLO) will maintain dialogue with fishermen prior to all BOWL construction activities to ensure that fishermen are informed of the activity and are aware of any restricted areas. The fishing community can raise issues regarding the activity with the FLO. Information regarding the works will be provided to the fishing industry through appropriate bulletins, publications and Notices to Mariners.
Consultation with asset owners	BOWL will maintain consultation with the developer of the Caithness to Moray cable to ensure coexistence of the projects.
Environment	
Pollution Prevention	Marine pollution prevention and contingency planning measures are set out in the approved BOWL Environmental Management Plan (BOWL, 2015d) and Marine Pollution Contingency Plan (MPCP) approved by MS-LOT (ref LF000005-PLN-165 BOWL Marine Pollution Contingency Plan). The overarching onshore Construction Environmental Management Plan (CEMP) (BOWL, 2016g) will contain proposed measures for the mitigation of construction noise and vibration, and dust.
Waste Management	All wastes will be managed in line with the BOWL EMP (BOWL, 2015d) and CEMP (BOWL, 2016g), which include waste management measures to minimise, recycle, reuse and dispose of waste streams in compliance with relevant waste legislation.
Archaeological mitigation	The installation contractors will be briefed on the exact locations of AEZ and a chart of these locations will be provided to ensure limited interference with AEZs. Installation activities will avoid AEZs unless absolutely necessary or otherwise agreed with MS-LOT in consultation with Historic Environment Scotland. BOWL's Archaeological Written Scheme of Investigation and Protocol for Archaeological Discoveries (WSI and PAD) (BOWL, 2016f) will be followed during the installation activities.

5 Assessment of Effects

5.1 Approach

The following sections provide an assessment of the potential environmental impacts of the alternative landfall cable installation activities in relation to the following environmental topics:

- Physical Processes;
- Benthic Ecology;
- Fish and Shellfish;
- Marine Mammals;
- Birds;
- Commercial Fisheries;
- Shipping and Navigation;
- Marine Archaeology; and
- Infrastructure and Other Users.

Aviation, Military and Communications have been screened out of assessment, as agreed with MS-LOT and their advisors during the meeting held on the 14 October 2016 (see Section 1.2).

Each assessment concludes whether the alternative landfall cable installation activities are likely to result in a negligible, minor, moderate or major effect on the receptor.

5.2 Physical Processes

Trenching activities may directly damage or disturb geomorphological features of the Spey Bay SSSI

The total plan area affected by trenching from the Direct Pipe entry points to MLWS will be 1,364 m^2, of which 586 m^2 is within the SSSI. This represents 0.013% of the designated site and therefore the extent of the impact is very small. Even when considered over the 'sub-unit' within the SSSI between Spey Mouth and Portgordon (covering 44 ha), then the total area directly affected by trenching represents only 0.13%. There is then a further very small area of shallow nearshore seabed affected (2,236 m^2), but this will rapidly infill naturally with sediment under the normal tidal and wave regime. This area is seaward of MLWS and is therefore outside of the SSSI.

Disturbance will be relatively short term (up to 7 months in 2017 and an additional 5 months in 2018 as a worst case), occurring over one installation event per cable, and will be temporary, since there are viable proposals to reinstate the morphology of the shingle berm and intertidal zone affected by the trench following installation of the cables.

For these reasons, and due to the designed-in mitigation measures set out in Section 4, it is considered that any effects on the geological features for which the Spey Bay SSSI is designated will be **negligible**.

Construction working areas may directly damage or disturb geomorphological features of the Spey Bay SSSI

The total potential construction working area across the shingle berm could extend to

2,010 m^2 as a worst case and a further 2,370 m^2 across the intertidal zone. However, construction will not take place across the full corridor for the full construction period, with many areas either un-impacted, or left undisturbed and able to recover for a period of time after exposure to initial impacts.

Disturbance across the working area will be relatively short term (up to 7 months in 2017 and an additional 5 months in 2018 as a worst case), occurring over one installation event per cable, and temporary. Following cessation of works it is expected that the behaviour characteristics of the directly affected areas will be reinstated naturally within a few tidal cycles (for the intertidal area) or after a few storm events (for the shingle berm).

For these reasons, and due to the designed-in mitigation measures set out in Section 4, it is considered that effects from this impact on the geological features for which the Spey Bay SSSI is designated will be **negligible**.

The presence of temporary storage areas may directly damage or disturb geomorphological features of the Spey Bay SSSI

The temporary storage areas will occupy an indicative total plan area of 1,800 m^2 but these sites will be located landward of the SSSI boundary. Disturbance will be relatively short term (up to 7 months in 2017 and an additional 5 months in 2018 as a worst case), occurring over one installation event per cable, and will not affect the Spey Bay SSSI, as the storage areas will lie landward of the SSSI boundary.

For these reasons, and due to the designed-in mitigation measures set out in Section 4, it is considered that effects from this impact on the geological features for which the Spey Bay SSSI will be **negligible**.

Cable installation activities may affect sediment transport processes

The temporary presence of the trench and (where present across the shingle berm only) the temporary presence of the steel sheet piling both create the potential for some interruption of longshore sediment transport. The sheet piling across the hinterland will not affect these processes but the sheet piling through the shingle berm, seaward to its toe; will be proud of the land surface.

The works are at the eastern end of this sediment transport pathway and net transport rates are relatively low. The modelled potential annual longshore sediment transport rate at Spey Bay is approximately 3,000m3 (ABPmer, 2012). In comparison to typical 'sediment-dominated' systems with governing longshore sediment transport patterns, this rate is at least one order of magnitude or more typically two orders of magnitude lower.. With the trench/sheet piles being present for up to 7 months in 2017 and an additional 5 months in 2018 as a worst case, additional mitigation measures are recommended, including monitoring of sediment levels and accumulation on either side of the trench/sheet piles, and the use of sediment bypassing in the form of an excavator removing and relocating accumulated sediment to enable the continuous feed of the sediment transport system. With such a vast volume of sediment available elsewhere within Spey Bay, any effects of the trenching on sediment transport processes are likely to be minor (given that the total plan area affected by trenching is only 0.013% of the designated site.

Due to the duration of the trenching and/or sheet piling works, there is the potential that one or more major landforming storms could occur while the trench or the sheet piles are in place. However, most storm waves approach relatively perpendicularly to the shore and over the shingle berm (where sheet piles will be present) these waves govern more the offshore to onshore transport of sediment, moving it up and over the crest of the ridge to create washover fans. This process will only be inhibited directly in the footprint of the trench and piles. It is theoretically possible, however, that a storm, or storms, could occur with a wave approach angle that is oblique to the shore. In this case there is potential for either the open trench or the sheet piles to interrupt modest rates of sediment transport. Under such events, sections of trench will likely become partially or totally infilled in unsupported (open) sections (i.e. those areas that are open across the intertidal and shallow seabed during this process) and may interrupt longshore sediment transport where the sheet piling is present through physical 'blockage'. Due to this, the proposed additional mitigation measures recommended above, involving monitoring of sediment accumulation on either side of the trench/sheet piles, and the use of sediment bypassing operations, will ensure the continuous feed of the sediment transport system. As a result of this mitigation measure, any effects of the trenching and presence of sheet piles during major landforming storms on sediment transport processes are likely to be minor and these effects will be mitigated a short time after the storm has passed.

When the trench is infilled and, where present, when the sheet piles are removed, the morphology of the shingle berm and intertidal zone will be reinstated and there is not expected to be any further effects.

Taking into account the additional mitigation measures noted above and due to the short-term, temporary nature of the potential impact and the small area affected, it is considered that effects upon longshore sediment transport processes within Spey Bay as a result of the temporary presence of the trench will be **minor**.

Cable installation activities in the intertidal and subtidal zones may increase suspended sediment concentration (SSC) within the water column and deposit material on seabed

Increases in SSC will be limited in spatial extent to the length of the trench and, for deposition, a short distance either side. The impact will be limited in temporal extent to a short duration of trenching and backfilling activity. In addition, digging a trench through the sandstone bedrock will cause temporary disruption but likely at a lesser scale than through sand, which is more likely to be disturbed into suspension in the water column (before settling). Broken out Sandstone will likely be large fragments that will reside on the sea bed and be used to backfill the trench following cable installation.

Furthermore, the location of the trenching in the intertidal and subtidal zones is an area of breaking wave activity where sediment transport is most likely to occur (although this natural process is limited in magnitude) and hence there would be relatively high SSC levels in these zones under baseline conditions.

The temporary and localised increase in SSC and associated deposition is not likely to be beyond the range of conditions naturally experienced due to varying wave climate under the baseline conditions. Therefore, due to the short-term, temporary nature of the potential impact and the small area affected, the effect of cable installation activities on increased SSC within the water column and associated deposition is considered to be **negligible**.

5.3 Benthic Ecology (including Annex I habitats)

Cable installation activities may result in temporary intertidal habitat loss/disturbance

The excavation of two trenches (of approximately 40 m length x 4 m width) across the intertidal zone, together with the working/access area running parallel to each trench, will create a direct footprint of disturbance for intertidal benthic communities. Temporary habitat loss would lead to a removal of the key characterising species and its habitat.

Recolonisation is likely to occur via recruitment from adjacent populations, and therefore recovery potential is considered to be high (Tilling and Budd, 2016). Impacts on the structure of the shingle berm and the associated communities are considered as part of the geomorphological assessment (see Section 5.2) and the terrestrial ecology assessment (BOWL, 2016g) respectively. The terrestrial ecology assessment concluded that potential impacts on the shingle berm would be minor due to the small proportion of the habitat affected, the short duration of construction activity and due to all habitat being reinstated following installation of the cable (BOWL, 2016g).

Due to the small scale of the impact and the recoverability of the benthic communities, the effect of temporary habitat loss/disturbance is considered to be **negligible**.

Cable installation activities may result in temporary subtidal habitat loss/disturbance

The excavation of two trenches within the nearshore area and out to approximately 250 m offshore using a Menzi Muck and/or barge mounted excavator, will result in direct disturbance to subtidal benthic communities. The benthic communities in this area are likely to be tolerant of disturbance and will have a high recovery potential due to the nature of the dynamic environment within which they exist. Habitat loss will lead to a decline in species abundance within the impacted area, however, re-colonisation from neighbouring areas is likely to occur within a short time frame following cessation of the activities. For example, tube worms and encrusting bryozoans are noted to re-colonise an area within 4 months. Whilst reproduction may peak in spring or early summer, for some species, such as the tube worm *Spirobranchus triqueter* reproduction can occur throughout the year (Tilling and Tyler-Walters, 2016). Low/Medium resemblance Annex 1 cobble reef is considered to be of medium sensitivity to cable installation activities and given the highly localised extent of loss/disturbance, and the distribution of similar habitat across the area, there is considered to be high recoverability.

Due to the small scale of the impact and the recoverability of the benthic communities, the effect of temporary habitat loss/disturbance is considered to be **negligible**.

Cable installation activities in the intertidal zone may result in temporary increases in SSC and associated sediment deposition

The excavation of two trenches within the intertidal area involving the removal of up to 956 m^3 of sediment may result in temporary elevations in SSC in the water column in the event that these works are not undertaken at low water (i.e. in the dry). Increased SSC may also then result in the deposition of sediment on the seabed leading to smothering of intertidal benthic communities. Benthic fauna characterising this habitat, such as amphipods, live within the sediment and are therefore unlikely to be directly affected by an increase in the concentration of suspended sediment in the water column and will be tolerant of light smothering by sediment. Smothering could lead to a reduction in the available interstitial spaces and therefore cause a local decrease in abundance in the benthic fauna (Tillin and Budd, 2016). However, this is unlikely; instead it is likely that most sediment will be re-mobilised and transported within one tidal cycle, and therefore any increases in sediment deposits will be short lived and temporary. In addition, the mobilisation of the entire 956 m^2 of sediment will not occur simultaneously and it is likely that much smaller volumes will be released at any one time, aiding dispersion.

Due to the small scale of the impact, the potential for rapid dispersal of the sediments, and the high tolerance of associated benthic species, the effect of increased suspended sediment and associated sediment deposition is considered to be **negligible**.

Cable installation activities in the subtidal zone may result in temporary increases in

SSC and associated sediment deposition

Trenching activities within the nearshore subtidal area may result in temporary elevations in SSC in the water column and subsequent deposition on the seabed resulting in smothering of subtidal benthic communities. The total volume of sediment potentially disturbed in the nearshore environment is minimal (up to 4,472 m^3 with the amount released in any one day substantially less than this). The communities in the subtidal zone occur in a dynamic and scoured environment and are therefore tolerant of high sediment concentrations in the water column. In addition, it is likely that any sediment released will be re-mobilised and transported within one tidal cycle. Some increase in turbidity may be beneficial if the suspended particles are composed of organic matter although high levels could reduce filter feeding efficiency. As suspension feeders the tube worms, barnacles and bryozoans that characterise the SS.SCS.CCS.PomB biotope are generally tolerant of an increase in SSC although large increases could be detrimental due to clogging of their feeding apparatus. Animals within this biotope are also tolerant of light increases in sediment deposition. As sediments are likely to be rapidly removed from the biotope and scour tolerance of the characterising species would prevent significant mortalities (Tillin and Tyler-Walters, 2016).

Due to the small scale of the impact, the potential for rapid dispersal of the sediments, and the tolerance of the associated benthic species, the effect of increased suspended sediment and associated sediment deposition is considered to be **negligible**.

5.4 Fish and Shellfish

Cable installation activities in the subtidal zone may result in temporary subtidal habitat loss/disturbance

Trenching activities within the nearshore area and out to approximately 250 m offshore using a Menzi Muck and/or barge mounted excavator, will result in direct disturbance to subtidal sediments and potential indirect effects on fish and shellfish species, including diadromous fish species. The magnitude of the impact is considered to be small with the total subtidal area affected by trenching predicted to be up to 2,236 m^2. Given the lack of spawning areas within the alternative cable landfall installation method application area for cod and herring (see Section 3.5), the large nursery area for herring, the lack of nursery areas for cod (Coull *et al.,* 1998; Ellis *et al.* (2010)) and the lack of extensive areas supporting important sandeel populations (BOWL, 2014b) the area affected is not particularly sensitive. Given the area of the Moray Firth (6,563 km^2) where more general fish habitat is available the overall area affected is minimal (less than 0.0001%). The herring nursery area is slightly larger than the area of the Moray Firth (Ellis *et al*., 2010) and therefore only a very small proportion of this habitat will be affected (i.e. much less than 0.0001%).

As described above, the effects on benthic subtidal habitat are considered to be small scale, localised, and reversible and therefore indirect effects on fish and shellfish communities due to loss of habitat will be similar. Mobile species will be able to avoid the impacted area and there is unlikely to be any discernible effect due to the availability of similar habitat in the wider area. Sessile shellfish species may be more vulnerable and habitat loss/disturbance could lead to direct loss of individuals in the impacted area. However, the area affected in comparison to the distribution of these species in the wider area is very small. Once installation activities have ceased habitats will begin to recover and within one or two tidal cycles will have returned to baseline conditions.

Due to the small scale and temporary nature of the impact and potential for habitat recovery, the effect of temporary subtidal habitat loss/disturbance is considered to be **negligible**.

Cable installation activities in the subtidal zone may result in temporary increases in SSC and associated sediment deposition

Trenching activities within the nearshore subtidal area may result in temporary elevations in SSC in the water column which may have adverse effects on fish and shellfish, including diadromous fish species. The total volume of sediment potentially disturbed in the nearshore environment is minimal (up to 4,472 m^3 with the amount released in any one day substantially less than this). Migrating fish may avoid the area affected by increased SSC, but the effects are likely to be very localised and reversible, and fish are not considered to be sensitive receptors in this situation. Deposition of sediment on the seabed may result in smothering of animals, and shellfish species may be particularly vulnerable due to their low mobility (e.g. scallops, crabs, lobster, and whelks). Sediment deposition could also lead to smothering of sensitive areas for species such as herring and sandeels. However, the surveys undertaken by BOWL (see Section 3.5) demonstrate that herring spawning grounds do not occur in the Moray Firth (BOWL, 2014a, 2016d, 2016e) and there are not extensive areas supporting important sandeel populations (BOWL, 2014b). As described previously for benthic communities (Section 5.3) increases in suspended sediment and associated deposition are likely to be short term, localised and reversible and the proportion of fish and shellfish habitat affected will be negligible. The increased SSC will also return to normal concentrations rapidly once installation activity has ceased. In addition, the total area affected represents less than 0.0001% of the total area of the Moray Firth and much less than 0.0001% of the herring nursery area present in the Moray Firth. Therefore, any effects are likely to be minimal.

Due to the small scale and temporary nature of the impact, the potential for rapid dispersal of the sediments, and the tolerance of the associated fish and shellfish species, the effect of increased suspended sediment and associated sediment deposition is considered to be **negligible**.

Cable installation activities may result in underwater noise

Trenching activities within the nearshore subtidal area using a Menzi Muck and/or barge mounted excavator have the potential to generate underwater noise which may have adverse effects on fish and shellfish receptors and on the migratory behaviour of diadromous fish species which are designated features of the River Spey SAC. Noise from cable installation activities is likely to be received as a low level chronic exposure (as opposed to acute impulse and intense noises from e.g. piling operations) and can affect fish and shellfish by masking sounds in the sea soundscape (Popper *et al*., 2014). Sound plays an important role in fish and invertebrates, allowing them to communicate with one another, detect predators and prey, navigate their environment, and avoid hazards. Different species have different sensitivities with herring, shad, eels and cod being amongst the most sensitive species, Atlantic salmon and sea trout being of moderate sensitivity and flatfish and lampreys of low sensitivity. Noise during cable installation activities may result in avoidance of the ensonified area, although persistent noise disturbance could affect fish on migration. However, the cable landfall lies over 2 km from the mouth of the River Spey and noise disturbance is predicted to be very localised (<100 m from the cable route even for the most hearing sensitive fish species) (BOWL, 2012).

Due to the low level, small scale, localised, short term and reversible (as fish will start to return to the area once activity has ceased) nature of the impact, and taking into consideration the sensitivity of the receptors (including Atlantic salmon and sea lamprey as features of the River Spey SAC), the effect of increased noise on fish and shellfish receptors is considered to be **negligible**.

5.5 Marine Mammals

Cable installation activities may result in noise disturbance of marine mammals

Trenching activities within the nearshore subtidal area using a Menzi Muck and/or barge mounted excavator has the potential to generate underwater noise which may have adverse effects on marine mammals. The magnitude of the impact is considered to be small on the basis that the works will be restricted to shallow, near-shore waters (i.e. where marine mammals are unlikely to be routinely present) and the noise modelling undertaken for the Beatrice Project ES (BOWL, 2012) demonstrated that the effect ranges associated with cable installation activities are highly localised and limited to the immediate vicinity of the area where works are being carried out.

Subsea noise can affect marine mammals through 'masking', whereby vocal communication either between individuals of the same species or during hunting for prey may become ineffective. Studies of responses of marine mammals to vessel noise in particular, show that harbour porpoise, as one of the most hearing sensitive species, generally avoid vessels, whilst dolphins may demonstrate other behavioural reactions such as increased swimming speed, increased group cohesion and longer dive duration (Miller *et al*., 2008). Sensitivity to subsea noise from vessels is most likely related to the marine mammal activity at the time (Senior *et al*., 2008). For example, resting animals are likely to avoid vessels, foraging animals may ignore them and socialising animals may approach vessels (Richardson *et al*., 1995).

Radiated vessel noise relates to factors including ship size, speed, load, condition, age, and engine type (Hawkins *et al*., 2014). Subsea noise from barges and excavators will most likely fall within a low frequency spectrum and the speed of the vessels/machinery will be slow for the duration of the cable installation activities. Therefore the potential for impacts, such as masking communications, will be low compared with, for example, high speed vessels (Pirotta *et al*., 2015). In addition, the noise from cable installation is considered likely to represent a negligible increase compared to the already high level of vessel noise in the wider area (e.g. shipping, fishing, recreation). Marine mammals in the area are likely to have become habituated to vessel noise.

Although the baseline assessment shows that marine mammals frequently occur within Spey Bay the densities are low and due to the low magnitude of the impact and the potential habituation of marine mammals in the area to vessel noise, the effect of subsea noise is considered to be **negligible**.

Vessel traffic associated with cable installation activities may result in collision risk

Trenching activities within the nearshore subtidal area using a Menzi Muck and/or barge mounted excavator has the potential to generate machinery/vessel movements which may result in an increased collision risk for marine mammals. The magnitude of the impact is considered to be small on the basis that the machinery/vessel movements will be limited to a single Menzi Muck and/or barge mounted excavator and that the works will be restricted to shallow, nearshore waters, where marine mammals are unlikely to be routinely present.

Evidence from the literature suggests that large vessels (>80 m) travelling at speeds in excess of 14 knots may represent a threat to marine mammals (Laist *et al*., 2001). However, the risk of collision from the Menzi Muck and/or barge mounted excavator is expected to be very low as the vessel/machinery to be used will either be moving very slowly or will be stationary. Animals will therefore be able to avoid the vessel/machinery and collision is considered to be unlikely. Therefore, the effect of vessel traffic leading to collision risk is considered to be **negligible**.

5.6 Birds

Cable installation activities may result in temporary disturbance or displacement of seabirds, divers and seaducks

Cable installation activities in the intertidal and subtidal zones have the potential to disturb and displace birds due to the presence of construction vessels/plant. In terms of the extent of the potential impact, birds will only be expected to be affected by the presence of machinery (plant) during active trenching operations in the intertidal and subtidal zones. Note that there is a potential for onshore works, including installation of the sheet piles through the shingle berm, to also cause temporary disturbance to birds on the water. However, as this activity will predominantly take place above MHWS this is not considered likely to cause any greater disturbance to birds on the water than that resulting from trenching activity in the intertidal and subtidal zones. In addition, the overall duration of construction activity is not considered to be of concern. Thus the area over which disturbance could occur will be small, extending over species-specific buffer distances from active plant. Furthermore, the duration of the impact will be short-term (up to 9 months in 2017 and 4-7 months in 2018 depending on whether trenching is conducted simultaneously or phased), temporary, reversible and predominantly expected to take place outside the nonbreeding season period during which the sensitive species identified in Section 3.7 are present (i.e. works would take place between July and November 2017 and March and July in 2018).

To illustrate the limited potential for an impact, the following section provides an estimate of the possible displacement of divers. The combined density of great northern divers and red-throated divers in the construction area is approximately 0.2-0.4 birds/km^2 (SNH, 2016). Using a worst case semi-circular displacement buffer of 2 km (since no individuals would be expected to be present inshore of vessel/plant) extending offshore from construction activity, an area of up to 6 km^2 could be affected. At a maximum density of 0.4 birds/km^2, up to two individual divers could be displaced by construction activity (although only if construction activity takes place during the nonbreeding season when these species are present). As the area of diver distribution in the Spey Bay area is approximately 500 km^2 (SNH, 2016) a temporary displacement of this magnitude would clearly have an undetectable effect on the density across the remainder of the pSPA and therefore the effect on the diver populations would be negligible.

Divers are the most sensitive species included as features for the pSPA. Therefore, while other species are more abundant (e.g. common scoter and long-tailed duck) the extent of potential displacement would be much smaller due to their greater tolerance to disturbance. The only other species for which it is possible to estimate the potential density of birds in the alternative landfall cable installation works area are common eider and long-tailed duck. Estimated densities for these species were 1-4 and up to 2 birds per km^2 respectively. Avoidance distances are not available for these species, however they will almost certainly be smaller than for divers, which are known to be extremely intolerant to disturbance, However, if a worst case buffer of 2 km is applied this would suggest that up to 24 eider and up to 12 long-tailed ducks could be displaced during construction activity. The total populations for these species in the pSPA are given as 1,733 and 5,001 respectively, with both species primarily located in areas away from the landfall location. Given the wide distributions of both species and the limited overlap between the species and the construction activity, both spatially and temporally, these maximum displacement effects would be considered likely to give rise to a negligible effect on the populations.

The other species identified in Section 3.7 (Slavonian grebe, common scoter, velvet scoter, common goldeneye and red-breasted merganser) would all be expected to experience similar or smaller effects than those described above, due to combinations of low densities in the location of the landfall works and low sensitivity to disturbance.

Due to the short duration and localised nature of the impact, the timing of the activity predominantly outside the core sensitive periods for key species, and the low densities of birds in the construction area, disturbance and displacement effects are considered to be **negligible**.

5.7 Commercial Fisheries

Cable installation activities may interfere with fishing activity

The extent of the impact is considered to be very small, with displacement of fishing activities limited to a small area associated with the presence of an advisory safety zone around a short section of subtidal cable installation works. Any advisory safety zone in the subtidal area will be implemented over a short period of time, occurring potentially over up to four months in 2017 (August to November) and a further four months in 2018 (April to July). In addition any advisory safety zones will be across a small area (up to 500 m radius around the installation works) in relation to the wider available fishing area. Any advisory safety zones will be close to shore and in shallow water, where fishing activity is likely to be at lower intensity (although not necessarily absent) than the wider Moray Firth.

In addition, there are a number of embedded mitigation measures which will reduce the magnitude of any impact to commercial fisheries receptors. Notices to Mariners and communication with the fishing industry through the BOWL FLO will ensure that the fishing industry is aware of the location and timing of any activity and will be able to plan in order to minimise disruption. Once the works are completed fishing activity will be able to resume within the previously restricted area.

Due to the short duration of the impact, the small area affected, the low intensity of fishing activity and the measures in place to ensure that the fishing industry is aware of the cable installation activity, the effects of interference, restriction and displacement are considered to be **negligible**.

Cable installation activities may lead to a temporary increased risk of gear/anchor snagging

Cable trenching activities may lead to a temporary increased risk of gear/anchor snagging from partially installed cables during the installation works and also from the creation of any spoil berms either side of the trench. However, the activity is being undertaken close to shore where fishing intensity is relatively low and most fishing activity is carried out using creels and pots which are less likely to become snagged.

The cables will be buried to a depth of 2 m in the subtidal zone such that once installation is completed it is unlikely that fishing gear will become snagged on the cable. Given the active nature of the seabed close to shore, tidal movements in the area and the fine-medium sands and gravels with small patches of hard substratum (see Section 3.3), it is expected that any berms will be reworked into the seabed relatively rapidly (in the order of days) and any potential effects will be short term and temporary.

As noted above there are a number of embedded mitigation measures which will be implemented to reduce effects on other sea users, including notification of the timing and location of the works through Notices to Mariners, the establishment of advisory safety zones designed to prevent access to areas of snagging risk, and the appointment of a qualified FLO, as detailed in the OfTW Construction Method Statement (BOWL, 2016h).

Due to the short duration of impact, the small area affected, the low intensity of fishing activity and the measures in place to ensure that the fishing industry is aware of the cable installation activity, the effect of a temporary increased risk of gear/anchor snagging is considered to be **negligible**.

5.8 Shipping and Navigation

Cable installation activities may result in obstructions to shipping and navigation

Cable installation activities in the subtidal zone have the potential to obstruct shipping and navigation due to the presence of construction vessels/plant and associated advisory safety zones. The extent of the impact is considered to be very small, with any obstructions limited to a small area associated with the presence of an advisory safety zone around the vessels/plant carrying out the installation works. The magnitude of the impact is also considered to be small on the basis that the works will be restricted to shallow, nearshore waters where there is unlikely to be commercial shipping and anchorage activity (see Section 3.9), and on the basis of the mitigation measures that will be implemented to reduce effects on other sea users during the works, including notification through Notices to Mariners and the use of radio navigation warnings, as detailed in the OfTW Construction Method Statement (BOWL, 2016h).

Any obstruction will be short term and intermittent occurring potentially over up to four months in 2017 (August to November) and a further four months in 2018 (April to July).

Due to the short term, temporary nature of the works, the low level of shipping activity in the vicinity of the alternative landfall cable installation works, the availability of alternative anchorages in the area, and the embedded mitigation measures, the effect is considered to be **negligible**.

Cable installation activities may lead to a temporary increased risk of anchor snagging

Cable installation activities in the subtidal zone have the potential to lead to an increased risk of anchor snagging from partially installed cables during the installation works. The extent of the impact is considered to be very small, with any increased risk limited to the short (~250 m) section of subtidal cable. The magnitude of the impact is also considered to be small on the basis that the nearshore installation works will take place in shallow waters where there is unlikely to be commercial shipping and anchorage activity (see Section 3.9), and on the basis of the mitigation measures to be implemented to reduce effects on other sea users during the works, including notification through Notices to Mariners and the establishment of advisory safety zones (designed to prevent access to areas of snagging risk), as detailed in the OfTW Construction Method Statement (BOWL, 2016h).

The works will be short term and intermittent occurring potentially over up to four months in 2017 (August to November) and a further four months in 2018 (April to July).

Due to the short term, temporary nature of the works, the low level of shipping activity in the vicinity of the alternative landfall cable installation works, and the embedded mitigation measures, the effect is considered to be **negligible**.

5.9 Marine Archaeology

Cable installation activities may affect marine archaeology

Cable installation activities have the potential to affect marine archaeology through direct and indirect impact to the seabed. It is also possible that finds of archaeologist interest may be identified as a result of trenching activities.

As specified in Table 4.1, cable installation works will avoid AEZs, in accordance with the Beatrice Marine Archaeological WSI and PAD (BOWL, 2016f), unless absolutely necessary or otherwise agreed with MS-LOT in consultation with Historic Environment Scotland. A single wreck with high archaeological potential and a 100 m AEZ (HA1008) is in the vicinity of the landfall activity. However, the HA1008 AEZ is within the Outer Study Area considered within the Marine Archaeological WSI and PAD (BOWL, 2016f) (i.e. within the 1km buffer either side of the OfTW corridor) and therefore greater than 100 m from the cable installation activity. As a result, and due to the implementation of the AEZ, it is unlikely that the cable installation will affect this asset.

Seabed disturbance may cause secondary physical effects to marine archaeology assets through settlement of SSC out of the water column, however the increases in SSC from the cable installation activities are anticipated to be short term and localised with the associated sediment deposition also localised and discrete.

Any object that is identified as potential archaeology during cable installation will be reported to the project Archaeologist in accordance with the Marine Archaeological WSI and PAD (BOWL, 2016f).

Due to the planned avoidance of AEZs, implementation of the embedded mitigation measures for archaeology, and the short term and localised nature of increased SSC, the effects of the alternative landfall cable installation activities on marine archaeology is considered to be **negligible**.

5.10 Infrastructure and Other Users

Cable installation activities may affect the activities of infrastructure and other receptors in the vicinity

Cable installation activities in the intertidal and subtidal zones have the potential to affect the activities of infrastructure and other receptors in the vicinity, including activities associated with the nearby Caithness to Moray transmission cable, and recreational receptors. Onshore recreational receptors will be considered in the landfall CEMP (BOWL, 2016g).

The extent of the impact will be limited to a short section of the intertidal and subtidal cable route, with any potential exclusion of other activities limited to a small area associated with the presence of any marked off working areas (intertidal) and an advisory safety zone (subtidal) around the cable installation works. The magnitude of the impact is also considered to be small on the basis of the mitigation measures that will be implemented to reduce effects on other sea users during the works, including: notification through Notices to Mariners; in terms of recreational receptors, as detailed in the OfTW Construction Method Statement (BOWL, 2016h); and continued consultation with the developer of the Caithness to Moray cable to ensure coexistence of the projects. It is considered that any effects will be short term and temporary.

Due to the short term, temporary nature of the works, and the embedded mitigation measures, the effect is considered to be **negligible**.

6 Cumulative Effects

This section considers the potential for cumulative impacts arising from the alternative landfall cable installation activities identified in Section 2 alongside other activities. These other activities are described in Table 6.1, and are based on those identified in the Consenting Approach document (BOWL, 2016b).

Table 6.1: Other activities considered in cumulative assessment.

Activity/Project	Description
Remaining BOWL OfTW installation works	Activities associated with other phases of the BOWL OfTW installation works including the Pipe Thruster Pit, exit point for the DirectPipe ducts 250m from the shore and the remaining OfTW works consented under the existing OfTW Marine Licence, including the initial Direct-Pipe works (prior to Direct-Pipe failure, should this occur), the remaining offshore OfTW installation works to the OWF site. The remaining OfTW works are schedule to start in March 2017
Installation activities at nearby cable projects	The Caithness to Moray transmission cable makes landfall in vicinity of BOWL's OfTW, running along the eastern edge of the BOWL OfTW corridor. The Caithness to Moray landfall cable will be installed via HDD (Scottish Hydro Electric Transmission Plc, 2015). The landfall for the Caithness to Moray transmission route is approximately 0.4 km from the proposed alternative cable landfall location. The HDD drilling rig will be established at the landing point, set back 50 to 75m back from the shoreline, drilling underneath the SSSI out to sea before emerging approximately 250 m beyond the shoreline (SHE-T, 2010). The Caithness to Moray transmission route works are scheduled to start in January 2017 and be completed in the final quarter of 2017, with the pull in of the cable scheduled for May 2017.

An assessment of the potential cumulative effects is presented in Table 6.2. The assessment of cumulative effects with the remaining BOWL OfTW installation works has been based on the assessments undertaken in BOWL (2012, 2013). The assessment of cumulative effects with the Caithness to Moray transmission cable route is based on publically available information and has been based on the assessment of potential effects included in the marine environmental appraisal document (SHE-T, 2010). Based on the information available for the Caithness to Moray transmission cable the project will use HDD to install their cable, from a point 50 to 75m back from the shoreline, drilling underneath the SSSI, emerging approximately 250 m from the shoreline. Based on the timelines available the projects have the potential to take place at the same time.

The assessment in Table 6.2 considers the cumulative effects from the aspects of the alternative landfall cable installation that take place below MHWS and from the remaining OfTW installation works and the Caithness to Moray transmission route installation works that take place below MHWS. Potential cumulative effects with the Onshore Transmission Works OnTW) for both projects were also considered. Given the OnTW works occur within the terrestrial environment and above MHWS it is unlikely that there will be any cumulative effects as there is no impact pathway between the OnTW works and receptors present below MHWS. However, birds that are present in intertidal areas may potentially be found in terrestrial habitats and may be affected by both the OnTW works and the alternative cable installation works and have the potential to be disturbed by noise form both activities. Therefore, cumulative effects on birds have been assessed in Table 6.2.

Table 6.2: Assessment of Cumulative Effects.

Receptor	Other BOWL Construction Activities	Installation activities at nearby cable projects
Physical Processes	The remaining OfTW installation works (i.e. the installation of the export cable from the point at which the alternative cable landfall works are completed (250m offshore) to the OWF) will take place in the subtidal zone. As a result these works are only likely to interact with the subtidal aspects of the alternative cable landfall works. Increases in SSC and deposition will be limited in spatial extent to the length of the trench, and for deposition, a short distance either side. Any potential effects will be of short duration. The intertidal and subtidal zones are an area where relatively high SSC levels are expected as a baseline. Effects from the subtidal parts of the remaining BOWL OfTW installation works are expected to be minor (BOWL, 2012) and will occur further offshore than those from the alternative cable landfall (i.e. beyond 250 m from the shore) and are unlikely to add to SSC levels in the same area due to this spatial separation. As a result any cumulative effects are expected to be **minor**. There is considered to be no potential for cumulative effects to the shingle berm and the geomorphological features of the Spey Bay SSSI as other BOWL project activities to install the export cables in subtidal areas (e.g. jetting and ploughing activity) will not disturb the SSSI. There will be no cumulative effect on sediment transport processes as other BOWL activities will not interact with or disturb sediment transport processes.	The alternative cable landfall works are only likely to interact with the subtidal works of the Caithness to Moray transmission route (as the remainder of that route will be installed using HDD). Increases in SSC and deposition will be of short duration and limited in spatial extent to the length of the trench and, for deposition, a short distance either side. Furthermore, the nearshore subtidal zone is an area of relatively high SSC at baseline levels. Effects from the subtidal parts of the remaining Caithness to Moray transmission route works are expected to be minimal (SHE-T, 2010) and will occur further offshore than those from the alternative cable landfall (i.e. beyond 250 m from the shore). As a result they are unlikely to add to SSC levels in the same area due to this spatial separation. As a result any cumulative effects are expected to be **minor**. As the Caithness to Moray landfall cable will be installed via HDD there is no potential for cumulative effects to occur on the shingle berm and the geomorphological features of the Spey Bay SSSI. There will be no cumulative effect on sediment transport processes as other Caithness to Moray transmission route activities will not interact with or disturb sediment transport processes.

Receptor	Other BOWL Construction Activities	Installation activities at nearby cable projects
Benthic Ecology	There is no potential for cumulative effects in the intertidal zone as the remaining OfTW installation works will only take place in the subtidal zone. Physical damage to habitats in the subtidal zone with potential for loss of infauna and epifauna during OfTW installation works was assessed in the ES as minor (BOWL, 2012). The impact of the alternative landfall cable installation is assessed as being negligible. However, these effects are likely to occur in different areas and are spatially separated (within 250 m of the shore as a result of the alternative cable landfall and beyond 250 m for the remaining OfTW installation works). Therefore the effects of habitat loss on subtidal benthic communities are not expected to significantly overlap and cumulative effects are considered to be **minor**. The impact of the alternative landfall cable installation is assessed as being negligible. Effects from the subtidal parts of the remaining BOWL OfTW installation works are expected to be minor (BOWL, 2012) and will occur further offshore than those from the alternative cable landfall (i.e. beyond 250 m from the shore) and are unlikely to add to SSC levels in the same area due to this spatial separation. Therefore, the cumulative effect of increased SSC and sediment deposition on subtidal benthic communities is considered to be **minor.**	As the Caithness to Moray landfall cable will be installed via HDD there is no potential for cumulative effects to occur on intertidal ecology. In the subtidal zone the Caithness to Moray transmission route (0.4 km to the east),will be installed using similar techniques as described for the BOWL OfTW (e.g. trenching and jetting). The effects, assessed as minimal by SHE-T (2010), are similar to those predicted for the BOWL alternative landfall cable installation in terms of subtidal habitat loss/disturbance and would result in a negligible effect. However, these effects are likely to occur in different areas and are spatially separated (within 250 m of the shore as a result of the alternative cable landfall and beyond 250 m for the Caithness to Moray transmission route). Therefore, the effects of habitat loss/disturbance on subtidal benthic communities are not expected to significantly overlap. The cumulative effect is therefore considered to be **negligible**. There is potential for an increase in SSC arising from the Caithness to Moray transmission route. However, the effects were predicted to be minimal by SHE-T (2010) and similar to those predicted for the BOWL alternative landfall cable installation activities. As a result and due to the spatial separation between the two projects any cumulative effects are considered to be **negligible**.
Fish and Shellfish	The potential impacts of the alternative landfall cable installation activities are assessed as being negligible for the temporary subtidal habitat loss and disturbance on fish	The landfall of the Caithness to Moray transmission route (0.4 km to the east) will be installed using HDD. Installation in the subtidal zone will be via similar

Receptor	Other BOWL Construction Activities	Installation activities at nearby cable projects
	and shellfish communities. The remaining OfTW installation works to the OWF site are likely to result in localised, temporary and reversible impacts on fish and shellfish from habitat loss/disturbance. The total area affected by both the alternative cable landfall works and the remaining OfTW works will be less than 0.0001% of the total area of the Moray Firth and herring nursery grounds also present in the firth. Therefore cumulative impacts are assessed as being **negligible**. Cable trenching activities along the OfTW resulting in an increase in SSC and sediment deposition were assessed as minor (BOWL, 2012). The impact of the alternative landfall cable installation activities is also assessed as negligible. Effects from the remaining aspects of the OfTW will occur further offshore than those from the alternative cable landfall (i.e. beyond 250 m from the shore) and are unlikely to add to SSC levels in the same area due to this spatial separation. Fish that occur in subtidal areas close to shore are also tolerant of high levels of SSC. Therefore, the cumulative effect of increased SSC and sediment deposition on fish and shellfish communities is considered to be **minor.** Underwater noise from other BOWL OfTW construction activities will result in short term, localised disturbance to fish and shellfish and the effects were considered to be negligible (BOWL, 2012). The impact of underwater noise from the alternative landfall cable installation activities is also assessed as negligible. Any impacts experienced will be short term, localised and reversible with fish returning	techniques as described for the BOWL OfTW. There is potential for cable installation to result in subtidal habitat loss/disturbance. Given the spatial separation between the two landfalls, the areas where subtidal effects occur (beyond 250 m for the SHE-T works and within 250 m of the shore for the alternative cable landfall works) and the available habitat within the Moray Firth the cumulative effect of temporary subtidal habitat loss/disturbance is considered to be **negligible.** There is potential for an increase in SSC to add cumulatively to the SSC arising from the alternative landfall cable installation activities. However, the effects were predicted to be minimal by SHE_T (2010) and for the alternative landfall cable installation. Given the spatial separation between the two landfalls, the areas where subtidal effects occur (beyond 250 m for the SHE-T works and within 250 m of the shore for the alternative cable landfall works) and the tolerance of fish species in coastal areas to high levels of SSC the cumulative effect of temporary increases in SSC and associated sediment deposition is considered to be **negligible.** There is potential for subsea noise arising from the Caithness to Moray transmission route installation activities to add cumulatively to the subsea noise arising from the alternative landfall cable installation activities. However, given the spatial separation of activities for both projects, the low level, small scale, localised, short term and reversible effects for both projects, with fish returning to the area shortly after activity has ceased the e

Receptor	Other BOWL Construction Activities	Installation activities at nearby cable projects
	to the area once activities have ceased. Therefore, the cumulative effect of noise disturbance from all BOWL OfTW construction activities and the alternative cable landfall is considered to be **negligible.**	cumulative effect of underwater noise is considered to be **negligible**.
Marine mammals	The potential impacts of the alternative landfall cable installation activities are assessed as being negligible for the disturbance of marine mammals. During BOWL OfTW construction activities at the landfall site will be short term, localised disturbance to marine mammals from underwater noise. Effects were considered to be minor (BOWL, 2012). The impact of underwater noise from the alternative landfall cable installation activities is also assessed as negligible. Given the spatial separation between the two activities, the low densities of marine mammals, low magnitude of the impact and the habituation to vessel noise by marine mammals present in the Moray Firth the cumulative effect of noise disturbance is considered to be **minor**. Collision risk may arise from construction vessels during installation of the OfTW. During these activities there will be a short term, localised risk to marine mammals which will cease immediately following completion of the activity. Effects were predicted to be minor (BOWL, 2012). The impact of collision risk from the alternative landfall cable installation activities is assessed as negligible. Given the short term nature of the impacts, the low density of marine mammal populations in the vicinity of the landfall and the low number of vessels involved as a consequence of both	The potential impacts of the alternative landfall cable installation activities are assessed as being negligible for the disturbance of marine mammals. The Caithness to Moray transmission route (0.4 km to the east), will be installed at the landfall using HDD and installation in the subtidal zone will be via similar techniques as described for the BOWL OfTW. As a result there is the potential for cumulative subsea noise effects to occur. Given the spatial separation between the two projects, the low densities of marine mammals, low magnitude of the impact and the habituation to vessel noise by marine mammals present in the Moray Firth the cumulative effect of noise disturbance is considered to be **negligible**. There is potential for collision risk from the Caithness to Moray transmission route installation and the alternative landfall cable installation activities to result in a cumulative effect. , The effects from the Caithness to Moray transmission route were predicted to be minimal (SHE-T, 2010). Combined with the short term nature of any impacts, the low density of marine mammals in the vicinity of the landfall and the low number of vessels involved as a result of both projects the cumulative effect of collision risk is considered to be **negligible**.

Receptor	Other BOWL Construction Activities	Installation activities at nearby cable projects
	the remaining OfTW and the alternative landfall cable installation activity the cumulative effect of collision risk is considered to be **minor.**	
Birds	There is potential for cumulative disturbance/displacement of the divers and seabirds during any temporal overlap between the alternative cable landfall installation works and installation of the remaining OfTW cable. This will only be of concern if it occurs during the nonbreeding season when sensitive species are present. Given that it is predicted that a maximum of two divers (the most sensitive species) are likely to be displaced due to noise generated due the presence of machinery and plant from the alternative landfall cable installation and that displacement form cable laying activity in subtidal areas adjacent to the landfall will be minimal and temporary (BOWL, 2012) it is considered that the cumulative effect of temporary disturbance or displacement is **negligible.** There is the potential that that the remaining OnTW works for the BOWL export cable will act cumulatively with the alternative landfall cable installation works on birds present in both intertidal and terrestrial environments. Birds in the intertidal area are likely to be disturbed by noise generated by plant and machinery. However, it is unlikely that noise generated by the machinery and plant operating onshore will add to this disturbance due to the distance between the activities. In addition birds identified in the intertidal and subtidal areas have not been recorded in terrestrial environments where the OnTW works will take place (BOWL, 2016g). Therefore, it is considered	There is potential for the Caithness to Moray transmission route installation works (0.4 km to the east) to contribute to a cumulative disturbance/displacement effect in combination with the alternative landfall cable installation. This will only be likely if such work occurs during overlapping time periods and within a spatial area where the same populations of sensitive bird species could be affected. Given the negligible magnitude of effects predicted for the alternative landfall cable installation works and that potential impacts to birds were scoped out of the Environmental Appraisal for the Caithness to Moray transmission route (indicating no potential impact) (SHE-T, 2010) the cumulative effect of temporary disturbance or displacement is considered to be **negligible**.

Receptor	Other BOWL Construction Activities	Installation activities at nearby cable projects
	that cumulative effects of temporary disturbance or displacement are unlikely to occur and if they did they would be **negligible.**	
Commercial Fisheries	Temporary advisory safety zones around the alternative landfall cable installation and along the remaining BOWL OfTW cable route have the potential to result in cumulative interference with fishing activity. Given the low level of fishing activity predicted in the subtidal area in the vicinity of the alternative landfall cable installation (see Section 3.8), that the implementation of advisory safety zones for both the alternative landfall cable installation and the remaining OfTW installation will be limited in spatial extent and temporary, and the embedded mitigation measures described in Section 4 and within the BOWL Commercial Fisheries Mitigation Strategy (BOWL, 2015f), it is predicted that cumulative effects of interference with fishing activity will be **negligible**. Installation of the BOWL cable landfall and the remainder of the BOWL OfTW activities may lead to a temporary increased risk of gear/anchor snagging. Given the short duration of the alternative landfall cable installation activity, the small area affected, the likelihood that any spoil berms will be reworked into the seabed relatively rapidly, the low intensity of fishing activity close to shore and the embedded mitigation measures described in Section 4 and within the BOWL Commercial Fisheries Mitigation Strategy (BOWL, 2015f) it is expected that any cumulative effects will be **minor**.	The Caithness to Moray transmission route, (0.4 km to the east), will be installed using HDD and in the subtidal zone installation will be via similar techniques as described for the BOWL OfTW. Impacts to commercial fishing activity were scoped out of the Environmental Appraisal for the Caithness to Mary transmission route (SHE-T, 2010) and it is expected that there will be no impacts from the Caithness to Moray transmission route installation. The lack of impacts form the Caithness to Moray transmission route coupled with the temporary nature of activity for the alternative landfall cable installation, the limited spatial extent of any advisory safety zones, and the embedded mitigation measures in place (also likely to be implemented as best practice for the Caithness to Moray transmission route), cumulative effects of interference with fishing activity are expected to be **negligible**. Installation of the subtidal elements of the BOWL alternative cable landfall and the Caithness to Moray transmission route may lead to a temporary increased risk of gear/anchor snagging. Impacts to commercial fishing activity were scoped out of the Environmental Appraisal for the Caithness to Mary transmission route (SHE-T, 2010) and it is therefore expected that there will be no impacts from the Caithness to Moray transmission route installation. The lack of impacts form the Caithness to Moray transmission route coupled with the short duration

Receptor	Other BOWL Construction Activities	Installation activities at nearby cable projects
		of the alternative landfall cable installation activity, the small area affected, the likelihood that any spoil berms will be reworked into the seabed relatively rapidly, the low intensity of fishing activity close to shore (see Section 3.8) and the embedded mitigation measures described in Section 4, it is expected that any cumulative effects will be **minor**.
Shipping and Navigation	Activities associated with the alternative landfall cable installation method have the potential to result in obstructions to commercial shipping and navigation, which are assessed as being negligible. It was similarly concluded in the ES (BOWL, 2012) that, assuming the implementation of industry standard mitigation measures, the remaining OfTW works would result in negligible effects. Therefore, given the short duration of activity and the very low density of shipping activity in the vicinity of the alternative landfall cable installation the cumulative effect is assessed as being **negligible**. Activities associated with the alternative landfall cable installation method have the potential to result in a temporary increased risk of anchor snagging, which are assessed as being negligible. It was similarly concluded in the ES (BOWL, 2012) that, assuming the implementation of industry standard mitigation measures, the OfTW works would result in negligible effects on shipping and navigation. Therefore given the short duration of activity and the very low density of shipping activity in the vicinity of the alternative landfall cable installation (see Section	Other nearby activities that may result in obstructions to shipping and navigation include cable installation activities associated with the Caithness to Moray transmission route (0.4 km to the east). Impacts to shipping and navigation were scoped out of the Environmental Appraisal for the Caithness to Mary transmission route (SHE-T, 2010) and it is therefore expected that there will be no impacts from the Caithness to Moray transmission route installation. The lack of impacts form the Caithness to Moray transmission route coupled with the embedded mitigation measures relevant to navigation (see Section 4), it is considered that the cumulative effect on commercial shipping and navigation receptors will be **negligible**. Due to the embedded mitigation measures relevant to navigation, the scoping out of impacts within the Caithness to Moray Environmental Appraisal (SHE-T, 2010) and the low density of shipping activity close to the alternative landfall cable installation activity (see Section 3.9), it is considered that the cumulative effect of temporary increased risk of anchor snagging on commercial shipping and navigation receptors will be **negligible**.

Receptor	Other BOWL Construction Activities	Installation activities at nearby cable projects
	3.9) the cumulative effect is assessed as being **negligible**.	
Marine Archaeology	The potential impacts of the alternative landfall cable installation activities are assessed as being negligible for effects on marine archaeology. Other BOWL OfTW construction activities have the potential to affect archaeological assets, particularly the trenching works for the remainder of the OfTW cable route to the OWF. Six AEZs have been prescribed within the OfTW corridor and an additional 1 km buffer either side of the corridor. Given that these AEZs will be avoided and any object of potential archaeological interest is reported in accordance with the Marine Archaeological WSI and PAD (BOWL, 2016f) for both the remaining OfTW and the alternative landfall cable installation it is considered unlikely that any impacts will occur to the wrecks and archaeological assets present along the cable route. Therefore, it is considered that any cumulative effects will be **negligible**.	The potential impacts of the alternative landfall cable installation activities are assessed as being negligible for effects on marine archaeology. Construction activities for the nearby Caithness to Moray transmission route (0.4 km to the east) will take place in the subtidal zone only (the remainder will be installed using HDD). As a result, in the subtidal area, installation activities have the potential to affect marine archaeology assets. However, the Caithness to Moray transmission route is unlikely to affect the same assets as potentially affected by the alternative landfall cable installation. Given the spatial separation between the two projects and the fact that from 250 m offshore to shore the Caithness to Moray transmission route will be HDD drilled under the seabed it is highly unlikely that archaeological assets along the 250 m portion of the alternative landfall cable installation that occurs in subtidal areas. Due to the established AEZs being avoided, any object of potential archaeological interest being reported in accordance with the Marine Archaeological WSI and PAD (BOWL, 2016f) and combined with the Environmental Appraisal scoping out potential effects to marine archaeology and any obstructions (such as wrecks) being avoided during installation of the Caithness to Moray transmission route (SHE-T, 2010), it is considered that any cumulative effects will be **negligible**.
Infrastructure	Activities associated with the alternative landfall cable	Activities associated with the alternative landfall cable

Receptor	Other BOWL Construction Activities	Installation activities at nearby cable projects
and Other Users	installation method have the potential to affect infrastructure and other users receptors in the vicinity, which has been assessed to be negligible. Cable installation activities along the remaining OfTW route may also affect infrastructure and other users receptors. It was considered in the ES (BOWL, 2012) that as there is no requirement for cable crossings there would be no significant effects on the Caithness to Moray transmission cable project. Similarly it was considered in the ES that while there is likely to be sediment released during the OfTW cable installation activities, most material is likely to be deposited locally and within the cable corridor, thereby the effect of such accumulations on other cables was considered to be negligible. The overall impact on recreational vessels from the OfTW installation was considered in the ES to be not significant, given the available sea room within Spey Bay for vessels to safely pass cable works (out with main shipping routes). Given that the combined area of the remaining OfTW installation and alternative landfall cable installation activities is minimal it is likely that the available sea room within Spey Bay for vessels will still allow vessels to safely pass cable works Therefore the cumulative effect is assessed as being **negligible**.	installation method have the potential to affect infrastructure and other users receptors in the vicinity, which has been assessed to be negligible. Cable installation activities along the Caithness to Moray transmission route may also affect infrastructure and other users receptors. Other nearby activities that may affect infrastructure and other users receptors include cable installation activities associated with the Caithness to Moray transmission route (0.4 km to the east). However, this effects was scoped out of the within the Caithness to Moray Environmental Appraisal (SHE-T, 2010) and is therefore considered to have negligible impact. As a result and combined with the embedded mitigation measures outlined in Section 4t is considered that the cumulative effect will be **negligible**.

7 Consideration of Likely Significant Effect on Protected Areas

The location of the alternative landfall cable installation works in relation to the pSPA and SACs identified in Section 3.2 is shown in Figure 3.1. Consideration of the potential for Likely Significant Effects (LSE) on these sites is discussed below.

7.1 Moray Firth pSPA

The Moray Firth pSPA covers an approximate 'y' shaped area, comprising shallow waters (<20 m) along the Moray, Sutherland and Caithness coasts, from Berriedale in the north to Inverness in the south-west and Portsoy in the east. The comparatively sheltered aspect, combined with the input of freshwater and sediments from rivers flowing into the Moray Firth generates a variety of conditions suitable for fish and shellfish and as a result the area is an important spawning ground. Consequently the region supports high densities of wintering waterfowl (see Table 3.1 for details). Most of the species for which the pSPA has been proposed are winter migrants, with only shag listed as a breeding feature.

The only predicted potential for LSE of the alternative landfall cable installation works on the diver and seaduck features of the Moray Firth pSPA are due to disturbance and displacement as a result of the works themselves. As discussed in Section 5.6, this work will be short term, temporary and predominantly undertaken during periods when the bird features are not present. Consequently a very small magnitude of effect is predicted.

On the basis of the very small magnitude of potential effect on the diver and seaduck features of the proposed Moray Firth pSPA (Section 5.6) it is concluded that there is no LSE nor population level effects on qualifying features due to the alternative landfall cable installation, acting either alone or in-combination with other plans or projects.

7.2 Moray Firth SAC

The most recent population estimate for bottlenose dolphin in the Moray Firth, based on photo-identification work collected between 2006 and 2007, is 195 individuals (95% Confidence Interval: 162 - 253) (Cheney *et al*., 2012). The current status assessment of the population is "Stable (increasing)" (Cheney *et al*., 2012) and the most recent condition assessment (2001 to 2012) assesses the UK bottlenose dolphin population as "favourable" for range, habitat, population and overall (JNCC, 2012).

The Moray Firth SAC lies 15 km west of the alternative landfall cable installation site. Bottlenose dolphin from the SAC may forage in the Spey Bay and therefore may be affected by subsea noise and vessel activity in the vicinity of the cable landfall. However, the effects are assessed as being localised, short term and reversible (i.e. once the activity has ceased normal behaviour will resume and animals will return to the area where disturbance occurred) and the potential for the activities to result in negative effects on bottlenose dolphin as a feature of the Moray Firth SAC is considered to be negligible. Therefore, there is no LSE nor population level effects on qualifying features arising from any of the impacts identified in this assessment.

7.3 Dornoch Firth and Morrich More SAC

The Dornoch Firth and Morrich More SAC supports approximately 2% of the UK population of harbour seal (JNCC, 2015). Harbour seal, as a feature of this SAC is assessed as "Unfavourable, declining" (SNH, 2013) due to the decrease in numbers over the last two decades (SCOS, 2015).

The Dornoch Firth and Morrich More SAC lies 51.2 km north of the alternative landfall cable installation site. Harbour seal from the SAC may forage in the Spey Bay and therefore may be affected by subsea noise and vessel activity in the vicinity of the cable landfall. However, the effects are assessed as being localised, short term and reversible (i.e. once the activity has ceased normal behaviour will resume and animals will return to the area where disturbance occurred) and the potential for the activities to result in negative effects on harbour seal as features of the Dornoch Firth and Morrich More SAC is considered to be negligible. Therefore, there is no LSE nor population level effects on qualifying features arising from any of the impacts identified in this assessment.

7.4 River Spey SAC

The Atlantic salmon feature of the River Spey SAC is assessed as “Unfavourable, recovering”, sea lamprey is assessed as “Favourable, maintained”, otter is assessed as “Favourable, maintained” and freshwater pearl mussel is assessed as “Unfavourable declining” (SNH, 2013).

The River Spey SAC lies 2.5 km due west of the alternative landfall cable installation site. Whilst there may be some potential for the migratory fish citation species (Atlantic salmon and sea lamprey) to be affected by habitat loss/disturbance, elevated SSC or underwater noise within the vicinity of the cable landfall site, the effects are all considered to be localised and reversible (i.e. once the activity has ceased normal behaviour will resume and animals will return to the area where disturbance occurred) and negligible. Effects on otter were scoped out of the terrestrial assessment (BOWL, 2016g) and it is unlikely that otter from the River Spey are present in the area of the alternative landfall cable installation activity. Freshwater pearl mussels are sessile organisms found in the upper reaches of the River Spey. They are unlikely to be directly affected by the alternative landfall cable installation but may be indirectly affected by impacts on migratory Atlantic salmon and sea trout populations (hosts for the parasitic larval stage of the freshwater pearl mussel). However, given effects on these species are considered to be negligible it is likely that any effects on freshwater pearl mussels will also be negligible.

Therefore, there is no LSE nor population level effects on qualifying features arising from any of the impacts identified in this assessment.

7.5 Lower River Spey – Spey Bay SAC

The Coastal shingle vegetation outside the reach of waves habitat feature of the Lower River Spey – Spey Bay SAC is assessed as “Favourable, declining” (SNH, 2013).

The Lower River Spey – Spey Bay SAC lies 2.5 km due west of the alternative landfall cable installation site. The site is designated for the presence of two Annex I habitats and there is no potential for impacts arising from the cable installation activities in the intertidal zone to lead to negative effects on these habitats. Therefore, there is no LSE arising from any of the impacts identified in this assessment.

8 Summary

The existing OfTW Marine Licence permits the installation of two transmission cables via two preinstalled horizontal pipes using HDD at the landfall location. As a prudent project risk management measure, BOWL wishes to apply for consent for an alternative installation methodology to be implemented in the event that the Direct Pipe (the preferred form of HDD installation) methodology proves unsuccessful in the field. This alternative method is for open trenching, between the original proposed landward pipe entry points and offshore final exit points of the original Direct Pipe profile. Some of the trenching works fall within the designated Spey Bay SSSI.

This Environmental Report has been prepared in support of a Marine Licence application for the alternative landfall cable installation activities within Spey Bay and has provided an assessment of the potential environmental impacts of the licensable activities. A summary of the environmental effects is presented in Table 8.1 below.

The key potential impacts from the cable installation activities are in relation to the geomorphological aspects of the Spey Bay SSSI. The open trenching and use of sheet piles has the potential to affect the geomorphological features of the Spey Bay SSSI and the processes that form these features. However, through burial of the cable to a sufficient depth to ensure the cable is not re-exposed by the landward movement of the shingle berm, the use of sheet piled trench walls to reduce the area of the trench in the hinterland and shingle berm and measures to move sediment accumulated by the presence of the sheet piles, it is considered that any potential effects on the geomorphological features of the Spey Bay SSSI will be short term, temporary and affecting only a small proportion of the feature. Further designed-in mitigation measures also include the selection of appropriate plant, minimisation of working and stockpiling areas, excavation in separate sediment layers and reinstatement of excavated material on a 'layer by layer' basis in reverse order. With the application of these measures potential impacts have been concluded to be negligible to minor.

It is considered that there will be no population level effects on qualifying features of the Moray Firth pSPA, and Moray Firth, Dornoch Firth and Morrich More, River Spey and Lower River Spey SACs from the alternative landfall cable installation activities and therefore no LSE.

Table 8.1: Summary of Environmental Effects.

Receptor	Potential Impact	Assessment of Effect
Physical Processes	Trenching activities may directly damage or disturb geomorphological features of the Spey Bay SSSI	Negligible
	Construction working areas may directly damage or disturb geomorphological features of the Spey Bay SSSI	Negligible
	The presence of temporary storage areas may directly damage or disturb geomorphological features of the Spey Bay SSSI	Negligible

Receptor	Potential Impact	Assessment of Effect
	Cable installation activities may affect sediment transport processes	Minor
	Cable installation activities in the intertidal and subtidal zones may increase suspended sediment concentration (SSC) within the water column and deposit material on seabed	Negligible
Benthic Ecology	Cable installation activities may result in temporary intertidal habitat loss/disturbance	Negligible
	Cable installation activities may result in temporary subtidal habitat loss/disturbance	Negligible
	Cable installation activities in the intertidal zone may result in temporary increases in SSC and associated sediment deposition	Negligible
	Cable installation activities in the subtidal may result in temporary increases in SSC and associated sediment deposition	Negligible
Fish and Shellfish	Cable installation activities in the subtidal zone may result in temporary subtidal habitat loss/disturbance	Negligible
	Cable installation activities in the subtidal zone may result in temporary increases in SSC and associated sediment deposition	Negligible
	Cable installation activities may result in underwater noise	Negligible
Marine Mammals	Cable installation activities may result in noise disturbance of marine mammals	Negligible
	Vessel traffic associated with cable installation activities may result in collision risk	Negligible
Birds	Cable installation activities may result in temporary disturbance or displacement of seabirds, divers and seaducks	Negligible
Commercial Fisheries	Cable installation activities may interfere with fishing activity	Negligible
	Cable installation activities may lead to a	Negligible

Receptor	Potential Impact	Assessment of Effect
	temporary increased risk of gear/anchor snagging	
Shipping and Navigation	Cable installation activities may result in obstructions to shipping and navigation	Negligible
	Cable installation activities may lead to a temporary increased risk of anchor snagging	Negligible
Marine Archaeology	Cable installation activities may affect marine archaeology	Negligible
Infrastructure and Other Users	Cable installation activities may affect the activities of infrastructure and other users receptors in the vicinity	Negligible
Cumulative Effects	[All receptors]	[Negligible/Minor]

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Appendix A - Beatrice Offshore Wind Farm, Geomorphological Assessment of Alternative Landfall Option, Document Ref: LF000005-TCN-277

Beatrice Offshore Wind Farm - Geomorphological Assessment of Alternative Landfall Option

November 2016

Beatrice Offshore Windfarm Ltd

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Project Title	Beatrice Offshore Wind Farm
Date:	November 2016

Beatrice Offshore Wind Farm

Geomorphological Assessment of Alternative Landfall Option

Rev	Prepared By	Signed	Checked By	Signed	Approved By	Signed	Date of Issue
01.0	Dr. Nick Cooper (Haskoning DHV)	[signature]	Naomi Campbell (BOWL)	[signature]	Jonathan Wilson (BOWL)	pp [signature]	24 /11/2016

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Glossary

Term	Definition
Cable	Beatrice Offshore Wind Farm's transmission high voltage (HV) alternating current (AC) 220 kV subsea export cable.
Back of the berm	Landward edge of the shingle berm, where the limit of the storm shingle washover fans meet the vegetation edge of the hinterland as measured by BOWL's 2016 topographic survey
Depth of Closure	The depth of water beyond which annually significant wave events will cease to contribute to beach sediment supply and morphological processes.
Direct Pipe	Direct Pipe® is a pipeline installation methodology pioneered by Herrenknecht which combines the advantages of micro tunnelling and HDD technology. This technique excavates the borehole using a micro tunnelling machine, pushed by the prefabricated final pipeline in one single step. The necessary thrust force is provided by the Pipe Thruster which pushes the micro tunnelling machine forward (or pulls it backward) together with the pipe – with a thrust force of up to 750 tonnes in increments of 5 metres. The push force is transferred to the Direct Pipe through the Pipe Thruster's clamping unit and then to the tunnelling machine's cutterhead.
EC1	Beatrice OWF's transmission subsea Export Cable 1 (Easterly cable)
EC2	Beatrice OWF's transmission subsea Export Cable 2 (Westerly cable)
Entry point	The onshore entry point for the pipe on completion of the Direct Pipe installation activities and after the pipeline has been cut to the required length. Typically the final pipe entry point corresponds to the front wall of the Pipe Thruster Pit.
Horizontal Directional Drilling (HDD)	A steerable, trenchless, method of installing an underground pipe, conduit or cable in a shallow area along a prescribed bore path by using surface-launched drilling equipment, with minimal impact on the surrounding area.
Landward transgression	A term used to describe the geomorphological behaviour of a landform under processes which lead to its landward movement over time.

Term	**Definition**
Landward translation	A term used to describe an analytical process whereby a survey transect is displaced in the horizontal plane by a defined distance (in this case the ‘set back distance’)
MHWS	Mean high water spring tide mark is located part-way along the seaward face of the shingle berm. BOWL’s 2016 topographical survey established the distance from MHWS to ‘back of berm’ was variable but approximately 25m
Pipe Thruster Pit	The onshore location of the Pipe Thruster unit. The Pipe Thruster Pit (sometimes known as the launch pit) is a temporary pit structure which provides the necessary structural anchorage for the Pipe Thruster Unit and is configured to allow the required ground entry angle for the pipe. The Pipe Thruster Pit is usually constructed from sheet piles and concrete which is fully removed on completion of the pipeline installation.
Set back distance	The distance by which landfall infrastructure will be set back from the shore so that projected future coastal erosion over the next 25 years can be accommodated without compromising the infrastructure. The set back distance is measured from the back of the berm. It has been established as a distance of 50m.
Shingle Berm	The wave-built, gently sloping, often sizable shingle or gravel barrier, between the seaward foreshore and landward backshore plane or hinterland. The barrier is usually characterised with a series of storm ridges on its seaward face and shingle wash over fans landward of its ridge.
Transition Joint Bay (TJB)	The onshore location where the 220 kV subsea cable is jointed to the 220 kV land cable. The TJB is part of the permanent cable infrastructure and is set some distance back from the onshore pipe entry points.
Vegetation edge	This is the edge of the hinterland vegetation where it meets the marine influenced beach topography. It is typically where shingle storm washover fans meet the vegetation edge of the hinterland. It is otherwise referred to as the ‘erosion edge’ or ‘back of the berm’.

1 Introduction

Beatrice Offshore Wind Farm (OWF) is located in the outer Moray Firth, with a consented landfall to the west of Portgordon. Beatrice Offshore Windfarm Limited (BOWL) currently has a Marine Licence and planning permission for the pre-installation of two horizontal pipes or ducts for the landfall installation of the two offshore transmission HV 220 kV cables. The pipes or ducts are to provide safe conduits for the cables underneath the designated Spey Bay Site of Special Scientific Interest (SSSI) coastal area.

As a prudent project risk management measure, as the pre-installation of the landfall pipes could encounter unworkable ground conditions, BOWL needs to apply for a separate and additional Marine Licence to cover a potential alternative cable installation methodology at the landfall. The additional Marine Licence application will cover the alternative open trenching of the landfall extending out to circa 420 – 450 m offshore from the current planned onshore pipe entry points (at the Direct Pipe Thruster Pits) across the hinterland, shingle berm, inter-tidal beach and shallow nearshore. Some of these open trenching works will take place directly within the Spey Bay Site of Special Scientific Interest (SSSI).

However it should be noted that BOWL's preferred approach for cable installation at the landfall remains a form of HDD, called Direct Pipe®. This is a pipe installation methodology pioneered by Herrenknecht which combines the advantages of micro tunnelling and HDD technology. This technique excavates the borehole using a micro tunnelling machine, pushed by the prefabricated final pipeline in one single step.

The potential effects of the cable installation at the landfall using this preferred method were previously assessed within the Beatrice OWF Environmental Statement (Ref: BOWL, 2012) and its subsequent Addendum (Ref: BOWL, 2013). The project received Section 36 consent (Ref: Scottish Ministers, 2014) and two Marine Licences in 2014, as varied in 2016 (Refs: Marine Scotland, 2014 and 2016).

There remains high engineering confidence that cable installation using Direct Pipe will be possible, and further engineering assessments are underway to provide further reassurance that this is the case. However, some problems associated with the use of HDD have been encountered on at least one other OWF project in the UK, and during technical due diligence by BOWL's financiers the use of any HDD technique was identified as a high potential single source project risk for which there is currently no alternative consented option. Additionally within the legal finance documents there is an obligation on BOWL to consent an alternative approach to the HDD technique such that the programme of construction works is not compromised. BOWL considers it practical and good industry practice to consent an alternative approach that would be implemented only in the event that the preferred installation approach of Direct Pipe fails. The development of an acceptable alternative methodology is required and sensible to demonstrate appropriate project risk management during the planning and delivery phase for all stakeholders.

This Technical Note provides the Geomorphological Assessment necessary to determine the potential effects arising from an alternative open trenching installation method at the cable landfall on the geological (geomorphological) features of the Spey Bay SSSI. Details on the Notified Natural Features of the SSSI are discussed in Section 2 of this document.

2 Baseline Environment

2.1 Physical Setting

The landfall location is located approximately 1.5km west of Portgordon harbour, directly within Spey Bay, Moray (Figure 1) and towards the eastern limit of the Spey Bay SSSI. It is proposed that 2 no. cables will make landfall approximately 350m to the west of the channel of the Burn of Tynet, with each cable separated by a distance of approximately 180m.

When considering the potential geomorphological effects of the proposed alternative installation method at the landfall, it is first necessary to understand the wider coastal setting within which the landfall is located. In this instance, an appropriate geographical extent for the geomorphological assessment is from Portgordon harbour in the east to Spey Mouth in the west (Figure 2).

This is deemed a suitable 'far field' study area because:

- at the eastern boundary, the eastern harbour wall at Portgordon harbour (Plate 1) provides an obvious barrier to the littoral[1] transport of beach sediment, which is generally from east to west along the frontage (although of course drift reversals can occur dependent upon the prevailing metocean conditions); and
- at the western limit, the hydraulic effect of fluvial discharge from the River Spey offers a partial barrier to this littoral transport of beach sediment, although it is acknowledged that sediment transport process can continue within the mouth and potentially beyond via complex process interactions between the beaches/spits, nearshore sea bed and tidal deltas at the mouth.

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[1] Littoral sediment transport refers to processes of beach sediment particles moving predominantly alongshore within the littoral zone.
This covers the inter-tidal zone and part of the nearshore sea bed.

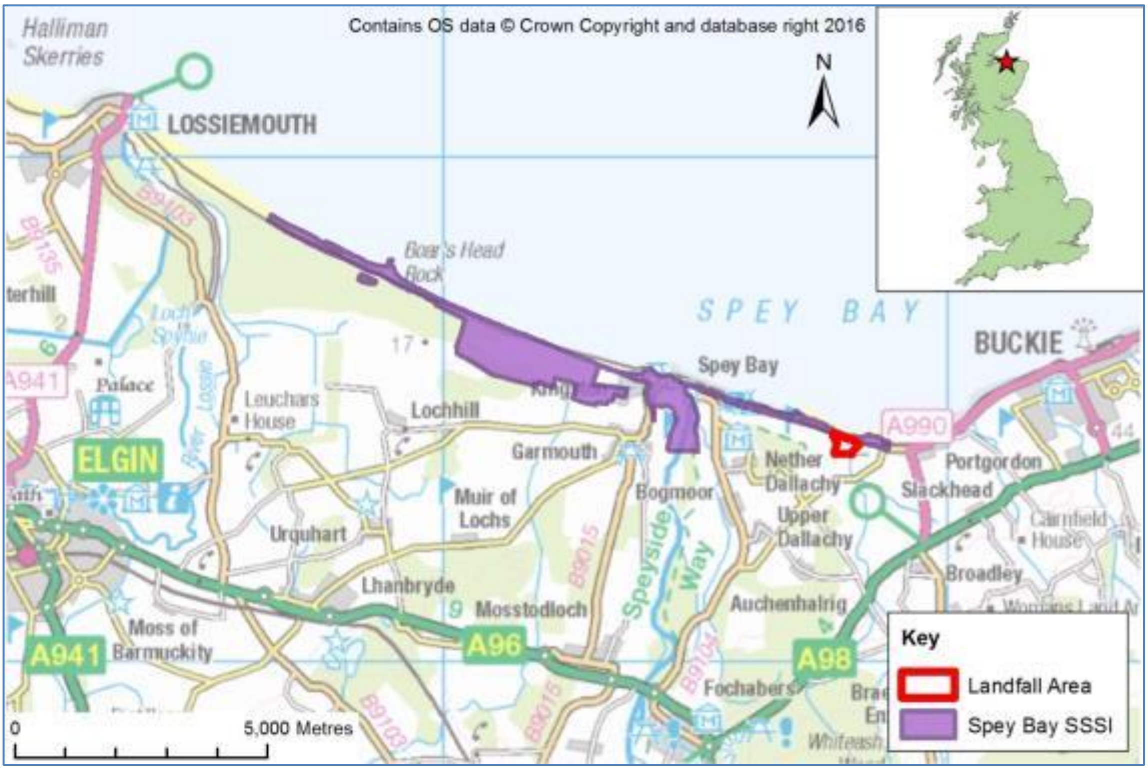

Figure 1: Location Plan

Figure 2 – Study Area

2.2 Previous Baseline Characterisation

Extensive work has previously been undertaken to characterise the baseline physical processes and coastal geomorphology within this study area as part of the Beatrice OWF Environmental Statement (BOWL, 2012 & 2013). This previous work has drawn fully from all known available published and 'grey' literature sources (e.g. Ritchie *et al.*, 1978; Ritchie, 1983; Dobbie & Partners, 1990; Hansom & Black, 1994; Riddell & Fuller, 1995; HR Wallingford, 1997; Ramsay & Brampton, 2000; Gemmell, 2000; Gemmell *et al.*, 2001) and whilst the work is not repeated here in full, it can be made available upon request. This section draws from the previous work to summarise the key findings from the earlier baseline characterisation thus:

- The coastline is orientated west northwest to east southeast.
- Portgordon harbour intercepts the westerly littoral drift of shingle. To the east of the harbour is a significant accumulation of shingle against the eastern harbour arm. A shingle beach and, further east still towards Buckie, exposed bedrock shore platform characterise the coastline to the east of the harbour.
- West of the harbour there is a concrete seawall with a sloping apron which is also protected by rock armour. This coastal defence protects properties at the western end of Portgordon. At this location the foreshore is characterised by sandy sediments.

- The rock armour extends some 50m beyond the seawall to provide protection to the eroding shingle bank, which sits at the top of the sandy foreshore.
- There are two outfall pipes which extend across the foreshore to discharge at sea.
- The shingle berm first emerges at Porttannachy and extends westwards from here to Spey Mouth, becoming progressively higher and wider with distance to the west.
- At Porttannachy, the beach is characterised by a relatively wide inter-tidal area named Tannachy Sands. This is composed of patchy sand overlying a conglomerate rock base. The active shingle berm is a low angled feature at this location, backed by a grassed bank which shows evidence of erosion and overtopping.
- At Tugnet, towards Spey Mouth, the sandy foreshore is entirely replaced by gravel and the coastline is characterised by a high shingle berm.
- The shingle berm has characteristic storm ridges on its seaward face and overwash fans landward of its crest along its entire length.
- Spey Bay is intersected by the outflow of the Burn of Tynet, located approximately 500m west of the eastern end of Tannachy Sands. At the time of the previous baseline assessment report (BOWL, 2012) it was stated that "the stream has maintained its present course since at least 1977". However, since production of the report, the outfall at the mouth has taken a more easterly deflection before discharging to sea – see Section 1.2, which summarises the notes from a site visit undertaken on 24th August 2016, for further information].
- The previous baseline assessment report (BOWL, 2012) also states that "evidence of undercutting and recession of the [Burn of Tynet] river bend can clearly be seen at the site. This is most likely due to a combination of high fluvial discharges during periods of heavy rainfall and storm wave activity within the drainage outlet across the beach".
- The net longshore drift direction is westerly, with a modelled potential annual transport rate of approximately 3,000m^3 (BOWL, 2012). Waves tend to dominate in driving sediment transport processes as currents are generally too weak to exert much influence.
- However, the magnitude and direction of transport can vary considerably depending on wave climate, indicating the dynamism of the coastal system.
- Historic shoreline evolution, based on mapping of mean high water and mean low water marks from historic Ordnance Survey maps shows that the coastline to the east of the Spey has experienced net recession over the past century. This is consistent with anecdotal evidence of changes at Spey Bay Golf Club, but is in contrast to the coastline west of Spey Mouth which has experienced accretion over the same time period.
- Based on analysis of historic maps and charts, an average annual erosion rate of 0.64m per year was calculated over an 85 year period.
- The beach closure depth (the seaward limit beyond which the sea bed does not form part of the 'active' beach profile for sediment transport) was calculated to be at a water depth of 5.8m below lowest astronomical tide (LAT). [Agreement has been reached between BOWL and SNH that 6m water depth shall be used as a basis for assessment].

2.3 Site Visit

To further develop baseline understanding of the characteristics of the study area, a site visit was undertaken on 24th August 2016 by Dr Nick Cooper (RHDHV) and Naomi Campbell (BOWL). The visit was planned around either side of low water to enable maximum exposure of the foreshore. The visit commenced at Portgordon harbour and proceeded westwards along the foreshore to Spey Mouth, returning to Portgordon along the backshore so that the full context of the environment could be appreciated.

The findings of the previous baseline assessment were corroborated, with one exception. At the time of the site visit, the outlet channel of the Burn of Tynet flowed for a short distance in an easterly direction before straightening at its exit to the beach (Plate 2). Previous maps (including OS Explorer 424) and aerial photographs (see Google Earth) show a braided channel with an initial westerly alignment before straightening and discharging (Figure 3), and the previous baseline assessment report (BOWL, 2012) stated that “the stream has maintained its present course since at least 1977”. It is now known that this localised change in alignment of the mouth is due to a new ‘cut’ being artificially created by the landowner. It is considered that whilst a dynamic process, the potential envelope of different mouth alignments is located within a relatively short length of frontage and that the landfall locations (starting around 350m to the west of the burn) will not be affected, nor will installation at the landfall, affect this dynamism.

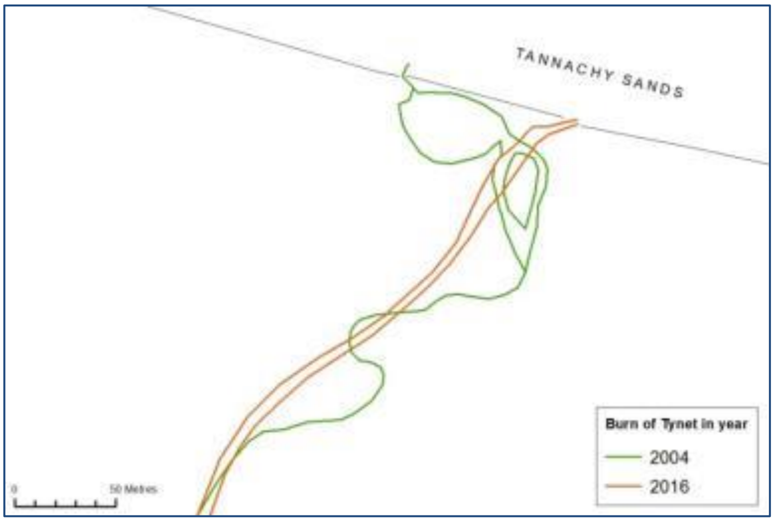

Figure 3 – Changes in location of the outlet channel of the Burn of Tynet

During the site visit, it was also thought that storm waves, many of which approach normal (or near-normal) to the shore profile were important processes to consider. Due to the low levels of obliquity with the shore profile, most waves will generally move sediment along an onshore-offshore axis, rather than alongshore. This explains why the potential net longshore drift rates defined by previous modelling of the characteristic wave climate are relatively low at approximately 3,000m^3 per annum (in many other areas in the UK dominated by sediment transport, net annual littoral drift can easily be one or two orders of magnitude greater). This understanding also helps explain the processes of storm-driven 'washover' at the crest of the shingle berm which leads to washover fans on the backshore (Plate 3), and the series of storm ridges which have formed at distinct levels on the seaward face of the shingle berm itself (Plate 4).

During the site visit, the opportunity was taken to record the morphology and sediments at a series of points along a shore-normal transect in the general vicinity of the proposed landfall of the two offshore transmission cables (Annex A). This clearly shows the shingle berm being a high and steep but relatively narrow feature sitting on top of a mid beach characterised by a mixed shingle and sand matrix, with a sandy lower foreshore and nearshore environment (Plate 5). This is in contrast to the shingle berm near to Spey Mouth, where the feature is a much wider structure, with shingle occupying the entire inter-tidal zone (Plate 6). In addition, the gravel clasts on the crest of the berm at the landfall location (Plate 7) are slightly smaller in general than those on the crest at Spey Mouth (Plate 8), although in both cases the clasts are relatively large pebble and cobble sizes and are well-rounded, indicating a relatively long residence time and having being part of an active transport system in the littoral zone. It should be noted, however, that some of the gravels on the delta deposits and berm at Spey Mouth may have been transported down river by fluvial flows in addition to the marine-derived sediments which undoubtedly are present in significant volumes.

With progression westwards along the study area from Porttannachy to Spey Mouth, it becomes apparent that the landfall location represents the approximate start of the shingle berm because the height, width and hence volume of pebble and cobble increases markedly towards Tugnet and Spey Mouth. Any short term disturbance during works would therefore be limited to the periphery of the feature.

2.4 Additional Data Sources

2.4.1 National Coastal Change Assessment for Scotland

The Scottish Government (SG) is currently undertaking a *National Coastal Change Assessment* for Scotland (Rennie *et al.* 2016). Between August and October 2016, Scottish Natural Heritage (SNH) provided BOWL with interim outputs from this study which were intended to inform BOWL about past and projected future projections of coastal change at the landfall site.

This information enabled BOWL to re-assess its previous engineering considerations of suitable set back distance of the Direct Pipe landfall infrastructure. This reassessment was based upon both the new information available from the *National Coastal Change Assessment*, and BOWL's risk appetite through the 25 years lifetime.

The dialogue between BOWL and SNH on the topic of erosion projections took place on several occasions and concluded with a telephone meeting between Dr. Alistair Rennie (SG/SNH) and Dr. Nick Cooper (technical adviser to BOWL) on 4th October 2016. A record of the dialogue on the erosion projections is presented in a sequential manner in Annex B. A synopsis of the principal findings associated with erosion rates arising from interpreting the outputs from the *National Coastal Change Assessment* project is below:

- The long term erosion rate for the landfall site is around 0.6m/year (1903 – 2014), measured as the change in Mean High Water Springs (MHWS). This matches well with a rate of 0.64m/year used to inform the engineering design considerations.
- The past epoch which is likely to provide the most appropriate analogue for the likely future changes over the next 25 years is the most recent 25 years. This is because the rates of recent past sea level rise, sediment supply and ground conditions are likely to be most similar to those projected for the next quarter-century.
- The average erosion rate in MHWS over the past 25 years (actually 24 years based on available data between 1990 and 2014) is around 1.24m/year. If this rate is projected over the next 25 years, then the erosion will affect 31m of land.
- As emerging information from the National Coastal Change Assessment project was refined between the first and second outputs, the erosion rate appears to have been altered (increased).
- When SNH were further updated with the most recent survey data provided by BOWL from 2016, the most recent rates of erosion (between 2003 and 2016) were calculated to be 0.9m/year at the western cable (EC2) and 0.6m/year at the eastern cable (EC1).
- If these most recent data are combined with data from 1990 to 2003, the average rates over the past quarter-century (actually 26 years) are 1.35m/year at EC1 and 1.05m/year at EC2.
- Recognising that there could be errors within the calculation of the erosion rates as an inherent consequence of inaccuracies in mapping the position of MHWS from historic data, a further sensitivity test was undertaken to consider the worst case of potential errors acting upon the worst case erosion rate established for any one given epoch.

Based on the above points, BOWL re-assessed its considerations of suitable set back distance for design and construction of the permanent landfall works, taking due account of a range of different projected rates, and sensitivities on those rates associated with uncertainties and errors in data mapping.

In addition and as part of the alternative cable installation methodology, BOWL has used the above to re-assess the depth of burial required to ensure that the cables do not become exposed by the ongoing landward coastal recession or storm-induced erosion events, over the 25 year design lifetime. This issue is further addressed in Section 4.

2.4.2 Geotechnical Investigation

A nearshore ground investigation was undertaken along the proposed export cable route of the Beatrice OWF by Fugro Seacore Limited from 13th February 2015 to 9th April 2015. The investigation was performed from the jack-up drilling platform Aran 120A and involved the drilling of 7 no. boreholes in water depths of between 2.59m to 9.20m. The location of the boreholes is shown in Figure 4 (reproduced from BOWL, 2015a). Borehole depths reached between 18.0m and 35.5m below sea bed level.

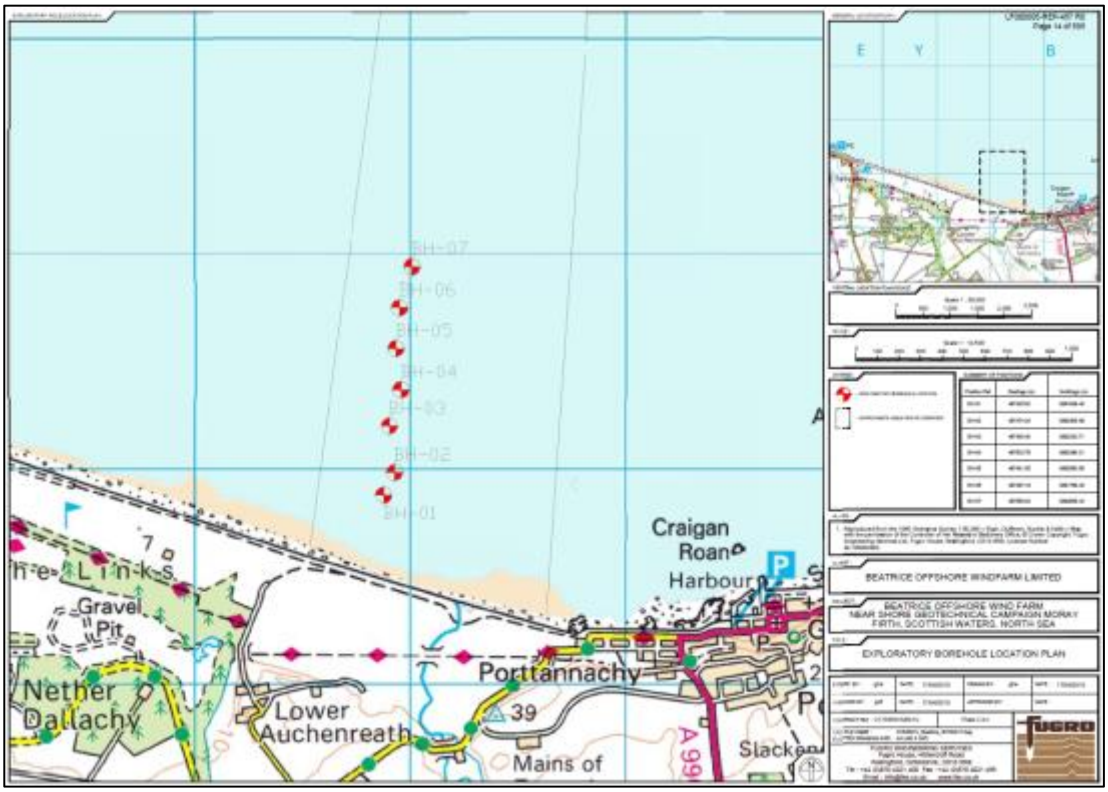

Figure 4 – A reproduction of Fugro's Exploratory Borehole Location Map (source: BOWL, 2015a)

The ground investigation identified conditions which comprise discontinuous deposits of Holocene sand, gravels and silts, over Quaternary Glacial Tills and Outwash Deposits with rest on Devonian Old Red Sandstone (BOWL, 2015b). The particle size analysis of soil samples from the borehole logs, at the sea bed and at depth, resulted in soil descriptions mostly of 'sands' and 'gravels' with varying quantities of silts or cobbles, but there were also some gravelly and/or sandy 'silts' and some gravelly 'cobbles'. The geotechnical data arising from the ground investigations are currently being utilised by BOWL and its technical advisors in planning the cabling operations in the nearshore and at the landfall.

3 Spey Bay SSSI

Spey Bay is designated as a SSSI, primarily because of its geological interest[2]. This geological interest is specifically attributable to its outstanding geomorphology, representing a site of the highest importance to Scotland for a number of reasons. The Spey Bay citation (SNH, 2012) lists the geology features as follows:

1. The active shingle ridges are the finest in Scotland. These are developed on a massive scale over a distance of 8km and provide almost unique evidence for short and medium-term dynamic coastal processes. [Note the SSSI extends west beyond Spey Mouth a considerable distance towards Lossiemouth].
2. The delta at the mouth of the Spey is a complex and shifting area with a documented history of dramatic changes.
3. The magnificent strand plain of post-glacial shingle ridges records the progressive history of coastal development.

The scale of this development, juxtaposition and inter-relationships of the above three elements makes Spey Bay 'one of the most important coastal physiographic sites in Britain' (SNH, 2012). Full description of the geomorphology of the Spey Bay SSSI is provided by J.D. Hansom in the Geological Conservation Review site report for Spey Bay published by the Joint Nature Conservancy Committee (JNCC). This has been reviewed in detail to inform the present assessments.

The designated site is 458.8 hectares in area and encompasses the delta at the mouth of the River Spey and the gravel deposits to both the west and east. Its cross-shore extent covers the inter-tidal zone and inland beyond, to a variable distance ~10 - 20m landward of the high water mark to encompass the shingle berm.

The following operations which are relevant to the cable landfall works would require consent from SNH within the SSSI:

1. construction of roads, tracks, fences, hardstands, or other earthworks, or the laying or removal of pipelines and cables; and
2. use of vehicles or craft likely to damage or disturb features of interest.

[2] The Spey Bay SSSI also has designated biological interest features.

4 Alternative Cable Installation Method

4.1 Background

The installation of the two High Voltage Alternate Current (HVAC) 220 kilo volts (kV) export cables from the Beatrice OWF to the onshore substation at Blackhillock, close to Keith, is expected to commence onshore in 2016. The installation of two pre-installed cable ducts (between 420 to 450 m in length), using Direct Pipe methodology, at the landfall at Portgordon is currently programmed to commence in January 2017 with site set-up, and complete by June 2017.

In support of the cable installation schedule an alternative methodology for an open trench installation method at the landfall has been developed by Nexans Norway, who has been commissioned to deliver and install the two export cables (BOWL, 2016). This alternative method has been developed following analysis of the geophysical and geotechnical surveys and the seismic refraction survey described at the end of this section. Key information relating to the proposed alternative methodology is provided below and in summary form in Table 1.

4.2 Alternative Open Trench Methodology

Under the alternative methodology, it is proposed that 2 no. cables would make landfall approximately 350m to the west of the Burn of Tynet, with each cable separated by a distance of approximately 180m (Figure 6). At each cable location, burial of the cable at landfall would be achieved through open trenching across four distinct zones, namely the hinterland, the shingle berm, the inter-tidal zone and the shallow nearshore (extending seawards to a depth of around 1m below LAT) (Figure 5). The trenching will continue offshore beyond this point, however that element of the cable route does not form part of this Technical Note and has previously been addressed separately as part of the original Marine Licence.

The sediment characteristics of the four zones differ as follows:

- **Hinterland** - comprising ~40cm of topsoil overlaying sand with some gravel.
- **Shingle berm** - predominantly gravel and cobbles, with some sand.
- **Inter-tidal** - characterised predominantly by sand and gravel, with low cobble content. and locally silty patches.
- **Shallow nearshore to 1m below LAT –** as above.

The zones are illustratively shown on Figure 5.

Figure 5 – The four sediment zones identified

4.3 Burial Depths

Cable burial at landfall needs to take due account of both: (i) changes in beach levels that may be associated with individual storms (short term responses); and (ii) net landward migration of the nearshore beach profile and shingle berm over the 25-year planned lifetime of the wind farm (longer term responses). As previously discussed, a highly conservative set back distance for the landfall works of 50m is being adopted for the purposes of the construction works, to account for the longer term response of the shingle berm, informed by the following:

- historic erosion rate including both localised nearshore seabed lowering and landward retreat;
- projected changes in MHWS over time;
- projected sea level rises;
- Scottish Environment Protection Agency (SEPA) flood maps (flooding in area); and
- changes to the river morphology, especially at the mouth of the Burn of Tynet.

Engineering design, which focused on ensuring the integrity of the cables over their 25 year design life, established depths of burial for each of the four distinct zones as follows:

- **Hinterland** – Up to 8m depth to allow landward transgression of the shingle berm, tapering to ~1.3m depth where the landfall cable will align with the land cable through the transition joint bay.
- **Shingle berm** – Up to 8m depth.
- **Inter-tidal** – Up to 3m depth
- **Shallow nearshore** – Up to 2m depth, aligning the landfall cable with the sea cable depth of 1.7m below mean low water (MLW) in a water depth of around 1m below LAT.

For the locations requiring modest cable burial depths (i.e. those across the inter-tidal and shallow nearshore), the trench is likely to be 1.0m in width at its base. The current thinking is that the trench would be trapezoidal in cross-sectional shape across these locations.

However, where the trench needs to be considerably deeper (i.e. through the shingle berm and hinterland) two options have been considered: (i) an unsupported trench wall with a trapezoidal cross-section; and (ii) a sheet-pile supported trench wall with a rectangular cross-section. The selection of the preferred approach to burial through the hinterland and shingle berm is discussed later.

Figure 6 – Schematic Landfall Details

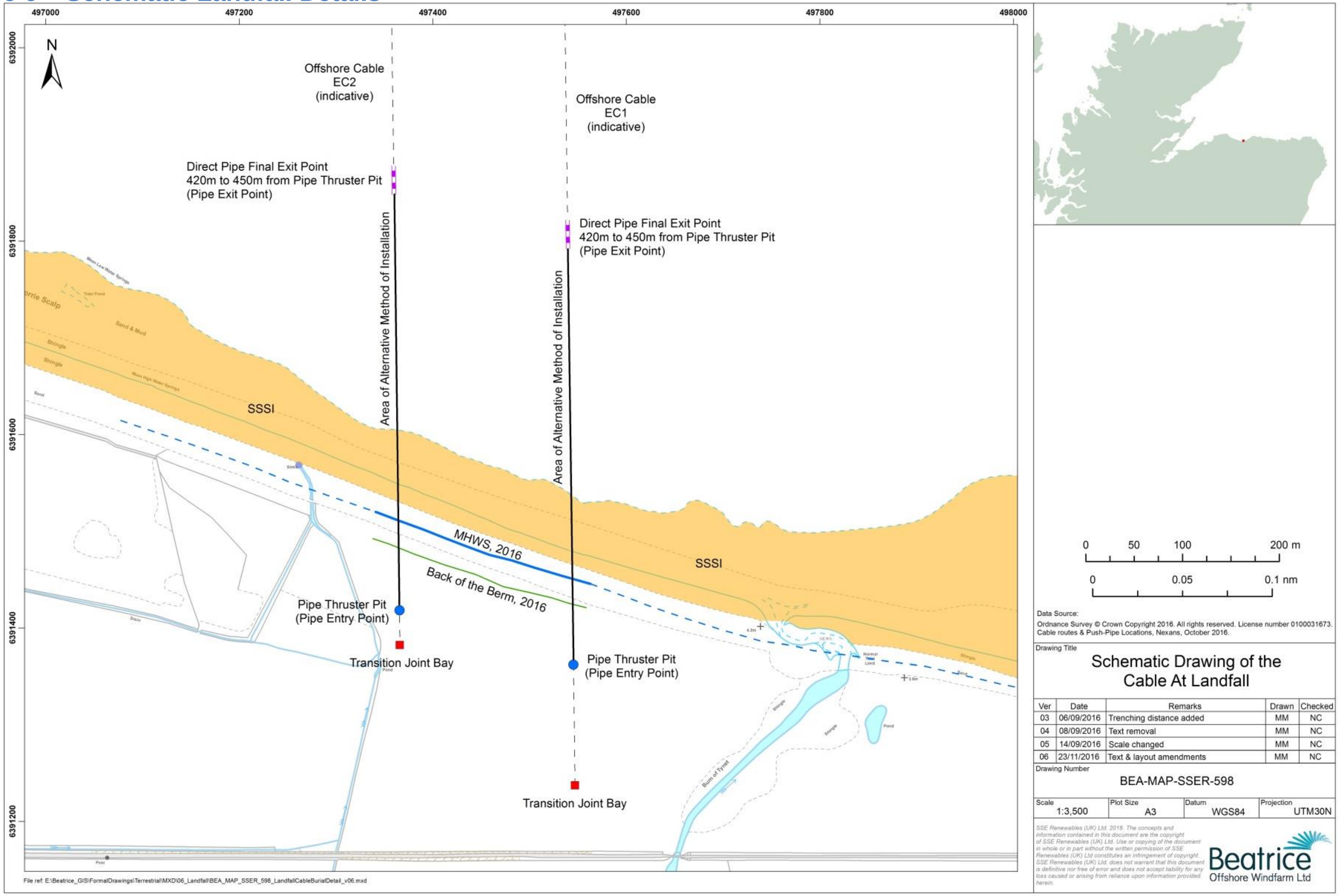

Table 1 – Summary Information on Construction Method for Open Trenching at Cable Landfall (all values rounded to nearest whole number)

Description	Details	Comments
Number of trenches	2	Export Cable 1 (EC1) (East) and Export Cable 2 (EC2) (West)
Separation of trenches	Approximately 180 m	-
Dimensions of trenches	Hinterland: rectangular trench EC1: 93 m x 4 m x 8 m EC2: 102 m x 4 m x 8 m Shingle berm: rectangular trench EC1: 33 m x 4 m x 8 m EC2: 34 m x 4 m x 8 m Intertidal: trapezoidal trench EC1: 39 m x 4 m x 3 m EC2: 40 m x 4 m x 3 m Subtidal: trapezoidal trench EC1: 255 m x 4 m x 2 m EC2: 244 m x 4 m x 2 m	Length x Width (at base) x Depth (min and max depth values are the same) Hinterland: assumes steel sheet pile supported trench walls Shingle berm: assumes steel sheet pile supported trench walls
Plan area of trenches	Hinterland: EC1: 372 m^2 EC2: 408 m^2 Shingle berm: EC1: 130 m^2 EC2: 137 m^2 Intertidal: EC1: 157 m^2 EC2: 162 m^2 Subtidal: EC1: 1,020 m^2 EC2: 974 m^2	Values for intertidal and subtidal (trapezoidal trenches) will be slightly greater as width at surface will be greater than width at base, however the differences will not be significant due to the shallow depths of these trenches. Total area affected from the Pipe Thruster Pits to MLWS = 1,366 m^2, of which 586 m^2 is within the SSSI, representing only 0.013% of the designated site. If only the 'sub-unit' of SSSI between Spey Mouth and Portgordon is considered (covering 44ha), then the total area represents only 0.13% of this 'sub-unit' of the SSSI.
Volume of sediment extracted	Hinterland: EC1: 2,979 m^3 EC2: 3,261 m^3 Shingle berm: EC1: 1,043 m^3 EC2: 1,098 m^3 Intertidal: EC1: 472 m^3 EC2: 485 m^3 Subtidal: EC1: 2,039 m^3 EC2: 1,948 m^3	All values rounded to nearest whole cubic metre. Total volume of material excavated from the Pipe Thruster Pits to MLWS = 9,337 m^3, of which 3,097 m^3 is within the SSSI.
Working areas	30 m width (including trench width)	Conservative estimate, with working area running parallel to the trench, from the Pipe Thruster Pits to MLWS.
Storage areas	Two 30 m x 30 m (approx.) areas	Located landward of the SSSI boundary and MHWS.

4.4 Programme

There are two installation scenarios for the alternative open trench installation approach for the offshore transmission cables:-

- Option 1 involves a phased approach, whereby the first export cable (EC1) would be installed in August/September 2017, with the second cable (EC2) installed in March/April 2018.
- Option 2 involves a simultaneous approach, whereby land excavation works for both EC1 and EC2 are carried out in 2017. However for the EC2 cable a suitable cable duct would need to be installed in the open trench and then back filled and the ground reinstated. Later in March / April 2018 the EC2 cable duct exit would be opened up on the beach and the cable pulled in, followed by nearshore burial works.

Under Option 1, the total duration for the installation of the export cables is 9 months (EC1) and 7 months (EC2) across two years. The last 2 months of each cable's installation would involve nearshore cable burial works only and the sheet piling and inter-tidal trench would be already completed and the areas fully reinstated.

Under Option 2, the works would predominantly take place during 2017 over 9 months (EC1 and EC2 cable duct), with the remaining EC2 works taking place over 4 months in 2018. Similar to above, the last 2 months of each cable's installation would involve nearshore cable burial works only and the sheet piling and inter-tidal trench would be already completed and the areas fully reinstated.

Timescales will be confirmed following appointment of the installation subcontractor.

4.5 In-Built Mitigation

A number of 'mitigations through design' and 'mitigations during construction' have been considered in selection of the appropriate methodology for the open trench method, as discussed below.

- *Mitigation through design – selection of appropriate trenching method*

There are two possible solutions for installing the cable at the landfall through an open trench method. The first is to dig a trench with relaxed side slopes to provide a safe and manageable width within which to work without risk of collapse of the sides of the trench. The other is to use steel sheet piles to support trench walls and hence minimise the overall width of trench.

The second approach has been selected in preference to the first, throughout the hinterland and shingle berm, because the use of supported walls helps to minimise the extent of excavation that is needed in the loose and unconsolidated sediments, where the depth of cable burial needs to be considerably greater (up to 8.0m) than for the inter-tidal or shallow nearshore zones. For example, for each cable the total work area (trench plus transport area either side) for the unsupported wall option would be 75m wide, whereas for the supported wall option this is reduced to a 30m total work area width, with the trench itself through the sheet piled section only needing to be 8m wide at its base. Not only would this reduce the plan area of disturbance but it would also significantly reduce the volume of material that will need to be excavated, temporarily stored and then replaced. As the depth of burial in the inter-tidal and shallow nearshore areas is not so great, there are no such advantages in the use of steel sheet piles to support trench walls and hence they will be unsupported. In fact, the use of steel sheet piles in these areas would potentially have (minor) adverse effects on sediment transport within the littoral zone. Consequently the length of the sheet piles will extend across the hinterland and shingle berm, but terminate at the toe of the shingle berm. The sheet piles would stand proud of the land surface across the hinterland and shingle berm. There is, therefore potential for some interruption of longshore sediment transport (although longshore sediment transport rates are low and much of what occurs does so between MHWS and MLWS and less so on the shingle berm itself, which is more dominated by cross-shore sediment transport during storms which cause the longer-term 'rollback' of the berm over time).

- *Mitigation through design – landward set back distance*

An observed long term erosion rate of 0.64m per year has previously been derived from analysis of historic maps (BOWL, 2012). For the purposes of design of the landfall works, this rate was translated into a highly conservative set back distance for the landfall works of assuming 50m recession over 25 years, measured from where the landward limit of shingle washover fans meets the vegetation edge of the hinterland in the present day (2016). This was calculated as follows:

- Long term erosion rate = 0.64m/year, rounded up to 0.7m/year for conservatism
- 25 years x 0.7m/year = 17.5m erosion
- Factor of safety = 2.0
- 2.0 x 17.5m = 35m
- Additional contingency = 15m
- Total set back distance = 35m + 15m = 50m measured from the back of berm

In addition, there is a (variable) distance of circa 25m between this point and the mark of mean high water springs (MHWS) on the seaward face of the shingle berm.

Since establishing a 50m set back distance (from the back of berm) for the permanent landfall infrastructure, outputs have become available from the Scottish Government's National Coastal Change Assessment (as previously discussed in Section 2.4.1).

Due to this a re-assessment of the landward set back distance has been undertaken (see Annex B) in light of this emerging information, taking due account of a range of different projected rates and sensitivities associated with uncertainties and errors in data mapping. After this re-assessment BOWL remains confident that its use of a 50m set back distance measured from the back of berm is a suitably conservative approach given the inherent uncertainties in extrapolating past rates into future projections.

Re-analysis of BOWL's engineering design following establishment of the erosion rates and the set-back distance confirmed the suitability of the depths of burial across each of the four distinct zones. This is further described below.

- *Mitigation through design – cable burial depth*

The cable burial depth has been designed to accommodate anticipated erosion over the 25 year lifetime of the development in terms of both vertical (downward) lowering and horizontal (landward) recession of the active beach profile.

To assess the suitable cable burial depth between the toe of the shingle berm and the closure depth of the active beach profile under storm wave action, it would be ideal to have bathymetric data covering the seabed over at least two (and ideally more) successive surveys separated by a suitable gap in time to capture seasonal, annual or decadal scale changes. However, in the absence of such data an alternative is to use widely adopted empirical ‘rules of thumb’ relating to the maximum potential depth of sediment disturbance (sometimes referred to as the ‘mixing depth’) at the shore or seabed caused by waves of a certain maximum theoretical height. This can be used as proxy for the maximum potential seabed lowering during short-term storm events.

However, just because the sediments could theoretically be disturbed to this depth does not mean that the shore or seabed will change its morphology and, in fact, more usually most disturbed sediment will settle rapidly back down with no net resulting lowering of the shore or seabed. Notwithstanding this, it is recognised that material infilling the cable trench between the toe of the shingle berm and the depth of closure may be less consolidated than the surrounding sediment and therefore may more readily be quarried by waves. Consequently, applying this approach provides a useful check on the indicative order of burial depth that may be required to avoid a cable being exhumed by storm waves.

The empirical approach considers the maximum attainable depth-limited wave in shallow water in flat seabed regions using the simple ‘rule of thumb’ developed by Nelson (1994):

$$h = d * 0.55$$

Where:

h = wave height (in m)

d = water depth (in m)

It then applies a further simple ‘rule of thumb’ to determine the maximum depth of disturbance (also known as mixing depth) under the maximum attainable wave height, based upon the research of Ferreira *et al.* (2000):

$$z = h * 0.23$$

Where:

z = depth of sediment disturbance (in m)

h = wave height (in m)

Note: The above relationship between wave height and depth of sediment disturbance is similar to other researchers’ findings in areas with steep bed gradients, but yields results significantly greater than those observed on gentle bed gradient. It must therefore be considered highly conservative for the very gently sloping seabed between the exit point and closure depth of the active beach profile at Spey Bay. In fact Ferreira et al. (2000) found in their tests that the results from the equation were around 8 times greater than those observed in areas of gentle gradients.

Application of these simple empirical 'rules of thumb' to conditions at the exit point and at the closure depth provides the results shown in Table 2.

Table 2 – Maximum potential depth of sediment disturbance by waves

Location	Maximum attainable water depth at HAT (m)	Maximum attainable wave height (m)	Maximum depth of disturbance (m)
-1.1m LAT (EC1) -1.0m LAT (EC2)	5.0 (EC1) 4.9 (EC2)	2.75 (EC1) 2.70 (EC2)	0.63 (EC1) 0.62 (EC2)
Closure depth -6.0m LAT (EC1 & EC2)	9.9	5.45	1.25

The water depth at Highest Astronomical Tide (HAT) represents the worst case for maximum attainable wave heights. The maximum attainable water depth at HAT has been calculated using the water levels presented in the UK Hydrographic Office's Admiralty Tide Tables for 2016. The nearest Standard Port to the landfall site is at Fraserburgh (where Chart Datum (CD) is 2.20 m below Ordnance Datum Newlyn. The water levels stated are:

- LAT = 0.4 m above CD
- MLWS = 0.8 m above CD
- MLWN = 1.5 m above CD
- MSL = 2.3 m above CD
- MHWN = 3.0 m above CD
- MHWS = 3.8m m above CD
- HAT = 4.3 m above CD

The above assessment shows that the target burial depths (3m across the inter-tidal, 2m across the nearshore subtidal to a water depth of around 1m below LAT and 1.7m thereafter to the closure depth) are considerably lower than the maximum theoretical depth of sediment disturbance at these locations.

Furthermore, a suitable factor of safety exists between the theoretical maximum depth of seabed disturbance and the depth of cable burial. This should ensure that the cable remains buried between the toe of the shingle berm and the depth of closure of the active beach profile throughout the 25 year operational life of the development in respect of storm wave action.

The inter-tidal shore and seabed is understood, through site visits and bathymetric and geophysical surveys, to be relatively flat and featureless, but the formation of bar/swale features cannot necessarily be discounted during storm events. Nonetheless the wave heights of these features on the bed or shore are small (order of centimetres to a few tens of centimetres) and such features would not cause the cable to become exposed.

In order to assess maximum potential seabed changes in the longer term associated with landward transgression of the active beach profile, a digital ground model has been developed using the available topographic, bathymetric and geological data of the hinterland, shingle berm, inter-tidal and near-shore seabed along a transect for each offshore transmission cable, extending seawards to the closure depth at 6m water depth.

A translation approach has then been undertaken to relocate the whole transect, from back of the berm to the depth of closure, landwards by a distance of 50m. This translation distance was determined using the methods previously described and has been re-assessed in light of emerging evidence from the Scottish Government's National Coastal Change Assessment project in the manner previously described earlier in this section.

This approach represents a pragmatic means of assessing the profile response to landward transgression adopting the principles of conservation of mass and continuity of form and function. The fact that the approach does not incorporate longshore sediment transport is not considered a fundamental constraint on its applicability to Spey Bay because the longshore transport rates are relatively low, estimated at approximately 3,000m^3 per annum (BOWL, 2012).

The landward translation model does simplify the processes which control the migration of the profile, and especially the shingle berm, but it is considered that these processes are inherently incorporated within the determination of long-term erosion rates. For example, the 'roll-back' of the shingle berm will not likely be associated with an ongoing, progressive change, but is more likely to be governed by episodic storm events that force pebbles and cobbles to wash over the crest of the berm and form wash-over fans on the landward side (Orford & Anthony, 2011). However, these processes will have occurred in response to storms in the past and therefore are inherently incorporated within a net average long term rate of recession.

Furthermore, the landward translation model is deemed conservative because only a horizontal component has been incorporated. The 'Bruun Rule' for coastal retreat under rising sea levels (Bruun, 1954; 1962; 1988), which forms the underlying basis of the landward translation model, assumes that as the recession occurs material eroded from the upper shore will become deposited on the lower shore and near-shore and thus the whole profile will experience a vertical shift upwards in its position as the landward translation occurs. This vertical component has been omitted from the landward translation model considered here, partly because the shingle berm will not necessarily behave in this manner (it is more likely to roll-back under storm wave action) and partly because the 'uplift' component in the Bruun Rule is due primarily to sea level rise. At Spey Bay the rates of sea level rise over the next quarter-century are projected to be relatively low and there is a good level of confidence in projections over such timescales. Confidence in climate change projections decreases with progression into the future, say 50 years and especially 100 years.

With the above in mind, the landward translation model represents the most pragmatic (and arguably only technical feasible) means of assessing whether future changes in the seabed over a 25 year operation life will impact upon cable exposure. The important point is to recognise the uncertainties associated with the projections and ensure that a sufficient factor of safety is built into the design.

Reflecting this approach, it is possible to determine the change in seabed level between the present and future projected active beach profile after landward translation of the profile by a conservative distance of 50m. Along both EC1 and EC2 the change in sea bed level due to the landward translation is < 0.2m at any point between the final exit point and further seawards across the active beach profile over the 25 year operation life of the Development. Within the zone between MLWS and LAT there can be occasional ‘high points’ in the bathymetry due to the presence of minor swale or bar features, but these only protrude a height of approximately 0.3m above the sea bed and when combined with the general 0.2m (maximum) lowering over 25 years, the total change in sea bed level can be of the order of 0.5m locally within this nearshore zone. The above assessment shows that the target burial depths (3m across the inter-tidal, 2m across the nearshore subtidal to a water depth of around 1m below LAT and 1.7m thereafter to the closure depth) are well below the maximum theoretical extent of seabed change at these locations. This should ensure that the cable remains buried between the toe of the shingle berm and the depth of closure of the active beach profile throughout the 25 year operational life of the development in respect of storm wave action.

In addition to the need to ensure the cable remains buried between the toe of the shingle berm and the depth of closure of the active beach profile, it is also important to ensure that the cable remains buried below the shingle berm and hinterland as the shingle berm translates landward.

Figure 7 shows detail of the 50m landward translation of the active profile in the vicinity of the shingle berm. The maximum change in surface level at any point along these sections due to the translation is 5.3m (directly under the moving crest of the shingle berm). This value, plus a further minimum 1m residual burial sets the minimum burial depth to avoid re-exposure of cable to be 6.3m.

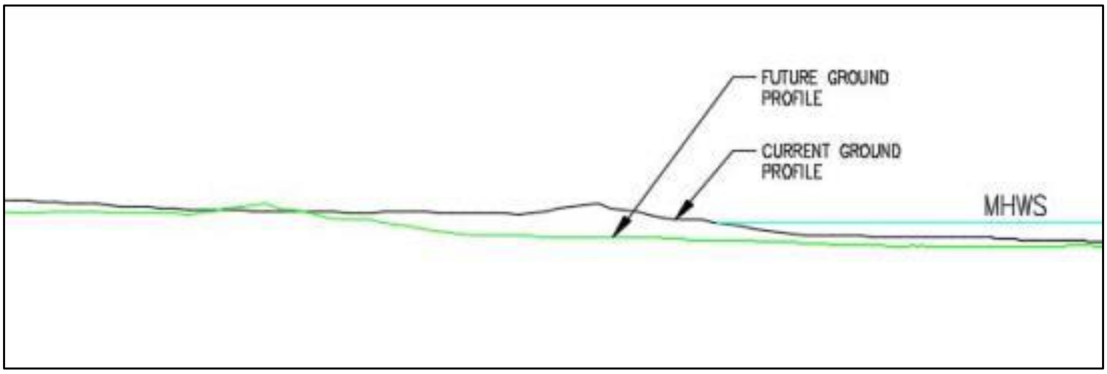

Figure 7 – Landward translation of the shingle berm by a set back distance of 50m

The above assessment demonstrates that the cable is designed to be buried at a sufficient depth (8m) below the hinterland and shingle berm to accommodate the longer term landward transgression of the profile in the vicinity of the shingle berm without re-exposure of the cable.

- *Mitigation during construction phase – selection of appropriate construction plant*

Consideration has been given by Nexans Norway (construction contractor) to the plant that it may use during the trenching operations. Whilst the exact detail will not be known until subcontractors have been appointed, it is likely that a number of excavators, dumpers and cranes/winches would be required. In particular, there is an intention to use a Menzi Muck in preference to an excavator in the areas between (around) MLW and 1m below LAT. In this location, a Menzi Muck is more manoeuvrable and has the ability to work in 1- 2m water depth. Selection of appropriate plant would reduce the potential for over-excavation and reduce time delays during construction. Figure 8 below shows a Menzi Muck of a type similar to that proposed for the alternative installation method.

Figure 8 – Menzi Muck of type proposed for excavation work in the lower shore (image courtesy of Nexans Norway)

- *Mitigation during construction phase – working and stockpiling areas*

Working and stockpiling areas would be kept to a minimum size during the construction phase. This would reduce the potential for adverse effects associated with a 'direct footprint' on the designated areas by keeping plant/stockpiles off the SSSI and minimising working/stockpiling within it. A preliminary estimate is that a stockpiling area for each of the two cables would need to be approximately 30m by 30m in plan area, with these temporary stockpile areas being located well inland of the SSSI boundary. The working area for transport/access would need to be 30m wide (including the trench width), running parallel to the trench.

- *Mitigation during construction phase – soil handling*

In so far as is practicable, excavation of material along each trench would be undertaken in separate sediment layers and material of different grades would be stored separately within the temporary stockpile area for the respective cables.

- *Mitigation during construction phase – reinstatement*

Reinstatement of the shingle berm, inter-tidal beach and shallow nearshore seabed is likely to be a key consideration when ensuring that SSSI is not significantly impacted in the medium to long term, despite the inevitable short term and localised disruption that will occur using this method of cable installation. Reinstatement will be undertaken on a 'layer by layer' basis in reverse order to the excavation sequence. This reduces potential for adverse effects on the sediment structure of the shingle berm within the affected area.

4.6 Surveys and Studies

In addition to the in-built mitigation above, a number of further surveys and studies have been undertaken to further inform understanding of the environment and in so doing influence the development of the installation methodology. These are:

- *Export Cable Geophysical and Geotechnical Survey*

A geophysical and geotechnical survey was undertaken along the proposed export cable route (and inter-array cable routes) of the Beatrice OWF by MMT in August and September 2015. The geophysical survey comprised bathymetric, side scan sonar and sub-bottom profiling data collection (also with transverse gradiometer for unexploded ordnance (UXO) detection). A Remotely Operated Vehicle (ROV) was also used to acquire video imagery of the sea bed. The geotechnical survey comprised vibrocore samples and cone penetrometer tests. The geophysical and geotechnical data arising from the survey are currently being utilised by BOWL and its technical advisors in planning the cabling operations in the nearshore and at the landfall.

- *Export Cable Seismic Refraction Survey*

A seismic refraction survey was undertaken along the landward section of the cable in May 2016 and along the marine section of the cable in June 2016 to inform cable installation design at the landfall.

6 Geomorphological Assessment

Based on the available information presented in this document, the potential effects that may occur to the SSSI are described and assessed in relation to construction stage effects, operation & maintenance stage effects and decommissioning stage effects.

6.1 Construction Stage

- **Trenching activities may directly damage or disturb geomorphological features of the Spey Bay SSSI**

It is considered that this potential impact is not likely to have a significant effect on the environment, taking into account the criteria in Schedule 1 of the EIA Regulations, for the following reasons.

In terms of the extent of the impact, the total plan area affected by trenching from the Pipe Thruster Pits to MLWS will be 1,366 m^2, of which 586 m^2 is within the SSSI. This represents 0.013% of the designated site and therefore the extent of the impact is very small. Even when considered over only the 'sub-unit' within the SSSI between Spey Mouth and Portgordon (covering 44ha), then the total area directly affected by trenching represents only 0.13%. There is then a further very small area of shallow nearshore seabed affected (1,994 m^2), but this will rapidly infill naturally with sediment under the routine daily tidal and wave regime.

In terms of duration, frequency and reversibility of the impact, disturbance will be relatively short term (up to 7 months in 2017 and an additional 5 months in 2018 as a worst case), occurring over one installation event per cable, and will be temporary, since there are viable proposals to reinstate the morphology of the shingle berm and intertidal zone affected by the trench following installation of the cables.

For these reasons, and due to the designed-in mitigation measures previously described, it is considered that there will be no likely significant effects on the geological features for which the Spey Bay SSSI is designated from this impact.

- **Construction working areas may directly damage or disturb geomorphological features of the Spey Bay SSSI**

It is considered that this potential impact is not likely to have a significant effect on the environment, taking into account the criteria in Schedule 1 of the EIA Regulations, for the following reasons.

In terms of the extent of the impact, the total potential construction working area across the shingle berm could extend to 2,007 m2 as a worst case and a further 2,370 m2 across the inter-tidal zone. However, construction will not take place across the full corridor for the full construction period, with many areas either un-impacted, or left undisturbed and able to recover for a period of time after initial impacts.

In terms of duration, frequency and reversibility of the impact, disturbance across the working area will be relatively short term (up to 7 months in 2017 and an additional 5 months in 2018 as a worst case), occurring over one installation event per cable, and temporary.

Following cessation of works it is expected that the behaviour characteristics of the directly affected areas will be reinstated naturally within a few tidal cycles (for the intertidal area) or after a few storm events (for the shingle berm).

For these reasons, and due to the designed-in mitigation measures previously described, it is considered that there will be no likely significant effects on the geological features for which the Spey Bay SSSI is designated from this impact.

- **The presence of temporary storage areas may directly damage or disturb geomorphological features of the Spey Bay SSSI**

It is considered that this potential impact is not likely to have a significant effect on the environment, taking into account the criteria in Schedule 1 of the EIA Regulations, for the following reasons.

In terms of the extent of the impact, the temporary storage areas will occupy an indicative total plan area of 1,800 m2 but these sites will be located landward of the SSSI boundary.

In terms of duration, frequency and reversibility of the impact, disturbance will be relatively short term (up to 7 months in 2017 and an additional 5 months in 2018 as a worst case), occurring over one installation event per cable, and will not affect the Spey Bay SSSI, lying landward of the SSSI boundary.

For these reasons, and due to the designed-in mitigation measures previously described, it is considered that there will be no likely significant effects on the geological features for which the Spey Bay SSSI is designated from this impact.

- **Cable installation activities may affect sediment transport processes**

The temporary presence of the trench and (where present across the shingle berm only) the temporary presence of the steel sheet piling both create the potential for some interruption of longshore sediment transport. (The sheet piling across the hinterland will not affect these processes but the sheet piling through the shingle berm, seaward to its toe, will be proud of the land surface). It is considered that this potential impact is not likely to have a significant effect on the environment, taking into account the criteria in Schedule 1 of the EIA regulations, for the following reasons.

The works are at the eastern end of this sediment transport pathway and net transport rates are relatively low. With the trench/sheet piles being present for up to 7 months in 2017 and an additional 5 months in 2018 as a worst case, additional mitigation measures are recommended, including monitoring of sediment levels and accumulation on either side of the trench/sheet piles, and the use of sediment bypassing in the form of an excavator removing and relocating accumulated sediment to enable the continuous feed of the sediment transport system. With such a vast volume of sediment available elsewhere within Spey Bay, any effects of the trenching on sediment transport processes are likely to be minor.

Due to the duration of the trenching and/or sheet piling works, there is the potential that one or more major landforming storms could occur while the trench or the sheet piles are in place. However, most storm waves approach relatively perpendicularly to the shore and over the shingle berm (where sheet piles will be present) these waves govern more the onshore to offshore transport of sediment, moving it up and over the crest of the shingle berm to create washover fans. This process will only be inhibited directly in the footprint of the trench and piles. It is theoretically possible, however, that a storm, or storms, could occur with a wave approach angle that is oblique to the shore. In this case there is potential for either the open trench or the sheet piles to interrupt modest rates of sediment transport. Under such events, sections of trench will likely become partially or totally infilled in unsupported (open) sections (i.e. those areas that are open across the inter-tidal and shallow seabed during this process) and may interrupt longshore sediment transport where the sheet piling is present through physical 'blockage'. Due to this, the proposed additional mitigation measures recommended above, involving monitoring of sediment accumulation on either side of the trench/sheet piles, and the use of sediment bypassing operations, will ensure the continuous feed of the sediment transport system. Due to this mitigation, any effects of the trenching and piling during major landforming storms on sediment transport processes are likely to be minor and these effects will be mitigated a short time after the storm has passed.

When the trench is infilled and, where present, when the sheet piles are removed, the morphology of the shingle berm and intertidal zone will be reinstated and there is not expected to be any further effects.

Taking into account the additional mitigation measures noted above, it is considered that there will be no significant impact upon longshore sediment transport processes within Spey Bay as a result of the temporary presence of the trench.

- **Cable installation activities in the intertidal and subtidal zones may increase SSC within the water column and deposit material on seabed**

It is considered that this potential impact is not likely to have a significant effect on the environment, taking into account the criteria in Schedule 1 of the EIA regulations, for the following reasons.

In terms of the extent of the impact, it will be limited in spatial extent to the length of the trench and, for deposition, a short distance either side. It will be limited in temporal extent to a short duration of trenching and backfilling activity.

Furthermore, the location of the trenching in the intertidal and subtidal zones is an area of breaking wave activity where sediment transport is most likely to occur (although this natural process is limited in magnitude) and hence there would be relatively high SSC levels in these zones under baseline conditions.

The temporary and localised increase in SSC and associated deposition is not likely to be beyond the range of conditions naturally experienced due to varying wave climate under the baseline conditions.

6.2 Operation and Maintenance Stage

- **Cable exposure and the need for re-burial**

Cable burial depths have been determined based upon an understanding of both the maximum theoretic depth of seabed disturbance across the inter-tidal shore and nearshore seabed and a conservative estimate of future landward transgression (sometimes referred to as ‘rollback’) of the shingle berm across the hinterland. These considerations should ensure that the cable remains buried over this time period and exposure is not experience and therefore re-burial is not required. There will therefore be no impacts arising from the cable during the 25 year operational lifetime of the development.

However, if in the future the cable is exposed or at risk of exposure at any point seaward of the toe of the shingle berm, the cable could be reburied by undermining the cable either using localised excavation or water jetting techniques. This would effectively lower the cable within the sediments.

6.3 Decommissioning Stage

After the 25 year operational life of the wind farm, the cable will then either be left in situ (in which case there will be no decommissioning impact) or replaced/removed. In the latter event, the potential impacts of decommissioning will be of a similar nature and magnitude to those discussed above for cable installation.

6.4 Summary

While there will be disturbance within the construction area, and a portion of that disturbance will also be within the SSSI, this disturbance will be short term, temporary (recoverable) and localised. Mitigation by design will be the main tool to manage impacts within the SSSI and in particular impacts to the shingle berm, through those measures detailed earlier, in Section 3. The adoption of wider best practice and construction mitigation practices will also help to minimise wider generic construction impacts on the hinterland, shingle berm, inter-tidal zone and nearshore seabed.

Due to appropriate cable burial depths, which take due consideration of both short-term changes (i.e. storm-induced shore or seabed lowering) and longer-term changes (i.e. landward transgression of the shingle berm and active beach profile), there will be no impacts throughout the 25 year operational lifetime of the development.

The proposed in-built mitigation is considered sufficient to allow prediction of no likely significant effect on the geological features for which the Spey Bay SSSI is designated, although as good practice wider mitigation should be considered.

7 Wider Mitigation

The alternative cable installation methodology proposes a series of mitigation methods that have been incorporated in the design and planning of the works or will be executed during the construction of the works. These in-built mitigations have resulted in the conclusion that there will be no likely significant effect on the geological features for which the Spey Bay SSSI is designated. Despite this, it always remain appropriate to consider good practice approaches during construction that will further minimise any potential effects arising from the project.

The first recommended good practice mitigation relates to reinstatement of the trench following cable laying. The proposed methodology allows for the trench to be backfilled with sediments in layers, in reverse order to the excavation sequence, and for each layer, or each 0.5m depth of reinstated soil to then be compacted.

As a result of the review undertaken to produce this document, it is now recommended that reinstated sediments on the shingle berm portion of the cable route are not compacted. This is because the structure of the sediments within the shingle berm is presently naturally sorted, leading to high porosity. This enables percolation of tidal water through the interstices between gravel and cobble clasts and is a fundamental reason why these geomorphological features are so effective at attenuating incoming wave and tidal energy. The natural dynamism of a shingle berm helps it to respond naturally to storm wave action by modifying its morphology through the washover process and, over time, enables the landward ‘rollback’ processes of the feature as an entity to continue unabated. If compacted, the grain size sorting and porosity of shingle berms can be adversely altered, causing reflection, rather than absorption, of incoming energy and this can lead to problems of ‘cliffing’ within the seaward face and seaward loss of material.

There are no similar concerns on the inter-tidal or shallow nearshore areas seaward of the shingle berm or on the hinterland, where compaction of the backfilled trench could occur.

The second recommended good practice mitigation relates to monitoring of sediment accumulation against the eastern sheet piles, where and when present across the shingle berm, and sediment bypassing in the form of an excavator removing and relocating accumulated sediment beyond the trench to the west to enable the continuous feed of the sediment transport system. Although the effects of the temporary presence of the trench and (for the shingle berm only, the temporary presence of the sheet piling) are not likely to have a significant effect on the environment, the recommended actions are deemed good construction practice and will ensure any (low magnitude) impact that may arise is rapidly mitigated with no long-lasting adverse effects.

8 Conclusions and Recommendations

- Cable installation at the landfall is planned near the eastern extremity of the Spey Bay SSSI, where the shingle berm is at its lowest height and narrowest width, and potential impacts are therefore minimised. Activities at this location will have minimal potential effect on the remainder of the SSSI, and is preferred when compared to the potential impact of undertaking work further to the west in the SSSI.
- The installation method of open trenching will undoubtedly cause temporary, localised disturbance to the hinterland, shingle berm, inter-tidal beach and shallow nearshore seabed. This will primarily be in the form of a direct 'footprint' of disturbance caused by:
  - (i) trenching;
  - (ii) working areas; and
  - (iii) temporary stockpiling areas.

  However, there is considered to be no significant impact upon longshore sediment transport processes within Spey Bay as a result of the temporary presence of the trench. This is because longshore drift rates are relatively low and the works will be for a temporary and short duration. Trenching activities directly on the hinterland and shingle berm will be for a small number of months. Sediment transport processes will be fully reinstated once the trench has been infilled. This type and scale of potential interruption to a modest rate sediment transport at the very eastern extremity of the feature is well within the range of natural variability experienced in transport rate based on differences in wave height and direction.
- Appropriate mitigation has been built-in to the design/planning and will be adopted during the construction phase. This will further minimise any potential impacts.
- The proposed mitigation by design is sufficient for the landfall cable installation activities to be considered unlikely to have a likely significant effect on the geological features for which the Spey Bay SSSI is designated.
- In addition to the proposed mitigation by design, wider good practice mitigation is recommended which will: (i) prevent compaction of sediment layers in the trench through the shingle berm during reinstatement. This will contribute to ensuring that the porosity of the structure is not unduly affected by the reinstatement works and that the berm retains its percolation properties; and (ii) monitoring accumulation of sediment against the eastern face of the sheet piling (where and when present) and the bypassing of any accumulated sediment across the trench/piling to the west to continue to feed the (low magnitude) sediment transport system.
- Baseline and post-works topographic surveys of the affected hinterland, shingle berm and inter-tidal will be considered to ensure that the reinstated morphology matches the baseline as closely as possible. Achievement of such reinstatement will mean that no long term impact on sediment transport patterns will be experienced.

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PLATES

Plate 1 – Gravel accretion on eastern side (left of image) of Portgordon harbour wall

Plate 2 The mouth of the Burn of Tynet

Note the initial eastward alignment behind the gravel ridge before discharging across the foreshore

Plate 3 – Washover fans to the rear of the gravel barrier

Plate 4 – Storm ridges on the seaward face of the gravel barrier
(note the rack marks to help distinguish the different storm ridges in the photograph)

Plate 5 – Narrow gravel barrier at landfall

Plate 6 – Wide gravel barrier near Spey Mouth

Plate 7 – Typical clast sizes on crest of gravel barrier at landfall location

Plate 8 – Typical clast sizes on crest of gravel barrier at Spey Mouth

Annex A: Morphology and sediments along a transect at the landfall location

A **back of shingle berm**
B **crest of shingle berm**
C **upper seaward face of shingle berm**
D **mid seaward face of shingle berm**
E **lower seaward face of shingle berm berm**
F **upper inter-tidal (just seaward of toe of shingle berm)**
G **upper mid inter-tidal**
H **lower mid inter-tidal**
I **lower inter-tidal**


A
B


C
D


E
F


G
H

Annex B: BOWL and SNH discussions regarding erosion projections

B1 Background

The Scottish Government (SG) is currently undertaking a *National Coastal Change Assessment* for Scotland (Rennie *et al.* 2016). Between August and October 2016, Scottish Natural Heritage (SNH) provided BOWL with interim outputs from this study which were intended to inform BOWL about past and projected future projections of coastal change.

This information enabled BOWL to re-assess its previous engineering considerations of suitable set back distance, based upon both the new information and BOWL's risk appetite through the 25 year lifetime of the project.

The dialogue between BOWL and SNH on the topic of erosion projections took place on several occasions and concluded with a telephone meeting between Dr. Alistair Rennie (SNH) and Dr. Nick Cooper (technical adviser to BOWL) on 4th October 2016.

Both parties agreed that it would be useful to present the development of the thinking on the issue in a sequential manner, reflecting the evolving nature of the outputs. However, it was felt most appropriate that this information would be best presented in this manner in the form of a Technical Appendix to any submitted reports, with a brief synopsis of the approach and conclusion summarised in the main report.

This Technical Appendix presents the dialogue on the erosion projections in a sequential manner and each sub-section concludes with a re-appraisal of the set back distances used in BOWL's design of the infrastructure at the cable landfall based upon the information presented at that stage.

B2 National Coastal Change Assessment for Scotland (first outputs)

In August 2016, SNH provided an image to BOWL showing that project's interim historic erosion assessments from its *National Coastal Change Assessment* superimposed upon an aerial image of the cable landfall area taken from the onshore planning application (reproduced here as Figure B1). It is noticeable that SNH very usefully broke down the historic rates of change in position of Mean High Water Springs (MHWS) under different epochs, as shown in Table B1, rather than solely providing a long term average between the earliest and most recent dates.

Table B2 – SNH's Assessment of Historic Erosion Rates of MHWS at Landfall Location

Start Date	End Date	Retreat distance (m)	Average annual rate (m/yr)
1903 (historic maps)	1990 (OS map)	37	0.43
1990 (OS map)	2003 (Lidar)	20	1.54
2003 (Lidar)	2014 (aerial photo)	9.7	0.88
Additional calculations			
1990 (OS map)	2014 (aerial photo)	29.7	1.24 most recent 25 year period
1903 (historic maps)	2014 (aerial photo)	66.7	0.60 long term (century scale) average

* Note that all data have spatial errors (see figure for details)

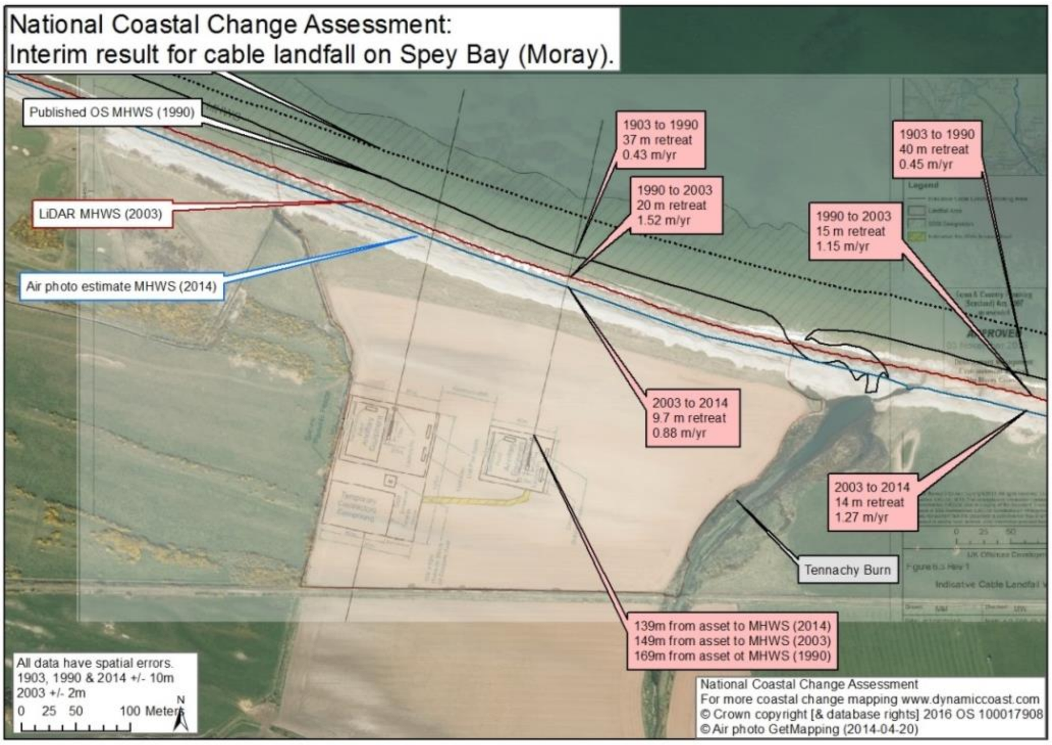


Figure B1 – A reproduction of SNH's First Assessment of Historic Erosion Rates of MHWS at the Landfall Location

In addition to the data provided by SNH, the long term recession rate of MHWS over the period 1903 to 2014 has also been calculated and presented in this table, together with a rate for the most recent quarter-century period, namely 1990 to 2014. The latter may be the most representative of the likely rates over the next quarter of a century, since the sea level, sediment supply and ground conditions will be most similar to those experienced during that period.

Whilst noting the inherent uncertainties and inaccuracies in the analysis, the resulting long term average value of 0.60m/year between 1903 and 2014 is highly consistent with a value of 0.64m/year determined form analysis of historic OS maps and bathymetric charts during assessments in relation to the Shetland HVDC Link project (ABPmer, 2009), which in formed the BOWL Environmental Impact Assessment. It is also broadly comparable to slightly higher level estimates by Hansom and Black (1994) of 0.74m/year loss between 1960 and 1994 at Spey Bay Golf Club.

Even using the average rates from the most recent quarter century, which are higher than the long term average by a factor of approximately 2, the erosion of MHWS would be 31m over the next 25 years, with a sufficient remaining ‘buffer’ of over 30m between the landfall works (set back 50m from where the landward limit of shingle washover fans meets the vegetation edge of the hinterland in the present day) and the projected position of MHWS in 25 years’ time, taking a width between this vegetation edge and MHWS of approx. 10m as a minimum (conservative) value.

Using the maximum average annual erosion rate calculated by SNH for any one time period, namely 1.54m/year between 1990 and 2003, the recession of MHWS over 25 years would be 38.5m, with a remaining buffer of over 20m between the landfall works (set back 50m from where the landward limit of shingle washover fans meets the vegetation edge of the hinterland in the present day) and the projected position of MHWS, taking a similar width between this vegetation edge and MHWS as above.

Based upon the above analysis, a landward set back distance of 50m for the landfall works is deemed suitably conservative by BOWL for the 25 year operational life of the Beatrice OWF even under the worst case recession over the short-term presented in Table 1 of 1.54m/year.

B3 National Coastal Change Assessment for Scotland (second outputs)

At a meeting in early September 2016, SNH presented to BOWL further outputs from its *National Coastal Change Assessment* (reproduced as Figure B2). In providing these outputs, SNH was clear to point out that it was provided as information and that BOWL should:

1. use this information to inform its own assessments of suitable set back distance, based on BOWL’s risk appetite through the 25 years lifetime of the project; and
2. note that whilst the measurements imply precision, there is considerable uncertainty in future assessments and therefore all values are presented to aid discussions and should not be considered definitely as predictions.

BOWL acknowledges both of these points and accepts that the outputs are ‘projections’ to aid assessment on future erosion and help explore uncertainties and are not definitive predictions.

The historic changes in MHWS show an annual recession rate of ~0.3 – 0.4m/yr in the vicinity of the cables between 1905 and 1990, increasing measurably to ~1.5 – 1.8m/yr between 1990 and 2003. These rates are broadly consistent with the interim results presented in Table 1, although the upper envelope is slightly greater in magnitude. It should be noted that the 2003 data are derived from Lidar survey and such technology from over a decade ago was known to have lower accuracies than contemporary Lidar systems.

It is also noticeable that whilst the interim results updated the analysis to 2014, using aerial photography, the further analysis omits these data and bases its projections on the “worst case” rates from 1990 – 2003. Given potential concerns over the accuracy of Lidar data from 2003, it could be argued that the (lower) rates observed between 1990 and 2014 would be more representative of the likely future projections over the next quarter-century since they perhaps use more reliable datasets and they represent well the recent-past, contemporary and near-future sediment supply, ground conditions and rates of sea level rise.

It is also noted that data is presented to show up to 10m landward movement in the edge of vegetation on the hinterland, which marks the landward limit of the washover fans from the shingle berm, between 2009 and 2014. This is then averaged to suggest an average annual recession rate of up to 2m/year. Whilst acknowledging that the datasets do show such a change in places, there are two points worth noting:

1. The dataset is short term and would be expected to capture morphological changes due to storm-driven wash-over processes. The occurrence, magnitude and sequencing of storms over the period under consideration may play an important part in the observed changes and these may not necessarily be representative of storm-driven changes within a longer period of time, nor of longer term rollback of the ridge. For example, the winters of 2010 and 2013 were particularly noted for the severity of storms which affected large parts of the eastern UK coast.
2. There are some locations where there was no measurable change in position of the vegetation edge.

Notwithstanding these matters, BOWL acknowledges that the long term prognosis is for the shingle berm to transgress landwards over the lifetime of the Development. Due to this, the projections provided by SNH of future changes in MHWS (based on extrapolation of historic rates between 1990 and 2003) are extremely useful to inform considerations of set back distances for landfall infrastructure. Recognising the aforementioned limitations and uncertainties of the data, such projections are inherently conservative.

Results show that if past rates from between 1990 and 2003 are projected to the years 2025 and 2050, the landfall infrastructure is unaffected. In fact, at these rates the infrastructure would remain unaffected for between 91 years (EC1) and 99 years (EC2).

Using the same approach, if the erosion rate was lower, at say the 1.24m/year shown by the interim SNH outputs between 2003 and 2014, the infrastructure would remain unaffected for between 132 years (EC1) and 119 years (EC2).

SNH also presented a sensitivity analysis to aid discussions, whereby the past rates from between 1990 and 2003 were increased in the future projections by factors of 25% and 50%. This showed that under these scenarios the projected ‘2050 erosion line’ would actually be reached by 2041 (25 years) and 2034 (18 years) respectively.

A back-calculation approach along the same lines as before shows that under a 25% increase in past rates from between 1990 and 2003, the infrastructure would remain unaffected for between 73 years (EC1) and 79 years (EC2). Even with a 50% increase in past rates from between 1990 and 2003, the infrastructure would remain unaffected for between 61 years (EC1) and 66 years (EC2).

BOWL concludes therefore that even under the highest observed past historic rates (with all the inaccuracies and uncertainties noted) and with a highly conservative approach of a 50% increase in these, the infrastructure would remain unaffected through its operational lifetime of 25 years.

It is envisaged that sea level rise changes over the next 25 years would only have a minor influence on coastal rollback of the shingle berm and therefore remains confident in the 50m set back (measured from where the landward limit of shingle washover fans meets the vegetation edge of the hinterland in the present day) used in its design.

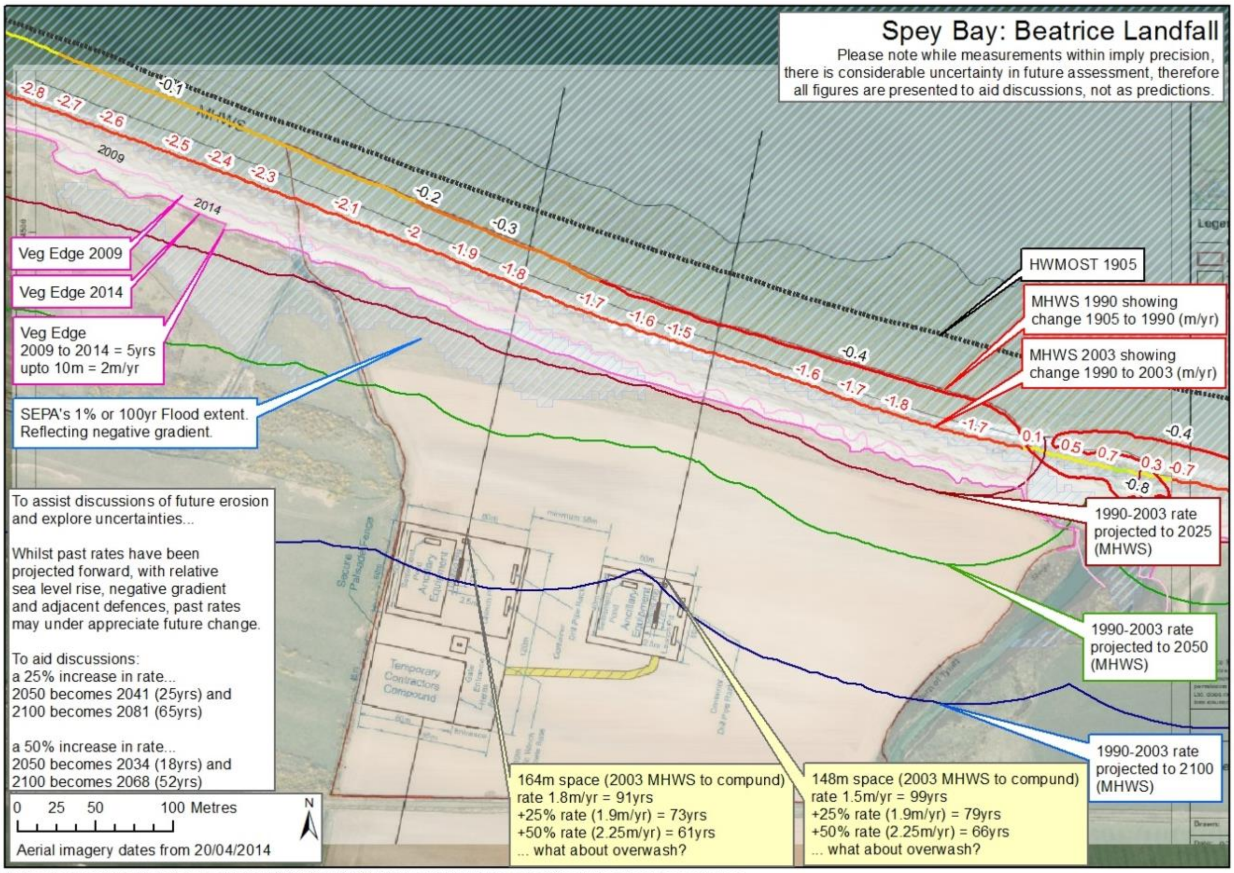


Figure B2 – A reproduction of SNH’s Second Assessment of Historic Erosion Rates of MHWS’ at the Landfall Location

B4 National Coastal Change Assessment for Scotland (third outputs)

Following BOWLs interpretation of the first and second outputs from the *National Coastal Change Assessment*, SNH provided a third set of outputs on 12th September 2016 (reproduced as Figure B3). This updated the second outputs with beach topographic survey data provided to SNH by BOWL from 2016.

SNH's analysis showed that between its 2003 survey (using Lidar) and BOWL's 2016 survey (topographic) some 11.6m and 8.4m retreat of MHWS was recorded at EC1 and EC2 respectively. These erosion distances equate to average annual rates over the period 2003 to 2016 of 0.9m/year and 0.6m/year respectively. This shows that the most recent observed changes are within the bounds of the previous conservative assessments and, in fact, are nearer to the long term average value of 0.60m/year observed between 1903 and 2014 than some of the higher values considered in the sensitivity tests described previously.

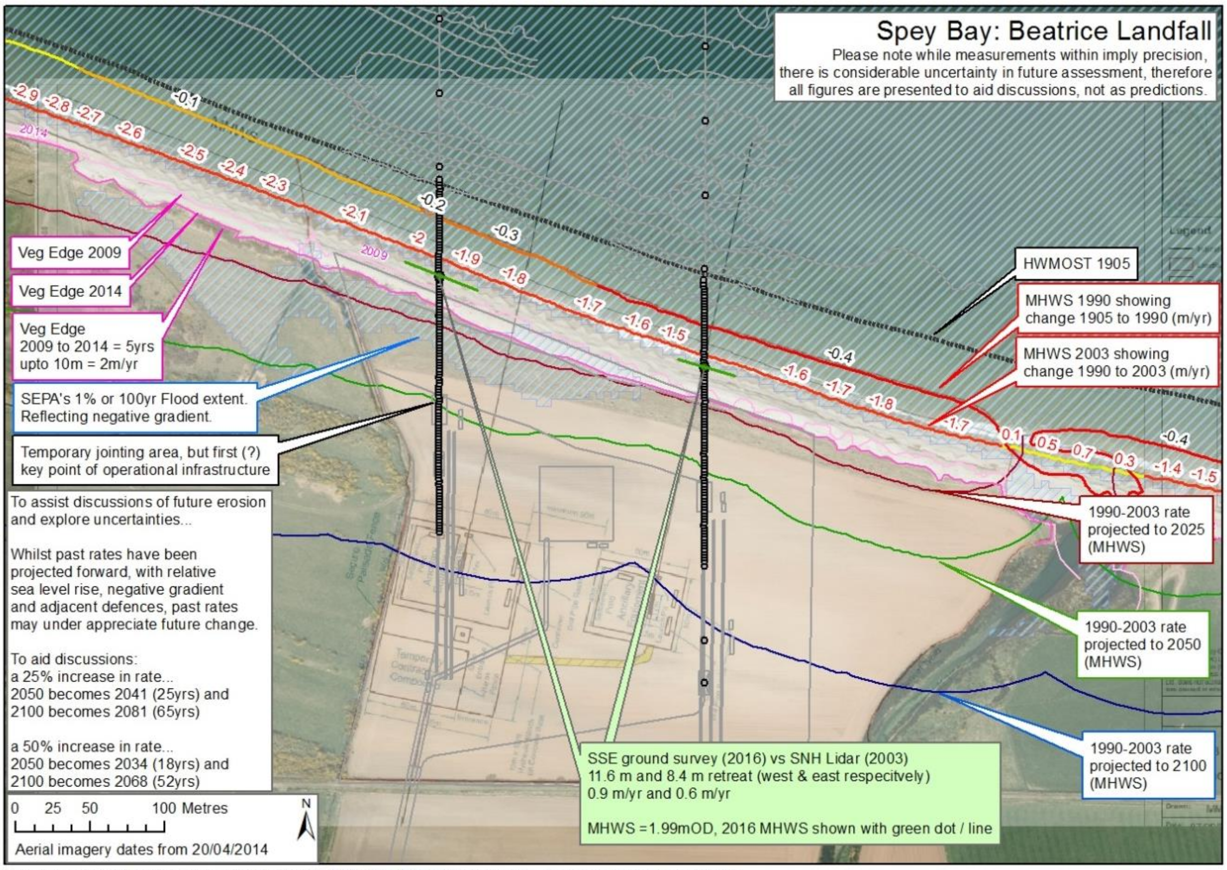


Figure B3 – A reproduction of SNH's Third Assessment of Historic Erosion Rates of MHWS' at the Landfall Location

Figure B3 does infer that the projected erosion of MHWS by 2050 will begin to impinge on some areas of ‘operational infrastructure’ at the landfall, but these locations are actually where Pipe Thruster Pits will temporary be sunk during the construction phase to enable cable laying rather than being more permanent operational infrastructure (such as Transition Joint Bays). Assessment of suitable depths for these Pipe Thruster Pits and the associated burial depths for the export transmission cable at its landfall has taken into consideration the landward transgression of the cross-shore profile, assuming it maintains it present morphology (form, function and level), to ensure is remains buried over the 25 year operational life.

Given that these most recent data between 2003 and 2016 show annual average erosion rates that are well within the conservative estimates used in determining a suitable set back distance, BOWL remains confident that a 50m set back (measured from where the landward limit of shingle washover fans meets the vegetation edge of the hinterland in the present day) of the landfall infrastructure is a conservative engineering decision.

Furthermore, if one was to consider the observed annual average erosion over the past 26 years (1990 to 2016) as a valid indicator of the likely projected rates over the next 25 years, the rate would be 1.35m/year at EC1 (1.8m/year between 1990 and 2003 and 0.9m/year between 2003 and 2016) and 1.05m/year at EC2 (1.5m/year between 1990 and 2003 and 0.6m/year between 2003 and 2016). Again, under this sensitivity test the 50m set back distance (measured from where the landward limit of shingle washover fans meets the vegetation edge of the hinterland in the present day) remains conservative.

B5 National Coastal Change Assessment for Scotland (fourth outputs)

Dr. Alistair Rennie (SNH) and Dr. Nick Cooper (technical adviser to BOWL) held a telephone meeting on 4th October 2016 to discuss the methods used to assess past and projected future coastal recession at the landfall location in producing the SNH outputs. There was common understanding on the science and discussion particularly focused on the associated inherent uncertainties in mapping erosion rates from historic datasets given the mapping scales used.

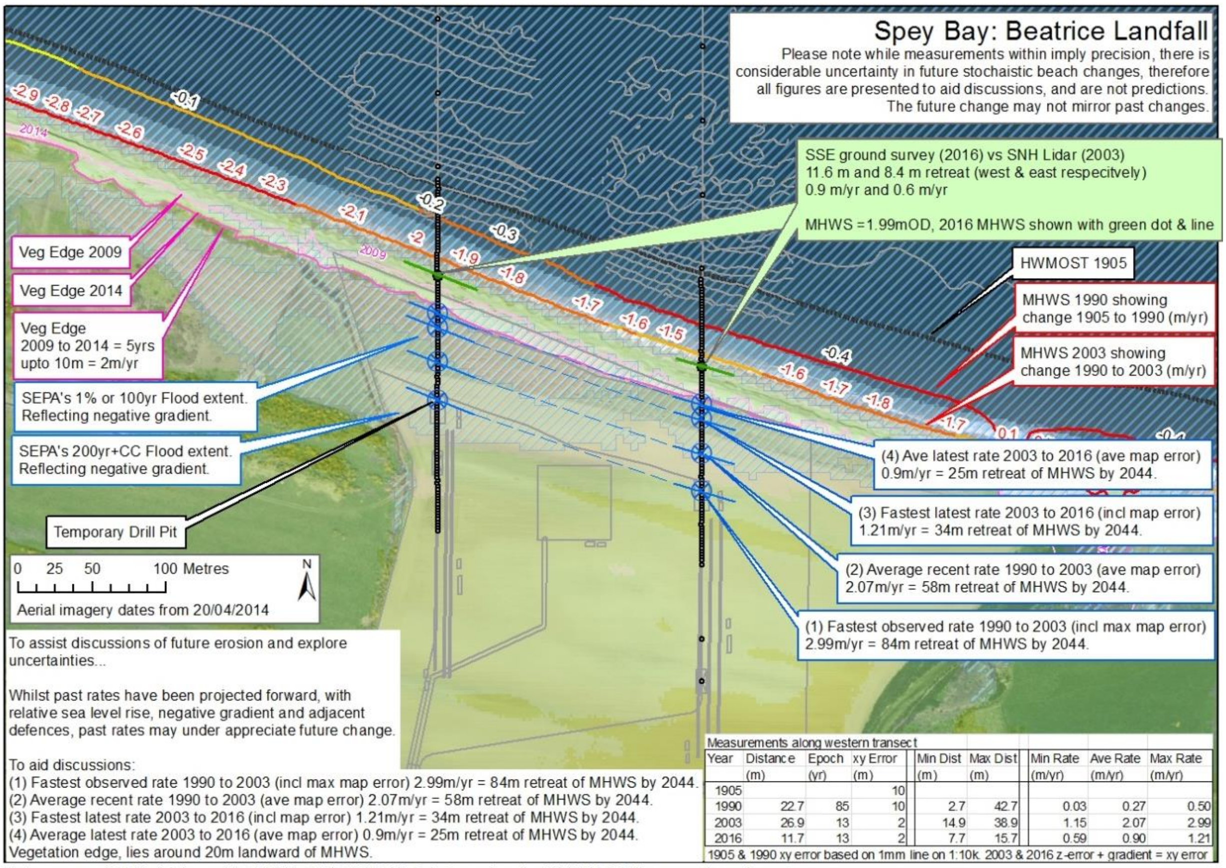
Using the erosion rates observed at the western cable (which are higher than those at the eastern cable), Dr. Rennie presented an envelope of potential erosion rates around the average (or ‘central’) estimates previously provided. This envelope was based on maximum negative error and maximum positive error in mapping. Negative error would result in lower than central estimates, and positive error would result in greater than central estimates.

To explore the sensitivities of the potential positive errors, an updated figure was produced (reproduced as Figure B4). This took a base date for construction of 2019, and considered erosion projections after the planned operational life of 25 years from this date (i.e. by 2044) under four erosion rate scenarios at the western cable, namely:

- Average erosion rate 2003 to 2016 (central estimate) = 0.9 m/year
- Above plus maximum positive error in mapping = 1.21 m/year

- Average erosion rate 1990 to 2003 (central estimate) = 2.07 m/year*
- Above plus maximum positive error in mapping = 2.99 m/year

* This is higher than the rate presented by SNH in the project's second outputs for the western cable.



Year	Distance (m)	Epoch (yr)	xy Error (m)	Min Dist (m)	Max Dist (m)	Min Rate (m/yr)	Ave Rate (m/yr)	Max Rate (m/yr)
1905			10					
1990	22.7	85	10	2.7	42.7	0.03	0.27	0.50
2003	26.9	13	2	14.9	38.9	1.15	2.07	2.99
2016	11.7	13	2	7.7	15.7	0.59	0.90	1.21

Figure B4 – A reproduction of SNH's Fourth Assessment of Historic Erosion Rates of MHWS' at the Landfall Location

Based on these outputs, under all but one scenario the infrastructure shown in the figure at the landfall is unaffected by the projected coastal erosion over the 25 year operational life.

The one scenario which does show some impingement on the infrastructure shown in the figure is the one which takes the following:

- Cable location with the highest past erosion rates of the two cables;
- Worst case erosion rate (1990 – 2003) for that location; and
- Worst case maximum positive error.

However, even under this scenario it is only the temporary Pipe Thruster Pits which become affected by erosion by 2044. The permanent infrastructure (such as Transition Joint Bays) remains considerably further landward. Furthermore, the landfall infrastructure has been further refined since the above image was produced and the updated details are provided in Figure 1 of the main NSCERA report.

Acknowledging that the cable needs to be buried to a sufficient depth across the hinterland to ensure that it does not become exposed by the coastal erosion, BOWL remains confident in its use of a 50m set back distance (measured from where the landward limit of shingle washover fans meets the vegetation edge of the hinterland in the present day) as used in its engineering design for the permanent landfall works.