Appendix B.2:
Desk Top Survey and Route Engineering Study Route Option Analysis Report

Co-financed by the European Union
Connecting Europe Facility

NorthConnect KS
Servicebokss 603, Lundsiden
N-4606 Kristiansand
Norway

Phone +47 38 60 70 00
Mail: post@northconnect.no
Web: www.northconnect.no

Desk top survey and route engineering study
Route Option Analysis Report
NorthConnect KS

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Xodus Group Ltd
The Auction House
63A George St
Edinburgh
EH2 2JG
UK

T +44 (0)131 510 1010
E info@xodusgroup.com
www.xodusgroup.com

Integrated Services
Total Field Development

Route Option Analysis Report

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Table of Contents

EXECUTIVE SUMMARY

NorthConnect awarded Xodus Group the contract for the Desk Top Survey and Route Engineering Study (DTS-RS) on the 2nd of May 2012, in respect of the proposal to install a HVDC subsea cable between the UK and Norway.

At the start of this study, the project was at outline design stage. NorthConnect had completed a pre-FEED study which included a cable corridor routing appraisal, environmental screening and constraints mapping for a series of possible locations for the UK landing point, and CAPEX and OPEX estimations. Peterhead was selected as the preferred UK cable landfall point.

The Route Option Analysis Report presents the scope of work, the methods and results of the DTS-RS for the proposed NorthConnect subsea cable from the UK to Norway.

The overall objective of this report is to ensure that all potential effects on people and the environment have been considered, assessed and documented for all route options identified. It reports on the results of the option screening sessions and the preferred Peterhead to Sima and Peterhead to Samnanger routes selected.

This study has analysed route options for both the Peterhead to Sima and Peterhead to Samnanger Norwegian landfall options. The assessment has not covered in detail the constraints associated with the onshore cable routing, the onshore grid connection and potential requirements for local grid upgrades when comparing the Sima and Samnanger options. NorthConnect will present the results (in conjunction with the Ramboll findings for the onshore part) to the National Regulator in Norway as part of the consultation process. The National Regulator is a key stakeholder and decision-maker during project feasibility, consenting and permitting phases.

The study has taken into consideration a wide range of environmental and technical issues as well as feedback from EIA contractors. Technical and environmental constraints have been mapped and visualised into GIS. The study has been conducted based on data sets provided by SeaZone during phase 1 and phase 2 of this project. Additional data sources such as charts and seal haul-out data have also been incorporated into the constraint mapping exercise. One key constraint is the limited amount of information available in terms of future offshore development projects and the location of cable repeaters as this information was not available. The reader must bear in mind that this study has considered a snapshot in time using all available data sources to do so.

Xodus has made an assessment of soil conditions and trenchability, with recommendations in terms of installation methods, burial depth, cable protection and crossing arrangements. Cost estimates and execution schedules have been established to allow for a quantitative assessment.

Route cost per kilometre primarily considers cable length and number of cable crossings. Minimising cable length and number of crossings has been an objective adopted from the outset of the project.

Through careful route assessment and selection, a range of mitigation measures have been incorporated into the design of the project.

The identification, assessment and selection of route options has taken into account project objectives and key drivers captured at the start of the project. The qualitative and quantitative option screening process conducted as per Xodus' Value, Decision and Risk Management (VDRM) methodology has proven very effective in terms of measuring different routeing options against key drivers as well as against each other. The methodology has provided a concise auditable justification for the scoring applied to each option assessed which has included formal minuted inputs from the project team.

The methodology has ensured that a number of potentially significant adverse impacts and effects have been avoided, reduced or offset. Some adverse effects may still impose disturbance to people and the environment and will require further assessment during stakeholder consultation and consenting.

9 corridor options were identified which allowed for several permutations for potential cable routes as illustrated in figure below.

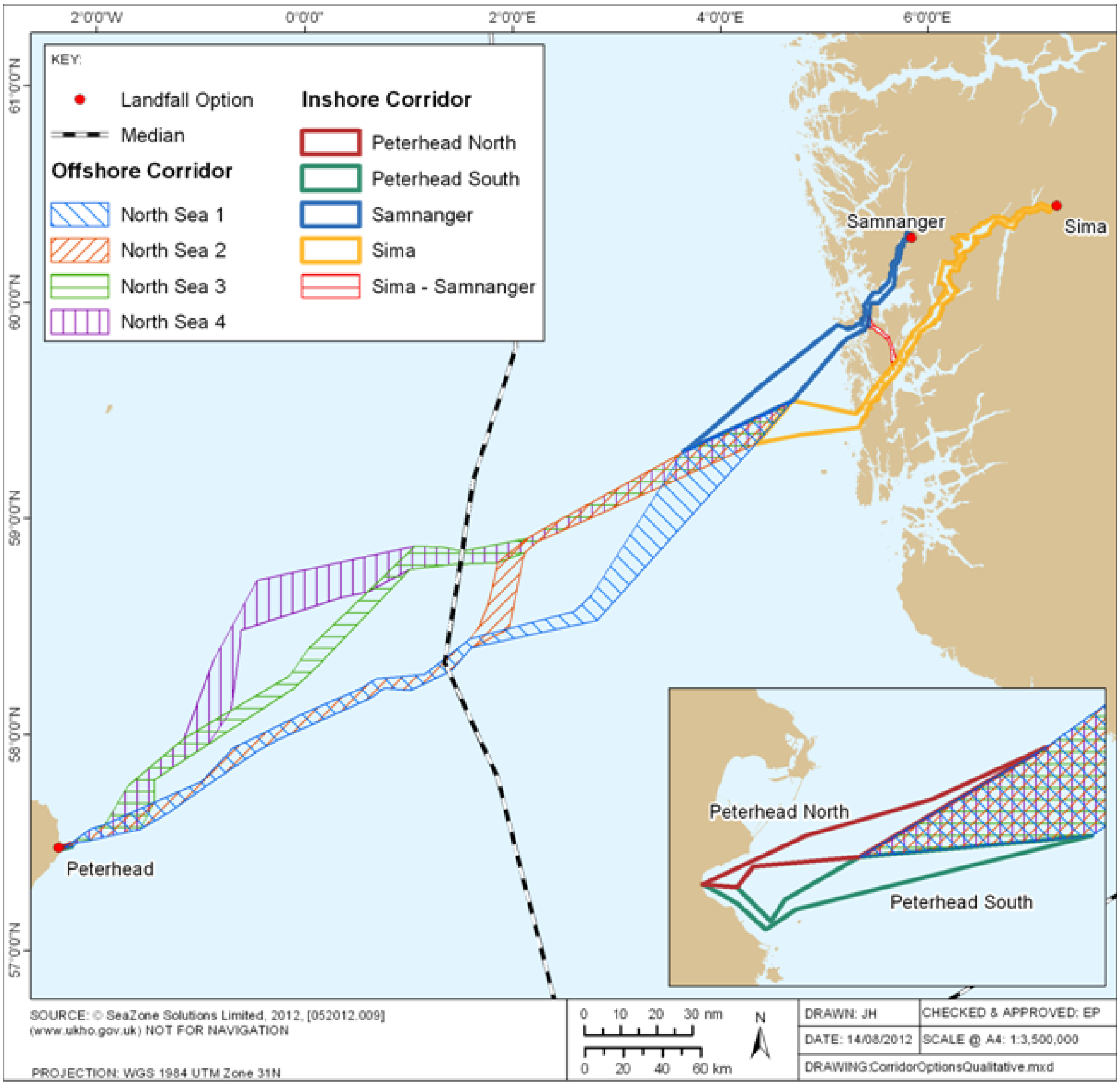


Figure 0.1: Corridor options

Peterhead North was identified as preferred UK landfall option. Peterhead South options were removed due to environmental impact and issues related to consenting & permitting. Consultations with pipeline owner Sandford Bay will be required to discuss potential crossing arrangement.

North Sea 1 option was selected as preferred option. North Sea 3 and North Sea 4 options were removed based on economic viability and technical suitability. North Sea 2 options were removed from scope due to cumulative effects and likelihood interference with planned development projects within the Utsira High area. Detailed survey is required to reveal sand waves, pock marks and any other hazards along the North Sea 1 route selected.

Sima-to-Samnanger (Bomla Fjord – Langenuen – Selbjorn Fjord – Bjørna Fjord)) route was removed from scope due to significant cost variance caused by cable length (30 – 35km) and 8 extra crossings.

Both Peterhead North to Sima and Peterhead North to Samnanger options have been taken forward to meet requirements of the national regulator. Technical feasibility of both Norwegian landfall options needs to be confirmed. Depth profile, fish farms, cable crossings and unexploded ordnance are key challenges to be addressed during the next phase of the project.

Xodus has developed a route proposal which causes least disturbance to people and the environment. Considering the scale of development and the type of constraints identified for the preferred route, it is expected that the environmental appraisal will meet the expectations of all stakeholders involved.

Preferred routes selected are:

> 'Peterhead North + North Sea 1 + Samnanger' (i.e. option1); and

> 'Peterhead North + North Sea 1 + Sima' (i.e. option 4).

Both options are taken forward to the next phase, i.e. Detailed Survey and Detailed Route Design.

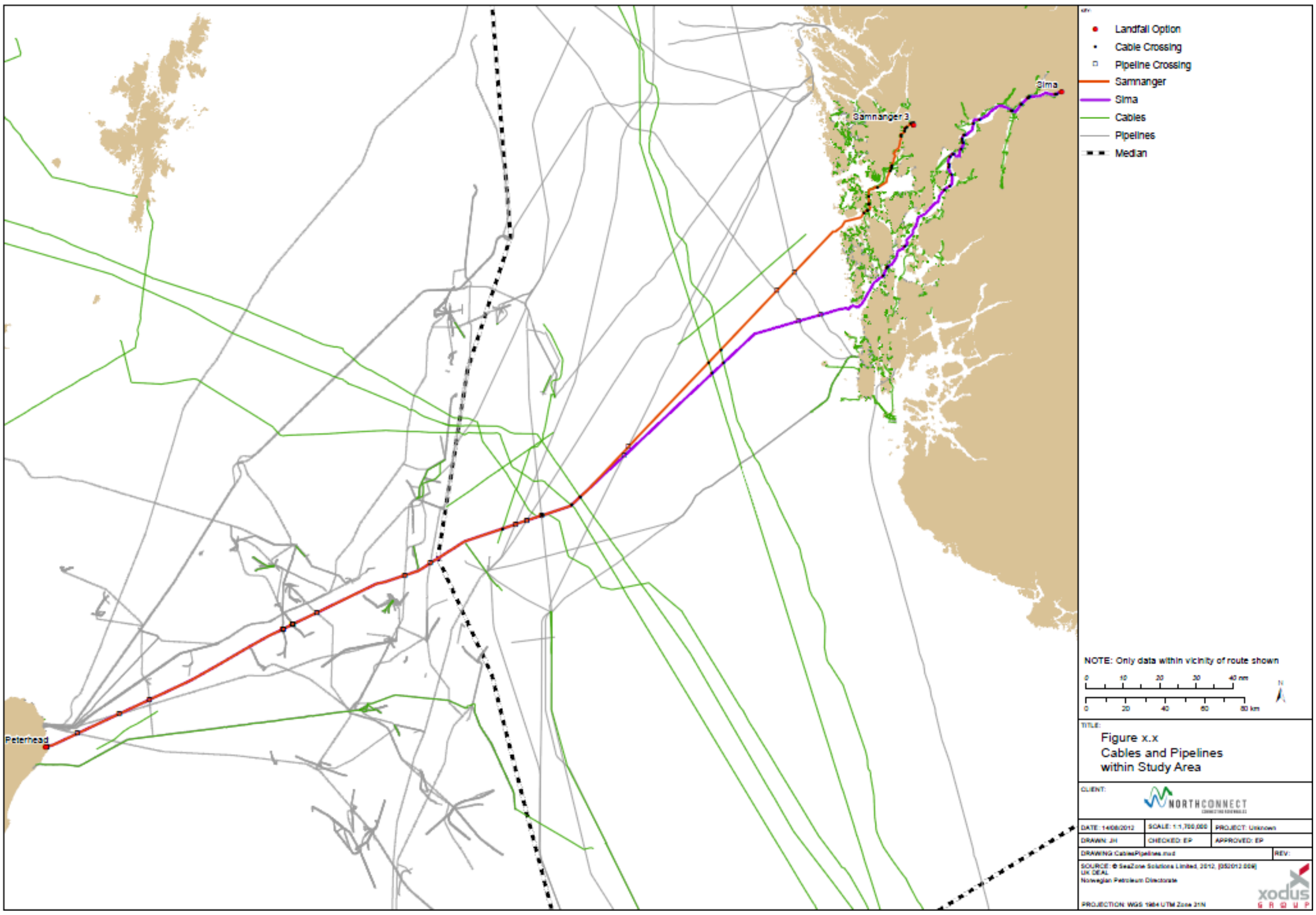


Figure 0.2: Preferred routes.

Xodus recommends the Project to:

> Consider approaches to detailed survey (i.e. single campaign versus phased campaign);

> Perform detailed survey(s) to obtain high-resolution data for further analysis;

> Perform a detailed route design to avoid hazards along the preferred route(s);

> Perform a burial depth assessment to optimise trench depth and minimise cost;

- Perform a detailed trenching study for the proposed routes to refine the trenching rate adopted within the cost estimating exercise;
- Assess local challenges of the Samnanger route in more detail to validate technical feasibility;
- Perform an unexploded ordnances risk assessment for specific UXO area identified within Sima route;
- Set up good communication and liaison with navigational stakeholders and local fisheries;
- Engage with Oil & Gas companies along the North Sea route to allow for alignment regarding future development;
- Engage with cable and pipeline owners to formalise crossing designs, fine-tune the installation strategy and refine project costs;
- Obtain information on location of cable repeaters to ensure minimum distance between the repeater and the new cable crossing;
- Clarify requirements for reduced cable capacity as it may impact overall project requirements (i.e. establish fallback scenario in case of failure of one 500kV HVDC cable);
- Perform a risk assessment to capture events that may have significant budgetary impacts;
- Define and quantify mitigation actions for each risk identified to establish budget requirements;
- Engage with cable installation companies to confirm cable installation methods (i.e. subsea and landfall), cable burial depth and cable/scour protection;
- Engage with the supply chain to create positioning within the supply market, facilitate strategic partnerships and help secure production capacity and vessel availability;
- Liaise with installation companies to confirm safety distances for trenching near existing cables and pipelines as well as safety constraints for crossing arrangements;
- Engage with cable manufacturers to assess production rates and to understand potential constraints;
- Align cable manufacturing and cable installation schedules to optimise supply chain (i.e. sourcing, manufacturing, transport and installation) and project financing;
- Increase accuracy of cost and schedule information in order to facilitate informed decision-making and increase confidence level;
- Define installation philosophies and perform option screening against key drivers identified at project kick-off.

1 INTRODUCTION

1.1 Project Background

The electricity generation portfolio is moving towards an increasing proportion from renewable sources which have a less predictable generation capacity. The United Kingdom has ambitious plans to increase its installed offshore wind capacity by 2020. Investment in offshore wind farms is likely to raise demand for reserve electricity production capacity during periods when the wind farms cannot meet demand. This reserve capacity can be provided by the hydro power generated in the Nordic region.

The NorthConnect Project aims to develop, construct and operate a High Voltage Direct Current (HVDC) cable connection between Norway and the UK by 2020. The length of the subsea cable will be between approximately 600 km and 680 km, dependent on the Norwegian landing point and subsea cable route selected.

The project is a joint venture between five owner companies, i.e. SSE Interconnector Ltd (SSE), Vattenfall UK and Norwegian power companies Agder Energi, E-CO and Lyse.

NorthConnect has awarded Xodus Group the contract for the Desktop Survey and Route Engineering Study (DTS-RS) in respect of the proposal to install the HVDC subsea cable connection between Norway (Sima or Samnangar) and Peterhead on the east coast of Scotland.

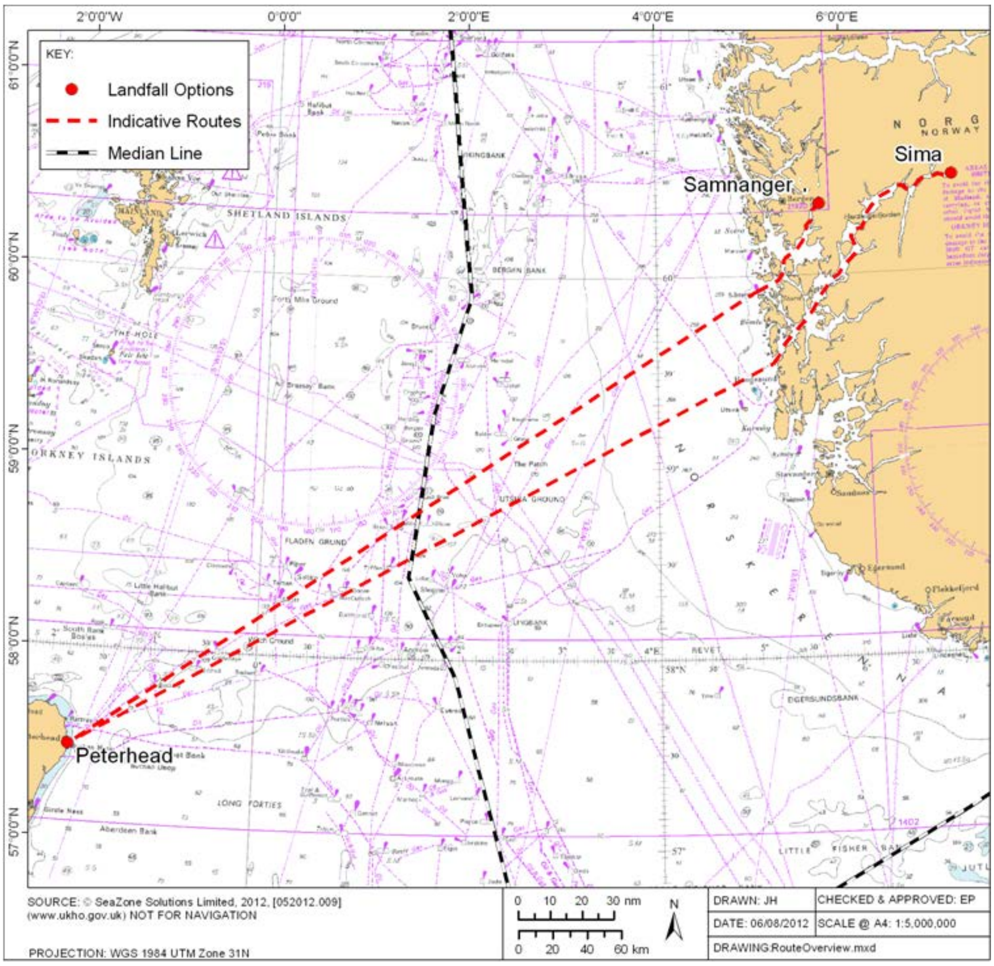


Figure 1.1: NorthConnect Route and Norwegian landing points

The NorthConnect Project supports international co-operation in the European energy sector by providing a cable connection between two complementary and hitherto disconnected power systems: hydro power generated in the Nordic region and offshore wind power generated in the UK. The key benefit of the project is that it will allow hydro power to provide reserve electrical production capacity during periods when the wind farms cannot meet demand, thereby mitigating the less predictable generation capacity associated with wind power generation.

1.2 Project Development

NorthConnect previously completed a pre-FEED study which included a cable corridor routing appraisal, environmental screening and constraints mapping for a series of possible locations for the UK landing point, and CAPEX and OPEX estimations.

Peterhead was selected as the preferred UK cable landfall point. HVDC converter stations will be required in the UK and Norway. The UK HVDC converter station is likely to be located on non-operational land adjacent to Peterhead power station. There will be a short onshore buried cable route between the landfall point and the HVDC converter station site, and a short AC connection between the converter station and the grid connection point.

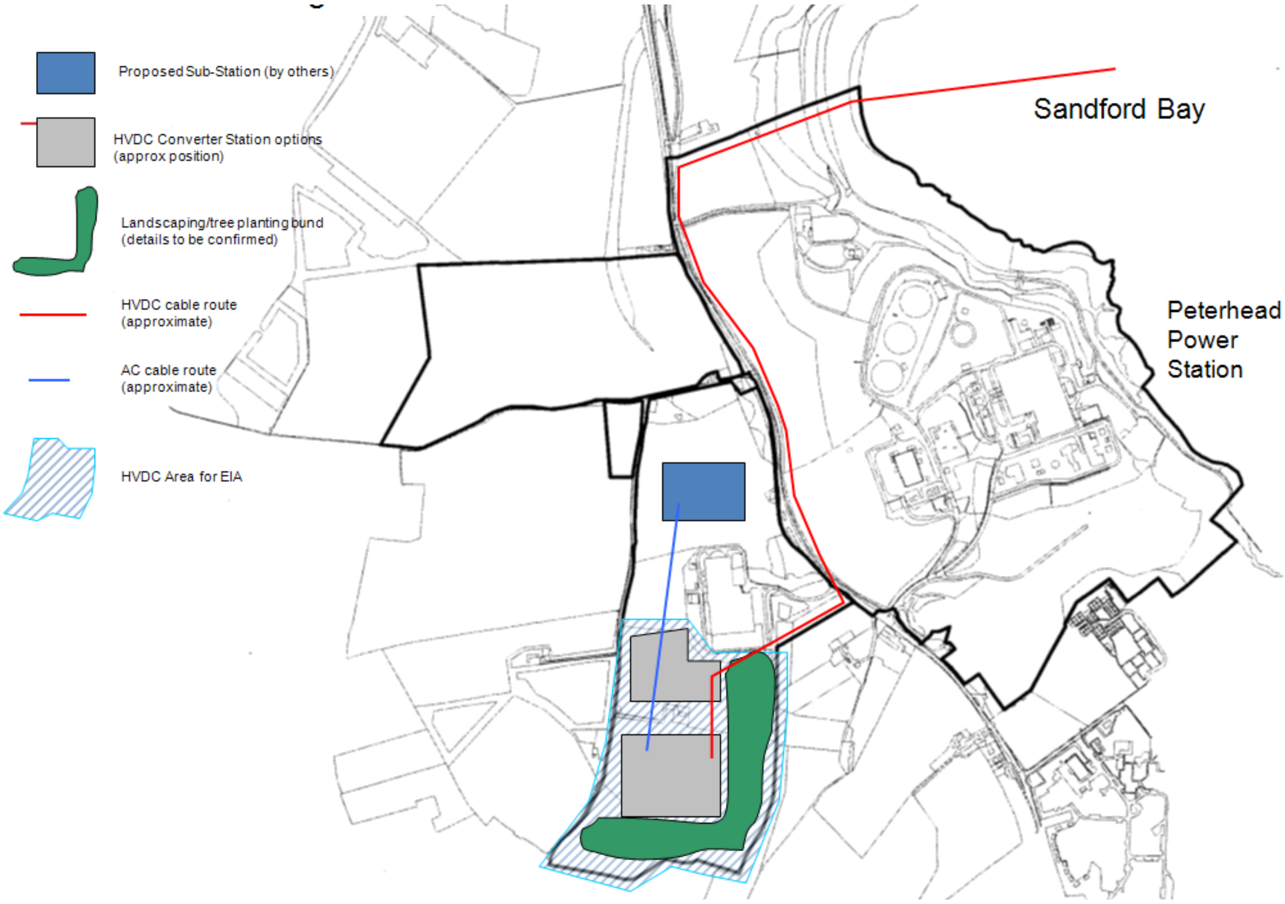


Figure 1.2: Peterhead landing point

Two potential Norwegian landfall options were identified during pre-FEED, Sima and Samnanger.

The Sima landfall option implies a longer marine cable route. The converter station and grid connection would be located in close proximity of the shoreline, and therefore the onshore cable route would be minimal. The grid connection infrastructure has been stated by NorthConnect as adequate for the project.

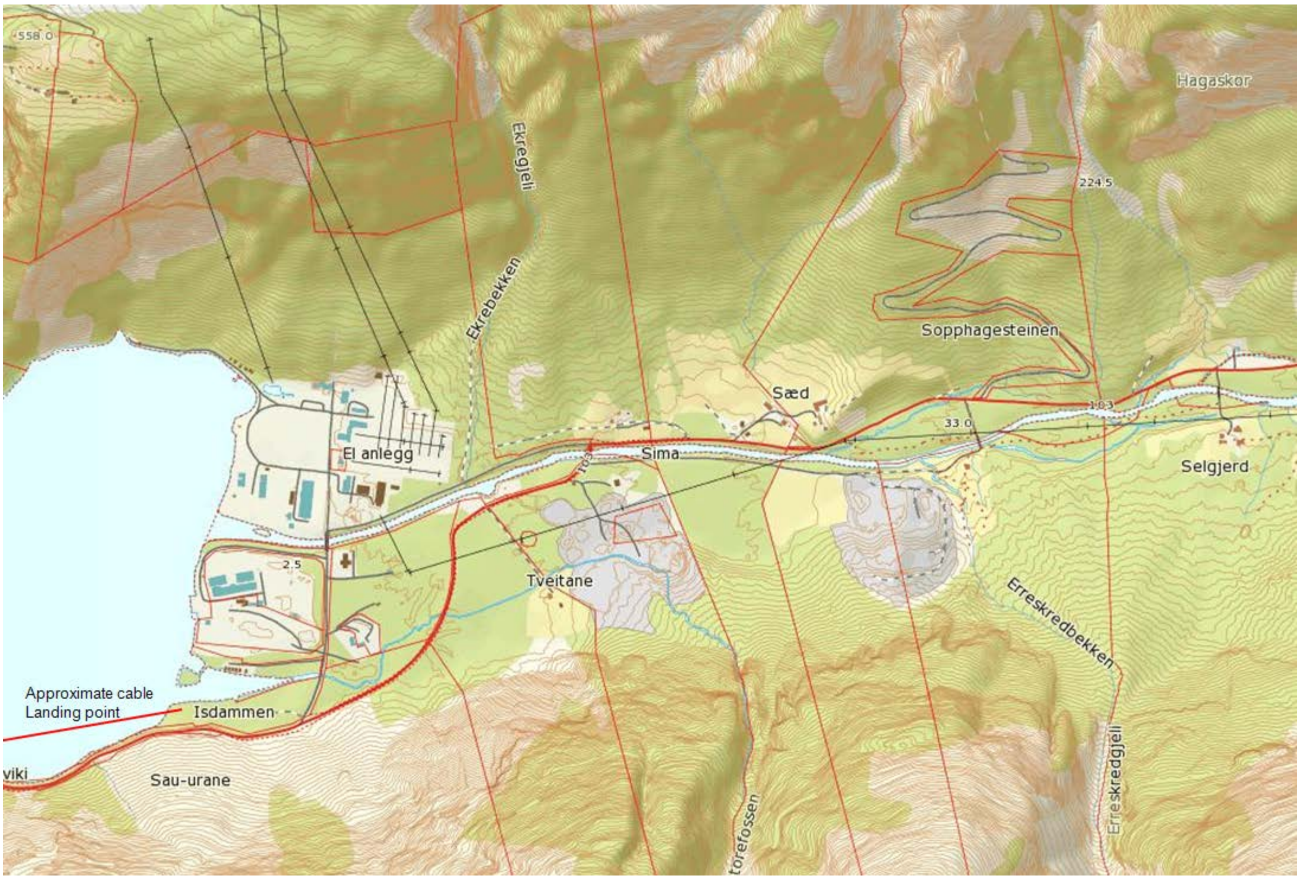


Figure 1.3: Sima landing point

The Samnanger landfall option implies a shorter marine cable route. The onshore cable connection to the proposed HVDC converter location is considered significant. Four different cable landing point options have been suggested as per the illustration below. The local grid connection infrastructure is considered inadequate to accommodate the connection for the interconnector and requires upgrading.

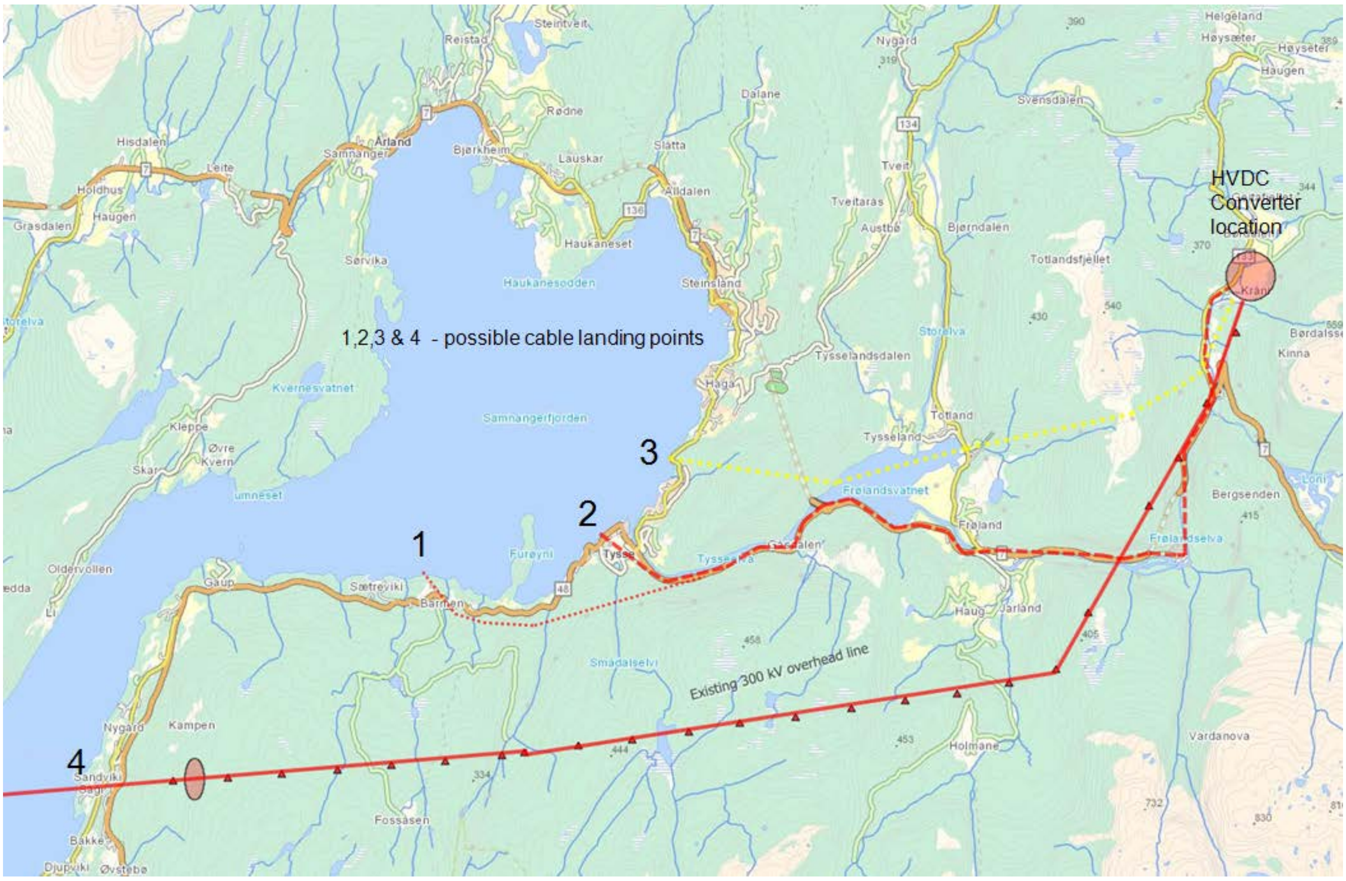


Figure 1.4: Samnanger possible landing points

The subsea cable corridor transits the North Sea between the UK and Norway. Part of the marine cable will run along Norwegian Fjords at water depths up to 900 meters.

Xodus was appointed to perform the DTS-RS including the beach landing points. The scope of work excludes onshore cable routing.

A number of other studies (e.g. Environmental Impact Assessment) have been progressed during the course of the DTS-RS, and Xodus has worked closely with AMEC, Ramboll, Ambio and Mott MacDonald to address certain topics.

A detailed marine survey will be commissioned separately at a later stage of the project. The survey will be conducted based on outputs generated by the DTS-RS, i.e. technical specification for detailed survey. The Technical Specification for Detailed Survey [1] has been delivered together with this report.

1.3 Project Description

The DTS-RS was designed to consider a range of constraints influencing the planning and development of the NorthConnect HVDC connection between the UK and Norway.

In development of the preferred cable route, a number of alternative cable route options were considered to avoid or mitigate environmental, consenting & permitting, technical and economic constraints.

The overall aim of the Desktop Survey and Route Selection study is to identify ‘preferred’ route options for the NorthConnect marine cable route to Sima or Samnanger. The study has been conducted as a constraint driven

[1] A-30722-S04-SPEC-001-A01 Technical Specification Detailed Survey.

option screening and selection exercise, considering a wide range of environmental, consenting, technical, economic and regulatory constraints. The process adopted allows for informed and transparent decision making. A preferred option for each Norwegian landfall has been selected, considering technical, economic, environmental and socio economic factors. This study has assessed different corridor and route options whilst considering:

- Different corridor options within the main (UK to Norway) corridor;
- Both Sima and Samnanger corridor options;
- Different route options within both Norwegian corridors;
- Environmental, technical, economic and regulatory constraints;
- Mitigation measures to avoid, prevent, reduce or offset adverse impacts or effects; and
- Key drivers identified at project kickoff.

2 OBJECTIVES

The key requirements of the desk top study are summarised as follows:

- Identification of potential obstructions and/or areas to avoid;
- Identification of other subsea cables, pipelines and infrastructure;
- Identification of potential crossing difficulties or constraints;
- Review of technical engineering constraints that may have an effect on the installation or operation of an HVDC interconnector cable;
- Identification of potential installation difficulties and recommendations on how to mitigate these;
- Execution of constraint mapping for corridor and route selection;
- Identification and prioritisation of realistic cable routes;
- Calculation of cable route lengths and armour types required;
- Identification of any specialist survey requirements;
- Cable route assessment and selection;
- Production of map based drawings highlighting cable route characteristics (e.g. cable burial, installation method, protection measures);
- Preparation and delivery of route option report;
- Preparation and delivery of technical survey specification with detail of physical seabed surveys required to confirm assumptions used in route option reports;
- Preparation and delivery of Route Positioning Lists and Straight Line Diagrams;

3 SCOPE OF WORK

The overall aim of the cable route selection study is to identify a 'preferred route option' for the NorthConnect High Voltage Direct Current (HVDC) interconnector which balances technical feasibility and economic viability whilst ensuring the least disturbance to people and the environment.

The key elements of the scope of work have been identified as follows (and summarised in Figure 3-1):

> Item 1: Inception Report – Document the methodology describing how the project will be executed and managed. The objective of the methodology is to deliver on time, within budget and at quality level expected. The methodology should also produce the tools and deliverables allowing NorthConnect to perform informed and transparent decision making.

> Item 2: Collection of Background Data – Perform a strategic routeing focused on major constraints and the development of routing corridors or search areas (primary constraints mapping).

> Item 3: Analysis of Information – Perform detailed routeing considering additional constraints leading to the development of detailed routes and identification of specific sites (secondary constraints mapping).

> Item 4: Deliverables – Produce option analysis report, detailed map based drawings and survey specification.

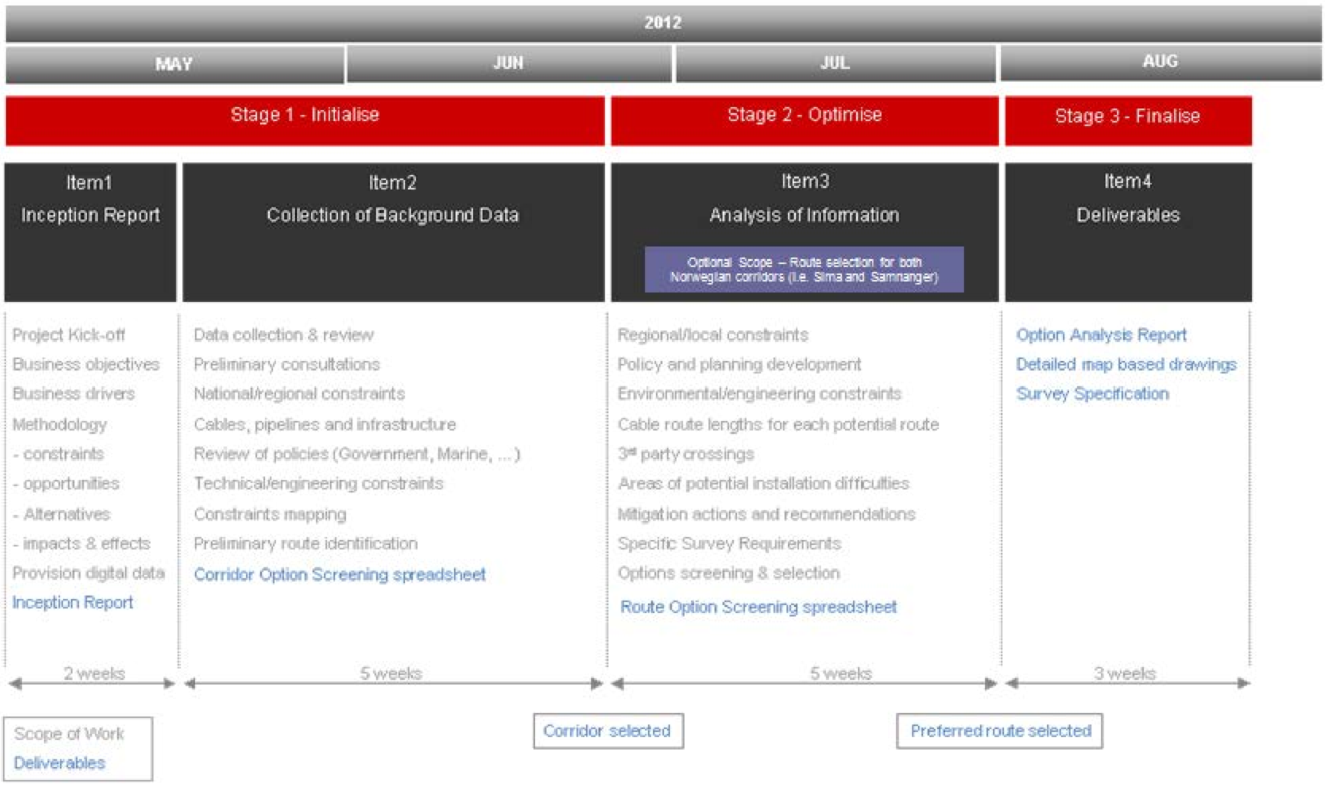


Figure 3.1: Overview scope of work

The project was initiated early May with formal project kick-off meeting on 16th May 2012.

The project was executed in different phases, following the structure of the scope items. Deliverables and target dates were agreed as per details listed in the figure below.

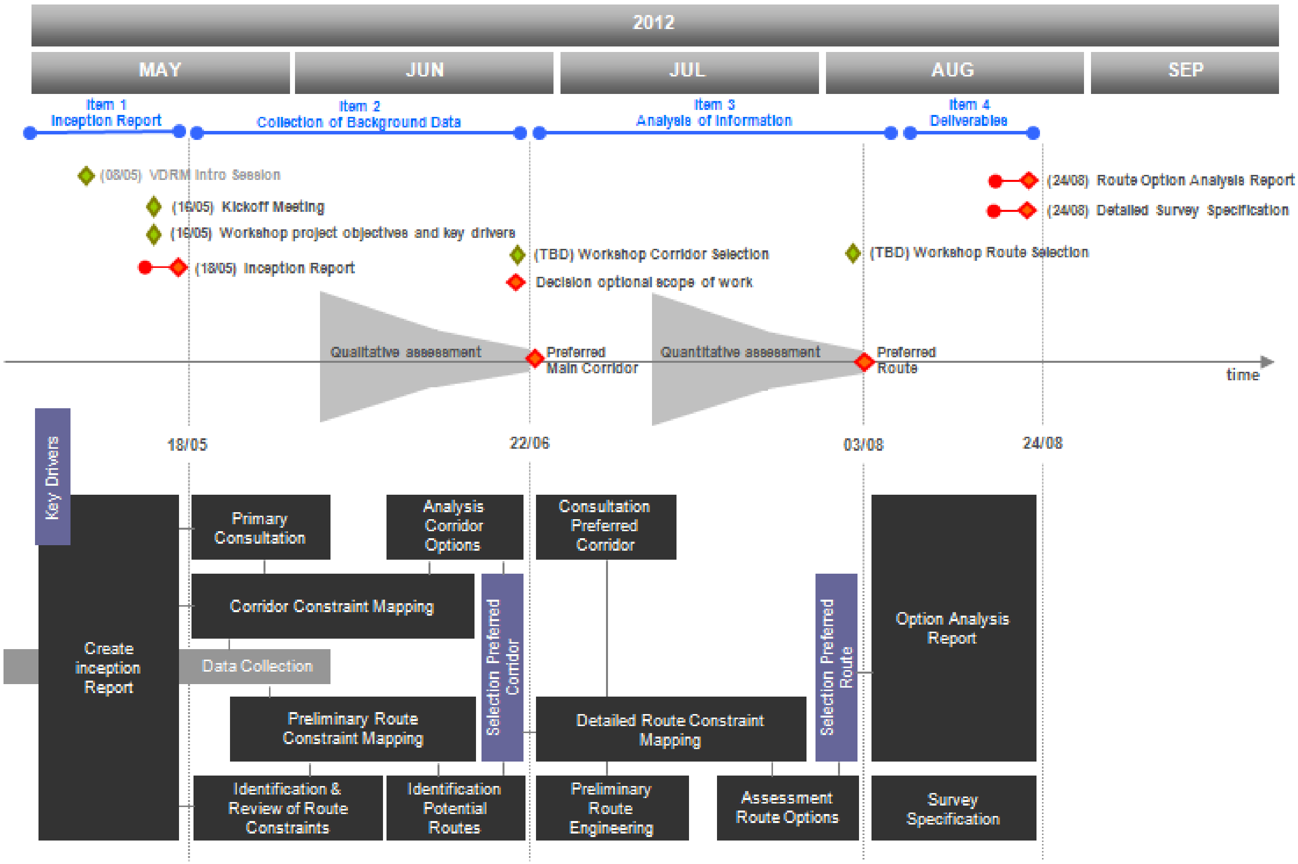


Figure 3.2: Overview scope of work

Option screening workshops were conducted towards the end of Item 2 and Item 3, i.e. qualitative assessment of corridor options and quantitative assessment of route options took place on 26th June and 8th August respectively. Findings were captured and documented in the Route Option Analysis Report (i.e. this report) and the Technical Specification for Detailed Survey has been delivered.

4 METHODOLOGY

The approach and method presented below is described in the Inception Report[2] delivered as part of Item 1 of this study. The objective of the Inception Report was to provide NorthConnect with a clear understanding of how the project has been executed and managed.

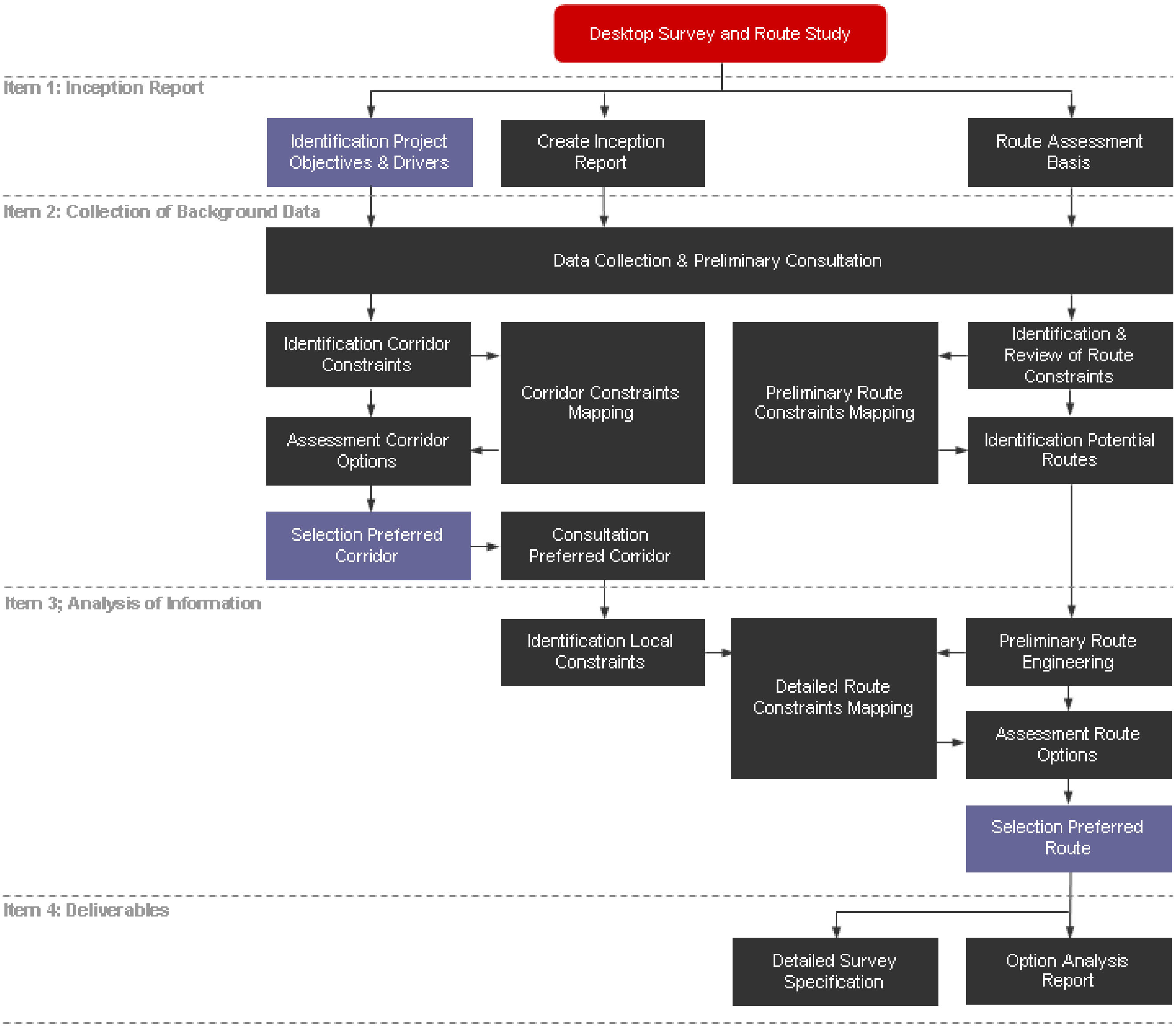


Figure 4.1: Project methodology

[2] A-30722-S04-REPT-001-A01 Inception Report.

5 SUBSEA CABLE ROUTE ENGINEERING

5.1 Cable Characteristics

General information on cable characteristics was provided to Xodus by the HVDC Contractor (Mott Macdonald). The detailed technical data sheets can be found in Appendix E ("Cable Technical Data Sheet 500kV") and Appendix F ("Cable Technical Data Sheet 36kV").

The NorthConnect HVDC link will comprise of 3 cables, i.e. two 500kV cables and one 36kV cable.

Each 500kV high voltage cable is approximately 125mm in diameter, weigh approximately 52kg/m and has a minimum bending radius of 3m. They have a copper core, are insulated with water washed wood pulp HVDC cable paper impregnated with high viscosity cable oil for DC cables and are protected by steel cable armouring.

The 36kV low voltage cable is approximately 93mm in diameter, weighs approximately 26kg/m and has a minimum bending radius of 1.7m. It has a copper core, is insulated with an extruded layer of insulating cross-linked polyethylene (XLPE) and is protected by steel cable armouring.

The cables will be installed bundled (together) or unbundled (separate) dependent on crossing arrangements, landfall requirements and electromagnetic impact on navigation, marine life or offshore infrastructure. Mott Macdonald indicate that compass deviations induced from the electromagnetic fields generated by unbundled cables need special consideration in water depths of < 40m in UK territorial waters if the cables are laid in a North-South direction. In this instance only the approach to the landfall section at Sandford Bay in Peterhead would need further consideration. However, the cable route approach is unlikely to be in North-South direction based on the geography of the site and further thought to bundling the cables at the landfall approaches could help mitigate such a concern. It is emphasised that such issues are for detailed design consideration and further thought into installation methodology to follow on from this study. Xodus suggest that these issues be addressed in future phases of the project in consultation with the cable manufacturers and installation contractors to determine the best solution.

During route design, special consideration has been given to (existing/future) offshore infrastructure, soil conditions, slope analysis, installation method, burial depth, crossing arrangements, scour protection and cable protection to protect the cables from failure during operations and to ensure maximum availability during the project lifecycle.

It is assumed that 30m cable separation would be a base case safe separation distance for installation activities (i.e. lay and trenching), as is commonly adopted in the offshore oil and gas and renewables industry to mitigate any risks associated with minor route deviations that can occur during operations. Therefore a 120m wide installation corridor is suggested for all 3 cables, i.e. 30m either side of the outer cables.

For cable failure and repair operations where the damaged cable is removed and extra lengths of the new cable are installed, specific and focussed survey should be undertaken to identify any seabed hazards in the laydown area where the extra length(s) are to be laid. It would be expected that repair of the outer cables would involve lay away from the centre cable so interference is avoided. For repair of the central cable specific crossing arrangements would need to be investigated and designed for to minimise interactions with the outer cables. Such issues regarding repair activities need special consideration and require further attention during the next phase of the project in discussion with cable designers and installation contractors.

5.2 Geotechnical & Geophysical Assessment

Xodus requested support and input from Geomarine Limited (a geotechnical consultancy), to provide appropriate geological and geotechnical information held in Geomarine archives to assist with route selection. The geotechnical and geophysical assessment of this data used field and project information relevant to the proposed routings to produce a preliminary geohazard risk assessment for the proposed route and further perform a trenchability assessment for installation considerations during cost estimate appraisals.

The sections below present the data that were reviewed and how the geology was assessed to help determine the effects of route selection.

5.2.1 Available Information

With external support from Geomarine, data from the following fields and sources have been used in preparation of this study:

1. Johnson, H., Richards, P.C., Long, D. and Graham, C.C, 1993. United Kingdom offshore regional report: the geology of the northern North Sea. London: HMSO for the British Geological Survey.
2. Gatliff, R.W., Richards, P.C., Smith, K., Graham, C.C., McCormac, M., Smith, N.J.P., Long, D., Cameron, T.D.J., Evans, D., Stevenson, A.G., Bulat, J. and Ritchie, J.D., 1994. United Kingdom offshore regional report: the geology of the central North Sea. London: HMSO for the British Geological Survey.
3. Holtedahl, H.H, 1993, Marine geology of the Norwegian continental margin. Nor. Geol. Unders., Special Publication 6, 1-150.
4. Mareano database of the Norwegian Havforskningsinstituttet (Institute of Marine Research) : http://www.mareano.no/
5. Geophysical and geotechnical data from in-house Geomarine sources include the following fields/projects:
    - Buzzard
    - Ettrick
    - Goldeneye
    - Goldeneye to St. Fergus
    - Rob Roy
    - Telford
    - Galley
    - Macculloch
    - Donan
    - Lochranza
    - Birch
    - Larch
    - Brae
    - Miller
    - Brenda
    - Balmoral
    - Thelma
    - Kingfisher
    - Enoch
    - Glitne
    - Sleipner Vest
    - Balder

The geological and geotechnical appraisal is confined to the evaluation of data provided within these documents and sources, with the primary focus on the underlying Quaternary soil conditions across the proposed routes in the North Sea. However, it should be noted that descriptions of soil conditions of the Norwegian inland waters of the fjords are not available and hence are only briefly described.

5.2.2 Quaternary Soils

5.2.2.1 Overview

The proposed cable routes across the North Sea are expected to cross a similar geology, with minor differences in what is considered hard soils and soft soils for trenching activities. Because the route is so long the following sections broadly describe the seabed features and shallow soil stratigraphy along the general route corridor.

5.2.2.2 Bathymetry and Seabed Features

Major seabed zones along the route comprise:

- Megaripple fields and sand ridges between Peterhead and the start of the large soft sediment basin defined by the Witch Ground Formation;
- Pockmark fields, with local autogenic carbonate occurrences in connection with the very soft clays of the Witch Ground Formation, which is expected to be a dominant soil encountered in the UK sector;
- An overall gentle western slope into the Norwegian Channel, with local steep sections which descend from the eastern North Sea Plateau at approximately 150 m water depth into flat bottom of the Norwegian Trench at over 300 m depth. Iceberg scars are present and may cause local areas of seabed undulations;
- Pockmark fields in the very soft clays of the Kleppe Senior Formation at the base of the Norwegian Trench;
- A relatively steep slope on the eastern side of the Norwegian Channel, with rough sections due to iceberg scarring. Outcrop of glacial till, or local bedrock highs may be encountered, more prevalent toward the coast.

Note most of the above features are expected to lie across the cable corridor route and hence are unavoidable without significant route deviation. Therefore, a detailed route survey will be required to understand the impact of such features to lay and trenching activities and to determine if any route deviations are required if such hazards present a major risk to installation operations.

Figure 5.1 presents a chart of the seabed global bathymetry across the North Sea from Sandford Bay, Peterhead to the two landfall options at Samnanger and Sima in Norway. This is also presented in Appendix H (“Bathymetry”).

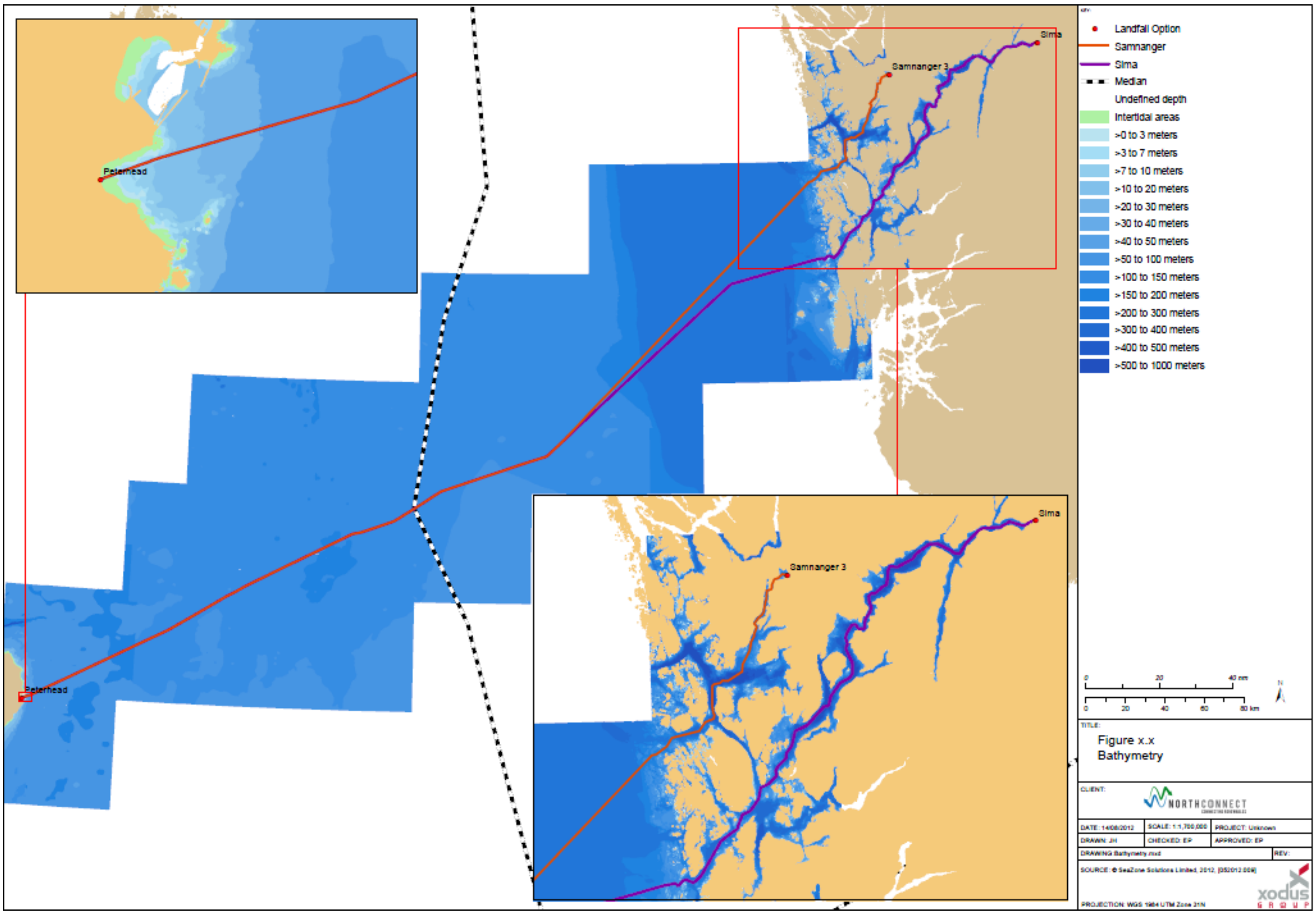


Figure 5.1: Global Bathymetry across the proposed route corridor

5.2.2.3 Shallow Soil Conditions

The expected main soils are summarised in Figure 5.2 (and in Appendix G), which is based on Quaternary soil data from the UK sector from the British Geological Survey and more general information from the Norwegian sector. The legend in the attachment indicates the geological formations which are expected to be encountered within the uppermost 3 m below seabed for the UK and Norwegian sectors. A short summary description of these soils follows here.

UK Sector – The Quaternary soil formations crossed by the cable routes within the UK sector are summarised in Table 5.2. The distribution of the formations can be localised using the map in Figure 5.2.

Norwegian Sector – The Quaternary soil formations which may be encountered by the cable routes within the Norwegian sector are summarised in Table 5.3. The distribution of the formations can be localised using the map in Figure 5.2.

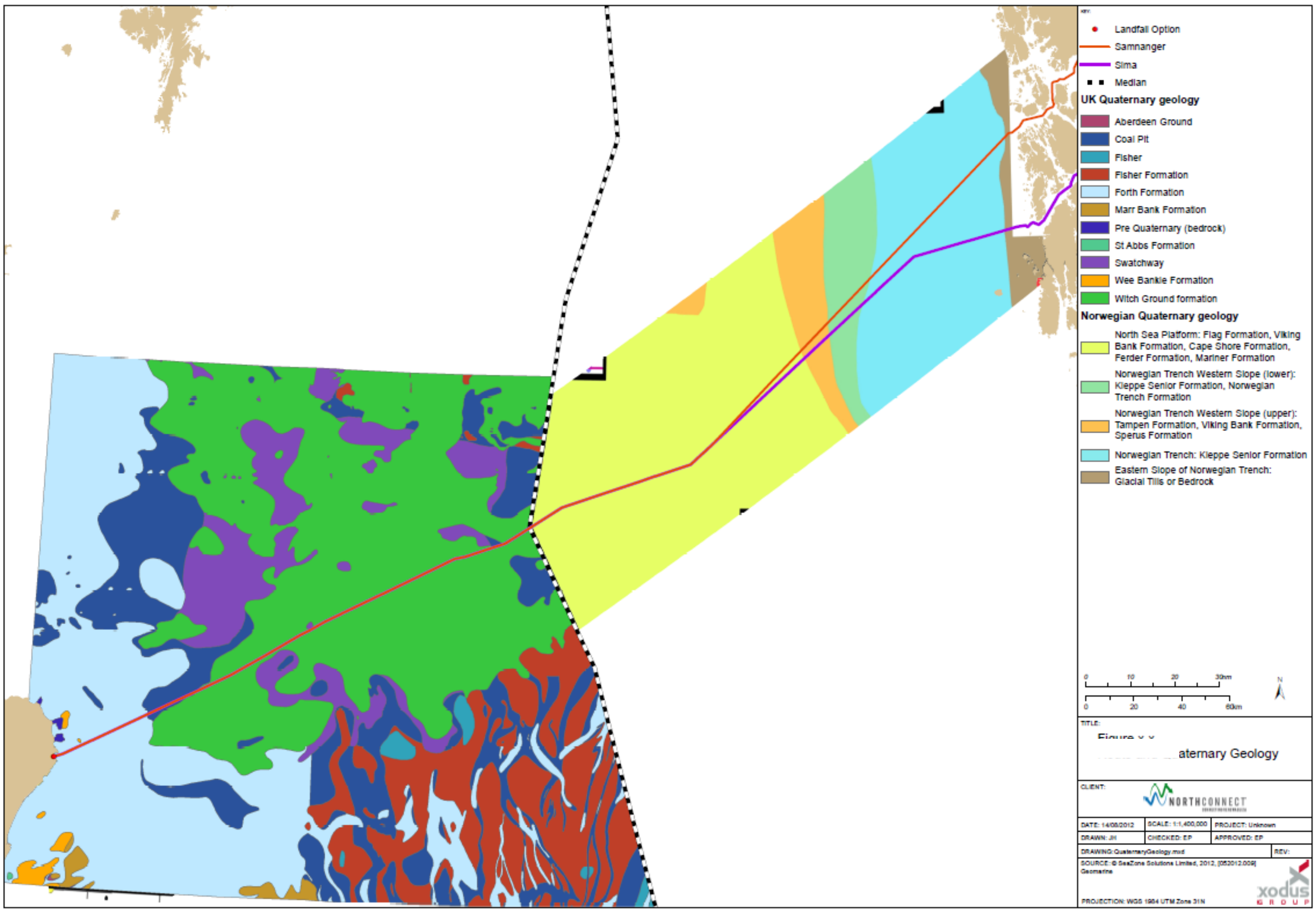


Figure 5.2: Quaternary Geology of the North Sea

Soil Formation	Main Soil Type	General Description
Forth Formation, Upper	Sand	Medium dense to very dense fine SAND, locally gravelly
Forth Formation, Lower	Clay	Very soft to stiff slightly sandy CLAY, partings and layers of sand. Near the Scottish coast, includes the St Andrew's Bay member, soft to stiff laminated plastic CLAY with gravel.
Witch Ground Formation	Clay	Very soft to soft slightly sandy CLAY with fine to coarse gravel, can grade to SILT or to SAND soils at the margins of the Witch Ground Basin
Swatchway Formation	mainly Clay	Silty sandy CLAY with rare gravel, typically soft or firm clay close to seabed
Coal Pit Formation	Sand and Clay	Firm to very stiff CLAY and dense to very dense SAND
Fisher Formation	Clay and Sand	Stiff to very hard slightly sandy to sandy CLAY with bands and horizons of sand and gravel; Grades in part to medium dense to very dense SAND

Table 5.2: Shallow soils expected in the UK sector

Soil Formation	Main Soil Type	General Description
Flags Formation	Clay	Correlates with Witch Ground Formation in UK sector. Very soft to soft CLAY
Viking Bank Formation	Mainly Sand	Generally well-sorted sands, forming topographic rises, clays at base can form channel-fill deposits
Kleppe Senior Formation	Clay	Very soft to soft CLAY, correlates with Witch Ground in time and soil character
Norwegian Trench Formation	Glacial Till	Gravelly stiff to hard CLAY
Tampen Formation	Glacial Till	Firm to very stiff sandy silty CLAY, sand partings and local gravel lenses
Sperus Formation	Glaciomarine Clay	Mainly firm to very stiff, sandy silty CLAY with shells and pebbles
Cape Shore Formation	Sand	Reworked soil, predominantly sandy with pebbles. Grades to more clay-dominated soil further north
Ferder Formation	Clay (and gravelly sand)	Mainly firm to hard sandy gravelly CLAY, some sections more laminated with silt and sand layers
Bedrock (Prequaternary)	Rock	May outcrop locally at seabed out to approx. 25 km from the coast

Table 5.3: Shallow soils expected in the Norwegian Sector

It is expected that the channel deposits at the base of the fjords comprise fine grained sediments, such as fine sands, silts and clays. Very limited data is available to confirm the soil conditions along the Samnanger and Sima routes, therefore it is a requirement that, further geotechnical survey is performed to confirm the above assumption.

5.2.3 Bedrock Outcrops and Coral Deposits

It should be noted that pre-Quaternary bedrock outcrops will occur along the coastal sections of the landfall area at Sandford Bay Peterhead, and within the steep sided flanks of the Norwegian fjords for both Samnanger and Sima route options. Known outcrops at Sandford Bay have been identified and presented in Figure 5.3. Unfortunately no such information is available for the Norwegian fjord approaches. However, coral deposits are recorded and are presented in Figure 5.4.

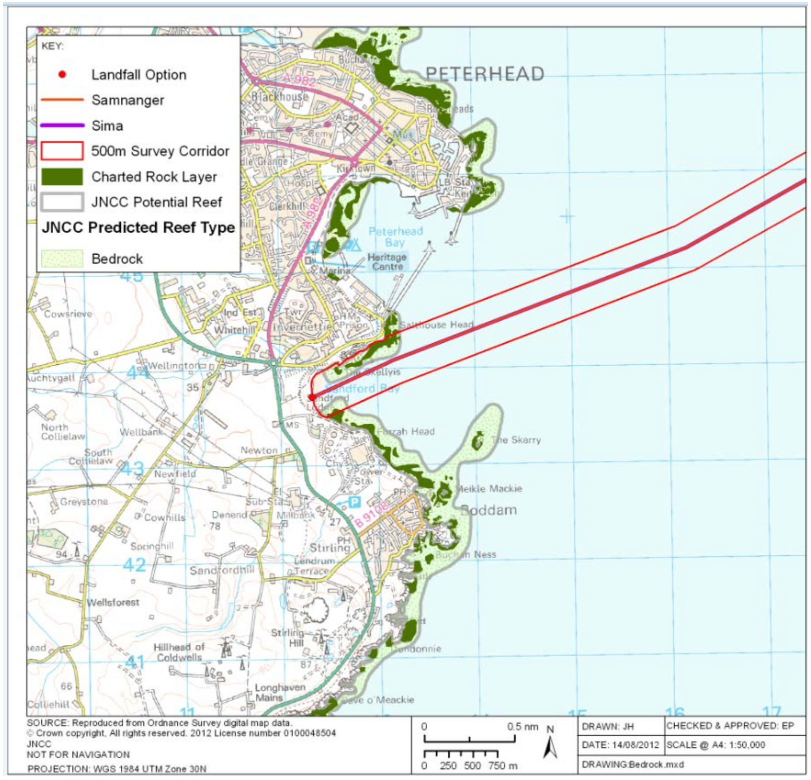


Figure 5.3: Bedrock outcrops at Sandford Bay, Peterhead

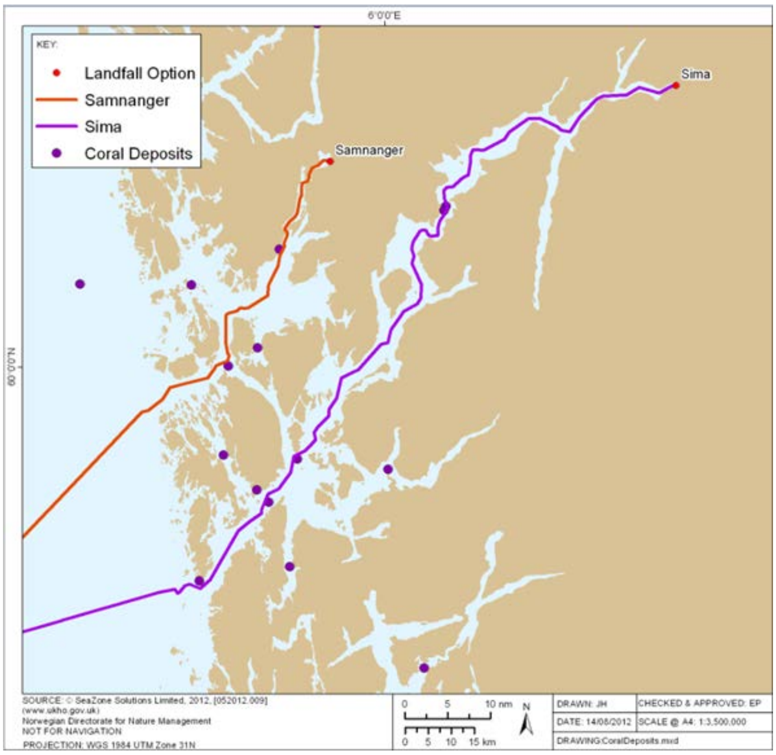


Figure 5.4: Coral deposits within Norwegian Sector

5.2.4 Geohazards and Geotechnical Risks

A preliminary identification of possible geotechnical-related risks along the routes include:

- Seabed and sub-seabed boulders
- Megaripples
- Pockmarks
- Shallow Gas
- Gas-cemented hard ground (Marine Derived Authogenic Carbonate, MDAC)
- Iceberg scars
- Local steep seabed gradients
- Local areas of unstable sediments
- Bedrock
- Gravel beds or horizons

Additional risks include existing debris or dropped objects in areas of existing subsea infrastructure and local areas with strong bottom currents. Such risks need to be confirmed by a site specific route corridor survey to gauge the level of risk such hazards have on final route alignment, cable installation, and further design considerations (e.g. crossings).

5.2.5 Trenchability

A preliminary review of the expected soils within depths relevant to trenching (< 3 m below seabed) has been carried out to develop an initial classification of soils for a trenching assessment along potential routes between Peterhead and the Norwegian landfalls at Samnanger and Sima.

For the corridor options considered after qualitative option screening of preliminary route corridor options, segments were assigned to describe specific soil conditions to that route option and to consider soil-related risks for each. These segments are presented in Figure 5.5. It should be emphasised that this evaluation is based on approximate distances and that the assessment must be considered to be preliminary and high-level at this stage, before any route specific survey is carried out. It is expected that significant local variations are possible in the shallow geology of any section and that this uncertainty will only be identified during such a survey.

The following sections describe the geology for each corridor segment and then consider the most appropriate trenching tool for cable burial. A more detailed table of soil conditions, soils risks, and appropriate trenching tool most suited to the expected soil conditions is presented in Appendix G.

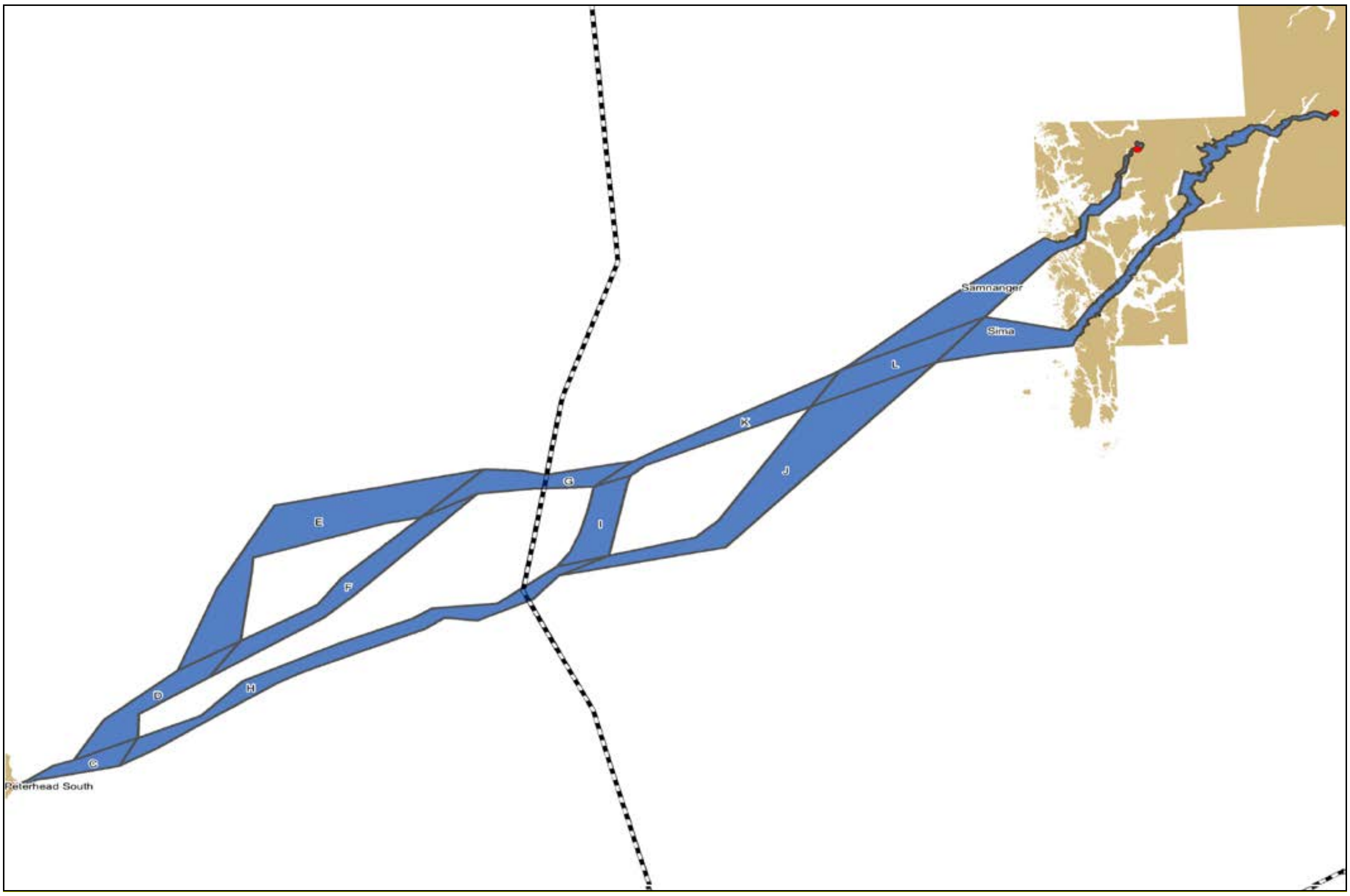


Figure 5.5: Preliminary route corridor options considered for trenching evaluations. Note the striped marker is the UK-Norway median line.

Corridor C comprises the Peterhead approach. Soil conditions expected to comprise predominantly granular soils with Holocene sands and gravelly sands over fine to medium sand and silts and local shelly lags (Forth Formation). Possible local highs of sandy and gravelly clay tills (Wee Bankie Formation) may be encountered.

Corridor D is expected to cross variable soil conditions, including sand and gravelly sand (Holocene sand and Forth Formation) soft to firm clay with gravel (Swatchway formation), interbedded loose to very dense sand with soft to very stiff clay (Coal Pit Formation) and areas of very soft to soft clay (Witch Ground Formation).

Corridor E consists predominantly of very soft to soft clays, with or without a Holocene sand veneer layer (Witch Ground Formation). On several sections soft to firm clay with gravel may be encountered (Swatchway Formation). At the easternmost end of the corridor, there is a risk of encountering interbedded sands and soft to very stiff clay (Coal Pit Formation) or stiff to very stiff clay (Fisher Formation).

Corridor F is expected to have similar soil conditions to Corridor E, with predominantly very soft to soft clays, (Witch Ground Formation) with or without a Holocene sand veneer layer. On several sections, soft to firm clay with gravel may be encountered (Swatchway Formation). At the easternmost end of the corridor, there is a risk for encountering both sands and soft to very stiff clay (Coal Pit Formation) or locally stiff to very stiff clay (Fisher Formation).

Corridor G the northern edge of the Witch Ground Basin, and variable soils are expected including sandy or very sandy soft clay (Witch Ground Fm.), gravelly sands and stiff sandy clay (Ferder Fm), sands and soft to very stiff clay (Coal Pit Formation) stiff to very stiff clay (Fisher Formation) and very sandy clay with gravel of possibly very high shear strength (Mariner Formation).

Corridor H crosses the entire Witch Ground Basin from WSW to ENE, with very soft to soft clay soils expected to comprise the major percentage of the route. However, at the western end, loose to very dense sand (Holocene sand and Forth Formation) soft to firm clay (Swatchway Formation) interbedded loose to very dense sand and soft to very stiff clay (Coal Pit Formation) will be encountered prior to entering the soft clay terrain. Local highs of firm clay (Swatchway Fm) may be encountered within the main Witch Ground Basin.

The corridor ends in Norwegian sector waters at the edge and east of the Witch Ground Basin in sands of variable thickness and firm to possibly hard clays are expected.

Corridor I soil conditions are somewhat uncertain, but the route is located near the eastern edge of the Witch Ground Basin, but is expected to lie outside of the main area of soft clay. As such, soil conditions are expected to comprise a thin layer of Holocene sand over stiff clay. Local basins of softer clay may be encountered.

Corridor J crosses the North Sea Plateau before descending the western Norwegian Trench slope and terminating at the bottom of the Norwegian Trench. On the Plateau, variable thicknesses of medium dense to dense sand (to > 3 m) over stiff to hard clay are expected. There is a risk of stiff clay occuring within 0.5 m of the seabed on the upper trench slope, this is more likely at the southern edge of the corridor. Sand is expected to predominate on the Norwegian Trench slope, with grain size decreasing with water depth until a transition to silts and soft clays is encountered on the lower slope. The base of the trench comprises very soft to soft clay.

Corridor K crosses the Norwegian sector of the North Sea Plateau and the upper portion of the western Norwegian Trench slope, with similar soil conditions to those within Corridor J. On the Plateau, variable thicknesses of medium dense to dense sand (to > 3 m) over stiff to hard clay are expected, howeverthere is a risk of localised outcoprs of stiff clay occuring in this area. Sand is expected to predominate on the slope of the Norwegian Trench, with grain size decreasing with water depth. Outcrop of stiff clay may occur on the uppermost slope.

Corridor L initiates on the upper portion of the western Norwegian Trench slope and traverses the entire slope as well as a majority of the trench base. Sand is expected to predominate on the slope of the Norwegian Trench, with grain size decreasing with water depth until a transition to silts and soft clays occurs on the lower slope. The base of the trench comprises very soft to soft clay.

5.2.5.1 Trenching Solutions

The preliminary assessment of the route options suggest that the only asset capable of burying the products along the entire route will be a plough, and that a cable plough is most suitable for the work scope. However, a combination of other tools would also be suitable. A summary of the various burial options follows.

- Ploughing – As mentioned, a plough is the only asset that can be employed as a stand-alone option for the entire route. A cable plough is recommended as most pipeline ploughs may not be suitable. Many pipeline ploughs are not designed to be used with small-diameter flexible products or if they are, there may be a risk of damage for a bundled fibre optic cable option (however, in this case not an issue). In addition, pipeline ploughs produce an open trench profile which leaves the cable vulnerable to damage if a backfilling pass is not carried out, which may make this approach economically unfeasible
- Cable ploughs produce a slot-like trench profile, or replace the soil wedge during the ploughing process, resulting in burial less vulnerable to damage from dragged or dropped objects.
- Water Jetting – Depending on the final required depth of lowering for the products, water jetting is evaluated to be suitable for product burial over the majority of the route, with the main limitation to the method being the occurrence of unjettable clay below the seabed sand veneer. Firm to hard clay may occur on sections of the route outside of the Witch Ground Basin in the UK sector and the Norwegian trench in the Norwegian sector. Additionally, jetting is considered to be the only viable solution to trench inside areas of the fjords due to the expected fine grained soils, and the fact that such tools have greater independent mobility (i.e. most are free-flying ROV based tools) to avoid seabed hazards and topographical constraints.

The feasibility of combining water jetting with another tool for use in unjettable clay areas will require data from a route-specific survey. It is, however, likely that in light of the length of the route and the difference in performance speed between water jetting options and a cable plough, that a plough solution will prove to be a lower risk and more economically attractive solution.

> Mechanical Cutter Jetter – A mechanical cutter is only suitable for use in combination with water jetting, on sections of the route where unjettable soils are present. The large percentage of very soft clay expected at seabed make this tool unsuitable for use on the majority of the route. In addition, the overall length of the route, relatively slow expected performance speed and high maintenance requirements make this asset only suitable for use as a secondary tool if further study shows that most of the route is jettable.

5.3 Cable Installation

Cable installation in terms of lay and trenching for protection can be performed from many different types of vessels, of all sizes, with all types of equipment, and with all types of capability to successfully deliver a project. Of primary importance is the Cable Lay Vessel (CLV), where only a few vessels in the world are available to be able to install a power cable of significant distance for a project such as this. A CLV such as the C/S “Skagerrak” (see Figure 5.6 below) that holds a 7,000Te cable turntable and dedicated trenching asset (Capjet jet trenching system) would be a suitable option to consider. This vessel was used to successfully lay the NorNed power cable between Norway and Holland in 2008 over a distance of 850km.

Figure 5.6: Nexans C/S “Skagerrak” DP2 vessel.

As discussed in Section 5.2.5.1 several types of trenching tools can be considered for safe and secure burial of the cables, which is heavily dependent on the seabed soil conditions encountered. A target burial depth of 1m above top of product should be sufficient to protect the cable against most fishing gear interaction activities. Greater burial depths would only be required where there is a risk of deep anchor penetration from passing vessels; however such areas would normally be avoided.

In areas where trenching cannot be performed due to constraints such as:

- soil conditions being too difficult to trench;
- where seabed topography is too steep for a trenching tool to safely bury a product (i.e. out of safe operating limits);
- at pipeline/cable crossings and areas of other seabed infrastructure;
- in areas where bedrock is exposed at the seabed (e.g. entrance to fjords and steep flanks),
- in anchorage areas;
- in shallow water potentially where wind, waves, tides can severely limit the operability of trenching tools;

then the cables will need alternative protection such as rockdump or concrete mattressing. This is discussed further below in Section 5.4.

5.4 Cable Protection

Cable protection at landfalls and crossings along the routes can be achieved using several methods. Typically for subsea applications it is rockdump with a minimum cover height of ca. 0.5m above top of product to protect against fishing activity. Concrete mattresses can also be considered if fishing activity is not considered to be a high risk in a particular area; however these are often not a long term solution.

At landfall approaches, concrete tunnel structures or large diameter conduits could be utilised to protect the cables. However, this solution may be more cost inefficient compared to rockdumping.

5.5 Scour Protection

Scour protection of the cables can be achieved by either concrete mattresses or rockdump. Both techniques can be performed efficiently and placement achieved to a high positional tolerance. Not until detailed design phase can this be considered further, however for this study it is assumed rockdump would be the most appropriate solution.

5.6 Cable & Pipeline Crossing Arrangements

Crossing design over existing pipelines and cables is generally site specific and tailored to the product to be crossed, which is heavily dependent on the requirements of the individual asset owners. However, typical crossing designs have been considered for this study and the typical drawings are presented below in Figures 5.7 and 5.8.

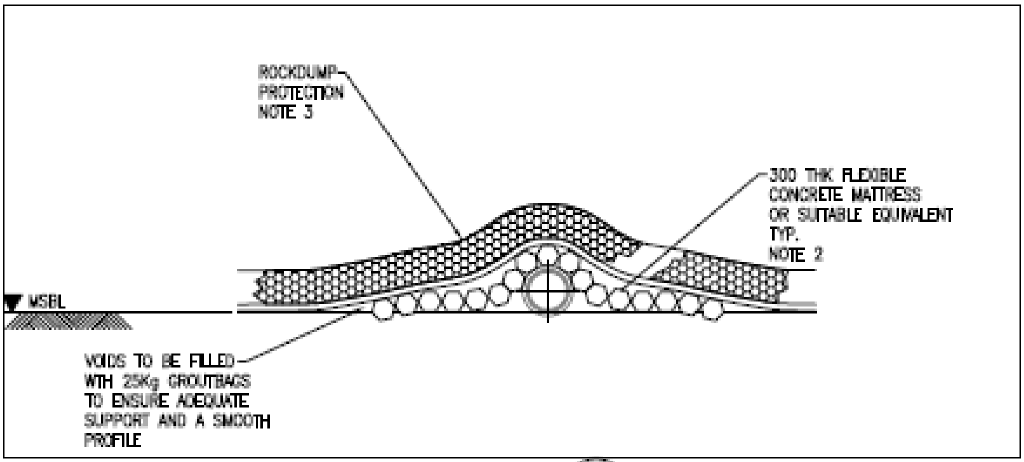


Figure 5.7: Section through a typical surface laid pipeline crossing

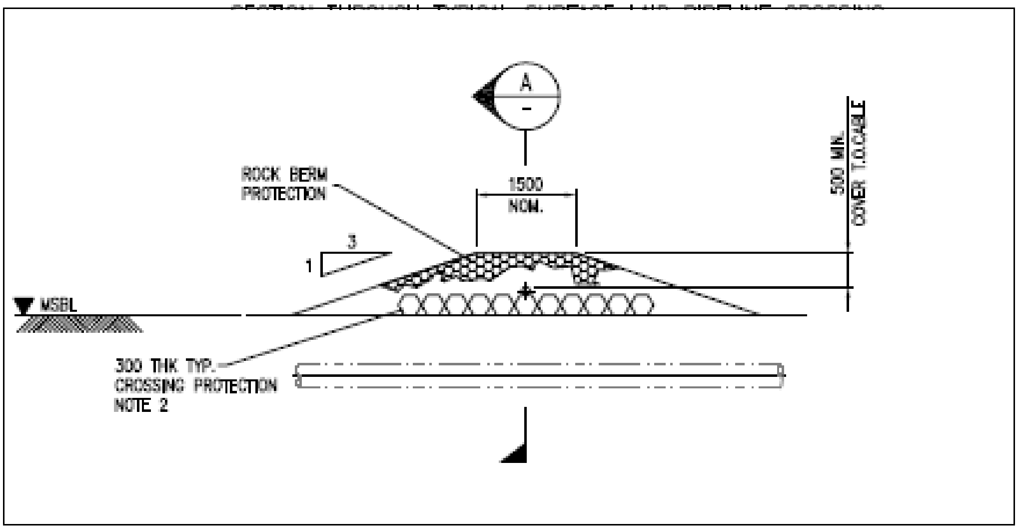


Figure 5.8: Section through a typical trenched and backfilled pipeline crossing

5.7 Thermal Properties of Seabed Soils

Thermal conductivity of seabed soils may have an impact on cable performance and should be considered by cable designers to ensure any effects have been addressed. Typical values for thermal conductivity of seabed soil types expected in the North Sea and for typical rockdump material are presented in Table 5.4 below.

Soil Type	Thermal Conductivity W/mK
SAND	1.5 - 2.5
CLAY	0.8 – 1.8
ROCK	2.0 – 2.5

Table 5.4: Typical thermal conductivity values for North Sea soils and rock dump material

6 CONSTRAINT MAPPING

6.1 Introduction

The overall objectives of the route engineering study are, where possible, to be technically the most secure, economically the most viable and the one causing the least disturbance to the environment.

This study was designed to provide a clear understanding of constraints and opportunities and to demonstrate negative and positive attributes of the project.

The constraint mapping exercise as part of the corridor and route selection process provided a means of identifying, assessing and reporting environmental effects of the project.

Constraint mapping was performed as an iterative process conducted in parallel with cable route design to identify and avoid potential environmental interactions or marine stakeholder constraints, and to develop mitigation measures to be incorporated into the design, installation and operation of the NorthConnect subsea cable route. The objective of constraint mapping was to:

- Identify and assess potential effects on environment, including marine stakeholders;
- Develop mitigation measures to avoid, prevent, reduce or offset effects.

6.2 Digital Data Sources

To carry out the constraints analysis, the various specialists listed the constraints to be included in the analysis. GIS data was then obtained from a variety of sources as required and as listed in section 6.6 ("Safety & Buffer Distances"). Much of the marine charted data was purchased from SeaZone in the form of their Hydrospatial Base product, which combines data from various sources, in this case the United Kingdom Hydrographic Office and the Norwegian Hydrographic Service, into one 'seamless' GIS data source. Data is licensed by half degree tile coverage and enough data was purchased to cover all practicable Northconnect cable routes. From this GIS database, the data themes required for analysis were extracted and buffered as required.

Other data sources were used for data not present in Hydrospatial, for example environmental designation areas and oil and gas infrastructure data. These other data sources are also listed in section 6.6.

Where the same spatial features were present in both Hydrospatial Base and data sourced from the data issuing authority, for oil and gas pipeline data and cable data, the data from the issuing authority was used instead of the Hydrospatial Base. This is because the data in Hydrospatial Base is derived from S57 charted data, and therefore the spatial accuracy of the data is dependent on the resolution of the charted data, which for offshore areas is at smaller scale and hence lower resolution. The pipeline data from UK DEAL or the Norwegian Petroleum Directorate is more accurate and can be regarded as the definitive data source. For offshore cables, cable location data provided by Kingfisher Information Service – Cable Awareness (KISCA) was used in preference to the data representing the same cables within Hydrospatial Base. Where a pipeline or cable was present in Hydrospatial Base but not in the data from the more official data source, such as cables not provided by KISCA, it was retained within the dataset to ensure as much data was captured as possible.

Bathymetry data in the form of a digital terrain model (DTM) was required to perform a slope analysis, which was originally purchased from SeaZone for the UK and had been ordered for Norwegian waters as a custom order. However, the UK data was deemed not fit for this purpose, as there were seams in the data where multiple sources had been joined, and the data was created using Delauney triangulation, thus had a triangular faceted appearance which would not have been suitable for slope analysis without significant further processing and interpolation. As there was extensive contour data and sounding data within the Hydrospatial Base product, this was used to create a DTM using the Spatial Analyst Topo to Raster tool in ArcGIS. This DTM was created with a 40 metre cell size and by comparing the DTM output to the original source contour and sounding data was deemed suitable for slope analysis at the level required by this stage of the project. For more detailed route design in the future, the survey derived bathymetry would be used to perform a higher resolution slope analysis with more accurate source data.

The data required were gathered in ESRI file geodatabases using ESRI ArcGIS (ArcView) GIS software. The datum for all project data is WGS84 and where required the data was transformed to this datum using the appropriate transformation within ArcGIS. The projected coordinate system used for most route-wide data was WGS84 UTM 31N. Although the route covers UTM zones 30N, 31N and 32N, there is minimal distortion up to 15 degrees from the central meridian of a UTM zone, so UTM31N was deemed fit for purpose for tasks such as creating buffers and calculating route lengths. A test comparison of using UTM32N against UTM31N for a 143km indicative route section through Hardangerfjord gave a difference of only 16 metres in length which was deemed not significant in the context of this level of route length analysis.

Constraints were grouped by weighting and layered accordingly in an ArcMap map, which was used as the basis for workshop sessions investigating the constraints and identifying the routes through them.

6.3 Consultations

During the qualitative option screening workshop dated 26th June 2012, a potential third Peterhead option was identified, i.e. installation of subsea cable through spoil ground area identified as part of the GIS constraint mapping. During the session also the anchorage point in the middle of the bay was noticed. Action item was raised for AMEC to consult the Peterhead Port Authorities.

AMEC has contacted the Peterhead Port Authorities to obtain more details with regard to the Peterhead options within Sandford Bay. In terms of the spoil ground, it was stated there was no knowledge of any dumping of material to occur within Sandford Bay and no knowledge of the spoil ground or anything in relation to it. For the temporary anchorage in the middle of bay area, it was stated it is used occasionally (mostly during periods of nicer weather) by vessels to anchor or swing. Feedback received indicates that the local port authorities would be reluctant to allow for any pipelines or subsea cables to be installed in that area even if buried.

During the qualitative option screening workshop dated 26th June 2012, feedback indicated that the North Sea 1 indicative route may be impacted by new O&G offshore infrastructure within the Utsira High area.

Xodus has consulted Statoil with regard to its future developments within the Utsira High area.

Xodus has consulted its Norwegian office to obtain input with regard to developments planned by Statoil, Lundin and Det Norske. Also, information about potential Carbon Capture and Storage (CCS) projects within the area (e.g. Monstad and Troll) was provided.

Xodus has consulted Ramboll and its subcontractor Ambio with regard to Sima and Samanger constraints. Feedback on the potential impact of the firing practice area, proposed protected area and proximity to unexploded ordnance has been received and included in this report.

6.4 Type of Constraints

6.4.1 Environmental, Consenting & Permitting Constraints

Environmental factors will influence both the security of the environmental system as well as the feasibility and safety of installation. Any route selected must be suitable from an environmental perspective for use for cable installation and operations.

The proposed route must be acceptable to the owners of the offshore seabed, the owners of the foreshore and military authorities. Any crossing proposals must be acceptable to the operators of existing cables and pipelines.

This study has considered opportunities to:

> Avoid known areas of environmental sensitivities (e.g. marine conservation areas, fishing grounds, and coastal nesting grounds);

> Assess suitability burial capability;

> Assess potential landing issues;

- Avoid areas where prevailing climatic or sea conditions (e.g. tides, currents and wave activity) will render installation or maintenance difficult or hazardous;
- Consider recommendations for an environmental mitigation plan, if required;
- Assess environmental and planning risks;
- Avoid disturbance to environmentally sensitive areas;
- Avoid disturbance to economically sensitive areas (ref. shipping lanes, recreation and tourism);
- Avoid military activity areas such as submarine exercise areas and artillery ranges;
- Ensure early communication/consultation with relevant (marine) stakeholders;
- Integrate with EIA contractor if and when appropriate;
- Consider planning and legal constraints;
- Assess risk in terms of consenting and permitting;

6.4.2 Technical constraints

The proposed route has taken into consideration technical constraints such as the following:

- Cables will have a diameter between 93 and 125 mm with a weight of 26 to 52 kg/m;
- Cables will be buried along their entire length apart from where burial is not possible, i.e. at cable or pipeline crossings or in areas where seabed characteristics do not allow for cable burial;
- In sections where cable burial is feasible, subsea cables will be buried at a recommended depth dependent on soil conditions;
- In sections where cable burial is not achievable, subsea cables will be covered with rock dump to provide a protective layer;
- The need for rock dump should be minimised because of the excessive capex and opex cost. It may be desirable to deviate the route significantly to minimise rock-dumping;
- A variety of installation vessels may be required due to the likely variable nature of the seabed along the corridor as well as specific installation requirements on the approaches to the landfall sites;
- The proposed route(s) must allow for sufficient space for the installation spread (e.g. area of 1000 m in length and 500 m in width) to operate;
- Marine cables will be laid in sections of a predefined length, dependent on cable characteristics, installation method and installation/cable-lay vessel capacity;
- If more than one subsea cable is required, consideration shall be given to bundled together as a pair in the same trench or unbundled laid apart in separate trenches;
- Subsea cables are suggested to be laid unbundled at distance typically 30 meters apart in water depths > 40m, to mitigate any issues with compass deviations from electromagnetic field generation of the cables. This is considered the base case lay methodology. For cable repair considerations, an appropriate approach further discussion to be had with installation contractors;
- Subsea cables could be laid further apart if local seabed obstructions apply;
- In areas defined as high risk for snagging, extra cable protection may be required;
- Cable joints will be installed between sections;

- Cable joints will be manufactured onboard the installation vessel;
- The location of cable joints will be dependent on the length of subsea cable that can be carried by the installation vessel in one load;
- The location of cable joints will be carefully chosen to permit installation, avoid areas of conflict and allow for future maintenance and repair activities;
- A transition or jointing pit will be required to connect the subsea cables and onshore cables at the landfall site;
- If more than one subsea cable is required, subsea cables may be bundled on the approach to landfalls;
- Preferred method of installation at landfall is to plough/open cut cables onto the shore. If this installation method is not feasible at landfall, cables will be installed by horizontal directional drilling (from onshore) and pulled onshore through conduits installed in underground bore.

The route study has addressed and considered the following:

- Avoid sea-bed hazards;
- Avoid obstructions such as wrecks and dumping grounds;
- Avoid, where possible, difficult or hazardous areas, such as steep slopes, irregular rocks, boulders, debris;
- Avoid, where possible, sand waves, mega-ripples, rock, coral and areas with soft sediment (moving sea-bed);
- Avoid areas of geological instability such as earthquake zones and landslip areas;
- Avoid, where possible, areas where it might be difficult to trench and bury cables;
- Avoid, where possible, other subsea cables (live/decommissioned) and pipelines;
- Avoid, where possible, areas of high marine activities such as shipping lanes, anchorages and fishing grounds;
- Avoid, where possible, areas where recovery of subsea cable for maintenance, repair and/or decommissioning would be difficult;
- Avoid areas of existing or planned marine development sites (oil & gas, wind, wave and tidal);
- Avoid areas sensitive to cable faults;
- Assess marine cable constraints;
- Assess cable installation constraints (minimise changes in direction and distances between alter courses)
- Assess appropriate means of cable protection (e.g. cable armour type, rock dump), if and where required;
- Assess cable burial depth and width required;
- Ensure safe distance from other marine infrastructure;
- Assess technical risk.

6.4.3 Economic Constraints

Economic viability has been identified as a key driver to corridor and route selection. Overall CAPEX costs will be derived from material, installation, maintenance and survey costs. OPEX cost is unlikely to be a key differentiator between individual route options and therefore has not been considered as a significant constraint.

The selected route must be financially viable, in terms of both installation and maintenance.

This study has considered opportunities to optimise cable corridor and route selection in order to:

- Minimise cable length;
- Minimise number of cable joints;
- Minimise amount of cable/pipeline crossings;
- Minimise need for cable protection;
- Select appropriate means of cable protection, when required;
- Optimise choice of installation method (in terms of cost and lead time);
- Maximise cable burial/trenching rates, i.e. look for cable routes through sea-bed which is easily ploughable;
- Ensure the route allows the cables to be installed by as many vessels as possible to ensure competitive tendering.

6.4.4 Technical Health, Safety & Risk Constraints

Technical health, safety & risk were identified as potential key drivers for the project. The selected route must be secure in terms of cable installation and operations. Therefore this study has assessed different options to:

- Avoid areas of Unexploded Ordnance (UXO);
- Look for areas allowing for safe installation and operation (e.g. offshore conditions, water depth, soil conditions, existing infrastructure);
- Recommend appropriate means of installation;
- Avoid busy shipping areas to minimize risk of collisions or interference with other vessels during installation;
- Ensure limited exposure of cables to other vessels or infrastructure;
- Ensure safe distance from other offshore infrastructure;
- Minimise amount of cable and pipeline crossings;
- Ensure appropriate means of cable protection is provided;

6.5 Weighting of Constraints

Constraints along any route identified, need to be differentiated in terms of magnitude, sensitivity and significance. The weighting proposed for this study is the following:

- Hard Constraints (High) – Cable route constraint mapping must avoid or prevent sensitive areas which impose a significant risk to key drivers such as project consenting, technical safety, cost and schedule (e.g. conservation areas, steep slopes, areas Unexploded Ordnance). Any cable route considered should avoid areas introducing adverse effects which need to be offset. Costs related to offsetting related activities (e.g. environmental mitigation plan, environmental management) are usually significant and may impact economic viability. These areas will be marked as ‘no-go’ areas.
- Medium Constraints (Medium) – Cable route design must reduce the effects in sensitive areas which impose a reasonable risk to project consenting (e.g. cable/pipeline crossings, shipping lanes).
- Soft Constraints (Low) – Cable route design must minimise the effects in sensitive areas which impose a small risk to project consenting (e.g. recreation & tourism).

6.6 Safety & Buffer Distances

Safety and buffer distances have been defined for offshore infrastructure (e.g. cables, pipelines and existing/future offshore development sites) and designated/sensitive areas (e.g. wrecks, seal hauls). These buffer distances have been incorporated as part of good practice in order to avoid collision risk and impact on the environment.

The buffer distances have been adopted in the GIS data as per details in tables below, with the exception of Offshore Safety Zones, which are themselves 500 metre buffers of sensitive infrastructure and were not buffered any further.

Weighting	Constraint	Data Provider	Buffer (where applicable)
High	Offshore SAC	JNCC	n/a
High	Anchorage Area	Seazone Hydrospatial Base	n/a
High	Anchorage Area point location	Seazone Hydrospatial Base	500 metres
High	Aquaculture Area	Seazone Hydrospatial Base	n/a
High	Aquaculture point location	Seazone Hydrospatial Base	500 metres
High	Restricted Area	Seazone Hydrospatial Base	n/a
High	Norway O&G Surface infrastructure	Norwegian Petroleum Directorate	500 metres
High	Norway O&G Subsurface infrastructure	Norwegian Petroleum Directorate	500 metres
High	Offshore Safety Zone	UK DEAL	n/a
High	UK O&G Surface infrastructure	UK DEAL	500 metres
High	UK O&G Subsurface infrastructure (active)	UK DEAL	500 metres
High	UK O&G Subsurface infrastructure (abandoned)	UK DEAL	200 metres
High	Bedrock areas	Seazone Hydrospatial Base	n/a
High	JNCC Potential Reef areas	JNCC	n/a
High	Former Minefield	Seazone Hydrospatial Base	n/a
High	Explosives Dumping Ground	Seazone Hydrospatial Base	n/a
High	Foul Ground	Seazone Hydrospatial Base	n/a
High	Foul Ground point location	Seazone Hydrospatial Base	500 metres
High	Wrecks & Obstructions	Seazone UKHO Wrecks Database	200 metres
High	Navigation Installation	Seazone Hydrospatial Base	200 metres

Figure 6.1: Buffer Distances for High Constraints (i.e. no-go area).

Weighting	Constraint	Data Provider	Buffer (where applicable)
Medium	Protected Areas - Direktoratet for Naturforvaltning - point	Direktoratet for Naturforvaltning	200 metres
Medium	Protected Areas - Direktoratet for Naturforvaltning	Direktoratet for Naturforvaltning	n/a
Medium	Proposed Protected Areas - Direktoratet for Naturforvaltning	Direktoratet for Naturforvaltning	n/a
Medium	Proposed Marine Protected Area - not in first round	Direktoratet for Naturforvaltning	n/a
Medium	JNCC Potential Annex I Reef areas	JNCC	n/a
Medium	JNCC Offshore SAC 500m Buffer	JNCC	500 metres
Medium	JNCC SPA with Marine Components	JNCC	n/a
Medium	SSSI	SNH	n/a
Medium	SMRU Seal Haul out locations	SMRUL	500 metres
Medium	SMRU Seal Haul out locations	SMRUL	500 metres
Medium	Fiskeridirektoriat Norwegian Spawning Areas	Fiskeridirektoriat	n/a
Medium	Fiskeridirektoriat Norwegian Cod Spawning Areas	Fiskeridirektoriat	n/a
Medium	Fiskeridirektoriat fish growing on areas	Fiskeridirektoriat	n/a
Medium	Directorate for Nature Marine habitats incl. Coral	Direktoratet for Naturforvaltning	n/a
Medium	Directorate for Nature Marine habitats incl. Coral point location	Direktoratet for Naturforvaltning	500 metres
Medium	Sandeel spawning grounds	CEFAS	n/a
Medium	Herring spawning grounds	CEFAS	n/a
Medium	Traffic Regulation Schemes	Seazone Hydrospatial Base	n/a
Medium	Military Activity Area	Seazone Hydrospatial Base	n/a
Medium	Marina	Seazone Hydrospatial Base	n/a
Medium	Bathing Waters	SEPA	n/a
Medium	OutdoorRecreationArea - Norway	Direktoratet for Naturforvaltning	n/a
Medium	Fishing areas - passive gear	Fiskeridirektoriat	n/a
Medium	Kelp occurrence areas	Fiskeridirektoriat	n/a
Medium	Shellfish areas	Fiskeridirektoriat	n/a
Medium	Fishing areas - active gear	Fiskeridirektoriat	n/a
Medium	Fish storage areas	Fiskeridirektoriat	n/a
Medium	Licence areas 20/2a and 21/10	UK DEAL	n/a

Medium	Pipelines	UK DEAL, NPD, SeaZone Hydrospatial Base	300 metres
Medium	Cables	KISCA, Seazone Hydrospatial Base	300 metres
Medium	Utsira Nord proposed offshore wind farm zone	NVE	n/a
Medium	Spoil Ground	Seazone Hydrospatial Base	n/a
Medium	Dredged Areas	Seazone Hydrospatial Base	n/a

Figure 6.2: Buffer Distances for Medium Constraints.

Weighting	Constraint	Data Provider	Buffer (where applicable)
Low	Norway Particularly Valuable Areas - Dirnat	Direktoratet for Naturforvaltning	n/a
Low	SPA 500m Buffer	JNCC	500 metres
Low	SSSI 500m Buffer	SNH	500 metres
Low	UK Discovery Fields	UK DEAL	n/a
Low	Norway Discovery Fields	NPD	n/a
Low	Restricted Areas	Seazone Hydrospatial Base	n/a
Low	Harbour Area	Seazone Hydrospatial Base	n/a
Low	Ferry route,recommended route centreline and track	Seazone Hydrospatial Base	300 metres

Figure 6.3: Buffer Distances for Low Constraints.

6.7 Iterative Approach

6.7.1 Corridor Selection – Iteration 1

The Constraints to be used in analysis were identified by all specialists as per tables listed in previous section. These data were then compiled into an ArcMap GIS map and colour coded and grouped by weighting. The constraints were layered as required, and by using the GIS on a large TV screen the corridors were identified during workshop sessions as ‘paths of least resistance’ through the constraints. Each corridor section was digitised during the workshop and then ‘fine-tuned’ afterwards to remove any digitising errors incurred during the live workshop session.

6.7.2 Route Selection – Iteration 1

Within this network of corridors, 16 indicative routes were created from Sandford Bay to Sima and Samnanger, incorporating all possible logical route options. At this stage, the routes were very indicative, representing a shortest possible route within the offshore corridors and a route through fjords that followed the route of least slope based on an initial coarse-resolution 100 metre resolution slope analysis, with no routing around small constraints within the corridors such as wrecks or wells.

6.7.3 Route Selection – Iteration 2

During the second workshop, a further corridor and route option was identified that joined Bomla Fjord to Selbjorn Fjord. This was digitised accordingly and an indicative route created through this corridor. During this session the North Sea 4 option was also dropped (see section 7.3 “Corridor Option Screening & Selection”). This gave 18 corridor options at this stage and indicative routes for the new options through the new corridor were digitised and indicative lengths and crossing numbers calculated.

The seabed terrain on the Norwegian side is significantly rougher than the North Sea and UK side, with very deep sections and significant rises and drops along the route. Therefore the indicative route lengths were calculated to take account of the terrain by using a GIS function that drapes the route over the terrain. Route profile graphs were also created to illustrate the undulating terrain.

6.7.4 Route Selection – Final Route Selection

Two of the 18 corridors were chosen as the final routes, Option 1 (Samnanger) and Option 4 (Sima), both following Peterhead North and North Sea 1 (see section 7.4 “Route Option Screening & Selection”).

To create the final route options, cables were buffered to 20 metres (40 metre corridor) and pipelines to 40 metres (80m corridor) to take account of recording laying methodology at crossing points. As the aim was to create a survey corridor of 500 metres width, wrecks and wellheads were buffered to 250 metres to be accounted for in final route design but still be outside the survey corridor. The existing identified corridors were buffered ‘inwards’ by 250 metres to ensure that the route created would allow for the 500 metre survey corridor without crossing into any of the previously avoided constraints.

The detailed routes were then created following the most logical route around constraints within the corridors such as wrecks, following the shortest practical line through the corridor. In the Norwegian fjords slope was a main constraint and a 40 metre resolution slope analysis was used to identify areas of least slope, which was used in combination with bathymetry data to route the cable through the subsea terrain.

Crossings of cables and pipelines were recorded and a route position list (RPL) created to represent the route sections.

At this stage turns in the cable were not represented by arcs but simply by changes in direction.

The final routes were buffered by 250 metres to create a 500 metres survey corridor. Where this overlapped with the mainland in narrow fjord sections the corridor was trimmed to the Hydrospatial Base coastline.

6.8 Challenges & Limitations

The data used to base the analysis upon is considered the best available within the time and budget context of the project. Survey derived bathymetry may be available for some of the route and this was discussed with Oceanwise, a marine data provider, at the start of the project, however at the time it would have taken too long for data to be processed and made available so was not an option within the current timescales. SeaZone Trudepth survey derived bathymetry was only available for a small area around the Peterhead part of the route, which is not a priority area for slope analysis due to the relatively flat seabed, so this was not obtained.

Xodus had originally planned on using Seazone Hydrospatial BE Gridded bathymetry data for slope analysis, but upon receiving this data it was decided it was not fit for this purpose. The data had been created using Delauney triangulation from sounding data, with linear interpolation. This meant the resulting terrain model was heavily triangulated in form, which during slope analysis gave ‘false’ slope results on triangular faces, which was not an accurate real world representation of areas of slope. Xodus investigated other interpolation methods using the sounding and contour data within Hydrospatial Base, to create a more realistic digital terrain model for use in slope analysis, and the Topo to Raster tool within Spatial Analyst was used to create a 40 metre resolution DTM.

The seal haul-out count data from the annual SMRU surveys are not appropriate for assessing fine scale distribution of haul-out sites. The data are a snapshot in each of the surveyed years and are really only appropriate to be interpreted on a regional scale. The numbers present at any one location can be highly variable between months and years and as such the data should not be used to inform decisions relating to micro-siting infrastructure. Data from the different years of survey illustrate there are few haul-out sites with a consistent presence of seals in all surveyed years. However, the data provides an indication of potential for disturbance to haul-out sites.

Quaternary geology data is not yet available as a digital product from the BGS so Geomarine digitised data was used. For Norwegian waters, whilst there is excellent geology data from the Norwegian Society for Geology (NGU) for many parts of the Norwegian seas, there was not any readily available for the Northconnect route area. Data may be available from other sources or obtainable in some format through Norwegian expert channels. Geomarine provided small scale data for the Norwegian offshore waters.

Norwegian intra-field pipeline data is not available to non-operator companies so was not included in the constraints analysis.

Tidal stream and other metocean data could not be readily sourced during the project timescale and was not included in analysis.

No information on tidal or wave energy sites was discovered, though the Utsira Nord offshore wind farm area was included in analysis.

Seal haul-out data for Norway was not sourced or included in analysis.

Cable repeater location data is not provided by KISCA with their cable coordinate data. The repeaters are shown on the KISCA pdf charts but the scale is too small to provide any reliable positional accuracy in relation to the Northconnect routing.

Pockmarks and depressions are not represented by the bathymetry data used and no detailed locational data is readily available. Seabed survey will identify these features as and when they occur.

Onshore landslide data is provided by the NGU but marine landslide data is not readily available so was not incorporated into the constraints analysis.

Fish farm data was taken from Hydrospatial Base, and where only a point location was provided was buffered to give it spatial representation. Whilst some fish farms are defined precisely and mooring cables shown in the data, for those that are not consideration may need to be given to the extent of the farm and mooring cables on a case by case basis.

Military activity areas were taken from Hydrospatial Base data but further specialist consultation would be required to confirm the extent and type of this activity in the project area.

7 VALUE, DECISION AND RISK MANAGEMENT

7.1 Objectives

The overall aim of the Desktop Survey and Route Selection study was to identify a 'preferred' route option for the NorthConnect marine cable route. The study was a constraint driven option screening and selection exercise, considering a wide range of environmental, technical, economic and regulatory constraints. The process allowed for informed and transparent decision making.

The preferred option selected allows for technical feasibility and economic viability whilst ensuring the least disturbance to the environment and people.

This study has assessed different corridor and route options whilst considering:

- Different corridor options within the main (UK to Norway) corridor;
- Both Sima and Samnanger corridor options;
- Different route options within both Norwegian corridors;
- Environmental, technical, economic and regulatory constraints;
- Mitigation measures to avoid, prevent, reduce or offset; and
- Key drivers identified at project kick-off.

The Xodus Group Option Screening process is ideally suited to identifying the best solution that achieves the project goals. It is a four stage process as described below:

- Identification of project drivers / success criteria and their relative importance (one-off) through brainstorming;
- Generation of proposed development options against the agreed project drivers / success criteria through brainstorming;
- The classification of how competing development options might contribute to each of those project drivers / success criteria (one-off); and
- A scoring system for testing each technology/option against the goals to find those that maximise their contribution (continual).

7.2 Project Drivers & Success Criteria

7.2.1 Identification of Key Drivers

At project kick-off, the brainstorming and ranking of the project drivers was done in a workshop attended by a range of disciplines such as:

- Project Management
- Project Engineering
- Environment and Technical Specialists

and facilitated by Xodus Group.

The process followed in the first part of the brainstorming session is outlined below.

- Identification main project driver headings.
- Group discussion to identify the criteria (values) that would influence the assessment process.

> Grouping of these criteria under the already identified driver headings, ideally with minimum overlap.

The project drivers and associated scope identified for this project is shown below.

Key Driver	Scope	Notes
Environmental	Protected areas	e.g. MOD, fisheries, dumping grounds, fish farms
	Protected species	
	Other marine users	
Consenting & Permitting	Cumulative impacts	e.g. other offshore developments
	Impacts & effects	Taking into account any mitigation actions
	Schedule risk	
	Reputational risk	
	Stakeholders	
Economic Viability	Cost of materials	
	Installation costs	
	Operations & maintenance costs	
	Availability	e.g. impact on revenues
Technical Suitability	Geotechnical/geophysical/geological	i.e. trenchability, permissible slope angles
	Marine conditions	e.g. weather, wind, waves, currents and tidal strea
	Offshore/Near-shore installation methods	
	Cable/pipeline crossings	
	Cable protection	
	Scour protection	
Execution Schedule	Cable length	
	Installation methods and number of transitions	
	Number of cable and pipeline crossings	
	Type and number of gradients	
	Hazards and number of direction changes	

Figure 7.1 Project Drivers

Workshop debate over separate driver, i.e. Health and Safety. It was decided not to include as safety considerations with any selection are a given. At this outline level it is difficult to differentiate options purely in safety terms. And ultimately, safety is inherently considered within the other key drivers, e.g. Consenting (e.g. avoiding clashes with other sea users), Technical (e.g. minimising the need for tricky sea operations) and Schedule (e.g. minimising exposure to risk/weather).

7.2.2 Project Drivers Weightings Matrix

Xodus Group has developed a unique process for identifying and ranking the relative importance of project drivers. This system is based on a pair-wise comparison where the relative importance of each driver is judged against each other in a qualitative way, using terms such as ‘much stronger than’ or ‘weaker than’. In this process, numerical (i.e. financial) and non-numerical drivers can be combined.

The Analytical Hierarchy Process (AHP) methodology was applied to pairs of project drivers and the degree of relative preference discussed and agreed within a workshop environment. As shown in the figure below, row items are compared with column items. For instance, “Environmental” was compared to “Economic Viability” in the third cell of the first row.

The consensus of the workshop, in this case, was that “Environmental” was a weaker (W) decision criterion than “Economic Viability”. “Economic Viability” was deemed to be the highest measure for the option screening process with a weighting of 26.27%. The driver weightings are as shown in Figures 7.2 and 7.3.

Key Drivers	Environmental	Consenting & Permitting	Economic Viability	Technical Suitability	Execution Schedule	Weighting
Environmental	N	N	W	W	S	17.93%
Consenting & Permitting	N	N	S	S	S	24.80%
Economic Viability	S	W	N	MS	S	26.27%
Technical Suitability	S	W	MW	N	S	16.93%
Execution Schedule	W	W	W	W	N	14.06%

Consistency Ratio: 5.5%

Number of Success Criteria 5

100.00%

Legend
Very Much Stronger **(VMS)**
Much Stronger **(MS)**
Stronger **(S)**
Neutral **(N)**
Weaker **(W)**
Much Weaker **(MW)**
Very Much Weaker **(VMW)**

Figure 7.2: Key drivers / success criteria weightings matrix

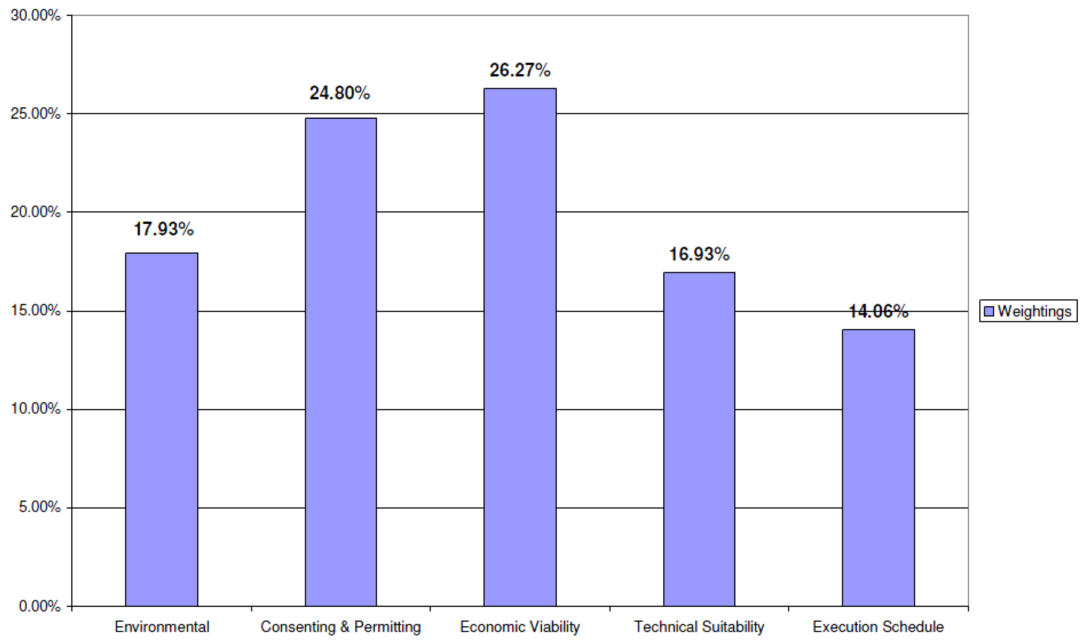


Figure 7.3: Option screening decision criteria relative weighting

7.2.3 Classification of Contribution

This section describes the ranking system for each of the project drivers identified, which allows us to compare the proposed technologies / options against each other. This activity is performed once in a workshop format. Below is the ranking corresponding to the above Value Measures and using a -3 to +3 range.

It should be noted that whilst the upper and lower limits of each of the project goals are described here, the ranking process allows seven ranks to be applied, i.e. each whole number between -3 and 3, including 0.

The classification of contribution has been defined together with NorthConnect staff on 20th July 2012, i.e. prior to quantitative assessment of route options.

Key Driver	Classification of Contribution		
	-3	0	+3
Environmental	Potential permanent negative impact on a sensitive environmental receptor (e.g. protected areas, protected species or other marine users). Or legal non-compliance issues.	Potential temporary, short term (up to 1 year), negative environmental impact which does not affect protected areas or protected species. No legal non-compliance issues.	No potential negative environmental impacts
Consenting & Permitting	Severe / significant impacts and effects with likely impact on execution schedule and/or company reputation - potential show stopper for obtaining project consent and/or permits.	Moderate / minor impact and effects which could result in acceptable permit conditions smoothly and on time.	Opportunity for environmental, social or economic enhancement.
Economic Viability	Significant risk of exceeding target costs requiring significant project management resource.	Tolerable risk of impact on target costs requiring some project management resource.	Potential opportunity to reduce costs.
Technical Suitability	Significant risk of hazards (people/ equipment) during installation or cable failure during operations.	Tolerable risk of hazards to people/equipment during installation or cable failure during operations. Tolerable number of cable/pipeline crossings and level of cable protection required.	Reduced risk of hazards (people/ equipment) during installation or cable failure during operations. Opportunity to minimise number of cable and pipeline crossings or minimise level of cable protection required.
Execution Schedule	Significant impact on first power transmission date (1 year delay).	Ability to meet first power transmission date. Ability to install in 2 seasons *.	Accelerate first power transmission date (6 months acceleration).

* One vessel used.

Figure 7.4: Classification of Contribution

7.3 Corridor Option Screening & Selection

7.3.1 Qualitative Assessment Method

The objective of the qualitative option screening method was to assess key drivers for each corridor option identified based on expert knowledge and engineering judgement. This method was used to rule out obvious showstoppers.

7.3.2 Corridor Options Identified

The corridor options identified during stage 2 of this study were the following:

- Peterhead North (UK landfall option);
- Peterhead South (UK landfall option);
- North Sea 1 (i.e. most Southern route);
- North Sea 2;
- North Sea 3;
- North Sea 4 (i.e. most Northern route);

> Samnanger (Norwegian landfall option); and

> Sima (Norwegian landfall option).

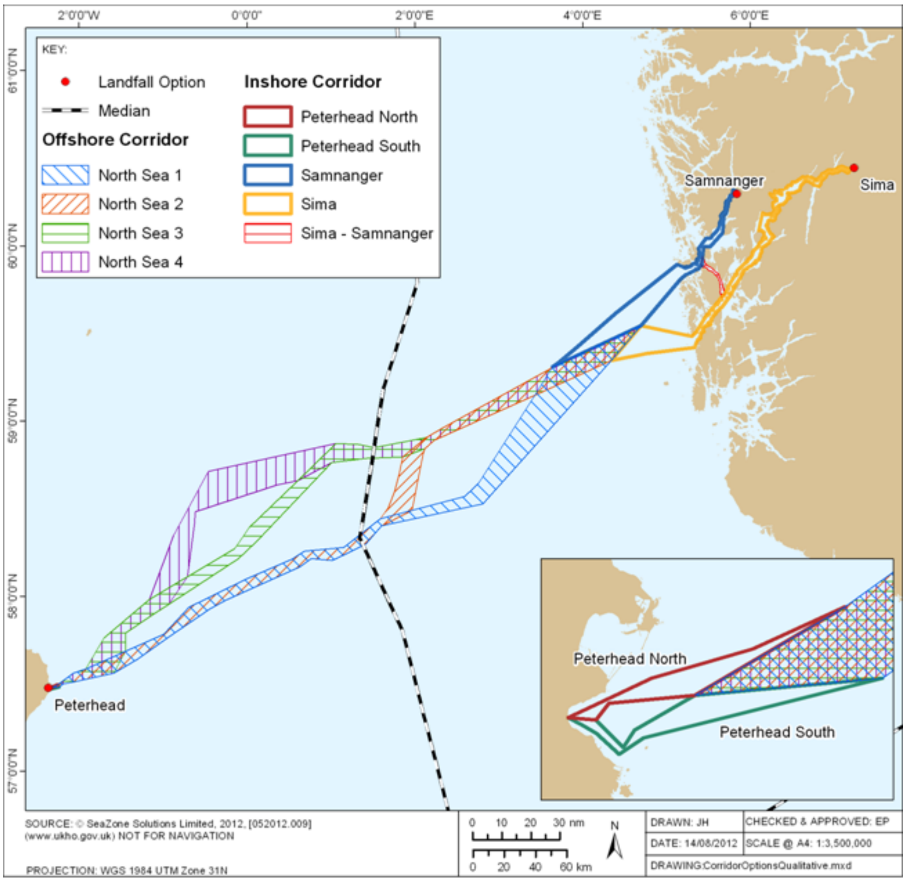


Figure 7.5: Corridor options

The 8 corridor options identified above allowed for several permutations for potential cable routes. In total 16 cable route options were identified as follows:

Indicative corridor route options	Peterhead North	Peterhead South	North Sea 1	North Sea 2	North Sea 3	North Sea 4	Samnanger	Sima	Segments
	Corridor options								
Option 1	Y		Y				Y		PN,C,H,J,L,Sam
Option 2	Y			Y			Y		PN,C,H,I, K, L,Sam
Option 3	Y				Y		Y		PN,C,D,F,G,K,L,Sam
Option 4	Y					Y	Y		PN,C,D,E,G,K,L,Sam
Option 5	Y		Y					Y	PN,C,H,J,L,Sim
Option 6	Y			Y				Y	PN,C,H,I, K, L,Sim
Option 7	Y				Y			Y	PN,C,D,F,G,K,L,Sim
Option 8	Y					Y		Y	PN,C,D,E,G,K,L,Sim
Option 9		Y	Y				Y		PS,C,H,J,L,Sam
Option 10		Y		Y			Y		PS,C,H,I, K, L,Sam
Option 11		Y			Y		Y		PS,C,D,F,G,K,L,Sam
Option 12		Y				Y	Y		PS,C,D,E,G,K,L,Sam
Option 13		Y	Y					Y	PS,C,H,J,L,Sim
Option 14		Y		Y				Y	PS,C,H,I, K, L,Sim
Option 15		Y			Y			Y	PS,C,D,F,G,K,L,Sim
Option 16		Y				Y		Y	PS,C,D,E,G,K,L,Sim

Figure 7.6: Corridor cable route options

For each corridor route option identified, an indicative cable route was designed in GIS allowing for the calculation of an indicative cable length. One of the project's key drivers is economic viability which is mainly driven by cost of materials and installation cost, i.e. cable length and number of pipeline and cable crossings.

7.3.3 Record of Discussion

The corridor option screening process was performed with representatives from NorthConnect, Mott MacDonald, AMEC and Xodus. Options were assessed against the project drivers / success criteria and the discussion recorded. The EIA, GIS, consenting, engineering, safety & risk and project management teams were asked for their recommendations.

Obvious show-stoppers were removed from the list of option to be analysed in more detail during route option screening.

The output from all sessions was then presented to the senior management team for discussion and confirmation or modification. The corridor option screening exercise has generated clear recommendations for further engineering, EIA and clarification.

An extract of the corridor option screening spread sheet can be found in Appendix A ("Option Screening - Qualitative Assessment).

UK landfall options:

- Peterhead North – The main constraint for this UK landfall option involves 2 pipelines located within Sandford Bay. The pipelines lead to a spoil ground area located in the middle of Sandford Bay. The project needs to consider pipeline crossing (over) or HDD (under). No environmental showstoppers were identified for this option. From a technical point of view, this was considered the most suitable option. In due course the Project will consult with the stakeholders to perform the appraisal. Any route will need to cross the intertidal area and other pipelines / cables so all of this will need to be negotiated once the preferred route is identified.

> Peterhead South – This option runs through SPA area and goes near grey seal haul-out area within the region. There is exposure to water discharge from the local power station. Installation is likely to prove challenging due to shallow water and constraints regarding spoil ground area. Based on environmental issues alone, this route was still considered feasible. The EIA had not been progressed sufficiently to provide detailed information at this stage. However, both the seal haul-out data and ornithological issues are constraints not showstoppers. It was assumed both these constraints could be overcome through seasonal construction of cable laying. More certainty will be obtained through EIA scoping and consultation process.

> Peterhead Bay – Constraints for this option are SPA, spoil dumping ground and anchorage point. Question was raised whether or not a cable route through the spoil dumping ground could be considered. Due to the unknown nature of spoil ground dumped to date and the potential impact of additional weight of future disposal ground dumped on top of the cable, this option required further analysis. Action item was raised for AMEC to consult harbour master on nature dumping ground and activities within Sandford Bay.

> There was an overall consensus Peterhead North is the more favorable route based on environmental, consenting, permitting and technical suitability project drivers. Peterhead North was flagged GREEN.

> There was an overall consensus Peterhead South may be a trickier route to assess than the Northern one as more potential impact associated with seals and birds and also in terms of HRA. Peterhead South was flagged AMBER.

> It was decided to take forward both Peterhead North and Peterhead South options for further analysis during stage 3 of this route study.

Subsea options:

> North Sea 1 – All North Sea 1 options scored very well together with North Sea 2 options (i.e. GREEN). The main constraint identified for this option is future O&G development within Norwegian waters. This potential candidate runs through the “Utsira High” area. Future developments within this area, e.g. Johan Sverdrup, Edvard Grieg, Dagny and Draupe, are likely to pose additional constraints and risks in terms of consenting & permitting, economic viability and execution schedule. There is a substantial risk future infrastructure may impact feasibility of the NorthConnect route (e.g. extra crossings, stakeholder involvement, legal agreements, costs). This option was flagged GREEN during the session. It was recommended to liaise with Statoil to obtain more information and clarity on the exact location of planned new offshore infrastructure in terms of new fields, platforms, pipelines and cables. It was understood this corridor option would most likely be downgraded during the next phase.

> North Sea 2 – All North Sea 2 options scored very well together with North Sea 1 options (i.e. GREEN). No major constraints were recorded for this option.

> North Sea 3 – This option has the most number of cable and pipeline crossings for all landfall options. This option was considered least favourable in terms of technical suitability. Also, this option was rated lower in terms of economic viability and execution schedule compared to North Sea 1 and North Sea 2 options. All North Sea 3 options were flagged AMBER.

> North Sea 4 – This option runs nearby unexploded ordnance area and through PSSA. It has the longest cable length and second most number of cable and pipeline crossings for all landfall options. As a result, this option was considered least favourable in terms of economic viability and execution schedule. All North Sea 4 options were flagged RED and it was decided not to take these options forward for further consideration.

> The likely presence of pock marks along the route has been identified for all options. Similarly, geographical constraints within Norwegian waters will apply for all options identified. A detailed route survey will be required to allow mitigation through detailed cable route design.

> It was decided to take forward North Sea options 1, 2 and 3 for further analysis during stage 3 of this route study. North Sea 4 was removed from scope.

Norwegian landfall options:

> Samnanger – The key constraint identified for this corridor option is the large firing practice area located in Norwegian waters near the entrance to the Selbjornsfjorden. Charts have shown the firing practice area is in continuous use. Action item was defined to obtain understanding as part of Norwegian EIA assessment.

> Sima – The data within GIS revealed a proposed protected area along the Sima corridor. Also, an unexploded ordnance area was identified further down the route. Based on the location and the results from the slope analysis, the sensitive area is located on a slope above the intended cable route. Concern was raised with regard to safety during installation and risk to the cable during operations. It was pointed out that due to the steep slope angles and the potential for movement, this option may not be the preferred option. Action item defined to perform risk assessment on potential impact UXO on NorthConnect cable route as part of Norwegian EIA. It was recommended to gather information on previous studies/cable lay. Also, this particular option implies the longest route with the most constraints in terms of cable crossings, ferry crossings, fish farms, etc. As a result, more stakeholder involvement will be required. It was decided to mark Sima options AMBER from a consenting & permitting perspective.

> Sima-to-Samnanger (Langenuen) – A new option was identified during the session. The route starts at Sima corridor and branches into the Samnanger corridor via Langenuen. The newly identified corridor avoids the proposed protected area, the unexploded ordnance area and the firing practice area listed as key constraints for the originally proposed Sima and Samnanger corridor options.

> It was decided to take forward all three options for further analysis during stage 3 of this route study.

The table below provides a summary overview of the various results for the different corridor options, indicative corridor route options and key drivers.

	Corridor options																Key Drivers					
Indicative corridor route options	Peterhead North	Peterhead South	North Sea 1	North Sea 2	North Sea 3	North Sea 4	Samnanger	Sima	Segments	Indicative Cable Length (m)	Indicative cable length (km)	Number of crossings - North Sea	Number of crossings - Fjord	Number of crossings - Total	Indicative Installation Cost (£1,000)		Environmant	Consenting & Permitting	Economic Viability	Technical Suitability	Execution Schedule	Recommendation
Option 1	√		√				√		PN,C,H,J,L,Sam	560,303	560	21	22	43	£560,863.30							IN
Option 2	√			√			√		PN,C,H,I, K, L,Sam	559,084	559	22	22	44	£559,643.08							IN
Option 3	√				√		√		PN,C,D,F,G,K,L,Sam	557,093	557	28	22	50	£557,650.09							IN
Option 4	√					√	√		PN,C,D,E,G,K,L,Sam	567,867	568	24	22	46	£568,434.87							OUT
Option 5	√		√					√	PN,C,H,J,L,Sim	649,597	650	21	28	49	£650,246.60							IN
Option 6	√			√				√	PN,C,H,I, K, L,Sim	652,570	653	22	28	50	£653,222.57							IN
Option 7	√				√			√	PN,C,D,F,G,K,L,Sim	651,043	651	29	28	57	£651,694.04							IN
Option 8	√					√		√	PN,C,D,E,G,K,L,Sim	661,817	662	25	28	53	£662,478.82							OUT
Option 9		√	√				√		PS,C,H,J,L,Sam	560,823	561	20	22	42	£561,383.82							IN
Option 10		√		√			√		PS,C,H,I, K, L,Sam	559,604	560	21	22	43	£560,163.60							IN
Option 11		√			√		√		PS,C,D,F,G,K,L,Sam	557,645	558	27	22	49	£558,202.65							IN
Option 12		√				√	√		PS,C,D,E,G,K,L,Sam	568,419	568	23	22	45	£568,987.42							OUT
Option 13		√	√					√	PS,C,H,J,L,Sim	650,117	650	20	28	48	£650,767.12							IN
Option 14		√		√				√	PS,C,H,I, K, L,Sim	653,090	653	21	28	49	£653,743.09							IN
Option 15		√			√			√	PS,C,D,F,G,K,L,Sim	651,595	652	27	28	55	£652,246.60							IN
Option 16		√				√		√	PS,C,D,E,G,K,L,Sim	662,369	662	23	28	51	£663,031.37							OUT

Figure 7.7: Summary of results option screening workshop (qualitative assessment).

7.3.4 Corridor Options Selected for further analysis

Corridor options taken forward to the next phase (i.e. route selection) are the following:

> Peterhead North (GREEN);
> Peterhead South (AMBER);
> North Sea 1 (GREEN);
> North Sea 2 (GREEN);
> North Sea 3 (AMBER);
> Samnanger (GREEN);
> Sima (AMBER); and
> Sima/Samnanger (NEW).

7.3.5 Limitations

During the session, it was mentioned data with regard to future/planned offshore development sites is limited. Development sites under development/planning may not be available in industry data sets. Therefore, the list of constraints applicable to this study may not be exhaustive. This limitation applies to all options as part of this option screening.

Indicative cable length calculated during this stage of the project did not take into account slope analysis. The cable lengths for the different options have been addressed during stage 3 of the project (i.e. cable route selection).

7.3.6 Action Items

The following action items were assigned:

Action	Owner
Peterhead landfall options – early consultation required to address and understand constraints and opportunities Sandford Bay.	AMEC, NorthConnect
North Sea O&G Development (Norway) – Find out more about future development O&G Norwegian waters as part of Norwegian EIA assessment and assess potential impact on North Sea route options.	Xodus, NorthConnect
Unexploded ordnance – Risk assessment required on potential impact UXO on Sima cable route options.	Ramboll, NorthConnect
Firing Danger Area – Obtain understanding of potential impact firing practice area on consenting of Samnanger route options as part of Norwegian EIA assessment.	Ramboll
Proposed protected area – Obtain understanding of potential impact proposed protected area on consenting of Sima route options.	Ramboll
Norwegian Corridor Route – Additional route option identified by Xodus which avoids Sima and Samnanger constraints. The route starts at Sima corridor route and branches into Samnanger corridor route. Corridor option to be analysed.	Xodus
Bundling versus Unbundling – Provide guidelines with regard to preferred installation. Unbundled cables stated as preferred option during kick-off meeting (with exception of crossings and landfall).	Mott MacDonald

Figure 7.8: Action items from Qualitative Assessment.

7.3.7 Conclusions & Recommendations

Conclusions and recommendations for the corridor option screening are described below.

- Environment – Peterhead South route options rated lower (AMBER) compared to Peterhead North route options (GREEN) because of impact on SPA and potential disturbance to grey seal haul-out areas.
- Consenting & Permitting – Sima options rated lower (AMBER) compared to Samnanger options (GREEN) as a longer route requires more stakeholder involvement and may cause additional exposure to reputational risk as well as risk to schedule for project consenting.
- Economic Viability – North Sea 1 and North Sea 2 options considered most favourable (GREEN). North Sea 4 options most expensive (RED). North Sea 3 options middle range (AMBER). North Sea 4 options have longest cable length and North Sea 3 options have most cable/pipeline crossings.
- Technical Suitability – North Sea 1 and North Sea 2 options considered most suited (GREEN), North Sea 3 options considered least suited (RED). North Sea 4 options middle range (AMBER). North Sea 3 options have most cable/pipeline crossings and North Sea 4 options have longest cable length.
- Bundling versus Unbundling – Guidelines required with regard to preferred installation. Unbundled cables stated as preferred option during kick-off meeting (with exception of crossings and landfall). Action item was defined for NorthConnect to confirm guidelines with Brian Barrett (Mott MacDonald).
- Execution Schedule – North Sea 1 and North Sea 2 options have least impact on execution schedule (GREEN). North Sea 4 options most impact on execution schedule (RED). North Sea 3 options middle range (AMBER). North Sea 4 options have longest cable length and North Sea 3 options have most cable/pipeline crossings.

  Installation Strategy – Guidelines required with regard to NorthConnect preferred installation strategy. Action item was defined for NorthConnect to provide preferred strategy.
- UK Landfall options – It was recommended to take forward both Peterhead North and Peterhead South options for further analysis during stage 3 of this route study. Action item was defined to inquire about opportunities to install cable going through the centre of Sandford Bay.
- Subsea options – It was recommended to take forward North Sea options 1, 2 and 3 for further analysis during stage 3 of this route study. North Sea 4 was removed from scope.
- Norwegian landfall options – It was recommended to take forward all three options (i.e. Samnanger, Sima and Sima-to-Samnanger) for further analysis during stage 3 of this route study.

7.3.8 Workshop Contributions

The following people contributed to the corridor option screening workshop at NorthConnect (Aberdeen) dated 26th June 2012:

- Richard Williams (NorthConnect – Engineering Manager);
- Richard Blanchfield (NorthConnect – Head of Technical Department);
- David Keeble (NorthConnect – Permitting UK);
- Terje Sten Tveit (NorthConnect – Technical Consultant);
- Gayle Boyle (AMEC – EIA Consultant);
- Jim Hunter (Xodus – Environmental Consultant GIS);
- Greg Cook (Xodus – Subsea Lead/Principal Engineer);
- Iain Dixon (Xodus – Principal Environmental Consultant);

- Graeme Birkhead (Xodus – Director/Project Manager Technical Safety & Risk); and
- Edwin Pauwels (Xodus – Project Manager).

7.4 Route Option Screening & Selection

7.4.1 Quantitative Assessment Method

The objective of the quantitative option screening method was to assess key drivers for each route option identified based on more detailed information. A rating system was applied as per definitions described in the ‘classification of contribution’. The ratings applied, combined with the weightings assigned to each project driver, defined the overall score for each option.

7.4.2 Route Options Identified

The route options identified were the following:

- Peterhead North (UK landfall option);
- Peterhead South (UK landfall option);
- North Sea 1 (i.e. most Southern route);
- North Sea 2;
- North Sea 3 (i.e. most Northern route);
- Samnanger (Norwegian landfall option);
- Sima (Norwegian landfall option); and
- Sima-to-Samnanger (Norwegian landfall option).

The figure below illustrates the different corridor route options:

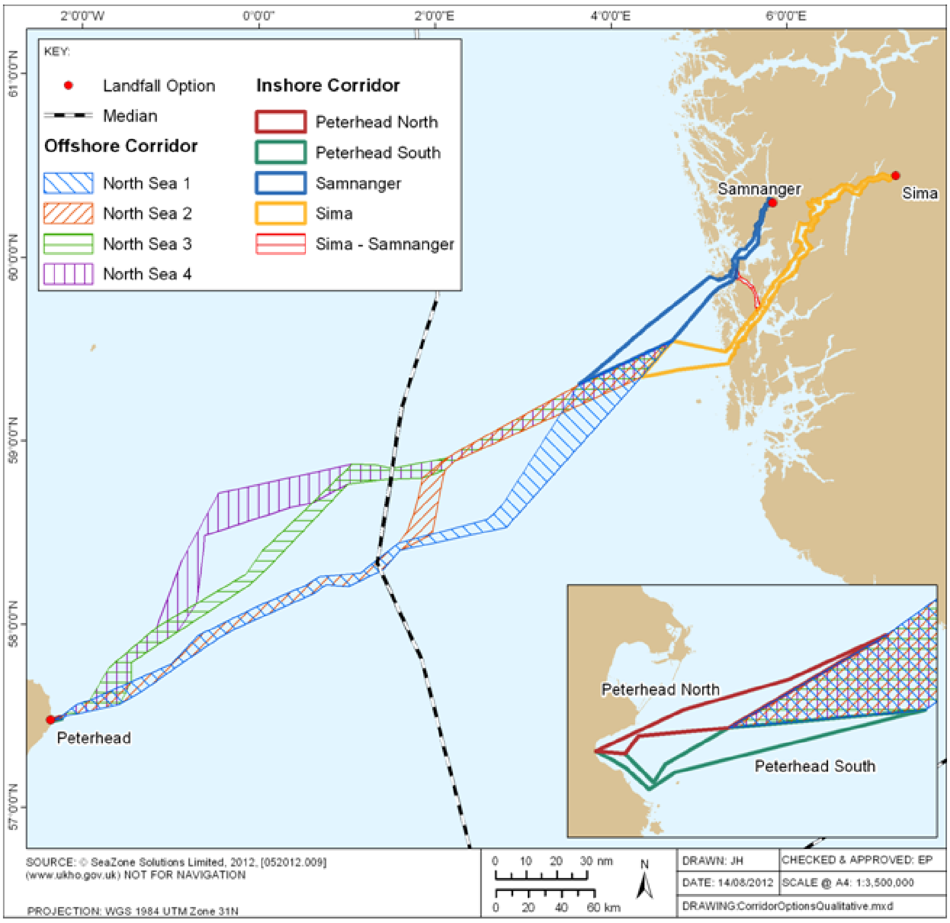


Figure 7.9: Summary of results option screening workshop (qualitative assessment).

Peterhead North, North Sea 1, North Sea 2 and Samnanger received the highest ratings during stage 2 qualitative option screening (i.e. GREEN). Peterhead South, North Sea 3 and Sima received the lowest ratings during stage 2 qualitative option screening (i.e. AMBER).

The various route options were analysed in more detail in terms of:

> Environmental, Consenting & Permitting – Interactions between Xodus, NorthConnect, EIA contractors (i.e. AMEC and Ramboll) and marine stakeholders provided more detailed information in terms of environmental impact and consenting & permitting.

> Economic Viability – Cost modelling was performed based on detailed cost information, i.e. calculation of cost of materials, installation costs, costs for cable/pipeline crossings and costs for vessel and equipment hire. Working assumptions were documented and results captured for the different options.

> Technical Suitability – Xodus performed detailed slope analysis to assess technical constraints in terms of cable installation, stability and availability. Onshore and offshore installation methods were defined in more detail. Cable and pipeline crossings arrangements were analysed and recommendations made. Solutions for cable and scour protection were documented.

> Execution Schedule – Xodus made an assessment of execution schedule for each option based on clearly defined installation strategies and vessel types. Cable lengths for the different options were revisited based on slope analysis to take into account the 3D aspect.

The 8 corridor options identified above allowed for several permutations for potential cable routes. In total 18 cable route options have been identified as follows:

Indicative corridor route options	Peterhead North	Peterhead South	North Sea 1	North Sea 2	North Sea 3	North Sea 4 (not taken forward)	Samnanger	Sima	Sima to Samnanger (NEW)	Segments
Option 1	Y		Y				Y			PN,C,H,J,L,Sam
Option 2	Y			Y			Y			PN,C,H,I, K, L,Sam
Option 3	Y				Y		Y			PN,C,D,F,G,K,L,Sam
Option 4	Y		Y					Y		PN,C,H,J,L,Sim
Option 5	Y			Y				Y		PN,C,H,I, K, L,Sim
Option 6	Y				Y			Y		PN,C,D,F,G,K,L,Sim
Option 7	Y		Y						Y	PN,C,H,J,L,Sim
Option 8	Y			Y					Y	PN,C,H,I, K, L,Sim
Option 9	Y				Y				Y	PN,C,D,F,G,K,L,Sim
Option 10		Y	Y				Y			PS,C,H,J,L,Sam
Option 11		Y		Y			Y			PS,C,H,I, K, L,Sam
Option 12		Y			Y		Y			PS,C,D,F,G,K,L,Sam
Option 13		Y	Y					Y		PS,C,H,J,L,Sim
Option 14		Y		Y				Y		PS,C,H,I, K, L,Sim
Option 15		Y			Y			Y		PS,C,D,F,G,K,L,Sim
Option 16		Y	Y						Y	PS,C,H,J,L,Sim
Option 17		Y		Y					Y	PS,C,H,I, K, L,Sim
Option 18		Y			Y				Y	PS,C,D,F,G,K,L,Sim

Figure 7.10: Corridor cable route options.

7.4.3 Record of Discussion

The route option screening process was performed with representatives from NorthConnect, Mott MacDonald, AMEC and Xodus. Options were scored against the project drivers / success criteria and the discussion recorded. The EIA, GIS, consenting, engineering, safety & risk and project management teams were asked for their recommendations. A key element of the VDRM screening process is the record of discussion. The record of discussion provides a concise auditable justification for the classification of contribution score which has been assigned to each option.

> Environment – During the qualitative option screening workshop dated 26th June 2012, a potential third Peterhead options was identified, i.e. installation of subsea cable through spoil ground area identified as part of the GIS constraint mapping. During the session also the anchorage point in the middle of the bay was noticed. Action item was raised for AMEC to consult the Peterhead Port Authorities.

  AMEC contacted the Peterhead Port Authorities to obtain more details with regard to the Peterhead options within Sandford Bay. In terms of the spoil ground, it was stated there was no knowledge of any dumping of material to occur within Sandford Bay and no knowledge of the spoil ground or anything in relation to it. For the temporary anchorage in the middle of bay area, it was stated it is used occasionally (mostly during periods of nicer weather) by vessels to anchor or swing. Feedback received indicates that the local port authorities would be reluctant to allow for any pipelines or subsea cables to be installed in that area even if buried.

UK landfall, North Sea and Norwegian landfall options have different environmental impacts which were discussed during the session. Peterhead South was considered option with bigger environmental impact compared to Peterhead North due to proximity to environmentally sensitive areas. All three North Sea route options considered similar in terms of environmental impact. Sima route options stated as the option with the highest environmental impact due to the length of the route and the proposed protected area. Sima-to-Samnanger routes are longer than Samnanger routes (i.e. extra 30 to 35km).

The following rankings were agreed:

Rating	Description
+1	Peterhead North + Samnanger options (3)
0	Peterhead North + Sima-to-Samnanger options (3) Peterhead South + Samnanger options (3)
-1	Peterhead North + Sima options (3) Peterhead South + Sima-to-Samanager options (3)
-2	Peterhead South + Sima options (3)

Figure 7.11: Ranking route options in terms of Environment.

> Consenting & Permitting – During the qualitative option screening workshop dated 26th June 2012, feedback indicated that the North Sea 1 indicative route may be impacted by new O&G offshore infrastructure within the Utsira High area. Research and consultations have revealed the following planned activities.

- All planned Johan Sverdrup (Statoil) installations and pipelines will be located north of North Sea 1 route option (i.e. north of the N 6 510 000 latitude).
- Intended Utsira High Power Hub and connecting cables are likely to impact both North Sea 1 and North Sea 2 route options.
- Dagny (Statoil) is located approx 30 km north west of Sleipner installations. The Dagny gas export pipeline to Sleipner A is likely to affect both North Sea1 and North Sea 2 route options.
- Edvard Grieg (Lundin) and Draupne (Det Norske) are located North West from Johan Sverdrup and were confirmed part of GIS constraint mapping.
- CCS project Monstad (North from Bergen) likely to connect to Troll (31/2, 31/3, 31/5, 31/6) or Utsira High area (i.e. with potential impact to the most Northern routes, i.e. North Sea 2 and North Sea 3).

During the qualitative option screening workshop dated 26th June 2012, constraints of the firing practice area were identified. Action items were raised for Rambol to obtain understanding of the impact of the firing danger area as part of Norwegian EIA assessment (Samnanger), to assess the potential impact of the proposed protected area (Sima) and to assess the potential risk of unexploded ordnance near a planned NorthConnect cable route (Sima). Due to Norwegian holiday season, Ramboll and its subcontractor were not in a position to provide feedback prior to the quantitative assessment. Therefore, the following working assumptions were adopted during the session:

- Firing practice area is not considered a showstopper for the Samnanger route option. It is assumed the constraint can be mitigated through consultations and implementation of an efficient and effective communication plan.
- Proposed protected area is not considered a showstopper for the Sima route as it is at proposal stage. Also, the disruption to the area in terms of vessel operations is temporary. It is recommended to mitigate effect through consultations, addressing impact of cable installation/burial with relevant stakeholders.

- Unexploded ordnance is not considered a showstopper at this stage of the project. Further analysis will be required to assess potential risk during cable installation and risk of cable failure during operations. It appears another cable has been installed in the Sima Fjord. The nature of constraints and impact of the unexploded ordnance area needs to be fully understood to allow for an informed decision around the Sima route option.

The above assumptions were confirmed after the workshop, i.e.

- Ambio has been in contact with the Norwegian military regarding the firing practice area outside Bømlo. It was confirmed that there are no problems crossing a firing practice area, but activities related to cable installation and operations need to be coordinated and clarified with the military.
- Valid guidelines for activities in the proposed protected area (Outer Hardangerfjord) state a general caution should be applied for installation of cables in proposed protected fjord areas. However, should greater society considerations/needs speak in favour of allowing cables through this kind of areas, route designs and installation technologies should be selected sensibly to ensure the least possible environmental impact.
- The area with unexploded ordnance is not a military responsibility. Either the area has to be avoided, or the project owner has to investigate the area and remove any unwanted object on his/hers own account before any further activities can be performed.

Peterhead North, North Sea 1, North Sea 2 and Samnanger were considered better options compared to respectively Peterhead South, North Sea 3, Sima and Sima-to-Samnanger in terms of consenting and permitting.

Sima and Sima-to-Samnanger routes were considered similar in terms of consenting, i.e. with a lower rating compared to Samnanger equivalent routes due to longer cable route (and area impacted), number of crossings and level of stakeholder involvement required. North Sea 3 options were rated lower compared to their North Sea 1 and North Sea 2 counterparts due to longer cable length and amount of cable/pipeline crossings. Peterhead South options received a lower ranking compared to equivalent Peterhead North options due to their proximity to grey seal haul-out areas and other environmentally sensitive areas.

The following rankings were agreed:

Rating	Description
+1	Peterhead North + North Sea 1/2 + Samnanger options (2)
0	Peterhead North + North Sea 3 + Samnanger option (1) Peterhead South + North Sea 1/2 + Samnanger options (2)
-1	Peterhead North + North Sea 1/2/3 + Samnanger (6) Peterhead South + North Sea 3 + Samnanger option (1) Peterhead South + North Sea 1/2 + Sima/Sima-to-Samnanger options (4)
-2	Peterhead South + North Sea 3 + Sima/Sima-to-Samnanger options (2)

Figure 7.12: Ranking route options in terms of Consenting & Permitting.

> Economic Viability – Assumptions and cost estimates for the different options are captured in section 8 ("Cost Modelling") and Appendix K ("Cost Estimates") respectively. Costs for Peterhead North and Peterhead South were considered similar as the cost of extra pipeline crossing almost breaks even with the cost of extra cable length. North Sea 1 and North Sea 2 options considered cheaper compared to corresponding North Sea 3 options due to less cable length required and lower number of cable/pipeline crossings involved. Sima routes are more expensive compared to equivalent Sima-to-Samnanger and Samnanger routes due to extra cable length. The Sima-to-Samnanger routes were also more expensive compared to similar Samnanger routes. The 30 to 35km extra cable length and 8 extra crossings imply an extra investment cost estimated at £50 million.

Reference was made to the original business case of a 600km cable route. As a result, it was decided there is an opportunity to reduce cost by selecting shorter Samnanger route options.

The following rankings were agreed:

Rating	Description
+1	Peterhead North + North Sea 1/2 + Samnanger options (2) Peterhead South + North Sea 1/2 + Samnanger options (2)
0	Peterhead North/South + North Sea 3 + Samnanger option (2)
-1	Peterhead North/South + North Sea 1/2 + Sima/Sima-to-Samnanger (8)
-2	Peterhead North/South + North Sea 3 + Sima/Sima-to-Samnanger options (4)

Figure 7.13: Ranking route options in terms of Economic Viability.

> Technical Suitability – Although technical installation at Peterhead South was expected to be more challenging compared to Peterhead North due to shallow water and rock formations, both options are considered similar. North Sea 3 route options have the most cable crossings and therefore are considered more cumbersome to complete. Sima is a longer route compared to Samnanger and Sima-to-Samnanger routes. Sima route options are also exposed to unexploded ordnance located on the steep slope in relatively close proximity of the indicative route.

The Samnanger corridor narrows down at landfall towards the end of the Fjord. Both Samnanger and Sima route options have their own challenges with regard to slope gradients and potential risk of landslides. Data from the detailed survey will confirm feasibility of both routes. Patterns will also reveal whether or not landslides are common within the fjords along both corridors.

Bundling versus unbundling was discussed during the session and further investigation will be required in terms of water depth (i.e. to limit compass deviation to 2 degrees) and installation strategy at landfall.

The following rankings were agreed:

Rating	Description
+1	Peterhead North + North Sea 1/2 + Samnanger options (2) Peterhead South + North Sea 1/2 + Samnanger options (2)
0	Peterhead North/South + North Sea 3 + Samnanger option (2)
-1	Peterhead North/South + North Sea 1/2 + Sima/Sima-to-Samnanger (8)
-2	Peterhead North/South + North Sea 3 + Sima/Sima-to-Samnanger options (4)

Figure 7.14: Ranking route options in terms of Technical Suitability.

> Execution Schedule – Assumptions and schedule estimates for the different options are captured in Section 9 (“Execution Schedule”) and Appendix L (“Execution Schedules”) respectively. Execution schedule has been derived from cost model and input from technical suitability. Execution schedule is largely defined by cable length, number of cable/pipeline crossings, number of cable joints, installation methods (and installation rate) and type of vessel used. North Sea 3 route options have longer cable length and number of crossings compared to North Sea 1 and North Sea 2 equivalent routes. Also, Sima and Sima-to-Samnanger route options are significantly longer and involve more cable crossings compared to Samnanger route options. However, assuming only one vessel used for installation, all options require 3 seasons. This is likely to be in line with execution schedule for manufacturing.

The following rankings were agreed:

Rating	Description

+1	Peterhead North + North Sea 1/2 + Samnanger options (2) Peterhead South + North Sea 1/2 + Samnanger options (2)
0	Peterhead North/South + North Sea 3 + Samnanger option (2)
-1	Peterhead North/South + North Sea 1/2 + Sima/Sima-to-Samnanger (8)
-2	Peterhead North/South + North Sea 3 + Sima/Sima-to-Samnanger options (4)

Figure 7.15: Ranking route options in terms of Execution Schedule.

- North Sea 1 versus North Sea 2 – The outcome of the quantitative assessment provided insufficient distinction between North Sea 1 and North Sea 2 route options. Both route options provided similar results for both Sima and Samnanger landfall options. There was common agreement future development within the Utsira High area would determine which route option should be taken forward to the next phase.

  A new cable between Sleipner and Gudrun will impact both North Sea 1 and North Sea 2 route options (i.e. one extra crossing for each route option).

  Future development for a power hub within the Utsira High area involves one cable route between Johan Sverdrup and Dagny (impacting North Sea 2 route option) and two cable routes between Johan Sverdrup and Kårstø (impacting North Sea 1 route option).

  In summary, the above development projects imply the following:

  - 3 extra crossings for North Sea 1 route options;
  - 2 extra crossings for North Sea 2 route options;
  - The extra cable crossings imply both options are on a par in terms of total number of crossings;
  - Cost Peterhead North + North Sea 1 + Sima < cost Peterhead North + North Sea 2 + Sima; and
  - Cost Peterhead North + North Sea 2 + Samnanger < cost Peterhead North + North Sea 1 + Samnanger.

  North Sea 1 route options run below Utsira High Area while North Sea 2 route options run through the Utsira High area. The likelihood of North Sea 2 options being impacted by future development within the Utsira High area has been considered a significant risk.

- Based on the above statements, it was decided to take forward options 1 and 4, i.e.

  - Peterhead North + North Sea 1 + Samnanger
  - Peterhead North + North Sea 1 + Sima

The table below provides a summary overview of the various results for the different indicative route options and key drivers.

	Corridor options															Key Drivers						
Indicative corridor route options	Peterhead North	Peterhead South	North Sea 1	North Sea 2	North Sea 3	Samnanger	Sima	Sima to Samnanger (NEW)	Segments	Indicative Cable Length (m)	Indicative cable length (km)	Number of crossings - Total	Indicative Installation Cost (£1,000)	Total number of days for installation *		Environmant	Consenting & Permitting	Economic Viability	Technical Suitability	Execution Schedule	Total Rating	Recommendation
Option 1	Y		Y			Y			PN,C,H,J,L,Sam	561,188	561	40	£952,758	1,027		1	1	1	1	0	85.94	IN
Option 2	Y			Y		Y			PN,C,H,I, K, L,Sam	559,858	560	41	£950,399	1,027		1	1	1	1	0	85.94	OUT
Option 3	Y				Y	Y			PN,C,D,F,G,K,L,Sam	557,867	558	47	£954,392	1,034		1	0	0	0	-1	3.87	OUT
Option 4	Y		Y				Y		PN,C,H,J,L,Sim	650,230	650	49	£1,093,055	1,053		-1	-1	-1	-1	-1	-100.00	IN
Option 5	Y			Y			Y		PN,C,H,I, K, L,Sim	653,203	653	50	£1,097,392	1,053		-1	-1	-1	-1	-1	-100.00	OUT
Option 6	Y				Y		Y		PN,C,D,F,G,K,L,Sim	651,676	652	56	£1,102,080	1,059		-1	-1	-2	-2	-2	-157.26	OUT
Option 7	Y		Y					Y	PN,C,H,J,L,Sim/Sam	590,987	591	48	£998,316	1,036		0	-1	-1	-1	-1	-82.07	OUT
Option 8	Y			Y				Y	PN,C,H,I, K, L,Sim/Sam	593,959	594	49	£1,006,491	1,039		0	-1	-1	-1	-1	-82.07	OUT
Option 9	Y				Y			Y	PN,C,D,F,G,K,L,Sim/Sam	592,433	592	55	£1,011,178	1,045		0	-1	-2	-2	-2	-139.33	OUT
Option 10		Y	Y			Y			PS,C,H,J,L,Sam	561,709	562	39	£951,880	1,025		0	0	1	1	0	43.20	OUT
Option 11		Y		Y		Y			PS,C,H,I, K, L,Sam	560,379	560	40	£950,406	1,025		0	0	1	1	0	43.20	OUT
Option 12		Y			Y	Y			PS,C,D,F,G,K,L,Sam	558,420	558	46	£954,387	1,033		0	-1	0	0	-1	-38.86	OUT
Option 13		Y	Y				Y		PS,C,H,J,L,Sim	650,751	651	48	£1,092,405	1,052		-2	-1	-1	-1	-1	-117.93	OUT
Option 14		Y		Y			Y		PS,C,H,I, K, L,Sim	653,724	654	49	£1,092,560	1,054		-2	-1	-1	-1	-1	-117.93	OUT
Option 15		Y			Y		Y		PS,C,D,F,G,K,L,Sim	652,228	652	55	£1,102,302	1,060		-2	-2	-2	-2	-2	-200.00	OUT
Option 16		Y	Y					Y	PS,C,H,J,L,Sim/Sam	591,508	592	47	£1,001,504	1,037		-1	-1	-1	-1	-1	-100.00	OUT
Option 17		Y		Y				Y	PS,C,H,I, K, L,Sim/Sam	594,481	594	48	£1,006,494	1,038		-1	-1	-1	-1	-1	-100.00	OUT
Option 18		Y			Y			Y	PS,C,D,F,G,K,L,Sim/Sam	592,985	593	54	£1,011,400	1,046		-1	-2	-2	-2	-2	-182.07	OUT

**Note: only options 1 and 4 have been updated with extra crossings (+2) after decision North Sea 1 versus North Sea 2 was made based on extra potential impact future development within the Utsira High area.*

Figure 7.16: Summary table quantitative assessment..

The output from all sessions will be presented to the senior management team for discussion and confirmation or modification. The route option screening exercise has generated clear recommendations for further engineering, EIA and clarification.

An extract of the route option screening spreadsheet can be found in Appendix B.

7.4.4 Route Options Selected

The preferred route options identified are the following:

> Peterhead North + North Sea 1 + Sima

> Peterhead North + North Sea 1 + Samnanger

7.4.5 Limitations

Slope analysis has been performed based on data with relatively low resolution data. To perform a proper analysis of challenges in terms of bathymetry, slope gradients and technical feasibility, detailed survey high resolution data is required to assess true level of complexity.

Information with regard to firing practice area (i.e. constraint Samnanger route options), proposed protected area (i.e. constraint Sima route option) and proximity unexploded ordnance to proposed cable route (i.e. potential risk

Sima route option) was not available during quantitative assessment of route options. Working assumption adopted during the session were the following:

> Firing practice area is not considered a showstopper for the Samnanger route option. It is assumed the constraint can be mitigated through consultations and implementation of an efficient and effective communication plan.

> Proposed protected area is not considered a showstopper for the Sima route as it is at proposal stage. Also, the disruption to the area in terms of vessel operations is temporary. It is recommended to mitigate effect through consultations, addressing impact of cable installation/burial with relevant stakeholders.

> Unexploded ordnance is not considered a showstopper at this stage of the project. Further analysis will be required to assess potential risk during cable installation and risk of cable failure during operations. The nature of constraints and impact of the unexploded ordnance area needs to be fully understood to allow for an informed decision around the Sima route option.

The above working assumptions were confirmed after the workshop.

No data regarding location of cable repeaters is available as part of data sets available on the market. When new cables are laid across an existing telecommunications cable system that contains repeaters, a minimum distance should be kept between the repeater and the new cable crossing. Repeaters should be topic of discussion during crossing arrangement discussions with cable owners. Detailed route design should capture exact location of cable repeaters and adopt minimum distance requirements.

7.4.6 Action Items

The following action items were assigned:

Action	Owner
Fine-tuning of cost and schedule estimates based on extra input with regard to typical lead times for cable jointing and offshore infrastructure.	Xodus
Provide details Utsira High Power Hub to allow for assessment extra crossings North Sea 1 and North Sea 2 cable route options.	NorthConnect
Confirm working assumptions on firing practice area, proposed protected area and unexploded area with Ramboll and/or subcontractor Ambio	Xodus
Confirm preferred Sima and Samnanger route options, i.e. decide between North Sea 1 and North Sea 2 route options.	Xodus, NorthConnect

Figure 7.17: Action items from Quantitative Assessment.

7.4.7 Conclusions & Recommendations

Conclusions and recommendations for the corridor option screening are described below.

> Remove Peterhead South options due to environmental impact and issues related to consenting & permitting.

> Remove North Sea 3 route options from scope due to cost variance (ca. £50 million) caused by cable length (30-35km) and 8 extra crossings.

> Remove North Sea 2 route options from scope due to cumulative effects and likelihood interference with planned development projects within the Utsira High area. The North Sea 1 route option is located south from the Utsira High area and is less likely to be impacted by future developments.

> Consider both Sima and Samnanger landfall options to meet requirements of the national regulator.

- Remove Sima-to-Samnanger route option from scope due to cost variance from extra cable length and crossings as well as extra potential impact on environment, consenting & permitting, technical suitability and execution schedule.
- Take forward route options 1 and 4 as preferred routes for detailed survey and route design during the next phases of the project, i.e.
    - Option 1 - Peterhead North + North Sea 1 + Samnanger
    - Option 4 - Peterhead North + North Sea 1 + Sima
- Recommendation to assess technical feasibility of Samnanger route as soon as possible. If proven the route is not suitable for installation of HVDC cables due to geological, technical, installation or access constraints, NorthConnect will have the opportunity to remove Samnanger option from scope and fully focus on the Sima landfall option. Early awareness and communication towards stakeholders and national regulator will benefit the project overall.
- Fine-tuning of Sima and Samnanger preferred route options to optimise corridor for detailed survey. The optimised 'medium' survey route will be used as a basis for the Route Positioning Lists and Straight Line Diagrams. The survey corridor will be handed over to the EIA work packs as input for environmental impact assessment and consultations with stakeholders.

7.4.8 Workshop Contributions

The following people contributed to the route option screening workshop at Xodus (Edinburgh) dated 8th August 2012:

- Richard Williams (NorthConnect – Engineering Manager);
- Richard Blanchfield (NorthConnect – Head of Technical Department);
- David Keeble (NorthConnect – Permitting UK);
- Terje Sten Tveit (NorthConnect – Technical Consultant);
- Brian Barrett (Mott MacDonald – HVDC Expert);
- Gayle Boyle (AMEC – EIA Consultant);
- Jim Hunter (Xodus – Environmental Consultant GIS);
- Greg Cook (Xodus – Subsea Lead/Principal Engineer);
- Chris Lovell (Xodus – Principal Consultant Technical Safety & Risk); and
- Edwin Pauwels (Xodus – Project Manager).

8 COST MODELLING

One of the key drivers captured at project kick-off was economic viability. A cost model was set up to assess of economic viability for each option taken forward to phase 3 of the project, i.e. analysis of information as part of the route selection phase.

The cost model has provided high-level estimated cost for each option considered, as discussed in the following Sections.

8.1 Cost Basis

Contained within this Section are costing norms and assumptions used in the generation of the cost estimates for the various options.

8.1.1 Battery Limits

The cost estimate covers all costs associated with the offshore installation and procurement for three power cables. The battery limits are at the beach crossings in the UK and Norway. No onshore costs, other than the beach crossing preparation are included.

8.1.2 General Assumptions

The following general assumptions have been adopted in order to generate the cost estimates:

- Costs are based on the requirement for 3 cables to be installed Ref [1], 2 of which are 500kV capacity and one of which is 36kV capacity. It is assumed that cables will be installed individually end to end so that installation activities can be carried out during summer months. It therefore follows that installation will be carried out in 3 campaigns;
- Cable properties pertinent to the cost estimate are presented in Table 8.1 Ref [2]. Full cable properties are contained in Appendix E (“Cable Technical Data Sheet – 500kV“) and Appendix F (“Cable Technical Data Sheet – 36kV”).

Property	Units	Value	
		500kV Cable	36kV Cable
Outer Diameter	mm	125.0	93.0
Conductor Diameter	mm	46.3	39.9
Weight	kg/m	52	26

Table 8.1 Cable Properties Ref [2]

- All costing norms are from in-house data unless otherwise specified;
- The cable lay vessel selected has an assumed capacity of 7,000 tonnes. This capacity allows for 134km of 500kV cable and 269km of the 36kv cable to be installed in a single trip. The potential route lengths dictate that for the 500kV cable; the entire capacity is utilised to keep vessel trips and consequently offshore connections to a minimum. This scenario is not true of the 36kV cable and for the purposes of the cost estimate it is assumed that 265km will be loaded to the vessel drum per trip, allowing a degree of spare capacity;
- Crossing preparation is carried out by a DSV or MSV for all crossing locations identified. Each cable will require an individual crossing at any one crossing location, grouping of cables at crossings will not be possible by virtue of the fact that cables will be installed individually as previously stated;

- Assumed crossing layouts and associated rock tonnages are detailed in Section 8.1.7;
- A survey vessel is utilised for pre-lay survey, survey support during lay and post-lay survey;
- It is assumed for the purposes of the cost estimate that the trenching spread will cost the same amount whether it is a plough or jet trencher. Additionally an interim mobilisation has been allowed for in order to change out the trencher;
- 3 guard vessels have been allowed for during each cable lay period;
- All vessel and procurement rates are from in house data unless otherwise stated;
- It is assumed that 1 day consists of 24 hours apart from in the case of the ROVSV and trenching spread where it is considered to consist of 20 hours. This is to allow for breakdowns and related downtime;
- For all cables it is assumed that 10% of the route will require rockdump in order to provide protection where trenching is not practicable and scouring may be an issue. This blanket rockdump is assumed at 2.5t/m;
- The beach crossings are assumed to consist of concrete tunnels with pre-installed messenger wires for cable pull-in, initiation and lay-down, which is sufficient to give order of magnitude costs at the appropriate level for a conceptual study. Once the landfall locations are finalised, the beach crossings can be assessed in more detail.

8.1.3 Vessel Rates

The vessels and their respective rates are as follows:

- Cable Lay Vessel £150,000/day
- DSV or MSV £180,000/day
- Survey Vessel £60,000/day
- ROVSV c/w Trenching Spread £110,000/day
- Rockdumping Vessel £115,000/day
- Guard Vessel £5,000/day

It should be noted that all rates assumed are current and make no allowance for projected inflation.

8.1.4 Mobilisation and Demobilisation

Vessel combined mobilisation and demobilisation durations are taken as follows:

- Cable Lay Vessel 3 days
- DSV or MSV 3 days
- Survey Vessel 2 days
- ROVSV c/w Trenching Spread 2 days
- Rockdumping Vessel 2 days
- Guard Vessel 2 days

8.1.5 Vessel Progress Rates

Transit times to and from the work site are assumed to be 1 day for the purpose of the cost estimates. It is acknowledged that transit times may be greater or less than this, however the figure stated represents the average expected transit time. Vessel operational speeds are detailed as follows:

- Cable Lay Vessel — 300m/hr, additional 2days at landfalls and 6 days per connection
- Cable Lay Vessel – Spool on — 400m/hr
- DSV or MSV — 0.5 days per pipeline crossing, 0.25 days per cable crossing
- Survey Vessel — 50km/day
- ROVSV c/w Trenching Spread — 250m/hr working on 20hr day to allow for equipment failure
- Rockdumping Vessel — 100m/hr with 0.5 days per crossing allowance
- Guard Vessel — N/A

8.1.6 Procurement

The procurement costs are detailed as follows:

- 500kV Cable — £310/m Ref [3]
- 36kV Cable — £140/m Ref [3]
- Cable connectors — £50,000 each
- Rockdump — £10/tonne
- Concrete plinths — £300 each
- Concrete tunnels — £350 each
- Mattresses — £500 each

8.1.7 3rd Party Pipeline and Cable Crossings

Crossings identified along each proposed route have been split into pipeline and cable crossings. It is outwith the scope of this study to assess each crossing individually, therefore in order to give an appraisal of rock requirement for each route, indicative crossing designs for a buried cable and surface laid pipeline have been assumed. A requirement of 525 tonnes and 1305 tonnes has been assumed for buried cable and surface laid pipeline crossings respectively.

8.1.8 Beach Crossing Works

The following onshore costs are included:

- Earthworks and excavations — £750/m^3
- Installation of concrete tunnels — £500/m

It should be noted that beach crossing costs are indicative of what may be a technically feasible solution. Greater resolution will be achievable once specific beach crossing designs are available.

8.1.9 Company Costs (Project Services)

The following project service and management costs are included:

> Company project management	12%
> Offshore representatives	Lump Sum £1,000,000
> 3rd Party verification	Lump Sum £330,000
> Insurance	5%

8.1.10 Other Costs and Contingencies

Additionally, the following allowances have been made:

- Offshore weather contingency of 30% applied to costs associated with vessel construction activities. It should be noted that this is not applied to vessel mobilisation, demobilisation or transit;
- Installation contractor's engineering and management at 10% applied to all offshore works;
- Overall project contingency of 20% applied to final costs.

8.2 Cost Results

Presented in Table 8.2 are the results of the cost estimates carried out. A full breakdown of the calculated costs is included in Appendix K ("Cost Estimates").

Route Option	Length (km)	Number of Crossings		Cost (£k)
		Pipeline	Cable	
1	561.88	16	24	952,758
2	559.858	16	25	950,399
3	557.868	22	25	954,392
4	650.230	15	34	1,093,055
5	653.203	15	35	1,097,392
6	651.676	21	35	1,102,080
7	590.987	17	31	998,316
8	593.960	17	32	1,006,491
9	592.433	23	32	1,011,178
10	561.709	15	24	951,880
11	560.379	15	25	950,406
12	558.420	21	25	954,387
13	650.751	14	34	1,092,405
14	653.724	14	35	1,092,560
15	652.228	20	35	1,102,302
16	591.508	16	31	1,001,504
17	594.481	16	32	1,006,494
18	592.985	22	32	1,011,400

Table 8.2 Cost Estimate Results

9 EXECUTION SCHEDULE

Execution schedule was defined as one of the key project drivers. For each corridor/route option, a schedule estimate was defined.

9.1 Route Cable Length

As a rule of thumb, the longer the cable route, the longer it will take to install the subsea cables. The length of the cable route will also define the number of cable joints required. Joining cables together is time consuming and will have an impact on overall execution time. This is assumed to take 6 days.

Also, longer cable routes may cause longer fabrication and delivery lead times. The project should consider risks associated to supply of raw materials, production rate and delivery on-site. Xodus recommends early engagement with supply chain.

9.2 Installation Strategy

The installation strategy focussed on overall approach in terms of installation methods, burial depth, cable protection measures, approach to landfall and number of specialised vessels.

9.3 Cable and Pipeline Crossings

Cable and pipeline crossings imply extra preparation work in terms of crossing arrangements. Execution schedules take into account preparatory work enough time in advance before subsea cables are installed.

Xodus recommends early engagement with Operators to formalise crossing arrangements from a technical, risk and legal point of view. Failing to come to an agreement may put project schedule at risk.

9.4 Specialised Vessels and Equipment

The selection of (installation/support) vessels and specialised equipment will impact execution schedule.

Xodus recommends early engagement with supply chain to secure availability of cable installation vessels and specialised equipment.

9.5 Sensitive Timings

Certain areas along the cable route selected may be sensitive to cable installation activities.

For example, during the constraint mapping exercise, grey seal haul-out areas were identified near Sandford Bay. The Environmental Impact Assessment may conclude no installation activities may occur during a predefined period during the year (e.g. from June to August) in order to reduce or avoid impact on seal populations within the area.

Firing practice areas may also invoke certain restrictions unless installation timeframe has been negotiated with stakeholders well in advance.

The cable installation has been scheduled so the critical tasks take place during the summer months, this includes the cable lay operations and trenching activities.

9.6 Assumptions

In addition to the assumptions stated for the cost estimates in Section 8.1, the following have also been assumed in the generation of the schedule:

- Installation will commence at the end of February in order to allow for cable lay during the summer months. This will be the case for all three cables therefore there will be a certain amount of vessel downtime over the winter months;
- Installation of all three cables will be undertaken by a single vessel;
- Trenching will commence once the penultimate section of cable has been laid and continue whilst remaining section is laid;
- Rockdumping activities are scheduled to commence so that by the time trenching is complete, half of the rockdumping has been completed;
- The as left survey will start during rockdumping and is scheduled to commence so as to be half completed once rockdumping activities have finished;
- No waiting on weather allowance is allowed for in the schedule, the figures presented show idealised installation durations for the purpose of comparison.

9.7 Installation Durations

The installation durations are presented in Table 9.1 and full schedules are included in Appendix L.

Route Option	Total Installation Duration Including Winter Down Time (Days)
1	1027
2	1027
3	1034
4	1053
5	1053
6	1059
7	1036
8	1039
9	1045
10	1025
11	1025
12	1033
13	1052
14	1054
15	1060
16	1037
17	1038
18	1046

Table 9.1 Installation Durations

10 PREFERRED ROUTE DESCRIPTION

10.1 Overview Proposed Cable Routes

The UK point of connection is located entirely within the local authority area of Aberdeenshire Council, Scotland. A HVDC converter station and adjoining 500kV sub-station are proposed in Peterhead and adjacent to Peterhead power station. These will connect to the existing electricity transmission network by underground AC cable.

The converter station will connect to the new substation and switch electricity from conventional AC to DC for onwards transmission of electricity (or vice versa depending on the direction of operation). Limited length of underground cable is proposed running from HVDC converter station to the landing point. This will connect to a landfall and the marine cable at Sandford Bay.

The Project considers two candidate route options, i.e.

- Preferred route from Peterhead to Samnanger; and
- Preferred route from Peterhead to Sima.

The marine cable route from Sandford Bay in Peterhead to Samnanger is approximately 565km long and passes through UK and Norwegian waters.

The marine cable route from Sandford Bay in Peterhead to Sima is approximately 655km long and passes through UK and Norwegian waters.

Both selected cable route options share a common route from Sandford Bay until the point both routes split direction just beyond the Johan Sverdrup Oil & Gas development site, located in Norwegian territorial waters.

The Samnanger cable route diverts from the south eastern point of Johan Sverdrup Oil & Gas field via the Selbjørnsfjorden into the Samnangerfjorden. NorthConnect has identified four different cable landing point options. The cable route will run onshore from the most suited landing point to the Samnanger power station and grid connection. The length of the onshore cable route is significant.

The Sima cable route diverts from Johan Sverdrup into the Selbjørnsfjorden and Hardangerfjorden to reach Sima. The power station and grid connection are located in close proximity of the shoreline. Therefore, the onshore cable route is minimal.

The Sima landfall option implies a longer subsea cable route and a shorter onshore cable route compared to the Samnanger landfall option.

The final selection will depend on environmental appraisal, technical feasibility, network upgrades required, business case and the position of the National Regulator in Norway.

10.2 Installation

The proposed subsea cable route has been optimised to make use of trenchable seabed to allow burial of the marine cables and to minimise the number of cable and pipeline crossings.

Careful route design has also reduced the need for rock dump required to protect subsea cables in areas where burial proves difficult or impossible due to hard soil conditions. 10% of the route lengths have been costed for potential rockdump as a general figure to cover areas that cannot be trenched.

It is assumed 3 No. cables are to be installed, i.e. 2 No. high capacity 500kV + 1 No. low capacity 36kV. These cables will be installed separately and trenched independently of each other. They are assumed to be bundled at the landfall approaches for connection to the substations, considering a beach crossing of 1.5km length protected by concrete tunnels.

The installation method of the cable offshore is considered to be from a single large CLV that starts from Peterhead and lays toward Norway. It is likely the cable will be manufactured outside of the UK (i.e. Norway), therefore several trips to and from site will be needed to complete the whole route, which is dependent on whether it be Samanager or Sima. At this stage, the cables are not to be laid as a bundle, therefore it is estimated that it will take approximately 1 season to lay and trench each cable (i.e. 3 years). Simultaneous trenching has not been considered due to the potentially higher risks during offshore installation, therefore each cable will require a separate Trenching Support Vessel (TSV) and associated spread to complete burial of the cable. In areas where trenching cannot be achieved, a rockdump support vessel will be required to complete full cable protection.

Where crossings are encountered and the cables laid over, a DSV/CSV will be required to lay mattresses or plinths, or alternatively a rockdumping vessel, to adequately and safely construct a separation between the existing product to be crossed and the to be laid cables. Obviously such campaigns will need to be planned prior to cable lay.

Installation method at the landfall depends on the site conditions, whether it be a typical beach crossing or a rock bench where the cable need to be pulled up. Standard landfall construction techniques involve an open trench from shore to low tide in which the cable is pulled up. However, if this cannot be achieved then other more costly methods such as long and short Horizontal Directional Drilling (HDD) can be considered. The most suitable and appropriate method can only be selected once a site inspection and associated geotechnical appraisal of the landfall site has been carried out.

Recommended cable burial depth is 1.0m from mean seabed level to top of cable. If trenching cannot achieve this due to difficult/unexpected soil conditions, or operator error, then rockdump can be added to achieve the required burial specification.

Due to the length and number of cables to be installed and trenched, specialist vessels and equipment are required to make this project a success. Securing such capability is of paramount importance to have this project delivered in a timely and safe manner. Therefore, it is recommended that discussion with cable manufacturers, procurement specialists and installation contractors should begin sooner rather than later to understand availability of such equipment and what technology is being invested to make such large scale projects viable in the near future.

10.3 Cable Protection

Cable protection is required along the whole route of the cable from landfall to landfall. This is to protect such a highly valued asset from detrimental environmental effects, fishing activity, and dropped objects at the landfalls and offshore. This can be achieved through concrete tunnels, rockdump, mattresses, and trenching.

10.4 Scour Protection

Scour protection is a consideration for detailed design once further site specific data has been obtained. It is only required where the cable is laid unprotected and is exposed to potentially high currents around other seabed infrastructure. However, the installation methodology adopted is to protect the whole length of cable from landfall to landfall through means of trenching, rockdumping, mattressing and concrete tunnel protection.

10.5 High-Level Cost Estimate

Table 10.1 presents the high level cost estimate for the two options considered for the NorthConnect cable route.

Route Option	Length (km)	Number of Crossings		Cost (£k)
		Pipeline	Cable	
1	565.232	16	26	958,948
4	654.984	15	36	1,100,593

Table 10.1 Refined Cost Estimate for Options 1 (Samnanger) and 4 (Sima)

10.6 High-Level Schedule Estimate

Table 10.2 presents the high level schedule estimate for the two options considered for the NorthConnect cable route.

Route Option	Total Installation Duration Including Winter Down Time (Days)
1	1028
4	1053

Table 10.2 Refined Schedule for Options 1 (Samnanger) and 4 (Sima)

11 IMPACTS & EFFECTS PREFERRED ROUTES

11.1 Cable & Pipeline Crossings

This study has looked at opportunities to mminimise amount of cable and pipeline crossings and keep minimum buffer distance between proposed cable routes and existing cable and pipeline infrastructure.

Figure below gives an indication of location and density of cables (green lines) and pipelines (grey lines) within the North Sea (see Appendix N for larger picture). Also the fjords towards the Norwegian landfall contain a significant number of cable crossings.

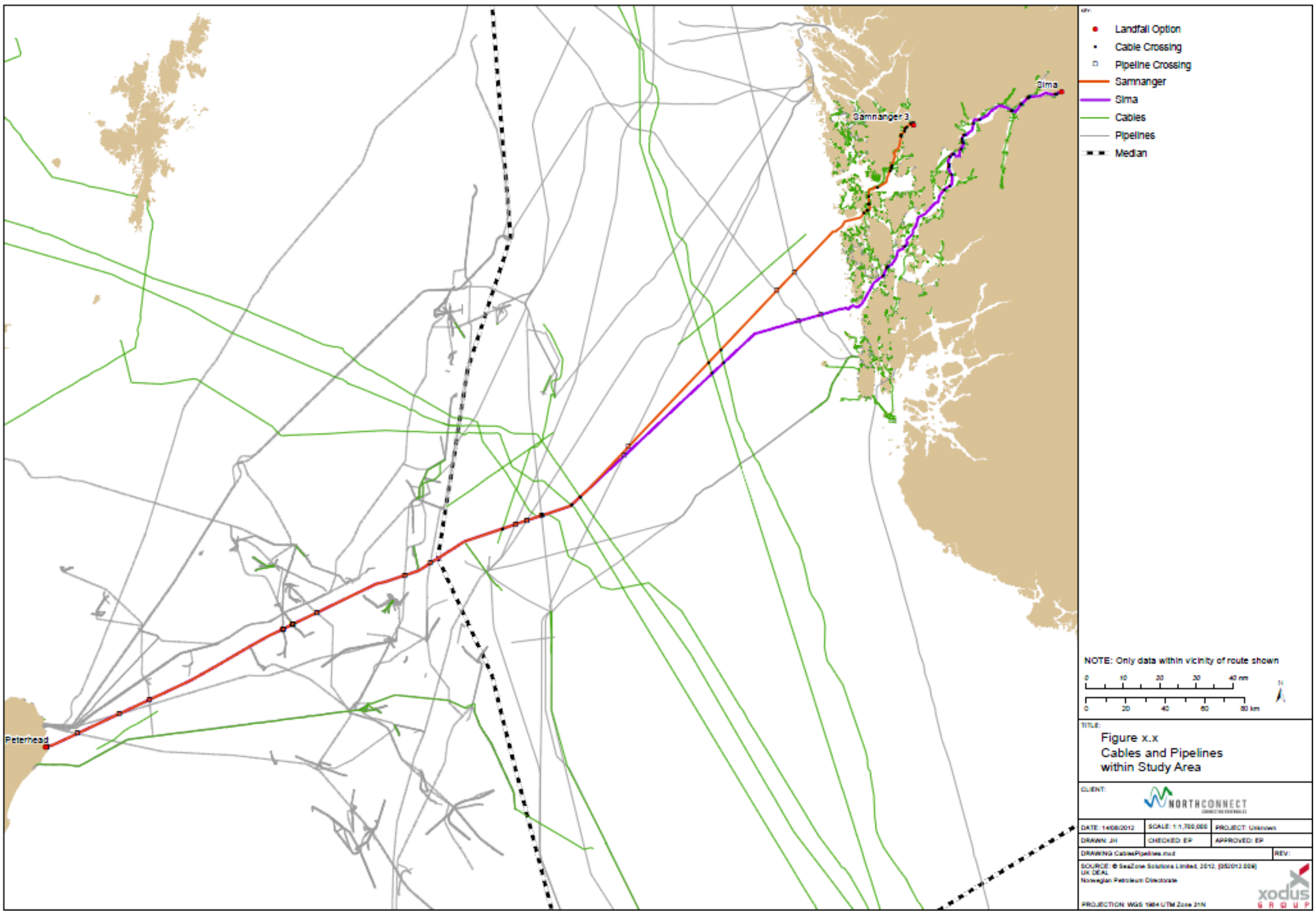


Figure 11.1: Cable and Pipeline infrastructure within the North Sea.

Cables and pipelines were modeled as medium constraints due to cost crossing arrangement as well as legal and financial risks involved. A buffer radius was introduced for safety purposes.

Some of the existing cables and pipelines are located closely together. The project has considered opportunities to group cables and pipelines into a single crossing in order to minimise environmental impact and optimise costs.

The proposed Sima cable route crosses 40 cables and 23 pipelines. Some of the cable and pipeline crossings can be grouped into a single crossing arrangement, resulting in a total of 51 crossings (i.e. 36 cable and 15 pipeline 'grouped' crossings) instead of 63 crossings.

The proposed Samnanger cable route crosses 28 cables and 24 pipelines. Some of the cable and pipeline crossings can be grouped into a single crossing arrangement, resulting in a total of 42 crossings (i.e. 26 cable and 16 pipeline ‘grouped’ crossings) instead of 52 crossings.

Mitigation measures will include formal Crossing Agreements with cable and pipeline owners. Good communication and liaison with navigational stakeholders will be required.

11.2 Offshore Oil & Gas Infrastructure

This study has considered opportunities to avoid any existing oil and gas sites, avoid any areas of known future offshore development and keep minimum buffer distance between proposed cable routes and existing as well as future developments.

The proposed cable routes penetrate a limited amount of existing Oil and Gas fields (e.g. Blackbird, Hannay, Rochelle, Sleipner Vest) while keeping a safe distance from offshore infrastructure (e.g. platforms, wells).

The proposed cable routes run past a significant number of Oil and Gas development areas platforms. The figure below illustrates. A larger illustration can be found in Appendix O.

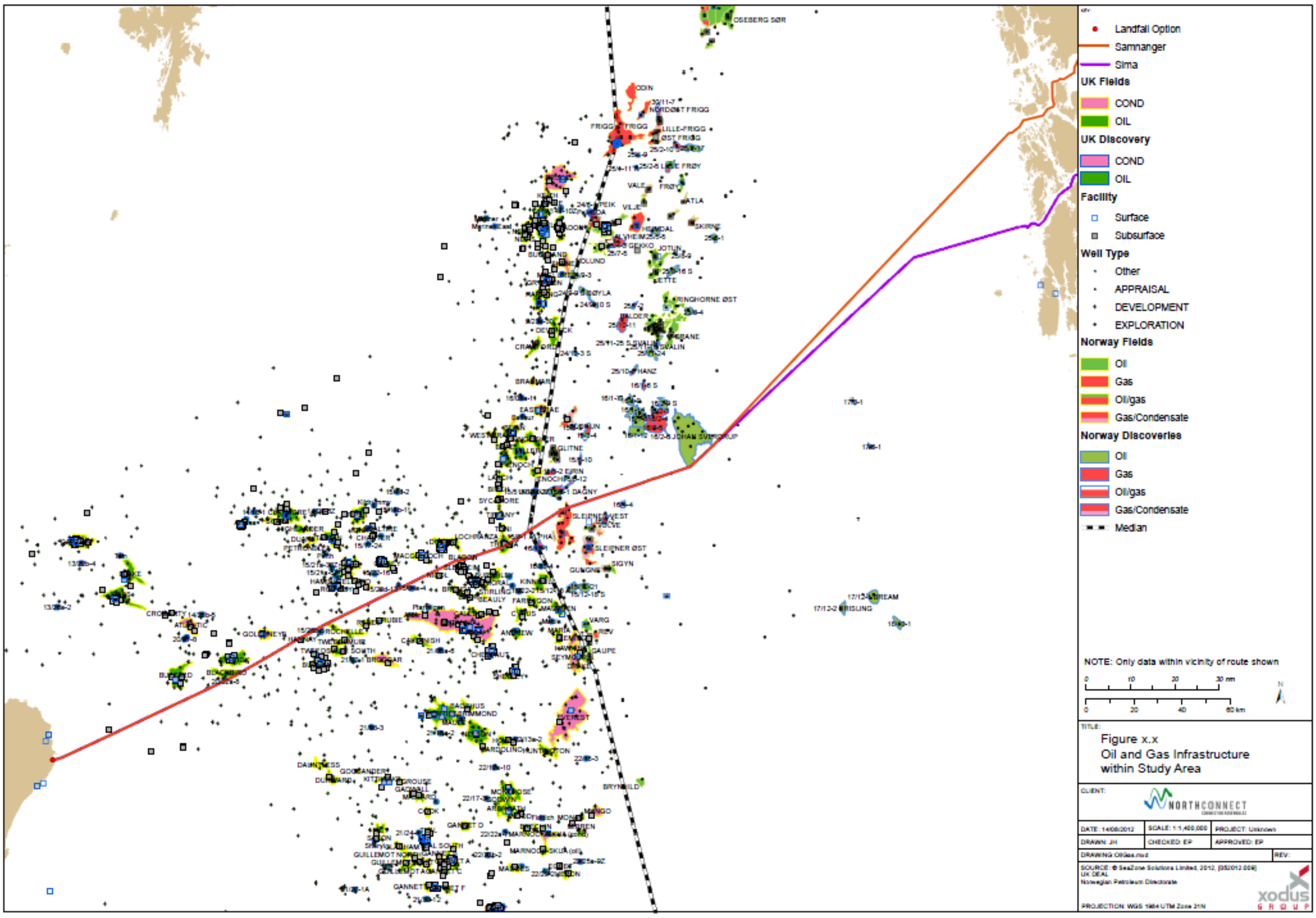


Figure 11.2: Offshore Oil & Gas Infrastructure within the North Sea.

All Oil & Gas development areas have been captured in GIS data which will be handed over to the EIA work packs for Environmental Appraisal.

O&G platforms were modeled as hard constraints, i.e. no-go area. A buffer radius was introduced for safety purposes.

The effects include potential interference with operations and maintenance activities of existing O&G infrastructure, planned decommissioning activities and installation of new O&G development sites.

Wells have been identified along the route. A buffer radius has been introduced for safety purposes and will be taken into account during detailed route design.

11.3 Offshore Renewable Energy Development Sites

Renewable energy development sites known to date were modeled as hard constraints, i.e. ‘no-go’ area. A buffer radius was introduced for safety purposes.

The effects include potential interference with O&M activities of existing wind, wave or tidal infrastructure, planned decommissioning activities and installation of new wind, wave or tidal development sites.

Only one offshore wind development site was identified along the study area, i.e. offshore wind development site planned off the Norwegian coast between Kårstø and the Sima corridor route called Utsira Nord. No other wind, wave or tidal projects were identified as part of the data sets provided by Seazone.

The proposed Sima route option runs north from the planned offshore wind farm. The Samanger alternative route option is further removed from the site and therefore causes no cumulative effect.

11.4 Commercial Fisheries

The selected route passes commercial fisheries as well as fish farms within the Samnanger and Sima corridor routes. The figures below provide indication of fishing density within UK and Norwegian waters.

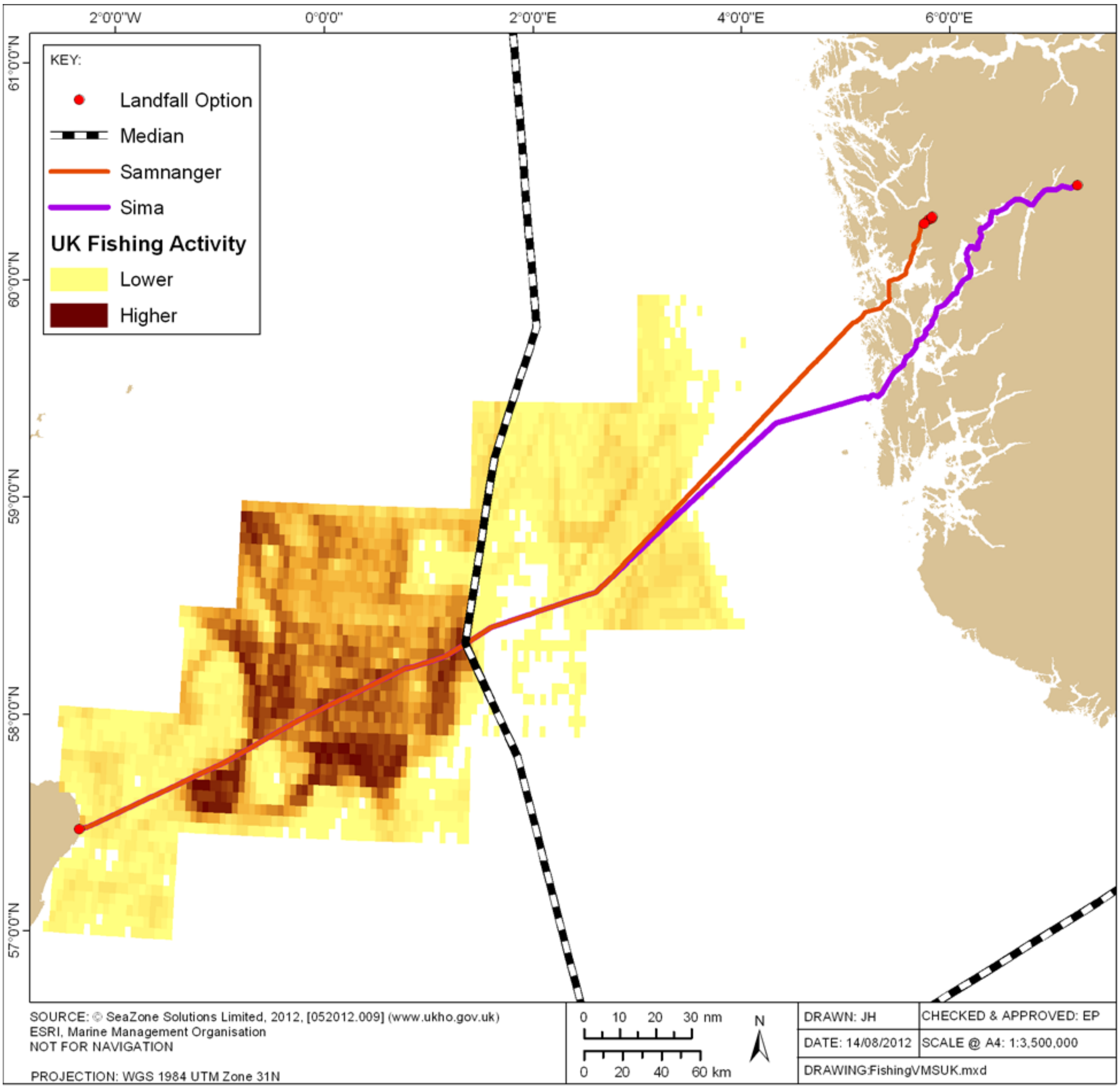


Figure 11.3: Fishing within UK waters.

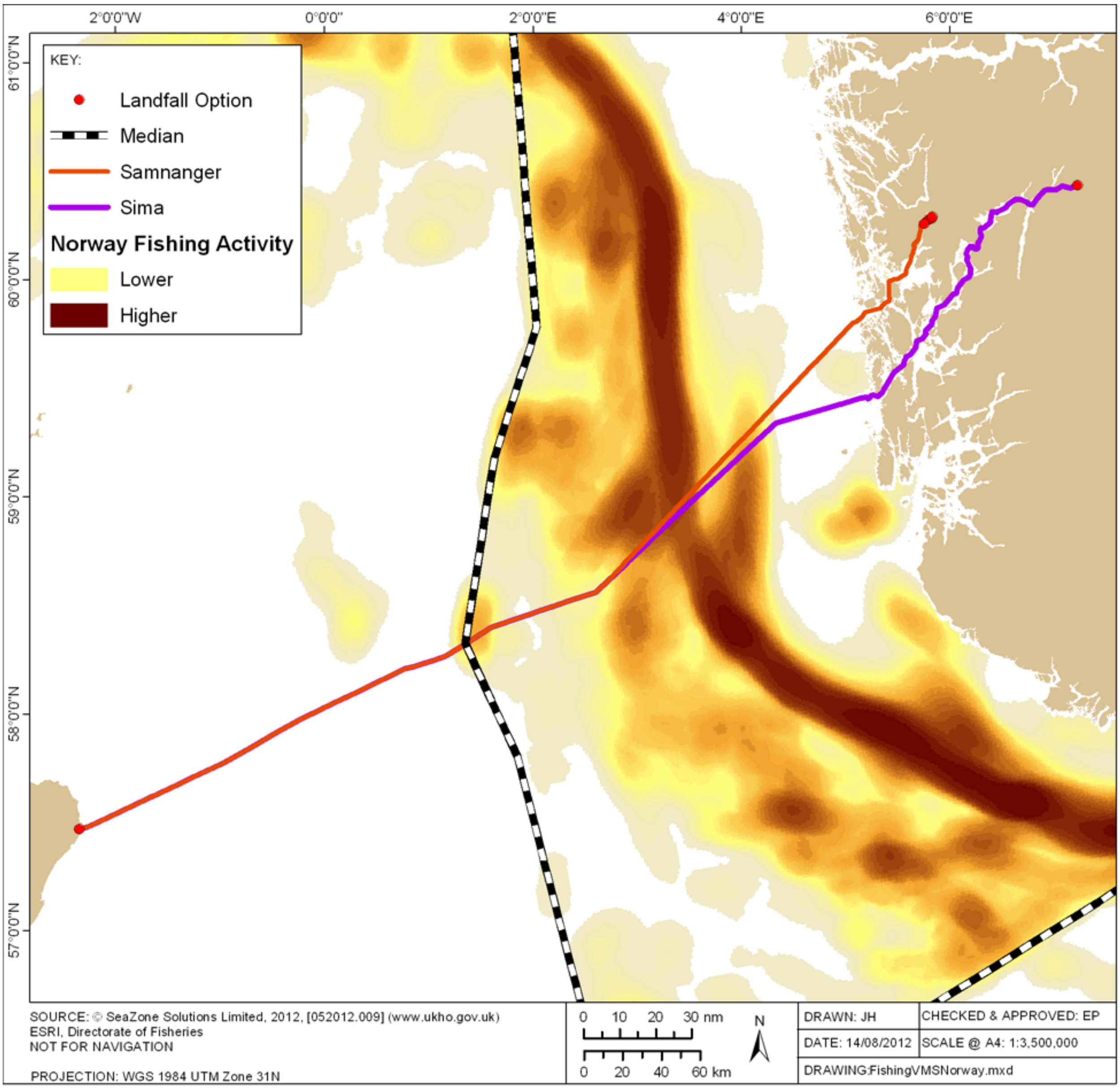


Figure 11.4: Fishing within Norwegian waters.

This study has looked at opportunities to avoid fishing areas with important commercial species or aquaculture developments, avoid major fishing ports in the region, maximise cable burial, apply rock dump when cables cannot be buried and document cable installation method to allow for effective communication with fisheries.

Potential effects during installation, operations, repair and maintenance are:

- Displacement of vessels using mobile/static gear from the mobile exclusion zone around installation vessels;
- Creation of sea-bed obstructions of sections with unprotected cable for a period following installation;
- Disturbance/damage of certain species;
- Safety risk of exposed and/or unprotected cable;
- Cable protection at crossing obstructing mobile gear;

> Disruption of fishing activity during cable repairs and maintenance;

> Disruption to aquaculture sites through

  - Accidental oil or chemical spill from cable installation vessels; and
  - Increased levels of suspended sediment dispersion and deposition

11.5 Shipping, Navigation and Anchorages

The Sima and Samnanger cable routes selected avoid or limit their exposure to shipping and navigation areas.

This study has considered opportunities to avoid and keep maximum distance from busy shipping areas by identifying navigational features, shipping routes, shipping roundabouts and to avoid anchorage areas. Figure below illustrates. A larger illustration can be found in Appendix P.

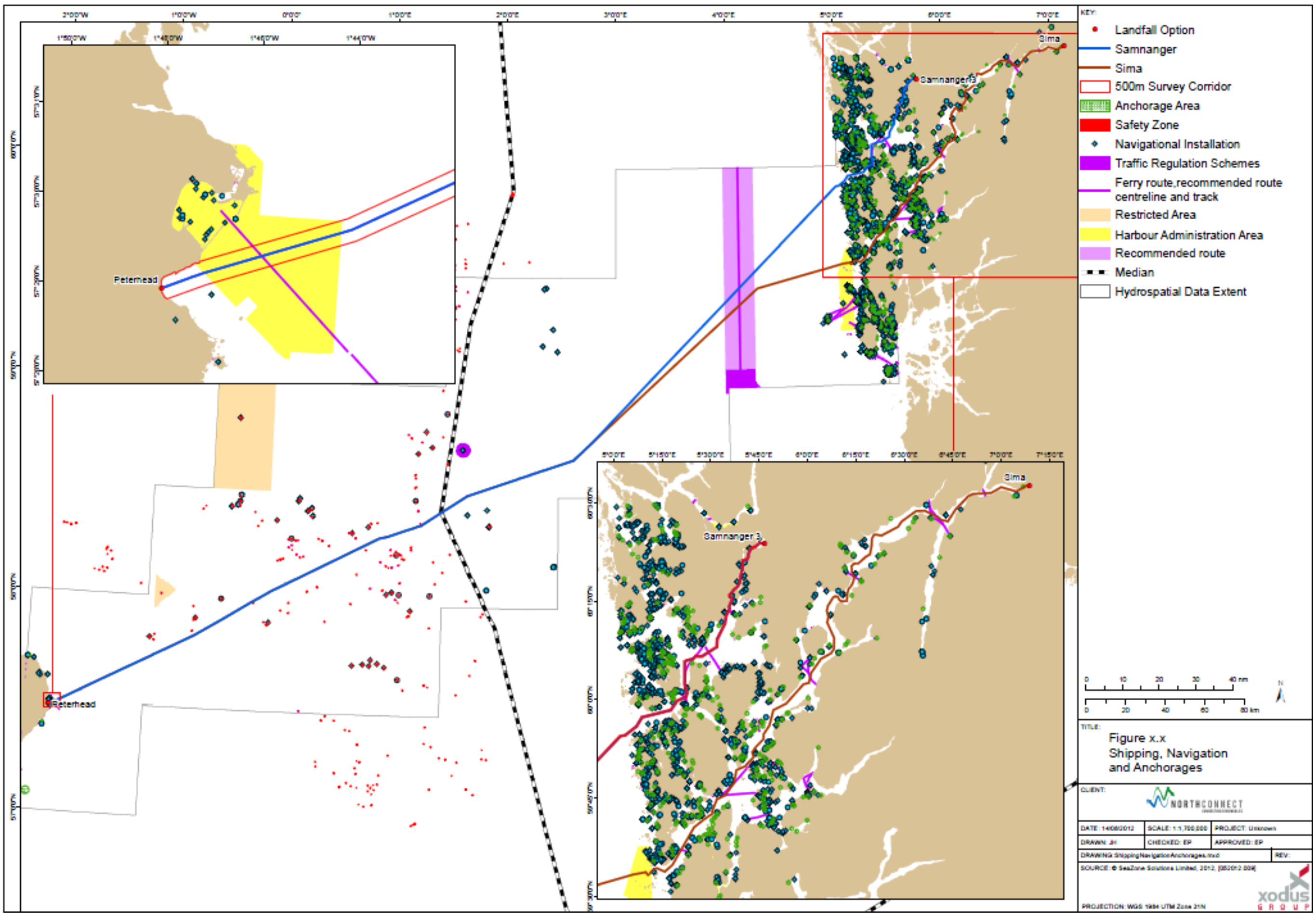


Figure 11.5: Shipping, Navigation and Anchorages.

Potential effects to compass deviation will be mitigated through detailed design. More detailed analysis will be conducted in terms of bundling versus unbundling, water depth and installation strategy at landfall to limit compass deviation to 2 degrees (as per UK specific requirement).

The potential effects to shipping and navigation include:

> Disruption of commercial shipping activity through the presence of cable installation, maintenance, repair and survey vessels;

> Collision risk with other vessels;

> Disruption of vessel anchoring;

> Anchor dragging or snagging the cable; and

> Compass deviation on ships navigating with magnetic compasses.

11.6 Dredging, Disposal and Military Practice Areas

A firing practice area has been identified along the Samnanger route option off the Norwegian coast. Figure below illustrates.

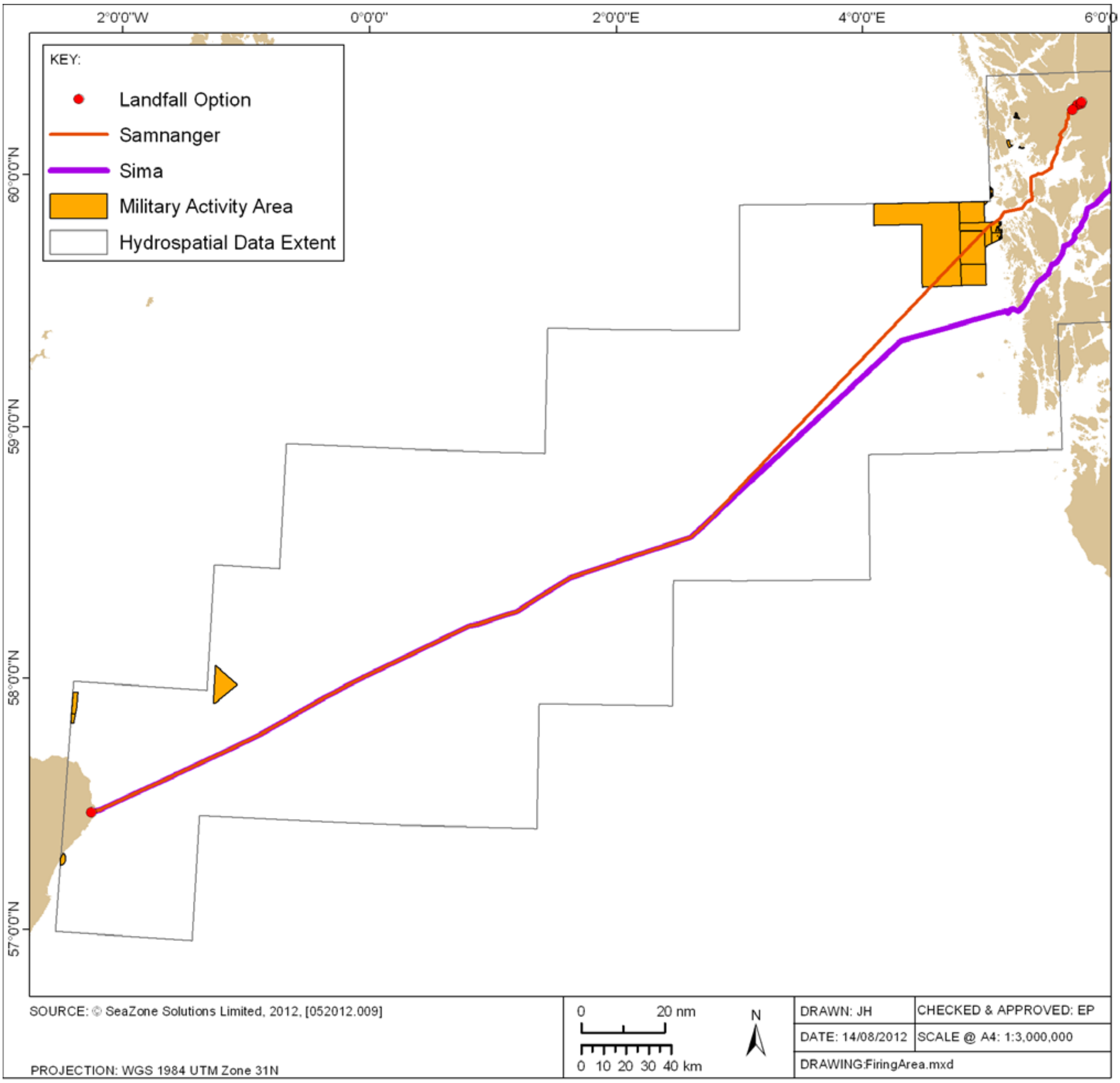


Figure 11.6: Military Practice Areas.

Unexploded ordnance has been identified in proximity of the Sima route option relatively close to Sima landfall.

Spoil ground areas have been identified near Peterhead landfall, i.e. at Sandford Bay and near Peterhead harbour.

The figure below illustrates dredging areas, spoil grounds, former mined areas and explosives dumping grounds along the preferred routes (for larger images refer to Appendix Q).

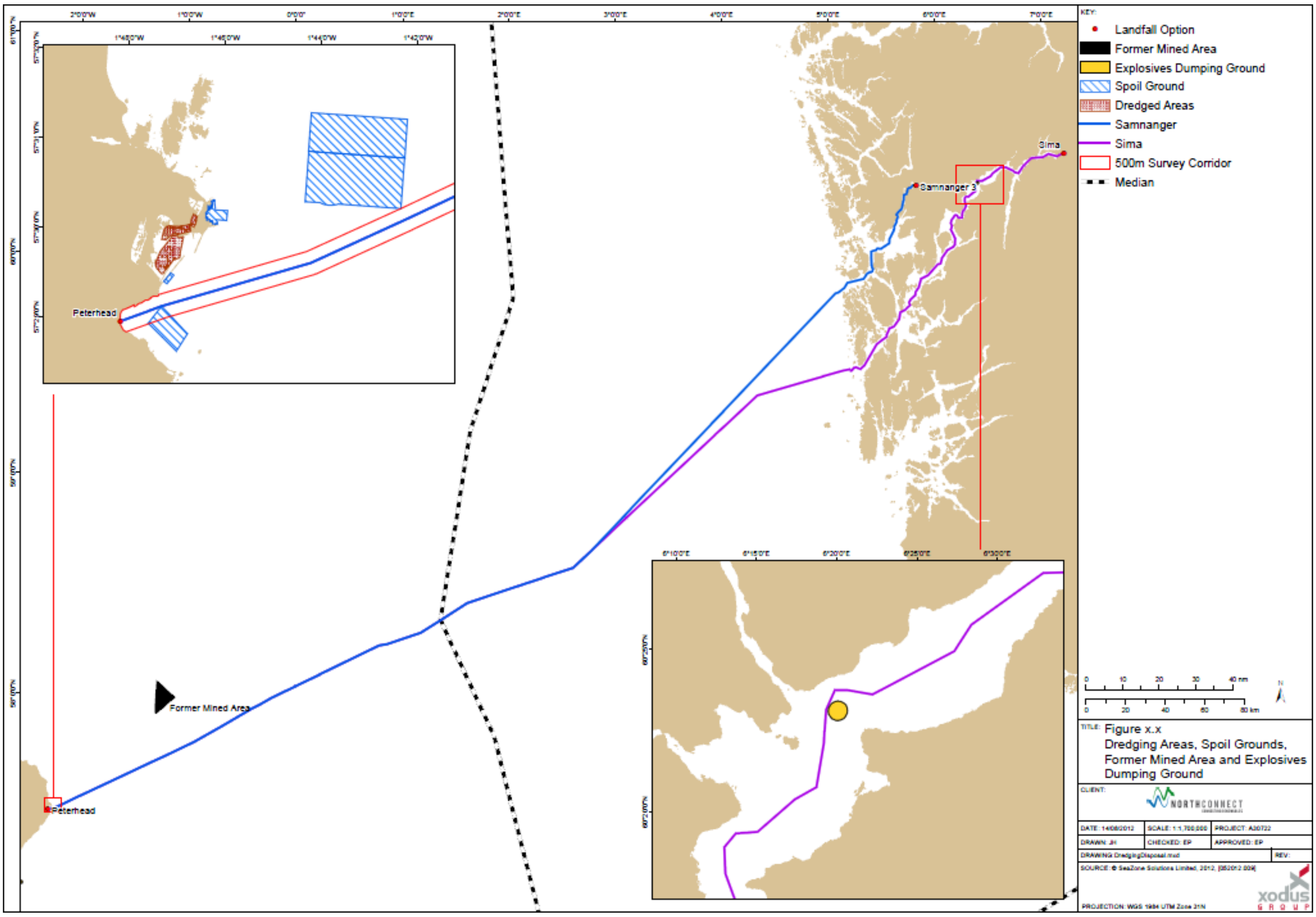


Figure 11.7: Dredging areas, spoil grounds, former mined areas and explosives dumping ground.

11.7 Cultural Heritage

There are no designated wrecks for cultural heritage significance by Historic Scotland within the vicinity of the project area.

Wrecks have been identified along both routes options. Buffer distances have been applied. The objective of the desktop route design was to avoid wrecks as much as possible. The corridor route defined for the detailed survey has been designed to avoid wrecks captured within the data sets provided by Seazone.

The objective of detailed route design is to avoid interference with registered wrecks as well as any wrecks identified through data from the detailed route survey.

11.8 Coastal Defences

No coastal defences have been identified at UK and Norwegian landfalls.

11.9 Environmental Impacts & Effects

No major constraints or showstoppers have been identified for the preferred routes.

A proposed protected area has been identified along the Sima route option.

SPA, potential Annex I reef and Grey seal haul-out areas have been identified near Sandford Bay.

Coral deposit areas have been identified along the routes towards both Norwegian landfals

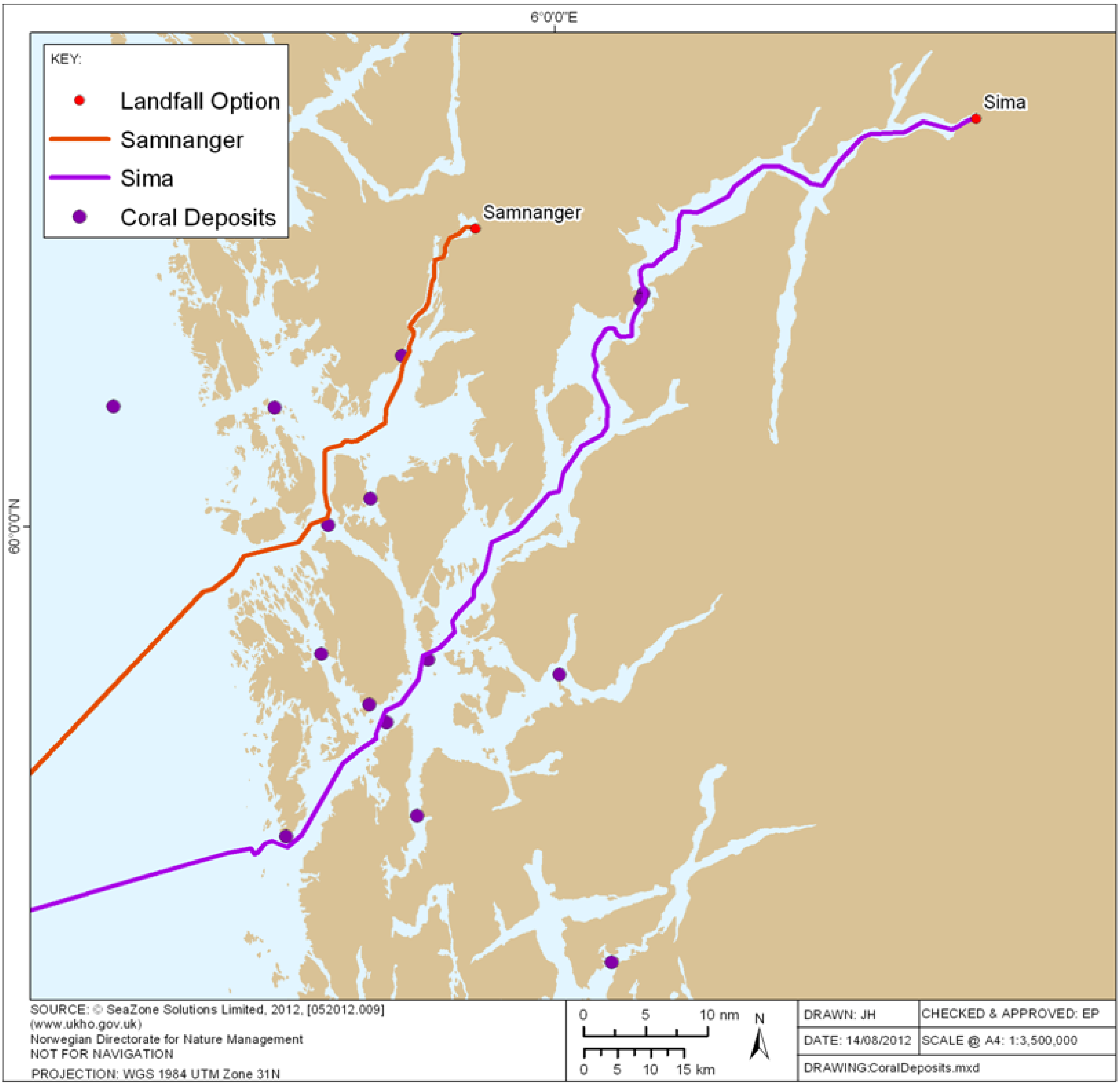


Figure 11.8: Coral Deposits.

12 ROUTE POSITION LISTS AND STRAIGHT LINE DIAGRAMS

The Route Positioning List (RPL) is a working spreadsheet which is used from desktop study right through to acceptance as part of the final cable manufacture and installation documents. The RPL is a controlled document.

The RPL's capture alter courses, changes in installation method, expected transitions in soil type, cable and pipeline crossings, plough-up and plough-down positions, etc.

RPL's and straight line diagrams (SLD's) have been prepared for the selected route options.

RPL's have been developed using excel spreadsheet. Individual RPL's for each cable will be created during detailed route design. Positions of crossings and changes in directions (alter courses AC) have been defined. 'Between Positions' values are calculated distances using Mercator Sailing computations for the defined geodetic system (WGS84).

Route Position Lists (RPL's) and Straight Line Diagrams (SLD's) have been captured separately[3].

[3] A-30722-S04-LIST-0XX-A01 Route Positioning List

13 DETAILED SURVEY SPECIFICATION

The project will undertake a pre-installation survey in order to confirm the viability of the proposed cable route. The detailed survey will take into account seabed conditions including bathymetry, geology and other seabed features.

The results from the detailed survey will be used to perform detailed route design. The detailed route design is intended to mitigate/avoid any obstructions (e.g. boulders) or geological challenges (e.g. steep slopes, sand waves, pock marks, hard soil conditions).

Also, the output of the detailed survey is essential in the validation of appropriate cable installation and protection methods identified during the route design study.

Xodus has developed a detailed survey specification to allow a survey to be completed that will confirm the physical condition of the seabed along the route developed during the desk top study, and to allow subsequent detailed route engineering and planning.

Xodus has prepared the Technical Specification for Detailed Survey [4] that lists the technical requirements for the route survey, including bathymetry, geophysical and in-situ testing, sampling and laboratory testing. Xodus with the support from Geomarine have developed the geotechnical requirements of the survey specification.

[4] A-30722-S04-SPEC-001-A01 Technical Specification Detailed Survey.

14 CONCLUSIONS

Preferred routes selected are ‘Peterhead North + North Sea 1 + Samnanger’ (i.e. option1) and ‘Peterhead North + North Sea 1 + Sima’ (i.e. option 4). Both options are taken forward to the next phase, i.e. Detailed Survey and Detailed Route Design.

The study has taken into consideration a wide range of environmental and technical issues as well as feedback from EIA contractors. Through careful route assessment and selection, a range of mitigation measures have been incorporated into the design of the project.

The identification, assessment and selection of route options has taken into account project objectives and key drivers captured at the start of the project. Documenting project objectives and key drivers at project kick-off has created focus. The qualitative and quantitative option screening process conducted as per Xodus Value, Decision and Risk Management methodology has proven very efficient and effective in terms of measuring different routeing options against key drivers as well as against each other. The process allowed for informed and transparent decision making. The record of discussion has provided a concise auditable justification for the score assigned to each option.

The methodology has ensured that a number of potentially significant adverse impacts and effects have been avoided, reduced or offset.

Despite some of the adverse effects being avoided, those which may still impose disturbance to people and the environment will require follow-up during stakeholder consultation and consenting.

Xodus has, through careful routeing, developed a route proposal which causes least disturbance to people and the environment. Considering the scale of development and the type of constraints identified for the preferred route, it is expected that the environmental appraisal meet expectations of all stakeholders involved.

Route cost per kilometer primarily considers cable length and number of cable crossings. Minimising cable length and number of crossings has been an objective adopted from the outset of the project.

The approach has also given significant consideration to technical feasibility, health & safety, economic viability and programme schedule. This should assist NorthConnect with the creation of the business case and with project governance in terms of informed decision making.

15 RECOMMENDATIONS

Detailed seabed surveys will be required to confirm sea bed conditions. Based on the results of the detailed survey, the exact cable route can be finalised through detailed route design. The detailed survey data is essential to confirm appropriate installation methods, burial depth and level of cable protection in different areas along the cable route selected.

ITT Detailed Survey – Detailed survey will be performed based on requirements captured in Technical Specification and details in Route Positioning Lists. To get the best value from the tender process for detailed survey, we recommend NorthConnect to consider an ITT which invites tender applicants to submit their offers for parts of the preferred route(s) as well as for the entire route. The objective is to increase transparency and to encourage competitive offers. The approach allows for selection of survey companies for individual sections of the route(s) or selection of a survey company for the project as a whole.

Execution Detailed Survey – Both Sima and Samnanger corridor routes have been confirmed as challenging based on depth profile and slope analysis, therefore implying significant level of uncertainty and risk. The cost of detailed surveys is significant, especially considering the cable length associated to both cable route options selected for further analysis. NorthConnect may want to consider different scenarios for execution of the detailed survey. For example, the detailed survey:

> Can be executed as part of a single campaign, i.e. the detailed survey is performed for both Sima and Samnanger options simultaneously;

> Can be executed following a phased campaign, i.e. perform detailed survey of both Sima and Samnanger corridors (i.e. fjords, incl. entrance), assess technical feasibility of both Norwegian route options simultaneously and survey UK-to-Norway subsea route afterwards based on landfall option selected;

> Can be executed following a phased campaign, i.e. perform detailed survey of Samnanger corridor (i.e. fjords, incl. entrance), assess technical feasibility of Samnanger corridor route options and survey UK-to-Norway subsea route afterwards based on landfall option selected.

A single campaign implies early and high investment cost despite all project risks associated.

A phased campaign allows for risk management, phased decision-making and potential cost savings. Part of the North Sea 1 subsea route does not require a detailed survey dependent which option is chosen as preferred. A detailed survey of the Sima route potentially could be avoided if the Samnanger route proves technically feasible, the overall (offshore/onshore) business case is positive and the National Regulator approves Samnanger as the proposed route. If the Samnanger route proves technically inadequate, all focus can be put on Sima.

Hazard Avoidance – Digital data from the detailed route survey will require detailed analysis of geotechnical and geophysical constraints (e.g. pock marks, rock exposures, debris, mounds, ridges, sand waves, mega-ripples, and soil types). The data will also reveal obstacles (e.g. boulders, uncharted wrecks) which will need to be captured and avoided during detailed route design.

Burial Depth Assessment – Burial depth or trench depth should be optimised based on data from detailed survey and risk based assessment as a means of minimising cost. We recommend a detailed trenching study for the proposed routes to refine the trenching rate adopted within the cost estimating excercise. We believe the biggest risk to the cost estimates are the trenching rates. They will vary and getting a better handle on rates along the route for the different soil conditions would prove useful. This study could also look at any differences of trenching rate between different equipment and perhaps fine tune trenching methods for different route sections. Trenching could well be a multi-contractor activity.

Confirm Technical Feasibility Samnanger – Although the Samnanger route option is considered most favourable in terms of environment, consenting & permitting, economic viability and execution schedule, doubts remain with regard to technical feasibility of cable installation. During the workshop for the quantitative assessment, it was recommended to perform the detailed survey for the Samnanger route urgently. High resolution data would enable the project to perform a more accurate slope analysis, to assess local challenges in more detail and to validate technical feasibility. The project would be in a position to advise on mitigation actions for success or to provide justifications of why the Samnanger option should be aborted.

Risk Assessment Unexploded Ordnance – An UXO specific survey should be commissioned to investigate the area and establish the level of risk involved. Any unwanted object will need to be removed on NorthConnect's own account before any further activities can be performed.

Consultations – Mitigation measures including formal Crossing Agreements with cable and pipeline owners and good communication and liaison with navigational stakeholders and local fisheries will be required. EIA work packs should engage with relevant stakeholders to inform them about the intended route and obtain early feedback through initial consultations. Any feedback on constraints, pain points or potential showstoppers should be used as input to detailed route design. Engagement with Oil & Gas companies along the North Sea route is recommended to allow for alignment regarding future development. Oil & Gas UK is a very useful starting point for such discussions.

Cable/Pipeline Crossings – Early engagement with cable and pipeline owners is recommended to formalise crossing design and fine-tune installation strategy and refine project costs. Legal side of the crossing arrangements will require attention to detail. Again it is recommended that O&G UK are consulted. Subsea Cables UK is the central forum for all cable operators in the UK (formerly the UK Cable Protection Committee). It is recommended that effective engagement is made with this group.

Cable Repeaters - When new cables are laid across an existing telecommunications cable system that contains repeaters, a minimum distance should be kept between the repeater and the new cable crossing. Repeaters should be a topic of discussion during crossing arrangement discussions with cable owners. Detailed route design should capture exact location of cable repeaters and adopt minimum distance requirements.

Budget versus Cost – Budget for the project should account for investment cost as well as cost associated to project risk. Risk management should become an integral part of the project life-cycle. A proper risk assessment should be conducted to capture events that may cause extra budget requirements. Mitigation actions should be defined and quantified for each risk identified. This is to avoid, reduce or offset impacts associated. Based on probability of occurrence and severity of impact, the project should perform a detailed risk assessment and define budget requirements to cover level of risk anticipated (i.e. project budget = project investment cost + cost risk management).

Early Supply Chain Engagement – During route detailed design, engagement with cable installation companies should confirm recommendations of cable installation methods (i.e. subsea and landfall), cable burial depth and cable/scour protection stated in this report. Early supply chain engagement will allow for positioning within the supply market, create strategic partnerships and help secure production capacity and vessel availability.

Liaison with installation companies should also confirm safety distance for trenching near existing cables and pipelines as it will define safety constraints for crossing arrangements. These constraints will need to be addressed during discussions with cable/pipeline owners and design of individual crossing arrangements.

Engagement with cable manufacturers will be required to assess production rates and understand potential constraints. Another project objective is to align cable manufacturing and cable installation schedules to optimise supply chain (i.e. sourcing, manufacturing, transport and installation) and project financing.

Cost and Execution Schedule – During route detailed design, more detailed cost, schedule and operability data should be obtained from cable suppliers and installation contractors. With the addition of detailed metocean data, the entire installation process can be modelled by simulation, thereby quantifying the extent of risk posed by each operation, e.g. cable splicing. Such a simulation can also be used to assess the impact of mitigation. The objective is to increase accuracy of cost and schedule information in order to facilitate informed decision-making and increase confidence levels.

Installation & Investment Strategy – Various factors influence cable route installation and investment strategies. Installation philosophies will need to be defined (e.g. number of vessels, type of vessels, 2 seasons versus 3 seasons, approach to landfall, equipment and resource requirements, impact on execution schedule). We recommend the Project to identify candidate options and to perform option screening against key drivers identified at project kick-off. Combined with cost modelling and due diligence, the Project should down-select to a predefined (and manageable) number of economically viable options for further investigation.

Output of this report and the data captured in GIS will be used as input to the UK and Norwegian Environmental Impact Assessments which in turn will feed the consultation process and Environmental Statement.

16 REFERENCES

1 Email from Barrett, Brian T to Edwin Pauwels, Subject: RE: FW: A-30722-S04 - DTS-RS – NorthConnect, Sent 24th July 2012 @ 15:58, Regarding cable layout and number and type of cables required

2 Email from Barrett, Brian T to Edwin Pauwels, Subject: FW: FW: A-30722-S04 - DTS-RS – NorthConnect, Sent 19th July 2012 @ 13:37, Regarding technical data for 500kV and 36kV power lines

3 Email from Barrett, Brian T to Edwin Pauwels, Subject: RE: FW: A-30722-S04 - DTS-RS – NorthConnect, Sent 19th July 2012 @ 12:27, Regarding quotation for 500kV and 36kV power lines

4 Soil Cover reference guidance from the Business, Enterprise & Regulatory Reform (BERR) Renewables Technical Report “Review of Cabling Techniques and Environmental Effects Applicable to the Offshore Wind Farm Industry, Jan 2008”

APPENDIX A OPTION SCREENING (QUALITATIVE ASSESSMENT)

xodus GROUP

NorthConnect Desk Top Study & Route Selection
Option Screening & Selection
Integrated Projects

Document Type Report

Document Number A-30722-S04

Date 26/06/12

A01	26/06/2012	Option Screening Spreadsheet	Ed Pauwels			
Rev	**Date**	**Description**	**Issued By**	**Checked By**	**Approved By**	**Client Approval**

PROJECT	**A-30722-S04 - NorthConnect - Desk Top Study and Route Study**
CLIENT	**NorthConnect KS**
SUBJECT	**Corridor Option Screening - Qualitative Assessment**
REVISION	**R01**
Date	**25/06/12**
Page	

Option	**Option Description (include image if possible)**	**Evaluation**					**Limitations of Evaluation**	**Recommendation**
		Environmental	**Consenting & Permitting**	**Economic Viability**	**Technical Suitability**	**Execution Schedule**		
Option name.	*General description of corridor options selected.*	*Provide an indication of the environmental impacts and impacts on other marine users (e.g. fisheries, MOD, shipping)*	*Provide an indication of consenting and permitting issues due to potential impacts on the envioronment and people, schedule risk and reputational risk.*	*Provide a qualitative indication of cost in terms of materials, installation, cable protection, scour protection and availability.*	*Is the option technically suitable for the route? This will require some initial design work to qualify.*	*Is there a risk of the option having an impact on the project programme?*	*Provide any details of the limitations in information for initial assessment.*	*Recommendation as to whether the option should be pursued.*
Corridor Route Option 1	Peterhead North North Sea 1 Samnanger	GREEN	GREEN	GREEN	GREEN	GREEN	Limitation data on future offshore development. Development sites under development/planning may not be available in industry data sets. Therefore list of constraints may not be exhaustive.. This limitation applies to all options part of this option screening.	GREEN
		UK - SPA, Potential Annex I Reef, grey seal haul out, Peterhead Harbour Area, traffic recommended track, spawning area, pipelines and cables, Peterhead spoil ground nearby, transboundary line, discovery fields, Offshore SAC (pockmarks) nearby. Norway - spawning area, nearby protected area, firing danger area, traffic separation scheme, particularly valuable sea area, habitats inc: kelp forest; terminal moraines; coral, passive and active fishing gear areas, fish storage, ferry routes, aquaculture, harbour district.	UK - Habitat Regulations Assessment probably required for potential SPA disturbance. **Schedule Risk:** No differentiation from other corridors into Peterhead. **Reputational Risk:** No differentiation from other corridors into Peterhead. **Stakeholders:** No differentiation from other corridors into Peterhead. **Cumulative impacts:** future O&G developments	**Est. cost materials:** £ 325.0M **Est. cost installation:** £ 739.6M **Est. cost cable/pipeline crossings:** £ 77.4M ***Est. cost cable protection:*** *£ 4.0M (included in installation cost above)* ***Estimated cost scour protection:*** *£ - (included in cable protection above)* **TOTAL: £1,142.0M**	**Estimated cable length:** - 560.3 km **Geotechnical/physical Assessment:** Predominant soil conditions: - Bedrock; very dense SAND; very soft CLAY; firm to very stiff CLAY and medium to dense SAND; gravelly stiff to hard CLAY; very soft CLAY; bedrock at Fjord entrance; very soft CLAY in fjords. - Sandwave features near Peterhead; pockmarks in Witch Ground Basin and Norwegian Trench; iceberg scars and glacial till outcrops on flanks of Norwegian trench; bedrock outcrops near Fjord entrance; boulder and cobble beds **Suitability Trenching:** - Jet trenching: 45% of route (approx. 250km) **Suitability Ploughing:** - Ploughing: 52% of route (approx. 290km) **Level of Rock Dump required (untrenchable):** - approx. 3% of route (approx. 20km)	**Cable Length:** 560 km **Number of cable/pipeline crossings:** 43 **Est. execution schedule (per individual cable):** 78 days cable lay; 3 days of jointing; 94 days trenching; 43 days of rockdumping; **Number of seasons:** 3 seasons (1 season per cable)		**Take option forward:** Yes **Areas of further investigation:** Future Norwegian oil/gas field developments could prove a hinderance - to monitor. Clarify future O&G development in Norwegian waters. Consultation(s) to claify Peterhead options. Consultation to assess impact firing practice area on feasibility Samnanger 1. Consider Smanganger 2 option. Fine-tune cost modelling, assessment technical suitability and execution schedule.
		Protected Areas: Yes - Corridor on edge of marine bird special protection area (Buchan Ness to Collieston Coast SPA). **Protected Species:** Yes - SPA regularly supports 95,000 individual breeding seabirds including: guillemot, kittiwake, herring gull, shag, fulmar. Corridor also passes close to grey seal haul-out sites. Norway - corridor potentially includes coral habitat. **Other marine users:** Yes: UK - Corridor crosses sewage effluent outfall pipes in Sandford Bay, other pipeline and cable routes in North Sea, Corridor in close proximity to Peterhead Harbour, ferry routes and traffic separation scheme; Corridor in close proximity to Peterhead harbour dredge spoil dumping ground, Norway - Corridor crosses cable routes in Norwegian fjords. also passes harbours in Norwegian fjords. Corridor passes through military firing area. Corridor passes numerous aquaculture sites/fish storage areas.		**O&M costs:** Considered similar for all options within this option category. **Availability:** Considered similar for all options within this option category.	**Number of grouped cable/pipeline crossings:** - 43 (Nth Sea: 21 / Fjord: 22) **Estimated number of subsea cable joints:** - 3 **Cable protection:** - Recommendation: Rockdump *- Estimated: 77,000Te (3% of route)* - Planned amount: 215,000 Te (10% of route) - Xings: 175,000Te **Scour protection:** - Recommendation: Rockdump - assumed as part of cable protection - Est. amount required: 5,000 Te(<0.5% of route) **Slope angles:** - Challenges: individual pockmarks and slopes on the flanks of the norwegian trench and fjords **Offshore conditions (wind/wave/tidal):** - danger zones identified: Yes; near the Peterhead coast and within Sandford Bay (power station outfall)			
Corridor Route Option 2	Peterhead North	GREEN	GREEN	GREEN	GREEN	GREEN		GREEN

	North Sea 2 Samnanger	As for Corridor Route Option 1.	As for Corridor Route Option 1	**Est. cost materials:** £ 324.3M **Est. cost installation:** £ 738.0M **Est. cost cable/pipeline crossings:** £ 79.2M ***Est. cost cable protection:*** *£ 4.0M (included in installation cost above)* ***Estimated cost scour protection:*** *£ - (included in cable protection above)* **TOTAL: £1,141.5M**	**Estimated cable length:** - 559.1 km **Geotechnical/physical Assessment:** Predominant soil conditions: - Bedrock; very dense SAND; very soft CLAY; firm to very stiff CLAY and medium to dense SAND; gravelly stiff to hard CLAY; very soft CLAY; bedrock at Fjord entrance; very soft CLAY in fjords. - Sandwave features near Peterhead; pockmarks in Witch Ground Basin and Norwegian Trench; iceberg scars and glacial till outcrops on flanks of Norwegian trench; bedrock outcrops near Fjord entrance; boulder and cobble beds **Suitability Trenching:** - Jet trenching: 45% of route (approx. 250km) **Suitability Ploughing:** - Ploughing: 52% of route (approx. 290km) **Level of Rock Dump required (untrenchable):** - approx. 3% of route (approx. 19km)	**Cable Length:** 559 km **Number of cable/pipeline crossings:**44 **Est. execution schedule (per individual cable):** 78 days cable lay; 3 days of jointing; 94 days trenching; 44 days of rockdumping; **Number of seasons:** 3 seasons (1 season per cable)		**Take option forward:** Yes **Areas of further investigation:** Future Norwegian oil/gas field developments may make this option a better consideration Consultation(s) to claify Peterhead options. Consultation to assess impact firing practice area on feasibility Samnanger 1. Consider Smanganger 2 option. Fine-tune cost modelling, assessment technical suitability and execution schedule.
				O&M costs: Considered similar for all options within this option category. **Availability:** Considered similar for all options within this option category.	**Number of grouped cable/pipeline crossings:** - 44 (Nth Sea: 22 / Fjord: 22) **Estimated number of subsea cable joints:** - 3 **Cable protection:** - Recommendation: Rockdump *- Estimated: 77,000Te (3% of route)* - Planned amount: 215,000 Te (10% of route) - Xings: 180,000Te **Scour protection:** - Recommendation: Rockdump - assumed as part of cable protection - Est. amount required: 5,000 Te(<0.5% of route) **Slope angles:** - Challenges: individual pockmarks and slopes on the flanks of the norwegian trench and fjords **Offshore conditions (wind/wave/tidal):** - danger zones identified: Yes; near the Peterhead coast and within Sandford Bay (power station outfall)			
Corridor Route Option 3	Peterhead North	GREEN	GREEN	YELLOW	RED	YELLOW		YELLOW
	North Sea 3 Samnanger	As for Corridor Route Option 1. Near unexploded ordnance area.	As for Corridor Route Option 1	**Est. cost materials:** £ 323.1M **Est. cost installation:** £ 735.4M **Est. cost cable/pipeline crossings:** £ 90.0M ***Est. cost cable protection:*** *£ 6.0M (included in installation cost above)* ***Estimated cost scour protection:*** *£ - (included in cable protection above)* **TOTAL: £1,148.5M**	**Estimated cable length:** - 557.1 km **Geotechnical/physical Assessment:** Predominant soil conditions: - Bedrock; very dense SAND; very soft CLAY; firm to very stiff CLAY and medium to dense SAND; gravelly stiff to hard CLAY; very soft CLAY; bedrock at Fjord entrance; very soft CLAY in fjords. - Sandwave features near Peterhead; pockmarks in Witch Ground Basin and Norwegian Trench; iceberg scars and glacial till outcrops on flanks of Norwegian trench; bedrock outcrops near Fjord entrance; boulder and cobble beds **Suitability Trenching:** - Jet trenching: 45% of route (approx. 250km) **Suitability Ploughing:** - Ploughing: 52% of route (approx. 290km) **Level of Rock Dump required (untrenchable):** - approx. 3% of route (approx. 17km)	**Cable Length:** 557 km **Number of cable/pipeline crossings:**50 **Est. execution schedule (per individual cable):** 78 days cable lay; 3 days of jointing; 93 days trenching; 50 days of rockdumping; **Number of seasons:** 3 seasons (1 season per cable)		**Take option forward:** Yes **Areas of further investigation:** Only if future developments in Norwegian Sector don't allow Option 1 and 2 cable routing+J22 Consultation(s) to claify Peterhead options. Consultation to assess impact firing practice area on feasibility Samnanger 1. Consider Samnanger 2 option Fine-tune cost modelling, assessment technical suitability and execution schedule.

				O&M costs: Considered similar for all options within this option category. **Availability:** Considered similar for all options within this option category.	**Number of grouped cable/pipeline crossings:** - 50 (Nth Sea: 28 / Fjord: 22) **Estimated number of subsea cable joints:** - 3 **Cable protection:** - Recommendation: Rockdump *- Estimated: 65,000Te (3% of route)* - Planned amount: 215,000 Te (10% of route) - Xings: 205,000Te **Scour protection:** - Recommendation: Rockdump - assumed as part of cable protection - Est. amount required: 5,000 Te(<0.5% of route) **Slope angles:** - Challenges: individual pockmarks and slopes on the flanks of the norwegian trench and fjord **Offshore conditions (wind/wave/tidal):** - danger zones identified: Yes; near the Peterhead coast and within Sandford Bay (power station outfall)			
Corridor Route Option 4	Peterhead North North Sea 4 Samnanger	GREEN	GREEN	RED	YELLOW	RED		RED
		As for Corridor Route Option 1, except this route also passes through PSSA. Nearby unexploded ordenance area.	As for Corridor Route Option 1	**Est. cost materials:** £ 329.4M **Est. cost installation:** £ 749.6M **Est. cost cable/pipeline crossings:** £ 82.8M ***Est. cost cable protection:*** *£ 6.0M (included in installation cost above)* ***Estimated cost scour protection:*** *£ - (included in cable protection above)* **TOTAL: £1,161.7M**	**Estimated cable length:** - 567.9 km **Geotechnical/physical Assessment:** Predominant soil conditions: - Bedrock; very dense SAND; very soft CLAY; firm to very stiff CLAY and medium to dense SAND; gravelly stiff to hard CLAY; very soft CLAY; bedrock at Fjord entrance; very soft CLAY in fjords. - Sandwave features near Peterhead; pockmarks in Witch Ground Basin and Norwegian Trench; iceberg scars and glacial till outcrops on flanks of Norwegian trench; bedrock outcrops near Fjord entrance; boulder and cobble beds **Suitability Trenching:** - Jet trenching: 45% of route (approx. 255km) **Suitability Ploughing:** - Ploughing: 52% of route (approx. 295km) **Level of Rock Dump required (untrenchable):** - approx. 3% of route (approx. 18km)	**Cable Length:** 568 km **Number of cable/pipeline crossings:** 46 **Est. execution schedule (per individual cable):** 79 days cable lay; 3 days of jointing; 95 days trenching; 46 days of rockdumping; **Number of seasons:** 3 seasons (1 season per cable)		**Take option forward:** No **Areas of further investigation:** Most expensive option to Samnanger from Peterhead North
				O&M costs: Considered similar for all options within this option category. **Availability:** Considered similar for all options within this option category.	**Number of grouped cable/pipeline crossings:** - 46 (Nth Sea: 24 / Fjord: 22) **Estimated number of subsea cable joints:** - 3 **Cable protection:** - Recommendation: Rockdump *- Estimated: 70,000Te (3% of route)* - Planned amount: 220,000 Te (10% of route) - Xings: 190,000Te **Scour protection:** - Recommendation: Rockdump - assumed as part of cable protection - Est. amount required: 5,000 Te(<0.5% of route) **Slope angles:** - Challenges: individual pockmarks and slopes on the flanks of the norwegian trench and fjords **Offshore conditions (wind/wave/tidal):** - danger zones identified: Yes; near the Peterhead coast and within Sandford Bay (power station outfall)			
Corridor Route Option 5	Peterhead North	GREEN	YELLOW	GREEN	GREEN	GREEN		GREEN

	North Sea 1 Sima	As for Corridor Route Opti+D28on 1. Sima proposed protected area, Nearby unexploded ordnance area.	As for Corridor Route Option 1; Norway - permitting in relation to marine protected areas not currently known. Slightly more stakeholder involvement required compared to Samnanger option.	**Est. cost materials:** £ 376.8M **Est. cost installation:** £ 857.5M **Est. cost cable/pipeline crossings:** £ 88.2M ***Est. cost cable protection:*** *£ 4.5M (included in installation cost above)* ***Estimated cost scour protection:*** *£ - (included in cable protection above)* **TOTAL: £1,322.4M**	**Estimated cable length:** - 649.6 km **Geotechnical/physical Assessment:** Predominant soil conditions: - Bedrock; very dense SAND; very soft CLAY; firm to very stiff CLAY and medium to dense SAND; gravelly stiff to hard CLAY; very soft CLAY; bedrock at Fjord entrance; very soft CLAY in fjords. - Sandwave features near Peterhead; pockmarks in Witch Ground Basin and Norwegian Trench; iceberg scars and glacial till outcrops on flanks of Norwegian trench; bedrock outcrops near Fjord entrance; boulder and cobble beds; steep slopes in Fjords **Suitability Trenching:** - Jet trenching: 44% of route (approx. 285km) **Suitability Ploughing:** - Ploughing: 49% of route (approx. 320km) **Level of Rock Dump required (untrenchable):** - approx. 7% of route (approx. 45km)	**Cable Length:** 650 km **Number of cable/pipeline crossings:** 49 **Est. execution schedule (per individual cable):** 91 days cable lay; 4 days of jointing; 109 days trenching; 49 days of rockdumping; **Number of seasons:** 3 seasons (1 season per cable)		**Take option forward:** Yes **Areas of further investigation:** Suitable if Sima is the chosen landfall base Clarify future O&G development in Norwegian waters. Consultation(s) to claify Peterhead options. Investigate potential impact unexploded ordnance and potential protected area on SIma corridor option as part of Norwegian EIA. Fine-tune cost modelling, assessment technical suitability and execution schedule.
				O&M costs: Considered similar for all options within this option category. **Availability:** Considered similar for all options within this option category.	**Number of grouped cable/pipeline crossings:** - 49 (Nth Sea: 21 / Fjord: 28) **Estimated number of subsea cable joints:** - 4 **Cable protection:** - Recommendation: Rockdump *- Estimated: 173,000Te (7% of route)* - Planned amount: 250,000 Te (10% of route) - Xings: 200,000Te **Scour protection:** - Recommendation: Rockdump - assumed as part of cable protection - Est. amount required: 5,000 Te(<0.5% of route) **Slope angles:** - Challenges: individual pockmarks and slopes on the flanks of the norwegian trench and fjords **Offshore conditions (wind/wave/tidal):** - danger zones identified: Yes; near the Peterhead coast and within Sandford Bay (power station outfall)			
Corridor Route Option 6	Peterhead North North Sea 2 Sima	GREEN	YELLOW	GREEN	GREEN	GREEN		GREEN
		As for Corridor Route Option 5.	As for Corridor Route Option 1; Norway - permitting in relation to marine protected areas not currently known. Slightly more stakeholder involvement required compared to Samnanger option.	**Est. cost materials:** £ 378.5M **Est. cost installation:** £ 861.4M **Est. cost cable/pipeline crossings:** £ 90.0M ***Est. cost cable protection:*** *£ 4.5M (included in installation cost above)* ***Estimated cost scour protection:*** *£ - (included in cable protection above)* **TOTAL: £1,329.9M**	**Estimated cable length:** - 652.6 km **Geotechnical/physical Assessment:** Predominant soil conditions: - Bedrock; very dense SAND; very soft CLAY; firm to very stiff CLAY and medium to dense SAND; gravelly stiff to hard CLAY; very soft CLAY; bedrock at Fjord entrance; very soft CLAY in fjords. - Sandwave features near Peterhead; pockmarks in Witch Ground Basin and Norwegian Trench; iceberg scars and glacial till outcrops on flanks of Norwegian trench; bedrock outcrops near Fjord entrance; boulder and cobble beds; steep slopes in Fjords **Suitability Trenching:** - Jet trenching: 44% of route (approx. 285km) **Suitability Ploughing:** - Ploughing: 49% of route (approx. 320km) **Level of Rock Dump required (untrenchable):** - approx. 7% of route (approx. 43km)	**Cable Length:** 653 km **Number of cable/pipeline crossings:** 50 **Est. execution schedule (per individual cable):** 91 days cable lay; 4 days of jointing; 109 days trenching; 50 days of rockdumping; **Number of seasons:** 3 seasons (1 season per cable)		**Take option forward:** Yes **Areas of further investigation:** Suitable if Sima is the chosen landfall base Consultation(s) to claify Peterhead options. Investigate potential impact unexploded ordnance and potential protected area on SIma corridor option as part of Norwegian EIA. Fine-tune cost modelling, assessment technical suitability and execution schedule.

				O&M costs: Considered similar for all options within this option category. **Availability:** Considered similar for all options within this option category.	**Number of grouped cable/pipeline crossings:** - 50 (Nth Sea: 22 / Fjord: 28) **Estimated number of subsea cable joints:** - 4 **Cable protection:** - Recommendation: Rockdump *- Estimated: 173,000Te (7% of route)* - Planned amount: 250,000 Te (10% of route) - Xings: 205,000Te **Scour protection:** - Recommendation: Rockdump - assumed as part of cable protection - Est. amount required: 5,000 Te(<0.5% of route) **Slope angles:** - Challenges: individual pockmarks and slopes on the flanks of the norwegian trench and fjords **Offshore conditions (wind/wave/tidal):** - danger zones identified: Yes; near the Peterhead coast and within Sandford Bay (power station outfall)			
Corridor Route Option 7	Peterhead North North Sea 3 Sima	GREEN	YELLOW	YELLOW	RED	YELLOW		YELLOW
		As for Corridor Route Option 5. Nearby unexploded ordnance area.	As for Corridor Route Option 1; Norway - permitting in relation to marine protected areas not currently known. Slightly more stakeholder involvement required compared to Samnanger option.	**Est. cost materials:** £ 377.6M **Est. cost installation:** £ 859.4M **Est. cost cable/pipeline crossings:** £ 102.6M ***Est. cost cable protection:*** *£ 6.75M (included in installation cost above)* ***Estimated cost scour protection:*** *£ - (included in cable protection above)* **TOTAL: £1,339.6M**	**Estimated cable length:** - 651.0 km **Geotechnical/physical Assessment:** Predominant soil conditions: - Bedrock; very dense SAND; very soft CLAY; firm to very stiff CLAY and medium to dense SAND; gravelly stiff to hard CLAY; very soft CLAY; bedrock at Fjord entrance; very soft CLAY in fjords. - Sandwave features near Peterhead; pockmarks in Witch Ground Basin and Norwegian Trench; iceberg scars and glacial till outcrops on flanks of Norwegian trench; bedrock outcrops near Fjord entrance; boulder and cobble beds; steep slopes in Fjords **Suitability Trenching:** - Jet trenching: 44% of route (approx. 285km) **Suitability Ploughing:** - Ploughing: 49% of route (approx. 320km) **Level of Rock Dump required (untrenchable):** - approx. 7% of route (approx. 46km)	**Cable Length:** 651 km **Number of cable/pipeline crossings:**57 **Est. execution schedule (per individual cable):** 91 days cable lay; 4 days of jointing; 109 days trenching; 57 days of rockdumping; **Number of seasons:** 3 seasons (1 season per cable)		**Take option forward:** Yes **Areas of further investigation:** Highest number of crossings out of all 16 options Consultation(s) to claify Peterhead options. Investigate potential impact unexploded ordnance and potential protected area on SIma corridor option as part of Norwegian EIA. Fine-tune cost modelling, assessment technical suitability and execution schedule.
				O&M costs: Considered similar for all options within this option category. **Availability:** Considered similar for all options within this option category.	**Number of grouped cable/pipeline crossings:** - 57 (Nth Sea: 29 / Fjord: 28) **Estimated number of subsea cable joints:** - 4 **Cable protection:** - Recommendation: Rockdump *- Estimated: 173,000Te (7% of route)* - Planned amount: 250,000 Te (10% of route) - Xings: 235,000Te **Scour protection:** - Recommendation: Rockdump - assumed as part of cable protection - Est. amount required: 5,000 Te(<0.5% of route) **Slope angles:** - Challenges: individual pockmarks and slopes on the flanks of the norwegian trench and fjords **Offshore conditions (wind/wave/tidal):** - danger zones identified: Yes; near the Peterhead coast and within Sandford Bay (power station outfall)			
Corridor Route Option 8	Peterhead North	GREEN	YELLOW	RED	YELLOW	RED		RED

	North Sea 4 Sima	As for Corridor+D31 Route Option 1 except: UK side - PSSA. Norway side - proposed marine protected area; UXO area; no military firing area. +D40	As for Corridor Route Option 1; Norway - permitting in relation to marine protected areas not E46currently known. Slightly more stakeholder involvement required compared to Samnanger option.	**Est. cost materials:** £ 383.9M **Est. cost installation:** £ 873.6M **Est. cost cable/pipeline crossings:** £ 95.4M ***Est. cost cable protection:*** *£ 7.07M (included in installation cost above)* ***Estimated cost scour protection:*** *£ - (included in cable protection above)* **TOTAL: £1,352.9M**	**Estimated cable length:** - 661.8 km **Geotechnical/physical Assessment:** Predominant soil conditions: - Bedrock; very dense SAND; very soft CLAY; firm to very stiff CLAY and medium to dense SAND; gravelly stiff to hard CLAY; very soft CLAY; bedrock at Fjord entrance; very soft CLAY in fjords. - Sandwave features near Peterhead; pockmarks in Witch Ground Basin and Norwegian Trench; iceberg scars and glacial till outcrops on flanks of Norwegian trench; bedrock outcrops near Fjord entrance; boulder and cobble beds; steep slopes in Fjords **Suitability Trenching:** - Jet trenching: 44% of route (approx. 290km) **Suitability Ploughing:** - Ploughing: 49% of route (approx. 325km) **Level of Rock Dump required (untrenchable):** - approx. 7% of route (approx. 47km)	**Cable Length:** 662 km **Number of cable/pipeline crossings:**53 **Est. execution schedule (per individual cable):** 92 days cable lay; 4 days of jointing; 111 days trenching; 53 days of rockdumping; **Number of seasons:** 3 seasons (1 season per cable)		**Take option forward:** No **Areas of further investigation:** Most expensive option and longest execution schedule for all 16 routes
				O&M costs: Considered similar for all options within this option category. **Availability:** Considered similar for all options within this option category.	**Number of grouped cable/pipeline crossings:** - 53 (Nth Sea: 25 / Fjord: 28) **Estimated number of subsea cable joints:** - 4 **Cable protection:** - Recommendation: Rockdump *- Estimated: 180,000Te (7% of route)* - Planned amount: 250,000 Te (10% of route) - Xings: 220,000Te **Scour protection:** - Recommendation: Rockdump - assumed as part of cable protection - Est. amount required: 5,000 Te(<0.5% of route) **Slope angles:** - Challenges: individual pockmarks and slopes on the flanks of the norwegian trench and fjords **Offshore conditions (wind/wave/tidal):** - danger zones identified: Yes; near the Peterhead coast and within Sandford Bay (power station outfall)			
Corridor Route Option 9	Peterhead South North Sea 1 Samnanger	YELLOW	GREEN	GREEN	GREEN	GREEN		GREEN
		As for Corridor Route Option 1 except: UK side - corridor does not cross pipelines in Peterhead Bay. Corridor passes closer to seal haul-out sites. More of the route within the SPA near Peterhead.	As for Corridor Route Option 1	**Est. cost materials:** £ 325.3M **Est. cost installation:** £ 740.3M **Est. cost cable/pipeline crossings:** £ 75.6M ***Est. cost cable protection:*** *£ 4.0M (included in installation cost above)* ***Estimated cost scour protection:*** *£ - (included in cable protection above)* **TOTAL: £1,141.2M**	**Estimated cable length:** - 560.8 km **Geotechnical/physical Assessment:** Predominant soil conditions: - Bedrock; very dense SAND; very soft CLAY; firm to very stiff CLAY and medium to dense SAND; gravelly stiff to hard CLAY; very soft CLAY; bedrock at Fjord entrance; very soft CLAY in fjords. - Sandwave features near Peterhead; pockmarks in Witch Ground Basin and Norwegian Trench; iceberg scars and glacial till outcrops on flanks of Norwegian trench; bedrock outcrops near Fjord entrance; boulder and cobble beds **Suitability Trenching:** - Jet trenching: 45% of route (approx. 250km) **Suitability Ploughing:** - Ploughing: 52% of route (approx. 290km) **Level of Rock Dump required (untrenchable):** - approx. 3% of route (approx. 21km)	**Cable Length:** 561 km **Number of cable/pipeline crossings:**42 **Est. execution schedule (per individual cable):** 78 days cable lay; 3 days of jointing; 94 days trenching; 42 days of rockdumping; **Number of seasons:** 3 seasons (1 season per cable)		**Take option forward:** Yes **Areas of further investigation:** Only becomes best option if Peterhead sewearge pipelines cannot be crossed Clarify future O&G development in Norwegian waters. Consultation(s) to claify Peterhead options. Consultation to assess impact firing practice area on feasibility Samnanger 1. Consultation to assess impact firing practice area on feasibility Samnanger 1. Consider Smanganger 2 option. Fine-tune cost modelling, assessment technical suitability and execution schedule.

				O&M costs: Considered similar for all options within this option category. **Availability:** Considered similar for all options within this option category.	**Number of grouped cable/pipeline crossings:** - 42 (Nth Sea: 20 / Fjord: 22) **Estimated number of subsea cable joints:** - 3 **Cable protection:** - Recommendation: Rockdump *- Estimated: 77,000Te (3% of route)* - Planned amount: 215,000 Te (10% of route) - Xings: 172,000Te **Scour protection:** - Recommendation: Rockdump - assumed as part of cable protection - Est. amount required: 5,000 Te(<0.5% of route) **Slope angles:** - Challenges: individual pockmarks and slopes on the flanks of the norwegian trench and fjords **Offshore conditions (wind/wave/tidal):** - danger zones identified: Yes; near the Peterhead coast and within Sandford Bay (power station outfall)			
Corridor Route Option 10	Peterhead South North Sea 2 Samnanger	YELLOW	GREEN	GREEN	GREEN	GREEN		GREEN
		As for Corridor Route Option 1 except: UK side - corridor does not cross pipelines in Peterhead Bay. Corridor passes closer to seal haul-out sites. More of the route within the SPA near Peterhead.	As for Corridor Route Option 1	**Est. cost materials:** £ 324.6M **Est. cost installation:** £ 738.7M **Est. cost cable/pipeline crossings:** £ 77.4M ***Est. cost cable protection:*** *£ 4.0M (included in installation cost above)* ***Estimated cost scour protection:*** *£ - (included in cable protection above)* **TOTAL: £1,140.7M**	**Estimated cable length:** - 559.6 km **Geotechnical/physical Assessment:** Predominant soil conditions: - Bedrock; very dense SAND; very soft CLAY; firm to very stiff CLAY and medium to dense SAND; gravelly stiff to hard CLAY; very soft CLAY; bedrock at Fjord entrance; very soft CLAY in fjords. - Sandwave features near Peterhead; pockmarks in Witch Ground Basin and Norwegian Trench; iceberg scars and glacial till outcrops on flanks of Norwegian trench; bedrock outcrops near Fjord entrance; boulder and cobble beds **Suitability Trenching:** - Jet trenching: 45% of route (approx. 250km) **Suitability Ploughing:** - Ploughing: 52% of route (approx. 290km) **Level of Rock Dump required (untrenchable):** - approx. 3% of route (approx. 20km)	**Cable Length:** 560 km **Number of cable/pipeline crossings:** 43 **Est. execution schedule (per individual cable):** 78 days cable lay; 3 days of jointing; 94 days trenching; 43 days of rockdumping; **Number of seasons:** 3 seasons (1 season per cable)		**Take option forward:** Yes **Areas of further investigation:** Lowest cost option and becomes a more favourable if future Norwegian oil/gas field developments hinder cable route J, and if Peterhead landfall has to avoid sewerage pipelines. Consultation(s) to claify Peterhead options. Consultation to assess impact firing practice area on feasibility Samnanger 1. Consider Smanganger 2 option. Fine-tune cost modelling, assessment technical suitability and execution schedule.
				O&M costs: Considered similar for all options within this option category. **Availability:** Considered similar for all options within this option category.	**Number of grouped cable/pipeline crossings:** - 43 (Nth Sea: 21 / Fjord: 22) **Estimated number of subsea cable joints:** - 3 **Cable protection:** - Recommendation: Rockdump *- Estimated: 77,000Te (3% of route)* - Planned amount: 215,000 Te (10% of route) - Xings: 176,000Te **Scour protection:** - Recommendation: Rockdump - assumed as part of cable protection - Est. amount required: 5,000 Te(<0.5% of route) **Slope angles:** - Challenges: individual pockmarks and slopes on the flanks of the norwegian trench and fjords **Offshore conditions (wind/wave/tidal):** - danger zones identified: Yes; near the Peterhead coast and within Sandford Bay (power station outfall)			
Corridor Route Option 11	Peterhead South	YELLOW	GREEN	YELLOW	RED	YELLOW		YELLOW

	North Sea 3 Samnanger	As for Corridor Route Option 1 except: UK side - corridor does not cross pipelines in Peterhead Bay. Corridor passes closer to seal haul-out sites. Nearby unexploded ordnance area (ex-minefield).	As for Corridor Route Option 1	**Est. cost materials:** £ 324.6M **Est. cost installation:** £ 738.7M **Est. cost cable/pipeline crossings:** £ 77.4M ***Est. cost cable protection:*** *£ 4.0M (included in installation cost above)* ***Estimated cost scour protection:*** *£ - (included in cable protection above)* **TOTAL: £1,147.7M**	**Estimated cable length:** - 557.6 km **Geotechnical/physical Assessment:** Predominant soil conditions: - Bedrock; very dense SAND; very soft CLAY; firm to very stiff CLAY and medium to dense SAND; gravelly stiff to hard CLAY; very soft CLAY; bedrock at Fjord entrance; very soft CLAY in fjords. - Sandwave features near Peterhead; pockmarks in Witch Ground Basin and Norwegian Trench; iceberg scars and glacial till outcrops on flanks of Norwegian trench; bedrock outcrops near Fjord entrance; boulder and cobble beds **Suitability Trenching:** - Jet trenching: 45% of route (approx. 250km) **Suitability Ploughing:** - Ploughing: 52% of route (approx. 290km) **Level of Rock Dump required (untrenchable):** - approx. 3% of route (approx. 18km)	**Cable Length:** 558 km **Number of cable/pipeline crossings:** 49 **Est. execution schedule (per individual cable):** 78 days cable lay; 3 days of jointing; 94 days trenching; 49 days of rockdumping; **Number of seasons:** 3 seasons (1 season per cable)		**Take option forward:** Yes **Areas of further investigation:** Only to be considered if soutern route options aren't feasible Consultation(s) to claify Peterhead options. Consultation to assess impact firing practice area on feasibility Samnanger 1. Consider Smanganger 2 option. Fine-tune cost modelling, assessment technical suitability and execution schedule.
				O&M costs: Considered similar for all options within this option category. **Availability:** Considered similar for all options within this option category.	**Number of grouped cable/pipeline crossings:** - 49 (Nth Sea: 27 / Fjord: 22) **Estimated number of subsea cable joints:** - 3 **Cable protection:** - Recommendation: Rockdump *- Estimated: 70,000Te (3% of route)* - Planned amount: 215,000 Te (10% of route) - Xings: 200,000Te **Scour protection:** - Recommendation: Rockdump - assumed as part of cable protection - Est. amount required: 5,000 Te(<0.5% of route) **Slope angles:** - Challenges: individual pockmarks and slopes on the flanks of the norwegian trench and fjords **Offshore conditions (wind/wave/tidal):** - danger zones identified: Yes; near the Peterhead coast and within Sandford Bay (power station outfall)			
Corridor Route Option 12	Peterhead South North Sea 4 Samnanger	YELLOW	GREEN	RED	YELLOW	RED		RED
		As for Corridor Route Option 1 except: UK side - PSSA. Corridor does not cross pipelines in Peterhead Bay. Corridor passes closer to seal haul-out sites. Nearby unexploded ordnance area (ex-minefield).	As for Corridor Route Option 1	**Est. cost materials:** £ 329.7M **Est. cost installation:** £ 750.3M **Est. cost cable/pipeline crossings:** £ 81.0M ***Est. cost cable protection:*** *£ 6.0M (included in installation cost above)* ***Estimated cost scour protection:*** *£ - (included in cable protection above)* **TOTAL: £1,161.0M**	**Estimated cable length:** - 568.4 km **Geotechnical/physical Assessment:** Predominant soil conditions: - Bedrock; very dense SAND; very soft CLAY; firm to very stiff CLAY and medium to dense SAND; gravelly stiff to hard CLAY; very soft CLAY; bedrock at Fjord entrance; very soft CLAY in fjords. - Sandwave features near Peterhead; pockmarks in Witch Ground Basin and Norwegian Trench; iceberg scars and glacial till outcrops on flanks of Norwegian trench; bedrock outcrops near Fjord entrance; boulder and cobble beds **Suitability Trenching:** - Jet trenching: 45% of route (approx. 255km) **Suitability Ploughing:** - Ploughing: 52% of route (approx. 295km) **Level of Rock Dump required (untrenchable):** - approx. 3% of route (approx. 18km)	**Cable Length:** 568.4 km **Number of cable/pipeline crossings:** 45 **Est. execution schedule (per individual cable):** 79 days cable lay; 3 days of jointing; 95 days trenching; 45 days of rockdumping; **Number of seasons:** 3 seasons (1 season per cable)		**Take option forward:** No **Areas of further investigation:** Most expensive option to Samnanger from Peterhead South, and longest route to Samnanger

				O&M costs: Considered similar for all options within this option category. **Availability:** Considered similar for all options within this option category.	**Number of grouped cable/pipeline crossings:** - 45 (Nth Sea: 23 / Fjord: 22) **Estimated number of subsea cable joints:** - 3 **Cable protection:** - Recommendation: Rockdump *- Estimated: 70,000Te (3% of route)* - Planned amount: 218,000 Te (10% of route) - Xings: 185,000Te **Scour protection:** - Recommendation: Rockdump - assumed as part of cable protection - Est. amount required: 5,000 Te(<0.5% of route) **Slope angles:** - Challenges: individual pockmarks and slopes on the flanks of the norwegian trench and fjords **Offshore conditions (wind/wave/tidal):** - danger zones identified: Yes; near the Peterhead coast and within Sandford Bay (power station outfall)			
Corridor Route Option 13	Peterhead South North Sea 1 Sima	YELLOW	YELLOW	GREEN	GREEN	GREEN		GREEN
		As for Corridor Route Option 1 except: UK side - Corridor does not cross pipelines in Peterhead Bay. Corridor passes closer to seal haul-out sites. Norway side - proposed marine protected area; UXO area; no military firing area; Unexploded ordnance area.	As for Corridor Route Option 1; Norway - permitting in relation to marine protected areas not currently known. Slightly more stakeholder involvement required compared to Samnanger option.	**Est. cost materials:** £ 377.1M **Est. cost installation:** £ 858.2M **Est. cost cable/pipeline crossings:** £ 86.4M ***Est. cost cable protection:*** *£ 4.5M (included in installation cost above)* ***Estimated cost scour protection:*** *£ - (included in cable protection above)* **TOTAL: £1,321.6M**	**Estimated cable length:** - 650.1 km **Geotechnical/physical Assessment:** Predominant soil conditions: - Bedrock; very dense SAND; very soft CLAY; firm to very stiff CLAY and medium to dense SAND; gravelly stiff to hard CLAY; very soft CLAY; bedrock at Fjord entrance; very soft CLAY in fjords. - Sandwave features near Peterhead; pockmarks in Witch Ground Basin and Norwegian Trench; iceberg scars and glacial till outcrops on flanks of Norwegian trench; bedrock outcrops near Fjord entrance; boulder and cobble beds **Suitability Trenching:** - Jet trenching: 44% of route (approx. 285km) **Suitability Ploughing:** - Ploughing: 49% of route (approx. 320km) **Level of Rock Dump required (untrenchable):** - approx. 7% of route (approx. 45km)	**Cable Length:** 650 km **Number of cable/pipeline crossings:** 48 **Est. execution schedule (per individual cable):** 91 days cable lay; 4 days of jointing; 109 days trenching; 48 days of rockdumping; **Number of seasons:** 3 seasons (1 season per cable)		**Take option forward:** Yes **Areas of further investigation:** Lowest cost option if Sima is chosen landfall Clarify future O&G development in Norwegian waters. Consultation(s) to claify Peterhead options. Investigate potential impact unexploded ordnance and potential protected area on SIma corridor option as part of Norwegian EIA. Fine-tune cost modelling, assessment technical suitability and execution schedule.
				O&M costs: Considered similar for all options within this option category. **Availability:** Considered similar for all options within this option category.	**Number of grouped cable/pipeline crossings:** - 48 (Nth Sea: 20 / Fjord: 28) **Estimated number of subsea cable joints:** - 4 **Cable protection:** - Recommendation: Rockdump *- Estimated: 175,000Te (7% of route)* - Planned amount: 250,000 Te (10% of route) - Xings: 197,000Te **Scour protection:** - Recommendation: Rockdump - assumed as part of cable protection - Est. amount required: 5,000 Te(<0.5% of route) **Slope angles:** - Challenges: individual pockmarks and slopes on the flanks of the norwegian trench and fjords **Offshore conditions (wind/wave/tidal):** - danger zones identified: Yes; near the Peterhead coast and within Sandford Bay (power station outfall)			
Corridor Route Option 14	Peterhead South	YELLOW	YELLOW	GREEN	GREEN	GREEN		GREEN

	North Sea 2 Sima	As for Corridor Route Option 1 except: UK side - Corridor does not cross pipelines in Peterhead Bay. Corridor passes closer to seal haul-out sites. Norway side - proposed marine protected area; UXO area; no military firing area	As for Corridor Route Option 1; Norway - permitting in relation to marine protected areas not currently known. Slightly more stakeholder involvement required compared to Samnanger option.	**Est. cost materials:** £ 378.8M **Est. cost installation:** £ 862.1M **Est. cost cable/pipeline crossings:** £ 88.2M ***Est. cost cable protection:*** *£ 4.5M (included in installation cost above)* ***Estimated cost scour protection:*** *£ - (included in cable protection above)* **TOTAL: £1,329.1M**	**Estimated cable length:** - 653.1 km **Geotechnical/physical Assessment:** Predominant soil conditions: - Bedrock; very dense SAND; very soft CLAY; firm to very stiff CLAY and medium to dense SAND; gravelly stiff to hard CLAY; very soft CLAY; bedrock at Fjord entrance; very soft CLAY in fjords. - Sandwave features near Peterhead; pockmarks in Witch Ground Basin and Norwegian Trench; iceberg scars and glacial till outcrops on flanks of Norwegian trench; bedrock outcrops near Fjord entrance; boulder and cobble beds **Suitability Trenching:** - Jet trenching: 44% of route (approx. 285km) **Suitability Ploughing:** - Ploughing: 49% of route (approx. 320km) **Level of Rock Dump required (untrenchable):** - approx. 7% of route (approx. 48km)	**Cable Length:** 653 km **Number of cable/pipeline crossings:**49 **Est. execution schedule (per individual cable):** 91 days cable lay; 4 days of jointing; 109 days trenching; 49 days of rockdumping; **Number of seasons:** 3 seasons (1 season per cable)		**Take option forward:** Yes **Areas of further investigation:** Future Norwegian oil/gas field developments may make this option a better consideration Consultation(s) to claify Peterhead options. Investigate potential impact unexploded ordnance and potential protected area on SIma corridor option as part of Norwegian EIA. Fine-tune cost modelling, assessment technical suitability and execution schedule.
				O&M costs: Considered similar for all options within this option category. **Availability:** Considered similar for all options within this option category.	**Number of grouped cable/pipeline crossings:** - 49 (Nth Sea: 21 / Fjord: 28) **Estimated number of subsea cable joints:** - 4 **Cable protection:** - Recommendation: Rockdump *- Estimated: 185,000Te (7% of route)* - Planned amount: 250,000 Te (10% of route) - Xings: 200,000Te **Scour protection:** - Recommendation: Rockdump - assumed as part of cable protection - Est. amount required: 5,000 Te(<0.5% of route) **Slope angles:** - Challenges: individual pockmarks and slopes on the flanks of the norwegian trench and fjords **Offshore conditions (wind/wave/tidal):** - danger zones identified: Yes; near the Peterhead coast and within Sandford Bay (power station outfall)			
Corridor Route Option 15	Peterhead South North Sea 3 Sima	YELLOW	YELLOW	YELLOW	RED	YELLOW		YELLOW
		As for Corridor Route Option 1 except: UK side - Corridor does not cross pipelines in Peterhead Bay. Corridor passes closer to seal haul-out sites. Nearby unexploded ordnance (ex-minefield). Norway side - proposed marine protected area; UXO area; no military firing area	As for Corridor Route Option 1; Norway - permitting in relation to marine protected areas not currently known. Slightly more stakeholder involvement required compared to Samnanger option.	**Est. cost materials:** £ 377.9M **Est. cost installation:** £ 860.1M **Est. cost cable/pipeline crossings:** £ 99.0M ***Est. cost cable protection:*** *£ 6.75M (included in installation cost above)* ***Estimated cost scour protection:*** *£ - (included in cable protection above)* **TOTAL: £1,337.0M**	**Estimated cable length:** - 651.6km **Geotechnical/physical Assessment:** Predominant soil conditions: - Bedrock; very dense SAND; very soft CLAY; firm to very stiff CLAY and medium to dense SAND; gravelly stiff to hard CLAY; very soft CLAY; bedrock at Fjord entrance; very soft CLAY in fjords. - Sandwave features near Peterhead; pockmarks in Witch Ground Basin and Norwegian Trench; iceberg scars and glacial till outcrops on flanks of Norwegian trench; bedrock outcrops near Fjord entrance; boulder and cobble beds **Suitability Trenching:** - Jet trenching: 44% of route (approx. 285km) **Suitability Ploughing:** - Ploughing: 49% of route (approx. 320km) **Level of Rock Dump required (untrenchable):** - approx. 7% of route (approx. 47km)	**Cable Length:** 652 km **Number of cable/pipeline crossings:**55 **Est. execution schedule (per individual cable):** 91 days cable lay; 4 days of jointing; 109 days trenching; 55 days of rockdumping; **Number of seasons:** 3 seasons (1 season per cable)		**Take option forward:** Yes **Areas of further investigation:** Most crossings to Sima Consultation(s) to claify Peterhead options. Investigate potential impact unexploded ordnance and potential protected area on SIma corridor option as part of Norwegian EIA. Fine-tune cost modelling, assessment technical suitability and execution schedule.

				O&M costs: Considered similar for all options within this option category. **Availability:** Considered similar for all options within this option category.	**Number of grouped cable/pipeline crossings:** - 55 (Nth Sea: 27 / Fjord: 28) **Estimated number of subsea cable joints:** - 4 **Cable protection:** - Recommendation: Rockdump *- Estimated: 180,000Te (7% of route)* - Planned amount: 250,000 Te (10% of route) - Xings: 225,000Te **Scour protection:** - Recommendation: Rockdump - assumed as part of cable protection - Est. amount required: 5,000 Te(<0.5% of route) **Slope angles:** - Challenges: individual pockmarks and slopes on the flanks of the norwegian trench and fjords **Offshore conditions (wind/wave/tidal):** - danger zones identified: Yes; near the Peterhead coast and within Sandford Bay (power station outfall)			
Corridor Route Option 16	Peterhead South North Sea 4 Sima	YELLOW As for Corridor Route Option 1 except: UK side - PSSA. Corridor does not cross pipelines in Peterhead Bay. Corridor passes closer to seal haul-out sites. Nearby unexploded ordnance (ex-minefield). Norway side - proposed marine protected area; UXO area; no military firing area.	YELLOW As for Corridor Route Option 1; Norway - permitting in relation to marine protected areas not currently known. Slightly more stakeholder involvement required compared to Samnanger option.	RED **Est. cost materials:** £ 384.2M **Est. cost installation:** £ 874.3M **Est. cost cable/pipeline crossings:** £ 91.8M ***Est. cost cable protection:*** *£ 7.10M (included in installation cost above)* ***Estimated cost scour protection:*** *£ - (included in cable protection above)* **TOTAL: £1,350.3M**	YELLOW **Estimated cable length:** - 662.4km **Geotechnical/physical Assessment:** Predominant soil conditions: - Bedrock; very dense SAND; very soft CLAY; firm to very stiff CLAY and medium to dense SAND; gravelly stiff to hard CLAY; very soft CLAY; bedrock at Fjord entrance; very soft CLAY in fjords. - Sandwave features near Peterhead; pockmarks in Witch Ground Basin and Norwegian Trench; iceberg scars and glacial till outcrops on flanks of Norwegian trench; bedrock outcrops near Fjord entrance; boulder and cobble beds **Suitability Trenching:** - Jet trenching: 44% of route (approx. 290km) **Suitability Ploughing:** - Ploughing: 49% of route (approx. 325km) **Level of Rock Dump required (untrenchable):** - approx. 7% of route (approx. 47km)	RED **Cable Length:** 662 km **Number of cable/pipeline crossings:**51 **Est. execution schedule (per individual cable):** 92 days cable lay; 4 days of jointing; 111 days trenching; 51 days of rockdumping; **Number of seasons:** 3 seasons (1 season per cable)		RED **Take option forward:** No **Areas of further investigation:** Only to be considered if Southern options are not viable
				O&M costs: Considered similar for all options within this option category. **Availability:** Considered similar for all options within this option category.	**Number of grouped cable/pipeline crossings:** - 51 (Nth Sea: 23 / Fjord: 28) **Estimated number of subsea cable joints:** - 4 **Cable protection:** - Recommendation: Rockdump *- Estimated: 180,000Te (7% of route)* - Planned amount: 250,000 Te (10% of route) - Xings: 210,000Te **Scour protection:** - Recommendation: Rockdump - assumed as part of cable protection - Est. amount required: 5,000 Te(<0.5% of route) **Slope angles:** - Challenges: individual pockmarks and slopes on the flanks of the norwegian trench and fjords **Offshore conditions (wind/wave/tidal):** - danger zones identified: Yes; near the Peterhead coast and within Sandford Bay (power station outfall)			

APPENDIX F CABLE TECHNICAL DATA SHEET (36KV)

REDACTED: CONTENT OUT OF DATE

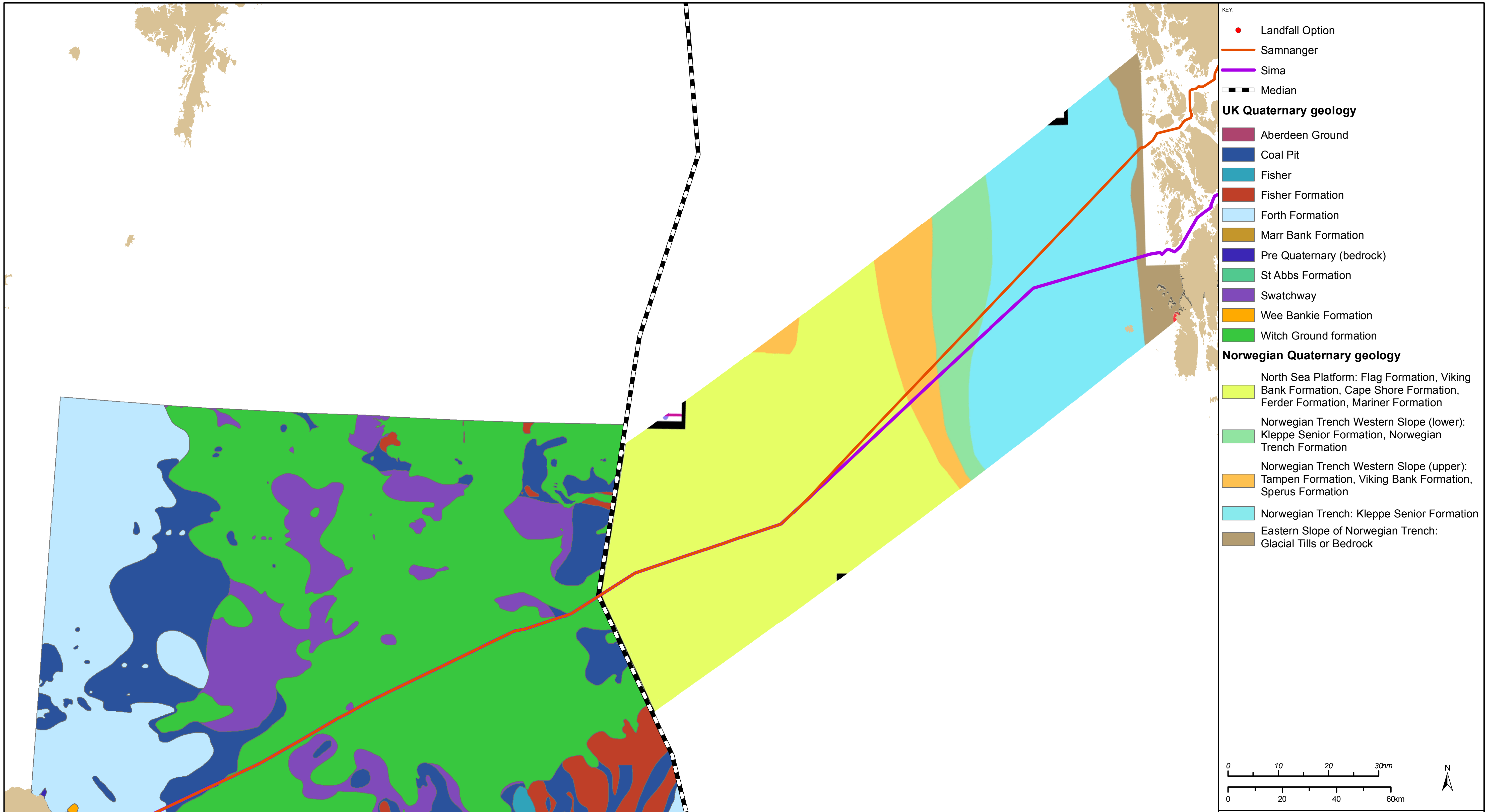
APPENDIX G QUATERNARY GEOLOGY

Corridor Section	Physical Geology	Expected Shallow Soils	Soil Risks	Suitable Burial Solution	Comment
C	UK continental shelf, shallow water, generally < 100m	SAND, locally gravelly, over very soft to stiff CLAY	sand waves or megaripples local areas of gravelly soils seabed or buried cobbles and boulders	Ploughing, Mechanical cutting/jetting	Route running primarily in Holocene sands and locally gravel underlain by the Forth Formation. Local highs of Wee Bankie may be encountered near the coast. Route specific survey required to determine if and where jetting methods could be feasible on sections of the route
D	UK continental shelf, waters generally > 100 m	SAND over very soft to very stiff CLAY interlayered with loose to very dense SAND or over firm CLAY	sand waves or megaripples areas of gravelly soils seabed or buried cobbles and boulders	Ploughing, Mechanical cutting/jetting, Possibly jetting	Route runs close to the edge of the soft clays of the Witch Ground Basin in soils interpreted to belong to the Coal Pit and Swatchway Formations Route specific survey required to determine if and where jetting methods could be feasible on sections of the route
E	UK continental shelf, waters generally > 100 m LAT	SAND overfirm CLAY or over very soft to very stiff CLAY interlayered with loose to very dense SAND	Gravel concentrations, possible seabed or buried boulders, pockmarks, authogenic carbonate, shallow gas, steep local slopes on pockmark slopes	Ploughing, Mechanical cutting/jetting, jetting in soft clay, possible jetting in areas of firm clay	Route runs north through primarily Swatchway Formation before turning east through Witch Ground with local highs of Swatchway Formation.
F	UK continental shelf, waters > 100 m LAT	Primarily very soft to soft CLAY, with or without sand veneer. Local sections of firm CLAY or soft to very stiff CLAY interlayered with loose to very dense SAND	Pockmarks, authogenic carbonate, shallow gas, steep gradients on pockmark slopes, local gravel concentrations, Occasional seabed or buried boulders	Ploughing, Mechanical cutting/jetting, Probably jetting	Corridor is expected to run primarily through Witch Ground soft clays with local areas of firm clay of the Swatchway Formation and at the Norwegian end of the sector Coal Pit Formation. Optimation will be required to select optimum route within corridor where pockmarks are present, or to avoid stiff clay for a jetting option.
G	UK and Norwegian continental shelf, waters > 100 m LAT	In UK sector predominantly very soft to soft CLAY, with or without sand veneer in Norwegian sector becomes sand veneer of variable thickness over firm to hard CLAY	Pockmarks, authogenic carbonate, shallow gas, steep gradients on pockmark slopes, local gravel concentrations, Occasional seabed or buried boulders	Ploughing, Mechanical cutting/jetting, jetting in UK sector	At UK start of section, Coal Pit Formation with a possibility of locally encountering Fisher Formation. Otherwise, remainder of UK sector and start of Norwegian sector expected to lie within Witch GroundBasin. Edge of Witch Ground Basin is crossed in the Norwegian section, likely into Cape Shore, Ferder or Viking Bank Formations
H	UK and Norwegian continental shelf, waters > 100 m LAT	Refer to H Option as outlined below			
I	Western edge of North Sea Plateau, water depths < 160 m	Sand veneer of variable thickness over firm to hard CLAY, possible local basins of very soft to soft CLAY.	Local concentrations of cobble and boulders or boulder fields, areas of hard soils	Ploughing, Mechanical cutting/jetting	Route specific survey and following route optimation likely required to select easiest route to avoid boulder concentrations
J	North Sea Plateau, with water depths < 160 m, Norwegian Trench slope waters > 160 m and base of Norwegian Trench with water depths > 200 m	On North Sea Plateau, sand veneer of variable thickness over firm to hard CLAY,with in areas basins of very soft to soft CLAY. On upper slope of Norwegian Trench, predominantly SAND or gravelly sand expected, local highs or exposures of firm to hard CLAY possible but not expected. Grades downslope to fine SAND, sandy or clayey SILT and soft CLAY. Very soft to soft CLAY, with or without sand veneer at base of Norwegian Trench	Local concentrations of cobble and boulders or boulder fields, areas of hard soils on North Sea Plateau. Local concentrations of cobble and boulders or boulder fields and possible unstable slopes on upper slope. Iceberg scars with possible local steep gradients, boulder and cobble concentrations on lower slope. At bottom of Norwegian Trench, pockmarks, authogenic carbonate, iceberg scars, shallow gas, steep gradients on scar and pockmark slopes	Ploughing, Mechanical cutting/jetting, jetting on Norwegian trench slope and trench	Route specific survey and following route optimation likely required to select easiest route to avoid boulder concentrations on North Sea Plateau
K	North Sea Plateau, with water depths < 160 m Upper Slope Norwegian Trench (western slope) waters > 160 m	On North Sea Plateau, sand veneer of variable thickness over firm to hard CLAY,with in areas basins of very soft to soft CLAY. On upper slope of Norwegian Trench, predominantly SAND or gravelly sand expected, local highs or exposures of firm to hard CLAY possible but not expected.	Local concentrations of cobble and boulders or boulder fields, areas of hard soils, possible unstable slopes on Norwegian Trench Upper Slope	Ploughing, Mechanical cutting/jetting, jetting on Norwegian trench slope	Route specific survey and following route optimation likely required to select easiest route to avoid boulder concentrations on North Sea Plateau
L	Norwegian Trench and western slope waters > 160 m	SAND or gravelly sand expected, local highs or exposures of firm to hard CLAY possible, but not expected. Grading downslope to fine SAND, sandy or clayey SILT and soft CLAY. Very soft to soft CLAY, with or without sand veneer at base of Norwegian Trench	Local concentrations of cobble and boulders or boulder fields and possible unstable slope on upper slope. Iceberg scars with possible local steep gradients, boulder and cobble concentrations on lower slope. At bottom of Norwegian Trench, pockmarks, authogenic carbonate, iceberg scars, shallow gas, steep gradients on scar and pockmark slopes	Ploughing, Jetting	Route optimation likely required to select route with least density of pockmarks and scars

Note: All water depths LAT

Corridor H					
Approximate Distance from Peterhead (km)	Physical Geology	Expected Shallow Soils	Soil Risks	Suitable Burial Solution	Comment
< 40	UK continental shelf, shallow water (generally < 100 m)	SAND, locally gravelly, over very soft to stiff CLAY	sand waves or megaripples local areas of gravelly soils seabed or buried cobbles and boulders	Ploughing, Mechanical cutting/jetting	Route specific survey required to determine if and where jetting methods could be feasible on sections of the route
40-80	UK continental shelf, waters generally > 100 m	SAND over very soft to very stiff CLAY interlayered with loose to very dense SAND or over firm CLAY	sand waves or megaripples areas of gravelly soils seabed or buried cobbles and boulders	Ploughing, Mechanical cutting/jetting, Possibly jetting	Route runs close to the edge of the soft clays of the Witch Ground Basin in interpreted Coal Pit and Swatchway Formation soils Route specific survey required to determine if and where jetting methods could be feasible on sections of the route
80-105	UK continental shelf, waters > 100 m	Very soft to soft CLAY, with or without sand veneer	Pockmarks, authogenic carbonate, shallow gas, steep gradients on pockmark slopes	Ploughing, Jetting	Route optimation likely required to select route where pockmarks are present
105-125	UK continental shelf, waters > 100 m	Thin sand veneer over firm CLAY or over very soft to very stiff CLAY interlayered with loose to very dense SAND	Gravel concentrations, possible seabed or buried boulders	Ploughing or Mechanical cutting/jetting, Possibly jetting	Route runs close to an interpreted boundary between CoaSwatchway/l Pit and Witch Ground Formation soils Route specific survey required to determine if and where jetting methods could be feasible on sections of the route
125-220	UK continental shelf, waters > 100 m	Very soft to soft CLAY, with or without sand veneer	Pockmarks, authogenic carbonate, shallow gas, steep gradients on pockmark slopes	Ploughing, Jetting	Route optimation likely required to select route with least density of pockmarks
220-230	UK continental shelf, waters > 100 m	Thin sand veneer over firm CLAY or over very soft to very stiff CLAY interlayered with loose to very dense SAND	Gravel concentrations, possible seabed or buried boulders	Ploughing, Mechanical cutting/jetting, Possibly jetting	Route runs close to an interpreted boundary between CoaSwatchway/l Pit and Witch Ground Formation soils Route specific survey required to determine if and where jetting methods could be feasible on sections of the route
230-median line	UK continental shelf, waters > 100 m	Very soft to soft CLAY, with or without sand veneer	Pockmarks, authogenic carbonate, shallow gas, steep gradients on pockmark slopes	Ploughing, Jetting	Route optimation likely required to select route if pockmarks are present
Norwegian Sector	North Sea Plateau waters < 160 m	Sand veneer of variable thickness over firm to hard CLAY,with in areas basins of very soft to soft CLAY	Seabed and buried boulders, areas of hard soils	Plough, Mechanical cutting/jetting	Route specific survey and following route optimation likely required to select easiest route

Note: All water depths LAT



TITLE:

Figure x.x
Route and Quaternary Geology

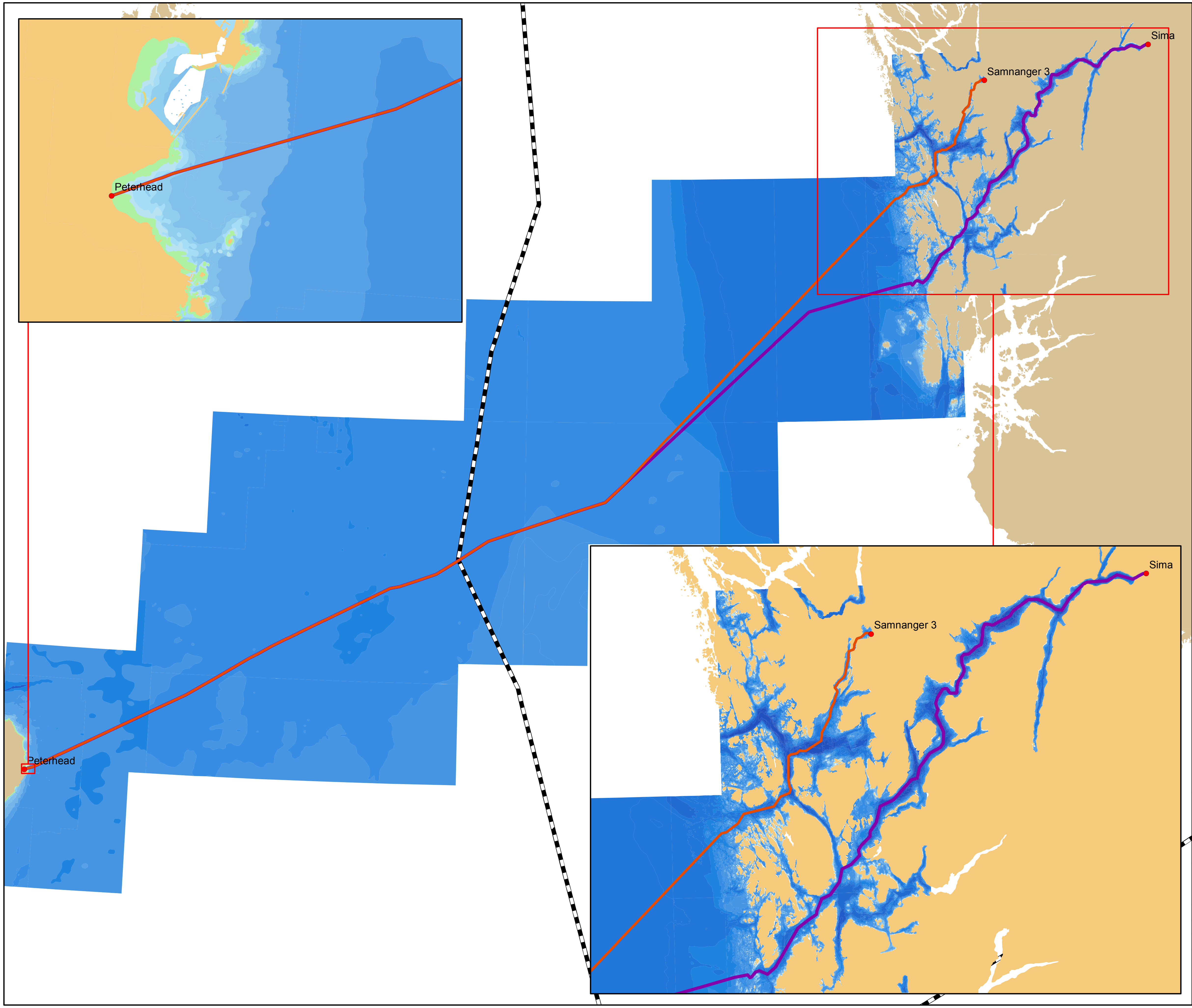
CLIENT: NORTHCONNECT CONNECTING RENEWABLES

DATE: 14/08/2012	SCALE: 1:1,400,000	PROJECT: Unknown
DRAWN: JH	CHECKED: EP	APPROVED: EP
DRAWING: QuaternaryGeology.mxd		REV:

SOURCE: © SeaZone Solutions Limited, 2012, [052012.009]
Geomarine

PROJECTION: WGS 1984 UTM Zone 31N

APPENDIX H BATHYMETRY



KEY:

- Landfall Option
- Samnanger
- Sima
- Median
- Undefined depth
- Intertidal areas
- >0 to 3 meters
- >3 to 7 meters
- >7 to 10 meters
- >10 to 20 meters
- >20 to 30 meters
- >30 to 40 meters
- >40 to 50 meters
- >50 to 100 meters
- >100 to 150 meters
- >150 to 200 meters
- >200 to 300 meters
- >300 to 400 meters
- >400 to 500 meters
- >500 to 1000 meters

0 20 40 nm

0 20 40 60 80 km

N

TITLE:

Figure x.x
Bathymetry

CLIENT: NORTHCONNECT CONNECTING RENEWABLES

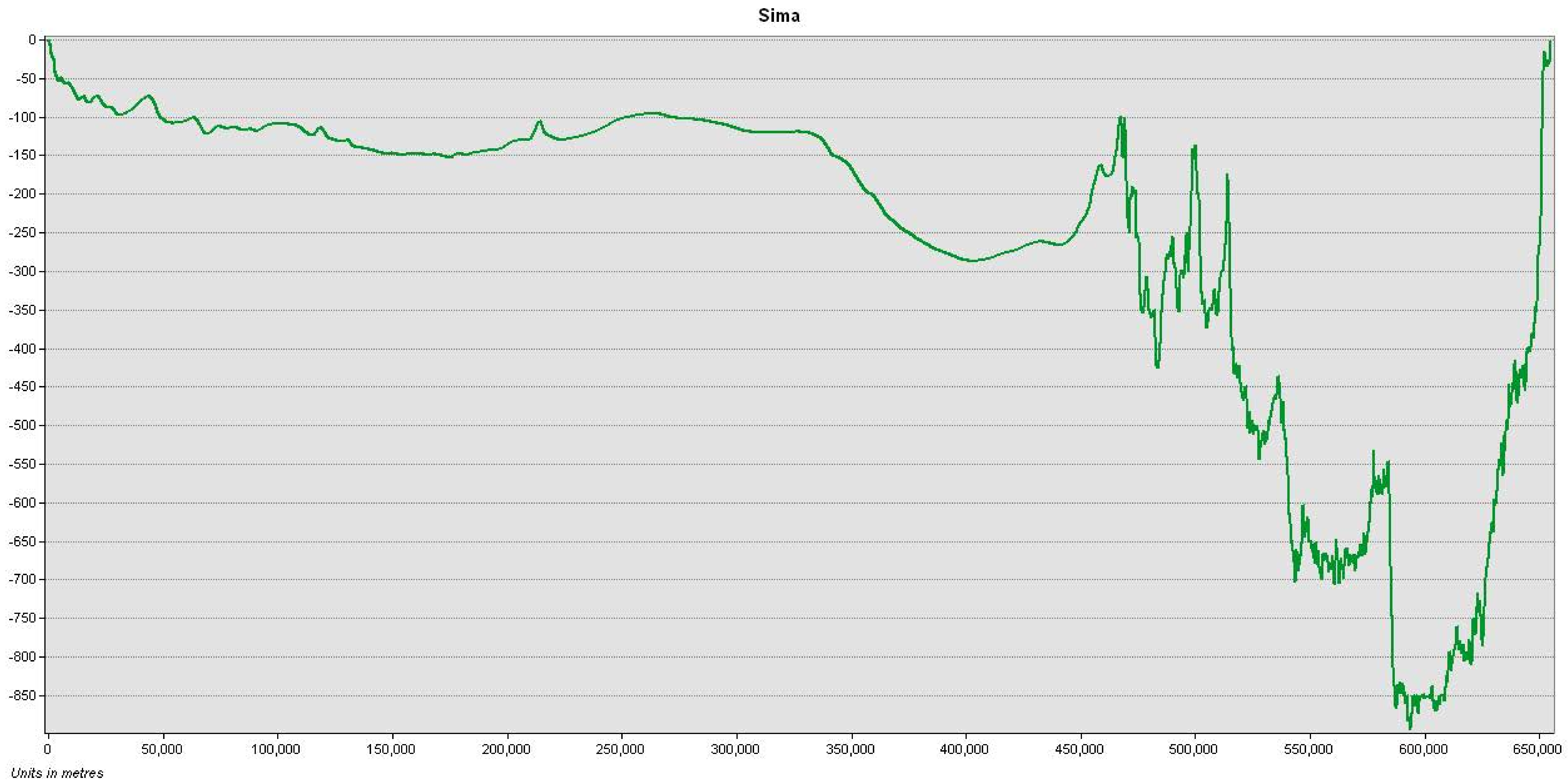
DATE: 14/08/2012	SCALE: 1:1,700,000	PROJECT: Unknown
DRAWN: JH	CHECKED: EP	APPROVED: EP
DRAWING: Bathymetry.mxd		REV:

SOURCE: © SeaZone Solutions Limited, 2012, [052012.009]

PROJECTION: WGS 1984 UTM Zone 31N

xodus GROUP

APPENDIX J DEPTH PROFILE SIMA ROUTE OPTION


Sima
0
-50
-100
-150
-200
-250
-300
-350
-400
-450
-500
-550
-600
-650
-700
-750
-800
-850
0
50,000
100,000
150,000
200,000
250,000
300,000
350,000
400,000
450,000
500,000
550,000
600,000
650,000
Units in metres

APPENDIX K COST ESTIMATES

REDACTED: CONTENT OUT OF DATE

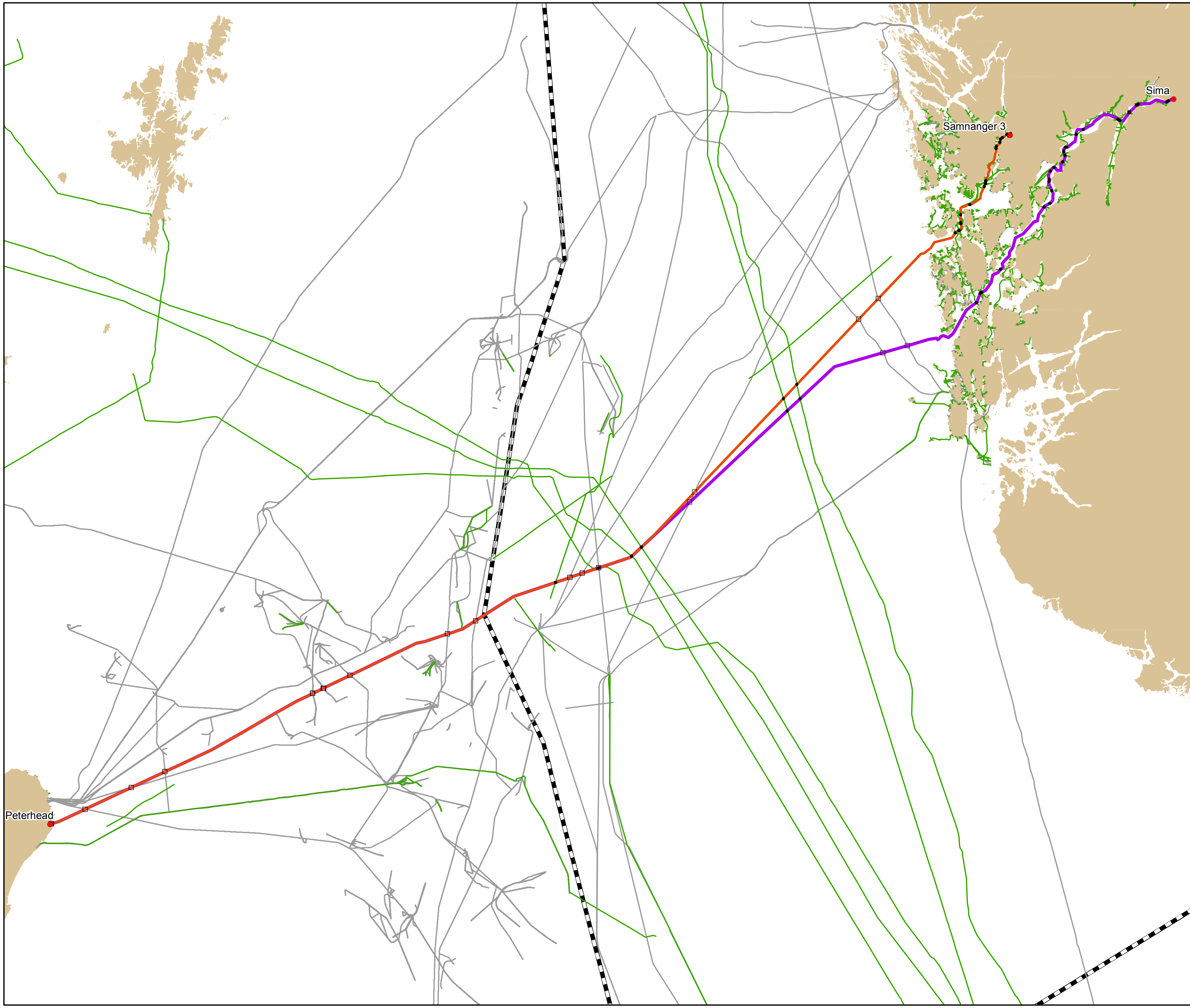
APPENDIX L EXECUTION SCHEDULES

REDACTED: CONTENT OUT OF DATE

APPENDIX M TYPICAL CROSSING ARRANGEMENTS

REDACTED: CONTENT OUT OF DATE

APPENDIX N CABLE AND PIPELINE CROSSINGS



KEY:

- Landfall Option
- Cable Crossing
- Pipeline Crossing
- Samnanger
- Sima
- Cables
- Pipelines
- Median

NOTE: Only data within vicinity of route shown

0 10 20 30 40 nm

0 20 40 60 80 km

N

TITLE:

Figure x.x
Cables and Pipelines
within Study Area

CLIENT:

NORTHCONNECT
CONNECTING RENEWABLES

DATE: 14/08/2012	SCALE: 1:1,700,000	PROJECT: Unknown
DRAWN: JH	CHECKED: EP	APPROVED: EP
DRAWING: CablesPipelines.mxd		REV:

SOURCE: © SeaZone Solutions Limited, 2012, [052012.009]
UK DEAL
Norwegian Petroleum Directorate

PROJECTION: WGS 1984 UTM Zone 31N

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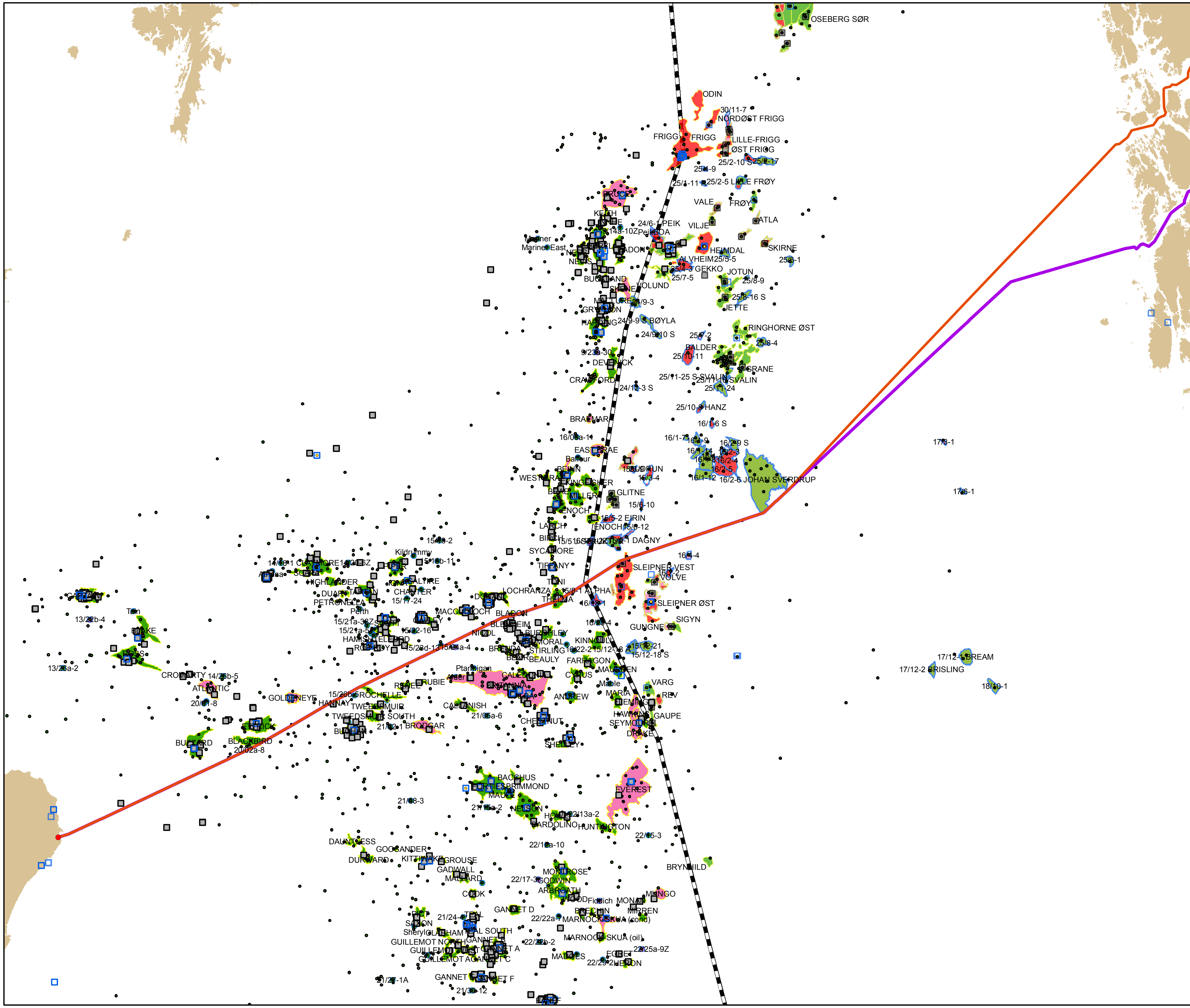
APPENDIX O OIL & GAS INFRASTRUCTURE



KEY:

- Landfall Option
- Samnanger
- Sima

UK Fields
- COND
- OIL

UK Discovery
- COND
- OIL

Facility
- Surface
- Subsurface

Well Type
- Other
- APPRAISAL
- DEVELOPMENT
- EXPLORATION

Norway Fields
- Oil
- Gas
- Oil/gas
- Gas/Condensate

Norway Discoveries
- Oil
- Gas
- Oil/gas
- Gas/Condensate
- Median

TITLE:

Figure x.x
Oil and Gas Infrastructure within Study Area

CLIENT: NORTHCONNECT

DATE: 14/08/2012	SCALE: 1:1,400,000	PROJECT: Unknown
DRAWN: JH	CHECKED: EP	APPROVED: EP
DRAWING: OilGas.mxd		REV:

SOURCE: © SeaZone Solutions Limited, 2012, [052012.009]
UK DEAL
Norwegian Petroleum Directorate

PROJECTION: WGS 1984 UTM Zone 31N

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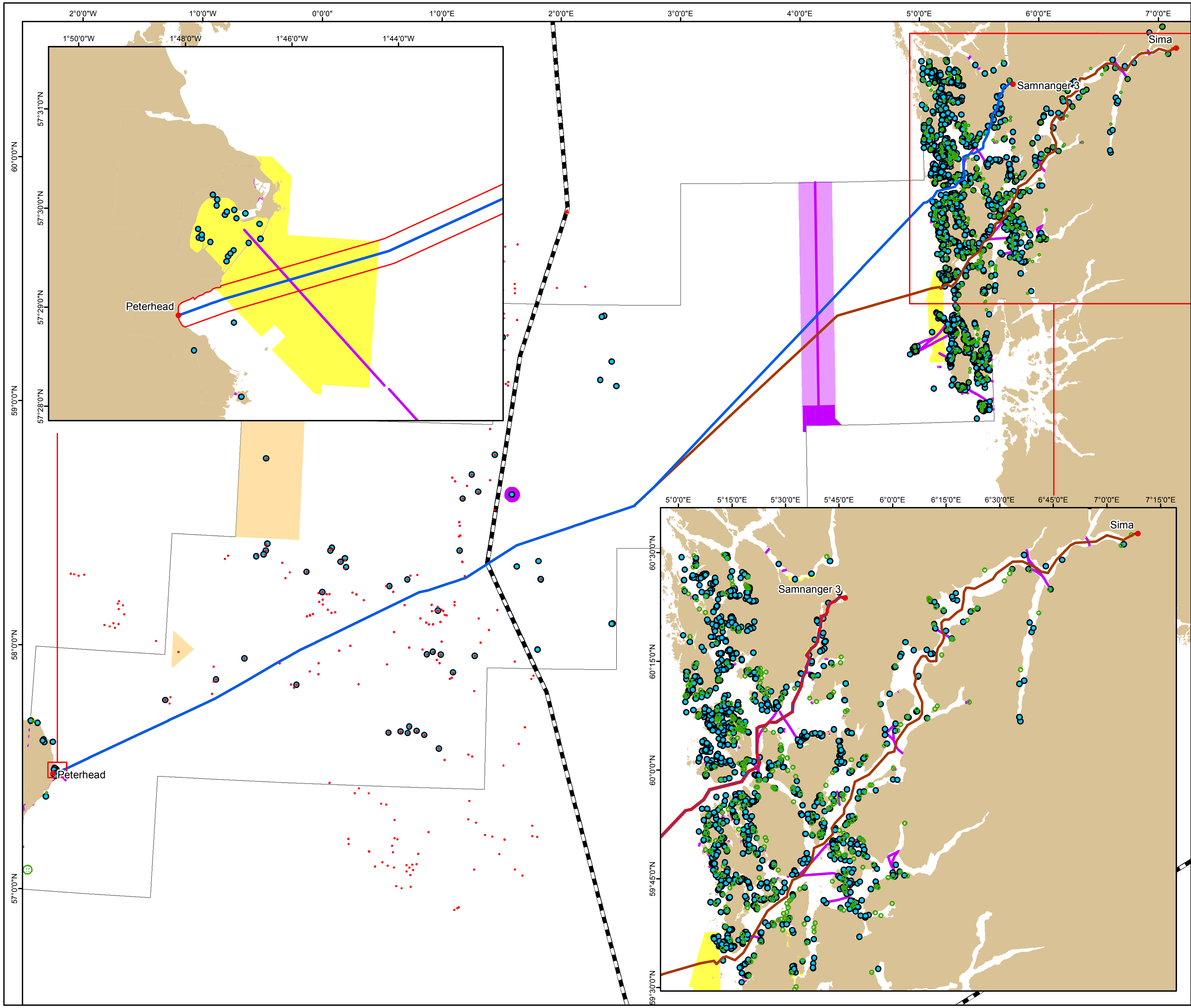
APPENDIX P SHIPPING, NAVIGATION AND ANCHORAGES



TITLE:

Figure x.x
Shipping, Navigation and Anchorages

CLIENT: NORTHCONNECT CONNECTING RENEWABLES

DATE: 14/08/2012	SCALE: 1:1,700,000	PROJECT: Unknown
DRAWN: JH	CHECKED: EP	APPROVED: EP
DRAWING: ShippingNavigationAnchorages.mxd		REV:

SOURCE: © SeaZone Solutions Limited, 2012, [052012.009]

PROJECTION: WGS 1984 UTM Zone 31N

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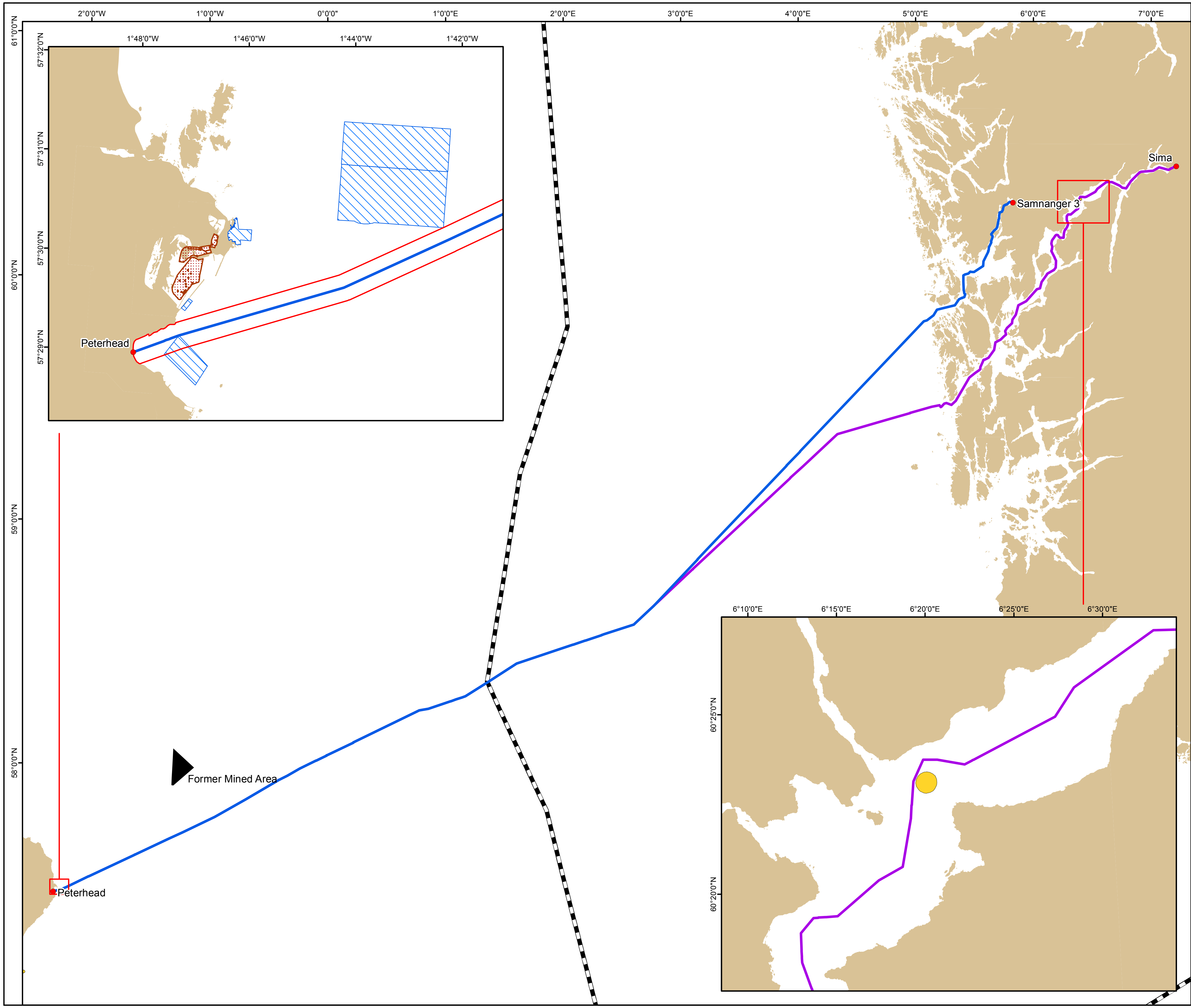
APPENDIX Q DREDGING, DISPOSAL AND MILITARY PRACTICE AREAS



KEY:

- Landfall Option
- Former Mined Area
- Explosives Dumping Ground
- Spoil Ground
- Dredged Areas
- Samnanger
- Sima
- 500m Survey Corridor
- Median

0 10 20 30 40 nm

0 20 40 60 80 km

N

TITLE: Figure x.x
Dredging Areas, Spoil Grounds, Former Mined Area and Explosives Dumping Ground

CLIENT: NORTHCONNECT CONNECTING RENEWABLES

DATE: 14/08/2012	SCALE: 1:1,700,000	PROJECT: A30722
DRAWN: JH	CHECKED: EP	APPROVED: EP
DRAWING: DredgingDisposal.mxd		REV:

PROJECTION: WGS 1984 UTM Zone 31N

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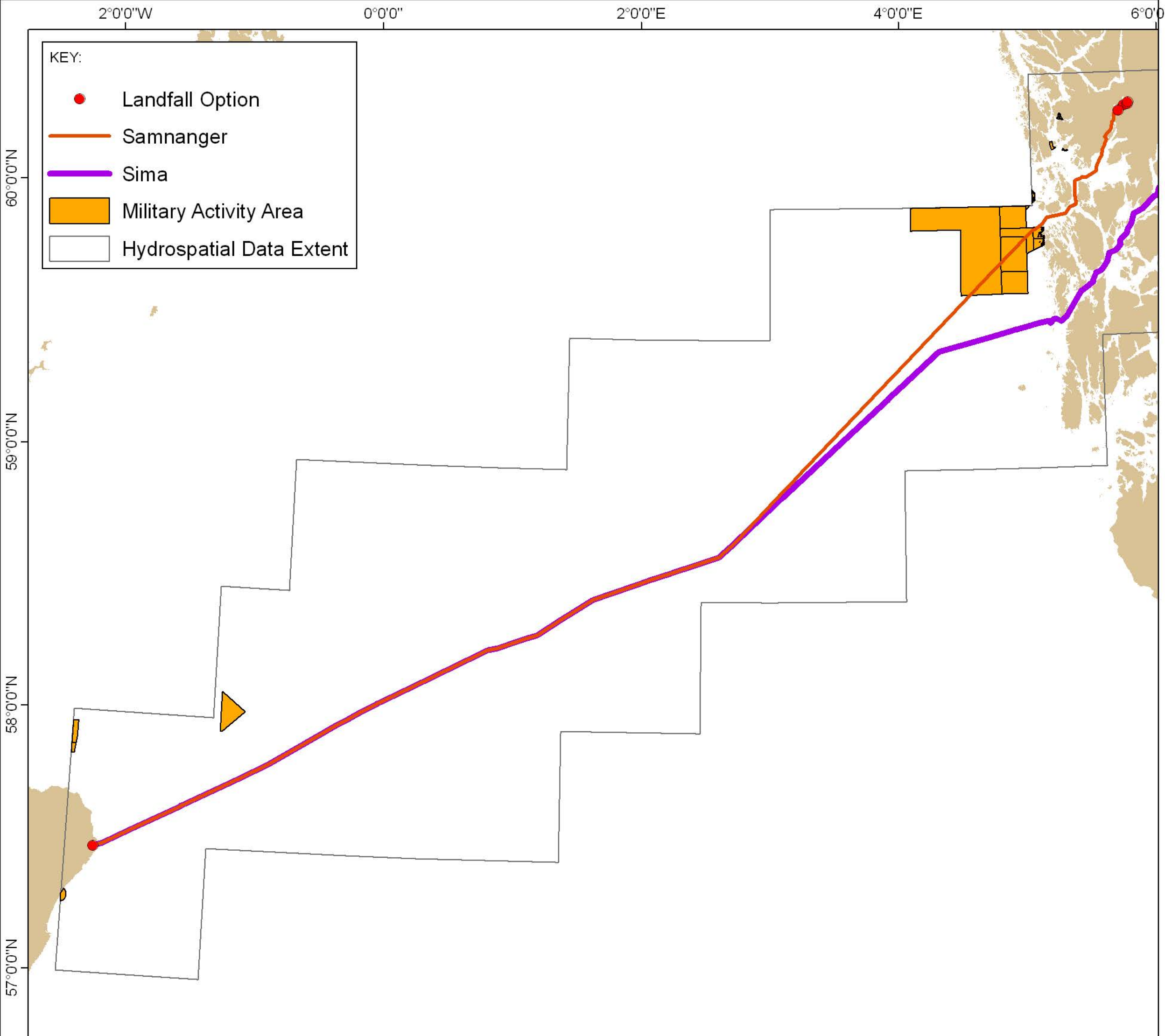


SOURCE: © SeaZone Solutions Limited, 2012, [052012.009]

PROJECTION: WGS 1984 UTM Zone 31N

0 20 nm

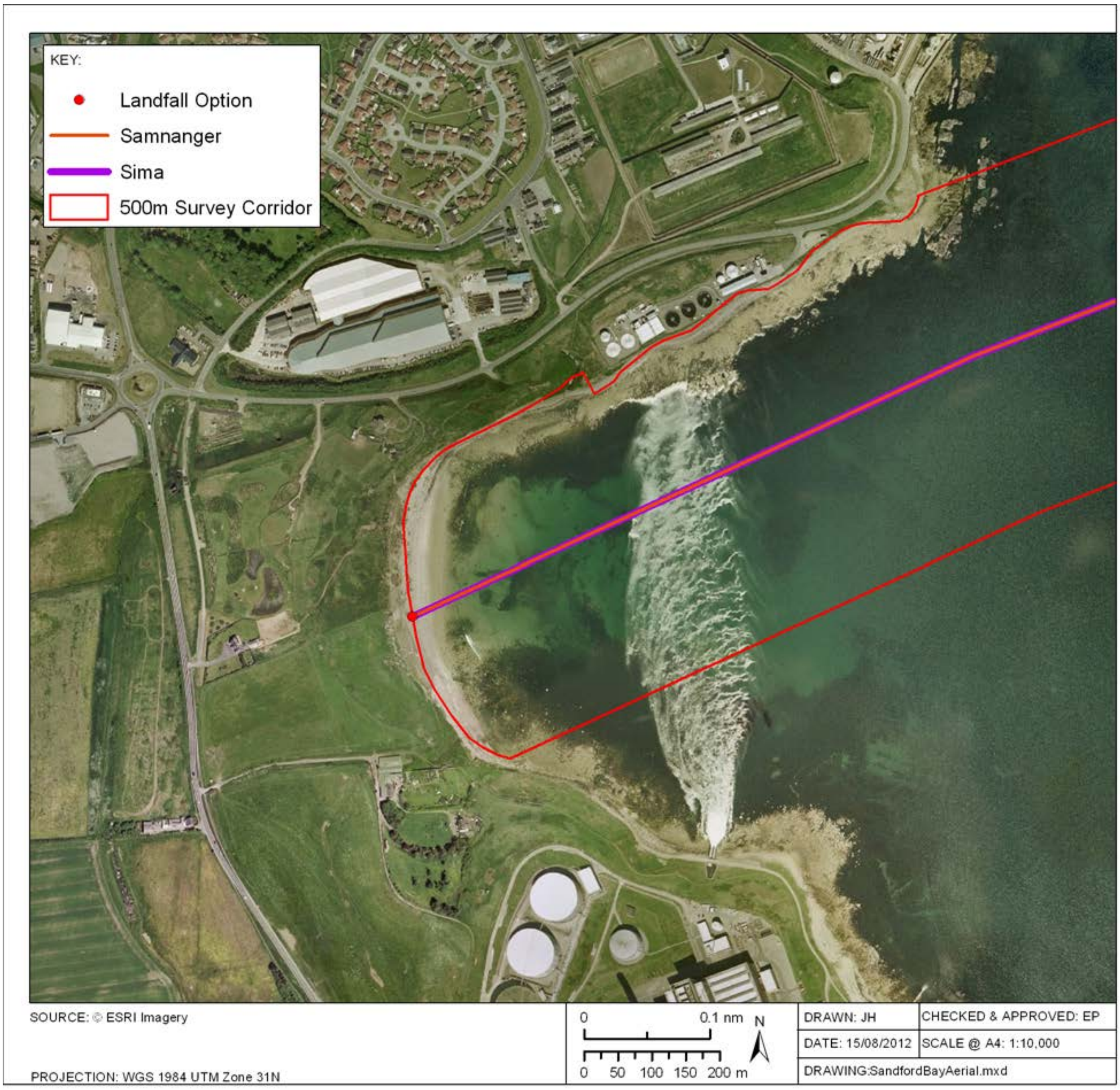
0 10 20 30 40 km

N

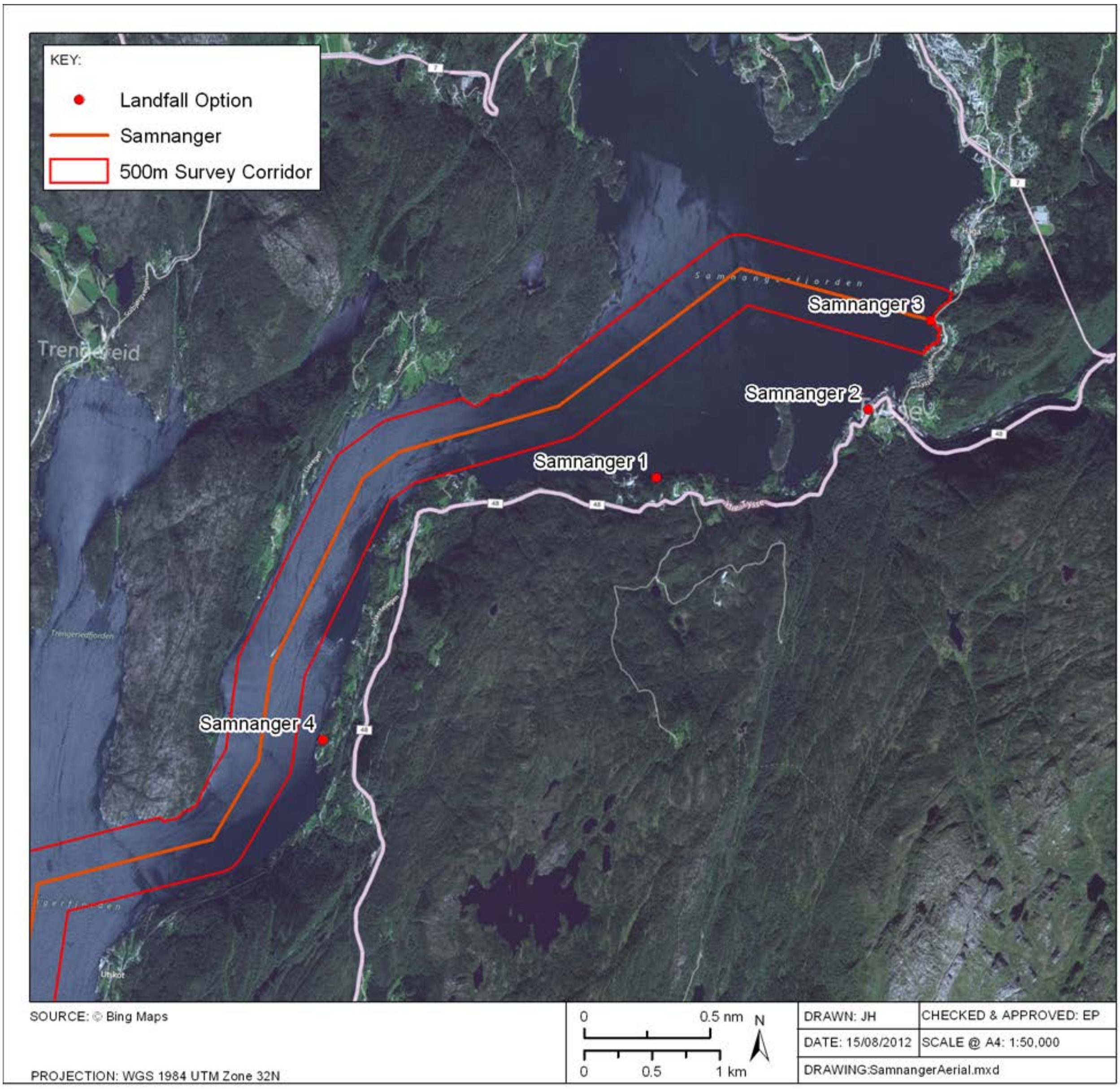
DRAWN: JH	CHECKED & APPROVED: EP
DATE: 14/08/2012	SCALE @ A4: 1:3,000,000
DRAWING:FiringArea.mxd	

APPENDIX R AERIAL VIEWS

Aerial view of Peterhead landfall:



Aerial view of Samnanger landfall:



Aerial view of Sima landfall: