

# SCOPE OF SERVICES

<b>Project</b>		Danish Offshore Wind 2030					
<b>Assignment</b>		Cable Route Survey					
<b>Document Title</b>		Scope of Services					
<b>Document No.</b>		23/00573-5					
<b>Audience</b>		Tenderers					
Version	Document status	Prepared by		Reviewed by		Approved by	
		Name	Date	Name	Date	Name	Date
1	Template	CGL	01-11-2022				
2	For tender	JCO	27-02-2023	NHW	07-03-2023	XPAN	27-03-2023

## TABLE OF CONTENTS

1. Introduction.....	2
2. Scope or Services.....	4
3. Time Schedule .....	5
4. Requirements .....	7
5. Area of investigation – Lot 1 .....	9
6. References.....	23
Annex 1 – Route Position Lists .....	24

Enclosure	No.
Technical Requirements	1
Standards of Deliverables	2
HSE requirements	3
Quality requirements	4

# 1. Introduction

## 1.1 Background and the project

Following a decision in the Danish Parliament 2022 Denmark is on the path to further develop offshore energy and related infrastructure in the Danish North Sea, in the Danish inner seas (*Kattegat*) and Danish Baltic Sea to connect more offshore wind energy.

Figure 1-1 illustrates the geographical location of offshore wind farm sites, for which The Client has been instructed - by the Danish Energy Agency - to commence site investigations. The Client has established the project

- **Danish Offshore Wind 2030**

to denominate development activities related to the following sites (numbers refer to Figure 1-1):

1. Kattegat II
2. Hesselø South
3. Kriegers Flak II North
4. Kriegers Flak II South
5. North Sea I

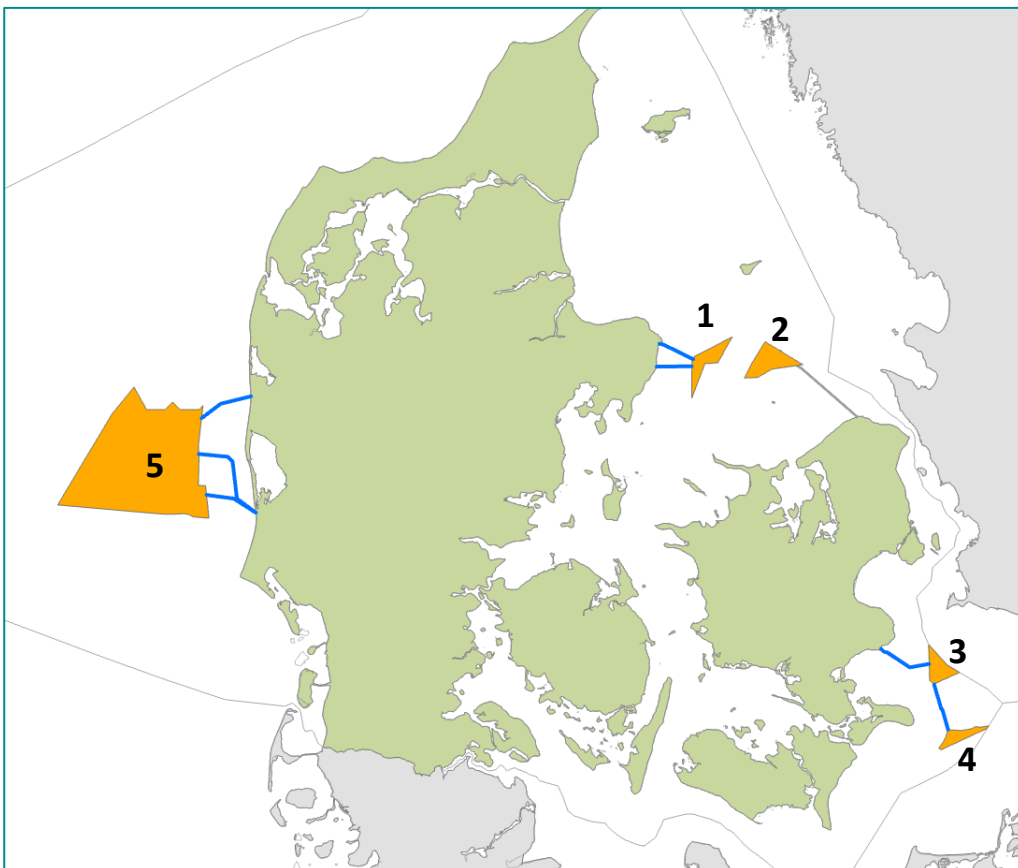


Figure 1-1 Project site locations for in Kattegat, the Baltic Sea and the North Sea: Offshore wind farm areas and export cable routes.

## 1.2 The project

The offshore elements of the project comprise the following main characteristics:

- Two offshore wind farm sites in Kattegat.
- Two offshore wind farm sites in the Southern Baltic Sea.
- One offshore development zone for multiple wind farm projects in the North Sea.
- Offshore platforms for substations.
- Export cables between offshore wind farms and the Danish mainland

The offshore wind farm (OWF) areas are shown in Figure 1-1. It is anticipated that the North Sea development zone at a later stage will be divided into multiple offshore wind farm project sites.

## 1.3 The assignment

The purpose of the present assignment is to provide surveys of the marine cable routes connecting the wind farm sites with land (export cable routes).

The work includes geophysical survey, shallow geotechnical investigations and crossing surveys of existing utilities.

The areas of investigation - subject to the present assignment - are described in chapter 5, are summarized in Table 1-1 and displayed in overview in Figure 1-1.

*Table 1-1. Overview of cable routes subject to the assignment. Indicative and preliminary quantities provided for route length, corridor width and water depth.*

Part	Export Cable route	Lot	Route Length	Corridor Width	Water Depth
1	North Sea I - Export cable route 1	1	23km	1500m	00m – 26m
2	North Sea I - Export cable route 2	1	41km	1500m	00m – 27m
3	North Sea I - Export cable route 3	1	23km	1500m	00m – 22m
4	Kattegat II - Export cable route 1	1	16km	1500m	00m – 20m
5	Kattegat II - Export cable route 2	1	15km	1500m	00m – 22m
6	Kriegers Flak II North – Export cable	1	23km	1500m	00m – 28m
7	Kriegers Flak II South – Export cable	1	20km	1500m	29m – 34m

**Note 1: Cable routes from Hesselø South offshore wind farm:** The cable route between Hesselø South (site no. 2 displayed in Figure 1-1) and land is not part of the present assignment. The cable route has been investigated during surveys in 2020.

**Note 2: Cable routes from Kattegat II offshore wind farm:** Two route alternatives are presently considered (see Part 4 and Part 5 in Table 1-1). If the Client decides for one of the two cable routes during the performance of the scope of services, then activities concerning the other cable route will be removed from the assignment.

## 2. Scope or Services

To support the development of the project the Consultant must provide a seabed survey covering the area of investigation described in chapter 5.

### 2.1 Purpose of assignment

The results of the survey should be able to be used for:

- Verification of the feasibility of the investigated cable routes.
- Initial marine archaeological site assessment.
- Planning of environmental investigation and assessment of environmental conditions.
- Design of subsea cable burial.
- Assessment of conditions for installation and maintenance.
- Site information enclosed the tender for offshore cable and installation.

### 2.2 Scope of assignment

The assignment includes the following work packages:

- WP A – Offshore cable route survey, WD > 10m MSL (\*)
- WP B – Nearshore and landfall survey, WD < 10m MSL (\*)
- WP C – Geotechnical investigations
- WP D – Crossings survey

#### Work Package A – Offshore cable route survey, WD > 10m MSL (\*)

A geophysical survey must be performed with commencement in 2023 and completion as soon as possible. The survey has full coverage in the cable corridor. The survey must map the bathymetry, the static and dynamic elements of the seabed surface and upper soil stratification to ca. 10m below seabed.

#### Work Package B – Nearshore and landfall survey, WD < 10m MSL (\*)

Same scope as Work Package A performed for shallow water and intertidal parts of the cable route. Work Package B also contains a few limited onshore activities for mapping of landfall. The Client requires at least an overlap of 250m between Work Packages A and B.

(\*) *Splitting Work Packages, A and B at 10m water depth is based on the Clients anticipations regarding selection of survey vessels. The Consultant may choose to separate the work packages at another water depth. Chapter 5.2 provide bathymetrical information based on archive sources.*

#### Work Package C – Geotechnical investigations

Upon completion and interpretation of the Work Packages A and B, a geotechnical campaign must be performed to provide the soil parameters of the interpreted soil strata.

#### Work Package D – Crossings survey

A dedicated ROV based survey with cable- and pipeline tracking sensors must be performed to map existing third-party utilities, that cross or intersect the area of investigation. The survey determines the horizontal location as well as the depth of burial of the third-party utility.

### 3. Time Schedule

#### 3.1 Requirements to time schedule

The Client has the following requirements to the time schedule:

- |    |   |            |
|----|---|------------|
| 1. | Commencement of marine activities may commence <i>as soon as possible</i> (ASAP) after signature of contract. |            |
| 2. | Contract signed   | 2023-07-01 |
| 3. | Interim Delivery Package #1 provided ASAP or no later than  | 2023-12-31 |
| 4. | Interim Delivery Package #2 provided ASAP or no later than  | 2023-12-31 |
| 5. | Cable Route Survey Reports, Part 1 to Part 7<br>REVISED issue provided ASAP or no later than                  | 2024-04-01 |

Definition and requirements for the Interim Delivery Packages #1 and #2 and for the Cable Route Survey Reports are defined in the document Enclosure 1, section 11.

#### 3.2 Contract milestones

As part of the Consultants tender response, the Consultant must supply milestone dates for the performance of the Scope of Services based on the template displayed in Table 3-1.

Together with the Consultants detailed time schedule (Gantt style) the provided milestone dates constitute the contracted time schedule.

A few selected milestones are subject to liquidated damages (LD) (see Table 3-1 below) as described in the Service Agreement:

- M101 Premob deliverables provided
- M102 WP A – Marine survey operations commenced
- M104 WP B – Marine survey operations commenced
- M110 Interim delivery package #1 and #2, report provided, **draft** issue
- M113 Cable Route Survey Report, report provided, **revised** issue

**Table 3-1** Template for contract milestones completed by Consultant as part of the tender proposal. The milestones 101, 102, 104, 110 and 113 are subject to liquidated damages as described in the Service Agreement.

Item	Event	Note	Due date	LD	Milestone
1	Commencement of contract		01-07-2023		
2	Project execution and QHSE plans provided				
3	Kick-off meeting				
4	Premob deliverables provided	3, 4		YES	<b>101</b>
5	<b>Work Package A – Offshore cable route survey</b>				
6	WP A - Marine survey operations commenced	1,3		YES	<b>102</b>
7	WP A - All marine operations completed				<b>103</b>
8	<b>Work Package B – Nearshore and landfall survey</b>				
9	WP B - Marine survey operations commenced	1,3		YES	<b>104</b>
10	WP B - All marine operations completed				<b>105</b>
11	<b>Work Package C – Geotechnical investigations</b>				
12	WP C - Marine survey operations commenced	1			<b>106</b>
13	WP C - All marine operations completed				<b>107</b>
14	<b>Work Package D – Crossings survey</b>				
15	WP D - Marine survey operations commenced	1			<b>108</b>
16	WP D - All marine operations completed				<b>109</b>
17	<b>Interim delivery package #1 and #2</b>				
18	Report provided, draft issue	2		YES	<b>110</b>
19	Report, Client review		(2 weeks)		
20	Report provided, revised issue	2,3			<b>111</b>
21	<b>Cable Route Survey Report</b>				
22	Report provided, draft issue	2			<b>112</b>
23	Report, Client review		(4 weeks)		
24	Report provided, revised issue	2,3		YES	<b>113</b>
Note 1	Event has occurred at first day with working time recorded as OPERATIONAL TIME.				
Note 2	Event has occurred when report, including all charts and all digital deliverables have arrived at the Clients office in Fredericia, Denmark.				
Note 3	Milestones marked with "YES" in the table column "LD" are subject to potential delay damages acc. to contract.				
Note 4	Premobilization deliverables must be provided within 20 calendar days of contract signature for Part 1 to 6. Premobilization deliverables include evidence for meeting the insurance requirements and the performance guarantee. See the Consultancy Agreement for detailed requirements.				

## 4. Requirements

For the area of investigation described in section 5 the Consultant must provide data acquisition, seabed sampling and testing, laboratory analyses, data processing, data interpretation and reporting.

### 4.1 Functional Requirements

To meet the purposes of the Scope of Services the Consultant must carry out a detailed mapping of the seabed surface within the surveyed area to provide:

- Accurate bathymetric data and charts in the surveyed area.
- The morphology and natural features of the seabed surface such e.g., as mega-ripples, sand-waves, boulders, outcropping geology, seaweed, and reefs.
- Possible man-made features such as wrecks, debris, fishing gear, trawl marks, anchor scars, objects of potential archaeological interests.
- Outline habitat and biotope mapping including ground truthing.
- Identification of features of potential conservation interest including but not limited to sandbanks, gravel reef, cobble reef, rocky reef and biogenic reef structures. (e.g., *Sabellaria spinulosa* and *Modiolus modiolus*).

The sub-surface of the seabed must be investigated to provide:

- The soil stratification and seismic units to 10m below seabed.
- The soil types, geotechnical properties and thermal properties of the soil units down to 6m below seabed.

At the landfall location the beach area behind the shoreline must be mapped:

- To provide a DTM that connects the marine bathymetry to the onshore topography.
- To chart any obstacles or infrastructure in the beach area.

### 4.2 Technical Requirements

To meet the functional requirements the following technical requirements shall apply for the scope of services:

The Geophysical seabed survey shall include the following:

- **Multi-Beam Echo-Sounding** for bathymetric mapping, complete coverage within corridor.
- **Side Scan Sonar** for mapping of the seabed surface. The coverage must have overlap to cover nadir of adjacent survey lines.
- **Magnetometer** for screening for larger ferrous objects and crossing cables and pipelines.
- **Sub-bottom profiling** with a single-channel seismic system able to provide a high-resolution mapping of the shallow geology. The system must be able to penetrate to 10m below seabed in sandy geological environment.
- **Grab sampling** to support the interpretation of the seabed surface geology.

Onshore survey activities shall include land surveying carried out from the low water mark (defined as Mean Low Water Spring mark) and further towards land to cover the full survey corridor.

The Geotechnical investigations shall include the following offshore in-situ activities:

- **Core sampling** of the seabed with a suitable corer device, 3m and 6m below seabed.
- **CPT tests** of the seabed, 3m and 6m below seabed and in-situ determination of thermal conductivity of the seabed.
- **Geotechnical laboratory tests** and tests of soil samples thermal properties.

The Crossing Survey shall include a working class ROV with the following:

- **Cable- and pipe-tracking sensors** to measure depth of burial of 3<sup>rd</sup> part assets.
- **Front cameras** for video recording of the seabed.
- **Subsurface positioning system**, motion sensor and attitude control system.

#### 4.3 Data processing, Interpretation and Reporting

The Consultant shall process and interpret all data acquired during surveying as well as carry out all necessary reporting according to the requirements specified in the documents:

- Enclosure 1 - Technical Specifications and
- Enclosure 2 - Standards of Deliverables.

#### 4.4 UXO risk mitigation

The Client is in the process of risk clarification for encountering UXO objects in the project area. The Client expects to receive the UXO desk study, clarifying the risk and mitigation measures before commencement of contract for this assignment.

The Client will provide the UXO desk study to the Consultant.

Based on the desk study, the Provider shall include in his project and QHSE plan a procedure to mitigate this risk related to direct seabed interactions (e.g seabed coring, CPT).

#### 4.5 HSE requirements

To manage the Health, the Safety and the Environmental under the assignment several requirements attached as Enclosure 3 must apply for Consultant's provision of the services.

#### 4.6 Quality requirements

To manage the Quality under the assignment several requirements attached as Enclosure 4 must apply for Consultant's provision of the services.



## 5. Area of investigation

This chapter describes the area of investigation applicable for the assignment.

### 5.1 Cable routes and corridors

The area of investigation is determined by the cable routes and the associated cable corridors.

The cable routes are listed in Table 5-1 and shown with admiralty maps below on Figure 5-1 to Figure 5-4.

Width of survey corridor:

- Nominal corridor width 1500m

Termination of survey corridor:

- Overlap with offshore wind farm site 250m
- Extending onshore from MHWS mark 250m

The *Route Position List (RPL)* for each part is enclosed in Annex 1.

For Part 1 to Part 6, KPO is located on the beach at the landfall. For Part 7, the cable route terminates offshore. KPO is located at the route connection point with the offshore wind farm site Kriegers Flak II North.

Table 5-1 Overview of the cable routes.

Part	Export Cable route	Route Length	Corridor Width	Water Depth
1	North Sea I - Export cable route 1	23km	1500m	00m – 26m
2	North Sea I - Export cable route 2	41km	1500m	00m – 27m
3	North Sea I - Export cable route 3	23km	1500m	00m – 22m
4	Kattegat II - Export cable route 1	16km	1500m	00m – 20m
5	Kattegat II - Export cable route 2	15km	1500m	00m – 22m
6	Kriegers Flak II North – Export cable	23km	1500m	00m – 28m
7	Kriegers Flak II South – Export cable	20km	1500m	29m – 34m



Figure 5-1 Part 1. Cable route and corridor (1000m wide). OWF Thor to the Northwest, OWF Vesterhav Syd to the South.

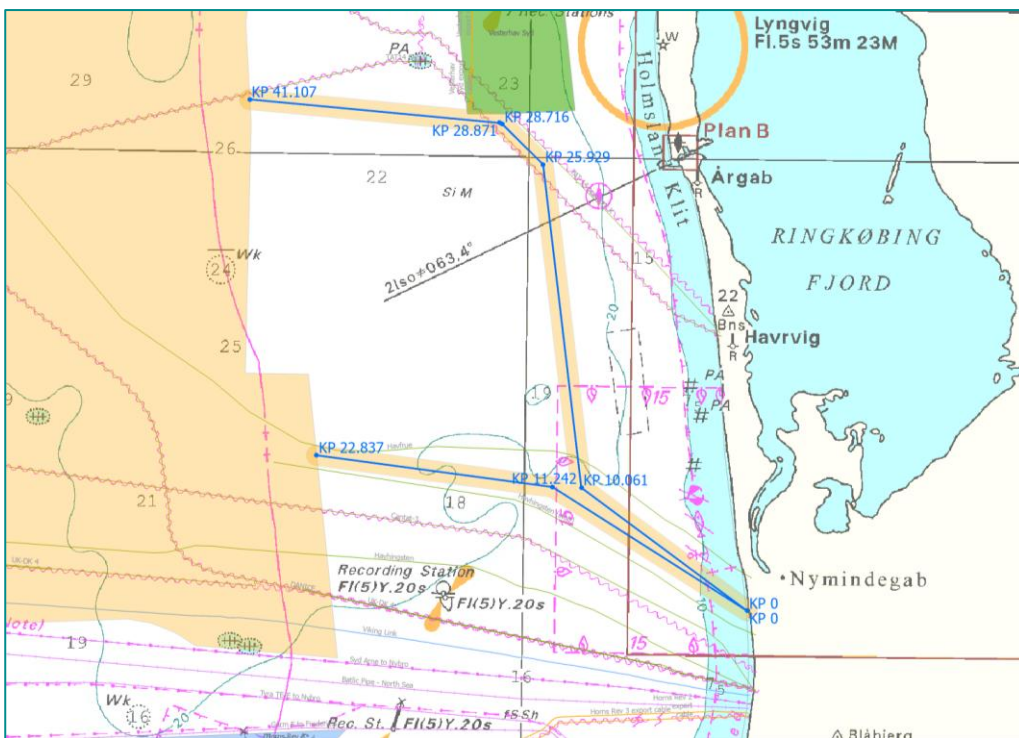


Figure 5-2 Part 2 and Part 3. Cable routes and corridor (1000m wide). OWF Vesterhav Syd to the North.

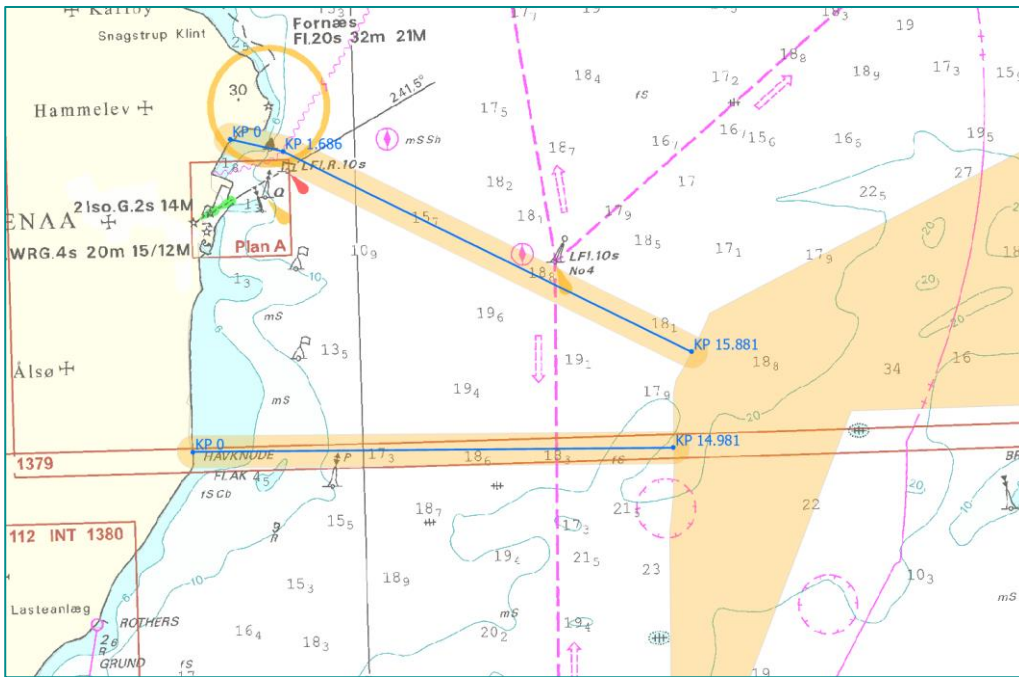


Figure 5-3 Part 4 and Part 5. Cable routes and corridor (1000m wide).

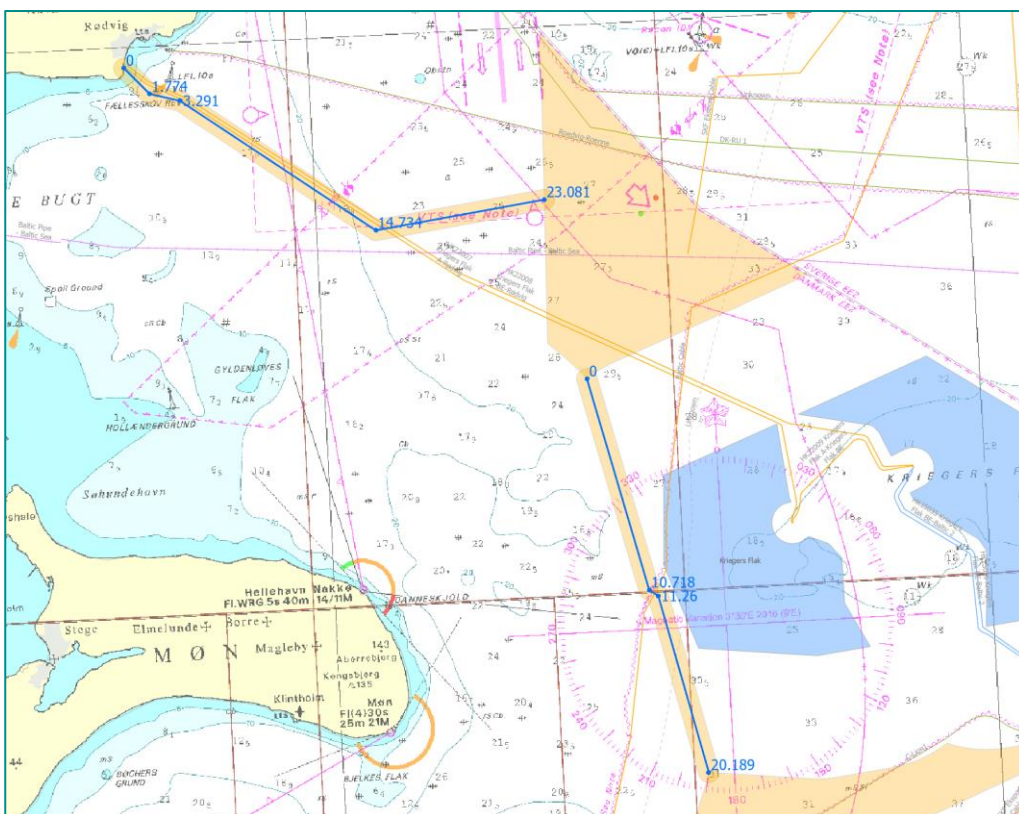


Figure 5-4 Part 6 and Part 7. Cable routes and corridor (1000m wide). OWF Kriegers Flak between the Kriegers Flak II North and South sites.

## 5.2 Landfall sites

The landfall sites are shown in the figures of this section for Part 1 to Part 6. There is no landfall for Part 7.

Table 5-2 Landfall location names.

Part	Landfall – location name
1	Vedersø Klit
2	Nymindesø
3	Nymindesø
4	Grenå Nord
5	Grenå Syd
6	Rødvig
7	NA

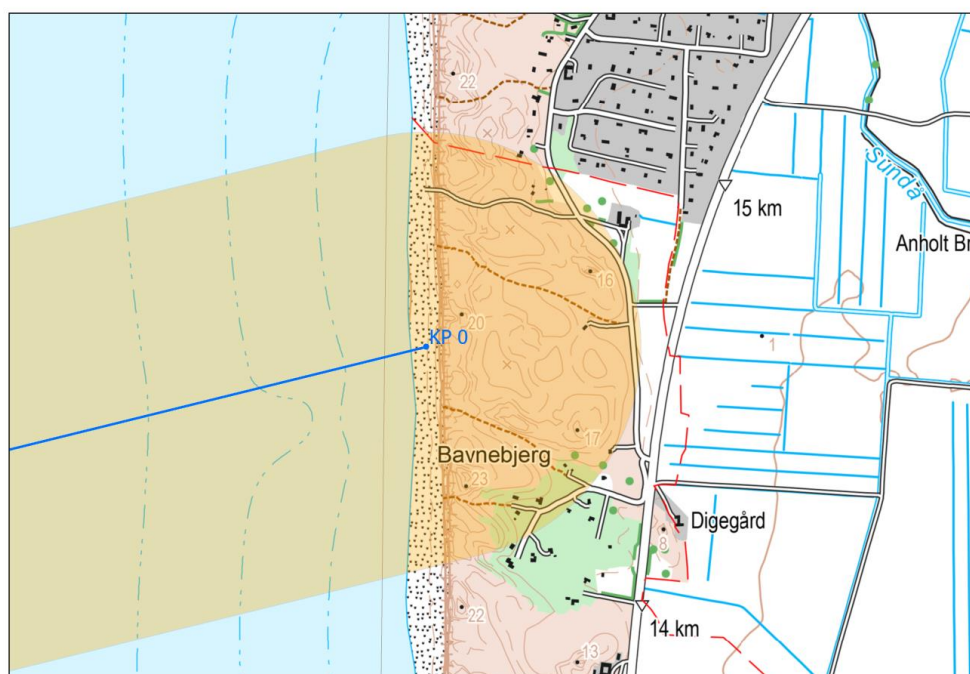


Figure 5-5 Part 1. Landfall site.



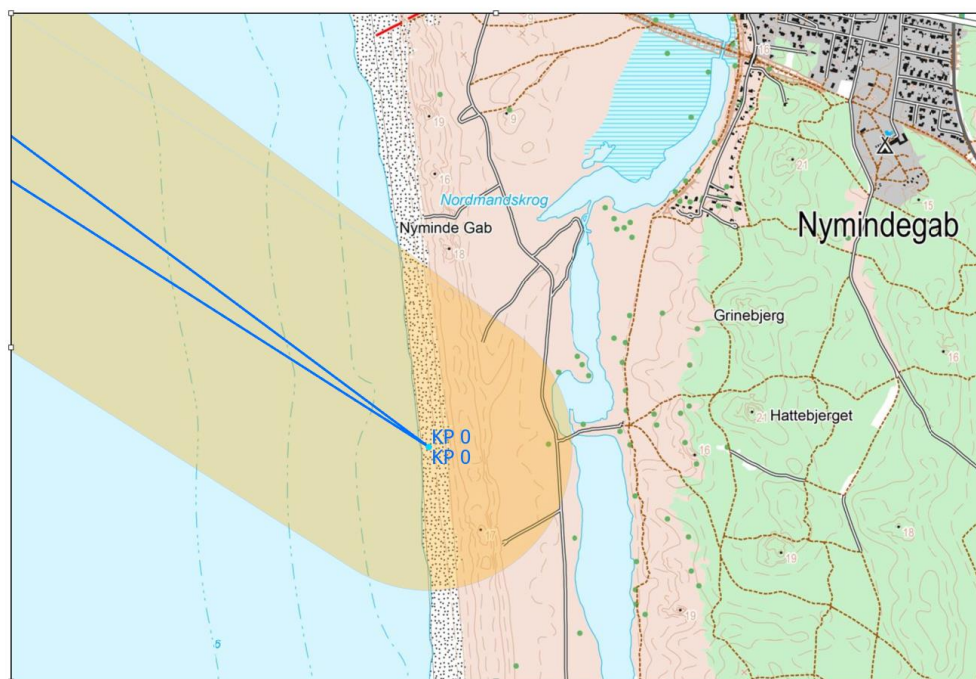


Figure 5-6 Part 2 and Part 3. Landfall site.

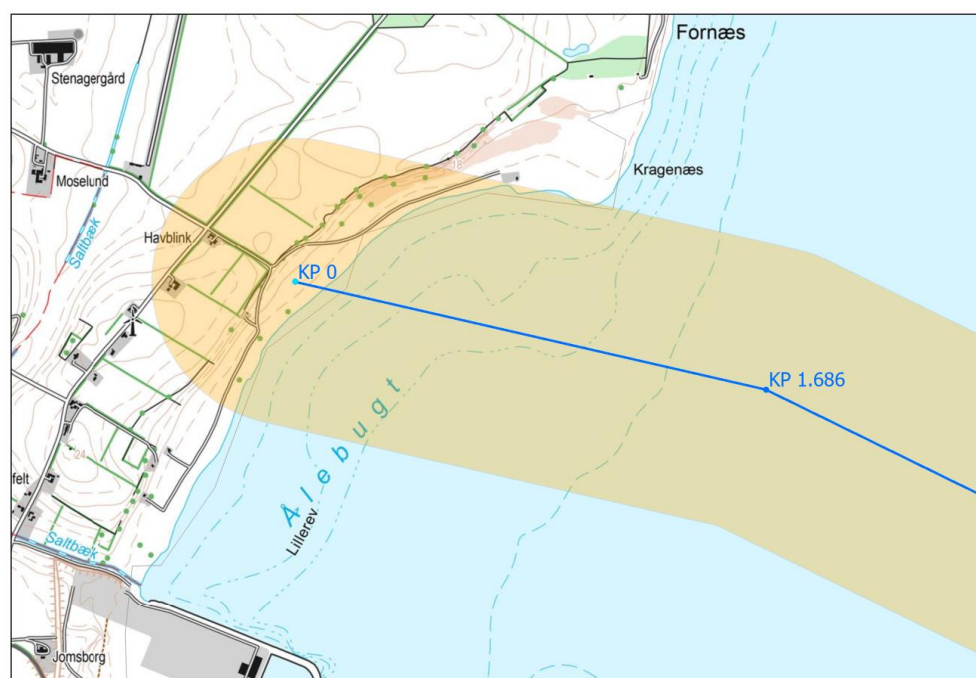


Figure 5-7 Part 4. Landfall site.

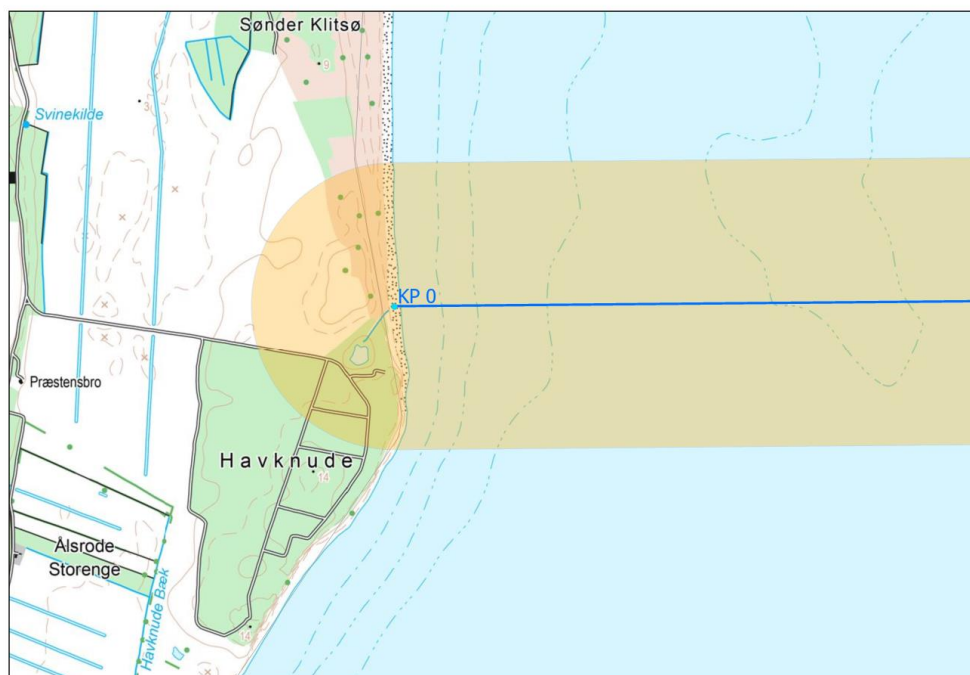


Figure 5-8 Part 5. Landfall site.



Figure 5-9 Part 6. Landfall site.

### 5.3 Water depths

The Client expects that the water depths are as indicated in Table 5-1. The depth information here is based on a bathymetrical DTM with a spatial resolution of 50m (see \1\).

Figure 5-10 to Figure 5-12 show the Clients initial expectations to water depth based on \1\). Assuming that the water depth separating route sections for WP A and WP B is 10m, then Table 5-3 show the lengths pr route and pr work package A and B respectively.

Table 5-3 Bathymetrical analysis of cable routes.

Cable route	Route length Total	Route length for WP A	Route length for WP B
		WD > 10m	WD < 10m
Part 1	23 445 m	18 521 m	4 923 m
Part 2	41 107 m	32 886 m	8 221 m
Part 3	22 837 m	15 072 m	7 765 m
Part 4	15 881 m	14 452 m	1 429 m
Part 5	14 981 m	11 535 m	3 446 m
Part 6	23 088 m	21 933 m	1 154 m
Part 7	20 198 m	20 198 m	0 m
Sum	161 536 m	134 597 m	26 939 m

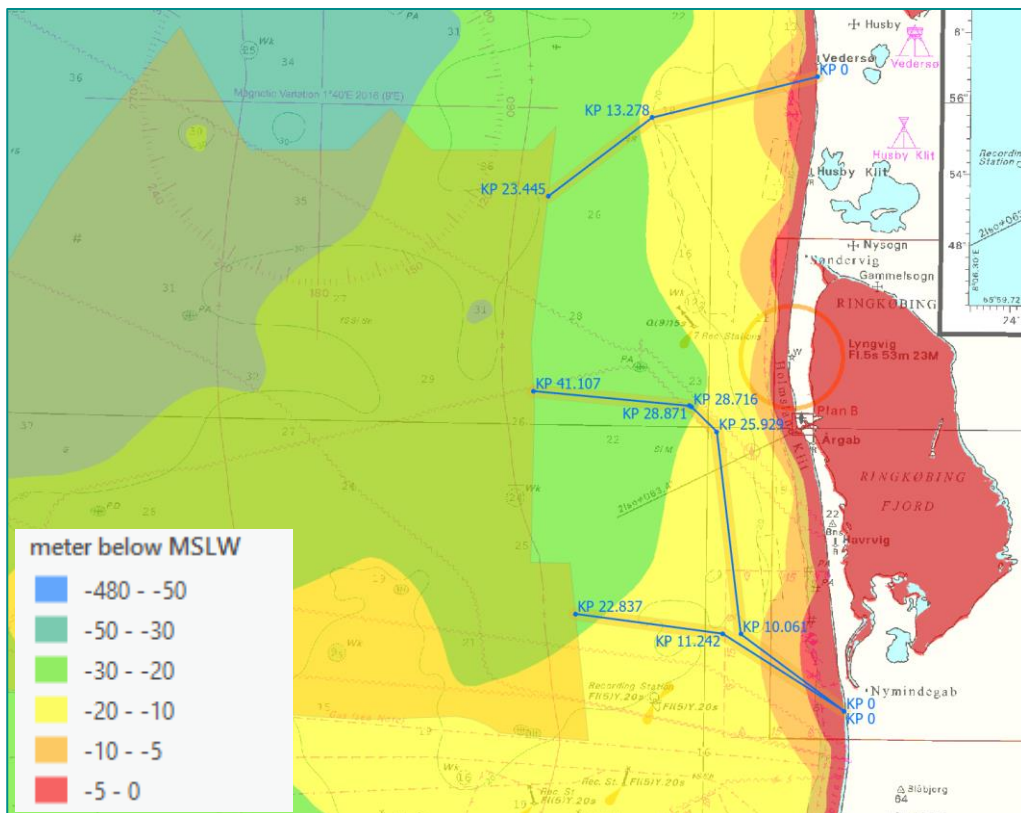


Figure 5-10 Water depths. Part 1 to Part 3. © Danish Geodata Agency \1\

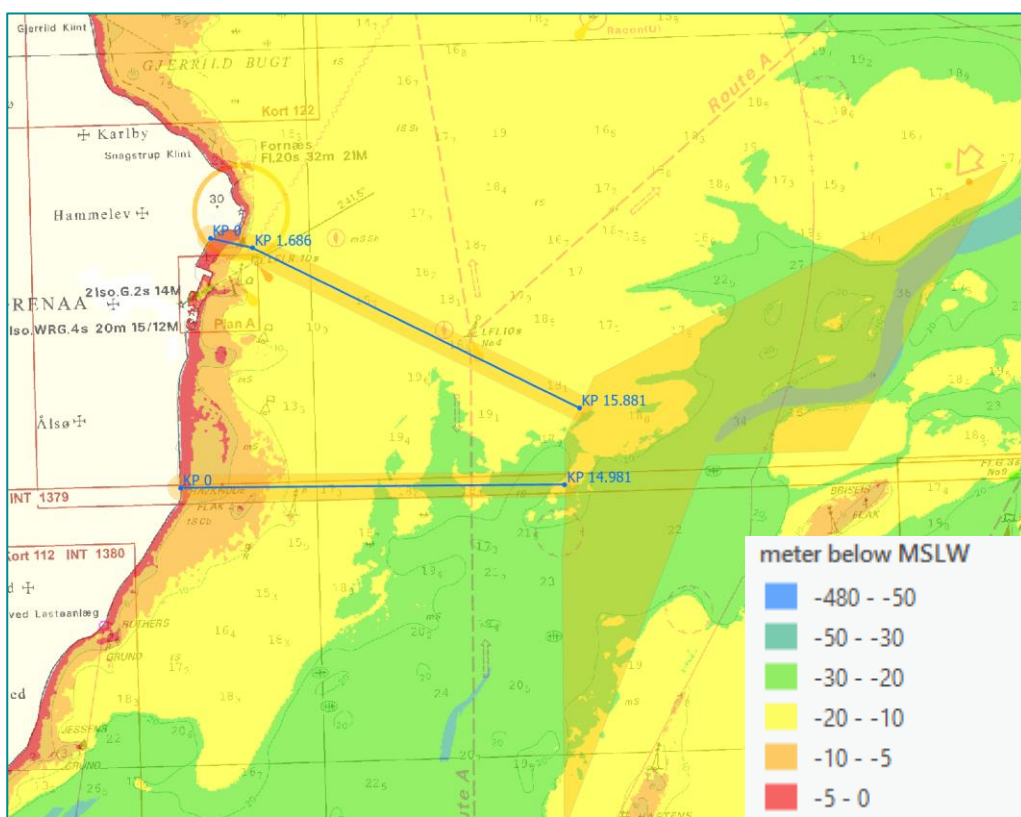


Figure 5-11 Water depths. Part 4 and Part 5. © Danish Geodata Agency \1\



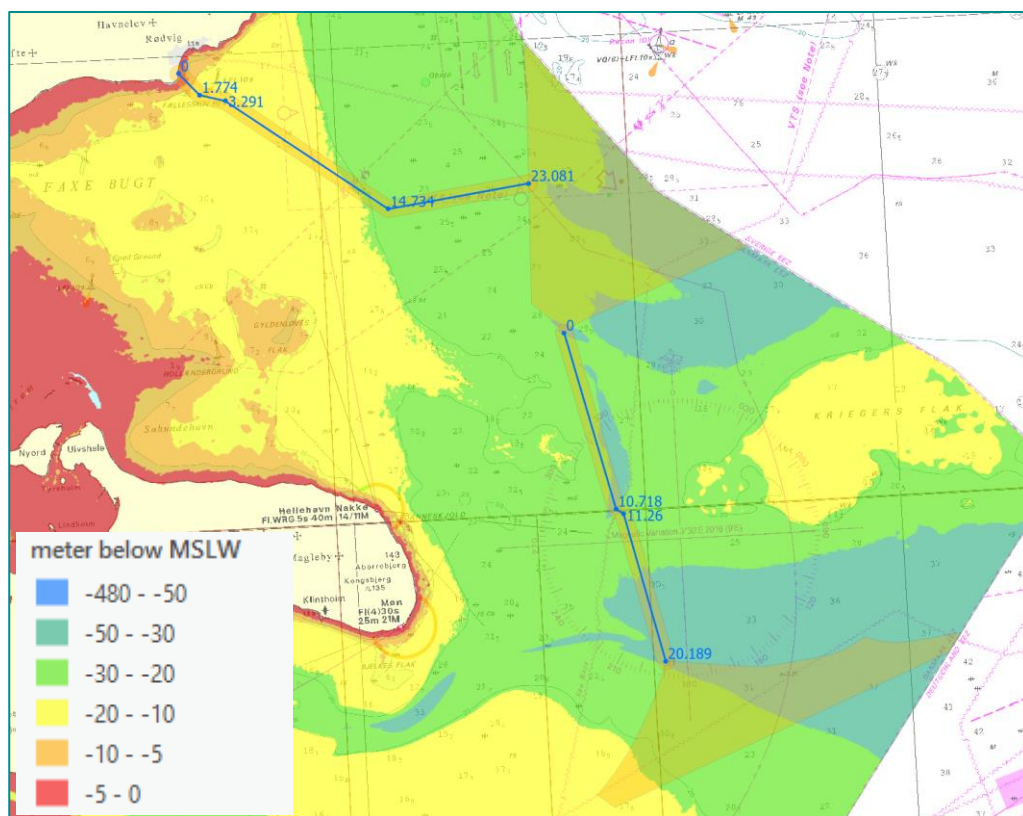


Figure 5-12 Water depths. Part 6 and Part 7. © Danish Geodata Agency \1\

## 5.4 Geology

The Geological Survey of Greenland and Denmark (GEUS) has published coarse maps of the seabed surface sediments. For the area of investigation, the maps of the seabed sediments are shown in Figure 5-13 to Figure 5-15.

For the cable routes in the North Sea (Part 1 to Part 3), the Client expects that the seabed sediments consist of Holocene sand and gravelly sand that appear as various mobile bedforms.

For the cable routes in Kattegat (Part 4 and Part 5) and in the Baltic Sea (Part 6 and Part 7), the Client expects that the seabed sediments appear with a base of glacial Till. Overlaying the Till a 0m to 3 m thick layer of postglacial, marine sediments of fine-grained sand and muddy sand is expected. Locally, channels have been eroded into the Till which again is filled with marine, postglacial sediments. Approaching land, consolidated limestone has been encountered in previous investigations.

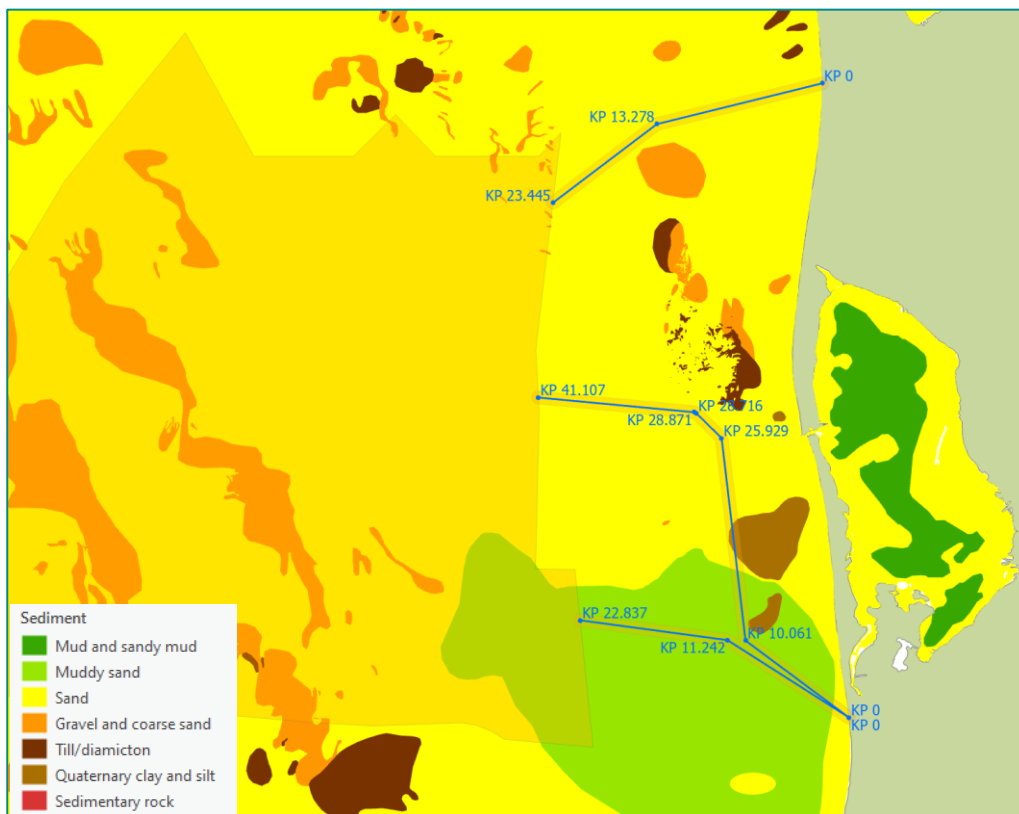


Figure 5-13 Seabed sediments. Part 1 to Part 3. © GEUS \2\.

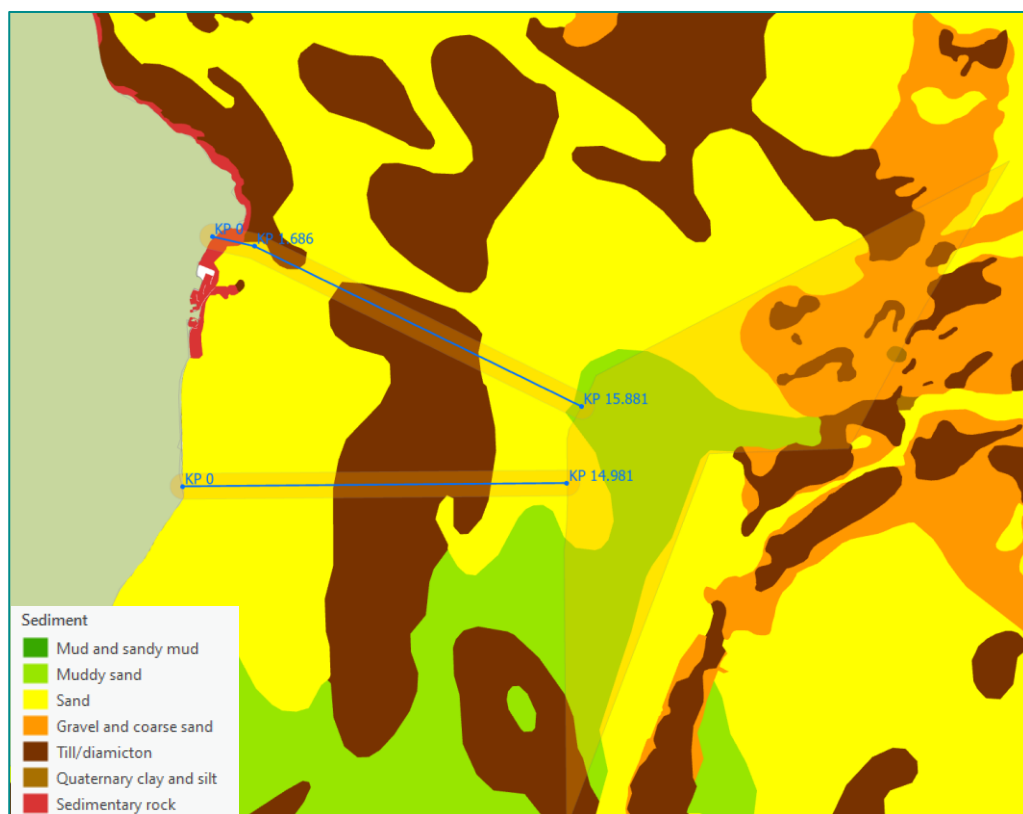


Figure 5-14 Seabed sediments. Part 4 and Part 5. © GEUS \2\.

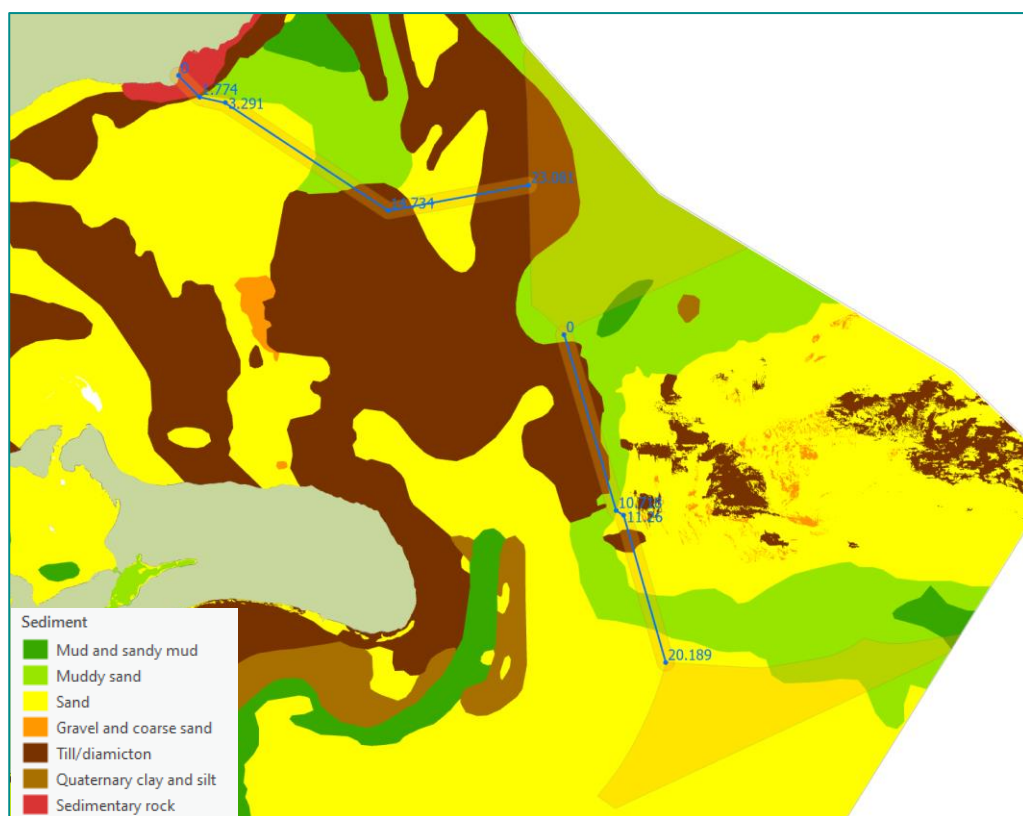


Figure 5-15 Seabed sediments. Part 6 and Part 7. © GEUS \2\.

## 5.5 Utilities

For some of the cable routes, the survey corridor of 1500m width intersects existing utilities such as communication cables, power cables or pipelines.

The Client has found by means of an initial and preliminary analysis the crossings listed in Table 5-4:

- No (zero) crossings seem to intersect Part 1 and Part 5. In total, 9 crossing utilities have been identified.
- Three crossings are owned by the Client. These crossings does not need to be surveyed – the Client will provide data from recent surveys for charting and reporting.
- The crossings listed in Table 5-4 represents the **PRELIMINARY** scope of work for Work Package D.

As part of the Consultants preparations, a *Utility Desk study* is requested as part of the scope of services. See Enclosure 1, section 8.9.2. Based on the Utility Desk study, the Consultant propose a modified scope of work for Work Package D which is agreed with the Client.

*Table 5-4 Crossings between the cable routes of this assignment and existing infrastructure. **PRELIMINARY.***

XNO	Part	KP	Crossing name	Crossing type	Expected Water Depth
101	2	30.3	Vesterhav Syd	OWF	20m – 25m
102	2	25.9 - 28.8	TAT-14 segment K	Fiber optical	15m – 18m
103	2	24.5 - 29.8	TAT-14 segment N	Fiber optical	19m – 23m
104	2	11.5	Havfrue	Fiber optical	12m – 15m
105	3	18.5 – 22.8	Havfrue	Fiber optical	19m - 21m
106	4	1.7	Anholt export cable (*)	Export cable	5m – 15m
107	6	15.1	HK22008 Kriegers Flak (*)	Export cable	0m – 20m
108	6	15.3	HK22007 Kriegers Flak (*)	Export cable	0m – 20m
109	7	11.0	Baltic Cable	Interconnector	28m – 30m

(\*) *Crossing utility owned and operated by Client. Client will provide survey data. Crossing utility excluded from Consultants marine activities.*

Figure 5-17 to Figure 5-19 show the preliminary identified crossings listed in Table 5-4.

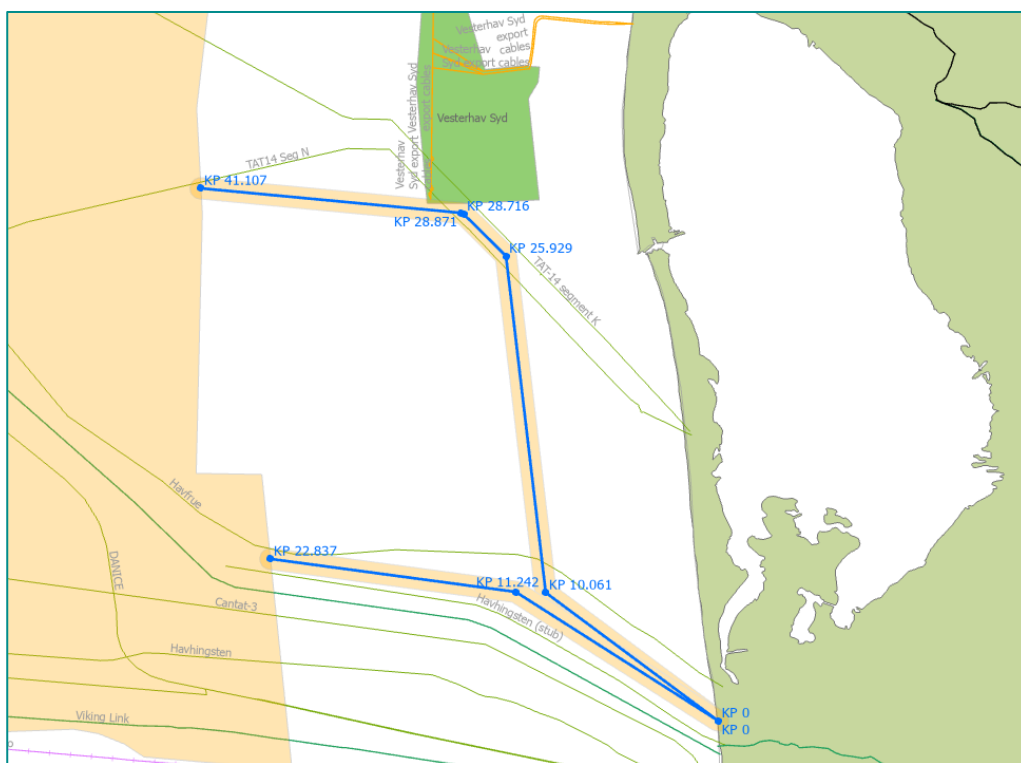


Figure 5-16 Utility crossings, XNO 101 to XNO 104 (see Table 5-4) for Part 2 and Part 3.

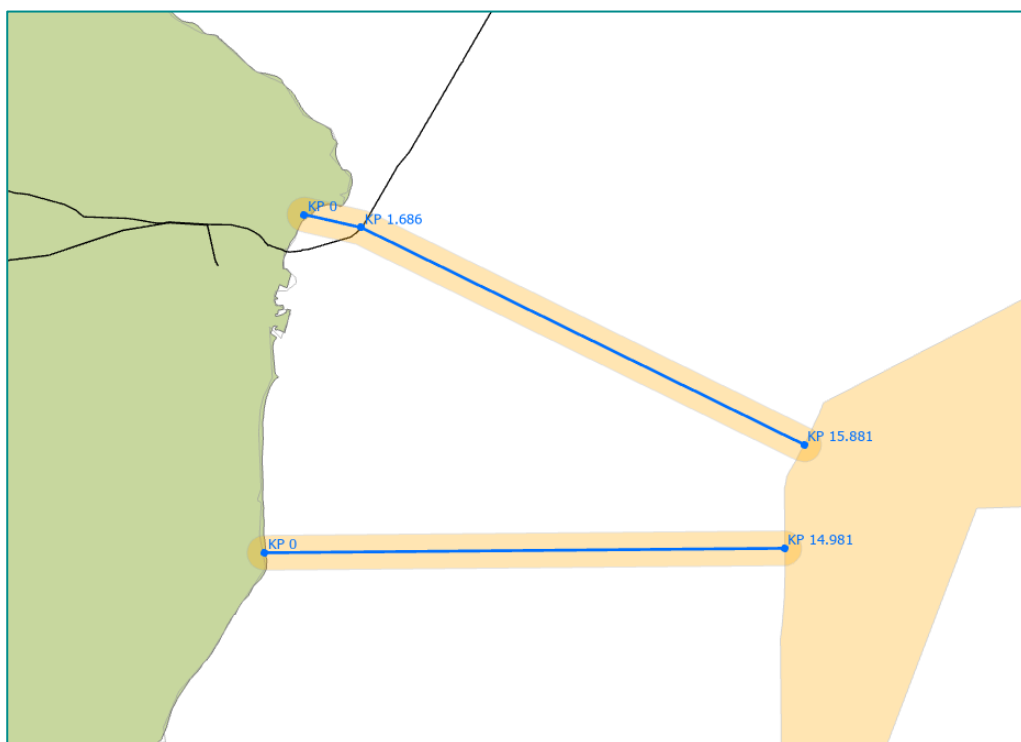


Figure 5-17 Utility crossings, XNO 105 (see Table 5-4) for Part 4.

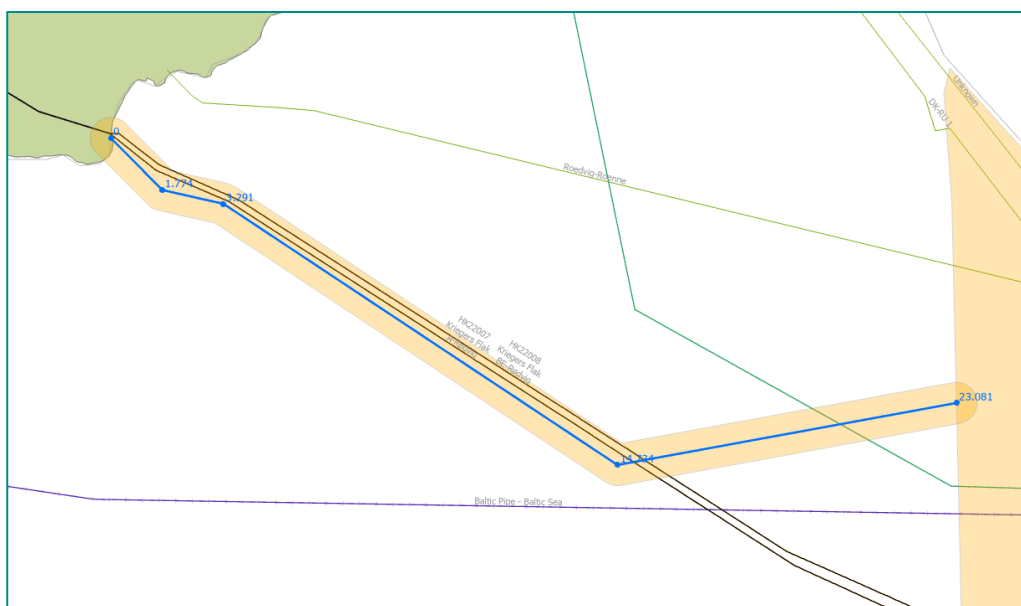


Figure 5-18 Utility crossings, XNO 106 and XNO 107 (see Table 5-4) for Part 6.

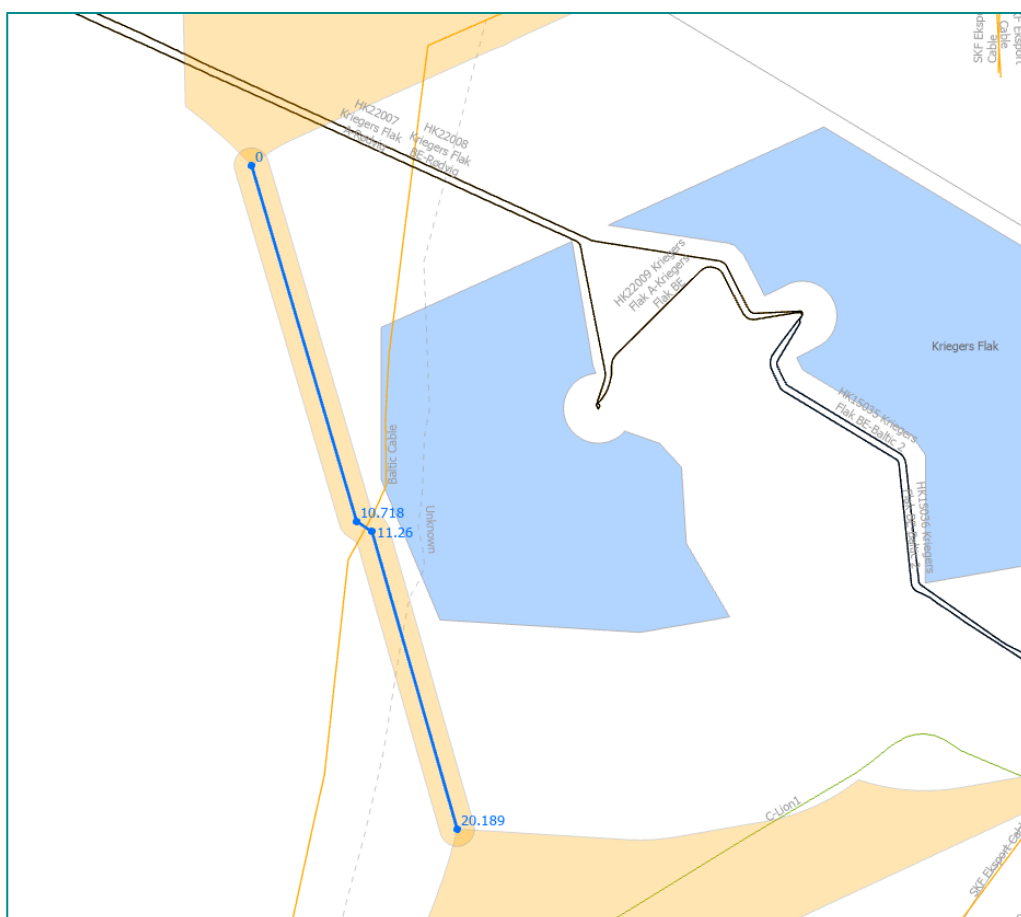


Figure 5-19 Utility crossings, XNO 108 (see Table 5-4) for Part 8.

## 6. References

- \1\ The Danish Geodata Agency, "Denmarks's Depth Model, 50 m resolution".
- \2\ GEUS. Geological survey of Greenland and Denmark. Seabed sediment map version 3. GeoViden 2014 no. 2.

## Annex 1 – Route Position Lists

Shapefiles attached:

- Annex\_1\_Cable\_Routes\_utm32.shp
- Annex\_1\_Cable\_Routes\_utm33.shp

KP	EASTING meter	NORTHING meter	LATITUDE DD MM.mmm	LONGITUDE DDD MM.mmm
<b>Part 1 North Sea I - Export cable route 1</b>				
<b>ETRS89 UTM ZONE 32N</b>				
00.000	446 143	6 233 809	56° 14.765 'N	008° 07.855 'E
13.278	433 250	6 230 635	56° 12.956 'N	007° 55.422 'E
23.445	425 140	6 224 504	56° 09.579 'N	007° 47.681 'E
<b>Part 2: North Sea I - Export cable route 2</b>				
<b>ETRS89 UTM ZONE 32N</b>				
0.000	448 247	6 184 422	55° 48.157 'N	008° 10.463 'E
10.061	440 169	6 190 420	55° 51.335 'N	008° 02.653 'E
25.929	438 306	6 206 178	55° 59.814 'N	008° 00.651 'E
28.716	436 322	6 208 136	56° 00.854 'N	007° 58.715 'E
28.871	436 180	6 208 198	56° 00.886 'N	007° 58.578 'E
41.107	423 998	6 209 346	56° 01.398 'N	007° 46.837 'E
<b>Part 3: North Sea I - Export cable route 3</b>				
<b>ETRS89 UTM ZONE 32 N</b>				
0.000	448 247	6 184 422	55° 48.157 'N	008° 10.463 'E
11.242	438 761	6 190 455	55° 51.343 'N	008° 01.303 'E
22.837	427 269	6 191 999	55° 52.079 'N	007° 50.266 'E
<b>Part 4: Kattegat II - Export cable route 1</b>				
<b>ETRS89 UTM ZONE 32 N</b>				
00.000	619 453	6 256 126	56° 26.071' N	010° 56.233' E
01.686	621 096	6 255 751	56° 25.844' N	010° 57.821' E
15.881	633 848	6 249 514	56° 22.277' N	011° 10.027' E
<b>Part 5: Kattegat II - Export cable route 2</b>				
<b>ETRS89 UTM ZONE 32N</b>				
00.000	618 300	6 246 401	56° 20.849' N	010° 54.849' E
14.981	633 280	6 246 530	56° 20.680' N	011° 09.385' E
<b>Part 6: Kriegers Flak II North – Export cable</b>				
<b>ETRS89 UTM ZONE 33N</b>				
00.000	332 072	6 124 816	55° 14.473' N	012° 21.518' E
01.774	333 210	6 123 455	55° 13.763' N	012° 22.639' E
03.291	334 656	6 122 995	55° 13.544' N	012° 24.018' E
14.734	343 623	6 115 887	55° 09.891' N	012° 32.704' E
23.081	351 932	6 116 675	55° 10.469' N	012° 40.498' E
<b>Part 7: Kriegers Flak II North – Export cable</b>				
<b>ETRS89 UTM ZONE 33N</b>				
00.000	353 249	6 107 805	55° 05.714' N	012° 42.013' E
10.718	355 391	6 097 304	55° 00.094' N	012° 44.345' E
11.260	355 810	6 096 959	54° 59.915' N	012° 44.748' E
20.189	357 526	6 088 197	54° 55.224' N	012° 46.617' E



# TECHNICAL REQUIREMENTS

<b>Project</b>		Danish Offshore Wind 2030					
<b>Assignment</b>		Cable Route Survey					
<b>Document Title</b>		Scope of Services – Enclosure 1 – Technical Requirements					
<b>Document No.</b>		22/00573-6					
<b>Audience</b>		Tenderers					
Version	Document status	Prepared by		Reviewed by		Approved by	
		Name	Date	Name	Date	Name	Date
1	Template	CGL	01-11-2022				
2	For tender	JCO	28-02-2023	NHW	07-03-2023	XPAN	27-03-2023

## Table of Contents

1. Introduction.....	2
2. Geodetic Reference system .....	3
3. Work packages and quantities .....	4
4. Planning and variations .....	7
5. Permissions and consenting processes .....	9
6. Vessels .....	10
7. Personnel and crew .....	12
8. Equipment and Methods .....	13
9. Data Processing .....	21
10. Data Interpretation .....	22
11. Reporting requirements .....	24
12. Meetings.....	31

## 1. Introduction

In the document “Scope of Services” the objectives and the general outcome of the survey activities are described.

This specification, when read in conjunction with the Agreement, referenced standards, specifications and other listed documentation, defines the minimum technical, functional and procedural requirements for the Services associated with the project.

The Consultant shall take responsibility to ensure all survey operations are conducted safely and with full regard to national, international and area specific environmental considerations.

### 1.1 Constraints

The Client’s approval of the Consultant’s time schedule, organisation plan, list of subcontractors, list of equipment, etc., shall not relieve the Consultant of any responsibility for the performance of his obligations.

The Consultant shall perform the Services in accordance with best professional standards and practice within the industry plus in accordance with equipment and software manufacturer’s recommendations and descriptions.

The presence of and the inspection and supervision by the Client at the worksite as well as any approval, consent, comments and the like given to the Consultant by or on behalf of the Client shall not relieve the Consultant from his obligations and responsibilities.

All data and reports that are a result of the Services are confidential and cannot be distributed to third parties without written permission from the Client.

## 2. Geodetic Reference system

The survey data is acquired, processed, reported, and charted with respect to the following geodetic requirements:

- Datum: ETRS89
- Projection – Part 1 to Part 5 UTM 32N
- Projection – Part 6 to Part 7 UTM 33N
- Offshore datum: Mean Sea Level (MSL). Use model DTU21MSL
- Onshore datum: DVR90
- Vertical reference for reporting: Offshore datum

All vertical information is provided as *depths* relative to MSL such that water depths are positive *downwards*.

### 3. Work packages and quantities

A number of Work Packages are defined to organize the different requirements in the document “Scope of Services”:

- WP A – Offshore cable route survey, WD > 10m MSL (\*)
- WP B – Nearshore and landfall survey, WD < 10m MSL (\*)
- WP C – Geotechnical investigations
- WP D – Crossings survey

(\*) Splitting Work Packages, A and B at 10m water depth is based on the Clients anticipations regarding selection of survey vessels. The Consultant may choose to separate the work packages at another water depth.

This chapter describes the general technical requirements for work packages A - D.

#### 3.1 Work Package A - Offshore cable route survey

Within the survey corridor the following requirements must be fulfilled by the survey:

- Multibeam Echo-sounding survey with full bathymetric coverage. The data quality must accommodate the preparation of digital elevation models (DTMs) of the bathymetry with 25cm spatial resolution. (min. 4 soundings pr. 0.25 m<sup>2</sup> cell)
- Dual frequency side scan sonar with > 200% coverage to ensure overlap with the nadir of adjacent survey lines. Detection of all objects > 0.5m.
- Single magnetometer or gradiometer towed after vessel, all survey lines.
- Sub-bottom profiling: One high resolution and relative high frequency single channel system, 10 m depth, all survey lines.
- Horizontal positioning uncertainty < 0.5m for vessels.
- Horizontal positioning uncertainty < 2.0m for towed equipment.
- Vertical positioning uncertainty – IHO, S-44 Special order < 0.2m
- Grab-sampling, approximative 1 (one) sample pr. route km.

##### 3.1.1 Grab sampling

The aim of the grab samples is to provide in-situ information of the seabed surface to support the interpretation of bathymetric and side scan sonar data. The requested amount of grab samples is subject to change according to seabed sediment complexity.

All grab samples to support geological interpretation must be subject to laboratory tests:

- Particle size, Sieve analysis
- Particle size, Hydrometer analysis
- Organic content, Loss on ignition

### 3.2 Work Package B - Nearshore and landfall survey

The Landfall survey area extends from the Mean High Water Spring mark (MHWS) and offshore to the water depth that at least can be surveyed by vessels from Work Package A.

The survey area of the landfall activities must have sufficient overlap with survey activities related to Work Package B to provide a coherent and connected bathymetric DTM.

The landfall survey area must be mapped using the following methods:

- Multibeam Echo-sounding survey with full bathymetric coverage. The data quality must accommodate the preparation of digital elevation models (DTMs) of the bathymetry with 25cm spatial resolution. (min. 4 soundings pr. 0.25 m<sup>2</sup> cell)
- Dual frequency side scan sonar with > 200% coverage to ensure overlap with the nadir of adjacent survey lines. Detection of all objects > 0.5m.
- Single magnetometer or gradiometer towed after vessel, all survey lines.
- Sub-bottom profiling: One high resolution and relative high frequency single channel system, 10 m depth, all survey lines.
- Horizontal positioning uncertainty < 0.5m for vessels.
- Horizontal positioning uncertainty < 2.0m for towed equipment.
- Vertical positioning uncertainty – IHO, S-44 Special order < 0.2m
- Grab-sampling, approximative 1 (one) sample pr. route km.

#### 3.2.1 Grab sampling

Same requirements as in 3.1.1.

### 3.3 Work Package C – Geotechnical investigations

The Scope of Service must include geotechnical investigations with combined Cone Penetration Testing (CPT), core sampling with either a Vibrocore system or equivalent system.

- Geotechnical investigations, approximative 1 (one) test pr. route km.

At each location subject to geotechnical investigations both a CPT test and a core sample must be performed. The distance between the CPT test and the core sampling must be less than 10m and no closer than 5m.

The requested target depth of the geotechnical investigations is 3m to 6m below the seabed.

The quantities of the geotechnical cores, the laboratory classification tests and the CPTs are included in the Pricelist.

Geotechnical classification tests must be performed on soil samples extracted from the cores. Section 8.12 and 8.13 provide a detailed description of the required laboratory analyses.

It must be expected that the quantities are varied and adapted to the encountered conditions.

### 3.4 Work Package D – Crossings survey

All existing 3rd party utilities that intersect the survey corridor must be subject to an inspection survey that maps the intersecting utility:

- Completely within the survey corridor and
- Additionally, 500 m (along-track the intersecting utility) to either side of the survey corridor.

The Consultant must perform crossing survey of all utilities intersecting the area of investigations. The pricelist includes a preliminary quantity that will be modified based on the Consultants utility desk study (see section 8.9.2).

If the Consultant identifies other potential crossings as part of his preparation or during the preliminary interpretation of the geophysical survey data, these must be investigated as well.

The inspection of the object and surrounding seabed must include the following:

- High-resolution still images.
- High-resolution multibeam echosounding performed from surface vessel.
- High-resolution acoustic profiling performed from subsea ROV.
- Tracking of the objects lateral and vertical position as well as the burial of the object with a suitable cable- or pipe-tracking system.

Furthermore, Work Package D include processing and reporting of the acquired data as described in section 9 and specified in the document “Standards of Deliverables”, Section 4.

As part of the premobilization activities the Consultant performs a desk study to identify all known and potential utilities, that cross the area of investigation (cable corridor). See section 8.9.2.

To be able to submit a tender response and to setup a plan, the Clients has provided pre-printed quantities for the number of crossings in the Pricelist. The quantities shall be modified to reflect the actual survey crossings.

## 4. Planning and variations

As an integrated part of the Scope of Services the Consultant must carry out planning related to the Scope of Services. The planning work must include:

- Preparation of survey line plans for Work Packages A and B.
- Planning of grab sampling for Work Package A and B.
- Planning of geotechnical sampling and laboratory analyses for Work Package C.
- Preparation of survey line plans for Work Package D.

### 4.1 Survey line and infill planning

Before commencement of the marine activities the Consultant must prepare a survey line plan that meets the technical requirements for Work Packages A, B and D. The survey line plan is subject to Client approval before commencement.

The survey line plans must accommodate that the quality requirements described in section 8 are met.

On a continuous basis and during the execution of the survey the Consultant must monitor the quality of the acquired data and assess if the requirements are met. If the requirements are not met the Consultant must plan infill lines and progress with supplementary survey activities.

Additional survey lines may be instructed by the Client Representative and agreed as variation orders to the contract.

#### 4.1.1 Local extension of survey corridor width

On a continuous basis and during the execution of the survey the Consultant must carry out a preliminary data interpretation to analyse if the survey corridor contains challenges that can obstruct the planning and installation of power cables.

Such challenges can for example be, but not limited to, environmental sensitive areas such as reefs, geological hazards, wrecks, debris, or potential UXO objects.

If such locations occur the Consultant must propose a plan to adjust the route locally to mitigate the encountered constraint including a corresponding survey corridor.

The program must be planned together with and approved by the Client Representative.

Local extensions of the survey corridor shall be agreed as variation orders to the contract.

### 4.2 Planning of grab sampling

For Work Package A and B the Consultant must prepare a program for grab sampling on basis of a preliminary interpretation of the geophysical data.

Grab samples aim to provide data to support geological interpretation.

The program for grab sampling will primarily be related to selecting the geographical locations for sampling. The locations shall be selected such that seabed surface units of variable sonar reflectivity are sampled.

Adjusting the quantities of the seabed sampling will not constitute a variation order but would be commercially regulated by the rates stated in the Price List.

The program must be reviewed and approved by the Client Representative.

#### **4.3 Planning of vibrocore sampling and CPT testing**

For Work Package C the Consultant must prepare a program for geotechnical seabed tests. The plan proposes the geographical locations of the tests and the target depths.

Ideally, the Consultant plan the locations for geotechnical investigations based on a preliminary interpretation of the centreline survey data from the geophysical survey (Work Package A and B).

Alternatively, the Client accepts, that a plan for geotechnical investigations is developed from archive data assuming that this would allow for a faster commencement of the geotechnical work.

Principles for planning the geotechnical tests and cores will be addressed at the kick-off meeting.

Adjusting the quantities of the seabed sampling will not constitute a variation order but would be commercially regulated by the rates stated in the Price List.

#### **4.4 Programme for laboratory analyses**

The Consultant must prepare a plan for laboratory analyses of the acquired soil samples from sampling with grab and Vibrocore.

The program must be adapted to the encountered conditions. Therefore, a geological and lithological description of the cores and samples must be carried out as an integrated part of the recovery of the samples.

The program must be approved by the Client Representative. Principles for laboratory program planning – including types and quantities - will be addressed at the kick-off meeting.

Adjusting the quantities of the laboratory analyses will not constitute a variation order but would be commercially regulated by the rates stated in the Price List.



## 5. Permissions and consenting processes

The following permits and consenting processes are required ahead of the marine activities:

1. Danish Energy Agency, Permission for site investigations
2. Danish Geodata Agency, Permission for survey
3. Danish Maritime Agency, Risk Assessment of traffic safety
4. Danish Maritime Agency, Notice to Mariners

The Client is responsible for acquiring #1, #2 and part one of #3.

The Client has defined 2023-07-01 as deadline for completing #1, #2, #3.

The Consultant is responsible for completion of part two of #3 and submission of #4 before commencement of the marine activities and in due time as requests by the authorities.

## 6. Vessels

### 6.1 General requirements

Based on the Consultant's experience and detailed operational knowledge, it's the responsibility of the Consultant to select the proper number of vessels necessary for performing the Scope of Services.

The Client assumes that vessels used for

- Work Packages A, C and D will be operating on 24-hour basis
- Work Package B will be operated on 12-hour basis.

Based on the Consultants experience and availability of appropriate vessels, it's the responsibility of the Consultant to propose and carry out most favourable mode of operations.

The vessels shall have been purpose built or suitably converted to undertake the specified work in the designated geographic area.

The vessels shall be able to operate under the meteorological and oceanographic conditions within the limitations stated by the Consultant in the tender.

The vessel(s) shall be equipped with adequate communication equipment for telephone communication plus continuously high-speed internet connections with a speed of at least 1 Mbit/s for digital data distribution.

The vessels used for Work Package A and B shall be proven to be acoustically quiet to enable good quality acoustic data to be acquired. The acoustic noise signature shall be acceptable outside the acoustic frequency range of the survey equipment to be deployed from the vessels.

Vessel deck areas used for survey operations shall have good lighting and be free of trip hazards. All areas of the vessel used for the survey equipment deployment/recovery shall be either visible from the bridge, or good quality closed-circuit television pictures of such areas shall be provided on the bridge at all times of such operations.

Alternative vessel setups like unmanned surface vehicles can be used for geophysical surveying if all national and international permits and consents are held.

### 6.2 AIS

The vessels shall be equipped with AIS. The AIS transponder on board the vessels shall automatically, and with the required accuracy and update rate, provide other vessels and authorities with relevant information about the vessels and their navigation.

The transponder shall be configured in such a way that the Client can follow the vessel position on public available websites during the entire duration of the survey operations.

### 6.3 Client Representative

The Client will employ a Client Representative to provide offshore presence during the mobilisation and operation at any vessel offered by the Consultant.

The specific roles and responsibilities of the Client Representatives will be addressed at the project kick-off meeting.

On the vessels, operated at 24 hours basis, the Consultant must allow for two (2) Client Representatives. If vessels are operated at 12 hours basis, the Consultant must allow for one (1) Client Representative.

The Client Representative cabin shall be a single cabin and fitted with telephone, at least 1 Mbit/s internet connections and adequate offline facilities for evaluation of the results.

Alternatively, if the vessels do not allow to accommodate the requested offshore client representatives, then the Consultant must provide other facilities such that the offshore client representative can monitor progress of work, quality for the acquired data and performance of equipment, vessel, and offshore personnel.

#### 6.4 Marine mammal protection measures

The Danish authorities are expected to include measures for protection of marine mammals as permit conditions to carry out the offshore work.

The conditions would usually require the application of *soft-start* procedures, *Marine Mammal Observers* (MMO) and *Passive Acoustic Monitoring* (PAM) systems, when offshore work include seismic methods or the use of USBL.

Table 6-1 lists the requirements for application of marine mammal protection measures for the offshore activities of this assignment.

Remarks:

1. There are no formal requirements for fulfilling the role of MMO.
2. The role of MMO may be undertaken by one person with another role on the vessel as well.
3. For this assignment, the Client accepts performing WP C and grab sampling in WP A and WP B without using USBL.

Table 6-1 Requirements for marine mammal protection measures

	Soft-start procedures	MMO	PAM
WP A – Offshore geophysical survey	Yes	Yes	Yes
WP B – Nearshore geophysical survey	Yes	Yes	No
WP A and B – Grab sampling Exclusive use of USBL	No	No	No
WP C – Geotechnical investigations Inclusive use of USBL	Yes	Yes	Yes
WP C – Geotechnical investigations Exclusive use of USBL	No	No	No
WP D – Crossings survey	Yes	Yes	Yes

## 7. Personnel and crew

The manning of the survey team is the responsibility of the Consultant. The Consultant must provide sufficient competent supervisory, technical, and other personnel to properly perform the service.

The Consultant may not replace key personnel without written approval from the Client. All marine personnel should be qualified in accordance with the requirements of the flag of registration.

The master and other principal vessel officers must be fluent in written and spoken English. All personnel sailing on the vessels are expected to be medically fit and the Consultant is required to ensure that regular medical examinations are undertaken.

The Party Chief shall be the Consultant's nominated Survey Representative and shall liaise directly with the Client Representative.

## 8. Equipment and Methods

The Consultant's equipment, materials, supplies and tools shall be of first-class quality and shall be in good and safe operational condition, approved for use in the survey area. The Consultant shall maintain and repair all equipment and tools and maintain adequate stock levels and spare parts and spare equipment to ensure timely operations.

All equipment shall be installed and operated in such a way no interferences or disturbances between the various equipment units, or the vessel and the equipment units occur.

All equipment and instruments must be able to operate under the meteorological and oceanographic limitations stated by the Consultant in his tender.

As a minimum but not limited to, the vessels shall be equipped with the equipment specified below.

### 8.1 Vessel Positioning System

The positioning of the vessels shall be determined with a highly accurately Global Navigation and Satellite System (GNSS) positioning system(s). Positioning shall be carried out such that coordinates are derived with sufficient accuracy to meet the objectives and needs of the project as specified in section 3.

As part of the mobilization and acceptance test in the port(s) of mobilization, the GNSS antennas position determined by the GNSS-system(s) shall be compared with the GNSS antennas position determined by land survey methods.

At least two independent vessel positioning systems need to be available. Furthermore, the vessel(s) shall be equipped with motion sensor and gyro.

The vessel gyro shall meet the following specifications:

- Dynamic heading accuracy of  $\pm 0.2^\circ$  or better
- Static heading accuracy of  $\pm 0.05^\circ$  or better

The horizontal and vertical accuracy of the vessel position shall be better than 0.5m.

#### 8.1.1 Landfall vessels(s)

For the vessel(s) provided for Landfall activities (Work Package B) the vessel position must be determined by use of an RTK-based GNSS-system or equivalent. The horizontal and vertical accuracy of the vessel position shall be better than 0.25m.

### 8.2 Towed Equipment Positioning System(s)

All towed equipment shall be positioned relative to the vessel by highly accurately positioning systems, e.g., Ultra-Short Baseline (USBL) systems, with a horizontal accuracy better than 2m.

The relative positions of all the towed equipment in relation to the vessel shall be interfaced to the positioning computer to provide orientations and distances for computation of offset positions from the GNSS antenna(s) as well as absolute positions. Mini beacons must be provided to support the positioning of towed equipment, CPT and coring equipment.

The relative as well as the absolute positions of the towed equipment shall be stored in the positioning database.

The tow cable winch shall be remotely controlled from the geophysical survey instrument room and fitted with a remote alarm.

Layback of the towed equipment shall be measured by a calibrated meter on the deployment pulley and by USBL. Alterations to the tow cable length during surveying shall automatically be recorded in the acquisition system.

### 8.3 Bathymetric System(s)

#### 8.3.1 Work Package A and B

The bathymetric data shall be acquired with a multi-beam echo-sounding (MBES) system and provide a spatial density that at least has **16 depth soundings pr. square meter**.

The data quality must accommodate the preparation of digital elevation models (DTMs) of the bathymetry with 25cm spatial resolution without extrapolation.

The data shall be acquired in *equal distance* mode.

The MBES system shall record backscatter images.

The bathymetric system shall be supplied with ability to compensate for motion such as Pitch, Roll, Yaw and Heave.

### 8.4 Sound Velocity Profiler

The speed of sound in water shall be measured in the survey area at intervals not exceeding 6 hours.

The measurement shall be made using calibrated sound velocity profiler. Measurements shall be taken at suitable intervals from the sea surface to the seabed.

A second set of readings shall be taken from the seabed to the sea surface and the speed of sound computed from the measured values.

It's the responsibility of the Consultant to ensure the required vertical as well as horizontal resolutions are achieved and maintained during all periods of surveying. If so needed, the Consultant must apply and operate a moving sound velocity profiler system, which allows continuous monitoring of the entire water column. If needed to be able to achieve the required resolutions, acoustic ray bending algorithms shall be applied for depth and position calculations.

### 8.5 Dual Frequency Side Scan Sonar System(s)

A dual channel side scan sonar system shall be provided. The Consultant shall propose an instrument with operating HF and LF frequencies that will optimize the performance with respect to coverage and resolution in relation to the objectives of this survey. Expected frequency range is between 100 kHz and 900 kHz.

Objects larger than 0.5m along the shortest axis must be resolved in the sonar images.

The applied operational range of the side scan sonar system shall be selected to ensure as high resolution as possible plus to ensure side scan sonar overlap to cover nadir regions of adjacent survey lines (i.e. Coverage > 200%).

The Client anticipates that the side scan sonar system shall be installed and operated in a terrain following mode at a fixed height above seabed at 8-12% of the operational range. The Consultant may propose other configurations if this are a benefit for the survey.

The towing system shall be designed and operated to ensure the side scan sonar system is adequately decoupled from vessel's heave, pitching, and rolling motion.

The survey speed at which side scan sonar surveys are undertaken shall normally be maintained at 4.0 knots ( $\pm 10\%$ ).

## 8.6 Sub-bottom profiler system

The sub-bottom system shall be able to in details to map at least the uppermost 10m of seabed sediments and sedimentary bedrock in a variety of geological conditions.

One high-frequency single-channel sub-bottom profiler system must be provided (e.g. Innomar SES-2000 or similar) to map shallow geology including layer interfaces to 10m below seabed with a vertical resolution better than 0.3m.

To achieve this the Consultant must provide a system that is optimized for the above-mentioned objective regarding:

- Altitude of towfish with seismic system
- Ping rate
- Signal frequency

## 8.7 Magnetometer

A marine magnetometer (e.g., Geometrics G-882 or similar) must be towed behind the vessel.

The magnetometer must be towed in a distance from the vessel such that the instruments are free of the vessel magnetic noise.

The seabed altitude of the magnetometer must be recorded with an altimeter.

The following requirements must apply for the magnetometer:

- Magnetometer seabed altitude:  $\leq 5$  m
- Magnetometer measurement sensitivity: 0.01 nT
- Magnetometer sampling frequency: 1 – 20 Hz (selectable)
- Noise level  $\leq 2$  nT
- All measurements must be recorded digitally.

## 8.8 Grab sampling

An appropriate number of Ground Truth Sampling, e.g., grab samples or similar, must be carried out to be able to, in conjunction with the results from the side scan sonar and bathymetric system(s) to characterize the seabed according to industry standard and to be used for environmental tests of hazardous substances.

The locations for grab sampling must be selected together with the Client's Representative on basis of a preliminary interpretation of the swathe bathymetric and side scan sonar results.

The Grab Sampling shall be carried out not more than 5m from the designated position. The accuracy of the positioning of the Ground Truth Sampling shall be better than 2m.

If less than 5 kg of geological sample material is obtained, the Client Representative may instruct up to two (2) additional attempts on each site, without any extra costs.

Samples shall be preserved. After a preliminary visual geological description of the soil, the samples shall be carefully sealed and stored on the vessel for potential later transportation to an onshore laboratory for potential further testing.

All grab samples must be subject to a geological characterization according to

- A guide to engineering geological soil description. G. Larsen et. al. DGF-Bulletin 1. Danish Geotechnical Society.

Among other things this requirement means that samples must be described regarding:

- Lithology
- Depositional environment
- Geological age

Grab samples must be subject to the following geotechnical classification tests:

- Particle size, Sieve analysis
- Particle size, Hydrometer analysis
- Organic content, Loss on ignition

## 8.9 Geotechnical data acquisition

Shallow geotechnical investigations including sampling with Vibrocore and Cone Penetration Tests (CPT) must be carried out within the survey corridor and coincide with a survey line from the Geophysical Seabed Survey.



The locations of the geotechnical investigations must be decided together with the Client Representative and shall be based on a preliminary interpretation of the sub-bottom profiling (see section 4.3).

At each location subject to geotechnical investigation one CPT test and one core sample must be performed.

In general, the target penetration depth below seabed of the CPT and the vibrocore sampling shall be 3m and 6m, due to present site conditions like crossing of traffic corridors, seabed dynamics (sand waves) and spoil ground.

#### 8.9.1 UXO risk management

To mitigate the potential threat from Un-Exploded Ordnances (UXO) and other Man-Made-Objects (MMO's) the geotechnical test positions shall be localized within 5 m of geophysical survey lines free of any anomalies.

#### 8.9.2 Utility desk study

It is the responsibility of the Consultant to ensure that the geotechnical investigations are carried out with sufficient safety distance to subsea utilities. Therefore - as a part of the mobilization the Consultant must undertake a desk study to map out known utilities along the route such as but not limited to oil and gas pipelines, power cables (both operational and dead) and telecommunication cables.

### 8.10 CPT

The Consultant shall provide, maintain, and operate equipment for in-situ CPT-testing plus evaluate and report the testing carried out.

The equipment specified for CPT shall be in accordance with IRTP (2001), *International Reference Test Procedure (IRTP) for the Cone Penetration Test (CPT)* and the *Cone Penetration Test with pore pressure (CPTU)*, Report of the International Society for Soil Mechanics and Geotechnical Engineering (ISSMGE), 2001.

All CPTs shall be performed with conical (60 degree) electrical cones which permits simultaneous measurement of the cone tip resistance, local sleeve friction and pore pressure.

The pore pressure filter and transducer position shall be at the cone shoulder, although cones with the pore pressure element on the cone face should be available on site, if required.

For a selected number of test-locations the CPT is supplemented with a test to determine the thermal conductivity by using a CPT cone to determine the thermal properties. The test is performed 1.0m below seabed.

The number of test locations is specified in the pricelist.

Sufficient calibrated piezocones (10cm<sup>2</sup> type) shall be on board the survey vessel.

The CPT system must be able to provide at least 75 kN of thrust.

A selection of cones shall be mobilised with pore pressure sensors mounted on the shoulder and cone face. All assigned field cones shall be newly calibrated before start of the Services

and copies of the calibration documentation shall be available to the Client as part of the list of pre-survey deliverables.

The penetrometer shall be positioned in such a way as to provide the perfect verticality of push rods.

The porous filter shall be accurately vacuum deaerated and positioned in order to ensure self-saturation.

The CPT units shall be controlled from the deck of the investigation vessel.

The CPTs shall be carried out not more than 5m from the designated position. The accuracy of the positioning of the CPTs shall be better than 2m.

#### Re-testing

The CPTs shall be carried out from the seabed to the target depth or refusal. If less than the target depth penetration is obtained, the Client Representative may instruct up to additional two (2) re-attempts on each site, without any extra costs.

The seabed elevation at the test location shall be recorded by pressure transducers mounted on the subsea rig and corrected for specific gravity of the water column at the location.

Settlement due to the net weight of the subsea rig shall be registered.

Field checks on site of cones and the data acquisition system shall be performed as part of the mobilization and every time a new cone is used.

Before conducting each CPT, the tip and friction sleeve readings must be zeroed and the pore pressure reading checked to comply with the water depth. Zero readings shall be reported.

The cone shall be pushed into the soil at a constant rate of 20mm per second.

During CPT operations and before start of the penetration of the push rods into the soil, the Survey Consultant shall record simultaneous, continuously and in real-time the following data in digital and graphical format and in strict accordance with the ISSMGE guidelines:

- A full record of the individual test offsets and zeros shall be kept checking that the tool is still in calibration.
- Water depth at time of test.
- The tip resistance at the penetrating probe.
- The local sleeve friction.
- The pore pressure at the cone shoulder starting from the elevation of the working platform.

The raw measured results shall be stored on digital format and backed up for subsequent processing and interpretation.

### 8.11 Vibrocore sampling

The Consultant shall provide, maintain, and operate equipment for Vibrocore sampling (in short – just core sampling) plus evaluate and report the sampling carried out.

Core sampling equipment capable of coring the seabed to the target depth shall be used. The sample diameter shall be at least 70 mm or more.

Sufficient lifting cable and power umbilical shall be provided to ensure safe operation of the system in all water depths in the survey areas.

The core sampling equipment shall be capable of collecting samples from clay, silt, gyttja or other organic formations with undrained shear strength of 2-200kN/m<sup>2</sup> as well as from less consolidated sea bottom sediments and consolidated sand.

To ensure maximum core recovery in the varying formations, core catchers of different stiffness and tightness shall be available.

To ensure all coring systems and deck handling equipment are operable, the coring systems must be tested in the harbor during mobilization and the Client Representative shall have the opportunity to witness the test.

The core samples shall be carried out not more than 5m from the designated position. The accuracy of the positioning of the cores shall be better than 2m.

The seabed elevation at the test location shall be recorded, preferably by pressure transducers mounted on the core rig, and corrected for specific gravity of the water column at the location. Penetration rate shall be recorded continuously on the vessel during coring.

Possible settlement, due to the net weight of the corer shall be recorded.

Seabed sampling on a site shall be made in such a way that at least 2m penetration and maximum recovery is obtained unless local seabed and soil conditions dictate otherwise.

#### Re-testing

If less than the target depth penetration is obtained, the Client Representative may instruct up to additional two (2) re-attempts on each site, without any extra costs.

Samples shall be preserved in the core barrel liner. Liner with samples shall be cleaned and cut into one metre lengths. After a preliminary soil description of the one metre sample, the sample shall be carefully sealed and stored in boxes on the vessel for later transportation to the onshore laboratory for further testing.

Samples must at all times be handled so risk of disturbance is minimized.

## 8.12 Geotechnical laboratory works

As a part of the Geotechnical Investigations (Work Package C) laboratory tests on extracted soil samples must be performed.

As an integrated part of the handling of all cores and samples the materials must on recovery from the seabed be subject to a visual geological description and denomination by geologist. The characterization must include photographs of samples and characterization of color and smell.

The soil sample description must include a

- Lithological description
- Description of the depositional environment
- Description of the depositional age

Geological description shall be in accordance with

- A guide to engineering geological soil description. G. Larsen et. al. DGF-Bulletin 1.

All cores must be subject to test with Pocket penetrometer or vane shear strength determination on fine grained cohesive materials. Furthermore, the thermal conductivity must be determined with a hand held instrument on selected samples of the cores.

The laboratory tests shall contain:

1. Natural Moisture content
2. Particle size analyses (sieve)
3. Particle size analyses (hydrometer)
4. Particle density
5. Organic content (loss on ignition)
6. Density, wet and dry
7. Density, Bulk density of intact core
8. Density, relative on sand.
9. Atterberg Limit Test (plasticity)
10. Thermal conductivity
11. C14-dating of organic samples

The laboratory tests shall be carried out in accordance with ASTM standards or equivalent standards.

The Client prefers if the tests #1, #5 and #10 are performed offshore.

The cores must be properly stored and archived in **at least 2 years after demobilization**. The stored samples must be clearly labelled with "PROPERTY OF ENERGINET".

## 9. Data Processing

The Consultant shall process all data acquired during the survey operations.

The data processing shall improve the subsequent interpretation and ensure the highest possible quality and resolution of the digital deliverables.

Requirements to data formats and specific deliverables are described in the document “Standards of Deliverables”.

According to the Service Agreement the Consultant is obligated to amend any non-conformances of the provided services.

Therefore, the Consultant shall include safe storage of all digital hydrographical, geophysical, geotechnical and other data that has been acquired as a part of the project.

## 10. Data Interpretation

To meet the objectives of the assignment plus the requirements for charting, reporting and digital deliverables, the Consultant shall interpret all the acquired and processed data to meet the highest possible quality.

The Consultant must carry out several integrated interpretations using both the geophysical and geotechnical data.

### 10.1 Geophysical anomalies

When processing of the geophysical data is completed then the data must be analysed to identify anomalies in Multi-beam Echo-sounding, Side Scan Sonar, Sub-Bottom Profiling and Magnetometer.

After the identification of the anomalies, they have to be analysed and compared to be interpreted e.g., as man-made-objects or as natural seabed features.

Detailed requirements for the deliverables from the interpretations are listed in the document “Standards of Deliverables”.

### 10.2 Integrated seabed surface interpretation

An integrated data analysis of the geophysical and the geotechnical data must be carried out to identify and interpret the following seabed surface themes:

1. **Seabed Surface Features** including morphological units such as dynamic seabed, biology, scars from man-made activities, gas escape features, slopes, scour patterns, erosion and deposition features and boulders. The Consultant must propose criteria for interpretation of survey data as individual boulders or areal boulder zones. The Client anticipates that “large” boulders are always individually picked in data.
2. **Seabed Surface Geology** including lithological zones, zones of different boulder coverage, outcropping till and others. The Client requests consistency between the geophysical data, the grab samples and the geotechnical investigations in the results of the interpretation of the Seabed Surface Geology.
3. **Seabed Substrate Class** including predefined seabed sediment classes determined by Danish environmental legislation.
4. **Debris and Man-Made-Objects** including wrecks, cables, pipelines, potential UXO objects, fishing gear and others.

The integrated interpretation of the abovementioned themes #1 to #4 must be done such that full class coverage is obtained within the area of investigation.

Detailed requirements for the deliverables from the interpretations are listed the document “Standards of Deliverables”.

### 10.3 Geology

Seismic data acquired with the sub-bottom profiler system must be interpreted for all survey lines.

The seismic lines must be interpreted to be used for assessment of:

- Morphological features below the seabed, e.g. stone and bubble reefs.
- Depth, thickness and distribution of geological layers.
- Geological hazardous features below seabed, e.g. soft seabed, shallow gas, pock-marks, boulders and peat.

The interpretation of seismic units shall be in accordance with

- A guide to engineering geological soil description. G. Larsen et. al. DGF-Bulletin 1.

The seismic data shall be interpreted to achieve consistency

- With the ground-truthing information from the geotechnical investigations and the surface geophysical results.
- Between along route survey lines and cross-lines.

Adjacent survey lines must be compared, and seismic reflectors must be correlated and joined to form a set of interpretation points, such that layer surface grids and isopach grids can be derived coherently for the area of investigation.

Detailed requirements for the deliverables from the interpretations are listed the document “Standards of Deliverables”.

### 10.4 Geotechnical properties of soil units

The geophysical and geotechnical results must be subject to a joint analysis and interpretation to

- describe soil units with equal or similar lithology, age, and depositional origin.
- describe the geotechnical properties of the identified soil units such as friction angle, undrained cohesion, plasticity, thermal resistivity, and bulk density.

The analysis and interpretation must be included in the Cable Route Survey Report (see section 11.8).

## 11. Reporting requirements

During the various stages of the assignment the Consultant must deliver a number of plans, reports and digital deliverables.

Table 11-1 provides a schematic and staged overview of the outputs that must be provided as an integrated part of performing the Scope of Services.

This section gives - in conjunction with the document “Standards of Deliverables” - a description of the requirements that apply to the deliverables.

Furthermore - for the Client to complete his part of the application for permissions the Consultant must upon request and without delay provide the Client with any supplementary relevant master data or metadata relating the vessels, instruments, crew or other parameters related to the survey.

For the provision of the draft deliverables indicated in Table 11-1 the Client will use the time indicated in the document “Scope of Services”, section 3 for Client review. Hereafter, the Consultant will finalize revised deliverables based on the Client’s comments and feedback.

*Table 11-1. Schematic overview of the various deliverables that must be provided during the assignment.*

Event	Deliverable	Document reference	WP
Contract  Kick-off meeting	Project Execution Plan HSE Management Plan Quality Management Plan	Section 11.1	A – D
Mobilization start  Mobilization end	Acceptance Test Report	Section 11.2	A – D
Survey operations	Daily Progress Reports Weekly Management Reports Monthly HSE Reports Interim Delivery Packages #1 and #2	Section 11.3 Section 11.4 Section 11.5 Section 11.6	A – D
De-Mobilization end	Operational Report no 1, 2 and 3	Section 11.7	A – D
Provision of <b>Draft</b> deliverables	Cable Route Survey Report no 1, 2 and 3 Crossings Survey Report no 1, 2 and 3 Digital Deliverables for report no 1, 2 and 3	Section 11.8 Section 11.9 Section 11.10	A – D
Provision of <b>Revised</b> deliverables	Do.	Do.	A – D



### 11.1 Project Execution and QHSE plan's

As a part of the project mobilization prior to marine activities the Consultant must prepare and forward three plans to the Client:

- A plan for Project Execution
- A plan for Quality Plan
- A plan for Health, Safety and Environment (HSE)

The Consultant shall forward the plans to the Client in due time for the Client to review before the kick-off meeting. The Client request reception at least three days in advance.

The Project Execution Plan shall at least include the following parts:

1. Program planning.
  - a. A high-level description of main activities and their order of performance.
  - b. Technical method statement regarding marine operations (e.g. LARS activities).
  - c. Description of survey line plan and how the plan accommodates that the quality requirements described in Chapter 8 are met. The survey line plan must be provided in an ESRI digital format.
  - d. Description of how to plan the scope of the geotechnical investigations (CPT and Vibrocore) and grab sampling.
2. Plan for technical quality assurance and quality control.
  - a. Plan for nomenclature and denomination of survey lines, tracks, locations, grabs, cores and CPT tests.
  - b. Plan for nomenclature and denomination of digital deliverables.
3. Plan for the execution of the acceptance tests including pass criteria
  - a. Template for the acceptance test reports for instruments applied for the execution of the Services.
4. Templates for all requested reporting incl. digital deliverables.
5. Utility desk study (see section 8.9.2).

The HSE management plan shall fulfil the requirements specified in the document:

- Scope of Services - Enclosure 3 - HSE requirements

The Quality management plan shall fulfil the requirements in the document:

- Scope of Services - Enclosure 4 - Quality requirements

Based on the Client's comments the Consultant shall forward a final Project Execution Plan to the Client for approval.

No quality related services must be commenced prior to the approval of the Project Execution Plan by the Client. This means that the plan needs to be approved prior to commencing land-fall/nearshore activities.

## 11.2 Acceptance Test Reports

The vessels are mobilized when all equipment are tested and calibrated and the data acquisition can begin.

As part of the mobilization of the vessels, the final testing and calibrating shall be witnessed by the Client Representative and reported by the Consultant in an Acceptance Test Report for each vessel to be applied for execution of the services.

The Client Representative and the Consultant's party chief shall by signing the Acceptance Test Report agree that the vessels are mobilized and ready for survey.

## 11.3 Daily Progress Reports

Daily Progress Reports for a vessel shall be prepared and submitted from start of mobilization and uninterrupted until end of demobilization.

The Daily Progress Reports must include information regarding:

- Survey status: Completed quantities (current day and cumulated) and remaining quantities.
- Time break down: Mobilization, Operation, Standby, Transit, etc. (current day and cumulated).
- Weather observations (sea state, wind and visibility).
- Weather forecast – next 24 hours.
- Instrumental deviations from normal operation (break downs, calibration issues, etc.).
- QHSE incidents.

The Daily Progress Report must be submitted by e-mail to the Client before 09.00 am the following day.

The final format of the Daily Progress Report should be addressed at the project kick-off meeting and agreed with the Client.

## 11.4 Weekly Management Reports

From commencement to completion of contract, Weekly Management Reports (WMR) shall be prepared and submitted by the Consultants contract manager.

The purpose of the report is to inform managers, directors, and non-technical stakeholders about the performance and progress. The Client assumes, that the WMR's are prepared based on the business data available in the already provided Daily Progress Reports.

The weekly management reports shall cover the previous week's services plus the actual status of the project as on Sunday at 24:00 hrs. UTC.

The WMS is using a short (maximum two pages) and fixed format covering the following information:

Progress table displaying:

- Survey quantities (e.g. line-km, grab samples, box surveys, inspections,...), planned
- Survey quantities, completed last week
- Survey quantities, completed in total
- Survey quantities, remaining

Time-break-down table displaying information about the time categories

- Operations
- Transit
- Down-time, weather
- Down-time, other
- Port call
- ...

For each time category the following figures are provided:

- Planned time
- Time completed last week
- Time completed in total
- Time expected remaining

A table with status on selected milestones

- All marine activities completed
- Report provided, revised issue

For each milestone the following figures are provided:

- Milestone date agreed, time of contract
- Milestone date agreed, revised agreement
- Consultants forecast of date for completion

The Weekly Management Reports are issued every Monday before EOB.

### 11.5 Monthly HSE reports

On a monthly basis the Consultant is required to submit work hour statistics to the Client. The requirements to the HSE report is described in the document “HSE requirements”, section 1.21.

The specific format of delivery is discussed and agreed at the project kick-off meeting.

### 11.6 Interim Delivery Package #1 and #2

To support interfacing activities that rely on the survey results from Work Package A and B the following intermediate deliverables are provided:

- Interim Delivery Package #1: Survey data for environmental investigations

- Interim Delivery Package #2: Survey data for archaeological assessment

#### 11.6.1 Interim Delivery Package #1 for environmental investigations

The Client commences marine, environmental investigations in 2023 with third party suppliers. To aid the planning and execution of these investigations the following products are required as digital and preliminary results:

- Bathymetry
- Seabed surface classification, Geology
- Seabed surface classification, Morphology
- Seabed surface classification, Substrate type (\*)
- Grab samples, geological classification and laboratory tests

(\*) See Annex 2 of the document “Standards of Deliverables”.

Requirements to the digital formats of the products are described in the document “Standards of Deliverables”.

#### 11.6.2 Interim Delivery Package #2 for marine archaeological assessment

The Client commences marine archaeological site assessment early in 2023 with designated museums. To aid the planning and execution of these investigations the following products are required as digital and preliminary results:

- Bathymetry
- Side Scan Sonar
- Magnetometry
- Seabed surface classification, Geology
- Sub-bottom geology, horizon elevation grids
- Sub-bottom geology, layer isochore grids

The sub-bottom geology grids are - in particular - relevant for the archaeologist’s ability to evaluate soil units with potential stone age heritage potential.

Requirements to the digital formats of the products are described in the document “Standards of Deliverables”.

### 11.7 Operational Report

The Consultant must submit Operational Reports:

- Operational Report no 1 covering marine activities for Part 1 to Part 3 (North Sea I)
- Operational Report no 2 covering marine activities for Part 4 to Part 5 (Kattegat II)
- Operational Report no 3 covering marine activities for Part 6 to Part 7 (Kriegers Flak II)

Within four weeks after demobilisation the Consultant must submit an Operational Report that documents vessels, instruments and equipment, methods, and procedures, etc. The Operational Report shall be provided for Work Package A – D.

The Operational Report must cover the operations of all offshore and landfall/nearshore resources. The Acceptance tests reports must be attached the Operational Report.

Requirements to the Operational Report are described in the document “Standards of Deliverables”.

### 11.8 Cable Route Survey Report

The Consultant must submit Cable Route Survey Report no 1, 2 and 3 by the time indicated in the contracted time schedule:

- Cable Route Survey Report no 1 covering Part 1 to Part 3 (North Sea I)
- Cable Route Survey Report no 2 covering Part 4 and Part 5 (Kattegat II)
- Cable Route Survey Report no 3 covering Part 6 and Part 7 (Kriegers Flak II)

In general, the reports inclusive charts and digital deliverables shall provide an integrated presentation of the results and findings of the survey from the work packages:

- WP A – Offshore cable route survey
- WP B – Nearshore and landfall survey
- WP C – Geotechnical investigations
- WP D – Crossings survey

The reports shall be interpretive and provide a detailed assessment of the seabed and sub-seabed conditions by correlating the results gained from the various instruments during the survey activities.

The preparation of the reports must follow the requirements described in the document “Standards of Deliverables”.

Throughout the preparation of the reports, charts and the digital data deliverables, the Consultants Reporting Manager shall maintain a regular dialogue with the Client.

After receiving the reports, charts and the digital data deliverables the Client will use four weeks for reviewing and commenting on the delivery.

Hereafter the Consultant must amend the reports, charts and digital deliverables according to the feedback from the Client.

### 11.9 Crossings Survey Report

Together with the Cable route survey report the Consultant must issue a separate Crossings Survey Report that documents the findings of Work Package D.

The purpose of the Crossing report is to provide a basis to negotiate potential crossing agreements with third party asset owners and have full documentation of all crossings within the area of investigation.

Further requirements are described in the document “Standards of Deliverables”,

### 11.10 Digital deliverables

Together with Cable Route Survey Report no 1, 2 and 3, digital deliverables must be supplied for all work packages.

The digital deliverables are organized and provided as three separate packages:

- Digital Deliverables for Cable Route Survey Report no 1
- Digital Deliverables for Cable Route Survey Report no 2
- Digital Deliverables for Cable Route Survey Report no 3

Each individual package includes the measured data from the various geophysical and hydrographical sensors as well as GIS deliverables.

IN PARTICULAR: Each individual digital delivery package includes own stand-alone:

- GIS databases
- Folder structure with measured and processed data
- Folder structure with charts

The format and specifications of these deliverables must follow the requirements described in the document “Standards of Deliverables”.

## 12. Meetings

### 12.1 Kick-off meeting

The Consultant must facilitate a project kick-off meeting at his own premises where at least the following topics will be a part of the agenda:

- Mobilization and acceptance test criteria
- Project execution plan and Daily Progress Reports
- Principles for planning and adjusting the program of work
- Project Deliverables
- Time Schedule
- Organisation, roles and responsibilities
- QHSE
- Commercial matters
- Contractual matters

The project kick-off meeting shall be scheduled prior to the mobilization of the marine resources.

### 12.2 Weekly Management Meetings

From commencement of the services and uninterrupted until the completion of the services, every Tuesday morning and based on the previous day's weekly management and technical reporting, management web-meetings between the Consultants and the Client's project management incl. reporting manager shall be held.

The Consultant shall facilitate the web-meetings.

The Consultant shall minute the meetings and not later than 24 hours after ending of the meeting, the minutes shall be distributed as on the project kick-off meeting.

### 12.3 Monthly Status Meeting

The Consultant must participate in monthly status meetings that will be hosted every second month by the Client in Frederica, Denmark and every second month by the Consultant.

The purpose of the Status Meeting is to address the status and progress, the data quality, the deliverables as well as the commercial and contractual status of the contract. Furthermore, relevant technical key topics may be addressed depending on current project phase.

The Consultant shall at least be represented by two persons of whom the Consultants project manager is one of them.

Unless otherwise agreed the Monthly Status meetings shall be held until revised issues of the Geophysical Survey Report and the Benthic report have been accepted by the Client.

# STANDARDS OF DELIVERABLES

<b>Project</b>		Danish Offshore Wind 2030					
<b>Assignment</b>		Cable Route Survey					
<b>Document Title</b>		Scope of Services - Enclosure 2 - Standards of Deliverables					
<b>Document No.</b>		22/00573-7					
<b>Audience</b>		Tenderers					
Version	Document status	Prepared by		Reviewed by		Approved by	
		Name	Date	Name	Date	Name	Date
1	Template	CGL	01-11-2022				
2	For tender	JCO	28-02-2023	NHW	07-03-2023	XPAN	27-03-2023

## Table of Contents

1. Introduction.....	2
2. Operational Report .....	3
3. Cable Route Survey Report .....	4
4. Crossings Survey Report.....	6
5. Digital deliverables .....	7
6. References.....	14
Annex 1 – Requirements to TSG .....	15
Annex 2 – Substrate type classification .....	16



## 1. Introduction

This document specifies a set of base requirements that must apply for the deliverables supplied to the Client by Consultants.

The concept of "minimum requirements" is used to express a set of general requests for the deliverables supplied to the Client. This concept does not relieve any Consultant from producing deliverables that meet the general industry standard.

The Consultant can only deviate from these specifications upon agreement with the Client.

All reports including all attached charts, profiles, enclosures and annexes must be provided in English language and as standard PDF files.

The Scope of Service does not require that any deliverable is provided as printed paper reports.

## 2. Operational Report

The Operational Report must in general describe how the survey was completed. As such the Operational report must at least include the following:

- a. Executive summary.
- b. Description of any QHSE events
- c. Project introduction and background.
- d. Description of the applied vertical and horizontal reference systems.
- e. Description of all applied vessels.
- f. Detailed description of all instruments and measurement equipment.
- g. Documentation of the calibration and system tests (enclose Acceptance Test Reports).
- h. Definition of area of investigation. For Cable Route Surveys applied Route Position Lists shall be enclosed.
- i. Description of planned offshore scope such as survey line plans and seabed test locations.
- j. Description of completed offshore scope including cumulative quantities.
- k. Documentation of the spatial accuracies achieved for the different systems including multi-beam echo-sounding system, subsea positioning systems, ROV operational systems and geotechnical systems.
- l. Description of data processing and interpretation methods.
- m. Description of norms and standards applied for the various work packages.
- n. Description of the cumulative time breakdown from the start of the mobilization to the end of the demobilization.

### 3. Cable Route Survey Report

The Cable Route Survey Report must present the results of the survey, the achieved data quality and the interpreted data products.

The report must at least include the following:

- a. Executive Summary.
- b. Project introduction and background.
- c. Description of area of investigation.
- d. Applied geodetic system and vertical reference system.
- e. Summary of the vessels and instrumental spread.
- f. Assessment of the achieved data quality.
- g. Presentation of survey results for the seabed surface:
  - a. Bathymetry
  - b. Seabed surface geology
  - c. Geotechnical properties
  - d. Seabed surface morphology
  - e. Seabed surface features.
- h. Presentation of survey results for the seabed geology including:
  - a. A summary of the regional geological history based on desk study.
  - b. A presentation of the identified seismic reflectors including statistics on reflector depth below seabed and reflector elevation relative to applied vertical datum.
  - c. Geotechnical sample interpretations, relating to the soil parameters from the CPT tests and the lithological descriptions and laboratory analysis of the vibrocores.
  - d. An interpretation of the soil units associated with the identified reflectors. The interpretation include expectations to sedimentology, depositional environment as wells as age of sediment deposition, also reflecting the geotechnical samples. Nomenclature and conventions according to /1/.
- j. Detailed route analysis from “start” to “end” of route with description of hydrographic, morphological, geological/geotechnical, archaeological and environmental challenges to the route. Must be KP referenced.
- k. Summary of archaeological findings and anomalies with archaeological potential.
- l. Overview of the digital deliverables.

### 3.1 Charts

The Cable Route Survey Report must as a minimum be enclosed the following charts:

Overview / North Up charts:

- a. Overview chart showing coastlines, EEZ, large scale bathymetric features and area of investigations.
- b. Chart showing actual performed survey lines and seabed sampling positions.

Alignment charts with KP markings including the below information:

- c. Bathymetry as colour shaded relief, with depths contours
- d. Side Scan Sonar mosaic image, High frequency
- e. Seabed surface classification, Geology
- f. Seabed surface classification, Morphology.
- g. Seabed objects, identified objects and lineaments (swathe bathymetric and side scan sonar objects, lineaments, magnetic objects, etc.).
- h. Seabed features chart, with all identified seabed features including, morphological, archaeological, seabed obstructions and infrastructure.
- i. Seabed elevation profile, showing seabed surface and interpreted geological horizons and geological structures relative to vertical reference datum.
- j. Seabed depth profile, showing seabed surface and interpreted geological horizons and geological structures relative to seabed.

Integrated geotechnical profiles:

- k. Integrated geotechnical profiles showing lithological profiles based on the core samples together with CPT measurements and results from the geotechnical laboratory analyses.

Target catalogue presenting for each target (excluding boulders):

- l. Anomaly ID, coordinates, geophysical method, water depth (MSL)
- m. All relevant geophysical attributes.
- n. Imagery panels with bathymetry, side scan sonar mosaic and magnetometry (if applicable).

For all charts/alignment charts, the Consultant shall propose for Client approval the formats of the maps. This should at least include content, symbology, paper size, map scale and layout.

## 4. Crossings Survey Report

The Crossings Survey Report must present the results of from Work Package D.

The Crossings Survey Report must at least include the following:

- a. Executive Summary.
- b. Project introduction and background.
- c. Summary of the vessel(s) and technical setup related to Work Package D.
- d. Description of the surveyed crossing utilities:
  - a. Type, Owner, Asset name, Location
  - b. Conclusion of utility inspection: Utility found or not found.
  - c. Bathymetry, Burial, Geotechnical conditions, etc.
- e. Description of the digital deliverables.
- f. The Utility desk study completed as a part of the Project Execution Plan must be attached as an Annex.

The Crossings Survey Report must be enclosed a number of charts and must as a minimum be enclosed the following charts:

- g. Overview map showing coastlines, EEZ, the cable routes with KP markings, locations of the investigate crossing utilities.

For each crossing utility that has been surveyed, the results are provided as alignment chart including:

- a. Bathymetry as colour shaded relief, with depth contours.
- b. ROV-tracks and – if found – location of the crossing utility.
- c. Seabed elevation profile, showing seabed surface and – if found - utility depth of burial.
- d. Seabed depth profile, showing seabed surface and – if found - utility depth of burial.
- e. Events identified along the survey of the crossing utilities.

For all charts/alignment charts, the Consultant shall propose for Client approval the formats of the maps. This should at least include content, symbology, paper size, map scale and layout.

## 5. Digital deliverables

### 5.1 General structure

This section describes the digital deliverables that must be provided as a part of the delivery.

The digital deliverables are specified below as a numbered list such that each deliverable has a unique ID. This ID must be used in referencing the specific deliverable during the project execution.

The package of digital deliverables must be provided with a suitable spreadsheet that lists the individual deliverables including the following information:

- Unique deliverable ID number
- Deliverable name
- Deliverable type
- Revision number
- Date of issue
- Data file format

The digital deliverables are provided on external hard drives in two (2) copies.

### 5.2 GIS deliverables

A number of the digital deliverables must be delivered for ESRI ArcGIS using the Clients template as described in Annex 1. The template is referred to as a *Template Survey Geodatabase* or as TSG.

In the list below describing the requirements for the digital deliverables, references will be made to specific data objects in the TSG.

Multiple deliverables are required to be loaded to the same TSG data object. For instance, it is required that vessel tracks and instrument-specific tracks are stored in the same object (TRACKS\_LIN). To distinguish between the different input data, the attributes must be configured to reflect the different sources.

For the geophysical survey data (MBES, SSS, MAG and SBP) targets are required at two levels:

- As anomalies (the ANOMALY data objects).
- As interpreted targets (the MMO and the SEABED\_FEATURE data objects).

In this context *anomalies* should not be interpreted – these are considered as data markers only. Interpretation of *targets* should be performed taking all swathe data into consideration. The data objects MMO and SEABED\_FEATURES include attributes to store interpretation, certainty and anomaly reference.

The Consultant may propose changes to the TSG code lists (ESRI *Domains*).

### 5.3 Bathymetric data

The results of the bathymetric survey are delivered as processed and despiked data with the following deliverables:

1. Un-gridded soundings, (X,Y,Z) values in ASCII format.
2. Gridded soundings, 0.25m resolution, (X,Y,Z) values in ASCII format.
3. Gridded soundings, 1.00m resolution, (X,Y,Z) values in ASCII format.
4. Gridded soundings, 5.00m resolution, (X,Y,Z) values in ASCII format.
5. Gridded soundings, 0.25m resolution, GeoTIFF grid format.
6. Gridded soundings, 1.00m resolution, GeoTIFF grid format.
7. Gridded soundings, 5.00m resolution, GeoTIFF grid format.
8. Bathymetric contour curves with 50cm interval, as TSG object CONTOURS\_LIN
9. Vessel tracks, as TSG object TRACKS\_LIN, indicate equipment carrier and equipment type in attributes.
10. Bathymetry - TVU 1.00 m resolution, GeoTIFF grid format
11. Bathymetry - THU 1.00 m resolution, GeoTIFF grid format
12. Bathymetry - Backscatter 32bit Geotiff (amplitude populated channels).
13. Sound velocity profiles (SVP) in native format
14. MBES Anomaly target list, as TSG object MBES\_ANOMALY\_PTS, anomaly characteristics provided in attributes.

Deliverable item 1, Ungridded soundings:

- Vertical reference: Z-values provided as *depths* positive *downwards*.
- Are delivered as datafiles < 250 Mbyte otherwise the datafiles must be split.

Deliverable items 2 to 4, Gridded soundings, ASCII XYZ:

- Vertical reference: Z-values provided as *depths* positive *downwards*.
- Are delivered as datafiles < 250 Mbyte otherwise the datafiles must be split.

Deliverable items 5 to 7, Gridded soundings, GeoTIFF:

- Vertical reference: Z-values provided as *elevations* positive *upwards*.
- GeoTIFF Grids are stored in an ESRI file geodatabase.
- *Spatial Reference* has been configured.
- *Calculate Statistics* has been performed.
- *Build Pyramids* has been performed.

## 5.4 Side scan sonar data

The results of the SSS data must be supplied as:

15. Raw side scan data as native file format with corrected navigation, High frequency.
16. Raw side scan data as native file format with corrected navigation, Low frequency.
17. Navigation files, CSV-format.
18. SSS instrument tracks, as TSG object TRACKS\_LIN, indicate equipment carrier and equipment type in attributes.
19. SSS Anomaly target list, as TSG object SSS\_ANOMALY\_PTS, anomaly characteristics provided in attributes.
20. SonarWiz project:
  - a. All data clipped/trimmed visually of pycnocline effects.
  - b. Delivered in blocks project size < 400 GB. Alternatively sub-blocks if project exceeds 400GB or speed of project is declined due to size.
  - c. SSS contacts included.
  - d. GIS/data:
    - i. MBES\_ANOMALY
    - ii. MAG\_ANOMALY
    - iii. SURVEY\_POL (with survey blocks)
    - iv. MBES 0.25m tif – Provided in elevations.
    - v. SSS HF .tif
    - vi. Coverage maps (trimmed data only)
    - vii. ReadMe file for included files and data.

## 5.5 Magnetometer data

The results of the MAG data must be supplied as:

21. MAG measurements, CSV-format, with the following data columns
  - a. Date (YYYY-MM-DD)
  - b. Time (HH:MM:SS)
  - c. Location ID (Unique location ID number)
  - d. Magnetometer line ID (Unique line number)
  - e. Survey line Heading
  - f. Total field (Raw magnetic measurement, nT)
  - g. Residual field (Residual magnetic field, nT)
  - h. Easting1, Northing1 (Measured coordinates, meters)
  - i. Easting2, Northing2 (Processed coordinates, meters, filtered coordinates and reduced for obvious noise)
  - j. Lay-back (Instrument lay-back distance, meters)
  - k. Altitude (Instrument altitude above seabed, meters)
22. MAG instrument tracks, as TSG object TRACKS\_LIN, indicate equipment carrier and equipment type in attributes.
23. MAG Anomaly target list, as TSG object MAG\_ANOMALY\_PTS, anomaly characteristics provided in attributes.
24. Oasis montaj Project.

Deliverable item 21, MAG measurements:



- The magnetic residual field (item g above) is the result of a process where the measured Total magnetic field (item f above) is subtracted medium- and long-wavelength signals caused by the geomagnetic field, ionospheric and sources and regional geological sources.
- The magnetic Residual field must be processed to reflect any ferrous or magnetic objects on the seabed or with shallow burial within the seabed e.g. wrecks and large debris, subsea cables and pipelines or other Man-Made ferrous objects.

## 5.6 Sub-bottom profiling data

The results of the seismic data acquisition must be supplied as:

25. Processed SBP, SEGY format. Processing includes at least that
  - a. SEGY headers are configured with geometry
  - b. Traces are corrected for motion
  - c. Traces are aligned with datum
26. Kingdom Suit Project containing at least:
  - a. Time and depth converted SEGY-files.
  - b. Gridded horizons, both BSB (Below seabed and MSL)
  - c. 5m MBES grid
  - d. Survey area including track lines
  - e. Geotechnical data: Vibrocorer and CPT.
27. SBP instrument tracks, as TSG object TRACKS\_LIN, indicate equipment carrier and equipment type in attributes.
28. SBP anomaly target list, as TSG object SBP\_ANOMALY\_PTS, anomaly characteristics provided in attributes.
29. Interpretation of the processed seismic data. These data include interpretation points for digitized horizons identified in the seismic recordings. The data must be delivered as a point list file in CSV-format with the following data columns:
 

a. PointID	Unique identification number
b. Survey line ID	Unique survey line identification
c. SEGY_Name	Filename of SEGY file
d. KP	Km point
e. Easting, Northing	Coordinates, meters
f. TWT	Two-way-time, millisec
g. Elevation	Elevation, MSL, meters
h. Depth BSB	Depth Below Seabed, meters, based on constant velocity
i. Type	The interpretation points must be assigned a "type value" to identify the observed layer boundaries, etc.
30. Generated **elevation grids** relative to vertical datum for each interpreted horizon in 5 m resolution as
  - a. GeoTIFF grid
  - b. An (X,Y,Z) values in ASCII format (Z as the horizon elevation in meter)
31. Generated **depth below seabed** (BSB) grids for each interpreted horizon in 5 m resolution as
  - a. GeoTIFF grid

- b. An (X,Y,Z) values in ASCII format (Z as the horizon depth BSB in meter)
- 32. Generated **Isochore** (layer thickness) grids for each interpreted soil unit in 5 m resolution as
  - a. GeoTIFF grid
  - b. An (X,Y,Z) values in ASCII format (Z as the layer thickness in meter)

## 5.7 Grab sampling

The results of the ground truth sample data must be delivered as:

- 33. Grab sample positions, as TSG object GEOTECHNIC\_PTS, indicate sampling characteristics in attributes.
- 34. Grab sample classification, MS-Excel spread sheet with the following data columns:
  - l. Unique sampling ID
  - m. Geological description of the recovered sample,
    - i. Lithology
    - ii. Depositional environment
    - iii. Depositional age
- 35. Grab sample laboratory analysis, overview table and result tables, MS-Excel spread sheet.

## 5.8 Geotechnical investigations

The results for the geotechnical investigations must be delivered as:

- 36. Vibrocore and CPT sample positions, as TSG object GEOTECHNIC\_PTS, indicate sampling characteristics in attributes.
- 37. Geotechnical laboratory test, overview table and result tables, MS-Excel spread sheet.
- 38. All CPT tests, Vibrocore, Piston core, in situ and laboratory test results provided as an AGS 4 data file (see e.g., [www.agsdataformat.com](http://www.agsdataformat.com)).

## 5.9 Integrated seabed surface interpretation

The acquired data must be used for an integrated interpretation of the following themes related to the seabed:

- Seabed Surface Features.
- Seabed Surface Geology.
- Seabed Substrate type (see Annex 2)
- Debris and Man-Made Objects.

The Client assumes that the most feasible solution for interpretation of

- **boulders** on the seabed are performed using automatic boulder interpretation methods.
- **seabed surface** geology, features and substrate type are performed with backscatter images.

The results of the interpretation must be provided as:

39. Seabed Surface Geology, as TSG object SEABED\_GEOLOGY\_POL, indicate surface geological unit in attributes.
40. Seabed Surface Features, as TSG object SEABED\_SURFACE\_PTS, indicate surface forms in attributes.
41. Seabed Surface Features, as TSG object SEABED\_SURFACE\_LIN, indicate surface forms in attributes.
42. Seabed Surface Features, as TSG object SEABED\_SURFACE\_POL, indicate surface forms in attributes.
43. Seabed Substrate type, as TSG object SEABED\_SUBSTRATE\_POL, indicate substrate type in attributes (see Annex 2).

The polygon deliverables 39 and 42 must have full coverage within the survey area.

44. Man-Made-Objects, as TSG object MMO\_PTS, indicate MMO type in attributes.
45. Man-Made-Objects, as TSG object MMO\_POL, indicate MMO type in attributes.
46. Man-Made-Objects, as TSG object MMO\_LIN, indicate MMO type in attributes.

#### 5.10 ROV inspection data for Crossings Survey

The digital deliverables from the Crossings Survey include data from seabed survey with multibeam echosounder and ROV inspections with cable/pipe-tracking sensors.

Bathymetric deliverables:

47. Un-gridded soundings, (X,Y,Z) values in ASCII format.
48. Gridded soundings, 0.25m resolution, (X,Y,Z) values in ASCII format.
49. Gridded soundings, 0.25m resolution, GeoTIFF grid format.

Additional requirements for items 47 to 49 apply as described in section 5.3.

ROV-inspection deliverables:

50. ROV-tracks as TSG object TRACKS\_LIN
51. Processed five-point-file, \*.5pt in ASCII format.
52. Processed five-point-file as TSG object FIVE\_POINTS\_TAB, Indicate crossing number (XNO) in attributes.
53. Seabed profile as TSG object CABLE\_DOB\_PTS
54. Location of crossing between cable route RPL and crossing utility as TSG object CROSSINGS\_PTS, indicate KP and ASSETNAME in attributes.
55. Polyline of crossing utility as TSG object CROSSINGS\_LIN

#### 5.11 Reports, Charts and Annexes

A PDF copy of all reports including all attached charts, profiles, enclosures and annexes must be provided as a part of the digital deliverables:

56. Operational Report.
57. Cable Route Survey Report.

The Consultant may use suitable subdivision to reflect substructure with e.g., charts, annexes or enclosures.

## 6. References

- /1/ A guide to engineering geological soil description. G. Larsen et. al. DGF-Bulletin 1.  
Danish Geotechnical Society.

## Annex 1 – Requirements to TSG

The consultant should follow the description provided in Scope of Services - Encl 2 - Standards of deliverables - Annex 1 - v024.

TSG's (feature class (F) and raster (R)) should be denoted with a suffix denoting the corresponding revision.

- SN0000\_000\_F\_ETRS89\_UTMXXN\_revXX
- SN0000\_000\_R\_ETRS89\_UTMXXN\_revXX

For the crossing survey a suffix denoting "C" should

- SN0000\_000\_F\_ETRS89\_UTMXXN\_C\_revXX
- SN0000\_000\_R\_ETRS89\_UTMXXN\_C\_revXX

## Annex 2 – Substrate type classification

The substrate type map is divided into the following substrate types, cf. the Danish Råstof-bekendtgørelsen (BEK no. 1680 of 17/12/2018, Phase IB):

**Substrate type 1 - Sand, silt and mud:** Areas consisting of fine-grained soft bottom or solid sand bottom (possibly with dynamic bottom shapes (sand ripples etc.)) with varying amounts of shells and gravel. Sand is defined as grain sizes in the range of 0.06-2.0 mm.

Typically, substrate type 1 is subdivided into substrate type 1a (silty, soft bottom), 1b (solid sandy bottom) and 1c (clay bottom), which is not stated in the “Råstofbekendtgørelsen”. It is a standard substrate type subdivision used in a wide range of marine raw material investigations, Natura 2000 projects etc. The subdivision is approved by MST (MST = Danish Environmental Protection Agency).

**Substrate type 2 - Sand, gravel and pebbles:** Areas consisting of a mixture of coarse sand and gravel with a grain size of approx. 2-20 mm and pebbles with sizes of approx. 2-10 cm. The substrate type also contains some larger stones from approx. 10 cm and larger, covering from 1-10% of the seabed.

Substrate type 2 can be subdivided into substrate types 2a and 2b, respectively. According to the “Råstofbekendtgørelse”, these two types constitute the same substrate type, but on the basis of their different characteristics a division can be made. Substrate type 2a consists mainly of coarse sand, gravel and pebbles. This type of substrate typically consists of only a few larger stones over 10 cm. Substrate type 2b consists of 1-10% larger stones typically on a coarse sandy bottom.

**Substrate type 3 - Sand, gravel and pebbles, and larger stones:** Areas consisting of mixed substrates with sand, gravel and pebbles with a varying amount of larger stones from approx. 10 cm covering 10-25% of the seabed. The substrate type differs from substrate type 2 by containing a greater number of stones from ca. 10 cm and upwards. The stones are usually scattered, and only in one layer.

**Substrate Type 4 - stony areas and stone reefs with 25-100% of larger stones:** Areas dominated by stones from approx. 10 cm and up - from dense irrigation to actual stone reefs with or without cavities. There may also be varying amounts of sand, gravel and pebbles, as well as biogenic reefs or limestone reefs in this substrate type. The stones can be in one layer, or form actual stone reefs, which rise above the surrounding bottom with several layers (cavity forming).

Table 1. Substrate classes.

Class	Description of substrate class
1a	Sand, silty, soft bottom
1b	Sand, solid sandy bottom
1c	Clay bottom
2a	Sand, gravel and pebbles – few larger stones
2b	Sand, gravel and pebbles – seabed cover of larger stones 1% to 10%
3	Sand, gravel and pebbles – seabed cover of larger stones 10% to 25%
4	Stony areas and stone reefs - seabed cover of larger stones 25% to 100%