Vattenfall Wind Power Ltd

Thanet Extension Offshore Wind Farm

Environmental Statement Volume 2

Chapter 1: Project Description (Offshore)

June 2018, Revision A

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Vattenfall Wind Power Ltd

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Volume 2

Chapter 1: Project Description (Offshore)

June 2018

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Table of Contents

1 PROJECT DESCRIPTION (OFFSHORE)

1.1 Introduction

1.1.1 This chapter of the Environmental Statement (ES) describes the offshore elements of the proposed development. This chapter accompanies the application for development consent. The Thanet Extension Offshore Wind Farm (Thanet Extension) is a proposed development around the existing Thanet Offshore Wind Farm (TOWF). The offshore components comprise up to 34 Wind Turbine Generators (WTGs), up to one Offshore Substation (OSS), up to one Meteorological Mast (Met Mast), up to one LIDAR device, up to one wave buoy, inter-array cables and up to four offshore export cables (and associated scour/ cable protection). It provides a description of the offshore project design as currently understood and the proposed methods of construction, Operations and Maintenance (O&M), and decommissioning of the wind farm components.

1.1.2 Where there is clear physical cross over in the offshore and onshore study areas, such as the intertidal area of landfall at Pegwell Bay, a description is provided in this chapter of the works below Mean High Water Springs (MHWS) with a brief description of the onward ‘onshore’ works for completeness. Full details of the onshore elements of the proposed development are provided in Volume 3, Chapter 1: Project Description (Onshore) (Document Ref: 6.3.1).

1.1.3 The data required to identify and assess the likely significant effects of the project upon the environment are provided in this chapter. Where measures to reduce or avoid adverse environmental effects are built-in to the project design, these are also described.

1.1.4 At this stage in the Thanet Extension development process, the project description is indicative and the ‘envelope’ has been designed to include flexibility to accommodate further project refinement during detailed design, post-consent. This chapter therefore sets out a series of options and parameters for which maximum values are shown. The maximum values constitute the worst-case scenario in relation to Thanet Extension.

1.1.5 The maximum design values defined in this project description have be compiled using expert opinion on Offshore Wind Farm construction, operation and maintenance (O&M). Specific information regarding construction and O&M values has also be gained from the existing Thanet Offshore Wind Farm (TOWF).

1.2 Design (Rochdale) Envelope Approach

1.2.1 The use of the design envelope approach has been recognised in the Overarching National Policy Statement (NPS) for Energy (NPS EN-1) (DECC, 2011a) and the NPS for Renewable Energy Infrastructure (NPS EN-3) (DECC, 2011b). This approach has been used in the majority of Offshore Wind Farm (OWF) applications.

1.2.2 In the case of offshore wind farms, NPS EN-3 (paragraph 2.6.42) recognises that:

“Owing to the complex nature of offshore wind farm development, many of the details of a proposed scheme may be unknown to the applicant at the time of the application, possibly including:

Precise location and configuration of turbines and associated development;

Foundation type;

Exact turbine tip height;

Cable type and cable route; and

Exact locations of offshore and/ or onshore substations.”

1.2.3 NPS EN-3 continues:

“The Secretary of State should accept that wind farm operators are unlikely to know precisely which turbines will be procured for the site until sometime after any consent has been granted. Where some details have not been included in the application to the Secretary of State, the applicant should explain which elements of the scheme have yet to be finalised, and the reasons. Therefore, some flexibility may be required in the consent. Where this is sought and the precise details are not known, then the applicant should assess the effects the project could have to ensure that the project as it may be constructed has been properly assessed (the Rochdale [Design] Envelope)”. (DECC, 2011b). NPS EN-3 also states that:

“The ‘Rochdale [Design] Envelope’ is a series of maximum extents of a project for which the significant effects are established. The detailed design of the project can then vary within this ‘envelope’ without rendering the ES [Environmental Statement] inadequate”.

1.2.4 The design envelope approach is widely recognised and is consistent with The Planning Inspectorate (PINS) Advice Note Nine: Rochdale Envelope (PINS, 2012) (page 11) states that:

“The ‘Rochdale Envelope’ is an acknowledged way of dealing with an application comprising EIA development where details of a project have not been resolved at the time when the application is submitted”.

1.2.5 Throughout the Scoping Report and subsequent EIA, the design envelope approach has been taken to allow meaningful assessments of Thanet Extension to proceed, whilst still allowing reasonable flexibility for future project design decisions.

1.3 Thanet Extension Boundary

1.3.1 The offshore boundary of Thanet Extension is shown in Figure 1.1. The offshore development boundary encompasses:

- The Thanet Extension array area. This is where the OWF will be located, which will include the WTGs, WTG foundations, inter-array cables, Met Mast (if required), LIDAR device (if required), Wave buoy (if required) and OSS (if required, including foundations); and
- The Thanet Extension Offshore Export Cable Corridor (OECC). This is where the permanent offshore electrical infrastructure (offshore export cables) will be located.

Project Overview

1.3.2 Thanet Extension will comprise of WTGs and all infrastructure required to transmit the power generated by the WTGs to the national grid network via the grid connection location at Richborough. It will also comprise any offshore infrastructure required to operate and maintain the wind farm.

1.3.3 Thanet Extension will have a maximum of 34 WTGs, which will generate up to 340 MW of power. The project will also have up to four offshore export cables and may or may not include up to one OSS as part of the power transmission system, one LIDAR device, one wave buoy and one Met Mast (if required).

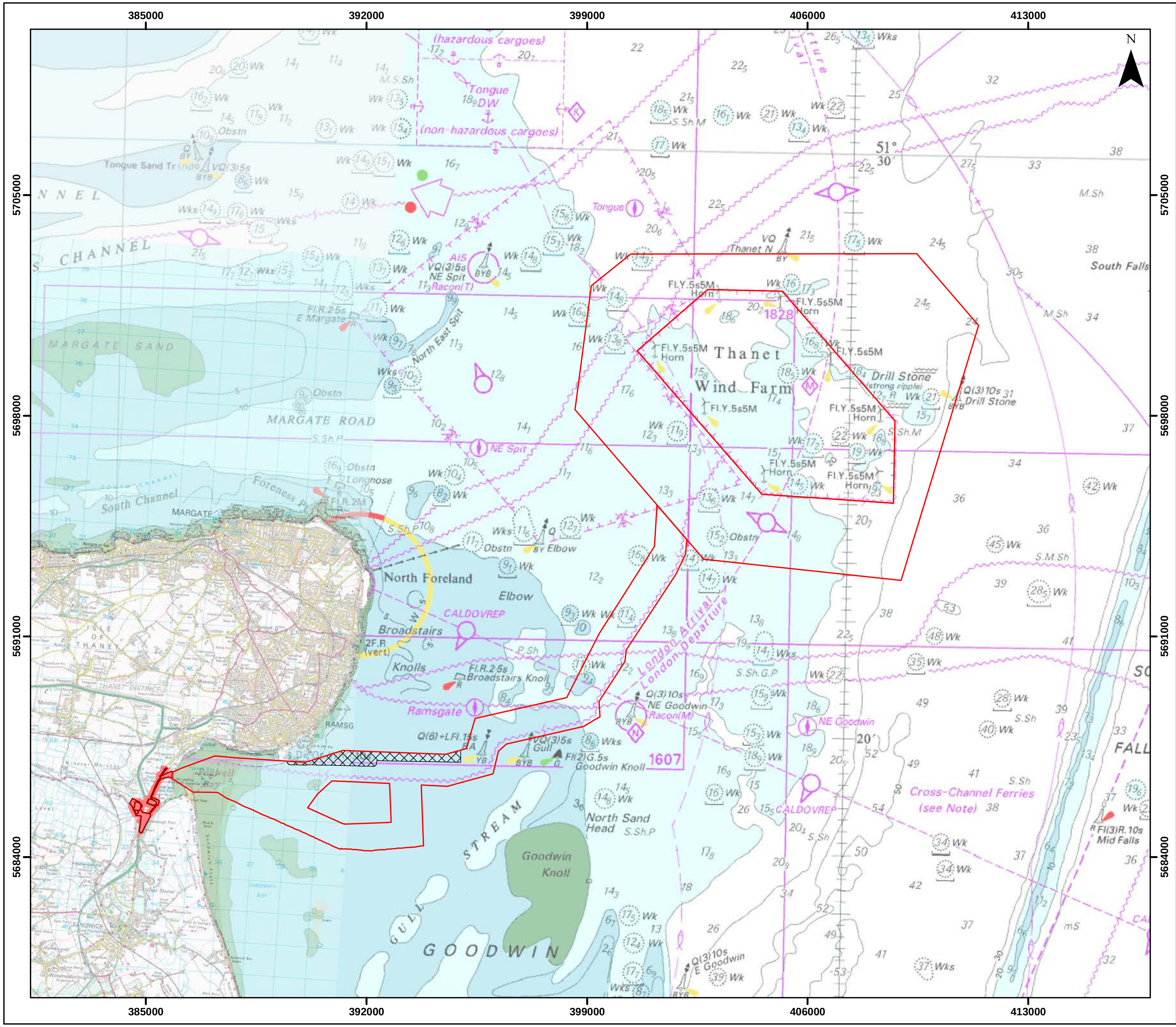
1.3.4 The key offshore components of Thanet Extension are likely to include:

- Offshore WTGs;
- OSS (if required);
- Foundations (for WTGs, Met Mast (if required) and OSS (if required));
- Subsea inter-array cables linking the individual WTGs;
- Subsea export cables from the OWF to shore; and
- Scour protection around foundations and on inter-array and export cables (if required).

1.3.5 It is likely that the components for Thanet Extension will be fabricated at a number of manufacturing sites across Europe, the United Kingdom (UK) and further afield. A construction base (port facility) may be used to stockpile some components, such as foundations and WTGs, before delivery to the array area for installation. Other components, such as pre-fabricated units and cables, may be delivered directly to the array area when required.

1.3.6 Figure 1.1 below shows the location of the Thanet Extension array area and OECC.

1.3.7 Figure 1.1 and Figure 1.2 below shows the Cable Exclusion Area located on the boundary of Ramsgate Harbour limits within the OECC. The Cable Exclusion Area will not have any infrastructure installed within but may be used for construction and maintenance vessel anchoring. The inclusion of the Cable Exclusion Area is to address the concerns of Ramsgate Harbour with regard to interactions with the harbour limits and depth regulated channel on the approach. This zone also addresses the concerns raised by Kent Wildlife Trust and Natural England regarding interactions with conservation areas by minimising the interaction with the features within this area.



THANET EXTENSION OFFSHORE WIND FARM

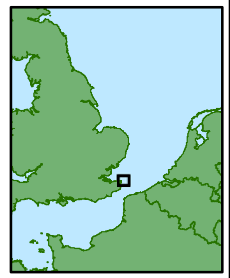
Figure 1.1

Thanet Extension Offshore Boundary.

Legend

- Offshore Red Line Boundary
- Onshore Red Line Boundary
- Cable Exclusion Area

Datum: ETRS 1989
Projection: UTM31N



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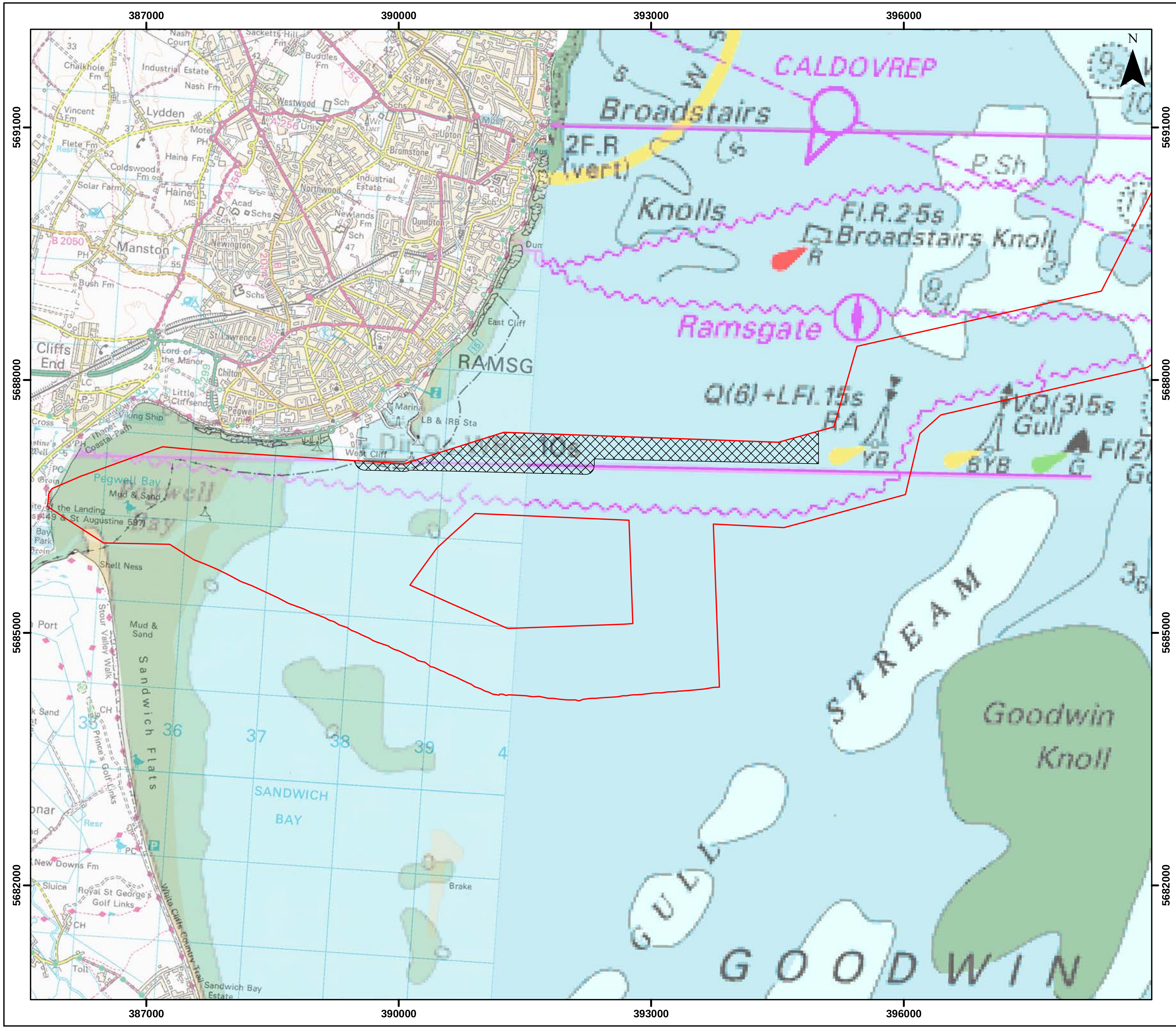
Rev	0.1	Date	25/05/2018	
By	DP	Layout	N/A	



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THANET EXTENSION OFFSHORE WIND FARM

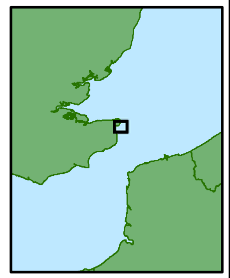
Figure 1.2

Thanet Extension Cable Exclusion Area.

Legend

- Offshore Red Line Boundary
- Cable Exclusion Area

Datum: ETRS 1989
Projection: UTM31N



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Drg No	Fig 1.2_TEOW_CEA		
Rev	0.1	Date	25/05/2018
By	DP	Layout	N/A

Figure 1.2

1.3.8 The general wind farm site information is shown in Table 1.1. Individual components are described in detail in the following subsections.

Table 1.1: Basic site information

Parameter	Maximum design envelope
Total site area array (km^2)	70
Total OECC area (km^2)	28
Shortest distance from array area to shore (km)	8
Site capacity (MW)	340
Maximum number of WTGs	34
Maximum number of OSSs	1
Maximum number of Met Masts	1

1.4 Offshore Infrastructure

Wind turbine Generators

Design

1.4.1 Thanet Extension requires flexibility in WTG choice to ensure that anticipated changes in available technology and project economics can be accommodated within the project design. The design envelope therefore sets maximum and, where relevant, minimum realistic worst-case scenario parameters against which environmental effects can be assessed. For the purposes of assessment, three WTG sizes are currently under consideration (8 MW, 10 MW and 12 MW). Subject to final design it is possible that an alternative, larger capacity, WTG (i.e. >12 MW) type may be selected. In this scenario the number of turbines would be reduced, but the overall maximum project capacity will remain at 340 MW and the physical parameters such as maximum blade tip height, rotor diameter, and height of nacelle will remain within the maximum envelope described in this chapter and subsequent technical assessment chapters.

1.4.2 Up to 34 WTGs are planned for Thanet Extension. A range of WTG models will be considered; however, they are likely to all follow the traditional offshore WTG design with three blades and a horizontal rotor axis.

1.4.3 The blades are connected to a central hub, forming a rotor which turns a shaft connected to a generator or gearbox (if required). The generator and gearbox are located within a containing structure known as a nacelle, attached to which is the rotor hub. The nacelle is supported by a tower structure affixed to the transition piece or foundation. The nacelle is able to rotate or 'yaw' on the vertical axis in order to face the oncoming wind direction. An illustration of this design is shown in Figure 1.3.

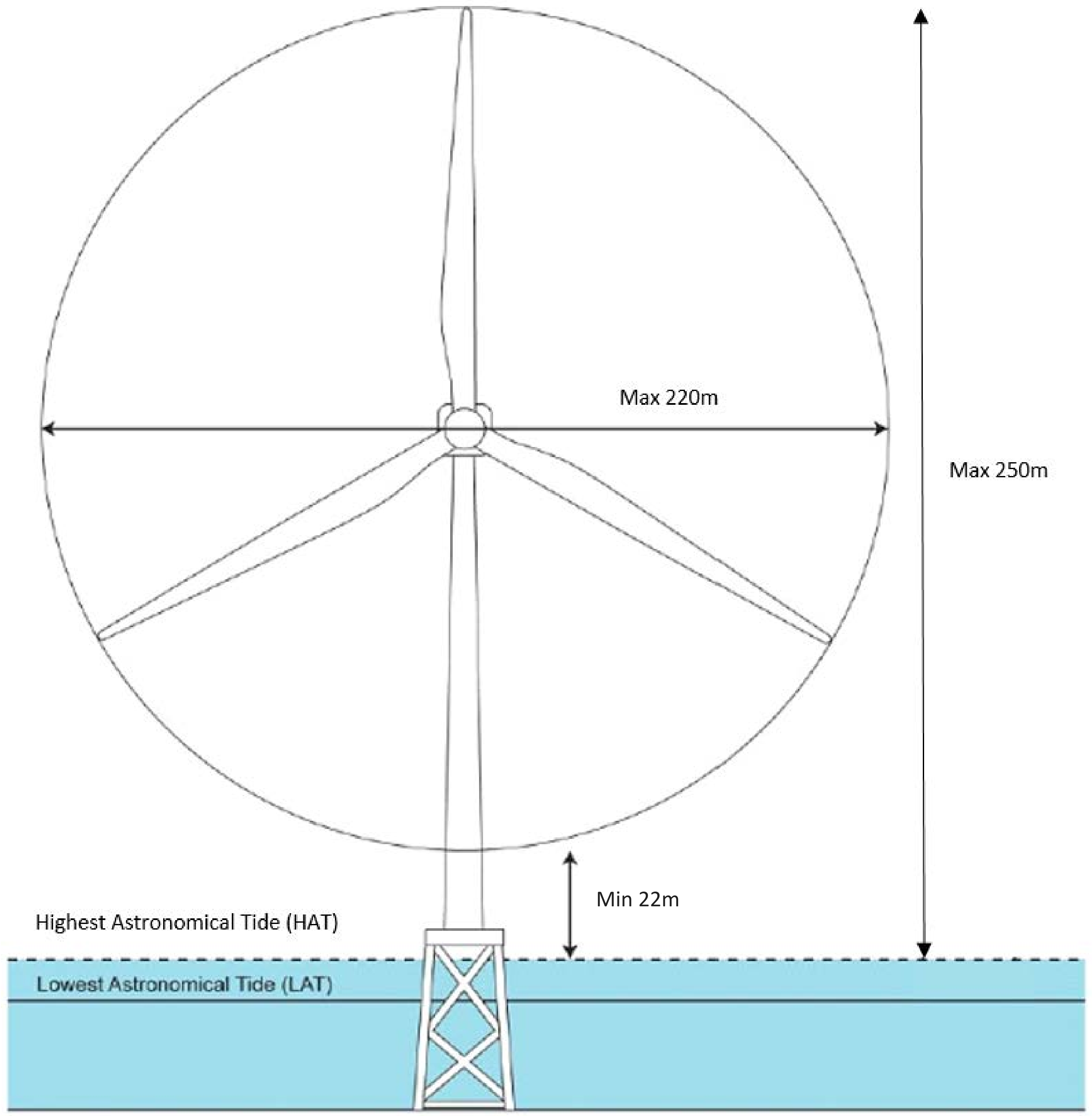


Figure 1.3: Illustration of an offshore WTG.

1.4.4 WTGs operate within a set wind speed range. At approximately 3 m/s (metres per second) the WTG will start to generate electricity and at around 15 m/s they will reach maximum output. At around 25 m/s and above the WTG output starts to reduce towards zero. Developments in WTG's and foundation technology are increasing the range of wind speeds at which WTG's can operate. This enables the WTG to shut down gradually in high wind speeds to protect the WTG and foundation, whilst enabling a gradual ramp down of the power output to support the operation of the National Grid.

1.4.5 Each WTG will have a minimum clearance between the Highest Astronomical Tide sea level (HAT) and the lowest point of the rotor of 22 m, however the rotor diameter and therefore maximum tip height will depend on the chosen WTG design. The design envelope and a comparison of WTG parameters is shown in Table 1.2. Since the project is limited by generation capacity (340 MW) and maximum number of WTGs (34), the worst-case scenario maximum design envelope is dependent on the size of WTG chosen.

Table 1.2: Design envelope for WTGs

Parameter	Maximum design envelope		
	8 MW	10 MW	12 MW (or higher)
Maximum number of WTG	34	34	28
Minimum height of lowest blade tip above MHWS (m)	22	22	22
Maximum blade tip height above MHWS (m)	194	210	250
Maximum rotor blade diameter (m)	164	180	220

Access

1.4.6 The WTGs may be accessed either from a vessel via a boat landing or stabilised gangway via the foundation or transition piece, or by hoisting from a helicopter to a heli-hoist platform on the nacelle. Any helicopter access would be designed in accordance with relevant Civil Aviation Authority (CAA) guidance and standards.

Oils and fluids

1.4.7 Each WTG will contain components that require lubricating oils, hydraulic oils and coolants for operation. Indicative maximum requirements for these oils and fluids for a single WTG are shown in Table 1.3. These values are based on a worst-case using a geared system, rather than a direct drive which would require less. All oils and fluids will be contained within the WTG in case of a spill. Oils in the WTGs shall be biodegradable where possible.

Table 1.3: Indicative maximum requirements for oils and fliuids (per WTG)

Parameter	Indicative maximum requirements (per WTG)	
	8 MW	12 MW (or higher)
Grease (l)	1,000	2,000
Synthetic oil/ hydraulic oil (l)	1,000	2,000
Nitrogen (l)	100	200
Transformer silicon/ oil (kg)	1,500	2,000
Sulphur hexafluoride (SF6) (kg)	50	100
Water/ glycerol (l)	1,000	2,000

Control systems

1.4.8 Each WTG has its own control system to carry out functions like yaw control and ramp down in high wind speeds. All the WTGs are also connected to a central Supervisory Control and Data Acquisition (SCADA) system for the control of the wind farm remotely. This allows functions such as remote WTG shutdown if faults occur. The SCADA system will communicate with the wind farm via fibre optic cables, microwave, or satellite links. Individual WTGs can also be controlled manually from within the WTG nacelle or tower base in order to control the WTG for commissioning or maintenance.

1.4.9 All WTGs will have diesel generators for commissioning and O&M activities. Generators are typically used for back-up power supply at the platform (crane lifting, lighting, ventilation, supply of chargers and Uninterruptable Power System etc.).

Installation

1.4.10 Generally, WTGs are installed using the following process:

- WTG components are picked up from a suitable port facility most likely in the UK or Europe either by an installation vessel or transport barge. To date, installation vessels have typically been Jack-Up Vessels (JUVs) or Dynamic Positioning (DP) vessels to ensure a stable platform for installation vessels when on site. Generally, blades, nacelles and towers for a number of WTGs are loaded separately onto the vessel;

- Typically, as much pre-assembly that can be carried out ahead of transit to site is completed to ease the installation process. The components will then transit to the wind farm array area and will be lifted onto the existing foundation or transition piece by the crane on the installation vessel. Each WTG will be assembled at site in this way with technicians fastening components together as they are lifted into place. The exact methodology for the assembly is dependent on WTG type and installation contractor and will be defined in the pre-construction phase post-consent;
- Alternatively, the WTG components may be loaded onto barges or dedicated transport vessels at port, and installed as above by an installation vessel that remains on site throughout the installation campaign.

1.4.11 For the EIA process, assumptions are made on the maximum number of vessels, and the number of return trips to the wind farm array area from port that are required throughout the WTG installation campaign. Vessel requirements are discussed in the 'Vessel Activities' section.

1.4.12 JUVs are assumed to have up to six legs with a combined leg area of up to 170 m^2. The total duration of the installation for WTGs is expected to be a maximum of six months (including one month downtime and assuming continuous working).

WTG layouts

1.4.13 Designing and optimising the layout of the WTGs and other offshore surface infrastructure is a complex, iterative process taking into account a large number of inputs and constraints including:

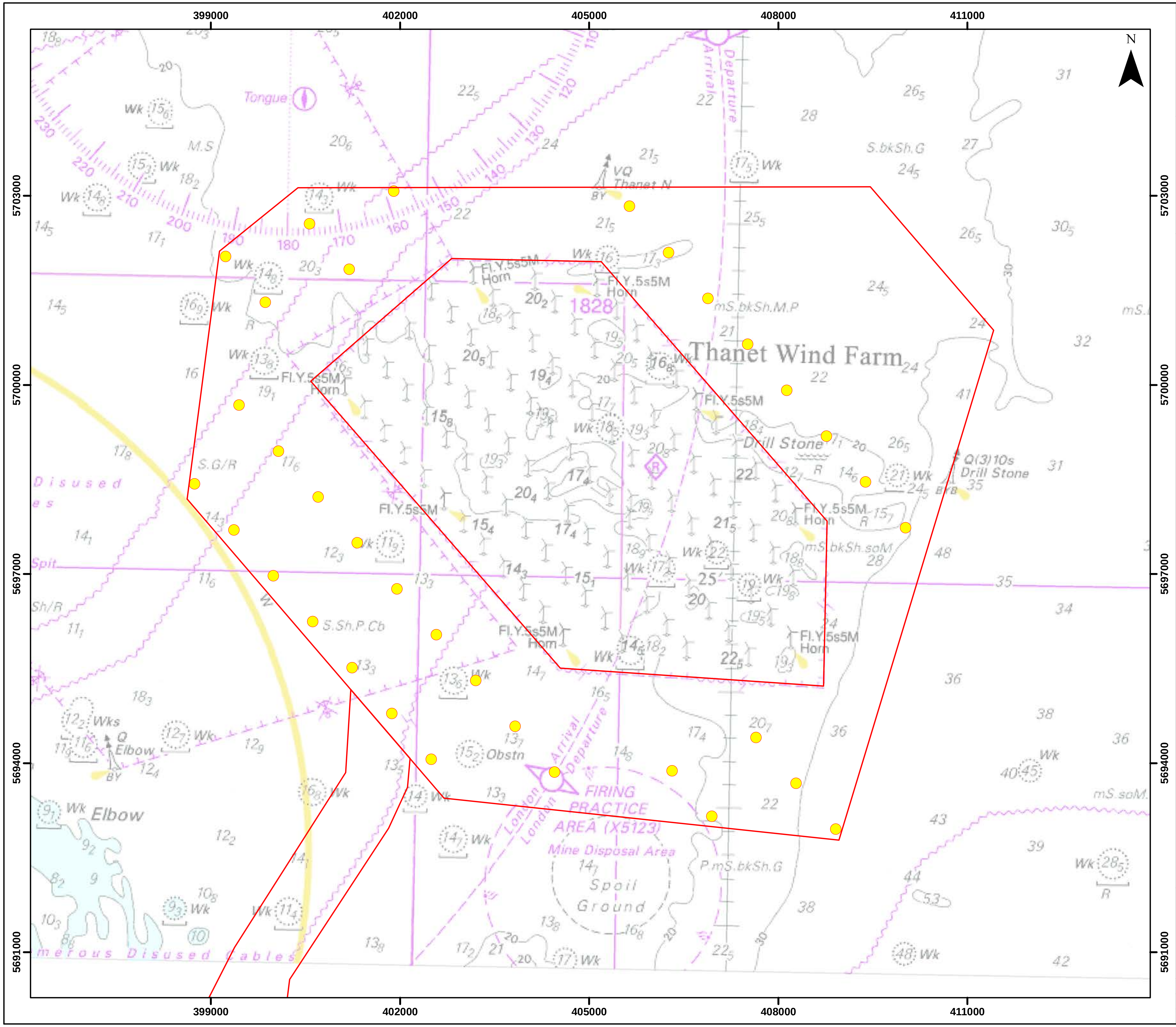
- Site conditions:
  - Wind speed and direction;
  - Water depth;
  - Ground conditions;
  - Environmental constraints (anthropogenic and natural); and
  - Seabed obstructions (wrecks, Unexploded Ordnance (UXO), existing cables).
- Design considerations:
  - WTG type;
  - Installation set-up;
  - Foundation design;
  - Electrical design; and
  - O&M requirements.

1.4.14 The Thanet Extension layout will have spacing between neighbouring WTGs of no less than 716 x 480 m. The layout may use dense borders, but will not breach this minimum spacing distance (subject to micro-siting of maximum 100 m).

1.4.15 In order to inform the EIA process, Thanet Extension has identified three worst-case layouts (Figure 1.4 to Figure 1.6). It is important to note that these layouts are indicative and may not reflect the final layout which is subject to micro-siting requirements. The final positions of the WTGs could be anywhere within the consented red line boundary. In any case, the final layout will not be in breach of the minimum WTG spacing (716 x 480 m) subject to micro-siting (100 m). Micro-sited infrastructure will still remain within the RLB.

1.4.16 Due to the irregular nature of the array RLB a maximum separation distance between WTGs is not possible to practically determine. The key parameters of ensuring appropriate lines of sight and orientation will be observed, and a minimum spacing distance ensured to allow for safe passage of vessels where appropriate and to facilitate search and rescue operations where necessary.

1.4.17 The final WTGs locations will be confirmed post-consent. It will be designed in accordance with the process and principles as agreed through the ongoing EIA process.



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THANET EXTENSION OFFSHORE WIND FARM

Figure 1.4

Indicative 34 Turbine Layout (Optimum Spacing).

Legend

Offshore Red Line Boundary

Indicative 34 WTG layout

Datum: ETRS 1989
Projection: UTM31N

1:60,000 — 0, 0.65, 1.3 km; 0, 0.35, 0.7 nm

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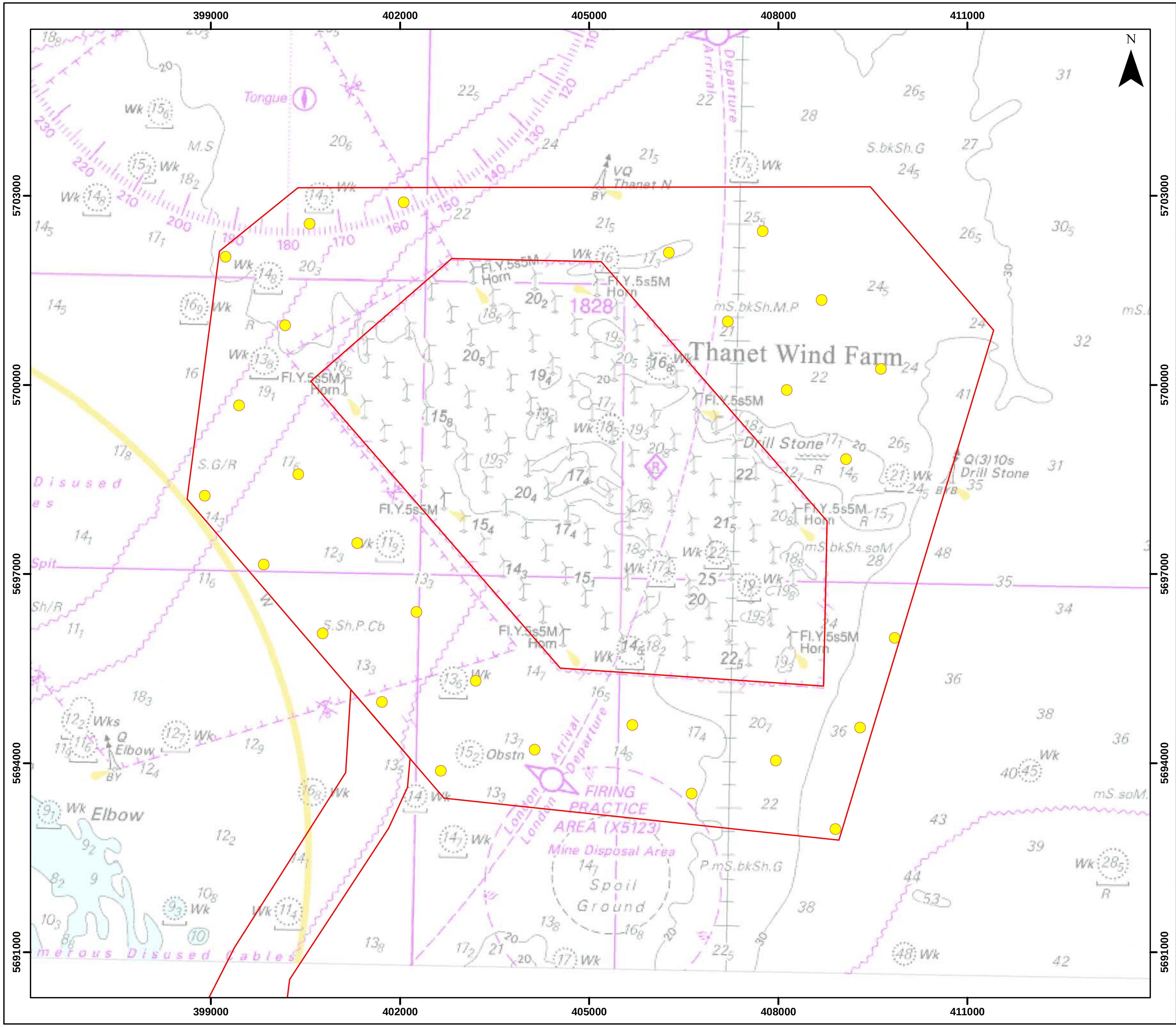
Rev	0.1	Date	25/05/2018
By	DP	Layout	THET2017

Figure 1.4



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THANET EXTENSION OFFSHORE WIND FARM

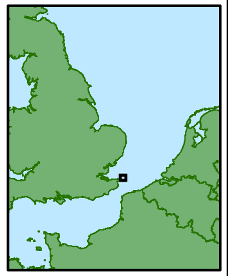
Figure 1.5

Indicative 28 Turbine Layout (Optimum Spacing).

Legend

- Offshore Red Line Boundary
- Indicative 28 WTG layout

Datum: ETRS 1989
Projection: UTM31N



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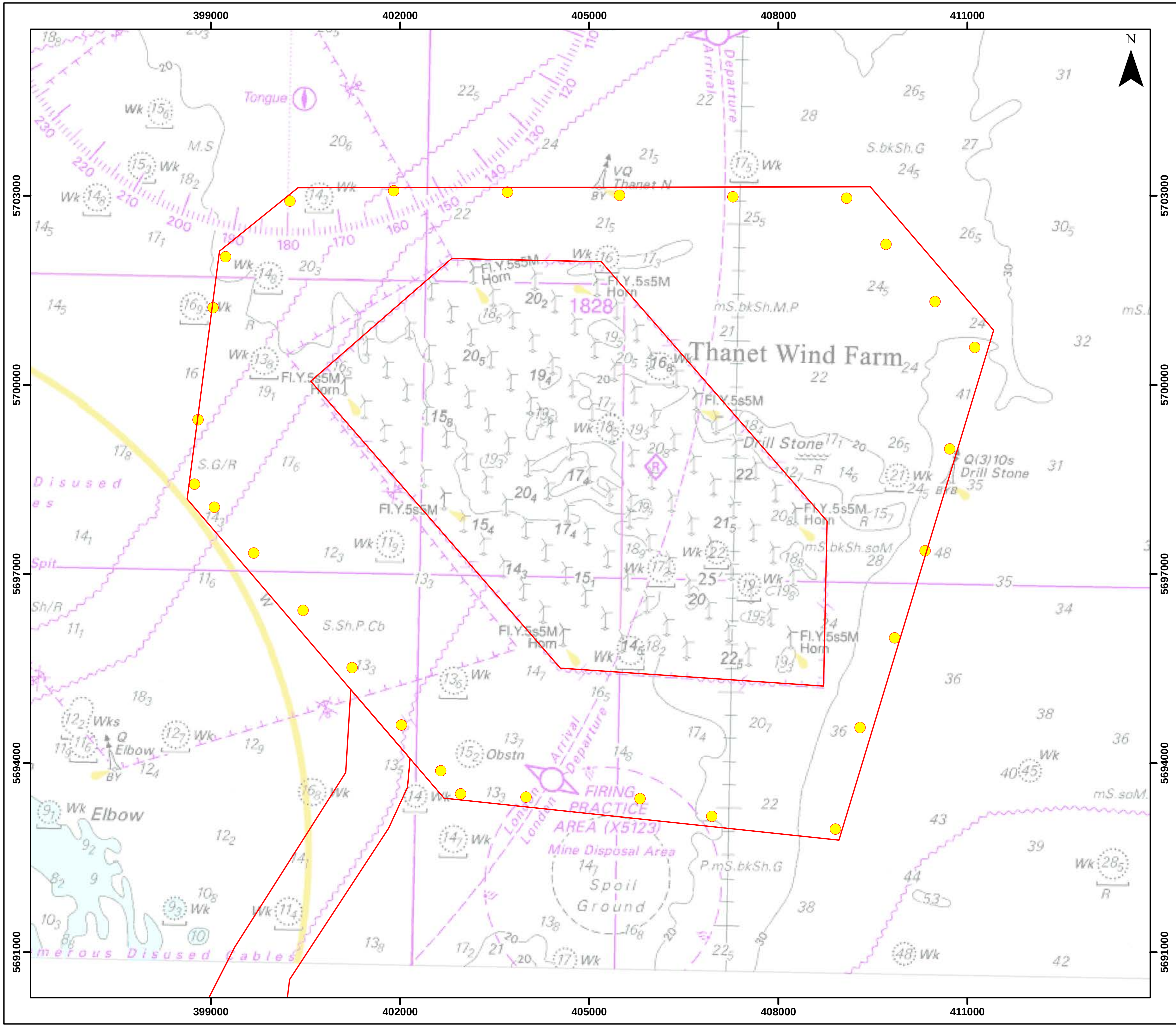
Drg No	Fig 1.5_TEOW_28_WTG_Op		
Rev	0.1	Date	25/05/2018
By	DP	Layout	THET2018a

Figure 1.5



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THANET EXTENSION OFFSHORE WIND FARM

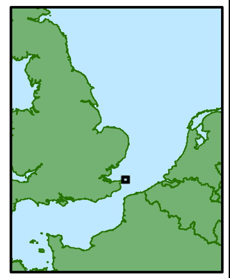
Figure 1.6

Indicative 28 Turbine Locations (Perimeter Spacing).

Legend

- Offshore Red Line Boundary
- Indicative 28 WTG layout

Datum: ETRS 1989
Projection: UTM31N



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Drg No	Fig 1.6_TEOW_28_WTG_Per			Figure 1.6
Rev	0.1	Date	25/05/2018	
By	DP	Layout	THET2018b	

Aids to navigation, colour, marking and lighting

1.4.18 The wind farm will be designed and constructed to satisfy the requirements of the CAA and the Trinity House Lighthouse Service (THLS) in respect of marking, lighting and fog-horn specifications. CAA recommendations on "Lighting of Wind Turbine Generators in United Kingdom Territorial Waters", September 2004 will be adhered to. THLS recommendations will be followed as described in "Renewable Energy Installation Farms and Fields-Provision and Maintenance of Local Aids to Navigation by Trinity House" and "International Association of Marine Aids to Navigation and Lighthouse Authorities (IALA) Recommendation 0-117 on the Marking of Offshore Wind Farms, Edition 2, December 2004".

1.4.19 The colour scheme for nacelles, blades and towers is generally RAL 7035 (light grey). Foundation steelwork is generally in RAL 1023 (traffic light yellow) up to HAT +15 m or to Aids to Navigations, whichever is higher. An AIS beacon may be considered if deemed appropriate and useful through future discussions with THLS.

1.4.20 During operations, lighting will be as per the above guidance and take into account any new directives from the current lighting trials being undertaken by the Navigation and Offshore Renewable Energy Liaison (NOREL) group. As a minimum, all WTGs will comply with Paragraph 5 of IALA Recommendation O-117 and the wind farm Paragraph 6. For aviation lighting compliance, as a minimum, will be with Section 1, Part 28, Paragraph 220 of CAP 393 Air Navigation: The Order and the Regulations.

1.4.21 Further information on aids to navigation, marking and lighting can be found in Volume 2, Chapter 10: Shipping and Navigation and Volume 3, Chapter 13: Aviation and Radar (Document Refs: 6.2.10 and 6.3.13 respectively). Lighting will also be specifically covered in a Lighting and Marking Strategy which will be developed if consent is given.

Foundations for WTGs

1.4.22 There are a number of foundation types that are being considered for Thanet Extension. As with WTG type, Thanet Extension will require flexibility in foundation choice to ensure that anticipated changes in available technology can be accommodated within the project design. The final selection will depend on factors including WTG type, physical and environmental constraints, project economics and supply chain strategy.

1.4.23 The WTGs, one Met Mast (if required) and one OSS (if required) are attached to the seabed by foundation structures or anchor systems. There are a number of foundation types that can be used and the types will not be confirmed until the final design of the wind farm post-consent. Consequently, the EIA will consider a range of types, including:

- Piled monopile foundations;
- Piled quadropod or tripod jacket foundations; and
- Suction caisson quadropod or tripod jacket foundations.

1.4.24 All foundation types and maximum parameters stated in the following sections include those for WTG foundations, as well as foundations for an OSS and a Met Mast (if required). Since the project is limited by generation capacity (340 MW), the worst-case scenario maximum design envelope is dependent on the size of WTG chosen and foundation options used.

1.4.25 The foundations will be fabricated offsite, stored at a suitable port facility and transported to site as needed. Specialist vessels will be needed to transport and install foundations. A filter layer and/ or scour protection layer (typically rock) may be needed on the seabed and will be installed either before and/ or after foundation installation.

1.4.26 Prior to the installation of foundations, pre-construction preparatory works may be required, such as Unexploded Ordinance (UXO) surveys, seabed levelling, sand wave clearance or boulder clearance. The requirement for any preparatory works would be informed by site-specific geophysical and geotechnical surveys post-consent.

Piled monopile foundations (monopile) - Design

1.4.27 Monopile foundations typically consist of a single tubular section, consisting of a number of sections of rolled steel plate welded together. A Transition Piece (TP) is fitted over the monopile and secured via bolts or grout. The TP may include boat landing features, ladders, a crane and other ancillary components as well as a flange for connection to the WTG tower. The TP is usually painted yellow and marked according to relevant regulatory guidance and may be installed separately following the monopile installation. An example of a piled monopile foundation is shown below (Figure 1.7) with design envelope parameters in Table 1.4.

Table 1.4: Maximum design envelope for monopile foundations

Parameter	Maximum design envelope		
	8 MW	10 MW	12 MW
Number of monopiles	34	34	28
Diameter of monopile (top) (m)	6.5	7	7.5
Diameter of monopile (bottom) (m)	8.5	9	10
Diameter of transition piece (top diameter at TP-tower interface) (m)	6.5	7	7.5
Diameter of transition piece (bottom diameter at MP-TP interface) (m)	8.5	9	10
Maximum Embedment depth (below seabed) (m)	75	75	75
Drill diameter (m)	6.5	7	7.5
Average drill penetration depth (m)	30	30	30
Maximum Volume of drill arisings per pile (m^3)	995	1,155	1,325
Locations requiring drilling (%)	50	50	50
Locations potentially installed by driven piling (%)	100	100	100
Maximum Total drill arisings (m^3)	16,923	19,627	18,555
Maximum grout volume per foundation (m^3)	80	100	120
Maximum Hammer energy (kJ)	4,000	4,000	5,000
Maximum Number of blows per foundation	8,000	8,000	8,000
Maximum piling time per foundation (assuming issues such as low blow rate, refusal etc.) (hours)	6	6	6

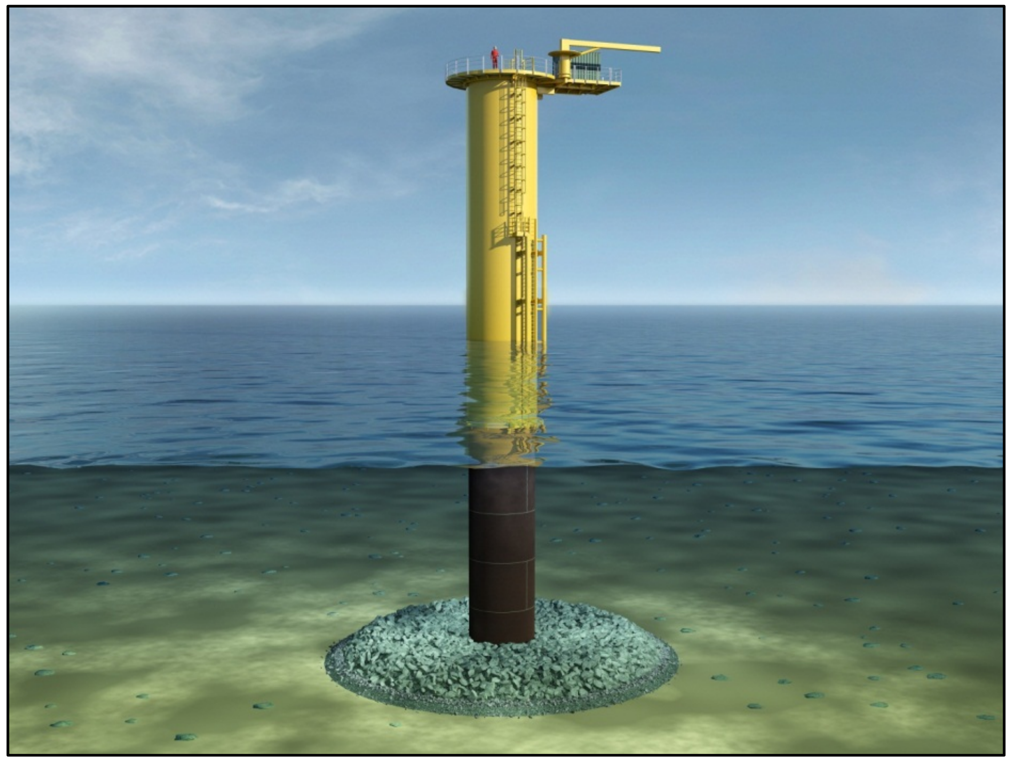

Figure 1.7: Illustration of a monopile foundation with transition piece

Piled monopile foundations (monopile) - Installation

1.4.28 Monopiles and transition pieces will be transported to site either on the installation vessel or on feeder barges as described in the WTG section. Monopiles can also be sealed and floated to site.

1.4.29 Once on site, the monopiles will typically be installed using the following process:

- Lift monopile into the pile gripper on the side of the installation vessel;
- Lift hammer onto monopile and drive monopile into seabed to the required embedment depth;
- Lift hammer from monopile and remove pile gripper;
- Lift TP onto monopile; and
- Secure TP onto monopile using either grout or bolts.

1.4.30 If percussive piling installation is not possible due to the presence of rock or hard soils, the material inside the monopile may be drilled out before the monopile is driven to the required depth. This can either be done in advance of the driving or if the piling rate slows significantly during piling (refusal). If drilling is required, spoil arising from the drilling will be disposed of adjacent to the foundation location.

1.4.31 The hammer would use an energy of up to 5,000 kJ for piling and would include a 'soft start', where the hammer energy is ramped up from approximately 10% energy to maximum over a period of approximately one hour, starting with 15 blows per minute, up to the maximum of 30 blows per minute (average 20 blows per minute).

1.4.32 The TP will either have a bolted or grouted connection to the monopile. The grout used is an inert cement mix that is pumped into a specially designed space between the TP and the monopile. The grout will be pumped either from the installation vessel or a support vessel. This process is carefully controlled and monitored to ensure minimal grout is lost to the surrounding environment. The bolted solution will use bolts to connect the TP to the monopile in a similar manner to that used to connect the WTG to the TP.

1.4.33 It may also be possible that the piles are installed via vibro-piling, where the pile is embedded using vibration rather than hammering or drilling. If any such methods were employed, it would be ensured that the noise emissions were within the envelope consented for hammering.

1.4.34 Continuous piling at a single foundation location will last up to six hours (assuming issues such as low blow rate, refusal etc.), though accounting for vessel repositioning and commissioning, installation may take longer. Total piled monopile foundation installation may take up to six months, including one month for downtime, and assuming continuous installation. Simultaneous piling will not be undertaken by the project. The details for the vessels and numbers of trips required can be found in the 'Vessel Activities' section (paragraph 1.4.117 *et seq.*).

1.4.35 Seabed preparations for monopile installation are usually minimal. If pre-construction surveys show the presence of boulders or other seabed obstructions at foundation locations, these may be removed if the foundation cannot be re-sited to avoid the obstruction.

Pin-piled jacket foundations - Design

1.4.36 Piled jacket foundations are formed of a steel lattice construction (comprising tubular steel members and welded joints) secured to the seabed by hollow steel pin-piles attached to the jacket feet (piling may take place once the jacket is in position, or alternatively may be pre-piled – see paragraph 1.4.40). The piles rely on frictional and end bearing properties of the seabed for support. Unlike monopiles, there is no separate TP; the TP and ancillary structure is fabricated as an integral part of the jacket. Pin-piles will typically be of a smaller diameter than monopiles.

1.4.37 Jacket foundations would have a maximum of four legs (quadropod) (worst-case), although three-legged (tripod) foundations are also considered for WTG foundations (Figure 1.8).

1.4.38 The design envelope for jacket foundations with pin-piles is shown in Table 1.5.

Table 1.5: Maximum design envelope for WTG quadropod jacket foundations

Parameter	Maximum design envelope		
	8 MW	10 MW	12 MW
Number of jacket foundations	34	34	28
Maximum number of legs per foundation	4	4	4
Separation of adjacent legs at seabed level (m)	30	30	40
Separation of adjacent legs at Mean Sea Level (MSL) (m)	20	20	20
Height of platform above HAT (m)	20	20	20
Leg diameter (m)	3.0	3.0	3.5
Max Piles per foundation	4	4	4
Embedment depth (below seabed) (m)	70	70	70
Maximum pile diameter (m)	3	3	4
Average drill penetration depth (m)	20	20	25
Maximum volume of drill arisings per foundation (four pin-piles) (m^3)	600	600	1,400
Locations requiring drilling (%)	50	50	50
Locations potentially installed by driven piling (%)	100	100	100
Maximum total drill arisings (m^3)	9,613	9,613	17,802
Maximum grout volume per foundation (piles) (m^3)	40	50	60
Maximum grout volume per foundation (screw piles) (m^3)	50	70	85
Hammer energy (kJ)	2,700	2,700	2,700
Maximum piling time per foundation (four pin-piles) (assuming issues such as low blow rate, refusal etc.) (hours)	6	8	10

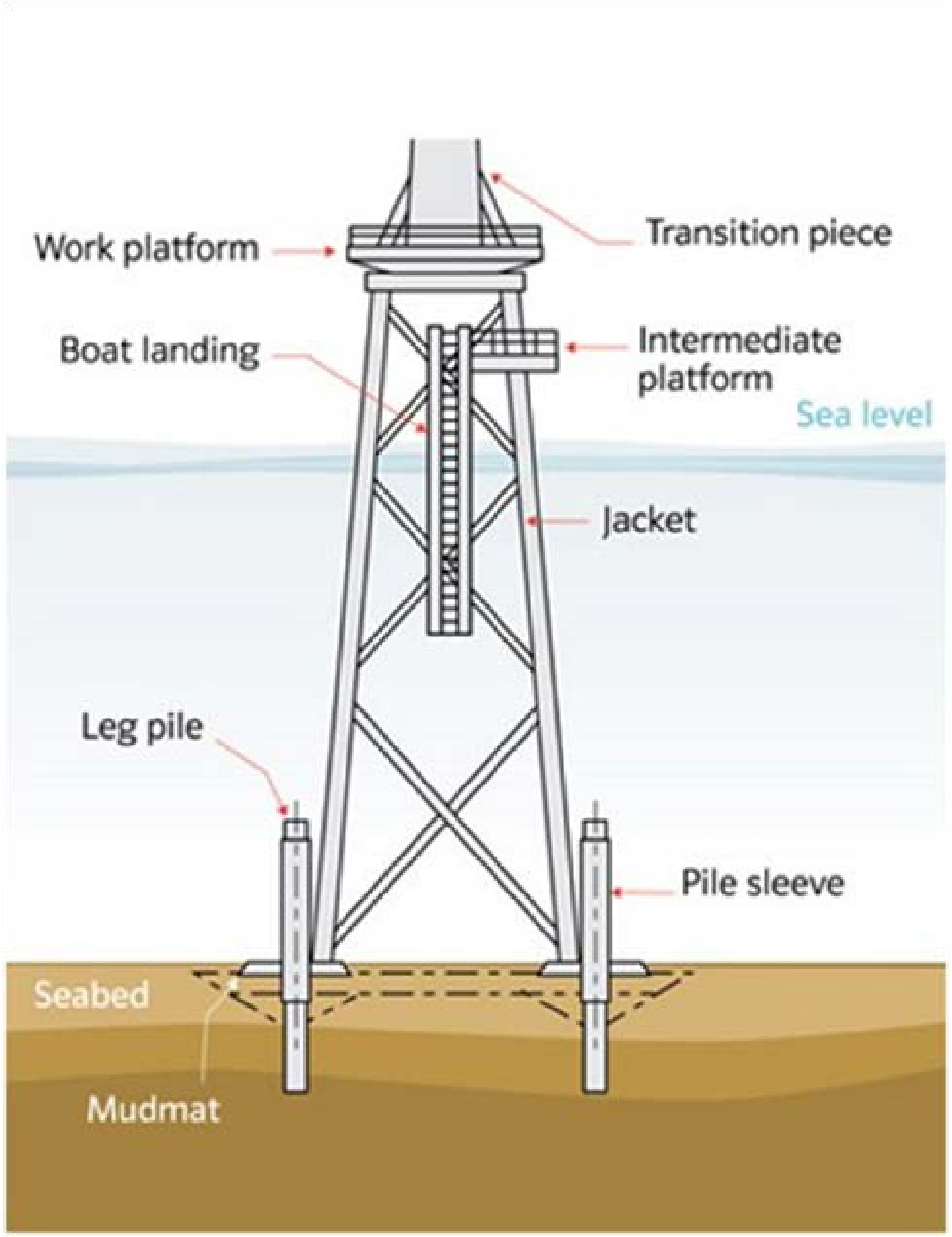

Figure 1.8: A typical jacket foundation.

Pin-piled jacket foundations - Installation

1.4.39 The installation of piled jackets will be similar to that of monopiles, with the structures transported to site by installation vessels or barges and lowered onto the seabed by the installation vessel.

1.4.40 The pin-piles can be installed either before or after the jacket is lowered to the seabed. If before; a piling template will be placed on the seabed to guide the pile locations. This is usually a welded steel structure. The piles will then be installed through the template, and the jacket affixed to the piles after it has been lowered into position, either welded or swaged. If after; the piles will be installed through the jacket feet at the seabed, or through the legs of the jacket from the top of the structure.

1.4.41 As with monopiles, there would be a 'soft start' procedure before ramping up to full hammer energy. The starting hammer energy would be approximately 10% of the maximum (270 kJ), with a soft start period of one hour, at a maximum of 30 blows per minute.

1.4.42 The pin-piles are driven, drilled or vibrated into the seabed, in a similar way to monopiles. However, as pin-piles are smaller than monopiles, and so the maximum hammer energy required to be used would be lower (2,700 kJ). The maximum duration of piling for a single foundation would be 10 hours (assuming issues such as low blow rate and refusal), with the possibility of up to two jackets being installed in a 24-hour period.

1.4.43 The vessel movements for the installation would be as for the monopiles, as described in Table 1.22. These assume continuous working.

1.4.44 As there is no separate TP, there is no requirement for installing an additional structure offshore.

1.4.45 The seabed preparation would be as for the monopile foundations, see paragraphs 1.4.35 *et seq*.

Suction caisson jacket foundations - Design

1.4.46 Suction caisson jacket foundations are formed of a steel lattice construction (comprising tubular steel members and welded joints) fixed to the seabed by suction caissons. The suction buckets are typically hollow steel cylinders, capped at the upper end, which are fitted in a horizontal position underneath the legs of the jacket structure. Unlike monopiles, but similar to piled jacket foundations, there is no separate TP; the TP and ancillary structure is fabricated as an integrated part of the jacket structure and is not installed separately offshore. An example of a suction caisson jacket foundation is shown in Figure 1.9, with the maximum design envelope described in Table 1.6.

1.4.47 Suction caisson jacket foundations would most likely be four-legged (quadropod) (worst-case) for an OSS, however, tripod suction caisson foundations are considered.

Table 1.6: Maximum design envelope for suction caisson jacket foundations

Parameter	Maximum design envelope		
	8 MW	10 MW	12 MW
Number of jacket foundations	34	34	28
Number of legs	4	4	4
Separation of adjacent legs at seabed level (m)	30	30	40
Separation of adjacent legs at mean sea level (MSL) (m)	20	20	20
Height of platform above HAT (m)	20	20	20
Leg diameter (m)	3.0	3.0	3.5
Suction buckets per foundation	4	4	4
Suction bucket diameter (m)	15	15	20
Bucket penetration depth (below seabed) (m)	15	15	20
Grout volume per foundation (m^3)	75	90	105
Depth of seabed preparation (m)	3	3	3
Area of seabed preparation per foundation (m^2)	1,800	1,800	3,200
Volume per foundation for seabed preparation work (m^3)	5,400	5,400	9,600
Volume for seabed preparation works (for WTG foundations only) (m^3)	183,600	183,600	268,800

Figure 1.9 Jacket structure with suction caissons

Suction caisson jacket foundations - Installation

1.4.48 Once at site, the jacket foundation will be lifted by the installation vessel using a crane, and lowered towards the seabed in a controlled manner. When the steel caissons reach the seabed, a pipe running through the stem above each caisson will begin to suck water out of each caisson. The buckets are pulled down into the seabed by the resulting suction force. When the bucket has penetrated the seabed to the desired depth, the pump is turned off. A thin layer of grout is then injected under the bucket to fill the air gap and ensure contact between soil within the bucket and the top of the bucket itself. As there is no separate TP, there is no requirement for installing any additional structure offshore.

1.4.49 The vessel movements for the installation would be as for the monopile, as described in Table 1.22.

1.4.50 As there is no separate TP, there is no requirement for installing an additional structure offshore.

1.4.51 As well as the boulder and obstruction removal that is described in the piled-monopile section, the suction caisson jackets may also require some seabed levelling, as described in paragraph 1.4.26.

Scour protection for foundations (all types)

1.4.52 Scour protection is designed to prevent foundation structures for WTGs and other offshore infrastructure being undermined by hydrodynamic and sedimentary processes, resulting in seabed erosion and subsequent scour hole formation. The shape of the foundation structure is an important parameter influencing the potential depth of scour hole formation. Scour around foundations is typically mitigated by the use of scour protection measures. Several types of scour protection exist, including mattress protection, sandbags, stone bags and artificial seaweeds. However, the placement of large quantities of crushed rock around the base of the foundation structure is the most frequently used solution (rock placement).

1.4.53 The preferred scour protection solution may comprise a rock armour layer resting on a filter layer of smaller graded rocks. The filter layer can either be installed before the foundation is installed (pre-installed) or afterwards (post-installed). Alternatively, by using a heavier rock material with a wider gradation, it is possible to avoid using a filter layer and pre-install a single layer or scour protection (Figure 1.10).

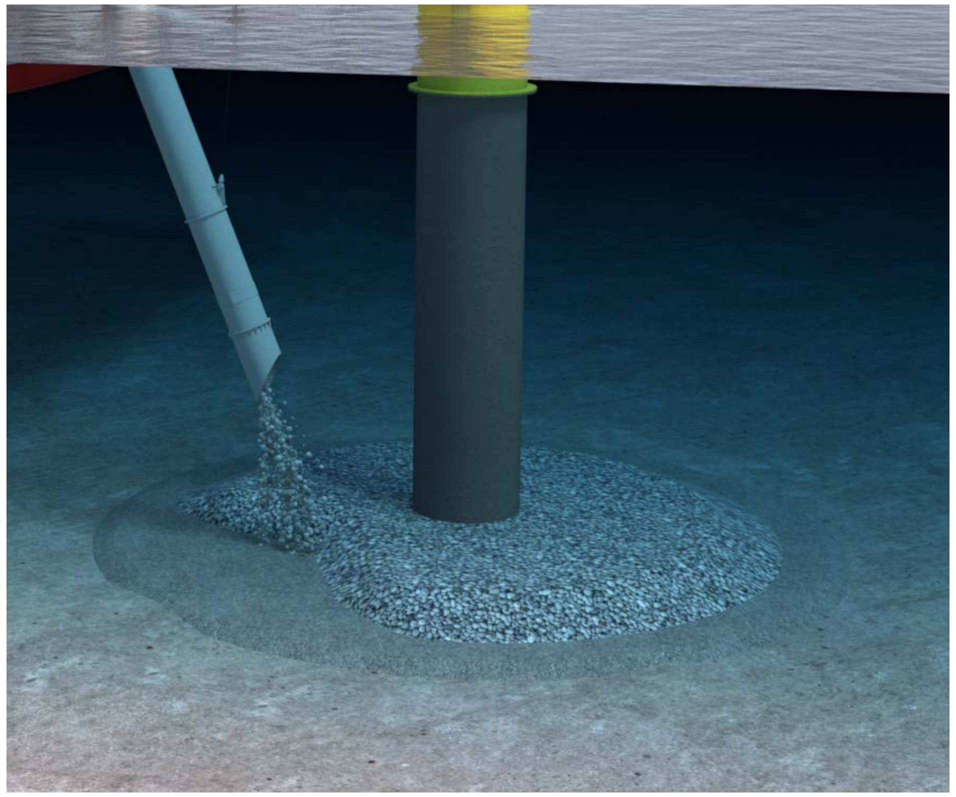

Figure 1.10: Example of rock dumping scour protection around a monopile foundation.

1.4.54 The Seabed Scour Control Systems Ltd (SSCS) Frond Mat System is also under consideration as scour protection for foundations. The frond mats comprise continuous lines of overlapping buoyant polypropylene fronds that when activated create a viscous drag barrier that significantly reduces current velocity. The frond lines are secured to a polyester webbing mesh base that is itself secured to the seabed by anchors or weighted bags pre-attached to the mesh base by polyester webbing lines (Figure 1.11). Grouted concrete mattresses may also be considered.

Figure 1.11: Example of weighted frond mats in a testing facility

1.4.55 The amount of scour protection required will vary for the different foundation types being considered for Thanet Extension. Flexibility in scour protection choice is required to ensure that anticipated changes in available technology and foundation design can be accommodated within the project design. The final choice and detailed design of a scour protection solution for Thanet Extension will be made after detailed design of the foundation structure, taking into account a range of aspects including geotechnical data, meteorological and oceanographic data, water depth, foundation type, maintenance strategy and cost. The design envelope for the scour protection system is shown in Table 1.7 below. These values are for suction caisson jacket foundations which would require the greatest amount of scour protection. The maximum area and volume of scour protection required would be for 12 MW WTGS on suction caisson jacket foundations, resulting in 7,854 m^2 and 39,270 m^3 per foundation respectively (Table 1.7). It is worth noting that for other foundation options, significantly less scour protection will be required.

Table 1.7: Maximum design envelope for scour protection (based on suction caisson jacket foundations which represent the greatest scour protection requirement)

Parameter	Maximum design envelope		
	8 MW	10 MW	12 MW
Median rock diameter (mm)	200	200	200
Scour protection depth (rock) (m)	5	5	5
Total scour protection area (WTG foundations only) (m^2)	150,207	150,207	219,912
Scour protection diameter	5 x pile diameter	5 x pile diameter	5 x pile diameter
Scour protection volume per foundation (m^3)	22,089.3	22,089.3	39,269.9
Maximum number of turbines	34	34	28
Scour protection total volume (WTG foundations only) (m^3)	751,037.0	751,037.0	1,112,647.4

Inter-array cables

1.4.56 Cables carrying the electrical current produced by the WTGs will link the WTGs to one another and to an OSS (if required), from where the electricity is transmitted to shore. A small number of WTGs will typically be grouped together on the same cable 'string', with multiple 'strings' connecting back to the OSS.

Design

1.4.57 In the event that an OSS is not required, inter-array cables will 'become' offshore export cables at the end of a WTG string, and transmit the electricity generated directly to shore.

1.4.58 The inter-array cables will consist of a number of conductor cores, usually made from copper or aluminium. These will be surrounded by layers of insulating material as well as material to armour the cable for protection from external damage and material to keep the cable watertight (Figure 1.12). The design envelope for the inter-array cables is shown in Table 1.8. The worst-case is based on a maximum site capacity of 340 MW.

Table 1.8: Maximum design envelope for the inter-array cables

Parameter	Maximum design envelope
System voltage (kV)	66
External cable diameter (mm)	300
Total length of inter-array cables (km)	64
Maximum burial depth (m)	3
Minimum burial depth (m)	0
Maximum trench width (m)	1

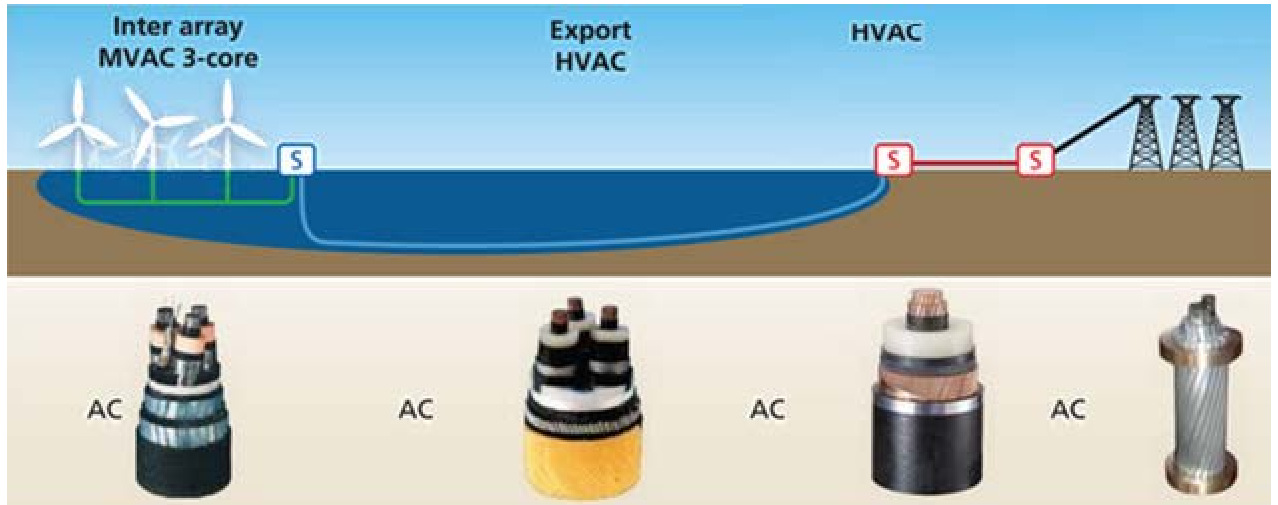

Figure 1.12: Indicative diagram of inter-array cables (Overhead Lines are not being considered for this project and can therefore be discounted).

Preparatory works

1.4.59 Geophysical and geotechnical surveys would be carried out before works commence and the information gained would allow route debris, boulders, UXO clearance, seabed features and sediment depth; and the nature and long-term stability of the seabed to be determined. An analysis of these factors would then inform the final route taken, the target burial depth, the installation methods to deploy and what, if any, additional protection would be required. Following the surveys, preparatory work could then be carried out.

1.4.60 Pre-Lay Grapnel Runs (PLGR) will be conducted to remove seabed surface debris along a 1 – 2 m wide area. The grapnel typically penetrates the seabed to 0.5 m depth and is selected and configured in accordance with the seabed conditions.

1.4.61 Surface boulders may be required to be removed from the route. This would be undertaken using a 'boulder grab' or boulder clearance tool such as a SCAR plough.

1.4.62 In the event that out-of-service (OOS) (redundant) cables are located, these will be left *in situ* wherever possible. However, it may be necessary in some locations for sections of the OOS cables to be removed to allow for installation of the inter-array/ export cables. Although telecommunications cables are typically laid on the seabed, it is likely that the cables will now be buried under mobile sediments. The process of locating and removing sections of OOS cable uses similar equipment to those proposed for cable installation. A typical sequence for the removal of OOS cables would be:

- Locate the cable if possible by camera mounted on a remotely operated vehicle (ROV);
- Where cables are buried, jetting may be required to locate and uncover the cables;
- A grapnel will be used to raise the cable, and the required section will be cut from the cable and removed to shore for recovery or disposal;
- The cut ends of the remaining cable will be weighted and returned to the seabed to minimise risk of fastening to fishing gear. Clump weights, typically 0.5 m in diameter by 0.2 m thick, or alternatively chain, may be used; and
- Admiralty charts will subsequently be amended to indicate which sections of cable have been removed and to record the locations of the weighted cable ends on the seabed.

1.4.63 A non-intrusive UXO survey would be undertaken along a OECC of approximately 100 m width centred on the nominal cable position. A UXO Threat Assessment will also be undertaken to assess the risk from seabed intrusive tools. Final cable routes would then be micro-sited within the surveyed corridors. More information on UXO can be found in Table 1.21.

Installation

1.4.64 The cables will be buried below the seabed wherever possible. The installation method and target burial depth will be defined post-consent in a Cable Burial Risk Assessment (CBRA) taking into account ground conditions as well as external aggressors to the cable such as trawling and vessel anchors. Possible installation methods include jetting, cutting and ploughing whereby the seabed is opened and the cable laid within the trench simultaneously using a tool towed behind the installation vessel. Alternatively, a number of these operations such as jetting or cutting may occur post-cable lay. The design envelope for inter-array cable installation is shown in Table 1.9. Values for rock berm protection are presented as an option where cable burial is not achievable, for example the length of cable approaching the WTG foundation.

1.4.65 In some cases, where burial cannot be applied, or where the minimum burial depth cannot be achieved, it is necessary to use alternative methods such as rock placement, concrete mattresses, frond mattresses or Uraduct (or similar) for up to 25% of the inter-array cable total length.

Table 1.9: Maximum design envelope for inter-array cable installation

Parameter	Maximum design envelope
Burial technique	Jetting/ Ploughing/ Trenching/ Cutting/ Mass Flow Excavation/ Pre-sweeping (dredging)
Length of inter-array cables (km)	64
Maximum burial depth (m)	3
Minimum burial depth (m)	0
Percentage cable requiring additional protection (%)	25
Length of cable requiring additional protection (m)	16,000
Indicative trench width (m)	1
Width of disturbance from jetting (m)	5
Area of disturbance from jetting (km^2)	0.3
Width of disturbance from ploughing (m)	10
Area of disturbance from ploughing (km^2)	0.06
Width of rock berm protection (m)	5
Area of cable protection (m^2)	80,000
Height of rock berm protection (m)	0.5
Volume of surface protection per km (based on a 0.5 x 5, trapezoid) (m^3 km^{-1})	1,250
Length of exposed cable approaching WTG foundation requiring rock dumping/ remedial protection (m)	50
Total area of WTG foundations requiring rock dumping/ remedial protection (m^2) (34 WTG and one OSS foundation)	17,500

Crossings

1.4.66 If the inter-array cables must cross infrastructure such as existing cables, both the third-party asset and the installed cable must be protected. This protection would usually consist of a rock berm on the existing cable (separation layer), as well as a second rock berm on the installed cable (protection layer). Alternatively, methods such as concrete mattressing, steel or concrete bridging may be used for inter-array cable crossings. The detailed design of the crossing would be decided in a crossing agreement developed by both parties. The design envelope for the cable crossing protection is shown in Table 1.10.

Table 1.10: Maximum design envelope for inter-array cable crossing protection

Parameter	Maximum design envelope
Crossing technique	Rock dumping/ concrete mattresses/ steel bridging/ concrete bridging
Number of cable crossings	12
Length of crossings (m)	100
Width of crossings (m)	10
Volume of post-lay rock berm protection per cable crossing (m^3)	500
Number of concrete mattresses (6 x 3 x 0.3 m) per crossing	24
Area of post-lay rock berm protection per cable crossing (m^2)	1,000
Total area of rock berm protection for crossings (m^2)	12,000
Total volume of rock berm protection for crossings (m^3)	6,000

1.4.67 The vessel requirements for inter-array cable installation are shown in Table 1.22 in the Vessel Activities section.

Offshore substation

Design

1.4.68 OSSs are offshore structures housing electrical equipment to provide a range of functions, such as changing the voltage (transformer), current type (converter), or power factor (booster). If a OSS is deemed to be required for Thanet Extension, it will be a transformer OSS used to step-up the voltage for transmission to shore. If required, the OSS will be clearly marked for aviation and navigation purposes. The exact location will be determined during the wind farm detailed design phase (post-consent), taking account of ground conditions and the most efficient cable routing amongst other considerations. The OSS would not be manned but once functional would be subject to periodic O&M visits by staff by vessel.

1.4.69 Thanet Extension requires flexibility in location and foundation choice of OSS to ensure that anticipated changes in available technology and pending greater understanding of ground conditions following detailed pre-construction Site Investigations can be accommodated within the project design. The foundation types under consideration for the OSS are the same as those for WTGs as detailed in previous sections, although a pin-piled quadropod jacket foundation is the most likely choice for the OSS (Figure 1.13).

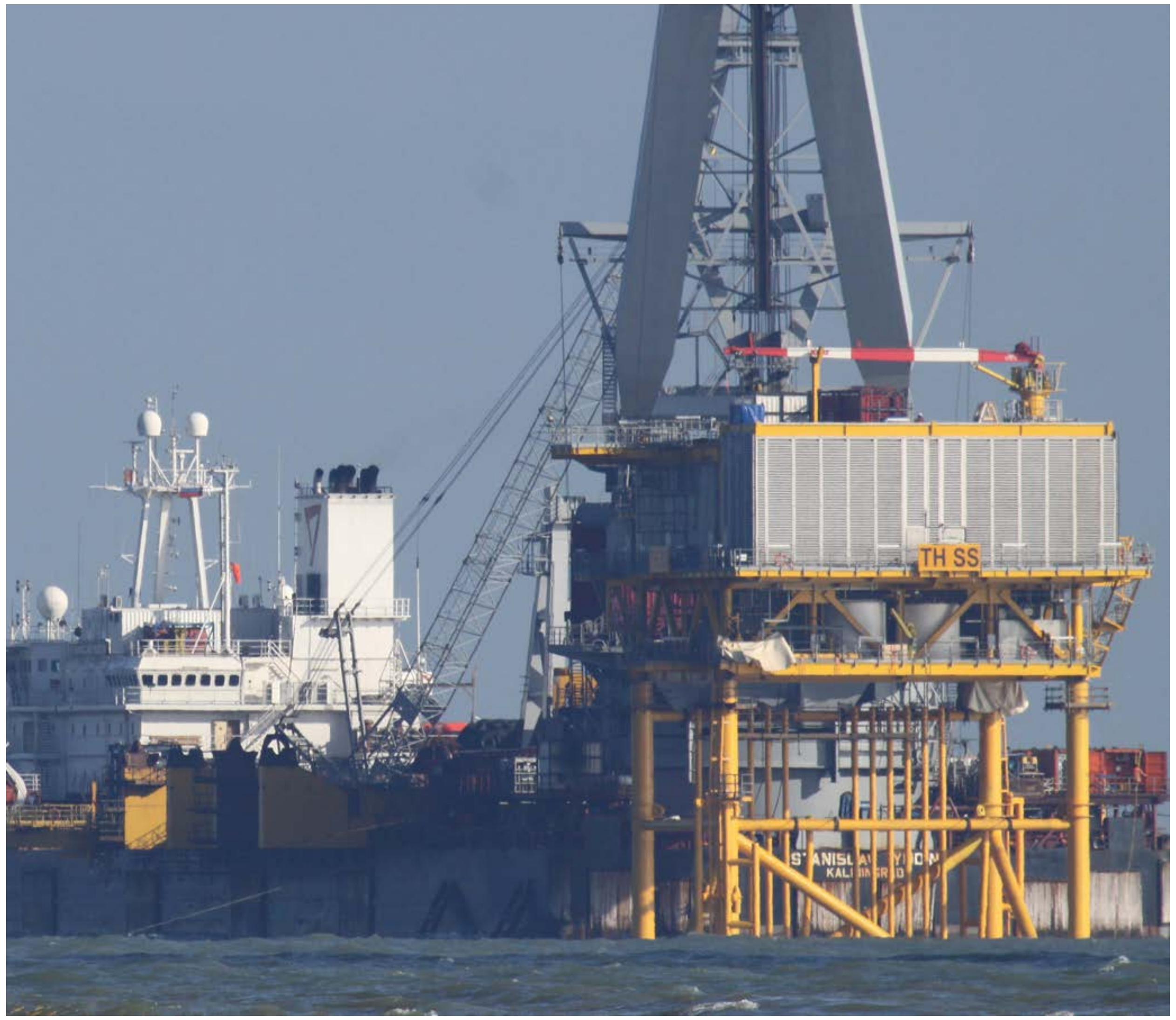

Figure 1.13 The existing TOWF OSS on a four-legged jacket foundation.

1.4.70 The OSS unit is pre-fabricated in the form of a multi-layered cube and will be mounted on a foundation at some height above the sea surface. The design envelope for the OSS topside module is shown in Table 1.11. The worst-case scenario is based on a maximum project capacity of 340 MW.

1.4.71 The OSS will have a diesel generator for commissioning and O&M activities. Generators are typically used for back-up power supply at the platform (crane lifting, lighting, ventilation, supply of chargers and Uninterruptable Power System etc.).

Table 1.11: Maximum design envelope for the OSS

Parameter	Maximum design envelope
Number of OSS platforms	1
Foundation options (see paragraph 1.4.23 *et seq.* and Table 1.13)	As WTG foundations, although a piled quadropod jacket is considered the most likely foundation choice for the OSS.
Topside weight (tonnes)	2,500
Topside length (m)	70
Topside width (m)	50
Topside height (excluding crane and helideck) (m)	30
Topside height above HAT (excluding crane and helideck) (m)	55
Topside height above HAT (including crane) (m)	80
Annual O&M time (weeks)	2
Diesel fuel (l)	200,000
Gray water (m^3)	1,000
Black water (m^3)	1,000
Transformer coolant oil (kg)	600,000
UPS Batteries (litres)	10
Fire suppression systems (l)	20,000
Sulphur hexafluoride (SF6) (kg)	1,500
Engine oil (m^3)	5
HVAC coolant (glycol) (m^3)	5

VATTENFALL

Installation

1.4.72 OSSs are generally installed in two phases, the first phase will be to install the foundation for the structure using an installation vessel as described in the foundations sections. Secondly, an installation vessel (same or different from the one installing the foundation) will be used to lift the topside from a transport barge/ vessel onto the pre-installed foundation structure. The foundation and topside may be transported by the installation vessel. The design envelope for the OSS platform can be seen in Table 1.12 for piled foundations and Table 1.13 for suction caisson foundations. Quadropod jackets are considered the most likely option, although a tripod would also be considered for the OSS foundation. The vessel requirements for this process can be seen in the Vessel Activities section.

1.4.73 For piling, a soft start procedure would be followed as with the WTG foundations. This would involve starting at a lower hammer energy (270 kJ) compared to the maximum (2700 kJ) for one hour before ramping up to full power. The hammer blow rate would also be reduced by half (15 blows per minute compared to 30 blows per minute) during the soft start period.

Table 1.12: Maximum design envelope for the installation of the OSS using driven piles (a tripod jacket foundation may also be used, but a quadropod is the worst-case jacket option)

Parameter	Maximum design envelope	
	Monopile	Tripod jacket
Pile diameter (m)	10	3
Pile penetration depth (m)	50	70
Width of jacket at seabed (m)	N/A	36
Width of jacket at MSL (m)	N/A	28
Jacket leg spacing (m)	N/A	34
Hammer energy (kJ)	5,000	2,700
Piling time per foundation (hr)	6	6
Foundations by driven piling (%)	100	100
Foundations installed by drilling (%)	50	50
Drill diameter (m)	6	4
Volume of risings per pile (m^3)	1,000	200
Volume of risings per project (m^3)	900	450
Grout volume per foundation (m^3)	160	100
Scour protection options	As WTG foundations.	
Scour protection depth (m)	5	5
Scour protection area (excluding structure footprint (m^2)	1,964	2,025
Topside indicative installation time excluding cable installation (from arrival on site) (weeks)	1	1

Table 1.13: Maximum design envelope for the installation of the OSS using a suction caisson jacket

Parameter	Maximum design envelope	
	Tripod	Quadropod
Suction bucket diameter above sea surface (m)	3	3
Suction bucket diameter (m)	20	15
Bucket penetration depth (m)	15	15
Grout volume per foundation (m^3)	150	200
Total grout volume for OSS (m^3)	450	800
Scour protection options	As WTG foundations.	As WTG foundations.
Scour protection depth (rock) (m)	5	5
Scour protection area (including structure footprint (m^2)	7,854	4,417

Offshore meteorological mast (Met Mast)

Design

1.4.74 Offshore Met Masts are used to collect data on meteorological variables such as wind speed and air temperature. This data is then used to refine design parameters post consent and optimise performance during operation. The Met Mast follows the minimum spacing of the 716 m x 480 m.

1.4.75 If required, the Met Mast will be marked for aviation and navigation purposes. The exact location will be determined during the wind farm detailed design phase (post-consent), taking account of ground conditions and the most efficient cable routing amongst other considerations. The Met Mast would not be manned but once functional would be subject to periodic O&M visits by staff by vessel.

1.4.76 The Met Mast unit is pre-fabricated in the form of a tower and will be mounted on a foundation at some height above the sea surface. The design envelope for the Met Mast is shown in Table 1.14.

Installation

1.4.77 Met Masts are generally installed in two phases, the first phase will be to install the foundation for the structure using an installation vessel as described in the foundations sections. Secondly, an installation vessel (same or different from the one installing the foundation) will be used to lift the mast from a transport barge/ vessel onto the pre-installed foundation structure. The foundation and topside may be transported by the installation vessel. Three foundation types could be used for the Met Mast - monopile, jacket or suction caisson. The choice of foundation will depend on seabed conditions and will be confirmed in the post-consent final design.

Table 1.14: Maximum design envelope for the offshore Meteorological Mast (Met Mast).

Parameter	Maximum design envelope
Number of Met Masts	1
Maximum elevation (mHAT)	Maximum hub height of WTGs
Hazardous materials (litres)	0
Indicative number of yearly O&M visits	15
Indicative instruments	Anemometers and wind vanes at a minimum of three measurement heights.

Offshore export cables

1.4.78 Offshore export cables are used for the transmission of power from the WTG strings (or OSS) to the landfall point. For High Voltage Alternating Current (HVAC) transmission systems offshore export cables will carry electricity from the wind farm to the landfall location.

1.4.79 An HVAC export cable solution has been chosen for Thanet Extension; High Voltage Direct Current (HVDC) infrastructure has been discounted due to the relatively short export cable length (approximately 32.5km in total offshore and onshore), and the installed capacity of the project. At this distance HVAC is a more efficient solution both in terms of minimising electrical losses and in minimising the size and amount of infrastructure required. Over a sufficiently long length the losses associated with conversion to and from HVAC are outweighed by the reduced losses from the HVDC transmission cables for very large projects, however the Thanet Extension export cable length and export capacity are considerably below what would make this option economic and efficient.

1.4.80 Thanet extension export cables will be between 66 kV and 220 kV; whilst 66 kV may in some circumstances be classified as a Medium Voltage, for the purposes of this ES all export cable voltages are referred to as HVAC.

Design

1.4.81 Thanet Extension requires flexibility in the type, location, depth of burial and protection measures for export cables to ensure that anticipated physical and technical constraints, changes in available technology and project design can be accommodated.

1.4.82 Like the inter-array cables, the offshore export cables will consist of a number of conductor cores, usually made from copper or aluminium. These will be surrounded by layers of insulating material as well as material to armour the cable for protection from external damage, and material to keep the cable watertight (Figure 1.12). Export cables however, are typically larger in diameter than inter-array cables, due to the larger conductor cores required to transport greater volumes of power. The design envelope for inter-array cables is shown in Table 1.15.

1.4.83 The offshore export cable will have a maximum micro-routing distance of 1000 m (OECC width). Micro-sited infrastructure will still remain within the RLB.

Table 1.15: Maximum design envelope for offshore export cables

Parameter	Maximum design envelope
Number of export cables	4
Cable specification	3-core XLPE (Cross-linked Polyethylene) or similar.
Cable voltage (kV)	220 kV
Indicative external cable diameter (mm)	300
Length of cables (km)	30 per cable
Total length of cables (km)	120
Indicative expected duration of installation activities (days)	30 days per cable
Indicative spacing between cables if unbundled (m)	50 m within pair; 120 m between pairs
Max spacing between adjacent cables if multiple cables (m)	250 m
Maximum trench width per cable (m)	10

Figure 1.14: **Cross-section of a typical subsea HVAC 3-core cable.**

OECC

1.4.84 The OECC is presented in Figure 1.1.

Preparatory works

1.4.85 The preparatory works for offshore export cables are likely to involve the same works as described for the inter-array cables.

1.4.86 Pre-sweeping of up to 0.48 km^2 of the cable route for each export cable may be required prior to installation.

Installation

1.4.87 The export cable installation methodology as well as the burial depth and any requirement for protection measures will be defined by a detailed CBRA, performed during the detailed design stage (post-consent).

1.4.88 It is likely that the installation techniques will consist of one or a combination of trenching, dredging, ploughing or cutting. As with the inter-array cables, the export cables will need to be made secure when the route crosses obstacles such as exposed bedrock, pre-existing cables or pipelines that mean the cable cannot be buried. This is typically achieved through some form of armouring (rock, concrete mattress, or proprietary separation layer) to maintain the integrity of the cable, and may be used for up to 25% of the cable route. The design envelope for offshore export cable installation can be seen in Table 1.16.

1.4.89 Cable installation and route preparation will be undertaken by specialist vessels. The vessel requirements for offshore export cable installation are described in the Vessel Activities section.

Crossings

1.4.90 The OECC crosses four existing assets, Nemo Link, Tangerine, Pan European Crossing (Belgium) and the existing Thanet OWF, which consists of two export cables. In total there will be 20 cable crossings consisting of five cables crossed by each of the four Thanet Extension cables. Crossings will be 100 m in length and 10 m in width. The design and methodology of these crossings will be confirmed in agreements with the asset owners, however it is likely that a berm of rock will be placed over the existing asset for protection, known as pre-lay berm, or a separation layer. The export cable will then be laid perpendicularly across this, and will then be covered by a second post-lay berm to ensure that the export cable remains protected and in place. Alternatively, existing assets may be crossed using similar methodology with concrete mattresses, or steel or concrete bridging. The parameters for these crossings are shown in Table 1.17. As with scour protection, artificial frond mats may also be used at crossings.

Table 1.16: Maximum design envelope for offshore export cable installation

Parameter	Maximum design envelope
Burial technique	Jetting/ Ploughing/ Trenching/ Cutting/ Mass Flow Excavation/ Pre-sweeping (dredging)
Maximum Burial depth (m)	3*
Minimum Burial depth (m)	0
Indicative trench width from jetting (m)	10
Percentage of cable requiring addition protection (%)	25
Width of disturbance from jetting (m)	10
Total area of disturbance from jetting (km^2)	1.2 (0.3 km^2 per cable)
Width of disturbance from ploughing (m)	12
Area of disturbance from ploughing (km^2)	1.4
Pre-sweeping length (dredging) (km)	24 (6 km per cable)
Pre-sweeping width of dredging corridor (m)	20
Pre-sweeping area of dredging corridor (km^2)	0.48
Pre-sweeping volume of dredging corridor (m^3)	1,440,000
Pre-lay grapnel run width (m)	20
Pre-lay grapnel run area (km^2)	2.4
Width of cable protection per cable (m)	7
Percentage of each cable requiring protection (%)	25
Length of cable protection (m)	7,500
Area of cable protection per export cable (m^2)	52,500
Total area of cable protection (m^2)	210,000

* below mean seabed depth

Table 1.17: Maximum design envelope for cable crossings for the offshore export cables

Parameter	Maximum design envelope
Crossing technique	Rock dumping/ concrete mattresses/ steel bridging/ concrete bridging.
Number of crossings	20
Total number of crossings$^{\alpha}$	80
Length of crossings (m)	100
Width of crossings (m)	10
Post-lay berm height (m)	0.5
Volume of post-lay rock berm protection per crossing (m^3)	500
Number of concrete mattresses (6.0 x 3.0 x 0.3 m) per crossing	50
Area of post-lay rock berm protection per cable crossing (m^2)	1,000

$^{\alpha}$ Assuming a four-cable scenario

Cable protection

1.4.91 In some cases, normal subsea installation methods cannot be applied and it is necessary to use alternative methods to provide an adequate degree of protection for the cable. Details of some of the techniques employed are given below:

- Rock placement involves the laying of rocks on top of the cable to provide protection which is effective on crossings and other areas requiring protection;
- Concrete mattresses, which are prefabricated flexible concrete coverings that are laid on top of the cable, are an alternative to rock placement. The placement of mattresses is slow and as such is only used for short spans. Grout or sand bags may be used as an alternative to concrete mattressing; this method is generally applied on smaller scale applications than concrete mattressing;
- Frond mattresses can be used to provide protection by stimulating the settlement of sediment over the cable. This method develops a sand bank over time protecting the cable but is only suitable in certain water conditions. This method may be used in close proximity to offshore structures though experience has shown that storms can strip deposited materials from the frond. An example of a typical frond mattress can be found below;
- Uraduct or similar, is effectively a protective shell which come in two halves and is fixed around the cable to provide mechanical protection. Uraduct is generally used for short spans at crossings or near offshore structures where there is a high risk from falling objects. Uraduct does not provide protection from damage due to fishing trawls or anchor drags.
- No cable protection will be used within the Sandwich Bay intertidal area.

Landfall

1.4.92 Where there is clear physical cross over in the offshore and onshore study areas, such as the intertidal area of landfall, the chapter describes the works below Mean High Water Springs (MHWS). This section provides a brief description of the onward 'onshore' works for completeness. Full details of the onshore elements of the proposed development are provided in Volume 3, Chapter 1: Project Description (Onshore) (Document Ref: 6.3.1).

1.4.93 The landfall denotes the location where the offshore cables are brought ashore and jointed to the onshore cables within Transition Joint Bays (TJBs). Three options are being proposed with final decisions based on post-consent survey results. The options with regards the landfall are described in detail in Volume 3, Chapter 1: Project Description (Onshore) (Document Ref: 6.3.1).

Export Cable Circuit Installation through the Intertidal Area

1.4.94 Open trenching using excavators will be required for all options within the intertidal area leading up to the saltmarsh area. This is mainly due to water depth or proximity to other infrastructure and areas of conservation importance, e.g. HDD pits and saltmarsh, not allowing offshore trenching methods such as ploughing to continue.

1.4.95 The maximum design envelope for open trenching through the intertidal area can be found in Table 1.18. It is assumed that the up to four export cable circuits will be installed by open trenching using excavators through the intertidal area. This will cover a maximum distance of 2 km per export circuit with a trench width of 1 m, a maximum depth of 3 m, separation of 5 m and associated temporary route tracks. In total the maximum width of disturbance will be 40 m and the total area of disturbance will be 80,000 m^2.

1.4.96 Material removed during the excavation will be positioned to the side of the trench and back filled once the cable has been installed.

Table 1.18: Maximum design envelope for open trenching within the intertidal area

Parameter	Maximum design
Open trench length per cable circuit (km)	2
Open trench depth (m)	3
Width of cable route (based on 4 cable circuits, temporary route tracks and sediment storage) (m)	40
Area of disturbance (m^2) for four cable circuits	80,000

Option 1 - Horizontal Directional Drilling (HDD)

1.4.97 Compared to the other two Options, Option 1 will negate the need to interact with the sea wall, and the saltmarsh present within the upper intertidal, as cables will be installed underneath it, via ducts installed connecting the TJBs to offshore punch-out locations within the intertidal, at least 100 m seaward of the existing sea wall. Option 1 assumes that the outcome of future SI works indicate that HDD within the Country Park is possible and does not present an unacceptable risk of contamination release. Table 1.19 outlines the maximum design envelope for the HDD option.

1.4.98 A temporary working area of 60 x 50 m will contain the HDD apparatus, and four ducts will be installed by HDD from the TJB locations, under the sea wall, to exit into four 20 x 20 m offshore containment areas in order to contain the water based drilling mud (usually inert clay based Bentonite). A common methodology that may be employed is the creation of a temporary mud lagoon will be installed in the landward drilling entry pit which will use a closed-circuit mud management system where the mud is constantly pumped out of the pit for processing. At the exit pit containment area, which may be excavated or surface based, some bentonite will collect in the exit pit and subsequently removed. Whilst the drilling mud will be water based, and will comprise an inert clay material (Bentonite), this approach will ensure that impacts to surrounding intertidal receptors will be kept to a minimum.

1.4.99 Following the installation of the HDD ducts, the offshore cables will be pulled through into the onshore TJBs. The TJBs would be installed below ground and, subject to the findings of the SI works, the onward cable trenched for the remainder of the onshore route.

1.4.100 HDD installation works may be progressed in advance of wider works. This is to ensure installation of the offshore export cable at landfall can be delivered on schedule.

1.4.101 Full details of option 1 can be found in Volume 3, Chapter 1: Project Description – Onshore (Document Ref: 6.3.1).

Table 1.19: Maximum design envelope for HDD landfall option

Parameter	Maximum design envelope
Temporary works compound area (m)	60 x 50
Onshore cofferdam area (m^2)	704
Excavated material from landfall/ TJBs (HDD) (m^3)	1,408
Offshore cofferdam area (m^2)	1,600 (20 m x 20 m per cable with a maximum of 4 cables)
Minimum punch out distance from sea wall (m)	100
Volume of drilling mud volume to be released to environment (m^3)	0 (to be captured within cofferdam)
Works duration (months)	18

Option 2 – Above ground cable installation

1.4.102 Option 2 involves extending the sea wall seawards by 18.5 m (Figure 1.15) to enable the offshore export cables to be laid over ground through the country park.

1.4.103 The extension is needed to avoid disturbing the historic landfill site. The extension enables the cable circuits to overcome the current height differential between the saltmarsh and Country Park, in the order of 1.5 m. In addition to this, it must be considered that cables would be buried to at least 1 m in the saltmarsh and raised above ground level in the Country Park. Therefore, to bridge this height difference whilst maintaining a reasonable burial depth and protection of the cables without undue stress in terms of bending, the Country Park and sea wall will need to be extended seaward with suitable backfill to form a zone where the cables can suitably transition height-wise between the saltmarsh and Country Park.

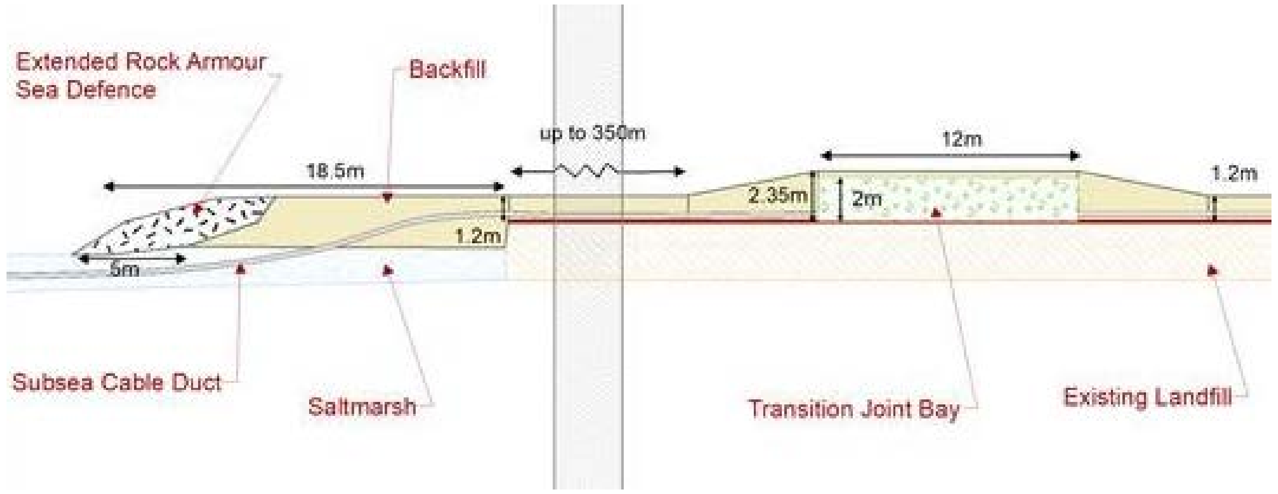

Figure 1.15: Inland TJBs in cross-section (over ground)

1.4.104 It will be necessary to access the saltmarsh to install the cable ducts through which the subsea cables will be pulled. This will entail disturbance to the saltmarsh for excavation of two to four trenches into which ducts will be installed and disturbance for the vehicular access for trenching, ducting and reinstatement. It is assumed that suitable running boards or mats will be laid on the saltmarsh to minimise vehicular damage. It is further assumed that the trenching and ducting from offshore will be suitably separated to the order of around 5 m between trenches at the sea wall with an additional 5 m either side and alongside each trench for vehicles and reservation of saltmarsh turfs (Figure 1.16).

1.4.105 Access to the saltmarsh will need to be secured, either from the Country Park or elsewhere (e.g. mudflats) or preferably both. From the Country Park, this is likely to need a (temporary) ramp created down and over the sea wall.

1.4.106 The offshore cables will then be pulled through the cable ducts under the extended sea wall to be jointed to the onshore cables at the transition pits on the landward side of the landfall site (see Volume 3, Chapter 1 (Document Ref: 6.3.1).

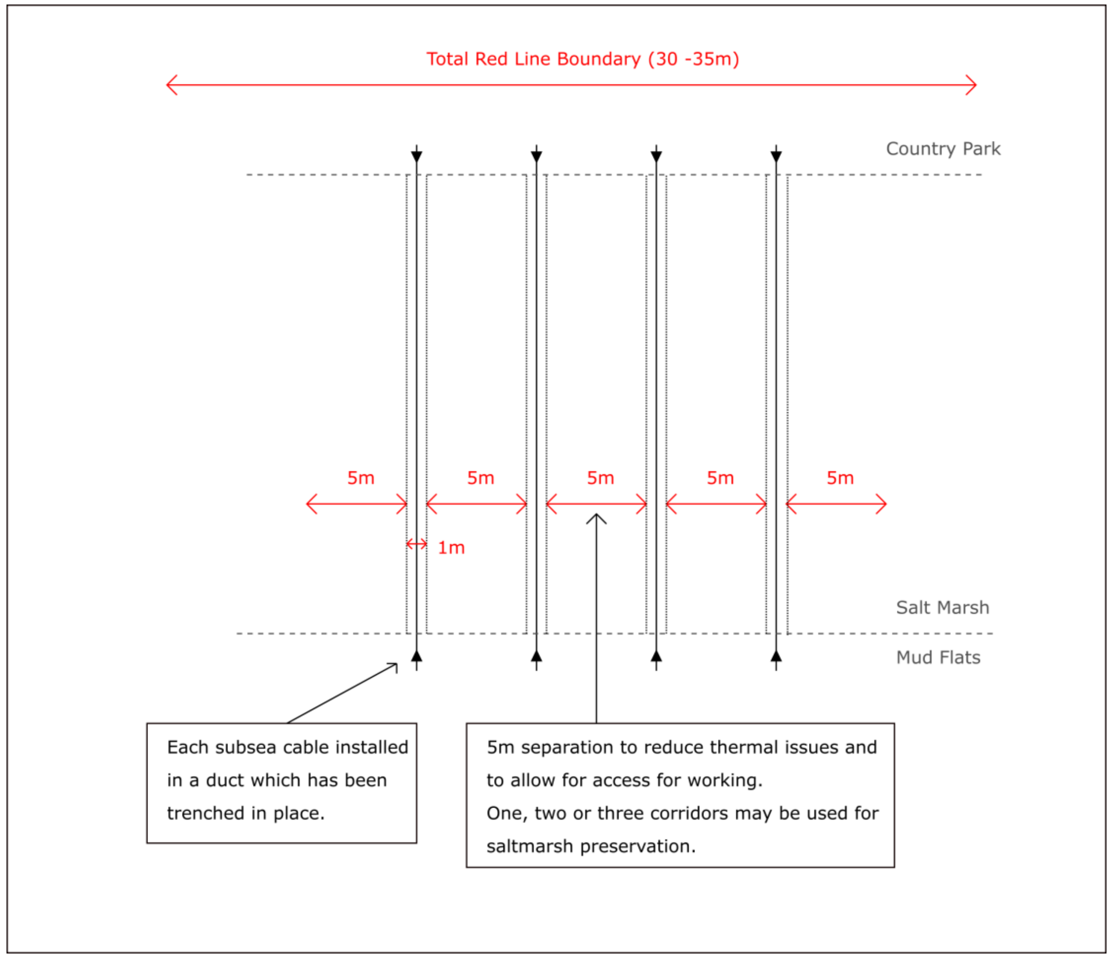

Figure 1.16: Assumed works corridor through saltmarsh

1.4.107 As a result of the evolving design process for the project, it became apparent that in order to ensure mitigation against the potential release of leachate from the historic landfill at Pegwell Bay, a cofferdam is required during construction. The proposed design and layout for the cofferdam is provided in Table 1.20 and Figure 1.17.

1.4.108 The cofferdam would be installed prior to dismantling, extending and reinstating the sea wall. This is to ensure that the intertidal area outside of the cofferdam is not accessible to any leachate from the landfall. The final design and layout of the cofferdam will enable trenching without the need to open up the cofferdam and expose the intertidal area to any exposed landfill whilst the sea wall is open.

Table 1.20: Maximum cofferdam and over ground cable installation design parameters

Parameter	Maximum design envelope
Width of cofferdam (m)	165
Depth of cofferdam (m)	25
Temporary works compound area (m)	40 x 30
Construction space required in saltmarsh (m^2)	3,872
Piling Noise level (dBA)	132
Duration of piling (days)	33
Depth of sea wall extension (m)	18.5
Max width of sea wall extension (m)	155
Area of permanent seaward extension (m^2)	1398.9
% loss of saltmarsh in the Thanet Coast and Sandwich Bay SAC	0.13
TJB and cable route bund slope (other than for crossings)	1:5
Bund height of onshore cable route (m)	1.2
Bund height of TJBs (m)	2.3
Bund width of TJBs (m)	45

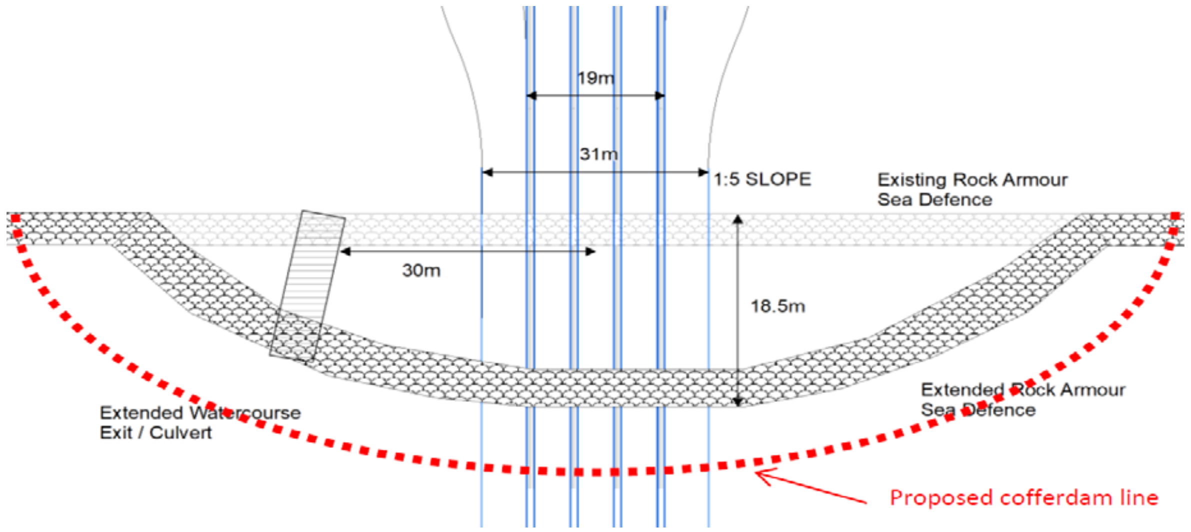

Figure 1.17: Indicative line of the proposed cofferdam at the sea wall.

1.4.109 The above ground landfall option would locate the TJBs on the landward side of the existing sea wall within the Pegwell Bay Country Park. This option would secure the TJBs in a dry and stable location up to 350 m inland from the existing sea wall. This option would require an extension of the offshore cables onshore to the location of the TJBs.

1.4.110 Full details of option 2 can be found in Volume 3, Chapter 1: Project Description – Onshore (Document Ref: 6.3.1).

Option 3 - Trenched landfall installation

1.4.111 Option 3 proposes burial, via trenching, of the offshore export cable through the saltmarsh, existing sea wall and Country Park where the offshore cables will connect to the TJBs. This option is dependent on ground conditions within the Country Park historic landfill enabling trenching and burial of infrastructure.

1.4.112 As described with option 2, access resulting in disturbance to the saltmarsh and a cofferdam will be required. This will enable the dismantling of the existing sea wall so that cable ducts can be installed via trenching through the sea wall and landfill which sits behind. The cofferdam will be *in situ* for the entire works and removed once the sea wall is reinstated. The final design and layout of the cofferdam will enable trenching without the need to open up the cofferdam and expose the intertidal area to any exposed landfill whilst the sea wall is open. The maximum design envelope for the cofferdam will follow that of option 2 (Table 1.20). However, the maximum width of the cofferdam is smaller (80 m) compared to Option 2 (165 m).

1.4.113 Full details of option 3 can be found in Volume 3, Chapter 1: Project Description – Onshore (Document Ref: 6.3.1).

Other offshore infrastructure

1.4.114 It is anticipated that a maximum of one LiDAR Device and one wave buoy may be required across the Thanet Extension site. The LiDAR, if required, will be floating and fixed using anchors. The wave buoy will be attached to the seabed using anchors.

Unexploded Ordinance (UXO)

1.4.115 Estimates of numbers and details of UXO clearance within the OECC and array area are detailed in Table 1.21.The assessment of UXOs up to 130 kg will be included in Thanet Extension ES. If larger UXOs are discovered these will be assessed through a separate Marine Licence.

1.4.116 UXO clearance activities may commence prior to construction starting on TEOW. This is to ensure that main construction activities can proceed on schedule.

Table 1.21: UXO assumptions

Assumptions	Comment
Number of UXO	30
Clearance date (dependent on final construction programme)	2020
Days to clear (based on 4 per day)	8
Detonations per 24 hr period	8
Minimum charge weight anticipated (kg)	0.05
Maximum charge weight anticipated (kg)	130

Vessel activities

1.4.117 The total vessel numbers on-site at any one time are summarised in Table 1.22. Note that many parts of the construction (e.g. foundation and WTG installation) are mutually exclusive and so the numbers provided in Table 1.22 provide a worst-case scenario and will not be representative for most of the construction period. The assumptions for JUVs are provided in Table 1.25 for the life cycle of the project.

1.4.118 Anchor handling and deployment may be required outside of the RLD. This is considered part of the overall footprint of impact, and is de minimis when considering the likelihood and number of deployments with respect to anchoring outside of the RLD. Anchoring outside of the RLB is not considered a licensable activity.

1.4.119 Vessels will, when necessary, undertake wet storage techniques for anchors and infrastructure across the construction area.

1.4.120 The assumptions for vessel moorings are presented in Table 1.27.

Table 1.22: Maximum construction vessel quantities on-site at the same time

Site capacity	Maximum vessel movements
Seabed preparation vessels	3
Foundation spreads per project	1
Number of vessels per foundation spread (includes tugs and feeders)	5
Transition piece installation vessels	2
Scour Installation Vessels	6
Number of vessels engaged in foundations	5
Wind turbine installation spreads	3
Max vessels per WTG installation spread	3
Total WTG installation vessels	6
Commissioning vessels	7
Accommodation vessels	1
Total IA cable vessels	4
Number of Export Cable spreads per Project	3
Number of vessels per Export Cable spread	2
Total export cable vessels	6
Landfall cable installation vessels	2
Substation/ collector IV	3
Other vessels	3
Total	48

Table 1.23: Construction period I&O Vessels Round Trips to Port for Project over 3 years

Vessel activity	Number
Seabed Preparation Vessel	15
Foundation Installation Spread	60
Transition Piece Installation	30
Scour Vessel	30
WTG Installation Spread	23
Commissioning Vessels	480
IA Cable Vessels	60
Export Cable Vessels	300
Landfall Cable Installation Vessels	30
Substation Installation Vessels	12
Other Vessels	120
Total	1,160

Table 1.24: Construction period I&O Vessels Round Trips to Port for Project over 3 years

Cable	Number
Foundation Delivery	30
Turbine Delivery	15
Cable Delivery	30
Scour Delivery	30
Substation Delivery	3
Total	108

Table 1.25: Jack-up Vessels

	Construction Period	O&M Period (30 years)	Decommissioning
Individual leg diameter (m)	10	6	6
Individual leg footprint area (m^2)	78.54	28.27	28.27
Max Number of legs	6	4	4
Combined leg area (m^2)	471.24	113.10	113.10
Leg penetration range	5-15	5-15	5-15
Jacking Operations per Turbine	2	10	1
Turbine sites	34	34	34
Total JUV visits	68	340	34

Table 1.26: Anchor footprints for construction of Thanet Extension

Description	Detail
Installation of foundations	
Number of anchors for assumed construction vessel	6
Individual anchor footprint area for one deployment and recovery (m^2)	25
Indicative anchor penetration depth (m)	3
Impacted anchor area for one deployment (m^2)	150
Assumed number of anchoring operations per installation	1
Total impacted area (m^2)	150
Total impacted volume (m^3)	450
Installation of topside (WTG and tower)	
Number of anchors for assumed construction vessel	4
Individual anchor footprint area for one deployment and recovery (m^2)	N/A
Indicative anchor penetration depth (m)	N/A
Impacted anchor area for one deployment (m^2)	N/A
Assumed number of anchoring operations per installation	N/A
Total impacted area (m^2)	N/A
Total impacted volume (m^3)	N/A
Installation of topside (OSS)	
Number of anchors for assumed construction vessel	6
Individual anchor footprint area for one deployment and recovery (m^2)	25
Indicative anchor penetration depth (m)	3
Impacted anchor area for one deployment (m^2)	150
Assumed number of anchoring operations per installation	1
Total impacted area (m^2)	150
Total impacted volume (m^3)	450
Installation of export cables	
Number of anchors for assumed construction vessel	6
Individual anchor footprint area for one deployment and recovery (m^2)	10
Indicative anchor penetration depth (m)	3
Impacted anchor area for one deployment (m^2)	60
Assumed number of anchoring operations per cable installation	120
Anchor deployments per asset crossing (per cable)	4
Total anchor deployments for asset crossings (per cable)	20
Anchor deployments per cable and foundation interface (per cable)	4
Total anchor deployments per cable installation	144
Impacted area per cable (m^2)	8,640
Impacted volume per cable (m^3)	25,920
Total impacted area (m^2)	34,560
Total impacted volume per cable (m^3)	103,680
Installation of array cables	
Number of anchors for assumed construction vessel	6
Individual anchor footprint area for one deployment and recovery (m^2)	10
Indicative anchor penetration depth (m)	3
Impacted anchor area for one deployment (m^2)	60
Assumed number of anchoring operations per installation	15
Number of installations	34
Total anchor deployments for inter-array installation	510

Impacted area per cable (m^2)	900
Impacted volume per cable (m^3)	2,700
Total impacted area (m^2)	30,600
Total impacted volume (m^3)	91,800

Table 1.27: Permanent vessel moorings

Description	Detail
Basic description	Steel or plastic floating buoy, moored to the seabed using a variety of mooring solutions. Buoy includes mooring loops, shackles or hooks, suitable to provide a mooring point for wind farm vessels during lulls in operation.
Max number of installations in total	2
Possible foundation types:	Concrete Gravity Base or Standard Ground Tackle
Surface structure	A floating mooring buoy up to 3 m in diameter, and 3 m above sea level.
Marking & Lighting	Marked and lit as required (assume high-viz yellow colouration, radar reflector, navigation light). AIS beacon may be considered judged valuable (and acceptable to THLS).

1.5 Construction Programme

1.5.1 The construction programme for Thanet Extension will be dependent on a number of factors which include:

- The grid connection dates specified in agreements with the National Grid (which may be subject to change);
- The date that development consent is granted; and
- The availability and lead times associated with procuring and installing the project components.

1.5.2 Construction of the offshore infrastructure is expected to commence in 2021. The offshore construction process is expected to take up to 28 months, continuously where possible. Offshore construction works are typically carried out under relatively calm metocean conditions which are normally experienced during the summer, although some construction activities may take place throughout the year.

1.5.3 Twenty-four hour working will be required, with illumination required by the installation vessels during night-time and low light conditions.

1.5.4 A high-level indicative construction programme is presented in Table 1.28 below. The programme illustrates the likely duration of the major offshore installation elements and how they may relate to one another if built out in a single construction campaign.

Table 1.28: Indicative construction programme (assuming no breaks to work)

Construction activity	Anticipated period (months)
Foundation installation	6 (includes 1 month weather downtime)
Cable installation (inter-array and export)	6 (includes 1 month weather downtime)
OSS (if required)	2.5 (includes 2 weeks for foundation installation and weather downtime)
Met Mast (if required)	2.5 (includes 2 weeks for foundation installation and weather downtime)
WTG installation	6 (includes 1 month weather downtime)
Scour protection installation	1 (includes 2 weeks weather downtime)
Total duration	28

1.6 Operations and Maintenance

1.6.1 The indicative project programme states that the O&M phase will not commence until 2023, based on an offshore construction start date in 2021. The operational life is expected to be 30 years.

1.6.2 The overall O&M strategy will be finalised once the technical specification is known, including WTG type and final project layout. O&M activities will take place from the existing hub in Ramsgate.

1.6.3 Maintenance activities can be categorised into two levels: preventative and corrective maintenance. Preventative maintenance is according to scheduled services whereas corrective maintenance covers unexpected repairs, component replacements, retrofit campaigns and breakdowns.

1.6.4 The offshore O&M will be both preventative and corrective. The O&M strategy will include an onshore (harbour based) O&M base at the existing hub in Ramsgate. Due to the proximity of the wind farm to the shore, it is unlikely that a Special Operations Vessel (SOV) would perform the function of an offshore accommodation base.

1.6.5 The general O&M strategy may rely on Crew Transfer Vessels (CTVs) and supply vessels for the O&M services that will be performed at the wind farm. The maximum vessel movements per year for the O&M activities can be found in Table 1.29 below. A vessel movement is defined as a return trip from port to the site, and back to port, see Table 1.30.

1.6.6 An indicative list of offshore O&M categories and proposed activities are outlined below:

- Inter-array cables – replacement (Table 1.31):
  - Additional cable laying;
  - Cable replacement;
  - Cable inspection;
  - Cable burial using surface protection;
  - Cable re-burial; and
  - Cable repair.
- Inter-array cables – repair/ re-burial (Table 1.32):
  - Cable re-burial; and
  - Cable repair.
- Export cables – repair/ re-burial (Table 1.33):
  - Cable inspection;
  - Cable replacement;
  - Cable burial using surface protection;
  - Cable re-burial;
  - Cable repair; and
  - Additional cable laying.
- Turbines (Table 1.34):
  - Annual wind turbine maintenance;
  - Wind turbine troubleshooting;
  - Wind turbine repair;
  - Blade inspection;
  - Blade and hub repair;
  - Blade replacement;
  - Transition piece repair;
  - Transition piece maintenance;
  - Transformer replacement;
  - Gearbox repair and replacement;
  - Generator replacement;
  - Anode replacement;
  - Bird waste removal;
  - Access ladder replacement;
  - Paint and repair; and
  - J-Tube and ladder cleaning.
- Offshore substation (Table 1.35):
  - Annual maintenance;
  - Major component replacement;
  - Regular maintenance/ troubleshooting;
  - Painting;
  - Bird waste removal;
  - Anode replacement;
  - Access ladder replacement;
  - Ladder cleaning;
  - J-tube maintenance;
  - General maintenance work; and
  - Switchgear replacement.

1.6.7 Intertidal O&M activities will comprise of two or three persons accessing the intertidal area on foot or using a small 4WD (such as ARGO Cat) or hovercraft. The intertidal activities are expected to last approximately two to three weeks, once a year.

Table 1.29: Maximum O&M vessel quantities per year

Vessel activity	Maximum O&M quantities per year
Small CTV O&M vessel	2
Large O&M Vessel	1
Lift vessels	1
Cable maintenance vessel	1
Auxiliary vessels	1

Table 1.30: O&M Vessel Round Trips to Port per year, per vessel

Vessel activity	Number
Small CTV O&M Vessel	150 (300 in total due to 2 vessels)
Large O&M Vessel	2
Lift Vessel	1
Cable Maintenance Vessel	1
Auxiliary Vessels	3
Accommodation O&M	0
Total (including all vessels)	307

1.6.8 Based on VWPL's experience and knowledge both at TOWF and other local OWFs best estimates of the potential worse case for offshore O&M works are provided in Table 1.31 to Table 1.35 below.

Table 1.31: O&M estimations – inter-array cables replacement worst-case estimates

Worst-case assumptions	Specification
Number of inter-array cable cable failure during lifetime of wind farm	7
Length of replacement (longest inter-array cable) (m)	2,000
Width of seabed being disrupted for replacement of inter-array cable (m)	10
Overall impact area (cable and JUV) per repair (m^2)	140,000
Total repair area (m^2)	980,000

Table 1.32: O&M estimations – inter-array cables repair worst-case estimates

	Proposed activities	Specification
Cable re-burial	Reburial (total inter-array length) (m)	64,000
	Frequency (once every 5 years)	6
Cable repair	Total width of disturbance (m)	10
	Total area (cable alone) (m^2)	640,000
	Overall cumulative impact area (cable +JUV) per repair (m^2)	3,840,000

Table 1.33: Export cable repairs/ reburial worst-case estimates

	Worst-case assumptions	Specification
Cable inspection	One failure per cable per 5 years (total repairs in lifetime of project)	24
	Assumed repair length (through removal) (m)	300
Cable burial using surface protection	Total width of disturbance (same method as installation but decreased from 30 to 10 m) (m)	10
Cable re-burial	Total area (cable alone) (m^2)	3,000
Additional cable laying	Overall cumulative impact area (cable +JUV) per repair (m^2)	72,000

Table 1.34: WTGs O&M worst-case estimates

Number of major component replacement over lifetime (10 per WTG)	Worst-case
Individual leg diameter (m)	6
Individual leg footprint area (m^2)	28.27
Max Number of legs	6
Combined leg area (m^2)	169.65
Leg penetration range	5-15
Jacking Operations per Turbine (1 visit every 3 years)	10
Turbine sites	34
Total operations	340
Total footprint during operational period (m^2)	57,680

Table 1.35: OSS O&M worst-case estimates

Number of major component replacement over lifetime	Worst-case
Individual leg diameter (m)	6
Individual leg footprint area (m^2)	28.27
Max Number of legs	6
Combined leg area (m^2)	169.65
Leg penetration range	5-15
Jacking Operations (total) (1 visit every 2 years)	12.50
OSS sites	1
Total operations	13
Total footprint during operational period (m^2)	2,121

1.7 Decommissioning

1.7.1 At the end of the operational lifetime of the offshore wind farm, it is anticipated that all structures above the seabed level will be completely removed. The decommissioning sequence will generally be the reverse of the construction sequence (reverse lay) and involve similar types and numbers of vessels and equipment. Closer to the time of decommissioning, it may be decided that removal would lead to greater environmental impacts than leaving components *in situ*, in which case certain components may be cut at or below the seabed (e.g. piles), or left buried (e.g. cables).

1.7.2 A decommissioning plan and programme would be required to be submitted prior to the construction of Thanet Extension. The decommissioning plan and programme would be updated during the lifespan of the wind farm to take account of changing best practice and new technology.

1.8 References

- Department for Energy and Climate Change (DECC) (2011a), Overarching National Policy Statement for Energy (EN-1) [online]. Available at: <https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/47854/1938-overarching-nps-for-energy-en1.pdf> [Accessed: May 2017].
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- The Planning Inspectorate (PINS) (2012), Advice note nine: Rochdale Envelope [online]. Available at: <https://infrastructure.planninginspectorate.gov.uk/wp-content/uploads/2013/05/Advice-note-9.-Rochdale-envelope-web.pdf> [Accessed: May 2017].