STAR OF THE SOUTH

Victorian Environment Effects Statement

Chapter 4 – Victorian works project description

Chapter 4 Victorian works project description

PART A – INTRODUCTION AND OVERVIEW

4.1 Introduction

This chapter describes the works in Victoria associated with the Star of the South Offshore Wind Farm Project (works in Victoria).

The description includes the main components and activities associated with construction, operation and decommissioning of the works in Victoria. It provides project details to inform the assessment of environmental effects associated with works within Victorian lands and waters.

The description of works in Victoria includes:

- The defined area where works will occur (also refer to *Attachment I – EES Map Book*)
- The scale and extent of physical infrastructure
- Construction activities, methods and timing
- Operation and maintenance of the works, including infrastructure that will be in place
- Decommissioning activities.

Design evolution and consideration of alternatives is discussed in *Chapter 3 – Victorian Works Project Development.*

4.1.1 Chapter structure

This chapter has been structured in four parts, following the physical layout of the Victorian works:

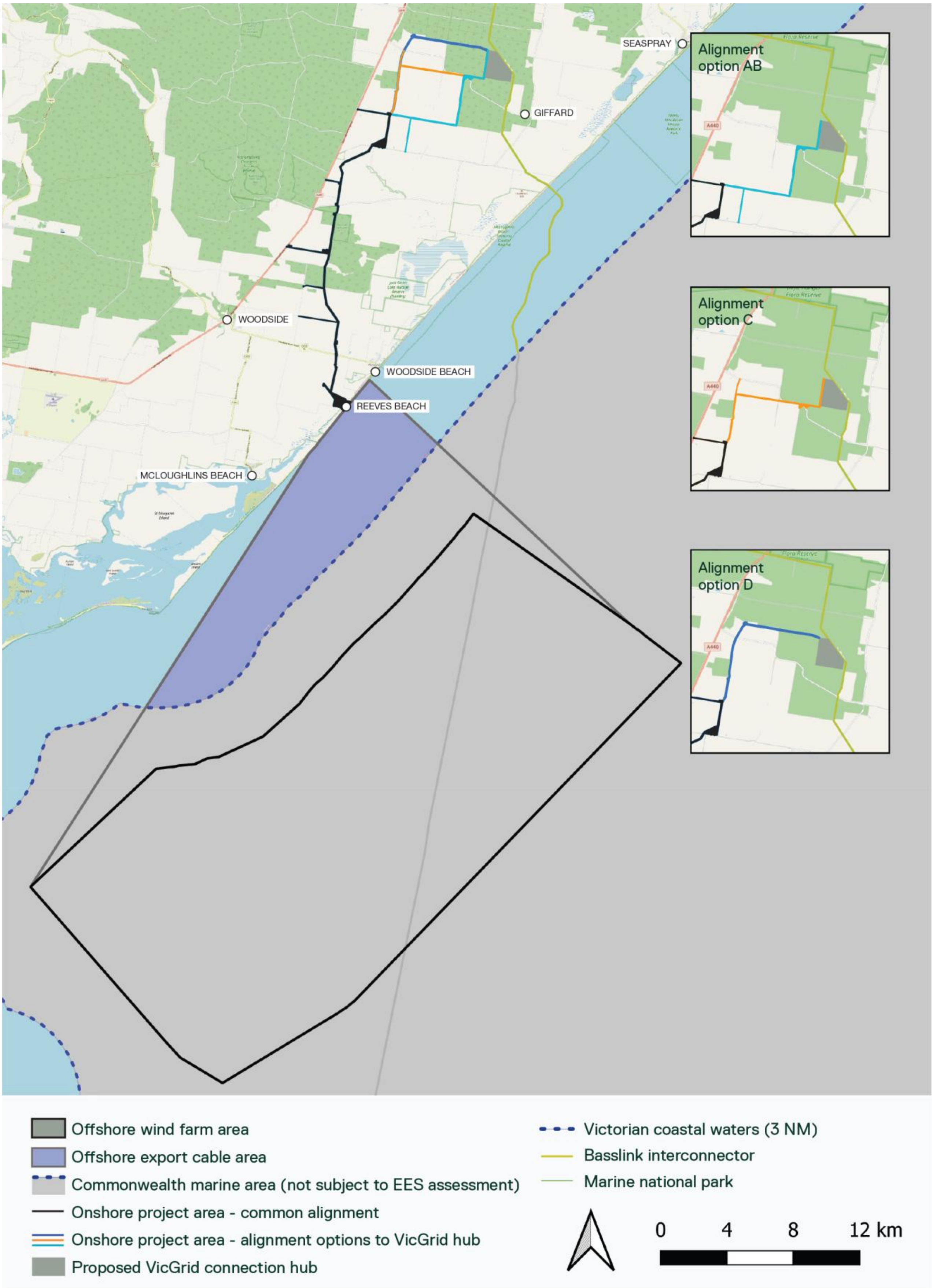
- **Part A – Introduction:** Introduces the Victorian works key features.
- **Part B – Offshore:** Describes the offshore export cables in Victorian waters.
- **Part C – Shore crossing:** Describes the area where offshore export cables transition to land.
- **Part D – Onshore transmission:** Describes the onshore Victorian works project area and transmission system.

4.2 Victorian works project area

The Victorian works project area is shown in Figure 4-1 and is broken down into three main sections - offshore, shore crossing, and onshore areas.

1. **Victorian offshore export cable area:** A 101 square kilometre marine area between the coast and the Victorian Coastal Water line (at 3NM). The area forms part of the broader 232 square kilometre offshore export cable area extending to the offshore wind farm area. The area would contain shore crossing duct entry points and offshore export cables.
2. **Shore crossing:** Located at Reeves Beach, this is where the offshore export cables transition to land and connect to the underground cable system onshore.
3. **Onshore project area**: An approximately 30 kilometre corridor extending from the shore crossing to the proposed VicGrid connection hub (also referred to as ‘proposed Giffard terminal station area’). Includes an underground cable system within a (common) alignment to Giffard West, at which point there are three alignment options (AB, C and D) to reach the proposed VicGrid connection hub in Giffard.

Figure 4-1 Victorian works project area overview

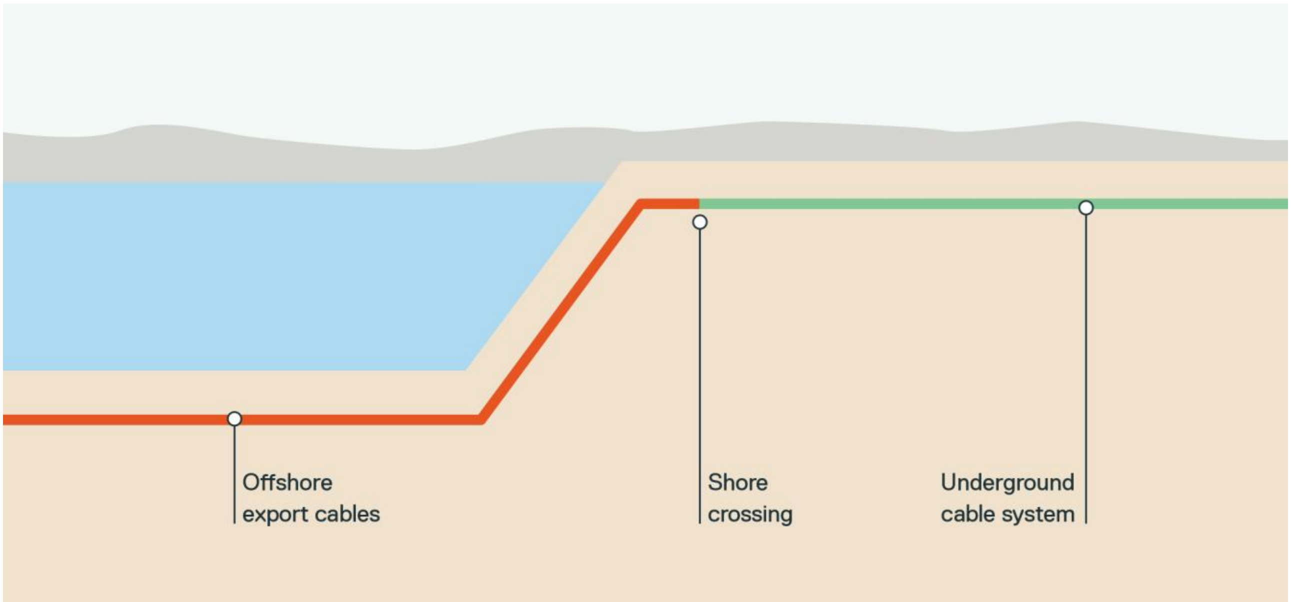


4.3 Works in Victoria - components

The components of the works in Victoria include:

- **Offshore transmission infrastructure**:
  - Up to eight offshore export cables.
- **Shore crossing infrastructure**:
  - Up to eight trenchless crossings containing the offshore export cables.
- **Onshore transmission infrastructure** which consists of:
  - An underground cable system connecting to the proposed VicGrid connection hub.

Figure 4-2 Victorian works components



4.4 Implementation

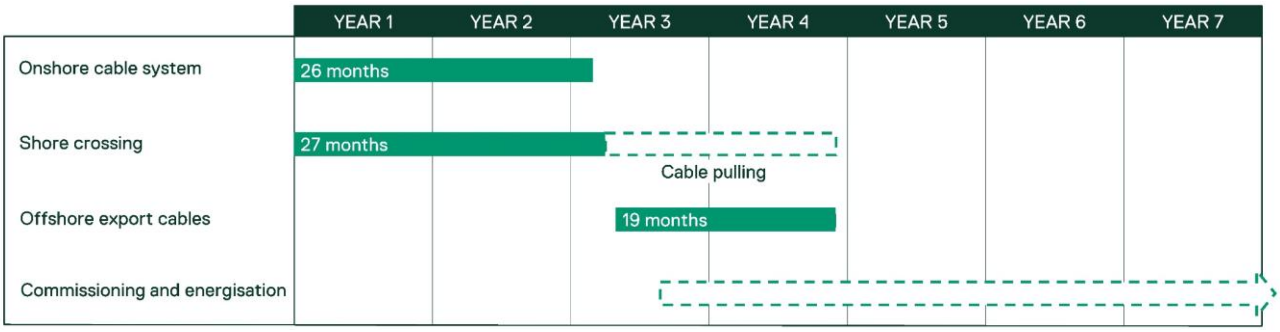
4.4.1 Timeline

The Star of the South Offshore Wind Farm Project has been under development for approximately seven years. If approvals are obtained in the next few years, construction could start around 2030 and electricity generation from 2032.

4.4.2 Construction schedule

The works in Victoria would be limited to construction and commissioning of the onshore cable system, shore crossing and offshore export cables.

Figure 4-3 Indicative construction schedule - Works in Victoria



4.5 Project design envelope

4.5.1 Purpose

The works in Victoria have been assessed using a 'project design envelope' approach. This allows for the assessment of a range of design options, rather than a single, fixed proposal. It ensures that the impacts of all options are considered, while maintaining flexibility for ongoing project refinement and innovation.

Project design envelope

A flexible project definition that sets clear upper and lower limits for design, construction, operation and decommissioning to inform environmental assessment.

This is a suitable approach for complex infrastructure projects that have long development timeframes and often continue evolving during detailed design, procurement and construction.

The design envelope is an internationally recognised approach for offshore wind farm infrastructure assessment and is used in the United Kingdom, United States, European Union and Taiwan. It is included in the United Kingdom Overarching National Policy Statement for Energy (EN-1) and the National Policy Statement for Renewable Energy Infrastructure (EN-3).

The project adopted the design envelope approach as it:

- Provides sufficient information for assessments to respond to EES requirements
- Results in a conservative assessment and confidence that actual impacts will not exceed those predicted
- Enables continued project refinement post approval, allowing key decisions to be made at an appropriate time
- Allows for the adoption of future technology and innovations to achieve desired project and environmental outcomes.

4.5.2 Application - maximum design scenario

The range of options in the project design envelope are used to define a maximum design scenario for each assessment topic. The maximum design scenario is the combination of design parameters that would result in the greatest potential impact. It represents a ‘worst case’ configuration within the range of project options still being considered.

Maximum design scenario

The combination of parameters within the project design envelope that represents the greatest potential (worst case) impacts.

Technical specialists have identified the maximum design scenario applicable for each impact assessment. The maximum design scenario for each assessment is detailed in relevant chapters and each technical report.

PART B – OFFSHORE

This section describes the infrastructure, construction, operation and decommissioning activities in Victorian offshore export cable area, as shown in Figure 4-1. The Victorian offshore export cable area would contain the offshore export cables, a key component of the wind farm transmission system.

4.6 Offshore infrastructure

4.6.1 Offshore export cables

Offshore export cables are high-voltage subsea electrical cables that transmit electricity from the offshore substations (located within Commonwealth waters) to the onshore transmission system. They have a higher capacity and are larger than inter-array cables installed in the offshore wind farm area.

Although an offshore export cable area has been identified, the exact location of each export cable within the area is yet to be determined. This will be determined based on information from future geophysical and geotechnical surveys, as well as the location of environmental sensitivities, such as reefs, and the location of the offshore substations.

The parameters for the offshore export cables within the Victorian offshore export cable area are provided in Table 4-1. Parameters for the shore crossing and connection to the onshore transmission system are contained within PART C – SHORE CROSSING.

Table 4-1 Parameters – offshore export cables

Design parameter	Unit	Parameters
Offshore export cable voltage	kV	275
Maximum number of offshore export cables	No.	8
Maximum total offshore export cable route length (within Victorian waters)	km	145
Minimum target cable depth (depth of lowering)	m	1
Maximum target cable depth (depth of lowering)	m	2

4.6.2 Cable protection and crossings

Where physical constraints prevent cables from being buried to achieve the minimum target depth, they will be covered by protective materials such as rock, concrete mattresses and mats. It is anticipated that up to five per cent of cables may need to be protected in this way. The parameters for cable protection are provided in Table 4-2.

Cable protection is also required for crossings (where cables cross other existing infrastructure, such as the Basslink Interconnector). No existing or planned infrastructure is expected to intersect the Victorian offshore export cable area during the assumed construction period; therefore, no cable crossings are anticipated. Cable protection may be required at offshore duct entry points, as outlined in Table 4-2.

Table 4-2 Parameters – cable protection and cable crossings

Design parameter	Unit	Parameters
Maximum extent of cable length requiring remedial protection	%	5
Maximum area with remedial protection	m^2	36,300
Maximum volume of rock to be used for remedial protection	m^3	54,400
Maximum number of cable crossings that require protection	No.	0
Maximum protection area for each cable crossing	m^2	200
Maximum total volume of rock to be used for cable crossings	m^3	0
Maximum protection area for each shore crossing duct entry	m^2	500
Maximum total volume of rock to be used for shore crossings	m^3	6,000

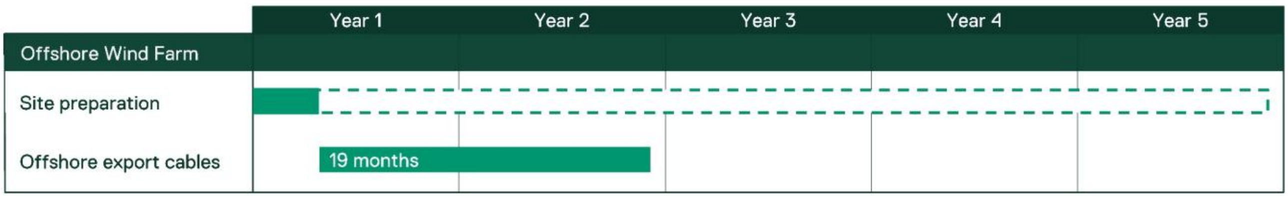
4.7 Offshore construction

4.7.1 Offshore construction schedule

An indicative timeline for offshore construction of the overall wind farm is shown in Figure 4-4. This schedule represents the longest potential duration, spanning up to 59 months (4 years and 11 months). Works within the Victorian offshore export cable area will be limited to shore crossing marine activities, offshore export installation and vessels transiting through to the Commonwealth areas of the wind farm. The shore crossing construction schedule is described in PART C – SHORE CROSSING.

Working hours may vary by component. The assessment assumes that offshore construction, although weather-dependent, would typically be undertaken 24 hours a day, seven days a week.

Figure 4-4 Indicative offshore construction schedule for Victorian Waters



4.7.2 Offshore construction staging

Offshore construction is likely to occur in the following order and take up to two years:

1. Site preparation activities
2. Offshore export cable installation

Further detail for each step is outlined in the following sections.

4.7.3 Site preparation activities

Site preparation may include pre-construction survey and seabed clearance. These activities are expected to start before offshore installation activities and continue throughout the construction program, as needed.

4.7.3.1 Pre-construction survey

Pre-construction and installation vessel footprints and cable routes will be surveyed for obstacles or hazards prior to works commencing. Survey methods include side-scan sonar or a multibeam echo-sounder from a vessel. Data is used to inform micro-siting or seabed clearance methods if required.

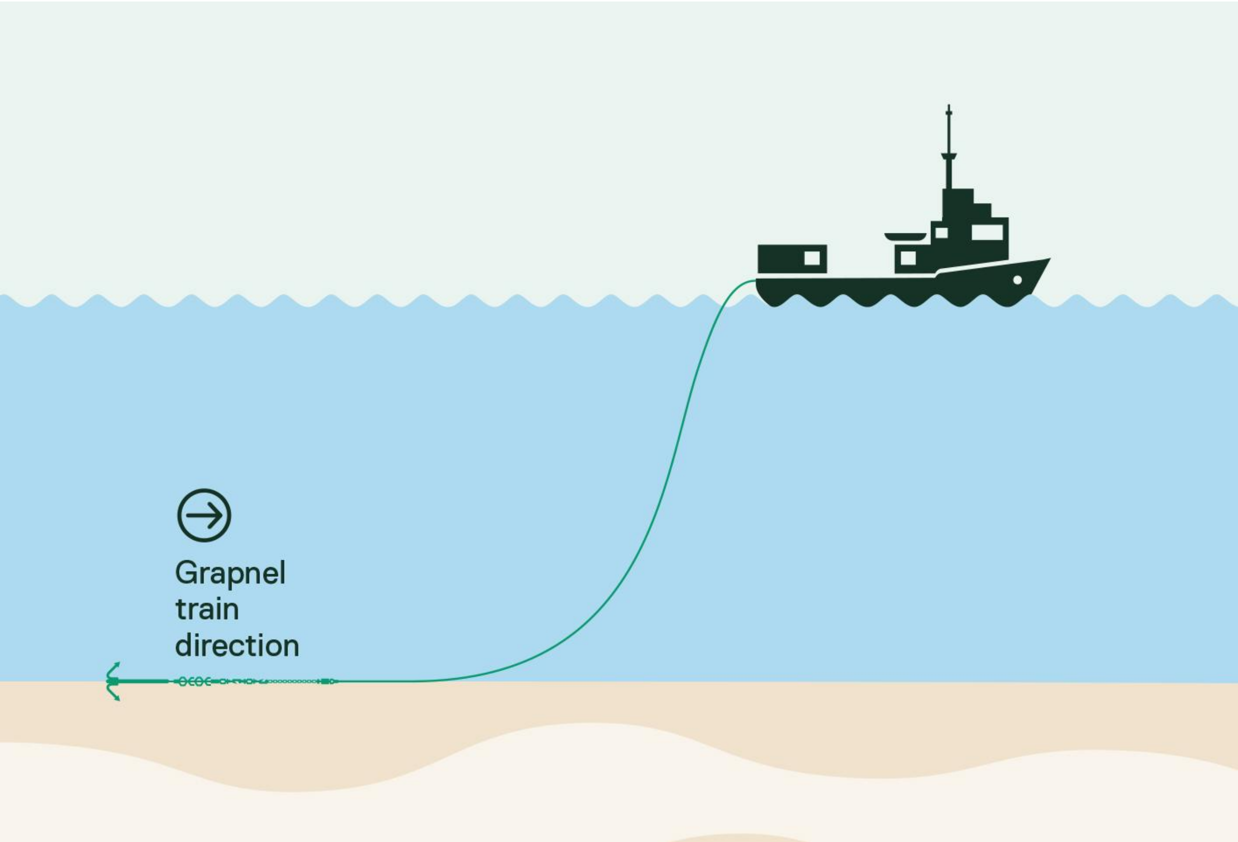
4.7.3.2 Seabed clearance

Seabed clearance methods are described below.

4.7.3.2.1 Pre-lay grapnel run

Following the pre-construction survey, a pre-lay grapnel run and clearance survey of the cable corridors may be undertaken. This involves using a multipurpose vessel equipped with a series of grapnels and chains and a recovery winch. The pre-lay grapnel run clears the site of loose items, such as ropes, chains and nets, that could impede the installation and burial of cables. Figure 4-5 shows an example of a typical pre-lay grapnel run arrangement.

Figure 4-5 Typical pre-lay grapnel run arrangement



4.7.3.2.2 Seabed levelling and pre-trenching

In limited cases, sand ridges, sand waves and other obstacles may need to be levelled or cleared to create a flat surface for construction or jacking up a vessel on its legs. Levelling can be undertaken using ploughs, grabs, jetting tools and other excavation methods.

Pre-trenching may be required to prepare an area for cable installation using ploughs or other trenching tools.

4.7.3.3 Vessels for site preparation activities

A range of specialist vessels will be used for site preparation activities, including survey vessels, service operation vessels (SOVs), trenching vessels, remotely operated vehicles (ROVs) and guard vessels. These highly specialised commercial vessels are typically small to medium-sized and would be mobilised for specific scopes of work.

4.7.4 Offshore export cable installation

Offshore export cable installation begins at the shore crossing, where the cable is pulled from an installation vessel to shore via pre-installed ducts and secured at the transition joint for later termination into the onshore transmission system. The installation vessel then proceeds towards an offshore substation in Commonwealth waters. This process is repeated for each cable. Post lay survey is undertaken to confirm the burial depth and precise installation route.

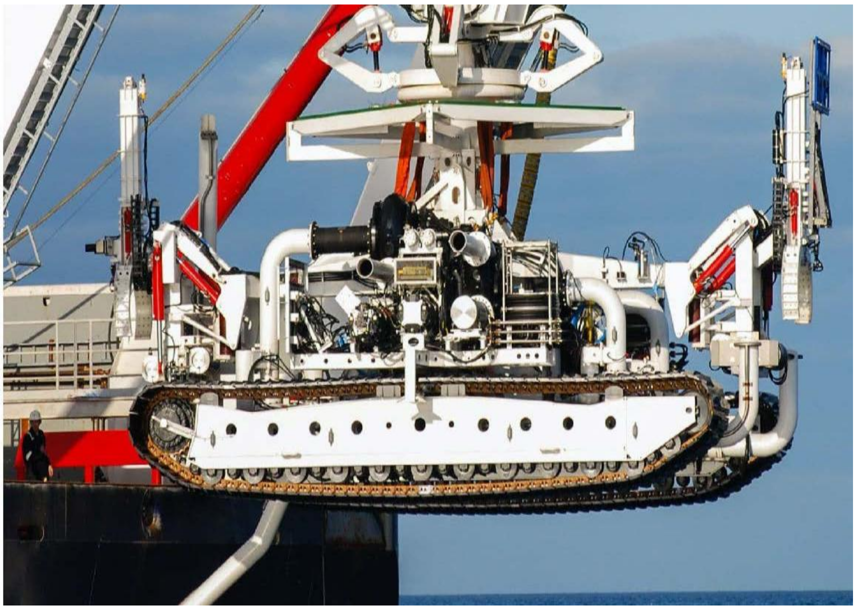
Cables will be buried using one of the following methods:

- Simultaneous lay and burial (plough)
- Post-lay burial (jet trenching)
- Trenching prior to cable lay (mechanical trenching).

A plough is typically used for export cable burial; however, any one or more of the methods described in Table 4-3 can be used. Method/s will be selected based on their effectiveness for the target burial depth and soil type.

Table 4-3 Cable installation methods

Tool	Description
Plough 	Cable ploughs are passive tools that cut through the seabed and create a narrow trench in which the cable is simultaneously inserted. Ploughs are usually towed by a vessel or ROV on the seabed.

Tool	Description
Jet trencher 	Jetting tools excavate a trench by directing a high-pressure jet of water at the trench face to fluidise the seabed, allowing the cable to sink to the required burial depth. Jet trenching tools are most effective in soft, fine-grained sediments (sands and soft clays) and can be towed, free-swimming or tracked.
Mechanical trenching 	Mechanical trenching machines use a series of picks or scoops mounted on a chain or on a wheel to excavate a trench in which the cable is then laid. Trenches are usually mounted on tracked vehicles.

4.7.4.1 Cable and crossing protection installation

In areas where cables are not buried sufficiently, cable protection materials like rock or concrete mattresses and matts will be transported to site via installation vessels and placed over the installed cables with cranes or fall pipes, sometimes with the aid of ROVs.

4.7.5 Construction vessels

4.7.5.1 Type of vessels

A range of vessels will be used in Victorian waters, including:

- Cable installation vessels
- Installation support vessels that supply equipment and support construction activities, including service operation vessels, tugs, escort vessels, remote operated vessels, survey vessels and crew transfer vessels
- Cable protection installation vessels

Vessels associated with shore crossing construction are detailed within Part C – Shore crossing.

Helicopters may also be used for emergency response, vessel transfers, and to winch personnel directly onto and off turbines or substations.

Vessel selection is typically the responsibility of the construction contractor and will depend on availability, technical suitability, health and safety considerations and price.

4.7.6 Lighting, marking and navigation aids

The construction area/s will be marked in line with Australian Maritime and Safety Authority requirements. These are referred to as demarcation areas. This is likely to consist of a combination of temporary cardinal buoys and special marks around the perimeter of construction areas. Select cardinal buoys may transmit their position via Automatic Identification System to appear on vessel navigation systems if required. All structures above the water level, regardless of their construction status, will be marked. All vessels will be marked and lit in accordance with the Convention on the International Regulations for Preventing Collisions at Sea, 1972.

4.7.6.1 Other safety measures and coordination

A range of measures may be employed to protect infrastructure and ensure the safety of workers and marine users during the construction phase. These include:

- **Safety zones:** A safety zone temporarily prohibits vessel access to a specific area, unless authorised, extending up to 500 metres around eligible infrastructure such as foundations and cables. Safety zones may be considered during construction, maintenance, or decommissioning activities.
- **Protection zones:** A protection zone restricts or prohibits certain activities in a specific area longer term, extending up to 1,852 metres (one nautical mile) from eligible infrastructure such as cables. Protection zones may be considered during operation to prevent interactions with installed infrastructure.
- **Escort vessels:** Escort vessels will be used to monitor the offshore project area during construction, communicate with and support the safety of third-party vessels, and avoid disruption to construction activities.
- **Marine coordination centre:** A marine coordination and construction management centre will manage vessel movements during construction and operations, including providing direction to escort vessels and issuing communications to mariners. The marine coordination and construction management centre is not a part of the assessment of the project.

Construction activity, demarcation areas, safety zones and other updates or alerts will be communicated through channels including Notices to Mariners, emails, text messages and website updates, to ensure marine users are aware of access and use restrictions within the offshore project area.

4.8 Offshore operations and maintenance

The works in Victoria are expected to have an operational life of approximately 30 years. An operations and maintenance (O&M) strategy will be confirmed once technical specifications are finalised.

4.8.1 Operations and maintenance activities

Infrastructure in Victorian waters will be monitored and operated remotely from a local O&M facility located at either Barry Beach Marine Terminal or Port Anthony, supported by a service operation vessel (SOV) and/or crew transfer vessel (CTV) logistics strategy.

O&M activities will be both preventative (planned) and corrective (unplanned).

Table 4-4 provides a list of planned and unplanned O&M activities expected within Victorian waters.

Table 4-4 Operation and maintenance activities for the Offshore Export Cable

Activity	Description	Expected method and vessel type	Expected frequency
Routine inspections	Inspections of the cable and cable protection, including where they enter the shore crossing ducts	Survey vessel or ROV (non-invasive).	Every 3 to 5 years.
Cable repair	Repair and replacement of offshore export cable sections.	Cable vessel or shallow barge (inshore).	Not expected during a 30-year lifetime as per failure rates.
Surveys (geophysical)	Survey of seabed and cable protection.	Survey vessel or ROV (non-invasive).	Every 3 to 5 years.
Cable reburial	Reburial of exposed offshore export cable section.	Cable vessel/SOV or shallow barge (inshore).	Every 3 to 5 years.

4.8.2 Operations and maintenance port

The O&M port will serve as a base for smaller maintenance vessels, crew transfers and operational activities. It will provide sheltered quayside facilities for SOVs and CTVs, berthing areas and have land available for:

- Warehouses and hardstand areas
- Offices with crew facilities
- Refuelling and spare part storage
- Staff facilities, including a car park.

Port land and facilities will be leased or licenced from the port operators during the project's operations phase. Any modifications required to support the project's O&M activities will be proposed and undertaken by the port operator and is subject to separate planning and approval processes.

4.8.3 Marking and navigational aids

Offshore export cables will be identified according to operational and regulatory requirements, including marking cables on navigational charts. No lighting or on water navigational aids are proposed in Victorian waters during operations.

4.8.3.1 Other safety measures and coordination

A range of measures may be employed to protect installed infrastructure and ensure the safety of O&M workers and marine users during major maintenance activities and daily operations. These measures are likely to be similar to those used during construction (refer to Section 4.7.6.1).

4.9 Offshore decommissioning

At the end of the project's life, decommissioning activities will begin. The main objective of decommissioning is to leave a safe, stable and non-polluting environment, and to minimise impacts during the removal of any infrastructure.

Key principles that will apply to decommissioning include:

- Considering environmental conditions and stakeholder interests when developing decommissioning plans
- Returning the seabed to baseline conditions as far as practicable.

Decommissioning export cables located in Victorian waters is expected to be limited, with the offshore cables expected to be retained in situ.

Decommissioning will be managed under approved management plans, prepared in accordance with relevant laws and policies in place at the time of decommissioning.

4.10 Waste

End-of-life infrastructure will be managed in accordance with the waste management hierarchy principles of avoid, reduce, reuse and recycle. The feasibility of continuing to use infrastructure beyond the project's expected lifespan will be assessed (avoid / reduce) before decommissioning begins.

If reuse is not feasible on site, some components may be suitable for use in other offshore projects in other jurisdictions. Where reuse is not possible, project components will be recycled, with the separation and processing of recyclable materials carried out in local facilities where possible.

A high proportion of offshore wind project components can be recycled. Commonly recyclable materials are summarised in Table 4-5.

Table 4-5 Recyclable materials in cables

Project component	Material	Parts
Cables	Aluminium, Copper	Cables and connections
	Plastic materials	Insulation and wiring
	Inert (rock/gravel)	Cable protection

PART C – SHORE CROSSING

This section describes the infrastructure and construction, operation and decommissioning activities at the shore crossing – the point where offshore export cables transition from sea to land and are connected (jointed) to the onshore cable system. The shore crossing is wholly within Victorian jurisdiction.

4.11 Shore crossing design

The preferred shore crossing location is Reeves Beach, a publicly accessible beach and basic campground at the southern end of the Ninety Mile Beach, approximately three kilometres south-west of Woodside Beach and approximately 10 kilometres from the offshore wind farm area in Commonwealth waters.

Up to eight individual shore crossings may be required to accommodate up to eight offshore export cables. The shore crossings are between 600 and 1,400 metres long (underground), running perpendicular to the shoreline and parallel to one another.

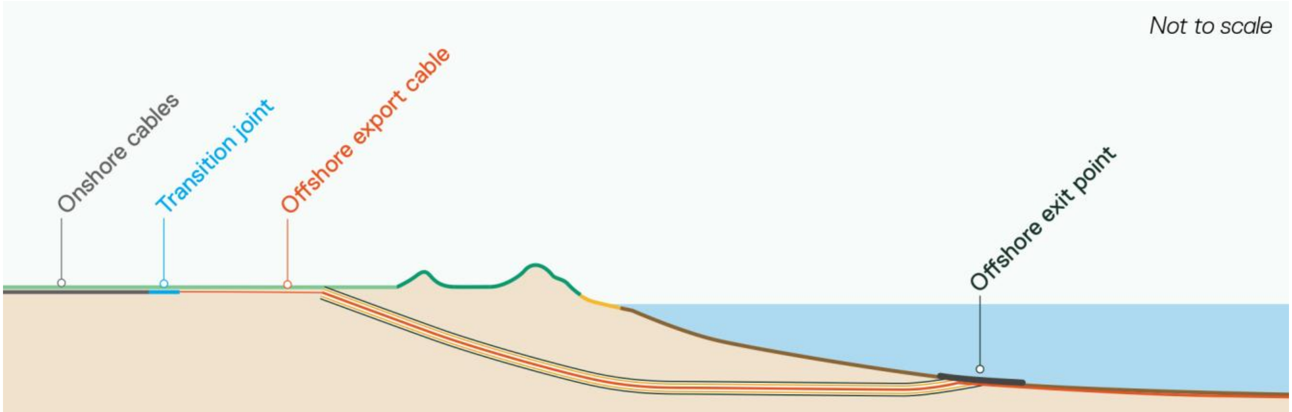
The exact size, profile and path of the shore crossings will depend on the final size and quantity of cables being used. Key design considerations include ground conditions, environmental constraints, adequate cover and separation between bores, and efficient duct and cable installation.

Parameters for the shore crossings are provided in Table 4-6.

Table 4-6 Parameters – trenchless shore crossings

Design parameter	Unit	Upper limit
Maximum number of ducts installed	No.	8
Maximum trenchless shore crossing horizontal length	m	1,400
Maximum bore depth from entry elevation	m	35
Minimum onshore export cable/bore separation	m	10
Minimum offshore export cable/bore separation	m	100
Maximum bore diameter	mm	1,350
Maximum duct diameter	mm	900

Figure 4-6 Shore crossing cross-section



4.11.1 Offshore interface

Offshore, each shore crossing ends at an offshore exit point located in water deep enough to avoid the intertidal and shallow wave zone and allow safe operation of the installation vessel, at least five to 10 metres deep.

Installed cables may require additional protection from currents, scour and vessel activity around the offshore exit point. This protection is typically achieved by burying the cables in the seabed and / or covering them with a rock mattress or other mechanical protection systems. Cable burial and protection options are detailed further in Section 4.6.2.

4.11.2 Onshore interface

Onshore, each shore crossing ends in a temporary construction compound located in farmland on the landward side of Reeves Beach. From this point, cables run a short distance underground to the transition joint, which connects the offshore export cable and the onshore cable system (including communications cables).

Because offshore and onshore cables are designed differently, one offshore cable (containing three separate cores) transitions to three single-core onshore cables at the transition joint.

The transition joint is housed within a transition joint bay, a concrete-lined pit that provides a clean and dry environment for cable jointing. Up to eight joint bays (one per offshore export cable) may be required, each approximately 10 metres wide, 30 metres long and five metres deep. These bays also have link pits for earth bonding and fibre pits for fibre connections which can be accessed via surface lids for periodic maintenance and testing. During operation, only these lids and safety signage are visible above ground, as shown in Figure 4-8.

The inside of a typical 220 kilovolt transition joint bay with joints is shown in Figure 4-7, and a concept layout of the transition joint bays at Reeves Beach is shown in Figure 4-8.

Figure 4-7 Transition joint bay internals

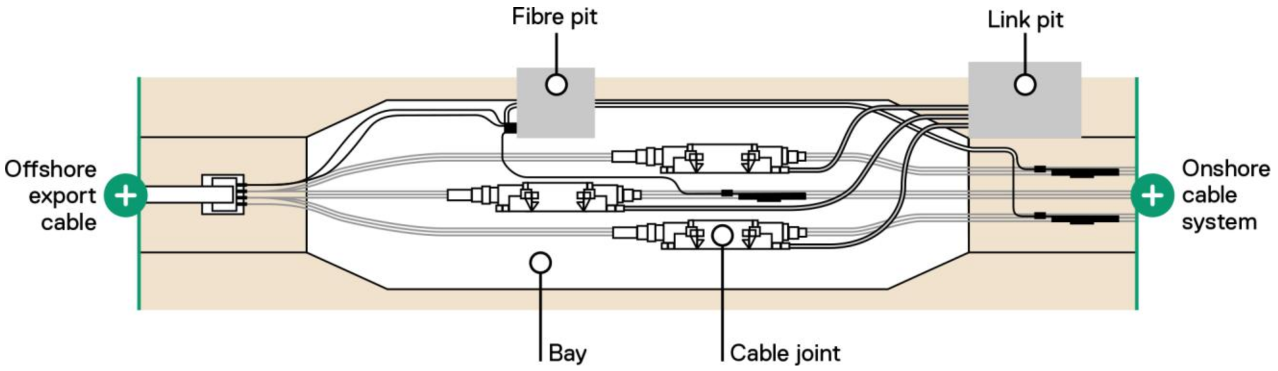
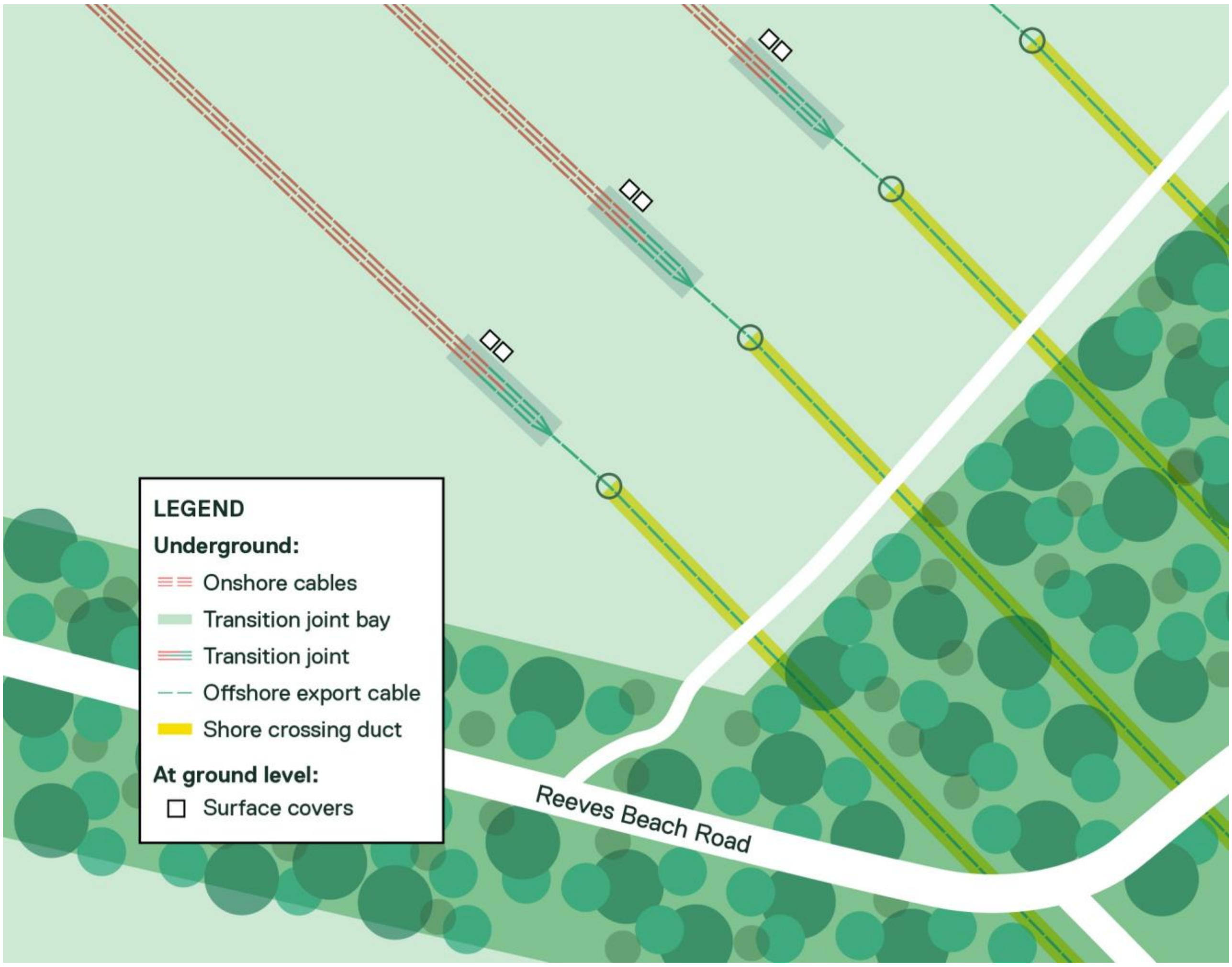


Figure 4-8 Transition joint bay cable concept layout



4.12 Shore crossing construction

4.12.1 Shore crossing construction schedule

An indicative timeline for shore crossing construction is shown in Figure 4-9. This schedule represents the maximum duration, and assumes all eight shore crossings are required.

Construction occurs in two main phases:

- **Drilling and duct installation**: Activities include site establishment (up to six months), bore drilling and duct installation (10 to 18 months, with each bore requiring four to six weeks of active drilling which typically runs 24 hours a day, seven days a week), and demobilisation (up to three months).
- **Cable pulling**: Each offshore export cable pull is expected to take up to one week, within the maximum 19 month export cable installation window, including setup and demobilisation. There will be a gap between each cable pulling operation while the cable vessel installs the offshore export cables or re-supplies.

Figure 4-9 Shore crossing construction schedule

4.12.2 Drilling and duct installation

A trenchless installation method is proposed to avoid open-cut trenching in the sensitive nearshore and coastal location. This involves drilling bores and installing ducts underground, through which the offshore export cables can be pulled, housed and later removed (if necessary).

There are trenchless crossings present along the Gippsland coastline, including at McGaurans Beach for the Basslink Interconnector, and in Wonthaggi for the desalination plant brine discharge pipe.

Based on the current understanding of the Reeves Beach area, nearshore features and target water depths, horizontal directional drilling is the method most likely to be used.

4.12.2.1 Onshore site establishment

Duct construction is initiated onshore within a temporary construction area. This area typically includes:

- A temporary construction compound at each bore location, containing the drilling rig and associated equipment
- Construction compounds for material storage, duct handling and assembly
- Temporary access tracks into the construction area and compounds.

Figure 4-12 shows a typical trenchless shore crossing construction compound.

Other works within the construction area include:

- Establishment of a temporary causeway over unnamed waterway - UFI:42824681 to allow materials and personnel to cross during construction
- Installation of a transition joint bay for each crossing to house the transition joints
- Open-cut trenching between each duct its corresponding transition joint bay to house the offshore export cable.

4.12.2.2 Offshore site establishment

Preparation works offshore may include seabed pre-clearance activities similar to those described in Section 4.7.3. Depending on the seabed condition, offshore exit points may be pre-excavated.

4.12.2.3 Bore drilling

Horizontal directional drilling uses a land-based rig to drill a borehole that exits offshore. The bore is drilled using rotation, thrust and water-based drilling fluids (such as bentonite or xanthan gum) which cool the drill bit, remove cuttings and prevent the bore from collapsing. The bore is typically drilled along a smooth, parabolic path with gentle inclines and declines to aid duct and cable installation.

The process begins with drilling a pilot hole, which is then enlarged through reaming to the required diameter for the cables. The drill bit exits the seabed at the offshore exit point, located beyond the wave zone in water deep enough for safe vessel access.

Medium to large vessels assist with drill head change out, duct feed in, and offshore export cable installation. Jack-up, dynamic positioning, moored, and smaller support vessels may also be used to support installation activities. Figure 4-10 and Figure 4-11 provide schematic overviews of pilot hole drilling and reaming.

Figure 4-10 Pilot hole drilling

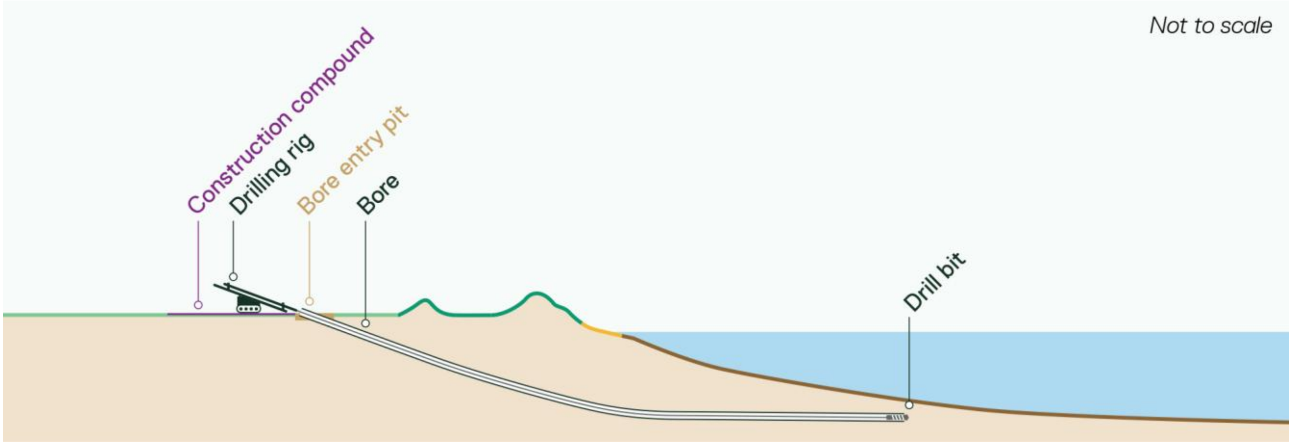


Figure 4-11 Pilot hole reaming

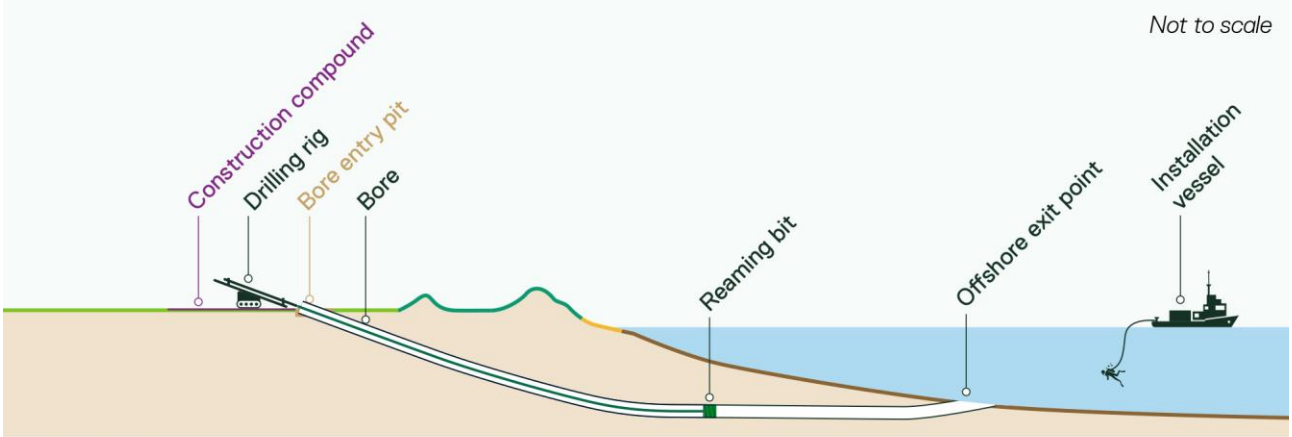


Figure 4-12 Shore crossing drilling operation, Vinyard Wind USA

4.12.2.4 Duct installation

Once the bore is enlarged to the required diameter, a pre-assembled duct string is installed. This may be done by thrusting it from land or pulling it in from offshore using the land-based drilling rig.

For thrust installation, duct assembly and handling will occur behind the drilling operations and across the pre-installed causeway. For offshore pull-in, the duct will be pre-assembled, towed to the shore crossing site and pulled through the bore with the same drill string used for drilling (refer to Figure 4-13 and Figure 4-14).

Once a bore has been drilled and the duct installed, the drilling rig is moved to the next position, and the process is repeated until all ducts are installed.

A combination of smaller, jack-up, and conventional vessels may be used to support duct installation activities.

Figure 4-13 Shore crossing duct being towed to site Vinyard Wind, USA

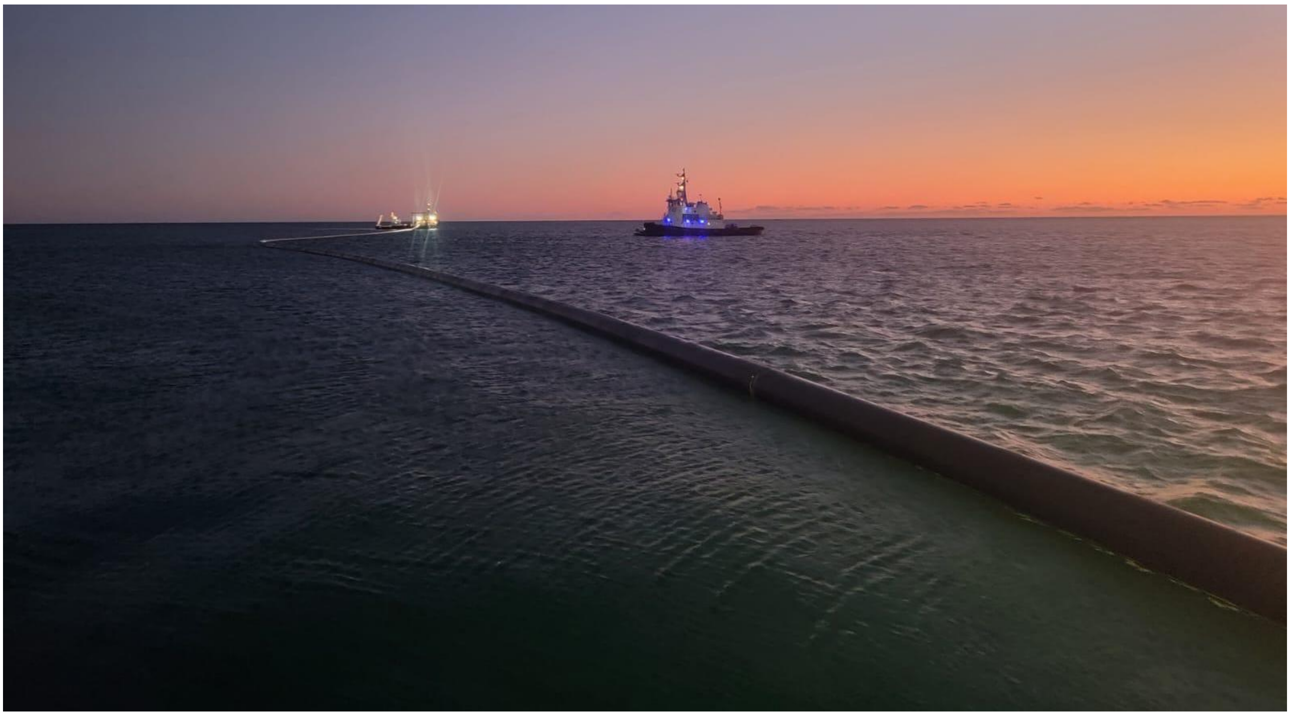
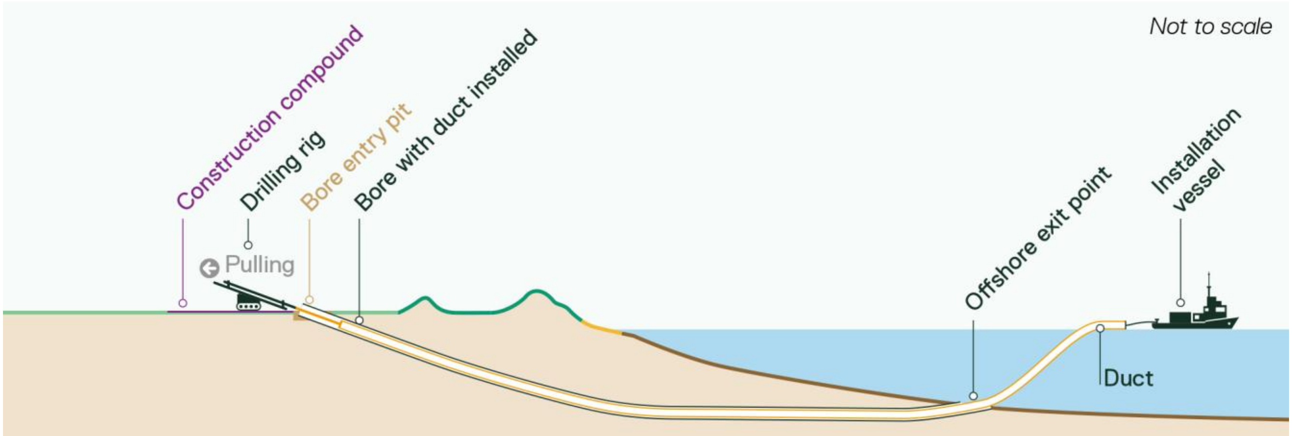


Figure 4-14 Duct installation



4.12.2.5 Drilling demobilisation

Once the last duct is installed, the drilling rig and associated equipment will be demobilised. Access tracks and temporary work sites will remain in place for cable pulling and jointing activities. A gap of several months may occur between the final duct installation and the beginning of cable pulling operations.

4.12.3 Cable pulling

Pulling the offshore export cable ashore from a cable laying vessel involves the following steps:

- Exposing and preparing the duct at the offshore exit point
- Positioning the cable laying vessel next to the pre-installed duct
- Pulling a winch cable through the duct from the onshore construction compound to the cable laying vessel and connecting it to the export cable
- Using the winch to pull the cable through the duct to shore
- Pulling the cable through an open trench to the pre-prepared transition joint bay, where it is secured ready for jointing to the onshore cable system.

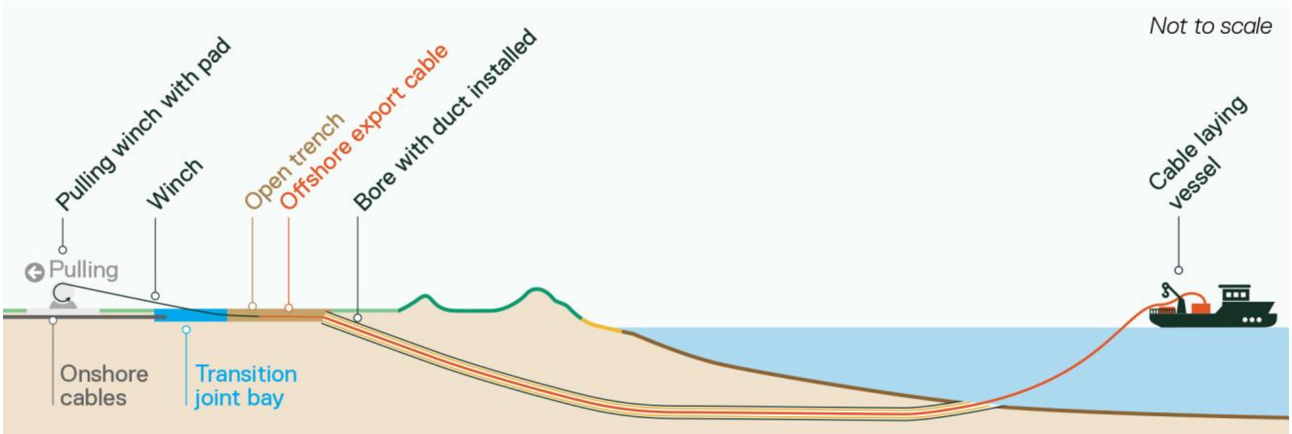
A bentonite mix or equivalent material may be installed in the ducts to fill voids around the cables and maintain thermal performance during operations.

Onshore export cable pulling typically takes one day per cable, excluding preparation activities and any mechanical failures or weather delays. Once each cable is pulled in, the cable laying vessel lays the rest of the offshore export cable between the shore crossing and the offshore wind farm area (refer to Section 4.7.4). This process is then repeated for each crossing.

Smaller, jack-up, and conventional vessels may support cable pulling activities, including guidance, cable tensioning and monitoring, with additional support from remotely operated vessels and/or divers if required.

A representative schematic of offshore export cable pulling is provided in Figure 4-15.

Figure 4-15 Offshore export cable pulling



4.13 Shore crossing operations and maintenance

O&M activities for the shore crossing are minimal. Periodic condition inspections are expected to coincide with offshore cable burial surveys and routine inspections of the onshore transmission system.

4.14 Shore crossing decommissioning

Underground infrastructure, including ducts and offshore export cables, is expected to remain in place at the end of the project’s life. Removal and remediation of the transition joint bays and onshore infrastructure would be carried out in accordance with the onshore transmission decommissioning plans outlined in Section 4.19.

PART D – ONSHORE TRANSMISSION

This section describes the infrastructure and construction, operation and decommissioning activities in the Victorian onshore project area.

4.15 Onshore project area and VicGrid interface

The project's underground cable system and all associated infrastructure and activities for its construction, operation and decommissioning are contained within the onshore project area (Refer to Figure 4-16). This includes the permanent cable easement, temporary construction corridor, and temporary construction facilities such as compounds and access tracks.

The onshore project area comprises the following alignments:

- **Common alignment:** Extends from the shore crossing at Reeves Beach to Giffard.
- **Alignment options AB, C and D:** Feasible options to reach the proposed VicGrid connection hub, which enable a comprehensive assessment of the project's potential impacts, pending confirmation of the final location of the hub and grid connection infrastructure within it.

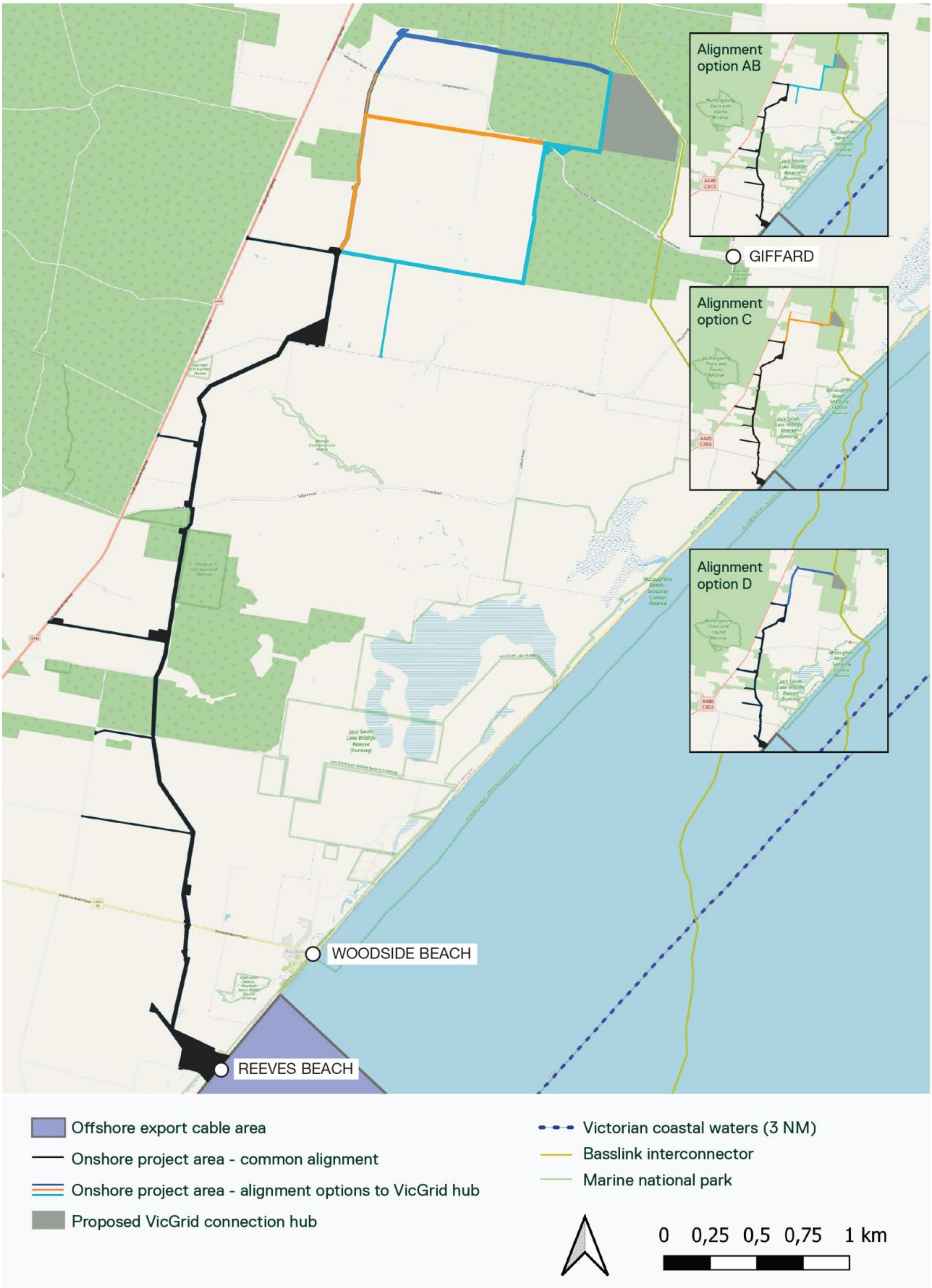
Star of the South has purchased land and/or agreed options with landholders for easements for most of this Common alignment.

The alignment option taken forward for the project will depend on the location of the final precise location of the VicGrid connection hub, as well as ongoing engagement with landholders. Once this location is known, project alignment options within the connection hub study area may require modification. Alignment options shown within the connection hub study area are therefore indicative.

The first 2 GW of offshore wind energy developed in Gippsland must connect to the grid at the VicGrid hub, which forms part of the VicGrid Offshore Wind Transmission 2 GW Project. VicGrid has released a study area in which the hub will be located, shown as a grey rectangle in Figure 4-16. The hub will include provisions for cable approach areas, substations and associated infrastructure required to connect offshore wind projects to the grid.

As the VicGrid Offshore Wind Transmission 2 GW Project (including the hub) is subject to a separate assessment and approval process, this assessment of the Star of the South Offshore Wind Farm Project's works in Victoria does not consider any infrastructure or works within the connection hub study area.

Figure 4-16 Onshore transmission system alignment



4.16 Onshore transmission infrastructure

4.16.1 Underground cable system

The underground cable system will be installed within an up to 40-metre-wide operational easement, widening up to 60 metres at select onshore trenchless crossing locations. The easement width at the shore crossing interface will taper down from the maximum width of the cable crossing footprint of 580m to up to 40m. The cable system will be installed within an up to 60-metre wide construction easement with widths increasing at select locations to account for laydown areas or access. The underground cable system extends approximately 30 kilometres, from the shore crossing to the proposed VicGrid connection hub at Giffard. It includes:

- Transmission cables to carry electricity
- Joints bays where sections of cable are jointed together
- Communications cables to transmit signals and data between the offshore wind farm and the cable system for performance monitoring.

The final design will be refined to reflect project capacity, site conditions and constraints (including landholder agreements), approval conditions, and National Electricity Market generation and transmission requirements.

Table 4-7 Parameters – underground cable system

Design parameter	Unit	Upper limit
Maximum cable voltage	kV	275
Maximum number of circuits	No.	8
Maximum number of trenches	No	4
Maximum number of circuits per trench	No	2
Maximum number of joint bays	No.	370
Maximum trench depth	m	2
Maximum joint bay depth	m	3
Maximum cable easement width (excluding select trenchless crossing locations and provision for directional change)	m	40
Maximum cable easement width at trenchless crossing locations and provision for directional change	m	60
Maximum construction easement width (excluding select trenchless and other crossing locations)	m	60

4.16.1.1 Transmission cables

Up to eight high voltage alternating current (HVAC) circuits may be required. Each circuit consists of three single-core cables that each carry an electrical phase. The final number and configuration of circuits will depend on the final offshore wind farm's electrical design, project capacity and grid connection requirements.

Cables will be installed approximately one metre below ground in parallel trenches. Up to four trenches may be required to accommodate eight circuits. Figure 4-18 provides a representative schematic of trenches within the cable easement.

Warning tape and other mechanical protection and markings systems will be installed above the circuits in accordance with standard electrical practice. Figure 4-17 provides a representative schematic of the underground cable circuits.

The components of a typical single-core onshore cable are shown in Figure 4-19. The conductor is expected to be either aluminium or copper and will be sized to meet the operating capacity of the system.

Figure 4-17 Typical underground cable circuits (two circuits shown)

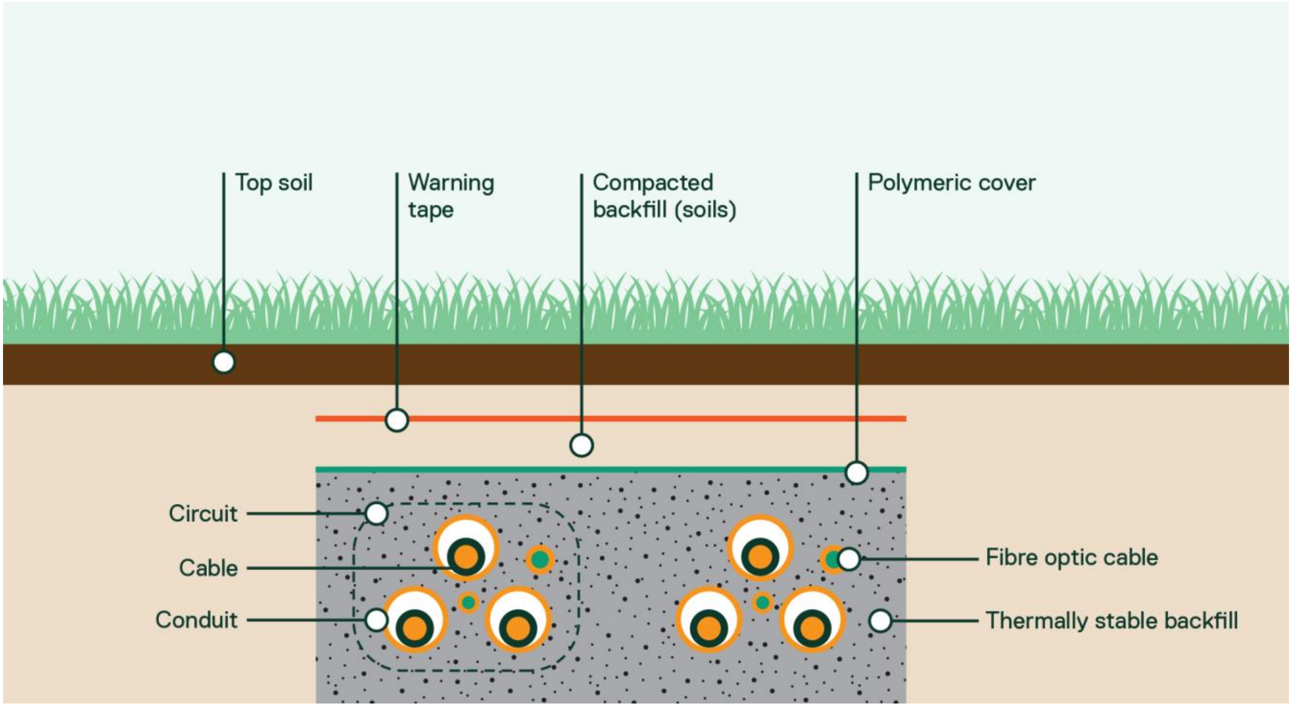


Figure 4-18 Example cable easement cross-section (eight circuits shown)

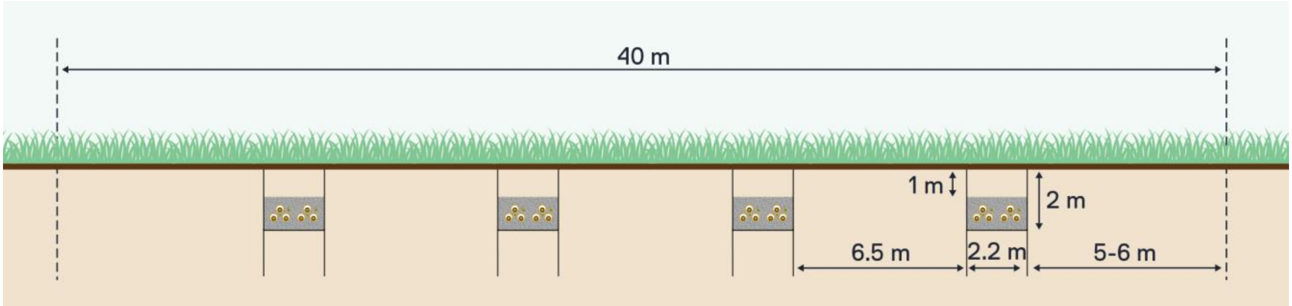
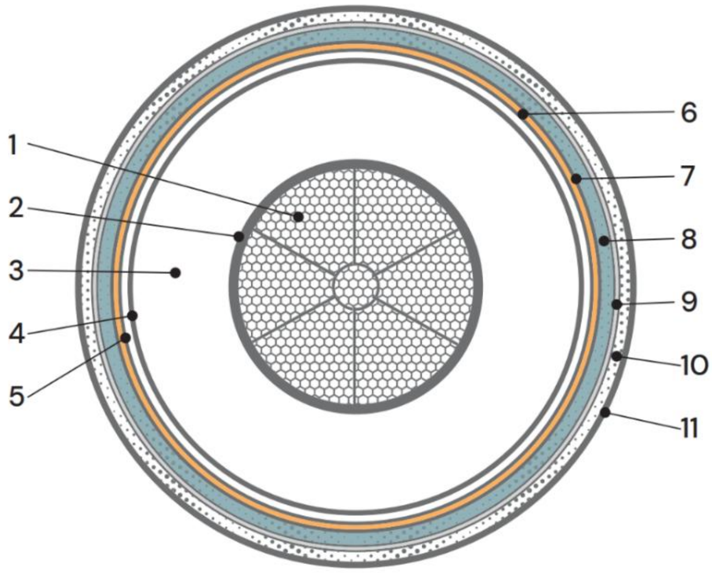


Figure 4-19 Onshore cable cross-section (single core)



No.	Description	Material
1	Conductor	Copper wires with water blocking tape
2	Conductor screen	Semi-conductive polymer
3	Insulation	XLPW cross linked polyethylene
4	Insulation screen	Semi-conductive polymer
5	Longitudinal water barrier	Semi-conductive water blocking tape
6	Metallic sheath	Smooth aluminium
7	Bonding material	Bonding compound
8	Non-metallic bedding	Medium destiny polyethylene
9	Anti-termite covering	Nylon
10	Outer sheath	High destiny polyethylene
11	Extruded semiconducting layer	Semi-conductive polymer

4.16.1.2 Joints and joint bays

Cable sections are connected using specialised in-line cable joints housed within joint bays. These are pre-cast, concrete-lined pits that provide a clean, dry environment for cable jointing and protection.

Up to 370 joint bays may be required, with a maximum size of 5 metres wide, 15 metres long and 3 metres deep, and spaced 0.8-1.2 kilometres apart along the cable corridor.

Joint bays are installed as open-topped assemblies, then backfilled with thermal fill and soil. They also contain link pits for earth bonding and fibre pits for fibre connections. These have surface access points and are typically only accessed during routine maintenance and testing, or in the event of a cable fault.

An example double circuit joint bay arrangement is provided in Figure 4-20. An image of cables being jointed is provided in Figure 4-22.

Figure 4-20 Example joint bay arrangement (double circuit arrangement shown)

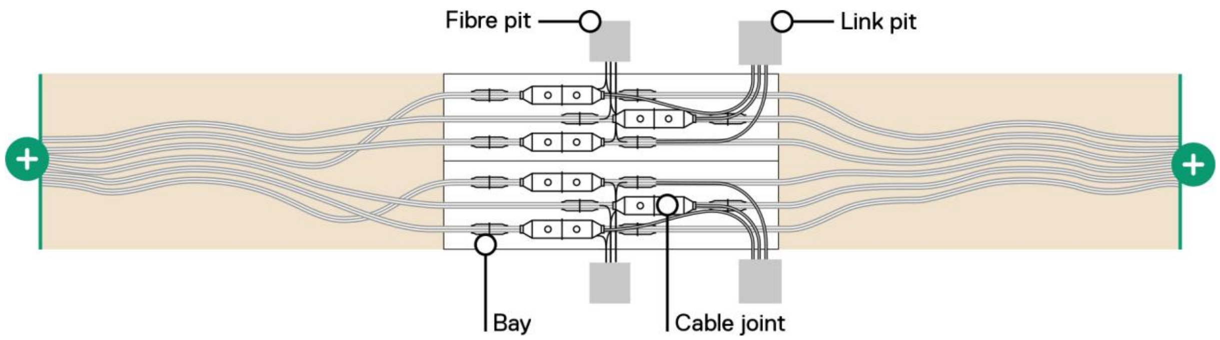


Figure 4-21 Joint bay locations within the underground cable system (five circuits shown)

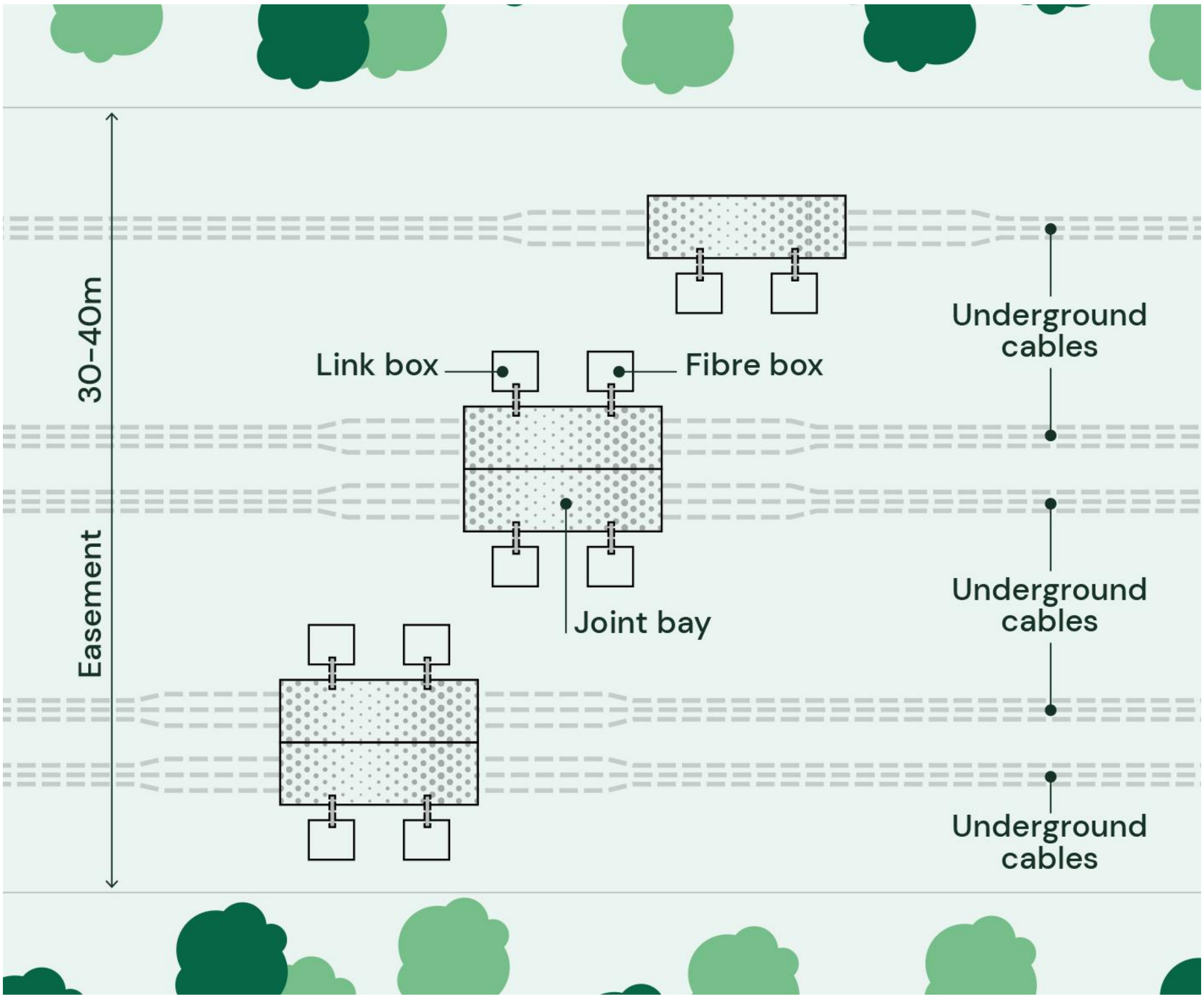


Figure 4-22 Cable jointing underway in a controlled environment (Australia)

Source Cable System Engineering

4.16.1.3 Communications cables

Fibre optic cables will be integrated into the system to enable data transfer and communication with the offshore wind farm. They may also be used for transmission system condition monitoring during operation.

The fibre optic cables are expected to run in parallel with each electrical circuit, underground.

4.16.1.4 Thermally stable backfill

Thermally stable backfill is an engineered material commonly used in high voltage cable systems to improve thermal conductivity and achieve reliable thermal performance during operation. Backfill materials vary from thermal sands compacted around cables to fluidised thermal fill - a specifically engineered mixture of aggregates, cement and additives that can flow and set around the cables.

For a conduit system, fluidised thermal fill is expected to be used as it can flow around the duct configuration to provide consistent thermal performance. The fill will be batched locally or within the project area and transported in concrete agitator trucks to be poured directly into the trench. Once set, it forms a product similar to low-strength concrete and can be backfilled with soil and compacted above.

Thermal sands may be used in addition or as an alternative to fluidised thermal fill.

Installation of thermal backfill displaces topsoil. Up to 488,400 cubic metres may be required for an eight-circuit system.

4.16.1.5 Cable easement

The underground cable system will be contained within a single easement that will be established, controlled and maintained where necessary to limit the growth of vegetation and prevent damage to the installed cables.

The easement will be up to 40 metres wide along most of the alignment, but it may narrow or widen in some areas to accommodate installation methods or constraints (for example, to avoid sensitive vegetation). The assessment of the project assumes the maximum potential easement width of 40 metres, with the following exceptions, as shown in *Attachment I - EES Map Book*:

- At the shore crossing interface where the larger width of 580 metres allows for variability in cable crossing locations, to be refined through detailed design
- A reduction to six metres as an option to avoid impacts on a farm dam to the south of Darriman H33 Bushland Reserve, though this is limited to a single circuit option.
- Up to 50 metres for the provision for alignment directional change just southeast of Darriman H33 Bushland Reserve
- A reduction to 30 metres for a section of Options C and D of approximately 1.5 kilometres north of Carstairs Road, though assumed to be a compact circuit configuration with constructability impact.
- Up to 60 metres at select trenchless crossing locations at Giffard West Road and the saline wastewater outfall pipeline.

4.16.2 Onshore substation

An onshore substation is required to connect the project to the electricity grid, located within the proposed VicGrid connection hub in Giffard. The VicGrid hub will include provisions for cable approach areas, substations and other infrastructure required to connect approved offshore wind farms to the grid and is subject to a separate assessment and approval process. The onshore substation is therefore not assessed as part of Star of the South Offshore Wind Farm Projects's works in Victoria.

4.17 Onshore construction

Construction of the underground cable system involves installing electrical cables, fibre optic cables, and cable joint bays within a temporary construction corridor, extending from the shore crossing at Reeves Beach to the proposed VicGrid connection hub in Giffard. It is planned as a single continuous activity, with multiple crews working simultaneously in parallel.

The primary construction activities would occur in the following stages:

- Site establishment
- Cable system construction (including trenching, installation and jointing)
- Pre-commissioning and commissioning of the cable system
- Demobilisation and rehabilitation of areas disturbed by construction.

4.17.1 Onshore construction schedule

An indicative timeline for construction of the underground cable system is shown in Figure 4-23. This schedule represents the longest potential duration, spanning up to 26 months (2 years and 2 months).

Onshore construction is expected to be primarily undertaken during regular working hours, from 0700 to 1800 hours, Monday to Friday, and from 0700 to 1300 hours on Saturday. Some works may be required outside regular working hours, where unavoidable or for safety reasons. In these instances, Star of the South will coordinate with relevant authorities and stakeholders prior to these activities occurring where this is possible to do so.

Figure 4-23 Indicative construction schedule – underground cable system

4.17.2 Site establishment

Initial site establishment activities include gaining access to work sites, installing environmental controls and fencing and setting up workforce amenities. The works area will be divided into sections or nodes and several work fronts established.

Temporary facilities required to support construction include:

- **Staging nodes (large laydown areas):** Staging nodes are temporary construction compounds (also known as laydown areas) that serve as central hubs for workforce mobilisation, managing equipment and materials logistics. Each node would occupy up to one hectare and are likely to include paved areas or hardstands that are accessible in all weather conditions. Staging nodes will be evenly distributed along the construction corridor, with sites selected for construction efficiency, accessibility, and to avoid and minimise impacts on land, the environment and residents. Up to ten staging nodes are required for any one alignment option.
- **Batch plants**: Up to five temporary batch plants will be sited along the construction corridor to provide local batching of thermally stable backfill and structural concrete. Each plant will occupy up to one hectare, with paved areas or hardstands that are accessible in all weather conditions. Temporary batch plants will be sited next to or in close proximity to staging nodes.
- **Site offices, worker parking and amenities:** These temporary facilities may be sited within staging nodes or along the onshore construction corridor.

- **Satellite compounds:** Smaller compounds may be required for specific activities, like trenchless crossings. In most instances, these will fit within the construction corridor, although additional space may be required in some locations.

Pre-construction activities to prepare the staging nodes and satellite compounds will include:

- Installing security fencing to define compound boundaries
- Removing vegetation where required
- Stripping and stockpiling topsoil and subsoil within the compounds
- Undertaking civil works, including drainage, as required
- Applying crushed stone to create suitable working surfaces.

4.17.2.1 Access

The construction corridor will be accessed at road crossings, along the corridor itself, or via temporary access tracks.

Existing private, local and regional roads will be used where possible and may require maintenance, vegetation trimming, and in some cases, upgrades or modifications depending on their use. Access will be planned to minimise impacts on the local road network and road users as much as possible.

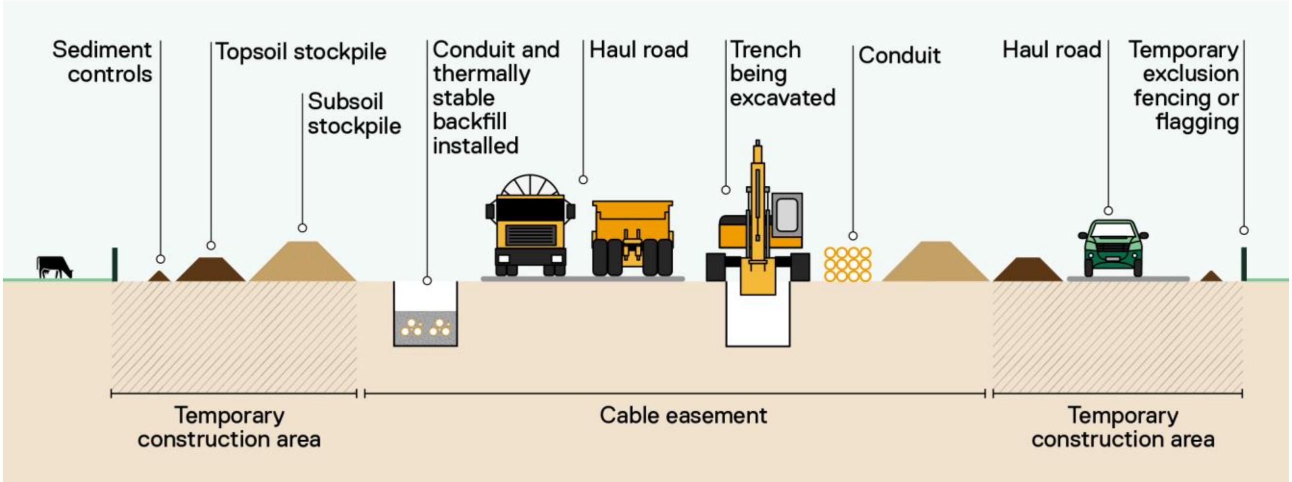
Temporary access tracks will be constructed within the onshore project area to enable construction vehicles to reach construction compounds from the public road network and to travel along the construction corridor. They will be constructed using suitable materials and maintained for the duration of the construction phase, then removed and reinstated.

4.17.2.2 Onshore construction corridor

The construction corridor will serve as a temporary workspace for constructing the underground cable system. It spans the length and width of the cable easement (up to 30 kilometres long and generally 40 metres wide), plus additional workspace adjacent to the easement (up to 20 metres). It will include fencing, environmental controls and exclusion zones. haul roads, temporary construction areas, drainage, and spoil management (refer to Figure 4-24).

Once environmental controls are in place, the construction corridor will be cleared and stripped in preparation for trench excavation.

Figure 4-24 Typical onshore construction corridor cross-section



4.17.3 Cable system construction

Construction of the underground cable system occurs in three main stages:

- Trenching and conduit installation (if used)
- Crossings installation
- Cable installation, jointing and testing.

Two installation methods are being considered for the underground cable system: conduit (ducted) and direct bury.

A conduit system involves pre-installing lengths of conduit in open trenches or via trenchless methods then pulling the cables through. The conduit is typically made of polyvinyl chloride (PVC) and is sized to fit the cable. Conduit systems use pre-moulded spacers to ensure uniform spacing and hold cables in place prior to backfilling.

Direct bury involves opening trenches and installing cables directly in the ground at a depth that provides adequate protection from external interference. Compacted thermal sand may be used to bed and backfill direct buried cables to improve thermal performance.

The following descriptions relate to a conduit system. Direct burial may involve fewer steps.

4.17.3.1 Trenching and conduit installation

Trenching and conduit installation is the first stage, allowing large sections of civil works to be completed before the cables arrive for installation.

Trenches will be excavated using typical civil construction equipment such as excavators, chain trenchers and haul trucks, as shown in Figure 4-25, and made safe for access including the use of shoring where required. Excavated material may be temporarily stored adjacent to the trench or immediately carted away for stockpiling or disposal.

Up to four trenches may be open at one time. Each trench would be up to 2.2 metres wide and two metres deep, accommodating two circuits. The number and length of trenches open at any one time depends on a range of variables such as the number of active work fronts and crew size.

Once excavated, conduit sections are assembled within the trenches and coupled to form continuous runs between joint bays (refer to Figure 4-26).

Thermally stable backfill (refer to Figure 4-27 and Section 4.16.1.4) is then installed around the conduit. Once it hardens, polymeric covers, warning tape, and any additional mechanical protection is installed. The trenches are then backfilled and compacted with subsoil and topsoil is reinstated, ready for revegetation.

Where the onshore construction corridor traverses sensitive areas, such as native vegetation, potential impacts will be avoided or minimised by reducing the construction footprint, micro-siting infrastructure, and, in some cases, using trenchless construction methods.

Once trenching is completed, the joint bay is installed and prepared to align with cable installation activities.

Figure 4-25 Cable trench excavation (Australia)

Source Cable System Engineering

Figure 4-26 Installation of conduit in a trench

Source Cable System Engineering

Figure 4-27 Thermal fill installation (Australia)

Source Cable System Engineering

4.17.3.2 Crossings installation

Construction of the underground cable system will require crossings of existing infrastructure and natural features such as waterways, roads and utilities. In most cases, open trench crossings are suitable and will be used where the project crosses features with relatively low sensitivity, such as minor watercourses, minor roads, tracks and service roads. Trenchless crossings will be used where open trenching would cause unacceptable disruption or environmental impact.

4.17.3.2.1 Open trench crossings

The approach proposed for the main types of open trench crossings is provided below:

- **Road crossings:** Traffic management will be used to maintain traffic flow on one half of the road while works occur on the other half. After excavating the first half, steel plates are placed across the trench for traffic to pass over while the second half is excavated. Pipe is then threaded through the trench under the steel plates before the trench is backfilled and the road re-surfaced.

- **Watercourse crossings:** Most minor watercourse crossings will be constructed using open-cut trenching. If needed, dry open-cut methods may be used, maintaining water flow through temporary dams, bypass pumping or diversion pipes.

4.17.3.2.2 Trenchless crossings

Two locations have been identified for trenchless crossings:

1. Unnamed waterway – UFI:42824681 at Reeves Beach, to reduce ecological impacts.
2. Woodside Beach Road, to reduce disruption to Woodside Beach residents, the road pavement and avoid roadside vegetation impacts.

Additional trenchless crossings may be considered as design progresses; however, these methods can affect cable ratings are not suitable in all locations.

Trenchless crossing methods include:

- **Horizontal directional drilling (HDD):** Similar to the shore crossing method (refer Section 4.12.2), onshore HDDs involve drilling bores and pulling through ducting.
- **Micro-tunnelling:** Micro-tunnelling installs straight sections of pipe between entry and receiving pits on either side of the crossing. These pits are excavated to the required depth and at a suitable distance from the feature being crossed. A micro-tunnel boring machine drills from the entry pit to the receiving pit, pushing pipe sections forward as it advances. Once the bore reaches the reception pit, the cutting head is removed and reinforced concrete jacking pipes installed to case the tunnel. Conduits are then installed through the casing.
- **Auger-boring:** Auger-boring follows a similar approach to micro-tunnelling but employs a rotating screw-type drill head. As the head advances, it cuts through the ground and moves spoil back through the casing pipe for removal.

4.17.3.3 Cable installation and jointing

Once a trench section is ready, cable drums are delivered to joint bay locations and cables are fed into the conduit using specialised pulling equipment. At each joint bay, the cable is jointed with the next section of cable (refer to Figure 4-29). Depending on the length and complexity of each section, intermediate pulling pits (also known as caterpillar pits) may be required to assist with pulling cables through the conduit.

This installation process is then repeated along the entire alignment until all cable is installed. Fibre optic cables are installed within their own conduit at the same time.

Finally, link and fibre pit lids are installed, the trenches and joint bays backfilled, and the area revegetated.

Figure 4-28 Cable being fed from a cable spool into conduit (Australia)

Source Cable System Engineering

Figure 4-29 Example of a caterpillar pit (Australia)

Source Cable System Engineering

Figure 4-30 Joint bay ready for backfill (Australia)

Source Cable System Engineering

4.17.4 Commissioning

All major project components, including onshore transmission infrastructure, will undergo a commissioning and testing process. System tests will be completed as the project is connected to the grid in stages. Typical commissioning checks and tests include:

- Site acceptance tests to verify that equipment has not been damaged during transport, loading or unloading
- Pre-commissioning tests to confirm that installation meets design requirements and that equipment interfaces correctly with other parts of the system
- Commissioning tests to verify that equipment operates as designed and interfaces correctly with other parts of the system
- First energisation
- Grid acceptance tests to demonstrate that the new infrastructure meets technical performance standards agreed during the grid application process
- Performance testing to verify the availability and reliability of the infrastructure, and any other performance criteria commercially agreed.

4.17.5 Demobilisation and rehabilitation

All construction areas will be rehabilitated as soon as practicable after construction activities are completed. Rehabilitation will occur progressively, where feasible, and will include the removal of temporary construction facilities and civil works, the application and grading of subsoil and topsoil, and revegetation.

Land will be handed back to landholders as soon as practicable following demobilisation and rehabilitation, and in accordance with landholder agreements.

4.18 Onshore transmission operations and maintenance

The following section describes operations and maintenance (O&M) activities for the underground cable system.

4.18.1 Operations and maintenance activities

4.18.1.1 Underground cable system

The underground cable system will be remotely monitored through control and condition monitoring systems. Routine access will be minimal, with testing required once or twice a year at the link pits located at each joint bay. This involves accessing the easement via light vehicle and opening the pit covers to access the system.

An O&M base is expected to be established at either the onshore substation or a separate location in the Gippsland region.

A small workforce will undertake periodic inspections and routine maintenance of the cable system using light service vehicles, including cable easement inspections to monitor and control vegetation and confirm compliance with easement terms (refer to Table 4-8).

Table 4-8 Cable easement controls

Activity	Within easement
Aerial activities such as crop dusting and water bombing	Permitted
Agricultural activities:	
• Ploughing and cropping (up to 300mm penetration, excluding at fibre and link pits)	Permitted
• Grazing	Permitted
• Deep ripping	Prohibited
• Spray irrigation	Permitted
Buildings (temporary or permanent)	Prohibited
Boring, digging or quarrying	Prohibited
Driving, parking or unloading vehicles and farm machinery	Permitted
Fencing	Restricted (may require prior approval)
Installation of underground services	Restricted (may require prior approval)
Landscaping and paving	Restricted (may require prior approval)

Activity	Within easement
Pipelines (above ground)	Restricted (may require prior approval)
Storing and stockpiling (soil, hay, large equipment)	Restricted (may require prior approval)
Trees, shrubs, orchards and plantations	Restricted (may require prior approval)
Water storage (dams, tanks, troughs)	Prohibited

Anticipated land use restrictions, changes may occur through the design process.

4.18.1.2 Onshore substation

As outlined in Section 4.16.2, parameters and impacts associated with the construction, operation and decommissioning of the onshore substation will be assessed by the VicGrid Offshore Wind Transmission 2 GW Project EES and are not considered as a part of this assessment.

4.19 Onshore decommissioning

Decommissioning will be planned and carried out in accordance with regulatory and landholder requirements current at the time. The decommissioning approach is expected to be agreed with regulators before project operations cease. The assessment assumes current industry practices will be adopted.

To minimise disturbance, most below-ground infrastructure is expected to be left in place, with cable ends cut, sealed and securely buried. Surface infrastructure such as signage, markers, link and fibre pits may be removed if required by landholders or if environmental impacts arise.

4.20 Waste

Waste generated by onshore construction may include vegetation, surplus soil, excavated rock and general construction waste. Where practicable, excess soil will be reused on site or given to landholders. The volumes of soil expected to be reused on site or sent offsite are provided in *Technical Report J - Soil and Waste*.

Water will be used for earthworks, civil foundation construction, and steelworks, however significant wastewater production or disposal is not expected to be required