EirGrid Dublin Fluid Filled Cables Replacement

Feasibility Study

December 2022

Mott MacDonald
South Block
Rockfield
Dundrum
Dublin 16
D16 R6V0
Ireland

T +353 (0)1 2916 700
mottmac.com

EirGrid
The Oval
160 Shelbourne Road
Ballsbridge
Dublin 4
D04 FW28
Ireland

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Information class: Standard

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Executive summary

Background

EirGrid is committed to the replacement of all Fluid Filled Cables (FFC) from the Dublin electricity transmission system. This is due to environmental risk, maintenance policy, age/condition of these assets and future scenario network planning that has identified system uprating requirements. The following existing underground FFC transmission circuit systems are located within the city of Dublin:

- Inchicore – Poolbeg #1 220 kV cable
- Inchicore – Poolbeg #2 220 kV cable
- Carrickmines – Poolbeg 220 kV cable

These circuits are critical backbone elements of the Dublin transmission grid and are essential to the optimal use of available generation in the capital city. The route for each of the circuits navigates busy urban environments, the industrial port zone and existing infrastructure.

The existing circuits have sensitivities surrounding their replacement as they have reached end of asset life but are required in the future scenario analysis for the transmission system. An analysis of the replacement options has been provided in this report for the purposes of determining the feasibility for the replacement of each circuit.

While this feasibility study focussed only on these three circuits, the conclusions reached regarding the need for new offline routes to be identified and installed are potentially likely to apply in a similar way to the other two FFC routes within the Dublin Area, namely the Finglas – Northwall and Northwall – Poolbeg circuits.

Project Scope

Some of the key scope elements of this feasibility study includes:

- Identification of potential cable replacement options including standard designs and any new cable/innovative technology that may be available for this project
- Assessment of the feasibility of re-using the existing routes for the new cable circuits
- Preliminary assessment of the feasibility of alternative/offline routes for the new cable circuits
- High level technical and cost assessment for the replacement works in conjunction with the three fluid filled cable circuits.

Due to the nature of the receiving environment and associated constraints and considerations the scope includes feasibility assessment of both onshore and offshore cable alignments. The offshore assessment includes:

- Identification of potential landfall sites and submarine cable alignments within the study area
- Outlining technically feasible options and assessment of the likely installation methods which could reduce potential impacts on mudflats in Dublin Bay.

Project Overview

Geospatial datasets were acquired from a variety of sources for the purposes of the review and a heatmapping exercise undertaken to provide a visual representation of the density of constraints across the study area. The dataset consisted of existing survey information and primary utilities including primary gas and water services and cable systems from 38kV and above. This dataset was then assessed and interrogated using a network analysis tool to provide potential feasible options for assessment. Key constraints for these alignments were identified to allow these options to be considered further.

Options Identified

The result of this assessment was potentially feasible options for the two routes required for Inchicore – Poolbeg and potentially feasible options for the single route for Carrickmines – Poolbeg.

It is considered that long outages on these transmission assets will present challenges to the Network Operator in ensuring safe and secure operation of the transmission network and it would not be operationally feasible to accept such plans. As this project requires the replacement of three cable circuits the anticipated outage restrictions and significantly longer construction durations associated with replacement using the existing cable routes (requiring decommissioning of the existing system in tandem with installation of the new cable system) would likely not meet EirGrid's Shaping Our Electricity Future timelines.

The potentially feasible options are likely to be largely new routes, with sections of the existing routes only re-used where absolutely necessary. The preliminary alignment options that were identified have been assessed prior to stakeholder engagement to enable informed discussions to progress. In line with EirGrid's six-step Framework for Project Development, it is anticipated that further work which considers stakeholder commentary based on the findings of this report will ultimately result in the identification of Best Performing Options (BPOs).

While this feasibility study focussed only on these three circuits, the conclusions reached regarding the need for new offline routes to be identified and installed are potentially likely to apply in a similar way to the other two FFC routes within the Dublin Area, namely the Finglas – Northwall and Northwall – Poolbeg circuits.

Known Infrastructure Projects

BusConnects Dublin Project: following engagement, the routes will be issued for statutory approval with construction due to commence on a phased basis between 2022 and 2027. Given the current timescales of that project it is important that consultation with the project sponsor (National Transport Authority) is undertaken to ensure any significant road changes are known which could impact on future works associated with the cable replacement works.

Early consultation is recommended with DLRCC / DCC regarding the potentially feasible route options for the Carrickmines to Poolbeg route and the Inchicore to Poolbeg route that coincide with the Eastern Bypass route corridor. It is understood that the Eastern Bypass is no longer being pursued and consultation regarding the future use of that corridor is recommended.

Early and continued engagement with owners and regulators of other key infrastructure is recommended as crossing agreements will need to be put in place where the new routes cross existing infrastructure. Examples of this infrastructure includes the LUAS, DART, Grand Canal and River Dodder.

Further Work

Further steps in the process, in line with Eirgrid's six-step Framework for Project Development will be required to identify the Best Performing Options for development to the consenting stages. It is recommended that this stage includes a review of the identified options in this report against any new data available as part of a consultation process and a more detailed and comprehensive set of utility service information that includes validation of all existing services including telecoms, LV systems and domestic supplies. Following this, additional confidence in routes can be achieved through the commissioning of localised ground and utility surveys.

Each of these routes and the study area in general are congested in terms of utilities and traffic. An opportunity for the installation of a cable tunnel has been identified in mitigation of this. The feasibility of a cable tunnel requires detailed assessment beyond the scope of this report. It is noted that at a high level, there appears to be a case for a cable tunnel from a wider network perspective. Although the cost of a cable tunnel would be significant, investigating the feasibility of such a system is recommended due to the equally significant advantages it may provide.

1 Background

1.1 The Project

EirGrid is committed to the replacement of all Fluid Filled Cables (FFC) from the Dublin electricity transmission system due to environmental risk, maintenance policy, age/condition of these assets and future scenario network planning that has identified system uprating requirements. This feasibility study considers the following three existing underground FFC transmission circuit systems, which are located within the city of Dublin:

- Inchicore – Poolbeg #1 220 kV cable
- Inchicore – Poolbeg #2 220 kV cable
- Carrickmines – Poolbeg 220 kV cable

These circuits are critical backbone elements of the transmission grid in Dublin and are essential to the optimal use of available generation in the capital city. The route for each of the circuits navigates busy urban environments, the industrial port zone and existing, operational and in many cases, aging and historical city infrastructure, both above and below ground.

These circuits have sensitivities surrounding their replacement as they have reached end of asset life but are required in the future scenario analysis for the transmission system.[1]

1.2 Purpose of this Report

The purpose of this feasibility study is to determine potential replacement solutions for future consideration for each of these circuits. The study presents a review of available technologies, the existing routes and potentially feasible options for the replacement circuits.

1.3 Structure of this Report

This section presents the structure of this report.

Chapter 2 provides an overview of this feasibility stage of the project, the three cable circuits under assessment, and the cable system design aspects which are relevant to the assessments carried out.

The approach to information gathering for this feasibility study is described in Chapter 3. This section also includes discussion of innovations and technologies that could be applied to overcome challenges likely to be encountered.

Chapter 4 discusses key constraints, considerations and opportunities with reference to consultation feedback where applicable. This section also includes preliminary traffic and transport study findings regarding the study area.

Chapter 5 provides the offshore cable feasibility assessment

Chapter 6 describes aspects related to decommissioning of the FFC systems.

Chapter 7 presents indicative order of magnitude costs and example construction programmes for online and offline replacement works.

Chapter 8 discusses preliminary considerations for cable tunnels.

[1] The report in the Irish Times (Massive oil leaks from ESB cables in Dublin investigated (irishtimes.com)) and other news articles will have raised public awareness of the issues and as a result, solutions developed for the replacement of the existing systems should pay due consideration to these publicly identified issues.

Chapter 9 presents the conclusions of the previous chapters and assessment.

Relevant appendices are included as referenced in the body of this report.

2 Project Overview

2.1 Introduction

The following sections provide a description of the three existing underground 220 kV cable circuits under consideration in this study.

- Inchicore – Poolbeg #1
- Inchicore – Poolbeg #2
- Carrickmines – Poolbeg

2.2 Scope

The scope of this feasibility study includes:

- Identification of potential cable replacement options including standard designs and any new cable/innovative technology that may be available for this project
- Assessment of the feasibility of re-using the existing routes for the new cable circuits
- Preliminary assessment of the feasibility of alternative alignments for the new cable circuits
- High level technical and cost assessment for the replacement works in conjunction with the three fluid filled cable circuits.
- Visual inspection of the existing routes to identify infrastructure which will require decommissioning
- Assessment of decommissioning requirements and methods
- Report on Liaison with relevant agreed stakeholders to develop the feasibility study, including any recommendations for consultation with other stakeholders as appropriate.

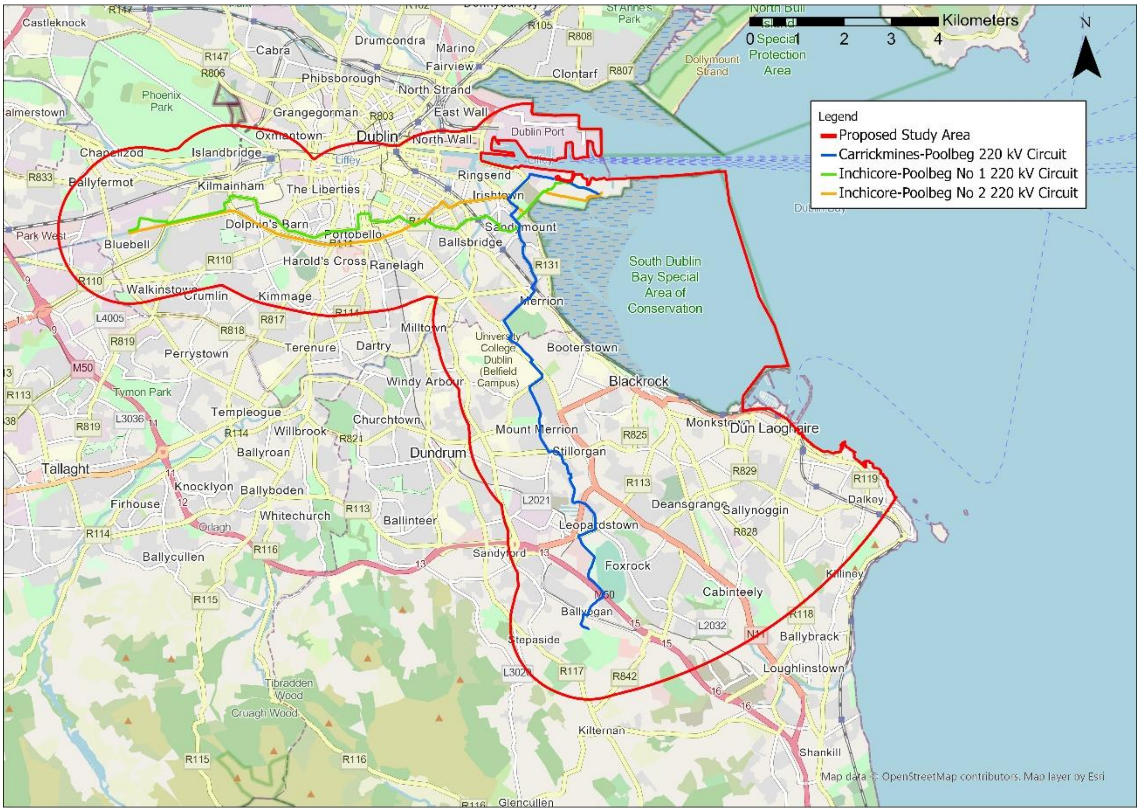
Due to the nature of the receiving environment and associated constraints and considerations the scope includes feasibility assessment of both onshore and offshore cable alignments. The offshore assessment includes:

- Identification of potential landfall sites and submarine cable alignments within the study area shown in Figure 2.1 to connect south Dublin with the substation at Poolbeg.
- Outlining technically feasible options and assessment of the likely installation methods which could reduce potential impacts on mudflats in Dublin Bay
- Undertaking a high-level evaluation of environmental and social constraints
- Outlining high level Appropriate Assessment (Habitat Directive) and consenting considerations
- Producing a matrix for the technical, economic, environmental, social, and deliverability feasibility of potential alignment options

2.3 Study Area

The study area for the three routes under consideration includes a buffer of approximately 1.5km on either side of each of the three existing cable routes, as well as consideration of Dublin Bay for offshore routing where this may be of benefit and as agreed with EirGrid, and an extension in the Carrickmines area to include Cabinteely, Dalkey and Dun Laoghaire. The study area is presented graphically in Figure 2.1. A more detailed map is provided as Map A0 in Appendix A.

Figure 2.1: Study Area



Source: Mott MacDonald (Open Street Map Layer by ESRI)

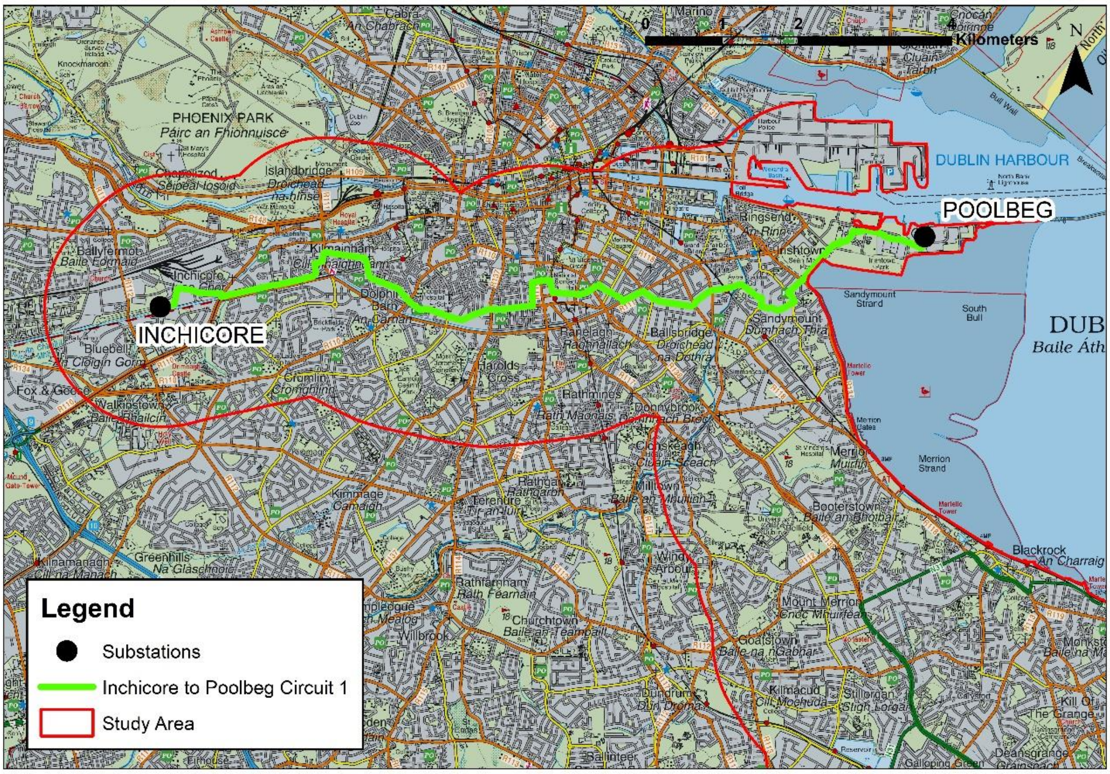
2.4 Description of Circuits Under Consideration

The sections below provide a review of the three existing cable circuits with respect to their configuration, key parameters, and initial assessment of areas of constraint along the existing routes. Data outlined in the following sections is based on the route record information and other data received at the time of writing. It is possible that additional services may have been installed and are not shown on these records.

2.4.1 Inchicore – Poolbeg #1

The Inchicore – Poolbeg #1 220 kV circuit was constructed and first energised in 1971. The circuit is approximately 12.5km in length and is a low pressure Self Contained Fluid Filled (SCFF) cable circuit. Records state that the cable has 3 x 485mm² Copper conductors typically in flat formation, and a rating of 266MVA. The cable route is shown on the map in Figure 2.2, with the circuit parameters outlined in Table 2.1 below.

Figure 2.2: Inchicore – Poolbeg #1 220kV FFC Route



Source: Mott MacDonald (OSI Licence No 0090319)

Table 2.1: Inchicore – Poolbeg #1 Existing Circuit Parameters

Parameter		Value
Voltage Rating		220 kV
Current Rating		266 MVA (698.1 A)
Circuit Formation		Flat (assumed generally touching)
Circuit Length		12.5 km
Cable	Conductor Material	Copper
	Cross section	3 x 485 mm^2
Oil Pressure		Unspecified
Pipe/ Duct size (where ducted)		6" (152.4 mm)[2]
Burial Depth		1.0 m – 2.3 m
Joint Bays	Type	Underground
	Number	28
Oil Tanks	Number of locations	3 (multiple tanks at each location)
	Capacity	300 L

Source: Route Records

A number of cable route sections have complex and/or a high number of utility crossings and could present a challenge for reutilisation of the route. These areas are summarised in the sections below.

2.4.1.1 Jamestown Road to Inchicore 220 kV Station

This part of the route consists of Joint Bay No. 25 and 26 of the cable system and a large number of utility services. Existing utility services crossing the existing 220 kV cable on Jamestown Road are listed below in Table 2.2 as per route record drawing provided by EirGrid.

Table 2.2: Utilities at Jamestown Road to Inchicore 220 kV Station

Utility/ Crossing	Depth	Location
Two 10 kV Cables	1.2 m	Jamestown Road
38 kV Cables	1.3 m	Jamestown Road
Two 9" E.W. Pipes	1.1 m	Jamestown Road
6" C.I. Gas main	0.6 m	Jamestown Road
4" C.I. Pipe	0.8 m	Jamestown Road
6" P&C Duct	0.6 m	Jamestown Road
110 kV Francis Street – Inchicore Cables	Unspecified	Inchicore 220 kV Station
110 kV Inchicore – Airton 2 Cables	Unspecified	Inchicore 220 kV Station

Source: Route Records

[2] Wavin pipe

2.4.1.2 South Circular Road

This section of the route is between Synge Street and Suir Road and consists of Joint Bay Nos 16 to 21 of the cable system and a high number of utility services. A number of crossings present on this route section are outlined in Table 2.3 below as per route record drawing provided by EirGrid.

Table 2.3: Utilities at South Circular Road

Utility/ Crossing	Depth	Location
18" C.I. pipe	1.0 m	South Circular Road
12" Gas main	1.0 m	South Circular Road
8" Gas main	0.6 m	South Circular Road
4" C.I. Water main	0.7 m	South Circular Road
Two H.T Cables	0.6 m	South Circular Road
Two L.T Cables	0.3 m	South Circular Road
4" Water main	0.8 m	South Circular Road

Source: Route Records

2.4.1.3 Pigeon House Road

Pigeon House Road contains Joint Bay No. 1, 2, 2A, 2B and a high number of utility services. This section runs between Poolbeg power station and South Bank Road. A few of the services present on this road are given in Table 2.4 as per route record drawings provided by EirGrid.

Table 2.4: Utilities at Pigeon House Road

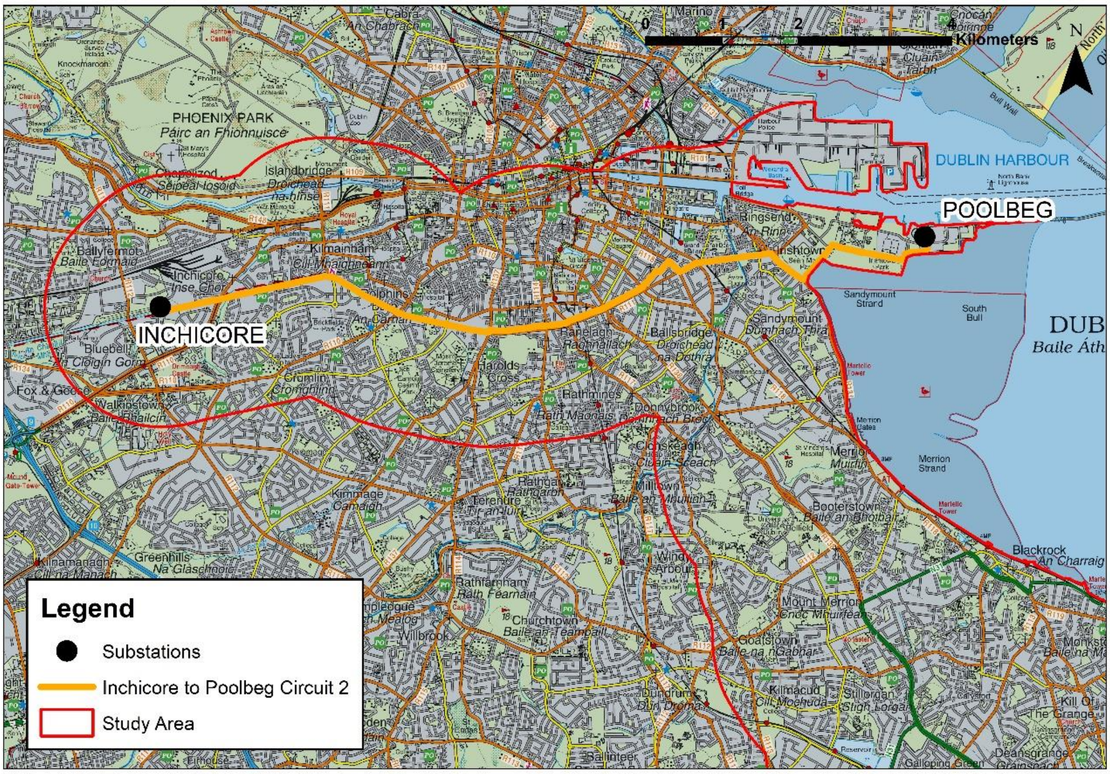
Utility/ Crossing	Depth	Location
38 kV Cables	1.1 and 1.2 m	Pigeon House Road
Two 4" Water pipes	0.8 m	Pigeon House Road
9" Water pipe	Unspecified	Pigeon House Road
Two Oil pipes	1.1 m (above ground)	Pigeon House Road
9" C.I. pipe	1.1 m	Pigeon House Road
Two 4" C.I. pipes	0.8 m	Pigeon House Road
2" C.I. pipe	0.6 m	Pigeon House Road

Source: Route Records

2.4.2 Inchicore – Poolbeg #2

The Inchicore – Poolbeg #2 220 kV circuit was constructed and first energised in 1984. The circuit is approximately 11.3km in length and is a low pressure SCFF cable circuit. Records state that the cable has 3 x 1300mm² Aluminium conductors in flat formation and a rating of 349MVA. The cable route is shown on the map in Figure 2.3, with the circuit parameters outlined in Table 2.5 below.

Figure 2.3: Inchicore – Poolbeg #2 220kV FFC Route



Source: Mott MacDonald (OSI Licence No 0090319)

Table 2.5: Inchicore – Poolbeg #2 Existing Circuit Parameters

Parameter		Value
Voltage Rating		220 kV
Current Rating		349 MVA (915.9 A)
Circuit Formation		Flat (assumed generally touching)
Circuit Length		11.3 km
Cable	Material	Aluminium
	Cross section	3 x 1300 mm^2
Oil Pressure		Unspecified
Pipe/ duct size (where ducted)		6” (152.4 mm)
Burial Depth		0.5 m – 1.45 m
Joint Bays	Type	Underground
	Number	21
Oil Tanks	Number of Locations	4 (multiple tanks at each location)
	Capacity	300 L

Source: Route Records

A number of cable route sections have complex and/or a high number of utility crossings and could present a challenge for reutilisation of the route. These areas are summarised in the sections below.

2.4.2.1 Davitt Road to Inchicore Station

The cable system at this section is installed along Davitt Road and the Grand Canal with several utility crossings. Some of the larger utilities on this section are listed below in Table 2.6 as per route record drawings provided by EirGrid.

Table 2.6: Utilities at Davitt Road

Utility/ Crossing	Depth	Location
27" C.I. Water	1.0 m	Davitt Road
18" High pressure gas main	0.4 m	Davitt Road
12" Water main	0.85 m and 1.3 m	Davitt Road
Two 6" Concrete ducts	0.75 m	Davitt Road
Two 3" Steel ducts	0.9 m	Davitt Road
110 kV Inchicore – Milltown Cables	Unspecified	Davitt Road
110 kV Citywest – Inchicore Cables	Unspecified	Inchicore Station
110 kV Inchicore – Airton 2 Cables	Unspecified	Inchicore Station
110 kV Cookstown – Inchicore Cables	Unspecified	Inchicore Station

Source: Route Records

2.4.2.2 Parnell Road

This route section includes Joint Bay No. 4 and several utility crossings. Some of the existing utility crossings on this section are shown in Table 2.7 as per route record drawings provided by EirGrid.

Table 2.7: Utilities at Parnell Road

Utility/ Crossing	Depth	Location
12" Gas main	0.7 m	Parnell Road
9" Water main	0.6 m	Parnell Road
6" Pipe	0.85 m and 1.15 m	Parnell Road
9" Pipe	0.6 m	Parnell Road
4" Pipe	0.85 m	Parnell Road
ESB L.T. Cables	0.85 m	Parnell Road
110 kV Francis Street – Inchicore Cables	Unspecified	Parnell Road

Source: Route Records

2.4.2.3 Bath Avenue

This route section runs along Bath Avenue between Shelbourne Road and Irishtown Road with a high number of utility crossings at relative positions and depths. On this part of the route, the existing cable system crosses the river Dodder in a steel tray. The cable system is encased in sand and protected by a concrete slab on the side of London Bridge. A number of utility crossings are present at this location as outlined below in Table 2.8 as per route record drawings provided by EirGrid.

Table 2.8: Utilities at Bath Avenue

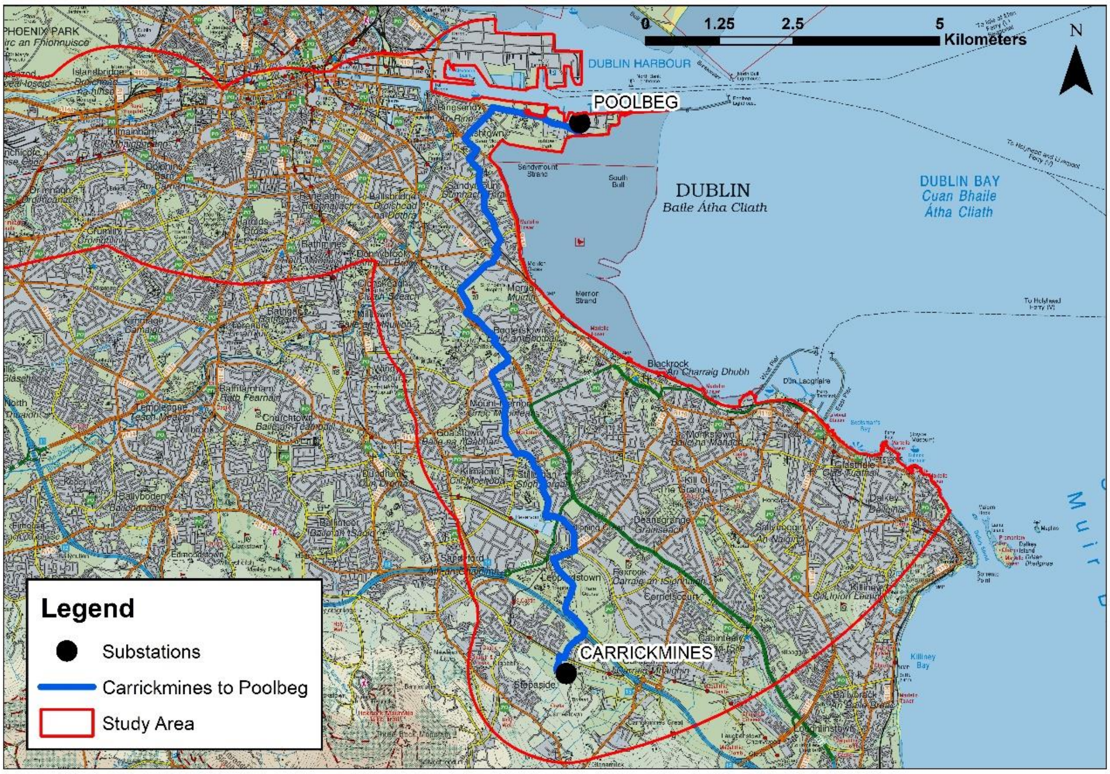
Utility/ Crossing	Depth	Location
38 kV Cables	0.55 m	Bath Avenue
Five ESB Cables	1.0 m	Bath Avenue
6” Gas main	Unspecified	Bath Avenue
Three 4” C.I. Pipes	Unspecified	Bath Avenue
Two 6” Ducts	Unspecified	Bath Avenue
Two H.T. Cables	0.6 m	Bath Avenue
London Bridge Crossing	Unspecified	Bath Avenue/ London Bridge Road

Source: Route Records

2.4.3 Carrickmines – Poolbeg

The Carrickmines – Poolbeg 220kV FFC circuit was commissioned in 1971. The circuit is approximately 14.5km in length and is a low pressure (1-2 bar) SCFF cable circuit. Records state that the cable has 3 x 800mm² Aluminium conductors in flat formation and a rating of 266MVA. The existing route for Carrickmines – Poolbeg is shown in Figure 2.4 with the circuit parameters outlined in Table 2.9 below.

Figure 2.4: Carrickmines – Poolbeg 220kV FFC Route



Source: Mott MacDonald (OSI Licence No 0090319)

Table 2.9: Carrickmines – Poolbeg Existing Circuit Parameters

Parameter		Value
Voltage Rating		220 kV
Current Rating		266 MVA (698.1 A)
Circuit Formation		Flat (assumed generally touching)
Circuit Length		14.5 km
Cable	Material	Aluminium
	Cross section	3 x 800 mm^2
Oil Pressure		1-2 bar
Pipe/ Duct size (where ducted)		6" (152.4 mm)[3]
Burial Depth		0.6 m – 1.8 m
Joint Bays	Type	Underground
	Number	23
Oil Tanks	Number of locations	6 (multiple tanks at each location)
	Capacity	300 L

Source: Route Records

A number of cable route sections have complex and/or a high number of utility crossings and could present a challenge for reutilisation of the route. These areas are summarised in the sections below.

2.4.3.1 Stillorgan Road

This cable route section runs parallel to the R138 (Stillorgan Road) between Foster's Avenue and Nutley Park and consists of Joint Bay No.11 and 12, a crossing under the R138, cable repair near the R138 road crossing and is very densely populated with existing utilities. Some of the larger utilities on this section as per route record drawings provided by EirGrid are shown in Table 2.10.

Table 2.10: Utilities at Stillorgan Road

Utility/ Crossing	Depth	Location
36" Water main	Unspecified	Stillorgan Road
24" Concrete pipe	Unspecified	Stillorgan Road
38 kV cables	1.3 m	Stillorgan Road
Twin stone culverts	Unspecified	Stillorgan Road
Three 6" Concrete ducts	0.7 m	Stillorgan Road
Three 10 kV Cables	0.8 m	Stillorgan Road
6" C.I. Gas	0.7 m, 0.8 m	Stillorgan Road
6" Water pipe	0.9 m	Stillorgan Road
4" Gas main	0.5 m	Stillorgan Road

Source: Route Records

2.4.3.2 Nutley Lane (Junction with Merrion Road)

This cable route section runs along Nutley Lane starting from Nutley Park to Ailesbury Park and consists of Joint bay No. 10, three repair joints and several utility crossings. Some of the larger utilities on this section as per route drawings provided by EirGrid are shown in Table 2.11.

[3] Wavin pipe

Table 2.11: Utilities at Nutley Lane

Utility/ Crossing	Depth	Location
110 kV Blackrock – Ringsend Cable	0.8 m – 1.0 m	Nutley Lane/ Merrion Road Junction
54” and 36” Dodder valley drainage scheme steel pipes	Unspecified	Nutley Lane
12” Concrete duct	0.8 m	Nutley Lane
12” Pipe	0.8 m	Nutley Park
9” C.I. pipe	0.8 m and 1.0 m	Nutley Lane
Three 6” Concrete pipes	0.8 m	Nutley Lane
Sewage Mains	1.0 m	Nutley Park
Two 4” Wavins	0.8 m	Nutley Park
6” C.I. Gas	0.8 m	Nutley Park

Source: Route Records

2.4.3.3 Sydney Parade Avenue

This section of the cable route runs along Sydney Parade between Ailesbury Park and Park Avenue and consists of a joint/repaired section to the R phase of the Carrickmines – Poolbeg 220 kV cable circuit and the existing service crossings as per route drawings provided by EirGrid as shown in Table 2.12.

Table 2.12: Utilities at Sydney Parade Avenue

Utility/ Crossing	Depth	Location
18” H.P Gas main	Unspecified	Sydney Parade Avenue
Dublin Wexford Railway[4]	Unspecified	Sydney Parade Avenue
9” C.I.	0.2 m, 0.5 m and 0.8 m	Sydney Parade Avenue
Gas pipe/ service	0.5 m	Ailesbury Park
5” C.I.	0.9 m	Sydney Parade Avenue
L.T. Cables	0.5 m and 0.6 m	Sydney Parade Avenue
H.T Cables	1.1 m	Sydney Parade Avenue
Three 6” and two 4” Wavin pipes	Unspecified	Sydney Parade Avenue
3” C.I.	0.2 m	Sydney Parade Avenue

Source: Route Records

2.4.3.4 Pigeon House/ Sean Moore Road

This route section runs along Pigeon House Road starting from Whitebank Road and terminates at Poolbeg station. It includes Joint bay No. 1, two PVC repairs on the existing circuit and a high number of existing utility crossings. A few existing services on this section are listed in Table 2.13 as per route drawings provided by EirGrid.

[4] This railway is named the Dublin Wexford Railway on the route records. This has since become the DART route also.

Table 2.13: Utilities at Pigeon House Road

Utility/ Crossing	Depth	Location
38 kV Cables	1.2 m	Pigeon House Road/ Whitebank Road
12" Water main	Unspecified	Pigeon House Road
Drainage Pipe	Unspecified	Sean Moore/ Pigeon House Road
400 mm Bored Gas	Unspecified	Sean Moore/ Pigeon House Road
Three L.T. Cables	1.0 m	Whitebank/ Pigeon House Road
Francis Street 110 kV Cable	Unspecified	Sean Moore Road
Two H.T. Cables	Unspecified	Sean Moore/ Pigeon House Road

Source: Route Records

2.5 Cable System Design

2.5.1 System and Cable Parameters

Table 2.14 summarises the rating requirements of the three new cable circuits.

Table 2.14: Rating requirements

Parameter	Value
System Voltage	220 kV
System Frequency	50 Hz
Current Rating	570 MVA @ 15^{0}C[5] (as per EirGrid Policy at time of writing, subject to change)

Source: EirGrid

Table 2.15 details the key parameters of the 220 kV, 2500 mm^2 single core cables with enamelled copper Milliken conductor, XLPE insulation, annealed copper wire sheath and PE over sheath. The cable model is derived from the datasheet provided by EirGrid.

Table 2.15: Key Cable Parameters

Parameter		Value	Reference/ Comments
Manufacturer		LS Cables	LS Cable & System Ltd datasheet[6]
Design		Single Core	
Design Specification		IEC 60228 and IEC 62067	
Voltage Rating		220 kV	
Conductor	Material	Copper	
	Cross Sectional Area	2500 mm^2	
	Skin Coefficient	0.35	IEC 60287-1-1[7]
	Proximity Coefficient	0.2	
Insulation	Temperature Withstand	90ºC (XLPE)	LS Cable & System Ltd Datasheet[6]
	Loss Factor (tanδ)	0.001	
	Permittivity (ε)	2.5	
Screen Material		Plain annealed copper wires	
Screen Cross sectional Area		257.6 mm^2	

Source: EirGrid

[5] The ambient soil temperature of 15^{0}C corresponds to the Spring/Autumn ratings as per EirGrid specifications.

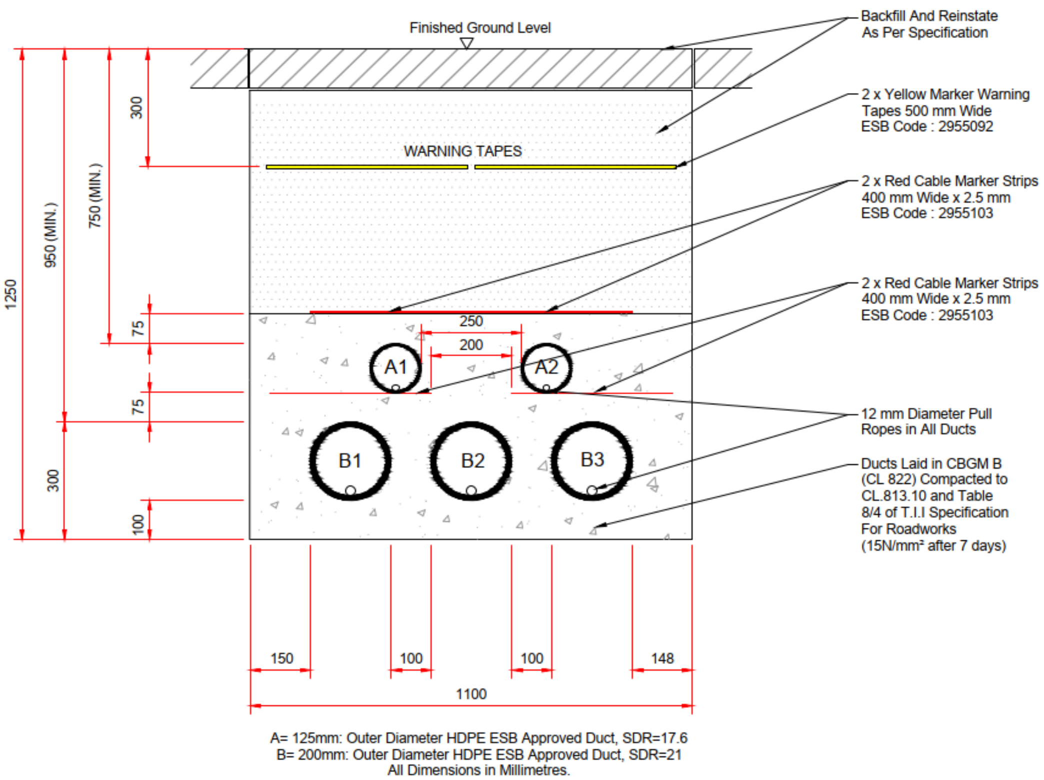
[6] 220 kV (Cu, Enamelled) 2500 Sq. Cu wire screen Cable Technical Specification. Ref No. LSGS-17-PC0219, Rev 1, 06/07/2018

[7] BS IEC 60287-1-1:2006 Electrical Cables – Calculation of the current rating – Part 1-1 Current Rating equations (100% load factor) and calculation of losses - General

2.5.2 Standard ESB Flat formation

Figure 2.5 presents the standard flat formation trench details proposed for a new ducted cable route as extracted from PE424-D7001-001-005-008[8]. The cable circuit is installed in flat formation in a surround of Cement Bound Granular Material (CBGM B). The nominal depth of installation to the crown of the power ducts will vary based on location but should typically be a minimum of 950mm. These dimensions are used as a basis for this feasibility study. It should be noted that the final installed dimensions may differ at localised points dependent on local terrain and constraints.

Figure 2.5: Standard ESB Flat Formation Trench



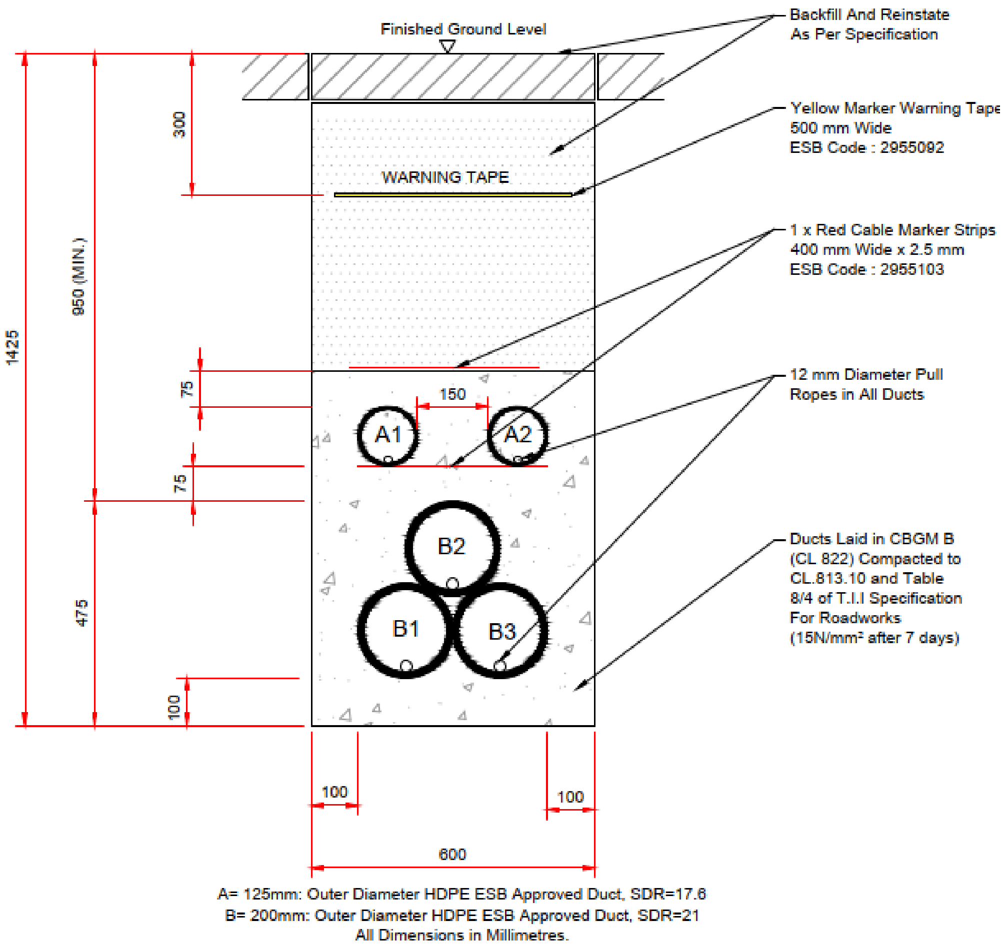
Source: EirGrid/Mott MacDonald

[8] PE424-D7001-001-005-008 Trench Cross Section 220 kV Cable 1.1 m Wide Trench in Flat Formation, 19/11/2019

2.5.3 Trefoil Formation

In areas of the route with more constrained route alignments, a narrower cable trench could be preferable. Figure 2.6 presents a ducted trefoil installation in a surround of CBGM B. The nominal depth of installation to the crown of the top power duct varies based on location but should typically be a minimum of 950mm. These dimensions are used as a basis for this feasibility study. It should be noted that the final installed dimensions may differ at localised points dependent on local terrain and constraints.

Figure 2.6: Trefoil Formation Trench

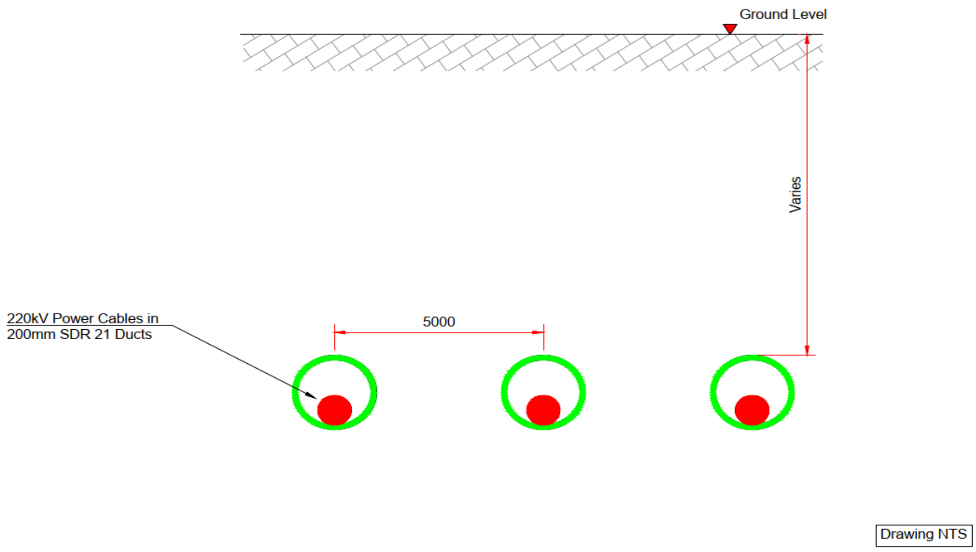


Source: EirGrid/Mott MacDonald

2.5.4 Horizontal Directional Drill (HDD)

Installations by Horizontal Directional Drill (HDD) are to be considered when crossing obstacles where open trenching is unsuitable due to topographic, social and environmental, or safety constraints. For the purpose of the rating study the circuit is assumed to be installed with each phase cable in separate SDR 21 PE ducts at a phase spacing of 5 m between adjacent bores as shown in Figure 2.7.

Figure 2.7: Indicative HDD Installation



Source: Mott MacDonald

2.5.5 Preliminary Cable System Ratings

The Cymcap software package (Version 8.0 Rev 1) was used to calculate the steady-state cable ratings as per the analytical techniques described by the IEC 60287[9] series.

The rating has been evaluated considering the thermal limits of the cable insulation which is indicated in the LS Cable datasheet[10] as being 90°C for continuous operation.

Installations are modelled in Cymcap as a two-dimensional cross section. As the rating of a cable is sensitive to the properties of the native environment, the definition of ambient conditions and cable parameters is critical. Parameters considered include cable design, cable system design, depth, proximity and separation of the cables and circuits, electrical characteristics, native/installed surrounding materials and ambient temperature. Ambient conditions and surrounding materials are modelled as per EirGrid requirements[11] and are provided in Table 2.16.

Unless otherwise noted the rating assessment considers only single circuit operation. For installations where two or more circuits run in parallel, this assumes that the adjacent circuits are out of service. The studies identify the ratings at standard depths as well as the depth that can be achieved for each installation cross section whilst meeting the target rating.

[9] BS IEC 60287, Electric Cables – Calculation of the Current Rating, BSI

[10] 220 kV (Cu, Enamelled) 2500 Sq. Cu wire screen Cable Technical Specification. Ref No. LSGS-17-PC0219, Rev 1, 06/07/2018

[11] CDS-HFS-02-001-R3, 110 kV Underground Cable Functional Specification Cable Materials, R3 12/03/2020

Table 2.16: Environmental and Installation Parameters

Parameter	Value		Reference/ Comments
Ambient Temperature	15 °C		EirGrid Requirement
Thermal Resistivity	Native soil	1.2 K.m/W	EirGrid Specification
	CBGM B	1.0 K.m/W	
Cables	Spacing	300 mm	Centre to centre of ducts, only applies for flat formation
	Bonding	Cross Bonded	Single Point Bonded used for HDD case
Ducts	Material	HDPE	SDR 21[11]
	Thermal Resistance	3.5 K.m/W	
	Inner Diameter	180 mm	
	Outer Diameter	200 mm	
Other Heat Sources	Not Modelled		Heat sources (LV/ HV cables, pipes for steam/ gas, fuel etc) are assumed to be at a separation such that the de-rating is negligible

Source: EirGrid / Mott MacDonald

For each cable installation, Table 2.17 below defines the current rating for burial at standard depth as well as the maximum depth which results in a conductor temperature of 90°C while maintaining the required 570MVA rating (as per EirGrid Policy at time of writing, subject to change). Depths are given to the crown of the top duct for both open cut trench and trenchless installations.

Table 2.17: Cable System Rating Results

Installation	Current/MVA	Depth	Maximum depth at 570 MVA
Standard Flat formation	1919 A / 731 MVA	0.95 m	5.25 m
Trefoil Formation	1797 A / 684 MVA	0.95 m	4.65 m
HDD	1547 A / 589 MVA	-	~50 m

Source: Mott MacDonald

2.6 Mechanical Considerations

Cable pulling tensions required to install the cable through the ducts are estimated using the method defined in the AEIC Pulling Guide[12]. Table 2.18 and Table 2.19 below presents the calculation assumptions when estimating tensions and distance for a cable pull.

Table 2.18: Pulling Tension calculation assumptions for Land Cable

Parameter	Value	Unit
Cable conductor size	2500	mm^2
No. of cable conductors	1	-
Cable outer diameter	127	mm
Cable weight	34	Kg/m
Duct Internal diameter	180	mm
Coefficient of Friction, µ	0.4	-
Minimum Bending Radius	6[13]	m
Initial Pulling Tension	100	N
Pulling Load Limit	170	kN

[12] AEIC Underground Extruded Power Cable Pulling guide.

[13] The LS Cable data sheet states 2.6m as the limit on the cable. ESB require a bending radius of not less than 6m.

Source: EirGrid HV Cable Datasheet[6]

Table 2.19: Pulling Tension calculation assumptions for Submarine Cable

Parameter	Value	Unit
Cable conductor size	2500	mm^2
No. of cable conductors	1	-
Cable outer diameter	144	mm
Cable weight	55	Kg/m
Duct Internal diameter	350	mm
Coefficient of Friction, µ	0.4	-
Minimum Bending Radius	Defined by duct/drill (e.g., 350m)	m
Initial Pulling Tension	100	N
Pulling Load Limit (assumed)	240	kN

Source: Nexans 420kV Subsea Cable Datasheet

Route selection affects the cable pulling process and therefore will affect position of the drums and winches. The following will need to be considered to safely pull the cable through the final selected route.

- Width of the roads on the route may limit access to the site and restrict transport feasibility for the cable drums. Cable drums for cable of the type anticipated for this project are normally transported as abnormal loads. Narrow roads should be avoided to simplify delivery of cable drums and some street furnishings may require temporary removal.
- Arrangement and physical positions of the cable drums, winch, cable hauling machines, access pits and anchoring requirements to achieve a less onerous pull may conflict with social impacts (e.g., access pits could introduce additional requirements for traffic control measures).
- Duct runs should be substantially straight with the minimum of bends to help control tensions
- Bend radii of ducts should be as large as possible to help control tensions and the inner diameter of the duct should be approx. 1.5 times the outside diameter of the cable as a minimum. Challenging installations may require a larger diameter duct.
- Access pits and joint bays should be combined where possible to reduce the quantity of openings required during cable pull in.

2.7 Online vs Offline Cable Replacement

An online cable replacement is undertaken through removal (recovery) of the existing circuit followed by installation (replacement) of a new circuit in the space the original circuit occupied. An offline replacement requires the identification of a new route that is independent of the existing route such that the two systems do not interact.

The major advantage of an online cable replacement is that the route alignment already exists, and therefore route selection is not necessary. The existing trench profile is typically similar to that required for a new trefoil arrangement. However online replacement comes with the complexities of decommissioning a circuit at the same time as installing a new circuit. Normally decommissioning would consider leaving the redundant service (in this case, the fluid filled cable circuits) in-situ (discussed further in Section 6) whereas online replacement would require the removal of the existing cable, thus adding to the complexity of the works.

Online replacement works are likely to be slower than offline and would require a circuit outage for the full duration of the installation works. It is understood that Inchicore – Poolbeg #1 has had a continuous outage in the past for a number of years. It may therefore be possible to sustain such an outage for that circuit again for the purposes of online replacement works. However, network operational restrictions mean only one of the 220kV fluid filled cable circuits can be in outage status at any one time, so a direct replacement approach would also mean that the works would need to take place in a sequential manner.

Such long outages on these transmission assets will present major challenges to the Network Operator in ensuring safe and secure operation of the transmission network and would likely not be feasible to accommodate.

It is likely that outages would only be accommodated during the outage season (approximately April to September) and not on a continuous basis for the duration of works as shown in the example construction schedule provided in Section 7. In the event that such outage restrictions are enforced, the works would be further complicated by the need to install the new cable at a similar stage as the duct replacement and then to install transition joints between XLPE and FF cables at the end of each outage season to ensure the circuit is available for use.

As this feasibility study considers the replacement of three cable circuits, the anticipated outage restrictions and longer construction durations associated with recover and replace mean project completion using direct replacement along existing routes is highly unlikely to align with EirGrid's Shaping Our Electricity Future timelines. This is likely to be further exacerbated by the inclusion of the Finglas–North Wall and North Wall–Poolbeg FFC circuits within the replacement programme.

Offline replacement has the advantage of installation works being possible in isolation of decommissioning works thereby reducing the extent to which a system outage will be required. It also provides some additional flexibility in terms of the decommissioning process and would facilitate installation of new ductwork in a number of locations at the same time which would have the benefit of facilitating a faster overall construction programme. Notwithstanding this however, there are locations within the study area where there are levels of constraint in existence that may dictate that the only reasonable feasible solution at those locations is the reuse of the existing route for the new cable circuit.

The final solution for each cable route is therefore likely to comprise significant elements of 'new routing' where practicable with some portions of 'replacement in situ' only in areas where constraints dictate there are no reasonable alternative feasible solutions.

3 Information Gathering

3.1 Introduction

The information gathering process was primarily a desk based study supported by technical and environmental site walkovers of the existing routes. This process is intended to set parameters in addressing the feasibility of the replacement works, without prejudice to future works on the projects including, among others, stakeholder engagement, consultant activity, and detailed route selection. The identification of constraints was considered under the following categories:

- Technical;
- Economic;
- Environmental;
- Socio-Economic; and
- Deliverability

3.2 Data Collection

Geospatial datasets were acquired from a variety of sources. In the first instance, a review of publicly available open datasets was undertaken. Other datasets were applied for under appropriate licencing. All Ordnance Survey of Ireland (OSI) data was acquired through EirGrid's OSI licence. The list of sources for these datasets are as follows:

- The Ordnance Survey of Ireland;
- The Department of Tourism, Culture, Arts, Gaeltacht, Sport and Media;
- The National Parks and Wildlife Service;
- The Office of Public Works;
- The Geological Survey of Ireland;
- The Environmental Protection Agency;
- The National Transport Authority of Ireland;
- Dún Laoghaire-Rathdown County Council;
- Dublin City Council;
- South Dublin County Council; and
- Utility Providers (Bord Gais, EirGrid, ESB, Irish Water).
- GeoDirectory

Each dataset underwent a review and check by a Geographic Information Systems (GIS) specialist to ensure they were complete, correct, and relevant. The datasets came in a variety of Geospatial formats and coordinate systems. They were all re-projected to IRENET95 Irish Transverse Mercator projection system (EPSG: 2157). The data was converted into an ArcGIS feature class and stored in an ESRI file geodatabase on the Mott MacDonald GIS platform. Each dataset was named according to the date it was acquired and they were grouped in the file geodatabase under the following themes: environmental, heritage, hydrology, infrastructure, land use, planning, sociocultural and transport. A full list of the datasets that informed the study can be found in Appendix B.

The following County Development Plans (CDP) and online resources were also reviewed:

- Dublin City Development Plan 2016-2022
- Dún Laoghaire-Rathdown County Development Plan 2016-2022

- South Dublin County Council Development Plan 2016-2022
- Myplan.ie online mapping
- National Parks and Wildlife Services, NPWS
- Environmental Protection Area (EPA) online mapping
- Geological Survey Ireland (GSI) online mapping
- National Monuments Service Historic Environment Viewer
- National Inventory of Architectural Heritage
- Heritage Mapping
- Transport Infrastructure Ireland Open Data Portal
- Data.Gov.ie Irelands Open Data Portal

3.3 Desk Based Assessment – GIS

GIS technology was used to collate and analyse constraint data. The primary software used for this task was ESRI ArcGIS Pro version 2.6.1 and its associated extensions. ArcGIS Web AppBuilder was used to create a custom online web mapping application. This allowed the wider team of professionals working on the project to access, visualise and interrogate data within a common data environment. It allowed team members to assess the data themed under their own specialism but crucially within that common data environment.

All GIS maps and web applications were prepared by the project GIS technical team who managed the data according to the most up to date Mott MacDonald GIS standards. These company standards are aligned with the framework and principles set out in the EU Infrastructure for Spatial Information in the European Community (INSPIRE) Directive.

The GIS methodology for identifying a list of potentially feasible route options involved 2 stages:

1. The production of a heat map surface layer for the study area identifying the density of constraints across the study area.
2. Assigning the resultant values of the heat map to a road network layer allowing a GIS network analysis tool to run scenarios based on a weighted network of roads.

3.3.1 Heat Mapping

Heat mapping is a decision support tool which provides a visual representation of the density of constraints across the study area, both in isolation and in combination (i.e., in areas where constraints overlap). Those areas least constrained can be said to be the “Areas of Opportunity” for potentially feasible route options and are displayed in yellow on the heat map. Heat mapping allows the project team to focus on these areas of opportunity when determining potential route corridors.

Each spatial constraint was assigned a buffer zone. These buffer zones were chosen based on professional judgment and experience on similar projects involving similar constraints. An important consideration when assigning a buffer extent was whether that buffer would capture the segment of the road network pertaining to that particular constraint. A number of scenarios were run on each constraint to identify the most appropriate buffer that would capture their related road segments and thus allow the creation of a network of roads based on the level of constraints across that network. This is discussed further in section 3.3.2.

Each constraint was evaluated along a scale in line with the EirGrid approach to option appraisal assessments carried out on other projects. This scale ranges from “more significant”/”more difficult”/”more risk” to “less significant”/”less difficult”/”less risk”. The scale ranges across 5 levels from "low"/"low-moderate"/mid-level/moderate"/"moderate-high"/"high". The colour key provided in Figure 3.1 is an illustration of this scale.

Figure 3.1: Level of risk definition by colours for a constraints map

Key	Level of Risk/Significance/Sensitivity
Yellow	Low
Green	Low-Moderate
Dark Green	Mid-Level / Moderate
Blue	Moderate-High
Dark Blue	High

Source: EirGrid

The table of input constraints to the heat map, the assigned buffer and the level of risk / significance / sensitivity applied to each constraint is provided in Appendix C.

The heat mapping process involved two steps with the output providing a raster surface layer for the entire study area. This included:

1. Initial data preparation of criteria specific layer files by converting and joining a Microsoft Excel file for each layer and assigning the appropriate buffer distance.
2. The outputs were then run through a weighted overlay GIS tool designed by Mott MacDonald which calculated statistics relative to weightings and the overlap of constraints.

The resultant heat map is a raster surface layer of the entire study area at a resolution of $1m^2$. This means that each pixel of the raster layer measures $1m^2$. Each pixel within the raster is assigned a value based on the impedance (or weighted) value of a constraint that falls within that area. Where multiple constraints overlap the pixel is assigned a cumulative value based on those overlapping constraints. To create a continuous raster image covering the entire study area a value of 1 is assigned where there are no constraints.

The heat map is presented visually in Map A1 of Appendix A by a colour ramp from blue to yellow with a standard deviation stretch applied. It is a visual method of representing the constraint density across the study area. Those areas least constrained can be said to be the "Areas of Opportunity" for route options and are displayed in yellow on the heat map. This information was then used to create a weighted network of roads within the study area.

3.3.2 Road Network Analysis

PRIME2 is the Ordnance Survey of Ireland's central database of spatial information and the most authoritative dataset in Ireland in terms of quality and accuracy[14]. The "Way" geometry from that dataset represents all drivable and walkable roads and paths. All "Ways" from motorway to single carriageway roads have line and polygon geometry. The dataset is modelled as a connected set of segments. A network segment is defined as a line geometry that joins one network point to another. The PRIME2 roads network layer within the study area thus allows for the querying of the data based on the connectivity of that network.

Each road polygon segment was assigned a value according to the mean pixel value of the heat map over which the segment traversed. This created a network of roads based on the constraints' analysis carried out in the heat mapping process. It allowed the most constrained road segments to be identified, making it possible to run a number of scenarios using the

[14] https://www.osi.ie/about/forbairti-sa-todhchai/prime2/?lang=ga

ArcGIS Network Analyst tool which calculates the shortest path between 2 points. The route solver algorithm within ArcGIS Network Analyst is based on Dijkstra's algorithm for finding shortest paths.[15]

A number of scenarios were processed through the network analyst tool to obtain preliminary routes between the following locations:

- Inchicore Substation to Poolbeg Substation;
- Inchicore Substation to Sandymount;
- Carrickmines Substation to Poolbeg Substation;
- Carrickmines Substation to Sandymount;
- Carrickmines Substation to Salthill;
- Carrickmines Substation to Blackrock Park; and
- Carrickmines Substation to Blackrock Substation.

This process is intended not for route identification but rather to inform the feasibility of offline replacement and identify areas of opportunity for further assessment. The resultant derived options are listed in Table 3.1.

For all derived options, the shortest path between the two points was identified using the complete road network within the study area. This provided a reference point for each option. For each scenario run, road segments with a mean constraint value above a particular threshold were chosen as barriers in the network analyst tool. The tool then determined the shortest path between the two points avoiding these road segments.

For Inchicore to Poolbeg, a tiered approach was used to find feasible areas of opportunity for cable installations. This was due to the majority of the high cumulative constraints being within the city centre thus allowing a number of scenarios to be generated in terms of most constrained to least constrained routes. The barriers used for each scenario is described in the table below and associated maps.

In certain instances, the same constraints were used as a barrier, but the starting points differed in order to allow opposing options to be generated running north and south of the Grand Canal. These are described as Option 1 and Option 2 for the given constraint where relevant.

This process was followed until a threshold at which no option connecting the two points can be found. It can be taken that no option was possible by reducing the maximum constraint value applied. This option, where the threshold was reached, can be taken as a least constrained route between the two points. It should be noted that this least constrained option may be substantially longer than the shortest path.

The meaning to be ascribed to each of these areas of opportunity is that it is the shortest path where every road segment has a mean constraint below a given threshold. This may not necessarily translate into the optimally least constrained area of opportunity on the road network.

Taken together, the below listed options are the preliminary alternative areas of opportunity arising from the heat mapping and network analysis undertaken in the GIS.

[15] https://desktop.arcgis.com/en/arcmap/latest/extensions/network-analyst/algorithms-used-by-network-analyst.htm

Table 3.1: Description of Preliminary Options

Option	Road Network Constraint Applied
Inchicore Substation to Poolbeg Substation	Shortest Path – No Constraint Applied
Inchicore Substation to Poolbeg Substation	Road segments with *a constraint value > 50% of the Maximum constraint* value excluded (Option 1)
Inchicore Substation to Poolbeg Substation	Road segments with *a constraint value > 50% of the Maximum constraint* value excluded (Option 2)
Inchicore Substation to Poolbeg Substation	Road segments with *a constraint value > 35% of the Maximum constraint* value excluded (Option 1)
Inchicore Substation to Poolbeg Substation	Road segments with *a constraint value > 35% of the Maximum constraint* value excluded (Option 2)
Inchicore Substation to Poolbeg Substation	Road segments with *a constraint value > 30% of the Maximum constraint* value excluded
Inchicore Substation to Sandymount	Shortest Path – No Constraint Applied
Inchicore Substation to Sandymount	Road segments with *a constraint value > 40% of the Maximum constraint* value excluded
Carrickmines Substation to Poolbeg Substation	Shortest Path – No Constraint Applied
Carrickmines Substation to Poolbeg Substation	Road segments with *a constraint value > 40% of the Maximum constraint* value excluded
Carrickmines Substation to Poolbeg Substation	Road segments with *a constraint value > 35% of the Maximum constraint* value excluded
Carrickmines Substation to Sandymount	Shortest Path – No Constraint Applied
Carrickmines Substation to Sandymount	Road segments with *a constraint value > 35% of the Maximum constraint* value excluded
Carrickmines Substation to Salthill	Shortest Path – No Constraint Applied
Carrickmines Substation to Salthill	Road segments with *a constraint value > 20% of the Maximum constraint* value excluded
Carrickmines Substation to Blackrock Park	Shortest Path – No Constraint Applied
Carrickmines Substation to Blackrock Park	Road segments with *a constraint value > 20% of the Maximum constraint* value excluded
Carrickmines Substation to Blackrock Substation	Shortest Path – No Constraint Applied
Carrickmines Substation to Blackrock Substation	Road segments with *a constraint value > 20% of the Maximum constraint* value excluded

Source: Mott MacDonald

It is important to note that the spatial analysis undertaken through heat mapping and network analysis does not "select" the preferred option corridor. It is an analytical tool which identifies areas of opportunity and informs the discussions of the environmental and engineering specialists who further refine corridor options. It provides a higher level of granularity to the analysis of multiple constraints and leads to more informed decisions regarding where to consider alignment options.

It should also be noted that there is a relatively low density of existing 38kV, 110kV and 220kV circuits within the study area, particularly south of the Grand Canal. The generated options have relatively little interaction with these circuits except near the Poolbeg, Inchicore and Carrickmines substations due to these being bulk electrical in-feeds into Dublin. Away from the substation locations, the key below ground driving factors for option selection are the presence and concentration of other utilities. The underground service concentration is then considered in context with other factors identified within the constraints mapping.

3.4 Site Walk-overs

Site visits were undertaken for the three existing fluid filled cable circuit routes under consideration in this feasibility study to validate the assessments which had been done using desk-based resources and mapping. Photographs were taken over the course of a week at regular intervals along each of the routes along with GPS coordinates. Visits to the circuit tank locations on the existing routes were also undertaken.

Generally, the infrastructure visible during the site walk matches the information provided on the mapping used for desktop assessment. The exception to this is the telecoms infrastructure for which data was not obtained, however this infrastructure was observed to be generally located within the footpaths.

Mapping of the electrical distribution networks above and including 38kV has been considered in the assessment. Mapping of systems below 38kV was not included in the assessment, and it is possible that the identified areas of opportunity and alignments may coincide with these networks. It is recommended at later stages of this project that ground investigations are undertaken to confirm the location of all existing utility services.

3.5 Key Stakeholder Consultation

An initial consultation process was undertaken including meetings with key stakeholders introducing the need to replace the existing FFC cables. These stakeholders included:

- Dublin City Council (DCC)
- Dun Laoghaire Rathdown County Council (DLR CC)
- Waterways Ireland
- Dublin Port Company

In addition, initial consultation letters were issued to the following key stakeholders.

- Dublin Bus
- Irish Water (IW)
- Transport Infrastructure Ireland (TII)
- Commission for Railways Regulation (CRR)
- Iarnród Éireann (IR)
- Gas Networks Ireland (GNI)

A copy of the consultation letter is provided in Appendix D. An overview of the existing routes was provided to the consultees and information on technical and environmental constraints was sought. A summary of the meetings/responses are detailed in Table 3.2 below.

It should be acknowledged that since the preparation of this report, engagement with all Public utility providers has progressed and will continue to progress through the Dublin Infrastructure Forum and related working groups.

Table 3.2: Key Stakeholder Consultation (Feasibility Stage)

Consultee	Response / Meeting date	Letter / Meeting	Key Response
Dublin City Council (DCC)	24 June 2021	Meeting	• DCC recommended engagement with roads department once the proposals once the options are more clearly defined. • DCC are not aware of any major projects in the areas identified on the existing cable route plans, though Bus Connects was referenced as a possible constraint. • DCC advised that a project implementation plan will need to be submitted to agree working arrangements at the appropriate stage should the project proceed. • Importance of getting road opening licences was highlighted along with adhering to approved working hours (DCC hrs 7am to 6pm (Mon to Fri), 8am to 2pm (Sat), No works Sun or B/Hs.) • DCC noted that contaminated land issues were encountered northside of the River Liffey as part of the docklands development.
Dun Laoghaire Rathdown	1 July 2021	Meeting	• DLRCC noted that they will require an environmental management plan/CEMP if the project proceeds. • DLRCC highlighted the critical nature of pollution control measures to ensure that contaminants do not enter watercourses (including groundwater). • DLRCC referenced that there may be existing spare (ESB) ducts adjacent to the M50 Carrickmines interchange. • DLRCC advised they would provide information on existing streams. • DLRCC mentioned that having a parallel community improvement scheme alongside the proposed works should be considered. • DLRCC highlighted that there will be a requirement to ensure all roads impacted have their finishes fully reinstated in line with council standards.
Dun Laoghaire Rathdown (DLRCC)	21 July 2021	Meeting	• DLRCC advised that working hrs should be agreed with DLRCC. • DLRCC queried the project timelines in the context of potential interaction with other planned works, e.g., new cycle lane in Leopardstown Road • Installation of ducts along this route to co-ordinated with DLRCC works was discussed. • DLRCC advised that they are keen to understand the way leaving requirements and any potential sterilisation impact this may have on their roads. • DLRCC advised that they are keen to see the proposed works avoid areas where substantial works have recently been undertaken, e.g. new COVA entrance at UCD, South Avenue-Kilmacud cycle path upgrade. • Reference was made to the Eastern Bypass as detailed in the County Development Plan (since ca. 1973) which has a potential tunnel running from Sandymount Strand coming above ground at St Helens and running across Foster Avenue (Coincident with existing cable route). • Query raised by DLRCC on decommissioning plans and whether or not the existing services containment system could be reused to host telecommunications services for other providers.

Consultee	Response / Meeting date	Letter / Meeting	Key Response
Dublin Port	12 August 2021	Meeting	• Presentation given by Dublin Port Company on their proposed master plan for works south of the river Liffey in the Ringsend area. The southern part of the port upgrade works is phase 3 and will the last stage to be completed. Works involve significant refurbishment/new cargo facilities along the river and an admin/service area beside the existing Irishtown Nature Park. There was reference to a potential greenway for pedestrian/cycle access in this area (not within the nature park itself). MM noted that this could be a possible route for cable ducting subject to agreement with the relevant parties. • Dublin Port Company also advised that they retain ownership of the strip of land between the IGB site and Dublin Bay. They advised that there will be resurfacing works in this area prior to construction of the new residential development on the IGB site and they recommended contact be made with the developer to co-ordinate any works in this area, as there are a number of transmission cables presently routed in this location.
Waterways Ireland	21 July 2021	Meeting	• Waterways Ireland currently engaging with ESB Networks regarding fluid filled cables and leak issues. • There is an active project in DCC considering a Greenway from Inchicore to Portobello alongside the canal • There are some ongoing projects in the locations where the existing cables are routed. These include potential land purchase from Waterways Irl by developer close to Inchicore, possible significant development along Grand Canal close to Baggot Street and bridge improvement works at Harolds Cross as part of Bus Connects project. • There are other projects near the canal which may be relevant if the new route deviates from the current cable alignments. • Other elements of Waterways Ireland will need to be involved in the consultation as the project develops and proceeds through its next stages, including Property and Legal.
Dublin Bus	6 July 2021	Letter	• Dublin Bus noted that they have future plans to electrify the fleet and this means new connections at eight of the depots across the city. Dublin Bus has engaged with ESB Networks regarding same. • Dublin Bus raised a query regarding any potential disruption of services due to the significant amount of works needed on replacement of cables (i.e. how will this be addressed?, will there be traffic management plans given well in advance of works?)
Irish Water	5 July 2021	Letter	• Irish Water (IW) referred to their website for an explanation about the process for building near Irish Water assets and links to the associated application forms etc: https://www.water.ie/connections/developer-services/diversion-and-build-over/ . • IW advised that datarequests@water.ie should be contacted to obtain the known records of the IW assets along the routes of the UGCs. • IW advised that the proposed works should be in compliance with Irish Water Codes of Practice and Standard Details (required clearance distances, depths of cover etc). • IW requested that EirGrid should apply, with the accompanying design information at such time as sufficient detail is available.

Consultee	Response / Meeting date	Letter / Meeting	Key Response
	13 July 2021	Letter	• TII requested clarity as to whether this is intended to be replacement exactly where the existing infrastructure is located, or could there be any relocation/new infrastructure involved
Transport Infrastructure Ireland	27 September 2021	Email	• TII noted that the routes interact with the LUAS Red and Green lines, M50, N31, Dublin Eastern Bypass Corridor Study Protection Area (DCC sector and DLRCC sector) and recommended consultation with the relevant stakeholders • TII noted that the Dublin Port M50 Southern Port Access Road (SPAR) as well as the Dublin Eastern Bypass Corridor Protection Study Area need to be referred to and considered as part of the project development. • TII highlighted the conditions applicable to crossing of national road infrastructure, in particular the M50 and the N31 • TII gave direction to relevant applicable standards and requirements for projects interacting with TII infrastructure
Commission for Railway Regulation	Not applicable	Letter	• No response received at the time of writing this report (January 2022).
Iarnród Éireann	Not applicable	Letter	• No response received at the time of writing this report (January 2022).
Gas Networks Ireland	Not applicable	Letter	• No response received at the time of writing this report (January 2022).

The BusConnects Dublin project will make significant changes to the existing road network to provide space for bus lanes and active travel infrastructure. This project is currently at an advanced stage with engagement ongoing to confirm the preferred route option for each corridor. Following this engagement, the routes will be issued for statutory approval with construction due to commence on a phased basis between 2022 and 2027. Given the current timescales of this project it is strongly recommended that consultation with the project sponsor (National Transport Authority) is undertaken during the next stage of this project to ensure any significant road changes are known which could impact on future works associated with the new cables.

3.6 Innovations & Technologies

As our terrestrial environment and urban centres become more populated and demand for energy increases, Network Operators are relied upon for providing secure electrical connections with minimum disruption. This often results in challenging installation scenarios and some novel methods to facilitate the installation. Whilst these methods are generally covered in Table 3.3, some specific examples include:

- Subsea cable installations: Western Link and Eastern Link (in planning) in the UK for the connection of Scotland to England avoids a long land installation route by routing around the coast of the two countries.
- London Power Tunnels: This scheme will have been progressed over the course of approximately 20 years to establish a network of underground tunnels across London approximately 65km in length running approximately 15-30m deep below London.
- City Cable: Some parts of Europe (Germany, The Netherlands and Belgium) installed significant lengths of gas type cable and pipe type cables. Once the cable systems reach end of life, it is sometimes possible to remove the existing cable and reuse the pipe for either all or part of a route. This can significantly reduce disruption and costs.
- Tunnel System in Japan: Japan was one of the first countries to construct a deep tunnel for cable systems. As part of this development, XLPE cable systems were designed for long cable pulls through the tunnel systems to reduce jointing requirements. The cable systems were designed with elevated sheath standing voltage and short circuit capability to withstand the impressed voltages experienced during fault conditions. There was also considerable design attention to the installation of the long cable lengths (circa 2km) requiring large diameter long drums to be transported to site.
- Multi-use tunnels: There are a few examples of multi-use tunnels around the world where HV services are incorporated with other services such as gas, water, transport (e.g. cars, trains etc). These are generally difficult to implement in practice due to the split priorities and obligations of each service owner.
- Cable system optimisation: Dependent on the original installation, operational and service history of the asset, it is sometimes possible to uprate the existing system and extend its usefulness and delay replacement or avoid installation of a supplementary service. Methods to achieve this include dynamic ratings, changing screen bonding arrangements, civil modifications to discrete sections that constrain the rating, installation of larger cables over discrete sections to eliminate constrained sections, retrospective installation of Distributed Temperature Systems (DTS) where possible. These methods have been employed on systems throughout Europe, UK and the US.

In summary, there are many methods that can be adopted to install new cable systems through densely populated environments and to negotiate specific constraints. The specifics of the challenge to be overcome will determine the best placed solution. However, in the specific case where densely populated environments are concerned and overhead routing is not permitted, the common solution is to install the systems deep underground. For single circuits over relatively short distances this can be achieved using methods such as HDD (Horizontal Directional Drilling). Where longer distances, multiple services and high power transfers are required, then a deep tunnel system may be the only suitable choice.

Having regard to the purpose of this study as addressing the feasibility of the replacement of existing 220kV cable infrastructure, it is not being concluded at this stage that deep underground installation is the sole, or preferred option, for cable replacement in this instance.

A summary of urban area cable system installation methods, along with their challenges and opportunities are explained in Table 3.3 below as per *Investigation of Innovative cable routing methods through congested urban areas*[16], commissioned by EirGrid in 2019.

[16] Investigation of Innovative cable routing methods through congested urban areas, V01, 23/09/2019

Table 3.3: Innovative cable routing methods through congested urban areas

Installation Technology	Methodology	Challenges	Opportunities
Open trench/ cut systems (Base case for comparison)	General technique consists of digging a trench and finally backfilling the trench and reinstalling the ground. Cables are directly buried or installed in ducts. Installation in ducts is the usual approach on the network in Ireland.	• Difficult to achieve in areas with busy utilities/ services network. This may lead to deeper installations and in some cases changing of the method of installation because of the impact on cable ratings.	• Ducted Installation offers the advantage of decoupling civil works from cable installation works. • Economical since no other heavy works are necessary apart from localised excavation and reinstatement works. • Better practice for urban areas because ducted installations sectionalises the cable installation into relatively short lengths.
Horizontal Directional Drilling (HDD)	Involves drilling a directionally controlled pilot hole (normally around 50-75 mm in diameter) from a surface position though to a surface or reception pit located at the far side. The pilot hole is then subsequently enlarged to form an over wash pipe prior to reaming out to allow the follow on installation of the product pipe.	• Thermal ratings for the cable system may be difficult to achieve where deep burial is involved. • Large laydown areas may be required for the work activities including layout of the HDD pipe. • Large bend radius of the pipe may force a longer drill length than would otherwise be required. • Significant land take may be required when multiple ducts are required, as ducts are normally required to be spaced a minimum of 5 m apart.	• Allows ducts to be routed under obstacles such as railways or significant waterways. • Start-up costs can be relatively low as drive and reception pits are not always necessary. • Relatively unobtrusive and uses equipment that can be operated from the surface without the requirement for the construction of drive/ reception pits housing thrust walls or jacking rings.
Micro-tunnelling	Slurry system – Uses a tunnel boring machine (TBM) for excavation. Use of hydraulic jacks at the base of a thrust pit to push concrete or steel pipes through the ground behind the shield/TBM. This method applies to tunnels up to 3 m in diameter. An annulus filled with bentonite lubricating fluid is maintained around the pipes	• There is no established method of calculation of cable current ratings in a naturally ventilated tunnel and forced ventilation is required. • Suitable for straight-line drills only. • Vibration from drilling activities during construction can travel long distances. Also, noise pollution	• A single tunnel can house multiple circuits and services • Cable systems can be visually inspected within shafts. • Cable systems can be replaced relatively easily.

Installation Technology	Methodology	Challenges	Opportunities
	during construction to facilitate jacking and reduce friction as the pipe gets longer.	from ventilation fans above ground can be difficult to mitigate. • Tunnel auxiliaries require maintenance. Maintenance within the tunnel is complicated by the tunnel generally being classified as a confined space for personnel entry. • Bentonite clay from slurry machine can cause ground and water contamination.	• Limited above ground environmental impact. Only a headhouse may be required at each shaft location.
	Thrust/ Auger boring –dry method of installation which does not generate slurry. A continuous flight auger contained within a concrete or steel pipe is rotated and simultaneously pushed into the ground, as the bore progresses the ground is open cut and the auger flight conveys the material back to the drive pit and the concrete or steel pipe forms the conduit for the cables.	• Suitable for straight-line drills only. • Generally suited to shorter distances, 10’s of metres. • Cable thermal ratings may be difficult to achieve dependent on ground and installation conditions. • Higher set up costs than HDD for length of drive as launch and reception pits are required together with thrust walls and ground water control systems as the drill face is open.	• Does not generate slurry and has a lower risk of disruption to ground surface than HDD as the bore is cased throughout. • A wide range of bore diameters can be achieved (e.g. 100 mm up to 2000 mm). • Bores can be closer together when compared with other techniques such as HDD. • Very large laydown areas are not required and relatively low set up cost dependent on depth of drive and reception site.
Dedicated cable tunnelling	Similar to Micro-tunnelling but with larger jacks to create larger diameter tunnel. The jacks are at the rear of the TBM and thrust against the tunnel lining. The lining is grouted immediately behind the machine. To launch a 4 m diameter tunnel, typically a 15 m diameter shaft would be used, at a depth of approximately 10 – 50 m.	• High costs involved in both construction phases and mobilisation of large plant material. • Above ground structure (head house) will be required at the top of each shaft to provide for access to the tunnels and ventilation inlets/ outlet. • Tunnel auxiliaries require maintenance	• Cable systems can individually be inspected. • Cable systems can be replaced relatively easily. • It may be possible to uprate the cable system by upgrading the ventilation system. • A single tunnel can house multiple circuits and services.

Installation Technology	Methodology	Challenges	Opportunities
		• Suitable for substantially straight-line drills only. • Maintenance within the tunnel is complicated by the tunnel generally being classified as a confined space for man entry. • Bentonite clay from slurry machine can cause ground and water contamination. • Vibration from drilling activities during construction can travel long distances. Also, noise pollution from ventilation fans above ground can be difficult to mitigate. • There is no established method for the calculation of cable current ratings in a naturally ventilated tunnel and forced ventilation is required. • An above-ground structure (headhouse) will be required at the top of each shaft to provide for access to the tunnels and ventilation inlets/ outlet.	• Limited above ground impact as it makes use of minimal site sizes. Only a headhouse may be required at each shaft location • Placement of segments directly behind the TBM makes it possible to make large radius turns with this technique. • Per km construction costs reduce with longer tunnel distances/ lengths. A longer tunnel can be more economic than a short tunnel.
Utility pipeline retrofitting	Technique involves identification of an installed utility (normally redundant) that can be reutilised for the purpose of installing a new service.	• Existing pipe/ conduit may not be large enough to install a system with the required capacity. • A cable with larger cross-sectional area may be required for installations within steel pipes due to induced current losses. • Full understanding of the service and quality of the utility pipe will be required as well as the route assessment to determine if modifications to the route are required.	• Reduced Construction size with reuse of existing pipe infrastructure. • Reduced need for utility surveys or ground condition monitoring.

Installation Technology	Methodology	Challenges	Opportunities
Use of water courses	Involves using bodies of water (e.g. river, canals, estuaries, lakes etc.) as routing options for submarine cables.	• Permits and environmental consent may be onerous particularly if there are protected habitats, existing infrastructure or archaeological heritage items in the area. • Flow rates can make installation difficult. • Land route will likely be required at each end to complete the route. • Rivers may not be navigable by the cable installation vessels, barges fitted with installation equipment can be slow moving. Cable may need to be transported by land and installed from land. • Land remodelling may be required at riverbanks to provide suitable transition for the submarine cable onto land.	• Lower impact to ground based traffic • May provide a relatively shallow route through densely populated areas where no other may exist.
Use of existing transport facilities	Transportation tunnel sharing – tunnels design considerations apply for this method,	• Cable system may be considered as fire risk due to short circuit and a danger to other tunnel users. • Installation may be in proximity to other existing services in the tunnel which could lead to electromagnetic interference and heating effects on other cables. • Need for cable system protection from debris that may impact from moving vehicles and trucks. • Cable maintenance is not within the control of the cable system owner • Tunnel infrastructure owned by third party and installation may be required to be completed within	• Use of existing tunnel structure could provide a significant cost saving. • The tunnel may already be ventilated which could reduce the need to use larger cables to maintain current ratings.

Installation Technology	Methodology	Challenges	Opportunities
		short windows of availability due to traffic to the tunnel. • Access to the cable system could be significantly constrained and/ or not under the control of the asset owner. Tunnel closures may be required for maintenance access. • Air temperature and flow may be difficult to control and require the upgrading of tunnel infrastructure.	
	Bridge structure utilisation – utilising bridges for the routing of utilities within highly urbanised areas	• Special cable designs (corrugated sheath) may be required to accommodate bridge vibrations. • May not be suitable for movable bridges. • Bridge may require a structural assessment to demonstrate no adverse effects from the cable system. • Bridge design and heritage may not be suitable for underslinging or visible installation on the side. • Changes of a visual nature to a bridge may not be acceptable. • Routing to the bridge may not be feasible. • There may insufficient capacity.	• Cable maintenance may be possible without interruption of traffic. • Use of existing infrastructure to cross a body of water or other substantial constraints. • It may be possible to install with reduced impact to traffic on bridge provided that the cable structure is installed on the bottom or under-side and the existing bridge is designed for access during operation.
	Highway utilisation – Utilising major transport routes between cities for cable route corridors and other service routes.	• Access to the asset could be constrained by high-speed vehicle flow in proximity to the cable system location. • Proximity of high-speed traffic could introduce H&S concerns during installation and maintenance.	• Easy installation site access from highways. • Relatively straight route corridor generally provides a simple cable pull. • Generally lower volume of existing/ installed services

Installation Technology	Methodology	Challenges	Opportunities
		• Highway areas could be congested by other existing utility/ service lines. • Installation of services in motorways is against Transport Infrastructure Ireland (TII) policy.	leading to fewer interactions with services.

4 Key Constraints, Considerations & Opportunities

4.1 Introduction

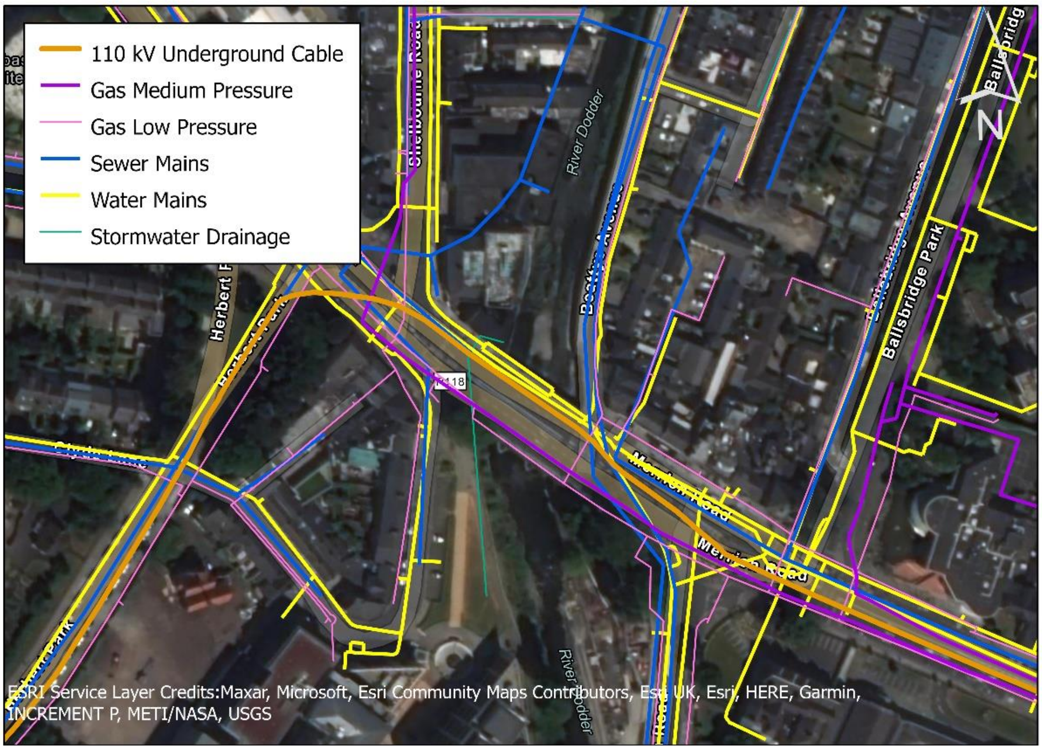
The following sections provide an overview of the key constraints and considerations associated with the study area. Opportunities identified for crossing key constraints are also discussed.

4.2 Generation of Screening Options for Long-listing

As discussed in the road network analysis in Section 3.3.2 above, the alternative areas of opportunity generated by the GIS tools are not a long-list but rather provide a focus for subsequent and separate route analysis and determination of the ultimate long list. The reason for this is that the network analysis may not have given due weighting to particular constraints in some areas.

For example, a bridge may have no or few services within it, and little by way of social constraints and would receive a low weighting in the heatmapping and may then appear in an optimised route from the road network analysis. However, the reason for the lack of services could be that there is insufficient depth of cover within the deck for the installation of utility services and that the bridge is not suitable for the installation of the circuit to the underside due to space, hydrology, and access constraints. As such, alternatives for this particular portion of the route would need to be identified as part of any separate and subsequent route optioneering process. A good example of such a scenario is the bridge at Ballsbridge. An extract from the GIS web mapping is shown in Figure 4.1 below which demonstrates the limited services within the deck with respect to the space available, but Figure 4.2 shows the shallowness of the deck as well as the construction of the bridge would not be suitable for installation of a new cable circuit.

Figure 4.1: Extract from web map depicting services at Ballsbridge



Source: Esri

Figure 4.2: Side view of bridge at Ballsbridge

Source: Mott MacDonald

In situations such as this, the potential for feasible alternative local routing options in the area are examined to avoid a particular barrier/constraint. In a more general sense, it should be noted that all road sections within an identified potentially feasible option are considered as focus points for analysis. Some sections of these initial options proved to be more favourable than others, but the option is not immediately discounted solely on the basis that isolated sections had restrictive constraints.

The next steps after development of the initial options are to:

- Identify local constraints not identified within the heat mapping process
- Identify any diversions from the initial potentially feasible options which may provide a benefit to separate and future route optioneering. This identification process includes the high-level assessment of the road networks in close proximity to the routes with respect to utility density.
- Identify any additional sections which sensibly join different sections of alternative initial options together. This will allow the assessment to take advantage of the favourable portions of different initial options where practicable.

The network was divided into zones which broadly aligned with the key constraints as described in sections 4.4 to 4.6 below.

Following this, each section which interacted with any of the key constraints was assessed to determine whether it represented a viable crossing of the constraint. If not, this section can be removed from the assessment unless a nearby viable alternative is identified. If this is case, the alternative can then be included in the network.

This refinement process results in a set of route sections which can then be assessed on a zone by zone basis. From here, full routes can be determined by connecting the zones together in later stages of the project. The interaction between zones is already accounted for in the key-constraints assessment as discussed above. As such, the inclusion of a zonal section in the full alignment can be determined by its performance within a zone, and not its interaction with the sections in other zones.

This process is intended at this stage only to confirm whether local and end-to-end feasible options exist to provide for overall offline cable replacement.

4.3 Social and Environmental Constraints

Given the urbanised nature of the study area, social and environmental constraints and considerations typically relate to nuisance and disturbance, built (architectural) heritage, water quality, biodiversity and ground conditions. These would need to be assessed in greater detail in later stages of this project. Of particular note are sensitivities associated with the area of Poolbeg and the Grand Canal, which are common to all options under consideration, and these are discussed below.

4.3.1 South Dublin Bay, Poolbeg and Sandymount Strand

The Poolbeg peninsula was infilled from the eighteenth century, with various materials. Subsequent developments included heavy industry, oil storage and power generation. Significant redevelopment of the Poolbeg area is planned, including residential, commercial and retail developments. The beaches and amenities associated with South Dublin Bay / Sandymount Strand serve the large population of Dublin City and beyond and have significant societal value.

The South Dublin Bay lies south of the River Liffey and extends from the South Wall to the west pier at Dun Laoghaire. It is an intertidal site with extensive areas of sand and mudflats. Several small sandy beaches with initial dune formation occur in the northern and western sectors of the site particularly at Poolbeg, Irishtown and Merrion/Booterstown (NPWS, 2015)[17].

[17] Site Synopsis: South Dublin Bay SAC', Available at: https://www.npws.ie/sites/default/files/protected-sites/synopsis/SY000210.pdf. , NPWS, 2015 '

Most of the marine intertidal South Dublin Bay area is included within the South Dublin Bay Special Area of Conservation and South Dublin Bay and River Tolka Estuary Special Protection Area.

Special Areas of Conservation (SAC), are designated under the Habitats Directive (Council Directive 92/43/EEC of 21 May 1992 on the conservation of natural habitats and of wild fauna and flora) Special Protection Areas (SPA) are designated under the Birds Directive (Directive 2009/147/EC on the conservation of wild birds)

Qualifying Interest and Special Conservation Interest details in relation to the SAC and SPA that require consideration in any options under consideration are included below

South Dublin Bay SAC

- Mudflats and sandflats not covered by seawater at low tide [1140]
- Annual vegetation of drift lines [1210]
- Salicornia and other annuals colonising mud and sand [1310]
- Embryonic shifting dunes [2110]

South Dublin Bay and River Tolka Estuary SPA

- Light-bellied brent goose (*Branta bernicla hrota*) [A046]
- Oystercatcher (*Haematopus ostralegus*) [A130]
- Ringed plover (*Charadrius hiaticula*) [A137]
- Grey plover (*Pluvialis squatarola*) [A141]
- Knot (*Calidris canutus*) [A143]
- Sanderling (*Calidris alba*) [A144]
- Dunlin (*Calidris alpina*) [A149]
- Bar-tailed godwit (*Limosa lapponica*) [A157]
- Redshank (*Tringa totanus*) [A162]
- Black-headed gull (*Chroicocephalus ridibundus*) [A179]
- Roseate tern (*Sterna dougallii*) [A192]
- Common tern (*Sterna hirundo*) [A193]
- Arctic tern (*sterna paradisaea*) [A194]
- Wetland and Waterbirds [A999]

Wintering waterfowl associated with the SPA are known to regularly utilise habitats in close proximity to Poolbeg[18], most notably Sean Moore Park, Irishtown Nature Park, and the strip of grassland to the north of the Irishtown Nature Park. Further, the seashore adjacent to these areas is known to be used by wintering wildfowl as foraging and roosting habitat.

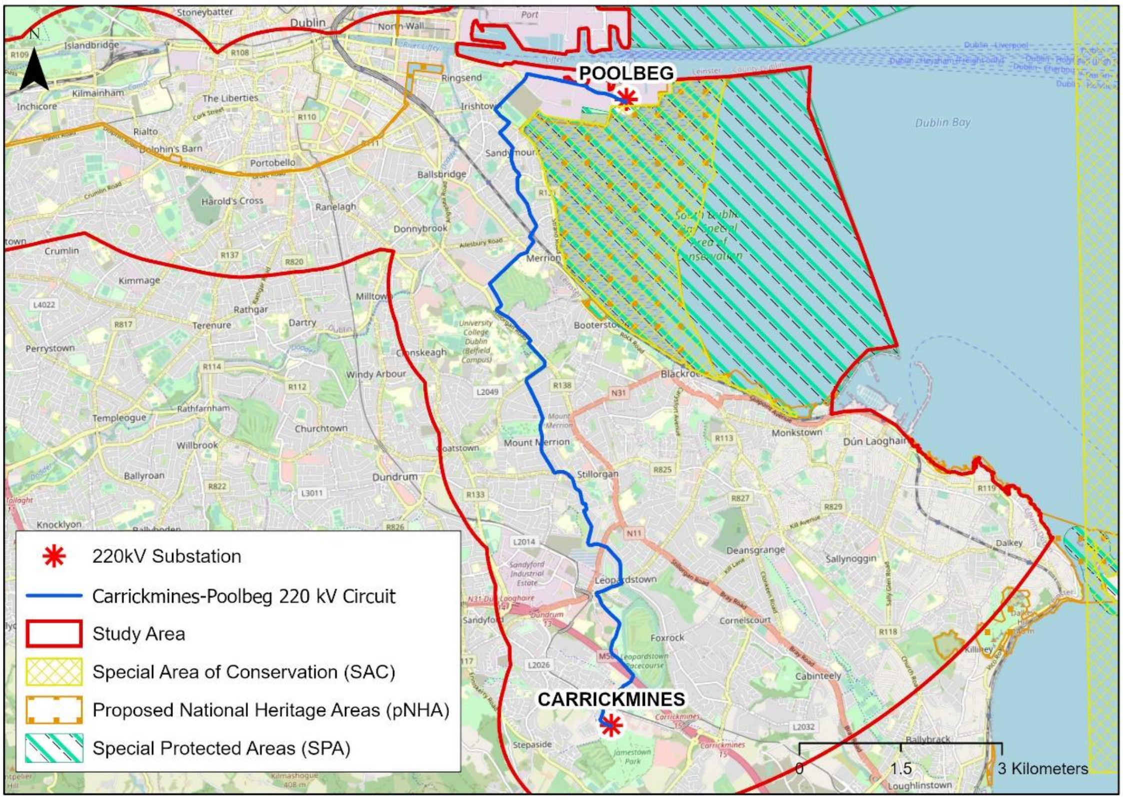
A portion of the SPA extent is also designated under the Convention on Wetlands (Ramsar 1971) as the Sandymount Strand/Tolka Estuary Ramsar site[19]. The information sheet for the site cites the sandy mud habitat, and waterfowl assemblages as features of note.

The location of European and Nationally Protected sites relative to the proposed study areas are detailed in Figure 4.3.

[18] NPWS (2014) North Bull Island Special Protection Area (Site Code 4006) and South Dublin Bay and River Tolka Estuary

[19] Sandymount Strand/Tolka Estuary | Ramsar Sites Information Service

Figure 4.3: European and Nationally Protected sites



Source: Mott MacDonald (Open Street Map Layer by ESRI)

Parts of the study area are included in the Proposed Dublin Bay UNESCO Biosphere zonation[20]. The following zones are included in the study area:

- Terrestrial transition zone
- Terrestrial buffer zone
- Terrestrial core zone
- Marine core zone

In terms of flood risk, it is noted that floodmaps.ie indicated flood risk around the periphery of Poolbeg peninsula only.

4.3.2 Grand Canal

The Grand Canal was constructed in the eighteenth century and includes a number of recorded sites of architectural significance including locks and bridges. The Grand Canal is also a proposed Natural Heritage Area (pNHA). The site synopsis[21] describes the Grand Canal as being a man-made waterway linking the River Liffey at Dublin to the River Shannon near Tarmonbarry. The pNHA is comprised of the central channel and the banks on either side of it. While there are a number of protected species associated with the site (for example otter (*Lutra lutra*), and opposite-leaved pondweed (*Groenlandia densa*)) the site synopsis notes that the ecological value of the site "*lies more in the diversity of species it supports along its linear habitats than in the presence of rare species*".

[20] https://www.catchments.ie/dublin-bay-unesco-biosphere/

[21] NPWS (1995) Site Synopsis: The Grand Canal pNHA Site Code 002104

4.4 Poolbeg

The area around Sean Moore Park through to Poolbeg substation past Ringsend and Irishtown is densely packed with existing high voltage circuits at 110 kV and 220 kV as well as other utility services. One new alignment has been identified through this area, however this alignment traverses through private land and is therefore less desirable from a stakeholder engagement and management perspective.

Where onshore alignments are being considered, such alignments would entail the re-use of the existing routes due for replacement. The feasibility of this would be dependent on outage constraints and construction scheduling.

Additional options have been identified as part of the offshore assessment for routing through Dublin Bay. Landfall options for the west and southwest of the bay have been identified at:

- Sandymount (Newgrove Ave)
- Sandymount Strand
- Merrion Strand
- Blackrock Park
- Salthill & Monkstown

Offshore routing and landfall assessment is discussed in more detail in Section 5.

Feedback from TII indicates that the Southern Port Access Road (SPAR) has progressed through pre-appraisal and should be considered in the assessment for routing of cables in this area. TII also advised that work is currently ongoing on a feasibility/scoping study for the project. From the indicative routing in the Dublin Port Masterplan[22], the route of the SPAR traverses through a utility dense region of Poolbeg. While the route indicated for the SPAR is close to potential cable routes under consideration, it is not considered to be a substantive additional constraint on the route selection given the already constrained nature of the area. However close consultation with the relevant stakeholders for SPAR would be important as the cable replacement project progresses through subsequent design stages.

4.5 Inchicore – Poolbeg 1 & 2

The key constraints identified within the study for the Inchicore – Poolbeg routes include the following:

- Grand Canal
- LUAS Red Line
- LUAS Green Line
- Commuter Rail
- DART
- River Dodder

The following sections provide a discussion on each of these key constraints. They also identify some potentially feasible crossing points of the key constraints. The sections also include assessment to recommend their inclusion or exclusion from further analysis as part of separate and subsequent work stages in the cable replacement process.

[22] Microsoft Word - DP Masterplan Review - Strategic Transport Study V5 (dublinport.ie)

4.5.1 The Grand Canal

While open-cut trench methods are possible, crossings via trenchless techniques may be preferred and may be requested by Waterways Ireland. Locations with sufficient space for site establishment to achieve these crossings are limited. Alternatively, crossing at bridges may be possible, however this will require assessment of the suitability of the proposed bridge structure.

4.5.1.1 Inchicore Substation

The existing Inchicore – Poolbeg #2 route crosses the Grand Canal at the Inchicore Substation. There may be an opportunity to use the existing trench and replace the cable at this location. Alternatively, space may be available for a trenchless crossing (e.g. auger bore), however, pits approximately 4 to 5m in depth are likely to be required on both sides which would present some Health and Safety challenges.

4.5.1.2 Herberton Bridge & Dolphins Barn Bridge

While there appears to be insufficient space within the deck for installation within any of these bridges, there may be opportunities along this stretch of the canal for a trenchless crossing.

4.5.1.3 Robert Emmett Bridge through to Baggot Street Bridge

While there appears to be insufficient space within the deck for installation within any of these bridges, there may be opportunities along this stretch of the canal for a trenchless crossing.

4.5.2 LUAS Red Line

The LUAS Red Line is fixed public transport infrastructure and obtaining a track possession long enough to trench across it will likely be difficult. In addition, there will also be the challenge of returning the tracks to the standard required for the proper operation of the LUAS. Crossing the LUAS will therefore likely need to be done at locations where there is sufficient space for drive and reception pits for trenchless techniques, or alternatively at suitable bridges either over or under the LUAS.

4.5.2.1 Blackhorse Bridge

There is a relatively high density of utilities at this location that will make crossing the LUAS at this location very difficult. There is also very limited space for a trenchless crossing alternative. It is therefore not considered feasible to cross at this location.

4.5.2.2 Suir Road

The density of services at this location is substantial and the use of trenchless techniques would consequently carry a high risk of hitting services. It is likely that an agreement would need to be reached with TII on an open cut trench method of crossing the LUAS at this location. Alternatively, consideration can be given to re-using the existing Inchicore – Poolbeg route provided the existing route is already ducted with suitable ducts under the LUAS and pulling cable through is assessed to be feasible as part of subsequent and separate analysis.

4.5.2.3 South Circular Road

The LUAS crosses under South Circular Road near St James' Walk / Mountshannon Road. Installation within the bridge deck may be possible and could be assessed as part of subsequent and separate analysis.

4.5.2.4 James Street / Steven's Lane

The density of services at this location is substantial and the use of trenchless techniques would consequently carry high risk. It is likely that an agreement would need to be reached with TII on an open cut trench method of crossing the LUAS at this location. Works of this nature at this location may require the closing of the road and will likely have a direct impact on access to Saint Patrick's University Hospital. This crossing is therefore not considered feasible.

4.5.3 LUAS Green Line

The LUAS Green line is fixed public transport infrastructure and is subject to substantially similar constraints as the LUAS Red Line.

4.5.3.1 Harcourt Street

The density of services near the Harcourt Street Luas Stop is substantial and the use of trenchless techniques would consequently carry high risk. It is likely that an agreement will need to be reached with TII on an open cut trench method of crossing the LUAS at this location.

4.5.3.2 Charlemont to Ranelagh

The LUAS is raised above the roads along this section and therefore open cut trenches in these locations would not impact the operation of the LUAS. Crossing here may be feasible, and routes would be limited instead by other utility constraints.

4.5.3.3 Beechwood

There is a high density of services and the crossing is also adjacent to a LUAS stop. The roads are narrow and there also appears to be a bridge type structure which may not have sufficient deck space to accommodate the cable. This crossing is therefore not considered to be feasible.

4.5.4 DART

The DART is fixed public transport infrastructure and is subject to substantially similar constraints as the LUAS Red and Green lines.

4.5.4.1 South Lott's and London Bridge Road

The DART is raised at these locations and open cut trenching techniques in this location would not interfere with the operation of the DART. Crossing here may be feasible, and routes would be limited instead by other utility constraints.

4.5.4.2 Lansdowne Road

There are a number of existing cable circuits crossing the DART at this location. There is insufficient space for trenchless techniques and obtaining a track possession to cross the DART with open cut method is not viewed as a feasible solution. Crossing at this location would require re-use of the existing route's ducts under the tracks and will require the decommissioning and removal of this section of fluid filled cable. Through discussion with ESB, It is understood the ducts in this location are 6" wavins, and provided the pull is short and straight, it may be possible to pull the new cables through. This can form part of separate and subsequent assessment.

There is a pedestrian underpass on the south of the River Dodder at Lansdowne Road. It is very narrow and has an existing watermain installed through it. There is considered to be insufficient space available for installation of the circuit in this area. Consequently, this crossing is not considered feasible.

4.5.4.3 South of the River Dodder

There are very few locations which would easily allow for a crossing of the DART south of the River Dodder. The two possible crossing points north of Strand Rd are Serpentine Avenue and Sydney Parade. All other crossings do not appear to have sufficient space in the surrounding area for the use of trenchless equipment. It may be possible to cross the DART at Serpentine Road with a trenchless method using the parking lot as a drive site. Crossing at Sydney Parade may only possible if the existing spare 110kV ducts are used for this circuit.

4.5.5 Commuter Rail

The Commuter Rail from Heuston Station is fixed public transport infrastructure and this infrastructure is subject to substantially similar constraints as the LUAS.

The network analysis identified Kylemore Road and Sarsfield Road as potential crossing options. Kylemore Road is a highly trafficked overbridge. It is also not clear visually that there is sufficient depth in the bridge deck to accommodate a new cable circuit. Crossing at this location is not considered feasible at this time.

Sarsfield Road is an under bridge, and subject to subsequent and separate analysis may be a feasible crossing point dependent on the density and as-built locations of existing utility infrastructure in the road. However, it should be noted that a route crossing here is likely to need to cross the rail line at Kylemore Road, and is therefore not considered feasible at this time.

4.5.6 River Dodder

The River Dodder is a challenging waterway in that suitable locations for crossing are limited. This includes consideration of the existing bridges, and potential locations for trenchless techniques to cross the river. There is significant development on either side of the river for substantial portions along its length. The existing bridge crossings typically either have a high density of services within them, have insufficient deck space, or may potentially be protected structures. Two potentially feasible locations for trenchless crossings have been identified for consideration at this stage.

4.5.6.1 Aviva Stadium

There is a service lane behind the practice pitch within the precinct which is a potential site for a drive or reception site. Opposite the Dodder there is some public green space which may also be suitable for a drive or reception site. While this will require engagement with private third parties, this is considered to be a potentially feasible option.

4.5.6.2 Herbert Park

Herbert Park has a significant amount of space and could be suitable for a drive or reception site. Installation of the cable route could be considered within the footpaths wherever practicable to reduce environmental disturbance. A further drive or reception site would be required at the edge of the Merrion Cricket Club. Conducting the works out of season would reduce the disruption. This is considered to be a potentially feasible option.

4.6 Carrickmines – Poolbeg

The key constraints identified within the study area for the Carrickmines – Poolbeg route includes the following:

- M50 Motorway
- LUAS Green Line and DART
- N11 & R138

- River Dodder

4.6.1 M50 & LUAS Green Line

Given the proximity and the interdependence on route sections crossing the M50 and LUAS with each other for the Carrickmines - Poolbeg circuit, these two constraints are treated together.

Trenching across the M50 motorway/motorway junctions is not a viable option. Identification of a suitable bridge which is not part of the motorway infrastructure or a site at which sufficient space for drive and reception pits for a trenchless solution will be necessary to achieve a crossing of this nature. This approach is in line with feedback from TII.

The road network analysis identified some possible options for crossing the M50, each of which is discussed briefly, as well as some additional options that were included upon further desktop review. The related LUAS crossing for each M50 crossing is discussed at the same time.

4.6.1.1 M50 Junction 14

Space for a trenchless method of installation under the M50 appears to be available just to the west of the junction, but still within the study area. The likely LUAS crossing associated with this route would be through a trenchless method at or near the Kilmacud LUAS stop. This would require the usage of green space within the Naomh Olaf GAA Club to the South, and within St Benildus College to the north. Space may also be available in the deck of the bridge crossing over the LUAS.

4.6.1.2 M50 North Bound Junction 13 (Leopardstown)

Space for a trenchless method under the M50 appears to be available both to the west and to the east of the junction.

To the west, the route would likely continue through the ESB Networks site, onwards through the Sandyford Industrial Estate, and then ultimately crossing the LUAS at Saint Raphaela's Road using a trenchless method driven from the LUAS Park & Ride at the Stillorgan LUAS stop into Saint Raphaela's Road. To the east, the route would continue on Leopardstown Road and cross under the LUAS bridge at the intersection with the R113.

4.6.1.3 Road Bridge at Leopardstown Racecourse

A bridge had been identified as a possible option for crossing the M50. However, upon visual inspection, it was noted that there is insufficient deck space within the bridge for the crossing to be considered further. As such the associated LUAS crossing for this option was not considered.

4.6.1.4 Leopardstown Racecourse overflow parking lot

A trenchless method under the M50 into the Leopardstown Racecourse overflow parking lot may be possible. Crossing the LUAS also using a trenchless method into Ballyogan Avenue would likely be required. The route would need to navigate around the local housing estate to the potential drive site.

4.6.1.5 M50 Junction 15 (Carrickmines)

The road network analysis identified a potential route that crosses the M50 at Junction 15, and then the LUAS on Glenamuck Road. It is not clear from visual inspections and assessments whether there is sufficient deck-space within the bridge over the LUAS to accommodate the cable system.

Alternatively, a trenchless method crossing under the M50 to the west of Junction 15 would have the advantage of crossing both the M50 and LUAS with the same bore and would avoid trenching through the bridge. The route would then need to progress onwards through the housing estates to the east of the racecourse. There appears to be sufficient open space on either side of the M50 and LUAS for the drive and reception sites.

4.6.1.6 M50 underpass and Barringtons Road

The crossing identified uses an M50 underpass in private lands and continues on through open land before joining up with Barringtons Road. This road crosses the LUAS at a bridge with significant cover that is deemed to be capable of accommodating the cable system. A substantially similar road alignment forms part of the Cherrywood development and it is understood that this will also cross the M50 in a similar location. For the purposes of the assessment, these two options are considered equivalent and potentially feasible with the preference being to use the Cherrywood development road alignment provided the projects timelines are suitable.

4.6.2 DART

The constraints are as detailed in Section 4.5.2.

4.6.2.1 Onshore Crossings

There are very few locations which would easily allow for a crossing of the DART south of the River Dodder. Two possible crossing points identified north of Strand Rd are Serpentine Avenue and Sydney Parade. All other crossings do not appear to have sufficient space in the surrounding area for the use of trenchless equipment. It may be possible to cross the DART at Serpentine Road with a trenchless method using the parking lot as a drive or reception site. Crossing at Sydney Parade is likely only possible if the existing spare 110 kV ducts can be utilised in some way for this circuit.

4.6.2.2 Offshore Crossings

South of Strand Rd, the DART runs adjacent to the coastline and is typically the first piece of infrastructure heading inland from Dublin Bay. Crossing the DART in this area would likely involve a trenchless crossing either into Dublin Bay or from Dublin Bay. This would result in an offshore route across the bay to Poolbeg. Two landfalls have been identified as potentially feasible, one at Blackrock Park and one at the Salthill & Monkstown DART station parking lot. Both sites are set back from both the DART and Dublin bay and have some land that may be suitable for a drive/reception site. Section 5 of this report provides a technical assessment of the routes across the bay.

4.6.3 N11 & R138

The N11 is a main arterial route for traffic entering Dublin. Once again, the preference would be to identify locations with sufficient space for trenchless installation, rather than trenching across the N11. In addition, the preference would be to keep the length of use of the N11 to a minimum to avoid impacts to traffic. The R138 is the extension of the N11 into Dublin and these two are therefore considered together.

4.6.3.1 Church of the Sacred Heart, Donnybrook

The R138 crosses the River Dodder at the church. This is a very busy intersection and the roads leading to it are heavily trafficked. Consequently, all route segments which connect to this intersection are not considered feasible at this stage.

4.6.3.2 Belfield Flyover

The Belfield Flyover at the UCD campus may be a viable crossing point subject to assessment of the bridge regarding suitability for cable installation as part of separate and subsequent assessment.

4.6.3.3 Stillorgan Village

There are two potential crossings of the N11 at Stillorgan Village. There is an underpass under the N11 near St Laurence's Park, and alternatively a parking lot south of Lower Kilmacud Road which appears to be potentially feasible drive site for a trenchless method. The choice between the two options is considered to be a micro-alignment exercise to be undertaken at detailed design and planning stage as both options start and end at substantially the same location.

4.6.3.4 White's Cross

White's Cross is a major junction on the N11. Trenching through the intersection is not deemed to be a preferred solution. From the assessments undertaken, no suitable locations for trenchless solutions were identified. This not considered a feasible crossing option.

4.6.3.5 Westminster Road / Kill Lane

To cross from Westminster Road to Kill Lane, the route will need to use approximately 200m of the N11. The crossing can potentially be achieved through a trenchless method from Westminster Road and with the route serviced by a trench being installed on the northern side of the N11 in or near the bus lane. Routing in the bus lane would need to be considered through stakeholder consultation and responses may render the route unfeasible.

4.6.3.6 Johnstown Road

This is a substantial intersection with the N11 which is a dual carriageway at this point with a grass centre island. Space appears to be available on either side for a trenchless method of crossing.

4.6.3.7 Kilbogget Park

The crossing of the N11 may be realised here through a trenchless method at the edge of the Park and driving through to the west of the N11. Impact on local residents is considered to be low as the lands to the east of N11 are still under development.

4.6.4 River Dodder

The River Dodder is a challenging waterway in that suitable locations for crossing are limited. This includes consideration of the existing bridges, and potential locations for trenchless techniques. Identified potentially feasible crossing points are likely to be used for an Inchicore – Poolbeg circuits. It is therefore not considered feasible for Carrickmines – Poolbeg routes to cross the River Dodder.

4.6.5 Spare 110kV Ducts

There is a potential opportunity to utilise an existing set of spare 110 kV ducts installed between the Blackrock 110kV Substation and Poolbeg which has been identified by ESB Networks and EirGrid.

While installing a 220kV cable within a 110kV duct system will be a challenge, it is possible that with sufficient time, resource and interest from an OEM, a bespoke cable can be designed to allow for this. This has the major advantage that the route alignment is available from Blackrock, and subsequently only the route from Carrickmines to Blackrock would need to be developed.

When pulling a cable into a duct it is predominately the cable weight, coefficient of friction, length of pull, bends and inclines (slopes) that will impact the overall pulling tension. The recommendations on duct diameter for cable pulling is that the internal diameter of the duct should be at least approximately equal to 1.5 times the diameter of the cable. The cable pulling head will be larger in diameter than the cable itself and this needs good space to fit in the duct. Consequently, normal duct sizes for a 220kV installation would be around 185mm internal diameter.

The discussions with ESB Networks to date have been around a new cable requiring development that utilises 400kV class XLPE insulation for a cable operated at 220kV. In theory this would permit the insulation thickness to be reduced. It is our understanding that ESB Networks have estimated this thickness to be reduced to 13mm which is around 7mm thinner than a conventional 220kV cable which would normally be expected to have a thickness of around 20mm dependent on manufacturer and conductor size.

A 125mm diameter duct is likely to have an internal diameter of around 110mm. To achieve a 1.5 spacing factor for installation, the largest cable OD should be around 73mm which, allowing for a reduction in insulation thickness, would be around the same diameter as a 400mm^2 aluminium screen cable. (note consideration would also need to be given to the short-circuit carrying capabilities of the screen which would likely increase the cable diameter further).

It may be possible to work towards satisfying all stakeholders that a smaller clearance in the duct would be acceptable, but this would require some time to consider the various risks and impacts and then to agree an acceptable clearance factor. By way of example, if it could be demonstrated that a 25% clearance was acceptable then a cable with OD of around 88mm could be considered.

As such, the spare ducts may not be feasible given that this approach requires significant additional investigation and design input, including correspondence with OEMs, to support the development of a low risk solution that can be developed into a working solution acceptable to all parties.

4.7 Traffic/Transport Constraints Study Stage 1

There are a number of locations within the study corridors where the existing and proposed circuits may interface with key elements of traffic and transport infrastructure, major trip attractors, and land use patterns. This section presents the key findings of an initial desktop study which appraised three potential 1.5km wide cable route corridors and highlights potentially significant/sensitive transport related constraints and likely construction impacts. The purpose of the initial transport related impact appraisal was to inform the development of new cable route alignments based on the traffic and transport constraints identified using the available GIS mapping.

4.7.1 Inchicore-Poolbeg Circuits

4.7.1.1 Route Description

Both existing routes run in an east-west axis starting at Poolbeg Power Station just south of Dublin Port, terminating at Inchicore sub-station on the Grand Canal just north of the small suburb of Bluebell to the west of Dublin. Route No.2 is the more direct of the routes, following a series of main arterial roads as it runs towards the western edge of the city. Route No.1 mirrors the general direction taken by Route No.2, but deviates considerably at points, where it cuts through residential areas (particularly around Dublin 8 and Rialto).

For the purpose of assessing potential traffic and transport-related constraints within the study corridor identified, Routes No.1 and No.2 are considered together.

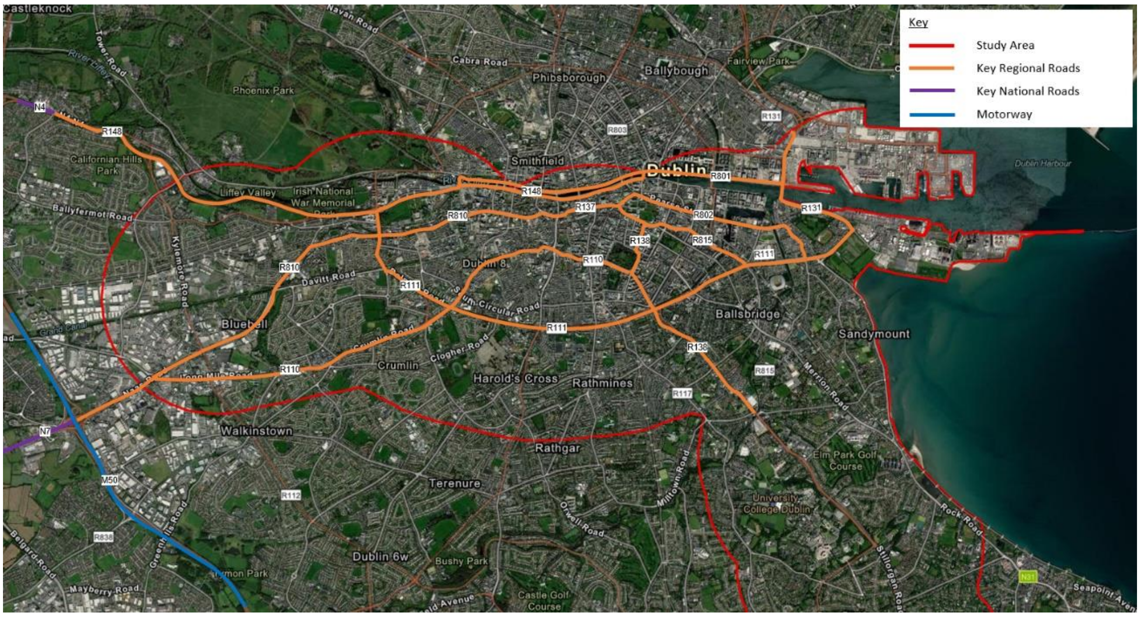
Potential traffic infrastructure constraints are provided in the following subsections.

4.7.1.2 Road Network

Figure 4.4 illustrates the key roads in the study area. Potential constraints have been identified as follows:

- Proximity of Route No.1 to Dublin South Circular Road.
- Proximity of Route No.2 to R111.
- Significant signalised junctions where east-west routes intersect with north-south links.
- Proximity of the city centre to the north of the existing cable routes. Generally, more constrained environment as roads and public transport infrastructure converge in the centre of the city.
- Roads adjacent to the River Liffey are subject to high volumes of traffic and will require significant traffic management arrangements.

Figure 4.4: Key Road Network



Source: Mott MacDonald based on Esri ArcGIS aerial mapping extracted from EirGrid Dublin 220kV Fluid Cable Replacement Webmap

4.7.1.3 Public Transport Infrastructure

As it spreads outwards from the city centre, the Dublin bus network relies heavily on arterial routes to provide access on both a north-south and east-west axis. The Dublin South Circular Road and R111 represent key, heavily trafficked, bus routes and therefore represent potential constraints given the proximity to both existing circuit routes. The R110 and R810 also form heavily trafficked bus routes travelling west-east through the study area. It should be noted that both routes also intersect key north-south bus routes – particularly the R110, R137, R114, R117, R138, and R118.

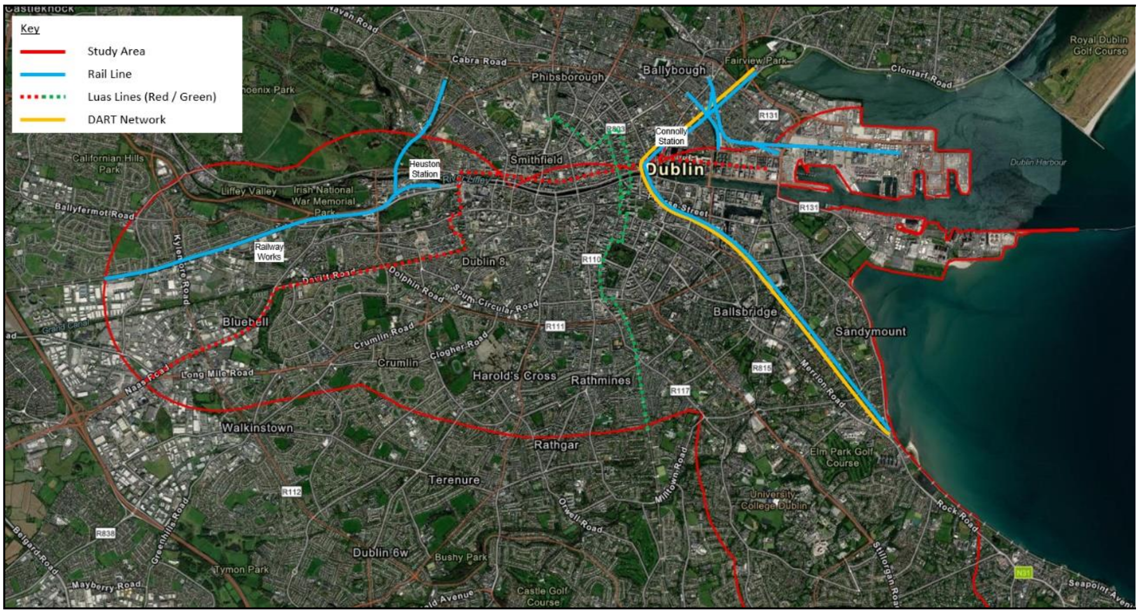
The BusConnects Dublin Project is a forthcoming public transport improvement scheme. The project, which is at an advanced stage, will introduce 16 improved core bus corridors throughout the city. Several of the proposed bus corridors are routed through the study area. The BusConnects Dublin project will make significant changes to the existing road network to provide space for bus lanes and active travel infrastructure. Engagement to confirm the preferred route option for each corridor is understood to be ongoing. Following this engagement, the routes will be issued for statutory approval with construction due to commence on a phased basis between 2022 and 2027. Given the current timescales of this project it is important that consultation with the project sponsor (National Highways Authority) is undertaken to ensure any significant road changes are known which could impact on future works associated with the new cables.

With regards to rail, the following infrastructure is located within the western study corridor:

- Luas (green line)
- Luas (red line)
- Irish Rail Network
- DART Network

This rail network is shown graphically in Figure 4.5.

Figure 4.5: LUAS, DART and Rail Network



Source: Mott MacDonald based on Esri ArcGIS aerial mapping extracted from EirGrid Dublin 220kV Fluid Cable Replacement Webmap

Potential constraints have been identified as follows:

- The bus network relies on strategic and arterial routes to provide access – two of the key routes providing east-west access are the Dublin South Circular and R111.
- Multiple routes running on north-south basis – the existing circuit routes intersect these at various points (R110, R137, R114, R117, R138, and R118)
- Rail infrastructure is present within the study area in the form of Luas, DART and Iarnrod Eireann (IÉ) railway lines. The existing circuit routes cross both lines with several Luas and DART stations in close proximity to the existing circuit routes.
- Requirement for any new cable to cross both LUAS lines and the DART line. Removal of the existing cable will also necessitate works within close proximity to this infrastructure.
- Several key stations and terminals are located within the study corridor (including Dublin Heuston) with supporting rail infrastructure (Inchicore works) also located close by.
- BusConnects Dublin project and associated changes to the existing road network.

- Requirement for increased traffic management arrangements at larger intersections with associated impact on traffic movements within the immediate locale.
- Junctions catering for Luas services may require more significant traffic management measures and may be subject to working restrictions to mitigate impact on services.

4.7.1.4 Active Travel Infrastructure

Active travel infrastructure – in the form of cycle lanes – is prevalent across the western study corridor, with routes located both within the city centre, as well as a concentrated pocket further to the west (to the immediate north of Inchicore).

As per the public transport network, active travel infrastructure is located on several strategic routes which also interface with the existing cable routes (specifically, along the Dublin South Circular and R111).

Additional active travel infrastructure is currently proposed as part of the BusConnects Dublin project.

Potential constraints have been identified as follows:

- Cycle lanes in Dublin are prevalent across the city and are located on strategic routes – particularly on regional and main roads (e.g. Dublin South Circular and R111)
- Concentrated pockets of infrastructure located just south of the city centre, as well as a concentrated pocket to the north of Inchicore where cycle lanes are present along the N4, as well as along the banks of the Liffey
- BusConnects Dublin project and associated active travel infrastructure.

4.7.1.5 Potential Land Use Constraints

Land use within the western study corridor is primarily residential in nature, interspersed with pockets of industrial, retail, and municipal use. Mapping reveals that there are several major trip attractors across a range of land uses located with the western study corridor; many of which are in close proximity to the existing circuit routes. Given the close proximity to the centre of Dublin (and major population centres), this includes key emergency and healthcare facilities (including 5 hospitals), as well as a number of educational facilities (e.g., Trinity College Dublin).

Each of these hospitals and other major attractors are located close to the strategic road network and as such, these roads represent the most obvious access routes to/from these locations – particularly for emergency services routing to and from the various hospitals. There is therefore potential for conflict between users given the close proximity of the cable route and road network. The routing of cables within close proximity to these hospitals should be limited where possible to mitigate any issues with access to/from these facilities for patients etc.

Other potential constraints have been identified as follows:

- Key trip attractors located along the length of both existing circuit routes and are largely unavoidable given proximity to the city centre. It is recommended that the cable routing should look to avoid these key trip attractors if possible, to limit any disruptions the construction/maintenance works will have on the operation of these areas. The areas around the Temple Bar, Grafton Street, St. Stephen's Green and Trinity College Dublin should all be avoided due to the high pedestrian flows and dense public transport network in these areas.
- Key constraints likely to be focused around 'conflict' points where these attractors interface with access routes – particularly in the case of emergency service routes to and from hospitals.

- Railway lines and supporting infrastructure represent 'hard' physical barriers and thus represent significant constraints and impact on the possible routing options. This is particularly prominent in the western segment of the study corridor where both the IÉ and Luas network are present.

4.7.2 Carrickmines - Poolbeg

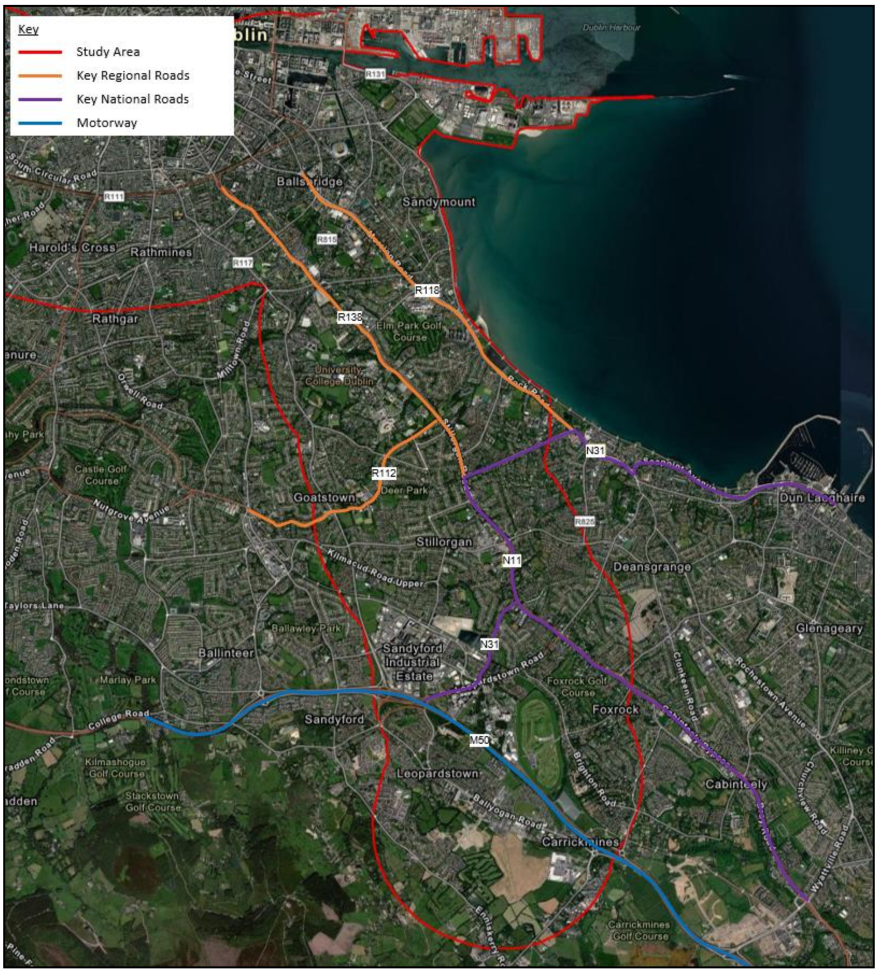
4.7.2.1 Route Description

The Carrickmines - Poolbeg circuit runs between the Poolbeg Power Station just south of Dublin Port, following the coastline southwards through Sandymount and deviating south through Stillorgan and Leopardstown before terminating at the Carrickmines substation. A 1.5km wide cable route corridor has been considered and the traffic and transport related constraints associated with this route are discussed below.

4.7.2.2 Road Network

From a review of the GIS mapping resources currently available for the Dublin EirGrid 220 kV feasibility study, there are a number of key national roads located within the study area. The national roads located within close proximity to the existing Carrickmines-Poolbeg circuit (with the potential to cause constraints) are the M50, N11, and N31; all administered by TII. The M50 is principally subject to a speed limit of 120kph, whilst the N11 and N31 are subject to a speed limit of 60-80kph within the study area. Figure 4.6 illustrates the key roads in the study area.

Figure 4.6: Key Road Network



Source: Mott MacDonald based on Esri ArcGIS aerial mapping

The M50 is the busiest motorway in Ireland and serves as a peripheral route running around the western edge of Dublin. The M50 provides a key link between Dublin City and the strategic road network, circling the northern, western and southern suburbs of Dublin before merging with the M11 at Shankill in South East Dublin. Within the context of this study, the M50 bisects the existing circuit route at Leopardstown, just south of the Sandyford Industrial estate, with three major motorway junctions located within close proximity of the route (Junctions 13, 14 and 15).

In addition, the N31, as well as some minor roads such as the R112, cross the existing route and provide important local connections to the wider road network (including the M50). The N31 in particular is a key local link between Dun Laoghaire Harbour to the southeast of Dublin and the N11.

Potential constraints have been identified as follows:

- Presence of M50 within the southern portion of the study area. This is a significant high-speed road subject to large volumes of traffic and greater restrictions on traffic management.
- Presence of other key arterial routes providing access south and southeast of Dublin – specifically the N11.

4.7.2.3 Public Transport Infrastructure

The bus network within the Carrickmines study corridor differs slightly to the distribution observed across the western corridor; being concentrated in a far more linear pattern and relying heavily on the two principal roads – these being the N11 and M50.

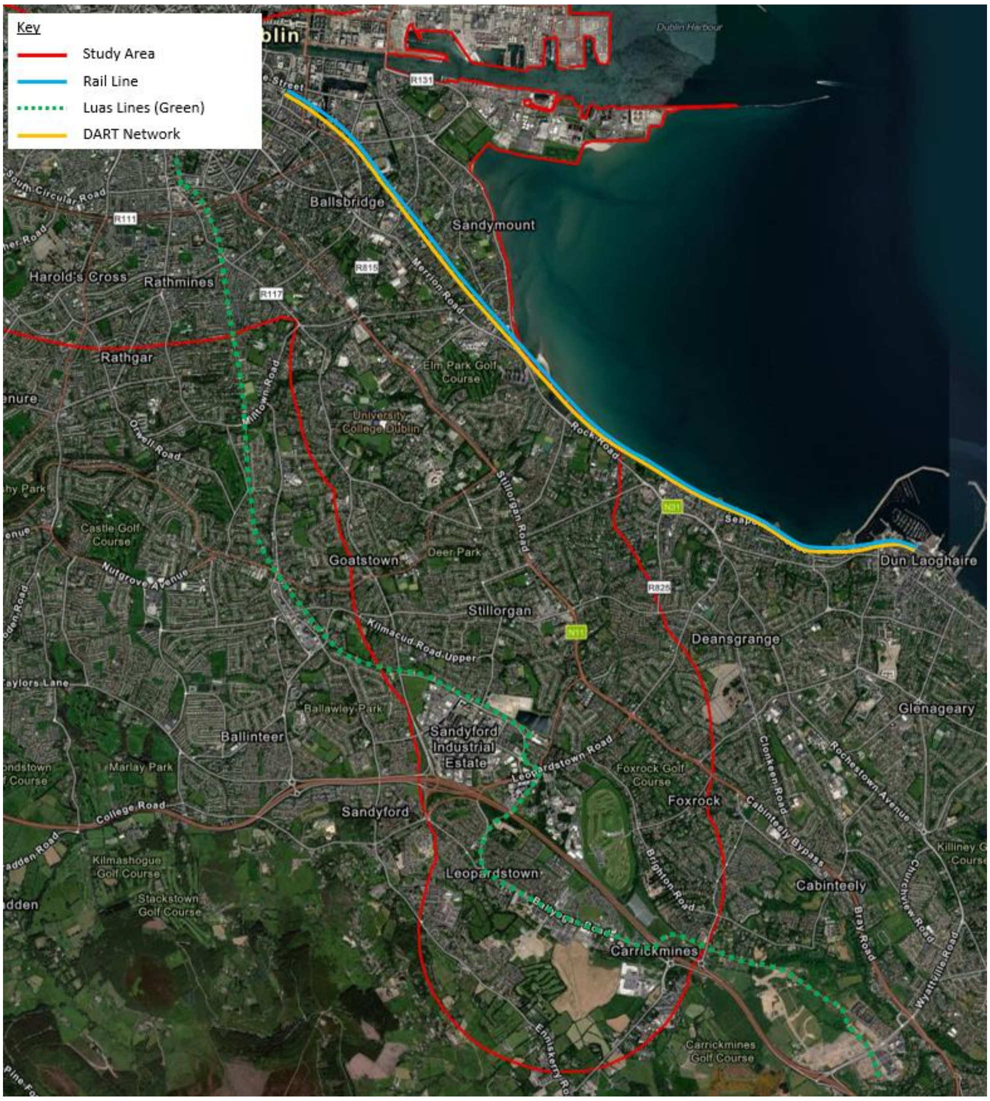
The BusConnects Dublin Project is a forthcoming public transport improvement scheme. The project, which is at an advanced stage, will introduce 16 improved core bus corridors throughout the city. Several of the proposed bus corridors are routed through the study area. The BusConnects Dublin project will make significant changes to the existing road network to provide space for bus lanes and active travel infrastructure. Engagement to confirm the preferred route option for each corridor is understood to be ongoing. Following this engagement, the routes will be issued for statutory approval with construction due to commence on a phased basis between 2022 and 2027. Given the current timescales of this project it is important that consultation with the project sponsor (National Highways Authority) is undertaken to ensure any significant road changes are known which could impact on future works associated with the new cables.

With regards to rail, the following infrastructure is located within the Carrickmines study corridor:

- Irish Rail Network
- Luas (Green line)
- DART Network

This rail network is shown graphically in Figure 4.7.

Figure 4.7: LUAS, DART and Rail Network



Source: Mott MacDonald based on Esri ArcGIS aerial mapping extracted from EirGrid Dublin 220kV Fluid Cable Replacement Webmap

Potential constraints have been identified as follows:

- The bus network relies on strategic and arterial routes to provide access – two of the key routes within this corridor are the N11 and M50 motorway.
- Rail infrastructure is present within the study area in the form of stretches of both the Luas and DART rail network. The existing circuit routes cross both lines with stations on both Luas and DART lines located adjacent to the existing circuit route.
- BusConnects Dublin project and associated changes to the existing road network.
- Requirement for increased traffic management arrangements at larger intersections with associated impact on traffic movements within the immediate locale.
- Junctions catering for LUAS services may require more significant traffic management measures and may be subject to working restrictions to mitigate impact on services.

4.7.2.4 Active Travel Infrastructure

Active travel infrastructure – in the form of cycle lanes – is again prevalent across the study corridor, with routes located both close to the city centre, as well as a concentrated pocket further to the south around Sandyford.

As per the public transport network, active travel infrastructure tends to be located on strategic routes which also interface with the existing cable route (most prominently in this instance on the N11).

Additional active travel infrastructure is currently proposed as part of the BusConnects Dublin project.

Potential constraints have been identified as follows:

- Cycle lanes in Dublin are prevalent across the city and are located on strategic routes – especially, regional and main roads (N11)
- Concentrated pockets of infrastructure located just south of the city centre, as well as a concentrated pocket to the south at Sandyford where cycle lanes bisect the existing cable route at numerous points.
- BusConnects Dublin project and associated active travel infrastructure.

4.7.2.5 Potential Land Use Constraints

Analysis suggests that there are a number of major trip attractors from across a range of land uses located within close proximity to the existing route – this ranges from hospitals (e.g. St Vincent's), educational facilities (University College Dublin campus), major retail areas (e.g. Stillorgan Shopping Centre and Carrickmines Retail Park), Leopardstown racecourse and other major employment locations (e.g. Sandyford Industrial Estate).

Each of these major attractors is located close to the strategic road network and as such, these roads represent the most obvious access routes to/from these locations. There is therefore potential for conflict between users given the close proximity of the existing route and road network.

There appears to be a particularly constrained area of the study corridor around Sandyford/Leopardstown where the existing route cuts between the Sandyford Industrial Estate and Leopardstown Racecourse and is bound by the M50 to the south.

Potential constraints have been identified as follows:

- Numerous key trip attractors located along the length of the existing circuit route and are largely unavoidable. It is recommended that the cable routing should look to avoid these key trip attractors where possible, to limit any disruptions the construction/maintenance works will have on the operation of these areas. It is recommended that any routing which impacts on access to the Sandyford Business Park and University College Dublin are avoided if possible, to mitigate any negative impacts on the operation of these facilities if access is restricted during construction/maintenance works
- Key constraints likely to be focused around 'conflict' points where these attractors interface with access routes – particularly junctions interfacing with N11/M50
- Railway lines and supporting infrastructure represent 'hard' physical barriers and thus represent significant constraints and impact on the possible routing options. This is more prominent in the southern segment of the study corridor where the Luas green line bisects the study corridor

5 Offshore Cable Constraints Feasibility Assessment

5.1 Introduction

The following sections provide an overview of key constraints associated with the consideration of the feasibility of cable route options in the offshore study area, either in whole or in part.

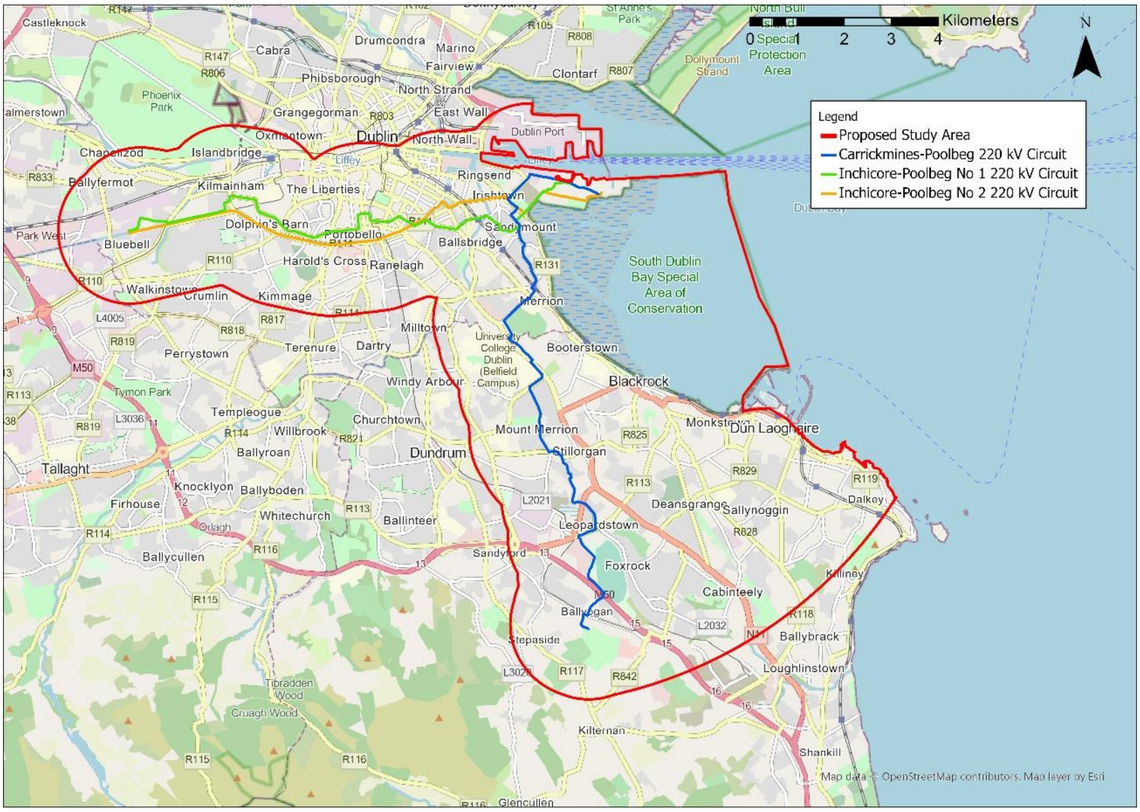
The key aims of this offshore cable feasibility analysis include:

- Identify potential feasible landfall areas and submarine cable options within the study area shown in Figure 5.1 to connect south Dublin with the substation at Poolbeg;
- Outline technically feasible options and assess the likely installation methods which reduce impacts on mudflats;
- Undertake a high level evaluation of environmental and social constraints;
- Outline high level Appropriate Assessment (Habitat Directive) and consenting considerations; and
- Produce a risk matrix for the technical, environmental, social and deliverability of potential options.

5.2 Study Area

The specific area for this element of the study is the offshore portion of the wider study area outlined in Figure 5.1.

Figure 5.1: Study Area



Source: Mott MacDonald (Open Street Map Layer by ESRI)

The South Dublin Bay lies south of the River Liffey in Co. Dublin and extends from the South Wall to the west pier at Dun Laoghaire. It is an intertidal site with extensive areas of sand and mudflats. Several small sandy beaches with initial dune formation occur in the northern and western sectors of the site particularly at Poolbeg, Irishtown and Merrion/Booterstown (NPWS, 2015)[23].

Most of the marine intertidal South Dublin Bay area is included within the South Dublin Bay Special Area of Conservation (SAC) and South Dublin Bay and River Tolka Estuary Special Protection Area (SPA).

In addition, the inner parts of South Dublin Bay are used for amenity purposes at low tides where bait-digging is a regular activity on the sandy flats while during high tides, some areas are used for wind-surfing and jet-skiing activities. Hence, South Dublin Bay shows a good example of a coastal morphological process and system with extensive sand and mudflats as well as incipient dune formations.

Refer to 4.3 for further information regarding the environmental and social constraints.

5.2.1 Geology and Sediments

An intertidal sand and mudflats survey in South Dublin Bay (SDB) was conducted by Aqua-Fact in 2006 (Aqua-Fact, 2006)[24] and this covers the project site. Two set of transects were deployed for the survey and an overview of the survey area at South Dublin Bay is illustrated in Figure 5.2. Based on the survey, the sediment materials and carbon content at the two transects at three different site locations around the transects area are tabulated in Table 5.1 and Table 5.2, respectively.

Figure 5.2: Survey area at South Dublin Bay

Source: Aqua-Fact, 2006

[23] Site Synopsis: South Dublin Bay SAC', Available at: https://www.npws.ie/sites/default/files/protected-sites/synopsis/SY000210.pdf. , NPWS, 2015 '

[24] A survey of intertidal mudflats and sandflats in Ireland, Aqua-Fact, 2006

Based on Table 5.1 for Transect 1, it is identified that the site is located on the intertidal sand and mudflats located at the South of Dublin Harbour (Figure 5.2). The highest percentage of sediment materials were contributed by the mud (fine to very fine sand, up to 80%) while sand (very coarse to medium sand) materials are lower than 15% at most. It is also observed that the upper and mild shore areas have higher percentage of fine sediments compared to the lower area. However, the area is covered by fine sediments overall and therefore, this indicates that this area is enclosed by extensive sand and mudflats.

For Transect 2, the survey area was located at the south-eastern end of Merrion Strand which is approximately 2km south of the Transect 1. Based on Table 5.2, the sediments ranged from very coarse to very fine sand similar as Transect 1 but in contrast, higher percentage of fine sediment materials were found the middle and lower shore. Overall, the area is dominated by fine sediment materials which specifies that this site is also covered by sand and mudflats widely.

Table 5.1 Sediment size and organic carbon content at Transect 1

Sandymount Transect 1	T1 S1 Upper shore	T1 S2 Mid shore	T1 S3 Lower shore
Sediment Type	(%)	(%)	(%)
Gravel	0	0	0
Very coarse sand	5.4	7.53	14.1
Coarse sand	1.05	0.85	0.18
Medium sand	6.32	3.41	3.67
Fine sand	80.01	76.79	68.21
Very fine sand	7.22	11.41	13.8
Silt	0	0.01	0
Total Organic Carbon (C%)	0.11	0.13	0.03

Source: Aqua-Fact, 2006

Table 5.2 Sediment size and organic carbon content at Transect 2

Merrion Transect 2	T2 S1 Upper shore	T2 S2 Mid shore	T2 S3 Lower shore
Sediment Type	(%)	(%)	(%)
Gravel	0	0	0
Very coarse sand	13.4	6.34	6.27
Coarse sand	0.11	0.63	0.5
Medium sand	24.72	3.77	2.44
Fine sand	58.82	73.49	72.82
Very fine sand	2.95	15.77	18
Silt	0	0	0
Total Organic Carbon (%C)	0.08	0.11	0.12

Source: Aqua-Fact, 2006

5.3 Identification of Potentially Feasible Landfall Areas

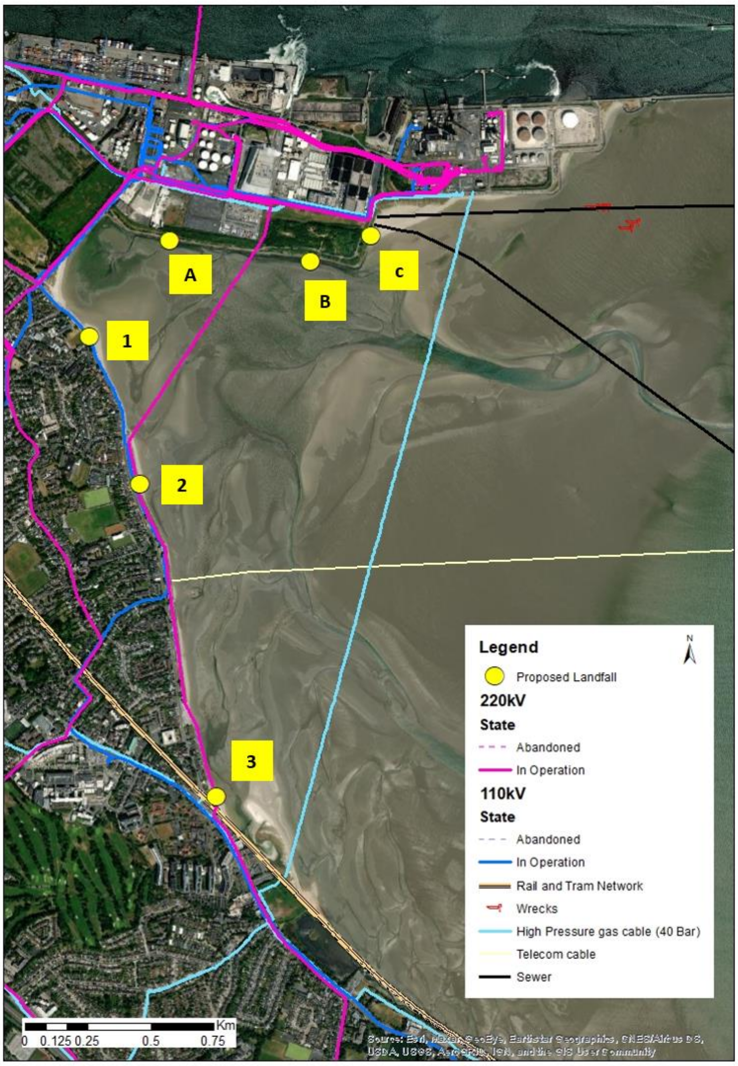
Initial consideration of potentially feasible landfall areas within the study area highlighted the following key constraints to location of landfalls:

- Railway line which runs parallel to the coastline
- Existing services including:
  - An existing 220kV cable
  - Telecom cable
  - High pressure gas pipeline
  - Sewer pipelines

It was considered that due to the very shallow bathymetry (which is exposed mudflat at low tide), third party vessel use in the nearshore area would not be a driving factor for landfall locations.

Three potentially feasible landfall locations were identified for the north shore landing, and three locations for the south shore landing. The location of the potential landfalls for two cable installation methods (Section 5.5) are shown in Figure 5.3 and are also tabulated in Table 5.3. However, these locations are not site specific and would be subject to future site specific analysis, depending on the access and restrictions on site. Associated key constraints are tabulated in Table 5.4.

Figure 5.3: Landfall Locations



Source: Mott MacDonald

Table 5.3: Location of landfalls in IRENET95 coordinate projection

Easting	Northing	Landfall
719167.89	732896.97	1
719370.10	732304.78	2
719676.22	731054.95	3
719490.63	733280.42	A
720050.99	733195.65	B
720291.98	733300.65	C

Source Mott MacDonald, 2021

A summary of the key constraints associated with the potentially feasible landfall areas is presented in Table 5.4. Environmental and social constraints applicable across all sites require further assessment and mitigation – see Section 4.3 for further detail.

Table 5.4: Summary of landfall locations and key site specific constraints

Landfall Location	Advantages	Constraints
North Shore		
A	Limited third party structures. Area relatively easy to segregate and secure for operations. Shallow water approach. (Cable Landing)	Restrictive vehicle access. Landowner permission required for access and use. Not near existing network.
B	Limited third party structures. Area relatively easy to segregate and secure for operations. Shallow water approach. (Cable Landing)	Restrictive vehicle access. Public park. Area built on reclaimed refuse dumping area in the 1980's
C	Limited third party structures. Area relatively easy to segregate and secure for operations. Shallow water approach. Good road access. Close to existing network. (HDD Landing)	Close to existing marine buried assets. Public beach.
South Shore		
1	Close to existing network. Good access. Utilisation of the beach for installation works. Segregated from structures. Shallow water approach. (Cable and HDD Landing)	Stakeholder engagement for access and use. Public beach. Close to built-up area and vehicle traffic activities'
2	Close to existing network. Utilisation of the beach for installation works. Segregated from structures. Shallow water approach. (Cable and HDD Landing)	Stakeholder engagement for access and use. Public beach. Close to built-up area and vehicle traffic activities
3	Close to existing network. Good access. Utilisation of the beach for installation works. Shallow water approach. (Cable Landing)	Stakeholder engagement for access and use. Public beach. Close to built-up area and vehicle traffic activities

5.4 Constraints on Installation of cable

A number of constraints were considered to impact the overall feasibility of an offshore cable route in this environment. These are summarised in Table 5.5.

Table 5.5: Summary of constraints in the marine environment

Dataset	Possible constraints / impacts on cable installation or operation
Bathymetry – depth	The shallow water aspects of the area create restrictions for equipment access and time limitations. Specialist installation equipment designed for working within an area which has both drying and flooded periods increases the complexity of the installation methodologies
Bathymetry – creeks	Changes in seabed profile will affect the required burial depth during the installation and the potential of future reduction of coverage over the asset lifetime – this is likely to result in deeper burial requirements for the cable which may limit the current carrying capacity of the system.
Sewer	These may need to be crossed either over or under depending on the installation method, routing and depth of the existing service. This could require additional works on the mudflats which would increase the impact of the works.
Gas Pipeline	Present routing avoids crossing this asset with the cable, but location and burial depth required if installation assets are required to pass over as part of the installation methodology. This could require additional works on the mudflats which would increase the impact of the works.
Telecom Cable	Crossing agreement required if cable route crosses this asset. Dependent on the burial depth, additional protection over the installation may be required due to segregation requirements. The protections requirements may result in a change to the seabed level which is unlikely to be permitted. This could require additional works on the mudflats which would increase the impact of the works.
220kV Power Cable	This asset may require to be crossed under if an HDD installation method is chosen.
Ship wrecks	These would be avoided by alternative routing
Structures	Avoidance by alternative routing
Environmentally designated sites (SAC, SPA, Ramsar)	The site covers extensive areas of sand and mudflats which are identified as a Special Area of Conservation (SAC) and overlapped with Special Protection Area (SPA), proposed Natural Heritage area (pNHA) and Ramsar site. This creates permitting and planning limitations in terms of construction methods and timing of works and what can be undertaken in the environment. Permanent impacts to intertidal habitats and temporary or permanent displacement /disturbance effects to birds may result in significant adverse impacts to the SAC and or SPA. Significant impacts may be permitted in the absence of other alternatives, for imperative reasons of overriding public interest IROPI (including those of a social or economic nature). Where this arises, EU countries must introduce compensatory measures to ensure the overall coherence of the Natura 2000 network. This procedure is regulated under Article 6(4) of the Habitats Directive.

Source Mott MacDonald, 2021

A similar method to that which is presented in Section 3.3.1 was undertaken. Each constraint was evaluated along a scale in line with the EirGrid approach to options appraisal assessments carried out on other projects. This scale ranges from “more significant”/”more difficult”/”more risk” to “less significant”/”less difficult”/”less risk”. The scale ranges across 5 levels from “low”/”low-moderate”/mid-level/moderate”/”moderate-high”/”high”. The colour key shown in Figure 5.4 provides an illustration of this scale.

Figure 5.4: Level of risk definition by colours for a constraints map

Key	Level of Risk/Significance/Sensitivity
Yellow	Low
Green	Low-Moderate
Dark Green	Mid-Level / Moderate
Blue	Moderate-High
Dark Blue	High

Source: EirGrid

Table 5.6 lists all the input constraints to the heat map, the assigned buffer/zone and the level of risk / significance / sensitivity applied to each constraint.

Table 5.6: Marine Constraints Applied

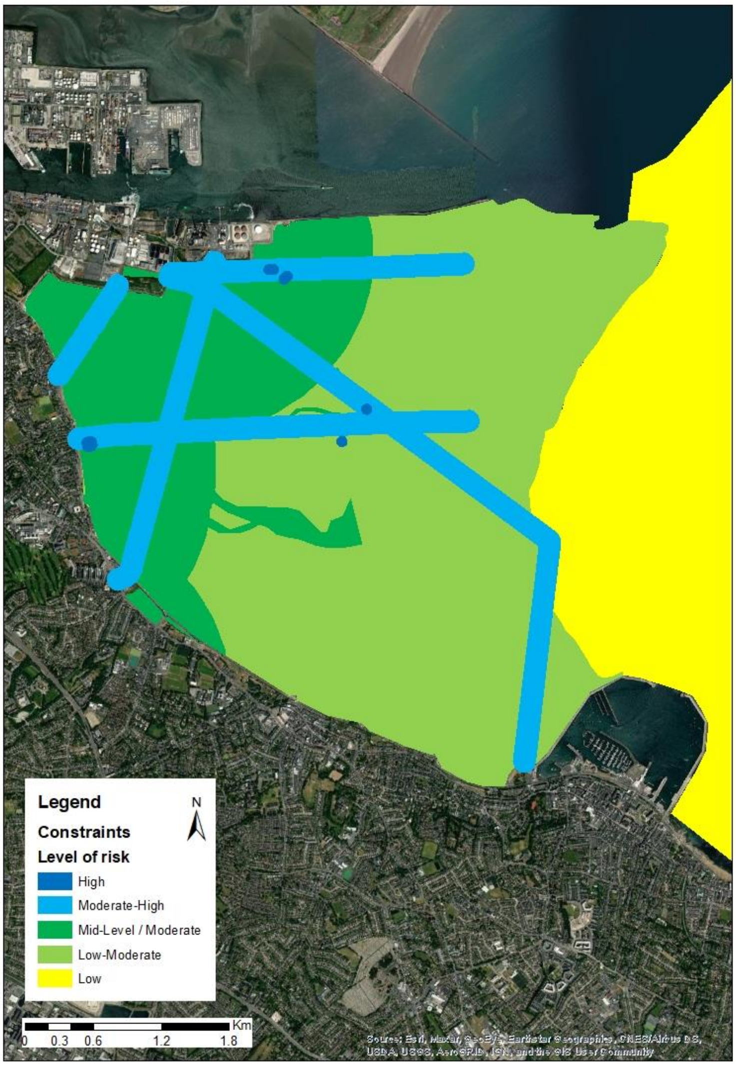
Dataset	Buffer (Metres) / Zone	Colour Weighting Key
Bathymetry – depth	<5m depth >5m depth	**Green** **Yellow**
Bathymetry – creeks	Creek areas	**Dark Green**
Sewer	100m buffer	**Blue**
Gas Pipeline	100m buffer	**Blue**
Telecom Cable	100m buffer	**Blue**
220kV Power Cable	100m buffer	**Blue**
Ship wrecks	50m	**Dark Blue**
Structures	50m	**Dark Blue**
Environmentally designated sites (SAC, SPA, Ramsar)	Designated Area included	**Dark Green**

Source Mott MacDonald, 2021

5.4.1 Constraints Map

Figure 5.5 shows a marine constraints map based on dataset information and the level of risk tabulated in Table 5.6. Based on Figure 5.5, it is indicated that the potential cable crossing routes are likely to be within Moderate to High levels of risk.

Figure 5.5: Marine Constraints Map



Source: Mott MacDonald

5.5 Potentially Feasible Marine Cable Alternatives

Based on a review of the study area, landfall locations and marine environment constraints, two types of cable installation method have been identified for consideration. The installation methods are denoted as:

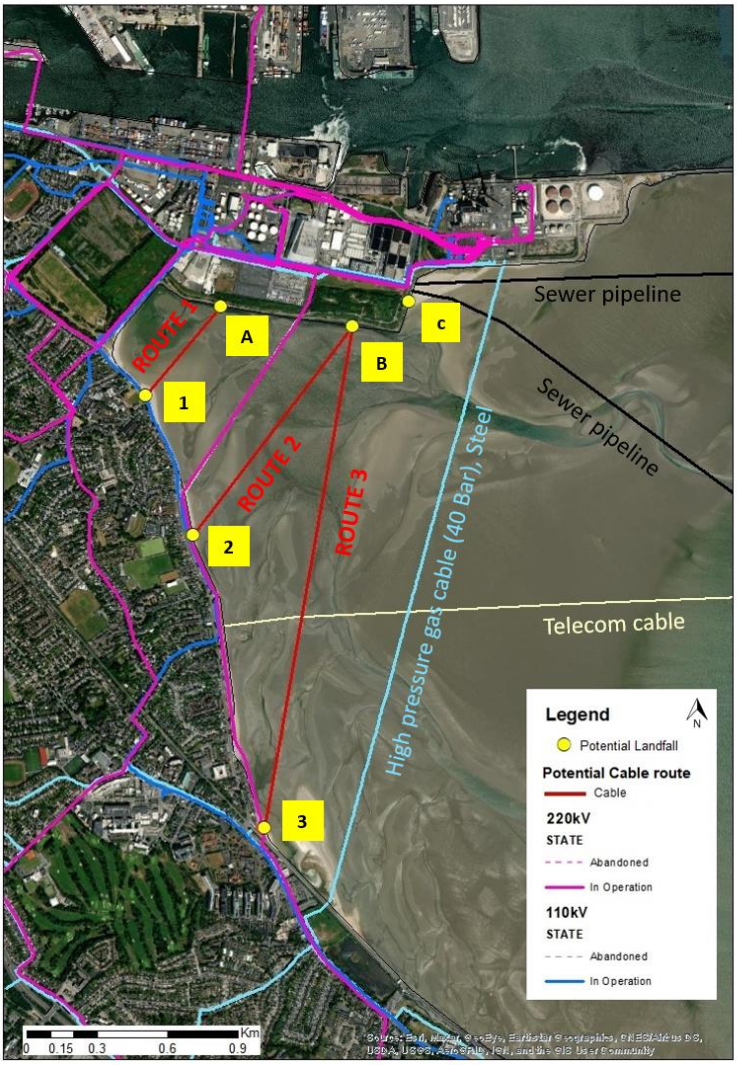
- Method 1: Surface cable crossing which involves potential seabed preparation, lay and cable burial. Cable would be protected by being buried in the mudflats and it is not anticipated that additional permanent protection on the mudflats would be required. However, additional protection may be required if existing services are crossed (see constraints discussion).
- Method 2: Horizontal Directional Drilling (HDD) which involves a construction technique whereby a duct or ducts are drilled under a waterway or other designated area, and the cables are subsequently pulled through the ducts.

The following sections identify potentially feasible point-to-point cable alignments that employ these methodologies. It is reiterated that these should not be considered to comprise identified route options. Such identification will require separate and subsequent analysis, outside the scope of this feasibility study.

5.5.1 Potentially Feasible Cable Alignments Using Surface Cable Crossing

Figure 5.6 shows an overview of the potentially feasible cable alignments by using Method 1 as described above. Three potentially feasible cable alignments are indicated as Route 1, 2 and 3. These alignments have been considered with a view to reducing crossings with other services.

Figure 5.6: Potential Feasible Offshore Surface Cable Alignments

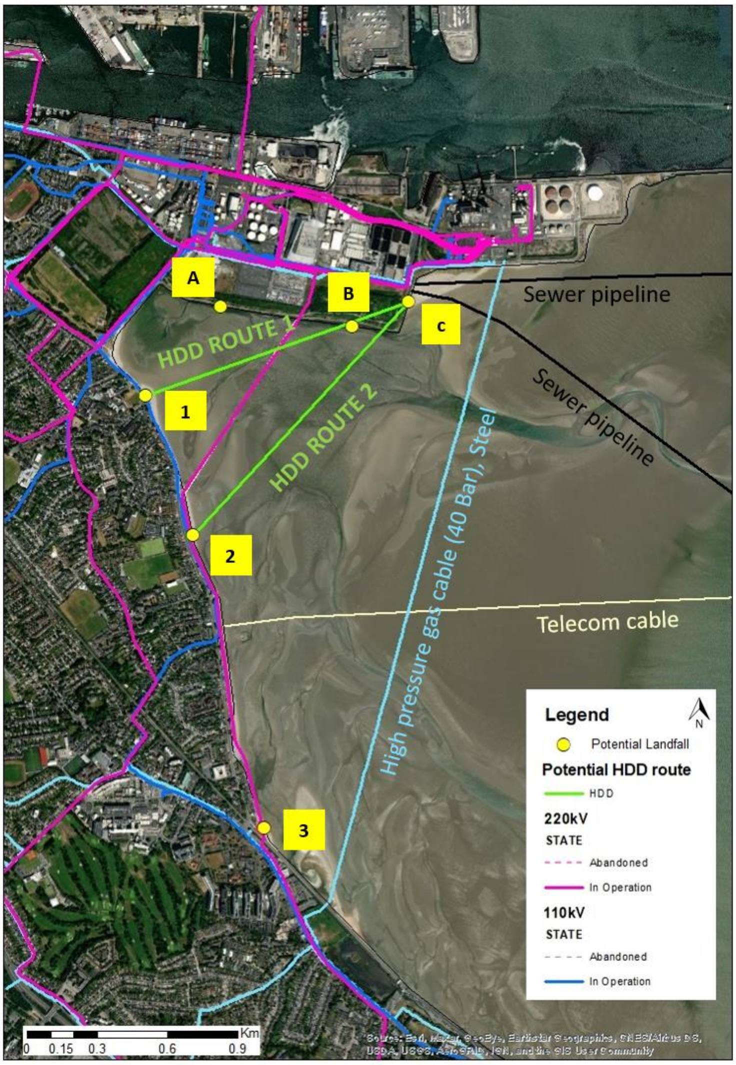


Source: Mott MacDonald

5.5.2 Potentially Feasible Cable Alignments Using HDD Installation Method

Figure 5.7 shows an overview of the potentially feasible cable alignments using HDD method (Method 2). Two potentially feasible HDD cable alignments and 3 potentially feasible landfall areas were determined, indicated as HDD Alignment 1 and 2. For the purposes of this study, a maximum HDD length of 2km has been assumed. However, it should be noted that a cable pull over this distance is very likely to be a significant challenge and will require special engineering consideration. Alignments 1&2 in Figure 5.7 are estimated to be around 1.3 km and 1.6km in length respectively. For installations of this length, and dependent on the construction specifics, HDD works sites (drive and reception) with areas in the order of 170m x 100m and 50m x 30m may be necessary.

Figure 5.7: Potential Feasible Offshore HDD cable Alignments



Source: Mott MacDonald

5.5.3 Evaluation of Alignments

For the purposes of considering feasibility, the five alignments have been considered against technical, economic, environmental and social categories and summarised below. However, it should be noted that this just reviews the marine crossing element of the route.

Each alignment is evaluated in accordance with EirGrid's Performance Matrix. The effect on each criteria parameter is presented along a range from "more significant"/"more difficult"/"more risk" to "less significant"/"less difficult"/"less risk". The following scale is used to illustrate each criteria parameter:

More significant/difficult/risk **less significant/difficult/risk**

Dark Blue (High)	Blue (Moderate-High)	Dark Green (Mid-level)	Green (Moderate-Low)	Yellow (Low)

Table 5.7 provides a summary of the constraints using the above colour coded scale.

Table 5.7: Summary of constraints for offshore alignments considered

Align-ment	Technical / Deliverability	Economic	Environmental	Social
Offshore Surface Alignment 1	Green – Intertidal environment (mud/sand) is soft soil but exposed for majority of tide reducing complexity of vessels and equipment to be used.	Green – short alignment with surface installation method.	Blue – Installation would disturb the designated area. Burial would need to be appropriate to reduce risk of impacting coastal processes during operation. IROPI case could still be required due to disturbance.	Green - limited impacts but installation of cable may cause some short term temporary disturbances.
Offshore Surface Alignment 2	Green – Intertidal environment (mud/sand) is soft soil but exposed for majority of tide reducing complexity of vessels and equipment to be used.	Green – short alignment with surface installation method.	Blue – Installation would disturb the designated area. Burial would need to be appropriate to reduce risk of impacting coastal processes during operation. IROPI case could still be required due to disturbance.	Green - limited impacts but installation of cable may cause some short term temporary disturbances.
Offshore Surface Alignment 3	Blue – alignment crosses the existing telecom cable. Crossing agreements and additional cable protection likely to be required.	Dark Green -additional costs related to crossing of services.	Dark Blue – the longest alignment over designated area and including a cable crossing which is likely to need further protection works which would increase the impact of the works and disturbance on the protected area. Compensatory habitat would be required.	Green - limited impacts but installation of cable may cause some short term temporary disturbances.
HDD Alignment 1	Dark Green – HDD method more specialist than surface installation, but reduces risks and issues related to crossing other services.	Blue -HDD generally more expensive installation technique compared to surface installation.	Dark Green – HDD is below surface and therefore less likely to cause disturbances. Seasonal restrictions likely to apply. Entry/exit points for the HDD likely to cause disturbance to designated area.	Green – HDD is below surface and therefore less likely to cause disturbances. However construction at entry/exit points likely to cause temporary disturbances.
HDD Alignment 2	Dark Green – HDD method more specialist than surface installation, but reduces risks and issues related to crossing other services.	Blue -HDD generally more expensive installation technique compared to surface installation.	Dark Green – HDD is below surface and therefore less likely to cause disturbances. Seasonal restrictions likely to apply. Entry/exit points for the HDD likely to cause disturbance to designated area.	Green – HDD is below surface and therefore less likely to cause disturbances. However construction at entry/exit points likely to cause temporary disturbances.

Other marine cable alignments have been identified that emanated from landfall locations South East of the gas pipeline at Blackrock Park and at Salthill & Monkstown. These locations, while also potentially feasible have not been further considered in this study due to the resultant distance deemed to be beyond the length considered to be technically practicable. Additional considerations for a longer route alignment would include:

- Landfall passes under the rail line running close to the shoreline
- Complex interface between land network to marine location
- An HDD option would most likely need to consist of two HDDs connected by a length of surface lay due to the limitations associated with installing cables in ducts
- Multiple third-party asset crossings
- Separation and asset protection may require surface rock or mattress installations that create environmental constraints and possible introduction of changes to water flow and creation of creeks with the potential of introducing future erosion
- Any future repair or maintenance requirements potentially require third-party asset agreements. If replacement was required, landfall ducting maybe required to be reinstalled

5.6 Installation in the Mudflat Environment

The installation utilising an alignment across the marine environment could potentially be completed using one of the following basic methodologies:

- Vessel based Lay and Burial
- Tracked based Lay and Burial
- Horizontal Directionally Drilled Ducts (HDD)

These are discussed in more detail within the sections below.

5.6.1 Marine Vessel Installation

A vessel based methodology would rely on the water depth at the location of the installation being sufficient to ensure an efficient installation progress against distance covered. Due to the very restricted periods of water coverage, this method would not be used for the indicative installation alignments proposed.

5.6.2 Installation using Tracked Vehicles

The tracked based methodology utilises a cable drum mounted on a low impact tracked vehicle with a simultaneous burial tool operation. These are specialised tools that have been designed with wide tracks to allow for use in locations where environmental impacts restrict standard land based equipment. In addition to the low impact, these tools are marinized to work in shallow waters so are not restricted by tidal constraints.

Where the installation method is based on vessel or tracked installation, a burial depth of the cable at this stage, subject to further survey investigation, would be proposed to be 1.5 metres below the surface profile. This depth is based on previous project experience and would normally be sufficient to provide protection from the anticipate range of external influences and activities likely to be occurring during the expected lifetime of the cable system.

The cable installed across this area would be designed to be a marine cable, with appropriate water blocking and armour protection. This cable would require specialised jointing for termination and connection into the existing network. Where there is an onward land cable system to connect to, a transition joint bay located close to the marine/land interface would also be required. In the event that a repair is required, the cable system repair would require a similar procedure to the installation in order to carry out the repair; e.g. cable mounted on a tracked vehicle with sufficient cable to span the area to be repaired and a dry facility such as a platform, to complete two joints.

5.6.3 HDD

With a marine horizontally drilled duct installation either shore to shore or onshore to offshore, the physical bore diameters are normally larger than those used for standard duct installations and HDDs onshore. This is to facilitate an easier pull in and also because the subsea cables that are normally installed in these ducts are of a larger diameter. Where a directional drilled duct is used to deliver the marine cable from the transition joint bay to the offshore, the duct diameter is normally sized to be between 2 and 2.5 times the diameter of the cable it will host.

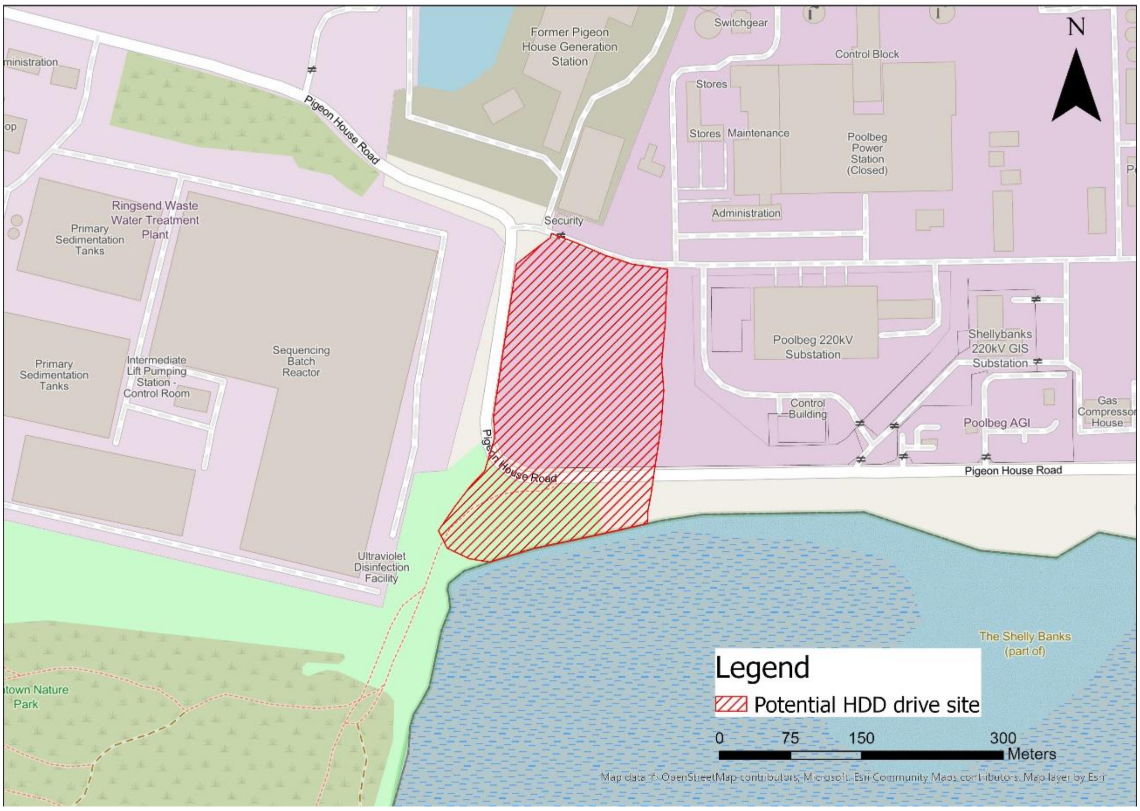
When the duct connects both the shore locations (land to land), the duct will be sized to accommodate the standard land network cables, however, a very long pull would also mean that a larger duct would be installed to host the cable. Typically, we would expect the internal diameter of the duct to be in the order of 2 to 2.5 times the outside diameter of the cable it will host. It may be possible to drill a single very large bore for a circuit, with three inner ducts for the individual cables, if ratings permit. However, this will increase the size of the drilling rig required and also the construction compound.

If the ratings achieved using a single large bore duct with three smaller ducts are insufficient, then individual ducts per cable on a wide spacing (e.g., 10m) can be considered where sufficient space exists. At this stage a detailed design has not been undertaken and the HDD profile and crossing solution is therefore unknown. However, based on the results of Section 2.5, an installation with depth greater than 4.6m is likely to require individual HDD bores to achieve the required thermal cable spacing.

On the basis that at least three bores may be required for each circuit (one for each power cable and a separate duct for communications) and with consideration of the lengths of bore that would be required, installation of multiple circuits increases the potential risk of permanent environmental impact, as well as the area required for the launch and reception sites. The availability of suitable land sites for the launch and reception pits along with the associated planning risks with multiple land sites also influences the quantity of HDD crossings possible. Subject to further discussions with relevant stakeholders and further investigations, it is therefore recommended that only one circuit be installed through HDD if this is option is chosen. Indicative working areas for the driving and reception sites are shown in Figure 5.8 and Figure 5.9 respectively.

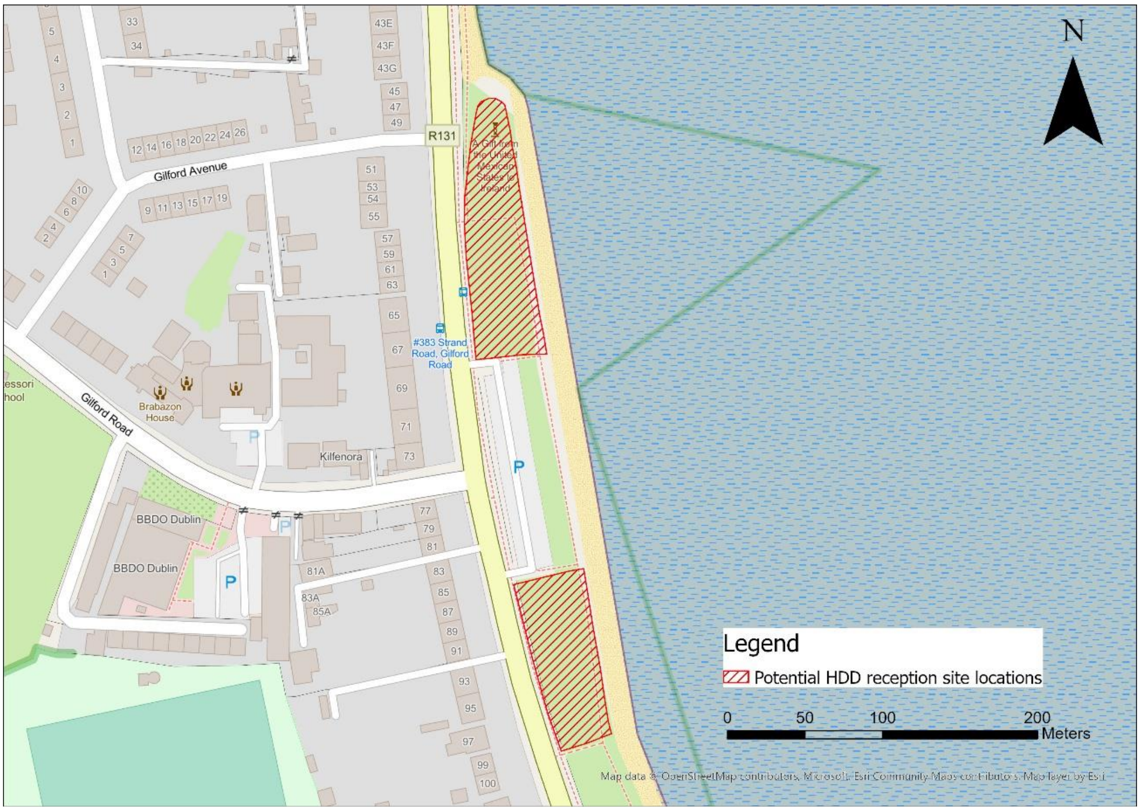
Where an HDD installation is chosen, the installation programme is separated between duct installation and cable installation. These can be scheduled to reduce disruption to services and to be sensitive to seasonal constraints so that the programme and activities can be optimised.

Figure 5.8: Indicative Working Area for driving site (for illustrative purposes only – not site or solution specific)



Source: Mott MacDonald (Open Street Map Layer by ESRI)

Figure 5.9: Indicative Working Area for reception site (for illustrative purposes only – not site or solution specific)



Source: Mott MacDonald (Open Street Map Layer by ESRI)

5.7 Conclusion

The environmental performance of each of the installation options, is as per the paragraphs below.

For open cut with rock armouring (Permanent impacts to mudflat habitat) the score is **High (Dark Blue)** as permanent impacts will arise to European sites and there is a high risk of IROPI.

The score is **Moderate-High (Blue)** for a trenched solution that does not require rock armour and assuming works within the intertidal area can be conducted outside the main wintering bird period and late summer period when concentrations of Sites of Community Interest (SCI) birds will be using the area.

For HDD the score is **Moderate (Dark Green)** provided a suitable entry and exit pit can be located outside the European site boundary and noisy works can be conducted outside the main wintering bird period and late summer period, when concentrations of SCI birds will be using the area. The score would be Moderate-High (Blue) if the entry and exit pits are inside the boundary but can be reinstated without permanent loss.

Due to the reduced environmental impacts that an HDD installation may have as compared to other marine installation techniques, it is anticipated that where marine installations is progressed, only the identified feasible HDD alignments are likely to be considered in subsequent and separate analysis, outside the scope of this feasibility assessment.

Table 5.8: Cable routing methods through mudflat areas

Installation Technology	Methodology	Challenges	Opportunities
Drummed tracked vehicle and simultaneous burial	The marine cable would be delivered to site and coiled onto the installation vehicle close to the installation alignment. The vehicle would locate near to joint location and commence laying and burial along the route. At the second end the cable would be streamed out and mechanically located into the second joint bay.	• Sufficient area to mobilise and load the vehicle. • Localised disruption during installation. • Future maintenance and repairs could be disruptive and require permissions. • Installation equipment is bespoke and not available locally. • Construction programme likely to be subject to challenging seasonal constraints.	• Simultaneous lay and burial • Not water depth restricted
Horizontal Directional Drilling (HDD)	Involves drilling a directionally controlled pilot hole (normally around 50-75 mm in diameter) from a surface position though to a surface or reception pit located at the far side. The pilot hole is then subsequently enlarged to form an over wash pipe prior to reaming out to allow follow on installation of the product pipe.	• Thermal ratings for the cable system may be difficult to achieve where deep burial is involved. • Large laydown areas may be required for the work activities including layout of the HDD pipe. • Large bend radius of the pipe may force a longer drill length than would otherwise be required. • Distances greater than 1km will require special consideration • Maximum distance likely to be <2.0km. • Construction programme likely to be subject to challenging seasonal constraints. • Area for exit / entry points rely on space availability – unclear whether this space exists outside of the environmental constraints.	• Allows ducts to be routed under obstacles • Relatively unobtrusive and uses equipment that can be operated from the surface • Avoids changes in network cable type • Reduces the surface environmental disturbance in the mudflats • Not weather dependent

6 Feasibility of Fluid Filled Cable Decommissioning Works

This section defines specific considerations to be made regarding the feasibility of decommissioning the three Fluid Filled Cable systems under study and presents techniques that can be applied to decommissioning systems of this nature.

6.1 Considerations for Decommissioning

Typical considerations for decommissioning fluid filled cable systems include safety, the environment, social impacts (disruption), future land use, system spares and costs. These are briefly discussed below.

6.1.1 Safety

Safety implications for each option are to be considered i.e., it may be safer to delay trenching out a circuit if it has an adjacent live circuit until both circuits are offline and can be safely decommissioned together.

6.1.2 Environment

Leaks in Fluid Filled Cables become more recurring partly due to the asset life of the cable system. Simply abandoning cables that still contain significant amounts of dielectric oil without suitable monitoring could potentially result to risk of unmonitored oil leakages as a result of continued deterioration.

It is particularly important to assess the environmental implications for decommissioning fluid filled cables. The impact of any potential oil leaks will be dependent on the location of the cable system i.e., if a cable system crosses through an environmentally sensitive area. Risks will vary depending on what decommissioning technique is used and, in some cases, it can be difficult to assess.

6.1.3 Disruption

Other land users may wish to use land while cable circuits are being decommissioned, i.e., road users in an urban place. Different decommissioning techniques need to be considered to evaluate which will practicably reduce the disruption.

6.1.4 Future Land Use

Existing fluid filled circuits may be in land that has development plans. If unused cables are left in the ground, there will be hazards to the developers for the potential re-use of the land. All equipment i.e., cables, oil tanks would need to be removed prior to release of land with the existing fluid filled cables either owned or obtained by wayleaves. In some cases, it may be better to retain the land of interest and the unused equipment.

At points where unused equipment is retained or used for a different purpose than originally intended, the cable system should be maintained, and records of the cable route kept in order to monitor health, safety and environmental risks.

6.1.5 Spares

Consideration is to be given to recovering potential equipment that can be held as spares for similar equipment remaining in service elsewhere. Additional work can be done to verify if the equipment is fit for reuse i.e., forensic analysis to estimate the asset condition for the equipment on the system.

6.1.6 Cost

The cost of each technique should be evaluated to ensure that benefits of any options are cost effective.

6.2 Methods of Decommissioning

Potential decommissioning methods are described below although other solutions may exist depending on the specific cable system installation. For each of the individual cases of the existing route, a range of options are considered to select a suitable decommissioning method taking into account economic costs and disruptions to both the asset owner, operator and land users. In addition, health, safety, and environmental risks generated with the process should be considered, this may result in different sections of the route using different decommissioning methods.

6.2.1 Removal of Cables and Joints by Open Trenches

In this method, all equipment (including ancillary equipment such as oil tanks and link boxes) are removed by excavation allowing the asset owner to release the land from operational status. This technique avoids long term risks associated with oil leaks from fluid filled cable systems, however removal of the existing cable and joints is costly and can cause major disruption to highways and other land users. As such, it is a relatively costly solution and may introduce short term safety and environmental risks associated with the handling of dielectric fluids and potentially contaminated ground.

Where fluid filled cables can be easily assessed i.e., in culverts, troughs and bridges, full removal needs to be considered as a favourable option.

It is usual that the cable ends and terminations at substations would be removed as far as the substation boundary or other practicable location within or beyond the substation.

6.2.2 Removal of Joints and extraction of Cable cores

In some instances, it is possible for cable cores to be pulled out of the cable. This results in recovering the copper conductor and oil paper insulation while cable joints are removed by excavating a pit at the joint bay location. The cable sheath and duct are cleaned and retained to limit any long-term risk of oil leakage leaving an unfilled duct that would form a part of a new asset. In addition to this, all cable ancillary equipment (i.e., link boxes and oil tanks) are removed. Current technologies limit the ease with which this technique can be applied, and the effectiveness of this technique depends on the cable system and installation.

6.2.3 Purging by Nitrogen and Further Draining

Oil is removed from the system by flushing the cable with nitrogen. Oil trapped in the insulation is further removed by fitting drainage/ monitoring points at set intervals to further drain the cable at low points. Nitrogen is used instead of compressed air to avoid the build-up of explosive mixtures of oil vapour and air. Several purges may be required to remove a substantial fraction of the oil from the cable and time between the purges should be allowed for the oil to drain out. Cable joints can be left in the ground or removed, however other ancillary equipment such as oil tanks and link boxes are removed. On completion of the process all cable ends are sealed with the provision of a bleed pipe for future monitoring of any fluids that may build up in the remaining system. Cable fluids removed from decommissioned cables are treated as hazardous waste and must be safely disposed of by specialist licensed contractors.

This solution reduces disruption and costs during decommissioning; however, the cable will still need to be removed if the land is to be released. In such a case, the risk of any remaining cable oil needs to be considered.

6.2.4 Removal of Oil by Pusher and Accelerated Biodegradation of Oil

A “pusher” compound is used to remove the oil from the cable. A pusher compound can either be set to encapsulate the oil or bacteria can be introduced to speed up the biodegradation of the oil. The cable remains in the ground while the cable joints can either be removed or left in the ground. However, the cable will need to be removed if the land is to be released and the risk of any remaining cable oil needs to be considered (although the risk is lower than nitrogen purging above). Ancillary cable equipment such as oil tanks and link boxes are removed, this technique reduces disruption to land users during decommissioning.

6.2.5 Maintain and Monitor Oil pressure on the system

This is not strictly a decommissioning technique but is an option to be considered particularly where the cable system is demonstrated to be in good condition. Any leaks can be detected by loss of pressure and action can be taken to rectify the situation. It is noted, however, that there is a commitment to the replacement of fluid filled cables on the network and this technique would not remove the risk of further oil spillages or leaks. This technique is therefore not considered to be a suitable option.

6.3 Oil tanks for removal

Table 6.1 and Table 6.2 provide the locations and details of oil tanks on the Inchicore – Poolbeg routes that will need to be removed as part of the decommissioning process, while Table 6.3 provides the same information for the Carrickmines – Poolbeg route.

Table 6.1: Inchicore – Poolbeg #1 Existing Oil Tank Locations

Tank Size	Pressure Capacity	Location
3 x 36 L	1.5 Atmospheres	Poolbeg 220 kV Generating Station
9 x 300 L	2.0 Atmospheres	Poolbeg 220 kV Generating Station
3 x 88 L	1.5 Atmospheres	Poolbeg 220 kV Generating Station
3 x 300 L	1.5 Atmospheres	Poolbeg 220 kV Generating Station
18 x 300 L	-	Pembroke Road
2 x 9 x 300 L	-	O’Leary Road/ Devoy Road
6 x 300 L	1.5 Atmospheres	Inchicore Substation

Source: Route Records

Table 6.2: Inchicore – Poolbeg #2 Existing Oil Tank Locations

Tank Size	Pressure Capacity	Location
3 x 36 L	1.5 Atmospheres	Poolbeg 220 kV Generating Station
9 x 300 L	2.0 Atmospheres	Poolbeg 220 kV Generating Station
3 x 88 L	1.5 Atmospheres	Poolbeg 220 kV Generating Station
3 x 300 L	1.5 Atmospheres	Poolbeg 220 kV Generating Station
6 x 300 L	-	Wilton Terrace

Tank Size	Pressure Capacity	Location
9 x 300 L	-	Wilton Terrace
15 units, capacity not specified	-	Dolphin Road (Herberton Road)
6 x 300 L	1.5 Atmospheres	Inchicore Substation

Source: Route Records

Table 6.3: Carrickmines – Poolbeg Existing Oil Tank Locations

Tanks Size	Pressure Capacity	Location
3 x 36 L	1.5 Atmospheres	Poolbeg 220 kV Generating Station
9 x 300 L	2.0 Atmospheres	Poolbeg 220 kV Generating Station
3 x 88 L	1.5 Atmospheres	Poolbeg 220 kV Generating Station
3 x 300 L	1.5 Atmospheres	Poolbeg 220 kV Generating Station
6 x 300 L	2.5 Atmospheres	Park Avenue (St. Johns Road)
6 x 300 L	3.0 Atmospheres	Park Avenue (St. Johns Road)
6 x 300L	-	Fosters Avenue
9 x 300 L	3.0 Atmospheres	North Avenue/ Greenfield Road
3 x 300 L	3.0 Atmospheres	North Avenue/ Greenfield Road
18 x 300 L	3.0 Atmospheres	Weirview Drive/ Ellesmere/ Brewery Road
6 x 300 L	-	Weirview Drive/ Ellesmere/ Brewery Road
6 x 300 L	2.0 Atmospheres	Carrickmines Power Station

Source: Route Records

6.4 Conclusion

All oil tanks and associated equipment for the existing fluid filled cable routes are recommended to be removed as part of the fluid filled cable decommissioning works irrespective of the routes that may have a potential of being reused. Where a section of the route may not require full removal, it is expected that the system in that section will be decommissioned through nitrogen purging as detailed in Section 6.2.3 to avoid unnecessary disruption. Use of a pusher compound to either encapsulate the oil or speed up the biodegradation of the oil could be used where there is either advantage or a requirement.

It is considered that decommissioning as described in the above paragraphs is feasible (and appropriate given their location and sensitivities) and will likely be undertaken after the offline replacement of the circuits under assessment. This would allow for more flexibility in the approach to decommissioning.

7 Indicative Costs and Construction Programme

7.1 Cable Costs

This section outlines the basis used for the development of order of magnitude capital costs for each cable system to be replaced.

The costs were assessed based on a standard per km cost for the following activities in an urban environment:

- Installation of 2500mm^2 Cu XLPE land cable (new trench)
- Installation of 2500mm^2 Cu XLPE land cable (direct replacement of fluid filled cables)
- Single bore HDD (700mm diameter).

To assess the costs, a number of broad assumptions have been made that include the following:

- Ground not along the alignment of the existing fluid filled cable routes is uncontaminated and does not require remediation
- Ground along the alignment of the existing fluid filled cable routes may be contaminated and requires remediation or disposal
- Crossing of existing bridges will be approximately twice the normal trenched route costs due to additional mechanical protection measures and constrained working conditions
- Trenchless crossings will be by HDD using a large diameter (e.g., 700mm) single bore containing four internal ducts
- Traffic management will attract a cost equal amongst all schemes on a per metre basis

Where contaminated land risk is concerned all waste generated will be required to be managed in accordance with the Waste Management Act 1996, as amended. Therefore, where there is a risk of contaminated land, an additional cost has been applied to account for disposal to landfill and other specialist contractor services including excavation works. While a generic cost has been applied, the actual cost for disposal/treatment of contaminated land could vary significantly depending on the concentration and type of contamination encountered and the treatment / disposal route required.

All costs have been derived from our internal cost database. This database is reviewed and updated on a frequent basis with information gathered through our involvement on many cables projects throughout Ireland and the UK. The costs are considered to be sufficiently accurate to evaluate options against each other, however these should not be used to inform an overall project budget and should be refined as the project develops through subsequent stages. Appropriate surveying is recommended to be undertaken to ascertain the risk and requirements along a route and improve cost certainty. For example, actual costs could be higher or lower dependent on the type of contamination, quantity of services encountered, contamination measures and required treatment/ remediation, special handling and imported fill. The per km cost of each installation type can be found in Table 7.1 below.

Focus has been given to comparisons for the costs of indicative online versus offline replacements which are provided in Table 7.2 for Inchicore – Poolbeg and Table 7.3 for Carrickmines – Poolbeg. For both indicative costing assessments, offline replacement has been assumed to be up to 20% longer as a reasonable account of the potential for longer deviations as compared to the existing route.

In the case of Inchicore, the 12.5km Inchicore – Poolbeg #2 has been used as the basis of online replacement, and with respect to its offline comparison, it has been assumed that the last 2km in Poolbeg could potentially be an online replacement due to the existing congestion of services in the area.

For Carrickmines, the offline costing assessment includes a 1.6km HDD under Dublin Bay, with a short allowance for online replacement at the termination points.

It should be noted that these assumptions are for the purposes of comparative cost analysis between indicative online and offline replacement, and are not intended to suggest any route option, installation methodology, circuit length, or expected capital costs.

The tables show that online replacement has the potential to be approximately double the cost of the indicative offline replacement.

Table 7.1: Unit Cost Summary

Item	Allocated Cost (€)	Unit
Installation of 2500mm^2 Cu XLPE land cable (new trench)	950,000	km
Installation of 2500mm^2 Cu XLPE land cable (online replacement of fluid filled cables)	3,400,000	km
Single bore HDD (700mm)	5,000,000	km

Table 7.2: Cost comparison for Inchicore – Poolbeg #2

Installation Type	Online Replacement		Offline Replacement	
	Length (km)	Cost (€)	Length (km)	Cost (€)
Installation in Regular Trench	0	0	13	12,350,000
Re use of Existing FFC Route	12.5	42,500,000	2	6,800,000
TOTAL	**12.5**	**42,500,000**	**15**	**19,150,000**

Table 7.3: Cost comparison for Carrickmines – Poolbeg

Installation Type	Online Replacement		Offline Replacement	
	Length in km	Cost	Length in km	Cost
Installation in Regular Trench	0.00	0	15.6	14,820,000
Re use of Existing FFC Route	14.50	49,300,000	0.2	680,000
HDD across Dublin Bay	0.00	0	1.6	8,000,000
TOTAL	**14.50**	**49,300,000**	**17.4**	**23,500,000**

7.2 Construction Programme

For comparison purposes we have considered the indicative offline and online builds used for the costing exercise and have provided high level durations for the various civil, electrical, commissioning and cable works.

The durations assume that all installation works are completed by three crews. Using multiple crews to perform the works is necessary to control the project installation schedule to a more acceptable duration but would be subject to crew availability. Using a single crew would result in project durations in the order of 10 years or more and is not considered feasible. The following assumptions have been considered when estimating the durations on the construction schedule.

- Cable works include detailed design for the manufacture, delivery and installation of the entire cable system and accessories. No allowance has been made for OEM factory availability to begin manufacture which will vary between OEMs and supply contracts.
- Civil works include underground cable trenching and ducting including trenchless installations as well as time required for setting up of traffic management and exposing existing utility services.
  - Installations where removal of FFC may not be required is assumed to be completed at the average rates provided in Table 7.4 below depending on the type of receiving environment (i.e., City Centre, Urban or Sub-Urban), as informed by EirGrid.
  - Installations that involve re-use of existing FFC alignment are assumed to be completed at approximately half the rate for installation only to allow for system purging, trenching, environmentally safe preparation of work site (e.g., spill capture), cutting, removal and handling of fluid filled cable, additional suitable measures for handling and exporting contaminated trench material and other environmental protection measures, and installation of new ducts.
  - Delineations between types of receiving environment have been agreed with EirGrid. Where a route section is on a border, the lower of the installation rates is used.
- Electrical works include the following:
  - Cable pulling including duct proving will be a comparatively quick process compared to the jointing and termination activities and is considered to be managed in parallel with the jointing activities
  - Cable jointing and termination. Cable jointing and terminations need approximately 3 weeks per set of joints or terminations for completion. Allowing for excavation and joint bay preparation, site set up, execution of jointing works, preliminary testing, demobilisation, and reinstatement.
- Offshore cable routing works are assumed to be undertaken in parallel with the onshore works and will therefore not increase the schedule relative to the onshore works.
- Communications works are expected to be completed in parallel with the cable installation works.
- Commissioning for the cable system is assumed to take approximately 4 months, 2 months for preparation and testing and 2 months for commissioning of the entire system.

Table 7.4: Installation rates for cable civil works

Receiving Environment Type	Offline Installation Rate (m/day)	Online Replacement Rate (m/day)
City Centre	9	4.5
Urban	18	9
Sub-Urban	27	14

Source: EirGrid, Mott MacDonald

Figure 7.1 below shows the indicative construction schedule for the online replacement of Inchicore – Poolbeg #2. The civil works are estimated to require 36 months of work for three crews spread over six full outage seasons. Electrical works are similarly spread as cable pulling and jointing of the new XLPE cable to the existing FFC will be required to bring the circuit back into service. The estimated programme for online replacement for this circuit is approximately seven years which would need to be completed prior to the start of works on the replacement of Inchicore – Poolbeg #1.

Figure 7.2 demonstrates an offline replacement programme. Works can progress continuously without impacting system operation with outages only required at the end for the online replacement works and system commissioning. The gap in the civil installation is to account for the need to complete the online works during an outage season at the end of the programme.

It is considered that similar considerations and programmes would be applicable to Inchicore – Poolbeg #1 as well as for Carrickmines – Poolbeg.

Figure 7.1: Indicative Construction Schedule for online replacement of Inchicore – Poolbeg #2

TASK	No. Of	Year 1				Year 2				Year 3				Year 4				Year 5				Year 6				Year 7			
Cable System Construction Schedule	Months	3	6	9	12	15	18	21	24	27	30	33	36	39	42	45	48	51	54	57	60	63	66	69	72	75	78	81	84
Cable Works																													
Cable Manufacturing	10																												
220 kV Cable Delivery and Accessories	4																												
Civil Works																													
UGC Trenching and Ducting (Including Trenchless Installations)	35																												
Electrical Works																													
Cable Pulling, Jointing and Termination (12.5 km Land route length)	15																												
Commisioning																													
Testing	2																												
Commisioning	2																												

Source: Mott MacDonald

Figure 7.2: Indicative Construction Schedule for offline replacement of Inchicore – Poolbeg #2

TASK	No. Of	Year 1				Year 2				Year 3				Year 4				Year 5				Year 6				Year 7			
Cable System Construction Schedule	Months	3	6	9	12	15	18	21	24	27	30	33	36	39	42	45	48	51	54	57	60	63	66	69	72	75	78	81	84
Cable Works																													
Cable Manufacturing	10																												
220 kV Cable Delivery and Accessories	4																												
Civil Works																													
UGC Trenching and Ducting (Including Trenchless Installations)	26																												
Electrical Works																													
Cable Pulling, Jointing and Termination (15 km Land route length)	16																												
Commisioning																													
Testing	2																												
Commisioning	2																												

Source: Mott MacDonald

7.3 Outage Requirements

The requirement to excavate and remove the existing circuits at a specific part of the route would depend on the locations where alignment of the existing FFC would be utilised. For an online cable system replacement outage, the duration is anticipated to be longer due to the need for the existing circuit to be out of service during both civil works and electrical works. The works during the outage will also need to factor in sufficient time for the reconnection of the newly installed cable to the old FFC cable.

For offline replacement the outage duration will be substantially less and will largely comprise of testing and commissioning works at the end of the construction programme. Table 7.5 below gives estimated outage durations in terms of months and outage seasons. It is anticipated that offline installation will likely require no more than a two outage seasons although it may be possible to complete the works within one season. By comparison online construction will require multiple season outages.

Table 7.5: Online vs Offline Outage Requirements

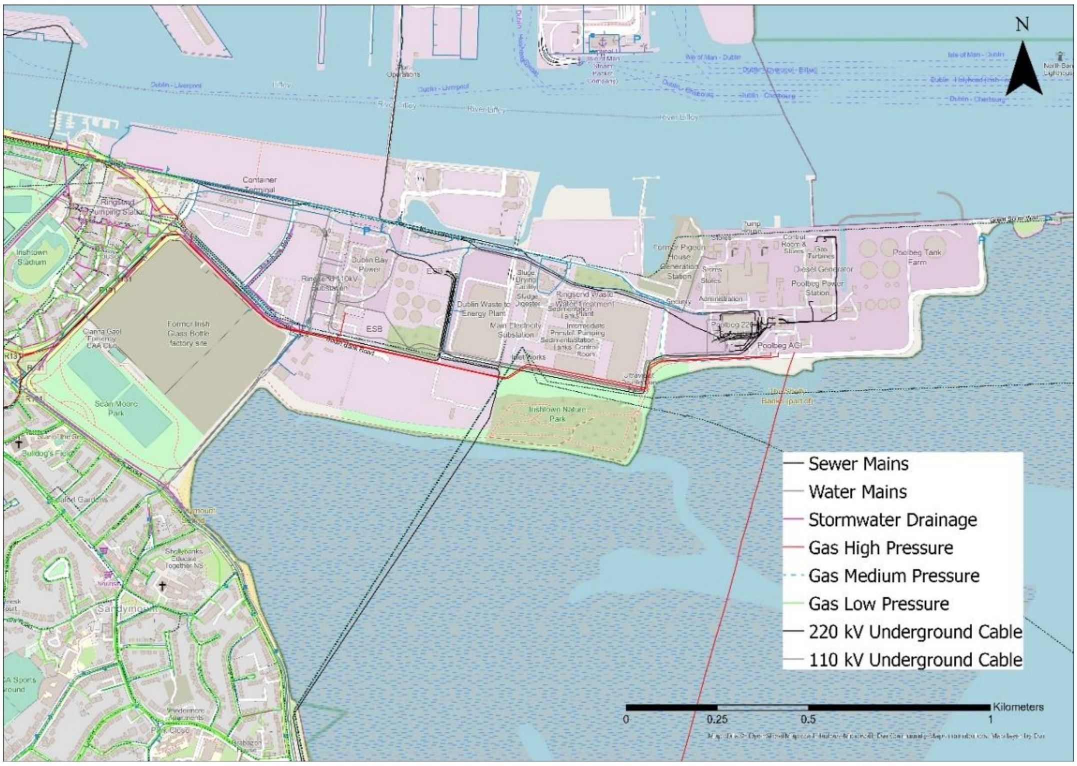
Circuit	Online (months / seasons)	Offline (months / seasons)
Inchicore – Poolbeg #1	33 / 6	6 / 2
Inchicore – Poolbeg #2	35 / 6	6 / 2
Carrickmines - Poolbeg	28 / 5	6 / 2

Source: Mott MacDonald

7.4 Installation in and around Poolbeg

Availability of outages and working in close proximity to existing HV services, particularly in the Poolbeg areas, will be complex and will require substantial engineering effort. The density of utilities in the Poolbeg area is shown in Figure 7.3. A thorough investigation of the area is required to establish the location and installation specifics of all services in the area to inform outage, programme, and safety plans. Particular regard should also be given to other infrastructure projects (both electrical and otherwise) within the area. Stakeholder engagement will be vital in this regard.

Figure 7.3: Utility Congestion in Poolbeg



Source: Mott MacDonald (Open Street Map Layer by ESRI)

8 Considerations for Tunnels

Whilst currently considered to be feasible, offline replacement of existing cable circuits has significant impacts with regard to utility congestion, constrained key infrastructure crossings, social impacts (e.g., traffic) and some options could have potential significant environmental impacts such as across Dublin Bay SAC.

An alternative potentially feasible option to the surface level installation techniques considered for the routes above would be the installation of a tunnel system for the new circuits. The merit of such a solution has not been considered in detail in this report as this would require a detailed geotechnical study, identification and assessment of available land throughout Dublin for construction purposes and the location of associated above-ground infrastructure (e.g., headhouses). This would be a significant undertaking and is considered to be beyond the scope of the present study. However, the sections below provide an initial overview of some of the advantages and disadvantages that may be applicable when considering the feasibility of a tunnel solution relative to the potential feasibility of online and offline surface-based cable replacement considered this far.

8.1 Tunnel Construction

Tunnel construction involves using a Tunnel Boring Machine (TBM), which is lined up with pre-cast concrete segments built into rings behind the machine's cutter head. The segments are delivered to the face on rail bound vehicles drawn by locomotives. The gap between the cut ground and lining is grouted as the TBM moves forward. There are number of options for the type of TBM, selection of which will depend on the outcome of ground investigations and rock properties.

A TBM uses bentonite slurry at the face of the chamber to stabilise the face during excavation works. Excavated material is then removed from the face in the slurry and separated at the surface before recirculation of the slurry.

If the ground is impermeable, it might be possible to use an open face rock machine. Grouting of the surface can be done to reduce fluid inflows. An Earth Pressure Balance Machine (EPBM) can also be used to support the face and to prevent water inflows.

A crane is required for raising and lowering materials in the drive shaft. During tunnelling, pre-cast concrete segments are delivered to the chamber and large amounts of earth are removed from the tunnel drive site. Sufficient storage and disposal working areas are required at the drive and reception sites. There could be multiple drive and reception sites required dependent on the length of the route.

8.2 Advantages

Overall disruption of road users during construction works is significantly reduced as the majority of the work takes place underground. Above ground construction sites would be limited to the shaft location sites which would be expected to be situated approximately every 3-5km.

Full unimpeded access to the cable system is possible and therefore maintenance and repair work on the cable circuits can also be carried out without significant interference to traffic, businesses, and residents.

Cigre attribute around 50% of faults on land cables to third party activities. As the proximity of third-party activities are almost completely removed by a tunnel system, the occurrence of faults on cable systems in tunnels are statistically rare.

A tunnel system can accommodate multiple cable systems to meet future cable demands as long as the tunnel and the ventilation system are sized appropriately. This needs to be considered at the design stage as once the tunnel diameter is fixed, it would not be possible to change without significant challenge and expense.

Failure modes become important once circuits are in operation e.g., consideration should be made for working conditions when a system requires maintenance and other circuits are live, or the risk to operational circuits if a parallel system fails during operation.

Future uprating or replacement of cable systems could also be accommodated without significant disturbance to the public.

Cable tunnelling systems provide improved knowledge of the current status and condition of the cable system due to the ability to physically/visually inspect and observe. Tunnel systems are generally considered to be more reliable for longer cable lengths. Although they carry a significant cost; the economic case improves for longer lengths and larger quantities of cable systems.

Circuit ratings can be improved through forced ventilation and optimization of bonding lengths as joint bay positions can be placed more uniformly than when installed at ground surface level.

Tunnel design life is in the order of 100 years meaning that a tunnel system can be re used for future circuits. The likely significant depth of installation means there are anticipated to be few existing utility constraints impacting on the alignment of the installation.

8.3 Drawbacks

Cable tunnels construction is generally costly and requires a significant investment.

Alignment is dependent on geotechnical conditions and above ground availability of space for headhouses. A comprehensive and extensive Geotechnical Investigation (GI) and route planning exercise is a key requirement. Tunnelling systems are only relatively cost effective compared to open trenching or other installation methods on a per kilometre basis for long tunnel distances and multiple circuits.

There are a number of operational risks introduced with a cable tunnel option, these include:

- working in confined spaces
- the need to reduce maintenance as much as possible to reduce the requirements for tunnel entry
- Insulated working to avoid the need to install and manage additional (earthing) conductors within the tunnel and avoid RoEP issues associated with the earthing conductor.
- Fire control and common mode failure events
- Training of employees for tunnel entry and/or availability of contractors to support tunnel entry and maintenance procedures (e.g., trained jointer with confined space training availability)

Ability to control temperature in the tunnel affects the thermo-mechanical design of the cable system. During operation and depending on the rate of rise of temperature in the tunnel system and cable design, the cable will expand and contract. Uncontrolled expansion and contraction of the cable may result to fatigue of the cable which may lead to reduced system life and ultimately result in cable failure.

Careful consideration needs to be given to thermal ratings and thermo-mechanical design of the cable tunnelling system. Thermal time constraints for in air installations are very short, therefore optimum performance of the cable ratings highly depends on the tunnel ventilation system. Poor ventilation system in the tunnel may lead to significant reduction of cable circuit ratings.

Limitations on tunnel ventilations systems for cable ratings and fire safety requirements would typically mean that headhouses are required approximately every 3 to 5km.

Secondary risks associated with tunnelling installations include induced/ impressed voltages where multiple systems are installed in the same tunnel. These risks are generally mitigated through correct design and the provision of safe systems of work.

8.4 Tunnel Costs

Costs for tunnel systems will vary due to aspects including geography, contractor experience, geotechnical conditions and client specific requirements.

An assessment of how many systems could be installed in a 4m diameter tunnel has not been completed but we would typically expect at least four large conductor systems. If it were possible to install a combination of 220kV and 110kV circuits, then whilst the total cost is almost certainly going to be greater for a tunnel, the comparative margin would not be as great.

8.5 Recommendations for Subsequent Project Stages

The feasibility of a cable tunnel requires detailed assessment beyond the scope of this report. In the event that a tunnel proves to be a feasible solution then further detail would need to be gathered, including as follows:

- Indicative options and route identification
- Assessment of the tunnel's integration into, and value provided for, the network development masterplan
- A detailed geotechnical investigation campaign to validate the feasibility of the tunnel
- Review of failure modes, their likelihood and impact within the tunnel and identification of those with multi-circuit consequences and mitigation methods for each

9 Conclusion

EirGrid has made a commitment to the replacement of all Fluid Filled Cables (FFC) from the Dublin electricity transmission system. This is due to the recognised environmental risk, EirGrid maintenance policy and the age/condition of these assets. In addition, future scenario network planning has identified system uprating requirements that necessitate the replacement of the following existing underground FFC transmission circuits within the city of Dublin:

- Inchicore – Poolbeg #1 220 kV cable
- Inchicore – Poolbeg #2 220 kV cable
- Carrickmines – Poolbeg 220 kV cable

These circuits have sensitivities surrounding their replacement as they have reached end of asset life but are required in the future scenario analysis for the transmission system. A straightforward retirement of the systems is therefore not possible. The potential feasibility of online and offline replacement of these circuits has been assessed with consideration of their relative merits.

Online replacement comes with the complexities of decommissioning a circuit at the same time as installing a new circuit. The replacement works are likely to be slow progressing at around half the rate of an offline installation. In addition, to install the new circuit would require a circuit outage for the full duration of the installation works and would likely be restricted to the outage seasons. As this project requires the replacement of three cable circuits, the anticipated outage restrictions and longer construction durations associated with recover and replace, mean that project completion using direct replacement along existing routes is anticipated to not to meet EirGrid Shaping our Electricity Future timelines. Considering this, offline routes are advised to be used wherever practicable. Re-use of existing routes should be limited to areas where a reasonable and feasible alternative cannot be identified to limit outage durations to a minimum.

Geospatial datasets were acquired from a variety of sources for the purposes of the review. Heatmapping was undertaken to provide a visual representation of the density of constraints across the onshore study area, both in isolation and in combination. An analysis of this data suggests that offline replacement of these existing cable, while inevitable challenging given the urban and inner-city locations, is feasible.

The marine assessment concluded that a subsea cable option is likely to incur significant resistance for environmental reasons and that a bay crossing may be best achieved through HDD of a length up to around 2km and would likely be required for at least one circuit due to the constrained corridors around Poolbeg. A 2km HDD cable installation is considered to be very long and will require special engineering attention to develop a working design solution.

In line with EirGrid's six-step Framework for Project Development, it is anticipated that further work that considers stakeholder commentary based on the findings of this report will result in the identification of Best Performing Options (BPOs).

In relation to the BusConnects Dublin Project, given the current timescales of that project it is important that consultation with the project sponsor (National Transport Authority) is undertaken to ensure any significant road changes are known which could impact on future works associated with the new cables.

Early consultation is recommended with DLRCC / DCC regarding any subsequent process of identification of route options for the Carrickmines to Poolbeg route and the Inchicore to Poolbeg route.

It is noted that recent development plans have indicated that the Eastern Bypass is no longer being pursued and this should be addressed with the local authorities during the subsequent route design stages of the project..

The assessment completed to date considers the feasibility of underground cable routing having regard to primary underground services only. These include primary gas, water and sewage services and transmission systems with operational voltage of 38kV and above. Subsequent analysis and route evaluation will require further consideration of the routes against the location of smaller and lower voltage supplies and services. Ultimately, a chosen route will require verification through both non-invasive and invasive route-proving exercises. Route-proving in busy and constrained areas may be difficult.

Consideration can be given to installing suitable ducts designed to accommodate standard 400kV cables as an option for future uprating of the system should network requirements necessitate. It should be noted that in such a case, designing a 400kV circuit with a particular desired rating may not be possible as the rating would largely be defined by the existing duct-bank system at the time. It may be possible to modify specific locations to remove a particular constraint if found to be beneficial.

The study area in general is congested in terms of utilities and traffic. An opportunity for the installation of a cable tunnel has been identified in mitigation of this and the advantages and disadvantages of a tunnel are briefly discussed. The feasibility of a cable tunnel requires detailed assessment beyond the scope of this report. It is noted that there may be a strategic case for a cable tunnel associated with future system developments and demand. It is considered that it may be beneficial to investigate the feasibility of such a system for comparison and future planning purposes.

Appendices

A. Mapping

B. Data Sources

Name of dataset	Theme	Source
Architectural Conservation Areas	Environmental	Dublin City Council
Candidate Conservation Areas	Environmental	Dun Laoighaire Rathdown County Council
Conservation Areas	Environmental	Dun Laoighaire Rathdown County Council
Grassland Habitats	Environmental	The National Parks and Wildlife Service
National Survey of Native Woodland Habitats	Environmental	The National Parks and Wildlife Service
National Survey of Native Woodland Releves	Environmental	The National Parks and Wildlife Service
Proposed National Heritage Areas	Environmental	The National Parks and Wildlife Service
Vegetation Relevés	Environmental	The National Parks and Wildlife Service
Special Areas of conservation	Environmental	The National Parks and Wildlife Service
Special Protected Areas	Environmental	The National Parks and Wildlife Service
Zones of Archaeological Interest	Environmental	Dublin City Council
Archaeological Survey of Ireland	Heritage	Department of Tourism, Culture, Arts, Gaeltacht, Sport and Media
Archaeological Survey of Ireland Zones of Notification	Heritage	Department of Tourism, Culture, Arts, Gaeltacht, Sport and Media
National Inventory of Architectural Heritage	Heritage	Department of Tourism, Culture, Arts, Gaeltacht, Sport and Media
Protected Structures	Heritage	Dublin City Council
Protected Structures	Heritage	Dun Laoighaire Rathdown County Council
Protected Structures	Heritage	South Dublin County Council
Canal	Hydrology	Ordnance Survey of Ireland Prime 2 Dataset
Canal Lock	Hydrology	Ordnance Survey of Ireland Prime 2 Dataset
Drain	Hydrology	Ordnance Survey of Ireland Prime 2 Dataset
Lakes	Hydrology	Environmental Protection Agency
Open Reservoir	Hydrology	Ordnance Survey of Ireland Prime 2 Dataset
Pond	Hydrology	Ordnance Survey of Ireland Prime 2 Dataset
River Network	Hydrology	Environmental Protection Agency
River Tidal	Hydrology	Ordnance Survey of Ireland Prime 2 Dataset
Single Stream Line	Hydrology	Ordnance Survey of Ireland Prime 2 Dataset
Stream	Hydrology	Ordnance Survey of Ireland Prime 2 Dataset
Water Line	Hydrology	Ordnance Survey of Ireland Prime 2 Dataset
Weir	Hydrology	Ordnance Survey of Ireland Prime 2 Dataset
110kV High Voltage Cable Circuit	Infrastructure	EirGrid
220kV High Voltage Cable Circuit	Infrastructure	EirGrid
Fixed Bridges	Infrastructure	Ordnance Survey of Ireland Prime 2 Dataset
High Pressure Gas Line	Infrastructure	Gas Networks Ireland
Rail and Tram Network	Infrastructure	Ordnance Survey of Ireland Prime 2 Dataset
Railway Bridge	Infrastructure	Ordnance Survey of Ireland Prime 2 Dataset

Name of dataset	Theme	Source
Sewer Mains	Infrastructure	Irish Water
Tram Platform	Infrastructure	Ordnance Survey of Ireland Prime 2 Dataset
Tunnel Rail / Road	Infrastructure	Ordnance Survey of Ireland Prime 2 Dataset
Water Mains	Infrastructure	Irish Water
Managed Woodland Coniferous	Land Use	Ordnance Survey of Ireland Prime 2 Dataset
Woodland Decideous	Land Use	Ordnance Survey of Ireland Prime 2 Dataset
Woodland Mixed	Land Use	Ordnance Survey of Ireland Prime 2 Dataset
Biodiversity Areas	Planning	Dublin City Council
Special Amenity Orders	Planning	Dun Laoighaire Rathdown County Council
Special Amenity Orders	Planning	Dublin City Council
Specific Objective Areas	Planning	Dun Laoighaire Rathdown County Council
Health Centres	Social	Health Service Executive
Nursing Homes	Social	Health Service Executive
Antiquity	SocioCultural	Ordnance Survey of Ireland Prime 2 Dataset
Arena	SocioCultural	Ordnance Survey of Ireland Prime 2 Dataset
Art Gallery	SocioCultural	Ordnance Survey of Ireland Prime 2 Dataset
Bus Depot	SocioCultural	Ordnance Survey of Ireland Prime 2 Dataset
Business Park	SocioCultural	Ordnance Survey of Ireland Prime 2 Dataset
Cemetery	SocioCultural	Ordnance Survey of Ireland Prime 2 Dataset
Church	SocioCultural	Ordnance Survey of Ireland Prime 2 Dataset
College	SocioCultural	Ordnance Survey of Ireland Prime 2 Dataset
Fire Station	SocioCultural	Ordnance Survey of Ireland Prime 2 Dataset
Garda Complex	SocioCultural	Ordnance Survey of Ireland Prime 2 Dataset
Golf Course	SocioCultural	Ordnance Survey of Ireland Prime 2 Dataset
Government Complexes	SocioCultural	Ordnance Survey of Ireland Prime 2 Dataset
Hospital Complex	SocioCultural	Ordnance Survey of Ireland Prime 2 Dataset
Hotel Complex	SocioCultural	Ordnance Survey of Ireland Prime 2 Dataset
Leisure Complex	SocioCultural	Ordnance Survey of Ireland Prime 2 Dataset
Library	SocioCultural	Ordnance Survey of Ireland Prime 2 Dataset
Monastery	SocioCultural	Ordnance Survey of Ireland Prime 2 Dataset
Museum	SocioCultural	Ordnance Survey of Ireland Prime 2 Dataset
Nursing Home	SocioCultural	Ordnance Survey of Ireland Prime 2 Dataset
Railway Station	SocioCultural	Ordnance Survey of Ireland Prime 2 Dataset
Railway Works	SocioCultural	Ordnance Survey of Ireland Prime 2 Dataset
Retail Park	SocioCultural	Ordnance Survey of Ireland Prime 2 Dataset
Schools	SocioCultural	Ordnance Survey of Ireland Prime 2 Dataset
Showground	SocioCultural	Ordnance Survey of Ireland Prime 2 Dataset
Sports Ground	SocioCultural	Ordnance Survey of Ireland Prime 2 Dataset
Sports Stadium	SocioCultural	Ordnance Survey of Ireland Prime 2 Dataset
Theatre Complex	SocioCultural	Ordnance Survey of Ireland Prime 2 Dataset
Water Works Complex	SocioCultural	Ordnance Survey of Ireland Prime 2 Dataset
Bus Eireann Routes	Transport	National Transport Authority
Commercial Bus Routes	Transport	National Transport Authority

Name of dataset	Theme	Source
Dublin BikeLife Routes	Transport	National Transport Authority
Dublin Bus Routes	Transport	National Transport Authority
Dublin Bus Stops	Transport	National Transport Authority
Luas Stops	Transport	Ordnance Survey of Ireland Prime 2 Dataset
Naptan Stop Areas	Transport	National Transport Authority
Naptan Stop Points	Transport	National Transport Authority

C. Heat Map Constraints

Table C.1: Table Heat Mapping Constraints

Dataset	Buffer (Metres)	Colour Weighting Key
110kV High Voltage Cable Circuit	1	**Green**
220kV High Voltage Cable Circuit	1.5	**Dark Green**
Antiquities	10	**Blue**
Archaeological Survey of Ireland (ASI)	10	**Blue**
Arenas	10	**Dark Green**
Art Galleries	10	**Green**
ASI Zone of Notification	1	**Dark Green**
Bus Depots	10	**Dark Green**
Bus Eireann Routes	10	**Green**
Business Parks	10	**Dark Green**
Canal Locks	1	**Dark Green**
Canals	1	**Dark Green**
Cemeteries	10	**Blue**
Churches	10	**Dark Green**
Colleges	10	**Dark Green**
Commercial Bus Routes	10	**Green**
DLRCC Candidate Conservation Areas	1	**Blue**
DLRCC Conservation Areas	1	**Blue**
DLRCC Protected Structures	10	**Blue**
DLRCC Special Amenity Orders	1	**Blue**
DLRCC Specific Objective Areas	1	**Blue**
Drains	1	**Green**
Dublin Bike Routes	10	**Green**
Dublin Bus Routes	10	**Green**
Dublin Bus Stops	2	**Green**
Dublin City Council Architectural Conservation Areas	1	**Blue**
Dublin City Council Protected Structures	10	**Blue**
Dublin City Council Zones of Archaeological	1	**Blue**
EPA Lakes	10	**Dark Green**
EPA River Network	10	**Dark Green**
Fire Stations	10	**Blue**
Fixed Bridges	10	**Yellow**
Garda Complex	10	**Blue**
Golf Courses	10	**Dark Green**
Government Complexes	10	**Green**
Grassland Habitats	1	**Dark Green**
Health Centres	10	**Green**

Dataset	Buffer (Metres)	Colour Weighting Key
High Pressure Gas Line	1	**Blue**
Hospital Complex	10	**Blue**
Hotel Complex	10	**Green**
Leisure Complex	10	**Green**
Libraries	10	**Green**
Luas Stops	2	**Green**
Managed Woodland Coniferous	1	**Dark Green**
Monasteries	10	**Green**
Museums	10	**Green**
National Inventory of Architectural Heritage	10	**Blue**
National Public Transport Access Nodes Stop Areas	2	**Green**
National Public Transport Access Nodes Stop Points	2	**Green**
National Survey of Native Woodland Habitats	1	**Blue**
National Survey of Native Woodland Releves	1	**Blue**
Nursing Homes	10	**Green**
Nursing Homes	10	**Green**
Open Reservoirs	1	**Dark Green**
OSI Single Stream Line	10	**Green**
OSI Water Line	10	**Dark Green**
Pedestrian Bridges	10	**Green**
Ponds	5	**Dark Green**
Proposed National Heritage Areas	1	**Dark Green**
Rail and Tram Network	5	**Blue**
Railway Bridge	10	**Dark Blue**
Railway Stations	10	**Dark Green**
Railway Works	10	**Dark Green**
Vegetation relevés	1	**Dark Green**
Retail Parks	10	**Green**
River Tidal (Liffey)	10	**Dark Green**
Schools	10	**Dark Green**
Sewer Mains	1	**Green**
Showgrounds	10	**Dark Green**
South Dublin County Council Protected Structures	10	**Blue**
Special Areas of conservation	50	**Dark Blue**
Special Protected Areas	50	**Dark Blue**
Sports Grounds	10	**Dark Green**
Sports Stadiums	10	**Dark Green**
Streams	10	**Green**
Theatre Complex	10	**Dark Green**
Tram Platform	1	**Blue**
Tunnel (Rail / Road)	10	**Dark Blue**
Water Mains	1	**Green**

Dataset	Buffer (Metres)	Colour Weighting Key
Water Works Complex	10	**Green**
Weirs	5	**Blue**
Woodland Deciduous	1	**Blue**
Woodland Mixed	1	**Blue**

D. Stakeholder Consultation Letter

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