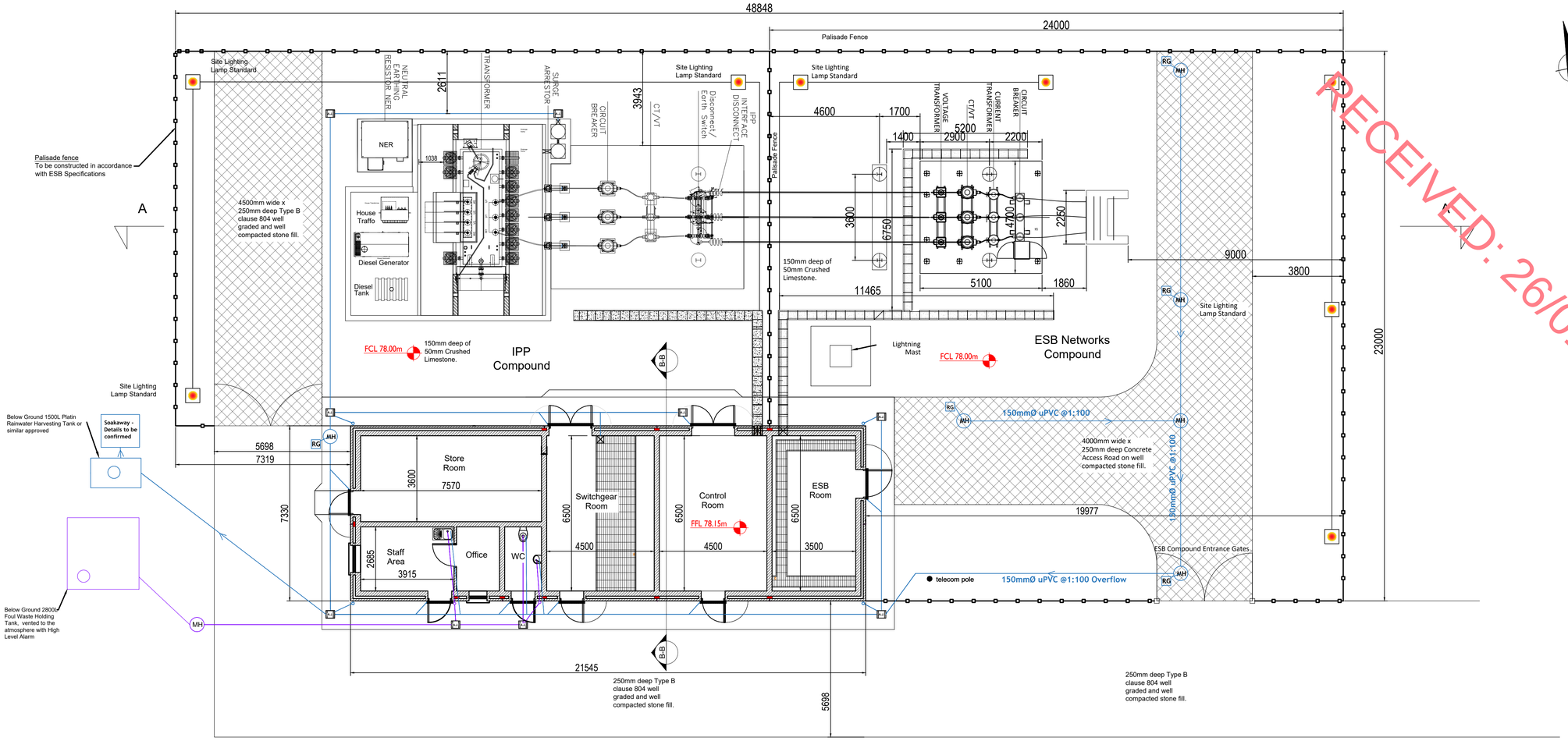
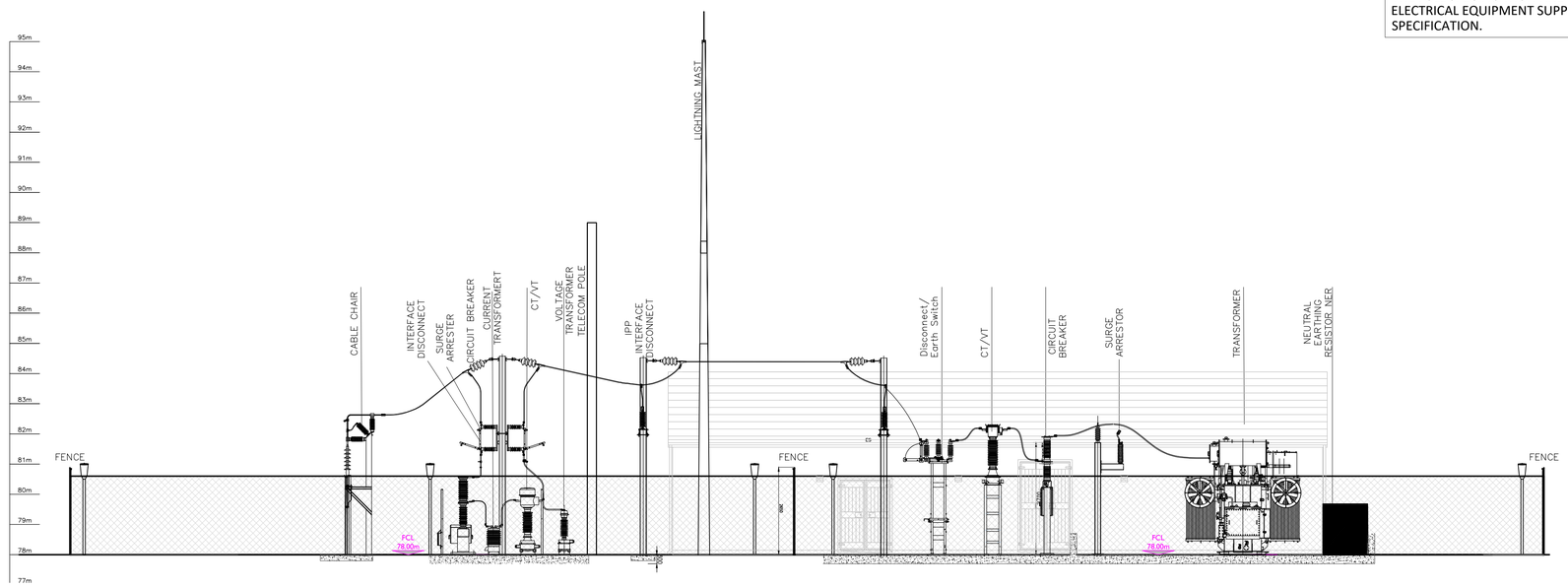
ISO A1 594mm x 841mm



Solar Farm-Substation Compound Layout

SCALE 1:100

PLEASE NOTE THAT THE SUBSTATION LAYOUT AND SUBSTATION COMPONENTS ILLUSTRATED ON THIS DRAWING ARE INDICATIVE ONLY. THE FULL SPECIFICATION AND DETAIL WILL BE DETERMINED FROM THE ELECTRICAL EQUIPMENT SUPPLIER AND ESB FUNCTIONAL SPECIFICATION.



Section A-A Through Substation Compound

SCALE 1:100

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PROJECT

Tullaghmore Wind Farm

38kV Substation

CLIENT

EMPower

CONSULTANTS

NOTES: -

- Configuration of substation equipment and infrastructure is subject to detailed design and ESB design approval.
- The proposed substation layout should be used for planning purposes only.
- This drawing is to be read in conjunction with relevant drawings, specifications and reports.
- Dimensions are in millimeters, unless noted otherwise.
- Drawings are not to be scaled use figured dimensions only.

LEGEND: -

Surface water drainage shown thus

Foul drainage shown thus

Lamp Standard shown thus

Proposed Levels Shown thus (Planning) FCL 54.60m

Proposed Levels Shown thus (Elevation and Sections) FCL 54.60m

Concrete Access Road shown thus

ISSUE/REVISION

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SHEET TITLE

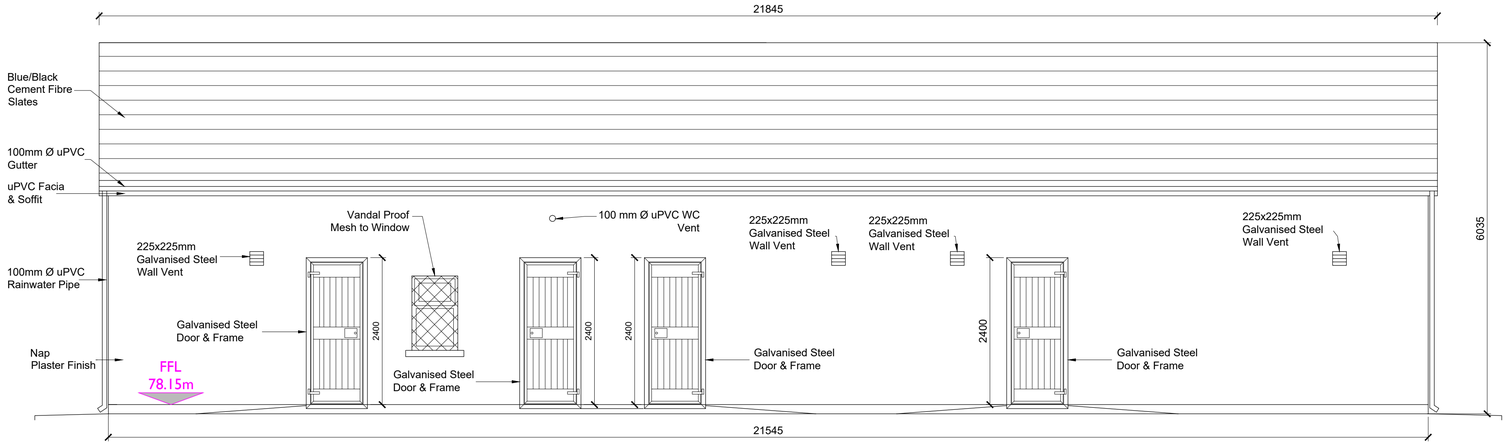
38kV Substation Compound Layout & Section

SHEET NUMBER

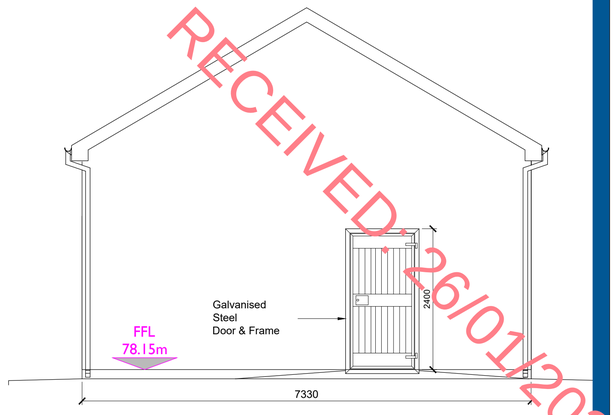
05830-DR-100

Project Management Initials: Designer: AF Checked: GH Approved: RG

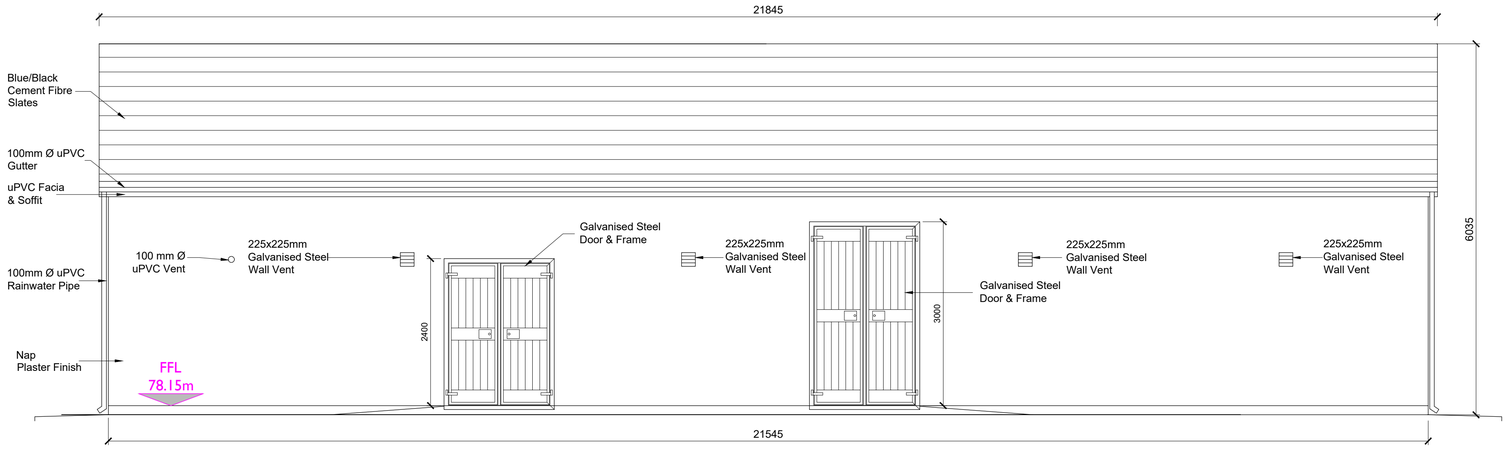
ISO A1 594mm x 841mm



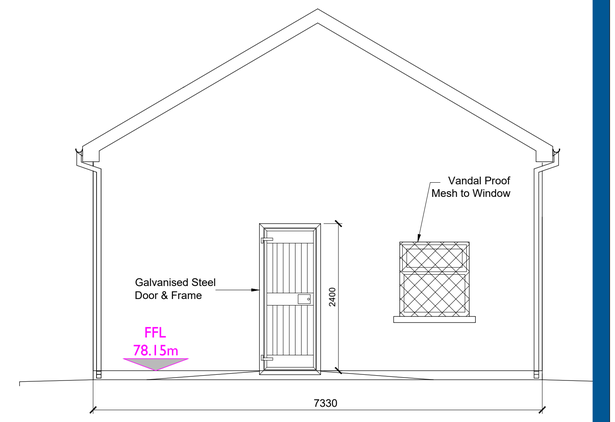
Front Elevation- South East
SCALE 1:50



Side Elevation- South West
SCALE 1:50



Rear Elevation- North West
SCALE 1:50



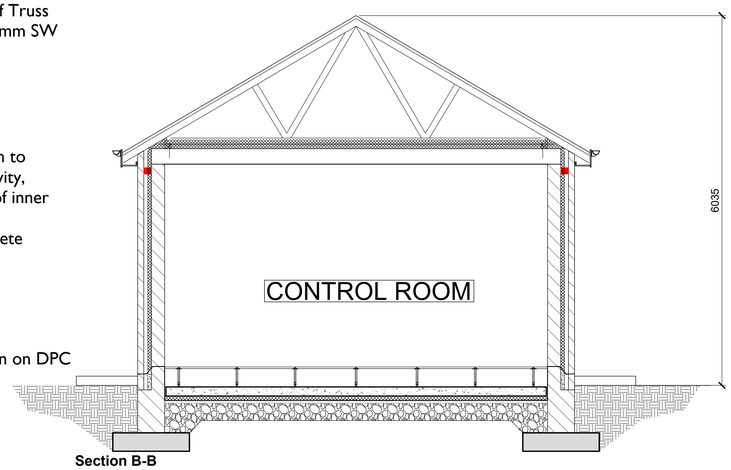
Side Elevation- North East
SCALE 1:50

Roof Construction:
Roof on,
treated SW Roof Battens on,
selected Breather Membrane on
selected SW Prefabricated Roof Truss
system fixed to treated 100x75mm SW
Wallplate.
Plasterboard internal ceiling.

Cavity Wall:
Flat Sand / Cement Plaster finish to
100mm Outer Leaf, 100mm Cavity,
215mm Inner Leaf. Inside face of inner
leaf to remain fair-faced.
Cavity wall supported on concrete
strip foundation.

Floor:
Raised Access Floor on
150mm Reinforced Concrete
Floor Slab on Selected Insulation on DPC
on Sand Blinding all supported
off Well Compacted Hardcore.

NOTE : Control Building surfaces need to be non - combustible



Section B-B
SCALE 1:50

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PROJECT

Tullaghmore Wind Farm
38kV Substation

CLIENT

EMPower

CONSULTANTS

NOTES: -

- Substation building is subject to detailed design and ESB design approval and should be used for planning purposes only.
- The proposed substation layout should be used for planning purposes only.
- This drawing is to be read in conjunction with relevant drawings, specifications and reports.
- Dimensions are in millimeters, unless noted otherwise.
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LEGEND: -

Proposed Levels Shown thus (Elevation and Sections) FCL 96.40m

ISSUE/REVISION

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05-830

SHEET TITLE

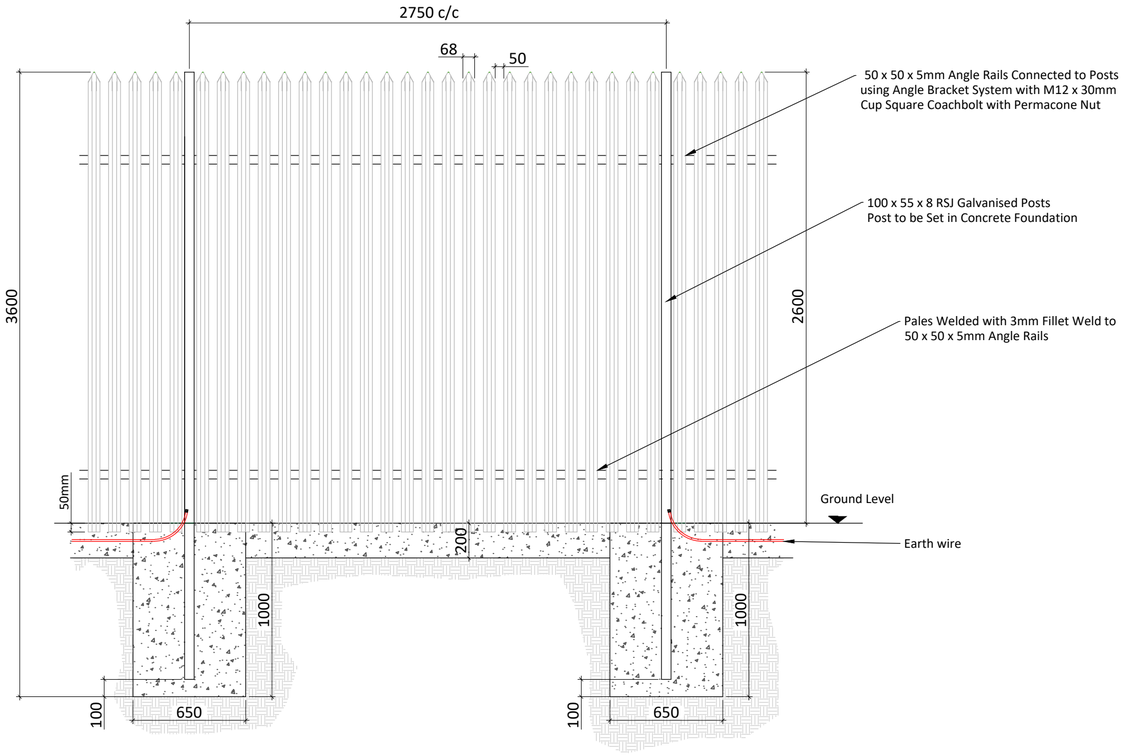
38kV Substation Building Elevations

SHEET NUMBER

05830-DR-101

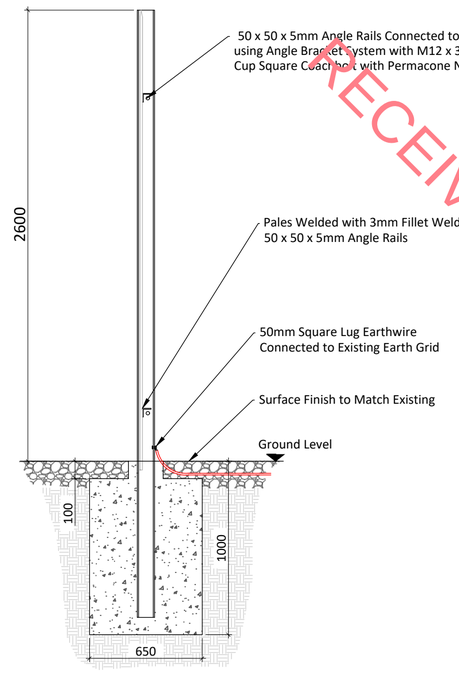
Project Management Initials: Designer: AF Checked: GH Approved: RG

ISO A2 420mm x 594mm



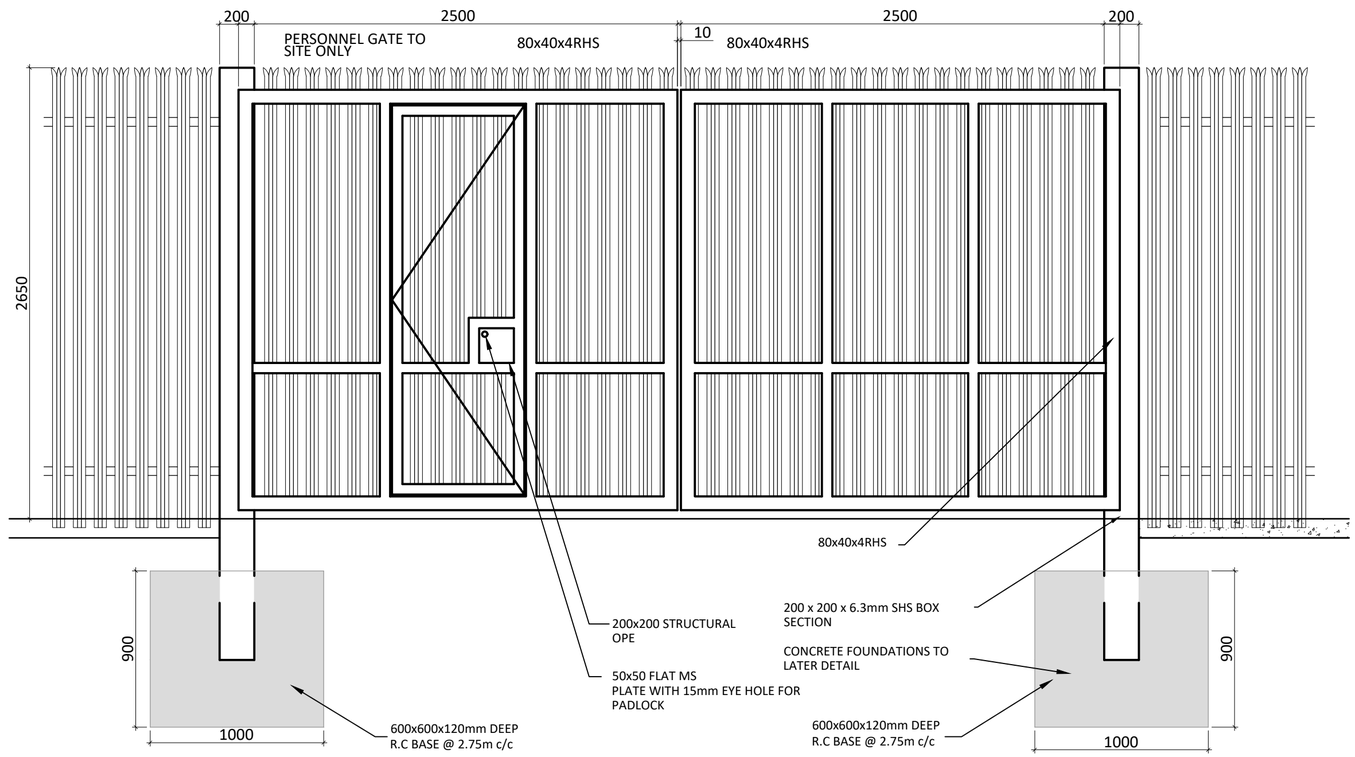
Palisade Fencing Details - Elevation

SCALE 1:25



Palisade Fencing Details - Section

SCALE 1:25



Typical Gate Elevation

SCALE 1:25

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PROJECT

Tullaghmore Wind Farm
38kV Substation

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LEGEND: -

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05-830

SHEET TITLE

Substation Fence Details

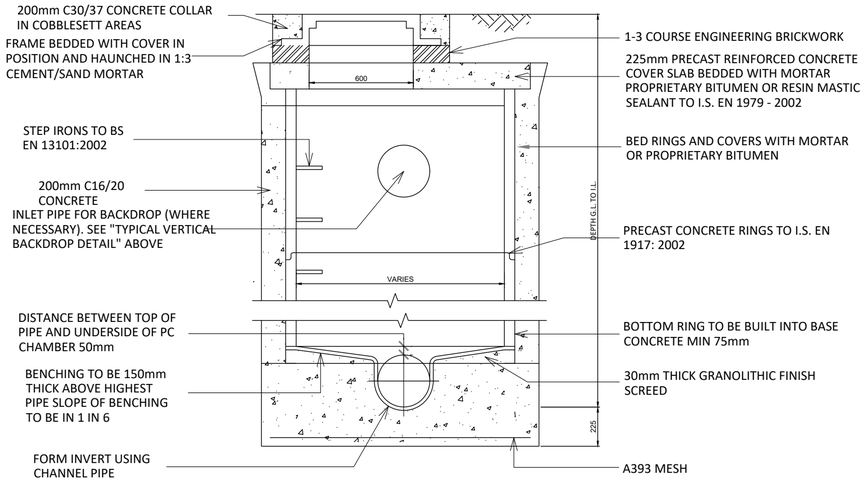
SHEET NUMBER

05830-DR-102

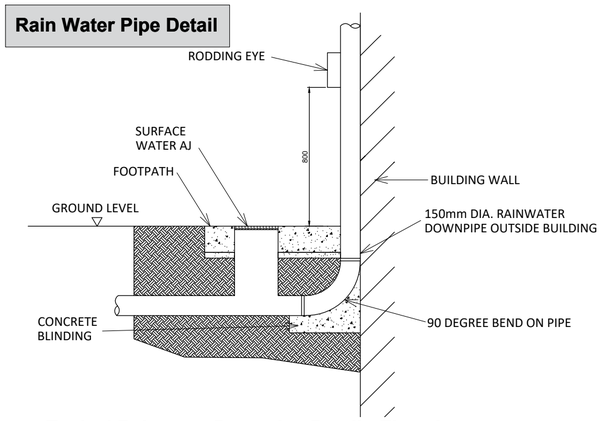
Project Management Initials: Designer: AF Checked: GH Approved: RG

ISO A2 420mm x 594mm

Manhole

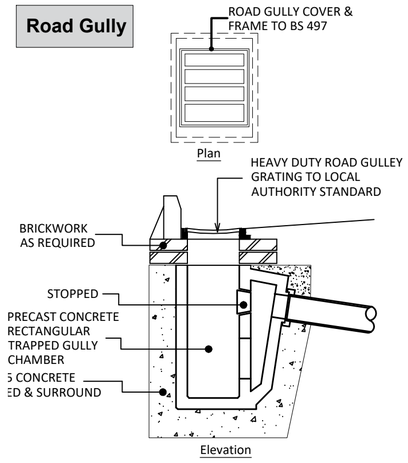


Rain Water Pipe Detail



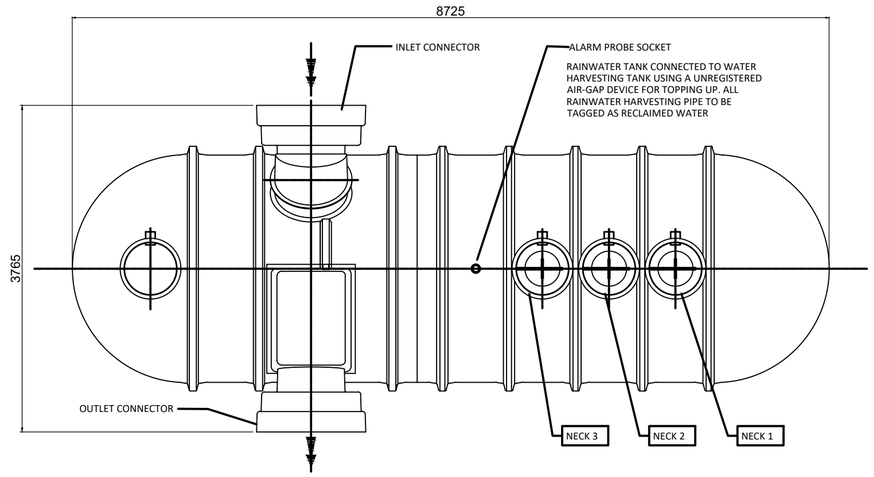
Typical Rainwater Downpipe Detail - Elevation
Scale : 1:25

Road Gully



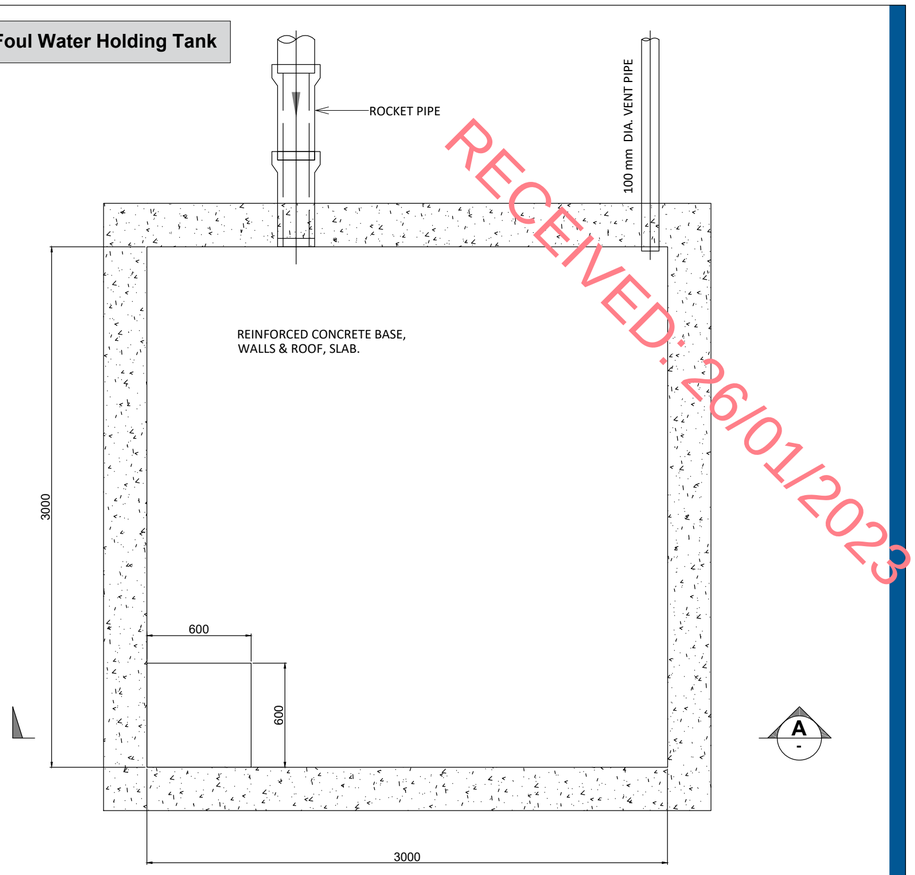
Typical Road Gully Detail
Scale : 1:25

Rainwater Harvesting Tank



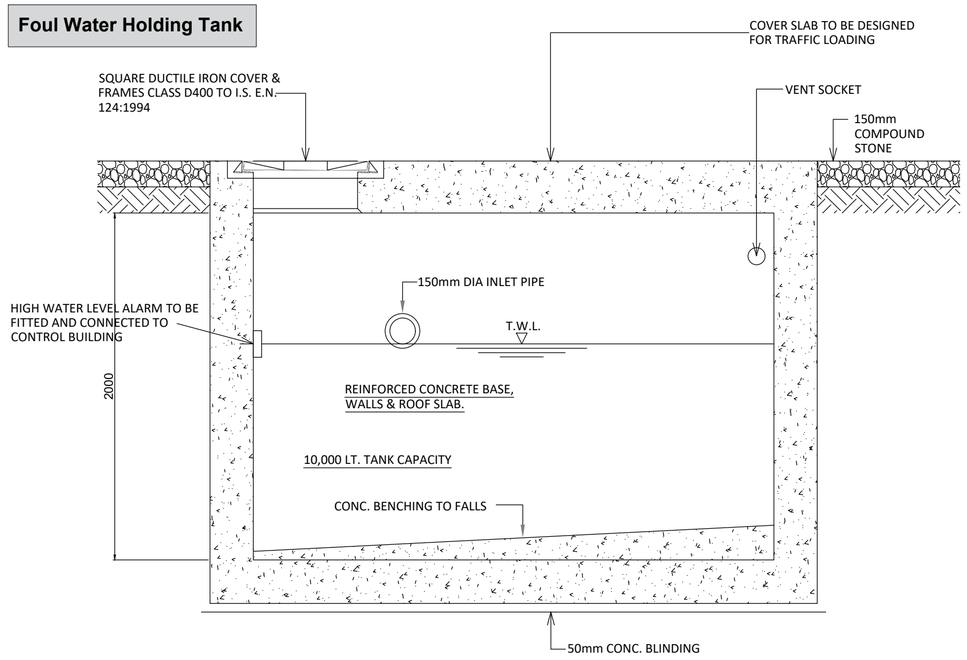
Typical Rainwater Harvesting Tank - Plan
Scale : 1:50

Foul Water Holding Tank



Typical Foul Water Holding Tank - Plan
Scale : 1:25

Foul Water Holding Tank



Typical Foul Water Holding Tank - Elevation
Scale : 1:25

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PROJECT

Tullaghmore Wind Farm
38kV Substation

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05-830

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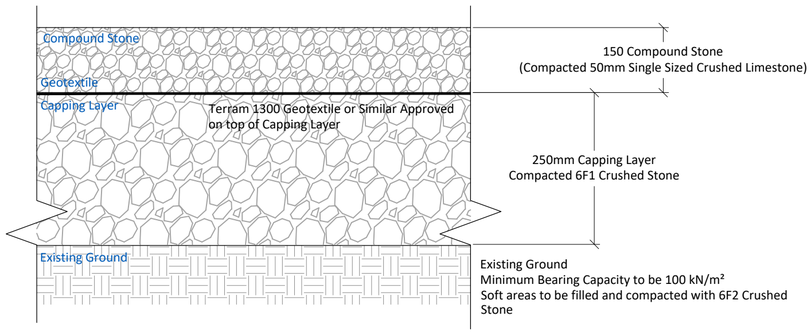
Substation Drainage Details

SHEET NUMBER

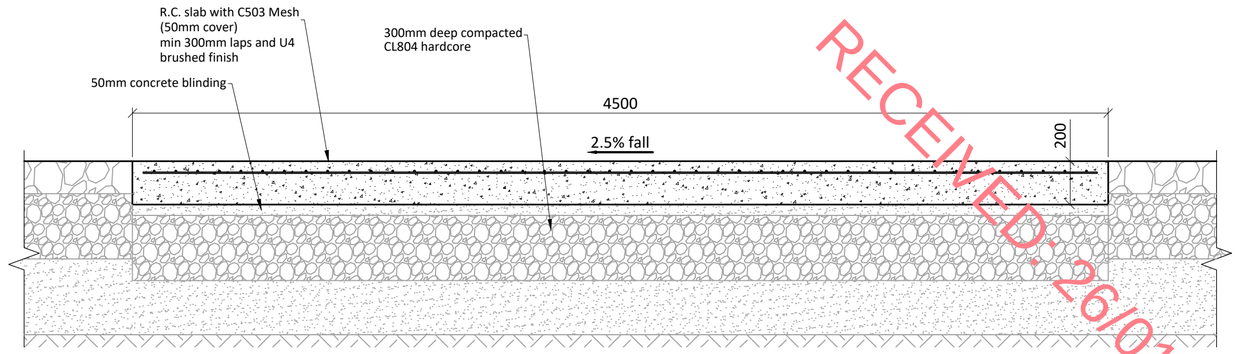
05830-DR-103

Project Management Initials: Designer: AF Checked: GH Approved: RG

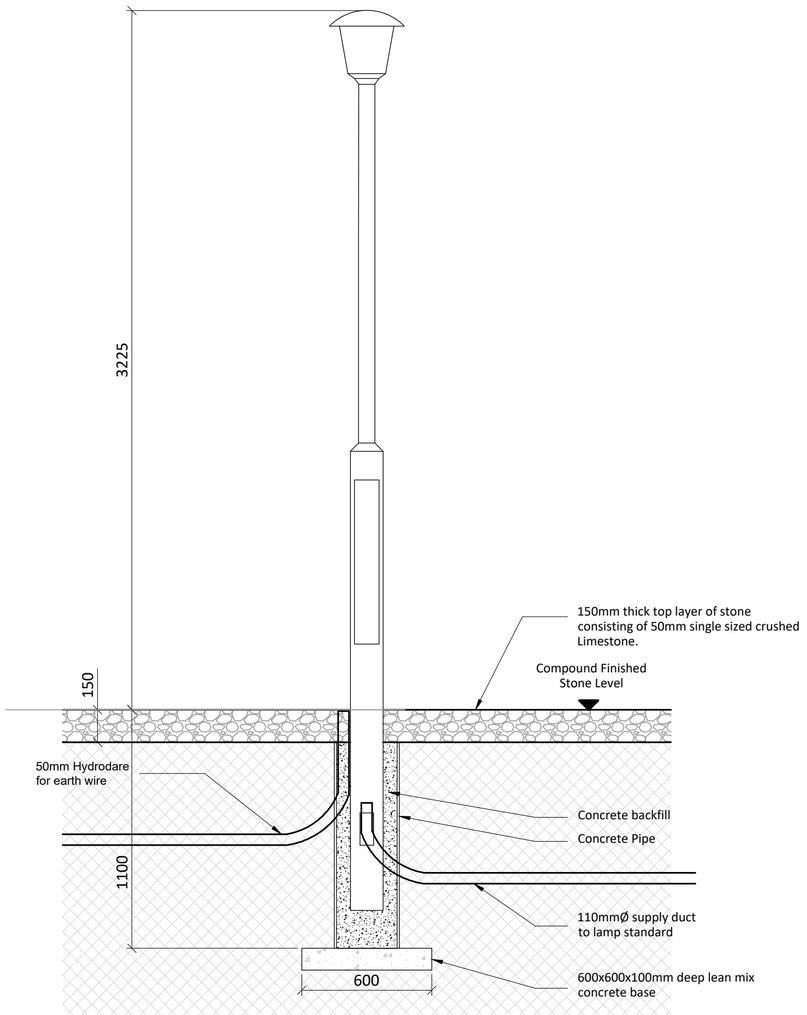
ISO A2 420mm x 594mm



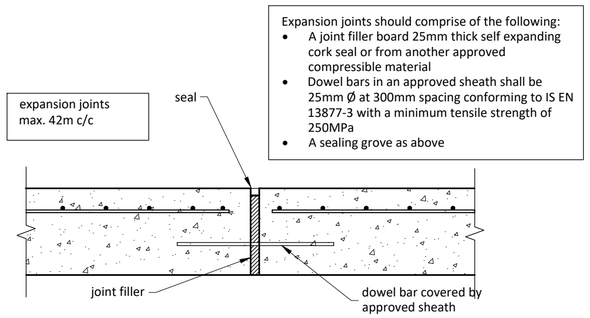
Typical Compound Detail
SCALE 1:10



Typical Section - Concrete Access Road
SCALE 1:20

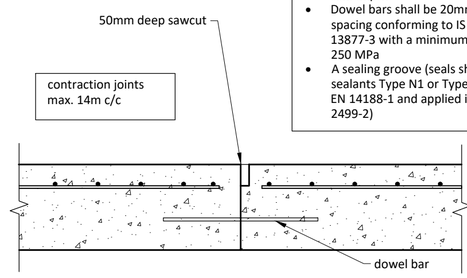


Lighting Column & Surround Detail
SCALE 1:20



Expansion joints should comprise of the following:
- A joint filler board 25mm thick self expanding cork seal or from another approved compressible material
- Dowel bars in an approved sheath shall be 25mm Ø at 300mm spacing conforming to IS EN 13877-3 with a minimum tensile strength of 250MPa
- A sealing grove as above

Concrete Access Road Expansion Joint
SCALE 1:10



Contraction joints should comprise of the following:
- A sawn groove joint 10mm wide at least ¼ the slab depth
- Dowel bars shall be 20mm Ø at 300mm spacing conforming to IS EN 10060 and IS EN 13877-3 with a minimum tensile strength of 250 MPa
- A sealing groove (seals shall be hot applied sealants Type N1 or Type F1 complying with IS EN 14188-1 and applied in accordance with BS 2499-2)

Concrete Access Road Contraction Joint
SCALE 1:10

Project Management Initials: Designer: AF Checked: GH Approved: RG

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PROJECT

Tullaghmore Wind Farm
38kV Substation

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05-830

SHEET TITLE

Substation Compound Details

SHEET NUMBER

05830-DR-104

OUTLINE CONSTRUCTION METHODOLOGY

Tullaghmore Wind Farm

Document No: 05830-R02-02

Revision:	Author:	Checked:	Date:	Notes:
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Table of Contents

1.0 Introduction 5
2.0 Proposed Grid Connection Route 5
3.0 Assessment of Proposed Route and Construction Requirements 7
4.0 Preliminary Site Investigations 14
4.1 UGC Route 14
5.0 UGC Construction Methodology 14
5.1 Marker Posts 16
5.2 Trenching Methodology 16
5.3 Managing Excess Material from Trench 18
5.4 Storage of Plant and Machinery 18
5.5 Joint Bays and Associated Chambers 18
5.6 Horizontal Direction Drilling (HDD) 21
6.0 Access Routes to Work Area 22
7.0 Traffic Management 23
8.0 Road Opening Licence 23
9.0 Relocation of Existing Services 23
9.1 Underground Cables 24
9.2 Water Mains 24
10.0 Cable Pulling 24
11.0 Reinstatement of Private Land 24
12.0 Emergency Response Plan 24
13.0 Best Practice Design and Construction & Environmental Management Methodology 25
14.0 Invasive Species Best Practice Measures 27
15.0 Waste Management 27
16.0 Archaeology 27

Table of Figures

Figure 1 – Proposed Grid Connection Route represented by the purple line 6
Figure 2 – Typical Trench in Regional Road 15
Figure 3 – Typical Trench in Off Road Section 15
Figure 4 – ESB Marker Posts 16
Figure 5 – Typical 38kV Underground Duct Installation 18
Figure 6 – Typical Section through Joint Bay and Link Box 19
Figure 7 -Typical Joint Bay and Link Box Plan Details 19
Figure 8 – Typical Communications Chamber 20
Figure 9 – Typical Sheath Link Chamber 20
Figure 10 – Typical HDD Installation (not to scale) 22
Figure 11 – Temporary Aluminium Panel Tracks 23

1.0 Introduction

The purpose of this document is to outline and explain the construction techniques and methodologies which will be implemented during construction of the proposed grid connection of Tullaghmore Wind Farm substation to the existing ESB owned Screeb 38kV substation. The grid connection will consist entirely of underground cable (UGC). The UGC works will consist of the installation of 4 no. ducts in an excavated trench to accommodate 3 no. power cables and 1 no. fibre communications cable to allow communications between the proposed Tullaghmore Wind Farm Substation and Screeb 38kV Substation.

This document is intended to be used as an aid to understand the methodologies to be employed during construction. In addition, this document is in outline form only and will be revised and updated prior to the commencement of any construction activities. Detailed Method Statements will be prepared in respect of each aspect of the proposed development.

2.0 Proposed Grid Connection Route

The proposed grid connection utilises UGC with a route length of approx. 19.50km in total. The proposed grid route runs in a northeast direction from Screeb 38kV Substation to the proposed Tullaghmore Wind Farm Substation. The proposed route is located in the corridor of regional roads, the N59 National Road and within the Tullaghmore Wind Farm site. The exact location of the UGC along the proposed grid route is subject to minor modifications following a further detailed assessment to be undertaken prior to construction and following consultation with Galway County Council and all other relevant stakeholders, having regard to all environmental protection measures outline in the planning application and accompanying technical reports.

Figure 1 outlines the proposed grid connection route on an aerial background.

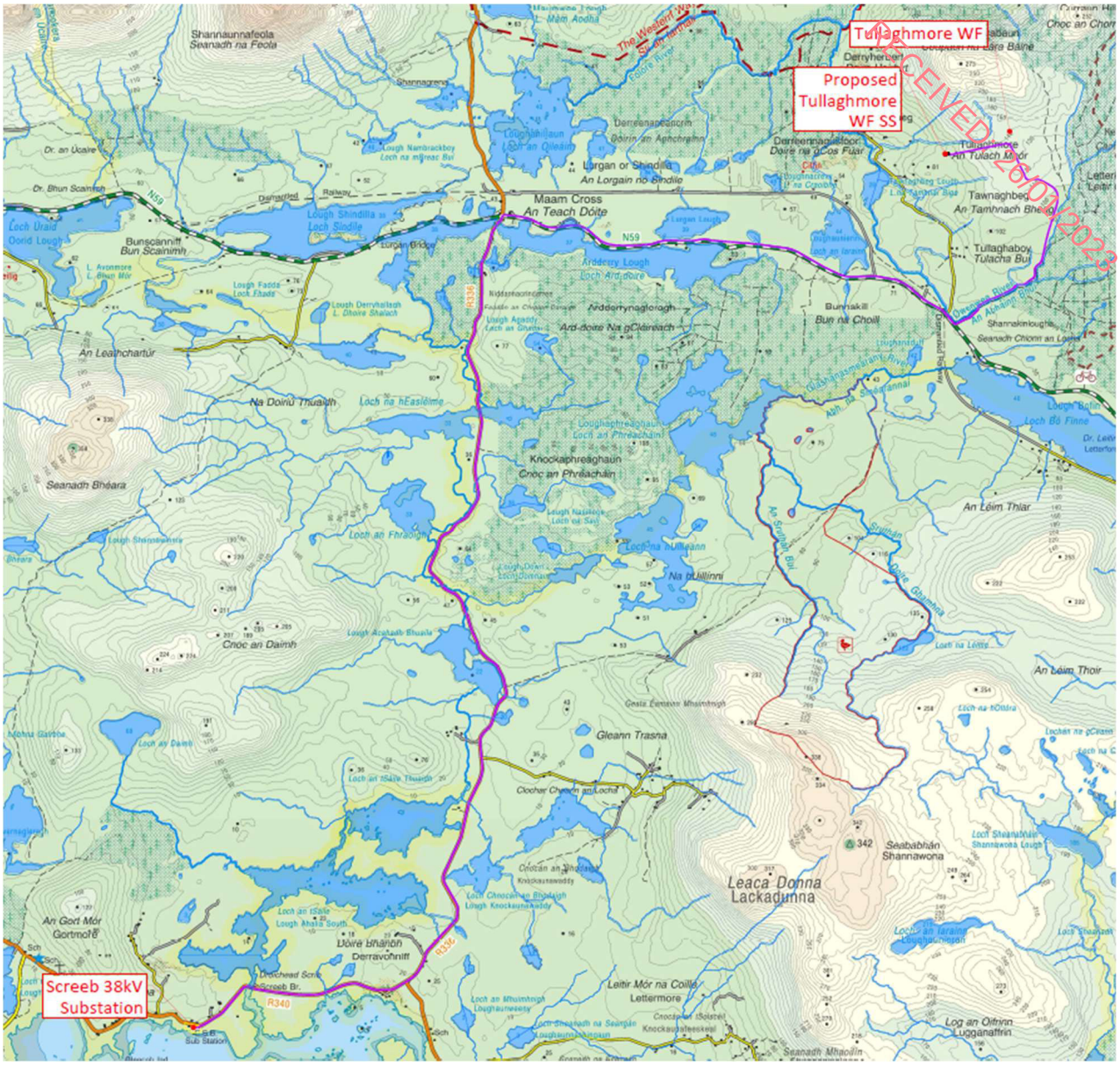


Figure 1 – Proposed Grid Connection Route represented by the purple line

Table 1 of this report summaries the route location, features of the underground cable connection and proposed route.

Table 1 – Approximate Route Location Summary		
Wind Farm Track (UGC)	**Public Roads (UGC)**	**ESB Screeb Substation**
3,292m	16,135m	73m

Table 1: Screeb 38kV Substation to Tullaghmore Wind Farm Substation –Route Location Summary

3.0 Assessment of Proposed Route and Construction Requirements

The table below separates the grid connection route into a number of sections and describes the specific construction requirements of each individual section.

Table 2 – Summary of Grid Connection Route	
Section	**Description**
Section 1 2,408m	**UGC from Screeb Substation to the Regional Road R336** The proposed route will exit the ESB Screeb 38kV Substation to the north, passing a number of UGCs in the vicinity of the substation gate, onto the R340 regional road, and head in an easterly direction. The route follows the R340 to the east for approx. 705m before meeting the first watercourse crossing of the route – Watercourse 1. Watercourse 1 [GC-R340-001.00] is a historically listed structure with Historical reference: Screeb Bridge – Reg. No. 30406504. The bridge is approx. 60m in length. This section of the route shares the road with an Irish Water pipe. Crossing this bridge will be achieved through the use of Horizontal Directional Drilling (HDD) under the bridge and the bed of the river, within the road corridor where possible, as there is insufficient cover within the bridge deck. From here the UGC route follows the R340 in an eastern direction for approx. 773m before meeting Watercourse 2 crossing of the route in the form of a bridge. This section of the route shares the road with the existing ESB UGC and the Irish Water pipe. Bridge 2 has a7pprox. 1300mm of cover between the road level and the top of the arch. This would indicate sufficient cover to crossing in flat formation within the bridge deck. There is an existing ESB UGC on the northern side, as noted by the existence of ESB cable marker plates, and an Irish Water pipe already located within this bridge. The UGC route follows the R340 for a further 876m before coming to a T-junction with the R336. From here the UGC follows the R336 north. <u>Features</u> • *3 No. Joint Bays and associated chambers* The joint bays will be located below ground and finished/reinstated to the required Galway County Council specification. All reinstatement works will be carried out in-line with the 'Guidelines for Managing Openings in Public Roads – 2017'. All Joint Bay infrastructure are to be installed within the corridor of the existing roadway. The link boxes and communication chambers will also be installed in the road corridor or verges where available. Road widening works may be required to facilitate the joint bays. The final position of the joint bay, link box and communication chamber will need to be agreed with ESB as part of the design approval process. • Joint Bay 01 (JB01) will be located at the gate to the Screeb 38kV Substation.

- Joint Bay 02 (JB02) will be located approximately 1,021m east of the Screeb Substation within the R340.
- Joint Bay 03 (JB03) will be located approximately 916m east of Joint Bay 01. The joint bay will be installed within the R340.

- *2 No. Bridge Crossings*

There is one bridge crossings within this section, which requires Horizontal Directional Drilling (HDD) to cross them.

1. Bridge 1: GC-R340-001.00 is a historically listed structure, Historical Reference: Screeb Bridge – Reg. No. 30406504. The bridge is approx. 60m in length. Approximately 43m after Joint Bay 01. There is insufficient depth within the existing bridge structure to permit the installation of ducts and as such this bridge will be crossed utilising the HDD method.
2. Bridge 2 located along the R340 has approx. 1300mm of cover between the road level and the top of the arch. This would indicate sufficient cover to crossing in flat formation within the bridge deck.

1no. HDD crossing will be carried out within the existing road corridor. The design and final location of the HDD launch/reception areas will need to be confirmed by a specialist drilling contractor following detailed site investigation works including bore holes. The total length of the proposed HDD will be approx. 40m – 100m. The HDD launch/reception pits will be reinstated with a transition coupler or transition chamber. All reinstatement works will be finished/reinstated to the required Galway County Council specifications. All reinstatement works in the public road will be carried out in line with the 'Guidelines for Managing Openings in Public Roads – 2017'. The final position of each individual HDD and possible transition chambers will need prior agreement with ESB as part of the design approval process.

- *Service Crossings*

Initial studies show the UGC will cross at least 6no. existing services within this section. These services will be crossed using an undercrossing or overcrossing method, which will be selected based on the cover available above the service. Service crossings have been designed in line with ESB specifications.

- *Protected Area*

The section of the R340 regional road to the R336 regional road form part of the Connemara Bog Complex SAC

Section 2 8,836 m	**UGC within the Regional Road R336 to the N59 National Road** The underground cable continues in the R336 north. Approx. 50m after the junction there is a ground mounted substation on the eastern side with LV UGCs crossing the road at this point. Approx. 785m after the T-junction between the R340 and the R336 the UGC meets the Watercourse 3 crossing of the route. This watercourse is in the form of a pipe culvert, which is to be crossed using a standard culvert undercrossing detail. This section of the route continues to share the road with the existing ESB UGC and the Irish Water pipe. The UGC follows the R336 north for another 940m. This section of the route would be required to share the road with the existing ESB UGC and Irish Water infrastructure. There is also another ground mounted substation off the road to the east and a pumping facility to the west. The UGC would be required to cross existing Irish water infrastructure supplying the pumping facility. The UGC then reaches the Watercourse 5 crossing of the route. This crossing is once again in the form of a culvert, which can be crossed using the standard culvert over/under crossing detail. The UGC continues in this section for 268m before it meets Watercourse Crossing 6 in the form of a box arch bridge. The cover on this bridge ranges from 500mm to 1200mm as the road banks down from right to left. From these measurements it may be possible to cross within the road on the eastern side, should this not be the case a HDD would be recommended. This bridge and section of the road, contain the ESB UGC. After crossing watercourse 5, the UGC continues within the R336 north for approx. 970m before meeting Watercourse 7 of the route. Watercourse 7 has approx. 300mm of cover between the top of the arch and the road level. This would require a HDD to cross. After transitioning Watercourse 7, the UGC continues north for 391m before meeting Watercourse 8. Watercourse 8 is in the form of a stone arch bridge, with the road sitting on top of the bridge arch. This Watercourse will require a HDD to cross. The UGC then maintains a northly course for a further 2,034m where it meets Watercourse 9. Watercourse 9 is in the form of a stone bridge that houses 2no 700mm pipe culverts. There is approx. 2000mm of cover between the culverts and the road level, this would provide adequate cover for the UGC to cross the bridge within the road network. Approx. 206m after watercourse 9, the UGC encounters Watercourse 10. This being in the form of a stone arch bridge with the road level sitting on top of the bridge arch. A HDD is required to cross this bridge. The UGC proceeds in the R336 north for a further 1,783m before meeting the final watercourse of this section. Watercourse 11 [GC-R336-013.00] is a bridge that is located on a bend and is a historically listed structure, Reg. No. 30403903. This bridge has approx. 400mm of cover. It is recommended that a HDD be used to cross this watercourse. It is proposed that the HDD bore follows the existing road corridor.

The UGC then completes this section 138m after crossing the bridge where it meets the N59 National Road.

Features

- *7 No. Joint Bays and associated chambers*

The joint bays will be located below ground and finished/reinstated to the required Galway County Council specification. All reinstatement works will be carried out in-line with the 'Guidelines for Managing Openings in Public Roads – 2017'. All Joint Bay infrastructure are to be installed within the corridor of the existing roadway. The link boxes and communication chambers will also be installed in the road corridor or verges where available. Road widening works may be required to facilitate the joint bays. The final position of the joint bay, link box and communication chamber will need to be agreed with ESB as part of the design approval process.

- Joint Bay 04 (JB04) will be located approximately 1,100m northeast of JB03 within the R336 road network.
- Joint Bay 05 (JB05) will be located approximately 1,125m north of Joint Bay 04 within the R336 road network.
- Joint Bay 06 (JB06) will be located approximately 1,067m north of Joint Bay 05 within the R336 road network.
- Joint Bay 07 (JB07) will be located approximately 1,172m north of Joint Bay 06 within the R336 road network.
- Joint Bay 08 (JB08) will be located approximately 1,065m north of Joint Bay 07 within the R336 road network.
- Joint Bay 09 (JB09) will be located approximately 1,128m north of Joint Bay 08 within the R336 road network.
- Joint Bay 10 (JB10) will be located approximately 1,178m north of Joint Bay 09 within the R336 road network.
- Joint Bay 11 (JB11) will be located approximately 1,031m north of Joint Bay 10 within the R336 road network.

- *Culvert Crossings*

The UGC will cross 3no. existing culverts within this section, 2 of which will require using a culvert undercrossing or overcrossing method which will be selected based on the cover available above the culvert. Culvert crossings have been designed in line with ESB specifications. Where it is not possible to cross under an existing culvert while maintaining the culvert in place, the culvert may be replaced. All reinstatement works will be carried out to the required Galway County Council specification and in line with the 'Guidelines for Managing Openings in Public Roads – 2017'.

- *4 No. Bridge Crossings*

There is one bridge crossings within this section, which requires Horizontal Directional Drilling (HDD) to cross them.

1. Watercourse 7 is in the form of a stone arch bridge. Measurements show an approx. cover of 300mm, which would provide insufficient cover. This is corroborated by the fact the existing ESB UCG is mounted externally to the bridge wall. Due to the lack of cover, it is recommended that a HDD be utilized within the road corridor to cross this bridge.
2. Watercourse 8 [GC-R336-017.00] is a stone structure with a stone slab sitting on top of the bridge arch, there is approx. 300mm cover between the slab and the road level. A HDD will be utilized within the road corridor to cross this bridge.
3. Watercourse 10 is a bridge in the form of a stone structure with a stone slab sitting on top of the bridge arch, similar to Watercourse 9, this bridge has a slab sitting on top of the bridge arch. The road level then sits on top of the slab. A HDD will be utilized within the road corridor to cross this bridge.
4. Watercourse 11 [GC-R336-013.00] is the final watercourse crossing on this section. This bridge is located on a bend and is a historically listed structure, Reg. No. 30403903. This bridge has approx. 400mm of cover. It is recommended that a HDD be used to cross this watercourse. It is proposed that the HDD bore follows the existing road corridor.

Where possible HDD bores will be carried out within the existing road corridor. The design and final location of the HDD launch/reception areas will need to be confirmed by a specialist drilling contractor following detailed site investigation works including bore holes. The total length of the proposed HDD will be approx. 40m – 100m. The HDD launch/reception pits will be reinstated with a transition coupler or transition chamber. All reinstatement works will be finished/reinstated to the required Galway County Council specifications. All reinstatement works in the public road will be carried out in line with the 'Guidelines for Managing Openings in Public Roads – 2017'. The final position of each individual HDD and possible transition chambers will need prior agreement with ESB as part of the design approval process.

- *Service Crossings*

Initial studies show the UGC will cross at least 5no. existing services within this section. These services will be crossed using an undercrossing or overcrossing method, which will be selected based on the cover available above the service. Service crossings have been designed in line with ESB specifications.

- *Protected Area*

	The R336 regional road forms part of the Connemara Bog Complex SAC, with the exception of a section between Joint Bay 10 and Joint Bay 11.
Section 3 8,256 m	**UGC in National Road (N59) and wind farm track to Wind Farm Substation** Following on from Section 2 the UGC follows the National Road (N59) east for approx. 4,964m before entering the proposed wind farm access track. This section of the road has been designed to follow a new more direct route with several new concrete culverts connecting water bodies to the north of the N59 to the south. From here the UGC follows the access track for approx. 3,292m to the proposed wind farm substation. <u>Features</u> • *7 No. Joint Bays and associated chambers* Section 3 contains 7 No. joint bays. The joint bays will be located below ground and finished/reinstated to the required Galway County Council specification. All reinstatement works will be carried out in-line with the 'Guidelines for Managing Openings in Public Roads – 2017'. All Joint Bay infrastructure are to be installed within the corridor of the existing road. The link boxes and communication chambers will also be installed in the road corridor or verges where available. Road widening works may be required to facilitate the joint bays. The final position of the joint bay, link box and communication chamber will need to be agreed with ESB as part of the design approval process. • Joint Bay 12 (JB12) will be located approx. 1,174m northeast of JB11. The joint bay will be installed in the N59 National Road. This Joint Bay location will also serve as the HDD launch site for Watercourse 13 where possible. • Joint Bay 13 (JB13) will be located approx. 1,005m east of JB12. The joint bay will be installed in the N59 National Road. This Joint Bay location will also serve as the HDD receptor site for Watercourse 14 where possible. • Joint Bay 14 (JB1) will be located approx. 956m east of JB13. The joint bay will be installed in the N59 National Road. This Joint Bay location will also serve as the HDD receptor site for Watercourse 15 where possible. • Joint Bay 15 (JB15) will be located approx. 1,048m east of JB14. The joint bay will be installed in the N59 National Road. This Joint Bay location will also serve as the HDD receptor site for Watercourse 16 where possible. • Joint Bay 16 (JB16) will be located approx. 1,176m east of JB15. The joint bay will be installed off the N59 National Road in the wind farm track.

	• Joint Bay 17 (JB17) will be located approx. 1,183m north of JB16. The Joint Bay will be installed in the wind farm track. • Joint Bay 18 (JB18) will be located approx. 1,066m north of JB17. The Joint Bay will be installed in the wind farm track. • There is a final run of approx. 1,017m from JB18 to the proposed Tullaghmore WF Substation. • *5 No. Culvert Crossings* Section 3 contains 5 No. Culvert crossings. Watercourses 13 through to 16 are newly constructed concrete box culverts with minimal cover to the road level. These will require HDDs to pass under. Watercourse 17 is a drainage culvert which will be crossed using the standard culvert undercrossing detail. Where possible HDD bores will be carried out within the existing road corridor. The design and final location of the HDD launch/reception areas will need to be confirmed by a specialist drilling contractor following detailed site investigation works including bore holes. The total length of the proposed HDD will be approx. 40m – 100m. The HDD launch/reception pits will be reinstated with a transition coupler or transition chamber. All reinstatement works will be finished/reinstated to the required Galway County Council specifications. All reinstatement works in the public road will be carried out in line with the 'Guidelines for Managing Openings in Public Roads – 2017'. The final position of each individual HDD and possible transition chambers will need prior agreement with ESB as part of the design approval process. • *2 No. Bridge Crossings* Section 3 contains 2 No. Bridge crossing. 1. Watercourse 12 is a newly constructed bridge located adjacent to Maam Cross to the east. This bridge is a stone structure that has a concrete box culvert. The UGC will cross this bridge using the standard trench formation as there is approx. 2000mm cover. 2. This watercourse crossing will require the installation of a new bridge over a watercourse where no bridge is currently installed. This bridge design is included as part of the planning application. The bridge will be designed to allow the UGC to cross within the bridge using a flat formation design.
Refer to the drawings submitted for location details. Note: The precise location of the proposed route is subject to change as result of ESB design review, existing services/utility locations, ground conditions and any environmental constraints.	

Table 2: Summary of Preliminary Grid Connection Design Route

4.0 Preliminary Site Investigations

It may be proposed to carry out Preliminary site investigations along the cable route prior to construction to confirm design assumptions.

The following items may be carried out:

4.1 UGC Route

Slit trenches at locations of major service crossings (Full Road width).

10 No. trial holes along the route to ascertain ground conditions and thermal resistivity of the soil.

Equipment:

- 4x4 vehicle
- Concrete vibrator
- Wheeled dumper
- Soil compactor
- 360° tracked excavator (only rubber tracked machines will be allowed on public roads)

5.0 UGC Construction Methodology

The proposed UGC trench will consist of 3 no. 110mm diameter HDPE power cable ducts and 1 no. 110mm diameter HDPE communications duct to be installed in an excavated trench, typically 600mm wide by 1220mm deep, with variations on this design to adapt to service crossings and watercourse crossings. The power cable ducts will accommodate 3 no. power cables. The communications duct will accommodate a fibre cable to allow communications between the Tullaghmore Wind Farm substation and the ESB Screeb Substation.

The ducts will be installed, and the trench reinstated in accordance with the landowner's requirements where installed in private lands. The installation of the electrical cabling/fibre cable will be pulled through in one section. Construction methodologies to be implemented and materials to be used will ensure that the UGC is installed in accordance with the requirements of the private landowners.

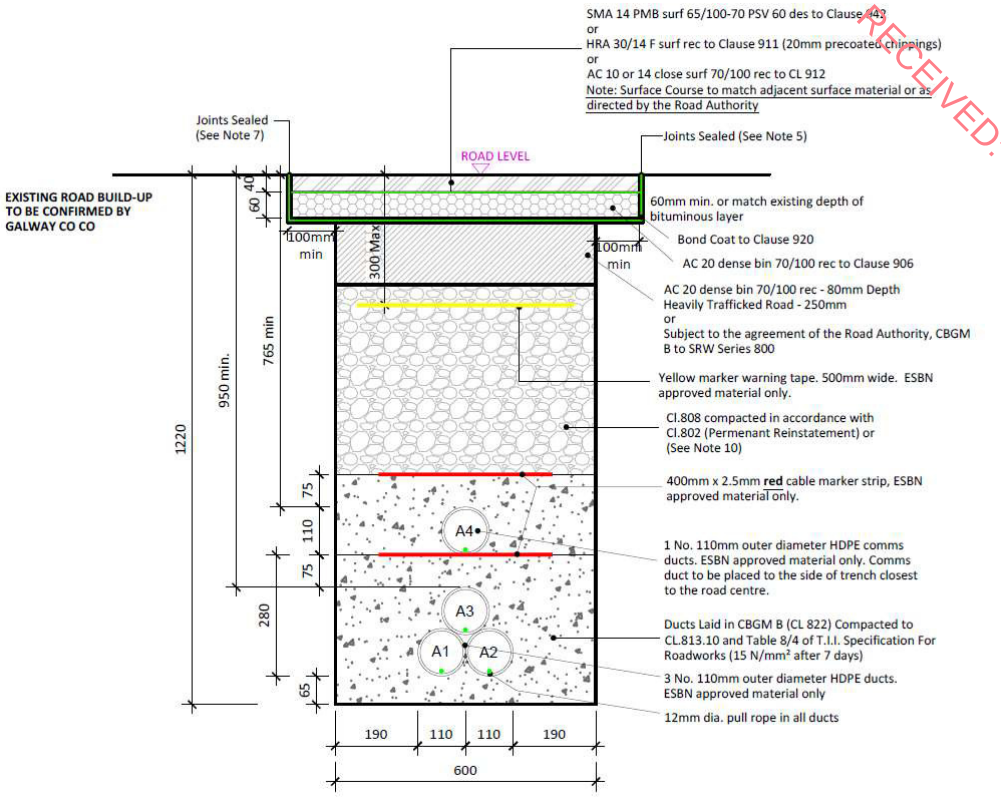
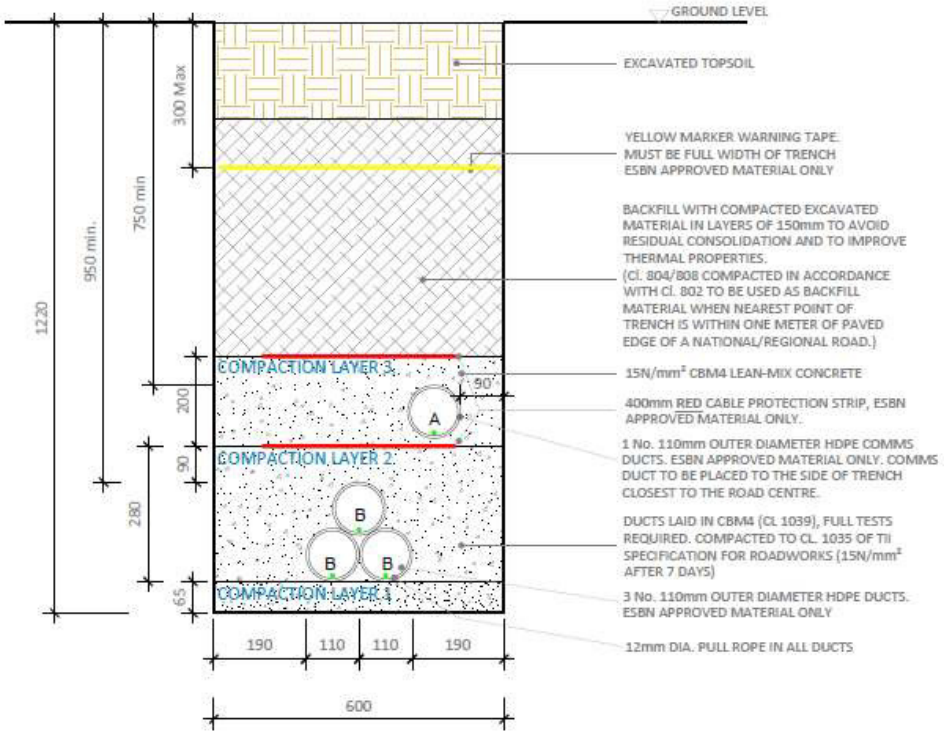


Figure 2 – Typical Trench in Regional Road



A =110mm:Outer diameter HDPE ESB Approved Duct, SDR=11.5;

B =110mm:Outer diameter HDPE ESB Approved Duct, SDR=11.5;

Figure 3 – Typical Trench in Off Road Section

5.1 Marker Posts

Surface cable markers will be placed along the route where cable depth is unavoidably shallow, due to constraints such as existing services, to indicate the precise location of the UGC. These markers will be metallic plates in accordance with ESB standards.

Marker posts will be used on non-roadway routes to delineate the duct route and joint bay positions. Corrosion proof aluminium triangular danger signs, with a 700mm base, and with centred lightning symbol, on fluorescent yellow background shall be installed in adequately sized concrete foundations. Marker posts shall also be placed in the event that burial depth is not to standard. The precise siting of marker posts will be dictated by ESBN as part of the detailed design process.

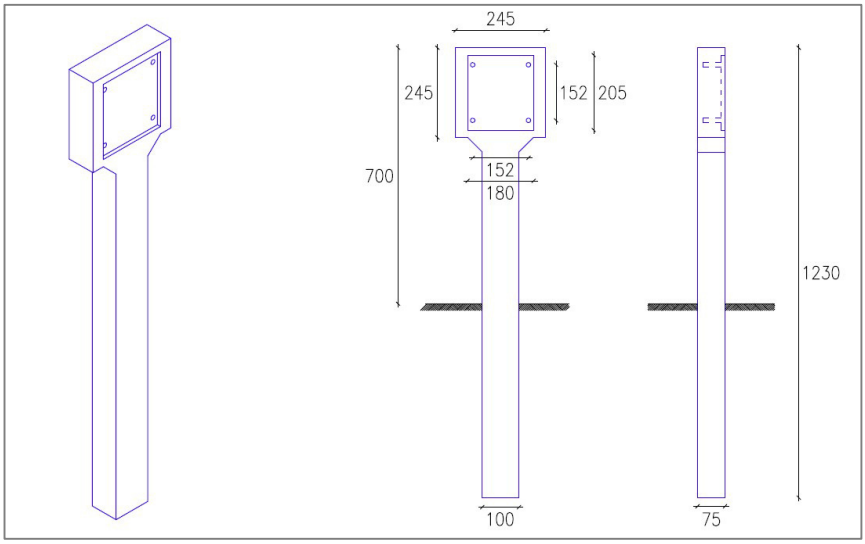


Figure 4 – ESB Marker Posts

5.2 Trenching Methodology

The following section outlines the methodology to be followed during trenching works:

- The Contractor, and their appointed Site Manager, will prepare a targeted Method Statement concisely outlining the construction methodology and incorporating all mitigation and control measures as required by conditions where relevant.
- All existing underground services shall be identified on site prior to the commencement of construction works.
- Traffic management measures will be implemented in accordance with those included in the Traffic Management Report, and a detailed Traffic Management Plan will be prepared and agreed with Galway County Council.
- The excavated trench will be approximately 600mm in width and approximately 1220mm deep within private lands.
- The base of the excavated trench will be lined with sand bedding to be imported to site from a local licensed supplier. The 110mm diameter HDPE cable ducting will be placed into the prepared trench, inspected, and backfilled as per Figures 2 & 3.
- Excavated material will be temporarily stockpiled onsite for re-use during reinstatement. Stockpiles will be restricted to less than 2m in height. Stockpiles will be located a minimum of 50m from

surface water features and all stockpiling locations will be subject to approval by the Site Manager and Project Ecological Clerk of Works (EcoW).

- Excavated material shall be employed to backfill the trench where appropriate and any surplus material will be transported off site and disposed of at a fully authorised soil recovery site.
- Any earthen (sod) banks to be excavated will be carefully opened with the surface sods being stored separately and maintained for use during reinstatement.
- The excavated trench will be dewatered if required, from a sump installed within the low section of the opened trench. Where dewatering is required, dirty water will be fully and appropriately attenuated, through silt bags, before being appropriately discharged to vegetation or surface water drainage feature.
- Where required, grass will be reinstated by either seeding or by replacing with grass turves.
- No more than a 100m section of trench will be opened at any one time. The second 100 metres will only be excavated once the majority of reinstatement has been completed on the first.
- The excavation, installation and reinstatement process will take on average of 1 no. day to complete a 100m section.
- Works will only be conducted in normal working hours of Monday to Friday 08:00 to 20:00 and Saturday 08:00 to 18:00, with no works on Sundays or Bank Holidays except in exceptional circumstances or in the event of an emergency.
- Following the installation of ducting, pulling the cable will take approximately 1 no. days.

Equipment:

- 1 Excavator Operator.
- 2-3 General Operatives.
- 1 no. tracked excavator.
- 1 no. dumper or tractor and trailer.

Materials:

- Sand for pipe bedding.
- Ready-mix Concrete where necessary (delivered to site).
- Trench backfilling material (excavated material and aggregates) to relevant specifications.
- 110mm diameter HDPE ducting.
- Temporary Surface Reinstatement Materials.

Figure 5 – Typical 38kV Underground Duct Installation

5.3 Managing Excess Material from Trench

All excavated material will be temporarily stored adjacent to the trench prior to re-use in the trench reinstatement (where applicable). Stockpiles will be restricted to less than 2m in height. Where excess material exists, it may be used in the reinstatement of the Wind Farm sites or disposed of to a licensed facility.

5.4 Storage of Plant and Machinery

All plant, machinery and equipment will be stored on site within the works area or within the temporary construction compound to be located within the permitted Wind Farm sites. Oils and fuels will not be stored on site and will be stored in an appropriately bunded area within the temporary storage compound.

5.5 Joint Bays and Associated Chambers

Joints Bays are to be provided approximately every 900m – 1150m along the UGC routes to facilitate the jointing of 3 no. lengths of UGC. 38kV Joint Bays are typically 2m x 4.5m x 1.275m pre-cast concrete structures installed below the finished ground level.

In association with Joint Bays, Communication Chambers are required at every joint bay location to facilitate communication links between Tullaghmore Wind Farm and the existing 38kV substation at Screeb. Earth Sheath Link Chambers are also required approximately every second joint bay along the cable route. Earth Sheath Links are used for earthing and bonding cable sheaths of underground power cables, installed in a flat formation so that the circulating currents and induced voltages are eliminated or reduced. Earth Sheath Link Chambers and Communication Chambers are located close to Joint Bays. Earth Sheath Link Chambers and Communication Chambers will typically be pre-cast concrete structures with an access cover at the finished surface level.

The precise siting of all Joint Bays, Earth Sheath Link Chambers, and Communication Chambers is subject to approval by ESBN. Marker posts will be used on non-roadway routes to delineate the duct route and joint bay positions. The marker posts will consist of a corrosion-proof aluminium triangular danger sign, with a 750mm base, and with a centered lightning symbol, on engineering grade fluorescent yellow background.

They will be installed in adequately sized concrete foundations and will also be placed where the cable has not been buried to the standard depth, due to existing road conditions. Drawings of the joint bays and communication chambers are included within this planning package

Equipment:

- 360° tracked excavator.
- 1 no. tracked dumper or tractor and trailer.

Materials:

- Sand for pipe bedding.
- Ready-mix Concrete where necessary (delivered to site).
- Trench backfilling material (excavated material and aggregates) to relevant specifications.
- Precast Chamber Units / Construction materials for chambers.
- Cable ducting.

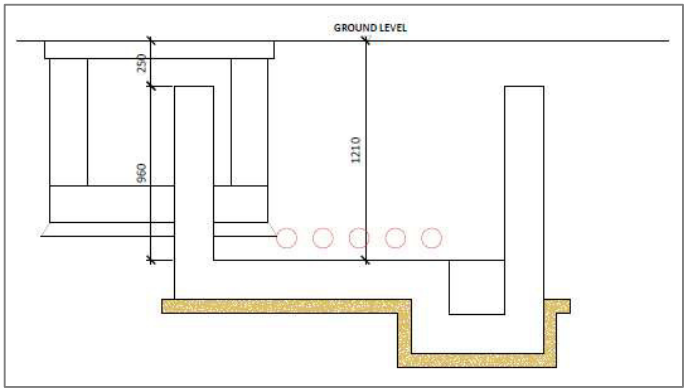


Figure 6 – Typical Section through Joint Bay and Link Box

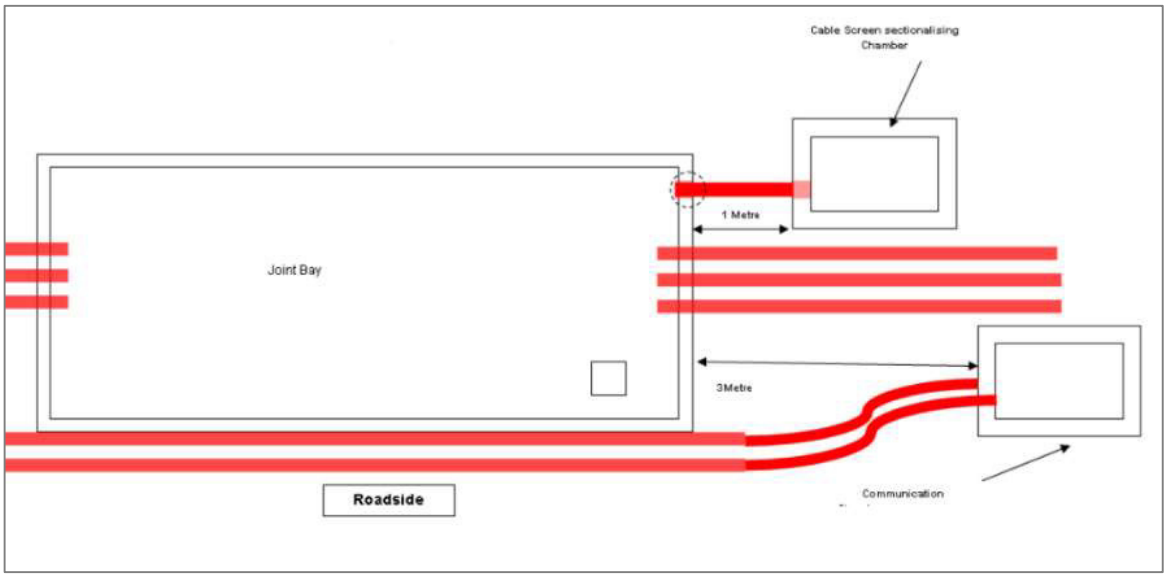


Figure 7 -Typical Joint Bay and Link Box Plan Details

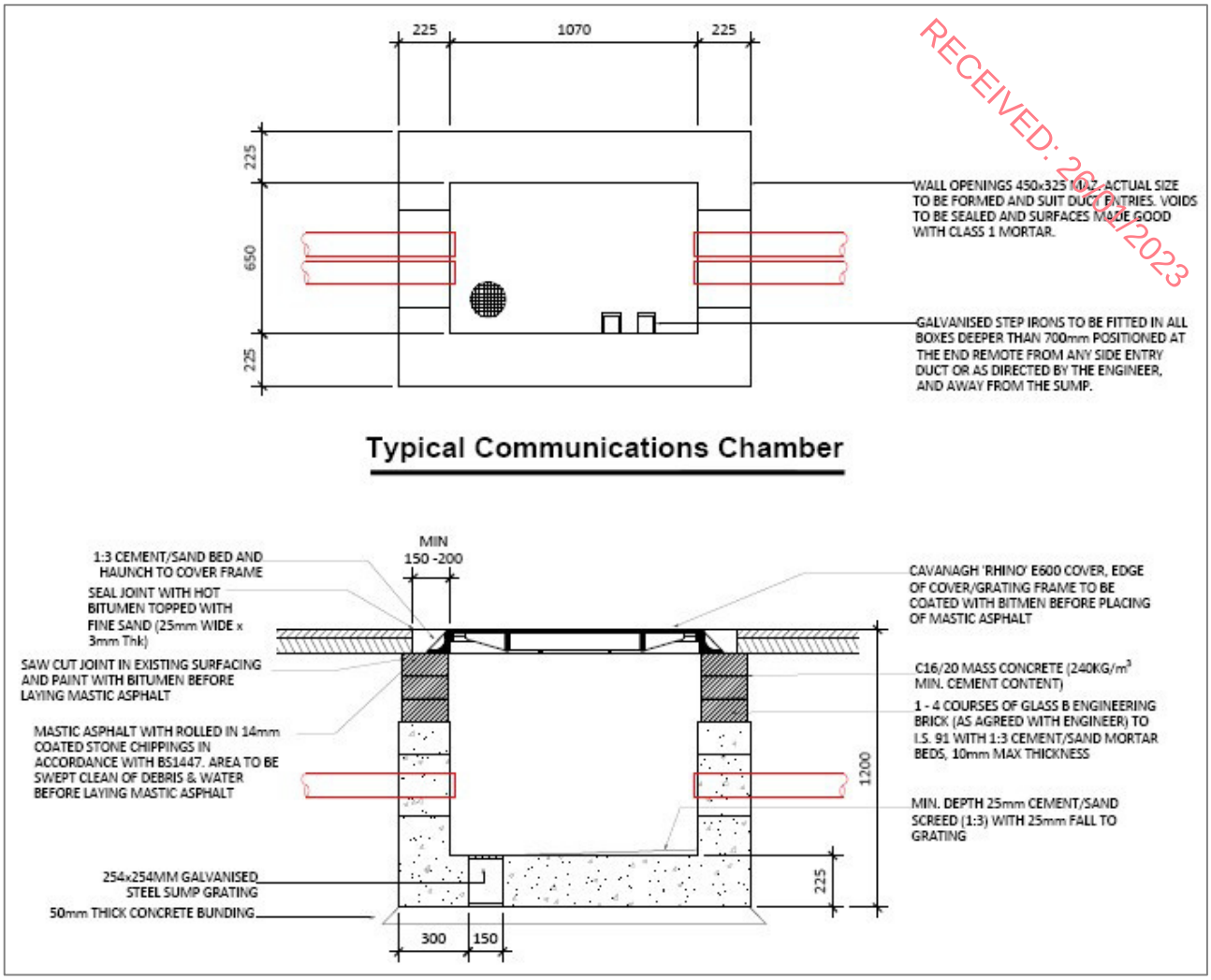


Figure 8 – Typical Communications Chamber

Figure 9 – Typical Sheath Link Chamber

5.6 Horizontal Direction Drilling (HDD)

Horizontal Direction Drilling (HDD) is a method of drilling under obstacles such as roads, bridges, railways, watercourses, etc. in order to install cable ducts under the obstacle. This method is employed where installing the ducts using standard installation methods is not possible. There are river crossings on this UGC route which will require HDD.

The proposed drilling methodology is as follows:

- A works area of circa 40m^2 for the HDD entry side, and circa 20m^2 on the HDD exit side will be required for the HDD equipment and vehicles. These areas will be fenced off during the HDD implementation.
- The drilling rig and fluid handling units will be located on the entry side of the local road and will be appropriately bunded using sandbags, which will contain any fluid spills and stormwater run-off.
- Entry and exit pits (approximately 2m (w) x 3m (L) x 1m deep) will be excavated using an excavator, the excavated material will be temporarily stored within the works area and used for reinstatement or disposed of to a licensed facility.
- The HDD pilot bore will be undertaken using a wireline guidance system. Assembly will be set up by the drilling team and steering engineer.
- The pilot bore will be drilled to the pre-determined profile and alignment under the watercourse crossings.
- The steering engineer and drill team will monitor the drilling works to ensure that modelled stresses and pressures are not exceeded.
- The drilled cuttings will be flushed back by drilling fluid to the entry and exist pits and recycled for re-use.
- Once the first pilot hole has been completed a hole-opener or back reamer will be fitted in the exit side which will then be pulled back to the entry side as part of the pre-reaming/hole opening process to enlarge the hole to the correct size.
- When the pre-reaming/hole opening/hole cleaning has been completed, a reamer of slightly smaller diameter than the final cut will be installed on the drill string to which the ducts will be attached for installation.
- The drilling fluid will be disposed of to a licensed facility.
- The ducts will be cleaned and proven, and their installed location surveyed.
- The entry and exit pits will be reinstated to the specification of ESB Networks and any requirements of Galway County Council.
- A joint bay/transition chamber/transition coupler will be installed on either side of the road verge following the horizontal directional drilling as per ESB requirements.

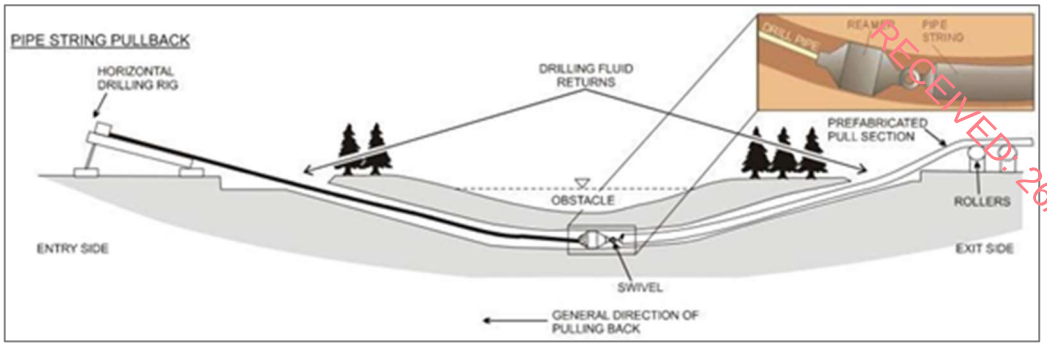


Figure 10 – Typical HDD Installation (not to scale)

6.0 Access Routes to Work Area

The proposed grid route will consist of UGC. Where the proposed underground cable will be installed predominantly within road networks, it will be accessed via the existing public road network. The contractor(s) will be required to utilise the local public road network in the vicinity of the work area and from there utilise private tracks, where appropriate. Prior to the commencement of development, precise access arrangements will be agreed with the respective landowners.

A detailed Traffic Management Plan will be prepared, and agreed with Galway County Council, prior to the commencement of construction.

Temporary access roads on private land (if required due to ground conditions and/or landowner requirements) will consist of timber or aluminium bog mats (Figure 10) to spread the weight of machinery over a greater area to prevent damage to the ground. If necessary, a low ground pressure excavator may also be utilised. This machine is designed to spread its weight across a wider area thereby reducing the pressure exerted on the ground. No invasive works will be undertaken when placing the matting. Upon completion of the works, all mats will be removed immediately. Access routes will be carefully selected to avoid any damage to land. Local consultation will be carried out with all relevant landowners to ensure that any potential disturbance will be minimised. Prior to the commencement of construction, the contractor will assess all access routes and determine the requirement for bog mats. Any such requirements will be incorporated into the relevant method statement.

Figure 11 – Temporary Aluminium Panel Tracks

7.0 Traffic Management

Traffic management and road signage will be in accordance with the Department of Transport: Traffic Signs Manual – Chapter 8: Temporary Traffic Measures and Signs for Road Works and in agreement with Galway County Council. All work on public roads will be subject to the approval of a road opening license application. The contractor will prepare detailed traffic management plans for inclusion as part of the road opening licence applications.

All traffic management measures will comply with those outlined in the accompanying Outline Construction Traffic Management Plan and will be incorporated into a detailed Traffic Management Plan to be prepared, in consultation with Galway County Council, before the commencement of development.

8.0 Road Opening Licence

The proposed UGC works will require a road opening licence under Section 254 of the Planning and Development Act 2000-2015 from Galway County Council. A Traffic Management Plan (TMP) will be agreed with Galway County Council prior to the commencement of the development. This TMP will outline the location of traffic management signage, together with the location of any necessary road closures and the routing of appropriate diversions. Where diversions are required, these will be agreed with Galway County Council in advance of the preparation of the TMP.

9.0 Relocation of Existing Services

In order to facilitate the installation of the proposed UGC, it may be necessary to relocate existing underground services such as water mains, telecoms, or existing cables. In advance of any construction activity, the contractor will undertake additional surveys of the proposed route to confirm the presence or otherwise of any services. If found to be present, the relevant service provider will be consulted with in order to determine the requirement for specific excavation or relocation methods and to schedule a suitable time to carry out works.

9.1 Underground Cables

If existing underground cables are found to be present, a trench will be excavated, and new ducting and cabling will be installed along the new alignment and connected to the network on either end. The trench will be backfilled with suitable material to the required specification. Warning strip and marking tape will be laid at various depths over the cables as required. Marker posts and plates will be installed at surface level to identify the new alignment of the underground cable, with the underground cables will then be re-energised.

9.2 Water Mains

The water supply will be turned off by the utility so work can commence on diverting the service. The section of existing pipe will be removed and will be replaced with a new pipe along the new alignment of the service. The works will be carried out in accordance with the utility standards.

10.0 Cable Pulling

Once the ducting is installed the electrical cables (situated on a drum) are pulled through the ducting by a specialised mechanical winch. The winch will also monitor the tension on the cables being pulled so as not to damage the cables. A guide rope is installed with the ducting to assist in the cable pulling process. The guide rope also is used for proving the ducts by attaching a mandrel, a sponge or brush, for cleaning the duct installed. Cable lubricant is applied to the outside of the cables being pulled through the duct. The lubricant assists in the pulling process by removing friction between the cable and the rollers. This not only speeds up the process but also prevents snagging and therefore damage to the cable.

11.0 Reinstatement of Private Land

Once all construction works are complete, the work areas will be reinstated with excavated soil and either seeded out with native species, allowed to vegetate naturally, or reinstated with excavated grass turves and will be restored to their original condition. This work will be carried out in in consultation with the landowner and in line with any relevant measures outlined in the CEMP and associated conditions.

12.0 Emergency Response Plan

All site personnel will be inducted in the provisions of the Emergency Response Plan. The following outlines some of the information, on the types of emergencies, which must be communicated to site staff (list not exhaustive);

- Release of hazardous substance – Fuel or oil spill
- Concrete spill or release of concrete
- Flood event – extreme rainfall event
- Environmental buffers and exclusion zones breach
- Housekeeping of materials and waste storage areas breach
- Stop Works order due to environmental issue or concern

The Emergency Response Plan must be completed by the appointed Contractor before the project begins.

13.0 Best Practice Design and Construction & Environmental Management Methodology

Prior to commencement of construction works the contractor will draw up detailed method statements which will be informed by this Outline Construction Methodology, environmental protection measures included within the planning application, measures within the CEMP, and the guidance documents and best practice measures listed below. This method statement will be adhered to by the contractors and will be overseen by the Project Manager, Environmental Manager and Ecological Clerk of Works (EcoW) where relevant.

The following documents will contribute to the preparation of the method statements in addition to those measures below: -

- Inland Fisheries Ireland (2016) *Guidelines on Protection of Fisheries during Construction Works in and Adjacent to Waters*. Inland Fisheries Ireland*, Dublin,*
- National Roads Authority (2008) *Guidelines for the Crossing of Watercourses during the Construction of National Road Schemes*. National Roads Authority, Dublin.
- E. Murnane, A. Heap and A. Swain. (2006) *Control of water pollution from linear construction projects.* Technical guidance (C648). CIRIA.
- E. Murnane et al., (2006) *Control of water pollution from linear construction projects*. Site guide (C649). CIRIA.
- Murphy, D. (2004) *Requirements for the Protection of Fisheries Habitat during Construction and Development Works at River Sites. Eastern Regional Fisheries Board, Dublin.*
- H. Masters-Williams et al (2001) *Control of water pollution from construction sites. Guidance for consultants and contractors* (C532).
- Enterprise Ireland (unknown). *Best Practice Guide (BPGCS005) Oil storage guidelines.*
- Law, C. and D'Aleo, S. (2016) *Environmental good practice on site pocketbook*. (C762) 4th edition. CIRIA.
- CIRIA *Environmental Good Practice on Site (fourth edition) (C741) 2015*.

The works will be carried out by employing accepted best working practices during construction, including the environmental management measures listed below. Please note that the following measures will be supplemented by further specific environmental protection measures that will be included in method statements prepared for specific tasks during the works and will form part of the detailed CEMP.

- All materials shall be stored at the temporary compound within the Tullaghmore Wind Farm site and transported to the works zone immediately prior to construction.
- Weather conditions will be considered when planning construction activities to minimise risk of run off from site.
- Provision of 50m exclusion zones and barriers (silt fences) between any excavated material and any surface water features to prevent sediment washing into the receiving water environment.
- If dewatering is required as part of the works e.g. in trenches for underground cabling or in wet areas, water must be treated prior to discharge;
- The contractor shall ensure that silt fences are regularly inspected and maintained during the construction phase.

- If very wet ground must be accessed during the construction process bog mats/aluminium panel tracks will be used to enable access to these areas by machinery. However, works will be scheduled to minimise access requirements during winter months.
- The contractor shall ensure that all personnel working on site are trained in pollution incident control response. A regular review of weather forecasts of heavy rainfall is required with the Contractor required to prepare a contingency plan for before and after such events.
- The contractor will carry out visual examinations of local watercourses from the works during the construction phase to ensure that sediment is not above baseline conditions. In the unlikely event of water quality concerns, the Environmental Manager and EcoW will be consulted.
- Excavations will be left open for minimal periods to avoid acting as a conduit for surface water flows.
- Only emergency breakdown maintenance will be carried out on site. Emergency procedures and spillage kits will be available and construction staff will be familiar with emergency procedures.
- Appropriate containment facilities will be provided to ensure that any spills from vehicles are contained and removed off site. Adequate stocks of absorbent materials, such as sand or commercially available spill kits shall be available.
- Concrete or concrete contaminated water run-off will not be allowed to enter any watercourses. Any pouring of concrete (delivered to site ready mixed) will only be carried out in dry weather. Washout of concrete trucks shall be strictly confined to a designated and controlled wash-out area within the temporary construction compound at the substation site, remote from watercourses, drainage channels and other surface water features.
- A designated trained operator experienced in working with concrete will be employed during the concrete pouring phase.
- Concrete wastewater can be pumped into a skip to settle out; settled solids will need to be appropriately disposed of off-site.
- Wash-down water from exposed concrete surfaces will be trapped to allow sediment to settle out and reach neutral pH before clarified water is released to the drain system or allowed to percolate into the ground.
- Where dust suppression is considered to be required by the Contractor, such requirements and methodology shall be subject to the agreement with the Ecological Clerk of Works.
- Entry by plant equipment, machinery, vehicles and construction personnel into watercourses or wet drainage ditches shall not be permitted. All routes used for construction traffic shall be protected against migration of soil or wastewater into watercourses.
- Cabins, containers, workshops, plant, materials storage, and storage tanks shall not be located near any surface water channels and will be located beyond the 50m hydrological buffer at all times.

The following mitigation measures will be undertaken specifically with regard to horizontal directional drilling:

- A geotechnical assessment shall be carried out prior to horizontal directional drilling and drilling shall only be carried out at locations where conditions are suitable for the control of drilling materials.
- All works will be supervised by a qualified environmental engineer.
- No works will be undertaken near the river corridor or riverbanks. Reception and launch pits for the directional drilling process shall be excavated a minimum of 20m from the stream banks.

- No construction activity will take place in riparian areas. Stockpiling of construction materials, refuelling of machinery and overnight parking will take place elsewhere in the temporary compound near the proposed substation. Concrete truck chute cleaning will take place in a separate appropriate location.
- The area around the bentonite batching, pumping, and recycling plants shall be bunded using terram and sandbags in order to contain any spillages.
- Silt fencing will be erected 5m from the reception and launch pits used for directional drilling.
- Horizontal directional drilling works shall not take place at periods of high rainfall and shall be scaled back or suspended if heavy rain is forecast.

14.0 Invasive Species Best Practice Measures

Invasive species can be introduced into a location by contaminated plant, machinery and equipment which were previously used in locations that contained invasive species. Good site organisation and hygiene management shall be maintained always on site, and best practice measures will be implemented, as follows:

- The contractor will prepare an Invasive Species Action Plan to be implemented during construction, and all personnel will be made aware of the requirements contained within.
- Plant and machinery will be inspected upon arrival and departure from site and cleaned/washed as necessary to prevent the spread of invasive aquatic/ riparian species such as Japanese knotweed *Fallopia japonica* and Himalayan Balsam *Impatiens glandulifera*. A sign off sheet will be maintained by the contractor to confirm the implementation of measures.
- Site hygiene signage will be erected in relation to the management of non-native invasive material.

15.0 Waste Management

All waste products (general waste, plastic, timber, etc.) arising during the construction phase will be managed and disposed of in accordance with the provisions of the Waste Management Act 1996 and associated amendments and regulations, and a Waste Management Plan will be prepared by the contractor prior to the commencement of construction. All waste material will be disposed of at a fully licensed facility.

16.0 Archaeology

The following are the mitigation measures which will be carried out during construction where required.

- If required a project archaeologist will be appointed to oversee the project.
- Demarcation of protective buffer zones around cultural heritage sites where there is a potential for disturbance during the construction phase and inclusion of the same in site induction.

TECHNICAL NOTE 03

Project:	Tullaghmore WF – 38kV Grid Connection	Ref:	rev01
Section:	38kV Cable Rating Check	Job No:	05-830
			26.05.2022
Made By:	AF	Checked By: GH	Sheet No: 1 of 15

Instruction

Technical Lead:	Andrew Foley - TLI Group
Date of Writing:	26.05.22
Scope of Note:	Cable rating check conducted for the 38kV grid connection cable
Documents & Data Issued for Review:	N/A

Details

TLI Group (the Consultant) were engaged by EM Power (the Developer) to select and complete a preliminary design for planning of the 38kV grid connection for Tullaghmore Wind Farm in Co. Galway. The 38kV grid connection for Tullaghmore Wind Farm is currently expected to have a maximum export capacity (MEC) of 40.8MW, with the point of connection to the distribution system assumed to be at Screeb 38kV Substation. The point of connection for the wind farm will need to be confirmed by the DSO as appropriate as part of the grid connection offer process.

An underground cable (UGC) grid connection option is being implemented for the entire grid route between the wind farm and the substation.

A cable rating check was conducted to check the suitability of various 38kV cable sizes/types for the project's MEC and the current cable route design. The purpose of this exercise was to check the load capacity of the cable for the various trench designs incorporated as part of the cable route design under max load conditions.

The following standard 38kV cable sizes were assessed as part of this cable rating check:

- 630mm.sq Al Cable
- 1000mm.sq Al Cable
- 630mm.sq Cu Cable
- 1000mm.sq Cu Cable

Cable Study Parameters	
Nominal Voltage:	38kV
Power:	40.8MW
Power Factor:	0.95
Average Cable Section Length:	10,000m *(trefoil)*, 500m *(flat)*, 70m *(HDD)*
Cable Trench Design:	See Appendix A, B, C, D
Ambient Temp (Soil)	20˚C *(Summer rating)*
Soil Thermal Resistivity	1.2 K·m/W *(Summer rating)*
Backfill Thermal Resistivity	1.0 K·m/W *(Summer rating)*

Table 1 - Cable Study General Parameters

Cable Study Results

1.0 Standard Trefoil Trench Design

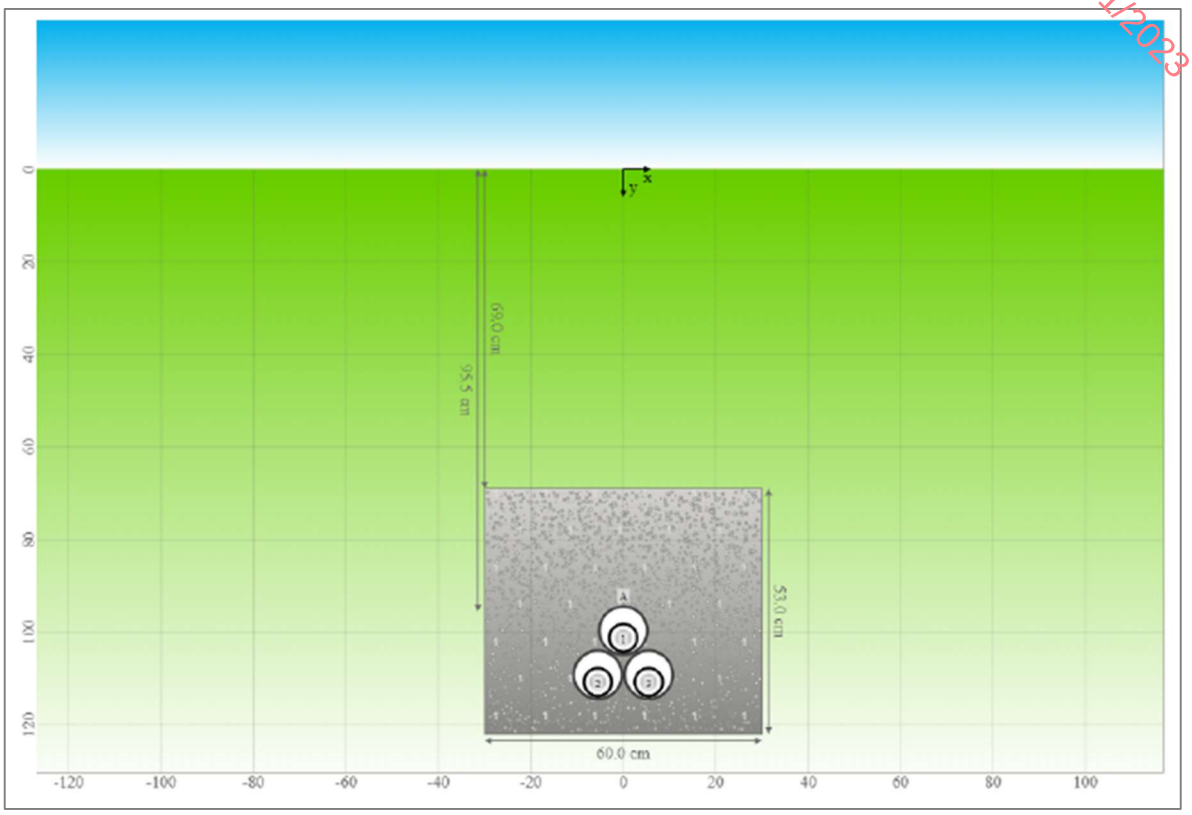
The standard trefoil trench design is the trench design which will be utilised for the majority of the cable route. Alternative trench designs should only be utilised at watercourse/service crossing points as required. The standard trefoil trench design for the project has been designed in line with the ESB Functional Specifications, see Drawings No. 05830-DR-150/151/152/153 and Appendix A. This trench design was modelled using the parameters outlined in **Table 1**. Cable rating calculations were carried out using various cable models under summer conditions. The maximum capacity of the cable when installed in this trench design was calculated for each cable model. The cable rating results for the various cable models when installed using the standard trefoil trench design are summarised in **Table 2**.

Cable Rating Ref	Season	Ambient Temp (˚C)	Circuit Config.	Duct Spacing (mm)	Duct Depth (mm)	Rated Current	Rated MW
NKT 630 Al-Standard Trefoil-Summer	Summer	20	Trefoil	-	950	606	37.9
SolidAl 630 Al-Standard Trefoil-Summer	Summer	20	Trefoil	-	950	613	38.3
NKT 1000 Al-Standard Trefoil-Summer	Summer	20	Trefoil	-	950	749	46.8
SolidAl 1000 Al-Standard Trefoil-Summer	Summer	20	Trefoil	-	950	758	47.4
Sample 630 Cu-Standard Trefoil-Summer	Summer	20	Trefoil	-	950	733	45.8
Sample 1000Cu-Standard Trefoil-Summer	Summer	20	Trefoil	-	950	876	54.8

Table 2 - Standard Trefoil Trench Results

It can be seen from **Table 2** that it will be possible to achieve the required rating for the project (40.8MW) when using any of the listed cable models shown in green in the standard trefoil trench design.

An extract from cable rating study 'NKT 1000 Al-Standard Trefoil-Summer' is detailed below for reference.



Systems

Following systems are active in the arrangement:

System	Object	Current I_c [A]	max Temp. θ_c | θ_e (θ_{de}) [°C]	Losses W_{sys} [W/m]
System A	NKT 1000mm2 Al XLPE (38kV)	748.8	90.0 | 82.2 (69.3)	86.8

Figure 1 – Standard Trefoil Trench Results (NKT 1000mm^2 Al)

2.0 Culvert/Service Undercrossing Design (1500mm depth)

The Flat Formation Culvert/Service Undercrossing Design (1500mm depth) is the trench design which should be utilised for crossing under existing services/culverts, with a maximum duct depth of 1500mm. This design should be utilised where it is not possible to cross over the existing service/culvert using the standard trefoil trench design while maintaining sufficient cover. It should be noted that ESB's preference is to cross under existing services and culverts where possible when the standard trefoil trench design cannot be utilised.

The Culvert/Service Undercrossing Design (1500mm depth) for the project has been designed in line with the ESB Functional Specifications, see Drawings No. 05830-DR-155/157 and Appendix B. This trench design was modelled using the parameters outlined in **Table 1**. Cable rating calculations were conducted using various cable models under summer conditions. The maximum capacity of the cable when installed in this trench design was calculated for each cable model. The cable rating results for the various cable models when installed using the Culvert/Service Undercrossing Design (1500mm depth) are summarised in **Table 3**.

Cable Rating Ref	Season	Ambient Temp (˚C)	Circuit Config.	Duct Spacing (mm)	Duct Depth (mm)	Rated Current	Rated MW
NKT 630 Al-Flat 1500D 100DS-Summer	Summer	20	Flat	100	1500	533	33.3
SolidAl 630 Al-Flat 1500D 100DS-Summer	Summer	20	Flat	100	1500	539	33.7
NKT 1000 Al-Flat 1500D 100DS-Summer	Summer	20	Flat	100	1500	626	39.2
SolidAl 1000 Al-Flat 1500D 100DS-Summer	Summer	20	Flat	100	1500	634	39.6
Sample 630 Cu-Flat 1500D 100DS-Summer	Summer	20	Flat	100	1500	609	38.1
Sample 1000Cu-Flat 1500D 100DS-Summer	Summer	20	Flat	100	1500	692	43.3

Table 3 - Culvert/Service Undercrossing Design (1500mm depth) Results

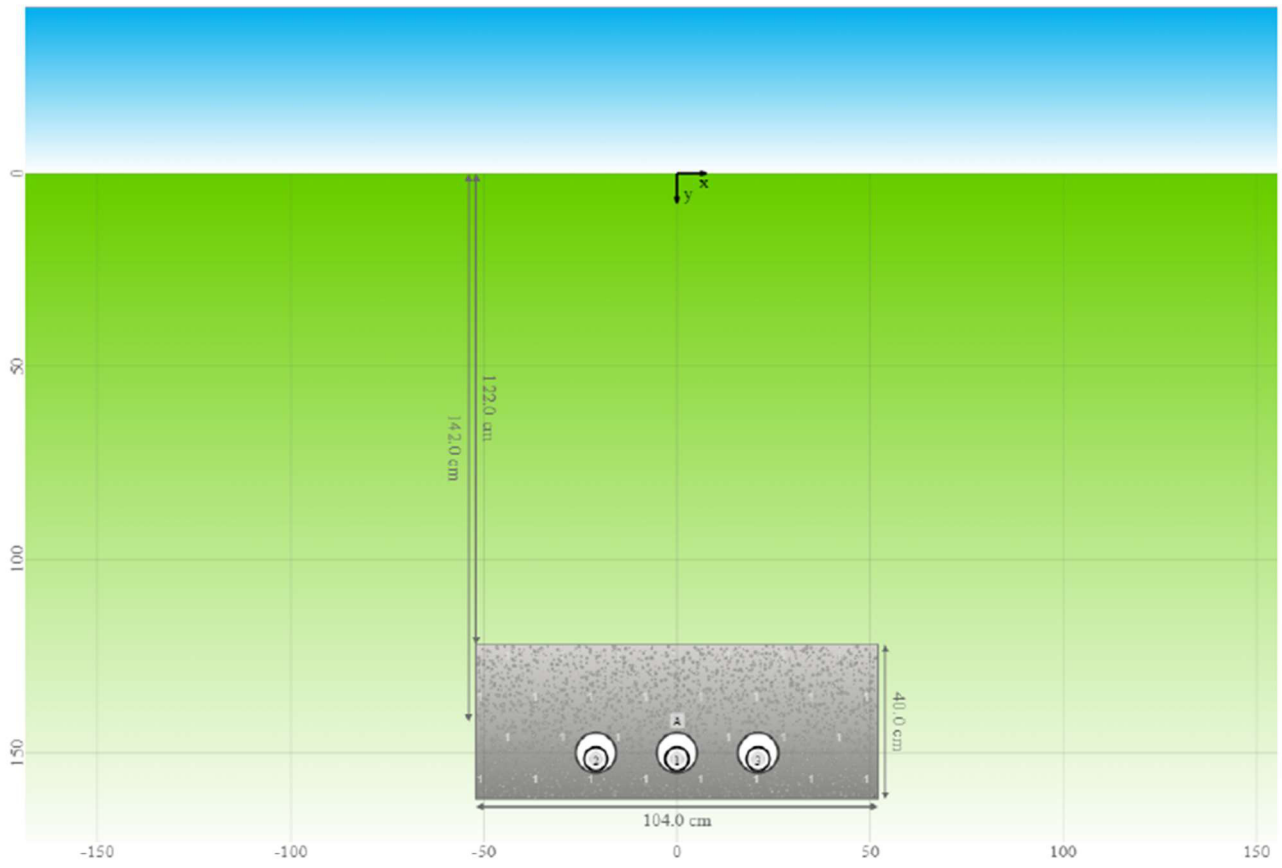
It can be seen from **Table 3** that it only be possible to achieve the required rating for the project (40.8MW) when using a 1000mm^2 Cu Cable installed in the Culvert/Service Undercrossing Design (1500mm depth). It is not possible to achieve the required rating when using a 1000mm^2 Al Cable, a 630mm^2 Al or a 630mm^2 Cu Cable for the project.

Alternative design options available would be to cross over the existing service/culvert (subject to ESB approval). The use of any non-standard cable would also be subject to ESB approval. It may also be possible to move/replace the culvert/service in order to achieve a crossing depth which can maintain the required cable rating when using one of the 630mm2 Al cable models. All proposed crossings and associated crossing depths will need to be assessed in detail as part of the detailed design phase.

An extract from cable rating study 'NKT 1000 Al-Flat 1500D 100DS-Summer' is detailed below for reference.

Statistics

Number of iterations of the solver	N_{calc}	6
Sum of currents from all systems	I_{sum}	626.3 A
Sum of average conductor temperatures from all systems	θ_{sum}	82.7 °C
Number of overheated electrical systems		0
Sum of losses from all systems	W_{sum}	82.314 W/m



Systems

Following systems are active in the arrangement:

System	Object	Current I_c [A]	max Temp. θ_c | θ_e (θ_{de}) [°C]	Losses W_{sys} [W/m]
System A	NKT 1000mm2 Al XLPE (38kV)	626.3	90.0 | 84.0 (70.0)	82.3

Figure 2 – Culvert/Service Undercrossing Design Results (1500mm depth - NKT 1000mm Al)

3.0 Culvert/Service Undercrossing Design (2000mm depth)

The Flat Formation Culvert/Service Undercrossing Design (2000mm depth) is the trench design which should be utilised for crossing under existing services/culverts, with a maximum duct depth of 2000mm. The maximum capacity of the cable when installed in this trench design was calculated for each cable model. The cable rating results for the various cable models when installed using the Culvert/Service Undercrossing Design (2000mm depth) are summarised in **Table 4**.

Cable Rating Ref	Season	Ambient Temp (˚C)	Circuit Config.	Duct Spacing (mm)	Duct Depth (mm)	Rated Current	Rated MW
NKT 630 Al-Flat 2000D 100DS-Summer	Summer	20	Flat	100	2000	515	32.2
SolidAl 630 Al-Flat 2000D 100DS-Summer	Summer	20	Flat	100	2000	521	32.6
NKT 1000 Al-Flat 2000D 100DS-Summer	Summer	20	Flat	100	2000	604	37.8
SolidAl 1000 Al-Flat 2000D 100DS-Summer	Summer	20	Flat	100	2000	612	38.2
Sample 630 Cu-Flat 2000D 100DS-Summer	Summer	20	Flat	100	2000	588	36.8
Sample 1000Cu-Flat 2000D 100DS-Summer	Summer	20	Flat	100	2000	668	41.7

Table 4 - Culvert/Service Undercrossing Design (2000mm depth) Results

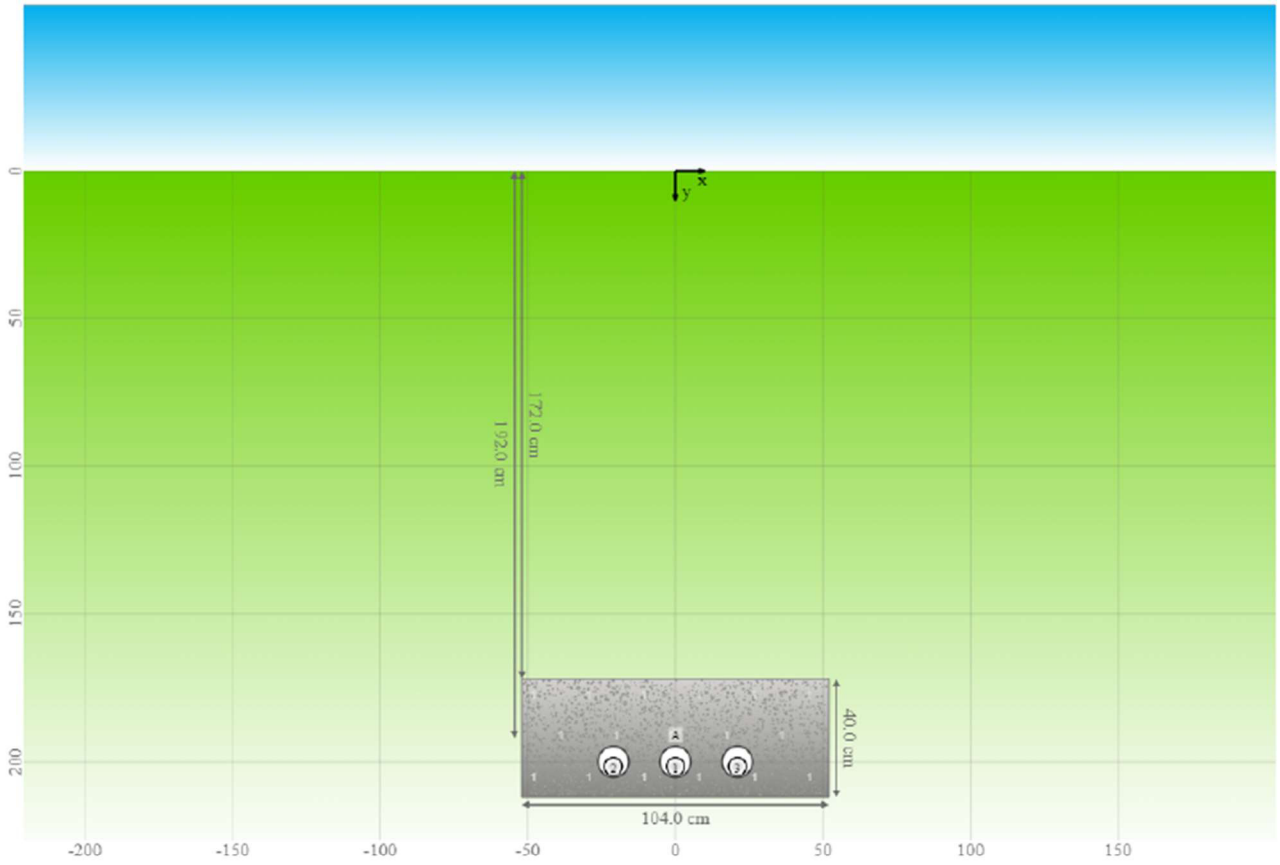
It can be seen from **Table 4** that it will not be possible to achieve the required rating for the project (40.8MW) when using a 630mm^2 Cable installed in the Culvert/Service Undercrossing Design (2000mm depth). However, it is possible to achieve the required rating when using a 1000mm^2 Cu Cable for the project. The 1000mm^2 Cu Cable will be capable of achieving approx. 42MW in the Culvert/Service Undercrossing Design (2000mm depth).

Alternative design options available would be to cross over the existing service/culvert (subject to ESB approval). The use of any non-standard cable would also be subject to ESB approval. It may also be possible to move/replace the culvert/service in order to achieve a crossing depth which can maintain the required cable rating when using one of the 630mm2 Al cable models. All proposed crossings and associated crossing depths will need to be assessed in detail as part of the detailed design phase.

An extract from cable rating study ‘NKT 1000 Al-Flat 2000D 100DS-Summer’ is detailed below for reference.

Statistics

Number of iterations of the solver	N_{calc}	6
Sum of currents from all systems	I_{sum}	604.4 A
Sum of average conductor temperatures from all systems	θ_{sum}	82.6 °C
Number of overheated electrical systems		0
Sum of losses from all systems	W_{sum}	76.642 W/m



Systems

Following systems are active in the arrangement:

System	Object	Current I_c [A]	max Temp. θ_c | θ_e (θ_{de}) [°C]	Losses W_{sys} [W/m]
System A	NKT 1000mm2 Al XLPE (38kV)	604.4	90.0 | 84.4 (71.4)	76.6

Figure 3 – Culvert/Service Undercrossing Design Results (2000mm depth - NKT 1000mm Al)

4.0 Culvert/Service Shallow Overcrossing Design (450mm depth)

The Flat Formation Culvert/Service Shallow Overcrossing Design (450mm depth) is the trench design which should be utilised for crossing over existing services/culverts, with a minimum duct cover of 450mm. This design should only be utilised where it is not possible to cross over the existing service/culvert using the standard trefoil trench design while maintaining sufficient cover and where it is not possible to cross under the existing culvert/service while maintaining the required cable rating. It should be noted that ESB's preference is to cross under existing services and culverts where possible when the standard trefoil trench design cannot be utilised. This trench design can only be used subject to ESB approval.

The Culvert/Service Overcrossing Design (450mm depth) for the project has been designed in line with the ESB Functional Specifications, see Drawings No. 05830-DR-156 and Appendix C. This trench design was modelled using the parameters outlined in **Table 1**. Cable rating calculations were carried out using various cable models under summer conditions. The maximum capacity of the cable when installed in this trench design was calculated for each cable model. The cable rating results for the various cable models when installed using the Culvert/Service Overcrossing Design (450mm depth) are summarised in **Table 5**.

Cable Rating Ref	Season	Ambient Temp (˚C)	Circuit Config.	Duct Spacing (mm)	Duct Depth (mm)	Rated Current	Rated MW
NKT 630 Al-Flat 450D 100DS-Summer	Summer	20	Flat	100	450	622	38.9
SolidAl 630 Al-Flat 450D 100DS-Summer	Summer	20	Flat	100	450	630	39.4
NKT 1000 Al-Flat 450D 100DS-Summer	Summer	20	Flat	100	450	738	46.1
SolidAl 1000 Al-Flat 450D 100DS-Summer	Summer	20	Flat	100	450	748	46.8
Sample 630 Cu-Flat 450D 100DS-Summer	Summer	20	Flat	100	450	713	44.6
Sample 1000Cu-Flat Trefoil 450D-Summer	Summer	20	Flat	100	450	818	51.1

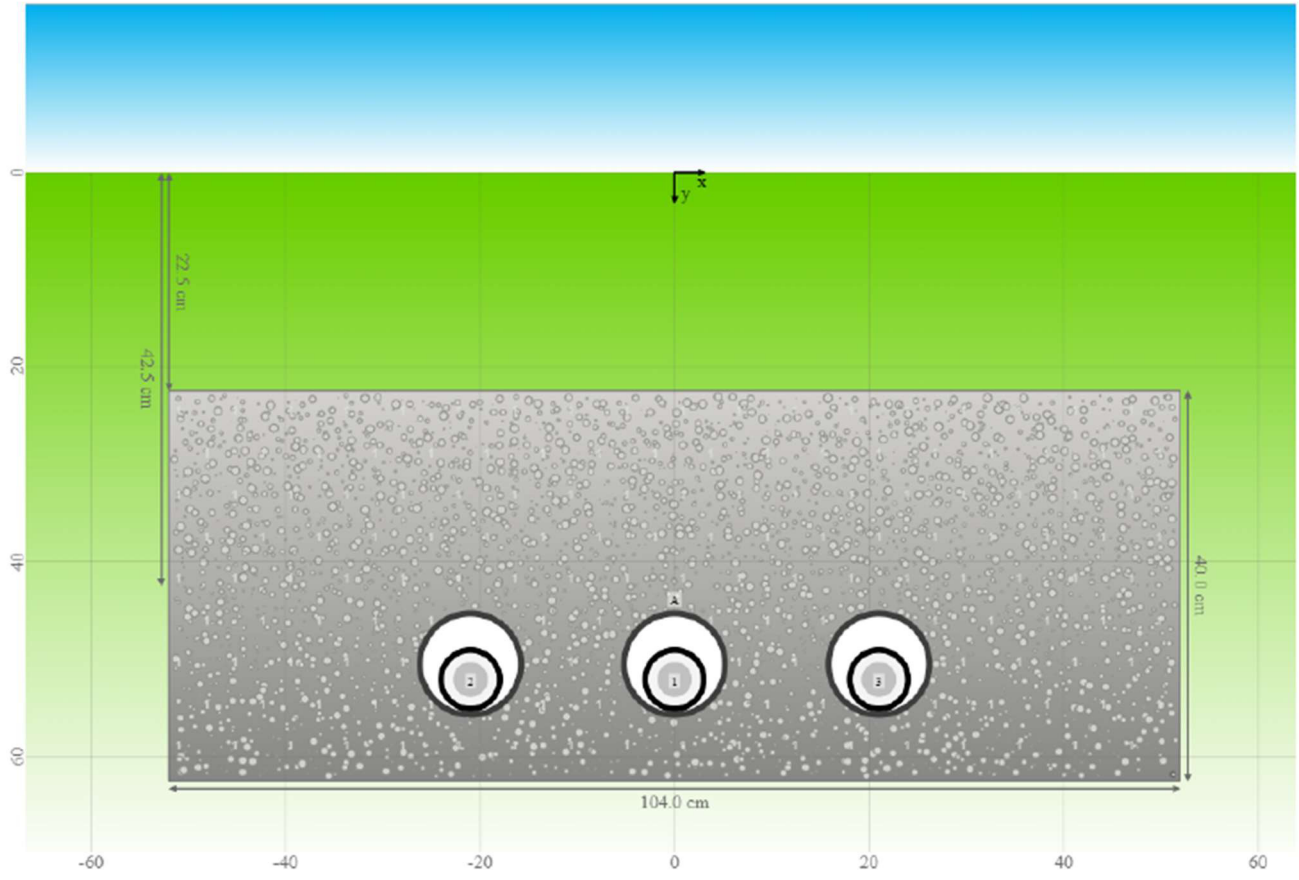
Table 5 - Culvert/Service Shallow Overcrossing Design (450mm depth) Results

It can be seen from **Table 5** that it will be possible to achieve the required rating for the project (40.8MW) when using any of the listed cable models in green in the standard flat trench design.

An extract from cable rating study 'NKT 1000 Al-Flat 450D 100DS-Summer' is detailed below for reference.

Statistics

Number of iterations of the solver	N_{calc}	6
Sum of currents from all systems	I_{sum}	737.7 A
Sum of average conductor temperatures from all systems	θ_{sum}	83.3 °C
Number of overheated electrical systems		0
Sum of losses from all systems	W_{sum}	114.504 W/m



Systems

Following systems are active in the arrangement:

System	Object	Current I_c [A]	max Temp. θ_c | θ_e (θ_{de}) [°C]	Losses W_{sys} [W/m]
System A	NKT 1000mm2 Al XLPE (38kV)	737.7	90.0 | 81.6 (61.9)	114.5

Figure 4 – Culvert/Service Overcrossing Design Results (450mm depth - NKT 1000mm Al)

5.0 Horizontal Directional Drill (3000mm depth)

The Horizontal Directional Drill (3000mm depth) is the design which will be utilised for drilling under watercourses and bridges where it is not possible to cross within the existing bridge structure. This design assumes a maximum depth of 3000mm to the top of the ducts.

The Horizontal Directional Drill (3000mm depth) for the project has been designed in line with the ESB Functional Specifications, see Appendix D. This design was modelled using the parameters outlined in **Table 1**. Cable rating calculations were conducted using various cable models under summer conditions. The maximum capacity of the cable when installed in this design was calculated for each cable model. The cable rating results for the various cable models when installed using the Horizontal Directional Drill (3000mm depth) are summarised in **Table 6**.

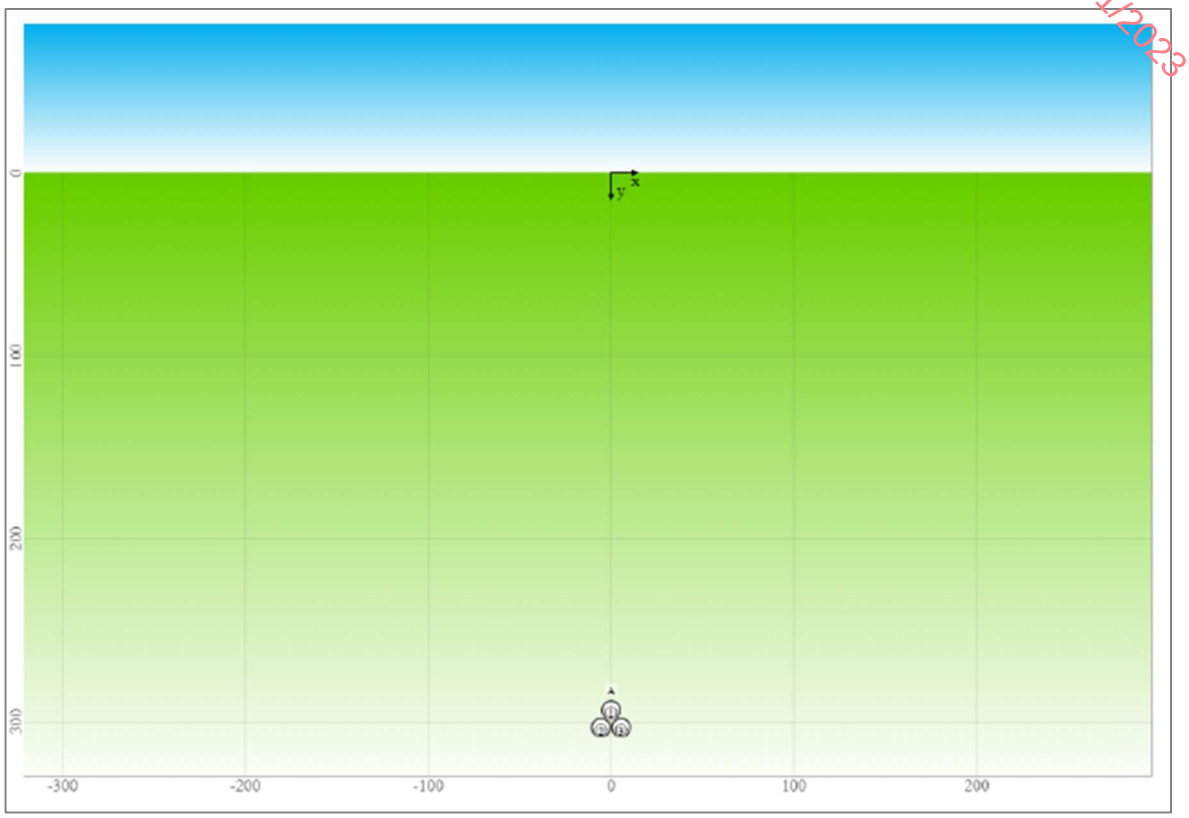
Cable Rating Ref	Season	Ambient Temp (˚C)	Circuit Config.	Duct Spacing (mm)	Duct Depth (mm)	Rated Current	Rated MW
NKT 630 Al-HDD Trefoil 3000D-Summer	Summer	20	HDD Trefoil	-	3000	532	33.3
SolidAl 630 Al-HDD Trefoil 3000D-Summer	Summer	20	HDD Trefoil	-	3000	537	33.6
NKT 1000 Al-HDD Trefoil 3000D-Summer	Summer	20	HDD Trefoil	-	3000	653	40.8
SolidAl 1000 Al-HDD Trefoil 3000D-Summer	Summer	20	HDD Trefoil	-	3000	661	41.3
Sample 630 Cu-HDD Trefoil 3000D-Summer	Summer	20	HDD Trefoil	-	3000	642	40.1
Sample 1000Cu-HDD Trefoil 3000D-Summer	Summer	20	HDD Trefoil	-	3000	846	52.9

Table 6 - Horizontal Directional Drill (3000mm depth) Results

It can be seen from **Table 6** that it will not be possible to achieve the required rating for the project (40.8MW) when using a 630mm^2 Al Cable or the 630mm^2 Cu installed in the Horizontal Directional Drill (3000mm depth) design. However, it is possible to achieve the required rating when using a 1000mm^2 Al Cable or a 1000mm^2 Cu Cable for the project. The 1000mm^2 Al Cable will be capable of achieving approx. 41MW in the Horizontal Directional Drill (3000mm depth) design, with the 1000mm^2 Cu Cable being capable of achieving approx. 53MW.

Alternative HDD crossing designs could also be utilised, subject to review and approval by ESB. Detailed SI works should be completed at all HDD locations in order to determine the ground conditions and final proposed crossing depth. All proposed crossings and associated crossing depths will need to be assessed in detail as part of the detailed design phase.

An extract from cable rating study 'NKT 1000 Al-HDD Trefoil 3000D-Summer' is detailed below for reference.



Systems

Following systems are active in the arrangement:

System	Object	Current I_c [A]	max Temp. $\theta_c \mid \theta_e\ (\theta_{de})$ [°C]	Losses W_{sys} [W/m]
System A	NKT 1000mm2 A1 XLPE (38kV)	653.0	90.0 | 84.1 (73.4)	66.0

Figure 5 – Horizontal Directional Drill (3000mm depth - NKT 1000mm Al)

6.0 Horizontal Directional Drill (4000mm depth)

The Horizontal Directional Drill (4000mm depth) is the design which will be utilised for drilling under watercourses and bridges where it is not possible to cross within the existing bridge structure. This design assumes a maximum depth of 4000mm to the top of the ducts. The maximum capacity of the cable when installed in this design was calculated for each cable model. The cable rating results for the various cable models when installed using the Horizontal Directional Drill (4000mm depth) are summarised in **Table 7**.

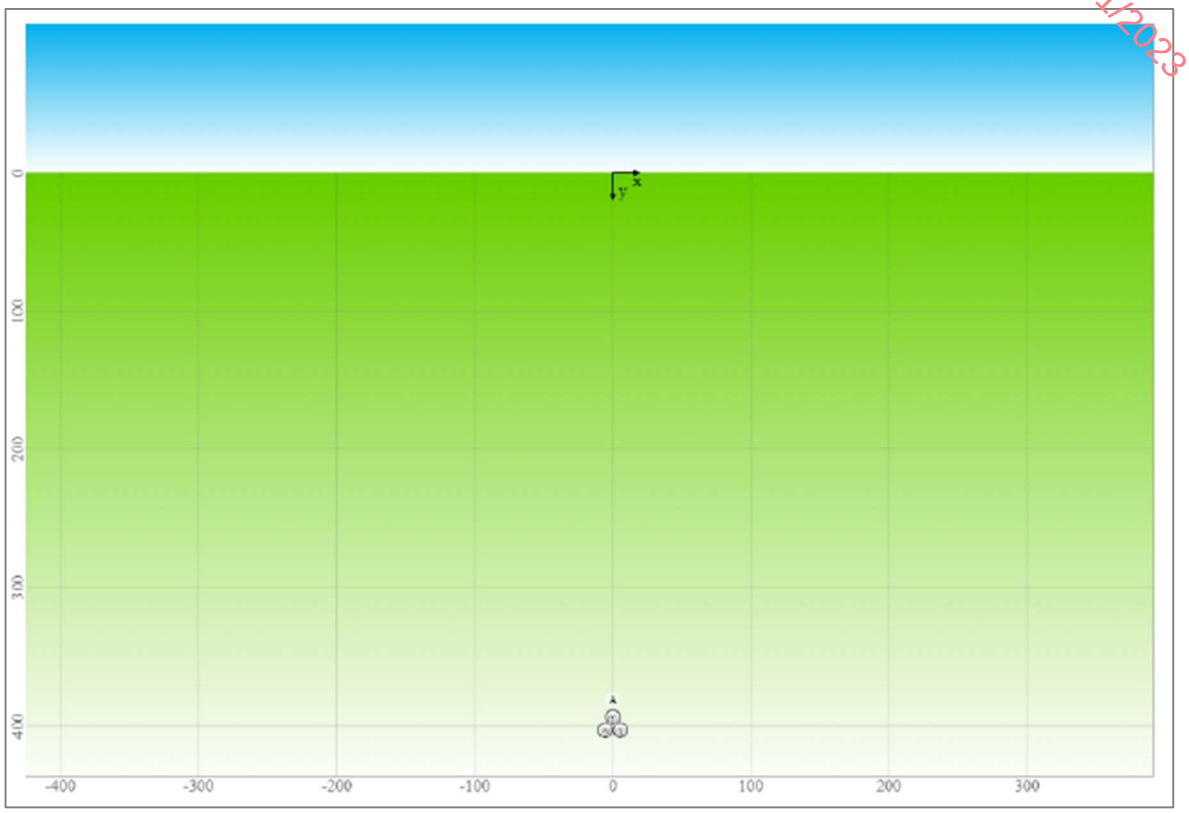
Cable Rating Ref	Season	Ambient Temp (˚C)	Circuit Config.	Duct Spacing (mm)	Duct Depth (mm)	Rated Current	Rated MW
NKT 630 Al-HDD Trefoil 4000D-Summer	Summer	20	HDD Trefoil	-	4000	519	32.5
SolidAl 630 Al-HDD Trefoil 4000D-Summer	Summer	20	HDD Trefoil	-	4000	524	32.8
NKT 1000 Al-HDD Trefoil 4000D-Summer	Summer	20	HDD Trefoil	-	4000	637	39.8
SolidAl 1000 Al-HDD Trefoil 4000D-Summer	Summer	20	HDD Trefoil	-	4000	644	40.3
Sample 630 Cu-HDD Trefoil 4000D-Summer	Summer	20	HDD Trefoil	-	4000	626	39.2
Sample 1000Cu-HDD Trefoil 4000D-Summer	Summer	20	HDD Trefoil	-	4000	745	46.6

Table 7 - Horizontal Directional Drill (4000mm depth) Results

It can be seen from **Table 7** that it will only be possible to achieve the required rating for the project (40.8MW) when using a 1000mm^2 Cu Cable installed in the Horizontal Directional Drill (4000mm depth) design. It is not possible to achieve the required rating when using a 630mm^2 Al Cable, a 630mm^2 Cu Cable or a 1000mm^2 Al Cable for the project. The 1000mm^2 Al Cable will only be capable of achieving approx. 40MW in the Horizontal Directional Drill (4000mm depth) design, with the 630mm^2 Cu Cable being capable of achieving approx. 39MW.

Alternative HDD crossing designs could also be utilised, subject to review and approval by ESB. Detailed SI works should be completed at all HDD locations in order to determine the ground conditions and final proposed crossing depth. All proposed crossings and associated crossing depths will need to be assessed in detail as part of the detailed design phase.

An extract from cable rating study 'NKT 1000 Al-HDD Trefoil 4000D-Summer' is detailed below for reference.



Systems

Following systems are active in the arrangement:

System	Object	Current I_c [A]	max Temp. θ_c | θ_e (θ_{de}) [°C]	Losses W_{sys} [W/m]
System A	NKT 1000mm2 A1 XLPE (38kV)	636.9	90.0 | 84.4 (74.2)	62.8

Figure 6 – Horizontal Directional Drill (4000mm depth - NKT 1000mm Al)

Conclusions and Recommendations

Based on the initial cable rating assessment completed, a 38kV 1000mm^2 Cu UGC will be capable of achieving the required MEC rating for the project (40.8MW) when installed in a standard trefoil trench design.

Culvert/service undercrossings where the ducts are installed at a depth of 1500mm or less are capable of achieving the required cable rating for the project when using a 1000mm^2 Cu UGC for the project. There is additional capacity available in the cable when installed at this depth.

Culvert/service undercrossings where the ducts are installed at a depth of 2000mm or less are capable of achieving the required cable rating for the project when using a 1000mm^2 Cu UGC for the project. There is little additional capacity available in the cable when installed at this depth. Every culvert/service crossing on the proposed cable route will need to be assessed in detail as part of the detailed design phase in order to confirm the proposed crossing method to be implemented.

Culvert/service shallow overcrossings where the ducts are installed at a depth of 450mm are capable of achieving the required cable rating for the project when using any of the listed UGC models for the project. It should be noted that this design can only be utilised where all other options have been expended and subject to ESB approval.

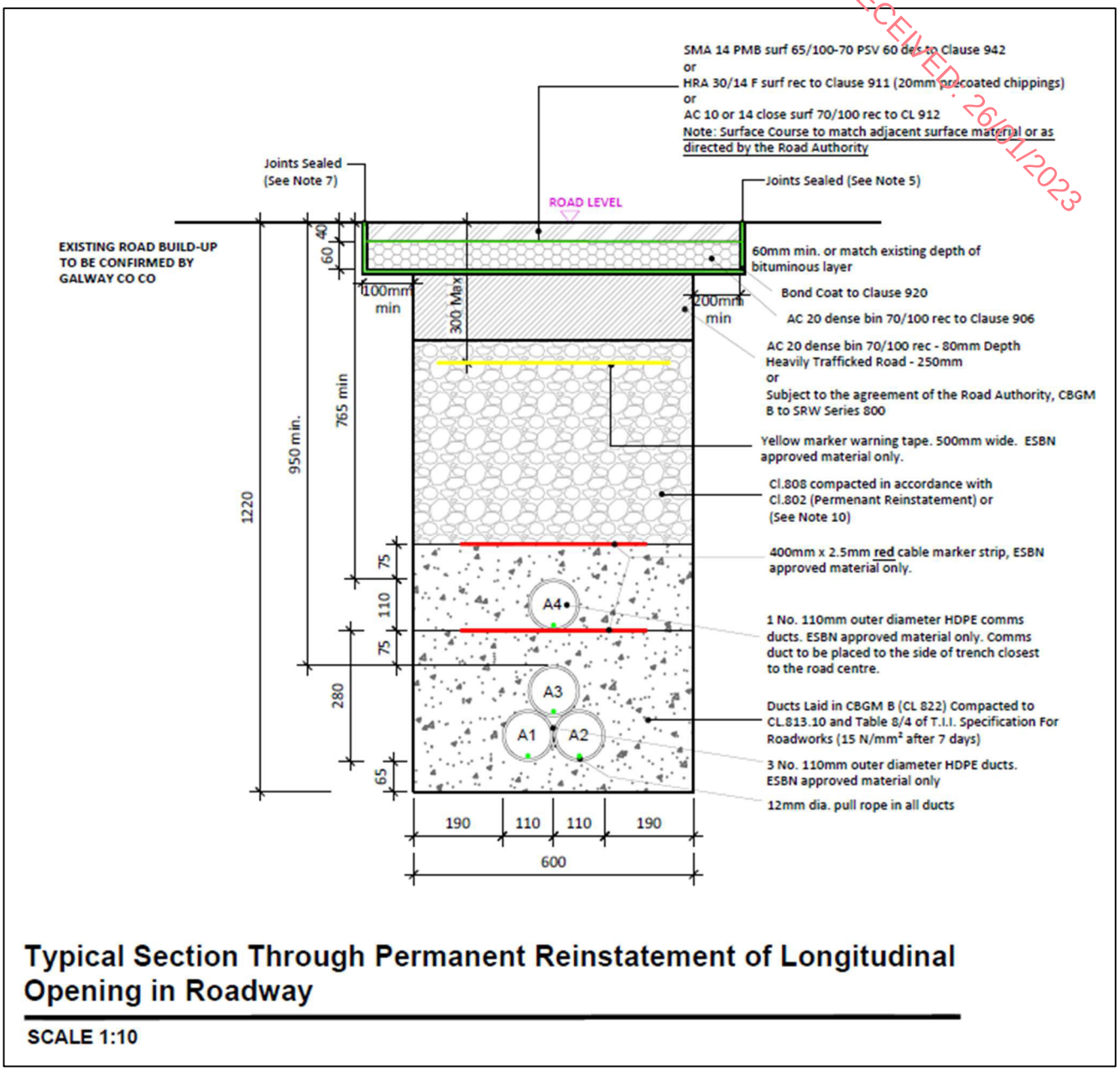
HDD crossings where the ducts are installed at a depth of 3000mm or less are capable of achieving the required cable rating for the project when using a 1000mm^2 Cu UGC for the project. There is additional capacity available in the cable when installed at this depth.

HDD crossings where the ducts are installed at a depth of 4000mm or less are capable of achieving the required cable rating for the project when using a 1000mm^2 Cu for the project. There is additional capacity available in the cable when installed at this depth.

The use of any non-standard cable is subject to ESB approval. Any alternative HDD crossing designs could also be utilised, subject to review and approval by ESB. Detailed SI works should be completed at all HDD locations in order to determine the ground conditions and final proposed crossing depth. All proposed crossings and associated crossing depths will need to be assessed in detail as part of the detailed design phase.

Appendix A – Standard Trefoil Trench Design

**See Drawing No. 05830-DR-150*



Typical Section Through Permanent Reinstatement of Longitudinal Opening in Roadway

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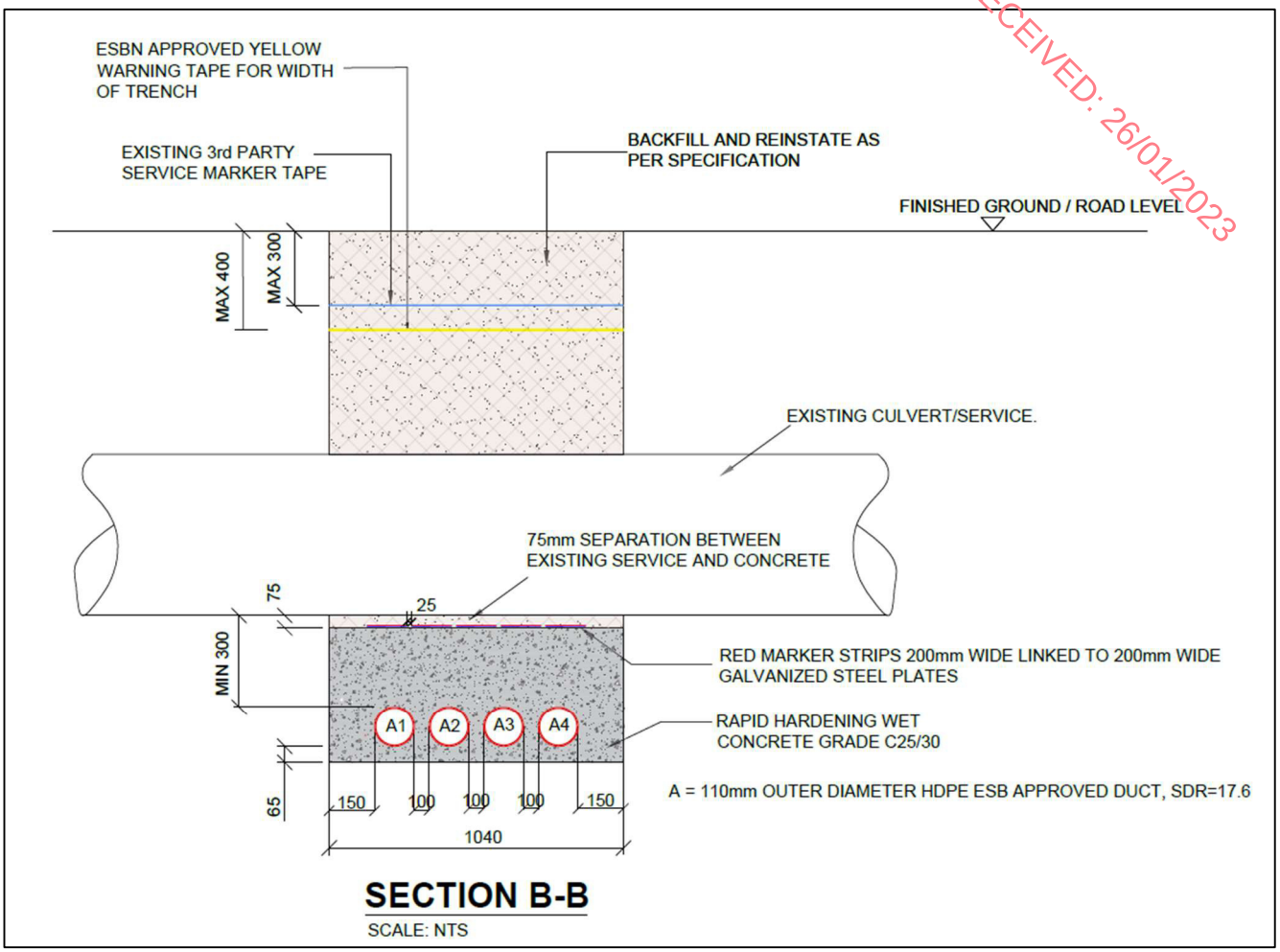
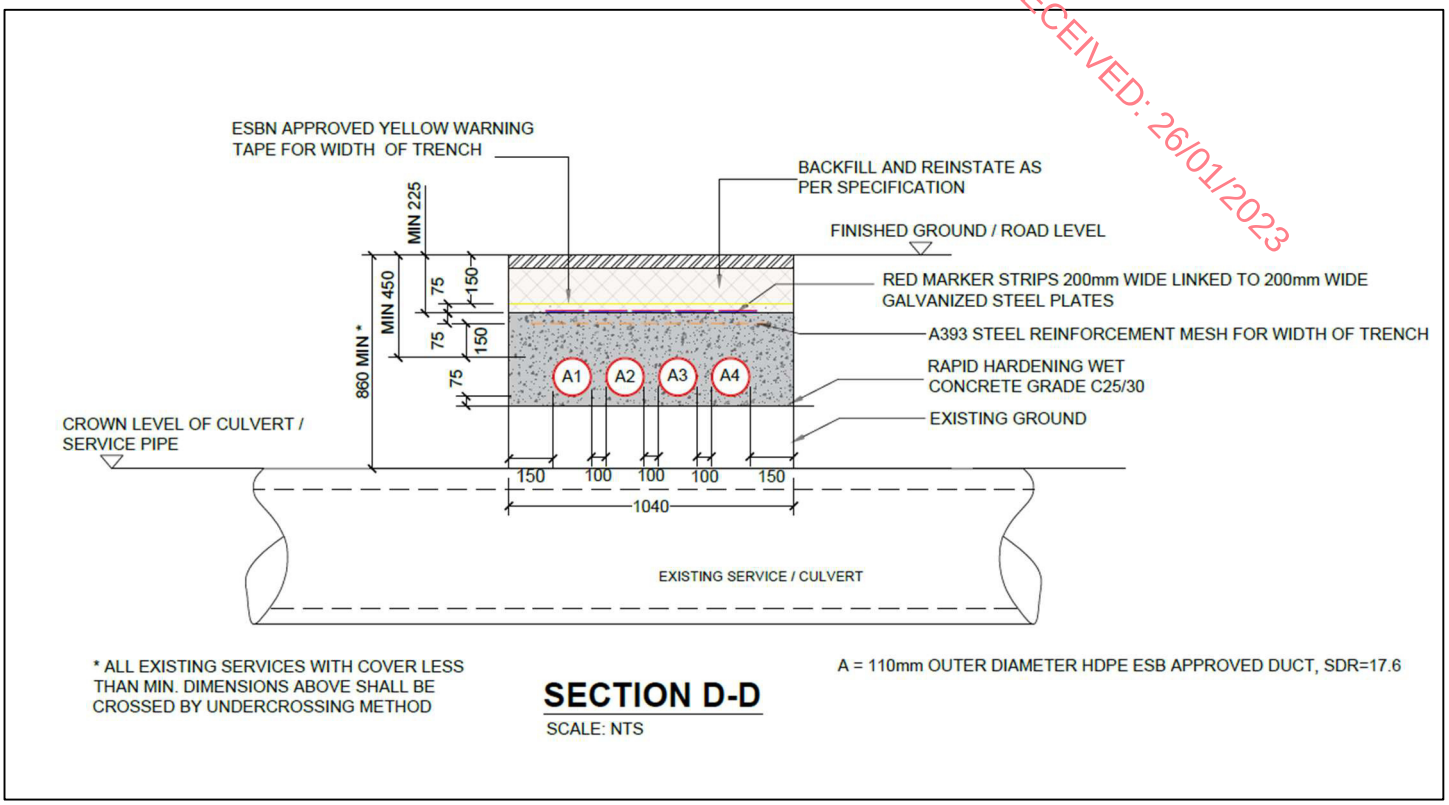
Appendix B – Culvert/Service Undercrossing Design

**See Drawing No. 05830-DR-155/157*



Appendix C – Culvert/Service Overcrossing Design

**See Drawing No. 05830-DR-156*

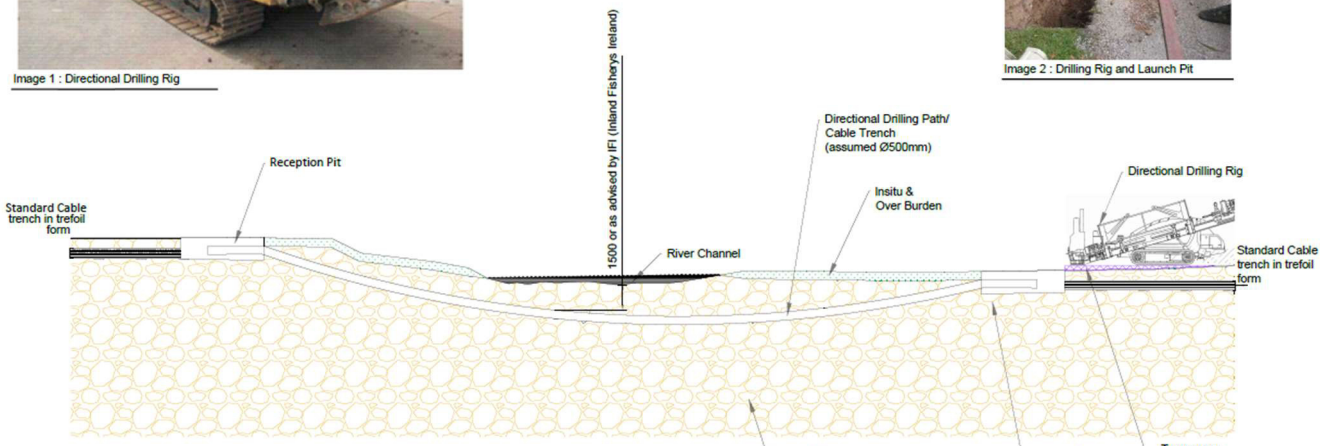


Appendix D – Typical HDD Crossing Design

**See Drawing No. 05830-DR-159*

Image 1 : Directional Drilling Rig

Image 2 : Drilling Rig and Launch Pit



Directional Drilling Water Crossing Detail

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