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A18.4

MetroLink/ESBN Construction Methodology of HV Cable Routes

Executive Summary

This report has been compiled as a guide to provide suitable information on the standard trenching and ducting techniques required to complete a HV cable project. The completion of ducting works has been provided in a step by step guide along with the civil work aspects regarding joint bay construction, typical water crossing procedures and High Voltage (HV) cable installation.

The report has provided information on the standard aspects of a HV cable civil project with project specific methodologies for non-standard aspects of project work, being addressed in this report.

The methodologies in this report are the current expected methodologies for the construction of a project. These approaches may require local variation during the detailed design and construction of a project depending on the best working practices and preferred construction techniques of the selected contractor, following on the ground detailed design and survey; however, it is considered that such methodologies are adequate for an understanding by the Planning Authority of the proposed development, particularly in the context of determining a planning application request for a project.

Contents

1 Table of figures

2 Introduction

It is the policy of ESB that, in so far as possible, high voltage underground cables shall only be installed under public roads. One of the key advantages of laying cables under roadways is that there is usually no permanent impact on the environment additional to that caused by the presence of the roadway. When an underground cable is laid under an existing roadway the potential for impact is normally only a short term impact during the construction phase.

The joint bays proposed along the cable route shall be predominantly located in the road carriageway, however where the road and margin widths permit, in some instances the joint bays can also be located off-road. The selection of joint bay locations involves technical and environmental evaluation of the sites to ensure that the area is suitable for construction works. A working area is defined which provides adequate space for cable pulling and jointing around the joint bay. This working area shall also provide space for movement of all construction vehicles. The working area shall immediately adjoin the public road, as the cable shall be diverted from the road into the off-road joint bay. Due consideration must also be given to the possible presence of existing underground and overhead services, traffic management requirements, landowner agreements and existing ground conditions. Once agreements with each landowner are reached, site investigations shall be carried out to prove these locations suitability and allow the civil works commence. For information purposes only, see drawing of typical joint bay and chamber layouts in appendix A for 220 kV and 110 kV installations. Drawing PE424-D3025-019-001-001 in appendix A shows a typical joint bay and passing bay arrangement for certain locations where a passing bay, if possible to construct, may be needed to reduce any obstructions to traffic flow.

A civil contractor carrying out the standard HV trenching and ducting specification shall typically complete between 30 to 50 linear metres of trench in a roadway per day depending on the site conditions. All road works involving cable and pipe laying e.g. watermains, broadband, television etc., require traffic management procedures when installing within public roads. It may be a temporary requirement that some roads are closed along particular sections of the cable route. This can have a disruptive effect locally on residents over the period of the installation works. In the case of wider roads, one carriageway may be closed with use of the other carriageway restricted and controlled by temporary traffic lights or a “stop and go” traffic management system. The traffic management plan and corresponding works shall be carried out with the agreement of the local authority.

3 Trenching and Ducting

3.1 Site Investigations

Site investigations along the proposed route shall be carried out in advance of the approved designs being finalised and before the contractor commences trenching and ducting civil works. These site investigations shall include slit trenches along the road ways to detail the route and to ensure that there is sufficient space to install a 110 kV cable trench typically measuring approximately 1.25 m by 0.6 m, and a 220 kV trench measuring 1.1 m of 1.7 m in width. Construction drawings which detail the cable alignment and off road joint bay locations and river crossing proposals shall be made available to the contractor. Further site investigations may be required to gather additional information on the road cover available over existing bridges and culverts with the relevant local authority approval. This information may be used to prove the requirement for off-road alignments if insufficient cover exists. There shall be additional trial holes or bore holes required at the off-road locations for joint bays and river crossings.

3.2 Contractors Duties

In advance of starting the works, the contractor or the appointed wayleave officer shall liaise with all directly impacted landowners. The design engineer shall also set out the route alignment, off road joint bay positions and river crossing alignments for the contractor.

The contractor shall obtain plans, maps and other relevant information about buried services from statutory authorities and other public utilities. The contractor shall also ensure that the relevant road opening concessions have been obtained from the local authority.

The contractor's general work requirements shall be:

- Present professionally drafted traffic management plans for each stage of the works.
- Secure each work area with adequate protective barriers and organise traffic signs and traffic management controls to the approval of the Engineer.
- In off road locations, a temporary hardstand working area shall be created and fenced to facilitate the joint bay construction and associated traffic. These working areas shall be removed upon completion of the cable installation and jointing works.
- Provide secure and clean storage facilities for all ducting and trenching materials, cable installation equipment and cable drums.
- Carry out a surface check for underground services with appropriate detection equipment.
- Clean and sweep adjacent public roadways and footpaths during and after the works.
- Saw cut to full depth of existing asphalt/bitmac layers and/or concrete surfacing. In grassed fields, carry out the works in accordance with specification.
- A rock breaker or other approved method shall be used to break the trench section of the road surface.

- Commence excavation of this section of trench with due attention to the presence of other services and to the grade of the trench. Hand dig when within 500 mm of services and around trees. Note that a length of 12 m of proven excavation should be exposed ahead of any commencement of ducting. This is to allow for the bending of ducts to avoid obstacles and the possible requirement for digging back on re-commencement of new excavation if an obstacle is encountered within the 12 m.
- Where possible, crossing of existing services shall be carried out at right angles. The contractor shall provide a standard minimum 300 mm vertical clearance between the proposed ducts and the existing services to be crossed.
- Where possible, the contractor should ensure a minimum distance of 500 mm horizontal separation is maintained between the edge of the power ducts and existing services.
- Simultaneously load and remove soil, and dispose of properly to a site or sites to be selected by the contractor and agreed with the relevant authority. In grassed fields the excavated soil shall be stored within the wayleave.
- Protect all services against damage due to trenching, ducting, backfilling and compaction.
- Remove all ground water from the trench. Treat and dispose of the waste water in accordance with current legislation and best practice, under permit from the local authority if required.

3.3 General Methodology

For the trenching and ducting works the following step by step methodology shall apply:

1. Grade, smooth and trim trench floor when the required depth and width have been obtained.
2. Place bedding layer of Cement Bound Granular Mixture B (CBGM B) material in accordance with the specification and compact it so that the compacted thickness is as per the drawings.
3. Lay the bottom row of ducts in the formation as detailed on the design drawings. Use spacers as appropriate to establish horizontal duct spacing (see Figure 1). Fit a secure cap / bung to the end of each duct run to prevent the ingress of dirt or water.
4. Provide pits for lubrication and bentonite grouting the ducts at 100m-200m intervals.
5. Carefully surround and cover ducts with CBGM B in accordance with the design drawings and specifications and thoroughly compacted without damaging ducts.
6. Place cable protection strips on compacted CBGM B directly over the ducts.
7. Lay the top row of ducts onto the freshly compacted CBGM B including the cable protection strips above the bottom row of ducts. Place a secure cap at the end of each duct to prevent the ingress of dirt or water.
8. Carefully surround and cover ducts with CBGM B material in accordance with the drawings and thoroughly compact without damaging ducts.

9. Place red cable protection strip on top of compacted CBGM B over each set of ducts as shown on the drawings.
10. Place and thoroughly compact CBGM B material or Clause 804 backfill or soil backfill as specified and place warning tape at the depth shown on the drawings.
11. For concrete and asphalt / bitmac road sections, carry out immediate permanent reinstatement in accordance with the specification and to the approval of the local authority and/or private landowners, unless otherwise agreed with local authorities. (See Figure 2)
12. For unsurfaced/grass sections, backfill with suitable excavated material to ground level leaving at least 100 mm topsoil or match existing level at the top to allow for seeding or replace turves as per the specification of the local authority or landowner.
13. Clean and test the ducts in accordance with the specification by pulling through brush and mandrel. Install 12 mm polypropylene draw rope in each duct and seal all ducts using robust duct end seals fitted with rope attachment eyes in preparation for cable installation at a later date. All the works should be witnessed by a Clerk of Works (CoW)

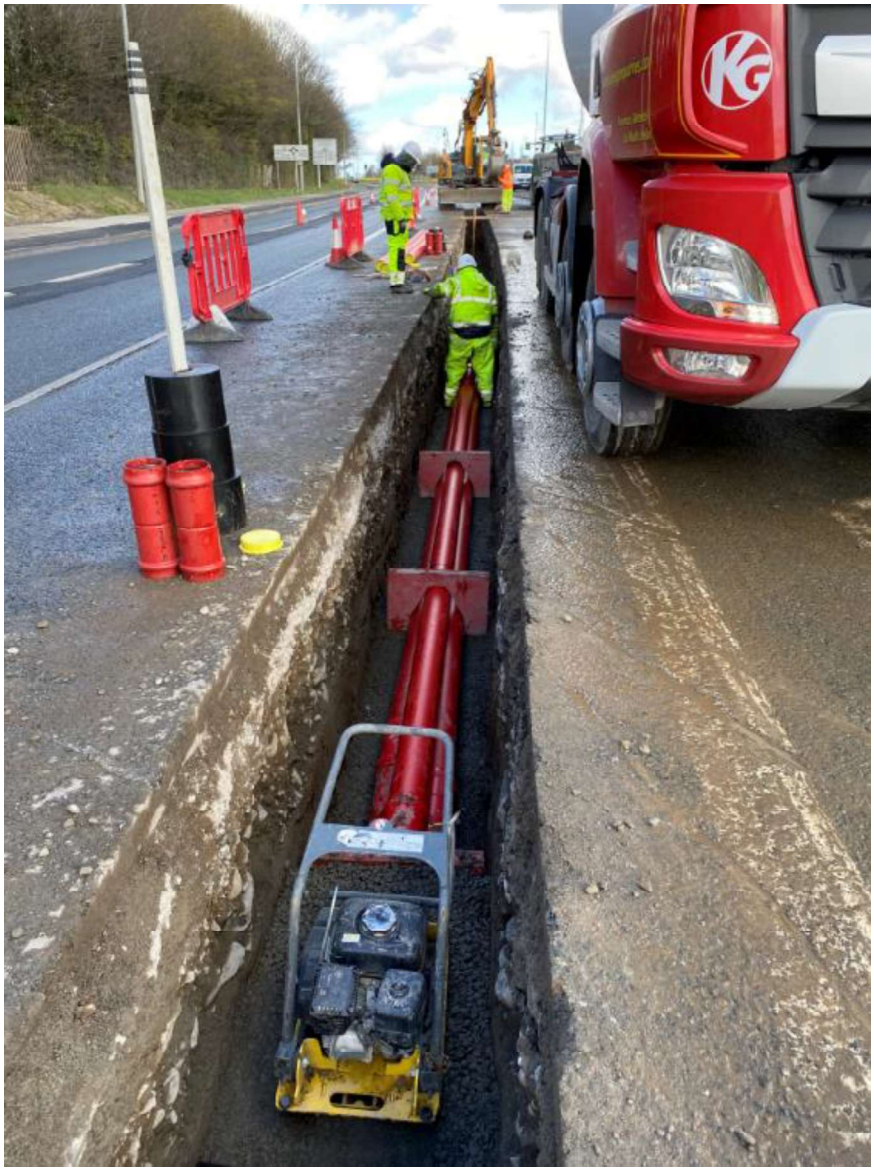


Figure 1 - Typical HV Trench Cross Section

Figure 2 - Reinstatement of Road Surface Over Trench

3.4 A Project Specific Methodology

Particular attention is required for the aspects of the trenching and ducting works which shall be confined to within an existing road corridor except where the route needs to deviate slightly from the public road at joint bay locations or at watercourse crossings. Aspects of trenching which require particular attention in this instance include: 1. management of trench spoil, 2. trench de-watering, 3. adding CBGM B and 4. bentonite injection to ducts. Industry accepted best practice shall be applied at all times in dealing with the above.

1. Soil management: For all trenching along a road, all excavated material shall be taken off site in trucks and disposed of, under licence from the relevant authority, thus preventing any contaminated run-off to roadside drains during heavy rainfall. In off road areas where the top 400 - 500 mm of topsoil shall be set aside within the wayleave for later reinstatement, these stockpiles shall be stored at least 15 m back from drains and watercourses on level ground with a silt fence inserted at the base.

2. Trench de-watering: Ground water and surface water accumulating in the base of trenches shall not be pumped directly to roadside drains or watercourses unless it is clean and free from solids. The trench water will be pumped through silt socks on to grass areas. Solids-contaminated water shall be discharged to a designated percolation area designated by a competent person if the soil is not water logged. In the case of heavy contamination, the water shall either be tankered off site for disposal in a licensed facility or pumped to a portable on-site settlement tank for treatment. These operations shall be monitored by a designated competent

member of the construction team on a regular basis to ensure that they are working effectively.

3. Adding CBGM B: CBGM shall be installed directly from the chute of the truck into the trench avoiding any risk of cement laden run-off entering any water courses. On occasion it may be necessary to stock pile small amounts of CBGM for placement in trenches where truck access is not safe or possible. In such instance's hardstands will be installed for storing the CBGM. Hardstand areas shall only be located where there is no direct drainage to surface waters and where the area has been bunded e.g. using sand-bags and geotextile sheeting or silt fencing to contain any solids in run-off.
4. Bentonite injection: Bentonite grout injection is considered to be a low risk activity given that the injection process happens within a bunded pit inside of the cable trench. Nevertheless, the fact that the grout itself could be harmful to aquatic life, if it reaches watercourses, means that the construction team undertaking this work shall be made aware of the risks associated with the use of the material, and the process shall be carefully monitored, especially when being undertaken on off-road trench sections sloping toward watercourses. Unused bentonite grout and any spillages within the bentoniting pit shall be removed off site for disposal under licence in an approved facility.

4 Joint Bay Details

4.1 Typical Construction

Joint bay dimensions are typically in the order of 6 m or 8 m in length for 110 kV and 220 kV installations respectively, with a width of approx. 2.5 m and a depth of approx. 2.5 m. The joint bays are designed to be covered over with the land above to be potentially available for agricultural use following reinstatement. The installation of precast joint bays is preferred and the construction methodology for the joint bays is outlined below.

The following steps outline the methodology for joint bay construction and reinstatement:

1. The contractor shall excavate a pit for joint bay construction, including for a sump in one corner.
2. Grade and smooth floor; then lay a 50 mm thick sand (for pre-cast concrete construction) on 200 mm thick Clause 804 granular material.
3. Pre-cast concrete construction. Place pre-cast concrete sections on sand bedding. (See Figure 3 and Figure 4)
4. Carry out temporary reinstatement of surface as specified.
5. Temporary joint bay covers may be used as temporary reinstatement. These covers are placed over the constructed joint bay and are then removed at the cable installation stage of the project.
6. At a later date to facilitate cable installation and jointing, reinstate traffic management signage, secure individual sites, re-excavate three consecutive joint bays and store excavated material for reuse.

7. The cable is supplied in pre-ordered lengths on large cable drums (See Figure 5). Installing “one section” of cable normally involves pulling three individual conductors into three separate ducts. The cable pulling winch must be set at a predetermined cut off pulling tension as specified by the designer. The cable shall be connected to the winch rope using approved suitably sized and rated cable pulling stocking and swivel or the pulling head fitted by the cable manufacturer (See Figure 6). A sponge may also be secured to the winch rope to disperse lubricant through the duct. Lubrication is also applied to the cable in the joint bay before it enters the duct.
8. Once the “two sections” of cable (total of 6 conductors) are pulled into the joint bay (see Figure 7), a jointing container is positioned over the joint bay and the cable jointing procedure is carried out in this controlled environment. (See Figure 8 and Figure 9)
9. Following the completion of jointing and duct sealing works in the joint bay, thermal sand shall be placed and thoroughly compacted in approximately 150 mm layers to the level of the cable and cable joint base to provide vertical support. Additional layers of thermal sand shall be installed, and each layer compacted by hand until the thermal sand is 100 mm above the top of the cable and the cable joint. Cable protection strip shall be installed. Backfill with thermal sand to a depth of 300 mm below the top of the joint bay walls and with well compacted CBGM B to the top of the joint bay walls and carry out permanent reinstatement including placement of warning tape at 300 mm depth below the finished surface. (See Figure 10 and Figure 11)

4.2 A Project Specific Construction Methodology

Due diligence for the location of joint bays shall be observed to minimise conflict with other services and to facilitate the ease of installation and maintenance. The joint bays proposed along the cable route shall be predominantly located in the road carriageway. However, where the road and margin widths permit, in some instances the joint bays can also be located off-road.

Associated communications chambers and link boxes shall be installed off the carriageway where possible. Joint bays, link boxes and C2 chambers shall be accessible by heavy vehicles (10 tonne) to accommodate cable installation and maintenance/fault repair as required. The location of the link box at joint bays shall not exceed a maximum distance of 10 m from the centre of the joint bay, see 220/110 kV typical joint bay and chamber layouts drawing PE424-D3025-022-001-000 in appendix A for reference.

Activities associated with joint bay construction which could give rise to harm to Annex II and other species include: 1. site access and ground preparation, 2. soil excavations, 3. pit de-watering, 4. concrete pouring and 5. back-filling with cement-bound sand. The following aspects of best practice construction have been listed in the same order and are based on the assumption that the joint bay is near a water course or surface drainage channels. Clearly, in open level ground with few drains, the risks are much lower.

1. Site access and ground preparation: The access track from the road to the joint bay and back shall have the surface layers of soil stripped and terram laid,

followed by a layer of Clause 804 aggregate to form a working surface for vehicles, thereby preventing soil damage and rutting. Bog mats shall also be provided in areas where peat is present. This surface shall be regularly assessed for damage and additional aggregate added if required. The area around the edge of the proposed joint bay which shall be used by heavy vehicles shall also be surfaced with a terram cover and stone aggregate to minimise ground damage. Any roadside drains within the temporary works area shall be culverted and check dams made from stone or sandbags covered with terram shall be inserted upstream and downstream of these culverts to intercept any solids generated during the insertion or which wash out during the works. If the ground slopes from the working area toward a watercourse or if there is evidence of solids washing off the works area toward nearby watercourses or drains, a silt fence with straw bales, shall be interposed between the works area and the watercourse.

2. Soil excavations: All soil temporarily stockpiled on site shall be placed at least 15 m back from the nearest watercourse on level ground and shall be ringed at the base by silt fencing and be regularly monitored by a designated competent person for signs of solids escape. In which case an additional line of silt fencing with straw bales shall be added.
3. Pit de-watering: If the joint bay needs to be dewatered, this shall be pumped to a percolation area if the soil is not saturated, otherwise a settlement tank shall be used to remove any solids from the de-watering's.
4. Concrete pouring: The risk of concrete reaching surface waters is considered very low given that all concrete shall be poured into the pit excavated for the joint bay so that spills shall be contained. The requirement therefore is that all pouring operations be constantly supervised to prevent accidental spillages occurring outside the pit.

Figure 3 - Typical Joint Bay under construction (pre-cast)

Figure 4 - Completed Joint Bay prior to Cable Installation (pre-cast)

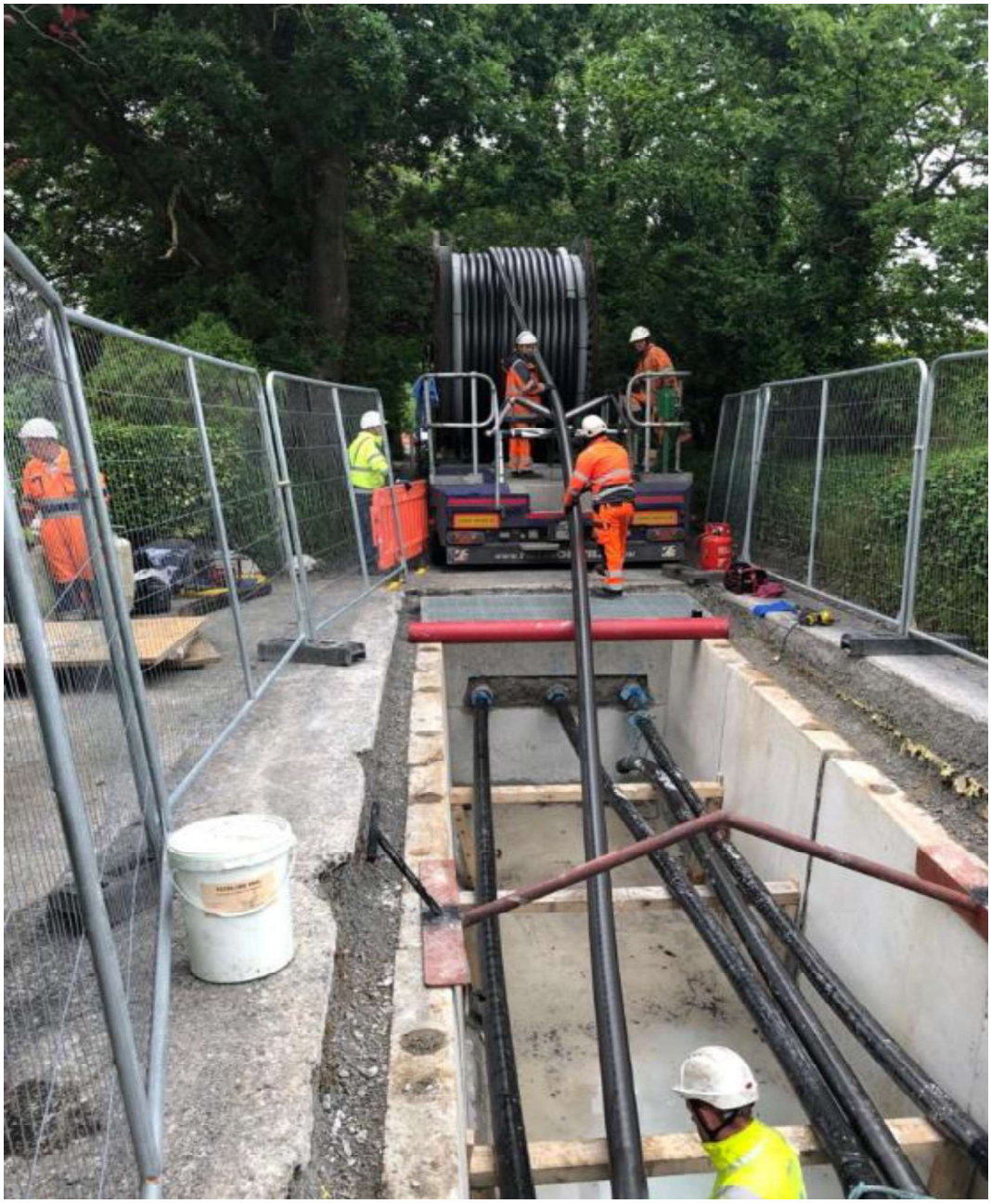


Figure 5 - Typical Set-Up of HV Cable Pulling Procedure

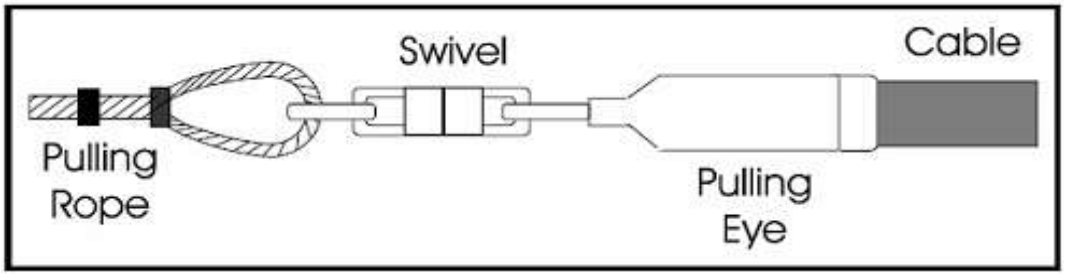


Figure 6 - Swivel & Pulling Eye

Figure 7 - Typical Winch Set Up for HV Cable Pulling Procedure

Figure 8 - Typical HV Cable Jointing Container

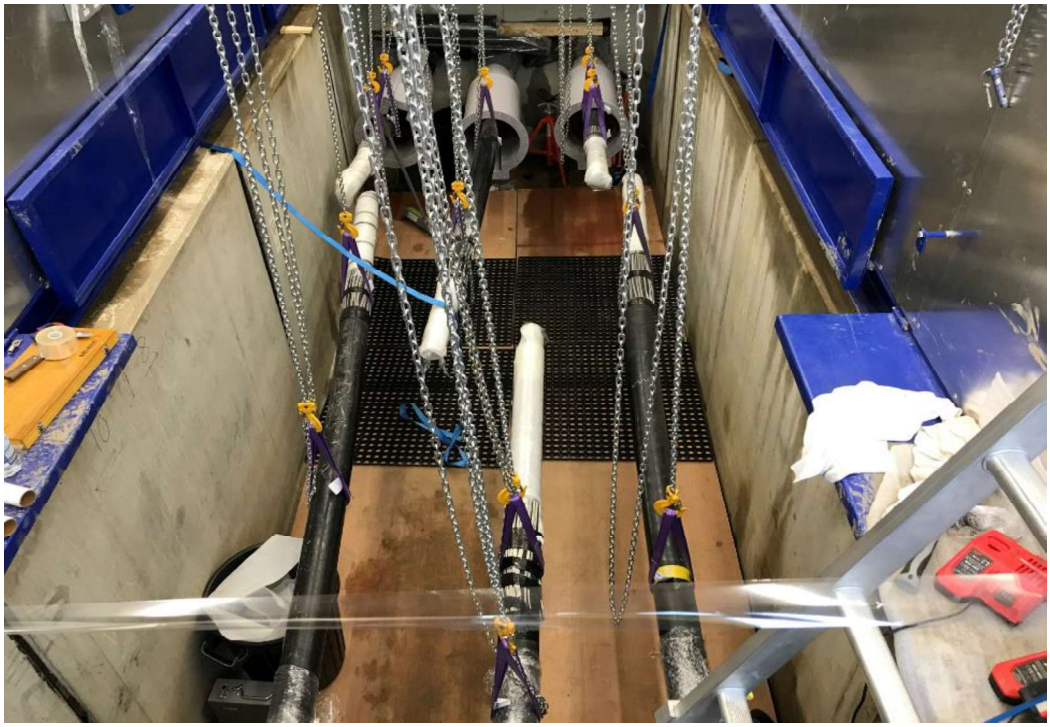


Figure 9 - HV Cable Jointing Procedure

Figure 10 - Typical Joint Bay Backfilling Procedure

Figure 11 - Cable Protection Strip installed during Joint Bay Backfilling Procedure

5 Water Crossings

Existing road bridges over water courses cannot always accommodate high voltage cables. In such cases it shall be necessary to pass underneath the water course. Crossings of smaller ditches and drains shall be carried out by open trench using damming and overhead pumping.

The crossing of streams and rivers shall be carried out by open trench method or trenchless methods. The open trench method crossing of streams and rivers can be carried out by "damming and fluming" or "damming and pumping" as discussed below.

The method adopted shall be implemented only with the approval of Inland Fisheries Ireland (IFI). Where applicable, the construction shall take place outside the salmon spawning period from October to April unless otherwise agreed with IFI.

Appropriate measures shall be put in place by the contractor to prevent ground damage on the access routes to watercourse crossings on both banks, particularly where the ground is soft or slopes steeply toward a crossing. This shall prevent solids reaching a watercourse from damaged access tracks.

5.1 Ditch / Drain Crossings

5.1.1 Open Trench (Damming and Pumping)

The crossing of ditches and drains along the HV cable route shall be achieved by damming and pumping of the water flow overhead. Silt traps, such as geotextile membrane, straw bales etc. shall be placed downstream of the trenching location prior to construction to minimise silt loss. A dam shall be constructed using sand bags and suitable clay material. Temporary pump sump(s) shall be provided to house the pumps used to move the water downstream. The pumping rate shall be suitable to move the flow rates. The cable ducts shall then be installed in the ditch / drain bed as described in Section 3. Following the installation of the cable ducts, the bed of the ditch / drain shall be re-instated with original or similar material. The duration of this process shall vary depending on the site location, crossing length, ground/weather conditions etc.; however, it would typically take 3-7 days to complete each crossing.

5.2 Stream / River Crossing

5.2.1 Option 1 – Open Trench (Damming and Fluming)

The crossing of the stream/river shall be achieved by fluming the existing river flow through one or more pipes depending on the size of the flows in the stream/river. The flume pipe(s) shall be approx. 10 m long and the diameter suitable to accommodate the existing flows.

Where applicable, under the supervision of an aquatic ecologist, spawning gravels shall be removed at the stream crossing areas where construction shall take place. The extent of spawning gravel removal shall be agreed for each site with IFI prior to construction commencing.

1. The flume pipe(s) shall be set out on the bed of the existing stream.

2. A dam shall be constructed using sand bags and suitable clay material around the flume pipe(s) and across the stream so that all the flows are diverted through the pipe(s).
3. Silt traps, such as geotextile membrane, straw bales etc. shall be placed downstream of the in-river trenching location prior to construction, to minimise silt loss.
4. Excavate the proposed trench in the dry stream bed and under the flume pipe(s). If required, a temporary pump sump can be established and a pump used to remove any additional water.
5. Install the cable ducts in the stream bed as described in Section 3 or install a precast concrete slab incorporating the ducts, ensuring the designed cable route alignment is maintained.
6. Following the installation of the cable ducts, the stream bed shall be re-instated with original or similar material and the spawning gravels replaced under the supervision of the aquatic ecologist.
7. Once the stream bed is appropriately re-instated the dam and the flume pipe(s) shall be removed thus restoring the stream to its original condition.

5.2.2 Option 2 – Open Trench (Damming and Pumping)

1. The crossing of the stream/river shall be achieved by damming the existing river upstream of the proposed crossing area.
2. Where applicable, under the supervision of an aquatic ecologist, spawning gravels shall be removed at the stream crossing areas where construction shall take place and shall be stored appropriately to be used during the reinstatement stage of the crossing. The extent of spawning gravel removal shall be agreed for each site with IFI prior to construction commencing.
3. Silt traps, such as geotextile membrane, straw bales etc. shall be placed downstream of the in-river trenching location prior to construction, to minimise silt loss.
4. A dam shall be constructed using sand bags and suitable clay material.
5. Temporary pump sump(s) shall be provided to house the pumps used to move the water downstream. The pumping rate shall be suitable to move the flow rates of the existing stream.
6. Install the cable ducts in the stream bed as described in Section 3 or install a precast concrete slab incorporating the ducts.
7. Following the installation of the cable ducts the stream bed shall be re-instated with original or similar material and the spawning gravels replaced under the supervision of the aquatic ecologist.
8. Once the stream bed is appropriately re-instated the dam and the pumps shall be removed thus restoring the stream to its original condition.

5.3 A Project Specific Methodology – Open Cut Crossing

If required, all open-cut watercourse crossings will be carried out during the May to September period in order to avoid the period of salmon and trout spawning. Subject to approval, aspects of these crossing methods which are highlighted for best practice construction are detailed below and relate to the following headings: 1. site access and ground preparation, 2. In-stream habitat damage within the footprint of the crossing and immediately downstream, 3. watercourse damming process, 4. trench excavation, 5. de-watering of the trench excavation, 6. pumping over, and 7. site reinstatement.

1. Site access and ground preparation: The access track to the watercourse crossing shall be prepared in the same way as that for the joint bays, i.e. topsoil stripping, followed by terram laying and the addition of a layer of aggregate to protect the ground from rutting. This shall also be undertaken parallel to the crossing point in order to protect the bank from heavy vehicle damage. Bog mats shall also be provided in areas where peat is present.

2. In-stream habitat damage: All clean coarse surface material (gravel, cobbles and boulders) on the bed of the river or stream to a depth of 200 mm shall be removed. A thinner layer shall be removed if deeper material is mainly clay or sand. This shall be set aside back from the watercourse on a geotextile base for use to reinstate the stream bed surface.

3. Watercourse damming: At damming and pumping sites the damming shall be undertaken using sand bags and/or clean stone covered with an impermeable layer of thick polythene or similar material in order to minimise the use of clay materials. If managed carefully, these materials should be reusable at several crossing sites. At sites to be flumed the diameter of the flume pipe shall be chosen to accommodate flows at the time with spare capacity to cover that predicted over the following 3-7 days that the works would be expected to last. Construction of the dam around the flume pipe shall require use of clay material to create a practical seal. In this case the dam shall be designed to reduce to a minimum the amount of clay to be used. The clay used shall be puddle clay or equivalent.

4. Trench excavation: material excavated from the trench (and an upstream pump sump if required) shall be placed on terram on level ground as far back from the watercourse's edge as is practicable and surrounded on its downslope side by a silt-fence to prevent solids re-entering the stream. This material if deemed suitable can be used to partially backfill the trench. However, a significant amount shall be in excess and shall be removed off site under licence from the County Council.

5. De-watering of watercourse crossing excavation: Dewatering's of the excavation shall be treated on site using settlement tanks before the settled water is returned to the watercourse. A second tank in series with the first shall be used if the first isn't sufficient to remove enough solids.

6. Pumping over: Pumped over water shall be directed to a splash plate to prevent erosion of the river bed at the downstream side.

7. Site reinstatement: The surface coarse substrate which was set aside shall be used to reinstate the stream bed after the ducts have been installed and the flume pipe has been removed as well as all the damming materials. All surfaces shall be re-instated to the satisfaction of the landowner and re-seeded to assist soil stabilisation. A silt fence shall be placed along the river bank where the works were undertaken in order to prevent solids washed off the works area during heavy rainfall entering the stream while the surface adequately re-vegetates. This measure shall be particularly important at sites which slope to the edge of the watercourse.

5.4 Stream / River Crossing – Option 3

5.4.1 Trenchless Installation

It is common practice to use trenchless technology to install cable ducting under wider watercourses where technically viable. The trenchless technology chosen may depend upon many different factors such as the length of the trenchless section, ground conditions at the specific site, the suitability of staging areas either side of the trenchless section and budget costs. These trenchless installation methods may involve horizontal directional drilling, micro tunnelling, pipe ramming, pipe jacking or auger boring. The most commonly used method of trenchless installation utilised on HV cable circuits in Ireland at present is Horizontal Directional Drilling (HDD) and a detailed methodology of this procedure can be found in Appendix B.

5.5 A Project Specific Methodology – Trenchless Watercourse Crossings

Aspects of this crossing method which could give rise to potential impacts shall be addressed by best practice construction methods under the following headings: 1. site access and ground preparation, 2. bentonite preparation, injection and re-cycling, 3. bentonite blow-out and 4. site re-instatement.

1. Site access and ground preparation: The access track and works area around the HDD launch and reception areas at both sides of the river shall be top-soil stripped, laid with terram and surfaced with suitable aggregate material to prevent ground damage and associated wash-out of solids toward the river. The works area shall be a minimum of 15m back from the river and within this zone, the natural vegetative cover shall not be altered and no construction traffic shall use the area so that the natural filtering capacity of the vegetation if required shall remain intact. Stripped topsoil shall be stored on level ground at least 15 m back from the river and ringed by silt fencing to prevent solids washout.

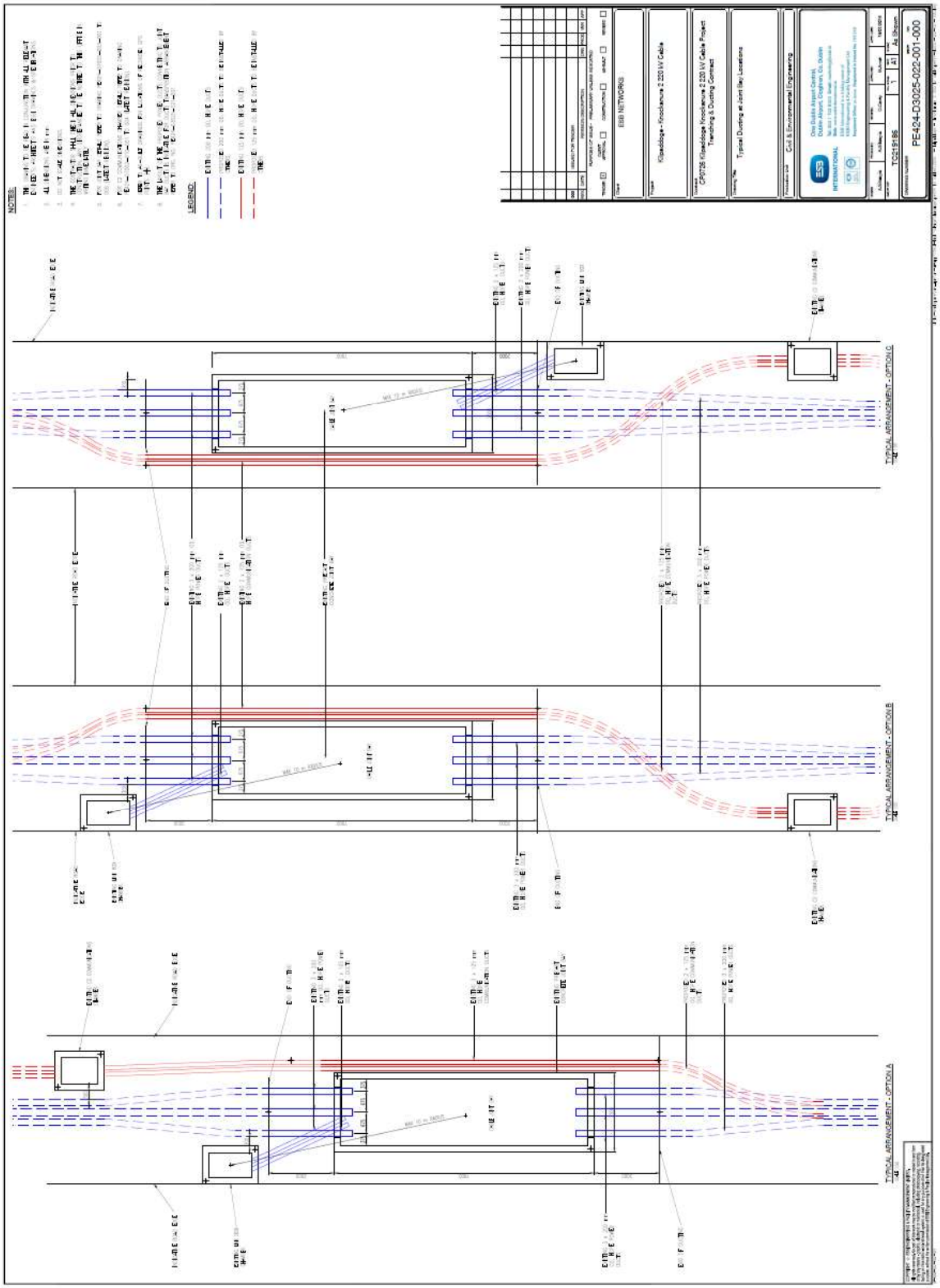
2. Bentonite preparation, injection and re-cycling: The area around the bentonite batching, pumping and re-cycling plants shall be bunded using terram and sandbags in order to contain any spillages. One or more lines of silt fences shall be interposed between the works area and the river on both banks to prevent solids laden runoff from the works areas reaching the watercourse. Spills of bentonite or bentonite contaminated with drill arisings from any aspect of the bentonite handling process shall be cleaned up immediately and transported off site for disposal at a

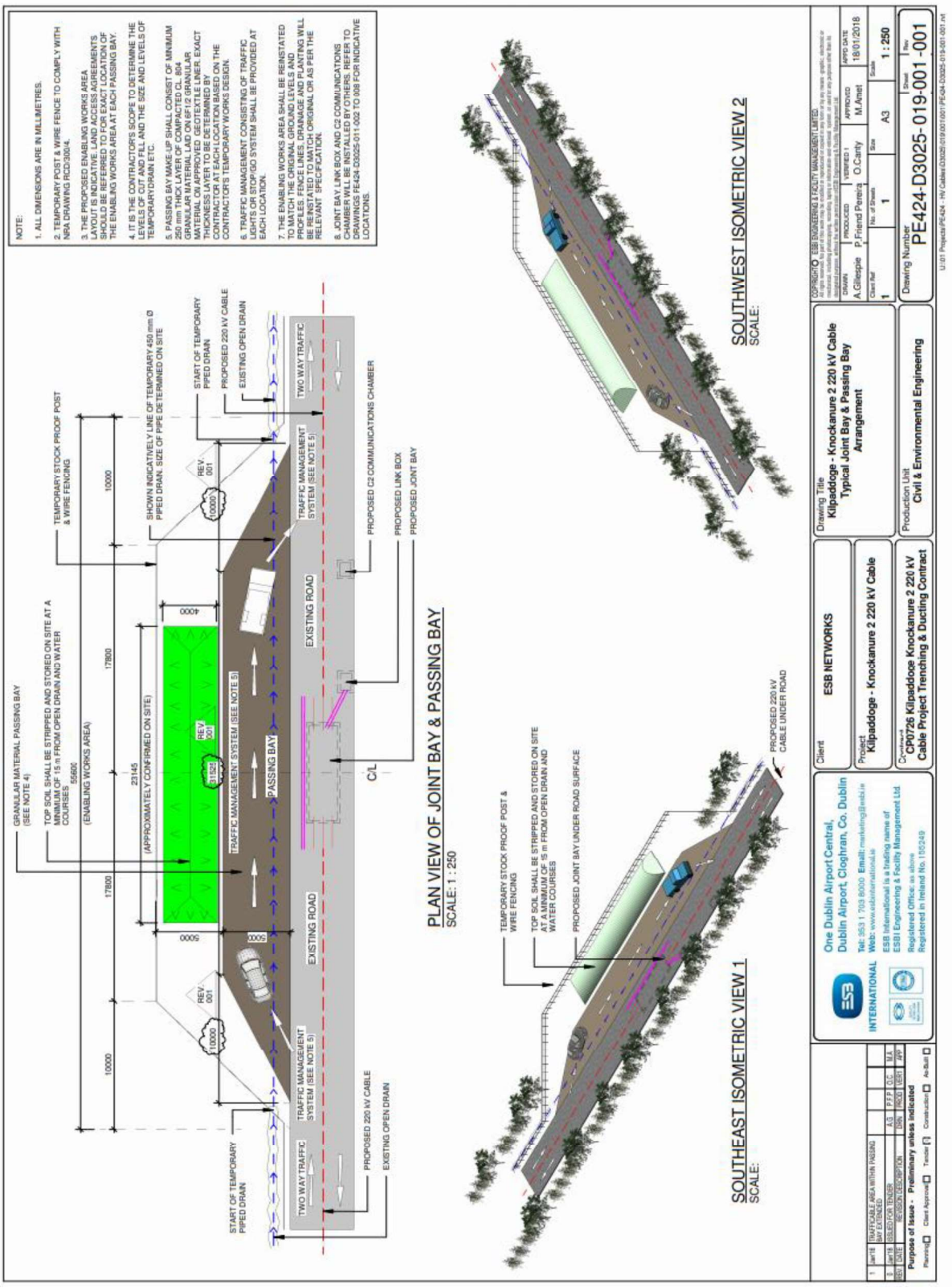
licensed facility. As these operations shall take place within or adjacent to the road network, any watercourses involved would be roadside ditches or field drains in some cases and not true watercourses, i.e. their connectivity with a watercourse with aquatic life of ecological interest would be limited. Any bentonite spills on the road shall be immediately visible and be removed to secure skips on site. In addition, as stated above it is proposed to locate any bentonite pits a minimum of 15 m from streams and rivers to prevent any possibilities of bentonite entering these watercourses. If arisings are being temporarily stored on site, they shall be held in adequately sized skips with adequate freeboard to accommodate intense rainfall during the storage period without overflowing.

3. Bentonite blow-out: A number of geologies are considered unsuitable for HDD because they increase the chances of bentonite being lost and eventually breaking up through the overburden into the watercourse. A typical example is fissured or fractured rock. A thorough geotechnical assessment of the possible routes shall be undertaken to determine the suitability of the site for this installation method. The drilling process shall be constantly monitored to detect any possible leaking of bentonite into the surrounding geology and possible breakout. This can be gauged by monitoring pumping rates and pressures as well as observing for a bentonite plume. If any of these signs appear, then drilling and bentonite pumping shall be stopped immediately and an attempt made to bypass the affected section by using a higher viscosity bentonite mix. If this fails then an alternative crossing alignment or an alternative crossing method shall be considered. This would only arise in cases where the soil through which the HDD was directed is unsuitable for this process. Prior site investigation including detailed geotechnical investigations shall ensure that HDD shall only be employed where the soil and geological conditions are suitable. The possibility of any bentonite breaking through into the watercourse above during the HDD process is therefore negligible.

4. Site reinstatement: While silt fences remain in place, all the temporary surface dressings on access tracks and working areas shall be removed for offsite disposal and stored topsoil replaced and reseeded. The area shall be reinstated to the satisfaction of the landowner.

Appendix A – 220/110 kV Typical Joint Bay & Chamber Layouts




NOTE:
1. ALL DIMENSIONS ARE IN MILLIMETRES.
2. TEMPORARY POST & WIRE FENCE TO COMPLY WITH NRA DRAWING RCD/300/4.
3. THE PROPOSED ENABLING WORKS AREA LAYOUT IS INDICATIVE. LAND ACCESS AGREEMENTS SHOULD BE REFERRED TO FOR EXACT LOCATION OF THE ENABLING WORKS AREA AT EACH PASSING BAY.
4. IT IS THE CONTRACTOR'S SCOPE TO DETERMINE THE LEVELS OF CUT AND FILL AND THE SIZE AND LEVELS OF TEMPORARY DRAIN ETC.
5. PASSING BAY MAKE UP SHALL CONSIST OF MINIMUM 250 mm THICK LAYER COMPACTED GRANULAR MATERIAL LAID ON 6F1/2 GRANULAR MATERIAL ON APPROVED GEOTEXTILE LINER. EXACT THICKNESS LAYER TO BE DETERMINED BY CONTRACTOR AT EACH LOCATION BASED ON THE CONTRACTOR'S TEMPORARY WORKS DESIGN.
6. TRAFFIC MANAGEMENT CONSISTING OF TRAFFIC LIGHTS OR STOP/GO SYSTEM SHALL BE PROVIDED AT EACH LOCATION.
7. THE ENABLING WORKS AREA SHALL BE REINSTATED TO ITS ORIGINAL CONDITIONS AS REGARDS SOIL PROFILES, FENCE LINES, DRAINAGE AND PLANTING WILL BE REINSTATED TO MATCH ORIGINAL OR AS PER THE RELEVANT SPECIFICATION.
8. JOINT BAY LINK BOX AND C2 COMMUNICATIONS CHAMBER WILL BE LOCATED AS SHOWN HERE TO DRAWINGS PE424-D3025-011-002 TO 008 FOR INDICATIVE LOCATIONS.
PLAN VIEW OF JOINT BAY & PASSING BAY
SCALE: 1 : 250
SOUTHEAST ISOMETRIC VIEW 1
SCALE:
SOUTHWEST ISOMETRIC VIEW 2
SCALE:
GRANULAR MATERIAL PASSING BAY (SEE NOTE 4)
TOP SOIL SHALL BE STRIPPED AND STORED ON SITE AT A MINIMUM OF 15 m FROM OPEN DRAIN AND WATER COURSES
(ENABLING WORKS AREA)
TEMPORARY STOCK PROOF POST & WIRE FENCING
SHOWN INDICATIVELY LINE OF TEMPORARY 450 mm Ø PIPED DRAIN. SIZE OF PIPE DETERMINED ON SITE
START OF TEMPORARY PIPED DRAIN
PROPOSED 220 kV CABLE
EXISTING OPEN DRAIN
TWO WAY TRAFFIC
TRAFFIC MANAGEMENT SYSTEM (SEE NOTE 5)
EXISTING ROAD
PASSING BAY
PROPOSED C2 COMMUNICATIONS CHAMBER
PROPOSED LINK BOX
PROPOSED JOINT BAY
C/L
PROPOSED 220 kV CABLE
EXISTING OPEN DRAIN
PROPOSED 220 kV CABLE UNDER ROAD
PROPOSED JOINT BAY UNDER ROAD SURFACE
TEMPORARY STOCK PROOF POST & WIRE FENCING
TOP SOIL SHALL BE STRIPPED AND STORED ON SITE AT A MINIMUM OF 15 m FROM OPEN DRAIN AND WATER COURSES
REV 001
10000
17800
23145
5000
4000
ESB NETWORKS
Kilpaddoge - Knockanure 2 220 kV Cable
CP0726 Kilpaddoge Knockanure 2 220 kV Cable Project Trenching & Ducting Contract
Kilpaddoge - Knockanure 2 220 kV Cable Typical Joint Bay & Passing Bay Arrangement
Civil & Environmental Engineering
PE424-D3025-019-001-001
1 : 250
A3
18/01/2018
One Dublin Airport Central, Dublin Airport, Cloghran, Co. Dublin
INTERNATIONAL
ESB International is a trading name of ESBI Engineering & Facility Management Ltd
Registered Office: as above
Registered in Ireland No. 165249

Appendix B – Typical HDD Procedure

Setting up the Site

The drilling contractor prepares a site area of approximately 30 m x 25 m, accommodated within the agreed site area. If areas are overgrown with thick vegetation, a section of it shall be removed appropriately and disposed of via a licensed waste contractor. The area is then levelled where required by using the front bucket of a 180º excavator; however, there may be a requirement for the working area to be stripped of topsoil. Instead it may be overlain with a suitable geotextile material and 200 mm of appropriate stone. The boundaries of the rig up area and exit area would both be defined with security fencing positioned to ensure adequate access is maintained.

Entry and exit pits (1 m x 1 m x 2 m) are excavated using an 180° excavator and the resultant spoil bunded in 0.5 mm PVC liner within the designated working areas. A steel box (1 m x 1 m x 2 m) is placed in the ground to control drilling fluid returns from the borehole. Drilling fluid is pumped down the drill string and through the down hole motor, which converts the fluids hydraulic power to mechanical power and rotates the drill bit. The drill bit is oriented by the surveyor, and the driller pushes the drill string into the ground maintaining the bore path. The drilled cuttings are flushed back by the drill fluid flowing via nozzles in the bit, up the annulus to surface, where they are separated from the fluid fraction for disposal.

Drilling Fluids Circulation System

The drilling rig and fluid handling units may be placed on bunded 0.5 mm PVC to contain any fluid spills and storm water run-off. The major components of the drill rig circulation system are five tanks, two solids separation cycles, a mud pump and a mud-mixing hopper. The solids removal system includes both a high-speed linear shale shaker and a desander/desilter. Centrifugal pumps circulate drilling fluid returns through the mud cleaners before being pumped back downhole. Solids removed from the drilling fluid are diverted into tipping skips. Drilling fluids returning to the surface are diverted through a conductor pipe to a mud pan on the surface. This mud is then lifted to the shale shaker by a hydraulically powered centrifugal pump. The ability to clean and re-circulate drilling fluids keeps the volume of drilling fluids required to a minimum. Constant monitoring of fluid volume, pressure, pH, weight and viscosity is undertaken. Constant attention is given to amount of cuttings produced so that no over cutting takes place and that hole cleaning is maintained. The mud returns are pumped to the circulation system trailer by means of a bunded centrifugal pump.

Bore Construction

A steering system, guided by tri-axial magnetometers and accelerometers that provide real time directional information to the surveyor at the driller's console, is used to navigate the bores. Once the first pilot hole has been completed a hole-opener or back reamer is fitted at the exit side and pulled back through the bore to the entry side. A drill pipe is added at the exit side to ensure that a mechanical presence is always present within the bore. On completion of the hole-opening phase a towing assembly consisting of tow heads, a swivel and a reamer shall be used to pull the ducts into the bore. Close attention is paid to modelled drag forces during pullback with constant monitoring of load stress undertaken to

ensure that modelled tensile stress, collapse pressures, hoop stress and buckling stress are not exceeded.

Waste Disposal

The drilling fluid used shall consist of sodium bentonite which is NSF/ANSI Standard 60 certified for use in drilling water wells etc.

During drilling, the control and minimisation of waste fluids are the responsibility of the Fluids Technician and the Drilling Superintendent. Fluids can be minimised by the following procedures:

1. Cleaning and recirculating the drilling fluid.
2. Maintaining excellent fluid properties (pH, density, viscosity, gel strength, shear strength) while drilling to eliminate the need for additional drilling fluid.
3. Monitoring of borehole volumes, flow rates, pressures and drag characteristics to ensure that all cuttings are being circulated out of the borehole and that critical annular fluid velocities are not exceeded maintaining laminar flow to prevent eddying and sloughing of the borehole.

The fluid used is inert clay and can be classified in the European Waste Catalogue under 01-05-04 as freshwater drilling muds and wastes. The cuttings circulated from the bore can be classified under 17-05-04 as soil and stones not containing dangerous substances. The fluid and the cuttings are non-hazardous wastes and therefore suitable for disposal to landfill. MSDS (Material Safety Data Sheets) and COSHH (Control of Substances Hazardous to Health) Sheets for all materials shall be kept on site.

Drilled cuttings are stored on site for disposal via a licensed waste contractor. The European Waste Catalogue reference is 17-05-04. Drilling fluid volumes shall be minimised. Excess fluid disposal shall be via a licensed waste contractor. The European Waste Catalogue reference is 01-05-04

The Contractor shall provide a site office, mess and welfare facilities. These units shall be powered by a bunded and silenced generator and water shall be stored in on-site tanks. The units shall be serviced on a weekly basis which includes removal of all wastewater by a licensed contractor.

Reinstatement of Site

Prior to reinstatement, the ducts shall be tested and proved and the duct bundles shall also be gyro-surveyed to provide an accurate as constructed record.

On completion of the works, the stone and geo-membrane shall be carefully removed using a backhoe or 360° excavator and transported to a licensed disposal unit. Topsoil shall be imported to sites where necessary and the area reseeded. The site area shall then be reinstated as per the landowner and statutory requirements.

Typical plant to be utilised on site would comprise the following: -

- 2 No. 4 x 4 Twin cab pick-up truck
- 1 No. Luton Box Van
- JCB 3CX 180° Backhoe Loader
- Terrain 7m Telehandler.
- JCB Fastrac and 2000 gallon bowser

A crew of approximately six people operate all of the above equipment.