3 CIVIL ENGINEERING

3.1 GENERAL INTRODUCTION

This chapter provides additional information on the civil engineering design rationale and works for the various elements of the proposed Shronowen Wind Farm (hereafter the 'proposed development') and its associated infrastructure.

The following items are described in this chapter:

- Site Access Sightlines
- Internal Site Service Roads Design, Engineering and Rationale
- Turbine, Hardstand and Wind Farm Infrastructure Siting
- Internal Site Cable System
- Drain/Watercourse Crossing Design
- Substation, Permanent Met Mast, Temporary Construction Compounds
- Peat Storage Design
- Site Drainage Systems Design
- Sediment and Erosion Plan

3.2 SITE ACCESS

Access to the wind farms site during the construction phase will be from an existing entrance off the L-6021 local road to the east of the site (Access Junction A), and from a proposed new entrance off the L-1009 local road to the west of the site (Access Junction B). The western access onto the L-1009 is proposed as a temporary access to be used during the early construction phase only. The eastern entrance is proposed as the main access point to the wind farm until decommisioning. Access will also be required for the proposed substation via a proposed new access point (Access Junction C) from the L-6021.

The site entrances on the L-6021 (Junction A and C) and L-1009 (Junction B) Local roads will require appropriate sight distance in both directions.

The requirements for junction sight distance are set out in Transport Infrastructure Ireland (TII) "DN-GEO-03060: Geometric Design of Junctions (priority junctions, direct accesses, roundabouts, grade separated and compact grade separated junctions)". Sight distance is measured from a point 3.0m from the near edge of the major road along the centre of the minor approach road. This distance is referred to as the 'x-distance'. The visibility distance along the major road is referred to as the 'y-distance' and is measured to the near edge of the major road in both directions. The required sight distance in the vertical plane is based on eye and object heights of 1.05m. The 'y-distance' requirement depends on the design speed of the major road. This is the 85th percentile speed which is the speed below which 85% of vehicles travel.

The statutory speed limit on the local roads listed above is 80km/h. A design speed of 80km/h has been taken as being appropriate at these locations with a sight distance of 160m. Topographical surveys were carried out at each of the proposed entrances and these confirm that 160m sightlines are achieved at each of the proposed entrances without the need to move any boundary ditches.

The sightline distance will be achieved by installing of a timber post and rail fence and keeping an area outside the fence free of vegetation or other obstructions. The sight distance splays in both directions with the modifications in place are shown in **Chapter 2** and Planning **Drawing 19876-MWP-00-00-DR-C-5017.** These improvements will remain in place permanently and will benefit users of the wind farm when exiting the site onto the public road. A photograph of a typical wind farm entrance with sightlines improved is given in **Figure 3-1**.

Drainage will be provided, as appropriate to prevent water from the site entrance, internal access roads and substation compound junctions flowing onto the public roads. This will include creating falls within the proposed site infrastructure which direct water away from the proposed entrances and hence the public road. Cut off drains will be installed at each site entrance as a further measure to prevent water flowing from the site onto the public road. Existing drains adjacent to the public roads at the proposed entrances will also be maintained throughout the works. Each junction is designed to facilitate access for all vehicles associated with the construction and subsequent maintenance of the wind farm.

Figure 3-1 Typical Wind Farm Entrance

3.3 INTERNAL WIND FARM SITE SERVICE ROADS DESIGN, ENGINEERING AND RATIONALE

The internal site access road design objectives and design rationale for the proposed wind farm development are outlined below. The access road drawings are presented in A1 format in the planning application pack. These include:

- Proposed Internal Access Road Layout including identification of existing roads to be upgraded and widened and new roads to be constructed (refer to **Planning Drawings 19876-MWP-00-00-DR-C-5005 to 5010**);
- Proposed Internal Access Road Typical Details (refer to **Planning Drawings 19876-MWP-00-00-DR-C-5403**);
- Junction Sight Distances (refer to **Planning Drawings 19876-MWP-00-00-DR-C-5017**); and
- Proposed areas of clear fell associated with access roads and turbine infrastructure (refer to **Planning Drawings 19876-MWP-00-00-DR-C-5019**).

Internal access roads are required in order to interconnect elements of the site and allow access to all wind turbines and wind farm infrastructure. The primary objectives when designing the new internal access roads was to utilise existing tracks where possible and to locate infrastructure where ground conditions are suitable. Maximum use has been made of existing roads.

The proposed wind farm will use approximately 4.43km of existing tracks and approximately 6.85km of new roads will be constructed within the proposed development site. The existing routes were identified initially from high resolution aerial photography and thereafter from site visits, where the existing roads were assessed in terms of their width, gradient and associated drainage. The existing tracks used to access the wind farm accounts for approximately 40% of the total road length required to service this wind farm. The remaining roads will be a combination of floated and excavated roads in various parts of the site to suit the local peat depths.

The new access roads will have a running width of generally 5.0m along straight sections of road with localised wider areas at bends to accommodate the efficient transport of the wind turbine components (See drawings **19786-MWP-00-00-DR-C-5005 to 5015**). These roads will be constructed using excavated and floating road techniques depending on the ground conditions. These methods of construction are outlined in the following sections.

The following outlines the internal access roads design rationale:

- The access road design was based on the necessity to deliver wind turbines with a maximum blade length of 66.7m.
- Road gradients throughout the majority of the site are 5% or less which is sufficient for turbine delivery.
- The maximum camber and crossfall gradient on the access roads is 2.5%.
- As turbines are normally grouped and linked in electrical circuits, consideration was given to cable circuit layouts in the internal access roads route selection process. It is planned to run all cables along the internal access roads; it is important to ensure that access routes facilitate efficient cabling.
- The construction of turbines immediately adjacent to the main site roads was avoided because of the potential conflict with construction traffic and the associated safety issues. These turbines will be accessed from short spur roads linked to the main access roads.
- Stream crossings and water bodies have been avoided, where possible.
- Road alignments were selected that will have adequate turning radii for delivery of turbines; and

- Aerial photography, Ordnance Survey Ireland (OSI) contour data were used to inform the internal road design.

The following constraints were taken into account in the final design of the internal access road layout within the site:

- Site topography (OSI contour data) to avoid steep slopes for turbine delivery vehicles (note this site is flat and therefore avoidance of steep slopes was easily achieved);
- Hydrology buffer maps where streams were buffered (a buffer zone of 50m form watercourses shown on OSI Discovery Series Maps was applied);
- Avoidance of ecologically sensitive areas;
- Avoidance, where possible, of risk areas as identified in the Peat Stability Report (**Volume 3, Appendix 9-1 of EIAR**);
- Take account of existing public road and peat harvesting access track junctions where the wind farm access roads will interface.

The design of any particular length of site access road will depend on local geotechnical, topographical and hydrological conditions. Both excavated and floating road construction methods will be employed so as to achieve an access road structure appropriate to the site conditions.

The transition between the floated section and excavated section will be in accordance with the Scottish Natural Heritage / Forestry Commission Scotland (Forestry Civil Engineering - FCE) method illustrated below in **Figure 3-2**.

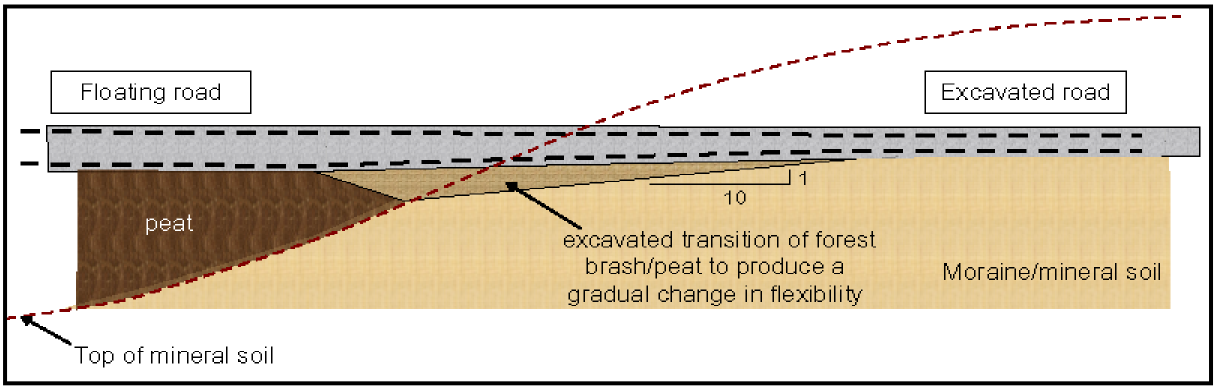

Figure 3-2 FCE method of transition from floated to excavated road

The stone required for the construction of the internal access roads will be imported to the site. Where materials are required from off site, it is expected they will be sourced from local authorised quarries. These are likely to include, but are not limited to, Ardfert Quarry, located in Ardfert approximately 25km southwest of the site, P. Galwey Quarries Ltd. located in Fahaduff approximately 26km south, Creeves Quarry Ltd. located in Shanagolden approximately 26km north east of the site, Roadstone located in Foynes approximately 29km north east of the site, Liam Lynch Quarries Ltd. located in Adare approximately 45km east of the site, Costello Quarry Products & Plant Hire Ltd. located in Bruree approximately 50km east of the site and other existing quarries in the surrounding area. Construction materials' delivery vehicles routes are likely to include the N69 National Road, Regional Roads R551 and R552 and Local Roads L-1009, L-1622-1, L-6021, L-1012and L-1013

The drainage network associated with the access roads will also be inspected and maintained throughout the works period. The appointed contractor shall complete daily inspections of the drainage network. Any blockages or other issues noted during the inspections shall be rectified on the same day as the inspection to ensure continued performance of the drainage network.

Overall, the internal site layout design has been optimised in terms of its minimal impact on the existing public road network in the vicinity of the site. The layout is low risk in terms of peat stability and associated environmental impacts. It uses the existing drainage network, existing tracks where possible, considers connectivity to the public road network and supports ease of construction in this location.

3.3.1 Upgrading and Widening of Existing Tracks

Existing tracks within the site are floated on peat (i.e. peat was not excavated from underneath the original access track). They will be widened by constructing a road on a layer of geogrid or geotextile or timber logs laid over the existing access track and extended onto the widened areas.

The location of proposed new and upgraded roads is given in planning drawing 19876-MWP-00-00-DR-C-5005 to 5011. This road construction will be similar in build up to the excavated road construction which is outlined in detail in **Section 3.3.2**. The new width of road and the existing road surface, where required, will be capped with a 150mm layer of hard wearing Class 6F or similar stone see typical Wind Farm access road in **Figure 3-3**.

This road type will have a crossfall of 2.5% from one edge to the other. The existing roadside drains on the lower side of the road will be used as part of the dirty water drainage system for the site. The existing roadside drains on the higher side of the road will be retained as clean water drains.

Typically, the sequence for upgrading and widening existing access roads will comprise the following:

I. The appointed contractor will set out the extent of the area to be widened.
II. The material required for widening and upgrading the existing site roads will be sourced from external quarries. Sufficient passing bays will need to be constructed to allow for the safe movement of site traffic along the existing roads. Locations of proposed passing bays within the site are shown on Planning Drawings 19876-MWP-00-00-DR-C-5005 to 5011. Dimensions of proposed passing bays within the site are shown on Planning Drawings 19876-MWP-00-00-DR-C-5403.
III. Widening works will begin with the use of excavators that will first remove any topsoil / vegetative layer which may be present. This material will be transported to an agreed temporary storage area and maintained for re-use during the restoration phase of the wind farm construction. Topsoil / vegetative removal will be kept to a minimum in order to prevent any runoff of silt during heavy rainfall.
IV. Excavators will continue to strip and excavate the soft subsoil / peat underneath which will be temporarily stored adjacent to the access roads in accordance with approved methods with the use of an articulated dumper truck. Excavated material will only be temporarily stored on slopes under 5° and to a maximum height of under 2.0m until they are transported to the selected deposition areas where they will be permanently stored.
V. Once a section of the widened access road is marked out; a layer of geogrid or geotextile or timber logs will be placed over the existing track and extend to the widened areas.
VI. The stone to be used for the widening works will be delivered to the required work area and spread out locally with the use of excavators on top of the geogrid / geotextile / timber logs.

This will be compacted with the use of a roller which will roll the stone aggregate in maximum 250mm layers in order to achieve the required design strength. A minimum 150mm layer of hard-wearing Class 6F stone will be required across the full running width of the road. The overall finished road surface will be a minimum 350mm of compacted stone.

VII. The road upgrading works will involve the use of a roller compacting stone aggregate in maximum 250mm layers laid over the existing road pavement. A layer of geogrid or geotextile material may be placed along the existing road pavement prior to the placement of the stone aggregate in order to achieve the required design strength.

VIII. All upgraded / widened access roads will be constructed to a minimum drivable width of 5.0m with a maximum crossfall of 2.5% in order that water can flow off the roads and reduce the risk of rutting / potholes occurring.

IX. Roadside drains (as per Section **3.14**) will be constructed to manage clean and dirty water runoff along widened and upgraded access roads.

X. Any surplus spoil material generated from the road widening works will be transported to the peat deposition areas to aid final reinstatement. Excavated topsoil and subsoil will be kept separate at the excavation and storage areas.

XI. All excavations to be carried out will be battered back to a safe angle of repose (minimum slope angle of 45°) and comply with the Construction and Environmental Management Plan (CEMP) (**See Appendix 2-1**).

XII. Where drop offs greater than 1.0m in height occur alongside road edges; physical edge protection will be constructed in order to reduce the risk of vehicles overturning. Roadside marker posts will also be erected to delineate road edges in poor weather.

XIII. The appointed contractor will ensure that all on-site personnel are aware of environmental constraints / sensitive areas within the wind farm site in which works are to be avoided.

Figure 3-3 Typical upgraded forestry road on a wind farm

Figure 3-4 Existing Access Track in Shronowen

3.3.2 New Excavated Roads

New excavated access roads will be constructed in areas where peat depth is approximately 1.5m or less. These areas are near T1, T2, T4 and T7. New excavated roads will be constructed using imported stone aggregate obtained from external quarries and placed over a layer of geogrid, after all organic and soft subsoil material is excavated to formation level. Geotextile material, used to separate the road building material from the subsoil, may also be laid at formation level.

I. The appointed contractor will set out the area of the proposed road.
II. Excavators will first remove any topsoil / vegetative layer which may be present. This material will be transported to an agreed temporary storage area and maintained for re-use during the restoration phase of the wind farm construction. Topsoil / vegetative removal will be kept to a minimum in order to prevent any runoff of silt during heavy rainfall.
III. Excavators will continue to strip and excavate the soft subsoil / peat underneath which will be temporarily stored adjacent to the access roads in accordance with approved methods with the use of an articulated dumper truck. Excavated material will only be temporarily stored on slopes under 5° and to a maximum height of under 1.0m until they are transported to the selected deposition areas where they will be permanently stored.
IV. All excavations to be carried out will be battered back to a safe angle of repose (minimum slope angle of 45°) and will comply with the Construction and Environmental Management Plan (CEMP) (See **Appendix 2-1**).
V. Once a section of the excavated access road is exposed to suitable formation; a layer of geogrid or geotextile material may be placed along its formation depending on ground conditions which will be covered with aggregate stone as required compacted in maximum 250mm layers.

VI. The material required for construction of new excavated roads will be sourced from quarries (see above).

VII. The stone will be delivered to the required work area and spread out locally with the use of excavators and compacted with the use of a roller which will roll the stone aggregate in maximum 250mm layers on top of the geogrid / geotextile material in order to achieve the required design strength.

VIII. All new excavated access roads will be constructed to a minimum drivable width of generally 5.0m with a maximum crossfall of 2.5% in order that water can flow off the roads and reduce the risk of rutting / potholes occurring.

IX. Roadside drains (as per Section **3.14**) will be constructed to manage clean and dirty water runoff along excavated access roads.

X. The final running surface of the new excavated access roads will be capped with a minimum 150mm layer of hard wearing Class 6F stone or similar using a road grader.

XI. Any surplus spoil material generated from the excavated access road works will be transported to the peat deposition areas to aid final reinstatement. Excavated topsoil and subsoil will be kept separate at the excavation and storage areas.

XII. Where drop offs greater than 1.0m in height occur alongside road edges; physical edge protection will be constructed in order to reduce the risk of vehicles overturning. Roadside marker posts will also be erected to delineate road edges in poor weather.

XIII. The appointed contractor will ensure that on site personnel will be aware of environmental constraints / sensitive areas within the wind farm site in which works are to be avoided.

Figure 3-5 Typical new excavated road on a wind farm

3.3.3 New Floated Roads

Floating roads will be required in areas of deep peat that could not be avoided in the design of the access road layout. The use of floating road methods will minimize the excavation of peat and reduce interference with the existing drainage regime in these areas of the site.

Two types of floated road details are typically used on wind farms constructed in deep peat environments. These are as follows:

- Stone and Geogrid Construction Detail
- Timber Logs, Stone and Geogrid Construction Detail

The stone and geogrid option is the most widely used option in Ireland, however, the timber log option has been used on sites where peat deeper than 3m is widespread across the site. Both types are assessed for this project as peat depths range from 0m to over 7m in different areas of the site. Both types of floated road construction have been assessed to cater for both cases.

3.3.3.1 New Floated Roads – Option 1 – Stone and Geogrid Construction Detail

A combination of geogrid and geotextile will be placed over the vegetation on the existing surface to be traversed with the floating road. A minimum thickness of 450mm of stone will be placed over the bottom layer of geogrid / geotextile. This will be overlain with a 150mm surface layer of Class 6F or similar material.

Typically the sequence of constructing floating roads will comprise the following as per guidance from the COFORD – Forest Road Manual (Guidelines for the design, construction and management of forest roads) and Scottish Natural Heritage / Forestry Commission Scotland (Forestry Civil Engineering - FCE) on the construction of floated roads over peat:

I. The appointed contractor will mark out the line of the proposed floated road using a GPS / total station;
II. The intended floating road area is cleared of major protrusions such as rocks, trees, bushes etc down to ground level but residual stumps and roots are left in place.
III. The local surface vegetation and soils are left in place where possible as the existing vegetation and root mat may be the strongest layer in the system and care should be taken to preserve this layer.
IV. Any local hollows and depressions are filled in with a suitable local lightweight fill such as tree brash, logs, or geogrid / geotextile material with stone aggregate.
V. A formation, 7 to 8m, wide is prepared where a layer of geogrid / geotextile is laid out by hand along the line of the proposed floated road.
VI. The specification for geotextiles will be finalised by the design engineer at pre-construction stage. Past empirical experience on previous constructed wind farms within Ireland and Scotland has proven the suitability of floated road construction over peat.
VII. Where there is a drainage requirement, suitably sized HDPE drainage pipes shall be laid on top of the installed geogrid / geotextile prior to the placement of stone aggregate. Cross drains will be laid at appropriate intervals to maintain the existing drainage regime on the site.
VIII. The material required for construction of new floated roads will be sourced from external quarries (see above).
IX. Wide tracked 360° excavators will be used for constructing the floated roads by cascading a minimum 450mm thickness of stone aggregate over the geogrid / geotextile. The suitable stone aggregate should be suitably sized in order to achieve a sound interlock with the geogrid

/ geotextile material. The stone aggregate is compacted following placement of the stone and geogrid.

X. An additional layer of geogrid / geotextile may be placed over the stone aggregate if necessary before a minimum capping layer of 150mm of Class 6F or similar material is laid out with excavators. This may be necessary where sections of the floated road have settled or rutting of the road has become prominent.

XI. All floated access roads will be constructed to a minimum drivable width of 5.0m with a maximum crossfall of 2.5% in order that water can flow off the roads and reduce the risk of rutting / potholes occurring.

XII. Roadside drains as per Section **3.14** will be constructed to manage clean and dirty water runoff along floated roads.

XIII. Where drop offs greater than 1.0m in height occur alongside road edges; physical edge protection will be constructed in order to reduce the risk of vehicles overturning. Roadside marker posts will also be erected to delineate road edges in poor weather.

XIV. To allow for the safe movement of site traffic during the construction of floated roads; a site traffic management plan will be prepared by the appointed contractor.

XV. The appointed contractor will ensure that on site personnel will be aware of environmental constraints / sensitive areas within the wind farm site in which works are to be avoided.

Figure 3-6 Typical floated road on a wind farm

3.3.3.2 New Floated Roads – Option 2 – Timber Logs, Stone and Geogrid Construction Detail

In areas where the peat depth exceeds 3m, control of settlement of the road with conventional floating road techniques becomes difficult. By using timber logs in the road makeup, the weight of the road is reduced and a large span of load spread is provided to resist wheel loads during traffic movements. This lighter weight and large load spread from the logs, reduces road settlement in these areas. This construction technique has been successfully implemented on similar wind farms constructed in similar peat bogs to Shronowen (for example Tullahennel Wind Farm in Co. Kerry).

The timber logs are placed in orthogonal layers on top of a geogrid to maximise the load spread capacity of the road, as can be seen in Figure 3-7. Brash and stone may be included to aid the constructability. The use of this method will minimize the excavation of peat and reduce interference with the existing drainage regime in these areas of the site. A combination of geogrid and geotextile will be placed over the lumber. A minimum thickness of 450mm of stone will be placed over the bottom layer of geogrid / geotextile. This will be overlain with a 150mm surface layer of Class 6F or similar material.

Long term settlement is controlled by the use of timber with a density less than 800kg/m3. As the road settles, the lower sections of timber become submerged. This results in further settlement being reduced by the resistance caused by the buoyancy action of the timber when submerged. This is illustrated in Figure 3-8 where settlement stopped at the second layer of logs in a road across a flush area. The lumber and brash used in this methodology will either be sourced on site from the areas being felled or from external suppliers. The stone required will be imported from external quarries.

Where these tracks will be constructed through forested areas (e.g. at T1), the felled trees may be used in the construction of the floating roads. Any additional timber logs will be sourced from commercial licensed sources.

Typically the sequence of constructing floating roads will comprise the following, generally as per guidance from the Scottish Natural Heritage / Forestry Commission Scotland (Forestry Civil Engineering - FCE) on the construction of floated roads over peat:

I. The appointed contractor will mark out the line of the proposed log road using a GPS / total station;
II. The intended floating road area is cleared of major protrusions such as rocks, trees, bushes etc down to ground level but residual stumps and roots are left in place.
III. The local surface vegetation and soils are left in place where possible as the existing vegetation and root mat may be the strongest layer in the system and care should be taken to preserve this layer if at all possible.
IV. Any local hollows and depressions are filled in with a suitable local lightweight fill such as tree brash, logs, or geogrid / geotextile material with stone aggregate.
V. A formation, 7 to 8m, wide is prepared where a layer of geogrid / geotextile is laid out by hand along the line of the proposed log road.
VI. The specification for geotextiles will be finalised by the design engineer at construction stage but past empirical experience on previous constructed wind farms within Ireland and Scotland has proven the suitability of log road construction over peat.
VII. Where there is a drainage requirement, suitably sized HDPE drainage pipes shall be laid on top of the installed geogrid / geotextile prior to the placement of the lumber. Cross drains will be laid at appropriate intervals to maintain the existing drainage regime on the site.
VIII. The material required for construction of new log roads will be sourced from on site or imported external sources.
IX. Timber logs are then placed in rows perpendicular to the road direction through the use of excavators and forestry equipment on top of the geogrid/ geotextile placed on the existing ground.

X. Vertical sections of lumber are then driven at generally 6 metre spacings into the peat. These are to prevent the upper layer from rolling off the base layer and their spacing will be dictated by the length of the lumber in this upper layer.

XI. The upper layer is then placed on top on of the bottom layer but this time parallel to the road direction.

XII. A geogrid/ geotextile layer is then rolled by hand along this upper layer.

XIII. Wide tracked 360° excavators will be used for constructing the floated roads by cascading a minimum 450mm thickness of stone aggregate over the geogrid / geotextile. Suitable stone aggregate should be suitably sized in order to achieve a sound interlock with the geogrid / geotextile material. It is common practice for floated road construction on wind farms that the compaction of the stone aggregate is done by the wheels and tracks of construction plant alone.

XIV. An additional layer of geogrid / geotextile may be placed over the stone aggregate if necessary, before a minimum capping layer of 150mm of Class 6F or similar material is laid out with excavators.

XV. All log roads will be constructed to a minimum drivable width of generally 5.0m with a maximum crossfall of 2.5% in order that water can flow off the roads and reduce the risk of rutting / potholes occurring.

XVI. Roadside drains as per Section **3.14** will be constructed to manage clean and dirty water runoff along floated roads.

XVII. Where drop offs greater than 1.0m in height occur alongside road edges; physical edge protection will be constructed in order to reduce the risk of vehicles overturning. Roadside marker posts will also be erected to delineate road edges in poor weather.

XVIII. To allow for the safe movement of site traffic during the construction of floated roads; a site traffic management plan will be prepared by the appointed contractor. Care will be taken when reversing vehicles on floating roads to ensure that they do not run along the edge of the road but stay within the delineated safe running zone.

XIX. The appointed contractor will ensure that on site personnel will be aware of environmental constraints / sensitive areas within the wind farm site in which works are to be avoided.

Figure 3-7 Typical Log Road in process of construction on a Wind Farm

Figure 3-8 Lightweight floated road in place across flush area

3.3.4 New Access Roads Construction at Drainage / Stream Channel Crossings

None of the works within the wind farm will cross any of the watercourses mapped by the OSI. Crossings will occur over existing drains.

Where the crossing of an existing natural or artificial drainage or stream channel is unavoidable, a suitable crossing will be designed. Typically, this will be in the form of precast concrete or HDPE pipes. All crossings will be designed for a minimum 1 in 100-year return rainfall event. The invert of the pipe is typically submerged approximately $^{1}/_{4}$ of its diameter below the original drainage bed. Where natural gradients allow, a nominal back fall in the pipe will be incorporated to prevent scour and promote the settling of natural material along the invert of the pipe. An example of a permanent drain crossing is illustrated in **Figure 3-9**. New turbine service roads will be required to cross several minor drains / streams within the site. All such crossings and widening will be agreed with Inland Fisheries Ireland prior to construction. All construction method statements for crossings will be approved by Inland Fisheries Ireland.

Figure 3-9 Typical drainage channel crossing

Figure 3-10 shows a typical measure to be put in place at existing drains and watercourse crossings in order to ensure dirty water from the development does not enter existing drains or watercourses. For the proposed development, the proposal is to use vegetated soil bunds to divert dirty water generated on the section of road over the crossings to the dirty water system. Alternatively, temporary silt curtains, as shown in **Figure 3-11**, can be placed along the existing roads within the hydrology buffer zone. These silt curtains can run longitudinal to existing drains or watercourses with a layer of stone placed along the bottom to prevent any seepage if there is a risk of silted runoff.

Figure 3-10 Dirty water containment at existing drains or watercourse crossings

Figure 3-11 Silt curtain containment along existing roads near existing drains or watercourses

3.4 TURBINE LOCATIONS

A key step in the positioning of turbines was to minimise the volume of excavated peat and locate turbines away from areas of steeper gradient. The site is generally flat with without steep slopes and therefore locating the turbines in areas of low gradient was easily achieved. Peat depths across the site vary considerably. Turbines were located in areas of cutaway peat wherever possible in order to reduce peat volumes. Table 3-1 gives information on the conditions at each proposed turbine location, including land use, ground slope and peat depth at and in the vicinity of each of the proposed turbines.

Table 3-1 Summary of ground parameters at Turbines

Turbine	Land use category	Slope	Approximate Peat depth
T1	Forestry plantation	<3°	0.0m
T2	Agricultural Grassland	<3°	2.0m
T3	Area containing both cut over peat and banks of uncut peat turbary	<3°	3.3m
T4	Cut over peat turbary	<3°	0.8m
T5	Peat turbary	<3°	4.9m
T6	Cut over peat turbary	<3°	1.3m
T7	Area of both cut away peat and forestry plantation.	<3°	0.6m
T8	Uncut peat turbary	<3°	6.2m
T9	Uncut peat turbary	<3°	4.3m
T10	Uncut peat turbary	<3°	4.6m
T11	Uncut peat turbary	<3°	4.9m
T12	Area containing both cut over peat and banks of uncut peat turbary	<3°	5.4m

3.5 TURBINE CRANE HARDSTANDS

The layout of the crane hardstand is designed to accommodate the delivery of the turbine components prior to their erection and to support the cranes during erection. Hardstands are also used for maintenance during the operation of the turbine. The hardstands will be approximately rectangular in shape with additional minor hardstand areas to accommodate lay down of the turbine blades and assist cranes. The area of a single hardstand is approximately 62.5m long by 25m wide. Refer to **Planning Drawing 19876-MWP-00-00-DR-C-5401** for further details. Hardstands for support cranes are also required. The two support crane hardstands include measure approximately 10m x 12m in area. A typical layout hardstand is shown in **Figure 3-12** and **Figure 3-13**.

Significant loads will be imposed on the crane hardstands by the outriggers of the lifting crane during the turbine erection process. The hardstands need to withstand the high bearing pressures from these cranes. The peat onsite will not provide strong enough resistance to these loads. For this reason, the peat will either need to be removed and replaced with compacted stone or the hardstand will need to be piled such that the loads are transferred to a stronger material under the peat. Both options are described below and are assessed in the EIAR to ensure the worst-case scenario is assessed.

Figure 3-12 Typical finished hardstand on a wind farm

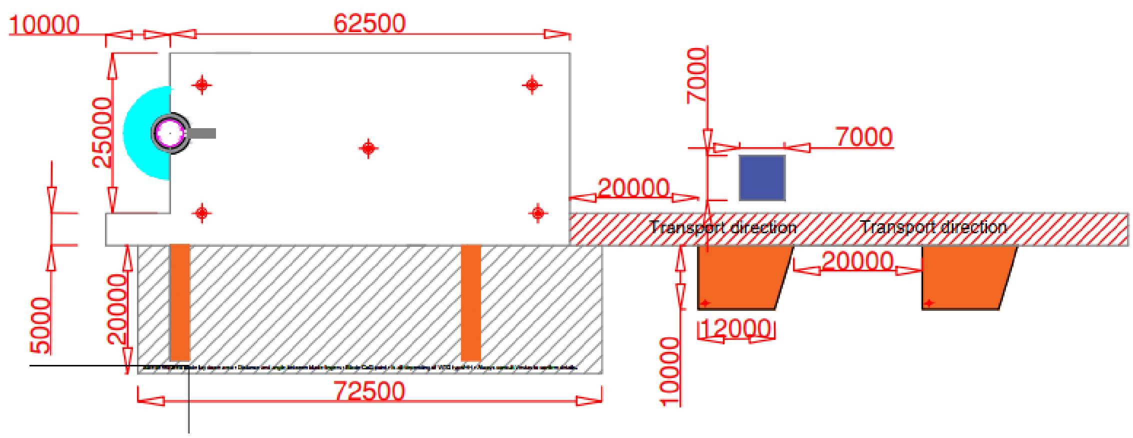

Figure 3-13 Typical hardstand dimensions and layout

3.5.1 Turbine Crane Hardstands – Options 1 – Removal of Peat

Using this methodology, hardstands will be constructed using excavation methods to solid formation stratum (below the depth of peat) over the footprint of the hardstand area / turbine base. The peat depths vary considerably from hardstand to hardstand ranging from 0.3m to over 7m. The excavated material will be placed in the spoil storage areas and reused elsewhere within the site. The hardstand areas will be excavated to achieve a suitable formation. The depth of excavation will depend on the depth of peat at each hardstand location and the depth and quality of subsoil under the peat.

The construction of crane hardstands in areas of peat with depths greater than 1.5m will require substantial temporary works consisting of either temporary sheet piles or retention berms to prevent peat moving into the excavation. Where peat is less than 1.5m, peat will be sloped to a stable angle without a retention berm or sheet piles. All of these solutions lead to a wider zone of impact of the construction activities than the finished dimensions of the hardstand Figure 3-14. This widest zone of impact has been assessed as part of the EIAR to capture the worst-case scenario.

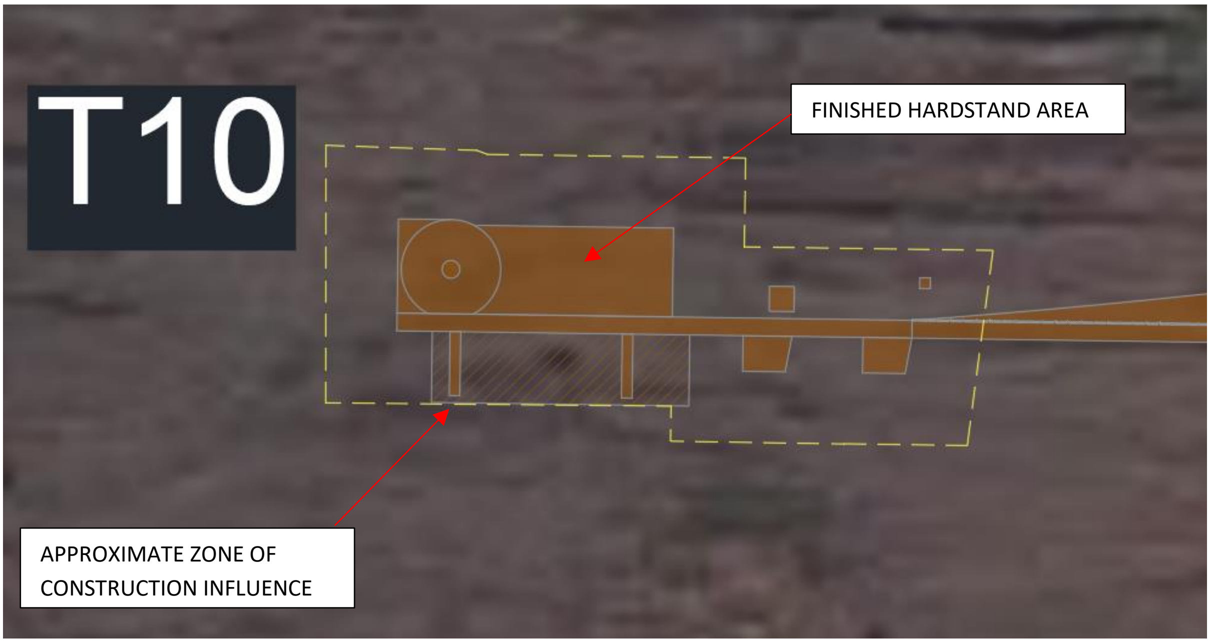

Figure 3-14 Sketch of typical zone of construction influence around a hardstand in deep peat

The proposed works will be restricted to the turbine locations and will comprise the following in areas where sheet piling is not required (typically where peat is less than 3m in depth):

I. Temporary berms are constructed around the perimeter of the proposed crane hardstand by removing the peat and replacing with stone fill. The berm is only required where peat is great than 1.5m in depth. The side of the excavation is sloped to a safe stable angle without a berm where peat is less than 1.5m.
II. Excavation then takes place within the hardstand area to a competent subgrade of the underlying subsoil / rock.
III. The excavated material is removed to peat deposition areas or used as berms alongside the roadside.
IV. The excavation is then filled with a suitable imported stone aggregate, obtained from external quarries, laid on a geotextile filter membrane. The top layers of the crane hardstanding will be formed from imported Class 6F2 fill.
V. The stone aggregate will be compacted in 250mm layers and will vary in depth depending on the depth of peat and gradient of the underlying subgrade.
VI. Temporary set down areas will be formed to facilitate the storage of the turbine components at each crane hardstand (e.g. the turbine blades, the turbine towers and nacelle). The temporary lay down areas will be cleared of vegetation, graded and generally left unfinished. Some sections of the lay down area will be surfaced using compacted stone aggregate. These sections will be recovered with soil after all turbines have been erected.
VII. Plate bearing test results will be undertaken on the finished hardstand surface to check if ground bearing strengths are to the wind supplier's specifications. Once complete the assembly cranes will be set up on the hardstand and erect the wind turbine into place.

In areas of larger peat depth typically greater than 3.0m, the use of sheet piling would be considered to reduce the excavated quantities and safety risk associated with large excavations. The typical methodology for this approach is as follows:

I. Temporary Sheet piling platform/mats are set up along the perimeter of the hardstand. Sediment control measures are set up also. The sheet piles are then installed from this mat/platform, Figure 3-16.
II. Excavation of peat from within sheet piled cofferdam. Peat is initially removed from near the inside face of the sheet pile cofferdam. As each load of peat is removed to a suitable formation level, a load of crushed rock is immediately placed along the inside edge of the sheet pile wall to provide support to the sheet piles prior to carrying out bulk excavation in the central area of the cofferdam, Figure 3-17. Sediment control measures will be put in place prior to commencement of excavation.
III. Excavation is then advanced towards the central area of the sheet pile cofferdam using the traditional excavation methodology, Figure 3-18. This may occur while stage II is ongoing. Pumps are used to keep the excavation dry with the pumped water being passed through a silt pond or through silt traps prior to discharge. Each crane hardstand is excavated to a formation on competent subgrade of the underlying subsoil / rock which will comprise of imported stone aggregate, obtained from external quarries, laid on a geotextile filter membrane. The top layers of the crane hardstanding will be formed from imported Class 6F2 fill. The excavated material is removed to material storage areas or used as berms alongside the roadside.

IV. The stone aggregate will be compacted in 250mm layers and will vary in depth depending on the depth of peat and gradient of the underlying subgrade.

V. Temporary set down areas will be formed to facilitate the storage of the turbine components at each crane hardstand (e.g. the turbine blades, the turbine towers and nacelle). The temporary lay down areas will be cleared of vegetation, graded and generally left unfinished. Some sections of the lay down area will be surfaced using compacted stone aggregate. These sections will be recovered with soil after all turbines have been erected.

VI. Plate bearing test results will be undertaken on the finished hardstand surface to check if ground bearing strengths are to the wind supplier's specifications. Once complete the assembly cranes will be set up on the hardstand and erect the wind turbine into place.

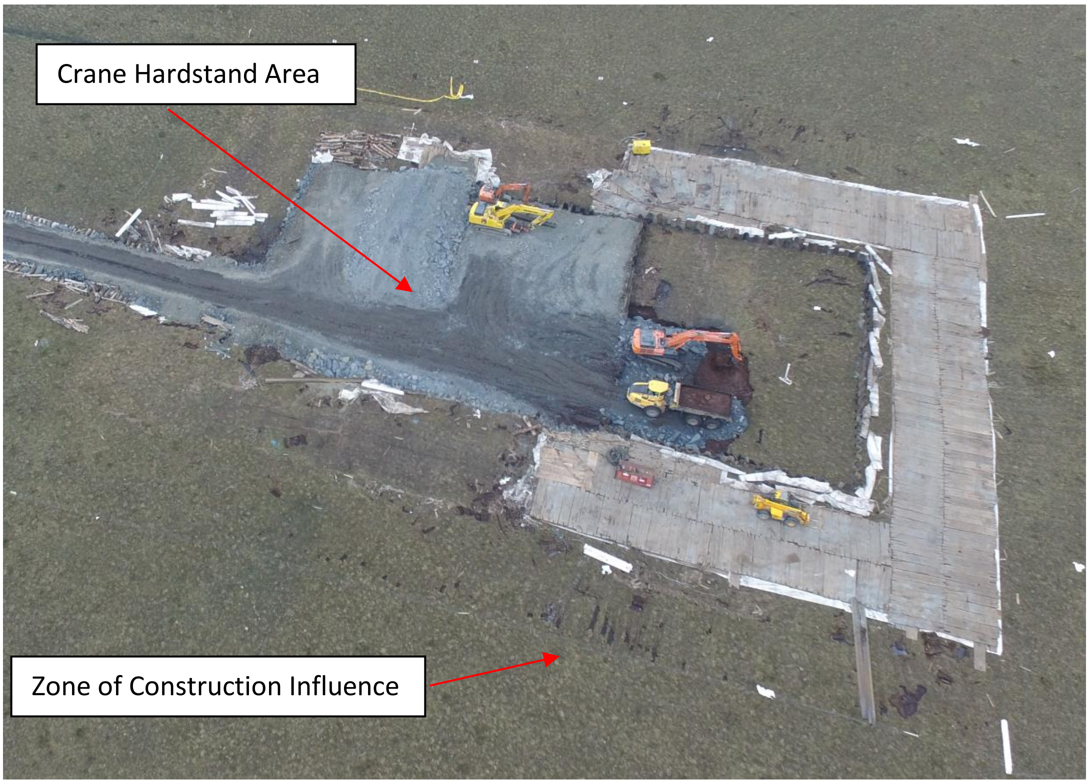

Figure 3-15 Photo of typical zone of construction influence around a hardstand in deep peat

Figure 3-16 Sheet Pile Installation

Figure 3-17 Excavating beside the Sheet Pile Cofferdam

Figure 3-18 General Excavation towards the centre after fill is placed beside the sheet piles

3.5.2 Turbine Crane Hardstands – Options 2 – Piling Through Peat

In areas where the peat depth is excessive or space constraints are present, a piled/floated hardstand method may be adopted. This is to mitigate against the excavation of peat and thereby avoiding the risk of sediment release posed by the Works. The crane outriggers are placed on platforms which are supported by piles due to the crane outriggers high loads while general traffic can be supported by the remaining floated areas of the hardstand. This platform can be a large single pad or split into four smaller pads, see Figure 3-19 for an example of a floating piled hardstand with 4No. platforms for the crane outriggers. This system involves:

I. Installing a layer of geo-grid/geotextile directly onto the top of the existing organic layer.
II. Placement and compaction of a layer of well graded coarse stone including additional layers of geogrid/geotextile if deemed necessary by the designers.
III. Placement of a finer well graded stone for the top surface.
IV. Installation of concrete piles at a determined spacing on the hardstand which coincide with the proposed outrigger locations for the crane. These piles could be driven or bored.
V. Concrete pads are then cast on top of the piles and will typically be 4m x 4m in area and 0.6m deep. The pads are cast within shuttering to avoid concrete escaping into the surrounding area.
VI. Shuttering is removed when the concrete reaches a predetermined strength and aggregate backfilled.

Figure 3-19 Typical Floating/Piled Hardstand Option

3.6 TURBINE BASES

It is proposed that the 12 No. wind turbines will have a reinforced concrete base with a central pedestal above the base that will in turn support the wind turbine tower. The concrete base will bear onto rock, imported 6N fill to a suitable depth using a spread foundation or sit on a piled foundation. Further ground investigation will be required prior to detailed design to inform the foundation design. A worst case of 8m excavation for spread turbine bases has been assessed. Piled foundations have also been assessed to cater for situations where spread foundations cannot be used. Details of peat depths are provided in the Peat Stability Risk Assessment included in **Volume 3 Appendix 9-1** of the EIAR.

A typical spread foundation will be approximately 28m in diameter and will generally be installed to a depth of approximately 3.0m below grade. Approximately 800m^3 of concrete and 85 tonnes of steel will be used in the construction of each turbine base.

A typical piled foundation consists of a ring of piles around the edge of the base. Piles are typically auger bored, 750mm in diameter, made from reinforced concrete. The depth of the piles is dictated by the depth to a solid stratum. The final dimensions of the turbine bases will be determined as part of detailed engineering design at pre-construction stage following confirmation of the turbine supplier and from using detailed geotechnical data (including boreholes) that will be conducted at each turbine location. A conservative base size of 28m diameter has been assessed to capture a worst-case.

The proposed works will be restricted to the turbine locations and will comprise the following:

I. The extent of the excavation will be marked out and will include an allowance for trimming the sides of the excavation to provide a safe working area and slope batter;
II. Any existing peat found within the footprint of the turbine base will be excavated out during the course of formation works at the adjacent crane hardstand area. The excavation works will be carried out using hydraulic excavators where surplus peat / subsoil material will be

transported to the on-site deposition areas via articulated dumper trucks or tractor and trailer for subsequent reuse in the permanent reinstatement of the peat deposition areas. Sheet piling may also be considered for some of the formations but is dependent on the depth of peat present at each respective location. The methodology for this is similar to that for the crane hardstands.

III. Standing water in turbine base excavations is likely to contain an increased concentration of suspended solids. Dewatering of turbine base excavations can result in significant flow rates to the drainage and settlement system if high capacity pumps are used. In order to avoid the need for pumping it is proposed to provide drainage channels from the excavations so as to prevent a build up of water. Where this is not feasible, temporary storage will be provided within the excavations and dewatering carried out at a flow rate that is within the capacity of the settlement ponds. Sediment control measures will be provided to prevent siltation of existing drains or watercourses (See Section 3.15 for further details);

IV. The excavated surface will be levelled and adequate drainage measures will be put in place along with suitable set back areas to facilitate placing of stone and ultimately the erection of shuttering for the turbine base;

V. In the event that poor ground conditions are encountered during confirmatory ground investigations and a significant depth to sub-formation is required, a piled foundation may be considered. A piled foundation requires the use of specialist piling equipment which typically uses an auger drilling technique. A number of holes are drilled around the area of the turbine base to the suitable sub-formation depth determined at detailed design stage. The piles typically extend 2 to 4 m into competent rock. Once all the holes have been bored, reinforcement steel is inserted into each with concrete poured afterwards.

VI. Suitable stone aggregate will be used to form a solid level working foundation surface. The stone will be rolled and compacted to a suitable formation level;

VII. Shutters and steel reinforcement will then be put in place and the foundation of the turbine will be prepared for pouring of concrete;

VIII. A layer of concrete blinding approximately 75mm thick will be laid directly on top of the newly exposed formation, tamped and finished with a screed board to leave a flat level surface. The concrete will be protected from rainfall during curing and all surface water runoff from the curing concrete will be prevented from entering surface water drainage directly;

IX. High tensile steel reinforcement will be fixed in accordance with the design drawings and schedules. The foundation anchorage system will be installed, levelled and secured to the blinding;

X. Ductwork will be installed as required, and formwork erected around the steel cage and propped from the backside as required;

XI. The foundation anchorage system will be checked both for level and line prior to the concrete being poured in the base. These checks will be passed to the turbine supplier for their approval;

XII. Ready-mix concrete will be delivered to each turbine base by a fleet of ready-mix concrete trucks via the internal access roads. Concrete will placed into each base by means of a concrete pump where vibrating pokers will be used to ensure that full and proper compaction of the concrete around the reinforcement in the turbine base has been made. Upon completion of the concreting works the foundation base will be covered and allowed to cure;

XIII. Steel shutters will be used to pour the circular chimney section;

XIV. Following curing, the shuttering around the turbine base will be struck and removed;

XV. Earth wires will be placed around the base; and,

XVI. The foundation will be backfilled using material arising during the excavation where possible and the surrounding area landscaped using the vegetated soil set aside during the excavation. A gravel access track will be formed from the main access track and hardstand to the turbine door and around the turbine for maintenance.

Figure 3-20 Typical construction of a wind turbine base

3.7 INTERNAL COLLECTOR SITE CABLES

A network of underground cabling connecting to each turbine will be installed within the site. The cabling will include electrical and signalling cables. These will connect the turbines to the proposed substation at the south east of the site.

Cabling on site will consist of either single or twin cable trenches for open ground sections and for trenches within internal access roads. A cable marker post will be installed on top in order to protect and identify the cable trench underneath. The typical build up for the internal site cable trenches will consist of selected excavated backfill on top of bedding material. The minimum cover depth over the ducts will be 750mm which is measured from the top of the cable duct to existing ground level. Where ducting is within internal access roads; the cable trench will be backfilled with lean-mix concrete in order to protect ducting from being damaged by heavy axle loads that will pass above. The excavated material generated from the trenches will be reused as backfill where possible or alternatively it will be deposited within the proposed on-site peat deposition areas as part of their reinstatement. In areas of poor strength, the bedding material will be wrapped in a geotextile, this is illustrated in Figure 3-21.

Where new log roads are constructed, the cable will sit within the structure of the road to avoid the need to excavate peat (See **Drawing 19876-MWP-00-00-DR-C-5403**).

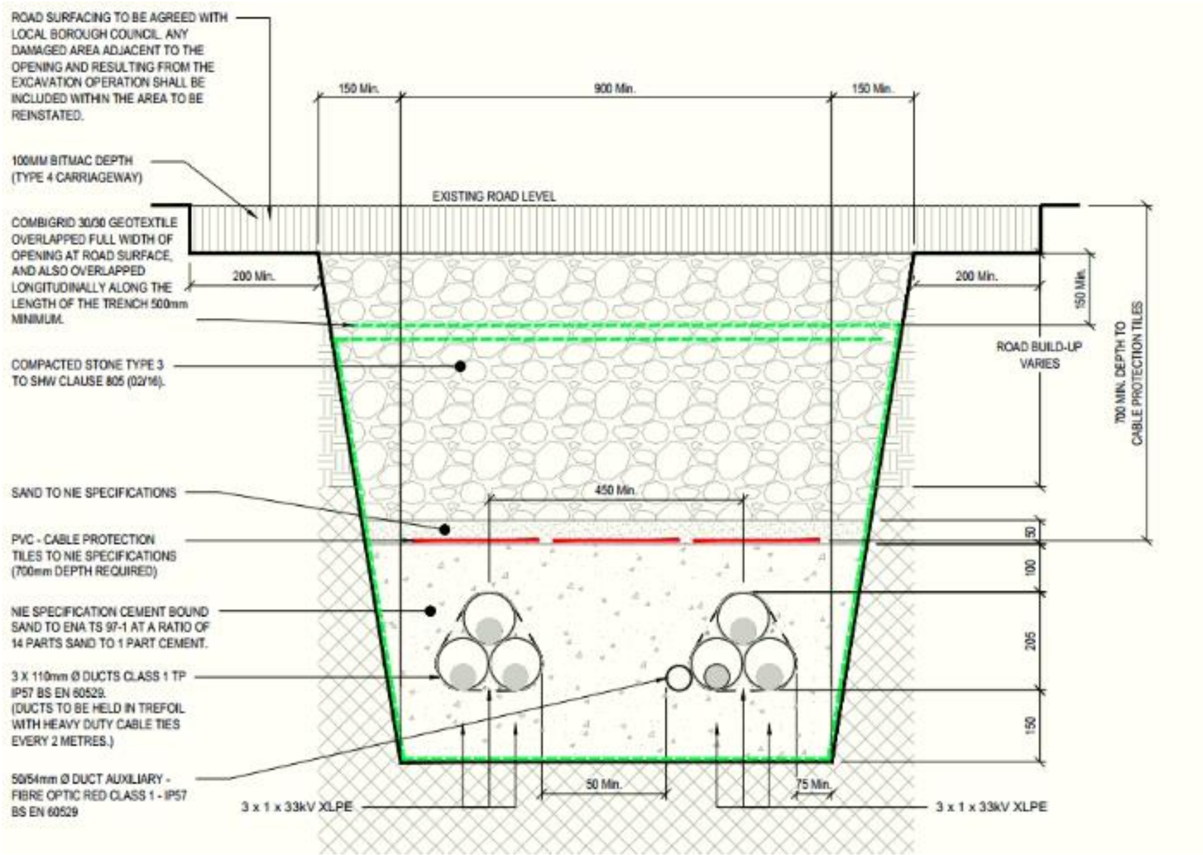

Figure 3-21 Cable Trench Detail for Areas of Deep Peat

Where an existing open drain or watercourse is encountered during the installation of the internal site cable trenches; the cable trenches will cross the existing open drain or watercourse within the road carriageway via new or existing road crossings points to remove the requirement for in-stream works. Marker tapes of non-corrodible material in bright red and yellow colour will be placed within the trench after backfilling for identification and safety purposes in accordance with ESB Networks guidelines. An earth berm will be placed over the cable trench with a marker post installed on top in a secure and robust manner so as to prevent the post from being damaged by animals or prevailing ground conditions. Cable marker posts will either be made of concrete, recycled plastic or timber material, see Figure 3-22. Each marker post will contain appropriately worded warning signage highlighting to persons the presence of high voltage electricity cables underneath.

Figure 3-22 Example of a typical cable marker post on a wind farm

3.8 OPTION 1 - SUBSTATION AND CABLE TO NEAREST POINT ON EXISITNG 110KV OVERHEAD LINE

This section describes the construction methodologies that will be used for the substation compound, substation buildings and cable from the substation to the existing 110kV OHL. The proposed substation is located adjacent to an existing 110kV OHL. The connection to the grid is completed by installing an underground cable in a trench which crosses the roadway by open trenching.

3.8.1 Substation and Compound Construction

The proposed works for the substation compound and buildings will be restricted to the site construction area and will comprise the following:

- Prior to construction, interception ditches will be installed upslope of the proposed substation compound to intercept any existing overland flows (clean water) and convey it downslope in order to limit the extent of surface water coming into contact with the works. The clean water conveyed will be discharged via a level spreader downslope of the works over existing vegetation.
- The area of the substation compound will be marked out using ranging rods or wooden posts and the soil stripped and removed to a temporary storage area for later use in landscaping. All remaining excavated material will be brought to the on-site deposition areas. The area will be surveyed and all existing services will be identified. All plant operators and general operatives will be inducted and informed as to the location of any services.
- Perimeter drains will be installed or upgraded to collect surface water run-off from the substation compound which will include the installation of check dams, silt traps, oil interceptor and level spreaders to cater for surface run-off.
- All soils/peat on the substation site will be removed and replaced with compacted crushed rock or granular fill;
- Formation of the substation compound will be achieved where the compound will be constructed with compacted layers of suitable hardcore;

- The foundations for both substation buildings will be excavated down to the level indicated by the designer and appropriately shuttered. Reinforced concrete will be laid over it.
- The blockwork walls for each building will be built up from the footings to damp-proof course (DPC) level and the floor slab constructed, having first located any ducts or trenches required by the follow on mechanical and electrical contractors;
- The blockwork will then be raised to wall plate level and the gables and internal partition walls formed. Scaffold will be erected around the outside of the two buildings for this operation;
- The concrete roof slabs will be lifted into position using an adequately sized mobile crane;
- The construction and components of the substation buildings will be to EirGrid and ESB Networks specifications;
- The timber roof trusses at each building will then be lifted into position using a telescopic loader or mobile crane depending on site conditions. The roof trusses will then be felted, battened, tiled and sealed against the weather.
- Installation of a domestic wastewater holding tank to hold effluent from the toilets within the substation buildings.
- Installation of a Class 1 full retention oil separator to collect and treat oil spills within the substation compound.
- Installation of a rainwater harvesting tank to collect rainwater from the roofs of the substation buildings for toilet flushing and hand washing.
- Commencement of civil works associated with the construction of the transformer bund, equipment plinths etc. within the substation compound.
- Commencement of civil works associated with construction of underground cable ducts and trenches within the substation compound.
- Installation of electrical equipment within the substation compound and buildings including transformers, busbars, circuit breakers, cable supports, switchgear, panels etc. and all associated cabling.
- Installation of palisade fencing and associated gates to perimeter of the substation compound.

3.8.2 Underground Cable Construction – Trench Through Road

The construction process for the underground cables in the road is detailed in Section 3.9. The same process will be followed for construction of the cable across the road. As it is a short length of road that requires crossing, the scale and duration of the works on the public road will be much less than those required for Option 2 described below. A temporary road closure of less than 1 week in duration will be required for this element of works. The road will be reinstated in accordance with "*Guidelines for Managing Openings in Public Roads, April 2017".*

3.9 OPTION 2 – SUBSTATION AND UNDERGROUND CABLES TO DROMBEG

The substation compound and buildings construction steps are as per those discussed in Section 3.8.

The potential alternative option of an underground grid connection along the public road between the proposed substation and the permitted Drombeg substation will be carried within a single cable trench which will be approximately 1.25m in depth and 0.6m in width. Photographs of typical cable installation works on public roads are shown in **Figure 3-23** to **Figure 3-25**. The installation will involve the following process:

- Prior to works commencing the area where excavations are planned will be surveyed and all existing services will be confirmed. A road opening licence will be obtained where required from

Kerry County Council for the relevant road sections. All plant operators and general operatives will be inducted and informed as to the location of any services.

- Prior to works commencing a dilapidation survey will be carried out photographing and noting any existing damage or defects to structures or road surfaces. A copy of this survey will be submitted to Kerry County Council prior to works commencing.
- Prior to works commencing the route will be inspected and marked out on the ground. Standard good practice preparatory measures are then put in place along the extent of the route. This will include any required warning notices, temporary barriers, etc.
- Prior to works commencing a traffic management plan will be prepared by the appointed contractor and agreed with Kerry County Council. A Traffic Management Plan is included in **Volume 3 Appendix 15-3** to this EIAR.
- During construction works, the trench will be excavated down through the existing stone in the road using an excavator machine. As stone fill is removed it is temporarily stockpiled adjacent to the trench for re-use in backfilling. In some instances some soil or unsuitable material may be encountered in the trench and this is removed from site and brought to an appropriately licensed facility for disposal.
- The trench is then prepared to receive concrete bedding and surround for the ducts. The ducts are surrounded by concrete with adequate cover over the duct.
- Once the concrete is suitability set, appropriate imported stone material is placed over the concrete surround and filled back up to the top of trench. Suitable warning tapes will also be installed in the trench. Once the trench is filled, the trenching and ducting process will move along the road in planned stages.
- The trench surface receives a temporary surface dressing of either spray and chip or macadam. Once the overall scheme is completed, the underground cable route and associated road areas will receive a new permanent macadam finish as agreed with Kerry County Council.
- Joint bays are to be installed where required along the cable route in the public road or along the grass margin of the public road. Once installed they are temporarily reinstated until they are opened again to allow for pulling cables through the ducts and jointing the cables afterwards. The joint bays will then be permanently backfilled and reinstated to the satisfaction of Kerry County Council.
- Directional drilling will be used where there is insufficient cover on a bridge or culvert crossing to allow the grid connection route pass over the crossing in a standard trefoil formation. The launch and reception pits to be made in the public road or grass margin will be permanently backfilled and reinstated to the satisfaction of Kerry County Council.
- The as-built location of the ducting will be surveyed using a total station / GPS. Marker posts will be installed along the grid connection route to also denote the location of ducting on the ground.
- A condition survey will be carried out on the roads impacted by the connection route, both pre and post construction. This will include a video survey of the road extent with any significant dilapidations further recorded by photography and local surveying as required.

Figure 3-23 Typical excavation works for a grid connection cable trench on public road

Figure 3-24 Typical ducting installation works for a grid connection cable trench on public road

Figure 3-25 Typical permanent reinstatement works for a grid connection cable trench on public road

3.9.1 Joint Bays for Underground Cable Route to Drombeg Substation

Joint bays are pre-cast concrete chambers that will be required along the cable route to the Drombeg Substation. They are required to join cables together to form one continuous cable. They will be located at various points along the connection route approximately every 500 - 1,000 metres depending on gradients, bends etc. Up to 11 joint bays will be required along the cable route to Drombeg Substation. The final locations of joint bays will be agreed in advance with Kerry County Council.

Where possible, joint bays will be located in areas where there is suitable widening or grass margin on the road in order to accommodate easier construction and disrupt less traffic. During construction, the joint bay locations will be fenced off and will be incorporated into the grid connection traffic management plan. While the within application for planning permission does not include the potential alternative grid connection under the public road, the Traffic Management Plan (TMP) included in **Volume 3 Appendix 15-3** of this EIAR considers the potential traffic impacts of the proposed alternative grid connection option. A final TMP will address the requirements of any relevant planning conditions, including any additional mitigation measures which are conditioned by the Board or which are subsequently required by Kerry Co Council. The final traffic management plan will be agreed with Kerry County Council prior to the commencement of works. Once the joint bays have been constructed, they will be temporarily backfilled until they are re-excavated later to allow for the pulling and jointing of cables at each joint bay. Once cable pulling is complete, the joint bays will be fully backfilled again and permanently reinstated to the satisfaction of Kerry County Council.

The joint bays, communication chambers and sheath link boxes will be either precast or cast *in situ*. In order to place the boxes, the area of excavation will first be marked out on the ground and any necessary preparatory protection measures put in place to avoid any run off or loss of soil materials. These will include appropriate siltation measures along road side drainage (silt fences, check dams etc.).

The materials excavated from the joint bay chambers will be brought to a suitably licensed or permitted facility depending on the material classification. Prior to the chamber being installed in a compacted layer of suitable stone or lean mix concrete will be placed in the excavation to provide a level surface. The boxes are then positioned *in situ* and backfilled around them with imported crushed stone material. The precast concrete joint bay chamber cover is then put in place at a suitable level to allow for a new road surface and chamber cover over.

Figure 3-26 shows a typical joint bay installation.

Figure 3-26 Typical joint bay construction

3.9.2 Watercourse Crossing for Underground Cable Route to Drombeg Substation

The proposed alternative grid connection route crosses three watercourses mapped on the OSI Discovery Series mapping. The locations are shown in Figure 3-27. A summary of the proposed crossing methodologies is given in Table 3-2.

A description of the proposed crossing options is provided below. In-stream works are not proposed along the proposed alternative cable route to Drombeg Substation.

Table 3-2 Summary of proposed crossing methodology

Crossing No.	Road Type	Watercourse Crossing Option Considered	Extent of In-stream works
1	Public Local Road	Option 1 – Trefoil cable arrangement over existing bridge/culvert Option 2 – Flat bed cable arrangement over existing bridge/culvert Option 3 – Horizontal directional drill under the watercourses	None proposed.
2	Public Local Road	Option 1 – Trefoil cable arrangement over existing bridge/culvert Option 2 – Flat bed cable arrangement over existing bridge/culvert Option 3 – Horizontal directional drill under the watercourses	None proposed.
3	Internal site access track to Drombeg Substation	Cable to be placed within new culvert for access road	None proposed.

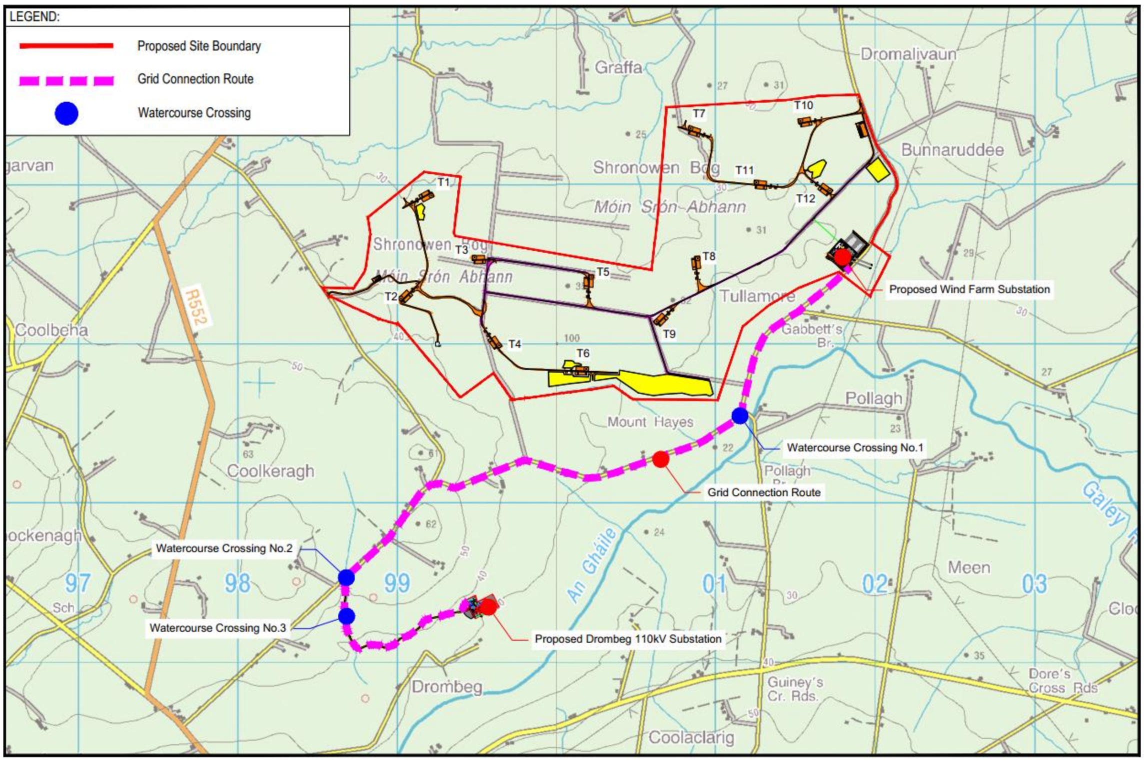

Figure 3-27 Water course crossing for cable route to Drombeg Substation

Option 1 - Crossings over Bridges/Culverts using Standard Trefoil Formation

Watercourses will not be directly impacted as no in-stream works or bridge alterations are proposed. Where adequate cover exists above a bridge, a standard trefoil arrangement will be used where the ducts will pass over the bridge without any contact with the top of the bridge or watercourse. The ducts will pass over the bridge in a standard cable trench as outlined in **Figure 3-28.**

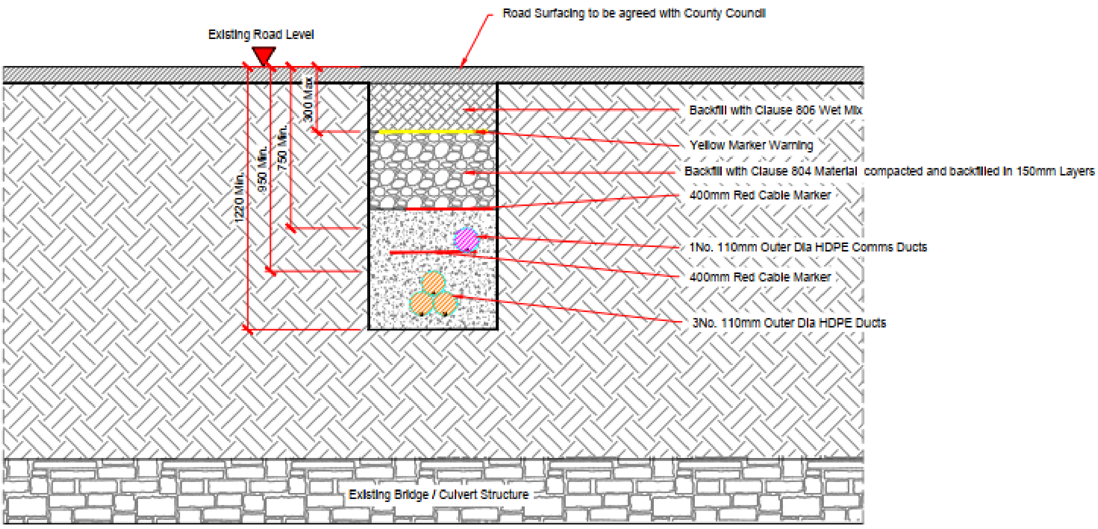

Figure 3-28 Typical Trefoil Arrangement at Bridge/Culvert Crossing

Option 2 - Flatbed Formation over Bridges/Culverts

Where cable ducts are to be installed over an existing bridge/culvert and sufficient cover cannot be achieved by installing a standard trefoil arrangement, the ducts will be laid in a much shallower trench. The ducts will be laid in a flatbed formation over the existing bridge and encased with galvanized steel plates in a concrete surround. This method of duct installation is further detailed in **Figure 3-29.** It may be necessary to locally raise the level of the existing road in order to achieve the required cover over the ducts. The increased road level will be achieved by overlaying the existing road with a new wearing course where any addition of new pavement will be tied back onto the existing road. Any works to locally raise the level of the existing road and potentially the bridge parapets will be agreed with Kerry County Council prior to commencement with all works and reinstatement carried out to their satisfaction. Once the ducts have crossed the bridge the ducts will resume to the standard trefoil arrangement.

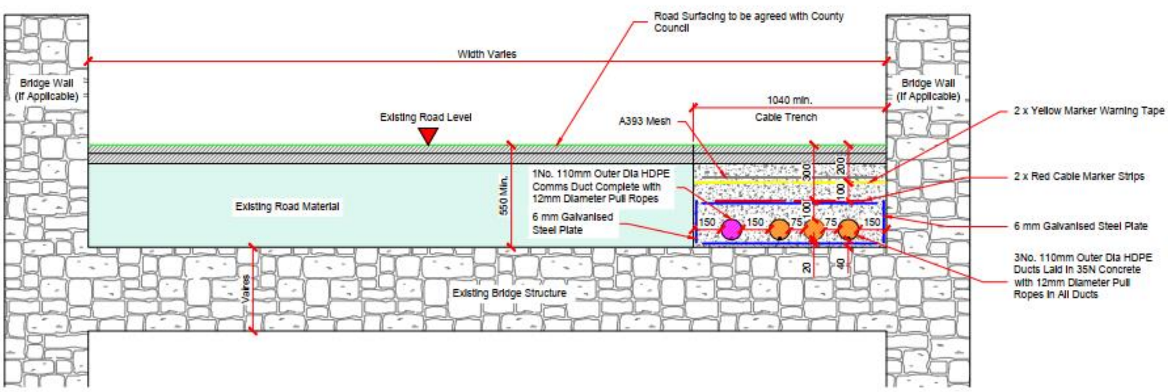

Figure 3-29 Typical Flatbed Arrangement at Bridge/Culvert Crossing

Option 3 - Directional Drilling under Bridges, Culverts and Watercourses

In the event that none of the above methods are appropriate, directional drilling will be utilised, which will require a service trench (launch pit) for the drill in the road either side of the watercourse. The directional drill process will require that the depth of the service trench will deepen in a defined slope as it approaches the watercourse crossing on either side, as to have sufficient passing depth under the watercourse. Images of a typical directional drilling methodology are shown in Figure 3-30 and Figure 3-31.

The direction drill will be carried out as follows:

- The directional drilling machine will set up at a launch and reception pit (an enlarged portion of on-road trench, i.e. a service trench on either side of the crossing point at an appropriate distance back from the watercourse). The drill will then bore in an arc under the watercourse feature.
- The drilling head of the boring tool has a series of nozzles that feed a liquid bentonite mix along the bore direction, which provides both lubrication and also seals the cut face of the bore.
- Once the bore reaches the far side, the duct is then attached to the drill head and the duct is pulled back along the route of the bore to the original drilling point.
- Any bentonite mix is deposited within the bore shaft and spillage is collected at either end of the bore with dedicated sump; all excavated material and excess bentonite will be removed from site and brought to an authorised waste facility.
- Once the duct is in place under the watercourse, the normal process of road trenching can continue from either side of the watercourse structure.
- The launch and reception pits will be backfilled in accordance with normal specification for backfilling excavated trenches and to the satisfaction of Kerry County Council.

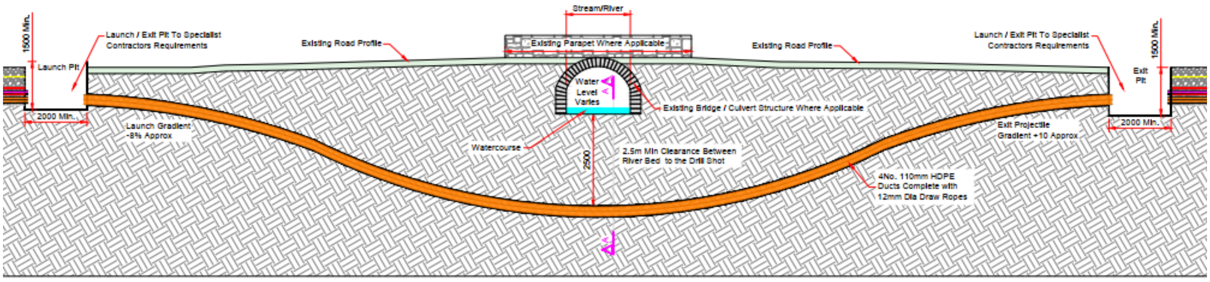

Figure 3-30 Typical directional drilling profile under a watercourse

Figure 3-31 Typical directional drilling rig and launch pit

3.10 DURATION OF CONSTRUCTION FOR GRID ROUTE OPTIONS

3.10.1 Option 1 – Underground Cable to Nearest Point on Existing 110kV line

Overall the works for the preferred grid connection option are estimated to take approximately 2 months. During the first 6 weeks, trenches will be constructed in the field on the opposite side of the road to the proposed substation. A trench will also be constructed across the public road which is anticipated to take less than 1 week. During the last two weeks, cables will be pulled through the ducts in the trenches and electrical works will be carried out.

3.10.2 Option 2 – Underground Cable to Drombeg

For the alternative grid connection option to the Drombeg substation, works are estimated to take approximately 3 months. During the first 1.5 months the cable trenches will be constructed. The second 1.5 months will involve sequentially opening up all joint bays (these are pre-cast concrete chambers that will be required along the grid connection route over its entire length) and pulling electrical cables pulled through ducts and then joining each cable together. Work at each joint bay will take approximately 2 to 3 days.

3.11 PERMANENT METEOROLOGICAL MAST

A permanent meteorological mast is proposed for the site to monitor the wind regime while the wind farm is in operation. The mast will be located in the area of the site close to T2 and T4 in an area of cut-away peat. It will be installed to a height of up to 90m which will be representative of the hub height of the turbines. The meteorological mast will be surrounded by a galvanised steel palisade fence, 2.4m in height. Details of the meteorological mast are shown in **Planning Drawing 19876-MWP-00-00-DR-C-5402.** Excavated material will be reused for backfill/adjacent landscaping or will be relocated to the on-site deposition areas.

Figure 3-32 Typical Permanent Meteorological Mast on a Wind Farm

3.12 TEMPORARY SITE CONSTRUCTION COMPOUNDS

The 2 No. temporary site construction compounds will be used for the construction phase of the wind farm. The compounds will have dimensions of approximately 95m x 50m and 55m x 25m respectively as shown on **Planning Drawings 19876-MWP-00-00-DR-C-5407 and 5408**. The peat will be excavated down to the underlying stratum. The peat and excavated materials will be stored locally on a temporary basis and will be used for reinstatement following completion of the works. This is discussed in more detail in Section 3.15.

The exposed surface will be levelled out by cutting and filling and will then be overlain with a layer of geotextile and crushed stone imported to site. The finished surface will be formed with a layer of Class 6F or similar aggregate imported from local quarries. Each of the site compounds will be graded and compacted out before the welfare container facilities are installed.

The compounds will be constructed early in the project in order to provide site offices and accommodation for staff and for the delivery of materials. Any surface water management, bunding, waste management measures etc. will also be put in place at the outset. Site security will have to be put in place adjacent to the entrance and will have to be maintained throughout all phases of the work. The compounds will be in place for the duration of the construction phase and will be removed once commissioning is complete.

Areas within the compounds will be constructed as access roads and used as vehicle hardstandings during deliveries and for parking. Typical requirements for temporary site compounds are listed below;

I. A bunded, impermeable containment area will be provided within the compounds for the storage of lubricants, oils and site generators etc.;
II. The compound will be fenced and secured with locked gates,
III. During the construction phase, a self-contained toilet/welfare facility with an integrated waste holding tank will be used on site for toilet facilities. This will be maintained by the service contractor on a regular basis and will be removed from the site on completion of the construction phase.
IV. Upon completion of the project the compounds will be decommissioned by backfilling the area with the material / peat arising during excavation, landscaped with topsoil as required.

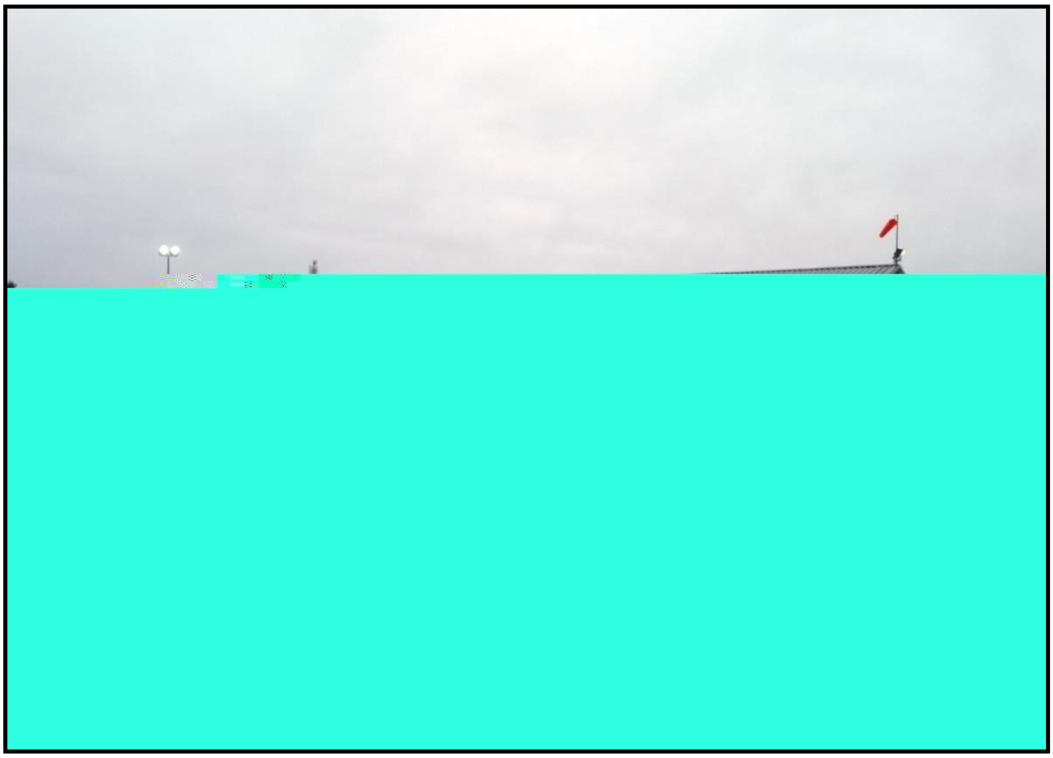

Figure 3-33 Typical temporary site construction compound on a wind farm

3.13 PEAT AND SPOIL STORAGE

3.13.1 Excavated Peat and Spoil Storage

The Peat and Spoil Management Plan for this development is included in **Volume 3 Appendix 9-2** of the EIAR and is also described briefly below.

In the first instance, excavated peat and spoil will be reused for the backfilling, landscaping and restoration around wind farm infrastructure such as turbines and hardstands.

Berms will be formed along sections of access roads in order to store an additional volume of excavated peat. These berms will also act as a physical edge protection measure to prevent vehicles falling off the raised floated road edge. This form of storage will be provided on both sides of the internal floated roads where the overall dimensions of the berms will generally be 1m high by 2.5m wide.

The remainder of the surplus excavated peat and spoil material will be stored within the peat deposition areas. The proposed locations for the peat deposition area are shown on **Planning Drawings 19876-MWP-00-00-DR-C-5005 to 5010.**

Retention berms founded on a solid formation layer below peat shall be constructed around the peat depositions areas. The retention berms shall be constructed from free drain granular material or cohesive material with drainage outlets to prevent water build up within the deposition area. The deposition areas shall also be split into cells using internal berms so that they are more manageable in size and to reduce risk of peat movement within the deposition area during construction. A drainage system shall be put in place around the perimeter of the deposition area to prevent siltation of any drains or water courses. See a typical berm detail in Figure 3-34.

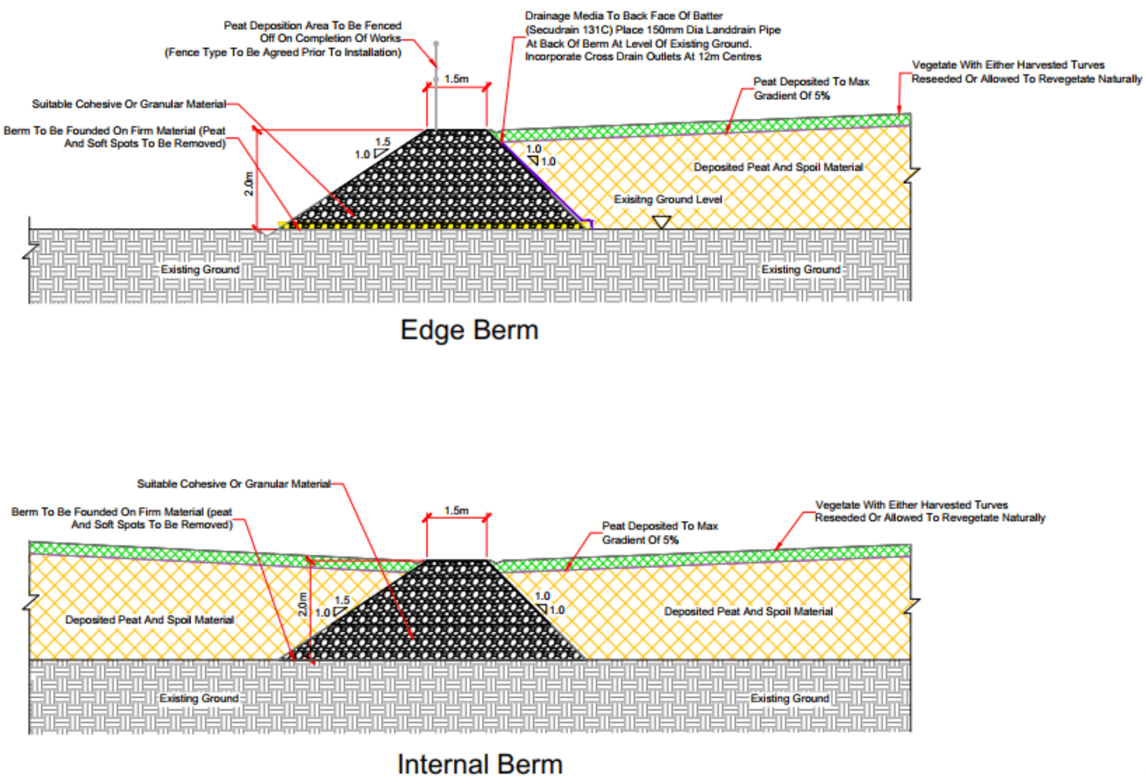

Figure 3-34 Typical Detail of Retention Berms at Peat Deposition Areas

Drainage and siltation control measures will be put in place in all peat deposition areas. This will include a dedicated drainage network, temporary silt fences and settlement ponds designed to cater for the size of each storage area. Further details of the drainage philosophy that will be applied as well as siltation control systems and attenuations systems is give in Section 3.14 of this report. Peat deposition areas will have a 50m buffer from any OSI mapped watercourses to mitigate against any risk of siltation. This buffer provides a natural filter to reduce the sediment that may be generated by the deposition area from reaching the watercourse.

3.13.2 Restoration of Peat Deposition Areas

Peat is characterised by two distinct layers, the lower *catotelm* layer of highly humified peat and the upper *acrotelm* layer of fibrous peat which contains the live seed bank. The *acrotelm* layer should be regarded as an ecological resource that can be used for habitat restoration rather than simply as surplus excavated material.

As peat is excavated the *acrotelm* layer will be stripped first and set aside temporarily for re-use. As the peat deposition areas are filled they will be covered over with the *acrotelm* layer. This includes the outer faces of the containing berm(s). The peat deposition areas need to be completed and restored in a continuous cycle so as to minimise the length of time the *acrotelm* is stored and to allow the vegetation to be re-established as quickly as possible. It is important that the *acrotelm* is handled carefully and that it is not allowed to dry out while it is being stored. Regular watering may be necessary during dry weather periods. This will be carried out by the appointed Contractor.

3.14 SITE DRAINAGE

3.14.1 Design Principles

The site drainage system was designed integrally with the wind farm layout as a measure to ensure that the proposal will not change the existing flow regime across the site, will not deteriorate water quality and will safeguard existing water quality status of the catchments from wind farm related sediment runoff.

A fundamental principle of the drainage design is that clean water flowing in the upstream catchment, including overland flow and flow in existing drains, is allowed to bypass the works areas without being contaminated by silt from the works. This will be achieved by intercepting the clean water and conveying it to the downstream side of the works areas either by piping it or diverting it by means of new drains or earth mounds.

This process will cause the normally dispersed flow to be concentrated at specific discharge points downstream of the works. In order to disperse this flow, each clean water drain will be terminated in a discharge channel running parallel to the ground contours that will function as a weir to disperse the flow over a wider area of vegetation. An alternative method is to allow the water to discharge through perforated pipes running parallel to the ground contours. Both of these methods will prevent erosion of the ground surface and will attenuate the flow rate to the downstream receiving waters. The specific drainage measures to be used at each location are shown on the drainage drawings included with the planning application. The clean water interceptor drains or earth mounds are all positioned upslope to prevent any mixing of the clean and dirty water. The outflow from these drains is then piped under the road at suitable intervals and at low points depending on the site topography.

Separating the clean and dirty water will minimise the volume of water requiring treatment. The dirty water from the works areas will be collected in a separate drainage system and treated by removing the suspended solids before discharging it to the existing downstream drain or watercourse over vegetated ground. Dirty water drains will be provided on both sides of the access roads and along the periphery of the turbines, crane hardstands, substation compound and the temporary site construction compounds.

The treatment system will consist of a series of settlement ponds at designated locations throughout the site. (Refer to **Section 3.17** below). The treated outflow from the treatment system will be dispersed over vegetation in the same manner as the clean water dispersion, and will become diluted through contact with the clean water runoff in the buffer areas before entering the exisitng downstream drains or watercourses. The site at Shronowen is relatively flat and low lying. As such, the flow rates in are low in existing drains and watercourses.

The site drainage layout is presented in Planning Drawings **19876-MWP-00-00-DR-C-5011 to 5016** with drainage details presented in Planning Drawings **19876-MWP-00-00-DR-C-5404 to 5405**. The drainage layout is overlaid on background OSI mapping in the A1 drawings that accompany the planning application.

3.14.2 Flood Attenuation

The creation of impermeable areas within a development site has the effect of increasing rates of runoff into the downstream drainage system and this may increase flood risk and flood severity downstream. This applies particularly to urban areas that drain to closed pipe systems which do not have the capacity to cater for increased hydraulic loads. The proposed development is located within a large rural catchment with an open drainage system. The footprint of the impermeable areas and the associated increase in runoff rate is minimal in the context of the catchment size and therefore represents a negligible increase in downstream flood risk. This can be seen by comparing the area of infrastructure to the area of the catchments in **Figure 3-35**. However, it is proposed to provide some attenuation in order to limit the flow rate into the settlement ponds during high intensity storm events so that they do not become overloaded. This will also attenuate the flow to the existing downstream drains or watercourses.

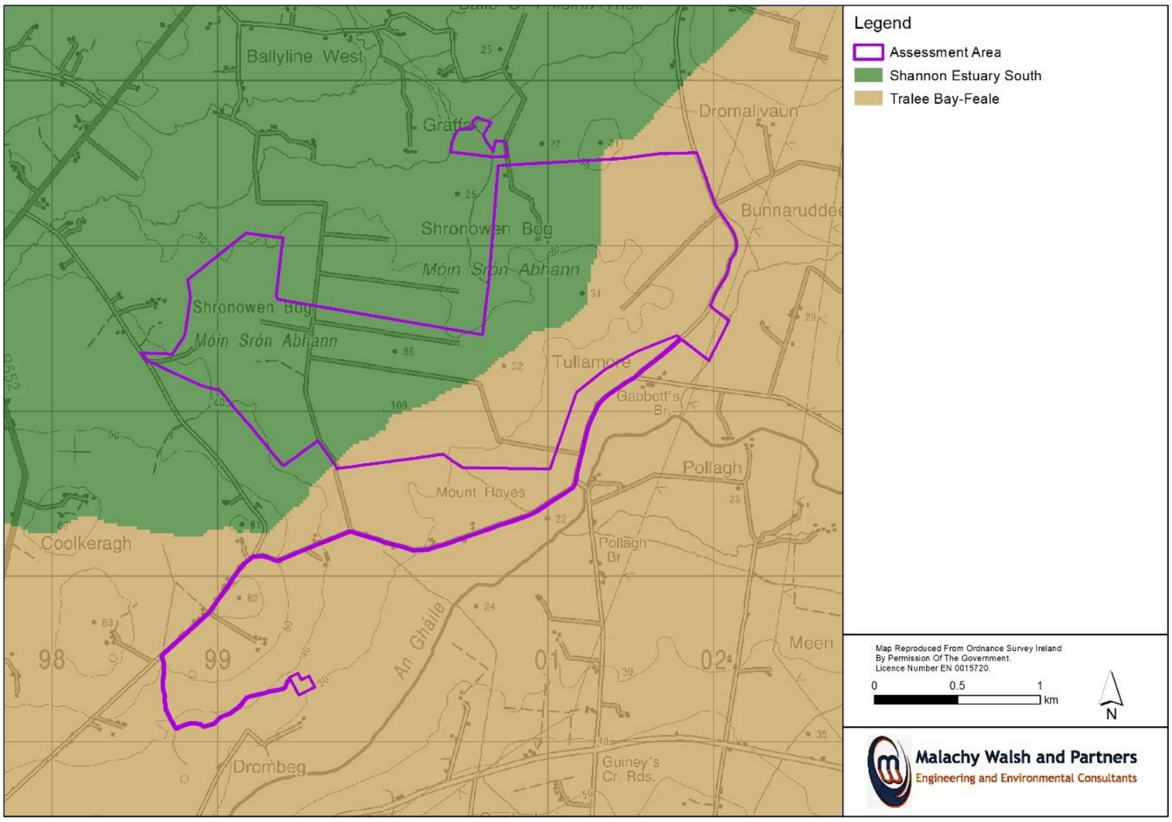

Figure 3-35 Proposed Infrastructure Overlaid on Catchments

The volume of water requiring attenuation relates to direct precipitation on the roads and other infrastructure footprint only. Due to their predominant unbound nature, the developed surfaces have some permeability and this reduces the attenuation requirement. Conventional attenuation systems use proprietary flow control units but these can become blocked with debris and vegetation and require regular maintenance. They are, therefore, not appropriate for use within an isolated environment, such as that peat bog in Shronowen, or where long-term routine maintenance would not be practical.

It is proposed to provide the temporary storage within the drainage channels by creating stone dams at regular intervals within the channels (See Figure 3-37). The spacing of the dams is typically 100 metres but will depend on the channel slope, with steeper channels requiring shorter intervals. As Shronowen is a flat site, it is not envisaged that closer spacing will be required. The dams, which are constructed with small sized aggregate held in place by large aggregate, also reduce the flow rate through the drainage system and are an effective means of providing flow control. Temporary silt fences will also provide storage and flow control.

3.15 SURFACE WATER MANAGEMENT SYSTEMS

3.15.1 General

If not controlled, sediment such as peat, clay, or silt can cause significant pollution during the construction phase of a civil engineering project due to the erosion of exposed soil by surface water runoff. The surface water quality management system and plan has been prepared in order to control erosion and prevent sediment runoff during the construction phase of the proposed development. The implementation of sediment and erosion control measures is essential in preventing sediment pollution (See **Planning Drawing 19876-MWP-00-00-DR-C-5404 to 5405)**. The system was designed having regard to:

- Knowledge of the site's environmental conditions;
- Numerous site visits and walkovers
- Previous construction experience of wind farm developments in similar peat environments;
- Previous experience of environmental constraints and issues from construction of wind farms in similar environmental conditions;
- Technical guidance and best management practice manuals. A list of best practice documents is given below and within the CEMP;

  - CIRIA (2000), Sustainable Urban Drainage Systems Design Manual for Scotland and Northern Ireland
  - CIRIA (2001) Control of water pollution from construction sites. Guidance for consultants and contractors (C532)
  - CIRIA (2004) Interim Code of Practice for Sustainable Urban Drainage Techniques
  - CIRIA (2005) "Environmental good practice on site" 145
  - CIRIA (2006) Control of water pollution from linear construction projects. Technical guidance (C648)
  - COFORD, 2004, Forest Road Manual, Guidelines for the design, construction and management of forest roads
  - Department of Agriculture, Food and the Marine, Standards for Felling and Reforestation (Oct 2019)
  - Department of the Marine and Natural Resources (1998), Fisheries Guidelines for Local Authority Works. Department of the Marine and Natural Resources, Dublin
  - Department of Environment Heritage and Local Government (2006), Wind Farm Planning Guidelines
  - Department of Housing, Local Government and Heritage, Draft Revised Wind Energy Development Guidelines (2019)
  - Department of Marine and Natural Resources (DMNR) (1998), Fisheries Guidelines for Local Authority Works. Department of Marine and Natural Resources, Dublin
  - Eastern Regional Fisheries Board. (Year Unknown). Fisheries Protection Guidelines. Eastern Regional Fisheries Board, Dublin
  - Enterprise Ireland, Best Practice Guide BPGCS005 Oil Storage Guidelines
  - Environment Protection Agency (EPA), http://www.epa.ie/pubs/advice/
  - Forest Service and Department of Agriculture, Fisheries and Food, 2000a, Forest Harvesting and the Environment Guidelines.
  - Forest Service and Department of Agriculture, Fisheries and Food, 2000b, Forest and Water Quality Guidelines
  - Forestry Civil Engineering and Scottish Natural Heritage, 2010, Floating Roads on Peat
  - Forestry Commission Scotland, 2004, Forests and Water Guidelines 4th Edition
  - Forests and Water, 2011, UK Forestry Standard Guidelines
  - Forestry and Water Quality Guidelines (Forest Service, Department of the Marine and Natural Resources, July 2000);
  - Forest Harvesting and Environmental Guidelines (Forest Service, Department of the Marine and Natural Resources, July 2000).
  - Inland Fisheries Ireland (2016) Guidance on Protection of Fisheries during Construction in and adjacent to Water
  - Irish Wind Energy Association and Sustainable Energy Ireland (2008), Best Practice Guidelines for the Irish Wind Energy Industry

- MacCulloch 'Guidelines for the risk management of peat slips on the construction of low volume/low cost roads over peat' (2006)
- National Roads Authority (2004), Guidelines for the treatment of badgers prior to the construction of national road schemes, NRA, Dublin
- National Roads Authority, (2008), Guidelines for the crossing of watercourses, during the construction of national road schemes
- Office of Public Works "Construction, Replacement or Alteration of Bridges and Culverts, 2013".

UK Pollution Prevention Guidelines (PPG):

- GPP 2 (2018): Above ground oil storage tanks
- GPP 4 (2017): Treatment and disposal of wastewater where there is no connection to the public foul sewer
- GPP 5 (2017): Works and maintenance in or near water
- PPG6 (2012): Working at construction and demolition sites
- GPP08 (2017): Safe Storage and Disposal of Used Oils;
- GPP 21 (2017): Pollution incident response planning
- PPG 22 (2011): Incident response - dealing with spills
- PPG 26 (2011) Safe storage - drums and intermediate bulk containers

The following site-specific information was used in the design of the drainage and treatment system:

- High resolution aerial photography;
- Topographical survey information;
- Review of existing drainage networks;
- Wind farm infrastructure layout (turbines, service roads and ancillary development);
- Hydrology maps (watercourses and buffer zones);
- Soil and land use maps; and
- Met Éireann extreme rainfall data.

The settlement ponds and check dams described in the following subsections provide the essential mechanism for the removal of silt from construction related runoff and the controlled return of the treated runoff to the existing downstream drains or watercourses.

The drainage and treatment system will ensure that the proposed development will not create adverse effects on the aquatic environment that could compromise the ability to meet Water Framework Directive objectives or to fulfil compliance with basic measures required including the Nitrates Directive, the Habitats and Birds Directives and the Drinking Water Directive.

3.15.2 Construction Works Areas

Runoff from the internal roadways, hardstands and other wind farm infrastructure will be isolated from the clean catchment runoff by means of a series of open drains that will be constructed within the works areas, existing drains will be utilised also where practicable. These drains will be directed to settlement ponds that will be constructed throughout the site, downhill from the works areas. Each drain will incorporate a series of check dams that will attenuate the flow and provide storage for the increased runoff from exceptional rainfall events. The ponds have been designed to a modular size to cater for a single turbine and hardstand area or a 1,200m^2 area of internal access road. Where larger areas of runoff have to be catered for at a single discharge point the size of the settlement pond will be increased pro rata.

Dewatering of turbine base excavations can result in significant flow rates to the drainage and settlement system if high capacity pumps are used. In order to avoid the need for pumping it is proposed to provide drainage channels from the excavations so as to prevent a build-up of water. Where this is not feasible, temporary storage will be provided within the excavations and dewatering carried out at a flow rate that is within the capacity of the settlement ponds.

3.15.3 Treatment Process

Contaminated runoff can be generated on the site access roads, construction compound, sub-station sites and turbine hard standing areas and is mainly due to excavation for the infrastructure or movement of delivery vehicles and on-site traffic. Drains carrying construction site runoff will be diverted into settlement ponds that reduce flow velocities, allowing silt to settle and reducing the sediment loading. A modular approach has been adopted for the design of the settlement ponds which have been sized to cater for a catchment area of 1,200m^2 works area.

The settlement ponds have been designed as a three-stage tiered system as described in the bullet point below. The three-stage system also facilitates effective cleaning with minimal contamination of water exiting the pond.

The design of the drainage and settlement pond system for the site is detailed in the Planning Drawing Planning Drawing19876-MWP-00-00-DR-C-5404. The hydraulic design of the settlement ponds is outlined in Section 3.15.4.

The settlement ponds have been designed with regard to the following:

- Runoff flow rate for the localised catchment area;
- Met Éireann Extreme Rainfall Data (statistical rainfall intensity / duration table);
- Character of the impermeable areas (runoff coefficients); and
- Design particle size and density.

The treatment process consists of primary, secondary and tertiary treatment as follows:

- The *primary treatment* consists of a three-stage settlement pond with an over-topping weir at each stage. The first chamber will remove most of the sediment load, while the remaining two chambers will remove most of the remaining load.
- Before the water is released onto the existing ground surface, it passes through a *secondary treatment* system in the form of a graded gravel filter bed which removes a further degree of siltation.
- The outflow from each interceptor is dispersed across a wide area of vegetation so that the velocity is minimised and the vegetation can filter out the residual sediment. This is the final or *tertiary* stage of the treatment process. Existing rills and collector drains within the tertiary treatment area are blocked off to prevent concentration of the flow.

Each individual sediment treatment pond at Shronowen has been micro-sited and designed using the contour maps and aerial photos to avail of any locally level areas and to ensure that the outflow is spread over as much vegetation as possible before entering an aquatic buffer zone. See planning drawings included in planning pack.

Settlement ponds will require inspection and cleaning when necessary. This will be carried out by the appointed contractor under low or zero flow conditions so as not to contaminate the clean effluent from the pond. The water level would first be lowered to a minimum level by pumping without disturbing the settled sediment. The sediment would then be removed by mechanical excavator and disposed of in areas designated for deposition of spoil. Settlement ponds will require perimeter fencing and signage to ensure that there are no health and safety risks.

Figure 3-36 below shows a well-constructed and maintained tiered settlement pond. This example is located in an upland environment with significant ground surface slope and operates efficiently provided that it is well maintained. The design has been developed in conjunction with Inland Fisheries Ireland personnel and Local Authority engineers. In contrast, the subject site in Shronowen is relatively flat therefore drainage is lower risk and more manageable.

Figure 3-36 Multi-tiered settlement pond with stone filter

The effluent from each settlement pond will discharge to an open channel, 8 to 10 metres in length, running parallel to the ground contours. This will form a weir that will overflow on its downhill side and disperse the flow across the existing vegetation. Buffer widths are designed in line with *Forests and Water, UK Forestry Standard Guidelines (Forestry Commission, 2011)* on protection of watercourses during forestry operations and management. This method buffers the larger volumes of run-off discharging from the drainage system during periods of high precipitation, further reducing suspended sediment load to existing surface drains and/or watercourses. Existing rills and drains within the dispersion zone will be blocked off where necessary to prevent concentration of the flow.

3.15.4 Settlement Pond Design

3.15.4.1 Pond surface area (roads and hardstands)

Generally, high intensity rainfall events have a short duration and lower intensity rainfall events tend to have a longer duration. The Met Éireann Extreme Rainfall Data for the area demonstrate that the chance of occurrence of a storm event of a given duration decreases (higher return period) as intensity increases. Table 3-4 shows the Point Rainfall Frequency, the total rainfall for each duration, and return period in millimetres. Table 3-5 shows the same data converted to a rainfall rate in mm/hour. For a given return period the total depth of rainfall increases with storm duration but the actual rainfall rate over that period of time decreases. For the operation of the settlement ponds it is the rate of flow rather than the total rainfall that is relevant. The return period is a measure of the likelihood that a storm of a particular intensity will occur in a given year. However, it is important to note that the chances of occurrence of a storm event with a particular return period are the same in each year but should on average occur once in that time period. For instance, a storm event with an intensity of 162mm/hour and 5-minute duration would be expected to occur once in a 100-year period (first row of Table 3-5). This is more appropriately expressed as an annual exceedance probability (AEP) of 1%; that is, it has a 1% chance of being equalled or exceeded in any year.

The runoff control measures for the wind farm site have been designed in the context of storm events of varying duration and intensity. The settlement ponds have been designed to cater for a maximum continuous flow rate associated with a medium-intensity rainfall event. Higher intensity runoff will be attenuated by the open drain collection system which provides temporary storage and limits the rate at which it enters the settlement ponds. This is achieved by the use of check dams within the open drains as described in section 3.15.6. Longer duration storms of 24 hours or more generally have very low intensity and are not critical in terms of the runoff rates that they generate.

The modular settlement ponds at Shronowen are designed to operate effectively for the runoff rate associated with a continuous high rainfall rate of 20mm/hour. This is approximately equivalent to a 60-minute duration storm event with a 10-year return period (M10-60) or a 10-minute duration storm event with a 100-year return (M100-10). These rates are taken from the Met Éireann Point Rainfall Frequency table close to the site location. Refer Table 3-4 for further detail.

The design runoff rate, used for the planning stage drainage design, is calculated using the formula:

$Q = c\,i\,A$

where c is the runoff coefficient,

i is the rainfall intensity in m/sec, and

A is the catchment surface area in m^2.

A runoff coefficient of 0.70 is assumed for the hardcore surface. For a rainfall intensity of 20mm/hour and an area of 1,200m^2 (which represents approximately the 240m of access road) runoff rate is:

$Q = 0.70 \times (0.02/3600) \times 1{,}200\ m^3/sec$

$= 0.0047\ m^3/sec$ (4.70 litres/sec)

The main design parameter for the settlement pond is the water surface area. The required surface area is the design flow rate in m^3/sec divided by the particle settlement velocity (V_s) in m/sec (Area = Q/V_s m^2).

The particle settlement velocity is determined using the formula derived by Stokes as follows:

V_s = $2 r^2 (D_p – D_f) / (9 n)$

where V_s is the particle settlement velocity (m/sec),

r is the radius of the particle (metres),

D_p is the density of the particles (kg/m^3),

D_f is the density of the fluid (kg/m^3), and

n is the viscosity of the fluid (0.000133 kg sec/m^2 @ 10°C).

For a particle density of 2,400kg/m^3, water density of 1,000kg/m^3 and particle diameter of 20 microns (radius 10^{-5} metres) the settlement velocity, V_s, is:

V_s = $2 \times (10^{-5})^2 \times (2,400 - 1,000) / (9 \times 0.000133)$

= $2 \times 10^{-10} \times 1,400 / 0.001197$

= 0.000234 m/sec.

The required settlement pond surface area is

A_p = Q/V_s

= 0.0047/0.000234

= 19.95m^2

Theoretically the pond depth is not relevant but in practice a minimum depth is required to ensure laminar flow and to allow temporary storage of settled silt. The modular settlement pond system at Shronowen has been designed with a surface area of 24m^2 (12m x 2m) and a depth of 1.25m (i.e. greater than the minimum above). This is divided into three chambers of equal length and in practice it has been found that most of the settlement occurs in the first chamber with very low turbidity levels being achieved in the final effluent. The design is conservative and therefore has sufficient redundancy to cater for occasional higher runoff rates or sediment loads.

3.15.4.2 Attenuation Design

For rainfall intensities above the design value of 20mm/hour the excess runoff needs to be temporarily stored. The storage can be provided in the drainage channels by installing check dams at intervals along the channel as described below.

The storage volumes required for 10-year storm events of various durations are shown in Table 3-3. The volumes are based on a catchment area of 1,200m^2 which represents approximately 240m of access track) and a runoff coefficient of 0.70. The maximum storage volume required is 5.88m^3 for 15 minutes storm duration. This is equivalent to approximately 21 minutes of flow through the settlement pond at the design through flow rate of 4.70litres/second. The stored water will drain off gradually as runoff from the works area. The storage volume represents an average depth of 0.05m in a 196m long, 0.60m wide open drain and can therefore be easily accommodated in the drainage system.

Table 3-3 Calculated storage volumes

Storm Event	Duration (minutes)	Rainfall rate (mm/hour)	Excess (mm/hour)	Runoff Coefficient	Storage Volume (m^3)
M10-60min	60	18.8	0.0	0.70	0.00
M10-30min	30	30.00	10.00	0.70	4.20
M10-15min	15	48.00	28.00	0.70	**5.88**
M10-10min	10	61.20	41.20	0.70	5.77
M10-5min	5	87.60	67.60	0.70	4.73

The ability to limit flow rates is fundamental to the control of sediment during extreme storm events. It is not proposed to use any proprietary mechanical devices for this purpose but instead to rely on the check dams to effectively limit flow rates to the required values. The check dams will be constructed with gravel or other suitable material and will be of sufficient length and height to provide the required attenuation rates.

Table 3-4 Met Éireann point rainfall frequency table (rainfall depth in mm)

Storm Duration	Return Period (years)							
	0.5	1	2	5	10	20	50	100
5 min	2.6	3.6	4.2	5.9	7.3	8.9	11.3	13.5
10 min	3.6	5.1	5.8	8.3	10.2	12.4	15.8	18.9
15 min	4.3	5.9	6.8	9.8	12	14.5	18.5	22.2
30 min	5.7	7.8	8.9	12.4	15	18	22.6	26.7
60 min	7.6	10.2	11.5	15.7	18.8	22.3	27.5	32.2
2 hours	10.2	13.3	14.9	19.9	23.6	27.5	33.6	38.9
3 hours	12.1	15.6	17.4	22.9	26.9	31.2	37.7	43.3
4 hours	13.6	17.4	19.3	25.3	29.5	34.1	40.9	46.8
6 hours	16.1	20.4	22.5	29	33.7	38.6	45.9	52.2
9 hours	19.1	23.8	26.2	33.4	38.4	43.7	51.6	58.3
12 hours	21.5	26.7	29.2	36.8	42.2	47.8	56	62.9
18 hours	25.4	31.2	34	42.3	48.1	54.1	62.8	70.2
24 hours	28.7	34.9	37.9	46.7	52.8	59.1	68.2	75.9

Table 3-5 Met Éireann point rainfall frequency table (rainfall intensity rate in mm per hour)

Storm Duration	Return Period (years)							
	0.5	1	2	5	10	20	50	100
5 min	31.20	43.20	50.40	70.80	87.60	106.80	135.60	162.00
10 min	21.60	30.60	34.80	49.80	61.20	74.40	94.80	113.40
15 min	17.20	23.60	27.20	39.20	48.00	58.00	74.00	88.80
30 min	11.40	15.60	17.80	24.80	30.00	36.00	45.20	53.40
60 min	7.60	10.20	11.50	15.70	18.80	22.30	27.50	32.20
2 hours	5.10	6.65	7.45	9.95	11.80	13.75	16.80	19.45
3 hours	4.03	5.20	5.80	7.63	8.97	10.40	12.57	14.43
4 hours	3.40	4.35	4.83	6.33	7.38	8.53	10.23	11.70
6 hours	2.68	3.40	3.75	4.83	5.62	6.43	7.65	8.70
9 hours	2.12	2.64	2.91	3.71	4.27	4.86	5.73	6.48
12 hours	1.79	2.23	2.43	3.07	3.52	3.98	4.67	5.24
18 hours	1.41	1.73	1.89	2.35	2.67	3.01	3.49	3.90
24 hours	1.20	1.45	1.58	1.95	2.20	2.46	2.84	3.16

3.15.5 Road Construction

On-site experience in wind farm construction and forestry development across the country has shown that the single most effective method of reducing the volume of sediment created by construction is the immediate surfacing of all service roads with high quality, hard wearing crushed aggregate such as basalt, granite, schist limestone, laid to a transverse grade. When storm water drains transversely across a road constructed from hard wearing aggregate, as opposed to low class aggregate, the level of suspended solids is reduced significantly. This mitigation measure is fundamental to effective water quality management and will form part of the Construction Contract. In the case of road construction in areas of peat, imported limestone will be used. This can have the added benefit of contributing a balancing pH to help protect water quality from acidic runoff. The proposed development area can be serviced by several quarries which are within relatively short distance from the site. These can be used as a source of hard-wearing aggregate for road construction where necessary.

3.15.6 Check Dams

Check dams will be placed at regular intervals, based on gradient, along all drains to provide flow attenuation, slow down runoff to promote settlement and to reduce scour and ditch erosion. Check dams are relatively small and constructed with gravel, straw bales or other suitable material. They will be placed at appropriate intervals and heights, depending on the drain gradient, to allow small pools to develop behind them. Examples of check dam or swales are shown below in **Figure 3-37**.

Figure 3-37 Examples of check dams along roadside drainage channels

3.15.7 Silt Fences

Silt fences placed along drains are another available method of reducing the volume of suspended sediment. It is proposed to use this method of silt control along the sections of floated road within this scheme. The silt fences will be placed at approximately 50m spacing on both sides of the floated roads as shown on the drainage drawings (Planning Drawing Numbers **19876-MWP-00-00-DR-C-5011 to 5016**). They will also be placed at the end of any locally steep section of drain. They have the double benefit of effectively producing a localised swale to reduce scour effects and also attenuating and filtering the discharge. An example of a typical silt fence installation is shown in **Figure 3-38** and **Figure 3-39.**

Figure 3-38 Example of a silt fence used in conjunction with check dams along roadside drainage channels

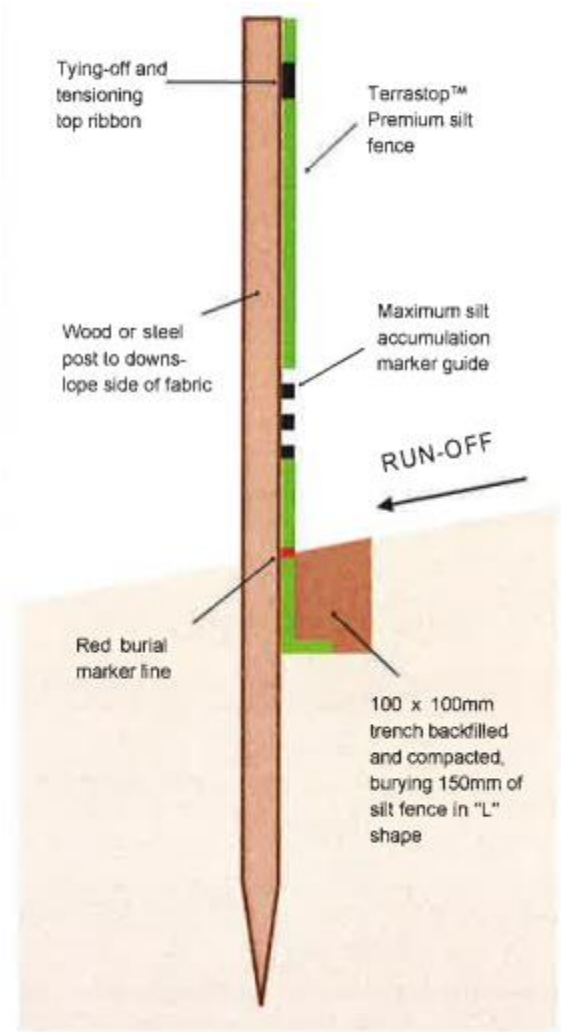

Figure 3-39 Schematic Detail of a Silt Fence

3.15.8 Operational Phase

The measures for control of runoff and sediment relate to the construction phase of the project when there is continuous movement of site vehicles, delivery vehicles and earthworks vehicles moving around the wind farm site. All major excavation work associated with the project will be carried out during the construction phase. Following construction, the amount of on-site traffic and excavation works will be negligible and there will be no particular risk of sediment runoff. Silt ponds and silt fences constructed for water quality protection, will remain in place. Six months post construction, where necessary, ponds will be partly filled with stone so that they will not present a long-term safety risk. Runoff from the hard-standings, and other works areas will continue to be directed to these ponds and from there to the outfall weirs. Check dams and silt fences within the drainage channels will also remain in place. The retention of this drainage infrastructure will ensure that runoff continues to be attenuated and dispersed across existing vegetation before reaching the downstream receiving waters.

3.15.9 Decommissioning Phase

The wind farm has been designed to have an operational life of 30 years and any further proposals for wind farm development at the site after this time will likely be subject to a new planning permission application. If planning permission is not sought after the expiry of the original planning permission, the site will be decommissioned and reinstated with the wind turbines and towers removed.

If the site is to be decommissioned, cranes of similar size to those used for construction will disassemble each turbine. The towers, blades and all components will then be removed. The turbine transformers will also be removed from site. It is likely that any turbine component will be reused as they have a life well in excess of the wind farm proposal i.e. greater than 30 years. Wind farm components may also be recycled.

The cables will not be removed if the environmental assessment of the decommissioning operation demonstrates that this would do more harm than leaving them in situ. The assessment will be carried out closer to the time to take into account environmental changes over the project life.

Hardstand areas will be remediated to match the existing landscape thus requiring agricultural pasture reinstatement, peatland restoration or reforestation. Access roads will be left for use by the landowners. The current view is that the disturbance associated with the removal and disposal of the material would be more deleterious than leaving them in place.

Any structural materials suitable for recycling will be disposed of in an appropriate manner. The financial costs of decommissioning, at current material values, will be more than met by the recycling value of the turbine components.

Prior to wind turbine removal, due consideration would be given to any potential impacts arising from these operations. Some of the potential issues could include:

- Potential disturbance by the presence of a crane, heavy goods vehicles and personnel on-site;
- On-site temporary compound would need to be located appropriately;
- Time of year and time-scale (to be outside sensitive periods); and
- Roads (site tracks may remain in use for the benefit of the landowner).

Prior to the decommissioning work, a comprehensive plan will be drawn up to ensure the safety of the public and workforce and the use of best available techniques at the time.

Prior to the decommissioning work, a comprehensive reinstatement proposal, including the implementation of a programme that details the removal of structures and landscaping, will be submitted to the Planning Authority.

REFERENCES

- COFORD, 2004, Forest Road Manual, Guidelines for the design, construction and management of forest roads.
- Forest Service and Department of Agriculture, Fisheries and Food, 2000a, Forest Harvesting and the Environment Guidelines.
- Forest Service and Department of Agriculture, Fisheries and Food, 2000b, Forest and Water Quality Guidelines.
- Forestry Civil Engineering and Scottish Natural Heritage, 2010, Floating Roads on Peat.
- Forestry Commission Scotland, 2004, Forests and Water Guidelines 4th Edition.
- Forests and Water, 2011, UK Forestry Standard Guidelines.
- Inland Fisheries Ireland, 2016, Guidelines on Protection of Fisheries During Construction Works in and Adjacent to Waters.
- Murnane, E., Heap, A. and A. Swain, 2006, Control of water pollution from linear construction projects. A Technical Guidance. A CIRIA publication.
- The Met Éireann Extreme Rainfall Data, https://www.met.ie/climate/available-data.
- Transport Infrastructure Ireland, 2017, DN-GEO-03060: Geometric Design of Junctions (priority junctions, direct accesses, roundabouts, grade separated and compact grade separated junctions)
- Office of Public Works, 2013, Construction, Replacement or Alteration of Bridges and Culverts.
- Quinty, F., Rochefort, L., 2003, Peatland Restoration Guide Second Edition.