3. CIVIL ENGINEERING

3.1 GENERAL INTRODUCTION

This chapter describes the civil engineering design of the various elements of the Carrownagowan Wind Farm Project's associated infrastructure, both permanent and temporary. Fundamental to the design was the requirement to eliminate or minimise adverse effects on the environment arising from the works during the construction and operational phases of the project. The primary considerations that were taken into account were to maintain the existing hydrological regime within the site, to avoid pollution of rivers within and outside the site, and to ensure that there was a low risk of occurrence of peat slides due to the works.

The following sections describe the process involved in the design of the project infrastructure and the water quality management system for the project. An assessment of the site access including the external turbine delivery route is also included.

The overall project, as set out in Chapter 1 and in section 2.3 of Chapter 2, and described throughout this EIAR, includes both the proposed development (the wind farm, including substation, met mast, access tracks, borrow pits, and works on the turbine delivery route) and the grid connection. Furthermore, replacement forestry lands, associated with the permanent felling to allow the construction of the wind farm, are also included as an overall project component. However, in terms of this Civil Engineering chapter, it is the civil works associated with the wind farm and its components, the works areas along the turbine delivery route and the grid connection that are described.

3.2 DESIGN PROCESS

3.2.1 Constraints

The first phase in the design of the wind farm involved the determination of all the 'high level' environmental, topographical, technical and engineering constraints present within the proposed development site in order to establish a potentially feasible buildable area. Malachy Walsh and Partners completed a detailed site assessment so as to identify areas of unstable ground, sensitive ecological habitats, any known archaeological features, noise sensitive locations, telecommunication links and hydrological features of the site. Buffers zones were set around the various constraints as set out in Table 3.1 below, and only those areas outside the buffer zones were considered in determining the locations for the turbines, access roads and other associated infrastructure. Table 3.1 below outlines the various constraints and criteria considered as part of the initial assessment and the buffers that were applied.

Table 3.1 Constraints and Buffers

Constraint	Setback/Buffer Distance	Reason
Houses (for third-party landowners)	750m setback from residences. (1km achieved in final design).	Protect residential amenity Distance is greater than 4 x blade tip height
Streams and rivers:	75m buffer applied to EPA registered watercourses;	Protect watercourses Setbacks of up to 20m apply to forestry activities and 50m to the use of hazardous materials. 75m was applied, beyond the

Constraint	Setback/Buffer Distance	Reason
		standard, as a conservative measure for the project.
Designated areas (SPA, SAC, NHA, pNHA):	150m from designated sites	Avoidance of sensitive habitat.
Sensitive ecological habitats	Avoid	Minimisation of infrastructure within ecologically valuable habitat
Archaeological features	n/a	No identified archaeological monuments on site
Telecommunication links	50m	Protect against signal interference
External Roads	170m + 10% setback	Buffer by turbine Falling distance
Site topography – steep slopes (>30°): – slopes >10°	- Avoid - Avoid for turbine locations	Avoidance of stability risk
Peat >5m depth	Avoid	Avoidance of high -peat risk and constructability risk areas

The constraints that directly affect the engineering design of the wind farm are the ground surface slope, ground stability and hydrological features. These are described in the following sub-sections.

3.2.1.1 Ground Surface Slope

The topography of the site varies considerably, with ground surface slopes varying from the relatively flat areas at the northern and central areas to the steeper areas at the southern end of the site. The steep areas were avoided because of the difficulty of transporting heavy loads on roads with excessive gradients and also because of the excessive volumes of material excavation that would be required for the construction of turbine bases and hardstand areas. Excavation in steep ground also carries the risk of slope instability. The ground surface gradients were determined from a digital terrain model of the site based on high density LiDAR data obtained from aerial survey. With the slope data from the LiDAR data the site was stratified into tiers of suitability for the various types of wind farm infrastructure. Based on experience, the areas with ground slope less than 9% were unconstrained for all types of wind farm infrastructure. Areas with a ground slope from 9 to 15% require additional civil engineering works to achieve suitability and are acceptable subject to other constraints such as peat stability. Areas with a ground slope from 15% to 30% require substantial civil engineering works to achieve feasibility requiring detailed investigation if infrastructure was required in these areas. Areas with a ground slope in excess of 30% were deemed unsuitable.

3.2.1.2 Ground Investigations

Malachy Walsh and Partners started site surveys and investigations during 2018 and continued as part of an iterative design process through 2019 to arrive at the preferred layout. Following the initial desk study constraints identification, investigations were carried out throughout the rest of the site. The investigations consisted of peat probing, gouge coring and shear testing. The analysis of this data, together with knowledge gained from site walkovers, was used to broadly classify the site in terms of low, medium and high risk areas in terms of peat landslide risk. The high risk areas were removed from areas deemed suitable for infrastructure as part of the constraints process. The analysis of the site investigation data is detailed in the Peat Stability Report included in **in Volume III, Appendix 9-2** of the EIAR.

3.2.1.3 Hydrology and Hydrogeology

All natural watercourses within the proposed development site were given a 75m buffer as decribed in Chapter 8 – Water of the EIAR. Works within buffer zones is limited to that required for the construction of crossings and associated felling. Other streams from the 6" maps were given a buffer on a case by case basis. In order to minimise the run-off requiring management, a key design parameter was to ensure that roadside drainage does not intercept overland flow from the forest drain network. The forestry drainage system by its nature quickly collects run-off from entire catchments. The flow rate from these catchments would exceed the design parameters of the wind farm infrastructure drainage system should they mix. Existing areas of high flow are addressed in terms of the design of the proposed interceptor drain network to ensure the separation of overland from road catchments.

On-site investigation of the existing drainage network identified areas of the site prone to heavy erosion. Parts of the site where roads are running in close proximity to streams were avoided. In this instance new roads were then incorporated into the wind farm infrastructure design.

3.2.2 Preliminary Design

When all of the high level environmental, technical and engineering constraints had been identified for the site, Malachy Walsh and Partners prepared a preliminary layout that fits within the remaining buildable areas within the site. These remaining areas were generally characterised by relatively low surface gradients and shallow peat depths. The layout included the preliminary internal road network and provisional locations for the electrical substation compound, permanent meteorological mast, borrow pits and deposition areas for excavated peat.

The technical design criterion for the layout was to maximise the annual energy yield while maintaining the required separation distances between turbines.

The preliminary design layout was then used as a basis for a more detailed site assessment and more specific ground investigations on which the final detailed design would be developed.

3.2.3 Detailed Design

The detailed design of the wind farm was driven by a process of *mitigation by avoidance* as well as a principle of maximising the use of suitable existing infrastructure. This involved an iterative design process using the preliminary design as a basis for more detailed site assessment and investigations.

Site investigations were carried out along the proposed internal road route, at each turbine location and at the sites of all other infrastructural elements. This detailed information allowed a location specific assessment of the peat stability risk to be carried out. Based on this information, turbine positions were adjusted, relocated or removed so as to reduce the risk of peat instability.

In many cases the relocation of a turbine is a multifaceted process due to the the interaction between turbines in optimising wind power. To move one turbine due to geotechnical analysis often required the moving of other turbines so as to maintain the optimum separation distances between them for their primary purpose of generating energy from wind. This in turn required further site investigations so that the suitability of the revised layout could be fully verified. The route of the internal access road also had to be modified and verified accordingly.

Because of this repetitive process, a very large amount of geotechnical data was collected and analysed for the site. This resulted in a comprehensive overview of the ground conditions throughout. The geotechnical information on the peat characteristics throughout the site can be found in the Peat Stability Report **in Volume III, Appendix 9-2** of the EIAR.

3.2.4 Final Layout Outline

The iterative design process resulted in an optimised layout for the permanent infrastructure which includes the internal site access road network, 19 no. turbines, a substation compound, a permanent meteorological mast, a visitor building as well as the temporary infrastructure which comprises 2 no. site construction compounds. Three proposed on-site borrow pits within the site will be used as sources of stone aggregate for construction and Peat deposition.

Below is a selection of high quality 3D images illustrating the optimised infrastructure layout for turbines, access roads, hardstands, borrow pits and watercourse crossings.

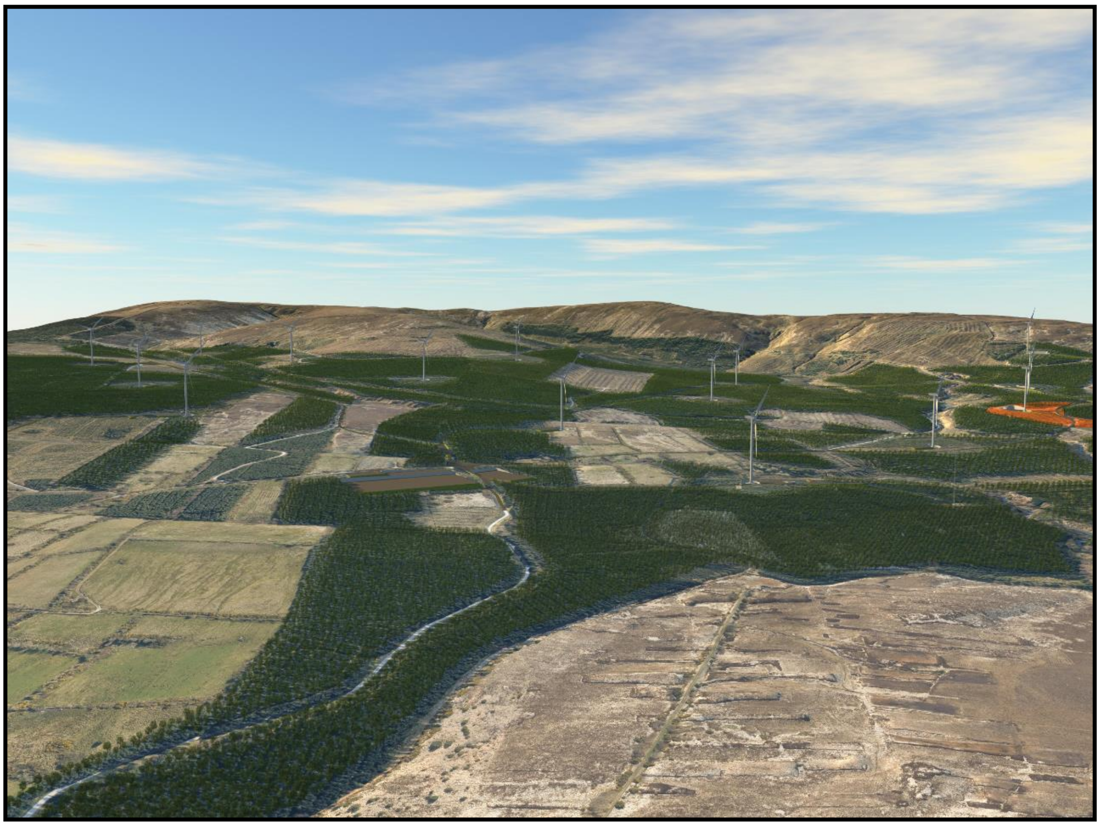

Figure 3-1 View of proposed wind farm looking south

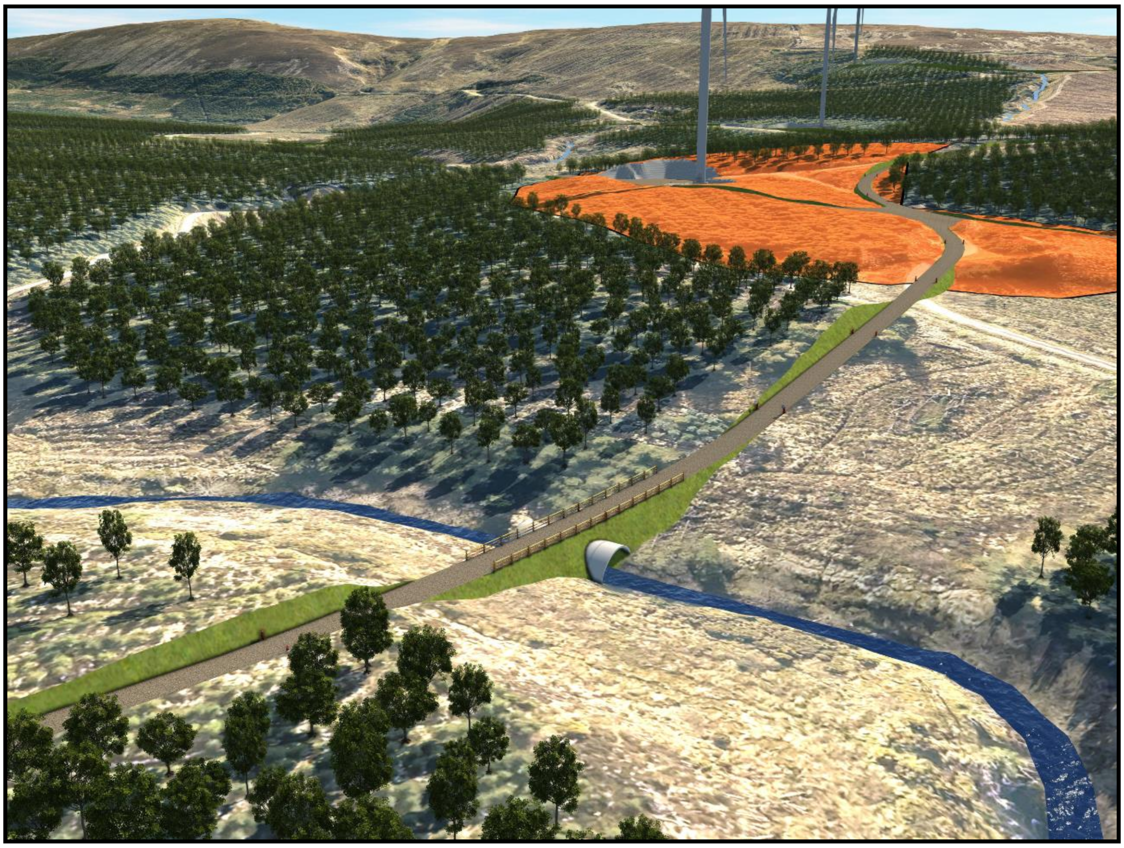

Figure 3-2 View of proposed watercourse crossing near T9 turbine

Figure 3-3 View of proposed T4 turbine looking south-east

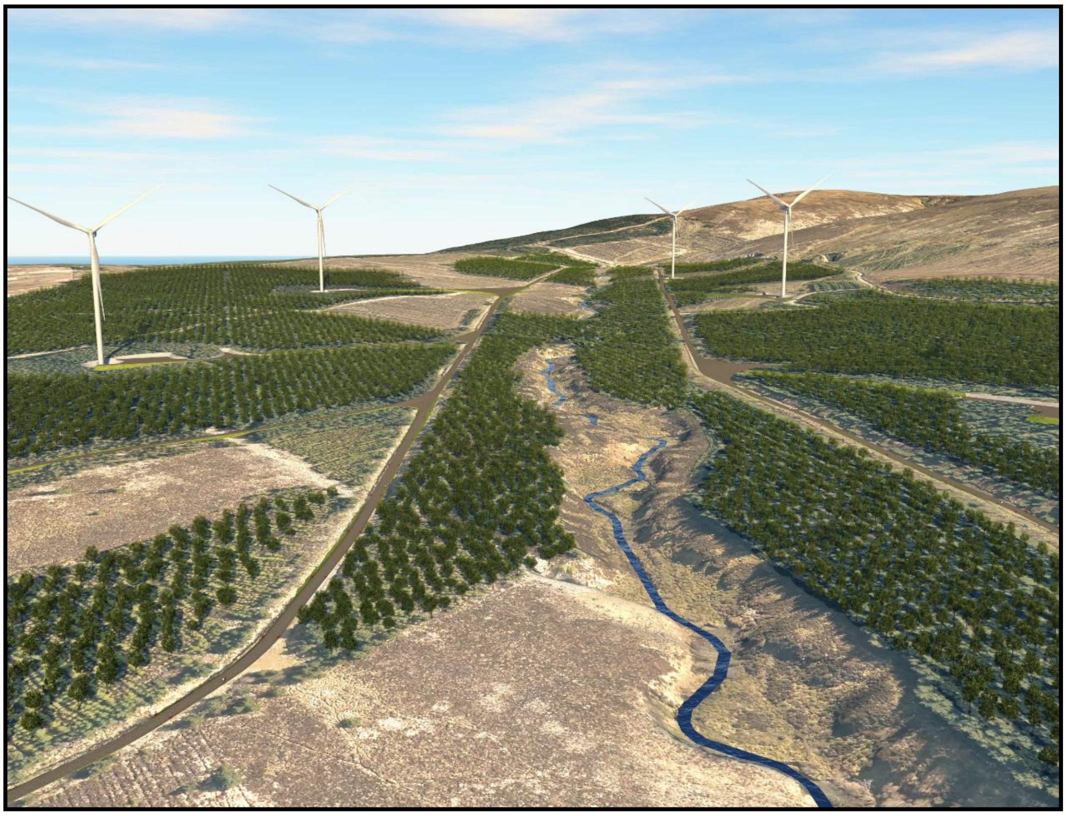

Figure 3-4 View of proposed T12, T13, T14 and T15 turbines looking south-east

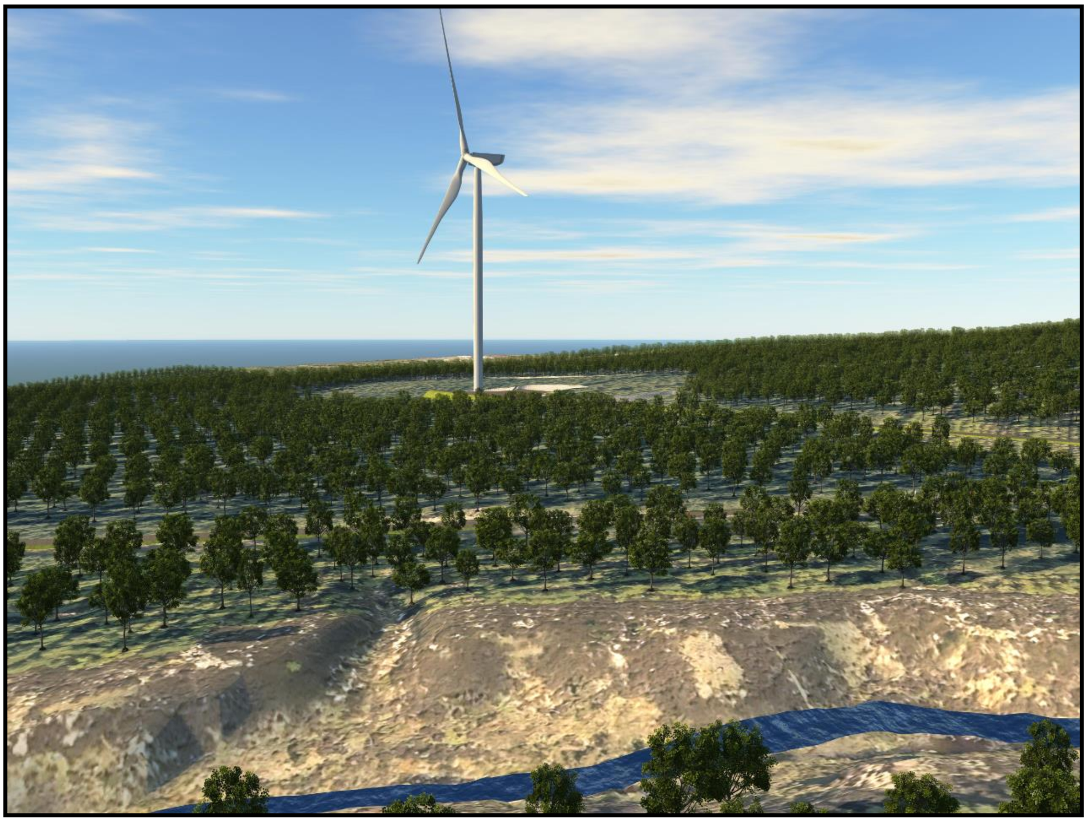

Figure 3-5 View of proposed T15 turbine looking east

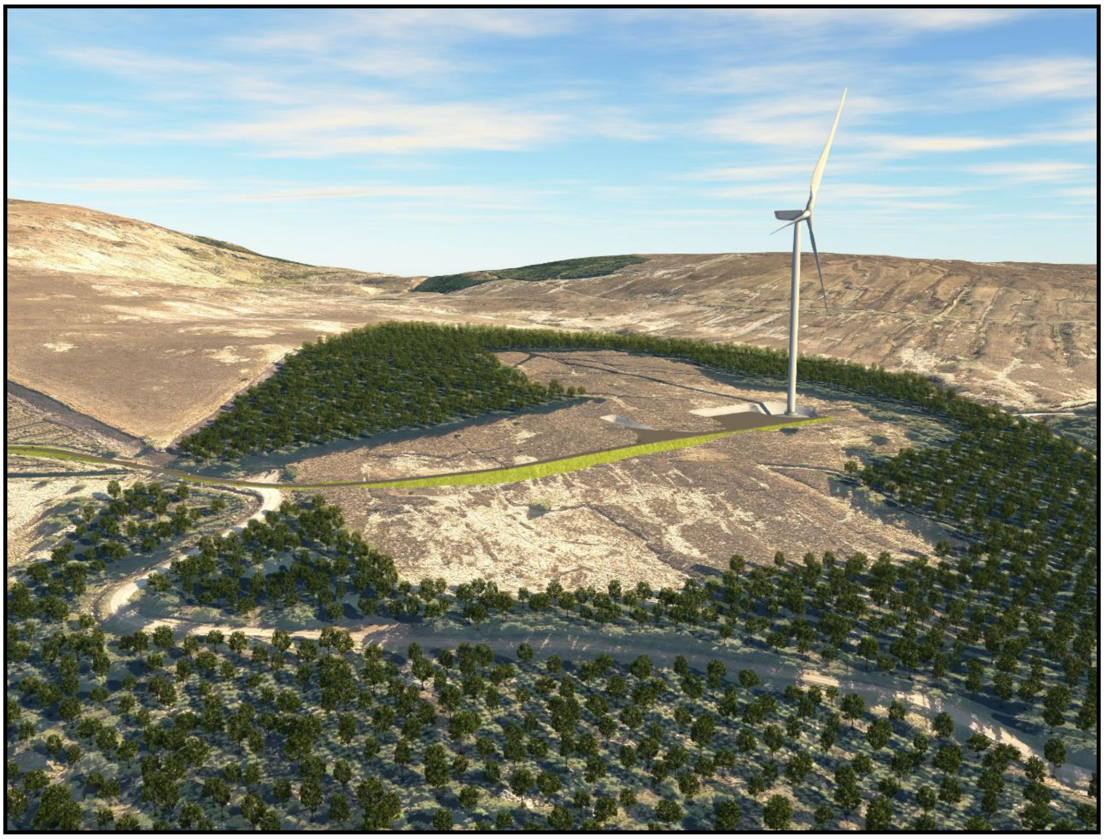

Figure 3-6 View of proposed T1 turbine looking south-west

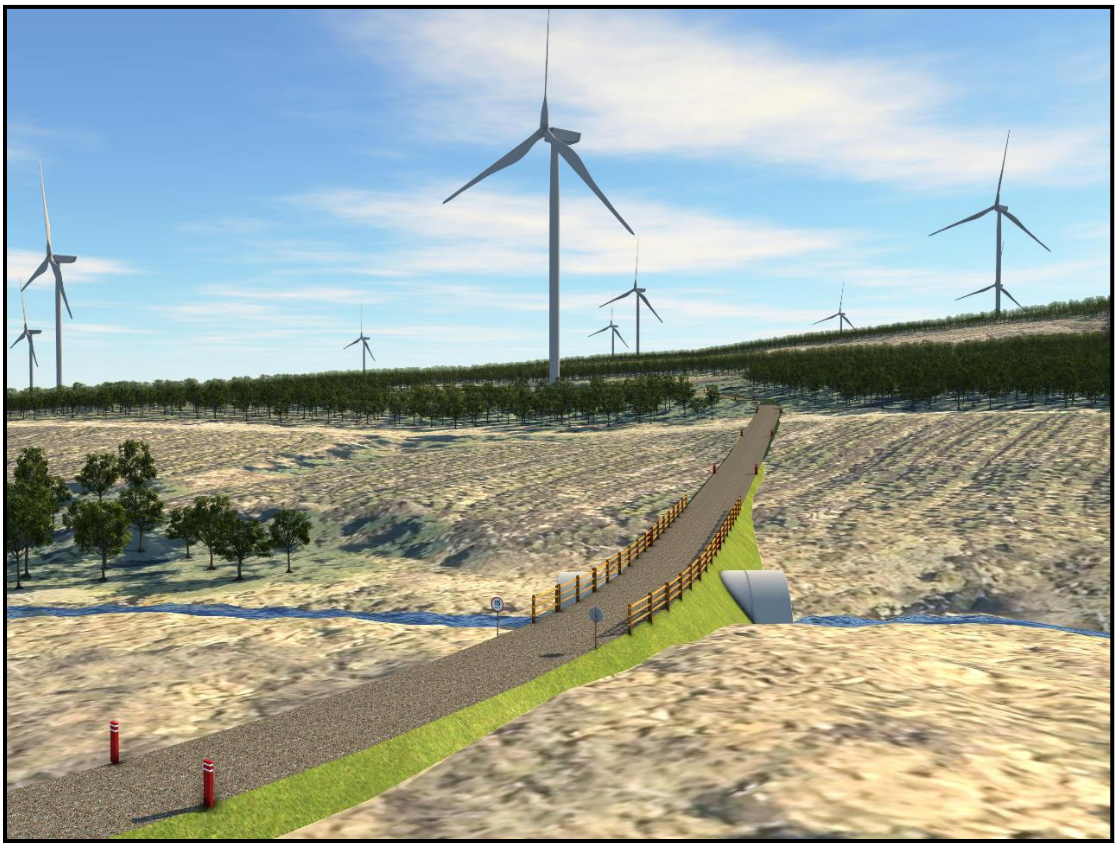

Figure 3-7 View of proposed watercourse crossing near T7 turbine looking east

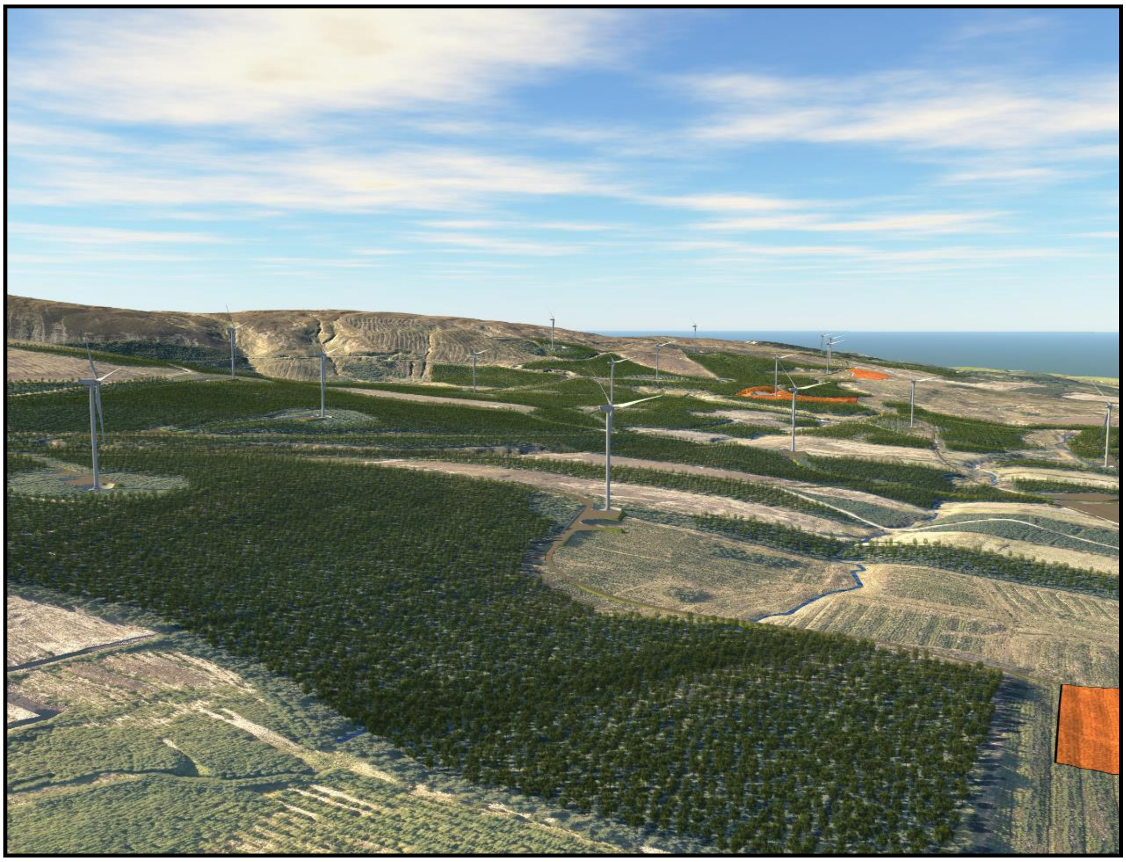

Figure 3-8 View of proposed wind farm looking west

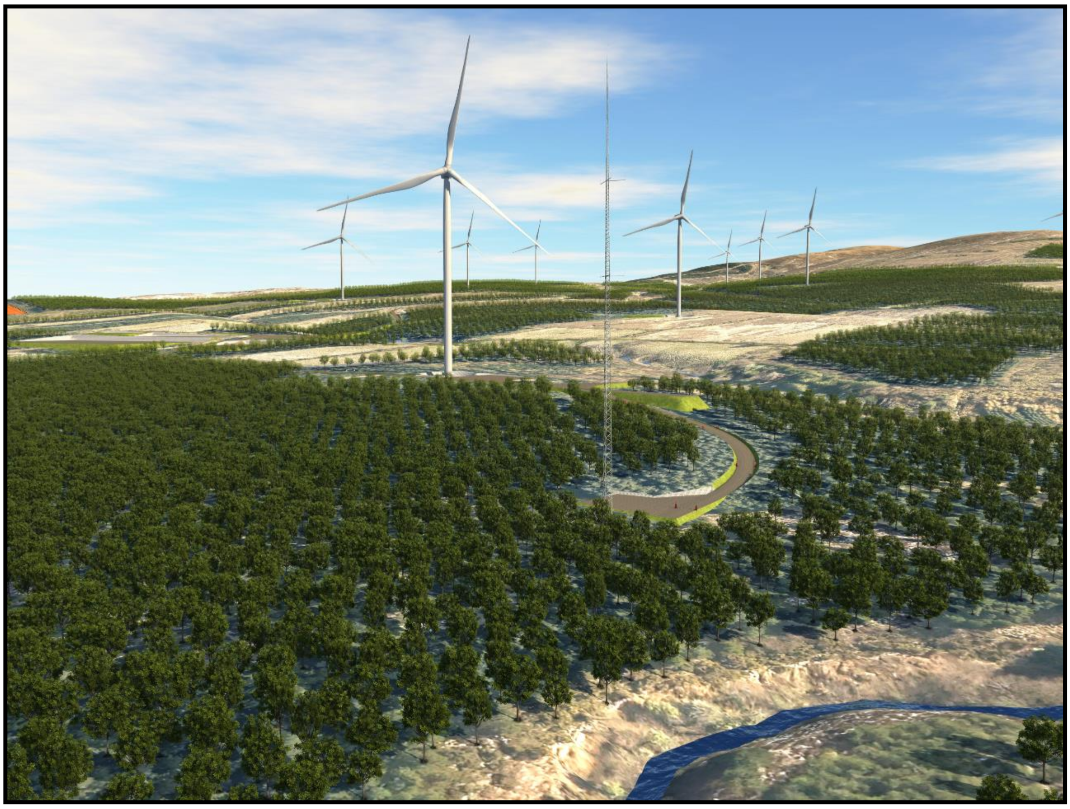

Figure 3-9 View of proposed permanent meteorological mast near T19 turbine looking south

3.3 LOCAL ACCESS ROUTES

The components for the 19 no. turbines will be delivered by cargo ships to either Foynes Port in County Limerick or Galway Port in Galway City. The components for each turbine will be delivered in separate loads, some of which are abnormal in terms of their width and length. The components will be transported from either Foynes Port or Galway Port to the site along the Motorway, National, Regional and Local road network.

There is no requirement for any road or junction widening from either Foynes Port or Galway Port to Junction 18 on the M18 Motorway. The following outlines works required along other sections of the turbine delivery route.

- An existing 90 degree bend along the R352 Regional road at Coolready is unsuitable for transporting turbine blades and therefore third party land will be required to facilitate widening on the northern side of the bend as shown in **Planning Drawings 19107-5057**.

- The junction of the R352 and R465 Regional roads in Bodyke village is also not suitable for turbine delivery nor are deliveries feasible at the preceding bend on the R352 Regional road. Consequently, a new section of access road measuring 0.5km in length is required through third party land to the south of Bodyke at Coolready and Ballydonaghan in order to access the R465 Regional road from the R352 Regional road.

- Additionally, the existing junction of the R465 Regional road and L-8221 Local road at Drummod is bound on two sides by private houses and will also require a new section of access road measuring 0.2km in length through third party lands for turbine deliveries to successfully turn onto the L-8221 Local road from the R456 Regional road.

There are agreements in place between the developer and the landowners for the third party lands required for these works.

All works at sections above will be constructed with imported 150mm crushed stone of Class 804, or similar aggregate on imported 450mm crushed stone Class 6F material and geogrid. Following the completion of the project, these delivery areas will remain permanent and will be cordoned off with fencing or a replacement ditch from the Regional and Local roads they bound. In the event that a turbine component requires replacement during the operation of the wind farm, the delivery access roads will be reused for transporting these components again. All material generated from the excavation works at these areas will be reused where possible or will be brought to an authorised waste facility. The proposed delivery works are shown in **Planning Drawings 19107-5057 to 5059** while Table 3.2 details the breakdown of quantities required.

Table 3.2 Summary of construction material quantities for turbine delivery areas

Item	Unit	Approx. Quantity
Total Excavation for all Turbine Delivery Areas	m^3	9,798
Total Imported Stone Aggregate Required for all Turbine Delivery Areas	m^3	4,525
Total Imported Capping Material Required for all Turbine Delivery Areas	m^3	1,038

The main access into the wind farm development for construction and operational phases will enter the site from the north, entering at an existing Coillte forest road entrance off the L -8221 in the townland of Caherhurly. Refer to **Planning Drawing 19107-5011-A.**

Figure 3-10 Site Entrance looking East from existing forestry entrance on L-8221

This local road L-8221 is the main designated haulage route for timber and this access point is the main entrance for this Coillte forest.

The L-8221 Local road from its junction with the R465 Regional road to Caherhurly has a paved width of between 3.0m to 3.5m between there and the site entrance. This will require widening to a finished width of 5.0m to facilitate delivery of turbine. This increased width will allow for two cars or a car and a truck to pass by each other. This section of road will be strengthened by overlaying with 100mm of macadam on geogrid and sealed with double surface dressing. It is envisaged that the road widening and strengthening works will be carried out under a road opening licence from Clare County Council and that it will be carried out by the developer. The widening of the L-8221 Local road will be permanent and will be of long-term benefit to local road users. There are agreements in place between the developer and the landowners for the land required to widen the L-8221 local road.

It is proposed that a reinforced concrete slab be installed above each of the identified bridge and culvert structures along the L-8221 Local road to ensure that they have sufficient structural capacity to cater for the delivery of abnormal loads to the wind farm. The Assessment of Existing Structures along the L-8221 Local Road, which is included in **Volume III, Appendix 3-8** of the EIAR, details this further. All material generated from the excavation works along the L-8221 Local road will be brought to an authorised waste facility (facilities are included in Chapter 2 and Chapter 15 Material Assets). The proposed road widening works are shown in **Planning Drawing 19107-5012** while Table 3.3 details the breakdown of quantities required.

Table 3.3 Summary of construction quantities for L-8221 local road widening

Item	Unit	Approx. Quantity
Total Excavation for L-8221 Local Road Widening	m^3	2,564
Total Imported Stone Aggregate Required for L-8221 Local Road Widening	m^3	2,564
Total Imported Capping Material Required for L-8221 Local Road Widening	m^3	769

The existing site entrance to the wind farm on the L-8221 Local road will require widening on its eastern side to allow the long turbine component loads turn south at this point. The widened area of the junction will be cordoned off to a radius of 12m for normal traffic and the space will only be made available specifically for turbine delivery. Following completion of the project the widened area will remain in place by cordoning off the area with a permanent fence installed to a 12m junction radius. This area will only be made available for any replacement turbine component deliveries. The position of this permanent fence will be consistent with the junction sight distance requirements as outlined in Section 3.4. The design of the widened junction for the turning movement of the longest load, which is the turbine blade truck, has been verified using swept path analysis software.

There is already a substantial network of existing access roads within the Coillte forest site. One of these roads includes the L-8218 Local county road which will be utilised in providing access to the western side of the site. The L-8218 will be widened to a drivable width of 5.0m over a length of 0.7km. It will also be strengthened with 150mm of Clause 804 aggregate on geogrid and sealed with double surface dressing. The developer will carry out the road widening and strengthening works, under licence by Clare County Council. Two new junctions will be constructed on the L-8218 Local road within the forest site so that access can be provided from the main site entrance to the rest of the wind farm. Each of the two new junctions will have widened splays on their western side in order for turbine deliveries to turn and manoeuvre successfully. Following completion of the project these widened splays will be cordoned off to a radius of 12m for normal traffic and the space will only be made available specifically for replacement turbine component deliveries. A Traffic Management Plan has been prepared and is included as Appendix 3-4 of Volume III.

Permanent access to the wind farm during the operational phase will only be from the L-8221 and L-8218 Local road entrances. Operational access from the L-8221 and L-8218 Local roads will be limited to cars and light goods vehicles. The L-30302 Local road to the south of the site will not be used for access to the wind farm and does not require any widening or strengthening works. Refer to **Planning Drawings 19107-5005-A to 19107-5012-A**.

The majority of the turbine delivery route will follow Motorway, National Primary and Regional roads as described. As such, it is not anticipated that any significant widening or strengthening of roads will be required along the transport routes apart from works described above. There will be a requirement, pending final confirmation of the transport delivery configuration at construction stage, for the temporary removal of road signage and/or temporary widening of grass road verges in order to cater for the swept path of these abnormal delivery vehicles. The developer will consult with the Road / Area Engineers of the relevant local authorities to temporarily remove any road signage and provide temporary grass verge widening where this may be required.

3.4 JUNCTION SIGHTLINES

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 85th percentile speed which is the speed below which 85% of vehicles travel.

Site entrance on the L-8221

The site entrance on the L-8221 Local road will require appropriate sight distance in both directions. The statutory speed limit on this road is 80km/h but the design speed is likely to be somewhat lower. Based on observations on site, a design speed of 60km/h has been taken as being appropriate at this location with a sight distance of the order of 90m due to the restricted horizontal alignment of the L-8221. This will be achieved with the installation of a timber post and rail fence. The area outside the fence should be kept free of vegetation or other obstructions and this will be maintained by the wind farm operator. The sight distance splays in both directions with the proposed modifications in place are shown in **Planning Drawing 19107-5046**. These improvements will remain in place permanently and will benefit users of the wind farm when exiting the site onto the public road.

Sightlines at internal junctions along L-8218 local road

The new internal access road junctions on either side of the L-8218 Local road will require appropriate sight distance in both directions. The statutory speed limit on this road is 80km/h but the design speed would be considerably lower because of the restricted road width. A design speed of 60km/h has been taken as being appropriate for this location. It is proposed to install a boundary fence on both sides of the road to the north and south of the junctions in order to achieve a sight distance of 90m in both directions from the access roads from an *'x-distance'* of 3.0m. The resulting visibility splays are shown in **Planning Drawing 19107-5046**. The land required for the boundary fence set-back along the L-8218 is within the control of the developer.

Sightlines at visitor compound junction along L-8218 local road

Access to the visitor building will be made via a new entrance from the compound onto the L-8218 Local road. As stated above the statutory speed limit on the L-8218 Local road is 80km/h and the design speed will be considerably lower because of its restricted road width. Therefore a design speed of 60km/h has been taken as being appropriate for this location. It is proposed to install a boundary fence along the northern side of the L-8218 Local road in order to achieve a sight distance of 90m in both directions from an *'x-distance'* of 3.0m taken at the new entrance. The resulting visibility splays are shown in **Planning Drawing 19107-5046**. The land required for the boundary fence set-back along the L-8218 is within the control of the developer.

3.5 INTERNAL ROAD LAYOUT

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 (refer to **Planning Drawings 19107-5005**);
- Proposed Internal Access Road Details (refer to **Planning Drawings 19107-5023**);
- Junction Sight Distances (refer to **Planning Drawings 19107-5012**); and
- Proposed areas of clear fell associated with access roads infrastructure (refer to **Planning Drawings 19107-5020**).

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.

Internal access roads are required in order to interconnect elements of the site and allow access to all wind turbines and wind farm infrastructure. Maximum use has been made of existing roads. The proposed wind farm will use 8.4km of existing roads and 11.4km of new roads will be constructed within the development site.

The new access roads will have a running width of 5.0m to accommodate the efficient transport of the wind turbine components. 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 existing routes were identified 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 8.4km of existing roads used to access the wind farm accounts for approximately 43% of the total road length required to service this wind farm. The remaining roads have been sited mostly where suitable ground bearing formation is attainable with shallow excavation (<1m), as has been confirmed by site investigations, and also as floating road construction where ground conditions dictated. Table 3.4 and Table 3.5 below show an approximate breakdown of the various types of internal access road construction required, the associated lengths of each and estimated material quantities required for their construction.

Table 3.4 Summary of internal access road infrastructure

Road Construction Type	Length (km)	Approx. Peat Excavation Volume (m^3)	Approx. Subsoil Excavation Volume (m^3)
Upgrade and Widening of Existing Roads	8.4	22,062	32,243
New Excavated Roads	7.6	50,934	
New Floating Roads	3.8	-	-
Totals	**19.8**	**72,996**	**32,243**

Table 3.5 Summary of construction material quantities for internal access roads

Item	Unit	Approx. Quantity
Total Site Won Stone Aggregate Required for all Access Roads	m^3	107,089
Total Imported Capping Material Required for all Access Roads	m^3	15,734

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 68m.
- Road gradients throughout the majority of the site are 12% or less which is sufficient for turbine delivery. (There is a short section of spur road to turbine T3 which is at approximately 12.5% and may require a push or pull vehicle to assist 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.
- Avoid stream crossings and water bodies, where possible.
- New sections of access roads should avoid deep peat or steep ground and natural drainage features.
- Road alignments were selected that will have adequate turning radii for delivery of turbines; and
- Aerial photography, Ordnance Survey Ireland (OSI) contour data and LiDAR 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:

1. Site topography (OSI contour data and LiDAR data) to avoid steep slopes for turbine delivery vehicles;
2. A hydrology buffer map where streams were buffered by 75m, except where crossings are required (**Volume III, Appendix 8-1 (Figure 8.22) of EIAR**);
3. Avoidance of ecologically sensitive areas;
4. Avoidance, where possible, of risk areas as identified in the Peat Stability Report (**Volume III, Appendix 9-2 of EIAR**);
5. Take account of existing public and forest road junctions where the wind farm access roads will interface.

The overall site layout is shown on **Planning Drawings 19107-5005**.

A network of existing forestry and public roads, which will be upgraded and widened, together with new excavated and new floating roads will be used to access each of the turbines, the substation compound and the meteorological mast. As shown on **Planning Drawings 19107-5005** the site is well serviced by an existing road network which will be supplemented with a series of spur roads to the turbines. Large splays will be required at the wind farm access points and at spur road junctions for the large turbine component delivery trucks. However, these splayed junctions will be coned off to 12m radii to ensure the safety of the junction for regular construction traffic. See **Planning Drawings 19107-5012** for details of the proposed junction layouts.

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 3-11.

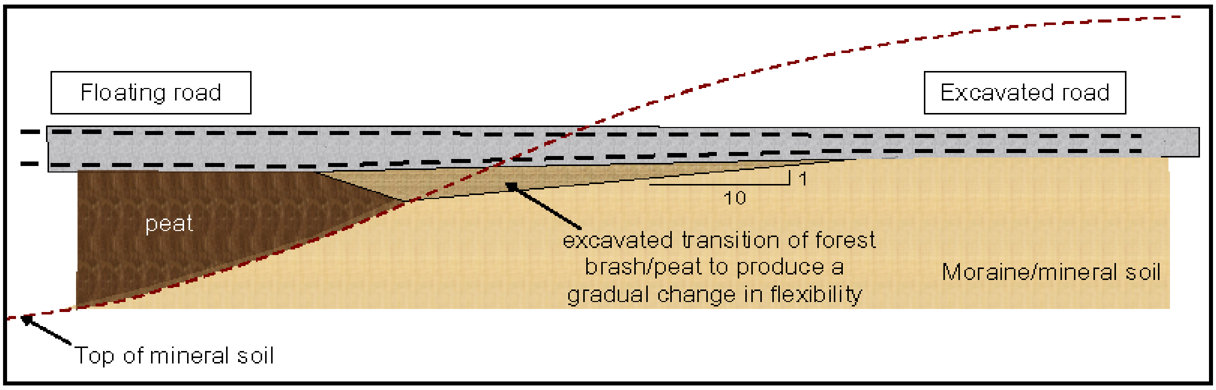

Figure 3-11 FCE method of transition from floated to excavated road

The stone required for the construction of the internal access roads, hardstands and substation compound will be sourced from three proposed on-site borrow pits. The access roads will be finished with a top layer of imported limestone from local quarries to give a clean hardwearing running surface for the delivery of turbines. There are two quarries that are likely to supply these materials, the closest of which is McGraths quarry in Tulla. A second, Ballycar Quarry, lies to the south near Ardnacrusha.

During the construction phase of the works, the affected sections of the public road network within the site will be maintained and improved. The drainage network associated with the access roads will also be inspected and maintained throughout the works period. The Clare County Council Roads Area Engineer will be consulted with prior to the works, during the works and on completion to confirm that all existing public roads are maintained to an acceptable standard throughout and on completion of the project.

The selection of the location of the turbines and the access roads, therefore, has been carefully considered based on the best engineering practice and has been informed by a detailed geotechnical inspection of the site along with walkover surveys and road design methods.

Overall, the internal site layout design is an optimal one in terms of its minimal impact on the existing public road network in the vicinity of the site, the low risk in terms of peat stability and associated environmental impacts, the use of a well developed existing drainage network, good access and connectivity to the public road network and the ease of construction in this location.

3.5.1 Internal Access Road Construction Methods

3.5.1.1 Upgrading and Widening of Existing Roads

For the construction of the wind farm it is proposed to utilise 8.4km of existing internal roads. These roads will be widened by removing organic material and soft subsoil to formation level and constructing a road on a layer of geogrid or geotextile. This road construction will be similar in build up to the excavated road construction which is outlined in detail in Section 3.5.1.2 below. 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.

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:

1. The appointed contractor will survey the area for any unforeseen hazards prior to the commencement of works and set up warning signage as appropriate.
2. Drainage measures to ensure the separation of overland clean water flow from construction run-off will be implemented as outlined in Section 3.17.
3. The material required for widening and upgrading the existing site roads is proposed to be won from the three proposed on-site borrow pits within the wind farm site. All roads will be finished with imported 150mm crushed stone of Class 804, or similar aggregate type material. Sufficient passing bays will need to be constructed to allow for the safe movement of site traffic along the existing roads. A traffic management plan has been prepared and is included as Appendix 3-4, Volume III.
4. The extraction of stone aggregate from the proposed borrow pits will be undertaken by 30-60 Ton 360° excavators and loaded onto articulated dumper trucks that will deliver the aggregate to the required road widening / upgrading locations.
5. 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 (within turbine hardstand areas) 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.
6. 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.
7. Once a section of the widened access road is exposed to suitable formation; a layer of geogrid or geotextile material may be placed along its formation depending on ground conditions.
8. 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 material. 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.

9. The road upgrading works will involve the use of a roller compacting the site won 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.
10. 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.
11. Roadside drains as per Section 3.17 will be constructed to manage clean and dirty water runoff along widened and upgraded access roads.
12. The final running surface of the new widened / upgraded access roads will be capped with a minimum 150mm layer of hard wearing Class 6F stone or similar using a road grader.
13. Any surplus spoil material generated from the road widening works will be transported back to the borrow pits to aid final reinstatement. Excavated topsoil and subsoil will be kept separate at the excavation and storage areas.
14. All excavations to be carried out will be battered back to a safe angle of repose (typically a max slope angle of 45°).
15. 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.
16. 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 3-12 Typical upgraded forestry road on a wind farm

3.5.1.2 New Excavated Roads

Approximately 7.6km of new excavated road construction will be required which accounts for the majority of new roads to be built to service the site. These will be constructed using site won stone aggregate obtained from the proposed borrow pits and placed over a layer of geogrid, where required, after all organic and soft subsoil material is excavated to formation level. Geotextile material, used to separate the road building material from the subsoil, will also be laid at formation level. The road will be finished with imported 150mm crushed stone of Class 804, or similar aggregate type material.

Typically the sequence of constructing new excavated access roads will comprise the following:

1. The appointed contractor will liaise with the wind turbine supplier prior to the commencement of the works to ensure that the design of the new excavated roads conforms with the wind turbine supplier's specifications and no works beyond that which have received planning permission will be undertaken.
2. The appointed contractor will survey the area for any unforeseen hazards prior to the commencement of works and set up warning signage as appropriate.
3. Drainage measures to ensure the separation of overland clean water flow from construction run-off will be implemented as outlined in Section 3.17.
4. 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.
5. 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.
6. All excavations to be carried out will be battered back to a safe angle of repose (max slope angle of 45°).
7. 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 site won aggregate stone as required compacted in maximum 250mm layers.
8. The stone aggregate required for the new access roads is proposed to be won from three on-site borrow pits within the wind farm site. The extraction of stone aggregate from the proposed borrow pits will be undertaken by 30-60 Ton 360° excavators and loaded onto articulated dumper trucks that will deliver the stone aggregate to the required excavated access road locations.
9. 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.
10. All new excavated access roads will be constructed to a finished carriageway 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.
11. Roadside drains as per Section 3.17 will be constructed to manage clean and dirty water runoff along excavated access roads.
12. 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.

13. Any surplus spoil material generated from the excavated access road works will be transported back to the borrow pits to aid final reinstatement. Excavated topsoil and subsoil will be kept separate at the excavation and storage areas.
14. 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.
15. 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 3-13 Typical new excavated road on a wind farm

3.5.1.3 Floating Roads

Approximately 3.8km of floating road 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. 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 site won 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.

Where new access tracks will be constructed through forested areas, the felled trees may be used in the construction of the floating roads as outlined in the Coford Forest Road Manual (2004, see references at end of document). This construction method involves layering the brash from the felling process on the existing ground surface and placing the felled trees perpendicular to the direction of travel to benefit from the load spread thereby provided. A combination of geogrid and geotextile will be placed on top of the felled trees and the road construction completed using the same construction method as that outlined above. Refer to **Planning Drawing 19107-5023** for further details.

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

1. The appointed contractor will mark out the line of the proposed floated road using a GPS / total station;
2. Drainage measures to ensure the separation of overland clean water flow from construction run-off will be implemented as outlined in Section 3.17
3. 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.
4. 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.
5. 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.
6. 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.
7. 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 floated road construction over peat.
8. 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.
9. The stone aggregate required for the floated access roads is proposed to be won from three proposed on-site borrow pits within the wind farm site. The extraction of stone aggregate from the proposed borrow pits will be undertaken by 30-60 Ton 360° excavators and loaded onto articulated dumper trucks that will deliver the stone aggregate to the work face of required floated access roads.
10. Wide tracked 360° excavators will be used for constructing the floated roads by cascading a minimum 450mm thickness of site won stone aggregate over the geogrid / geotextile. The suitable site won 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.
11. 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.
12. 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.
13. Roadside drains as per Section 3.17 will be constructed to manage clean and dirty water runoff along floated roads.
14. 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.

15. 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 in accordance with the TMP (Volume III, Appendix 3-4) submitted with this application. 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.
16. 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 3-14 Typical floated road on a wind farm

3.6 TURBINE LOCATIONS

The final step in positioning turbines was to minimise the volume of excavated peat and to achieve a balance of cut and fill of the underlying strata at each turbine location. This was achieved by orientating the turbine base and crane hardstanding area with its long axis parallel to the ground contours as much as possible while taking account of access criteria for delivery of turbine components. This generally required some adjustment to the position of the access road on the approach to the turbine site. Table 3.6 gives information of the site, ground slope and peat depth at and in the vicinity of each of the proposed turbines.

Table 3.6 Ground parameters at turbine sites

Turbine	Land use category	Slope	Peat depth
T1	Cutaway blanket bog	6.35°	Varies, ~0.65m
T2	Young coniferous forestry adjacent to an existing road	7.30°	Varies, ~1.20m with deeper peat to the north and west
T3	Coniferous forestry	8.75°	Varies, ~1.10m with deeper peat to the north and east
T4	Coniferous forestry	10.70°	Varies, ~1.20m
T5	Young coniferous forestry	2.00°	Varies, ~2.30m with deeper peat to the east
T6	Coniferous forestry adjacent to an existing road	6.85°	Varies, ~2.10m
T7	Young coniferous forestry adjacent to fire break	5.70°	Varies, ~1.00m with deeper peat to the north west
T8	Coniferous forestry	7.00°	Varies, ~1.40m
T9	Coniferous forestry adjacent to an existing road	3.45°	Varies, ~1.20m with shallower peat to the south
T10	Young coniferous forestry	3.25°	Varies, ~1.70m
T11	Coniferous forestry	6.80°	Varies, ~1.90m with shallower peat to the east
T12	Young coniferous forestry adjacent to an existing road	7.40°	Varies, ~2.40m with shallower peat to the east
T13	Young coniferous forestry adjacent to an existing road	3.65°	Varies, ~2.30m with shallower peat to the north
T14	Coniferous forestry	Nominal	Varies, ~2.40m with shallower peat to the west
T15	Coniferous forestry	5.70°	Varies, ~0.50m with deeper peat to the west

Turbine	Land use category	Slope	Peat depth
T16	Coniferous forestry	4.15°	Varies, ~1.00m with shallower peat to the west and deeper peat to the east
T17	Cutaway blanket bog	4.50°	Varies, ~0.20m
T18	Young coniferous forestry	4.35°	Varies, ~0.40m
T19	Coniferous forestry	Nominal	Varies, ~1.20m with shallower peat to the west

3.7 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 rectangular in shape with additional minor hardstand fingers to lay the turbine blades across once delivered. The area of a single hardstand is approximately 40m long by 35m wide. Refer to **Planning Drawing 19107-5021** for further details. Due to the significant loads that will be imposed by the outriggers of the main lifting crane during the turbine erection process; it is intended that the hardstands will be constructed using excavation methods over the footprint of the hardstand area / turbine base. Estimated material quantities required for the construction of the hardstands are shown in Table 3.7.

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

1. Each crane hardstand will be formed on competent subgrade of the underlying subsoil / rock which will comprise of site won stone aggregate, obtained from the on-site borrow pits, laid on a geotextile filter membrane.
2. Any existing peat or soil found within the footprint of the turbine hardstand will be excavated out during the course of formation works. 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 borrow pits.
3. The stone aggregate for the turbine hardstands will be compacted in 250mm layers and will vary from approximately 300mm to 900mm deep depending on the depth of peat and gradient of the underlying subgrade. Turbine locations have been selected to minimise the impact on peat which will minimise the volumes of peat needed to be excavated at each crane hardstand.
4. Temporary set down areas will be formed to facilitate the storage of the turbine components at each crane hardstand (e.g. the rotor hub assembly, the turbine blades, the turbine towers and nacelle). Each temporary set down area will be constructed using compacted stone aggregate which will be fully removed and reinstated after all turbines have been erected.
5. 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 Typical finished hardstand on a wind farm

Table 3.7 Summary of construction material quantities for turbine hardstands

Item	Unit	Approx. Quantity
Total Site Won Stone Aggregate Required for 19 no. Hardstands	m^3	45,957
Total Imported Capping Material Required for 19 no. Hardstands	m^3	6,686

3.8 TURBINE BASES

It is proposed that 19 no. wind turbines will be constructed where each turbine will have a reinforced concrete base pad foundation with a central pedestal above the base, that will in turn support the wind turbine tower. Each turbine base will bear onto rock or other such suitable bearing stratum and will be constructed utilising a spread foundation, which is wide and shallow. A typical foundation will be approximately 24m in diameter and will generally be installed to a depth of approximately 3.0m below grade. Approximately 700m^3 of concrete and 100 tonnes of steel will be used in the construction of each turbine base. The final dimensions of the turbine bases will be confirmed as part of detailed engineering. Estimated material quantities required for the construction of the turbine bases are shown in Table 3.8. Refer to **Planning Drawing 19107-5021** for further details.

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 borrow pits;
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;
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 excavation and a significant depth to sub-formation is required, a piled foundation may be considered. A piled foundation requires the use of a piling machine equipped with an auger drill to rotary bore a number of holes around the area of the turbine base to the sub-formation depth determined at construction stage. 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 using steel box section stools;

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 installed 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 with a cohesive material, where possible using the material arising during the excavation and landscaped using the vegetated soil set aside during the excavation. A gravel footpath will be formed from the access track to the turbine door and around the turbine for maintenance.

Figure 3-16 Typical construction of a wind turbine base

Table 3.8 Summary of construction material quantities for turbine bases

Item	Unit	Approx. Quantity
Total Concrete for 19 no. Turbine Bases (Approx 700m^3 per base)	m^3	13,300
Total Steel for 19 no. Turbine Bases (Approx 100 tonnes per base)	tonnes	1,900

3.9 INTERNAL SITE CABLES

A network of underground cabling serving each turbine with electrical power and signal transmission will be installed within the site. The distribution system will electrically connect the wind turbines to the substation compound by underground electrical cables along the internal access roads. Cable jointing bays will be required to allow cables to be joined from the turbines to the substation compound.

Cabling on site will consist of single or twin cable trenches within internal access roads. The typical build up for the internal site cable trenches will consist of selected excavated backfill on top of bedding material that will be specified by the electrical designer. The minimum cover depth over the ducts will be 750mm which is measured from the top of the cable duct to existing ground level. As 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 else it will be deposited within the proposed on-site borrow pits following their reinstatement.

Where an open drain or watercourse is encountered during the installation of the internal site cable trenches; the cable trenches will cross the open drain or watercourse within the road carriageway via new or existing road crossings points to ensure that no in-stream works occur.

Refer to **Planning Drawing 19107-5027** for further details.

3.10 GRID CONNECTION

The underground grid cable between the Carrownagowan Wind Farm and the existing 110kV substation in Ardnacrushna is almost entirely confined to the existing road network, diverging slightly from it at water course crossings and at some joint bay locations. The full length of the Carrownagowan Wind Farm grid connection route is approximately 25km.

The grid connection route, which is part of the overall project, will be installed along a series of public roads between the wind farm site and the existing substation in Ardnacrushna, passing through the townlands of Cloongaheen West, Cloongaheen East, Killeagy, Ballymoloney, Ballyquin Beg, Ballyquin More, Springmount, Leitrim, Fahy More South, Aharinaghmore, Tooreen, Cloghera, Trough, Knockdonagh, Roo West, and Lakyle.

3.10.1.1 Excavation and Duct Installation

The proposed grid connection cable will be carried within a single cable trench which will be 1.315m in depth and 0.6m in width. Further detail is included in Appendix 2-2, the Grid Connection Package, in Volume III of this EIAR.

The installation of the grid connection along the public, forestry and wind farm roads involve the following process.

- Prior to works commencing the area where excavations are planned will be surveyed and all existing services will be confirmed. All relevant bodies i.e. ESB Networks, EirGrid, Gas Networks Ireland, Eir, Clare County Council etc. will be contacted and drawings for all existing services sought. A road opening licence will be obtained where required from Clare 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 Clare 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 Clare County Council. A traffic management plan is included in **Appendix 3-4 of Volume III of the 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 appropriate 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 grid connection route and associated road areas will receive a new permanent macadam finish as agreed with Clare County Council.
- Joint bays are to be installed where required along the grid connection 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 Clare County Council.
- Directional drilling will be used where there is insufficient cover on a bridge crossing to allow the grid connection route pass over the crossing in a standard trefoil formation. Proposed locations are described in Table 3.10 below. 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 Clare 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 grid 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.

Further information on the construction of the proposed grid connection can be found in the Outline Construction Methodology - 110kV Underground Cable Connection report included in the Grid Connection Package in **Appendix 2-2 of Volume III of the EIAR.** Estimated material quantities required for the construction of the grid connection are shown in Table 3.9.

Table 3.9 Summary of construction material quantities for grid connection

Item	Unit	Approx. Quantity
Total Excavated Material from Trenching Works	m^3	19,725
Total Imported Concrete Bedding and Surround for Ducts	m^3	9,600
Total Imported Stone Material for Backfilling Trenches	m^3	10,125

Figure 3-17 Typical excavation works for a grid connection cable trench

Figure 3-18 Typical ducting installation works for a grid connection cable trench

Figure 3-19 Typical permanent reinstatement works for a grid connection cable trench

3.10.2 Grid Construction at Watercourse Crossings

There are a total of 9 no. major watercourse crossings along the proposed grid connection route. The preferred methodologies for the provision of the grid connection route at these locations are set out in Table 3.10, which provides a summary of the bridge survey and description of works for bridge crossings as outlined in the Outline Construction Methodology - 110kV Underground Cable Connection report included in **Appendix 2-2 of Volume III of the EIAR**.

A description of each crossing option is provided below. In-stream works are not required along the proposed grid connection route.

Option 1 - Crossings over Bridges 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 the Outline Construction Methodology - 110kV Underground Cable Connection report included in the Grid Connection Package in **Appendix 2-2 of Volume III of the EIAR.**

Option 2 - Flatbed Formation over Bridges

Where ducts are to be installed over an existing bridge 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 the Outline Construction Methodology - 110kV Underground Cable Connection report included in the Grid Connection Package in **Appendix 2-2 of Volume III of the EIAR.**

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 are to be agreed with Clare 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. This method of duct installation is further detailed in the Outline Construction Methodology - 110kV Underground Cable Connection report included in the Grid Connection Package in **Appendix 2-2 of Volume III of the EIAR.**

Option 3 - Directional Drilling under Bridges 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.

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 Clare County Council.

The directional drilling methodology is further detailed in the Outline Construction Methodology - 110kV Underground Cable Connection report included in the Grid Connection Package in **Appendix 2-2 of Volume III of the EIAR.**

Figure 3-20 Typical directional drilling rig and launch pit

Table 3.10 Summary of proposed crossing methodology

Crossing No.	Bridge Type	Cover from Road Level to top of Bridge	Description	Watercourse Crossing Option	Extent of In-stream works
1	Two span concrete bridge	340mm	Due to lack of cover over Trough Bridge, located on the L-70661 local road, the grid connection ducts will be installed under the watercourse by means of directional drilling. No contact will be made with the watercourse during the works.	Option 3	None. No in-stream works required
2	Single span concrete bridge	450mm	Due to lack of cover over this bridge, located on the R471 regional road, the grid connection ducts will be installed under the watercourse by means of directional drilling. No contact will be made with the watercourse during the works.	Option 3	None. No in-stream works required
3	Two span stone arch bridge	600mm	Due to lack of cover over this bridge, located on the R471 regional road, the grid connection ducts will be installed under the watercourse by means of directional drilling. No contact will be made with the watercourse during the works.	Option 3	None. No in-stream works required
4	Single span stone arch bridge	2.2m	The grid connection ducts will be laid in standard trefoil formation over Ahnagor Bridge, located on the L-3022 local road, due to sufficient cover present. No contact will be made with the watercourse during the works.	Option 1	None. No in-stream works required
5	Single span stone arch bridge	575mm	Due to lack of cover over this bridge, located on the L-3022 local road, the grid connection ducts will be installed under the watercourse by means of directional drilling. No contact will be made with the watercourse during the works.	Option 3	None. No in-stream works required
6	Single span stone arch bridge	520mm	Due to lack of cover over the bridge, located on the L-7004 local road, the grid connection will be installed under the watercourse by means of directional drilling. No contact will be made with the watercourse during the works.	Option 3	None. No in-stream works required
7	Single span stone arch bridge	750mm	It is proposed to lay the grid connection ducts in a flat formation over this bridge, located on the L-7004 local road. No contact will be made with the watercourse during the works.	Option 2	None. No in-stream works required

Crossing No.	Bridge Type	Cover from Road Level to top of Bridge	Description	Watercourse Crossing Option	Extent of In-stream works
8	Single span stone bridge	610mm	Due to lack of cover over this bridge, located on the L-7004 local road, the grid connection ducts will be installed under the watercourse by means of directional drilling. No contact will be made with the watercourse during the works.	Option 3	None. No in-stream works required
9	Single span stone arch bridge	600mm	Due to lack of cover over this bridge, located on the L-7004 local road, the grid connection ducts will be installed under the watercourse by means of directional drilling. No contact will be made with the watercourse during the works.	Option 3	None. No in-stream works required

3.10.3 Grid Connection Construction at Land Drainage Ditches

Where land drains are encountered on the proposed grid connection route there are two scenarios, as follows:

I. In the event that there is adequate cover over the drain crossing, then the new ducts and trench will pass over the drain without interruption to the drain. No works will be required within the drain at these locations. The trench at these locations will be installed in the existing public / access road.

II. In the event where there is insufficient cover over a drain crossing point, the new grid connection route will have to be installed underneath the existing drain crossing. In order to do this the following approach is adopted:

  - The drain is blocked upslope of the crossing and a sump is formed using sandbagging and stable clay soil material. This sump will accumulate water flow in the drain (if it exists) and will facilitate the use of a 50mm or 100mm submersible pump to over pump (fluming) the drain water across the road and back into the drain on the down flow section below the road.
  - Two silt fences and filters will be put in place on the downslope of the crossing point to prevent siltation/sedimentation. Once the sump and over-pumping mechanism is in place, then the service trench excavation will progress.
  - A section of drain crossing (pipe or stone culvert) is temporarily removed to allow the trench and duct to continue. The duct will pass under the drain and once in place it will be surrounded with lean mix concrete and then the trench will be backfilled with suitable stone from excavations, or imported.
  - The drain will then be put back in place, surrounded with stone/lean mix concrete and the track restored to its finished level. The over-pumping measure can then be removed and normal drain flow resumes. The duct/trench work can then progress over the remaining length of the public / access road.

3.10.4 Grid Connection Construction and Existing Underground Services

All relevant bodies i.e. ESB Networks, EirGrid, Gas Networks Ireland, Eir, Clare County Council etc. will be contacted and drawings for all existing underground services along the grid connection route sought. Any underground services encountered will initially be surveyed for levels in order to determine if there is adequate cover available for ducting to pass over these services. A minimum clearance of 300mm is required from the bottom of the ducting to the top of any underground service as per ESB Networks requirements. If this clearance cannot be achieved, the ducting will pass below the service with a minimum 300mm clearance maintained from the top of the ducting to the bottom of the service.

If the required separation distances cannot be achieved by either going above or below the underground service, then a number of alternative construction options are available as outlined in the previous sections. All excavations will be kept within the public roadway boundaries i.e. in road or grass margins.

3.10.5 Grid Connection Construction Joint Bays and Communication Chambers

Joint bays are pre-cast concrete chambers that will be required along the grid connection route over its entire length. They are required to join cables together to form one continuous cable. They will be located at various points along the grid connection route approximately every 500 - 1,000 metres depending on gradients, bends etc. It is proposed to install approximately 35 no. joint bays and communication chambers along the proposed grid connection route. These locations might deviate from those shown in the layout drawings and for this reason the potential impact of locating these along the full route has been assessed and they will be within the existing/permitted corridor of road network (**see Volume III, Appendix 2-2 Grid Connection Package**). The final locations will be agreed in advance with Clare 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. A traffic management plan is included in **Appendix 3-4 of Volume III of the EIAR.** The traffic management plan will be finalised and agreed with Clare 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 complete, the joint bays will be fully backfilled and permanently reinstated to the satisfaction of Clare 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 include appropriate siltation measures along road side drainage (silt fences, check dams etc.).

The material excavated from the joint bay chambers will be removed from site and brought to a suitably licensed facility. Prior to the chamber being installed in a compacted layer of suitable stone or lean mix concrete, appropriate material will be placed in the excavation to 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 3-21 shows a typical joint bay installation. Further information on the construction of the joint bays and cable installation can be found in the Outline Construction Methodology - 110kV Underground Cable Connection report included in **Appendix 2-2 of Volume III of the EIAR.**

Figure 3-21 Typical joint bay construction

3.11 SUBSTATION COMPOUND AND BUILDINGS

This section describes the construction methodologies that will be used for both the EirGrid and IPP substation buildings as well as the substation compound. Estimated material quantities required for the construction of the substation infrastructure is shown in Table 3.11.

The proposed works 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 (in development footprint) for later use in landscaping. All remaining excavated material will be brought to the on-site borrow pits for final deposition. 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 and level spreaders to cater for surface run-off.

- All soils/peat on the substation site will be removed and replaced with site won 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 and appropriately shuttered. Reinforced concrete will be laid over it.
- The blockwork walls for each building will be built up from the footings to 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.

Table 3.11 Summary of construction material quantities for substation compound and buildings

Item	Unit	Approx. Quantity
Total Site Won Stone Aggregate Required for Substation Compound	m^3	25,865
Total Imported Capping Material Required for Substation Compound	m^3	3,141
Total Concrete for Substation Infrastructure (including substation buildings, transformer and equipment plinths)	m^3	500

Figure 3-22 Typical substation building and compound

3.12 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 adjacent to the turbine access road at T19 and is situated in an area of low surface gradient and negligible peat stability risk. The meteorological mast will be installed to a height of up to 100m 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 19107-5022**. Excavated material will be reused for backfill/adjacent landscaping or will be relocated to the 3 no. on-site deposition areas.

Figure 3-23 Typical meteorological mast on a wind farm

3.13 VISITOR BUILDING

Upon completion of the wind farm development it is proposed to install a prefabricated modular building within the compound of Temporary Site Construction Compound No. 2. This building will function as a learning hub where it will host workshops for school groups and members of the public; and also act as a base for guided tours of the wind farm during its operation. The building will be 86m² in area and will accommodate a classroom and toilet facilities for up to 30 visitors during the lifetime of the wind farm

The foundation of the building will consist of a concrete slab while access to the building will be made via concrete stairs or ramps. The temporary site construction compound at this location will be repurposed for use as a car park and surrounded by a 2.6m high galvanised steel palisade fence. There will be a very small water requirement for toilet flushing and hand washing and therefore it is proposed to harvest water from the roof of the building. The discharge from the toilet within the building will go to a holding tank located within the compound where the effluent will be temporarily stored and removed at regular intervals.

Details of the visitor building and compound are shown in **Planning Drawing 19107-5047**.

Figure 3-24 Typical prefabricated modular building

3.14 SITE CONSTRUCTION COMPOUNDS

The 2 no. temporary site construction compounds will be used for the construction phase of the wind farm. The 2 no. compounds will have dimensions of 100m x 50m and 56m x 24m respectively as shown on **Planning Drawings 19107-5044 and 5045**. The peat depth at the compound locations within the northern area of the site is nominal as it is less than 0.4m in depth. The peat will be excavated down to the underlying stratum. All excavated material will be taken to the on-site deposition areas. This is discussed in more detail in Section 3.16.

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

The compounds will be constructed early in the development 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 with the exception of Temporary Site Construction Compound No. 2 as described in Section 3.13.

Areas within the compounds will be constructed as access roads and used as vehicle hardstandings during deliveries and for parking;

1. A bunded containment area will be provided within the compounds for the storage of lubricants, oils and site generators etc.;
2. The compound will be fenced and secured with locked gates,
3. During the construction phase, a self contained port-a-loo 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.
4. Upon completion of the construction phase, the compounds will be decommissioned by backfilling the area with the material / peat arising during excavation, landscaping with topsoil as required.

Table 3.12 Summary of construction material quantities for temporary site compounds

Item	Unit	Approx. Quantity
Total Site Won Stone Aggregate Required for Temporary Site Compounds	m^3	6,682
Total Imported Capping Material Required for Temporary Site Compounds	m^3	1,040

Figure 3-25 Typical temporary site construction compound on a wind farm

3.15 BORROW PITS

There are three borrow pits proposed within the site which will be used to obtain approximately 126,627m³ of site won stone aggregate. These borrow pits are located within the central, eastern and western areas of the site where they will be used as sources of hardcore for the construction of access roads, crane hardstands and construction compounds.

Table 3.13 Site won stone requirement

Item	Approx. Volume (m^3)
Estimated Stone Required for Access Roads, Hardstands, Substation Compound works etc.	185,826
Include additional 5% for contingency	9,291
Estimated Stone Required	195,117
Estimated Spoil Material to be Generated from Excavation Works	139,775
Assume Approximately 50% of Total Spoil is Reusable as Site Won Stone	68,490
Total Site Won Stone Required from Borrow Pits	**126,627m³**

Prior to the stripping of peat overburden over the area of the proposed borrow pits; an interceptor drain will first be excavated upslope in order to intercept existing overland flows and divert them around the borrow pits prior to discharge via a buffer zone on the downslope side. The shallow peat overburden will then be stripped and temporarily stockpiled, vegetated side upwards adjacent to the borrow-pit in order for it to be re-used in its reinstatement on completion. Temporary stockpiles will be maintained less than 1m in height, on even ground within the development footprint. Any subsoil material overlying the rock will then be excavated and stockpiled separately from the peat. The stockpile will be sealed and a perimeter drain installed to intercept any run-off so that it can be discharged through an appropriately designed silt trap.

Standing water and any surface water runoff from the borrow pits is likely to contain an increased concentration of suspended solids. Runoff from the borrow pits will be isolated from the clean catchment runoff by means of a series of open drains that will be constructed within the area. These drains will be of check dams that will attenuate the flow and provide storage for the increased runoff from exceptional rainfall events.

Inspections of the borrow pits will be made by a geotechnical engineer through regular monitoring of the opening works. The appointed contractor will review work practices at the borrow pits where periods of heavy rainfall are expected where work will be stopped so as to stop excessive runoff from being generated. Excavators will extract the stone using buckets and a ripper attachment or rock-breaker attachments may be utilised in the borrow pit locations. It is expected that 30-60 Ton 360° excavators will be utilised in tandem in the extraction of rock from the borrow pits. The larger excavators will extract rock from the face and floor of the excavation using digging buckets and rock rippers and will be assisted by smaller excavators, removing rock as it is broken, stockpiling locally within the excavation as well as loading articulated dumper trucks removing rock as required for distribution within the wind farm site. The sides of the excavations will be battered back to a suitable angle of repose to be determined by the nature of the rock present. Regular examination of these batters will be carried out by a geotechnical engineer to ensure that there is no risk of collapse. There will be no public access permitted to or within the borrow pits. Secure edge protection and fencing will be erected around the borrow pits with warning signage erected. A berm will be constructed as required, at the leading edge to ensure that articulated dumper trucks are stopped at a safe distance from the edge of the borrow pit during loading of extracted stone aggregate.

On completion of extraction activities at the borrow pits; these areas will be used for the permanent storage of some of the excavated peat and material from the infrastructure construction. This is outlined further in Section 3.16. The proposed locations of the borrow pits are shown on **Planning Drawings 19107-5029 to 5031.**

3.16 PEAT AND SPOIL STORAGE

3.16.1 Excavated Peat and Spoil Volumes

The quantity of peat and spoil material, requiring management on site has been calculated as shown in Table 3.14 below. A peat and spoil management plan is included in **Appendix 3-3 of Volume III of the EIAR.**

Table 3.14 Peat and spoil excavation volumes

Development Type	Approx. Peat Excavation Volume (m^3)	Approx. Spoil Excavation Volume (m^3)
19. no Turbine Base and Hardstand Areas	63,964	59,755
Substation Compound	2,108	38,296
2 no. Site Construction Compounds	1,670	9,231
Access Roads	72,996	32,243
Permanent Meteorological Mast Hardstand	37	250
Total	**140,775**	**139,775**
Total Peat and Spoil to be Managed	**280,550**	

It has been calculated that there will be approximately 280,550m^3 of material excavated during the construction of Carrownagowan Wind Farm. Of this, an estimated 140,775m^3 will be peat and 139,775m^3 will be spoil. Excavated peat, estimated at 68,370m^3, and spoil, estimated at 19,894m^3 will be reused for the backfilling, landscaping and restoration around wind farm infrastructure such as turbines and hardstands. Peat will be deposited only within the buildable areas around the turbines to a maximum height of 0.3m and will not impact on any of the constrained areas as defined at the preliminary stages of the design process.

Berms will be formed along sections of floated access roads in order to store an additional volume of 9,713m^3 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 be 1m high by 2.5m wide.

The remainder of the surplus excavated peat and spoil material, estimated at 114,083m^3 will be stored within the 3 no. deposition areas at the proposed on-site borrow pits. Additionally storage will be provided for peat that is stripped at the borrow pit locations and any remaining peat which cannot be stored within these borrow pit areas. The proposed locations for the peat and spoil storage are shown on **Planning Drawings 19107-2028.**

A summary of the peat and spoil storage volumes are shown in Table 3.15. Note a conservative assumption has been made that up to 50% of the total spoil material excavated on site (68,490m^3) will be reusable as site won stone aggregate and therefore will not require storage.

Table 3.15 Peat and spoil storage volumes

Peat and Spoil Storage Area	Approx. Volume (m^3)
Backfilling, landscaping and restoration around Turbine Bases and Hardstands	88,264
Roadside Berms along Internal Floated Access Roads (at 1m height)	9,713
3 no. Deposition Areas at Borrow Pit Locations	114,083
Total	**212,060**

3.16.2 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 berms. 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.

3.17 SITE DRAINAGE

3.17.1 Design principles

The site drainage system was designed integrally with the wind farm infrastructure 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 overland dispersal. Dirty water drains will be provided on both sides of the access roads and along the periphery of the turbines, crane hardstands, substation compound, met mast, borrow pits 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 3.19 below). The 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 eventually entering the downstream watercourses.

The site drainage layout is presented in **Planning Drawings 19107-5013 to 5019** with drainage details presented in **Planning Drawing 19107-5024 and 5025**. The drainage layout is overlaid on background OSI mapping in the A1 drawings that accompany the planning application. The Surface Water Management Plan, which is included in **Appendix 3-2 of Volume III of the EIAR,** details the proposed drainage measures further**.**

3.17.2 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 Carrownagowan Wind Farm 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 very small in the context of the catchment size and therefore represents a negligible increase in downstream flood risk. 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 downstream watercourses.

The volume of water requiring attenuation relates to direct precipitation on the roads and other infrastructure footprint only. 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 a forestry environment or where long-term routine maintenance would not be practical.

It is proposed to provide temporary storage within the drainage channels by creating stone dams within them at regular intervals. The spacing of the dams is typically 100 metres but depends on the channel slope, with steeper channels requiring shorter intervals. 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. Silt fences will also provide storage and flow control.

3.18 WATERCOURSE CROSSINGS

3.18.1 Major Watercourse Crossings

On Carrownagowan Wind Farm is it proposed that 4 no. major watercourse crossings will be constructed using clear span pre-cast concrete culvert crossings such as a bottomless arch or bottomless box culvert (Figure 3-26). The crossings are on the Carrownagowan River and Inchaluchoge River and along an unnamed tributary of same. In general the major watercourses within the wind farm site, namely the Carrownagowan, Coumnagun and Inchalughoge rivers, are cut into relatively deep channels. These channels would require significant upfill to maintain vertical alignment criteria for turbine deliveries along access roads. Clear span pre-cast concrete culverts are advantageous in several manners for this type of installation. As spans increase the height can increase accordingly allowing significant light penetration under the culvert. The increase in height is complimentary to the vertical alignment requirements for access road design. Refer to **Planning Drawing 19107-5026** for further details.

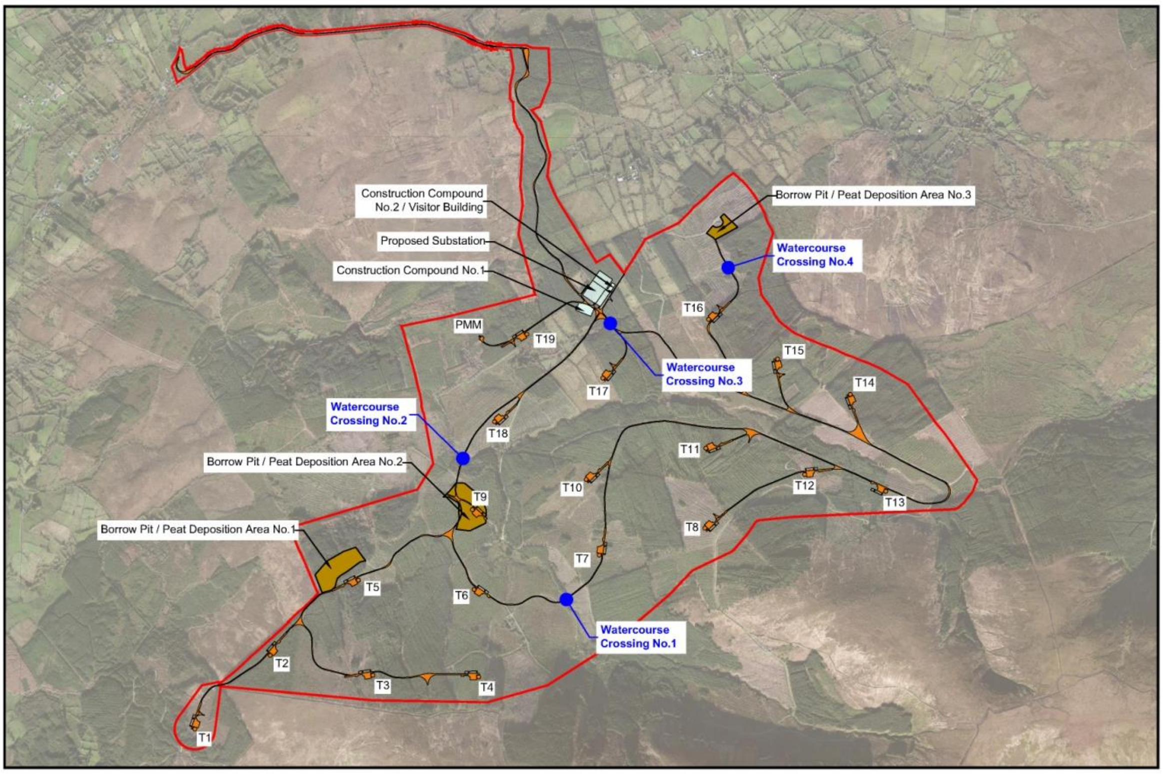

Figure 3-26 Location of 4 major watercourse crossings

The selection criteria for crossing natural streams and rivers within the site were:

- Avoid crossing streams or rivers at acute angles;
- Avoid meanders at the crossing location;
- Cross where foundations could be constructed without excess excavation;

- Consider vertical alignment requirements;

The design of a clear span pre-cast concrete culvert crossings will ensure that:

- The existing channel profile within the watercourse is maintained;
- Gradients within the watercourse are not altered;
- There is unrestricted passage for all size classes of fish by retaining the natural watercourse stream / river bed;
- There are no blockages within the watercourse. The large size of a clear span culvert allows for the passage of debris in the event of flood flow conditions;
- The watercourse velocity is not changed;
- The clear span of a culvert will ensure that the existing stream / river bank is maintained during construction which will in turn avoid the occurrence of in-stream works;

Construction of the four clear span crossings will be supervised by the Construction Manager, a suitably qualified engineer, the project manager and the Environmental Manager in accordance with Inland Fisheries Ireland *"Guidelines on Protection of Fisheries During Construction Works in and Adjacent to Waters, 2016"* and Office of Public Works *"Construction, Replacement or Alteration of Bridges and Culverts, 2013"*.

Typically the proposed installation works for a clear span pre-cast concrete culvert will comprise the following:

I. Prior to the commencement of works the design of the culvert will be submitted for approval to the Office of Public Works (OPW) under Section 50 of the Arterial Drainage Act, 1945 and to Inland Fisheries Ireland (IFI);

II. Upon design approval the extent of the excavations required for the culvert foundations at either side of the watercourse will be marked out. The foundations are to be set to an agreed minimum distance by IFI from the existing watercourse so as not to impact on the riparian habitat. Health and safety measures such as lifebuoys on stakes will be installed and where appropriate life jackets will be provided to persons working near the watercourse;

III. Appropriate environmental control measures such as silt curtains, silt traps, mats etc. will be erected on both sides of the watercourse. These environmental control measures will reduce the potential for sedimentation of the watercourse;

IV. Excavators will begin to excavate the foundations to formation level where all excavations will be battered back to a safe angle of repose (minimum slope angle of 45°) and comply with the final Construction and Environmental Management Plan (CEMP) to be produced by the appointed contractor for Carrownagowan Wind Farm. All excavation works will stop in the event of heavy rainfall.

V. All excavated material will be transported to the on-site deposition areas located outside of the 75m hydrology buffer zone at the proposed borrow pits. Some of the excavated material will subsequently be reused as backfill around the culvert abutments and structure upon installation. Bare ground will be minimised.

VI. Once formation is reached at suitable ground conditions; steel reinforcement and shuttering will be installed. The culvert abutments will be prepared for the pouring of concrete by dewatering standing water within the excavations, which is likely to contain suspended solids, via a pump to an adequately sized settlement pond located outside of the 75m hydrology buffer zone. The standing water will be treated through the settlement pond and clean filtration stone prior to outfall over vegetation away from the watercourse;

VII. Ready-mix concrete will be delivered to the culvert abutments by ready-mix concrete trucks and placed into each abutment by means of excavators. During the concreting works the watercourse will be temporary covered over with a tarpaulin so as to protect the watercourse from concrete spills. Upon completion the abutments will be covered and allowed to cure;

VIII. Following curing, the shuttering around the abutments will be struck and removed. A small temporary hardstand will be constructed so that a lifting crane, which will install the pre-cast concrete culvert components onto the abutments, can be set up;

IX. Deliveries of the pre-cast concrete culvert components will arrive to site. These components will be individually fitted and manoeuvred into position by the lifting crane onto the concrete abutments. The components will be inspected to ensure that each unit is level and secure;

X. Backfilling on either side of the culvert will commence using excavated material, in particular larger rock of a uniform size will be placed along the edge;

XI. The access road surface will be laid over the culvert structure using site won stone aggregate and compacted in maximum 250mm layers with the use of 10-20 Ton rollers. An internal cable trench will be installed within the carriageway of the culvert so that it can cross over the watercourse;

XII. Vegetated soil bunds, will be installed to divert dirty water generated on the section of road over the culvert crossing into the dirty water system outside of the 75m hydrology buffer zone. This will ensure that dirty water will not enter the clean watercourse;

XIII. Steel parapet railings and timber post and rail fencing will be installed at the sides and on the approaches to the culvert. This will prevent persons or vehicles falling into the watercourse while travelling across the culvert;

Figure 3-27 Typical clear span pre-cast concrete units in place over an existing watercourse

Figure 3-28 Completed clear span pre-cast concrete culvert crossing over existing watercourse

3.18.2 Drainage / Stream Channel Crossings

Where the crossing of an existing natural or artificial drainage / 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 200 year return rainfall event. The invert of the pipe is submerged approx $^1/_4$ 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 3-29 below. New turbine service roads will be required to cross several minor drains / streams within the site. All such crossings and widening will be in accordance with this application and/or conditions attached to a grant of planning permission and also agreed with Inland Fisheries Ireland prior to construction. All construction method statements for crossings will be approved by Inland Fisheries Ireland.

Figure 3-29 Typical drainage channel crossing

Figure 3-30 shows a typical measure to be put in place at drainage and watercourse crossings in order to ensure dirty water does not enter clean watercourses. For the Carrownagowan Wind Farm, the intention 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 silt curtains, as shown in Figure 3-31, can be placed along the existing roads within the 75m buffer zone. These silt curtains can run longitudinal to watercourses with a layer of stone placed along the bottom to prevent any seepage if there is a risk of silted runoff.

Figure 3-30 Dirty water containment at watercourse crossings

Figure 3-31 Silt curtain containment along existing roads near watercourses

3.19 WATER QUALITY MANAGEMENT SYSTEMS

3.19.1 General

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 water quality management system has been prepared in order to control erosion and prevent sediment runoff during the construction phase of the Carrownagowan Wind Farm development. The implementation of sediment and erosion control measures is essential in preventing sediment pollution. The system was designed having regard to:

- Knowledge of the site's environmental conditions;
- 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 (see references).

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

- High resolution aerial photography;
- LiDAR ground surface information;
- Wind farm infrastructure layout (turbines, service roads and ancillary development);
- Hydrology maps (watercourses and buffer zones);
- Soil and land use maps;
- Baseline water quality assessments; 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 downstream watercourses.

The drainage and treatment system will ensure that the construction and early post-construction phases of Carrownagowan Wind Farm will not create adverse effects on the aquatic environment.

3.19.2 Constructions 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. These drains will be directed to settlement ponds that will be constructed throughout the site, downhill from the works areas and as shown on the drainage layout planning drawings submitted with this application. 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.

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.

Figure 3-32 Stone check dam with large aggregate on downstream side

3.19.3 Treatment Process

Contaminated runoff can be generated on the site access roads, borrow pits, met mast, 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. This is equivalent to a road length of 240m or the area of a typical turbine base and crane hardstand.

The settlement ponds have been designed as a three stage tiered system and this has been proven to work effectively on wind farm construction sites. The three stage system also facilitates effective cleaning with minimal contamination of water exiting the pond.
The settlement ponds have been designed with regard to the following:

- Runoff flow rate for the modular 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.

- 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 sediment treatment unit has been micro-sited 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.

Settlement ponds will require inspection and cleaning when necessary. This will be carried out 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 3-33 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.

Figure 3-33 Multi-tiered settlement pond with stone filter

The design of the settlement pond system for the Carrownagowan site is detailed in the **Planning Drawing 19107-5024.** The hydraulic design of the settlement ponds is outlined in Section 3.19.4.

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. A minimum buffer width of 20m is specified between the overflow weir and downstream watercourses. 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 surface watercourses. The outflow weirs will not be located on slopes steeper than 3:1 or in areas of high instability risk. Existing drains within the dispersion zone will be blocked off where necessary to provide additional attenuation, disperse the flow across a larger area of ground and prevent the re-concentration to a single flow.

3.19.4 Settlement Pond Design

3.19.4.1 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 (Table 3.17 and Table 3.18) demonstrate that the chance of occurrence of a storm event of a given duration decreases (higher return period) as intensity increases.

Table 3.17 shows the Point Rainfall Frequency and the total rainfall for each duration and return period in millimetres. Table 3.18 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 170 mm/hour and 5-minute duration would be expected to occur once in a 100-year period (first row of Table 3.18). 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 3.19.6 below. 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. Since the design is for the construction phase only, no additional allowance has been made for a possible increase in rainfall intensity due to climate change in the future. While the design remains the same, the potential for extreme rainfall events may be more frequent which may result in more incidences of stopping work during heavy rainfall.

The modular settlement ponds are designed to operate effectively for the runoff rate associated with a continuous high rainfall rate of 20 mm/hour. This is equivalent to a 60-minute duration storm event with a 10-year return period (M10-60) or a 30 minute duration storm event with a 2-year return (M2-30). These rates are taken from the Met Éireann Point Rainfall Frequency table for the site location.

The design runoff rate 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 the runoff rate is:

Q = 0.70 x (0.02/3600) x 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 in 1851 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 x $(10^{-5})^2$ x (2,400 - 1,000) / (9 x 0.000133)

= 2 x 10^{-10} x 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 has been designed with a surface area of 24m^2 (12m x 2m) and a depth of 1.25m. 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.

3.19.4.2 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 3.16 below. The volumes are based on a catchment area of 1,200m^2 and a runoff coefficient of 0.70. The maximum storage volume required is 6.52m^3 for 15 minutes storm duration. This is equivalent to 25 minutes of flow through the settlement pond at the design through flow rate of 4.70 litres/second. The stored water will drain off gradually as runoff from the works area subsides. The storage volume represents an average depth of 0.05m in a 218m long, 0.60m wide open drain and can therefore be easily accommodated in the drainage system.

Table 3.16 Calculated storage volumes

Storm Event	Duration (minutes)	Rainfall rate (mm/hour)	Excess (mm/hour)	Runoff Coefficient	Storage Volume (m^3)
M10-60min	60	20.00	0.00	0.70	0.00
M10-30min	30	32.00	12.00	0.70	4.92
M10-15min	15	51.20	31.20	0.70	**6.52**
M10-10min	10	64.80	44.80	0.70	6.25
M10-5min	5	93.60	73.60	0.70	5.14

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. The number of dams will vary depending on the gradient of the drainage channel with higher gradients requiring a greater number of dams with larger dimensions. Their ability to retain water and release it slowly can be confirmed visually.

Table 3.17 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	2.80	3.90	4.50	6.30	7.80	9.40	11.90	14.20
10 min	3.90	5.40	6.20	8.80	10.80	13.10	16.60	19.80
15 min	4.60	6.40	7.30	10.40	12.80	15.40	19.50	23.30
30 min	6.20	8.40	9.50	13.20	16.00	19.00	23.80	28.10
60 min	8.20	10.90	12.30	16.70	20.00	23.60	29.00	33.90
2 hours	11.00	14.30	16.00	21.20	25.00	29.20	35.40	40.80
4 hours	14.70	18.70	20.70	26.90	31.30	36.10	43.10	49.20
6 hours	17.40	21.90	24.20	30.90	35.80	40.90	48.40	54.90
12 hours	23.30	28.70	31.30	39.20	44.80	50.60	59.00	66.10
24 hours	31.00	37.50	40.60	49.80	56.10	62.60	71.90	79.70
48 hours	39.70	47.30	51.00	61.50	68.60	76.00	86.40	95.00

Table 3.18 Met Éireann point rainfall frequency table (rainfall rate in mm per hour)

Storm Duration	Return Period (years)							
	0.5	1	2	5	10	20	50	100
5 min	33.60	46.80	54.00	75.60	93.60	112.80	142.80	170.40
10 min	23.40	32.40	37.20	52.80	64.80	78.60	99.60	118.80
15 min	18.40	25.60	29.20	41.60	51.20	61.60	78.00	93.20
30 min	12.40	16.80	19.00	26.40	32.00	38.00	47.60	56.20
60 min	8.20	10.90	12.30	16.70	20.00	23.60	29.00	33.90
2 hours	5.50	7.15	8.00	10.60	12.50	14.60	17.70	20.40
4 hours	3.67	4.67	5.17	6.72	7.82	9.02	10.77	12.30
6 hours	2.89	3.64	4.03	5.14	5.96	6.81	8.06	9.14
12 hours	1.94	2.39	2.60	3.26	3.73	4.21	4.91	5.50
24 hours	1.29	1.56	1.69	2.07	2.33	2.60	2.99	3.32
48 hours	0.82	0.98	1.06	1.28	1.42	1.58	1.79	1.97

3.19.5 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 finishing of all service roads with high quality, hard wearing crushed aggregate such as basalt, granite or limestone laid to a transverse grade. When storm water drains transverse across a road constructed from hard wearing aggregate, as opposed to low class aggregate, the level of suspended solids is reduced significantly. The internal roads will be finished with a hard wearing aggregate. In the case of road construction in areas of peat, imported limestone is normally used where the site won rock is not suitable. This can have the added benefit of contributing a balancing pH to help protect water quality from acidic runoff. The proposed development and grid route area is serviced by several limestone quarries which can be used as a source of hard wearing aggregate for road construction. There are two quarries that are likely to supply these materials, the closest of which is McGraths quarry in Tulla. A second, Ballycar Quarry, lies to the south near Ardnacrusha.

3.19.6 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 3-34.

Figure 3-34 Examples of check dams along roadside drainage channels

3.19.6.1 Silt fences

Silt fences placed along drains are an alternative method of reducing the volume of suspended sediment. They will 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 3-35.

Figure 3-35 Example of a silt fence used in conjunction with check dams along roadside drainage channels

3.19.7 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 and delivery vehicles moving around the wind farm site. Following construction the amount of on-site traffic will be negligible and there will be no particular risk of sediment runoff. It is therefore proposed to partly fill the sediment ponds with stone so that they will not present a long-term safety risk. Runoff from the roads, hard-standings, and other works areas will continue to be directed to these ponds and from there to the outfall weirs. Check dams 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. This infrastructure will be inspected regularly by the operational maintenance personnel. Water monitoring will continue during Years 1 and 2 of the operational phase, commencing after the completion of construction.

The regular inspections during the operational phase will ensure culverts are free from blockages, and there is no damage or erosion of the stream crossing wing walls, particularly after strom events. Silt ponds will also be inspected and maintained before the drains and verges have vegetated.

3.20 DECOMMISSIONING AND RESTORATION

Decommissioning is described in Chapter 2. No further civil engineering design is required. Bases and hardstand areas will be rehabilitated from the surface up and roads will remain in situ.

3.20.1 Wind Farm

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 be subject to a new planning permission application. If planning permission is not sought after 30 years, the site will be decommissioned and reinstated with all wind turbines and towers removed. Upon decommissioning, all that will remain will be the roads. The substation will likely remain in place as part of the permanent electrical infrastructure.

When 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 turbines, cabin and monitoring masts 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.

Underground cables will likely be cut back and left underground as removal may do more harm than leaving them *in situ*.

Hardstand areas will be remediated to match the existing landscape thus requiring peatland restoration or reforestation. Access roads will be left for use by the landowner. The current view is that the disturbance associated with the removal and disposal of the elements (hard core and sediment) would be more deleterious than leaving them in place.
Any structural materials suitable for recycling will be disposed of in an appropriate manner.

Prior to wind turbine removal, due consideration will be given to any potential impacts arising from these operations. Some of the potential issues 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 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 program that details the removal of all structures and landscaping, will be submitted to the planning authority for approval.

Wastes generated during the decommissioning phase will be taken off site and disposed of appropriately by a licensed waste operator.

3.20.2 Grid Connection

The grid cable will remain a permanent part of the national grid and therefore decommissioning is not foreseen. In the event of decommissioning, it will involve removing the cable from the ducting but leaving the ducting and associated supporting structure in place. It is also likely the substation will remain in place and will previously have been taken in charge by the system operator, after the wind farm is connected to the national electricity grid.

3.21 REFERENCES

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