Appendix 2B

Surface Water Management Plan

Surface Water Management Plan

Ballycar Wind Farm

Ballycar Green Energy

January 2024

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1. Introduction

This Surface Water Management Plan (SWMP) describes the drainage and the control measures for the construction phase of the proposed development. This document compiles the control and treatment measures which have been set out in the Environmental Impact Assessment Report (EIAR) and also includes the proposed surface water monitoring programme, included in the CEMP.

The plan forms part of the drainage design for the proposed development and should be read in conjunction with the drainage layout plan presented in Planning Drawing 22156-MWP-01-00-DR-C-5006 to 22156-MWP-11-00-DR-C-5006, as well as drainage details presented in Planning Drawing 22156-MWP-00-00-DR-C-5406.

1.1 Report Purpose and Objectives

The objective of this Surface Water Management Plan is to ensure all site works are conducted in an environmentally responsible manner so as to minimise any adverse impacts on surface water quality that may occur as a result of works associated with the development and operation of the proposed development, incorporating the following specific objectives:

- Provide overall surface water management principles and guidelines for the construction phase of the proposed development;
- Address erosion, sedimentation and water quality issues; and
- Present measures and management practices for the prevention and/or mitigation of potential downstream impacts.

This SWMP has been prepared taking into consideration the findings and conclusions presented within the proposed development EIAR and specifically Chapter 08 Water of the EIAR. The SWMP and associated drainage strategy is prepared for the high-level project design at the planning stage and therefore will be subject to further refining and revision following granting of planning permission during the detailed design stage.

The key aspect of the proposed drainage system, as it is constructed, is that it will not impact on the existing drainage regime.

2. Overview of Project

2.1 Proposed Development

The development for which planning permission is sought in the planning application (the proposed development) includes the following:

Core Wind Farm Elements:	• 12 No. Wind Turbines (blade tip height up to 158m, refer to **Table 2-1** for turbine dimensions). • 12 No. Wind Turbine foundations and Hardstand areas. • 1 No. Permanent Meteorological Mast (90m height) and foundation and associated hardstand areas. • 1 No. Electrical Substation (110kV) including associated ancillary buildings security fencing and all associated works. • 2 No. Developed Site Entrances, one temporary entrance to facilitate construction traffic and one permanent entrance. • New and upgraded internal site service tracks. • Provision of an on-site Visitor cabin and parking.
Associated Development Components:	• All associated underground electrical and communications cabling connecting the proposed turbines to the proposed onsite substation. • Turbine Delivery. • Laying of approximately 1.5km of underground electricity cabling to facilitate the connection to the national grid from the proposed onsite substation to connect to an existing 110kV overhead line. • Temporary works on sections of the public road network along the turbine delivery route (including hedge or tree cutting, relocation of powerlines/poles, lampposts, signage, and local road widening). • 1 No. Temporary construction site compound and additional mobile welfare unit. • 1 No. Borrow pit to be used as a source of stone material during construction. • 3 No. spoil deposition areas (one at borrow pit location). • Associated surface water management systems. • Tree felling for wind farm infrastructure.

In addition to the proposed development as described, there is a proposed underground connection between T1 and the proposed 110kV substation which will be located northwest of T1. The underground connection from T1 is routed along existing forestry tracks and through conifer forestry to the north west of the wind farm site and connects to the proposed 110kV substation. From the proposed 110kV substation, an underground cable is routed in a north west direction where it connects to the existing 110 kV overhead line. The proposed 110kV grid route is approximately 1.5km in length. 1.0km of the 110kV grid route is proposed within existing forestry tracks. The remaining 0.5km is routed through conifer forestry. It also crosses a 3m wide local public road. A new unbound stone access track will be constructed over the 110kV grid route on private lands to allow access for future maintenance. Refer to **Figures 1** and **2** below for layouts.

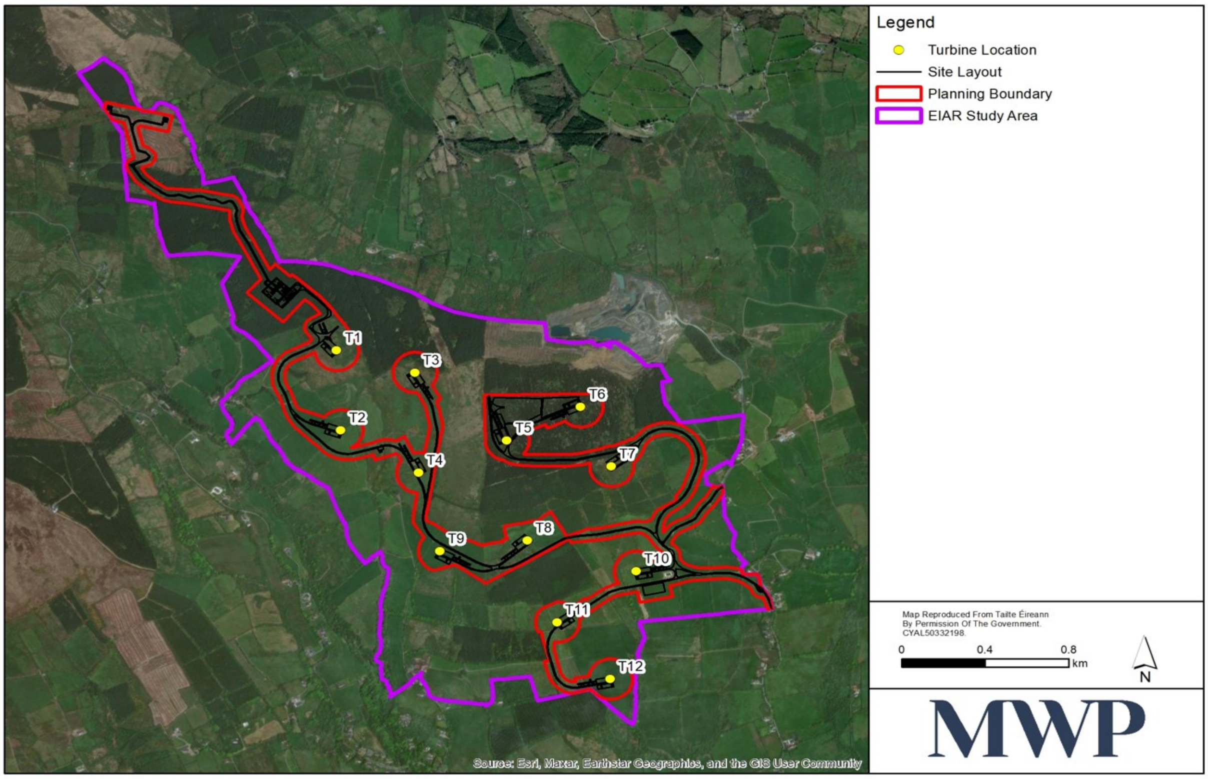

Figure 1: Proposed Wind Farm Layout

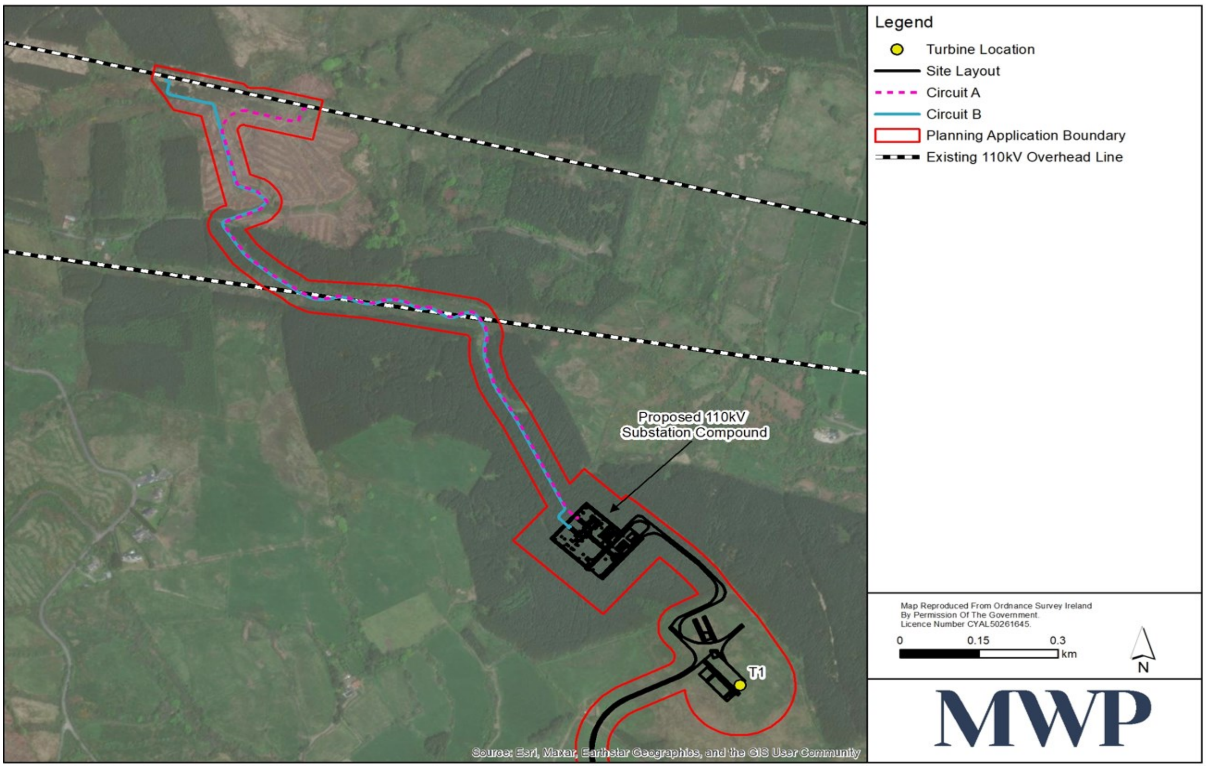

Figure 2: Proposed Substation and Grid Connection Route

2.2 Surface Water Features

The proposed development site and grid route is located within the Shannon International River Basin District. The WFD Catchment is the Lower Shannon (ID:25D) and the Shannon Estuary North (ID: 27). The WFD sub-catchment is Shannon [Lower]_SC_100 and Owenogarney_SC_020. There are five streams that flow from north to south within the landownership boundaries of the proposed site, these are:

- Cappateemore East
- West Ballycannan
- East Ballycannan
- North Ballycannan
- Unnamed Stream

One stream north of the substation site flows across the proposed grid connection route:

- Kilnacreagh

The Cappateemore East stream and the unnamed stream are tributaries to the Crompaun East stream which flows along the western perimeter of the proposed site, and the West and East Ballycannan streams are tributaries which flow into the North Ballycannan stream which also flows through the eastern section of the proposed site. These rivers and their network of tributaries extend from the northern extremities of the site and outfall to the River Shannon which is located approximately 3km south of the site. The South Ballycar stream and its tributaries flow south immediately east of the site boundary and outfall into the Shannon south east of the site.

The downstream areas (located outside of the site boundary) of the North and West Ballycannan streams are a part of the Lower River Shannon Special Area of Conservation (SAC) (Site Code 002165). The downstream areas of the Crompaun East stream are also within the SAC and the River Shannon and River Fergus Estuaries SPA (Site Code 004077). The Lower River Shannon SAC is located approximately 1km south of the T12.

During the site walkover, an additional stream/brook which flows through the site was identified. This stream flows from north to south between T2 and T3 and outfalls into the Cappateemore East stream, approximately 220m southwest of T4. This stream is visible on historic 6 inch mapping where it is indicated that this stream is the original course of the Cappateemore East stream, and the stream labelled “Cappateemore East” in the EPA datasets is an artificial land drain that outfalls into the Cappateemore East stream.

The proposed grid connection route and substation location to the north of the proposed wind farm site occur within the Blackwater (Clare) River catchment. The nearest watercourse to the proposed connection to the overhead line is the 1st order Kilnacreagh Stream (EPA segment code 25_3206) which flows into the Blackwater River (also known as the Trough River). The grid connection route crosses the 1st order Kilnacreagh Stream (EPA segment code 25_3206) which flows from west to east approximately 50m to the south of the nearest proposed tower to be erected to connect to the existing overhead line. The Kilnacreagh Stream joins the 1st order Trough River (EPA code 25B06, also known as the Blackwater River) which flows in a westerly direction for ca. 5.2 km until it is fed by the 3rd order Derryvinnann River. There is an unmapped watercourse near the northern extent of the proposed development site that flows into the Kilnacreagh Stream. This watercourse corresponds to an eroding / upland river.

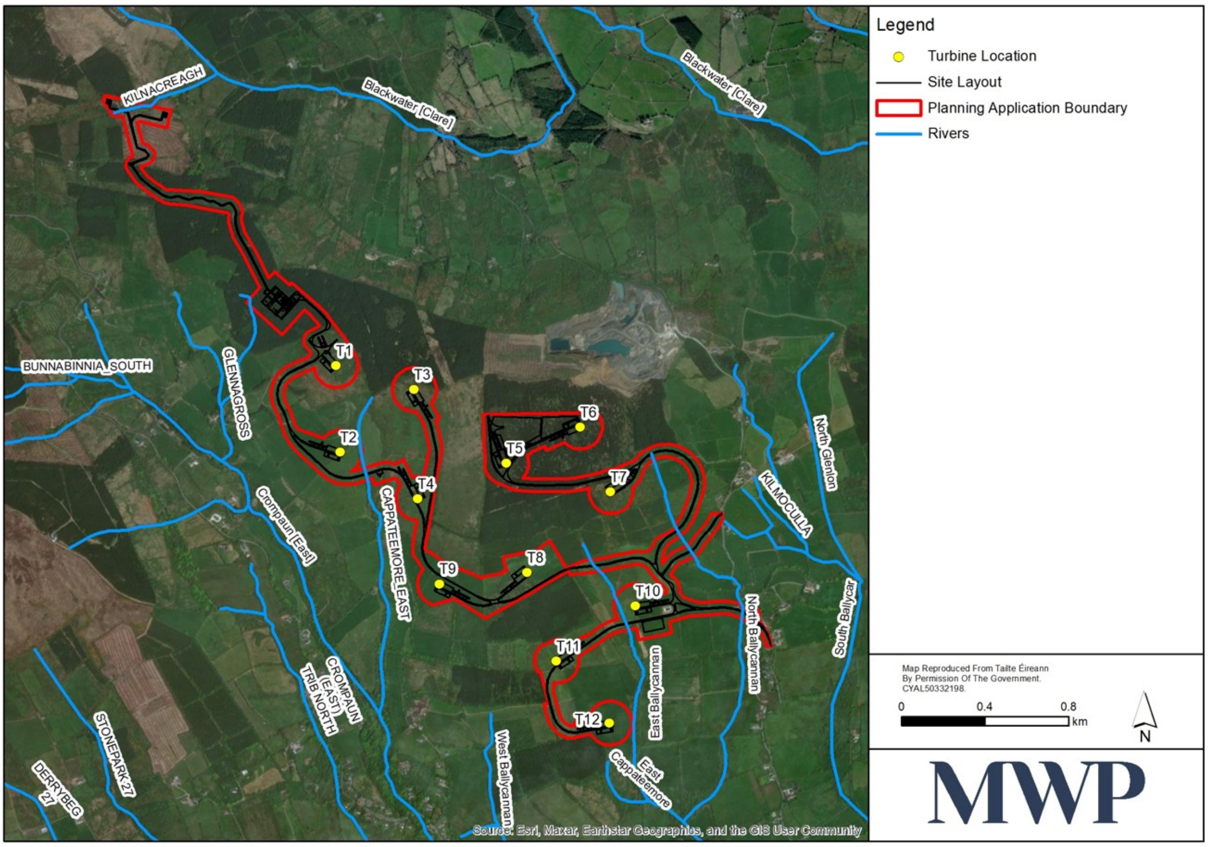

Figure 3: Surface Water Hydrology Map

2.3 Existing Drainage

Drainage in the northwestern section of the site has a seemingly random network of small artificially dug drains and in some areas, underground drains to improve the drainage in this area. It appears that these drains have been unsuccessful in lowering the water level by any noticeable degree as the area was still very waterlogged during the site visit. This ponding was, however, restricted to this area. The on-site assessments noted waterlogging at the initial T1 proposed location. Following a process of constraints led design, T1 was moved as far as possible north west, approximately 100m, to avoid this area of degraded upland bog, which is subject to waterlogging. Refer to **Chapter 06 Biodiversity** for a detailed description of the habitats in this area and the siting of T1 in relation to this area of degraded upland bog. These drains outfall to the upstream extent of the Cappateemore East stream.

There is no existing drainage system onsite outside of small-scale historic agricultural land drains (indicated on 6-inch historic mapping) that outfall into the various streams that flow through the site.

According to the 6 inch historic mapping, there are numerous historic land drains within the proposed site boundary.

3. Site Drainage

3.1 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. 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 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 track 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 tracks and along the periphery of the turbines, crane hardstands, substation compound, met mast, borrow pit and the temporary site construction compound.

The treatment system will consist of a series of settlement ponds at designated locations throughout the site (refer to Section 3.4.3). 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 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 access track at suitable intervals and at low points depending on the site topography. In the illustration 'dirty water' drains collect all incident rainwater that falls on the infrastructure. This water then drains to settlement ponds for removal of sediment before it is discharged via overland dispersal to the downstream watercourse.

The site drainage layout is presented in 22156-MWP-01-00-DR-C-5006 to 22156-MWP-11-00-DR-C-5006 with drainage details presented in Planning Drawing 22156-MWP-00-00-DR-C-5406. The drainage layout is overlaid on background OSI mapping in the drawings that accompany the planning application.

Figure 4: Separation of Clean and Dirty Water Drainage on A Wind Farm Site

3.2 Flood Attenuation

The creation of impermeable areas within a development site has the effect of increasing rates of runoff into the downstream drainage system and this may increase flood risk and flood severity downstream. This applies particularly to urban areas that drain to closed pipe systems which do not have the capacity to cater for increased hydraulic loads. The proposed development is located within a large rural catchment with an open drainage system. The footprint of the impermeable areas and the associated increase in runoff rate is 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 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 access tracks 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 and agricultural 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.

3.3 Drainage/Stream Channel Crossings

There will be some works within 50m of watercourses identified in Planning Drawing No. 22156-MWP-DR-C-5006 at the following locations.

- Temporary Construction Site Entrance;
- Grid Connection to OHL;
- Met Mast works.

Where possible existing drains will remain untouched. There will be a short section of an existing drain diverted in the vicinity of T4 to eliminate the risk of sediment release during construction. No other areas of works will take place within 50m buffer zones of EPA mapped watercourses identified Chapter 08 Water except for drainage/stream crossings and associated track construction. Working near watercourses during or after intense or prolonged rainfall events will be avoided and work will cease entirely near watercourses when it is evident that there is a risk that pollution could occur. All construction method statements will be developed in consultation with Inland Fisheries Ireland and in accordance with the details in the proposed development CEMP. Crossings will be subject to a Section 50 application to ensure flood risk upstream and downstream of the crossing is not increased.

The selection criteria for crossing natural / artificial drains and streams within the site were:

- Avoid crossing drains or streams at acute angles where possible;
- Avoid meanders at the crossing location;
- Cross where foundations could be constructed without excess excavation;
- Consider vertical alignment requirements;

Where crossings are cut into relatively deep channels these channels would require significant upfill to maintain vertical alignment criteria for turbine deliveries along access tracks. 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 track design. Refer to 22156-MWP-00-00-DR-C-5412 for further details.

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 / riverbed;
- 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 / riverbank is maintained during construction which will in turn avoid the occurrence of in-stream works.

Construction of any 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 will 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 the proposed development. 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 50m hydrology buffer zone at the proposed borrow pit. 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 50m 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 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 track surface will be laid over the culvert structure using 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 track over the culvert crossing into the dirty water system outside of the 50m 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 5: Typical clear span pre-cast concrete units in place over an existing watercourse

Alternatively precast concrete or HDPE pipes may be used for crossing existing natural or artificial drainage / stream channels. All crossings will be designed for a minimum 1 in 200-year return rainfall event. The invert of the pipe is submerged approximately $^{1}/_{4}$ of its diameter below the original drainage bed. Where natural gradients allow, a nominal back fall in the pipe will be incorporated to prevent scour and promote the settling of natural material along the invert of the pipe. An example of a permanent drain crossing is illustrated in Figure 6. New turbine service tracks will be required to cross several minor drains / streams within the site. All such crossings will be in accordance with this application and/or conditions attached to a grant of planning permission and agreed with the OPW and Inland Fisheries Ireland prior to construction.

Figure 6: Typical concrete pipe channel crossing

Figure 7 shows a typical measure to be put in place at drainage and watercourse crossings to ensure dirty water does not enter clean watercourses. For the proposed development, vegetated soil bunds will be used to divert dirty water generated on the section of track over the crossings to the dirty water system. Alternatively silt curtains, as shown in Figure 8, will be placed along the access tracks within the 50m buffer zone. These silt curtains will 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 7: Dirty water containment at watercourse crossings

Figure 8: Silt curtain containment along existing tracks near watercourses

3.4 Water Quality Management Systems

3.4.1 General

Sediment such as clay or silt can cause 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 proposed 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 experience of environmental constraints and issues from construction of wind farms in similar environmental conditions;
- Technical guidance and best management practice manuals.

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 tracks 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 the proposed development will not create adverse effects on the aquatic environment.

3.4.2 Construction Works Area

Runoff from the internal access tracks, 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 track.

Dewatering of turbine base excavations can result in significant flow rates to the drainage and settlement system if high-capacity pumps are used. To avoid the need for pumping drainage channels from the excavations will be implemented 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 9: Stone check dam with large aggregate on downstream side

3.4.3 Treatment Process

Contaminated runoff can be generated on the site access tracks, borrow pit, met mast, construction compound, substation site 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.

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 will first be lowered to a minimum level by pumping without disturbing the settled sediment. The sediment will 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 10 shows a well-constructed and maintained tiered settlement pond. This example is in an upland environment with significant ground surface slope and operates efficiently if it is well maintained. The design has been developed in conjunction with Inland Fisheries Ireland personnel and local authority engineers.

Figure 10: Multi-tiered settlement pond with stone filter

The design of the settlement pond system for the proposed development is detailed in the Planning Drawing 22156-MWP-00-00-DR-C-5406.

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. 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.

3.4.4 Inspection and Maintenance

The drainage and treatment system for the proposed development will be managed and monitored at all times and particularly after heavy rainfall events during the construction phase. The drainage and treatment system will be regularly inspected and maintained to ensure that any failures are quickly identified and repaired so as to prevent water pollution. A programme of inspection and maintenance will be designed and dedicated construction personnel assigned to manage this programme. A checklist of the inspection and maintenance control measures will be developed and records kept of inspections and maintenance works. These drainage controls will be kept in place during the operational phase of the wind farm until the vegetation is re-established.

3.4.5 Weather Monitoring

Weather monitoring is a key input to the successful management of the drainage and treatment system during the construction of the wind farm. This, at a minimum, will involve 24 hour advance meteorological forecasting (Met Éireann download) and on site rain gauge linked to a trigger-response system. When a pre-determined rainfall trigger level is exceeded (e.g., 1 in 5 year storm event), planned responses will be undertaken. These responses will involve control measures including the cessation of construction until the storm event has passed over and flood flows have subsided. Dedicated construction personnel will be assigned to monitor weather.

3.4.6 Water Quality Monitoring

A programme for water monitoring will be prepared in consultation Clare County Council and with Inland Fisheries Ireland prior to the commencement of the construction of the proposed development. The plan will include monitoring of water during the pre-, throughout and post construction phases.

Further baseline water quality monitoring of all streams near the development site will be undertaken prior to construction to confirm existing conditions at the time of construction. This baseline data will include the main components of a full hydrograph for the streams including both high spate flow and base flow where possible.

During the construction phase of the project, water quality in the streams and outflow from the drainage and attenuation system will be monitored, field-tested and laboratory tested on a regular basis during different weather conditions. This monitoring together with the visual monitoring will help to ensure that the mitigation measures that are in place to protect water quality are working effectively.

During the construction phase of the project, the development areas will be monitored regularly for evidence of groundwater seepage, water ponding and wetting of previously dry spots, and visual monitoring of the effectiveness of the constructed drainage and attenuation system to ensure it does not become blocked, eroded, or damaged during the construction process.

3.4.7 Water Quality Monitoring Surface Water Quality and Cementitious Material

It is important to prevent raw cement from entering waterways within and near the proposed development.

Cement is required as a constituent for concrete. Concrete will be used for construction of the 12 no. turbine bases, the substation buildings, grid connection, any culvert crossings and a small quantity will be needed for the meteorological mast foundation.

The primary method of reducing the potential impact from cementitious material on the hydrology of the wind farm site is the selection of ready-mixed concrete as opposed to site batching of concrete. Site batching requires the delivery and storage on site of significant quantities of raw cement. The chemical reactivity of cement is at its most vigorous in the early stages of its activation by water (hydrolysis, typically in the first 15 minutes). In the batching plant water is added to the cement at the correct water/cement ratio to fully activate the cement hydration process.

By removing cement in its raw state from the site the potential for a significant impact from hydrolysis of cement in the surrounding watercourses is eliminated. When ready-mixed concrete is used the hydrolysis stage of the cement process has already been completed during the batching process and the chemical reaction undergoes a dormancy period during which it enters a plastic state. During this period the concrete is delivered and placed. After approximately 3 hours the cement in the concrete enters a third stage of the chemical process where it hardens, primarily due to the hydration of tricalcium silicate. This process increases in activity for approximately 12 hours and then decreases over the following 20 hours. After approximately 36 hours the concrete is considered to have set.

As part of the curing process the top exposed surface of poured concrete is covered in a curing blanket which eliminates the effect of rain washing down uncured cement from the top surface. Concrete placement for a truck load is typically complete within 3 hours of batching. It is normal for the truck operator to wash out the drum and chutes of the truck on site. This typically requires approximately 250 litres of water to complete. This concrete washout contains cement that has not fully completed the hydration process and as a result can have an elevated pH level (higher alkalinity).

Concrete truck washouts for the proposed development will be limited to washing down chutes only, reducing water volume to approximately 25 litres. The chute wash down area, which will retain the washout water, will be located within the construction compound and there will be no other chute wash down activity on any other part of the wind farm site.

Washout of concrete truck drums will be carried out at the source quarry. There will be no on-site batching of concrete; concrete requirements will be met by ready-mix suppliers.

The environmental manager will monitor the pH of the water in the chute wash out bund and can dose with CO_2 or acidic water from the drains until the wash out water achieves neutrality before discharge. Any overflow of water will be collected in the site compound drainage system which will be connected to a settlement pond for treatment prior to discharge to the external drainage system. The concrete sediment in the construction compound washout area will be removed at regular intervals.

3.4.8 Sediment Ponds

Dedicated settlement ponds will be provided adjacent to access tracks, hardstands, substation, borrow pit, and deposition areas. The criteria for settling efficiency will be in accordance with that set down in CIRIA B14 Design of Flood Storage Reservoirs (Hall et al. 1993), for the efficient removal of suspended solids. Settlement ponds will be put in place prior to excavation for turbines or construction of site access tracks.

All drains adjacent to access tracks will discharge to settlement ponds which will reduce the flow velocity and allow the suspended solids to settle. There may be a requirement for a series of settlement ponds where storage volumes are insufficient to allow settlement. Drainage stone will be placed at the inlet and outlet to the ponds to filter the flows before they enter the ponds. The ponds will have a modular surface area of 24 m^2 to cater for a runoff area of 1,200 m^2. Where larger areas have to be catered for, the pond area will increase pro rata. The settlement capacity is independent of depth; however, a nominal depth of 1.00 metres will be used to allow for storage of settled material. The length to width ratio will be at least 5:1 to encourage uniform flow across the cross-section of the pond and to avoid short-circuiting of the flow.

In the event of an emergency, the settlement ponds will provide a temporary holding area for any accidental spills on site as it will be possible to block off the outflow for a limited period. The settlement ponds will be fenced off for safety.

The outfall detail from the ponds will include a stone filter bed of length 1.5m and 200mm depth. This stone filter bed will encourage the diffuse spread of flow back into the downstream watercourses. This will also help to mitigate the effect of flows above the design flow rate.

3.4.9 Settlement Pond Design

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 2 and Table 3) demonstrate that the chance of occurrence of a storm event of a given duration decreases (higher return period) as intensity increases.

Table 2 shows the Point Rainfall Frequency and the total rainfall for each duration and return period in millimetres. Table 3 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 168mm/hour and a 5-minute duration would be expected to occur once in a 100-year period (the first row of Table 3). 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 proposed development 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 3.4.11. Longer duration storms of 24 hours or more, generally have very low intensity and are not critical in terms of the runoff rates that they generate.

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

The design runoff rate, used for the drainage design, is calculated using the Modified Rational Approach formula:

$$Q = 2.78\ C_v\ C_r\ i\ A_i$$

where c_v is the volumetric coefficient which is dependent upon the catchment characteristics it is assumed to be 0.84 for the winter profiles as stated in the Flood Studies Report,

c_r is the routing coefficient, the Wallingford recommends this to be 1.3.

i is the rainfall intensity in mm/hr, and

A_i is the impervious area drained surface area in ha. The percentage imperviousness (PIMP) obtained by dividing the total directly connected impervious area (A_i) by the total contributing area (A). PIMP is assumed to be equal to 70% for the hardcore surface. (A_i =PIMP x A)

For a rainfall intensity of 20mm/hour and a total drained area of 1,200m^2 the runoff rate is:

Q = 2.78 x 0.84 x 1.3x 20 x (0.70 x 1,200) litres/second

= 5.10 litres/second ($0.0051m^3/s$)

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/s 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=$1*10^{-5}$ metres) the settlement velocity, V_s, is:

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

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

= 0.000234 m/sec.

The required settlement pond surface area is

A_p = Q/V_s

= 0.0051/0.000234

= 21.79m^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 1m. 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.

3.4.10 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 1. 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 6.61m^3 for 15 minutes storm duration. This is equivalent to 24 minutes of flow through the settlement pond at the design-through flow rate of 5.10 litres/second. The stored water will drain off gradually as runoff from the works area subsides. The storage volume represents an average depth of 0.055m in a 200m long, 0.60m wide open drain and can therefore be easily accommodated in the drainage system.

Table 1: Calculated Drainage Storage Volumes

Storm Event	Duration (minutes)	Rainfall rate (mm/hour)	Excess (mm/hour)	Storage Volume (m^3)
M10-60min	60	19.60	00.00	0.00
M10-30min	30	30.8	10.80	4.96
M10-15min	15	48.80	28.80	6.61
M10-10min	10	62.40	42.40	6.49
M10-5min	5	88.80	68.80	5.26

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 2: Met Éireann point rainfall frequency table (rainfall depth in mm)

Storm Duration	Return Period (Years)							
	0.5	1	2	5	10	20	50	100
5 min	2.6	3.6	4.2	6	7.4	9	11.6	14
10 min	3.6	5	5.8	8.4	10.4	12.6	16.2	19.5
15 min	4.2	5.9	6.8	9.9	12.2	14.8	19	22.9
30 min	5.6	7.7	8.9	12.6	15.4	18.7	23.7	28.3
60 min	7.4	10.1	11.5	16.1	19.6	23.5	29.5	35
2 hours	9.8	13.2	14.9	20.6	24.8	29.5	36.7	43.2
3 hours	11.5	15.4	17.4	23.8	28.5	33.7	41.8	49
4 hours	12.9	17.2	19.4	26.3	31.5	37.1	45.8	53.5
6 hours	15.2	20	22.5	30.4	36.1	42.4	52	60.5
9 hours	17.9	23.4	26.2	35.1	41.5	48.5	59.2	68.5
12 hours	20.1	26.1	29.2	38.8	45.8	53.4	64.8	74.8
18 hours	23.6	30.5	34	44.8	52.6	61	73.7	84.7
24 hours	26.6	34.1	37.9	49.6	58.1	67.1	80.7	92.5

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

Storm Duration	Return Period (Years)							
	0.5	1	2	5	10	20	50	100
5 min	31.2	43.2	50.4	72.0	88.8	108.0	139.2	168.0
10 min	21.6	30.0	34.8	50.4	62.4	75.6	97.2	117.0
15 min	16.8	23.6	27.2	39.6	48.8	59.2	76.0	91.6
30 min	11.2	15.4	17.8	25.2	30.8	37.4	47.4	56.6
60 min	7.4	10.1	11.5	16.1	19.6	23.5	29.5	35.0
2 hours	4.9	6.6	7.5	10.3	12.4	14.8	18.4	21.6
3 hours	3.8	5.1	5.8	7.9	9.5	11.2	13.9	16.3
4 hours	3.2	4.3	4.9	6.6	7.9	9.3	11.5	13.4
6 hours	2.5	3.3	3.8	5.1	6.0	7.1	8.7	10.1
9 hours	2.0	2.6	2.9	3.9	4.6	5.4	6.6	7.6
12 hours	1.7	2.2	2.4	3.2	3.8	4.5	5.4	6.2
18 hours	1.3	1.7	1.9	2.5	2.9	3.4	4.1	4.7
24 hours	1.1	1.4	1.6	2.1	2.4	2.8	3.4	3.9

3.4.11 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. Where access tracks have a greater than 2% gradient, check dams will be installed. 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. The check dams will be constructed in stone of minimum size 37.5mm and will be laid at a spacing of between 9m and 30m dependent on slope. The bottom of the upper check dam will be at same height as the top of lower check dam. Examples of check dam or swales are shown below in **Figure 11**.

Figure 11: Examples of check dams along trackside drainage channels

3.4.12 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 attenuating and filtering the discharge. An example of a typical silt fence installation is shown in Figure 12.

Figure 12: Example of a silt fence used in conjunction with check dams along trackside drainage channels

4. Implementation of Surface Water Management Plan

4.1 Construction Elements and Specific Control Measures

This section details the procedures which will be followed by the Contractor to ensure the proper implementation of appropriate water quality control measures during the construction of each element of works.

4.1.1 Drainage System

A robust drainage system, based on the design principles outlined in **Section 3**, will be put in place including maintenance and enhancement of existing drainage, as well as new systems, to minimise sediment release during construction. The existing drainage system will be retained and improved where required. Along new access tracks, interceptor drains and silt traps will be put in place simultaneously with the construction of site access tracks and turbine base construction, such that excavation works and any constructed hard surface or mineral soils storage areas will have a functioning drainage system in place in advance of the main construction activity. Drains adjacent to access tracks, and cable trenches, will be excavated as outlined in the Forest Road Manual (Ryan et al., 2004). The increase in the rate of run-off along the route of the site access tracks and hard-standing areas will be mitigated by the proposed drainage system which includes the provision of settlement ponds to reduce the concentration of suspended solids in the run-off from these areas, and the addition of silt fencing where deemed necessary.

Disturbance to the soil layer adjacent to these tracks will be minimised and thus there will be a low potential for an increase in suspended solids in the surface water run-off. Silt traps will be provided at regular intervals in the existing drains along the tracks to mitigate any increase in suspended solids in the surface water run-off due to trafficking these access tracks from the construction areas.

Where the tracks have a gradient greater than 2%, check dams will be installed in the drains. The check dams will be constructed in stone of minimum size 37.5mm and will be laid at a spacing of between 9m and 30m dependent on the site slope. The bottom of the upper check dam will be at same height as the top of lower check dam.

4.1.2 Existing Access Tracks and associated Drainage Infrastructure

Prior to commencing any construction works associated with the upgrading of the existing access tracks and associated drainage infrastructure, the Contractor will set out the proposed works identified in the drainage design drawings. This will include:

- Set out alignment of proposed modifications to existing access tracks including widening, realignment and strengthening/alterations to vertical alignment with ranging rods/timber posts in accordance with construction drawings.
- Set locations of any water quality control measures required to existing access tracks in accordance with those outlined in **Section 3** and drainage design drawings.
- Set out appropriate new interception drains upslope of the works, provision of check dams on trackside swales etc, as identified on drainage design drawings.

4.1.3 New Access Tracks and associated Drainage Infrastructure

Prior to commencing any construction works associated with the construction of new access tracks and drainage infrastructure, the Contractor will set out the proposed works identified in the design drawings. This will include:

- Setting out the alignment of the proposed access track centre lines with ranging rods/timber posts in accordance with design drawings.
- Set out and install interception drains upslope of new access tracks and associated pipework to convey 'clean water' to a discharge point via level spreader on the downslope side of road, in accordance with drainage design drawings.

All other water quality control measures identified on drainage design drawings including swales, culverts, check dams, settlement ponds, etc. will be installed, as appropriate either in advance or in conjunction with the access track construction works in order to ensure that no section of the works is left exposed to potential sediment run-off at any stage of the works.

4.1.4 Tree Felling

Some felling of coniferous trees is required in the vicinity of turbines, along the grid route and substation areas. Mitigation measures will be implemented in accordance with the Forestry and Water Quality Guidelines (DMNR, 2000) and Coillte (2009): Forest Operations & Water Protection Guidelines. These measures will prevent run-off erosion and consequent sediment release into the nearby watercourses.

4.1.5 Turbine Foundations, Crane Hardstanding Areas and associated Drainage Infrastructure

Prior to commencing any construction works associated with the construction of turbine foundations, crane hardstanding areas and associated drainage infrastructure, the Contractor will set out the proposed works identified in the design drawings. This will include:

- Set out turbine foundation and associated crane hardstanding area with ranging rods/timber posts in accordance with construction drawings.
- Set out location of all water quality control measures required at the crane hardstanding areas and turbine foundations in accordance with SWMP, including, as appropriate new interception drains upslope of the works, settlement ponds etc, as identified on the drainage design drawings.
- Install interception drain upslope of crane hardstanding area and turbine foundation including any associated pipework to convey 'clean water' to a discharge point via level spreader(s) on the downslope of the works in accordance with SWMP.

All other water quality control measures identified on the drainage design drawings including trackside swales, culverts, check dams, settlement ponds etc. will be installed, as appropriate, either in advance or in conjunction with the construction of the crane hardstanding area in order to ensure that no section of the works is left exposed to potential sediment run-off at any stage of the works. It is anticipated that the construction of the crane hardstanding and all water quality control measures associated with both the crane hardstanding and turbine foundation will be completed prior to commencement of the excavation and construction works for the turbine foundation.

The installation of each water quality control measure will be clearly recorded, along with its unique identification number, in accordance with the SWMP, on 'as-built' records of the works as the works proceed.

4.1.6 Substation Compound and associated Drainage Infrastructure

Prior to commencing any construction works associated with the construction of the substation compound and associated drainage infrastructure, the Contractor will set out the proposed works identified on the drainage design drawings. This will include:

- Set out substation compound area with ranging rods/timber posts in accordance with construction drawings.
- Set out locations of all water quality control measures required in the substation area in accordance with SWMP including, as appropriate new interception drains upslope of the works, settlement ponds, etc. as identified on the drainage design drawings.
- Install interception drain upslope of substation area including any associated pipework to convey 'clean water' to discharge points via level spreader on downslope of the works in accordance with SWMP.

All other water quality control measures identified on the drainage design drawings including swales, culverts, check dams, settlement ponds, etc. will be installed, as appropriate, either in advance or in conjunction with the substation compound construction works in order to ensure that no section of the works is left exposed to potential sediment run-off at any stage of the works.

The installation of each water quality control measure will be clearly recorded, along with its unique identification number, in accordance with the SWMP, on 'as-built' records of the works as the works proceed.

4.1.7 Temporary Construction Compound

Figure 13 shows the location of the temporary construction compound. Prior to commencing any construction works associated with the construction of the temporary construction compound and associated drainage infrastructure, the Contractor will set out the proposed works identified on the drainage design drawings.

- Set out the construction compound area with ranging rods/timber posts in accordance with drainage design drawings.
- Set out locations of all water quality control measures required at the construction compound area in accordance with SWMP including, as appropriate new interception drains upslope of the works, settlement ponds, etc. as identified on the drainage design drawings.
- Install interception drain upslope of construction compound area including any associated pipework to convey 'clean water' to discharge points via level spreader on downslope side of works in accordance with SWMP.

The installation of each water quality control measure will be clearly recorded, along with its unique identification number, in accordance with the SWMP, on 'as-built' records of the works as the works proceed.

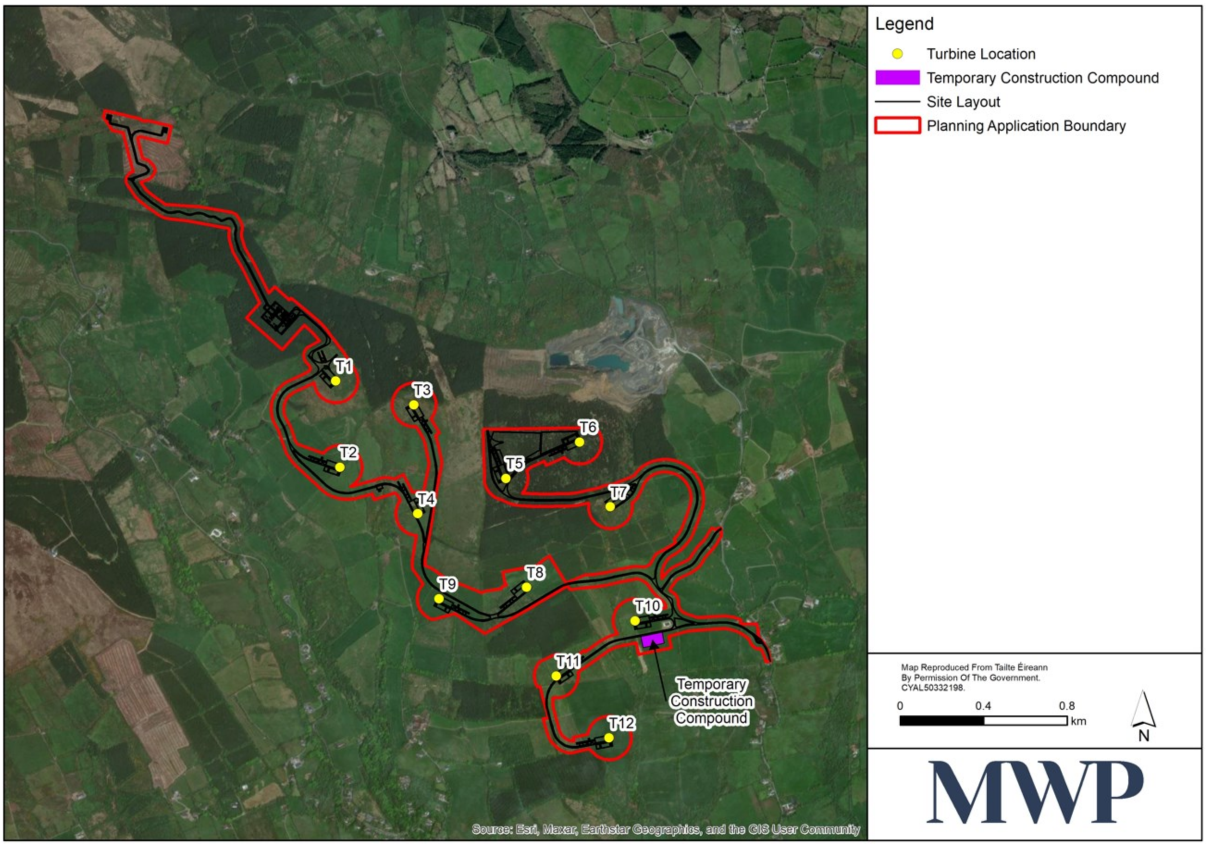

Figure 13: Location of Temporary Construction Compound

4.1.8 Borrow Pit and Deposition Area

There is one borrow pit and two dedicated spoil storage areas proposed. The borrow pit proposed within the site will be used to obtain approximately 30,000m^3 of subsoil and 165,000m^3 of site won stone aggregate for use in the construction of the wind farm. The borrow pit is located within the northern area of the site where it will be used as a source of hardcore for the construction of access tracks, crane hardstands, substation and construction compounds.

Prior to felling of trees over the area of the proposed borrow pit; an interceptor drain will first be excavated upslope to intercept existing overland flows and divert them around the borrow pit prior to discharge via a buffer zone on the downslope side.

Standing water, any surface water runoff or water pumped from within the borrow pit is likely to contain an increased concentration of suspended solids. Runoff or pumped water from the borrow pit 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 contain check dams that will attenuate the flow and provide storage for the increased runoff from exceptional rainfall events. The settlement ponds have been designed to a modular size where if larger areas of runoff must be catered for at a single discharge point the size of the settlement pond will be increased pro rata.

It is not anticipated that large volumes of groundwater will be encountered within the borrow pit. The bedrock in this area is comprised of sandstone bedrock which typically yields flow paths which are short, localised, and shallow. This is combined with the fact that there is no regional groundwater flow regime influencing groundwater inflows at the elevation of the borrow pit. Groundwater inflows will be influenced by recent rainfall and limited groundwater storage. It's location at the top of a ridge and alongside a watershed divide also ensures groundwater inflow will be restricted to recent recharge.

The engineered deposition areas are located away from drains and watercourses. During deposition, risk of erosion will be protected by a silt trapping apparatus such as a geotextile silt fence to prevent contamination of runoff. This will remain in place until deposition area is re-vegetated.

4.1.9 Concrete Control

During the pouring of concrete, effective containment measures will be implemented to avoid spilling concrete outside construction areas and to prevent concrete entering any part of the drainage system. To reduce the potential for cementitious material entering watercourses, concrete pours will be supervised by the construction manager. The construction manager will ensure that the area of the pour is completely drained of water before a pour commences. Pours will not take place during heavy rainfall.

There will be a dedicated concrete chute washout area on site. Concrete trucks will be washed out off site at the source quarry. Wet concrete operations are not envisaged for this site within or adjacent to watercourses or aquatic zones. No batching will take place on site. However, if wet concrete operations are required in such locations, a suitable risk assessment will be completed prior to works being carried out.

For the cable trench construction, temporary storage of Cement Bound Granular Mixtures will be in areas where there is no direct drainage to surface waters and where the area has been appropriately isolated with bunds.

4.1.10 Access Track Construction

To mitigate against siltation of storm water runoff, access track construction will consist of crushed aggregate with low fines content. The use of quarry dust will not be permitted.

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 track constructed from hard wearing aggregate, as opposed to low class aggregate, the level of suspended solids is reduced significantly. The internal access tracks will be finished with a hard-wearing aggregate. This can have the added benefit of contributing a balancing pH to help protect water quality from acidic runoff. The proposed development is serviced by a limestone quarry which can be used as a source of hard-wearing aggregate for road construction. The nearest quarry to the site is Ballycar Quarry and has the potential to supply these materials given its proximity to the site.

4.1.11 Wheel Washes

Wheel washes will be provided for heavy vehicles exiting the site to ensure that public roads outside of the site boundary are clean. These can take the form of dry or wet wheel wash facilities. In the case of a wet wheel wash a designated bunded and impermeable wheel wash area will be provided, and that the resultant wastewater will be diverted to a settlement pond for settling out of suspended solids.

4.1.12 Engineered Deposition Areas

Temporary engineered deposition areas will be designated where necessary at the turbine and hardstand locations to hold temporary stockpiles. These will be located away from drains and watercourses. Stockpiles that are at risk of erosion will be protected by a silt trapping apparatus such as a geo-textile silt fence to prevent contamination of runoff.

4.1.13 Cable Trenches

Cable trenches are typically developed in short sections, thereby minimising the amount of ground disturbance any one time and minimising the potential for drainage runoff to pick up silt or suspended solids. Each short section of trench is excavated, ducting installed and bedded and backfilled with the appropriate materials, before work on the next section commences. Measures to protect water quality during the installation of cable trenches include:

- Due cognisance will be given to prevailing ground conditions, season and weather conditions when undertaking the excavation works for the cable trenches to reduce the likelihood of surface water entering the excavations;
- The extent of cable trenches excavated prior to cable installation and backfilling will be limited in order to minimise the opportunity for surface water to enter the trenches;
- Temporary silt traps will be provided on longer trench runs and on steeper slopes;
- Where water quality control measures, such as trackside swales are disturbed to facilitate the cable installation, they will be immediately reinstated following the backfilling of the trench;
- Plugs of low permeability material will be installed at regular intervals along cable trenches which have the potential to act as conduits for surface water.

4.1.14 Storage Areas

Cement products are hazardous and will always be stored in a Control of Substances Hazardous to Health (COSHH) store or similar (such as a shipping container), and only be in the open when in use. If cement products are temporarily located in the open, then they will be located within an impermeable bunded area and covered to prevent contact with rainwater. This will prevent direct drainage of cement storage areas to surface waters. Bunding will be in the form of sandbags or silt fencing.

Spoil will also be stored around the turbines to a maximum height of 1m. The felled areas around the turbines have been identified as a potential additional area that will be used to store material; however, priority will be given to restoration of the borrow pit and the dedicated spoil storage areas.

No permanent stockpiles will be left on site after the completion of the construction phase works. After completion of the turbine base, reinstatement works will commence and all remaining stockpiles will be removed for permanent disposal at the proposed deposition areas within the site. Excavated soil will be removed to the designated material storage areas.

To facilitate both construction of the internal access tracks and disposal of excavated spoil and to avoid double handling and unnecessary transportation, excavated spoil will, where possible, be placed during construction directly into material storage areas.

Temporary stockpiles of spoil will not be permitted within 50m of any watercourse.

The drainage of the material storage areas will include the provision of settlement ponds to reduce the concentration of suspended solids in the run-off from these areas, and the addition of silt fencing where deemed necessary. Overland flows will be diverted around these areas. Material storage areas will be monitored to manage any potential loss of suspended solids to surface waters.

Any diesel or fuel oils stored on site will be protected by a bund with 110 % of the capacity of the storage tank.

4.1.15 Plant and Refuelling

Only qualified persons shall operate machinery or equipment. Machinery and equipment will be checked on a regular basis to ensure they are working properly (no oil/fuel leaks etc.). No refuelling will take place within 50m of any watercourse. Fuel will be stored in doubly-bunded bowsers or in bunded areas at the site compound. Plant nappies and spill kits will be readily available on plant equipment or when working with fuel operated heavy tools. To mitigate against sources of contamination, refuelling of plant and vehicles will only take place within designated areas of the site compound or in other areas specifically designated for this purpose. Only emergency breakdown maintenance will be carried out on site. Appropriate containment facilities will be provided to ensure that any spills from breakdown maintenance vehicles are contained and removed off site.

A suitable permanent fuel and oil interceptor will be installed to deal with all substation surface water drainage. Temporary petrol and oil interceptors will be installed at the site compound for plant repairs/storage of fuel/temporary generator installation.

4.1.16 Temporary Local Road Widening

To mitigate against siltation of storm water runoff, temporary road widening construction will consist of crushed aggregate with low fines content. The use of quarry dust will not be permitted.

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. Any temporary road widening will be finished with a hard-wearing aggregate. This can have the added benefit of contributing a balancing pH to help protect water quality from acidic runoff. The proposed development is serviced by a limestone quarry which can be used as a source of hard-wearing aggregate for road construction. The nearest quarry to the site is Ballycar Quarry and has the potential to supply these materials given its proximity to the site. Risk of erosion will be protected by a silt trapping apparatus such as a geotextile silt fence to prevent contamination of runoff. This will remain in place until the temporary widening area is re-vegetated.

4.1.17 Waste

A dedicated storage area will be provided at the site compound for building materials such as cables, geotextile membranes, blocks, tools and equipment, fence posts and wire, booms, pipes etc. A Waste Management Plan will be prepared by the Appointed Project Contractor for the construction phase. This will be prepared with reference to 'Best Practice Guidelines on the Preparation of Waste Management Plans for Construction and Demolition Projects' (DoEHLG, 2006).

Any material deemed unsuitable for re-use in the works will be transported off site in trucks and disposed of under license from Clare County Council. This will prevent any contaminated run-off to drains adjacent to access tracks during heavy rainfall.

All personnel working on site will be trained in pollution incident control response, and an emergency response plan will be prepared as part of the CEMP.

A NIS was completed for the proposed development and determined that there will be no adverse impacts on any qualifying interests of protected Natura 2000 sites hydrologically linked and downstream of the proposed site. Additionally, associated measures as outlined will be implemented as part of this SWMP and the CEMP during the construction and operational phases to ensure that there will be no significant adverse effects on the hydrological or hydrogeological regime pertaining to the development site.

4.2 Construction Phase Drainage Drainage Management

Prior to the construction works commencing, the ECoW will prepare an inspection and maintenance plan. Regular inspections of the drainage system and silt controls will be undertaken, especially after heavy rainfall. These drainage controls will be kept in place during the operational phase of the wind farm until the vegetation is re-established.

A Schedule of Works Operation Record (SOWOR), see Appendix 1 will be maintained throughout the construction phase of the proposed development. The SOWOR includes abandonment triggers, relating to the drainage and water quality treatment, so that site management are aware of the level of incidents which require abandonment of works. The abandonment triggers set out in the SOWOR will be adopted during inspections to ensure any of the conditions prescribed under an abandonment trigger does not exist at the locations under inspection.

Blockages, or standing water within the drainage systems will be identified and settlement ponds and silt controls will be inspected to ensure they are performing efficiently to treat the silt laden water. Following inspections, the ECoW will provide an action-list if there are improvements deemed necessary to the drainage and water quality control measures.

The following inspection programme is proposed:

- Periodic visual inspections at pre-determined water quality monitoring locations.
- The Environmental Manager/ECoW will walk the site each day and check the cross-drain pipes, dirty water drains and outlets, settlement ponds, interceptor drains and silt fences for any damage or blockages. Any damage or blockages will be repaired or cleared promptly.
- The following elements will be included for inspection:
    - All drainage systems of the proposed development;
    - All designated water quality monitoring locations;
    - Settlement ponds;
    - Silt fencing;
    - All site plant and equipment will be checked for leaks/plant condition.
- Event based inspections by the ECoW will be carried out as follows:
    - Following a high intensity localised rainfall event (10mm/hr);
    - Heavy rainfall within a day (25mm in a 24 hour period);
    - Higher than monthly rainfall within a week period.
- Quarterly site inspection of the drainage measures by the ECoW for a year following completion of construction phase.
- A written record will be maintained and available on-site of all construction phase monitoring that took place.

4.3 Operational Phase Drainage Management

The project ECoW will inspect and review the drainage system after construction has been completed to provide guidance on the requirements of an operational phase drainage system. This operational phase drainage system will have been installed during the construction phase in conjunction with the access track and hardstanding construction work as described below:

- Some interceptor drains will be left in place, upgradient of the proposed infrastructure to collect clean surface runoff, in order to minimise the amount of runoff reaching areas where suspended sediment could become entrained. It will then be directed to areas where it can be re-distributed over the ground by means of a level spreader;

- Swales/track side drains will remain in place to intercept and collect runoff from access tracks and hardstanding areas of the site, likely to have entrained suspended sediment, and channel it to stilling ponds for sediment settling;
- Check dams will be put in place at regular intervals along interceptor drains and swales/trackside drains in order to reduce flow velocities and therefore minimise erosion within the system during storm rainfall events; and,
- Settling ponds/settlement ponds, emplaced downstream of swales and trackside drains with buffer volumes of runoff discharging from the drainage system during periods of high rainfall, by retaining water until the storm hydrograph has receded, thus reducing the hydraulic loading to watercourses. Inspection of all settlement ponds, along with the entire drainage network, will be ongoing during the construction period.

In the operational phase of the wind farm, the reliance on the drainage system above will become reduced as areas naturally revegetate. Once areas revegetate, this will result in a resumption of the natural drainage management that will have existed prior to any construction.

5. Surface Water Quality Monitoring

A programme of surface water quality monitoring will be prepared in consultation with Inland Fisheries Ireland (IFI) prior to the commencement of the construction of the proposed development. The plan will include surface water quality monitoring during the pre-construction, construction and operational phase.

The following sections sets out a surface water quality monitoring programme, however is subject to change based on baseline monitoring results and agreements with IFI, Clare County Council etc.

5.1 Pre-Construction Baseline Monitoring

Pre-baseline construction monitoring will be carried out at the following proposed locations which drain the proposed development.

Table 4: Monitoring Locations Draining Proposed Development

Hydrometric Area	Subbasin	River Catchment	Watercourse	River Segment Code	Stream order	Monitoring Location	Coordinate x	Coordinate y
Shannon Estuary North	Crompaun (East)_010	Crompaun (East)	Crompaun	27_755	2	SW1	553790	663975
			Glennagross	27_431	2	SW2	554084	663753
			Cappateemore east	27_277	1	SW3	554792	663405
			Crompaun East	27_1129	3	SW4	555000	662040
Lower Shannon	North Ballycannan_ 010	North Ballycannan	North Ballycannan	25_866	1	SW5	556531	663068
			North Ballycannan	25_185	2	SW6	556445	661639
			West Ballycannan	25_1699	2	SW7	556084	661408
			South Ballycar	25_1694	1	SW8	556538	664031
			South Ballycar	25_181	3	SW9	557344	661790
			West Roo	25_1150	2	SW10	558026	662034
	Blackwater (Clare_010)	Blackwater (Clare)	Blackwater (Clare)	25_3209	3	SW11	559355	665585
			Kilnacreagh	25_3206	1	SW12	553630	665468

Baseline water quality monitoring will be required for each proposed monitoring location prior to commencement of the proposed development. Water quality field testing and laboratory analysis will be undertaken prior to commencement of felling and construction at the site. The monitoring programme will be subject to agreement with Clare County Council but will be based on the planning stage programme already outlined in the EIAR and CEMP and presented herein.

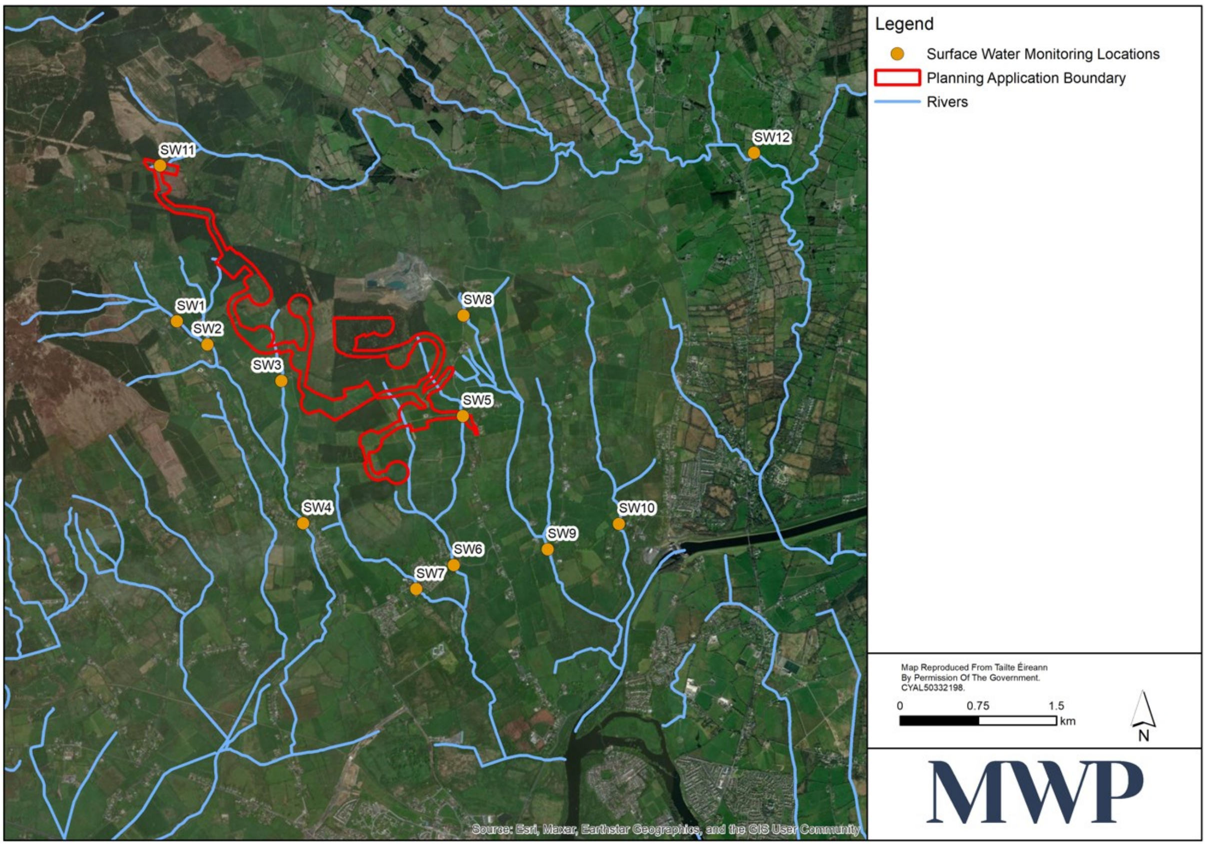

Figure 14: Water Quality Monitoring Locations

5.2 Construction Phase Monitoring

5.2.1 Continuous Field Monitoring

During the construction phase of the project, a surface water monitoring schedule, finalised prior to construction, will be followed. In summary, weekly field monitoring of surface water quality chemistry will be carried out at the identified 12 surface water quality monitoring locations in **Figure 14**, or others as required. The following parameters will be measured:

- pH (field measured);
- Electrical Conductivity (field measured);
- Temperature (field measured);
- Dissolved Oxygen (field measured);
- Total Dissolved Solids (TDS) (field measured);
- Turbidity (field measured).

5.2.2 Continuous, In-Situ Monitoring

Continuous, in-situ, monitoring equipment will be installed at selected locations. The monitoring equipment will provide continuous readings for turbidity levels, flow rate and water depth in the watercourses.

5.2.3 Monthly Laboratory Analysis

Each month, the ECoW will take samples from each location and bring to a laboratory for analysis on a range of parameters with relevant regulatory limits and EQSs. This will be compared with the baseline data obtained prior to construction from the EPA and from sampling. If the measured value exceeds the baseline values, the cause will be determined, and remedial measures put in place as necessary.

The analytical determinants of the monitoring programme (including limits of detection and frequency of analysis) will be as per S.I. No. 272 of 2009 European Communities Environmental Objectives (Surface Waters) Regulations and European Communities Environmental Objectives (Freshwater Pearl Mussel) Regulations 2009. The likely suite of determinants will include:

- pH;
- Total Petroleum Hydrocarbons (TPH);
- Temperature;
- Total Phosphorus;
- Chloride;
- Nitrate;
- Nitrite;
- Total Nitrogen;
- Orthophosphate;
- Ammonia N;
- Biochemical Oxygen Demand;
- Total Suspended Solids.

5.2.4 Visual Monitoring

Periodic visual observations at each of the monitoring points will be recorded with specific reference to flow, stream substrate and water colour. Photos will be taken to support visual observation, and inspection sheets including visual observation results and photographic records will be kept on site.

Visual observations will also be completed after major rainfall events along with photographs which will be collected and assessed by the EcoW.

The elements which will be included in the visual checklist are as follows:

- Appropriate period visual inspection of all watercourses which drain the proposed development by the ECoW or a suitably qualified and competent person delegated by the ECoW.
- All elements of drainage system will be monitored including settlement ponds, check dams, interceptor drains etc. Corrective action will be carried out if there is a visual indication of discolouration, oily sheen, odour or litter.
- Event based visual inspections by the ECoW as follows:
    - Following a high intensity localised rainfall event (10mm/hr);
    - Heavy rainfall within a day (25mm in a 24 hour period);
    - Higher than monthly rainfall within a week period.

- A record of all visual inspections will be included in the Construction Environmental Management Plan (CEMP) and maintained on site.

5.3 Surface Water Monitoring Reporting

The ECoW will be responsible for presenting the surface water monitoring results at or in advance of regular site meetings.

The reports will include results from field monitoring as well as visual inspections and laboratory analysis completed for that period. The reports will describe how the results compare with baseline results. Any deterioration in water quality deemed to be caused by construction activity will be flagged and appropriate remediation or corrective actions recommended.

5.4 Monthly Operational Monitoring

Monthly sampling of water monitoring locations will continue once construction is complete. Sampling will cease once the ECoW is satisfied there is no adverse impacts to the natural watercourses and that surface water quality parameters are in line with baseline levels.

Appendix 1

Scheduling of Works Operating Record Example (SOWOR)

Work Item No.	Description	Risk	Triggers to be met prior to works commencement				Stop Works Triggers (If any of the four triggers is met)			
			T1 Drainage treatment infrastructure installed prior to works commencing. All in good working order	T2 River/watercourse turbidity reading taken	T3 Daily visual inspection procedure in place by ECoW	T4 Weather forecast checked prior to works and current weather checked on site before works.	T1 Silt controls or drainage measures within the works catchment damaged	T2 Elevated Turbidity readings	T3 Deterioration in SW quality reported by ECoW	T4 Weather forecast checked prior to works and current weather checked on site before works.
1	Enabling works including site compound setup, fencing, tree felling.	High Risk	Drainage measures to be installed as per SWMP	Turbidity at baseline levels	Inspection procedure must be in place and ECoW must report satisfactory surface water quality before works can commence	Check forecast and refer to rainfall limits in Category 2 (below)	Stop works, ECoW to inform site manager. Corrective actions to be taken to fix silt controls or drainage system.	Turbidity 20% above baseline or 15 NTU (depending on baseline data analysis)	Stop works. Investigate issue causing deterioration in SW quality and recommend corrective actions.	Category 2 rainfall figures
2	Borrow Pit works	Very High Risk	Drainage measures to be installed as per SWMP	Turbidity at baseline levels	Inspection procedure must be in place and ECoW must report satisfactory surface water quality before works can commence	Check forecast and refer to rainfall limits in Category 1 (below)	Stop works, ECoW to inform site manager. Corrective actions to be taken to fix silt controls or drainage system.	Turbidity 20% above baseline or 15 NTU (depending on baseline data analysis)	Stop works. Investigate issue causing deterioration in SW quality and recommend corrective actions.	Category 1 rainfall figures
3	Roads excavations, road widening	Very High Risk	Drainage measures to be installed as per SWMP	Turbidity at baseline levels	Inspection procedure must be in place and ECoW must report satisfactory surface water quality before works can commence	Check forecast and refer to rainfall limits in Category 1 (below)	Stop works, ECoW to inform site manager. Corrective actions to be taken to fix silt controls or drainage system.	Turbidity 20% above baseline or 15 NTU (depending on baseline data analysis)	Stop works. Investigate issue causing deterioration in SW quality and recommend corrective actions.	Category 1 rainfall figures

Work Item No.	Description	Risk	Triggers to be met prior to works commencement				Stop Works Triggers (If any of the four triggers is met)			
			T1 Drainage treatment infrastructure installed prior to works commencing. All in good working order	T2 River/watercourse turbidity reading taken	T3 Daily visual inspection procedure in place by ECoW	T4 Weather forecast checked prior to works and current weather checked on site before works.	T1 Silt controls or drainage measures within the works catchment damaged	T2 Elevated Turbidity readings	T3 Deterioration in SW quality reported by ECoW	T4 Weather forecast checked prior to works and current weather checked on site before works.
4	New Access Tracks and associated drainage infrastructure	Very High Risk	Drainage measures to be installed as per SWMP	Turbidity at baseline levels	Inspection procedure must be in place and ECoW must report satisfactory surface water quality before works can commence	Check forecast and refer to rainfall limits in Category 1 (below)	Stop works, ECoW to inform site manager. Corrective actions to be taken to fix silt controls or drainage system.	Turbidity 20% above baseline or 15 NTU (depending on baseline data analysis)	Stop works. Investigate issue causing deterioration in SW quality and recommend corrective actions.	Category 1 rainfall figures
5	Substation Compound and associated Drainage Infrastructure	Very High Risk	Drainage measures to be installed as per SWMP	Turbidity at baseline levels	Inspection procedure must be in place and ECoW must report satisfactory surface water quality before works can commence	Check forecast and refer to rainfall limits in Category 1 (below)	Stop works, ECoW to inform site manager. Corrective actions to be taken to fix silt controls or drainage system.	Turbidity 20% above baseline or 15 NTU (depending on baseline data analysis)	Stop works. Investigate issue causing deterioration in SW quality and recommend corrective actions.	Category 1 rainfall figures
6	Turbine Foundations, Crane Hardstanding Areas and associated drainage infrastructure	Very High Risk	Drainage measures to be installed as per SWMP	Turbidity at baseline levels	Inspection procedure must be in place and ECoW must report satisfactory surface water quality before works can commence	Check forecast and refer to rainfall limits in Category 1 (below)	Stop works, ECoW to inform site manager. Corrective actions to be taken to fix silt controls or drainage system.	Turbidity 20% above baseline or 15 NTU (depending on baseline data analysis)	Stop works. Investigate issue causing deterioration in SW quality and recommend corrective actions.	Category 1 rainfall figures
8	Cable Trenches	High Risk	Drainage measures to be	Turbidity at baseline levels	Inspection procedure must	Check forecast and refer to	Stop works, ECoW to inform site manager.	Turbidity 20% above	Stop works. Investigate issue	Category 1 rainfall figures

MWP

Work Item No.	Description	Risk	Triggers to be met prior to works commencement				Stop Works Triggers (If any of the four triggers is met)			
			T1 Drainage treatment infrastructure installed prior to works commencing. All in good working order	T2 River/watercourse turbidity reading taken	T3 Daily visual inspection procedure in place by ECoW	T4 Weather forecast checked prior to works and current weather checked on site before works.	T1 Silt controls or drainage measures within the works catchment damaged	T2 Elevated Turbidity readings	T3 Deterioration in SW quality reported by ECoW	T4 Weather forecast checked prior to works and current weather checked on site before works.
			installed as per SWMP		be in place and ECoW must report satisfactory surface water quality before works can commence	rainfall limits in Category 1 (below)	Corrective actions to be taken to fix silt controls or drainage system.	baseline or 15 NTU (depending on baseline data analysis)	causing deterioration in SW quality and recommend corrective actions.	
9	Culvert Upgrade or replacement works	Very High Risk	Drainage measures to be installed as per SWMP	Turbidity at baseline levels	Inspection procedure must be in place and ECoW must report satisfactory surface water quality before works can commence	Check forecast and refer to rainfall limits in Category 1 (below)	Stop works, ECoW to inform site manager. Corrective actions to be taken to fix silt controls or drainage system.	Turbidity 20% above baseline or 15 NTU (depending on baseline data analysis)	Stop works. Investigate issue causing deterioration in SW quality and recommend corrective actions.	Category 1 rainfall figures
10	Access Track Drainage Works	Very High Risk	Drainage measures to be installed as per SWMP	Turbidity at baseline levels	Inspection procedure must be in place and ECoW must report satisfactory surface water quality before works can commence	Check forecast and refer to rainfall limits in Category 1 (below)	Stop works, ECoW to inform site manager. Corrective actions to be taken to fix silt controls or drainage system.	Turbidity 20% above baseline or 15 NTU (depending on baseline data analysis)	Stop works. Investigate issue causing deterioration in SW quality and recommend corrective actions.	Category 1 rainfall figures

	Rainfall Figures
Category 1 – Very High Risk	>10mm/hr (i.e high intensity rainfall event)
	>25mm/hr in a 24-hour period (heavy rainfall lasting most of the day); or,
	>half monthly average rainfall in any 7 days
	No overland flow or pathway for water movement
	Conditions on ground same as forecast
Category 2 – High Risk	>10mm/hr (i.e high intensity rainfall event)
	>25mm/hr in a 24-hour period (heavy rainfall lasting most of the day); or,
	>half monthly average rainfall in any 7 days
	Conditions on ground same as forecast
Category 3 – Medium Risk	Rainfall amounts lower than category 1 and 2
	<10mm/hr (i.e high intensity rainfall event)
	<25mm/hr in a 24-hour period (heavy rainfall lasting most of the day); or,
	<half monthly average rainfall in any 7 days
	Conditions on ground same as forecast