MWP

Appendix 8A – Flood Risk Assessment

Ballynisky Wind Farm

Ballynisky Green Energy Ltd.

December 2025

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SITE SPECIFIC FLOOD RISK ASSESSMENT

PROPOSED WIND FARM

BALLYNISKY

COUNTY LIMERICK

Prepared For: -

Malachy Walsh & Partners
Reen Point
Blennerville
Tralee
Co. Kerry

Prepared By: -

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August 2025

Project	Flood Risk Assessment			
Client	MWP			
Report No	Date	Status	Prepared By	Reviewed By
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	15/05/2023	Rev A		
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1. INTRODUCTION

Malachy Walsh & Partners (MWP) Consulting Engineers commissioned O'Callaghan Moran & Associates (OCM) to complete a Flood Risk Assessment (FRA) to accompany a planning application for the development of a Wind Farm at Ballynisky, Co. Limerick.

1.1 Methodology

The FRA followed the guidance in the 2009 Department of the Environment, Heritage and Local Government/ Office of Public Works Guidelines, 'The Planning System and Flood Risk Management Guidelines for Planning Authorities' (Guidelines) and had regard to the Limerick Development Plan 2022-2028: Strategic Flood Risk Assessment (2022-2028) (Strategic FRA) and Strategic Flood Risk Assessment January 2018 prepared by Aecom/Roughan O'Donovan as part of the preparation of the Proposed Variation No. 6, Limerick County Development Plan 2010-2016 (as extended).

The Strategic FRA requires that all proposed developments, regardless of location, must be subject to an appropriately detailed flood risk assessment. At a minimum this will include a "Stage 1 - Identification of Flood Risk". Where flood risk is identified, a "Stage 2 - Initial FRA" will be required and, depending on the scale and nature of the risk, a "Stage 3 - Detailed FRA" may be required.

A detailed topographic survey was completed, and site visits were carried out to establish potential sources of flooding, likely routes of flood waters and the site's key features.

MWP completed a hydraulic analysis in relation to the construction of a new internal access track incorporating a bridge crossing of the Ahacronane River. The analysis included assessment of local hydrology, flow estimation, and hydraulic modelling for the proposed bridge crossing. The assessment is in Appendix 1.

2. PLANNING SYSTEM AND FLOOD RISK MANAGEMENT GUIDELINES

The Guidelines require an assessment of flood risk to identify where the water comes from (i.e. the source), how and where it flows (i.e. the pathways) and the people and assets affected by it (i.e. the receptors). The Guidelines recommend the following staged approach:

- **Stage 1: Flood Risk Identification**: To identify any potential flooding or surface water management issues identified in regional flood studies, county development plans and Local Area Plans;
- **Stage 2**: **Initial Flood Risk Assessment**: To determine sources of flooding that may affect a proposed development site, to evaluate the adequacy of existing information and to scope the extent of risk of flooding. The scope will depend on the type and scale of development, the sensitivity of the area and on whether a Strategic FRA has been carried out by the planning authority; and
- **Stage 3: Details Flood Risk Assessment**: To assess flood risk issues in sufficient detail and to provide a quantitative appraisal of potential flood risk to a proposed or existing development of its potential impact on flood risk elsewhere and of the effectiveness of any proposed mitigation measures.

Flood zones are geographical areas within which the likelihood of flooding is in a particular range and they are a key tool in flood risk management within the planning process as well as in flood warning and emergency planning. There are three types or levels of flood zones:

- **Zone A** where the probability of flooding from rivers and the sea is highest (greater than 1% or 1 in 100 for river flooding or 0.5% or 1 in 200 for coastal flooding);
- **Zone B** where the probability of flooding from rivers and the sea is moderate (between 0.1% or 1 in 1000 and 1% or 1 in 100 for river flooding and between 0.1% or 1 in 1000 year and 0.5% or 1 in 200 for coastal flooding);
- **Zone C** where the probability of flooding from rivers and the sea is low (less than 0.1% or 1 in 1000 for both river and coastal flooding). Flood Zone C covers all areas of the plan which are not in zones A or B.

The designation of the zones does not take account of the potential for flooding from other sources, such as ground water or artificial drainage systems. These sources could occur in any of the zones and therefore must be considered.

The consequences of flooding depend on the hazards caused by flooding (depth of water, speed of flow, rate of onset, duration, wave-action effects, water quality) and the vulnerability of receptors (type of development, nature, e.g. age-structure, of the population, presence and reliability of mitigation measures etc). The Guidelines identify three vulnerability categories based on the type of development:

- **Highly vulnerable**, including residential properties, essential infrastructure and emergency service facilities;
- **Less vulnerable**, including commercial and industrial uses, sites used for short-let for caravans and camping and secondary strategic transport and utilities infrastructure, and water-compatible development might be considered appropriate;
- **Water compatible**, including open space, outdoor recreation and associated essential infrastructure, such as changing rooms.

The approach to the integration of flood risk assessment and management in the planning process requires the application of core principles that should inform and underpin planning policy and guidance at all levels in the planning process. These *inter alia* include:

- Flood hazard and potential flood risk from all sources should be identified and considered at the earliest stage in the planning process and as part of an overall hierarchy of national responses coupled to regional appraisal and local and site-specific assessments of flood risk;
- Development should preferentially be located in areas with little or no flood hazard thereby avoiding or minimising the risk. Development in the context of the Guidelines includes all construction, such as transport and utility infrastructure as well as residential and other buildings;

- Development should only be permitted in areas at risk of flooding, when there are no alternative, reasonable sites available in areas at lower risk that also meet the objectives of proper planning and sustainable development;
- Where development has to be located in areas at risk of flooding, an appropriate land use should be selected;
- A precautionary approach should be applied, where necessary, to reflect uncertainties in flooding datasets and risk assessment techniques and the ability to predict the future climate and performance of existing flood defences. Development should be designed with careful consideration to possible future changes in flood risk, including the effects of climate change and/or coastal erosion so that future occupants are not subject to unacceptable risks;
- Land required for current and future flood management, e.g. conveyance and storage of flood water and flood protection schemes, should be proactively identified on development plans and LAP maps and safeguarded from development; and
- Flood risk to, and arising from, new development should be managed through location, layout and design incorporating Sustainable Drainage Systems and compensation for any loss of floodplain as a precautionary response to the potential incremental impacts in the catchment.

The broad philosophy underpinning the sequential approach in flood risk management is outlined below.

AVOID	Preferably choose lower risk flood zones for new development.
SUBSTITUTE	Ensure the type of development proposed is not especially vulnerable to the adverse impacts of flooding.
JUSTIFY	Ensure that the development is being considered for strategic reasons.
MITIGATE	Ensure flood risk is reduced to acceptable levels.
PROCEED	Only where Justification Test is passed. Ensure emergency planning measures are in place.

The Guidelines list the following planning implications for each flood zone;

- **Zone A – High Probability of Flooding**. Development in this zone should be avoided and/or only considered in exceptional circumstances (through the Justification Test) if adequate land or sites are not available in Zones B or C. Most types of development would be considered inappropriate in this zone. Only water-compatible development, such as docks and marinas, dockside activities that require a waterside location, amenity open space, outdoor sports and recreation and essential transport infrastructure that cannot be located elsewhere, would be considered appropriate;
- **Zone B – Moderate Probability of Flooding**. Development should only be considered in this zone if adequate land or sites are not available in Zone C or if development in this zone would pass the Justification Test. Highly vulnerable development, such as hospitals, residential care homes, Garda, fire and ambulance stations, dwelling houses and primary strategic transport and utilities infrastructure, would be considered inappropriate in this zone. Less vulnerable development, such as retail, commercial and industrial uses, sites used for short-let for caravans and camping and secondary strategic transport and utilities infrastructure, and water-compatible development might be considered appropriate; and
- **Zone C – Low to Negligible Probability of Flooding**. Development in this zone is appropriate from a flooding perspective (subject to assessment of flood hazard from sources other than rivers and the coast), but needs to meet the normal range of other proper planning and sustainable development considerations.

Table 3.2 in the Guidelines (reproduced as **Table 2-1** in this report) identifies the types of development appropriate to each flood zone and those that would be required to meet the Justification Test.

Table 2-1: Matrix of vulnerability versus flood zone to illustrate appropriate development and that required to meet the Justification Test.

	Flood Zone A	Flood Zone B	Flood Zone C
Highly vulnerable development (including essential infrastructure)	Justification Test	Justification Test	Appropriate

Less vulnerable development	Justification Test	Appropriate	Appropriate
Water Compatible Development	Appropriate	Appropriate	Appropriate

For proposed developments that may be vulnerable to flooding and that would generally be inappropriate, as set out in **Table 2-1**, the following Justification Test criteria must be satisfied:

- The subject lands are zoned or otherwise designated for the particular use or form of development in an operative development plan that has been adopted or varied taking account of these Guidelines; and
- The proposed development has been subject to an appropriate flood risk assessment that demonstrates:
    - The proposed development will not increase flood risk elsewhere and, if practicable, will reduce overall flood risk;
    - The proposed development includes measures to minimise flood risk to people, property, the economy and the environment as far as reasonably possible;
    - The proposed development includes measures to ensure that residual risks to the area and/or development can be managed to an acceptable level as regards the adequacy of existing flood protection measures or the design, implementation and funding of any future flood risk management measures and provisions for emergency services access; and
    - The proposed development addresses the above in a manner that is also compatible with the achievement of wider planning objectives in relation to development of good urban design and vibrant and active streetscapes.

The scope of a Site-Specific FRA depends on the type and scale of development, the sensitivity of the area and if a Strategic FRA has been completed. In general, a Site-Specific FRA should include:

- Plans showing the site and development proposals and its relationship with watercourses and structures which may influence local hydraulics;
- Surveys of site levels and cross-sections relating relevant development levels to sources of flooding and likely flood water levels;

  Assessments of:
    - All potential sources of flooding;
    - Flood alleviation measures already in place;
    - The potential impact of flooding on the site;
    - How the layout and form of the development can reduce those impacts, including arrangements for safe access and egress;
    - Proposals for surface water management according to sustainable drainage principles;
    - The effectiveness and impacts of any necessary mitigation measures;
    - The residual risks to the site after the construction of any necessary measures and the means of managing those risks; and
    - A summary sheet that describes how the flood risks have been managed for occupants of the site and its infrastructure.

3. PROPOSED DEVELOPMENT

3.1 Site Location

The site is in the townlands of Ballynisky, Graigoor, Ballyegny More, Kilbradran, Ballysteen, Dunmoylan, Carrons and Lisbane, to the west of Coolcappa, Co Limerick. The site is approximately 9km north of Newcastle West and 6km northwest of Rathkeale (**Figure 3-1**). The site is accessible from the north along L1219 local road. The surrounding lands are predominantly in pasture with farm dwellings and farm buildings. There are also one-off houses along the public roads surrounding the site.

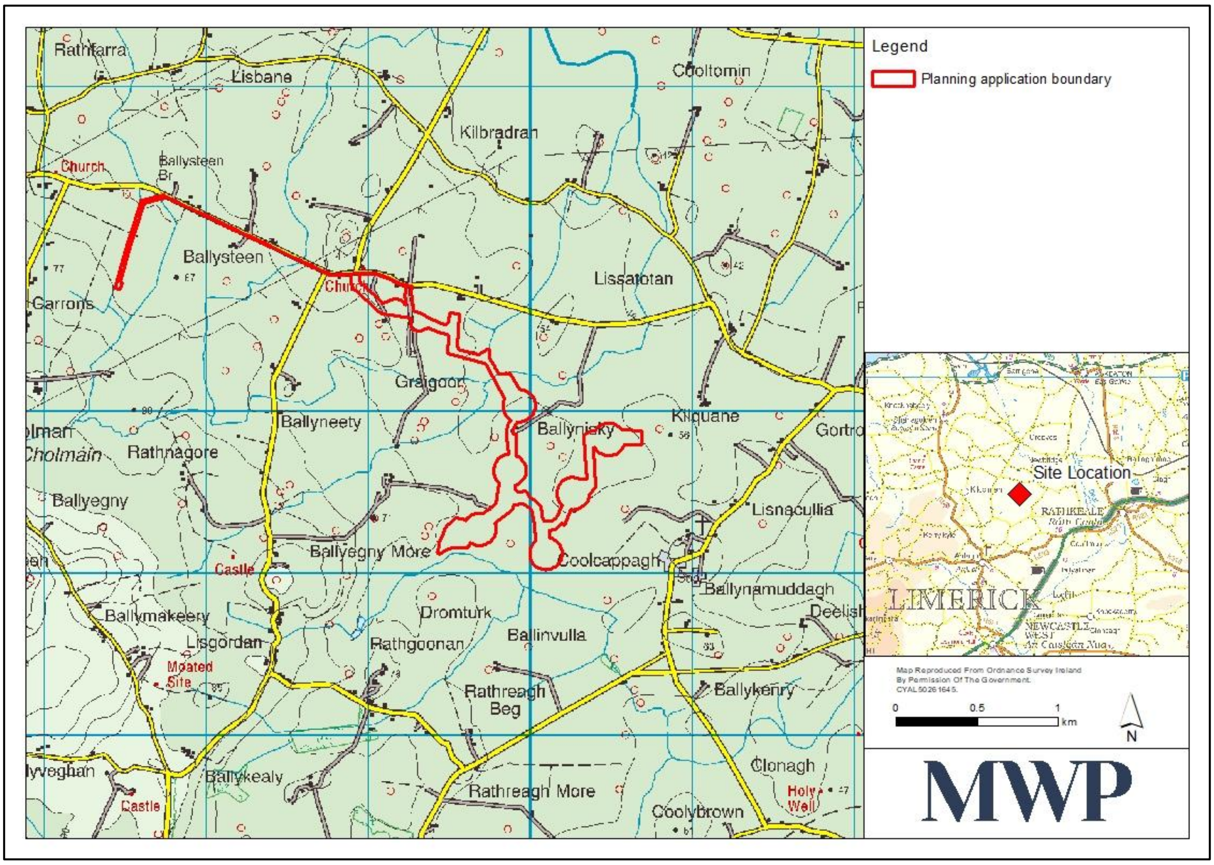

Figure 3-1: Site Location

3.2 Proposed Development

The proposed development area is ca 43.02 ha and the proposed site layout is shown on MWP Site Layout Drawing in **Appendix 2**. The proposed development involves the construction of six wind turbines and the associated supporting infrastructure, including access tracks, cabling ducts, a meteorological mast, a substation and temporary construction compound in the northwest of the site. Two (2) material storage areas will be created for the storage of overburden soils removed during development. A single river crossing is proposed to access the turbine site. Two other river crossings for the cabling route from the substation to the windfarm are required. One in the townland of Ballysteen where a crossing of the Knockardnacorlan Stream is required and one further to the west where the Creeves Stream crosses the public road. Both of these crossings will be completed using directional drilling methods to run the cables beneath the water courses.

3.3 Land Zoning

The subject lands are zoned residential but are identified in the Limerick Development Plan (2022 – 2028) as a preferred area for Wind Energy Locations.

3.4 Land Use

The land use is pasture for farm animal grazing and will remain in agricultural use after development of the windfarm.

3.5 Topography

The lands are generally flat, with some local highpoints in the northwest and along the northeastern boundary. The proposed development is in an area of relatively flat topography with an approximate range in height of 46-56m AOD. Along the Ahacronane River, which flows from west to northeast through the site, the bank level ranges from 44-48mOD. At the proposed river crossing the riverbank level is 46mOD.

3.6 Hydrogeology

The bedrock beneath the site is classified as a Locally Important Aquifer that is productive only in local zones. This is an aquifer in which the flow paths are short 10's to 100's of metres with groundwater discharge to local streams and rivers.

The proposed development is in the Shanagolden Groundwater Body (IE-SH-G-203) as under the EU Water Framework Directive (WFD). Ireland is now deemed one River basin area. There have been no changes to the designation of the GWB since the change from Regional Plans to a Single National Plan. The 2018-2021 Groundwater Body (GWB) status is Good.

3.7 Hydrology

The site surface water features are shown on (**Figure 3-2**). The main hydrological feature is the Ahacronane River which flows from southwest to northeast across the site. The Lissatotan stream, which is a tributary of the Ahacronane River, rises in the north of the site and flows north joining the Ahacronane c2km north of the site. The Rathnagore Stream flows from west to east along a section of the southern site boundary and joins the Riddlestown Stream at the southeastern site boundary.

The Ahacronane River has a catchment area of approximately 23km^2 and rises in the hills near Kilcolman, flowing north through Creeves before it discharges into the Robertstown Creek. The MWP Hydraulic analysis estimated the catchment area upstream of the proposed river crossing bridge to be approximately 7.674km^2.

MWP have calculated the 1% AEP 68% confidence level Mid-Range Future Scenario (MRFS) design flow estimated using the FSU 7-variable equation as 9.17m^3/s for the design flow rate for the bridge crossing.

There are field drains along many of the internal field boundaries and in particular along the boundaries of individual land holdings. The drains are relatively deep and wide (typically 1-2m deep and wide). Flow in the drains varies significantly from winter to summer. Sections of the drains appear to dry out during low flow conditions in the Summer and Autumn but there can be significant flows in the drains and even flooding during the winter.

The field drains comprise a western section flowing north, northwest and then north again where it connects to the Rathnagore Stream. To the south of Turbine 2 the western drain connects to a central drain. This central drain flows to the east and then south and discharges to the Riddlestown Stream along the southern site boundary.

The eastern field drain starts at the field boundary south of Turbine 5 and flows to the north and turns to the east along the field boundary north of Turbine 5. It then turns north and flows past the location for Turbine 6. There is a small possibly spring fed drain just south of Turbine 6 which connects to the eastern field drain. The eastern field drain flows north and discharges to the Ahacronane River c. 200m north of Turbine 6.

Field drain near Turbine 4

Field Drain near Turbine 2

Ahacronane River northwest of site

The site is in the catchment of the Ahacronane Surface Water Body which is defined under the EU Water Framework Directive (WFD) IE_SH_24A010900. Reports have been prepared on the ‘Status’ of each water body. Status means the condition of the water in a watercourse and is defined by its ecological and chemical status. Water bodies are ranked in one of five classes, High, Good, Moderate, Poor and Bad. The Waterbody WFD Status for 2016-2021 is Poor based on its ecological status. As part of the 2016–2021 Status Assessment the Rathnagore Stream has been assessed as being at Moderate Status based on modelling completed by the EPA.

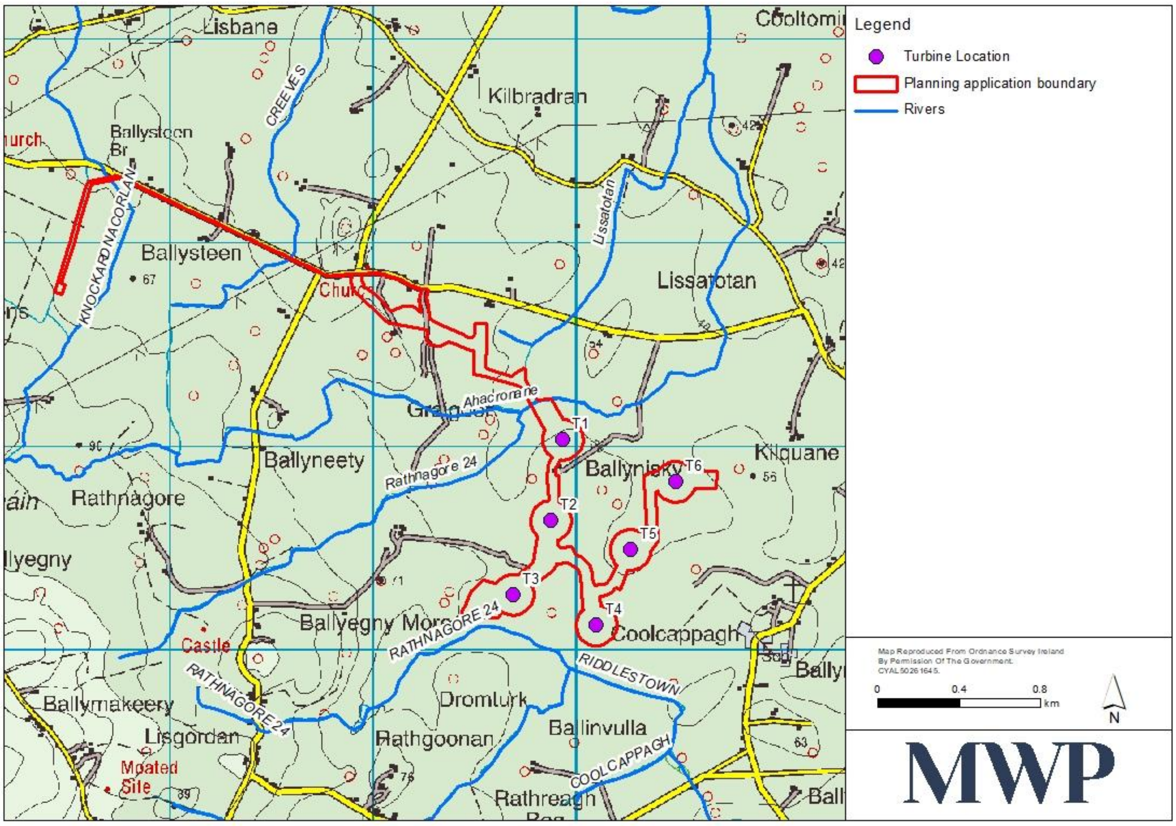

Figure 3-2: Hydrology

4. STAGE 1 FLOOD RISK IDENTIFICATION

Limerick City and County Council commissioned a Strategic FRA as part of the preparation of the Development Plan 2022 – 2028, however the lands that are subject to development are not included in the risk assessment.

An assessment of the Flood Risk for the Ahacronane River was undertaken in the Catchment Flood Risk Assessment and Management (CFRAM) study as part of the National Indicative Flood Extent Map (Present Day) Assessment.

The Flood Map indicates 10%, 1% and 0.1% annual exceedance probability (AEP) events, which are equivalent to the 1 in 10, 1 in 100 and 1 in 1,000-year flood events respectively.

The OPW Map indicates that the proposed location of the river crossing it is at risk from flooding from a 1 in 100-year fluvial flood event (Flood Zone A). Over the remainder of the site, the development is in Flood Zone C (**Figure 4-1**). The bridge crossing location is shown on the site layout **Drawing No. 22569-MWP-08-00-DR-C-5006** in **Appendix 2**.

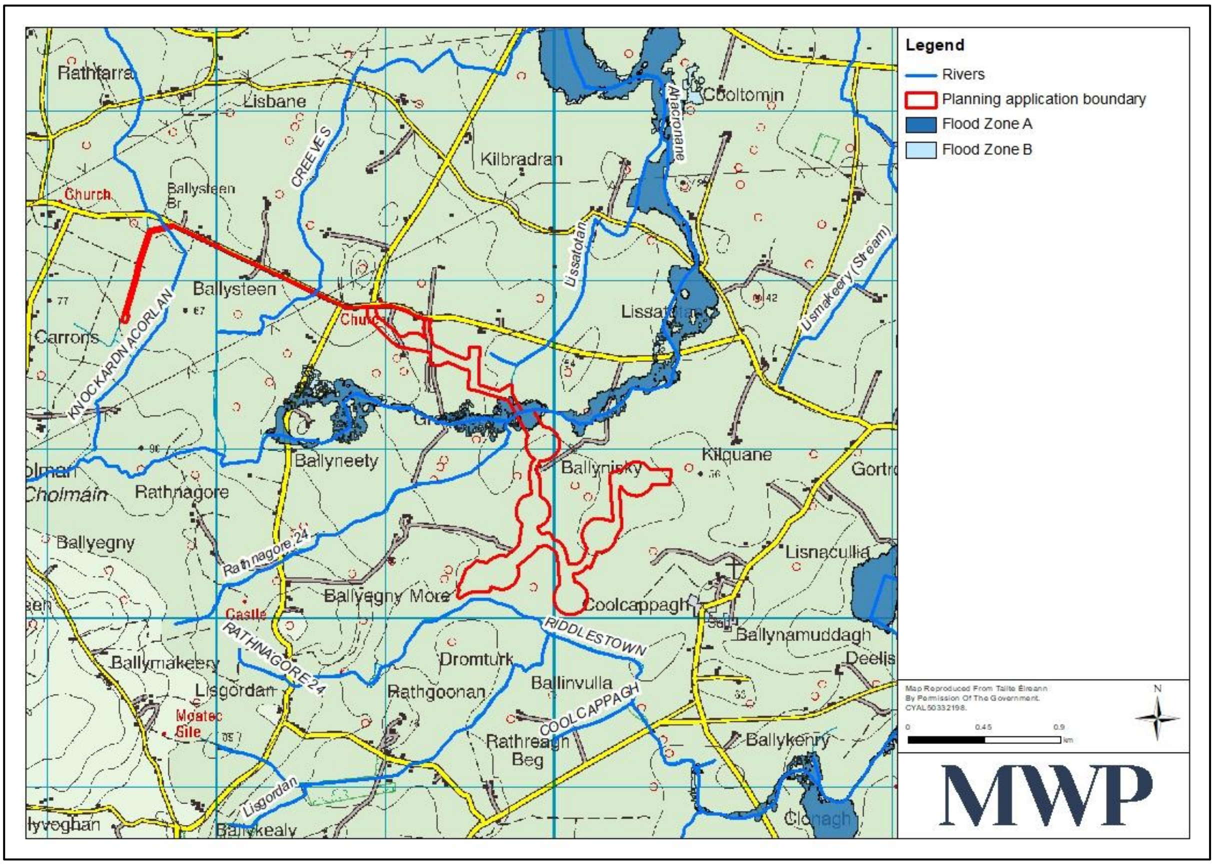

Figure 4-1: Flood Risk

5. STAGE 2 INITIAL SITE SPECIFIC FRA

5.1 Introduction
Developments located in moderate to high flood risk areas that are vulnerable to flooding will require the application of the Justification Test as defined in the Guidelines.

5.2 Flood Sources

The potential flood sources at the subject site:
- Fluvial;
- Pluvial; and
- Groundwater.

5.2.1 Fluvial
The Ahacronane River is at risk of flooding in a 1:100-year flood event where it is proposed to construct the river crossing. The bank level is c46.5mOD and the 1:100-year flood extent extends to c47.72mOD to the northwest and southeast of the crossing point. This is based on overlaying the CFRAMs flood extent map and the site survey 2m contour survey data (**Figure 5-1**).

5.2.2 Pluvial
Pluvial flooding is the result of rainfall-generated overland flows that occur before run-off can enter a watercourse or sewer and is usually associated with high intensity rainfall. The lands are undeveloped pastureland and not conducive to significant overland flow. Localised pluvial flooding was observed during the site walkover in February 2022 close to the Rathnogore Stream to the south of Turbine 3. While these lands are inside the planning application boundary, no development will be carried out on them. The proposed material storage area near Turbine 3 requires a buffer area of at least 50m from the river which will be away from the pluvial flood risk area.

5.2.3 Groundwater
Based on the type of the bedrock aquifer and the type and thickness of the subsoils, there is no risk of groundwater flooding. A review of the GSI Groundwater Flood Maps indicates that the site is not at risk of groundwater flooding.

5.3 Pathways
The flood water from the Ahacronane will extend to 47.72mOD to the northwest (c150m) and southeast (c110m) of the crossing point during a 1:100 flood event.

5.4 Receptors
The receptors are agricultural lands and the infrastructure associated with the proposed development. The proposed development is defined as utilities Infrastructure. The Guidelines designate this type of activity as less vulnerable land-use. The lands that would be impacted by flooding are all undeveloped grassland, which the Guidelines designate as a less vulnerable land use.

5.5 Surface Water Management
It is proposed to construct the river crossing in a manner that will not impede river flow and will not result in increased flood risk either up or downstream of the crossing point. Details of the bridge crossing are outlined in **Drawing 22569-MWP-00-00-DR-C-5413**.

5.6 Site Selection
The key selection criteria for the proposed development was the procurement of lands where flood risk is generally low and where the design layout would minimise the need for river or stream crossings. Consequently, only a single river crossing is required.

5.7 Mitigation

The Limerick Development Plan (2022-2028) requires developments to be cognisant of the flood risk zones and to provide flood mitigation measures where required.

The 2022-2028 Limerick Strategic Flood Risk Assessment (SFRA) recommends that for all types of development, the finished floor levels should begin with 1% AEP fluvial or 0.5% tidal events (depending on dominant flood source) as standard, with climate change and a suitable freeboard (300mm) included in the setting of finished floor levels.

The SFRA prepared in 2018 as part of the preparation of the Proposed Variation No. 6, Limerick County Development Plan 2010-2016 recommended that;

1. All watercourse crossings both culverts and bridges should be designed not to impede the flood conveyance through the structure and not cause any significant change in flood levels, flow depths and velocities that would result in any noticeable increase in flood risk or erosion/accretion either locally in the vicinity of the crossing or more remotely both in the upstream and downstream reaches;
2. Approval for watercourse crossings should be obtained from the OPW under Section 50 of the Arterial Drainage Act 1945 in advance of tender and construction of the proposed scheme;
3. Roads should be set at a minimum level that provides sufficient freeboard above the estimated 100 year flood level with suitable allowance for prediction errors and climate change. The recommended Climate change allowance is a 20% increase in flood flow magnitude, which for Ireland is generally equivalent to the current 1000 year flood becoming the future 100 year flood;
5. Where effective (conveying) overbank flood areas have been identified, flood conveyance needs to be retained by providing sufficient overbank openings through bridge spans as not to significantly impede flood flows and produce an unacceptable increase in upstream flood level and flood risk to properties and lands;
6. Where strategic floodplain storage is lost through the construction of the road embankments, adequate volumes of flood compensation should be provided where possible. Consideration should also be given to the provision of flood connectivity culverts through embankments to prevent the impedance of overland flows; and
7. River crossings should have a bridge soffit level with sufficient clearance above the 100 year flood level to allow the passage of floating debris. This is typically accounted for through the addition of freeboard as outlined in point 3 above.

The recommendations of the SFRA were taken into consideration in the design and proposed method of construction of the crossing.

5.7.1 Crossing Design

The crossing layout and details are shown on the Planning Drawing in **Appendix 2**.

The proposed crossing is a clear span bridge comprising a 9m long deck consisting of precast concrete beams and precast concrete slab placed on top. Edge protection for vehicles and pedestrians will also be provided. The deck will sit on in-situ concrete abutments set back from the riverbank. The deck soffit allows a 310mm freeboard above the 100-year return period flood level.

5.7.2 Construction

Construction of the bridge will require the provision of a temporary crane hardstanding adjacent that will be reinstated after installation is completed. An additional flood relief culvert will be installed under the site access track to the south of the bridge.

The culvert will be 24m south of the southern riverbank and will consist of a precast box culvert providing a clear 1.5m wide x 1.0m tall conduit. The base of the precast culvert will be set a minimum of 300mm below existing ground level and reinstated to existing level with spoil and topsoil.

5.7.3 Section 50 Approval

Section 50 approval for the river crossing will be sought from the OPW. Refer to **Figure 5-1** for the extent of Floodzone B at the river crossing.

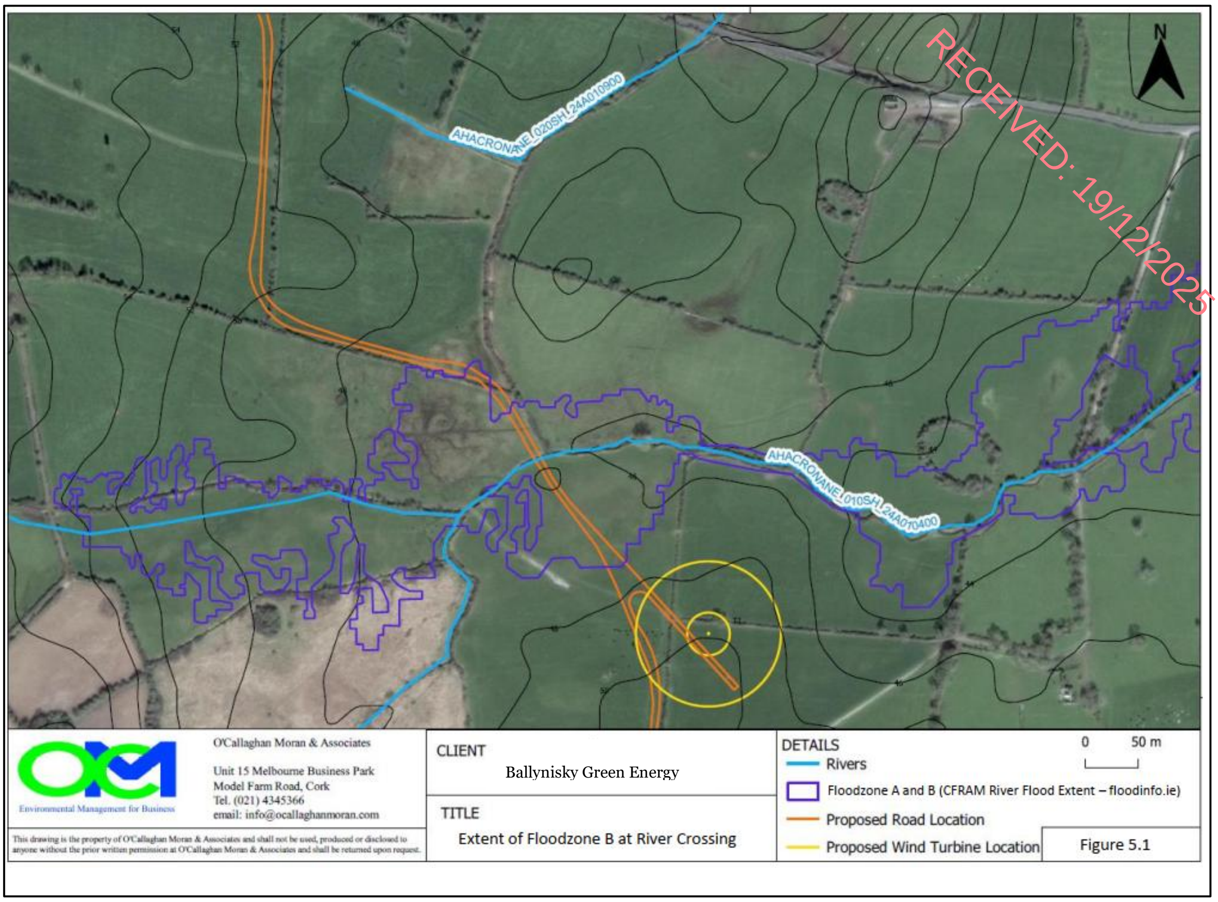

Figure 5-1: Extent of Floodzone B at River Crossing

6. CONCLUSIONS

A Site Specific FRA appropriate to the type and scale of development has been completed in accordance with the Guidelines. With the exception of the bridge crossing, the proposed windfarm development is located in Flood Zone C. The proposed bridge crossing is in Flood Zone A.

The proposed crossing has been designed with sufficient freeboard above the 100-year Flood Level and with allowance from climate change to prevent increasing flood risk upstream of the crossing.

Based on the site specific conditions and the recommended flood mitigation, resistance and resilience measures, the flood risk to the proposed development can be managed to an acceptable level.

Appendix 1

MWP River Crossing Hydraulic Analysis

TECHNICAL MEMORANDUM

Attention:		**Originated:**	BM	**Reviewed**	MF
Company:	Greensource	**Date:**	18/04/2023		
Project:	Ballynisky	**Project No.**	22569		
Subject:	Flood Risk Assessment & Section 50				

1. Introduction & Background

1.1 General

Malachy Walsh and Partners (MWP) have been commissioned by Ballynisky Green Energy Ltd to complete a Hydraulic analysis in relation to the construction of a new internal access track for a proposed wind farm and associated bridge crossing of the Ahacronane Stream. There is no existing structure at the proposed crossing location. A flood risk assessment in relation to the wind farm development has been carried out by O'Callaghan Moran & Associates, report ref. 22\099-02 MWP_Ballyegny.

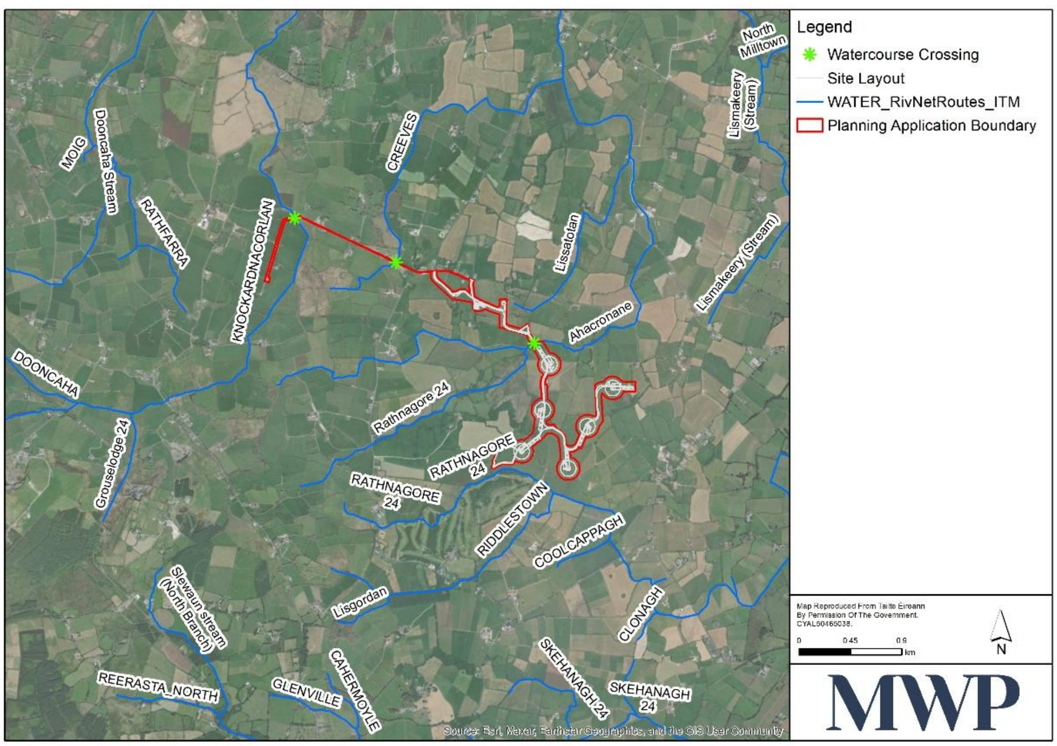

Figure 1-1: Site Location

2. Hydrology & Flow Estimation

The catchment area upstream of the bridge was estimated to be approximately 7.674km^2. The catchment was delineated using the FSU Catchments database.

There are no hydrometric stations on this watercourse that would be of use for flow estimation therefore extreme flows at the crossing were estimated using the statistical and empirical methods, as outlined in the following sub-sections.

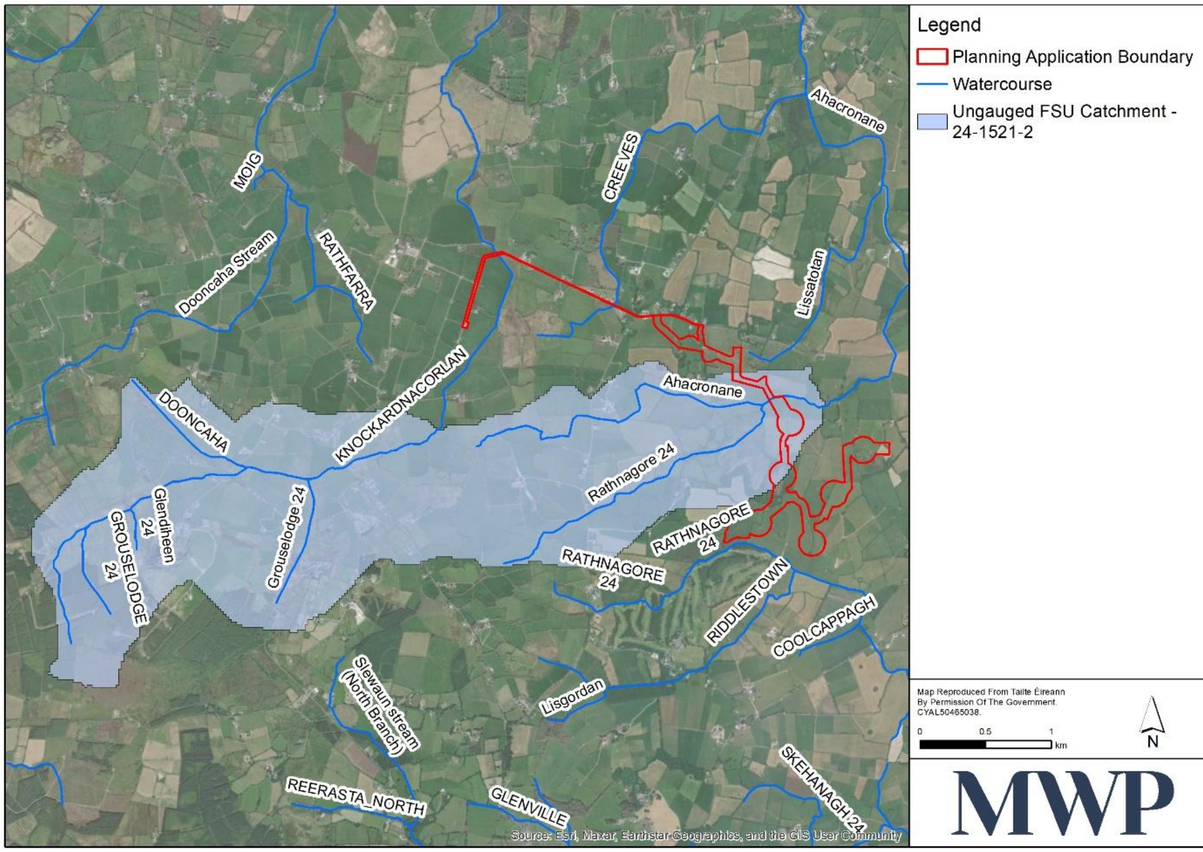

Figure 2-1: Catchment

2.1 FSU 7-Variable Equation

The Flood Studies Update (FSU) programme was undertaken by the OPW in order to provide improved extreme rainfall and flood estimation methods for Ireland. It is the most recent major study of its kind to be carried out in Ireland and is broadly recognised as the best practice method for estimating peak flood flows.

One of the key outputs from the FSU was the 7 variable regression equation for estimating the Index Flood (i.e. QMED) based on Physical Catchment Descriptors (PCD's). The Index Flood is the flow that can statistically be expected to be equalled or exceeded once in a 2 year period.

The FSU method for ungauged catchments uses Physical Catchment Descriptors (PCD's) to establish an initial estimate of the Index Flood (i.e., QMED) based on a seven variable regression equation. The initial value of Q_{MED} estimated using PCD's only is 2.435m^3/s.

The initial PCD estimate can be improved by using data from a hydrologically and/or geographically similar gauged site, referred to as a Pivotal Site. In normal circumstances this approach can be considered to provide the 'best estimate' of peak flow at a site. Table 2-1 below presents five pivotal sites. The following is noted:

- Station 30020 is the most hydrologically similar site and indicates an adjustment factor of 0.73 would be applicable. However, this is a karstic catchment and was therefore rejected.
- Stations 25034 and 25040 are hydrologically similar to the subject site and suggest an adjustment factor of 1.33 and 0.56 respectively with an average value of 0.95. Both stations have an A2 gauge classification. Clearly there is a significant difference between the adjustment factors. Notably, the catchment to Station 25034 has an ARTDRAIN2 value of 0.678 suggesting that a significant proportion of the catchment is artificially drained. ARTDRAIN2 of the subject site is 0 which may be a reason for rejecting Station 25040.
- The latest UK Environment Agency Flood Estimation Guidelines (LIT 11832, 2022 and Science Report SC050050) suggest that donor sites should be prioritised based on geographical distance from the subject site rather than hydrological similarity. On this basis the adjustment factors for a number of geographically close sites are also included on the table below. These provide an adjustment factor in the range of 1.02 to 1.52 with an average value of 1.3.
- Experience has shown that certain gauges on the FSU database may not provide reliable annual maxima flow data. In order to assess the potential implications of this, it is perhaps of some relevance to consider that the average adjustment factor from all stations which have an A2 or better gauge classification corresponds to 1.10.
- There is no universally agreed rule for selecting an appropriate pivotal site. The adjustment factors based on hydrological similarity indicate that Q_{MED} would be lower than the 68% confidence level flow based on a Factorial Standard Error of 1.37. The highest adjustment factor based on geographical similarity suggests Q_{MED} would be no more than about 10% higher the 68% confidence value, and on average about the same or lower than the 68% confidence level. Based on the totality of the information available, it is considered that the 68% confidence level flow would provide for a moderately conservative estimate at this site and avoid the risk of significant underestimation due to application of adjustment factors lower than unity. The corresponding value of Q_{MED} is $3.34m^3/s$.

Site	Hydrological Similarity	Distance (km)	Adjustment Factor	QMED Adjusted	Classification
30020	1.04	232	0.73	1.78	B
25034	1.15	259	1.33	3.25	A2
25040	1.17	168	0.56	1.36	A2
24013	3.75	25	1.02	2.48	A1
24012	3.53	27.9	1.44	3.51	B
23001	3.97	29.6	1.48	3.61	A2
24011	3.32	32.5	1.52	3.69	B
24030	2.90	33.5	1.04	2.52	B

Table 2-1: Potential Pivotal Sites

Flows estimated using the FSU 7-Variable Equation were determined for several return periods, however only the 1% AEP and 0.1% are presented in this technical memorandum.

The OPW uses the evidence from the IPCC and other authoritative sources, so that we project two possible scenarios that might arise in the future, the Mid-Range Future Scenario (MRFS) and the High-End Future Scenario (HEFS), taking into account the potential impacts of climate change. This report analysed the MRFS which corresponds to a 20% increase in peak flow. This is consistent with OPW requirements for Section 50 consent in relation to new bridge crossings.

For the preliminary sizing of the bridge cross section, it was necessary to adopt design flows which are compliant with OPW requirements for consent under Section 50 of the Arterial Drainage Act 1945. The Section 50 design flows correspond to the 1% AEP event estimated at an appropriate confidence level, with allowance for climate change in the MRFS.. The 68% confidence level design flow is considered appropriate for this assessment as there is no property at risk of flooding in proximity to the bridge crossing. Therefore, the 68% confidence level flows are relevant to all aspects of this analysis.

A summary of the flows is presented in Table 2-2 and Table 2-3 below.

Q_{MED} 68% Confidence Estimate (m³/sec)	1% AEP Growth Factor	Q_{100} (m³/sec)	0.1% AEP Growth Factor	Q_{1000} (m³/sec)
3.34	2.29	7.65	3.42	11.42

Table 2-2:Baseline - 1% & 0.1% AEP Flow (68% Confidence Level)

Q_{MED} 68% Confidence Estimate (m³/sec)	1% AEP Growth Factor	Climate Change Mid-Range Future Scenario	Q_{100} + Climate Change (MRFS) (m³/sec)
3.34	2.29	1.2	9.17

Table 2-3:1% AEP + MRFS Climate Change (68% Confidence Level)

2.2 IH124 Method

The Institute of Hydrology Report 124 method has been widely used in Ireland and the UK for flood estimation in small catchments. The equation uses three variables from the FSR to determine the mean annual flood flow Qbar, namely SOIL, SAAR and AREA. This is the flow that can statistically be expected to be equalled or exceeded once in a 2.33 year period. The IH124 equation has a standard error of 1.65 therefore the calculated value of Qbar was increased by a factor of 1.65 in order to achieve a 68% confidence that the flow will not be exceeded within the specified return period (refer to previous sub-section for the basis of selecting this confidence level). The FSR's regional growth curve for Ireland was used to determine the extreme flood flows for various return periods. A summary of the calculations carried out to determine the design flow at the site is included in Table 2-4 below. As shown on the table, the estimated 68% confidence level 1% AEP flow for the MRFS is 6.76m3/s.

IH124 Flood Estimation	
AREA (km^2)	7.674
URBAN AREA (km^2)	0.000
SAAR (mm)	1091.01
SOIL	0.30
Catchment Wetness Index (CWI)	125
Confidence Level for Design	68%
Climate Change Allowance	20%
Catchment Index (CIND)	30.72
Rainfall Continentality Factor (NC)	0.658
URBAN	0.000
$Q_{Bar\ Urban}/Q_{Bar\ Rural}$	1.000
$Q_{Bar\ Rural}$ (m^3/s)	1.741
$Q_{Bar\ Urban}$ (m^3/s)	1.741
Allowance for Selected Confidence Level	1.65
Climate Change Factor	1.20
Design Q_{Bar} (m^3/s)	3.45
Design Q_{100} (m^3/s)	6.76

Table 2-4: IH124 Flood Estimation

2.3 Selection of Design Flows

The 1% AEP 68% confidence level MRFS design flow estimated using the FSU 7-variable equation and the IH124 3-variable equation is 9.17m^3/s and 6.76m^3/s respectively. It is desirable to adopt a precautionary approach in this instance therefore the flows derived using FSU methodology have been selected.

3. Hydraulic Modelling

3.1 Model Overview

The hydraulic analysis was carried out using the Hydrologic Engineering Center River Analysis System (HEC-RAS) software which was developed by the US Army Corps of Engineers.

A survey of the existing river channel and floodplain was undertaken by Control Surveys in December 2022, and the data was supplied to Malachy Walsh and Partners who used it to create cross sections along the river reach. A 1m DSM was provided to Malachy Walsh and Partners by the client. The 1m DSM was used to capture out of bank flow in the floodplain. The 1m DSM and floodplain can be seen in Figure 3-1 below.

It was identified at an early stage that flood flows do not remain in the main channel and consequently a combined 1-dimensional (1D)/ 2-dimensional(2D) model was constructed for analysis. The baseline (existing) scenario and post-development scenario hydraulic model schematic are shown in below Figure 3-2 & Figure 3-3, including the location of the proposed bridge.

The downstream boundary conditions has been set to normal depth which was estimated to be 0.0149m/m based on the survey data provided.

Further information was also inputted into the model such as the existing concrete pipes upstream of the proposed bridge, proposed bridge geometry, inlet/exit loss coefficients, Manning's n values and expansion and contraction coefficients. Manning's n values were selected based photographs, site visits and Chow (1959). The key input parameters for the hydraulic model are summarised as follows;

- Manning's 'n' for channel varied between: 0.04 to 0.045

- Manning's 'n' for overbanks varied between: 0.04 to 0.045
- Expansion/Contraction Coefficients, Channel Sections: 0.1 & 0.3 respectively
- Expansion/Contraction Coefficients, Bridge: 0.3 & 0.5 respectively

An unsteady flow analysis was carried out using the design flows outlined in the previous section which is deemed adequate for the bridge design.

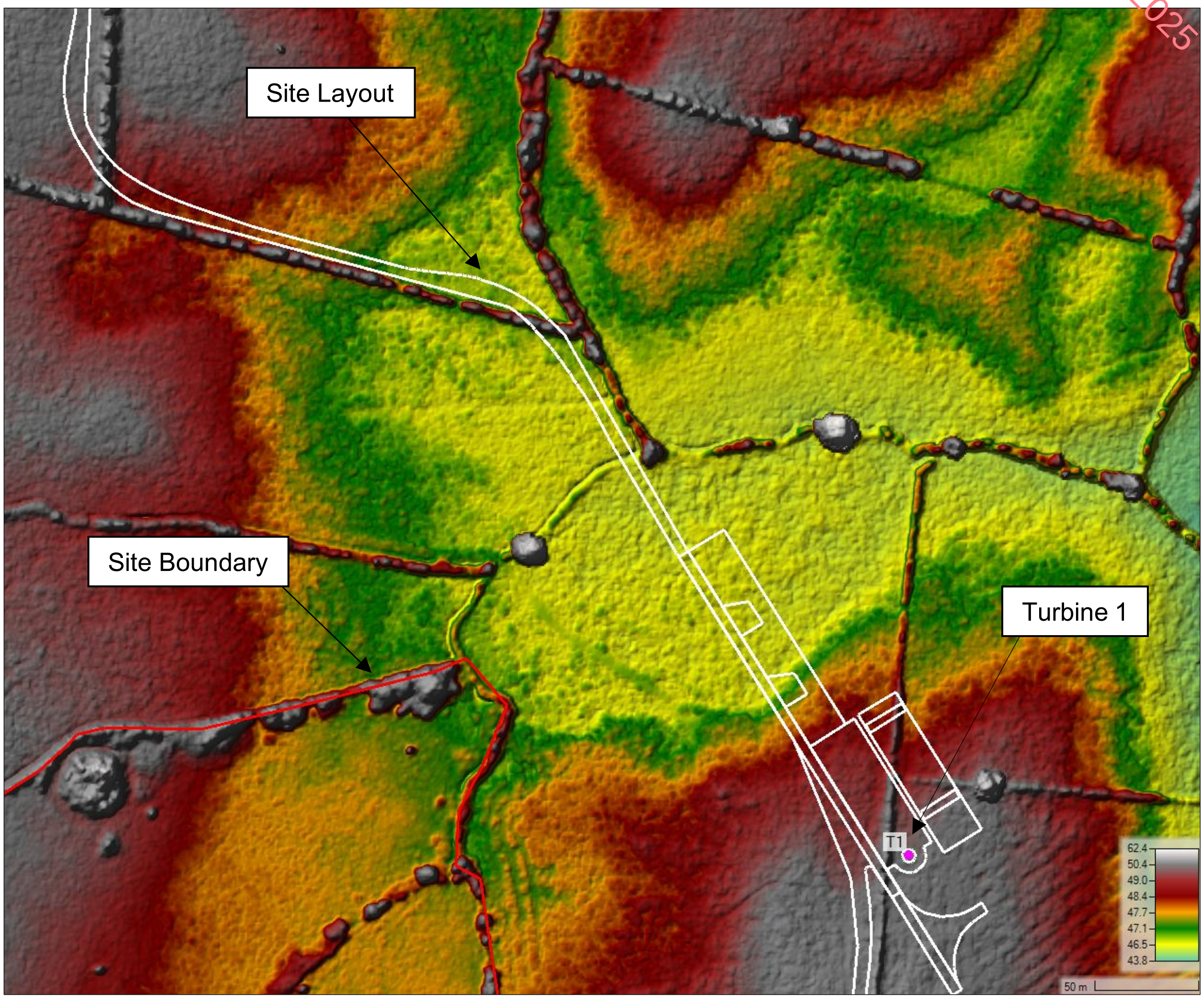

Figure 3-1: 1m DSM with Site Boundary, Site Layout and Turbine 1

Figure 3-2: Baseline Model Schematic

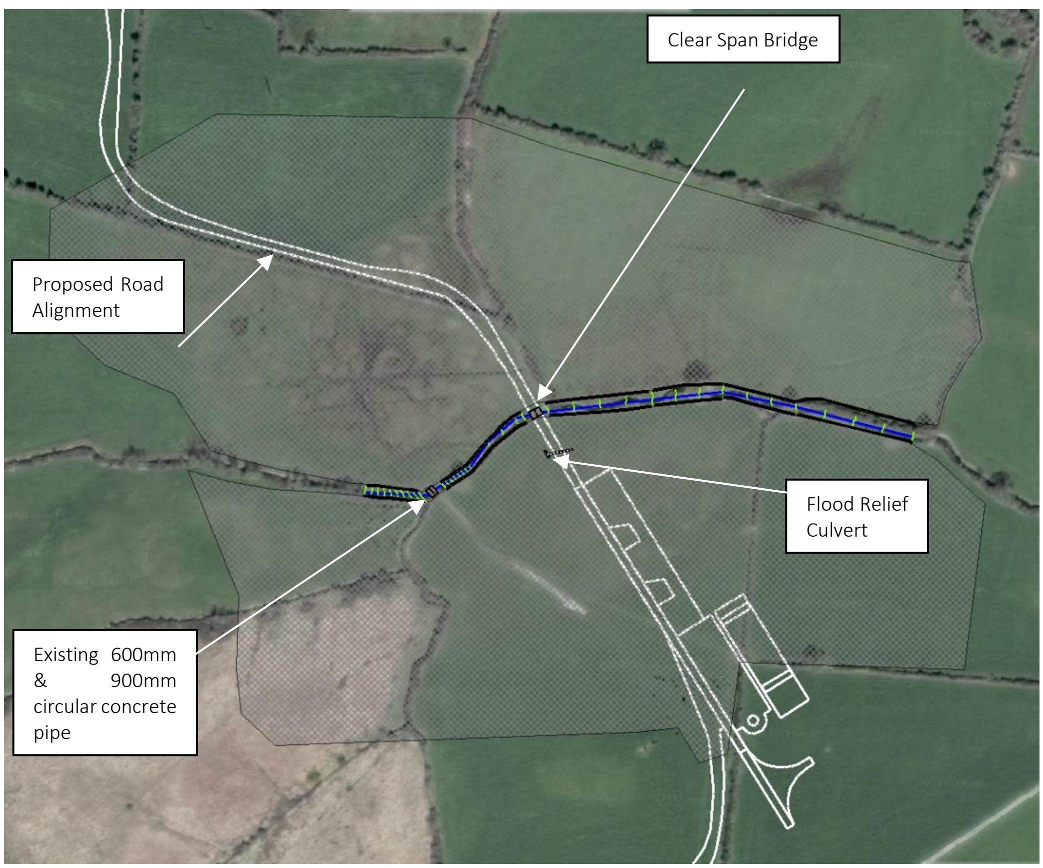

Figure 3-3: Post-Development Model Schematic

3.2 Baseline Results

The baseline scenario was run to redefine flood extents for Flood Zone A (1%AEP Event) and B (0.1%AEP Event). Figure 3-4 provides an overview of the site location and the flood extent maps within the Ahacronane Stream floodplain. The flooding mechanism of the Ahacronane Stream is overtopping of the right and left riverbanks.

Therefore, the site access track is identified as being partly within Flood Zone A/B.

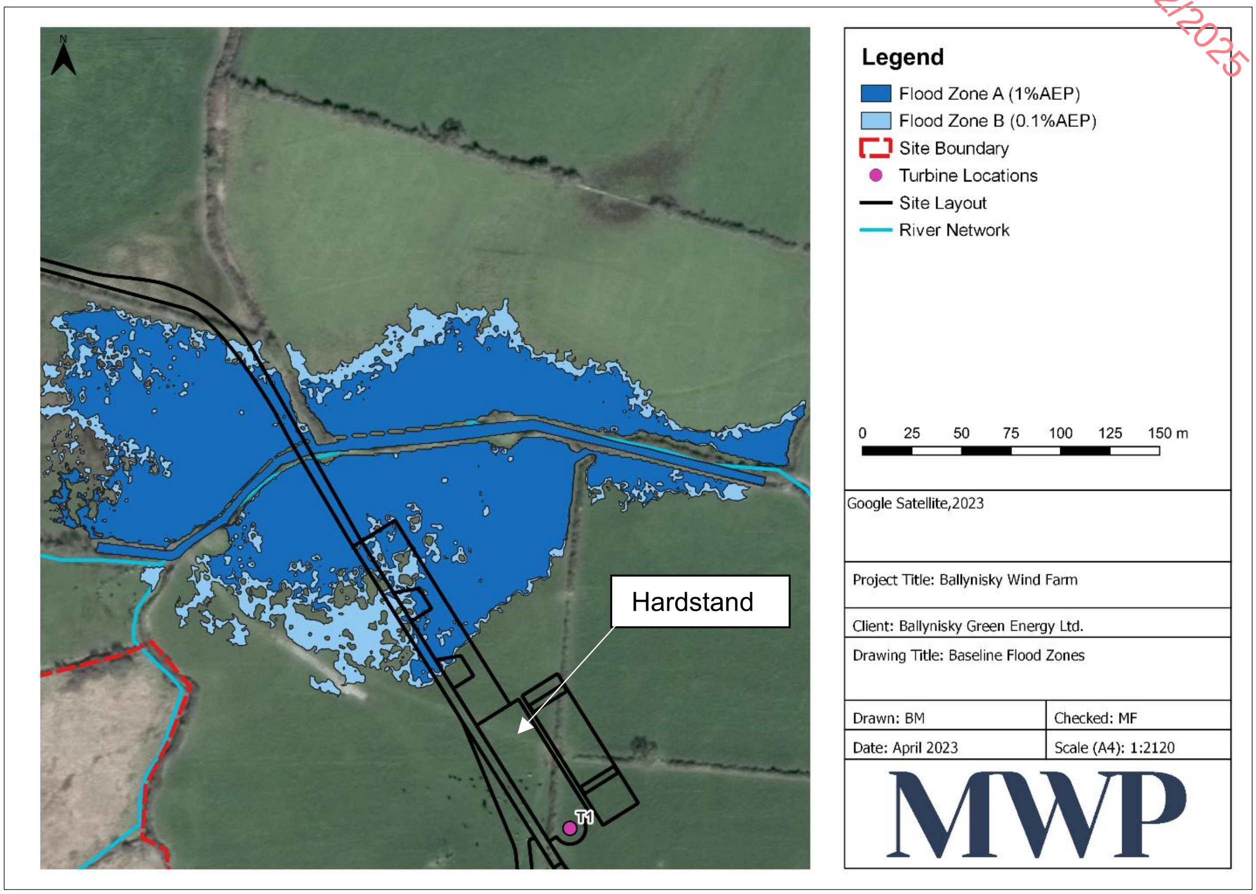

Figure 3-4: 1% and 0.1% AEP Flood Extents (Baseline)

3.3 Climate Change

Figure 3-5 provides an overview of the flood extent maps for the 1% AEP event and the 1% AEP event plus Climate Change (MRFS). The 1%AEP event plus Climate Change has less impact than the 0.1% AEP event. The site is identified as being at risk of flooding from the Ahacronane Stream under the Medium Range Future Scenario.

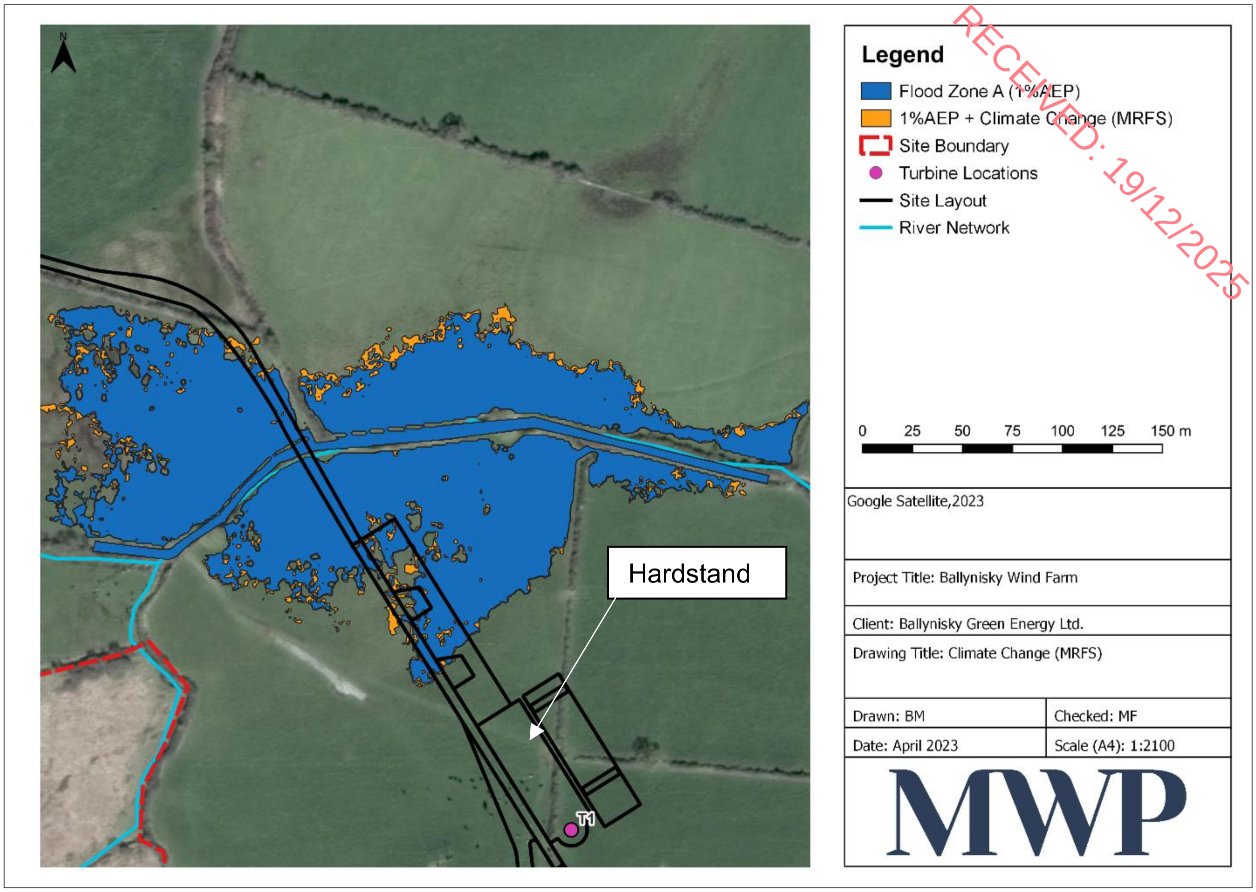

Figure 3-5: 1% AEP vs 1%AEP Climate Change (MRFS)

3.4 Post-Development Results

As part of the post-development scenario, a proposed access track will transect the existing floodplain. A bridge crossing will be required and the details of this are outlined in the following section. The post-development scenario was analysed to determine any increase in flood risk to lands upstream or downstream of the proposed access track for the 1% AEP and 0.1%AEP, and to determine an appropriate bridge geometry for future Section 50 consent

As would be expected, there is an increase in flood extent and water level for the 1% AEP post-development scenario as seen in Figure 3-6 below. The maximum increase in water surface elevation for the 1% AEP is c. 100mm.

There is a larger increase in flood extent and water level for the 0.1% AEP post-development scenario as seen in Figure 3-7 below. The larger increase in flood extent is a result of the proposed road crossing intersecting the floodplain and also due to the mild gradient of the floodplain upstream of the bridge. The flood water is stored upstream of the proposed access road. The maximum increase in water surface elevation for the 0.1% AEP is c. 329mm. The flood relief culvert on the right bank is keeping water levels below the 300mm tolerance for rural areas during the 1%AEP MRFS 68% confidence interval scenario in accordance with OPW requirements.

The design flood level is the 1% AEP MRFS with a 68% confidence interval. The maximum flood level for the 1% AEP MRFS 68% confidence interval is 47.72mOD in the channel at the upstream end of the hydraulic model. The maximum flood level for the 0.1%AEP MRFS is 47.94mOD in the channel at the upstream end of the hydraulic model.

On this basis the minimum level for the turbine hardstand area is 48.22mOD, which is the 1% AEP MRFS plus 500mm freeboard.

A sensitivity test was carried out on the 1% AEP MRFS event by applying the 95% confidence interval flow to the model. The maximum flood level for the 1% AEP MRFS 95% confidence interval is 47.89mOD therefore the model is not considered to be particularly sensitive to flow.

The existing ground elevation at Turbine 1 is c. 50.15mOD. Hardstanding areas and access roads associated with Turbine 1 are recommended to be placed above the design flood level of 48.22mOD. The plinth level of Turbine 1 should be set to at least 48.39mOD which provides for a freeboard of 500mm above the 95% confidence level flood level.

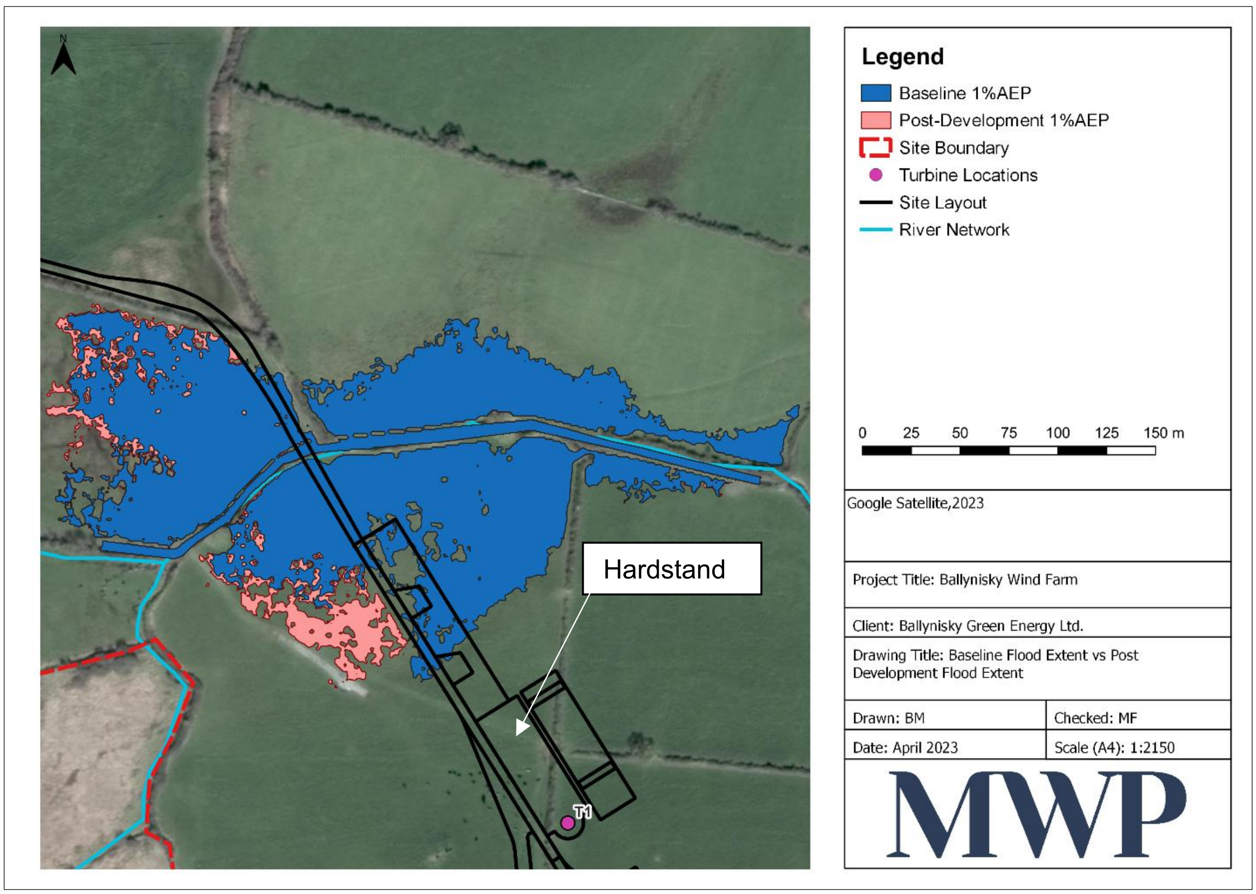

Figure 3-6: Baseline 1%AEP vs Post-Development 1% AEP Flood Extents

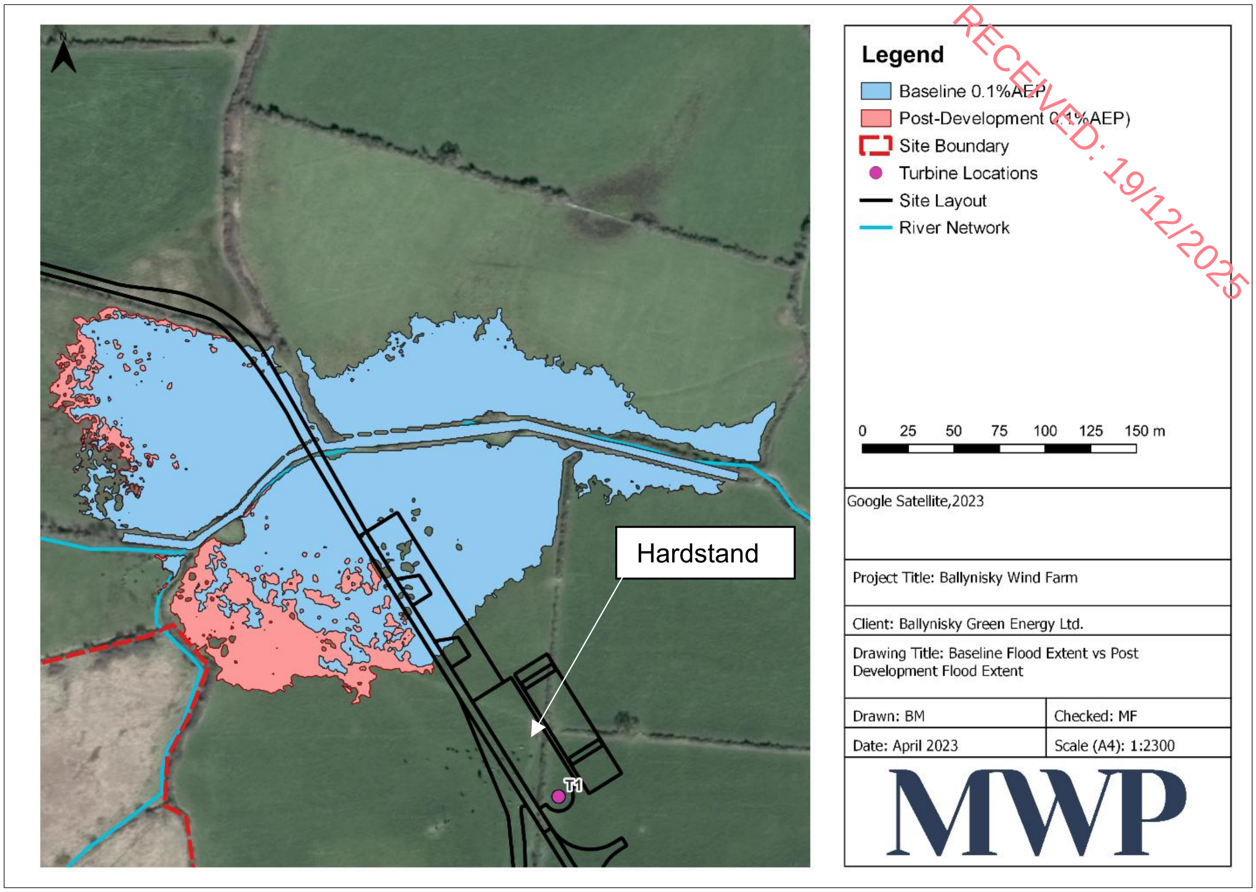

Figure 3-7: Baseline 0.1%AEP vs Post-Development 0.1% AEP Flood Extents

3.5 Summary

- The site access track is identified as being partly within Flood Zone A/B
- Hardstanding areas and access roads associated with Turbine 1 are recommended to be placed above the design flood level of 48.22mOD.
- The plinth level of Turbine 1 should be set to at least 48.39mOD which provides for a freeboard of 500mm above the 95% confidence level flood level
- A flood relief culvert has been added on the right bank of the proposed bridge crossing to allow the conveyance of flow under the proposed access track.

3.6 Bridge Sizing for Future Section 50 Consent

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3.6.1 Overview of Proposed Structure

It is proposed to construct an access track and associated bridge crossing. The proposed structure is a 9m clear span bridge. A flood relief culvert has been added, c.23m from the right bank abutment to comply with Section 50 requirements discussed in Section 3.6.2 below. The key dimensions of the 9m clear span bridge are as follows;

1. Soffit Level: 46.95m Upstream, 46.95m Downstream
2. Invert Level: 45.17m Upstream, 45.14m Downstream

3.6.2 Preliminary Analysis for Section 50

The Construction, Replacement or Alteration of Bridges and Culverts requires consent from the OPW. The calculated water surface elevation along the reach is shown on Figure 3-8 for both the existing and proposed scenarios. A model cross section through the upstream face of the bridge is provided in Figure 3-9. Based on a review of the hydraulic model and these output tables, the following observations were made;

- Upstream of the bridge, the predicted water surface elevation for the proposed bridge is 46.59mOD.
- When compared to the existing scenario, the proposed bridge therefore results in a 130mm increase in the flood level upstream of the bridge. This is less than the OPW's typical limit of 300mm in rural areas.
- The water surface elevation at the upstream face of the bridge is 46.61mOD and the upstream soffit level is 46.95mOD, therefore the freeboard is 340mm which is acceptable.
- The water surface elevation at the downstream face of the bridge is 46.59mOD and the downstream soffit level is 46.95mOD therefore the freeboard is 360mm which is acceptable.
- As indicated on the long profile below, the maximum afflux due to the structure is 130mm which is acceptable.
- The velocity through the bridge is 1.27m/s and 1.11m/s at the upstream and downstream faces respectively.

HEC-RAS Bridge Analysis Summary – Proposed Bridge – 1% AEP MRFS				
E.G. US. (m)	46.74	**Element**	**Inside BR US**	**Inside BR DS**
W.S. US. (m)	46.59	**E.G. Elev (m)**	46.70	46.66
Q Total (m3/s)	7.54	**W.S. Elev (m)**	46.61	46.59
Q Bridge (m3/s)	7.54	**Crit W.S. (m)**	46.34	46.20
0 Q Weir (m3/s)		**Max Chl Dpth (m)**	1.44	1.45
Weir Sta Lft (m)		**Vel Total (m/s)**	1.27	1.11
Weir Sta Rgt (m)		**Flow Area (m2)**	5.94	6.76
Weir Submerg		**Froude # Chl**	0.36	0.31
Weir Max Depth (m)		**Specif Force (m3)**	3.72	4.23
Min El Weir Flow (m)	47.45	**Hydr Depth (m)**	0.66	0.75
Min El Prs (m)	46.95	**W.P. Total (m)**	10.28	10.45
Delta EG (m)	0.15	**Conv. Total (m3/s)**	101.5	125.2
Delta WS (m)	0.13	**Top Width (m)**	9	9
BR Open Area (m2)	9.00	**Frctn Loss (m)**	0.03	0.02
BR Open Vel (m/s)	1.27	**C & E Loss (m)**	0.01	0.02
BR Sluice Coef		**Shear Total (N/m2)**	31.22	22.99
BR Sel Method	Energy only	**Power Total (N/m s)**	39.59	25.62

Table 3-1: HEC-RAS Bridge Analysis Summary

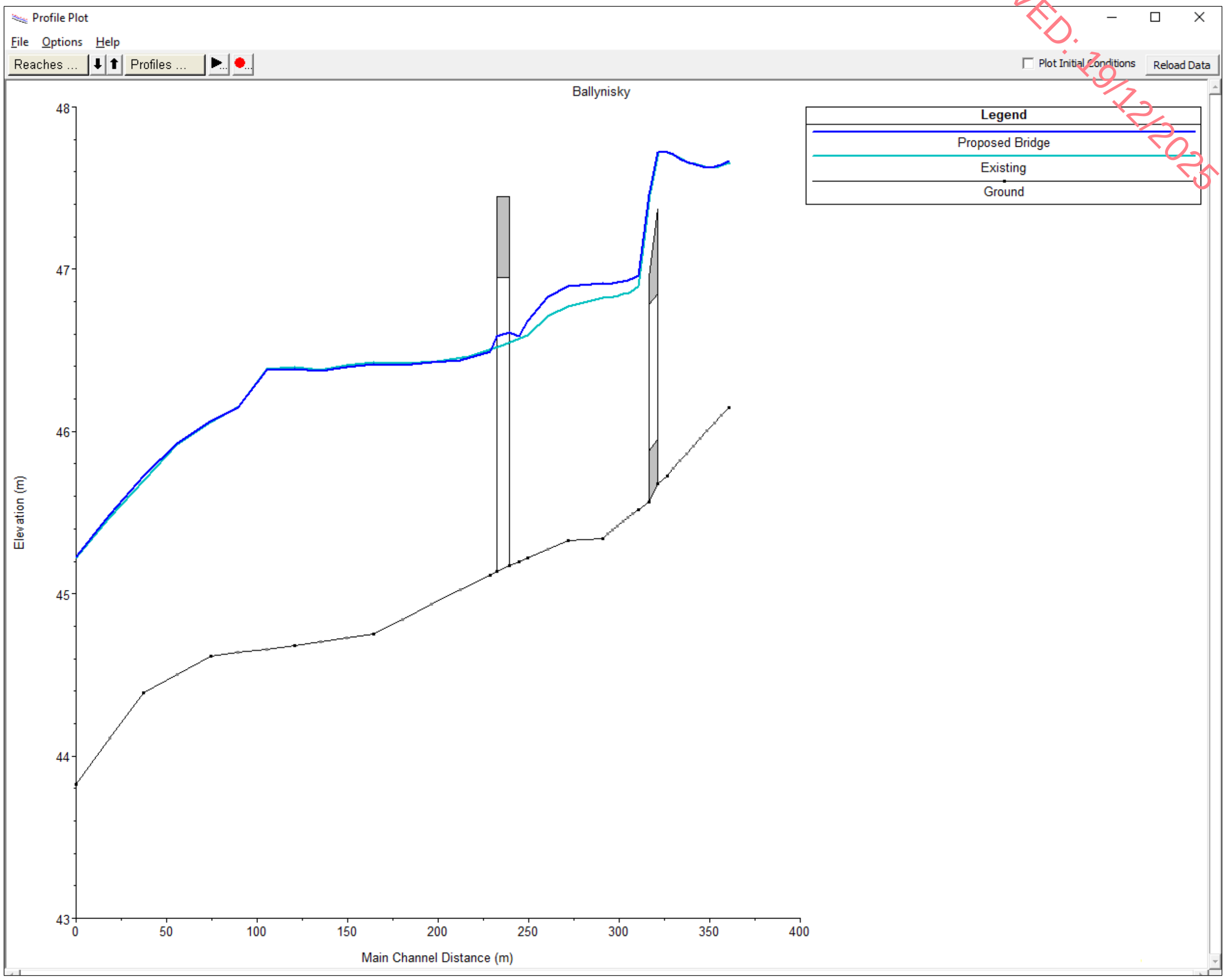


Figure 3-8: Longitudinal Profile for 1% AEP MRFS Flood Event – Existing & Proposed Scenario

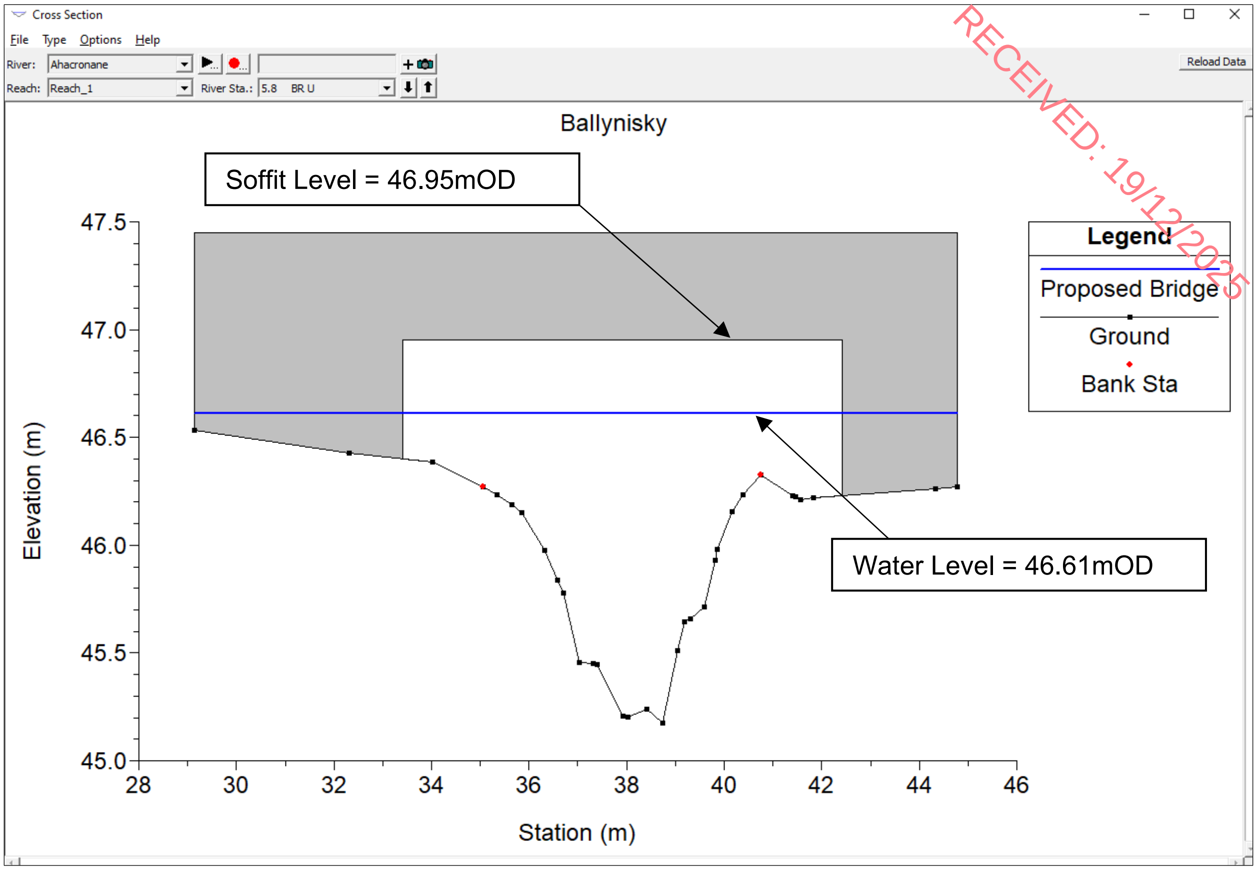
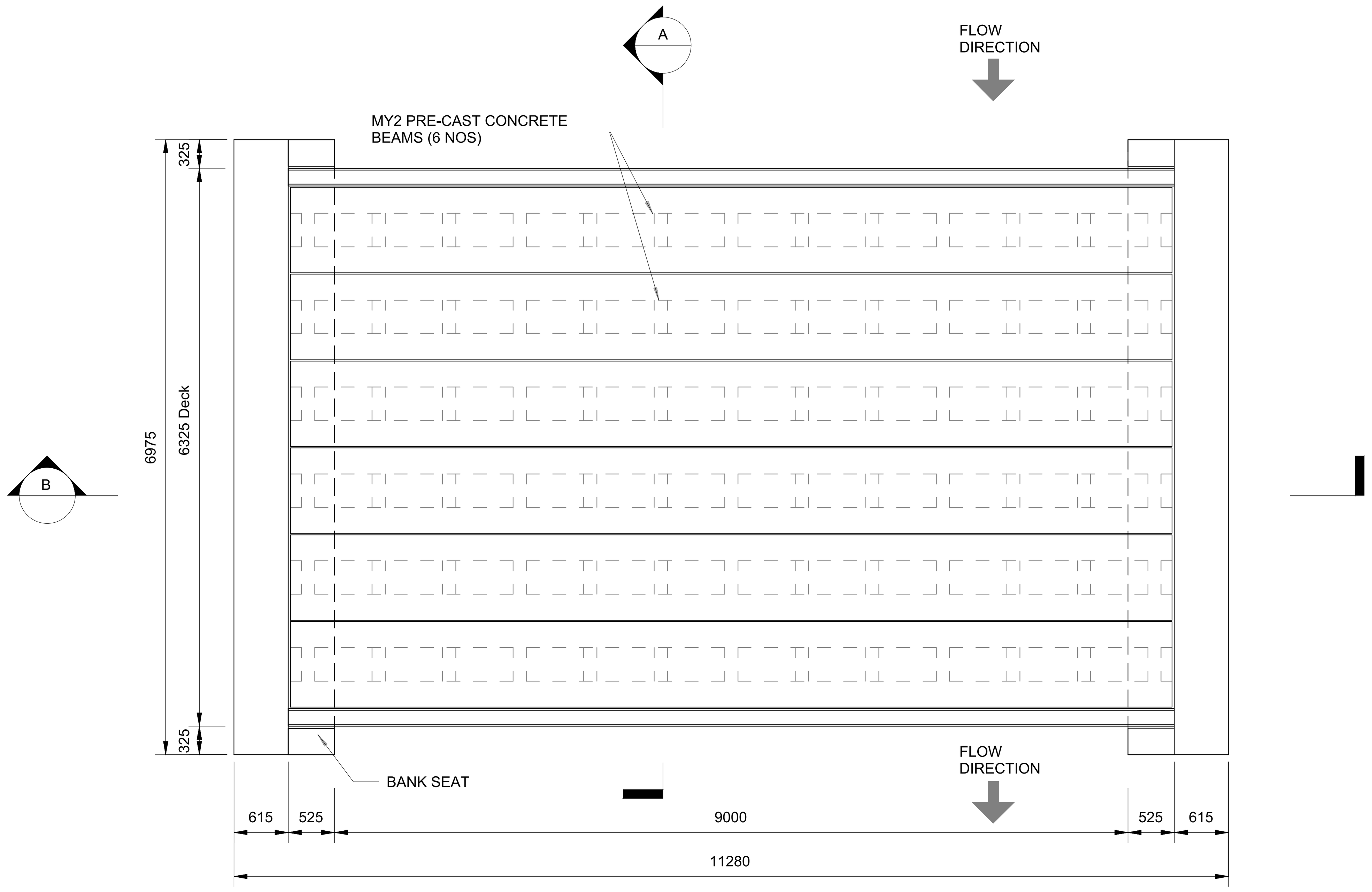


Figure 3-9: HEC-RAS Cross Section at Proposed Bridge, Upstream Face

Appendix

Preliminary GA Drawing of Proposed Bridge



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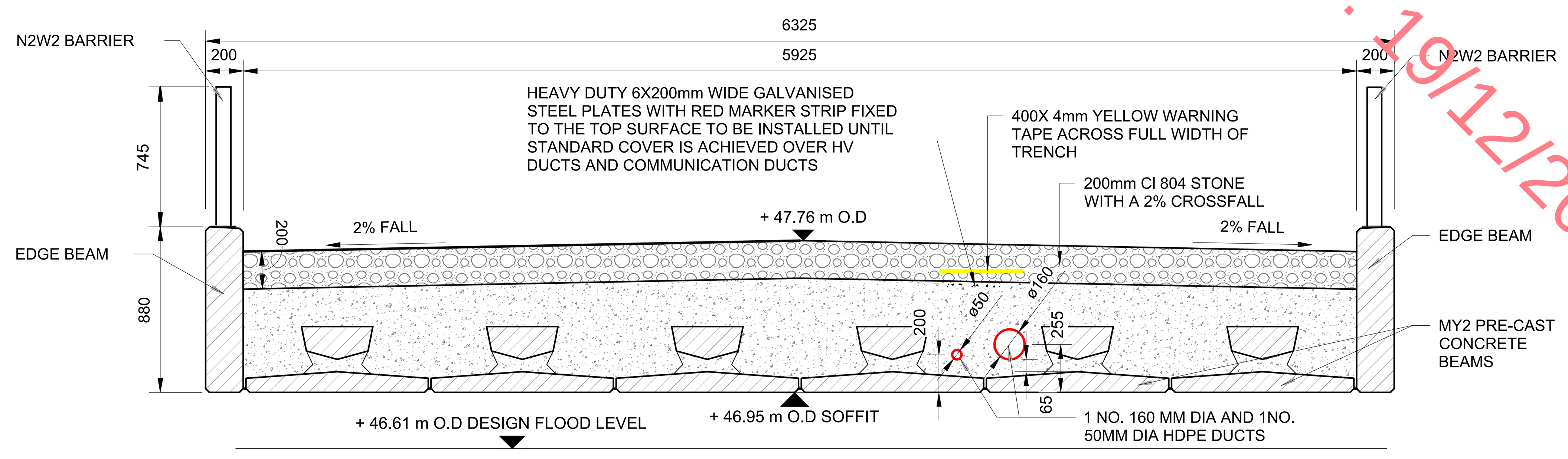

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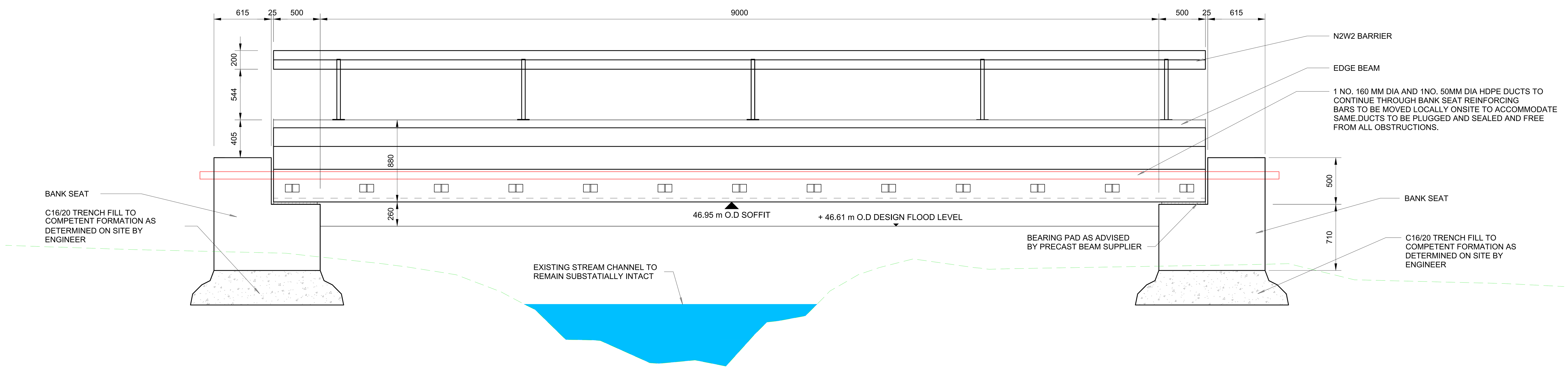

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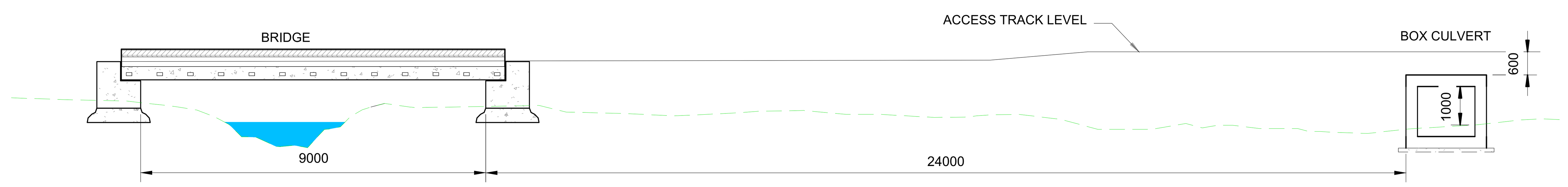

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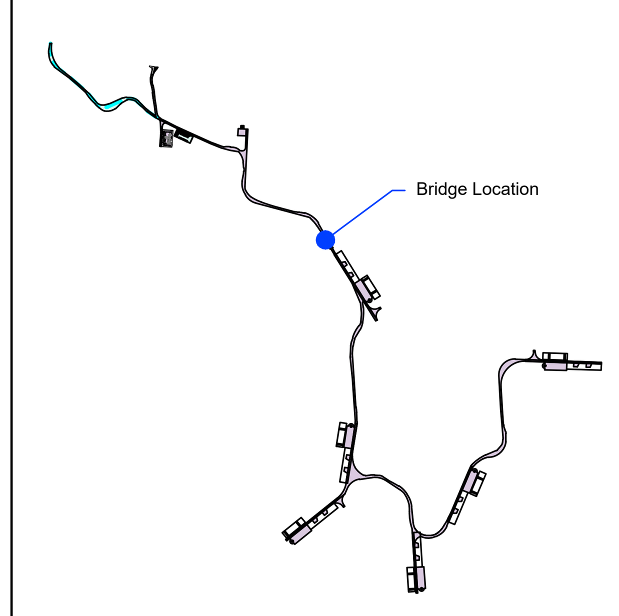

KEY PLAN

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P01	xxxx	Issued For Planning	JK	SH

PROJECT:
Ballynisky Wind Farm

TITLE:
Clear Span Bridge - General Arrangements

CLIENT:
BALLYNISKY Green Energy

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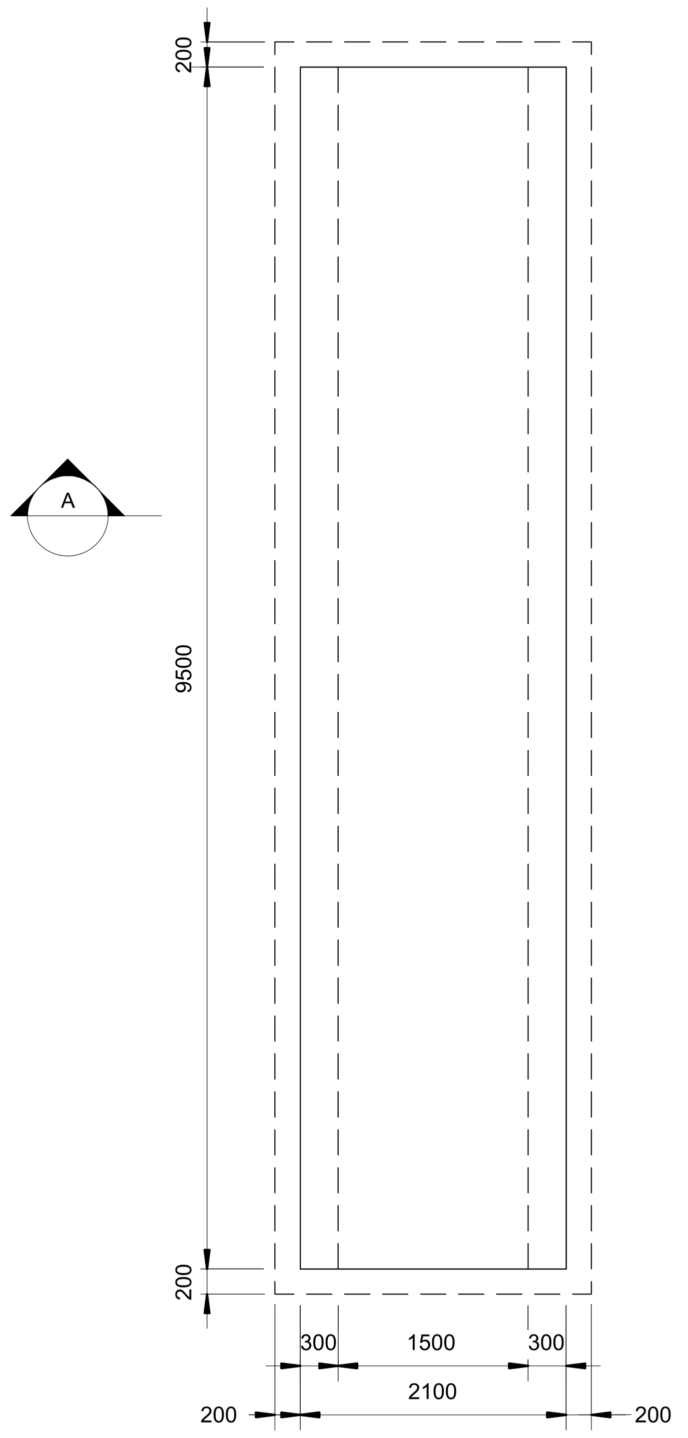

BOX CULVERT PLAN

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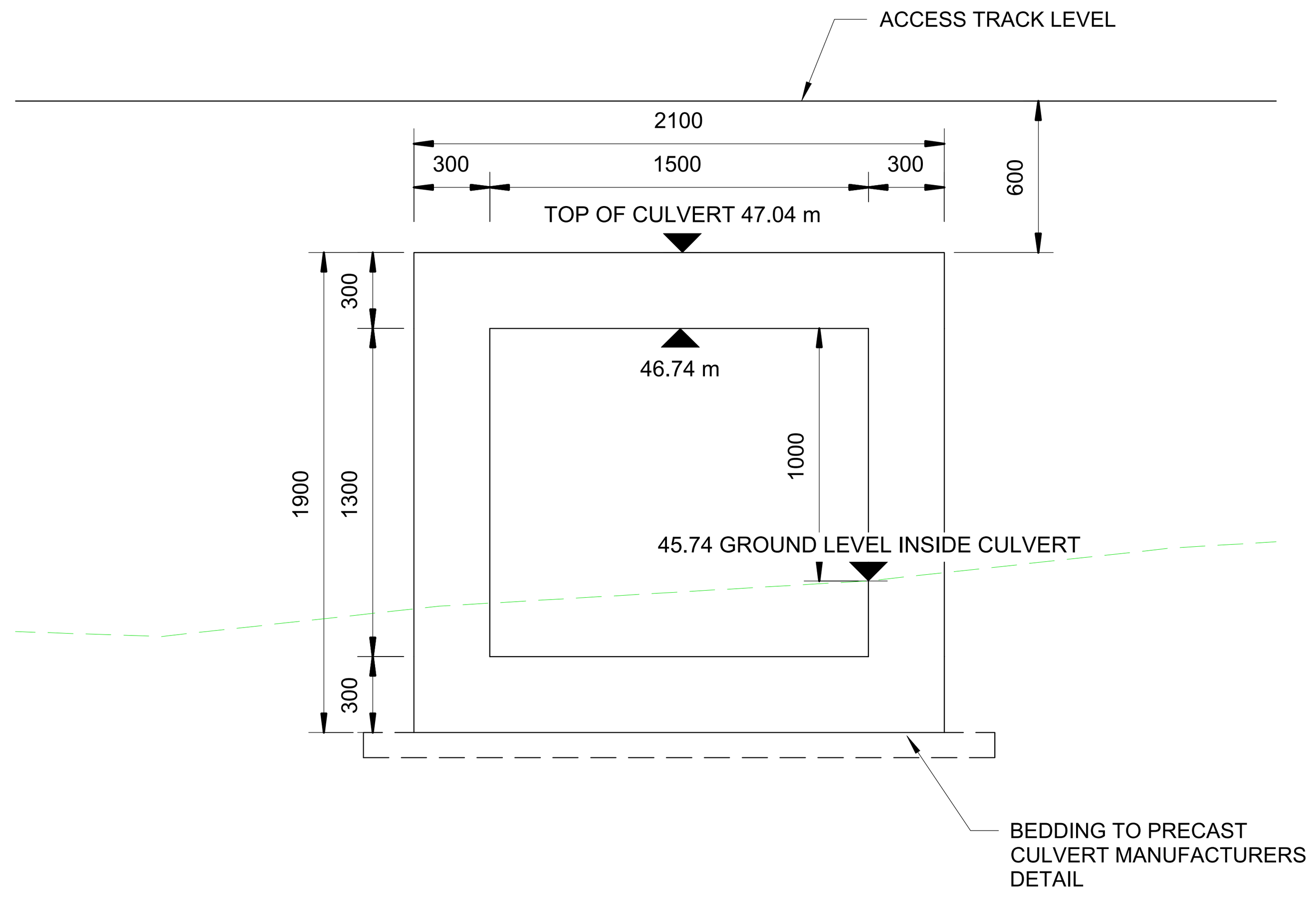

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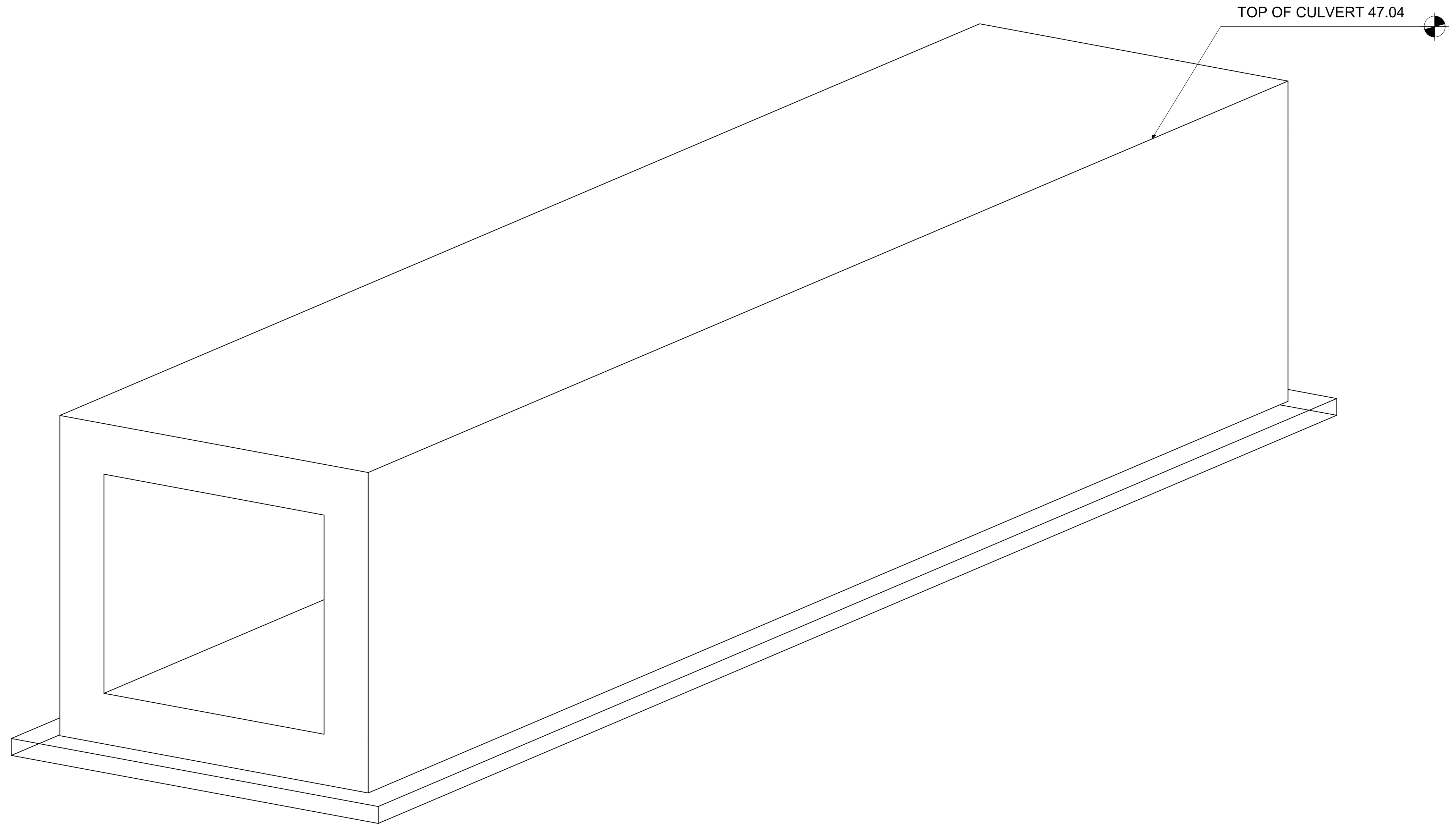

C BOX CULVERT 3D VIEW

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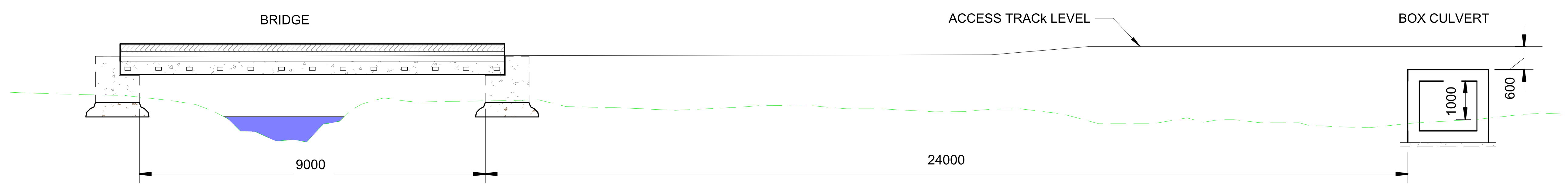

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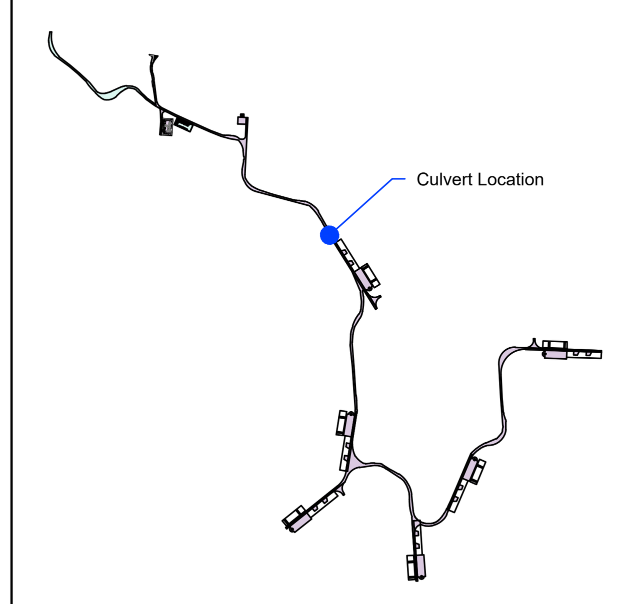

KEY PLAN

REV	DATE	DESCRIPTION	BY	APP
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PROJECT: Ballynisky Wind Farm

TITLE: Relief Culvert - General Arrangements

CLIENT: BALLYNISKY Green Energy

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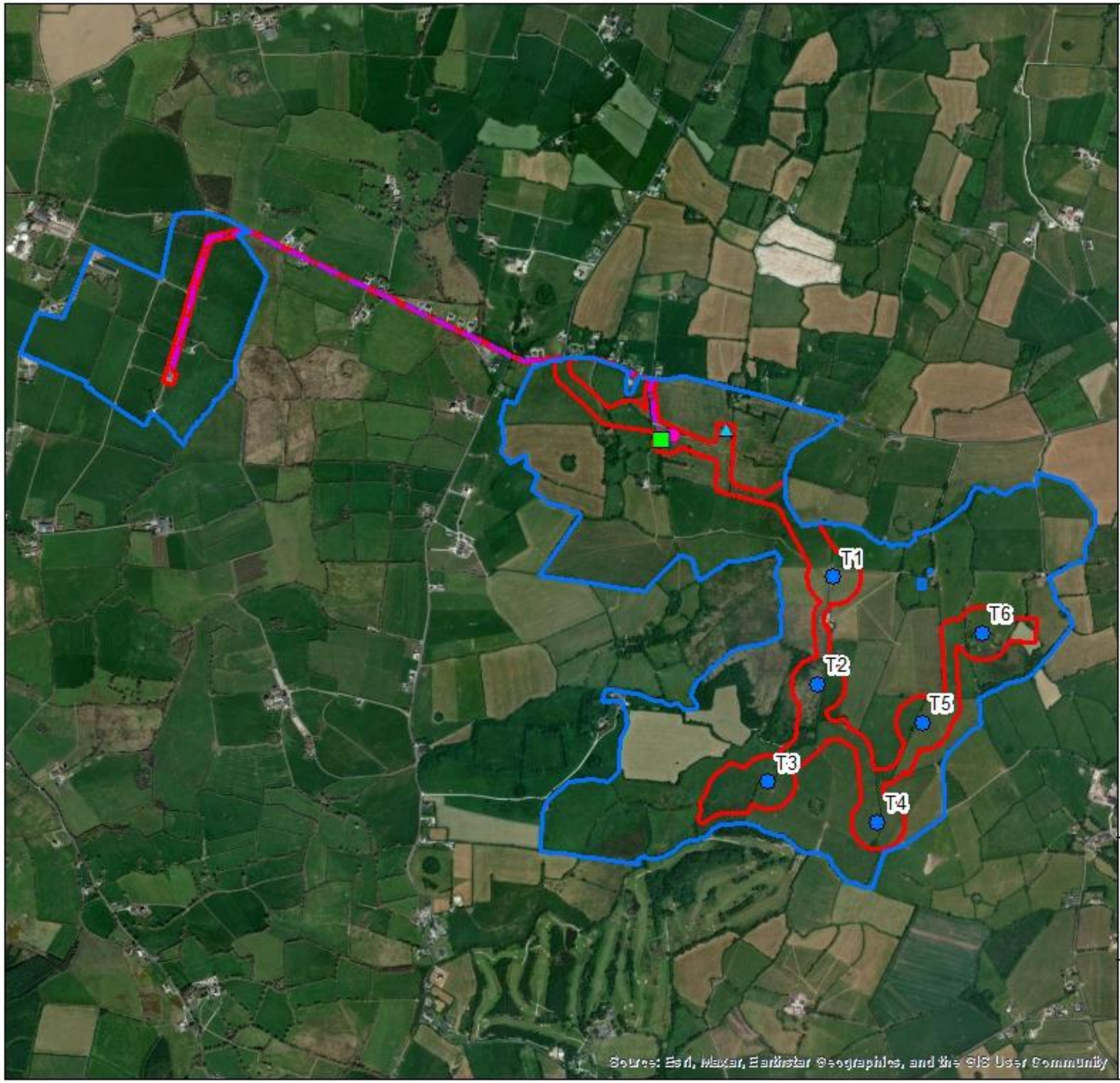
Appendix 2

Site Layout



Legend

- Landholding Boundary
- Met Mast
- Substation
- Temporary Site Construction Compound
- Turbine Location
- Grid Connection
- Planning application boundary

0 0.4 0.8 km

N

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