Appendix 9A

FLOOD RISK ASSESSMENT

Flood Risk Assessment

Brittas Wind Farm
Thurles, Co. Tipperary

BRITTAS WIND FARM LTD

SEPT 2024

Contents

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Project No.	Doc. No.	Rev.	Date	Prepared By	Checked By	Approved By	Status
23318	MWP-XX-XX-RP-Z-6013-S0	P01	12/09/2024	BM	MF	MF	ISSUE

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Glossary of Acronyms and Terms

AEP	Annual Exceedance Probability
API	Antecedent Precipitation Index
CFRAMS	Catchment Flood Risk Assessment and Management Study
DEFRA	Department for Environment, Food and Rural Affairs
DTM	Digital Terrain Model
EPA	Environmental Protection Agency
FFL	Finished Floor Level
FRA	Flood Risk Assessment
FSR	Flood Studies Report
FSU	Flood Studies Update
GDSDS	Greater Dublin Strategic Drainage Study
HEP	Hydrological Estimation Point
HEFS	High End Future Scenario
LAP	Local Area Plan
M aOD	Metres Above Ordnance Datum
MRFS	Mid Range Future Scenario
MWP	Malachy Walsh & Partners
OPW	Office of Public Works
PSFRM	The Planning System and Flood Risk Management Guidelines, November 2009
SAAR	Standard Average Annual Rainfall
SuDS	Sustainable Urban Drainage Systems

1. General

1.1 Introduction

MWP Engineering and Environmental Consultants have been commissioned to carry out a Flood Risk Assessment on behalf of Brittas Wind Farm Ltd. (the Applicant) who proposes to develop a wind farm (named Brittas Wind Farm) comprising ten (10) No. wind turbines and new 110kv substation approximately 3km to the north of Thurles, Co. Tipperary.

1.2 Overview of Existing Site

The proposed project area is located 3km north of Thurles town in the following townlands: Brittas, Rossestown, Clobanna, Brownstown, Killeenleigh and Kilkillahara in County Tipperary. Figure 1-1 shows the proposed main wind farm development.

The affected lands are made up of agricultural fields bounded by hedgerows and treelines. An area of broadleaf forestry is located at the southwest of the site. The River Suir transects the site from north to south. The N62 is located west of the site, running north to south, connecting Templemore to Thurles. The N62 provides a link to the M6, M7 and M8 motorways. The L8017 local road traverses the centre of site from east to west, crossing the River Suir at a bridge point.

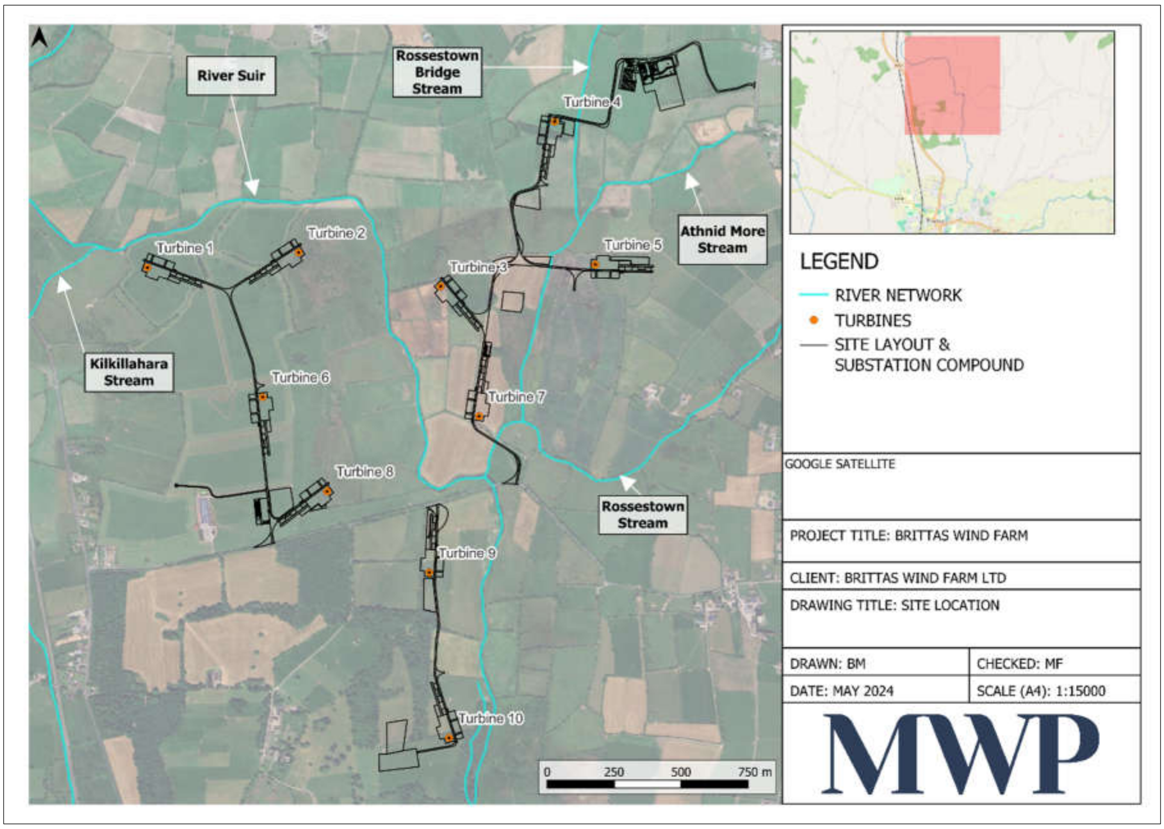


Figure 1-1: Site Location

1.3 Overview of Proposed Development

The development for which planning permission is sought in the planning application (the proposed development) consists of the following (see Figure 1-1 for site layout):

- 10 No. Wind Turbines with a blade tip height of 180m, hub height range from 102.5 to 105.5m and a rotor diameter range from 149m to 155m;
- 10 No. Wind Turbine foundations and Hardstand areas and associated drainage infrastructure;
- 1 No. Permanent Lidar unit and associated foundation, hardstand area and compound for Meteorological Monitoring;
- 1 No. 110kV Electrical Substation including 2 No. control buildings, electrical plant and equipment, welfare facilities, carparking, water and wastewater holding tanks, security fencing, lightening protection and telecommunications masts, security cameras, external lighting and, all associated infrastructure;
- Installation of medium voltage underground electrical and communication cabling connecting the wind turbines to the proposed onsite substation and associated ancillary works;
- Installation of approximately 7km of underground electricity and communication cabling between the proposed onsite substation and the nearby existing Thurles 110kV substation in the townland of Ballygammane, Co. Tipperary. The cabling will be laid primarily within the public road and will connect the proposed wind farm to the national grid;
- 4 No. Site Entrances from the public road and associated fencing and signage;
- Construction of new permanent site access tracks, turning heads and associated drainage infrastructure;
- The upgrading of existing access tracks and associated drainage infrastructure;
- 2 No. Temporary construction site compounds and mobile welfare facilities;
- 1 No. Borrow pit and associated drainage infrastructure to be used as a source of stone material during construction;
- Spoil deposition areas;
- Associated surface water management systems;
- Tree felling and hedgerow removal to accommodate wind farm infrastructure;
- Replanting of trees on site;
- Temporary accommodation works at 2 no. locations adjacent to the public road to facilitate delivery of turbine components to site within the townlands of Brittas and Brittasroad, Co. Tipperary. The works primarily relate to trimming and clearing of vegetation, temporary removal of street furniture and fencing, and installation of temporary stone hard standing; and
- All related site works and ancillary development;

Other elements of the project which are assessed throughout the EIAR but are not the subject of this SID planning application are as follows:

- Battery Energy Storage Facility (BESS)

- Rerouting of on-site ESB 38kV overhead powerline (OHL)
- Accommodation works along the turbine delivery route which includes temporary removal of traffic signs and lights, electricity poles, bollards and lamp posts, fences, and hedge and tree removal/trimming.

1.4 Objectives

The purpose of the report is to establish the flood risk associated with the proposed development and, if appropriate, to recommend mitigation measures to prevent any increase in flood risk within the site or externally in the wider area.

The report has been prepared in the context of *The Planning System and Flood Risk Management – Guidelines for Planning Authorities, November 2009*, published by the Office of Public Works and the Department of Environment, Heritage and Local Government. Flood Risk Assessments are carried out at different scales by different organisations. The hierarchy of assessment types are Regional (RFRA), Strategic (SFRA) and Site-specific (FRA). This report is site-specific.

1.5 Methodology

The Flood Risk Management Guidelines document outlines three stages in the assessment of flood risk as follows:

Stage 1 Flood risk identification – to identify whether there may be any flooding or surface water management issues related to a plan area or proposed development site that may warrant further investigation;

Stage 2 Initial flood risk assessment – to confirm sources of flooding that may affect a plan area or proposed development site, to appraise the adequacy of existing information and to determine what surveys and modelling approach is appropriate to match the spatial resolution required and complexity of the flood risk issues. The extent of the risk of flooding should be assessed which may involve preparing indicative flood zone maps. Where existing river or coastal models exist, these should be used broadly to assess the extent of the risk of flooding and potential impact of a development on flooding elsewhere and of the scope of possible mitigation measures; and

Stage 3 Detailed 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. This will typically involve use of an existing or construction of a hydraulic model or a river or coastal cell across a wide enough area to appreciate the catchment wide impacts and hydrological processes involved.

This report has been prepared generally in accordance with these stages.

1.6 Flood Risk & Zones

In the Planning System and Flood Risk Management Guidelines document, the likelihood of a flood occurring is established through the identification of Flood Zones which indicate a high, moderate or low risk of flooding from fluvial or tidal sources. Table 1-1 below includes the definition of Flood Zones as well as the implications for planning. The flood zone type is determined based on current water surface levels without allowance for climate change and without the benefit of any flood defences. It is important to note that the Flood Zones do not take other sources of flooding, such as groundwater or pluvial, into account, so an assessment of risk arising from such sources should also be made, where appropriate.

Flood Zone	Description & Summary of Planning Implications
Zone A High probability of flooding	More than 1% probability (1 in 100) for river flooding and more than 0.5% probability (1 in 200) for coastal flooding. Most types of development would be considered inappropriate in this zone.
Zone B Moderate probability of flooding	0.1% to 1% probability (between 1 in 100 and 1 in 1,000) for river flooding and 0.1% to 0.5% probability (between 1 in 200 and 1 in 1,000) for coastal flooding. Highly vulnerable development, such as hospitals, residential care homes, Garda, fire and ambulance stations, dwelling houses and primary strategic transport and utilities infrastructure, would generally be considered inappropriate in this zone.
Zone C Low probability of flooding	This zone defines areas with a low risk of flooding from rivers and the coast (i.e. less than 0.1% probability or less than 1 in 1,000). Development in this zone is appropriate from a flooding perspective (subject to assessment of flood hazard from sources other than rivers and the coast).

Table 1-1: Definition of Flood Zones

The Guidelines have outlined three Vulnerability Classifications for developments based on the proposed land use and type of development. These classifications and particular examples of development types which would be included in each classification are summarised as follows;

- Highly Vulnerable Development: This would include emergency services, hospitals, schools, residential institutions, dwelling houses, essential infrastructure, water & sewage treatment etc.
- Less Vulnerable Development: Retail, leisure, commercial, industrial buildings, local transport infrastructure.
- Water-compatible development: Docks, marinas and wharves. Amenity and open space, outdoor sports and recreation and essential facilities such as changing rooms.

The Guidelines include a matrix that determines the appropriateness of different types of development based on their vulnerability classification and the Flood Zones in which they are located. The matrix is reproduced in Table 1-2 below.

Where the matrix indicates that a development is not appropriate it may still be justified based on a procedure described as a Justification Test.

The proposed wind farm development is classed as Highly Vulnerable Development and development in Flood Zone C is appropriate. If the Justification Test is passed, development within Flood Zone A/B could be appropriate.

Vulnerability Classification	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

Table 1-2: Vulnerability Matrix

2. Flood Risk Identification (Stage 1)

Possible sources of flood risk were identified by;

- Geology & Soil Mapping
- Flood History - examination of available information on the OPW website (www.floodinfo.ie)
- National Indicative Fluvial Mapping
- Suir Catchment Flood Risk And Management Study (Suir CFRAMS)
- GSI Winter 2015/2016 Surface Water Flooding
- Internet Searches
- Walkover survey of the subject site and the nearby watercourses

2.1 Geology & Soil Mapping

The geology and soils at the site have been reviewed using the Geological Survey of Ireland database. The proposed site location is predominantly underlain by *AlluvMIN - Alluvial (mineral)* soil and *BminPDPT - Peaty poorly drained mineral (Mainly basic)* soil according to Teagasc soil data. The presence of Alluvium soils can be an initial indicator of an area which has been subject to flooding in the geological past but cannot be used to determine flood risk to an area. The quaternary sediment map indicates that the site is underlain by Alluvium and Till derived from limestones. The bedrock geology in this area is dominated by Ballysteen Formation and Waulsortian Limestones which is described as *Dark muddy limestone, shale* and *Massive unbedded lime-mudstone* respectively.

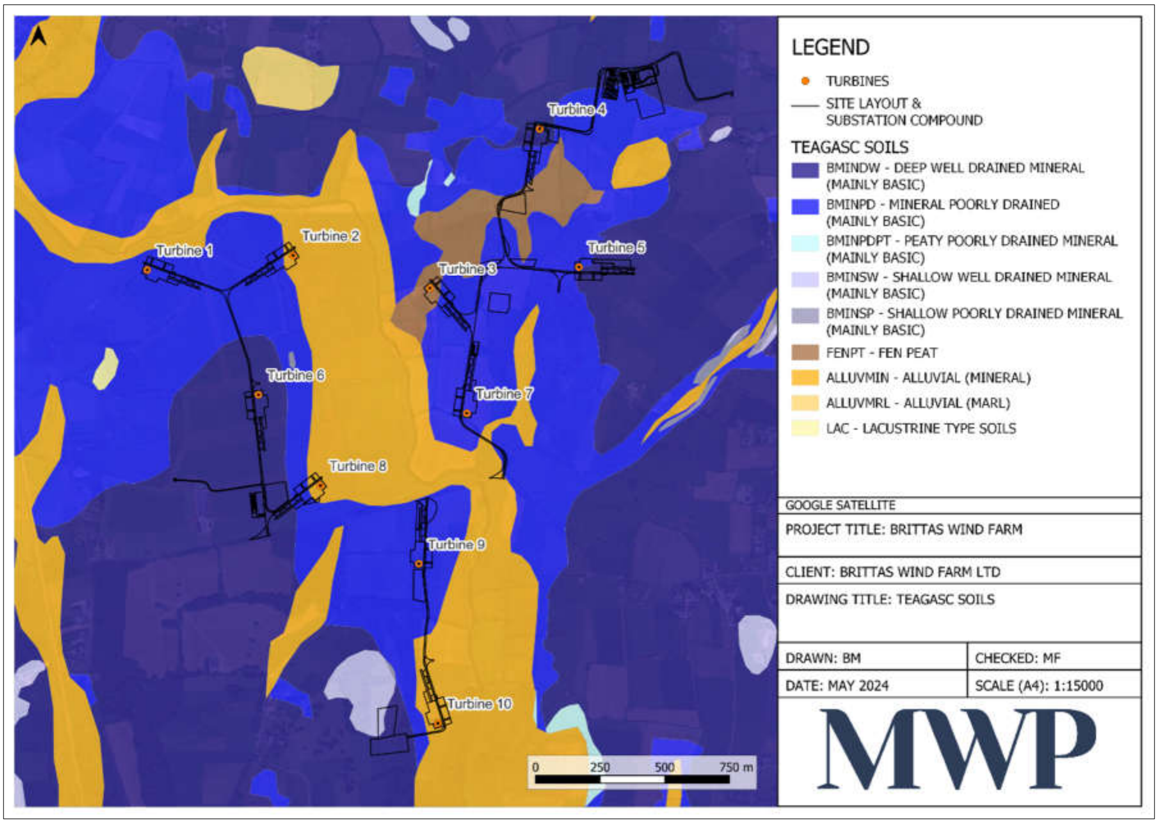


Figure 2-1: Teagasc Soil Map

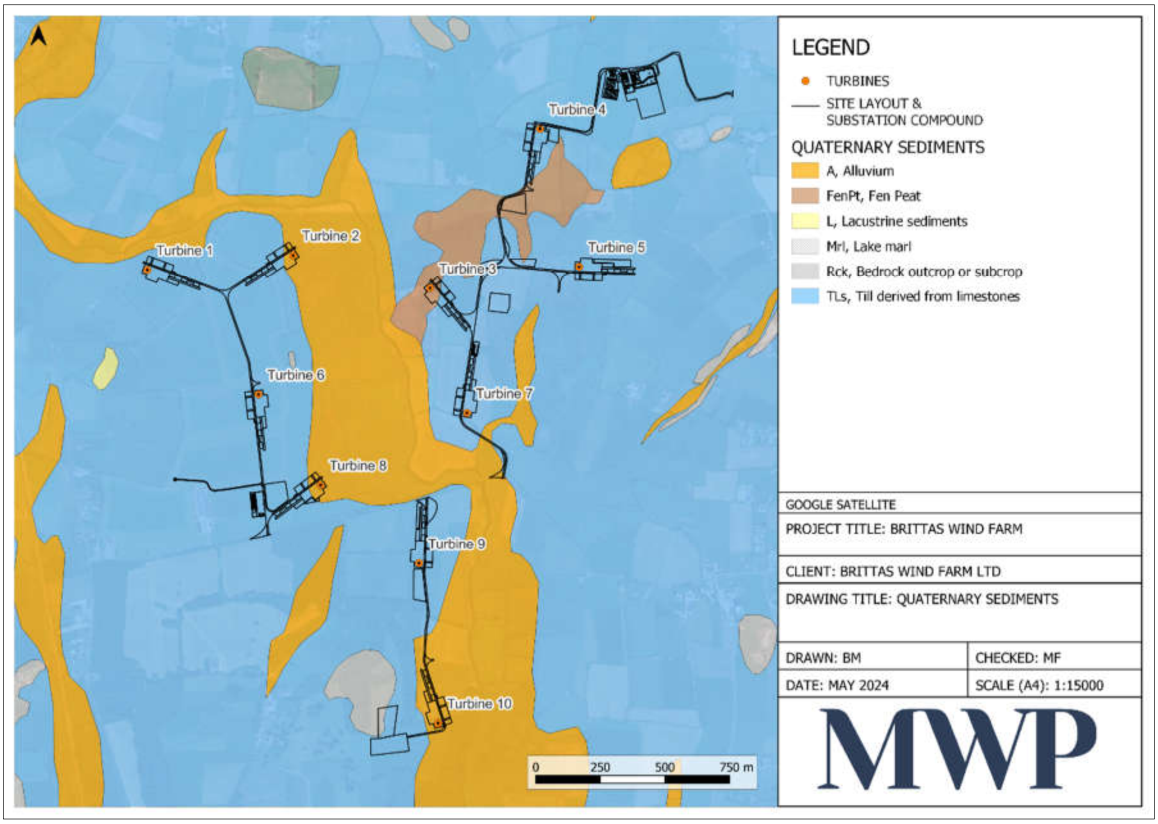


Figure 2-2: Quaternary Sediment Map

2.2 Flood History – OPW Local Area Summary Report

The Past Flood Event Local Area Summary Report which was obtained from the Office of Public Works (OPW) floodinfo.ie website is included on Figure 2-3 below. This report summarises all recorded past flood events near the site. There are two flood events near the site which have been reported and are summarised as follows;

ID-3751: Rossestown to Loughmoe Recurring (North of Thurles) - River Suir floods land along right bank and intermittently on left bank most winters.

ID-10571: Flooding took place along the river Suir in January 2008. Using aerial photography and video footage OPW staff digitised a portion of the flood extents as seen in Figure 2-4 below.

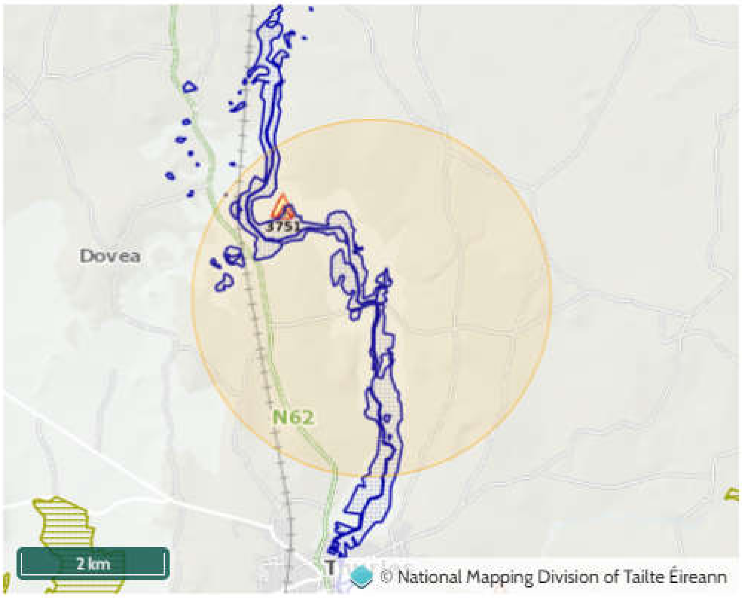
Past Flood Event Local Area Summary Report

OPW Oifig na nOibreacha Poiblí Office of Public Works

Report Produced: **16/1/2024 10:25**

This Past Flood Event Summary Report summarises all past flood events within 2.5 kilometres of the map centre.

This report has been downloaded from www.floodinfo.ie (the "**Website**"). The users should take account of the restrictions and limitations relating to the content and use of the Website that are explained in the Terms and Conditions. It is a condition of use of the Website that you agree to be bound by the disclaimer and other terms and conditions set out on the Website and to the privacy policy on the Website.



Map Legend

- Single Flood Event
- Recurring Flood Event
- Past Flood Event Extents
- Drainage Districts Benefited Lands*
- Land Commission Benefited Lands*
- Arterial Drainage Schemes Benefited Lands*

* Important: These maps do not indicate flood hazard or flood extent. Their purpose and scope is explained on Floodinfo.ie

2 Results

	Name (Flood_ID)	Start Date	Event Location
1.	Rossestown to Loughmoe Recurring (ID-3751)	n/a	Approximate Point
	Additional Information: Reports (2) Press Archive (0)		
2.	Suir Flood Jan 2008 (ID-10571)	10/01/2008	Area
	Additional Information: Reports (1) Press Archive (0)		

Figure 2-3: OPW Past Flood Event Local Area Summary Report

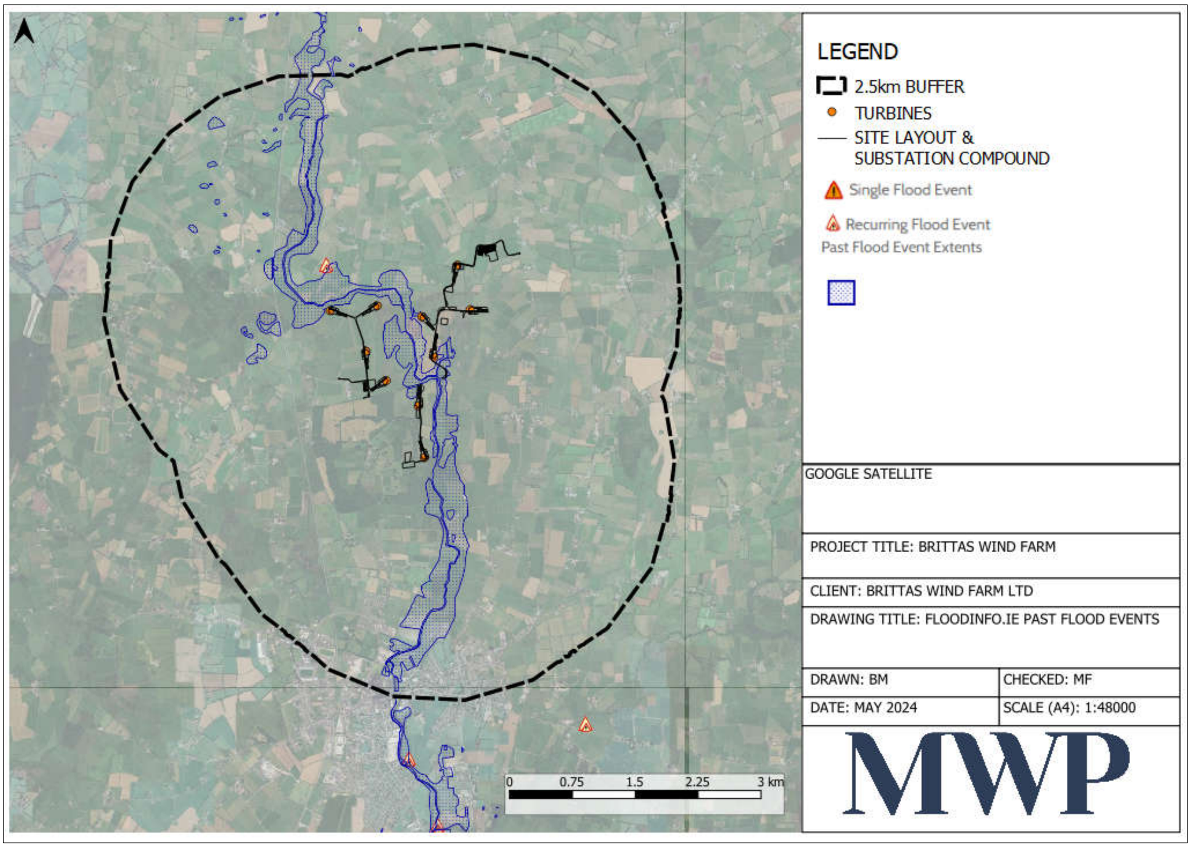


Figure 2-4: Past Flood Event Locations

2.3 National Indicative Fluvial Mapping

The National Indicative Fluvial Flood Maps have been produced for catchments greater than 5km^2 in areas for which flood maps were not produced under the National Catchment Flood Risk Assessment and Management Programme (CFRAM). As the River Suir was assessed under the Suir CFRAM study, no National Indictive Fluvial Flood Maps are available.

However, there is a tributary of the River Suir, the Rossestown Stream that converges with the River Suir downstream of Turbine 7. The tributary has been mapped under the National Indicative Fluvial Mapping program. An extract of the fluvial flood mapping for the current scenario is shown in Figure 2-5. These maps are not the best achievable representation of projected flood extents, such as those that could be generated through detailed hydraulic modelling, and are only indicative of the predicted flood extent of any given probability at any particular location. They should not be used for local decision-making or any other purpose without verification and seeking the advice of a suitable professional.

The flood maps may be used in the Stage 1 Flood Risk Assessment (Flood Risk Identification) to identify areas where further assessment would be required if development is being considered within or adjacent to the flood extents shown on the maps. Similarly, the maps may be used to identify whether flood risk might be a relevant issue when considering a planning application, or when discussing a potential application at pre-planning stage. Local site inspections, and / or making use of the knowledge of staff familiar with a particular area, are essential to determine if the maps for a given area are reasonable. For the purposes of flood zoning, or making decisions on planning applications, it is strongly recommended that a Stage 2 Flood Risk Assessment (Initial Flood Risk Assessment), as set out in the Planning System and Flood Risk Management Guidelines, is undertaken (where there are proposals for zoning or development, and where the area may be prone to flooding, as described above). These maps are 'predictive' flood maps showing indicative areas predicted to be inundated during a theoretical fluvial flood event with an estimated probability of occurrence, rather than information for actual floods that have occurred in the past, which is presented, where available, on the 'past' flood maps.

The maps refer to flood event probabilities in terms of a percentage Annual Exceedance Probability, or 'AEP'. This represents the probability of an event of this severity occurring in any given year. They are also commonly referred to in terms of a return period (e.g. the 100-year flood). The flood extents for the 1% and 0.1% AEP Present Day Scenario (Current Scenario) flood events are illustrated below in Figure 2-5 below.

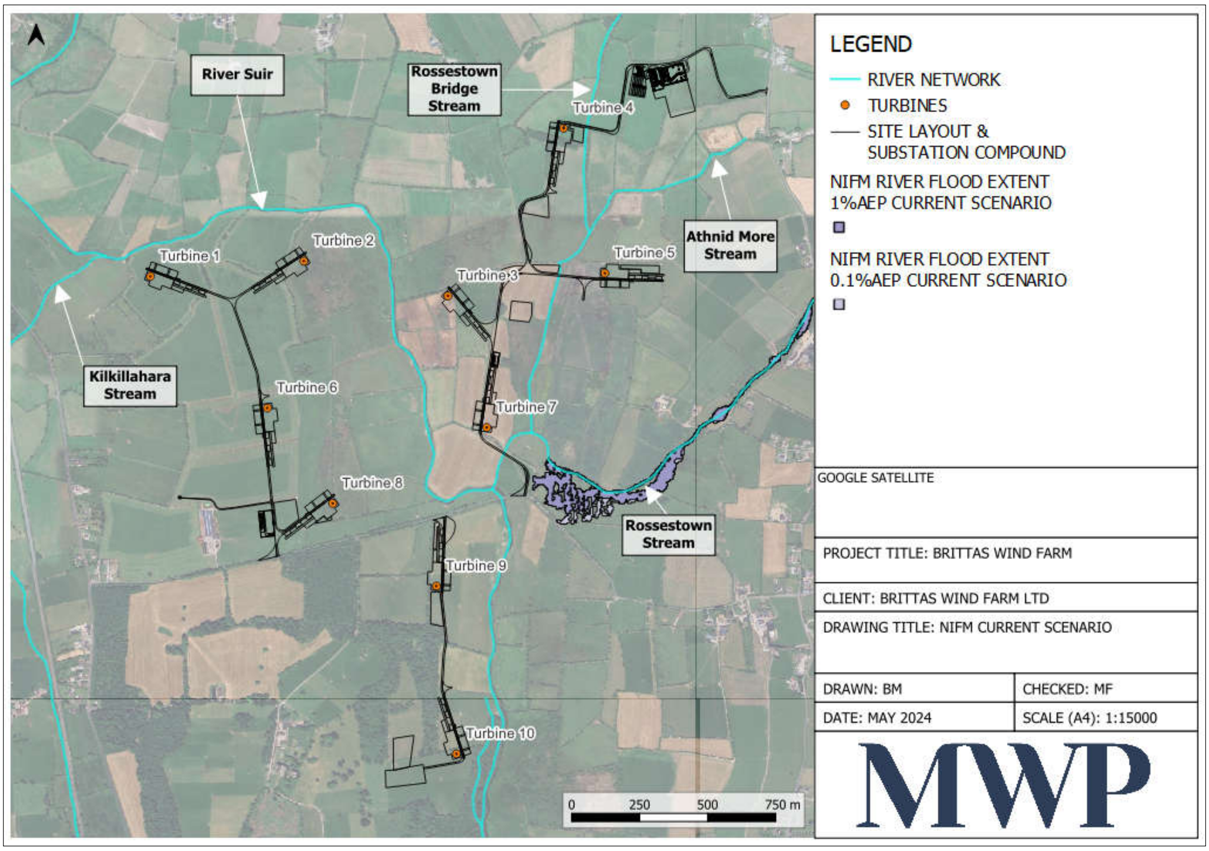


Figure 2-5: National Indicative Fluvial Mapping

2.4 Suir Catchment Flood Risk and Management Study (Suir CFRAMS)

The OPW Suir CFRAM study is the most detailed mapping in the area. The Suir CFRAM involved detailed hydraulic modelling of rivers and their tributaries along with coastal flooding. Flood extents have been generated for the River Suir. The mapping indicates that part of the proposed site is at risk of flooding during the 1% AEP and 0.1% AEP Fluvial Flood event. An extract of the flood extent map for the present-day scenario is shown in Figure 2-6 below.

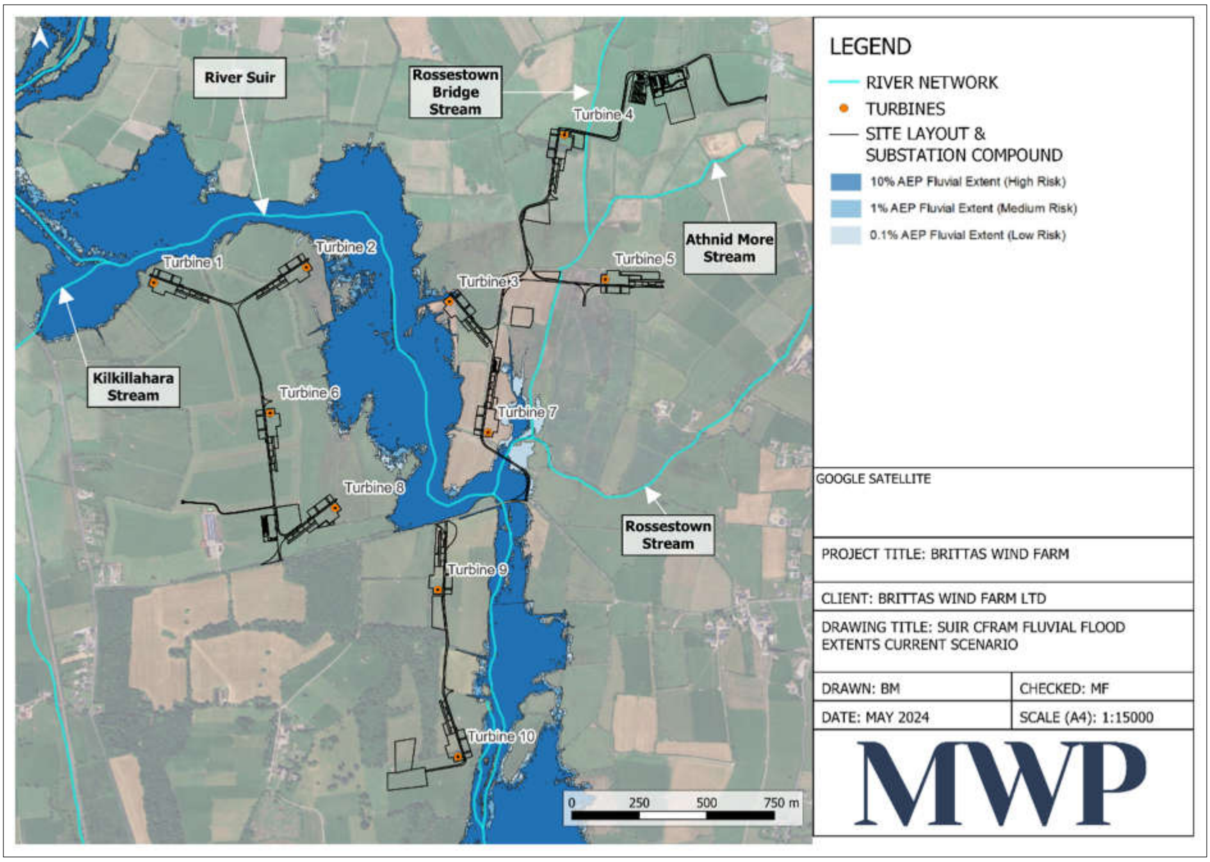


Figure 2-6: Southwestern CFRAM 10%, 1%AEP and 0.1%AEP Fluvial Flood Extent Map

2.5 GSI Winter 2015/2016 Surface Water Flooding

The Winter 2015/2016 Surface Water Flooding map shows fluvial (rivers) and pluvial (rain) floods, excluding urban areas, during the winter 2015/2016 flood event. There is flooding indicated within close proximity to the proposed development site during this flood event as seen in Figure 2-7 below.

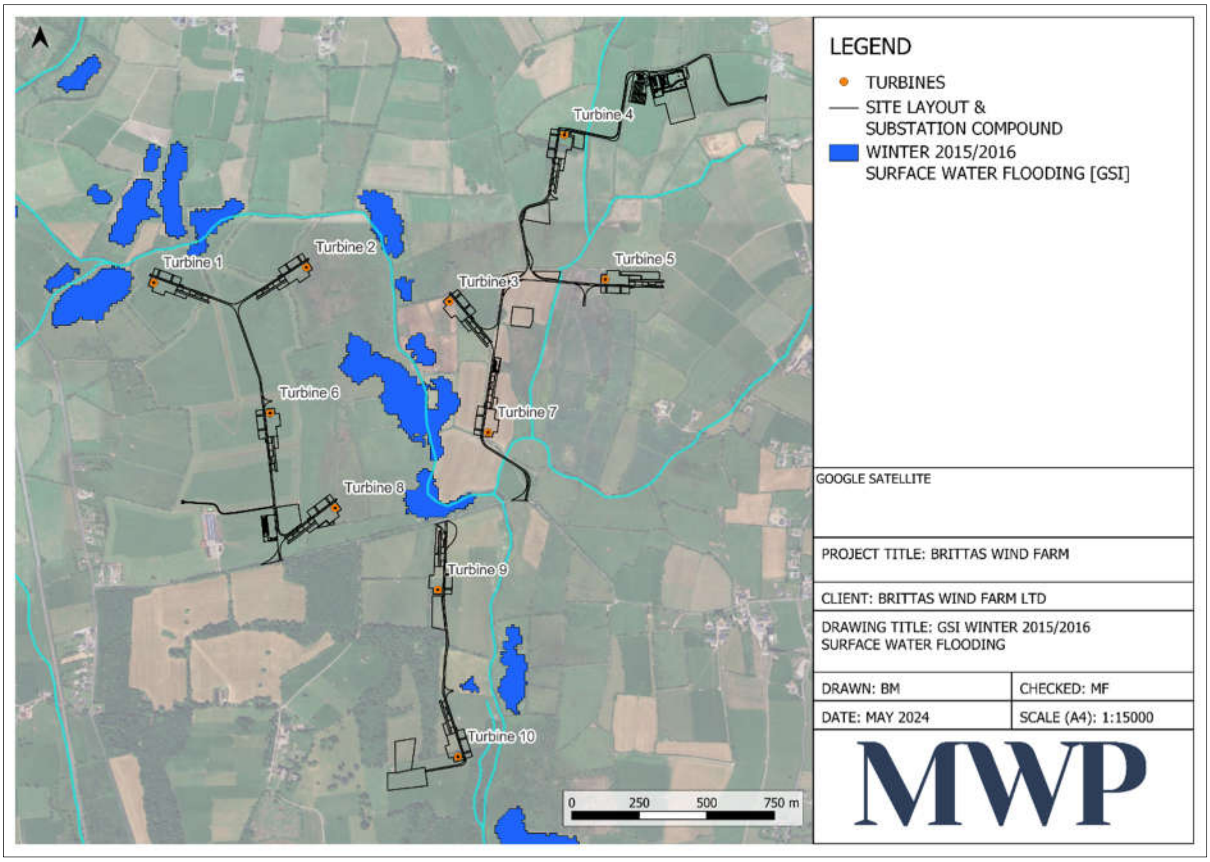


Figure 2-7: GSI Winter 2015/2016 Surface Water Flooding

2.6 Internet Searches

An internet search was conducted to gather information about whether the site was affected by flooding previously. There were no reports of flooding.

2.7 Walkover survey of the subject site and the nearby watercourse

A site walkover was carried out by MWP within the site boundary, upstream & downstream of the site on the 22nd June 2023 and the 29th September 2023. The main purpose of the site walkover was to identify any features that have not already been identified in the desktop study. No significant features pertinent to this flood risk assessment were identified on site during the walkover. Appendix A provides several photographs, which demonstrate the characteristics of the main channel, left overbank and right overbank.

2.8 Summary of Stage 1 FRA

The Stage 1 FRA has identified a potential flood risk at this site. Notwithstanding this, a Stage 2 FRA will be carried out to provide a more comprehensive assessment of the flood risk.

3. Initial Flood Risk Assessment (Stage 2)

The purpose of Initial Flood Risk Assessment is primarily to ensure that the relevant flood risk sources are identified so that they can be addressed appropriately in the Detailed Flood Risk Assessment.

3.1 Flooding Sources

The potential sources of flooding and their relevance to the flood risk at the site are outlined in the following sub-sections.

3.1.1 River Flooding

Fluvial flooding occurs when the capacity of a river channel is exceeded and water flows onto the adjacent land or floodplain. The main watercourse in the proximity of the site is the River Suir which flows from north to south through the site.

The Suir CFRAM has included detailed modelling of the River Suir. Although there is flood extents available for the proposed site, no flood maps have been produced for this area. Flood maps are available further south for Thurles town with a series of nodes which give the 10%AEP, 1%AEP and 0.1%AEP flow(m^3/sec) and water level (mOD). The flood extents in Figure 2-6 indicate that part of the proposed development is located within Flood Zone A/B.

An updated hydraulic model of the River Suir and tributaries of the River Suir will be required. It will be necessary to complete a Stage 3 - Detailed Flood Risk Assessment for this site. The Stage 3 assessment will determine freeboard for proposed turbines and associated hardstanding areas and any internal access tracks that could be potentially at risk of flooding. The Stage 3 Assessment will deliver flood extent maps, water surface elevations (mOD), depth(m) and flow(m^3/sec) for the proposed site.

3.1.2 Pluvial Flooding

Overland flow or pluvial flooding occurs when rainfall intensity exceeds the infiltration capacity of the ground. The excess water flows overland to the nearest watercourse or piped drainage system. Intense rainfall events can result in ponding in low areas or upstream of physical obstructions. Overland flow is most likely to occur following periods of sustained and intense rainfall when the ground surface becomes saturated. Flood risk from pluvial sources exists in all areas. The existing site is a greenfield site. Increase in hardstanding area will increase the risk of pluvial flooding. There is history of pluvial or surface water flooding on the site.

3.1.3 Estuarial Flooding

Estuarial or tidal flooding is caused by higher-than-normal sea levels which occur primarily due to extreme high tides, storm surges, wave action or due to high river flows combining with high tides. This risk is not relevant to this site as the proposed site is located inland. Therefore, this does not require further consideration in this report.

3.1.4 Groundwater Flooding

Groundwater flooding occurs when the water table rises to the level of the ground surface due to rainfall and flows out over the surface. Groundwater flooding occurs relatively slowly and generally poses a low hazard to people. There is no known history of such an occurrence in the vicinity of the site or no karstic landforms within the site. For these reasons this source of flooding will not be considered further in this report.

3.2 Stage 2 Summary of Identified Flood Risk

The information collected during the Stage 2 FRA indicates that the flood risk at this site is high and a Stage 3 Flood Risk Assessment is required.

Flooding Source	Stage 3 Requirement	Comment
Fluvial	Required	Suir CFRAM indicates that there is a risk of fluvial flooding within the site for the present day 1% AEP event and above.
Pluvial/Overland Flow	Not Required	Pluvial flooding exists in all areas. Adequate storm water drainage systems will minimise pluvial flood risk.
Estuarial/Coastal	Not Required	The site is located inland. Therefore, this flood risk is not relevant to this site
Groundwater	Not Required	There is also no known history of such an occurrence in the vicinity and no features associated with groundwater flooding were identified within or in close proximity of the site

Table 3-1: Summary of Identified Flood Risk

3.3 Appraisal of Availability and Adequacy of Existing Information

Reliable gauged flow data is available for the River Suir. It will be necessary to estimate the design flows at suitable locations along the reach for input to the hydraulic model. The Suir CFRAM Study includes detailed information with regard to the River Suir flood flows and flood elevations for Thurles town but does not extend as far north to the proposed site. A topographical survey of the site has been provided. Survey data exists for the River Suir that would have been collected during the Suir CFRAM Study. River survey data has been commissioned to improve the accuracy of the hydraulic model. A hydrographic survey of the river channel of the River Suir and Rossesstown Stream was carried out by Murphy Geospatial in Mach 2023, which includes open channel cross sections of the watercourses flowing through the project site. An additional hydrographic survey of the Rossesstown Stream tributaries was also carried out by Murphy Geospatial in January 2024, which also included open channel cross sections of the river channels. The client has provided Malachy Walsh & Partners with 2m Photogrammetric DTM. However, a comparison of the 2m Photogrammetic DTM and the topographical survey was carried out. The results indicated that the 2m Photogrammetric DTM was approximately 700mm higher on average when compared with the topographical survey. It was confirmed by the provider of the 2m Photogrammetric DTM that the variances observed are within the expected tolerances from a 2m DTM generated using photogrammetric processes namely with a 0.5m to 1m accuracy. LiDAR is required for floodplain modelling. The National Floodplain DTM – Combined DTM was made available to MWP. The National Floodplain DTM has a 2m resolution. A comparison between the National Floodplain DTM and the topographical survey was carried out as can be seen in Figure 3-1 and Figure 3-2 below. The results indicated that the National Floodplain DTM and topographical survey have a reasonable match for the overbank areas of the River Suir, Rossestown Stream and its tributaries. Therefore, the National Floodplain DTM data will be used to create a digital terrain model of the floodplain, allowing MWP to model overland flows and create flood extent and flood depth maps.

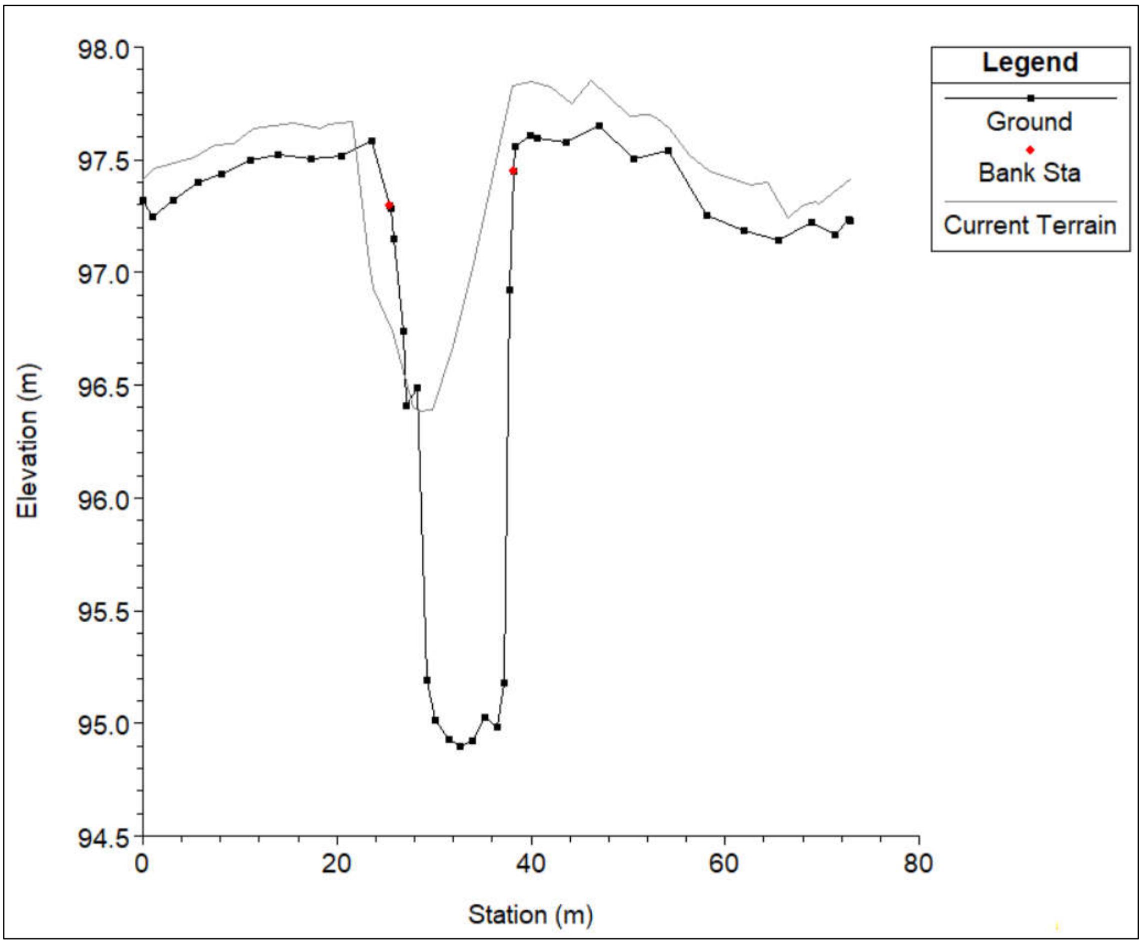


Figure 3-1: National Floodplain DTM and Topographical Survey River Cross Section (Upper River Suir Reach)

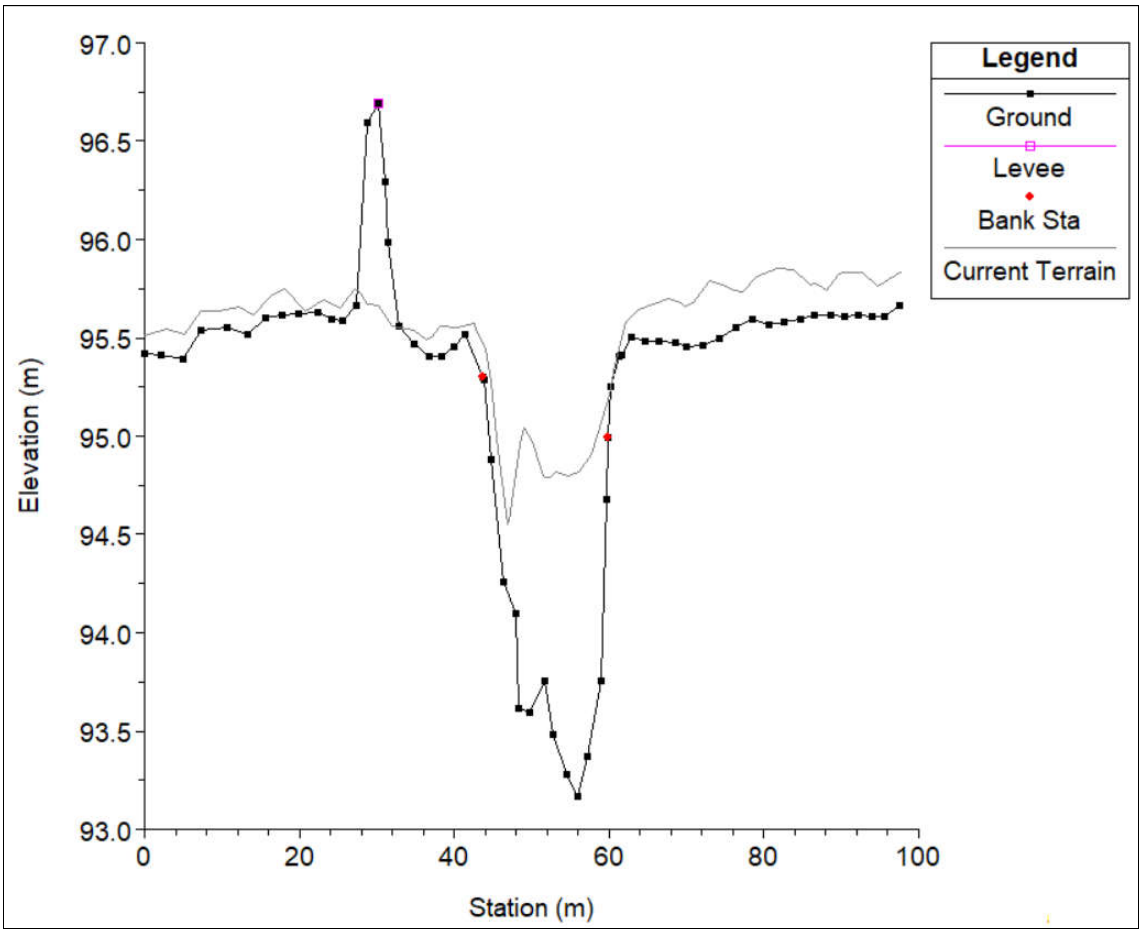


Figure 3-2: National Floodplain DTM and Topographical Survey River Cross Section (Lower River Suir Reach)

3.4 Flood Zone Identification

The Suir CFRAM Fluvial Mapping suggests that part of the proposed Wind Farm would be flooded in the current scenario during the 1% and 0.1% AEP fluvial events. This places the site within Flood Zone A/B.

3.5 Potential Impacts of Flooding Elsewhere

Depending on the findings of the State 3 FRA, the proposed development may have the following potential impacts on flooding outside of the site;

- Construction on or filling up of existing floodplains would result in a reduced floodplain storage volume which could increase the flood risk downstream of the site.
- It is generally considered that new developments constructed without flood attenuation on greenfield sites will result in an increased outflow from the site. This could cause an overall increase in the flood level (and hence flood risk) downstream of the site, particularly if large portions of the catchment are developed over time.

A Stage 3 FRA will be required to confirm the flood risk mitigation required for this site and to confirm the proposed development will not adversely impact flood risk elsewhere.

3.6 Requirements for a Stage 3 FRA

A Stage 3 detailed flood risk assessment will be carried out in Section 3.6 of this report in order to provide a quantitative appraisal of potential flood risk to the site and to examine the potential impact of the development on flood risk elsewhere. This will require the construction of a hydraulic model of the River Suir and tributaries of the River Suir and the completion of a hydrological assessment of the catchments. Any relevant mitigation measures will be reviewed and residual risks will be assessed.

4. Detailed Flood Risk Assessment (Stage 3)

4.1 Introduction

The purpose of this Stage 3 FRA is to assess flood risk issues in sufficient detail to provide a quantitative appraisal of potential flood risk to the site, of the potential impact of the development on flood risk elsewhere and to establish what mitigation measures, if any, may be required. The Stage 3 FRA will therefore require carrying out a detailed review of the River Suir and tributaries of the River Suir catchment hydrology to establish appropriate flood flows for various scenarios. A hydraulic model of the river reaches will then be created to determine key flood risk parameters such as flood levels and flood extents.

4.2 Fluvial Flooding - Hydrology & Flow Estimation

4.2.1 Overview

In this section a detailed assessment will be carried out to estimate the flood flows at the site for various Annual Exceedance Probabilities (AEP's). The AEP is the likelihood or probability of a flood of a given magnitude occurring or being exceeded in any given year. The results of this analysis will then form a key input into the subsequent hydraulic modelling of the study area which will enable the flood levels and extents to be determined.

4.2.2 Catchment & River Reach Description

The catchment delineations for the proposed site are shown in Figure 4-1 below. The catchments area are summarised in Table 4-1 below.

Catchment	Area (km^2)
001	0.67
002	2.29
003	3.33
004	30.84
005	189.6

Table 4-1: Catchment Characteristics

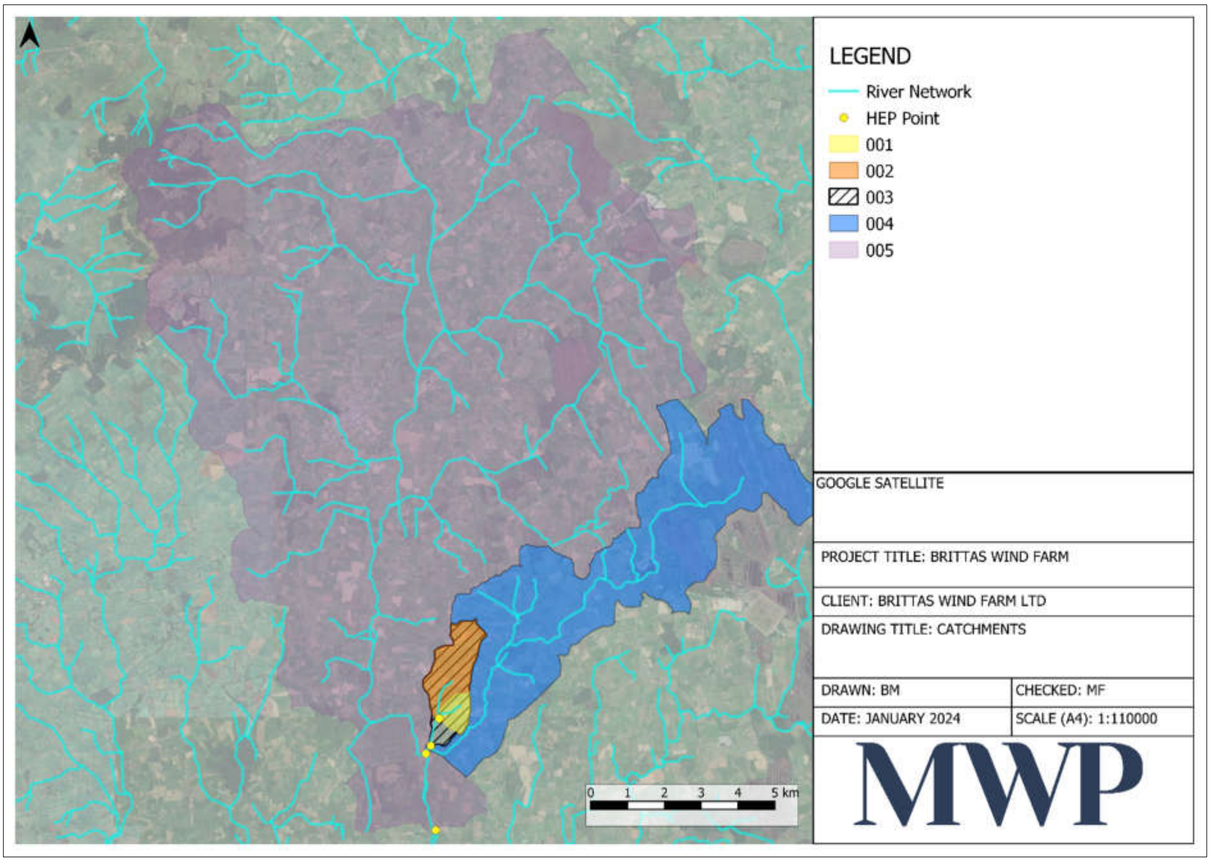


Figure 4-1: Catchment Delineation

4.3 Hydrological Estimation Point

Five hydrological estimation points (HEP) have been considered for the hydraulic design.

4.3.1 Design Confidence Levels

Where flows have been estimated using statistical methods, the design flow has been derived using the 95% confidence level flow, given the vulnerability of the proposed development and to demonstrate the acceptability of the proposed design. This is considered to provide a conservative upper bound estimate of design flow and associated flood risk.

4.3.2 Climate Change Allowance

In order to allow for the effects of climate change, the calculated flows have been increased by a factor of 1.2. This corresponds to the Mid-Range Future Scenario (MRFS).

4.4 Flow Estimation

4.4.1 Overview of Methodology

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. Q_{MED}) 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. Ideally the application of this equation would be limited to catchments greater than 25km², although it has been shown to perform reasonably well for smaller catchments. Given that two out of the five catchment areas are larger than this threshold, the FSU equation is deemed suitable for flow estimation. 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**.**

The general procedure for estimating the Index Flood at any HEP can be summarised as follows;

1. Review the Physical Catchment Descriptors at each HEP and identify suitable pivotal site(s);

2. Estimate the Index Flood at the potential pivotal site(s) using annual maxima data;

3. Estimate the Index Flood at the potential pivotal site(s) using Physical Catchment Descriptors and determine the appropriate adjustment factor (i.e. Q_{MED} Gauged / Q_{MED} PCD Rural);

4. Estimate the Index Flood at each HEP using Physical Catchment Descriptors;

5. Estimate the Design Index Flood flow at each HEP using the relevant gauging station as a pivotal site and adjust the rural estimate for urbanisation.

In order to estimate flows for various Annual Exceedance Probabilities (AEP's) it is necessary to derive a suitable flood growth curve which is used to scale Q_{MED} for the required return period. The growth curve can be derived from a single site analysis or from a pooled analysis, depending on the record length and data reliability.

4.4.2 Beakstown (16002) Annual Maxima

The catchment area of Catchment 005 and Beakstown (Station 16002) is estimated to be 189.6km² and 512km² respectively.

The FSU Web Portal (opw.hydronet.com) can typically be used to determine Q_{MED} from gauged flow data and to derive appropriate growth curves using either a single site or pooled analysis. At present the gauged data available on the Web Portal typically only includes up to hydrometric year 2004. There have been some significant flood events in the intervening period which would potentially influence the flood estimation therefore it was considered prudent to obtain the updated annual maxima series for Station 16002, rather than relying on the FSU Web Portal database.

Having reviewed the annual maxima flow for Beakstown (16002), a QMED of 52.66m³/s is recorded.

4.4.3 Clobanna (16051) Annual Maxima

The catchment area of Catchment 004 and Clobanna (Station 16051) is estimated to be 30.84km² and 34.19km² respectively. It can reasonably be expected that peak flows experienced at the site for the Rossestown Stream will be comparable to Clobanna which is located c.1km upstream. Therefore, key to establishing a reliable flow estimate for the Rossestown Stream at the site is validation of the flow data available for 16051.

The FSU Web Portal (opw.hydronet.com) can typically be used to determine Q_{MED} from gauged flow data and to derive appropriate growth curves using either a single site or pooled analysis. However, at present the gauged data available on the Web Portal typically only includes up to hydrometric year 2004. There have been some significant flood events in the intervening period which would potentially influence the flood estimation therefore it was considered prudent to obtain the updated annual maxima series for Station 16051, rather than relying on the FSU Web Portal database.

Having reviewed the annual maxima flow for Clobanna (16051), a QMED of 2.38m³/s is recorded.

4.4.4 FSU 7-Variable Equation

The FSU method for ungauged catchments uses Physical Catchment Descriptors (PCD's) to establish an initial estimate of the Index Flood (i.e. Q_{MED}) based on a seven variable regression equation.

The Index Flow Q_{MED} is estimated using the following seven variable regression equation which was presented in FSU WP2.3:

$$Q_{MED} = 1.237x10^{-5} AREA^{0.937} BFIsoils^{-0.922} SAAR^{1.306} FARL^{2.217} DRAIND^{0.341} S1085^{0.185} (1 + ARTDRAIN2^{0.408})$$

Where relevant, the adjustment for urbanisation is made by applying the following equation:

$$Q_{MED\ URBAN} = Q_{MED}(1 + URBEXT)^{1.482}$$

The factorial standard error (FSE) of this equation is 1.37.

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. The PCD estimate at Thurles was used in conjunction with the gauged Q_{MED} value to establish the adjustment factor for the site. The analysis is summarised on Table 4-2 and **Error! Reference source not found.** below.

	Data Description	Units	HEP	Source
1a	Catchment Area	sq km	512.00	OPW
1b	Urban Catchment Area	sq km	0.01	FSU
2c	Stream Slope S1085	m/km	1.29	FSU
3	BFIsoil		0.63	FSU
4	SAAR	mm	932.15	FSU
5	FARL		1.00	FSU
6	DRAIND	km/km²	0.89	Measure/FSU
7	ARTDRAIN2		0.00	FSU
8	URBEXT		0.01	Calculate
9	QMED Rural PCD Estimate	m³/s	47.15	FSU WP2.3
10	QMED Urban PCD Estimate	m³/s	47.92	FSU WP2.3
12	QMED Gauged		52.66	

13	Adjustment Factor		1.10	

Table 4-2: Station 16002 – Pivotal Site Adjustment Factor

	Data Description	Units	HEP	Source
1a	Catchment Area	sq km	34.19	Measure
1b	Urban Catchment Area	sq km	0.00	Measure
2c	Stream Slope S1085	m/km	1.62	FSU
3	BFIsoil		0.68	FSU
4	SAAR	mm	895.27	FSU
5	FARL		1.00	FSU
6	DRAIND	km/km^2	0.76	Measure/FSU
7	ARTDRAIN2		0.00	FSU
8	URBEXT		0.01	Calculate
9	QMED Rural PCD Estimate	m^3/s	3.46	FSU WP2.3
10	QMED Urban PCD Estimate	m^3/s	3.46	FSU WP2.3
12	QMED Gauged (Annual Maxima)		2.38	
13	Adjustment Factor		0.69	

Table 4-3: Station 16051

4.4.5 Institute of Hydrology 124 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 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 for catchments 001, 002 and 003 is included in Table 4-4.

Data Description	Catchment 001	Catchment 002	Catchment 003
AREA (km^2)	0.67	2.29	0.37
URBAN AREA (km^2)	0.00	0.00	0.00
SAAR (mm)	940.00	940.00	940.00
SOIL	0.47	0.47	0.47
Q_{Bar} Rural (m^3/s)	0.44	1.32	0.26
Q_{Bar} Urban (m^3/s)	0.44	1.32	0.26

Table 4-4: Institute of Hydrology Report 124 method

4.4.6 Flood Frequency Analysis

Based on the FSU guidance, an improved growth curve can generally be derived by pooling a number of station records. For this study a pooling group has been selected based on the most hydrologically similar gauged sites using the ranked list provided on the FSU Web Portal. For a target design event of 100 year return period, the 5T rule adopted by FEH 1999 and the FSU requires a minimum record length of 500 years.

The growth curves derived from the pooled analysis using both 2 parameter and 3 parameter distributions are plotted on Figure 4-2 along with the FSR Regional growth for Ireland and the Suir CFRAM Study growth curve. FSU research indicates that 3-parameter distributions are generally more suitable for ungauged sites. The GEV distribution fitted by L-moments has a downward trend and implies an upper bound value which is only 33.5% greater than the largest observation. The GLO coincides well with the Suir CFRAM Study curve for return periods up to 50 years.

QT	POOLED - EV1	POOLED - GEV	POOLED - GLO	POOLED - LO	SUIR MAIN CHANNEL CFRAM	SUIR MAJOR TRIBUTARY GROUP A CFRAM	FSR REGIONAL
2	1	1	1	1	1	1	0.95
5	1.23	1.22	1.2	1.31	1.22	1.22	1.2
10	1.38	1.35	1.33	1.48	1.35	1.35	1.37
20	1.52	1.46	1.45	1.65	1.47	1.48	1.6
30	1.61	1.52	1.52	1.74	1.53	1.54	1.65
50	1.71	1.59	1.62	1.86	1.61	1.63	1.77
100	1.85	1.67	1.76	2.01	1.72	1.74	1.96
200	1.99	1.75	1.9	2.17	1.82	1.84	2.14
1000	2.32	1.9	2.27	2.52	2.05	2.08	2.6

Table 4-5: Flood Growth Curves

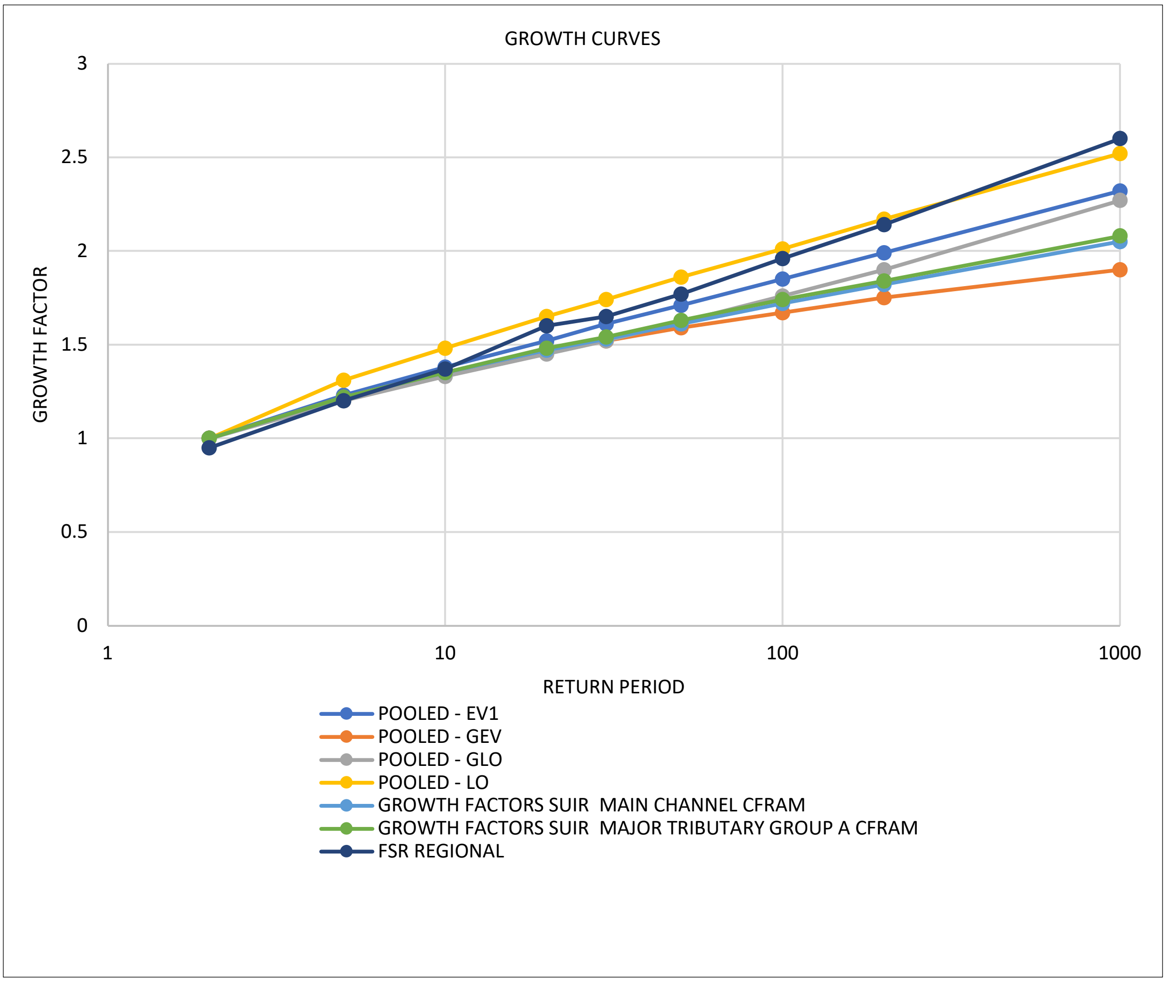


Figure 4-2: Flood Growth Curve Comparison

4.4.7 Summary of Design Flows

The design peak flows at the site for the catchments are summarised on for variois AEP's in Table 4-6 to Table 4-10 below.

Return Period, T	AEP(%)	Growth Factor	Peak Flow (m³/sec)	Peak Flow + Climate Change MRFS (m³/sec)
2	0.50	0.95	0.42	0.50
5	0.20	1.20	0.53	0.64
10	0.10	1.37	0.61	0.73
20	0.05	1.55	0.69	0.85
30	0.033	1.65	0.73	0.88
50	0.02	1.77	0.78	0.94

Return Period, T	AEP(%)	Growth Factor	Peak Flow (m^3/sec)	Peak Flow + Climate Change MRFS (m^3/sec)
100	0.01	1.96	0.87	1.04
200	0.005	2.14	0.95	1.14
1000	0.001	2.60	1.15	1.38

Table 4-6: Summary of Design Flows for Catchment 001

Return Period, T	AEP(%)	Growth Factor	Peak Flow (m^3/sec)	Peak Flow + Climate Change MRFS (m^3/sec)
2	0.50	0.95	1.25	1.51
5	0.20	1.20	1.58	1.90
10	0.10	1.37	1.81	2.17
20	0.05	1.60	2.05	2.46
30	0.033	1.65	2.18	2.61
50	0.02	1.77	2.34	2.80
100	0.01	1.96	2.59	3.11
200	0.005	2.14	2.83	3.39
1000	0.001	2.60	3.43	4.12

Table 4-7: Summary of Design Flows for Catchment 002

Return Period, T	AEP(%)	Growth Factor	Peak Flow (m^3/sec)	Peak Flow + Climate Change MRFS (m^3/sec)
2	0.50	0.95	0.25	0.30
5	0.20	1.20	0.31	0.38
10	0.10	1.37	0.36	0.43
20	0.05	1.60	0.40	0.48
30	0.033	1.65	0.43	0.52
50	0.02	1.77	0.46	0.55
100	0.01	1.96	0.51	0.61
200	0.005	2.14	0.56	0.67
1000	0.001	2.60	0.68	0.81

Table 4-8: Summary of Design Flows for Catchment 003

Return Period, T	AEP(%)	Growth Factor	Peak Flow (m^3/sec)	Peak Flow + Climate Change MRFS (m^3/sec)
2	0.50	1.00	2.42	2.91
5	0.20	1.20	2.91	3.49
10	0.10	1.33	3.22	3.87
20	0.05	1.45	3.52	4.22
30	0.033	1.52	3.69	4.42
50	0.02	1.62	3.93	4.71
100	0.01	1.76	4.27	5.12
200	0.005	1.9	4.61	5.53
1000	0.001	2.27	5.50	6.60

Table 4-9: Summary of Design Flows for Catchment 004

Return Period, T	AEP(%)	Growth Factor	Peak Flow (m^3/sec)	Peak Flow + Climate Change MRFS (m^3/sec)
2	0.50	1.00	25.97	31.17
5	0.20	1.20	31.17	37.40
10	0.10	1.33	34.54	41.45
20	0.05	1.45	37.66	45.19
30	0.033	1.52	39.48	47.38
50	0.02	1.62	42.08	50.49
100	0.01	1.76	45.71	54.86
200	0.005	1.9	49.35	59.22
1000	0.001	2.27	58.96	70.75

Table 4-10: Summary of Design Flows for Catchment 005

4.5 Hydrograph Derivation

In order to produce a design hydrograph to provide input to the unsteady-state hydraulic modelling, a hydrograph shape is required in addition to a design peak flow. The FSU Webportal module allows the user to derive a hydrograph for an ungauged site from a statistical analysis of the continuous flow records for gauged sites. Based on this approach, the design flow hydrographs are plotted on Figure 4-3 and Figure 4-4 below for several return periods.

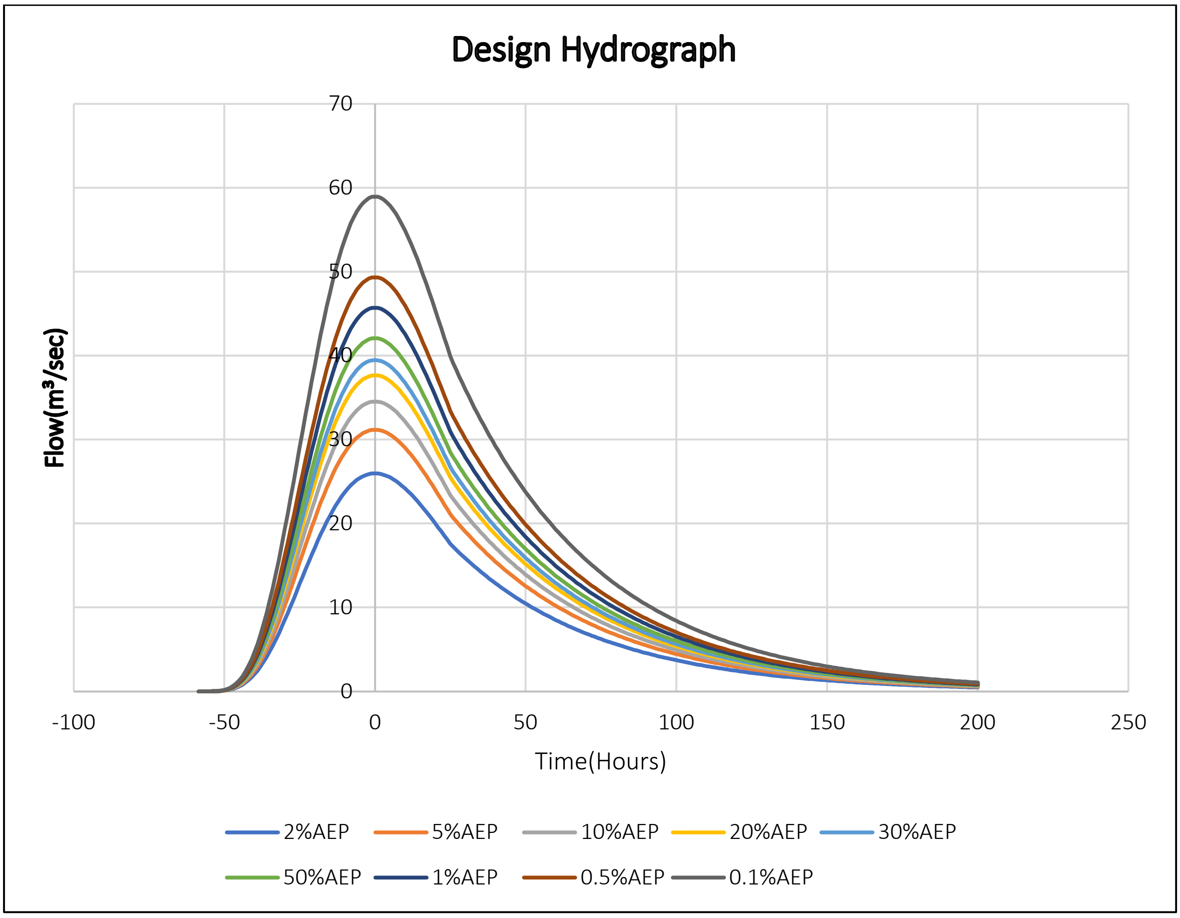


Figure 4-3: Design Flow Hydrographs for Catchment 005 (m^3/s)

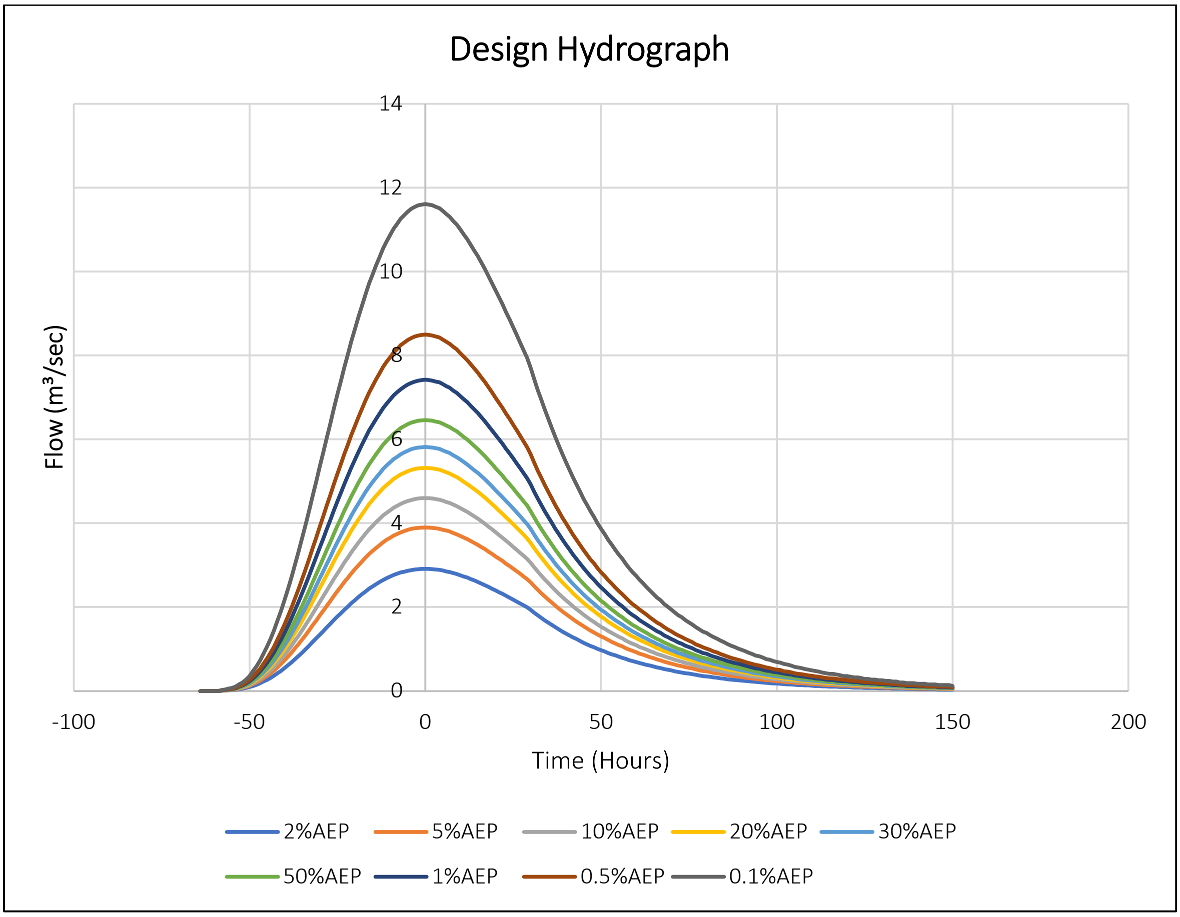


Figure 4-4: Design Flow Hydrographs for Catchment 004 (m³/s)

5. Hydraulic Modelling

5.1 Modelling Approach

The hydraulic analysis was carried out using the Hydraulic Engineering Centre River Analysis System (HEC-RAS 6.3.1) software which was developed by the US Army Corps of Engineers.

It was identified at an early stage that there is potential for complex overland flow paths to exist within the site boundary, therefore a 1D-2D hydraulic model was created.

The 1-dimensional (1D) model incorporates approximately 46 cross sections representing 6.74km of the River Suir, the Rossestown Stream and its tributaries. The model includes the Rossestown triple arch bridge along the reach. The 1D domain is intended to model the in-bank flows.

The 2D model domain includes the floodplains surrounding the proposed project. Its purpose is to model overland flows towards the turbines and other complex flow paths within the proposed wind farm which cannot be adequately represented by a 1D model. A 10m x 10m cell size was adopted however this was refined along roads and other areas for a more accurate assessment of flow paths.

The 1D and 2D models are linked by lateral weirs positioned adjacent to the main banks of the river. The weir elevation was set to coincide with the ground elevation at the interface between the 1D and 2D domains and positive or negative flow is permitted so that any water which enters the floodplain at one location could potentially flow back into the main channel at another location. A weir coefficient of 0.28 was generally adopted. This represents an upper bound value for non-elevated overbank terrain and a lower bound value for natural high ground 0.3 to 1m high.

The hydraulic model schematic is included in Figure 5-1.

An unsteady flow analysis was performed using flow hydrographs which were derived during the hydrological analysis. The downstream boundary condition was set as the average bed slope in the vicinity of the boundary condition.

Based on a walkover of the river reach, Manning's 'n' values were assigned based broadly on land use type and terrain. These are summarised on Table 5-1 below.

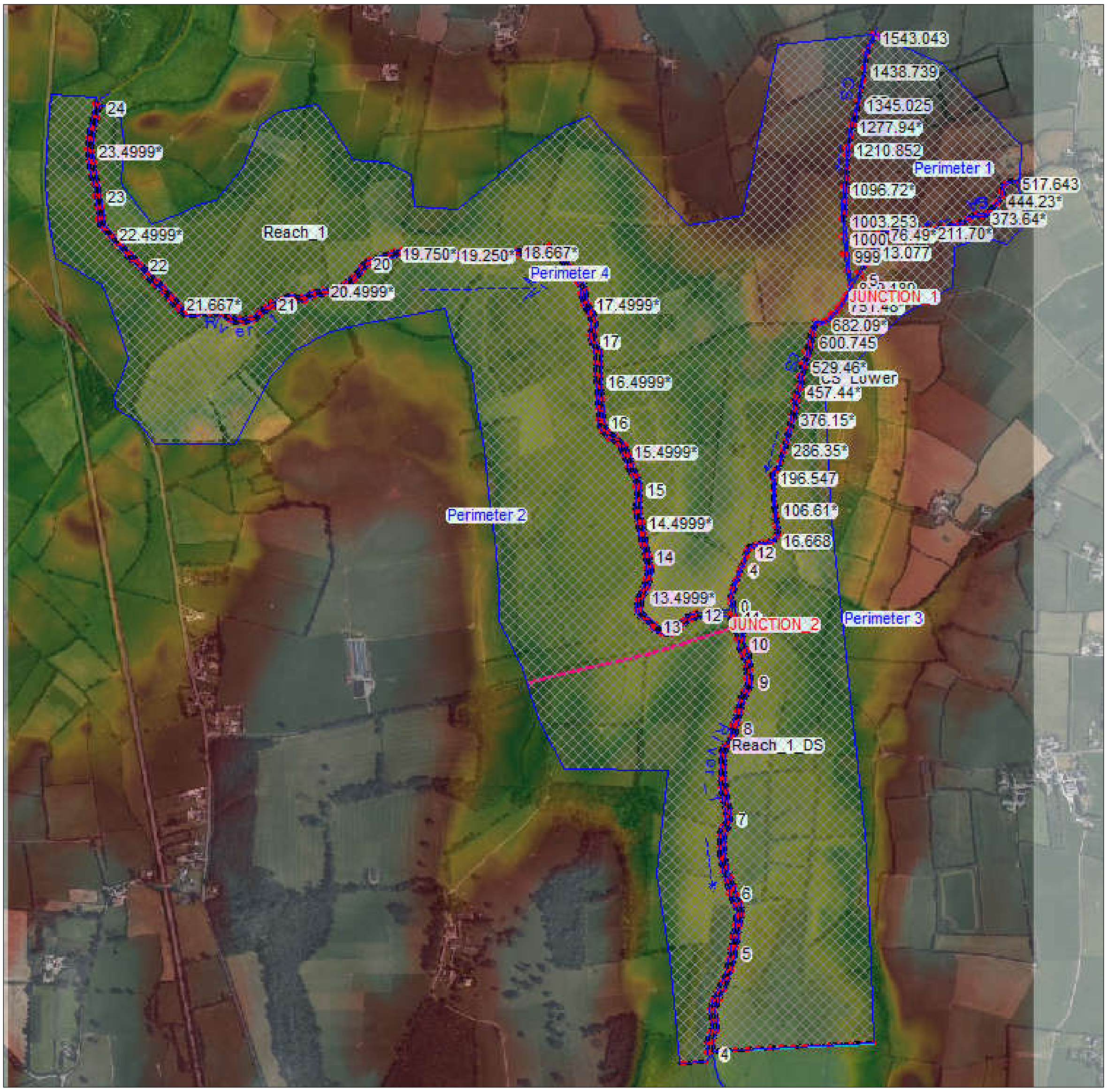


Figure 5-1: Model Schematic

Location	Manning's n
River Channel	0.04
Overbank and 2D Areas	0.05

Table 5-1: Manning's n Values

5.2 Flood Zone Mapping – Baseline Situation

The PSFRM Guidelines document defines three flood zone types as follows:

Flood 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);

Flood 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); and

Flood 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 flood zones are defined without taking the effects of future climate change into account.

The hydraulic model was used to establish the design flood levels at the site for the 1% AEP and 0.1% AEP flows and these were used to produce a flood zone maps for the site and surrounding floodplains. The Flood Zone Maps, which indicate the extent of Flood Zones A and B is shown on Figure 5-2 to Figure 5-6 below.

The turbine locations are in all three flood zones as defined in the Flood Risk Management Guidelines. As can be seen in Figure 5-2 the proposed Brittas Sub-station is located within Flood Zone C. The majority of the turbines are located outside of Flood Zone A and Flood Zone B, therefore placing the turbines in Flood Zone C.

The hardstand associated with Turbine 4 is shown to be within Flood Zone A. However, the depth of flooding at the hardstand for Turbine 4 is negligible.

The zoning of each of the turbines is summarised in Table 5-2.

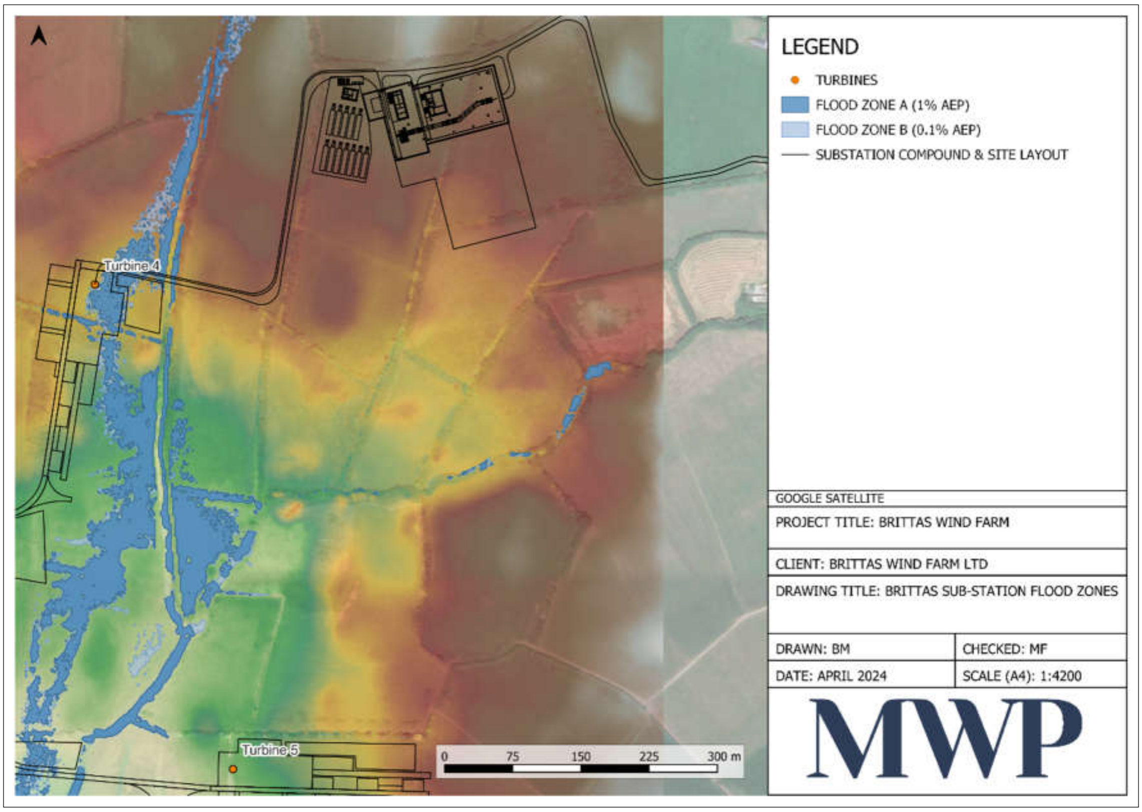


Figure 5-2: Brittas Sub-station Flood Zones – Existing Scenario

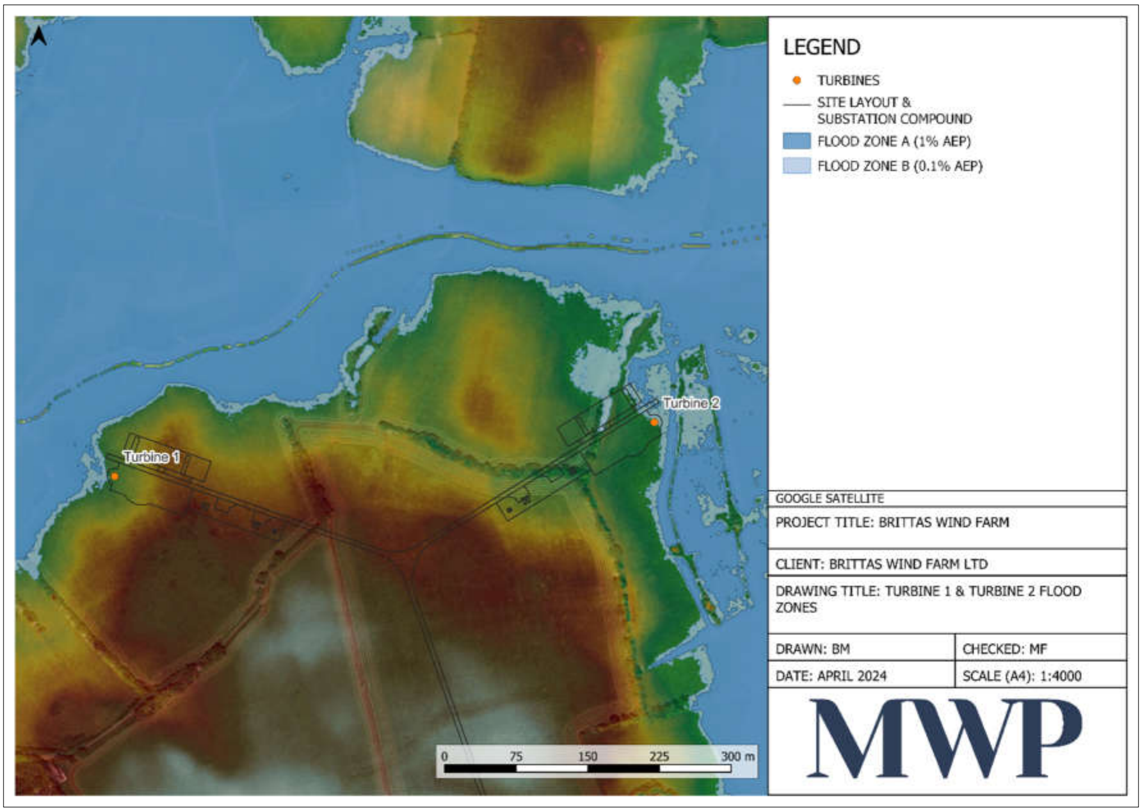


Figure 5-3: Turbine 1 & Turbine 2 Flood Zones – Existing Scenario

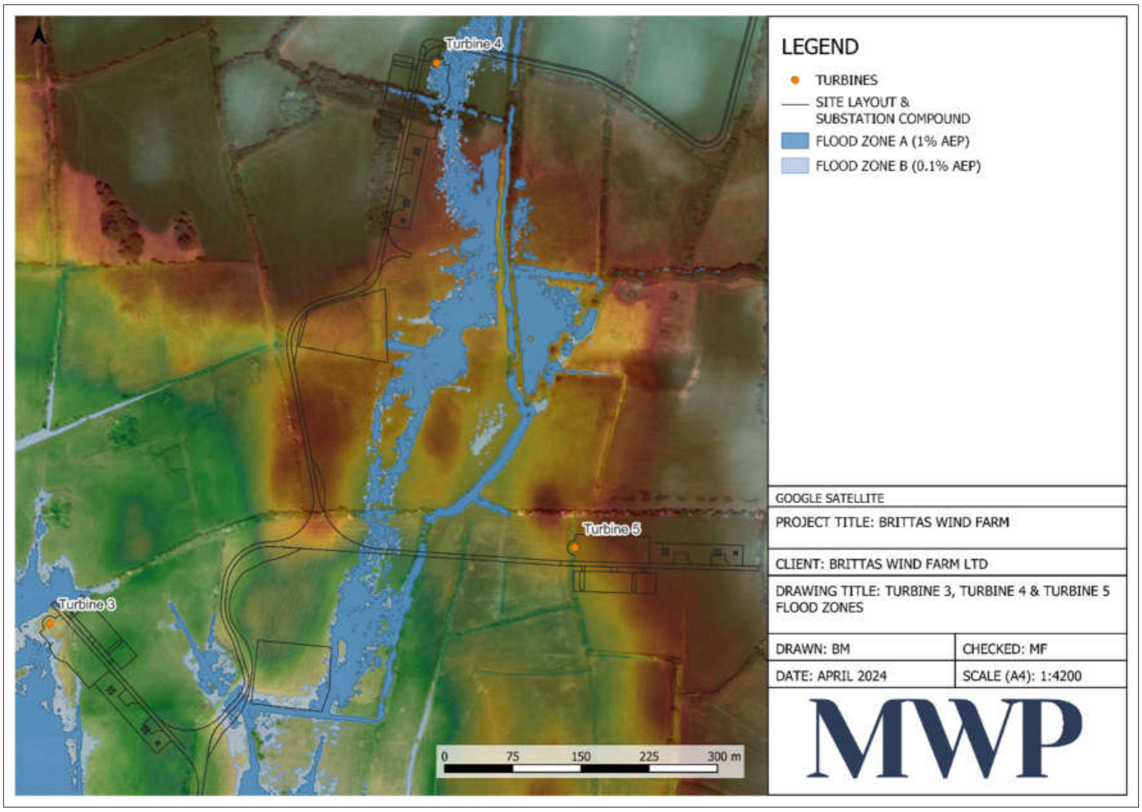


Figure 5-4: Turbine 3, Turbine 4 & Turbine 5 Flood Zones – Existing Scenario

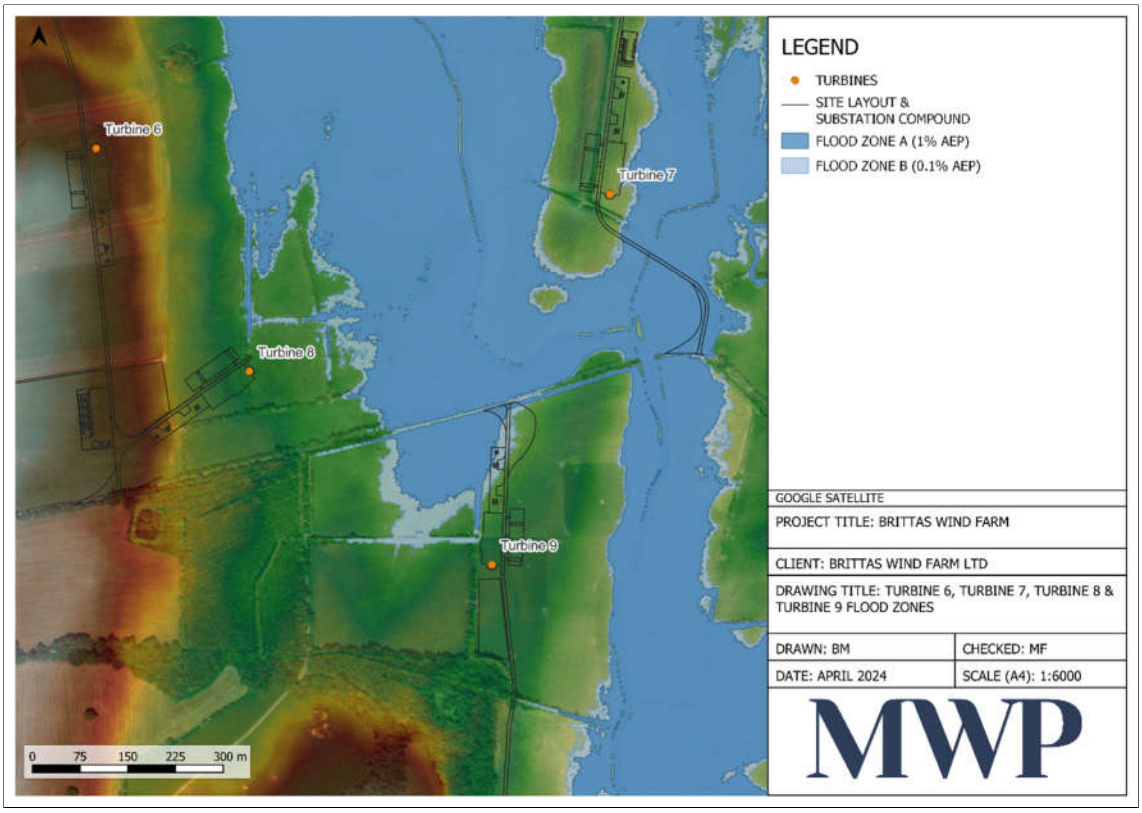


Figure 5-5: Turbine 6, Turbine 7, Turbine 8 & Turbine 9 Flood Zones – Existing Scenario

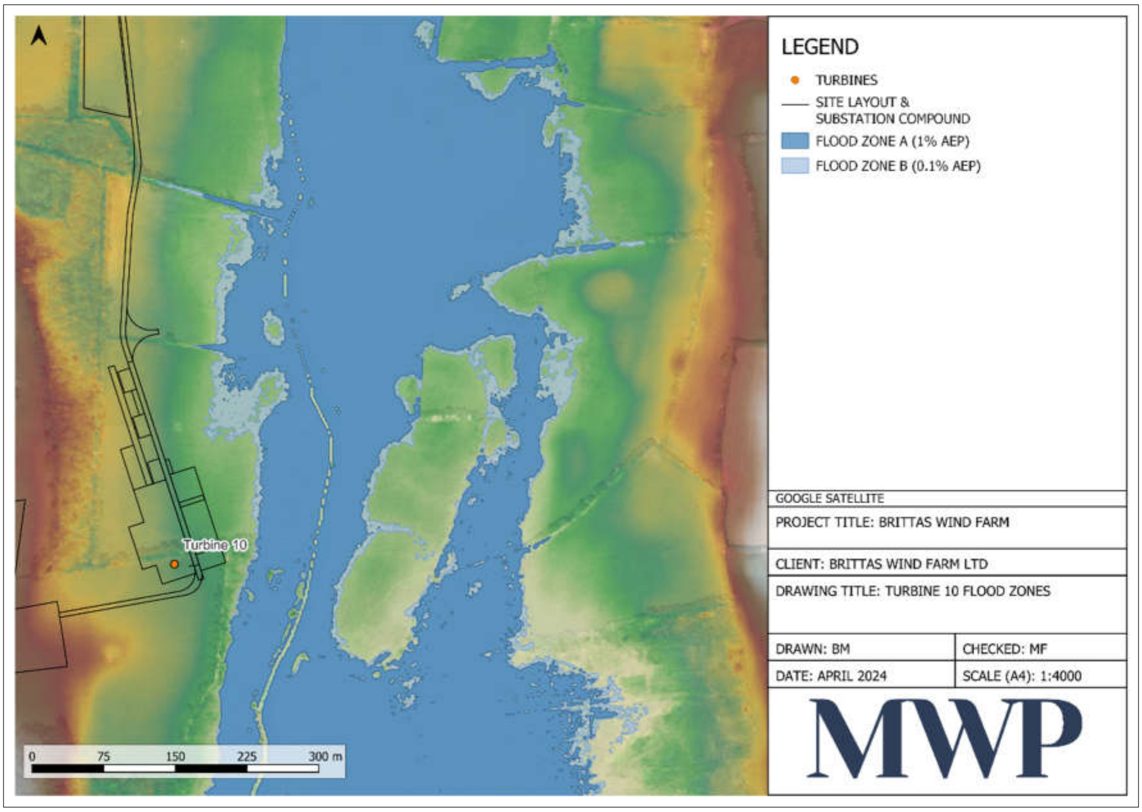


Figure 5-6: Turbine 10 Flood Zones – Existing Scenario

Turbine	Flood Zone
Turbine 1	B
Turbine 2	B
Turbine 3	B
Turbine 4	A
Turbine 5	C
Turbine 6	C
Turbine 7	B
Turbine 8	C
Turbine 9	C
Turbine 10	C

Table 5-2: Flood Zoning

5.3 Vulnerability of the Proposed Development

The PSFRM Guidelines have outlined three Vulnerability Classifications for developments based on the proposed land use and type of development. These classifications and particular examples of development types which would be included in each classification are summarised as follows;

1. Highly Vulnerable Development: This would include emergency services, hospitals, schools, residential institutions, dwelling houses, essential infrastructure, water & sewage treatment etc.

2. Less Vulnerable Development: Retail, leisure, commercial, industrial buildings, local transport infrastructure.

3. Water-compatible development: Docks, marinas and wharves. Amenity and open space, outdoor sports and recreation and essential facilities such as changing rooms.

The Guidelines also include a matrix of vulnerability versus flood zone to differentiate between developments which are appropriate in various flood zones and those which require a Justification Test. This table is reproduced as Table 5-3 below.

Vulnerability Classification	Flood Zone A	Flood Zone B	Flood Zone C
Highly Vulnerable Development	Justification Test	Justification Test	Appropriate
Less Vulnerable Development	Justification Test	Appropriate	Appropriate
Water Compatible Development	Appropriate	Appropriate	Appropriate

Table 5-3: Vulnerability Matrix

The proposed Brittas Sub-station falls under the essential infrastructure category. As the proposed Brittas Sub-station is within Flood Zone C, the development is considered to be appropriate. The Guidelines state that development types not listed should be considered on their own merits. The construction of wind turbines and the associated infrastructure are not listed, therefore the assumption is that they can be constructed in any of the flood zones provided that they are protected from flooding and that their presence does not increase flood risk elsewhere. A design water surface level was established along the River Suir, Rossestown Stream and its tributaries. The turbines will be set with a freeboard above the adjacent calculated 100-year flood level taking a 20% climate change factor into account. Since the development is considered to be an appropriate type in all three flood zones, a Justification Test, as described in Chapter 3 of the Guidelines, is not required for the 10 no. turbines.

5.4 Climate Change

The design flood level is the 1% AEP plus the mid-range future scenario (MRFS) which corresponds to a 20% increase in flow. A scenario was run to assess the risk from the 1%AEP MRFS. The 1%AEP flood extent and 1%AEP MRFS flood extent are presented in Figure 5-7 to Figure 5-11 below.

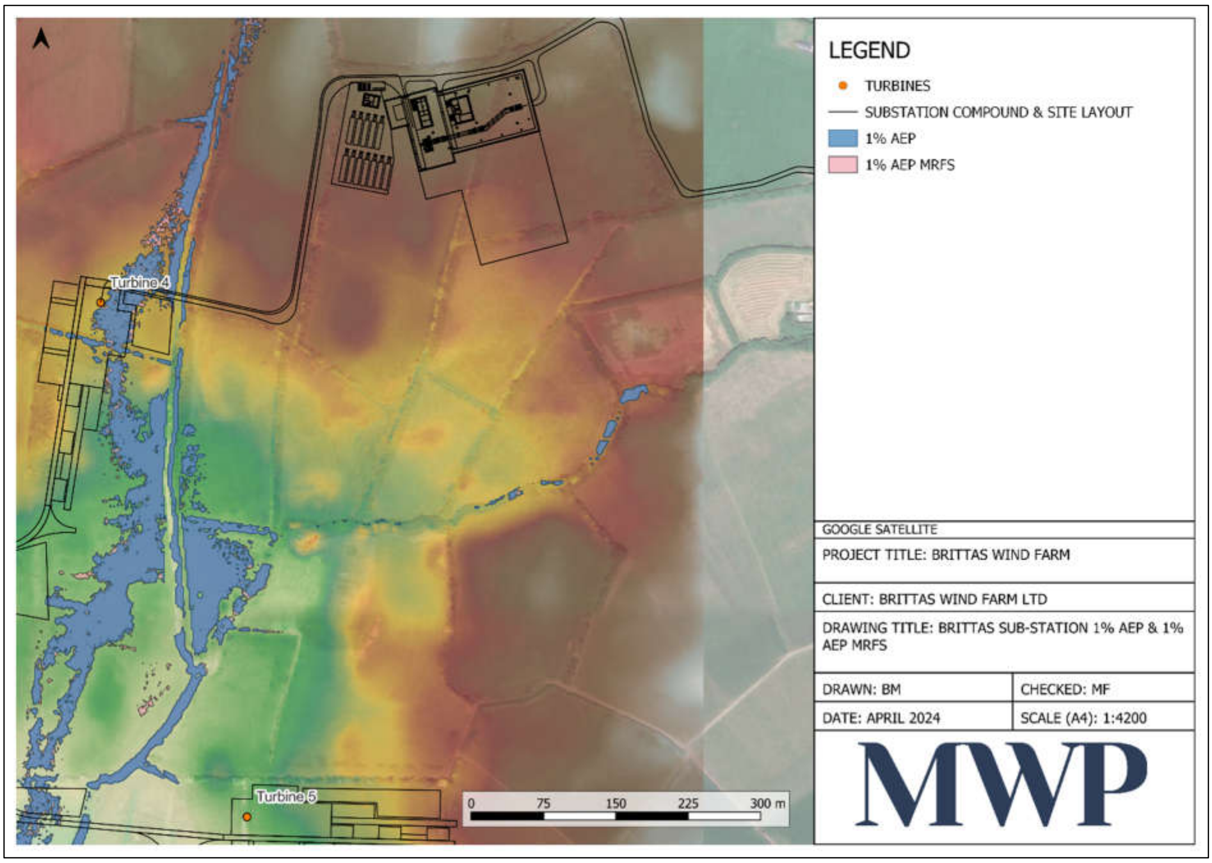


Figure 5-7: Brittas Sub-station 1% AEP Existing Scenario Flood Extent & 1% AEP MRFS Flood Extent

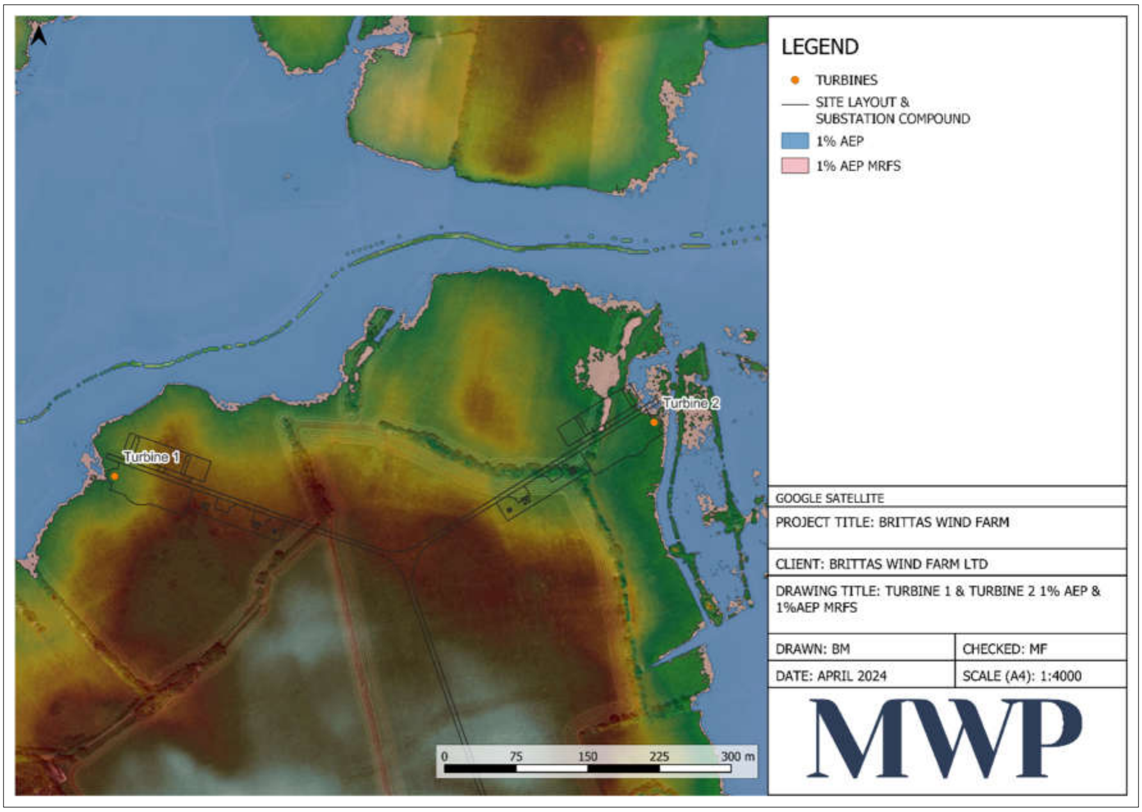


Figure 5-8: Turbine 1 & Turbine 2 1% AEP Existing Scenario Flood Extent & 1%AEP MRFS Flood Extent

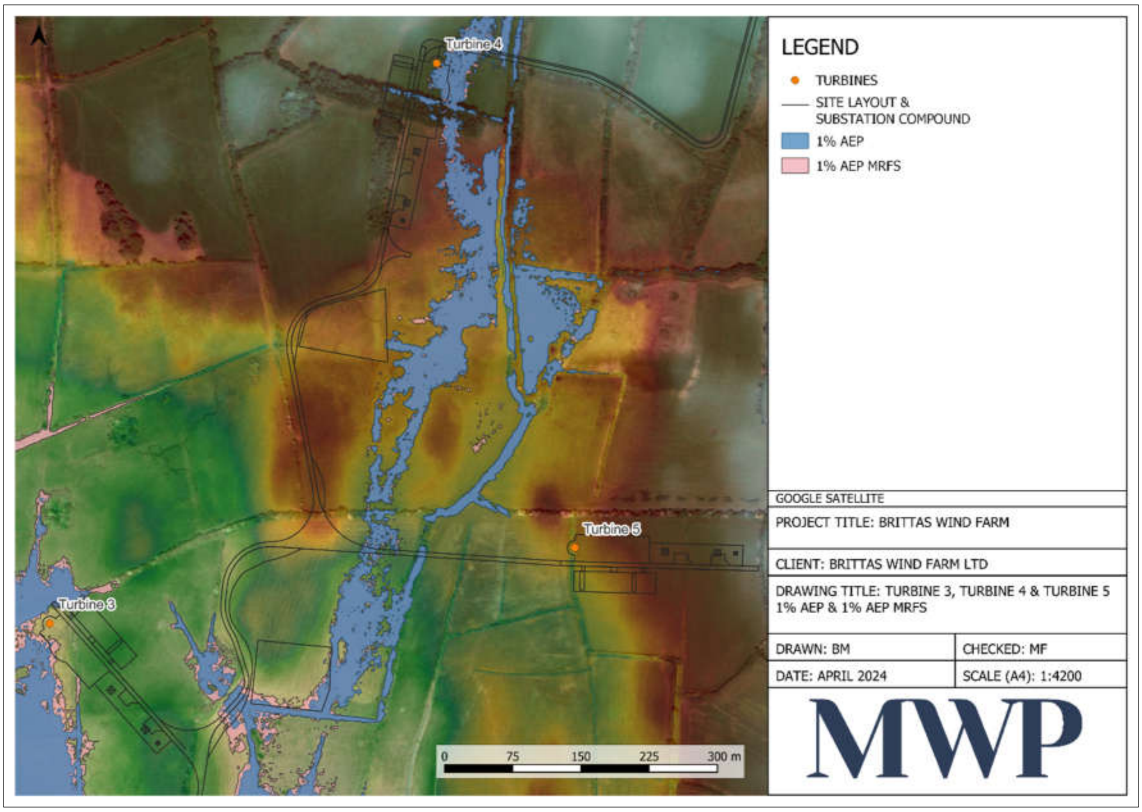


Figure 5-9: Turbine 3, Turbine 4 & Turbine 5 1% AEP Existing Scenario Flood Extent & 1%AEP MRFS Flood Extent

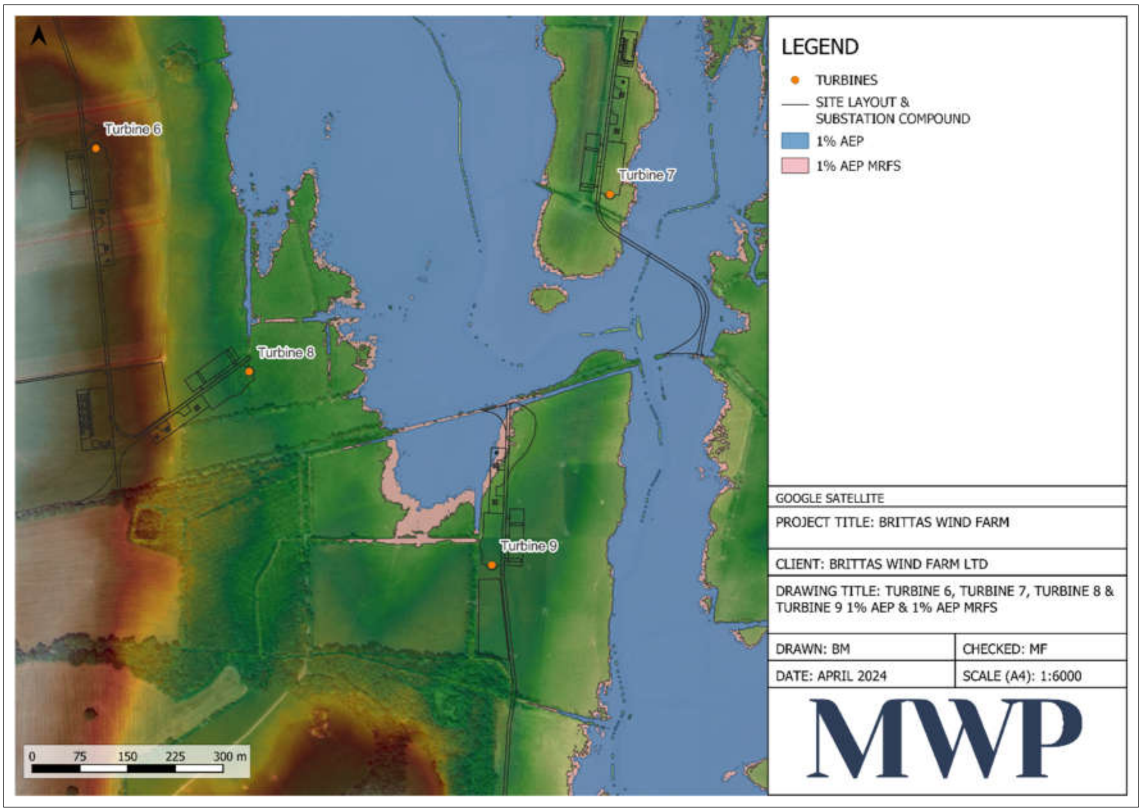


Figure 5-10: Turbine 6, Turbine 7, Turbine 8 & Turbine 9 1% AEP Existing Scenario Flood Extent & 1%AEP MRFS Flood Extent

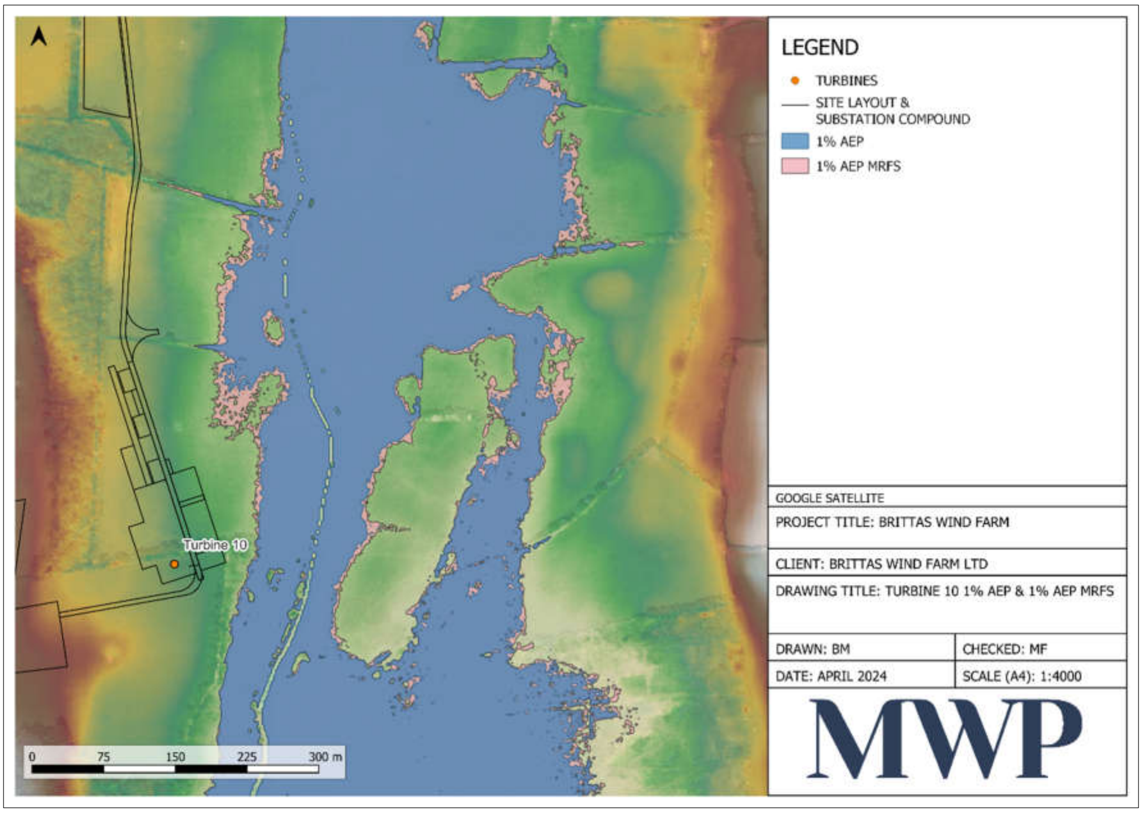


Figure 5-11: Turbine 10 1% AEP Existing Scenario Flood Extent & 1%AEP MRFS Flood Extent

5.5 Post Development Situation

The post-development situation includes for the proposed Brittas Sub-station, turbine hardstands, access tracks and turning heads. The hydraulic model was adjusted to include the proposed access track alignment and hardstands. This involved adjusting the DTM to include new internal site access tracks, 5.5m wide and 6480m in length and 10 No. Wind Turbine foundations and Hardstand areas. The revised DTM of the model is indicated on below Figure 5-12.

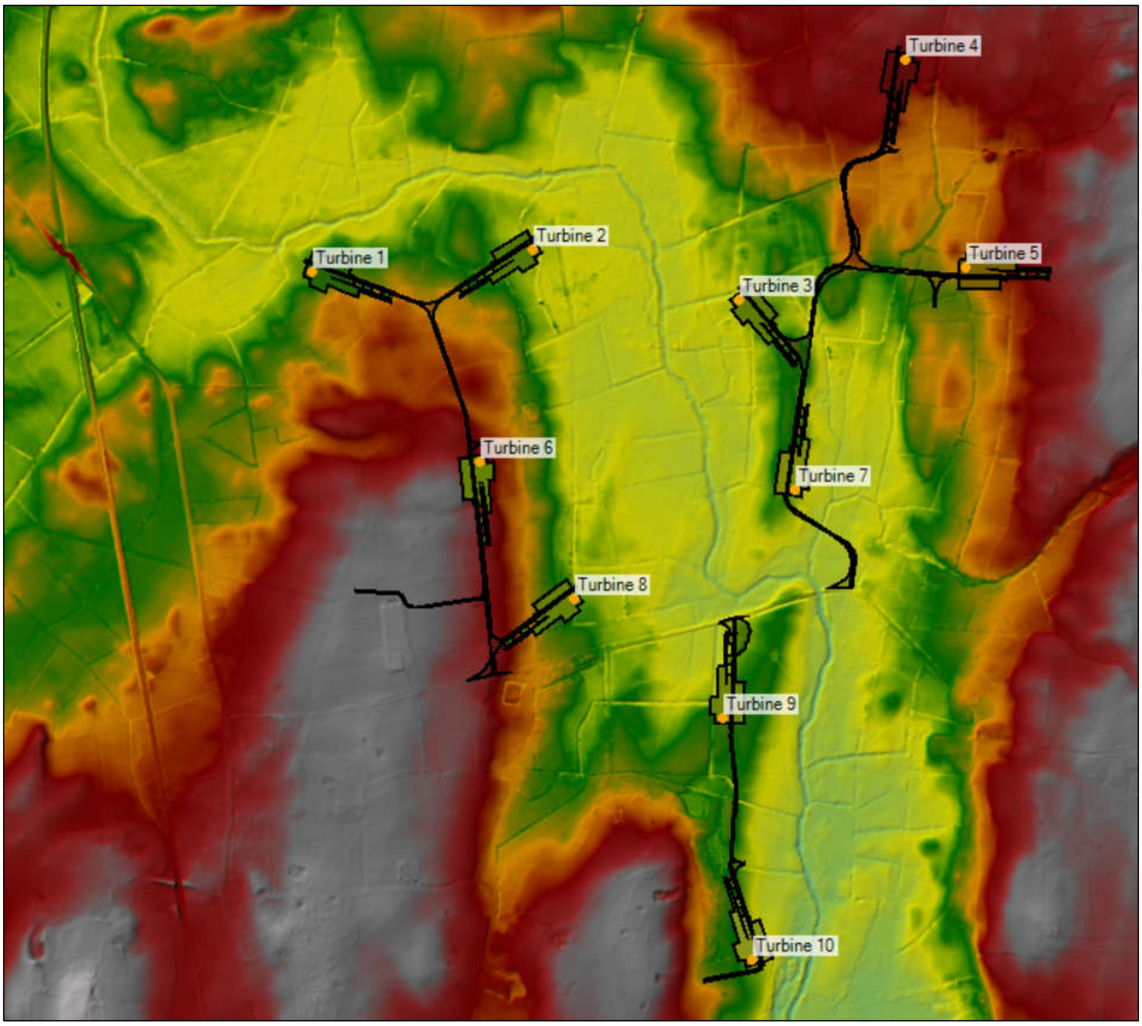


Figure 5-12: Post Development Revised DTM

The changes to the flood extents are highlighted on Figure 5-13 below. The increase in flood extent is insignificant. The impact of the proposed development on flood levels is mapped on Figure 5-14 below for the 0.1% AEP event, as this provides a slightly more conservative value when compared to the 1% AEP MRFS. The difference in water surface elevation is predominantly <= 10mm for the proposed development. However, there is a localised area south east of Turbine 7 which indicates an increase in water surface elevation of approximately 40mm to 50mm. This afflux can be attributed to the proposed access track which intersects the floodplain at this location. However, the afflux as a result of the proposed access track is well within the 300mm, which is a recommendation of the OPW for land affected by the construction of a bridge/culvert and at locations where properties are not at risk of flooding. The flood levels upstream and downstream of the site will not be adversely affected. Figure 5-15 below shows the existing and proposed flow hydrograph downstream of Turbine 10. As can be seen, there is no appreciable difference in hydrograph shape and the peak flow passed downstream is unchanged. Therefore, it is concluded that the proposed development will not adversely impact flood risk elsewhere.

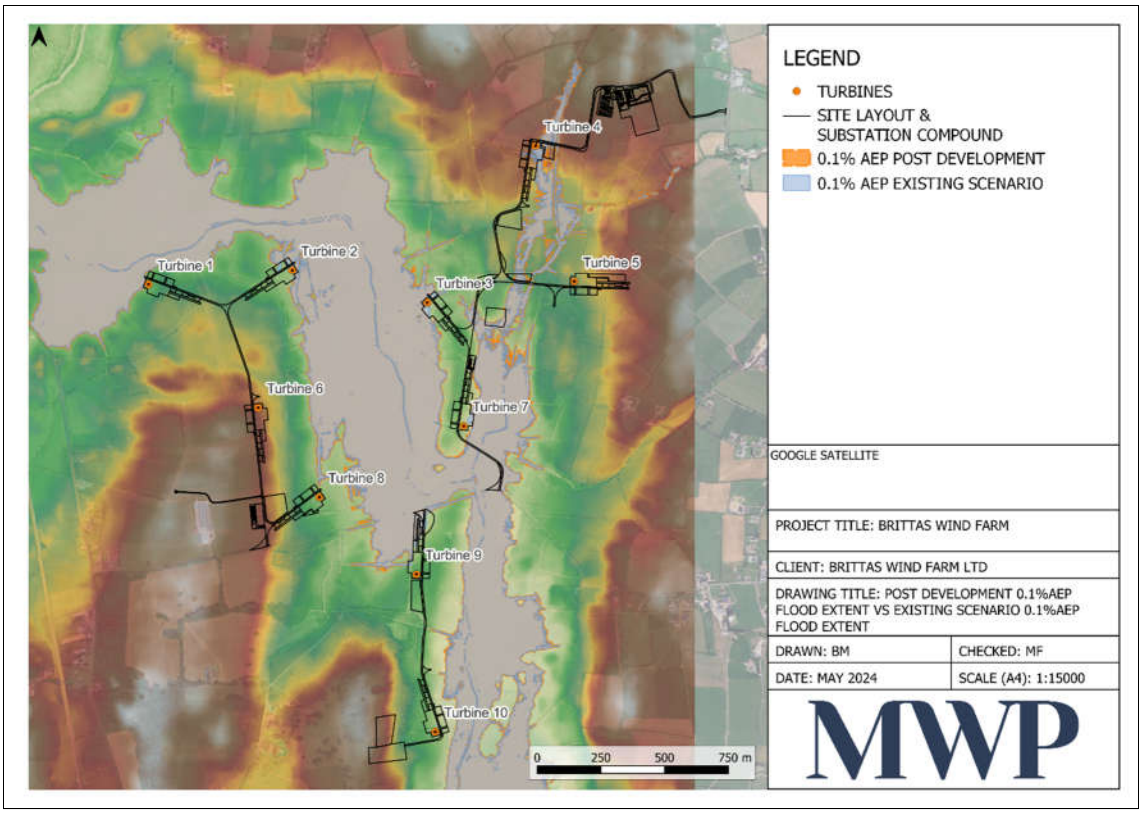


Figure 5-13: Post Development 0.1%AEP Flood Extent vs Existing Scenario 0.1%AEP Flood Extent

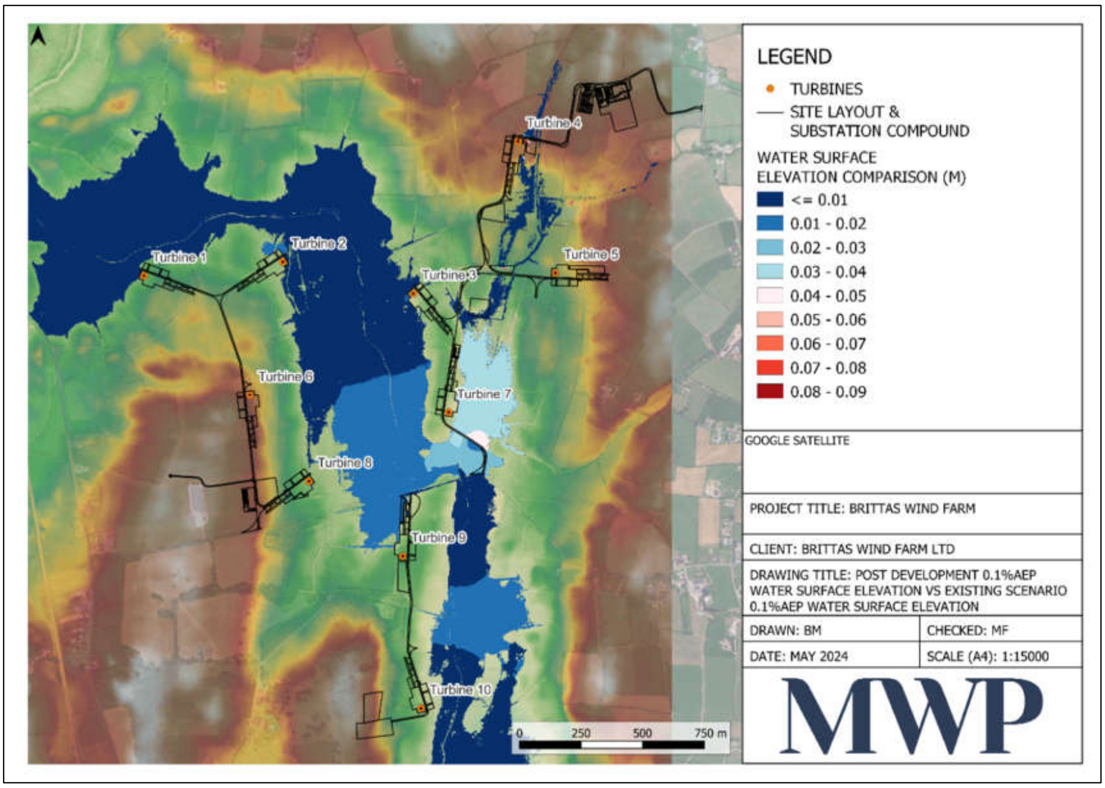


Figure 5-14: Post Development 0.1%AEP Water Surface Elevation vs Existing Scenario 0.1%AEP Water Surface Elevation

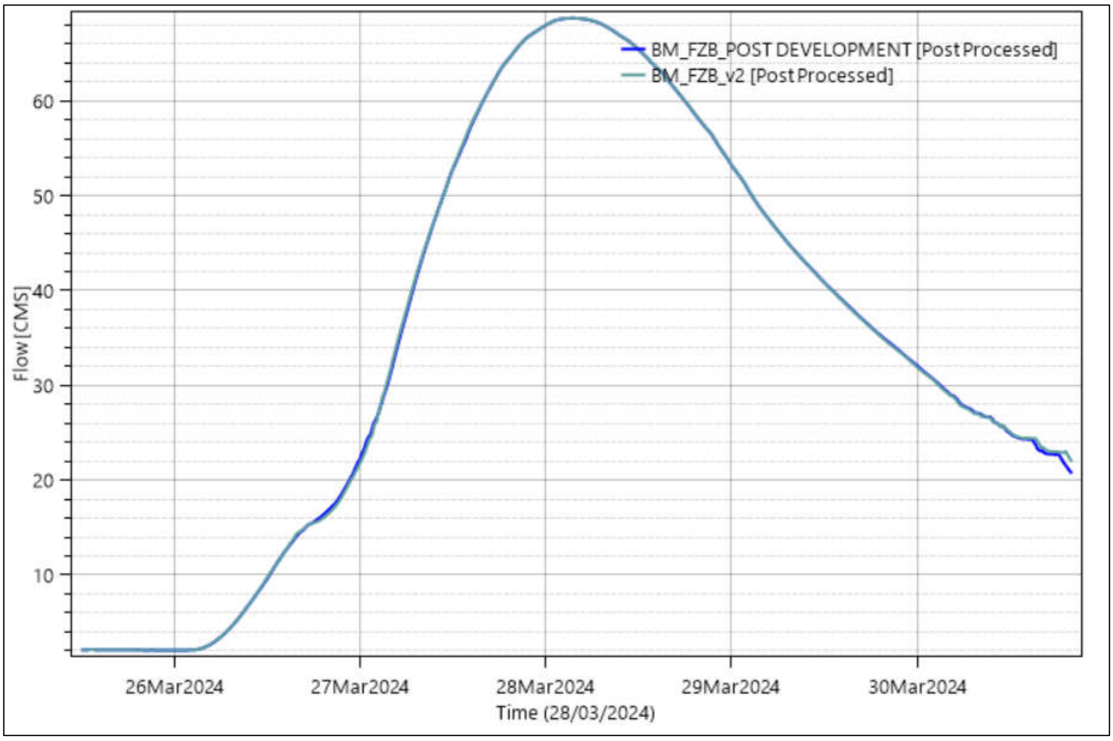


Figure 5-15: 0.1% AEP Existing Scenario Flow Hydrograph & 0.1%AEP Post Development Scenario Flow Hydrograph

5.6 Mitigation Measures

The PSFRM Guidelines recommend a precautionary approach be taken to allow for various uncertainties therefore requirements for flood mitigation would generally be assessed using higher confidence interval flows.

To ensure that there is no unacceptable flood risk to the proposed Brittas Sub-station and 10 no. turbines, the following mitigation measures are recommended:

1. The proposed Brittas Sub-station should be set above the 0.1% AEP MRFS 95% Confidence Interval flood level of 107.3mOD, plus 500mm freeboard. Therefore, the minimum proposed finished floor level of the proposed Brittas Sub-station is 107.8mOD. However, as per planning drawings the proposed finished floor level of the proposed Brittas Sub-Station is 107.85mOD.

2. The proposed 10 no. turbines should be set above the 1% AEP MRFS flood level plus 300mm freeboard. The minimum proposed finished levels for the 10 no. turbines are also presented in Table 5-4.

Turbine	Flood Level 1% AEP MRFS (mOD)	Proposed Finished Turbine Level - 300mm Freeboard Included (mOD)
Turbine 1	97.80	98.10
Turbine 2	97.40	97.70
Turbine 3	97.30	97.60
Turbine 4	103.80	104.10
Turbine 5	99.50	99.80
Turbine 6	97.25	97.55

Turbine	Flood Level 1% AEP MRFS (mOD)	Proposed Finished Turbine Level - 300mm Freeboard Included (mOD)
Turbine 7	97.00	97.30
Turbine 8	97.25	97.55
Turbine 9	97.15	97.45
Turbine 10	96.10	96.40

Table 5-4: Turbine Flood Levels

5.7 Residual Risks

The following residual risks have been identified;

1. Climate change effects larger than currently estimated
2. Flood Flows Larger than estimated

5.7.1 Climate Change Effects & Larger Flood Flows

During the sensitivity analysis an assessment was carried out to determine the impact a 0.1% AEP flood event for the MRFS (i.e. 20% increase in flows to allow for climate change). As would be expected, this event would result in an increase in flood level and extent throughout the proposed development. At most locations the increase would not cause flooding to the turbines and hardstanding areas and the extents would not differ significantly from the current scenario. However there are certain locations where an exceedance flow could have a more significant impact on flood risk. This includes:

1. Turbine 4 and the Turbine 4 hardstanding areas. However, the design event for the proposed 10 no. turbines is the 1% AEP MRFS flood level plus 300mm freeboard as discussed in Section 5.6.

6. Conclusions & Recommendations

A summary of the main findings of this FRA is as follows;

1. This report has been prepared in the context of *The Planning System and Flood Risk Management – Guidelines for Planning Authorities, November 2009 (PSFRM)*, published by the Office of Public Works and the Department of Environment, Heritage and Local Government.
2. The proposed development includes for the construction of no.10 turbines, hardstands, foundations, access tracks, internal underground connector cable, substation, battery storage, Lidar compound, borrow bit, felling areas and soil deposition areas.
3. The Stage 1 and 2 flood risk assessments indicated that there is potential for flooding at this site. The potential source of flooding was identified as fluvial flooding from the River Suir, the Rossestown Stream and its tributaries.
4. In particular, the Suir CFRAMS published flood extents which indicate that this site may be vulnerable to flooding.
5. A Stage 3 Detailed Flood Risk Assessment (FRA) was carried out to assess flood risk issues in sufficient detail to provide a quantitative appraisal of potential flood risk to the site.
6. There are flow records available for the River Suir and Rossestown Stream. The Flood Studies Update (FSU) was selected as the most appropriate flood estimation method to calculate the flood flows for catchments with an area >5km². The IH124 flood estimation method was adopted for catchments that have an area <5km².
7. In order to predict the flood extents and flood levels at the site, a combined 1D-2D hydraulic model was created using HEC-RAS river modelling software.
8. The model was used to create a flood zone map of the existing site which indicates the extent of Flood Zones A and B. Areas of the site outside of these Flood Zones are in Flood Zone C.
9. The flood zone map is included on Figure 5-2. It indicates that the proposed Brittas Sub-station is located within Flood Zone C. The majority of the 10 no. turbines are located in Flood Zone C which has a low probability of flooding (less than 0.1% annual exceedance probability or 1 in 1000).
10. Some of the 10 no. turbines are located within Flood Zone A/Flood Zone B, therefore having a high to medium probability of flooding during the 1% and 0.1% AEP events respectively.
11. To ensure that there is no unacceptable flood risk, the following mitigation measures are recommended:
    a. The design flood level for the proposed Brittas Sub-station is the 0.1%AEP MRFS 95% CI flood level plus 500mm freeboard.
    b. The design flood level for the proposed 10 no. turbines is the 1%AEP MRFS flood level plus 300mm freeboard
12. It was concluded that, once the above mitigation measures are implemented, the proposed development will not have an adverse impact on flooding elsewhere.
13. Residual risks associated with the development were also assessed and are considered to be acceptable.

Appendix A

Photographs

Figure 0-1: Main Channel north east of turbine 1


Figure 0-2: Left Bank north east of turbine 1

Figure 0-3: Right Bank north east of turbine 1

Figure 0-4: Upstream face of triple arch bridge Rossestown Road

Figure 0-5: Left Bank Upstream face of triple arch bridge Rossestown Road

Figure 0-6: Right Bank Upstream face of triple arch bridge Rossestown Road

Figure 0-7: Main Channel north of turbine 10 & turbine 11

Figure 0-8: Left Bank north of turbine 10 & turbine 11

Figure 0-9: Right Bank north of turbine 10 & turbine 11